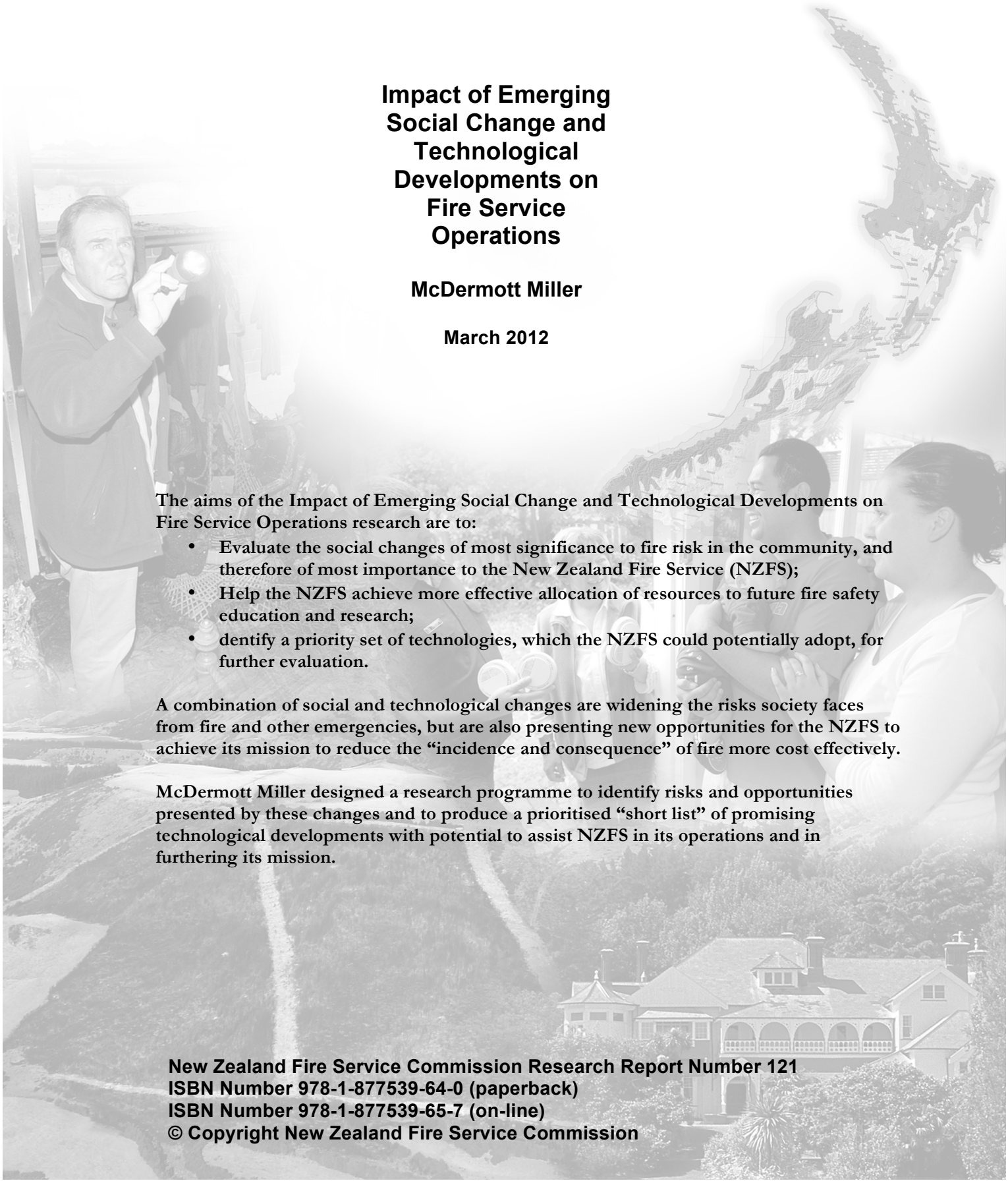
Fire Research Report

Impact of Emerging Social Change and Technological Developments on Fire Service Operations

McDermott Miller

March 2012



The aims of the Impact of Emerging Social Change and Technological Developments on Fire Service Operations research are to:

- Evaluate the social changes of most significance to fire risk in the community, and therefore of most importance to the New Zealand Fire Service (NZFS);
- Help the NZFS achieve more effective allocation of resources to future fire safety education and research;
- dentify a priority set of technologies, which the NZFS could potentially adopt, for further evaluation.

A combination of social and technological changes are widening the risks society faces from fire and other emergencies, but are also presenting new opportunities for the NZFS to achieve its mission to reduce the "incidence and consequence" of fire more cost effectively.

McDermott Miller designed a research programme to identify risks and opportunities presented by these changes and to produce a prioritised "short list" of promising technological developments with potential to assist NZFS in its operations and in furthering its mission.

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New Zealand Fire Service

Impact of Emerging Social Change and Technological Developments on Fire Service Operations

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McDERMOTT MILLER LIMITED *Strategy Consultants*
CPO BOX 629 WELLINGTON NEW ZEALAND
2nd FLOOR 90 THE TERRACE WELLINGTON
TELEPHONE (04) 471-8500
Email: strategies@mcdermottmiller.co.nz
Website: http://www.mcdermottmiller.co.nz

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McDermott Miller Limited, Strategic Planning Consultants
CPO PO Box 629 Wellington New Zealand
2nd Floor 90 The Terrace Wellington
Telephone (04) 471-8500
Email strategies@mcdermottmiller.co.nz
www.mcdermottmiller.co.nz

LIST OF EXHIBITS

EXECUTIVE SUMMARY

RESEARCH AIMS, AND BACKGROUND AND RESEARCH PROGRAM

The aims of the *Impact of Emerging Social Change and Technological Developments on Fire Service Operations* research are to:

- Evaluate the social changes of most significance to fire risk in the community, and therefore of most importance to the New Zealand Fire Service (NZFS);
- Help the NZFS achieve more effective allocation of resources to future fire safety education and research;
- Identify a priority set of technologies, which the NZFS could potentially adopt, for further evaluation.

A combination of social and technological changes are widening the risks society faces from fire and other emergencies, but are also presenting new opportunities for the NZFS to achieve its mission to reduce the "incidence and consequence" of fire more cost-effectively.

McDermott Miller designed a research programme to identify risks and opportunities presented by these changes and to produce a prioritised "short list" of promising technological developments with potential to assist NZFS in its operations and in furthering its mission.

Five core tasks were covered in the research programme:

- **Task 1 Assessment of Social Changes**. This task is reported in Section 2 below.
- **Task 2 Assessment of Consumer Technology Changes,** covered in Section 3 of this report
- **Task 3 Assessment of emerging property fire detection and suppression technologies**, in Section 4 of this report.
- **Task 4 Assessment of emerging technologies NZFS could adopt itself**, in Section 5 below.
- **Task 5 Interpretation and Reporting** – Overall assessment of risk and opportunity covered in Section 6.

MAIN FINDINGS

Impacts of Social Changes

Social Changes tending to Increase Fire Risk in the Community

- Modest economic growth means there is likely to be a persistent *"Lower socio- economic people"* segment of the community living in absolute (not just relative) deprivation; this group most

at risk from fire will continue to be a growing challenge for fire risk management.

- Increasing population of "*Older People*" combined with government "aging in place" policies and older people's preferences means more people living alone and a growing need to maintain fire safety in the home.
- "*Maori and Pacific Island People*" will become a larger proportion of the population; their needs will need to continue to be addressed in Fire Service's community education programmes.
- Rate of owner/occupancy will continue to decline; growing numbers of "*People living in rental property*".
- Greater mobility combined with increasing importance of "virtual" communities have weakened ties to a conventional neighbourhood/community; has implications for social capital including volunteerism and other aspects of mutual support within communities.
- Increasing immigration, with more Asian and other immigrant groups without English as a first language, means increasing challenges for effective fire safety community education...
- Consumption of alcohol is increasing, and a "binge" pattern of consumption is apparent (though not necessarily increasing).

Social Changes tending to Reduce Fire Risk in the Community

- Increasing levels of education which may boost community receptiveness to more sophisticated fire safety messages and adoption of fire safety behaviours;
- Rapidly increasing use of Consumer ICT facilitating transmission of fire safety messages from NZFS to community.
- Consumer ICT facilitating two-way communication between public and emergency response organisations during emergencies.
- Trend towards more intensive urbanisation, including infill housing in suburban areas and apartment living in downtown areas.

Impacts of Consumer Technology Changes

- Social media and smart portable devices have great potential for improved two-way communication between the public and emergency services, and communication between private individuals and groups during recovery from an emergency.
- Smartphones (and other portable devices) have potential for "crowdsourcing" data in "routine" fire incidents, so that the Fire Service has more intelligence available prior to arrival at an incident. This data could include:
    - Mobile phone caller location giving the précised location of incident, for rescue purposes or so that risk plans, floor plans etc can be retrieved by the responding officers in advance;

- Images and video, together with data from miniaturised sensors in the smartphone (eg detection of gasses).

Impacts of New Property Fire Detection and Suppression Technologies

Domestic

- Technologies for improving performance of residential smoke alarms through requiring less maintenance (10 year life with no battery change), reduction in false alarms etc; interconnection of smoke alarms.
- Wireless connection of residential smoke alarms to the internet and other devices in the home.
- In particular, wireless integration of smoke and heat detectors with other personal and household security sensors including for example medic alert alarms monitored by expert systems software can detect emergency situations and provide information to security providers and emergency responders. Such systems can support "aging in place".
- Partial coverage sprinklers have potential for cost-effective reduction of fire risk.

Commercial/Industrial

- Improving "Integrated building management systems" incorporating interconnected smoke detectors and sprinklers have potential for cost-effectively improving protection of commercial and industrial buildings. These enable earlier automatic detection and suppression, and provide intelligence to responding fire officers.
- More intelligent, accurate sprinkler systems.

Impact of Emerging Operational Technologies for NZFS

- The development of broadband wireless connectivity – 3G and WiFi – means that it is now possible for intelligent alarm/detection systems, OICs at incidents, firefighters themselves, Comcen, and the public's smartphones to transmit rich data to support fire fighting and other emergency response options. In future, implementation of 4G/LTE networks will increase wireless bandwidth much further.
- Greater computing power on portable devices, including smartphones, mean that more processing can be carried out in the field, eg running applications to analyse visible light and thermal images, or for command and control decision support purposes.
- Miniaturisation, reduce power demand and expanded range of sensors for detecting fire, environmental conditions in a fire, fire fighters physiological status; wireless interconnection between sensors and intelligent processing and interpretation of the data flowing from sensors.

- Reduced weight and lower power demand of such sensors mean they can be mounted on firefighters (eg head mounted video cameras or thermal imagers), in building structures or on walls, in cameras for visual monitoring on in the public's smartphones.
- With data coming from sensors placed within structures, on firefighters, on vehicles and possibly from the public's smartphones there is an increased prospect of incident commanders/managers being subject to "information overload". As covered in the literature review, decision support/expert systems are being developed for use by fire/emergency responders which will help commanders/command teams identify/distil what actions to take.
- Provision of improved intelligence (plans, other images, text, and other information) at incidents, and on the way to incidents, so that officers and their teams at incidents can be more rapidly effective.

OVERALL ASSESSMENT OF RISKS AND OPPORTUNITIES

Risks

The following trends tend to increase fire (and other emergency) risks:

- The "aging" of the population; in particular increasing numbers of people aged over 75 living independently in the community.
- Increasing population in other "at risk groups", including Maori, Pacific Islanders, and migrants who do not have English as a first language.
- A persistent high-alcohol consumption ("binge drinking") sub-culture, particularly among the population 16-25 (Males in this age group have an elevated risk of injury by fire refer AFAC 2009).
- If civil unrest occurs locally, social media and smartphones make it easier for crowds to assemble, which could (in principle) start fires and/or impede the Fire Service in its duties (we see this as a minor risk however).
- A constrained economy over the medium term will mean limited job growth and continuing high unemployment. This indicates, unless effective social, training and employment policies achieve otherwise, an "underclass" will persist and perhaps grow larger.
- Straightened economic conditions and house price decreases have led to households seeking to reduce debt rather than invest more in their houses. This means that households will be less inclined to take up the opportunities to reduce the risk of fire they faced by investing in interconnected "smart" domestic smoke alarms (hardwired or wireless).
- Similarly, a tight economy may mean owners of commercial/industrial properties not taking up the opportunity to invest in modern, intelligent detection or suppression systems.

Opportunities

On the other hand, trends that tend to create opportunities to enhance achievement of the Fire Services outcomes include:

- Falling population in younger, risk taking age groups.
- Successful road safety campaigns against drink-driving have meant a reduction in serious motor vehicle accidents, and provide a precedent for current campaign to reduce cooking while intoxicated.
- Adoption of safer home heating technologies, with portable radiant heaters and open fires being replaced by heat pumps. Government and regional incentives programmes to achieve the National Environment Standards for Air Quality are helping to promote this shift, which can be expected to have fire-risk as well as environmental benefits.
- Wireless interconnected domestic smoke alarms with long-life batteries will provide the benefits of hard-wired smoke alarms at lower cost and could therefore be taken up more rapidly by the household market. Even "stand-alone" domestic smoke alarms with 10-year battery life are a major advance on traditional types which require checking and replacement of batteries. Futher, dwellings that comply with Clause F7—Warning systems of the New Zealand Building Code, which came into effect in 2003, will be a growing proportion of the total housing stock.
- At a more sophisticated level, integrated domestic security, medical and fire safety systems wirelessly connected to security providers will become more intelligent and perhaps more affordable. These will involve multiple sensors, together with expert system software to identify situations requiring intervention/assistance and to automatically notify security providers or 111 accordingly. These systems, if adopted and installed in sufficient numbers, could partially offset the increased risk associated with an aging population. Those elderly people (for a given level of frailty) living independently, with such technology installed, will be safer than those of today.
- In commercial/industrial properties detection and suppression systems are also becoming more intelligent. Networks of sensors combined with expert system software can assess when emergency services need to be called, and this will reduce both damage from fires and the numbers of false alarms. Suppression systems, if triggered, will be more targeted and effective, and cause less water damage. An increasing proportion of new commercial/industrial buildings will be fully "intelligent". The challenge is, of course, to induce property owners to retro-fit such systems, when even the current generation of detection and suppression systems have had low rates of take-up.
- Such intelligent building systems can transmit data directly to the Fire Service comcen and responding appliances. Of course the Fire Service will need to invest in the technology to receive

and analyse this data, but, if so, they have the potential to make responding crews more effective, more quickly and so reduce fire damage, risks to fire fighters, and the environmental effects of fire-fighting.

- Decision Support/Expert systems are being developed by the Fire Service to assist Officers in Charge make more rapid and effective decisions based on the information provided to them.
- Smartphones and other consumer portable devices will carry an increasing range of sensors and be able to process the data to detect emerging situations and transmit it, along with video and images, to emergency responders. Technologies are being developed to assist emergency responders compile, analyse and interpret such "crowd sourced" data.
- Sensors on firefighters to measure environmental conditions to interact with those installed in buildings for purposes of location, combined with lighter Head mounted Displays (HMD) and biometrics have potential to make firefighters both safer and more effective.
- Existing, but not fully adopted by NZFS, fire fighting technologies such as CAFs also have potential to increase firefighter effectiveness.

Balance of Risks and Opportunities

On balance, social changes are tending to increasing fire risk, and technological changes to reduce fire risk and facilitate achievement of the Fire Service's National Goals and outcomes. Technological changes have the potential to more than offset increasing risk from social changes such as population aging.

The proviso is that new and emerging active fire protection technologies are adopted by households, commercial/industrial building owners and by the Fire Service itself. In the short term, in a tight economy, investment by any of these parties is likely to be limited. The challenge to the Fire Service is to help ensure the opportunities presented by the emerging technologies are realised.

PRIORITY FIRE SERVICE OPERATIONAL TECHNOLOGIES FOR FUTURE INVESTIGATION

Based on the assessment presented in this report, we suggest the following technologies as priorities for the Fire Service (not including technologies already being investigated under the Fire Service's ICT strategy) together with the rationale for selecting them. These are listed in a provisional descending order of priority; future, more detailed investigations could lead to this order being revised:

1. **Reduce false alarms by encouraging building owners to modernise fire alarm systems.** This emerges as a top priority for two reasons: first, false alarms impose unnecessary costs on the Fire Service, its volunteers, and on their employers. Second, most of the emerging technologies for collection, transmission

and analysis of intelligence by the Fire Service itself require inputs from a smart detection system.

2. **Vehicle-based or Portable Incident Information Display via IP (internet protocol) network, eg risk plans.** The provision of intelligence/information to OICs directly to help them establish effective command and control more quickly is a clear priority. This technology is also prerequisite for the other technologies such as cameras and thermal imagers mounted on or carried by firefighters, or data received from public's smartphones.
3. **Transmission of video by cameras on firefighters together with image analysis software to analyse video for location, size and movement.** This can include both visible light video, and thermal imagery. In the literature review we outline how the hardware and software (algorithms) have developed to increase the power to detect flame and hotspots, and to detect persons in both fire and Urban Search and Rescue situations. There are potentially substantial benefits in more effective command and control, and in firefighter safety and effectiveness.
4. **Technologies to maximise flexibility in training time/place and in learning style** (visual, auditory, kinaesthetic). The desirability of improving training of volunteer firefighters while managing demands on their time came through strongly in our consultation in the Survey of Area Managers.
5. **Modelling/simulation to refine location of stations and/or resources.** Methodologies for refining the models used to locate fire stations and allocate resources are reviewed in **Section 6.3.** While the Fire Service's current National Resource Allocation Model (NRAM) is, according to the Fire Service's 2011/14 Statement of Intent, a major technical advance on previous procedures, developing theory in this area may mean further improvements are achievable.
6. **Devices on firefighters for location in structures.** This is important for both for purposes of firefighter safety, and for effective fire fighting. A number of technologies for locating fires were covered in the literature review, including GPS and RFID tags, and "motes"; the latter two require investment by building owners.
7. **Innovative live fire simulators.** The reduction in real fire incidents means there is a need for live fire training and it is unlikely that computer simulations will ever entirely replace this need. We suggest the relatively low cost live fire simulators discussed **in Section 5.3** should be investigated further.
8. **Command and Control Simulators.** In the survey of Area Managers the command and control simulators for training were thought to have priority over computer (non-live fire) simulators. We suggest that further investigations be carried out into the command and control decision support

methodologies covered in the literature review. Most can be used for both training and as decision systems in actual operations.

9. **Location of caller's mobile phone together with capability to receive and analyse other data on incidents.** The various means by which the public can provide useful data to the emergency services are reviewed in **Section 5.3**; these range from the location of the calling phone (using GPS or more complex approach to locate the phone within a muti-storey structure), through images and video and eventually data from other sensors imbedded in the phone. Using Quick Response (QR) codes could be a further, future step.
10. **Compressed Air Foams delivery systems.** This is an existing technology, but we were informed by Fire Service managers that the potential of CAFs for more effective fire fighting, with less polluting water runoff, have not been realised. We suggest the reasons for this be examined in more detail than we have been able to here. We also recommend a cost-benefit study be carried out on the possible wider adoption and use of CAF by NZFS.

INVESTIGATION PRIORITIES

We conclude this research by identifying four high-priority topics for further investigation. While these are numbered one to four, we see these as being of approximately equal importance.

1. Research the commercial and industrial building market for modern intelligent IP connected alarm/suppression systems. The research would include:
   - building owners' awareness and perceptions of these technologies by;
   - the perceived barriers to retrofitting these in existing buildings them and how these could be overcome;
   - a financial cost-benefit assessment of these system, from the point view of building owner;
   - an economic cost-benefit assessment of these system from the national perspective (benefits include savings of false alarm callouts)
2. Research the domestic market for modern smoke alarms at increasing levels of cost and sophistication, including as part of an "intelligent" integrated domestic security system. The research would investigate, *inter alia*:
   - Domestic property owner's awareness and perceptions of these technologies;
   - The perceived barriers to adopting them and how these could be overcome;
   - a financial cost-benefit assessment of these system, from the point of view of the property owner;

- an economic cost-benefit assessment of these system from the national perspective

There should be two target samples in the research; first, owner-occupiers, and, second, landlords of domestic rental properties, who will make the required investments. Boost sub-sample should be made of "at risk" group households.

3. Evaluate vehicle-based or portable Incident Information Display systems for receiving, analysing and displaying:
   - risk plans
   - data from smart fire alarm systems
   - location, video and other data from the public's smartphones (crowdsourcing).
4. Evaluate technologies to maximise flexibility in training time/place and in learning style. This would involve *inter alia*:
   - Surveys of career and volunteer firefighters on how they prefer to learn;
   - Case studies of use of modern ICT, including Course Management Systems and games-technology based simulators, in emergency services training (particularly involving volunteers) in NZ and internationally;
   - Assessment of the barriers to more intensive use of these technologies in NZFS (technical/financial/attitudinal) and how these could be overcome;
   - Evaluation of specific training systems.

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McDermott Miller gratefully acknowledges the help and patience of the following New Zealand Fire Service Personnel:

Members of the Advisory Panel:
Elizabeth Grieve Principal Project and Risk Adviser
Brian Davey, National Manager Operational Standards

Information & Library Services Officers:
April Flux, Manager Information & Library Services
Emma Roache, Senior Information Officer

Other Managers whom we consulted:
Jim Stuart-Black, National Manager Special Operations
Jon Graham, National Advisor Operations,
Kerry Stewart, Risk Manager, Western Fire Region
Jeff Maunder, Advisor Operational Efficiency
Des Irving, Fire Risk Manager, Arapawa Fire Region
Chris Juris, Manager ICT Strategy and Programme
Neil Challands, Information Analyst
Alex Atwell, Team Leader Development
Simon Davis Engineering Manager

The **Area Managers and Assistant Area Managers** who responded to our email survey.

We also thank the **National Library of New Zealand** for assistance with the literature review.

1. SCOPE OF THE RESEARCH

1.1 RESEARCH AIMS

The aims of the *Impact of Emerging Social Change and Technological Developments on Fire Service Operations* research are to:

- Evaluate the social changes of most significance to fire risk in the community, and therefore of most importance to the New Zealand Fire Service (NZFS);
- Help the NZFS achieve more effective allocation of resources to future fire safety education and research;
- Identify a priority set of technologies, which the NZFS could potentially adopt, for further evaluation.

1.2 BACKGROUND

A combination of social and technological changes are widening the risks society faces from fire and other emergencies, but are also presenting new opportunities for the NZFS to achieve its mission to reduce the "incidence and consequence" of fire more cost-effectively.

Relevant social changes include:

- Increasing percentage of the population falling into the groups identified by the Fire Service as particularly "at-risk" of fire;
- Decreasing percentage of houses owned by their occupiers;
- Intensifying urbanisation including higher density housing – apartments, infill housing etc;
- Increasing levels of education which may boost community receptiveness to more sophisticated fire safety messages and adoption of fire safety behaviours.
- A perception that crowds are less likely to assist the NZFS and other emergency services, and may deliberately cause or exacerbate emergencies;

The use of social networks and smart portable devices which:

- can be used to transmit useful information to emergency crews responding to calls;
- can be used by emergency service to communicate with the community during emergences;
- provide opportunities for dissemination of fire safety messages; and,
- but can increase risks of rapid formation of crowds that cause or exacerbate emergency incidents;

New and emerging active fire protection and fire fighting technologies can potentially:

- increase the level of fire detection and suppression that property owners can provide for themselves;
- reduce NZFS response times, through improving location of resources and traffic information;
- provide more information to fire crews before they arrive at incidents so they become fully effective more quickly;
- Support Officer in Charge's command and control at incidence;
- improve firefighter safety and effectiveness at the fireground;
- cost-effectively improve training of both career and volunteer firefighters;
- reduce the impact of fire service operations on the environment.

Given the range of these trends, their interaction and contrasting directions of their potential effects, the NZFS perceived the need for an overall assessment of them under its Contestable Research Fund (2010-11 round). McDermott Miller designed a research programme to identify risks and opportunities and produce a "short list" of promising technological developments with potential to assist NZFS in its operations and in furthering its mission.

1.3 SUMMARY DESCRIPTION OF METHOD

The purpose of the research is to help the Fire Service anticipate social and technological changes that are likely to impact significantly on the fire risks faced by the community and on achievement of the Fire Service's Strategic Objectives (Refers Strategic Directions page of the Commission's website).

Research Questions

The research is essentially qualitative, with limited quantitative analysis. Therefore, the research objectives are framed as a series of questions to explore and answer, rather than as hypotheses to be tested.

The following research questions were framed, after consultation meetings with NZFS managers and an extensive literature review, to identify the direction of the research project and to limit its boundaries:

- What are the significant social changes that are impacting on levels of fire risk and therefore demand for NZFS services?
- What are the key developments in consumer technologies, and in their use by the community that present opportunities for more effective NZFS operations?
- Could the use of new and emerging technologies incur increased fire risks in any way?
- What emerging fire detection and suppression technologies should NZFS encourage residential and commercial property owners to adopt; in particular, which of these have most

potential to limit fire risk among growing "at risk" groups in the community?

- What are the most promising technologies that NZFS could itself adopt to cost-effectively improve its operational outcomes?

Research Approach

While the research includes original data analysis, the methodology consists largely of consultation and literature review. We have drawn on the existing knowledge within the NZFS of new and emerging operational and property fire detection and suppression technologies. But there is a need for this knowledge to be collated, assessed, compared with international experience / knowledge and made available to users/future researchers both within and outside the NZFS.

McDermott Miller *Strategies* has adopted a triangulation approach to the Impact of Emerging Social Change and Technological Developments on Fire Service Operations research by undertaking and bringing together the results of:

- Desktop study of situation, effects and outcomes from available data and information to hand.
- Qualitative assessment, using data and information collected by means of interviews or surveys with participating parties, and subsequently analysed.
- Primary quantitative assessment, where quantitative data is collected in email, telephone or face to face surveys of participating parties, and subsequently analysed.

In outline, the research process involves:

- An inception meeting with the National Director Fire Risk Management to finalise research objectives and deliverables, and to agree on appropriate managers and executive officers to invite to join the panel, and a wider circle to consult with;
- Establishing a panel of managers and executive officers willing to contribute to, support and guide the research; who we consulted with and who provided feedback on draft reports;
- Consultation with NZFS managers and executive officers on their perceptions of those social and technological trends that are most significant for achievement of NZFS's goals;
- Extending this consultation via an online survey of Area Managers;
- Selective review of existing NZFS reports and data. Relevant and significant unpublished reports were included, as well as Contestable Research Fund reports;
- Selective review of national and international literature relevant to the research questions;
- Projections of the size of selected "at-risk" groups, based on Statistics New Zealand's national projections;

- A prima facie cost effectiveness analysis from the point of view of domestic, commercial, industrial and rural owners of fire detection and suppression technologies, compared with that of existing technologies;
- Assessment of new technologies for the NZFS in terms of potential cost effectiveness using an evaluation matrix. The evaluation matrix facilitated identification of a limited set of new technologies for the NZFS which should be further evaluated beyond this research project.

Research Program

Five core tasks were covered in the research programme, designed to achieve the aims and objectives set out above. They were:

- **Task 1 Assessment of Social Changes**. This task is reported in Section 2 below.
- **Task 2 Assessment of Consumer Technology Changes,** covered in Section 3 of this report
- **Task 3 Assessment of emerging property fire detection and suppression technologies**, in Section 4 of this report.
- **Task 4 Assessment of emerging technologies NZFS could adopt itself**, in Section 5 below.
- **Task 5 Interpretation and Reporting** – Overall assessment of risk and opportunity covered in Section 6.

1.4 APPROACH TO SELECTIVE LITERATURE SEARCH

We have undertaken a systematic literature search. Our approach comprised relevant bibliographic sources to search, and identifying relevant search terms.

Sources for Relevant Literature

We met the Fire Services' Information Centre Manager and Senior Information Officer to discuss our information needs. We received guidance on NZFS's library catalogue system, and links to key web sites for relevant fire research literature.

The sources of relevant literature include:

Sources for technological developments in fire service operations:

- NZFS Information Centre catalogue: as well as providing references to published literature (both scholarly and non-academic) this referenced some unpublished Fire Service reports.
- Reports provided on a confidential basis by Fire Service managers we interviewed, particularly in the ICT area on past trials with new technologies.

- Review of unpublished NZFS Incident Statistics reports provided by the Information Analyst (this confirmed that households in "deprived" areas continue to be at elevated risk of fire).
- The NZFS website - for previous CRF research reports.
- Australian, British, US & Canadian fire service and emergency agency web sites (links supplied by NZFS Information Centre Officers) for research reports etc which are not necessarily referenced in the academic literature.
- Academic journal publisher's websites, eg Emerald, which index the journals they publish.
- EBSCO (link through WPL).
- Bibliographic sites accessed through National Library including Index New Zealand.
- Bibliographic sites accessed through VUW, including IEEE Xplore and Wiley Online Library.
- Web sites of publishers of relevant journals.
- Websites of producers and marketers of active fire protection and fire fighting equipment.
- What's Next www.nowandnext.com for international overview of "trends in society, business, science & technology, government and the environment".

Sources for Information on Social and Economic Trends in NZ:

- Futures Thinking Aotearoa www.futurestrust.org.nz
- The New Zealand Institute www.nzinstitute.org
- Population Association of New Zealand http://panz.rsnz.org
- Enhancing Wellbeing in an Ageing Society www.ewas.net.nz.
- Ministry of Social Development.
- The Social Report 2010 www.socialreport.msd.govt.nz.
- Statistics NZ.
- New Zealand Treasury.
- Ministry of Civil Defence and Emergency Management.
- 2025 Taskforce www.2025taskforce.govt.nz.
- www.eastonbh.ac.nz.

Identifying Search Terms

Relevant Search Terms were identified:

- From terms supplied by Executive Officers in our interviews with them;
- On the basis of our McDermott Miller's previous experience in undertaking CRF research (Fire Research Report 12);
- Discussions with Fire Service Information Centre manager;
- Review of key previous Contestable Research Fund reports;

Criteria for selective reports and articles for review

We carried out a selective review of the literature. The selection criteria used were:

- **Relevance:** After each search run, we read the titles of document discovered and their abstracts, if available. The prime criterion for selection for review was that the reference provided useful information relevant to the search terms. If the documents appeared to be sufficiently relevant we then considered the following subsidiary selection criteria:
- **Authorities of Publication:** The searches were not limited by publication type and a wide range has been considered including peer-reviewed scholarly journals, independent reports commissioned by fire services, internal fire service reports, government reports, magazines and web sites aimed at firefighters, non-peer reviewed conference papers. This was a pragmatic decision, as we considered limiting the search to the academic literature only was too limiting; and, publication generally not current enough.

  Not all material has been given equal weight. In reviewing the documents and considering the significance of their findings for the current study, we put most weight on articles in peer-reviewed journals, followed by reports and conference papers by professionally qualified authors that appear to have been prepared with a scholarly/scientific approach. Other material was used for "colour", or to glean search terms and (subject headings) for further searching.

- **Date of Publication:** Essentially we have limited the review to documents published since 2004 (except for NZFS CRF Research reports; all were considered since the series began; other pre-2005 NZFS reports have also be reviewed), to ensure the research is current. When large numbers of documents were found in a particular search, these were sorted in descending order and we only gave titles earlier than 2000-2004 a cursory scan. Some pre – 2004 documents of particular value have been reviewed, particularly if cited in more recent papers.

  In considering social and economic trends, more weight has been given to documents published since the financial crisis of 2008, since expectations for medium to long term economic environment shifted at that point.

  The development of wireless "connectivity", handheld devices and social media[1] websites in both the consumer and fire technology fields has meant earlier technical reports that do not take these into account have been superseded.

- **Language:** we have only considered documents published in English.

[1] Potential for use of social media for community education under fire risk management programmes was not included in the survey, as this is the subject of UMR (2011), another study funded under the Contestable Research Fund.

The results of the literature search are attached in **Annex A Select Bibliography**.

1.5 REVIEW OF "MACRO TRENDS"

We briefly reviewed "macro trends" that have implications for management of fire (and other emergency) risk faced by society, and how emergency incidents are responded to.

These "macro-trends" include interacting social/demographic, economic, technological and ecological trends.

Initial review work indicated the following trends are of importance for the Fire, and other emergency, services. Not all of these are covered in detail in the current project; those **not** covered are noted below.

- Climate change leading to more frequent and serious droughts (with associated drying out of both vegetation and structures making both more prone to fire) and also causing more frequent serious storm events, which also put demand on Fire Service Resources). We did not review this trend, as it has been the subject of other recent CRF projects.
- Continuing revolution in ICT; for example "cloud" computing and high-speed wireless connectivity linking all devices (including for example smoke alarms) to and through the internet, supporting both social connections and work. Accompanying this will be a breakdown of the distinction between "broadcast" and "social" media, a continuing explosion of information immediately available to individuals and business and greater "personalisation" of the information flowing to and from individuals.
- The global economy will continue to grow, but with a continuing shift in the balance of economic strength towards China and India; demand for raw material in these countries will continue to support the Australian economy. With constraints on food production in these economies, exports to them will underpin (modest) economic growth in New Zealand. This benefits fire safety in New Zealand through availability of capital to invest in fire safety technologies and through limiting expansion of a impoverished, high fire-risk, underclass.
- "Sustainability" will continue to be a concern in local, regional and national governance (and will be more so when following recovery from the current post-recessionary economic conditions). This means pressure on the Fire Service to:
    - introduce and upgrade the sustainability of its non-operational activities, but also to:
    - reduce the environmental effects of its fire-fighting activities. The latter arise in two ways: run-off water from fire-grounds can carry pollutants from the structure and/or its contents that are on fire; and, the foaming agents used by the Fire Service can themselves be hazardous, polluting chemicals.

2. IMPACT OF SOCIAL CHANGES

2.1 INTRODUCTION

In this chapter we identify and assess social and economic changes that have significant implications for achievement of NZFS's National Goals.

- In **Section 2.2** we report on our consultation with NZFS managers on their perceptions of social trends of significance to the Fire Service.
- In **Section 2.3** we present a selective review of New Zealand and international literature on socio-economic trends of significance for fire risk management, including New Zealand's economic outlook; growing income inequality; declining "Social Capital" and housing owner-occupancy; migration and urban; and, growth of "at risk" groups.
- In **Section 2.4** we present projections of "at risk" groups ie ethnic groups, older people, and one-person households.
- In **Section 2.5** we draw conclusions on key social and economic trends of significance to fire risk management, and turn to the implications of these for NZFS operations in **Section 2.6**.

2.2 CONSULTATION

NZFS managers were consulted on their perceptions of those social trends that are most significant for achievement of NZFS's goals (among other topics). Nine interviews were carried out face-to-face and one by telephone. The managers consulted were agreed with the NZFS Advisory Panel at project inception.

- From discussion with Fire Service managers and analysts, the NZFS' identified set of "at-risk" groups is founded on both a combination of objective analysis and professional experience.
- Managers expressed the view that this additional fire safety risk faced by Maori is simply a function of low socio-economic status or deprivation. This view does not appear to be based on research.
- A view was expressed in interviews that, in times of economic constraint, fire safety expenses and actions are less likely to be prioritised by households. Research on coroner's reports on fatal fires (Heimdall Research 2005) examines examples where use of candles due to disconnection (or perceived lower cost) has led to fatalities.
- While projections of numbers of people living under conditions of deprivation would be ideal, this is a complex question. Under the direction of the Advisory Panel, the emphasis in this projection was shifted towards the technology trends tasks

(reported in **Sections 3-5**). As a proxy, projections of selected at "risk groups" are presented **in Section 1.4** below.

- The growing proportion of the population with a first language other than English, due to immigration, means that successfully delivering fire safety community education to such communities is a challenge to the Fire Service. It means fire mitigation officers are required with specialised language skills. The Fire Service now prepares fire safety educational materials in some 12 different languages.

- Threats from crowds or bystander to firefighters responding to incidents was thought to be a very minor matter, and not perceived as a growing problem.

2.3 LITERATURE REVIEW

Themes emerging from the review of Literature on Social Trends

The following themes emerged from the review of Social Trends relevant to fire service operations:

1. Economic outlook is for constrained growth.
2. Growing Income Inequality
3. Declining "Social Capital"
4. Decline in Owner Occupancy Housing Tenure
5. Migration and Urbanisation
6. Growth of "at risk" groups
7. Increasing Consumption of Alcohol

We present our literature review under each of these themes in turn. Under some of the themes we present graphs of Statistics NZ and Ministry of Social Development data, in order to illustrate points made. Data source are given under each graph.

The "At Risk" Groups Identified by the Fire Service

In the literature review below we refer to "at risk" groups. The Fire Service identifies the following groups as being particularly "at risk" of death or injury by fire (p 28 National Fire Risk Management Plan 2010).

- *Children*
- *Older people*
- *Lower socio- economic people*
- *Maori and Pacific Island people*
- *Disabled people*
- *People in rental property*
- *People in rural property*
- *Business*

The Fire Services applies this classification in its design and delivery of fire safety community education programmes.

1 Economic Outlook: Constrained Growth	Consideration of New Zealand's economic prospects over the medium to long term is relevant to fire outcomes for the following reasons, *inter alia:* • The number of "at risk" low-income households is unlikely to decline without economic growth; • Real increases in Fire Service funding will require a growing economy (a necessary but not sufficient condition); • Property owners are more likely to invest in new technologies for active and passive fire protection, in a growing rather than a stagnant economy; and. • It is likely to be easier for "social capital" to build and for the Fire Service to recruit and retail volunteers under economic prosperity than under economic constraint/austerity. The prospects for New Zealand's economy are mixed. The latest available data on GDP (Statistics NZ www.stats.govt.nz July 2011) is that GDP in year ended March 2011 is 1.5% higher than in year ended March 2010. However, this equates to little more than nil growth in GDP per capita terms. Economic forecasters forecast an accelerating recovery from recession. The Consensus forecast published by NZIER in June 2011 is for real GDP growth to rise to 2.1% for March Year 2012, and then to 4% by March Year 2013 (the 2013 figures match The Treasury's forecasts (The Treasury, May 2011); The Treasury forecast a slight tapering off of growth of 3% (2% per capita) in 2014 and 2.7% (1.8% per capita) in 2015. While positive, these growth rates will do little to reduce the "income gap" with Australia (2025 Taskforce, 2010), nor, unless sustained for the long term, create a substantial increase in wealth per capita that will support improved fire outcomes. Given that 2015 is still the "short-term" for the purposes of this report, we need to consider whether economic growth beyond that point is likely to create conditions favourable to more positive fire outcomes. In **favour of sustained growth** are: • Economic growth and increasing wealth and population in the "developing world" outstripping growth in food production in such countries, creating market conditions favourable to New Zealand's food exports; • Adverse weather events associated with climate change adversely affecting food production overseas, again to the benefit of New Zealand's food industries; • The continuing rise of China and India as the "workshop(s) of the world"; these are both a market for New Zealand food and other primary-based products (forestry and coal);

	• Australia's prosperity is underpinned by its role as supplier of commodity inputs to China's manufacturing, and New Zealand's economy will continue to benefit from the prosperity of its Tasman neighbour. **Factors that moderate expectations for New Zealand's economy** include: *External factors* • The economic outlook for the world as a whole is uncertain due to the continuing "debt crisis" afflicting members of the Eurozone and the United States. The outcome, as at October 201, is highly uncertain on the outlook for these economies range from long term stagnation (on the precedent of Japan's experience since its asset-price crash of the late 1990's) to regained growth after a short-term period of adjustment; • In the absence of a (debt fuelled) consumer-led growth in the Western developed economies, China's growth may slow; • Consequently, commodity (including food prices) may fall which will impact on NZ's terms of trade; *Internal factors* • Continuing improvement in labour and multi-factor productivity are recognised as essential to drive improvement in wealth/GDP per capita (eg Howitt and Weil, 2008). The failure of NZ to match Australia's productivity gains is pointed to by the 2025 Taskforce's analysis as a reason for the wealth gap between the two countries. The Government's establishment of the New Zealand Productivity Commission on the Australian model is an acknowledgment that the problem of low productivity growth is exists, but is not itself a solution to it. • A closely related issue is low rates of investment by NZ firms. • After decades of initiatives aimed at creating innovative, added value products based on NZ's primary resources and to create a "knowledge economy", NZ's economic growth of the 2000's was underpinned by increased production and export of commodity dairy products. On balance, in our view, New Zealand's economy will grow over the next decade, but at only around 2-3% per year or sufficient to support 1-2% growth in GDP per capita. Due to Government debt constraints, there will be limited growth in Government spending to support incomes of low-income households. There is likely to be slow job growth, particularly in demand for low and unskilled labour. Consequently, there will continue to be numbers of households in high levels of deprivation.

2 Growing Inequality of Incomes

There is little objective data on the number of people falling into the Fire Service's identified "at risk" group "*lower socio- economic people.*" The practise of assigning people to deciles (eg the NZ Index of Deprivation used by Duncanson et al, 2000) means of course that 10% of the population is always in the lowest decile. Instead, as a proxy for numbers of lower socio-economic people, we reviewed the evidence for growing household income inequality.

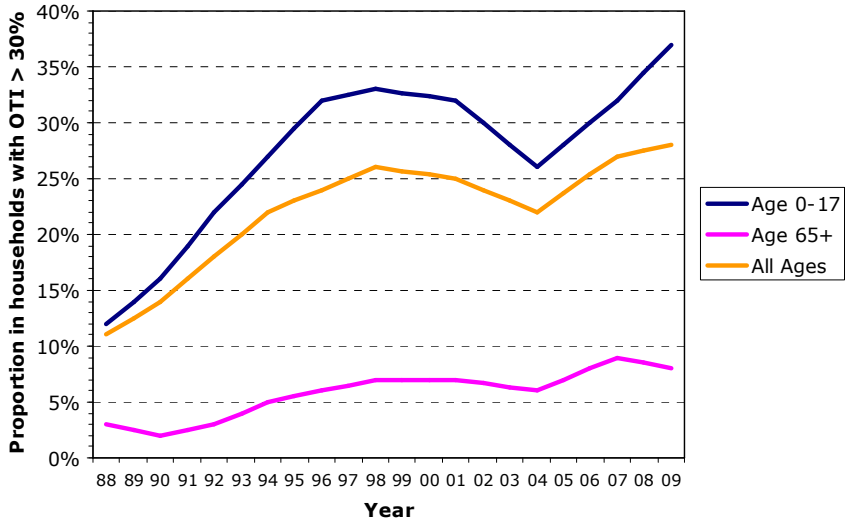
Inequality of household income has become more pronounced in New Zealand. According to the Government's *2011 Economic Indicators Report*,

"New Zealand's income inequality increased between the mid-1980s and the mid-1990s, and showed little change between the mid-1990s and the mid-2000s. In the mid-2000s, New Zealand had a higher degree of income inequality (as measured by the Gini coefficient) than the OECD average."

The Ministry of Social Development's Household Incomes Report 2010 found that:

- income inequality grew very rapidly from 1988 to 1992, followed by a slower but steady rise through to 2004
- from 2004 to 2007 inequality fell mainly as a result of the WFF package
- inequality remained much the same from 2007 to 2009 – the 80:20 ratio declined slightly and the Gini rose slightly
- in 2009 a household at the 80th percentile had an income 2.5 times that of one at the 20th percentile, compared with 2.2 in 1986
- compared with other OECD countries in 2004 New Zealand's household income inequality was a little above the OECD median and similar to Ireland and the UK (2004)
- on the latest information available for comparison, inequality in New Zealand is very close to Australia's (2008).

Figure 2.1: Proportion of individuals in households with housing cost OTIs greater than 30%, by age-group



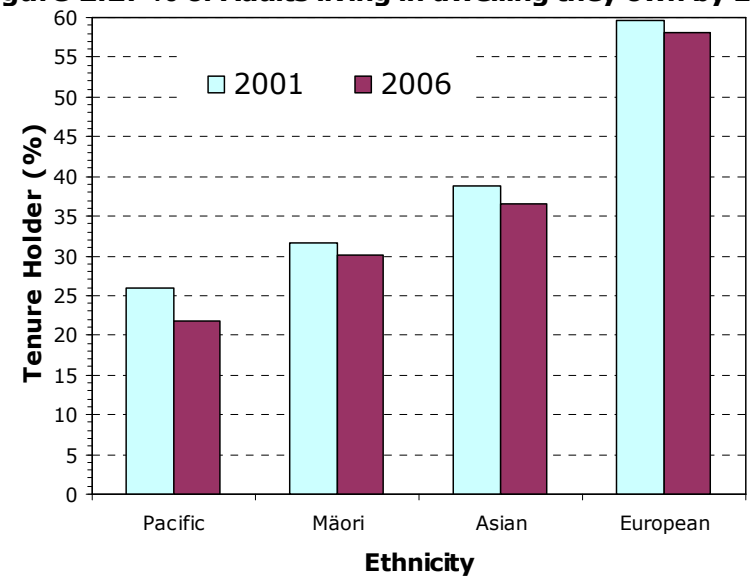
Source: MSD Household Income Report 2010, compiled by McDermott Miller Ltd.

	The Housing "outgoings to income ratio" (or OTI) is an indicator of financial stress, with 30% being deemed "high", **Figure 2.1** above shows that the proportion of children (aged 0-17) living in households with high OTIs increased from 12% in 1988 to 37% in 2009. Among those aged 65+, the proportion increased from 3% to 8% over this period. This is indicates that an increasing proportion of both children and older people are likely to be living in households living under financial stress.
3 Declining "Social Capital"	A low level of "social capital" in communities has been shown to correlate with increased risk of fire (Andrews and Brewer, 2010, discussed further below). The concept of "social capital" was originated by sociologists working in the field of education but entered economics since the 1990's. (Roskruge et al, 2001), It is way of conceiving of community interactions that, collectively, form a resource (analogous to physical productive capital or human capital) that is used to produce positive outcomes for society. Spellerberg (2001) defines "social capital" as *"relationships among actors (individuals, groups and/or organisations) that create a capacity to act for mutual benefit or a common purpose".* It has developed a procedure for measuring social capital in New Zealand. Roskruge et al (2011) used the New Zealand Quality of Life Survey (2006 and 2008) to estimate social capital in NZ, but merged the two samples so it is not possible to assess whether there was a shift in the social capital between the two surveys. The "Quality of Life Survey" (Nielsen 2011) examines "Community, Culture and Social Networks" and has indicators of "Social Capital" in its questions on Community, Culture and Social Networks. The 2010 survey (covering eight NZ cities) was released in March 2011. • There is a significant increase in the proportion of eight city residents who feel a sense of community with others in their local neighbourhood (60% agree or strongly agree in 2010 compared to 53% in 2008, and 56% in 2006). • There is no difference between 2008 and 2010 for the proportion of eight city residents who rarely or never felt isolated or lonely in the past twelve months (2006 2008 and 2010 are all 82%). This result indicates no shift in social capital over this short 4 year period. In a study comparing indicators of social capital with home ownership, Roskruge et al (2011) concluded: *"when an individual owns the home they live in, they report significantly higher levels of social capital than those who do not own their own home"* Andrews and Brewer (2010) examined the relationship between fire outcomes across areas of the United States with levels of social capital. They found that *"(higher) social capital is associated with a low unintentional fire death rate"* and concluded

	that "*social capital is likely to be an important determinant of fire service outcomes".* This is because communities rich in social capital and more likely to engage in "protective neighbouring", both to prevent fires and to rescue neighbours and notify fire services if fires do occur. Another manifestation of social capital of sense of community is, of course, willingness to volunteer as firefighters (some 72% of United States firefighters are volunteers). So a decline in social capital should be of concern to NZFS, as it would point to increased fire risk and a more challenging social environment in which to both achieve its goals and outcomes and also to recruit and retain its volunteers. The evidence for such a decline is mixed: • The indicators of social capital in the "Quality of Life" survey point to static social capital at the national level, but only over a short time period (four years); • The long-term trend to reducing home-ownership discussed in below is prima facie evidence of a decline in Social Capital and therefore of increasing fire risk. While such a trend (which is likely to continue) is of concern due to households in rental accommodation being more at risk of fire than owner-occupier households, a further concern is that this points to a continuing erosion of social capital with likely consequences for future volunteer recruitment.
4 Decline in Owner Occupancy Housing Tenure	"People in rental property" are one of the Fire Service's identified "at risk" groups. Therefore an increase in this group is an indicator of increasing fire risk in the community. The proportion of the households in rental tenure has been rising. In 1991, some 26% of households did not own their homes, this increased to 29% in 1996, further to 32% in 2001 and to 33% 67% in 2006.[2] (Source: Statistics NZ Housing Indicators 2008, Ministry of Social Development 2010). Another indicator of home ownership is tenure hold. The percentage of the adult population that own or part own the dwelling they live in fell from 55% in 2001 to 53% in 2006 (may understate actual fall due to classification change). The tenure hold measure reveals marked differences between different ethnicities. In 2006, some 58% of European adults owned or part owned the dwellings they live in **(Figure 2.1)**; this is nearly 3 times the percentage for Pacific peoples (22%) and nearly twice the percentage for Maori (30%).

[2] In 2001 households in houses owned by family trusts were deemed not to own their own home, but in 2006 this was changed to the opposite, ie they are now classed as owning their own home. So the true decline in owner-occupancy rate between 2001 and 2006 is higher than that indicated by the census results

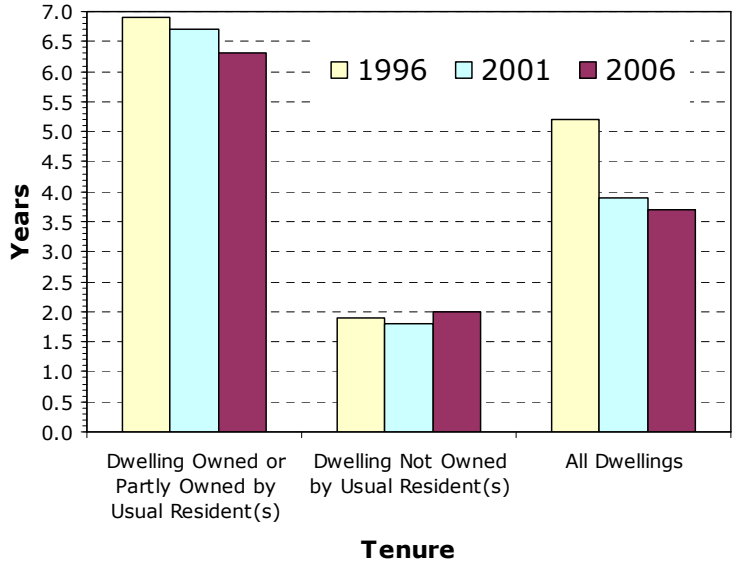
Figure 2.2: % of Adults living in dwelling they own by Ethnicity.



Source: Statistics NZ Housing Indicators 2008, compiled by McDermott Miller Ltd.

Figure 2.3: shows that people in houses they do not own spend less time in a particular residence so are less likely to invest "social capital" in the community they live in. There is, unsurprisingly, a marked difference in median years at usual residence between households in dwellings owned by their residents (6.3 years in 2006) and those rented (2.0 years). In 1996, the median number of years a household was in resident at its current dwelling was 5.2 years, but this had fallen to 3.7 years by 2005

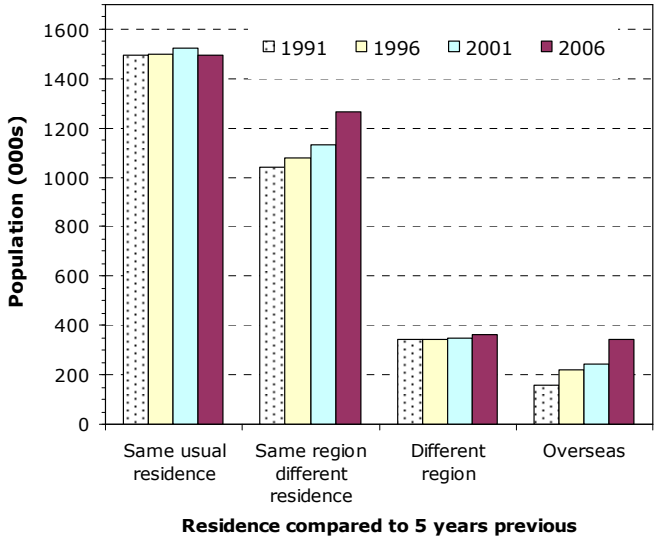
Figure 2.3 Median Years at Usual Residence by Tenure of Household



Source: Statistics NZ Census of Population and Dwellings compiled by McDermott Miller Ltd.

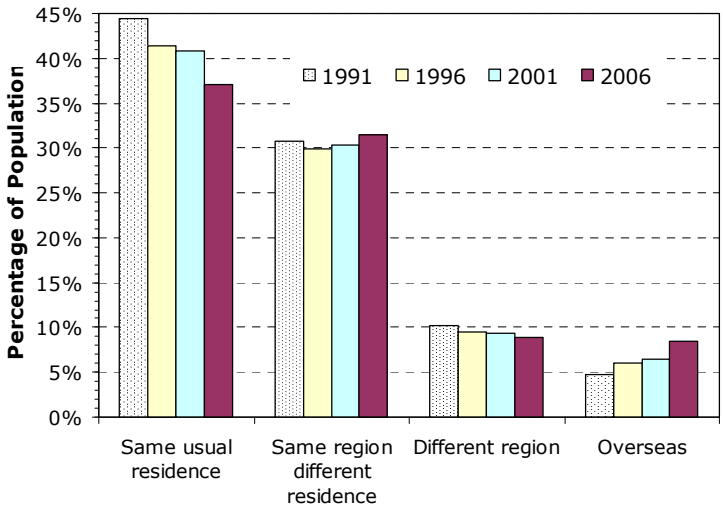
5 Migration and Urbanisation	**Migration and Mobility** People without English as a first language are not an identified "at risk" group, but the range of other first languages is a challenge fire safety community education (**Section 2.2**). Increased mobility within New Zealand is also an indicator of declining social capital (Bräuninger 2002), and so has fire risk implications. An indicator of the cumulative effect of migration is the population that has moved to a new usual residence since the previous census (Counts are shown in **Figure 2.4** and percentages in **Figure 2.5**). • The number of people who lived overseas five years previous to the Census grew nearly 100,000 over the period 2001 to 2006, from 244,000 to 344,000. This is represents an average annual increase of 7% per year. • In contrast, the number of people living at the same address declined by 0.4% per year. • The number of people living at different residence within the same region increased by 2.3% per year between 2001 and 2006. • The number who shifted from a different region increased by around 0.6% year. • At the 2006 census, some 69% of the population lived in the same region as 5 years previously, down from 75% in the 1991 census. • In 2006, some 17% lived in another region or overseas five years previously, up from 15% in 2001. This data indicates changes of significance to fire risk in the community: • Numbers of international migrants are increasing rapidly; which has implications for NZFS's community education activities (we present a projection of persons of Asian ethnicity in **Section 2.3** below). • A general pattern of increasing mobility; which is an indicator of reduced social capital which can increase fire risk;

Figure 2.4: Census Usual Resident Population Count By Usual Residence Five Years Ago (Counts)



Source: Statistics NZ Census of Population and Dwellings compiled by McDermott Miller Ltd.

Figure 2.5: Census Usual Resident Population Count By Usual Residence Five Years Ago (Percentages)



Source: Statistics NZ Census of Population and Dwellings compiled by McDermott Miller Ltd.

Urbanisation

Households' risk from fire decreases with increasing urbanisation (Challands, pers. comm.) While this may partly due to a greater proportion of households being covered by career firefighter stations, the mechanisms by which urbanisation benefits for fire risk are not fully understood (Challands, pers. comm.)

According to Statistics NZ "Urban-Rural Profile" data on the population living in urban and rural areas:

- The percentage of NZ's population living in a "main urban area" increased from 70% in 1996 to 72% in 2006.
- Over this same period, the percentage living in rural areas with "low urban influence" or remoter fell from 8% to 7%

	• Average annual increase in urban population over this period was 1.3%, but in rural areas population declined at an average rate of 0.07% per year.
6 Growth of "at risk" groups	The groups identified by the Fire Service as being particularly "at risk" of fire are listed above. • Previous research has demonstrated clearly that Maori face a much higher risk of fire fatality than the population in general (e.g. *Accidental Fire Fatalities in Residential Structures: Who's at Risk,* AFAC 2005)., In **Section 2.4** we present projections of Maori population growth as an indicator of continuing need for fire safety social marketing programmes focused on Maori. • The available research indicates that Pacific Islanders' households are no more at risk of fatal fire than other (non-Maori) ethnicities. • The relationship between social/economic deprivation and risk of fatal fire was demonstrated by Duncanson et al (2000). This study found that the rate of fatal fire incidents for dwellings in the most deprived 10% of meshblocks was 4.5 times the rate in the least deprived. While this research has not been repeated per se, the Fire Service Information Analyst has provided us with recent statistics which confirm that households in high deprivation meshblocks continue to face a substantially higher rate of fire incidence than the average. • The AFAC research cited above shows that in both New Zealand and Australia, elderly people face substantially higher risk of fire fatalities and injuries compared to the population average. (refer FEMA. 1999) As the older population increases, and a greater proportion "ages in place", there is likely to be increasing need for strategies to educate older people, and to provide their households with fire detection, alarm and suppression equipment. It is appropriate to consider this "aging" of the population as relevant social changes in the current study, and to present projections of the older population. • The literature shows that the risk of fire injury and death is a largely function of increasing disability with age, eg inability to hear alarms, to act appropriately if a fire does occurs. • There is research evidence that (AFAC, etc) people in rental properties are more at risk of fire than others. While this is partly a function of low socio-economic status, there is evidence that rental properties are less likely to have functioning smoke alarms than owner-occupier properties. Therefore the current research should consider the trend of an increasing proportion of the population living in rental housing and project this trend into the future. • AFAC and other research shows children under 5 are at particular risk of fatal fire, particularly if they are in deprived or Maori households. As noted under *"2 Growing Inequality of Incomes"* above, the proportion of children in households under financial stress has being increasing. • Another social trend, linked to the aging population trend together with aging-in-place policies, is rise in the number of

	one-person households. The fire risk significance of one person households is expressed in FEMA (1999) as "Individuals living alone and without social support are more susceptible to unduly high fire risks." According to CRESA (2009):"*One change is growth in the number of ageing one-person households. Research identifies older people as a group vulnerable to fire injury and death, given physical, sensory and cognitive disabilities. Their vulnerability increases when they live alone, given that there is no-one to help them respond appropriately in the event of a fire. Unfortunately, as people age (with increased likelihood of disabilities) the likelihood that they will live alone (especially for woman) also increases. The need for targeted interventions to reduce the fire risk of older people living alone will increase as the prevalence of older one-person households increases*."
7 Increasing Alcohol Consumption	Alcohol consumption across society as a whole is gradually increasing. Statistics NZ (2011) reports that *"In 2011, there were 9.5 litres of pure alcohol available per person aged 15 years and over, from 8.8 litres in 1996. This is equivalent to an average of 2.1 standard drinks per person per day, compared with 1.9 standard drinks per person per day in 1996."* The strong relationship between alcohol consumption and fire fatalities in New Zealand is demonstrated in Challands (2004), Duncanson (2001), and Heimdall Consulting Ltd 2005. Not only is alcohol consumption increasing, but more seriously there is a contention (refer ALAC and Ministry of Health websites) that "binge" drinking is widespread and increasing. According to ALAC (2011), in 2011 some 21% of adults are binge drinkers, but due to definitional changes it is not possible to verify whether this percentage has in fact been increasing The clear link between "binge" levels of alcohol consumption and death and injury from fire, motivate the Fire Services 'Don't Drink and Fry" campaign and such initiatives will have to continue. Alcohol consumption is also of course a factor in the Fire Service's motor vehicle accident rescue work.

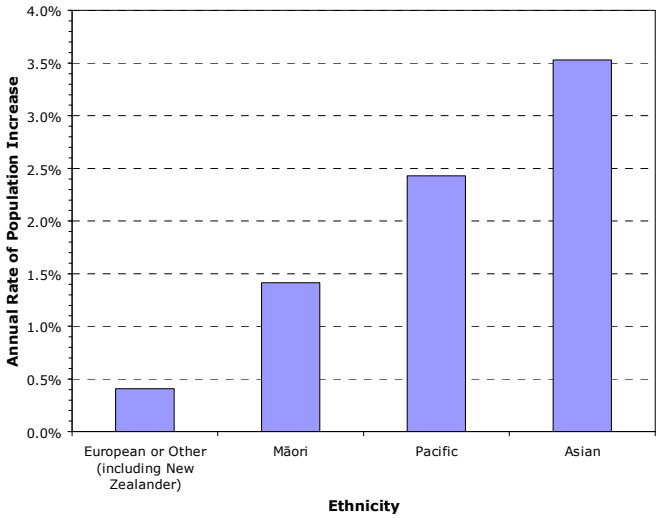
2.4 PROJECTIONS OF SIZE OF SELECTED "AT RISK" GROUPS

In this section we present projections of selected "at risk" groups. The purpose of this is to indicate the implications of the growth of "at risk" groups for the Fire Service's future fire risk management activities. The projections are based on Statistics NZ projections as indicated below:

1. Ethnic Groups - while Pacific Islanders and Asians (who may have weak English language skills) are no more at risk of fatal fire than other (non-Maori) ethnicities, their future growth may have implications for targeting future fire safety education

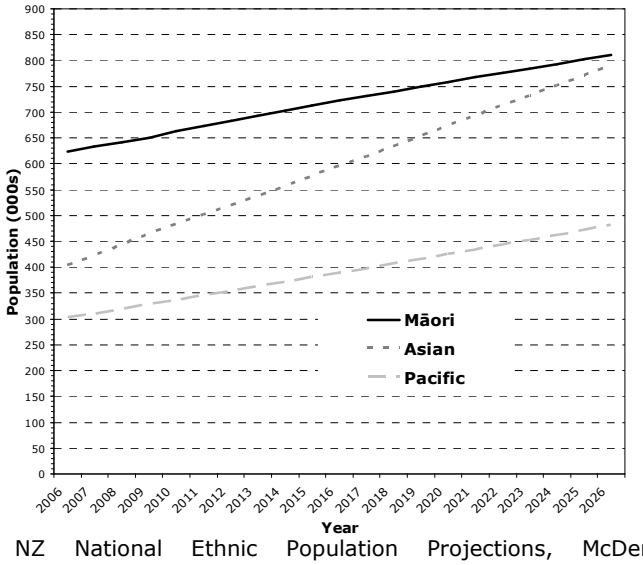
programmes (Source: Statistics NZ's National Ethnic Population Projections, 2010.)

2. Older People (Source: Statistics NZ. Moving age-sex pyramids. Statistics NZ. 2011)
3. One – Person Households (Statistics NZ. National Family and Household Projections. Statistics NZ. 2010)

1 Growth of Ethnic Groups	"Maori and Pacific Island" people are an identified "at risk" group and numbers of "Asians" are also of significance to the Fire Service due to the need for fire safety education in their own first languages. Statistics NZ estimates that over 2011-2016 the total population of New Zealand will grow at an annual rate of 0.9% per annum. However, there is a strong contrast in rates of growth of ethnic groups over this period[3]. • The "European or other" ethnic classification is projected to grow at only 0.4% p.a.; • In contrast, Maori growth is projected to be 1.4% p.a., Pacific growth 2.4% p.a.; • and the "Asian" ethnic classification is projected to grow at 3.5% p.a. (**Figure 2.6).** **Figure 2.6: Annual Rate of Growth of Ethnic Groups 2011-16**  Statistics NZ National Ethnic Population Projections, compiled by McDermott Miller Ltd. **Figures 2.7** and **2.8** shows the consequence of these differing growth rates. • The Maori population is estimated to be 674,000 in 2011 and is projected to reach 811,000 in 2026 (growth of 137,000);

[3] Ethnicity statistics must be treated with caution. Statistics NZ measures ethnicity using self-identification and respondents to the Census are permitted to identify with multiple ethnic groups. This means that, if the populations identifying with each ethnicity are totalled, the sum is greater than the total population

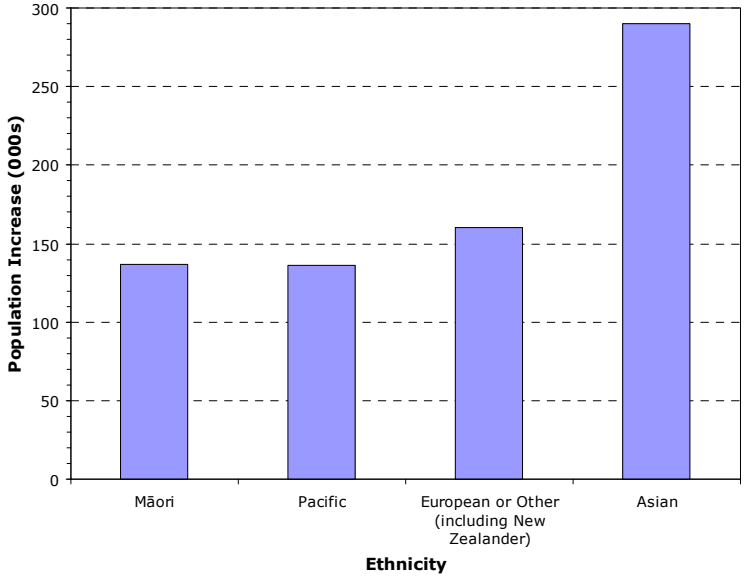
Figure 2.7: Projected Population by Ethnicity



Statistics NZ National Ethnic Population Projections, McDermott Miller Interpolations between Census years

- The Pacific population in 2011 stands at 345,000 but is projected to reach 481,000 in 2026 (growth of 136,000);
- The Asian population, 501,000 in 2011 is projected to reach 791,000 in 2026 (up 290,000).
- The European and other population, 3.31 million in 2011, is projected to be 3.472 million in 2026 (increase of 160,000).

Figure 2.8: Projected Absolute Growth in Population by Ethnicity



Source: McDermott Miller estimates based on Statistics NZ National Ethnic Population Projections

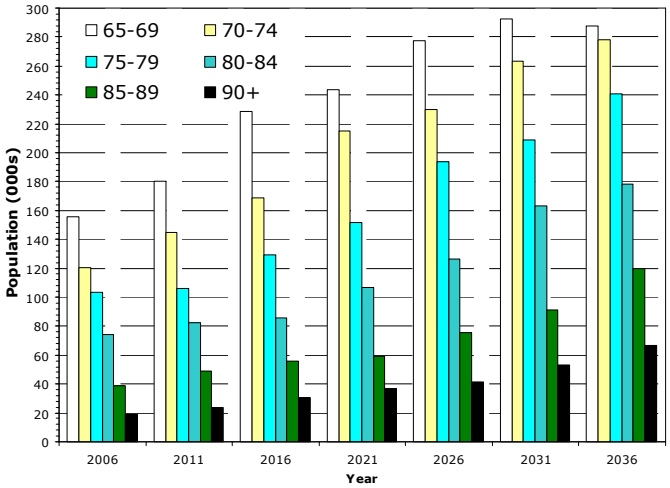
2. Growth of Older People

As discussed in **Section 2.3**, "Older People" are at increased risk for fire compared to the population in general. Future growth in this "at risk" group is of particular significance with the potential to increase the overall level of fire risk in the community.

- While the population as a whole is growing at 0.9% p.a., the population aged 65 and over is growing at 3.6%.p.a.
- At present, growth is fastest in the "young old" population as the first of the "baby boomers" reach 65; those aged 45-60 is growing at 4.9% p.a.
- After 2021, however, growth will be fastest among those aged 75 and over.

Figure 2.9 below shows how the population aged over 65 will expand over the next 27 years, in 5 year age bands. For example, those aged 90 and over is 24,000 in 2011 and is projected to reach 42,000 in 2026 (75% growth).

Figure 2.9: Projected Population of "Older People"

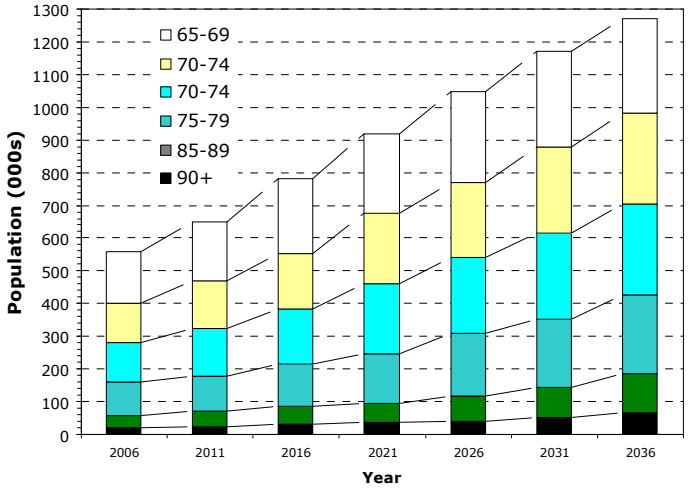


Source: Statistics NZ Age-Sex Pyramids 1951-2061, compiled by McDermott Miller

Figure 2.10 is a "stacked bar" chart of the same data as **Figure 2.9** in order illustrates the size of the "at risk" group at alternative ages at which the population may be deemed to be "older" and therefore "at risk". At descending lower bounds of being "older", the population aged:

- 85 and over is 73,000 in 2011 and is projected to reach 117,000 in 2026 (growth of 44.000 or 61%)
- 80 and over is 155,000 in 2011 and is projected to reach 243,000 in 2026 (growth of 88,000 or 57%)
- 75 and over is 261,000 in 2011 and is projected to reach 437,000 in 2026 (growth of 176.000 or 67%);
- 70 and over is 406,000 in 2011 and is projected to reach 667,000 in 2026 (up 261,000 or 64%);
- 65 and over is 586,000 in 2011 and is projected to reach 944,000 in 2026 (up 358,000 or 61%).

Figure 2.10: Projected Population over 65



Source: Statistics NZ Age-Sex Pyramids 1951-2061, compiled by McDermott Miller

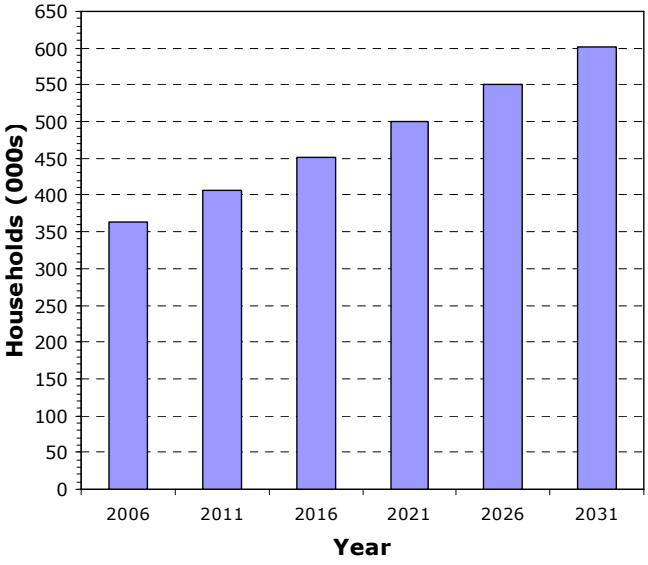
3. Growth in One – Person Households

The link between the increasing population in older age groups, one-person households, and heightened fire risk is noted in **Section 2.3** above.

Figure 2.11 presents projections of one-person households (occupied by all ages, not just the elderly), but the aging population combined with aging in place policies is a key driver of this growth.

- Currently, family and other multi-person households are growing at 1.1% per annum.
- In contrast, one-person households are growing at 2.1% per annum.
- In 2011, there are some 406,000 one-person households (**Figure 2.12**), but Statistics NZ projects this to rise to 500,000 by 2021, an increase of 94,000 over 15 years.

Figure 2.11: Projected One-Person Households



Source: Statistics NZ National Family and Household Projections:2006(base)–2031 update compiled by McDermott Miller Ltd.

2.5 CONCLUSIONS: KEY SOCIAL CHANGES

TRENDS IN NEW ZEALAND SOCIETY AND ECONOMY

1. Modest economic growth in New Zealand over the medium to long term resulting in an only gradual rise in wealth per capita.

2. Income inequality will continue to grow, and on the evidence of past decades' experience, the "underclass" in New Zealand is likely to persist. These people will face deprivation in an absolute as well as relative sense, and will continue to face much higher fire risk than the better off.

3. The number of people in the "Older People" at risk group will grow substantially. For example, the current population 75 and over is 261,000 in 2011 and is projected to reach 437,000 in 2026 (growth of 176.000 or 67%). More of these will be living in single person households, which also increases fire risk.

4. The "Maori and Pacific Island" identified "at risk" groups will grow at a faster rate (1.4% p.a. for Maori, 2.4% for Pacific) than NZ European (0.4% p.a.) so will constitute an increasing proportion of the population;

5. Immigration from Asian countries, combined with emigration of NZ born, mean the proportion of New Zealanders without English as a first language will grow (the population in the "Asian" ethnic classification is projected to grow at 3.5% p.a.) This means an increasing need for risk mitigation officers with the required language skills, as well as for non-English educational materials

6. Affordability of houses will continue to be a challenge for first home buyers; consequently more people will live in rental accommodation; this has fire risk implications due to "People being in rental property" being an "at risk" group..

7. More frequent house shifting – across town, inter-regionally, or internationally is contributing to a loss in "social capital", which has fire risk implications.

8. Alcohol consumption across society as a whole is gradually increasing; this is of concern because "binge" alcohol consumption strongly increases fire risk.

9. An aspect of declining social capital is reduced interest or willingness (particularly amongst younger adults) to be involved in community organisations, or when they do so, to commit for a shorter period than their forbearers did. This will continue to be a challenge for recruitment and retention of volunteer firefighters.

10. The population of New Zealand is increasing urbanised. Average annual increase in urban population over 1996-2006 was 1.3%, but in rural areas population declined at an average rate of

0.07% per year. More intensive urbanisation is a trend that reduces fire risk.

11. Population, economic production and consumption will become further concentrated in Auckland and its hinterland; Auckland will continue to be both the focus of domestic inter-regional migration and the preferred destination of immigrants. This means Auckland Fire Region may require a greater share of fire risk management resources.

2.6 IMPLICATIONS FOR NZFS

The identified social trends suggest, ceteris paribus, increasing average fire risk in the community through:

- increasing inequality of incomes and the prospects of at best, only a slow rise in GDP per capita means an increasing number of households living under financial stress, and within this an growing "underclass";
- increasing population in older age groups; in particular increasing numbers of "frail" older people living independently;
- increasing Maori, Pacific Islander and Asian immigrant population;
- increasing one-person households.

Despite these trends, the incidence of fires is decreasing (NZ Fire Service Commission (2010)). This suggests positive factors are more than counteracting the negative effect of these trends; these include:

- effectiveness of the Fire Service's Fire Risk Management initiatives, particularly those focused on educating and assisting members of the identified "at risk" groups;
- high rate of installation of domestic smoke detectors combined with Fire Service campaigns to help ensure they operate correctly;
- trend to eating as well as drinking away from the home, so reduced cooking while intoxicated;
- reduced use of portable radiant heaters and open fires.
- urbanisation – greater proportion of households covered by career firefighter stations; and,
- rising educational attainment and longer time in formal education contributing to greater receptivity to Fire Service's Fire Safety messages.

However, continued growth in at risk groups means there is potential for reversal of this downward trend in fire outcomes; this will be an ongoing challenge to the Fire Service. As a minimum, it should continue to ensure sufficient resources are allocated to fire risk management activities, including education and upgrading domestic smoke detectors

While social changes are tending to increasing fire risk, there are offsetting technological changes. Social changes and technological changes interact. For example, people's sense of their community is shifting from the neighbourhood where they reside to a world-wide "virtual" community linked through social media. In a sense is a symptom or cause of a decline in "social capital" and therefore increased fire risk. However, social media can also be a powerful and positive tool when major emergencies occur, as will be considered in the next chapter, on consumer technology changes.

3. IMPACT OF CONSUMER TECHNOLOGY CHANGES

3.1 INTRODUCTION

In this Section we review trends in technologies aimed at consumers, and uses they are put to, that have operational implications (both positive and negative) for the Fire Service:

- We consulted NZFS managers and executive officers on their views on potential fire risk management and operational implications of social media and smart portable devices, including experience with crowds that form as result of using these technologies (**Section 3.2**).
- In **Section 3.3** we present a selective review of literature on consumer technologies that are relevant to Fire Service operations, including the use of social networks to send distress messages, crowdsourcing of emergency information (eg provision by public of useful images or other information to the NZFS prior to arrival), communicating with the population in an emergency through Social Networks, and other uses of mobile phones in emergencies.
- In **Section 3.4** we draw conclusions on key trends in consumer technologies of significance to fire risk management, and consider the implications for NZFS in **Section 3.5**.

3.2 CONSULTATION

Face to Face Consultation with Managers

The following points on consumer technology trends emerged from our consultation:

- Social Media and smart portable devices are seen by managers to have potential for dissemination of fire safety/education messages. For example, to receive fire safety messages on weekend nights about not carrying out risky behaviours while drunk.
- The ability to locate the cell phone making an emergency call is seen as being highly desirable, but is not yet possible within a realistic time-frame, due in part to the number of operators and privacy issues. If comcen operators have this information, this could help locate an incident when the person making the call is unable to give much information.
- Social media are seen (at least at current levels of technology) as being of more utility for a two-way of exchange of information between the fire service and public during long-duration emergency such as floods and earthquakes, than in fires;

- There is little concern about Social Media being used to generate crowds that could cause incidents involving the fire service, or to impede the Fire Service as it carries out it actions.

Email Survey of Area Managers

The online-survey of Area Managers' included how consumer technologies could benefit fire service operations[4]. See **Annex** B for discussion of the survey method.

- Area Managers perceive a **system to locate caller's cell-phone** (the technology to do this not being specified in the survey) has a medium priority rating, with the potential benefit of provide more intelligence more quickly to the comcen operator and Officer in Charge (OIC).
- A specific technology is for Comcen and OICs being able to receive and analyse GPS data from public's devices. The current challenges of locating cell phones will ameliorate over time, due to increasing penetration of mobile phones with GPS capabilities. Emergency responders could obtain information very rapidly on location of person making an emergency call from a GPS capable device. As well as having potential benefits in locating the fire/incident ground more quickly (as above), it would give more precise data to assist in performing rescues (in structures or at MVAs). This received a similar medium-level priority rating from Area Managers to the above, in spite of the greater potential benefits. We presume that over time, as the penetration of GPS–capable devices achieve greater penetration of the consumer market, NZFS's managers' recognition of the potential of the NZFS being able to receive, analyse and make use of this data will increase.
- **Capability to receive and analyse photo and video data sent by public**: Area managers see this has having only low potential but this may be because of lack of awareness of what is/will be possible.

  The priority for NZFS would be to implement technologies for it to analyse and act on video data from cameras on appliances and firefighters, then extend capability to analysing visual data provided by public.

3.3 LITERATURE REVIEW

Themes emerging from the review of Literature on Consumer Technology changes

The following themes emerged from the review of Literature on Consumer Technology changes relevant fire service operations:

1 Experience with crowds that form as result of social networking services and portable devices

[4] Use of social media etc for fire risk management/fire safety education was not included in the survey, as this is the subject of another study funded under the CRF.

2 Using Social Networks to send distress messages to responders

3 Crowdsourcing of emergency information

4 Communicating with population in an emergency through Social Networks

5 Use of Mobile Phones in emergencies

We present our literature review under each of these themes in turn.

1 Experience with crowds that form as result of social networking services and portable devices	**London riots** Social media have been implicated in the instigation of incidents during the August 2011 unrest in the UK. Tonkin (2011) investigated the role social media in the unrest concludes that social networks were not causative factors in the social unrest, but that *"their absence would materially reduce the likelihood of ongoing unrest".* There have been calls to give Police power to temporarily shut down social media sites and/or individual mobile network masts, both to prevent unrest being organised and to prevent rumours spreading which results in false alarm call outs (Halliday 2011b). But social media were also self-policing; individual Facebook pages were shut down if other Facebook users reported them as being inflammatory. Halliday (2011 a) claims Facebook page was instrumental in instigating the initial riot following the shooting of Mark Duggan, but that thereafter the social network with the largest role in organising incidents was BlackBerry Messenger (BBM), which is *"free, instant and more part of a much larger community than regular SMS. And unlike Twitter or Facebook, many BBM messages are untraceable by the authorities"* Blackberry was already the most popular mobile phone among young, low income people in the UK. This, combined with the fact that BBM messages (unlike Facebook or Twitter) are encrypted, made it a very effective medium for disseminating messages on where and when incidents were to occur (Ball and Brown, 2011) But social media also had a positive role during and after the unrest: • Police used social networks to correct rumours, and to direct reassurance to concerned communities • individuals used Twitter and Facebook to mobilise the post-riot cleanup by citizens (Swallow 2011). • to help identify looters from posted images. Garside (2011) points out that it is possible for networks to detect crowd movement patterns, using systems to detect the gathering of a big crowd crowds (mobile phones signal where they are every 15 minutes), and the direction and speed of its movement can be pinpointed.

2 **Using Social Networks to send distress messages to responders**	The American Red Cross (2010) has published a document on integrating crisis response with social media; links to it and associated documents given in the bibliography Annex A. This document makes the following points: • young people (in particular) believe that sending distress messages through social media channels (eg Facebook or Twitter), or by texting, is an effective way of summoning help. In a web-based survey, *they found growing perception and practice that first responders can and do use the data from Twitter, SMS text messages and other services for a targeted response in times of crisis…The survey showed that 69 percent said that emergency responders should be monitoring social media sites in order to quickly send help* ***and nearly half believe that response agencies are already doing that*** • The majority of respondents "*expected quick response to an online appeal for help … less than an hour after their tweet or Facebook post"* • "Crowdsourcing", an "*open call for solutions to a problem*" arises from the exchange of information between those affected by the crisis and with emergency responders. • There is major challenge aggregating and analysing this data, and in conducting a triage process. This remains an essentially manual process. • The different ways different social networking tools collect data, and allow it to be searched (or not) is a challenge. • Authenticity and privacy issues are important but can be dealt with • Emergency responders should not just use social media to distribute information, but use it in a two-way exchange of information • Development of "*syntax, standards and protocols before the next disaster"* assists this type of collection and sharing effort. Speakers this conference emphasised the need for advanced planning instead of trying to figure out how to use social media systems during a crisis. The majority of respondents *"expected quick response to an online appeal for help … less than an hour after their tweet or Facebook post"* It was suggested that anyone should be able emergency management in a time of need, and that this could be done by creating a text code to accompany an Internet code, and this should be a free service.
3 Crowdsourcing of Emergency Information	Howard (2010) notes that round half of social media users would post information about an emergency on their social media site (predominantly Facebook). Personal Facebook pages most common form of social media used to post eyewitness accounts of emergency situations Attendees at American Red Cross' social media conference (2010) felt that videos and pictures carry more validity than text, partly due to risk of spamming. Location based reports can be

	triangulated by using multiple reports together with including crowd sourced filtering *"The crowd that is used to source information about a crisis can in turn be leveraged to verify information."* Tools for crowdsourcing data from social media and validating it a are available from http://ushahidi.com/, including • The Ushahidi platform: *"We built the Ushahidi platform as a tool to easily crowdsource information using multiple channels, including SMS, email, Twitter and the web.* • And the SwiftRiver Platform *"SwiftRiver is an open source platform that aims to democratize access to tools for filtering & making sense of real-time information, including crisis data."* Ertl and Christ (2007) test an experimental expert system delivered by Personal Digital Assistant (PDA) to support lay-helpers through the process of providing CPR to a victim, and for helping an unconscious trauma victim with severe bleeding. The group provided with this assistance performed higher than a control group relying on their current knowledge. Department of Homeland Security (2012) describes a prototype trial in which sensors built into smartphones measure dangerously elevated levels of carbon monoxide, and then the smartphone automatically calls emergency services. The sensors used include NASA's Ames nanosensor array and Synkeras' MEMS chemical sensors. The Crowdsourcing aspect means there are multiple sensors providing location and concentration information, which responders can make use of. Aoki et al (2011) report on use of social networking services and smartphones in management of civil emergencies – specifically earthquakes and flooding. The authors note that video information from smartphones has been conveyed to disaster management agencies and supported effective response. The authors report on an experiment in using social networks and smartphones to build trusting relationships, awareness of disaster prevention initiatives, and in information sharing in the event of a disaster, and helping neighbours. White et al (2008) conduct a search of then–current emergency wiki sites and evaluates the *"potential for wikis in the emergency domain"* potential players from numerous perspectives, and develops a *"conceptualization of what an effective emergency domain wiki should be"*. According to entry in the best-known wiki, Wikipedia: a wiki is a *"website that allows the creation and editing of any number of interlinked web pages via a web browser using a simplified markup language or a WYSIWYG text editor"* The authors contend that wikis can be used as collaborative system to support both emergency preparedness, and the exchange of information during emergencies: *"Wikis have to become Knowledge Exchange Centres (KEC) that form a network of application domains that can allow those that need information, knowledge, or volunteers with particular skills to be sought from a network of such centres in a manner that*

	does not require the users to separately understand each independent node in the network…In countries such as New Zealand, not only do citizens volunteer their talents in disasters, but companies and businesses volunteer useful equipment such as construction equipment, boats, communications equipment, medical supplies, etc. This requires systems which will allow those who want to volunteer such resources to be able to enter and update the material on their talents and the resources they command, which can be shared in a disaster situation." These ideas have been taken up by the Australian-based "Emergency 2.0 Wiki Project blog site" at http://emergency20wiki.org/ with the vision: *"To empower the community with the knowledge to use web2.0 and social media in emergency communications."* The goal of the site is to: • *provide best practice guidelines on how to utilise social media in all phases of emergency management (PPRR);* • *facilitate collaboration, knowledge sharing and crowdsourcing across the emergency, government, community, business and ICT sectors;* • *provide up to date news on the latest developments in emergency 2.0 and emergency communications.* The following is an example of such a wiki established to distribute useful information to the public and responders response to the Christchurch earthquakes: http://wiki.openstreetmap.org/wiki/2011_Christchurch_earthquake_Christchurch_recovery_map *Crowd Behaviours* Subba and Bui (2010) discuss how "convergence behaviours" in the physical world in a disaster (as people rush to a disaster site) now have parallels in the online world, and they discuss the interactions between the two and the challenges these can pose for disaster managers. No solutions are proposed in the paper. Demirbas et al (2010) present an argument that Twitter can provide an open publish-subscribe infrastructure for sensors and smartphones. They design and implement a "crowd-sourced" sensing and collaboration system over Twitter. Wireless Sensor Networks (WSNs) can include a wide range of sensors (magnetometers, accelerometers, passive-infrared based proximity, acoustics, light, heat) in small form-factor and with low power usage. WSNs are yet to fulfil their potential; the authors propose that Twitter can provide the needed publish-subscribe infrastructure for sensors, and they have developed a standard "TweetML" for tweeting sensor values. Smartphones have built in sensors that can take sensor readings; they propose three application domains for integration of smartphones to Twitter: Participatory sensing (collecting and transmitting data including images) crowdsourcing (distributing questions to Twitter users and collating replies) and social collaboration (more sophisticates

	version than crowdsourcing, involving back and forth interaction). Asimakopoulou and Bessis (2011) discuss whether crowdsourcing can be facilitated in the context of "smart" buildings and cities in order to support *"a more effective and efficient disaster management approach".* The European Commission ICT for Sustainable Growth Unit (2009) defines smart buildings as: *"Smart buildings means buildings empowered by ICT in the context of the merging Ubiquitous Computing and the Internet of Things: the generalisation in instrumenting buildings with sensors, actuators, micro-chips, micro- and nano-embedded systems will allow to collect, filter and produce more and more information locally, to be further consolidated and managed globally according to business functions and service."* In turn, a city can be defined as "smart" when *"it provides advanced applications and services to the community through cutting edge ICT"* (Alobaidan, 2009). *"Pervasive computing as a new paradigm aims to enable resource computation and utilization in a far more mobile or environmentally embedded manner".* Smartphones equipped with appropriate sensors can be used to gather "crowd sourced" data. The author contends that crowdsourcing could be used to implement a system that enables the community to contribute towards an integrated disaster management approach, while able to receive *"personalised and tailored warnings, evacuation routes and other messages according to the current situation".* Sensors and mobile APIs in smartphones would collect and exchange information about both their carrier's health and their environment. Similarly, sensors installed in buildings and cars could monitor information about their status and collect information about the environment. This constitutes a *"fully networked environment encompassing people, buildings, vehicles and critical infrastructure where all scan their surrounding environment (static or dynamic), monitor it and push relevant information to each other,"* and, if necessary, to emergency responders. In the event of fire or earthquake, sensors in buildings would calculate damage and could alert people inside and outside of the building. It would alert emergency response organisations, help responders and victims make decisions and prioritise tasks. The authors suggest that: *"this collective approach of capturing information on the go – from a number of sources – leads to gathering cross-referenced and thus, more accurate information about the environment"* Responders would be provided with accurate data to enable them to plan and organise their actions based on the actual situation. Palen et al (2007) discuss how online forums were used by citizens to co-ordinate their own responses to disasters, including New Orleans' Hurricane Katrina disaster of (2005), the SARS outbreak in China (2001) and 7/7 bombings in London (2005)

	(eyewitness images taken on camera phones were "incorporated into the recovery effort"). The authors note that disaster recovery managers should appreciate the public *"has always played a primary role in crisis response"*, and the ICT reveals this to the larger audience. The author suggests that: *"appropriate, flexible organisational structures that can incorporate information from and coordinate with multiple sources need to be in place. This is the basis for the inclusion of technical solutions for collecting, validating and transmitting information".*
4 Communicating with population in an emergency through Social Networks	Hui and Hayllar (2010) suggest ways in which citizens and respondents can jointly participate in the *"processes of creating and crafting web-based content and in enhancing service design".* For example, the Los Angles Fire Department uses Twitter to publish duty information and inform public of in-progress fires and rescues Mark S. Pfaff (2010) considers "crowdsourcing" involves only a gathering of information by governmental structures, and prefers the concept of "mega-collaboration", defined as a way to utilise the power of many people on web to come up with productive solutions to a crisis (or other events). In mega-collaboration *"independent actions from millions of people (a "city of strangers"), acting in their own interest collectively create a productive environment*". This concept is being jointly explored with ICT academics and psychologists AFAC (2011) reviews the use of social networking media and its role in information exchanges in the Queensland and Victorian flood crises of early 2011. Howard, A (2010) notes that half of US population would be willing to sign up to media alerts including text posts to keep informed in an emergency situation. Hickey, K (2011) refers to smartphone applications that can be used to alert people of locations of current fires. Emergency Alert (http://www.emergencyalert.gov.au/ accessed October 2011) is a website which set up to inform Australians about telephoned emergency alerts. These alerts are targeted to specific areas and each state has control over its own emergency alert procedures. Adding capability to send warnings to mobile phones based on the location of the handset is technically feasible. This capability is under development. American Red Cross (2010) note that once expectations are raised about Social Media as communication tool in emergency there has to be the skills to manage it, including the need to manage peoples' expectations about response time to Social Media messages. Creating systems such as an online queue and estimated time for response are proposed as helpful endeavours. AFAC (2011) refers to the "Google Crisis Response" website http://www.google.org/crisisresponse/. According to the website, This *"seeks to make critical information more accessible around natural disasters and humanitarian crises."*

	In the case of the Christchurch earthquakes, the "Google Crisis Response" webpage listed links to web pages and videos, and new stories. Geyer-Schulz et al (2010) and Ovelgönne (2010) describe a prototype "Social Emergency Alert Service" in which a user can call for help from nominated social contacts, as well as emergency responders. With one push of a button on his/her smartphone, the nearby members of the social group (a predetermined list of contacts) of the victims are notified of the victim's need for help and the victim's location. These persons may then be able to render assistance more quickly than emergency responders. This is to overcome the "bystander effect" whereby bystanders ignore or do not assist with an emergency. While designed primarily for medical emergencies personal safety emergencies, it may have application in fire, flood or MVA incidents, particularly in rural areas of New Zealand when neighbours may be able to provide assistance more quickly than the responding fire brigade. A Social Media and emergency Management website, http://idisaster.wordpress.com/, seeks to *"provide information about Web 2.o and other information communications technologies that are (or could be) used by members of the emergency management community. The intent is to provide exemplary practices, news and information about applications of new media, with the longer-term objective of improving practice and outcomes in emergency management."*
5 **Use of Mobile Phones in emergencies**	*Location of Emergency using Mobile Phone* Neves et al (2007) review potential applications for emergency services that will become feasible under the WiMAX broadband wireless access technology; we presume similar applications will be possible under the LTE technology which is more likely to be implemented in NZ (refer below). These applications include: • Environmental monitoring, eg to help monitor seismic and volcanic threats, and to warn populations; • "Telemedicine" two way exchange of video data between doctors in hospitals and ambulance crews; • Fixed video surveillance of remote mountain regions for purposes of early forest fire detection, and mobile video surveillance during a forest fire; • Transmission of video data and text data between control centre and mobile fire units in the field; • Wireless sensor networks in forest areas. Velez et al (2006) report planning a WiMAX cellular system for emergency services; one intended application is communication of video images from fire scenes (in particular forest fires) to command centres in, or to help co-ordinate, fire brigades.

	Pesout and Matustik (2010 1) and Pesout and Matusik (2010 2) describe a "smart emergency system" built into a smartphone that will analyse surroundings and, based on interpretation of data from its sensors, will evaluate whether an emergency call needs to be made. Their proposed system is described as an "*independent intelligent entity*" within the smartphone "*with the ability to identify imminent dangerous or crisis situation"* based on the interaction of embedded sensors and applications that apply pattern recognition algorithms to the signals from the sensors; such signals could be auditory (eg a gunshot) or visual (a flame). If an emergency situation is recognised, a signal would be sent to emergency services giving details, including the current location of the device. The system is at present theoretical, but in the authors' view the necessary level of technological development on smartphones and networks already exists. *Use of Mobile Phones for Emergency Evacuation* Chu (2010) design a mobile phone based *"hybrid building fire evacuation scheme"* (HBFES) using Radio Frequency Identification (RFID) techniques. The system assists the escapee to find the optimum evacuation route. The HBFES uses integrated temperature sensing to assess fire spread and indicate a safe/reliable evacuation route. An add-on Micro SD RFID reader is required to interrogate from passive RFID tags in the building but the authors anticipate that future smartphones will have inbuilt RFID reading capability. Inoue et al (2008) propose an "*Autonomous Navigation System*" based on smartphones (or PDA) for indoor emergency evacuation, using an "*indoor position system*". A wireless sensor-data management system detects indoor emergencies. If one is detected it activates an indoor navigation system consisting of radio beacon devices (ceiling mounted) transmits to a receiver carried by the user, which in turn transmits to the user's smartphone via Bluetooth. The smartphone then displays a map and/or GPS-like "navigation system" to indicate route the user should take. While this proposed system overcome the deficiency of GPS that it cannot be used indoors, it chief deficiency is the requirement that users carry a beacon receiving device. *Health Monitoring Systems* Barnickle et al (2010) design a "HealthNet" system consisting of a network of body sensors embedded in clothing that communicates wirelessly to the wearer's smartphone. The smartphone pre-processes the data and if necessary transmits (securely) to other parties, ie family or emergency medical services. Duval et al (2008) review advances in Virtual Reality and towards "ubiquitous computing", defined as: *"continuous contacts with computers that use sensors, actuators and networking. It covers* intelligent environments*, material environments like streets, offices and houses that react to people and events, and* wearable computers (a.k.a. wearables), *worn by users, embedded in, for example, earrings or clothes."*

	The authors envisage these as having potential quality of life benefits for the elderly, as well as the young. Ubiquitous computers can detect dangers, including fire, and alert family members or emergency services. Hickey, K (2011) outlines how an Californian fire department has released a free iPhone application to facilitate volunteer emergency response to cardiac emergencies. This application alerts a registered user (trained in CPR) within walking distance of a cardiac emergency that help required, and directs them, via Global Positioning System signals, to the closest publicly available Automated External Defibrillator. *High Speed Mobile Access with LTE* Many of these mobile applications will require high speed mobile technology. The front-running technology, most likely to be implemented in NZ is "3GPP Long Term Evolution". LTE. In September 2011, Alcatel-Lucent and Telecom launched an "LTE Showcase" in Auckland (Scoop 2011). LTE is out-competing the rival WiMax standard for broadband wireless access internationally. However, we presume applications developed internationally for emergency response services under the WiMAX standard are relevant to developing similar applications in NZ under LTE. It is possible there may only be one LTE network in NZ, shared by otherwise competing mobile operators (LTE: when will it arrive in New Zealand? Network Strategies August 2010) http://www.strategies.nzl.com/wpapers/2010011.htm_

3.4 CONCLUSIONS: KEY CONSUMER TECHNOLOGY CHANGES

- There is a social and generational change away from one-to-one audio communication to text messaging and use of social networks services and portable devices.
- Social media will need to be used by the Fire Service to disseminate community education messages as at risk groups, including the young, reduce their consumption of conventional mass media (this topic is covered in UMR 2011, NZFS Research Report 118).
- There is potential in the long term for 'crowdsourcing' of fire and other emergency data ie for the public to send useful information & images to the Fire Service prior to arrival at scene. This could include images and video, together with data from miniaturised sensors in the smartphone (eg detection of gasses).

- Technical developments and investments at both the transmission and receiving end are required for this potential to be realised.
- As has been demonstrated in Christchurch, social networks provide channels for two-way exchange of information between emergency responders and the public in an emergency.
- Similarly, again as demonstrated in Christchurch, they facilitate communication between private individuals and groups during recovery from an emergency
- Events in 2011 in Britain and Arab countries illustrate how, under conditions of civil unrest, crowds can be rapidly assembled and organised through the use of mobile communication and social networking services with portable devices.

3.5 IMPLICATIONS FOR NZFS

- NZFS and other emergency responders need to remind the public that audio calls placed via the 111 service remain the only way of obtaining an assured response by emergency services;
- On the other hand, it must recognise the reality many people's preference to communicate via text messages and social media and to develop the capability to accept and respond to messages and data communicated in this way.
- Social media and portable devices give the Fire Service the opportunity to send targeted fire safety messages, and to engage in a two-way exchange with the public, including members of "at risk" groups.
- During rescue events such as floods and earthquakes social media can provide channels to receive useful data – images, video, from the public;
- As technology to use video to detect fire (see **Section 4.3** below) matures and becomes more powerful, and at the same time the quality of video taken and transmitted by consumer devices improves, the Fire Service could develop the capability of receiving and analysing such data.
- As GPS-equipped portable devices become more common, a priority for the Fire Service is to be capable of receiving and analysing this data.
- The precedent of civil unrest in Britain, facilitated by social media, and straightened economic conditions increase the risk of similar unrest in NZ. However social media give the Fire Service an opportunity to promulgate its absolute neutrality if such unrest occurs, so to enable it to carry out its fire and rescue operations unimpeded.

There is much research and development in the field of video/image analysis in emergency detection and response, including fire. This could eventually support "crowdsourcing" of data from the publics' portable devices. In the literature to date the source of video data is usually taken to be CCTV or emergency services' thermal imagers, rather than consumer portable devices. This topic, considered is Chapter 4 along with other new fire detection and suppression technologies.

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4. IMPACT OF NEW PROPERTY FIRE DETECTION AND SUPPRESSION TECHNOLOGIES

4.1 INTRODUCTION

In this section we review new and emerging active fire protection technologies.

In carrying out this review, we consulted NZFS managers on new and emerging technologies for detection and suppression of domestic, commercial and industrial properties (**Section 4.2**). The consultation covered matters including:

- the fire detection and suppression technologies they perceive as being most effective (and cost-effective) currently available;
- emerging technologies having most potential for upgraded effectiveness over the medium and long terms;
- the barriers to adoption of new/emerging fire detection and suppression technologies by property owners;
- steps the NZFS could take to help overcome these barriers.

In **Section 4.3** we present a selective review of international and New Zealand literature on new and emerging property fire detection and suppression technologies.

We summarise the findings of the review and consultation in an evaluation matrix, in **Section 4.4**. The first part of the matrix summarises the benefits to the properties owners of the active fire protection technologies. The second part of the matrix is an indicative, prima facie cost effectiveness assessment of the technologies from the point of view of residential and commercial/industrial property owners. This assessment involved comparing the expected costs and effectiveness of the new and emerging active fire detection and suppression technologies with that of technologies in most common use.

We conclude by identifying the fire detection and suppression technologies for NZFS to promote, or to sponsor further research into (**Section 4.5**).

4.2 CONSULTATION

The following key points arose from our consultation with senior Fire Service Managers:

- **Reduce false alarms by encouraging building owners to modernise fire alarm systems:** An issue of serious concern to Fire Service managers is false alarms from automatic fire alarm systems installed in commercial and industrial premises.

There is both a direct financial cost to the Fire Service from attending such alarms, and a more indirect but possibly more serious effect on volunteers. The latter are more willing to give their time (and their employers to make them available) to real incidents than false alarm. Many such false alarms are avoidable, as they occur as a result of poor maintenance and/or use of out-dated technology. Reducing false alarms by encouraging building owners to modernise fire alarm systems with the benefit of managing demands on volunteer fire fighters also emerged as the highest priority technology/benefit pair from our survey of Area Managers (see **Section 5.3).**

- We were informed that the Fire Service's incident statistics do not record the age or any other details on the fire alarm systems used in cases of false alarm; this poses challenges for any future assessment of direct and indirect cost to Fire Service of old vs. new-technology commercial/industrial property fire alarm systems.
- Modern "analogue addressable" fire alarm technologies are on the market that have a lower rate of false alarms than dated, conventional alarm panel systems that prevail in New Zealand. However, due to cost to the property owner of purchase and installation they have not been retrofitted at a significant rate and, while they are installed in new buildings, NZ's rate of replacement of commercial properties is too slow to have major tangible benefits in terms of reduced false alarms.

- **Conventional domestic smoke alarms are inadequate and solutions are on the market:** New and increasingly affordable domestic smoke alarm technologies are on the market that largely overcome the well-known limitations of the most common domestics smoke alarms: limited battery life and false alarms leading to disable removal of batteries. New generation of photoelectric smoke alarms using long life batteries (up to 10 years) largely offset both these deficiencies. Further gains in effectiveness can be achieved with hardwired interconnected domestic smoke alarms, and by wirelessly interconnected long-life battery powered systems (interconnection means that if one detector is triggered, all alarms sound).

- **Domestic sprinkler systems seen as beneficial:** While gains in reduction of domestic fire risk can be achieved through installation of modern alarm systems, further gains require the use of domestic sprinkler systems. A reason for this is that most domestic fire fatalities occur well within the Fire Service's standard response time standard. Managers referred to the new NZ Standard NZS 4517:2010. Managers recognised that retrofitting of full sprinkler systems is unlikely to be popular due to cost, but thought that installation of sprinklers should become common practise. In some countries sprinklers are a legal requirement in all new dwellings. The perceived main reasons for builders not installing sprinklers is perceived to be their cost and the lack of any significant reduction in insurance

premiums if they are installed. There was disagreement over partial coverage domestic sprinklers (which are not consistent with NZS 4517:2010). One view is that full protection gains can only be achieved by full coverage systems; the opposing view is that partial coverage systems (usually in a kitchen covering a stove) can be cost-effective in terms of safety gains made in relation to investment made.

- **Modern addressable fire alarm panels provide more information than NZFS can receive:** These systems can provide rich information to responding appliances on the location and spread etc of fires, including location of activated sprinkler heads. Currently responding OICs can read this data from the panels. Some systems are now capable of transmitting data directly to responding appliances but NZFS does not have the technology to receive and analyse it.

4.3 LITERATURE REVIEW

"New" Technologies available on the New Zealand Market	• A useful overview of the range of active fire protection equipment available on the New Zealand market is given on Fire Protection Association of New Zealand website: http://www.fireprotection.org.nz/equipment.htm.
	• Wormald's New Zealand website http://www.wormald.co.nz provides information on the range of Wormald fire protection and fire-fighting products for commercial/industrial, domestic and fire service use. These range from portable extinguishers to the:
	  • "*VIGILANT® MX1 Fire Indicator Panel*", an intelligent analogue addressable fire panel system and the
	  • *VIGILANT® QE90 Emergency Warning and Intercommunication System (EWIS)* which supports progressive, zone-by-zone controlled building evacuation.
	• Chubb's New Zealand websiteprovides information on the company's fire detection and suppression products and systems (refer http://www.chubb.co.nz/Pages/Home.aspx).
	  • The company manages installation of a range of fire alarm systems to the New Zealand Standard NZS4512.
	  • Its suppression systems include gaseous systems, foam systems and Mari off water mist systems.
	• New Zealand Fire Extinguishers supply a "radio interlinked alarm" system for domestic use; the system includes heat detectors as well as smoke alarms. See http://www.newzealandfireextinguishers.co.nz/smoke-alarms.

Multi Sensor Detection, including Video	Much of the research in the field of active fire protection is in improving methods for detecting fire. Within this broad area, a particular area of development is developing fire detection algorithms that use video feeds from CCTV security cameras. The literature on the topic includes the following: • Verstockt et al (2011) describe multi-sensor smoke detectors which takes advantage of the different kinds of information represented by visual and thermal imaging sensors. *"Video smoke detection (VSD) has become a hot topic in computer vision over the last decade. Current research … shows that the video-based detection of smoke promises fast detection and can be a viable alternative or complement for the more traditional techniques, such as ionization and photoelectric fire detection. However, due to the variability of shape, motion, transparency, colours and patterns of smoke, existing VSD approaches are still vulnerable to missed detections and false alarms. The main cause of both problems is the fact that visual detection is often subject to constraints regarding the scene under investigation, e.g. changing environmental conditions, and the target characteristics. To avoid the disadvantages of using visual sensors alone, we argue that the use of other types of sensors, especially infrared (IR), can be of added value.* *"The proposed multi-sensor smoke detector takes advantage of the different kinds of information represented by thermal and visual images in order to accurately detect smoke. By fusing both modalities and using the strengths of each medium, smoke detection can be done more accurately and with fewer false detections.* *To detect the presence of smoke, the multi-sensor smoke detector analyzes the silhouette coverage of moving objects in visual and LWIR registered images.* *The multi-sensor detector adheres to all the relevant requirements: object-based automatic calibration/ registration, low number of false alarms, no missed detections and fast warning/alarming with different levels of detection".* • Borges et al (2008) propose a method for detecting fire in video (eg from surveillance cameras) based on random changes of fire from frame to frame. • Sekkas et al (2009) describe the SCIER (Sensor and Computing Infrastructure for Environmental Risks), funded by the European Community. The system is an: *"integrated system of sensors, networking and computing infrastructure"* with the purpose of *"detecting, monitoring, predicting and assisting in crisis management of natural hazards or accidents"* at the "*Urban-Rural Interface*". *In SCIER system temperature and humidity sensors (in-field) and vision sensors (out-of-field) are used. The last are based on a high-dynamic range contrast camera in which the contrast representation of a scene can be used (through various algorithms) to detect a smoke or flame and generate a*

	probability of a fire event". Data from the two categories of sensors are combined in a two-level data fusion scheme, which is claimed to improve the reliability of the system, providing early fire detection while reducing the false alarm rate. • Nugrohoa et al (2010) develop, via experiment, an image processing technique for early detection of cable fires using automatic video. The potential advantages of image processing detection over traditional smoke detection include providing more information about fire, such as location, size and growth rate. Motion segmentation is analyzed using the "*Adaptive Gaussian Mixture Model*", and the authors note that: *'One of the most important parts of the action recognition systems is the segmentation of moving foreground objects from the stationary background."* • Verstockt et al (2010) develop a standardized methodology to evaluate the effectiveness of video-based detectors. *"The proposed performance framework is able to determine optimal settings for each individual VFD algorithm and is also able to compare multiple algorithms against each other".*
Sensitive Sensors based on Aerospatial technology	One source of new technology sensors that can be applied in detecting fire is the aero spatial industry, including NASA. Examples include: • Aztec is a laser detection system developed by NASA (NASA 2004) for detecting gasses in planetary atmospheres and in space vehicles and aircraft. However, it has application in detecting incipient fires in terrestrial environments as well. • Sensors developed by NASA for use on Mars exploration robots also have application in fire detection. For example, ion mobility spectrometry sensors (NASA 2011) are another highly sensitive technology for detecting incipient fires. Ion Application Inc's ion mobility spectrometer technology is produced in hand held units.
Artificial Intelligence & Intelligent Buildings	There is considerable on-going research into advancing Artificial Intelligence (AI) theory to detect emergency conditions in "intelligent" buildings fitted with a plethora of sensors: • Sadri (2011) present a survey of "ambient intelligence" (AmI), including its applications, some of the technologies it uses, and its social and ethical implications. "*The applications include AmI at home, care of the elderly, healthcare… Among technologies, we focus on ambient data management and artificial intelligence; for example planning, learning, event-condition-action rules, temporal reasoning, and agent-oriented technologies."* • Wei et al (2008) set out the theory of a software interface, between fire fighting subsystem and the other systems, for use in intelligent buildings. They discuss approaches, based on AI theory, to "*raise the level of integration and intelligence in building management systems*"

	• Ma and Tian (2010) outline an AI Agent-based system for remotely monitoring buildings; for coordinating sensors (temperature, humidity, cameras) in "monitoring units". Data is exchanged between control machines and sensors. These include a "*Monitoring Agent*", a "*Decision-Making Agent*" and a "Communication Agent". If temperature or humidity values reach abnormal levels, the "*Decision Making Agent*" will give an alarm, and the "*Management Agent*" will respond to it, alerting emergency responders and providing them with information. • Wang et al (2010) describe an optimisation algorithm for "fusing" information from multi-sensor networks using the AI concept of "*support vector machines*". Fire detection technology based on multi-sensors and associated fusion technology is said to be a "development trend" in fire detection. In the AI field more broadly, "support vector machines" based on statistical learning theory, is gaining applications "*because of the high accuracy and good generalization capability".* The authors claim the complexity of fire process means that the detection technologies currently in use are deficient. Instead, they propose a "*support vector machines"* algorithm for fire detection information fusion which they claim gives more valid results. • Udgata and Sabat (2009) propose a wireless sensor network-based alarm system. They claim their proposed architecture is "intelligent" as it "*does not report alarms based on simple query processing and condition matching".* Rather, the system generates alarms when "*the gradient of change of sensed data with regard to space and time"* falls outside an "*acceptance range of threshold values".* The authors say their model is adaptive because it "*has a learning mechanism to learn from false alarms and correct the model in order to avoid such false alarms in future".* Their prototype system generates SMS (text) alerts which, following detection of an emergency, are sent to specified mobile phone numbers. • Din Ghauri et al (2010) describe an "agent-based" Decision Support System for prioritised evacuation from buildings during fire or related emergencies; the purpose of prioritisation is to prevent congestion in and around exit routes and points. The prioritised decisions are made with the help of "*Fire dynamics systems*" and "*Smoke dynamic systems*".

Advanced Sprinklers including Water Mists	There is continuing development and testing of suppression systems, with the aim of achieving rapid and effective control of fires while minimising damage by water or foams. Some examples are: *Commercial and Industrial* • Zhou et al (2010) report an experiment to gather data to characterise spray patterns of sprinklers, in order to calibrate computer models of sprinkler performance. • English and Bennett (2010) explore possible permissible compartment sizes when sprinklers are used. Their analysis shows that current compartments sizes in UK buildings could be increased when sprinklers are used. They outline a methodology that allows equivalent levels of fire performance to be derived when life safety and property protection sprinkler systems are used, compared to when they are not. • Klinzman and Hosser (2010) use probabilistic system analysis to explore the interaction of different active and passive safety measures on the overall safety level, with a view towards modifying German building codes to take into account the presence of sprinklers and other active fire protection measures. • Albrecht and Hosser (2010) provide more information on this holistic safety concept for structural fire protection that was developed in Germany, accounting for different types of occupancies and building materials. This concept is based on *"probabilistic methods and takes into account the required reliability of structural elements, the annual frequency of fires and the failure probability of active fire protection measures".* • Nilsen et al (2007) test the use of external window sprinklers in multi-storey buildings. The conclude that dedicated window sprinklers may hinder cracking of the window glass, given adequate water supply, and thereby reduce the risk of vertical fire spread up the building's façade. • Göransson and Husted (2007) compare the effectiveness of water mist vs. traditional sprinklers in buildings and industrial applications. The authors find that, compared to traditional sprinkler systems, water mist systems give the *"same extinguishing effects can be achieved by using five times less water, but the surface cooling effects are smaller, which can pose a problem for deep seated smouldering fires."* • Marchant (2004) in tests of water mist sprinklers to protect archives found that water mist systems are normally installed for activation by temperature sensitive frangible bulbs, but that *"from the test burns described briefly in this paper it is most unlikely that such a system will respond quickly enough to control a cellulosic fire".*

	Residential • Annabele and Williams (2007) report on a test of concealed (recessed) vs. pendent (visible) domestic sprinklers. They found none of the concealed sprinklers tested achieved a "quick response" rating, although the pendent sprinkler tested did so. The authors raise doubts about the suitability of concealed sprinklers for life safety applications, and suggest this is an issue for consideration by "the relevant British Standards committee". • Shelley and Spearpoint (2007) tested "fast response" domestic sprinklers with television set fires – which produce large volumes of smoke with low heat release. The authors found that *"untenable conditions can arise from a fire that does not produce sufficient heat to activate even a fast response sprinkler system"* and they recommended against the practice of not using smoke alarms if a sprinkler system is used (as can arise in New Zealand apartment buildings). • Fraser – Mitchell (2004) perform cost-benefit analyses of sprinkler systems in a range of residential building types in the UK. They concluded *"that residential sprinklers are not cost-effective for most dwellings"* but that *"residential sprinklers are probably cost-effective for residential care homes",* and for apartment blocks. The authors note that: *The results and conclusions of this analysis are consistent with the experience of sprinklers in other countries, which concluded that in order for sprinklers to become cost-effective (in a wider range of buildings), installation and maintenance costs must be minimal, and/or trade-offs may provide reduced costs by indirect means, and/or high risk buildings may be targeted, and justified on a case-by-case basis.* • Duncan and Wade (2001) outline an inexpensive domestic fire sprinkler design; this "multi-purpose" system involves a single mains connection that feeds both the sprinkler system and the domestic water supply. It is a reduced coverage system in that it omits sprinkler heads from rooms and spaces where few fatal fires originate, but covers bedrooms, lounge/dining rooms and kitchens, in which *"almost 90% of fatal fires originate"*. In a cost – benefit assessment, the authors estimated that such a system, combined with four stand-alone battery powered smoke alarms would provide much more life, injury and property benefits than smoke alarms only, at a similar cost per life saved. While not providing quite as much protection as a system meeting the then NZ standard (NZS 4515:1995), they estimated that cost per life saved ($891,000 in 2001 dollars) was much lower ie the reduced coverage system was found to provide most of the life, injury and property benefits for *"a fraction of the cost per life saved for a new sprinkler system installed to the current... standard)".*

	The authors conclude "Domestic fire sprinkler systems built to the current New Zealand standards are not cost effective. The multi-purpose sprinkler system, where the sprinkler system is integrated with the domestic plumbing, is a more cost-effective option for installing sprinklers in homes".

4.4 PRIMA FACIE COST EFFECTIVENESS ANALYSIS

Tables 4.3 and **4.4** below summarise the findings of the review and consultation with an **evaluation matrix.** It gives prima facie indication of cost-effectiveness of active fire protection technology options from the point of view residential and commercial/industrial property owners.

The **matrix** is in two parts. In the first, **Table 4.3**, the benefits to property owners of using the technologies are rated in relation to benefits of the technologies in most common use – first for residential property owners, second for commercial/industrial property owners.

Note, the benefits that each technology can provide from the baseline are summarised by a six point scale, ie the digits 0 – 5 (**Table 4.1**).

The first column of the second matrix Prima Facie Cost Effectiveness Analysis (**Table 4.4**), indicates the state of the development of the new technology. The final two columns show our indicative cost-effectiveness rating (again on the 0-5 scale, see **Table 4.2**) in two cases – retrofitting the active fire technology to an existing building, and second installing it as part of new building.

Table 4.1 Effectiveness Scale used in Table 4.3

Score	Description
0	Same Effectiveness as baseline
1	Minor improvement in effectiveness over baseline
2	Moderate improvement in effectiveness over baseline
3	Substantial improvement in effectiveness over baseline
4	Major improvement in effectiveness over baseline
5	Maximum effectiveness, state of the art

Table 4.2 Cost Effectiveness Scale used in Table 4.4

Score	Description
0	Likely to be cost ineffective
1	Not likely to be cost effective
2	Only likely to be marginally cost effective
3	Potential for some cost effectiveness
4	Potential to be significantly cost effective
5	Potential to be strongly cost effective

Table 4.3 Evaluation Matrix: Prima Facie Cost Effectiveness Analysis 1:

Technology	BENEFITS							
	More effecitive /reliable alarm of occupants	Reduce False Alarms	Communicate Alarm to Security Provider	Communicate Alarm to Fire Service	Improved Information on Alarm Panel	Communicate intelligence direct to Fire Service	More Orderly/ Guidance for evacuation	More effective suppression with reduced water etc damage
Domestic Fire Protection Technologies								
Standalone ionization and photoelectric smoke alarms (baseline)	*0*	*0*	*0*	*0*	*n/a*	*0*	*n/a*	*n/a*
Long-life photoelectric smoke alarms	2	1	0	0	n/a	0	n/a	n/a
Radio interconnected battery powered detectors	4	1	0	0	n/a	0	n/a	n/a
Hardwired interconnected smoke alarms	5	2	0	0	n/a	0	n/a	n/a
Integrated home security systems connected to security provider	5	4	5	4	n/a	0	n/a	n/a
Intelligent IP connected domestic fire/medical/security systems	5	5	5	5	n/a	5	n/a	n/a
Partial Coverage Domestic Sprinklers	n/a	n/a	n/a	n/a	n/a	n/a	n/a	3
Full Coverage Domestic Sprinklers	n/a	n/a	n/a	n/a	n/a	n/a	n/a	5
Commercial/Industrial Fire Protection Technologies								
Conventional alarm Fire Brigade panel systems (baseline)	*0*	*0*	*5*	*5*	*0*	*0*	*0*	*0*
Analogue Addressable fire detection and alarm systems with integrated Fire Brigade Panels	3	3	5	5	3	0	3	0
Intelligent, IP connected detection alarm systems with extended range of addressable sensors including video	4	4	5	5	5	4	4	0
"Intelligent Building" systems with IP (internet protocol) connections	5	5	5	5	5	5	5	0
Advanced suppression systems - water mists, foams, gas	n/a	n/a	n/a	n/a	n/a	n/a	n/a	5

Table 4.4 Evaluation Matrix: Prima Facie Cost Effectiveness Analysis

Technology	State of Development	Indicative Cost Effectiveness for building owner	
		Retrofitted	New Building
Domestic Fire Protection Technologies			
Standalone ionization and photoelectric smoke alarms (baseline)	*on market*	*1*	*0*
Long-life photoelectric smoke alarms	on market	2	1
Radio interconnected battery powered detectors	on market	4	4
Hardwired interconnected smoke alarms	on market	2	5
Integrated home security systems connected to security provider	on market	Depends, 5 if it enables elderly to live independently	
Intelligent IP connected domestic fire/medical/security systems	prototype	Depends, 5 if it enables elderly to live independently	
Partial Coverage Domestic Sprinklers	on market	1-2, but 5 if it enables elderly to live independently	
Full Coverage Domestic Sprinklers	on market	0-1, but 5 if it enables elderly to live independently	
Commercial/Industrial Fire Protection Technologies			
Conventional alarm Fire Brigade panel systems (baseline)	*on market*	1	0
Analogue Addressable fire detection and alarm systems with integrated Fire Brigade Panels	on market	3	2
Intelligent, IP connected detection alarm systems with extended range of addressable sensors including video	prototype	2	4
"Intelligent Building" systems with IP (internet protocol) connections	on market	1	5
Advanced suppression systems - water mists, foams, gas	on market	Depends	5

Interpretation of Evaluation Matrix

The Evaluation Matrix and indicative cost effectiveness assessment indicate:

- Active fire protection technologies already on the market have the potential to provide major benefits to both residential and commercial/industrial property owners;
- further improvements will involve greater intelligence built into detection and suppression systems, and capacity for exchange in information with the Fire Service and other emergency responders; however,
- increasing effectiveness does not necessarily equate to greater cost-effectiveness. All papers we have reviewed find that full coverage residential sprinkler systems area not cost effective for homeowners, although performance is better when sprinklers are installed when the house is built. It appears partial coverage systems are more cost-effective.

Further conclusions are discussed in **Section 4.5** below. We identify active fire protection technologies as high priorities for further investigation in **Section 6.4.**

4.5 CONCLUSIONS: KEY CHANGES IN FIRE DETECTION AND SUPPRESSION TECHNOLOGIES

1. Improvement of in-built property fire detection and suppression technologies is likely to be incremental. Existing technologies on the market are greatly improved from technologies generally in place. Interconnected and long-life domestic smoke alarms on the domestic side, and addressable fire alarm panels on the commercial/industrial side, are example of this. The Fire Service could promote adoption of these technologies by demonstrating to property owners the cost-effectiveness of the required investment.

2. In the commercial/industrial sector, intelligent IP connected alarm/suppression systems and 'Integrated building management systems" have potential to cost-effectively improve the protection of commercial and industrial buildings. These systems enable earlier automatic detection and suppression, and they provide intelligence to responding fire officers. However, even systems at the technological level now on the market (analogue addressable fire alarm panels) have not been taken up by NZ commercial building owners at a rate to comparable other countries. This is largely due to the cost of retrofitting existing buildings and slow rates of building replacement in New Zealand.

3. In the residential sector, the literature review and interviews show several key trends and issues:

   - Increasing sophistication and effectiveness of smoke alarms through interconnection (originally hard-wire, but now wireless as an alternative). Interconnected domestic alarm systems will grow increasingly more intelligent, involve a wider range of detectors and have the capability of sending an expanded range of data to security providers and the Fire Service. They will be increasingly integrated with security and medical alert systems, and fire detection will be become a function of the "intelligent house".

   - A new standard (NZS 4517:2010) for residential sprinklers has been introduced to reduce cost and improve cost/benefit performance, to new home builders, through recognition that the primary purpose of residential sprinklers is to maintain survivable conditions to enable safe evacuation of occupants. This does not appear to have resulted in increased installations (pers. comm. in interviews with NZFS managers).

   - Partial coverage sprinklers, eg over stoves, have a better benefit cost ratio than full coverage systems, especially in retrofitting, but are not supported by the Standard. Increased adoption may require modification to the Standard.

In **Chapter 5** we turn to emerging technologies with potential for improving NZFS's operations.

5. IMPACT OF EMERGING TECHNOLOGIES FOR NZFS

5.1 INTRODUCTION

In this section we assess new technologies available to NZFS to improve the effectiveness of its urban fire fighting and rescue operations using a systematic "product development" approach. We:

- Distil the views of NZFS managers and executive officers on perceived problems with, and limitations of, existing technologies used to obtain information about structures before and during rescue and fire fighting operations (**Section 5.2**).
- Present the views expressed in the face to face and telephone consultation in an email survey of a wider range of national and fire region managers and officers. The list of potential respondents to include in the survey was suggested by the Advisory Panel, and the list of technologies presented to survey respondents was agreed by McDermott Miller and the Panel (**Section 5.3**).
- Using the list of technologies set out in the survey of Area Managers as a starting point, in **Section 5.3** we also review selectively the international literature on new and emerging technologies for:
  - Technologies to Reduce Response Times
  - ICT Technologies:
  - Other Fire Fighting Technologies:
  - Rescue Technologies:
  - Training Technologies.
  - Environmental Protection Technologies.
- Compare NZFS experience with experience of other organisations reported in the literature to identify whether limitations identified in the past by NZFS with digital and other new technologies may have been overcome by technological development since past trials were carried out, or are likely to be overcome with future development.
- Assess new technologies in terms of potential cost effectiveness using an evaluation matrix, in which the performance of each technology is rated in terms of performance criteria, Potential to achieve a net annual cost reduction for NZFS, and Potential to achieve national economic net benefits (**Sections 5.4** and **5.5**).
- The evaluation matrix facilitates identification of a set of new technologies for the NZFS which could proceed to further evaluation (**Section 5.6**).
- We draw out implications of these technologies for Fire Service operations in **Section 5.7**.

Definition of New Fire Service Technologies

We have adopted Dittmar's (2007) definition of "new" fire service technologies, as follows:

"The technologies presented here are not necessarily "new" in the sense that the ideas were recently conceived. In some cases, "new" refers to a later stage in the development of a system, a refinement in the technology, or a first-time application. In other cases, the product may serve as a "bridge" that makes it possible for responders in regions to work together or as "fillers" for gaps in firefighter safety that were impossible to envision just a few years ago, according to some of the parties involved with the research. The following is an overview of some of the technologies in the categories in which considerable progress has been made in the past year or so."

5.2 CONSULTATION

Key points to emerge from our consultation with managers and executive officers are:

Technologies to Reduce Response Times

- There is potential for improved co-operation with roading authorities to improve road layouts to help with appliance travel times in heavy traffic. There have been trials with devices for appliances to trigger traffic lights to favour their direction of travel but these did not achieve a marked reduction in travel time (refer below).
- Currently, route decisions are made in a quick conversation between Comcen and OICs; opinion was expressed that technologies should be available to support improved route-finding in heavy traffic. There is a database of roads/routes at Comcen, but there is no intelligence in the system to provide current traffic information and to help select an efficient route.

ICT Technologies:

- There is on-going research internationally into "integrated building management systems", as a result of the World Trade Centre collapse of 2001; this showed that in a severe fire even a modern multi-storey building can collapse. Sensors built into the frame of a building can detect strain and incipient collapse.
- Modern commercial/industrial alarm transport systems employ a range of sensors. Their panels can provide much more information to the OIC indicating the location and rate of development of a fire and its smoke. The Fire Service has conducted research recently on how this data could be transmitted to computers mounted on appliances.

- Accompanying this volume of data is a need for decision support systems, to help commanders manage the information and make command decisions on the basis of it.
- In contrast, most commonly at present an officer dismounts and reads a 1950's era panel LED lights which presents challenges of interpretation. There is a low rate of retro-fitting of modern systems into older commercial buildings, and with low rates of replacement of building stock, the penetration of modern alarm transport systems is low and growing only slowly.
- The consensus that emerged is that improving intelligence to OICs is of first priority, above improving fire fighting tools/equipment.
- There has been a trend for appliances to carry a greater, and heavier, range of equipment. Some managers thought UK experiments with the opposite approach of having small appliances – even motorcycles – to arrive more quickly, at some calls could be worth trialling in NZ.
- There is scope for introduction of modern methods of command and control, and this process has started with the new Hazmat/Command vehicles.
- Some modern Scania appliances have control boxes which record data at incidents such as water used (discharged), but this is not uploaded to FS systems and therefore is not kept or analysed.
- False alarms are recorded in incident statistics, as is data on, broadly, what caused the false alarm. However, data is not recorded on the level of technology of automatic fire alarms, so it is not possible to quantify rate of false alarms from modern vs. old technology alarm and panel, systems, this means it is not possible to quantify benefits of replacing old with new alarm systems.
- In principle could introduce systems for real time tracking of people moving on the incident ground, this would appear to commanders as dots moving, so commanders always know where people are, but there are no plans to introduce this.
- New Plymouth District Council was cited as a leader in allocating mobile devices to its field staff, and in using geolocation for all its assets, to use with GIS system.
- "Double Knock" smoke detectors (need to receive smoke signal twice before triggering) are available to commercial building owners and these can reduce false alarms by 80%. They are economic for building owners to install because of low cost compared to loss of production during false alarms.
- Views were expressed that it is much better to have intelligence from modern alarm systems supplied direct to devices used by OICs, rather than having to relying on the intelligence being filtered through Comcen, which slows the process down, and possibly comcen operators make judgements about what is, and is not, important that is different to what OICs on the ground would think.

- The Fire Service's modern Hazmat/Command vehicles have good equipment to support more effective command and control at major incidents, but there remains a problem of connectivity, ie of access to fast and reliable wireless broadband.
- The provision of intelligence to responding crews before arrival is seen as a (the) prime task that new technology can potentially help with.
- There was comment that turnover of IT staff can be a barrier to effective implementation of new ITC systems in the Fire Service. It takes time for IT staff to acquire the necessary knowledge specific to NZFS – and once this is achieved they tend to move on.
- Another barrier to adoption of new technologies is reluctance of some (mainly volunteer) firefighters to accept and work with PCs and mobile devices, but that this is problem that is declining over time.
- Views were expressed that NZFS is making progress in implementing inter-agency communication via digital radio.
- A view was expressed that devices to locate firefighters, eg by GPS, would be valuable in major structure fires.
- A system is being developed by NZFS for contacting volunteers that uses different routes in turn until successful contact is made through an open route – landline, mobile phone, text, etc.
- Investigations, under the ICT strategy, into introduction of "Extended Alarm Capability", to the Fire Services are scheduled to commence. This will consider connecting modern alarms to the FS network. The investigation will consider modern alarms in commercial/industrial premises, but could be extended to modern intelligent domestic systems connected to wireless broadband as well.
- Using CCTV security cameras on the street could provide information to the Fire Service, eg on traffic conditions, or on the incident itself.
- NZFS research has shown that using mobile phones means, at present, a slightly slower response time due to "*marginally slower response owing to delays in locating incidents. This results in a measurably greater monetary loss".* (Challands, 2009)
- Main barriers to innovative ICT technologies are cost and guaranteed reliability. Other subsidiary issues are:
  - Privacy concerns, eg in using security camera video;
  - Training requirements; with limited time available for training (especially for volunteers) there is a need to prioritise or be selective on training topics.
  - Reluctance to adopt by some potential users.
  - Power drain and space available on trucks.

- These barriers can be overcome by:
  - Designing interfaces to best match the requirements of users.
  - Focus on engaging interest of early adopters; others will follow.
- In 2003 a major mobile ITC project was investigated, but it was found that connectivity/broadband constraints mean that its concepts could not be immediately implemented, Instead, a more gradualist approach has been adopted and, in the interim, connectivity has improved. The AVL (Automatic Vehicle Locators which let dispatchers know the location of each appliance through GPS so they can dispatch the closest appliance to a reported incident) system now being implemented is part of this process.

Other Fire Fighting Technologies:

- Foams (CAFs or Class A) have potential to fight residential and other fires externally more effectively – this is particularly advantageous for volunteers who often haven't had the training or experience to fight fires internally with safety, and who often face more advanced fires (compared to career firefighters) due to longer response times.
- Through use of foams, water carried on the appliance is more likely to be sufficient to achieve extinguishment.
- There was a difference in opinion expressed on the potential for CAFs and/or Class A foams. At one extreme, the view was that foams should be main method of extinguishment (used by volunteers in particular), others thought that primacy of water should continue.
- Replacement BA sets have been out to tenders; these would contain some new technology – monitoring of cylinder contents and communications from control point – other innovations are available such as monitoring external temperatures and use of Bluetooth for telemetry but, for reasons of cost, these have not been included in the specification.
- There is a gradual shift from the principal of equipping and training all brigades (career and volunteer) equally to equipping and training brigades appropriately for the risks/incidents that they face/experience.
- Class A foam pumps are on every appliance built in the last 7-8 years, but still not used very much even if available, due to lack of understanding of respective uses of solid stream water (pre-flashover) and foams (post-flashover).

Rescue Technologies:

- Technological innovations take place at brigade and area levels, eg development vehicles that are appropriate for the brigades. These innovations are sometimes, but not always, effectively disseminated through the Fire Service. Such innovations have particularly been for MVA rescue equipment.
- Fire service is facing challenges from global warming resulting in more intense storms, higher tides and worse flooding.
- New Hazmat vehicles have new detection, identification and decontamination systems, but do not have more sophisticated systems such as plume modelling, and no use is made of robotics.
- NZFS is working with universities, exploring use of robots in urban search and rescue, and dealing with dangerous fires involving, for example, acetylene cylinders. Cost of these could be justified in cost-benefit terms by minimising disruption to businesses etc through rapidly dealing with the situation.
- A lack of portable devices to take photos and report on what was done and where, was found to be a deficiency in USR work in Christchurch following the February 22nd 2011 earthquake. Because of this experience, there is likely to be introduction of devices to aid searching and clearing buildings, and to report on these activities.

Training Technologies:

- NZFS Training has adopted a "Blended learning" policy, to provide the learner with different ways of accessing information, which appeal to different preferred learning styles (many firefighters have a "kinaesthetic" preference).
- There are concerns about some volunteers' IT skills and interests; it is expected paper-based options will have to continue.
- Career firefighters have access to broadband at all stations, but NZFS has bandwidth limitation for streaming material, so there remains a need to publish video on DVD.
- The Fire Service uses "vector training" simulation already for command and control training.
- Of all applications of ITC in training, interviewees thought command and control training should be first priority.
- Fire Service has investigated emergency response driver training using simulators. Simulators would save wear and tear on trucks; simulators could be shared with other responders. Simulator could be mounted on a vehicle or trailer; a challenge is the range of vehicles operated by NZFS and need to simulate many of them.
- Volunteers can resist the demands on the NZFS places on their time for training,

- MVA training has to keep up with developments in cars; most significant are electric and hybrid vehicles which carry a risk of shock to rescuers, and cars made with hardened steel which are more difficult to cut.
- New models of "e-pad" are coming on the market. NZFS has considered purchasing one each for all volunteer firefighters but expects there would be some resistance to them. Smartphones are considered to be too small for training, but would have uses (eg sending out notices on Twitter).

Environmental Protection Technologies:

- Some managers expressed the view that environmental impacts of freighting must be considered, and that in some cases a defensive approach of allowing some buildings to burn while preventing spread can have lower environmental impact than using large quantities of water. Alternatively, relatively new fire fighting technologies such as foams have potential to extinguish fires with less risk to firefighters and the environment.
- There is a trade off between cost and environmental impact in foaming agents – more expensive agents can be used in lower concentration and have lower environmental impact. Also, using the lower-concentration agents may mean investing in new inductors to use them.

5.3 FINDINGS OF LITERATURE REVIEW AND SURVEY OF AREA MANAGERS

Survey of Area Managers

The online survey of Area Managers included how emerging technologies could benefit fire service operations[5]. Refer to **Annex B** for discussion of the survey method.

We used the responses given by Area Managers in the survey to derive an index for use in prioritising technologies. This index embodies both the priorities assigned to the benefits of technologies, and the rating of the potential for each technology to provide the benefits. Key results are given in below. More results are presented in **Section 5.5**, and intermediate results and details on how the index was derived, are provided in **Annex B.**

Technology Groups

We have grouped the technologies as follows:

- **Technologies to Reduce Response Times**
- **ICT Technologies**
- **Other Fire Fighting Technologies**

[5] Use of social media etc for fire risk management/fire safety education was not included in the survey, as this is the subject of another study funded under the CRF.

- **Rescue Technologies**
- **Training Technologies**
- **Environmental Protection Technologies.**

1. TECHNOLOGIES TO REDUCE RESPONSE TIMES

Modeling/simulation to refine location of stations and/or resources	**Rating by Area Managers** The collective view that emerged from the Survey of Area Managers is that optimal location of stations and resources is by far the most effective way of reducing response times (although this benefit only had a middle ranking terms of priority refer **Annex B**) **Status in ICT Strategy** Currently, the NZFS models location of stations and resources using the National Resource Allocation Modelling (NRAM). "Tactical" location of appliances is identified as a "Technology Opportunity" in the ICT: "*Guided by data on road route speeds and historic traffic conditions, appliances could be tactically located during heavy congestion periods to improve response times to events in such situations*" **Literature Review** Farahani et al (2011) present a comprehensive review of the theory of "covering problems" in facility location, and of applications of this theory. Covering problems have *"…applicability in real-world life, especially for service and emergency facilities".* Set covering problems were originally introduced to model and locate emergency service facilities (and especially fire stations). This review cites case studies which include location of fire stations and fire fighting resources. Farahani et al (2010) present a review on a related issue: Multiple Criteria Facility Location problems. These are in three categories: bi-objective, multi-objective and multi-attribute problems together with their solution methods. Wei et al (2011) present a fire station location case study which employs the multi-attribute decision making technique of Analytic Hierarchy Process (AHP) within the framework of GIS-based planning process. The attributes considered include population density, building loss after catching fire, and road distance to nearest station. Yang et al (2006) have developed a fuzzy multi-objective model to locate fire stations where there are a number of physical limitations. The proposed method is the combination of fuzzy multi-objective programming and a genetic algorithm: *"In this paper we converted a fuzzy multi-objective optimization model into a single unified goal and combined the goal with a genetic algorithm for the fire station location problem. Five objectives are created, the first one is to minimize the total setup and operating costs of fire stations and total loss cost of accidents*

	in a given area, and the remaining four are to minimize the longest distance from a fire station to any accident site. The optimal number of fire stations is obtained by solving the first objective, which is transferred into a constraint for the remaining four objectives." Zhang et al (2009) present preliminary theoretical research on analyzing current, and modeling possible future, distributions of fire stations involving a raster calculating method. They suggest this could be a valuable supplement to traditional vector network analysis in a Decision Support System for fire station location analysis. Badri et al (1998) present a case study of planning for fire-station locations using multi-objective modeling. The objectives include minimising costs, maximizing service of at risk areas, minimising distance covered from stations to incidents, minimizing travel time, and minimizing service overlaps.
Change/improve appliance design to improve performance through traffic **On-board route/navigation systems**	**Rating by Area Managers** This technology has a low priority rating in the survey of Area Managers. A comment by one respondent is that aids to relieve OIC of navigational issues, in order for him/her to concentrate on information concerning the incident, are overdue. A possibility raised in our consultation and in the survey of Area Managers was introduction of small rapid response vehicles. This received a low priority rating in the Survey of Area Managers. One respondent to the survey of Area Managers observed "Appliances go faster than my (Exec) car". **Status in ICT Strategy** A project to trial and possibly implement Automated Vehicle Monitoring is included in the ICT strategy. **Literature Review** Baharin et al (2009) propose a *Conceptual Framework of Integrated Routing Application for Emergency Response Management System.* They outline a Database Management System (DBMS) that could aid in the route decision making process: *"The research hypothesis is that a Spatial DBMS (with an appropriate spatial schema, indexing techniques, and operations) can drastically improve the effective management and analysis of moving objects in route analysis. The integration of context information into the model should provide further flexibility in querying and visualizing data".* Cohen et al (2006) describe a networked driving simulator using a virtual-reality interface (control and display system). The simulator includes a "rotary motion platform for azimuth-display, stereographic display for 3D graphics, and spatial audio way-finding cues". The authors intended to move from a simulator to deploying a similar intelligent driver support system including

	way-finding (involving GPS and "augmented audio reality") on a real vehicle. An example of a small rapid response vehicle is the motorcycle appliances that have been used with reported success in Liverpool. McGuirk (2005) describes the launch of a pilot by the Merseyside Fire and Rescue Service of a fire motorbike to attend automatic fire alarm calls, with the aim of beating rush hour and other congested traffic delays in the city. "*The fire motorbike will provide initial risk assessments at callout scenes while appliances are en route*." However, little can be inferred from overseas experience, as the road/traffic conditions in Liverpool would be very different from New Zealand. A trial in a NZ metropolitan city would be required
Control of traffic light phasing by on-board device	**Rating by Area Managers** This technology has a low priority rating in the survey of Area Managers. **Status in ICT Strategy** Not in the ICT Strategy **Literature Review** The potential for reducing response times by equipping appliances with a device that can control phasing of traffic lights, so that appliances have priority, was raised in our original brief. Butt (1999) report the design of a trial in New Zealand of 3M's "Opticome" system which "*comprises transmitters located in appliances which trigger receiver in traffic control systems the appliance is approaching which produces a green light in the direction of appliance travel".* However, we could not locate any document on the outcome of this trial. The recollection of NZFS managers we interviewed was that the improvement in travel time was very minor; one reason cited by a respondent to our survey for limited improvement was that appliances need to proceed through intersections at speeds at which they can safely stop in an emergency, whether or not they have a green light in their direction.

2 ICT TECHNOLOGIES

Vehicle-based Incident Information Display via IP (internet protocol) network eg risk plans **Delivery of incident information to stations via IP (internet protocol) network**	**Rating by Area Managers** Incident information displays in vehicles with the benefit of providing more intelligence more quickly was the second most highly rated benefit/technology combination in the Survey of Area Managers (Index of 113.3). Delivery of incident information to stations via IP has medium priority rating of 57.1, for the benefit of providing more intelligence more quickly to OICs. This is perceived as having lower priority than delivery of incident information direct to responding appliances. **Status in ICT Strategy** An identified "Technology Opportunity" in the ICT is: *Mobile Solutions may result in new generation touch-screen display devices in Appliances which could provide the dual function of information displays, as well as the ability to key-in K-codes.* "*Use of WAN (Wide Area Network) IP for Station turnout*" is a project identified in the ICT, including investigation of Vehicle-based Incident Information Display via Wifi "Information Display and Status Signaling in Appliances" is also a project identified in the ICT, to investigate "*introduce display/print technology in appliances and/or stations* to *automatically present the main information regarding the incident that the appliance has been turned out to, in support of accurate response and appropriate tactics"*. **Literature Review** Dittmar (2007) presents an overview of selected firefighting technologies. These include FireRMS Mobile™) which *"provides access to the master database while in the field so that CAD dispatches, fire preplans, inspection reports, maps, hazardous materials data, and patient care data can be retrieved wirelessly. In addition, the technology incorporates interoperable solutions through secure messaging and biometric fingerprint identification, and an integrated incident management system can be implemented"* AIMSonScene is an incident command system (ICS) and personnel accountability software (FieldSoft, Inc, 2009). "*AIMSonScene ICS software replaces tactical worksheets or marker boards currently used on incident scenes. Application features allow incident command staff who use the software to efficiently reduce command post workload, increase incident commander effectiveness, and generally better focus on incident strategy, incident tactics, and incident hazard.* The Rapid Responder® is a "Crisis management system" is described as providing: *"a complete solution: from collaborating with responders before*

	disaster strikes, to quickly locating all emergency, disaster, and crisis plans in the midst of a crisis, to managing the aftermath. Within seconds of a 9-1-1 call, Rapid Responder provides police, fire, and other responders access to: *• aerial and exterior photos;* *• the best access routes;* *• floor plans and utility shut-offs;* *• incident-specific response plans;* *• hazardous material inventories;* *• containment, evacuation and family reunification locations"* Industrial Fire World (2007) describes NetTalon, Inc's *"Virtual Command Technology.* This system requires a building to be equipped with proprietary sensors, but the manufacturers claim that: *"..the NetTalon Virtual Command system gives firefighters and police officers a virtual presence within an affected building. Within seconds of the alert they can understand a developing emergency and react to it… a facility equipped with NetTalon sensors is networked directly to police and fire department dispatch and operations centers. Every responding entity receives notification at once, eliminating time-consuming rerouting.* *Emergency notification reaches the fire or police responders directly, and in seconds they can view the inside of the building, virtually "looking at" the emergency. The alarm control panel in the building has a database containing all floor plans with icons representing sensors. In an emergency, sensor conditions are updated every second by changing their color, from "not in alarm" green to "early warning" orange and "alarm" red. The change of color shows the observer the nature of the developing emergency.* *The inbound fire apparatus and police cruisers access the same information en route, so they can see the incident and complete preliminary incident planning as they drive to the building. By the time they arrive at the building everyone has an assignment and incident mitigation begins immediately.*
Integrated building management systems with IP (internet protocol) connection to OIC and comcen.	**Rating by Area Managers** This technology was highly rated in the survey of area managers with the benefit of providing information to OICs (94.1), but less so with the benefit of providing information to comcen (35.3). **Status in ICT Strategy** There is a project to investigate receiving Extended Alarm Data from intelligent building sensors and panels in the ICT strategy, **Literature Review** Wilson et al (2007) describe UC Berkeley's "*Fire Incident and Rescue (FIRE) Project's*" hardware and software tools to *"improve fire fighting safety, efficiency and effectiveness"*. These include an in-built Wireless Sensor Network (WSN) called "SmokeNet" to track firefighters in large building incidents and to supply information including location, fire and health status. The system includes the "FireEye" Head Mounted Display (HMD), and

	electronic incident command (EICS) software to create a "*ubiquitous computing environment*" in buildings. The WSN system allows firefighters to determine where the fire started, how it is spreading and which evacuation routes are safe. The system includes "beacon motes" to broadcast a signal to motes carried by firefighters to monitor their location. The information is both relayed to the OIC and, ideally is shown to the firefighters themselves on the floor plan on their HMD. If an HMD is not being used, the IC would contact the firefighter if necessary via a "pager" mote. If motes to form the WSN are not preinstalled in the building, firefighters can "*drop motes as they go, creating a smart breadcrumb trail that can be followed to escape danger zones*". As the paper was written, the FIRE system was at prototype stage, and being tested by firefighters. Refer: http://fire.me.berkeley.edu/ Cowlard et al (2010) describes a series of studies conducted to determine the limitations of existing fire models and sensor technologies as tools during emergency fire response. The author then presents "*potential methodologies that can combine sensor technology and computational tools to provide assistance in the management of a fire emergency*". Werner et al (2008) describe how wireless sensor networks and 3-D virtual visualization can combine in a "Live Virtual Environment Streaming system" (LiVES). A wireless sensor network in a building detects fire, smoke, gases, temperature, and movement. A 3-D representation of the building is modelled from this. Suppose that the fire department system is registered with the monitoring service of that building. When sensors detect an emergency, the fire service is notified and a detailed live representation of the building is shown on both comcen and to the OIC on a mobile device. The same 3-D environment can also be used for simulation purposes in training (based on real or generated scenario). The authors note that (2008's) thin mobile devices have relatively low processing power, small storage resources, and inefficient 3-D graphics rendering hardware. This means demanding 3-D applications are limited to low-detail "Virtual Environments" (VEs), as downloading complex requires both high bandwidth and storage capability. The author's approach to overcome these challenges consists of moving the demanding geometry rendering task to a dedicated remote server that streams the rendering output to a client, leaving only display and minor image-based rendering tasks to the mobile hardware. The authors discuss a real-time streaming protocol able to connect streaming servers and clients through heterogeneous networks and that is able to transmit a large amount of data.
Devices on firefighters for location in structures	**Rating by Area Managers** This technology was highly rated in the Survey of Area Managers as having a high priority with the benefit of improving OICs' command and control (81.3), and at medium level for helping firefighters perform fire operations more safely and effectively (62.9).

Status in ICT Strategy
"Personnel accountability" is noted as a "technology opportunity".

Literature Review
Fischer and Gellersen (2010) present an overview of location and navigation support systems for firefighters. Localisation systems are classified as "Infrastructure-Based", "Wireless Sensor Networks", "Ad Hoc Relative Positioning", "Proximity Sensing", and "Dead Reckoning". The technologies are also classified by their primary function: "*Tracking determines team locations within a structure, and navigation shows the teams how to reach a target location without necessarily knowing exactly its member's location".* Available systems listed are: Lifeline; Torch; PASS; PathFinder; and, Commercial indoor localisation. Technologies listed at the prototype stage are PPL; SmokeNet; LifeNet; PDR alone; Map matching with particle filter; Map matching with RFID; Flipside RFID; Relate Trails; and, HeadSLAM.

Worcester Polytechnic Institute has developed a *"Precision Personnel Locator System"* to locate, track and monitor wirelessly fire fighters inside structures. A graphics display on a mobile device shows location of the firefighters. The system is being developed to integrate physiological monitoring. The system requires three or more appliances equipped with transmitters/receivers located around a building to capture the information and firefighters array carry "mobile phone sized transmitters'. The system senses elevation (refer http://www.wpi.edu/academics/ece/ppl/ (accessed October 2011).

SafeScene is an "automatic accountability" system is claimed to be able to detect the presence of emergency personnel at the incident scene at adjustable ranges of up to hundreds of feet and to log responders' identities and the equipment on the scene in a Microsoft*Windows-compatible application. Other features include personnel accountability report (PAR) timers to facilitate the allocation of resources or tasks and the monitoring of personnel and time stamped reports of incident events. Refer: http://www.safescene.us/. The datasheet for the product states:

"*SafeScene utilizes RFID technology to persistently monitor the incident scene for the arrival and presence of first responders and apparatus to which the SafeScene tags are affixed.*

The SafeScene application, loaded on a command laptop or notebook computer, is continuously updated with the identity of on-scene personnel and apparatus and allows the incident commander to assign personnel to crews or sectors, manage resources and monitor safety through PAR timers, among other incident management tasks."

Hampshire Fire and Rescue Service (2010) have developed a system that also usesRadio Frequency Identification (RFID) technology, involving the issuing of identifying tags to firefighters which are read electronically; the tag information is gathered on

	an electronic rote board monitored by IC. A second RFID tag is used as an access control, to log firefighters in and out of sectors; the information is sent by wireless link to the command support unit.
Sensors on firefighters to measure and transmit environmental data eg temperature, gases, smoke etc	**Rating by Area Managers** This technology was rated as having a medium high priority with the benefit of improving OICs' command and control (71.6), at medium level for helping firefighters perform fire operations more safely and effectively (52), and at a low level for post-operation review purposes (26.1). **Status in ICT Strategy** Not in ICT Strategy **Literature Review** Walter et al (2010) describe development of a glove mounted temperature sensor combined with a "tactile display" inside the glove that "*maps the sensed temperature into varying tactile patterns.*" That is, external temperature ranges are indicated by patterns of vibrations that the firefighter feels in his/her hand. Bonfiglio et al (2007) describe "Proetex", *"a European Integrated Project dedicated to micro- and nano-technology-based wearable equipment for emergency operators. During the first year of work, a careful analysis of several emergency scenarios has been carried out and has resulted in the design of a complete 'smart' uniform for fire-fighters and emergency rescuers. These garments aim at monitoring physiological parameters, position and posture of the operators and the presence of external potential sources of danger and to send these data to a remote coordinating uni...* *The external temperature (environment temperature) sensor will be realized with a thermocouple located in the neck area of the outer garment (in the front external part). Moreover a circuit for thermocouple compensation has to be placed near the sensor in the inner part of the outer garment.* Cavanaugh et al (2011) discuss the Worcester Polytechnic Institute (WPI) "Precision Personnel Locator System". This requires no pre-installed infrastructure. This system incorporates "*physiological monitoring sensors and real time display; automated solution of outdoor sensor positions for rapid deployment, synchronization technologies for wirelessly connected transceiver nodes and accuracy enhancement through sensor fusion*" Cyganski et al (2008) describe a "Portable Flashover Predictor" as an additional development of the WPI "Precision Personnel Locator System". This project included an "*integration effort in which a portable flashover prediction device fused with a data stream from a system … which provided simultaneous firefighter location and physiological information… the conditions at a low ignition temperature sentinel has been demonstrated as having excellent potential impending flashover in*

	a compartment fire. A forewarning of approximately 60 seconds was within the context of these tests' acceptable limits wherein the intent is to provide sufficient time to exit the compartment. The system was successfully integrated with an existing system developed under a previous AFG grant allowing a real time concurrent display of each firefighter's location, physiological information and current fireground environmental integrated system was demonstrated in a series of tests conducted at the Massachusetts Fire fighting Academy" Klann et al (2007) outline LifeNet, an "Ad-hoc Sensor Network and Wearable System to Provide Firefighters with Navigation Support". In this system: "*firefighters automatically deploy sensor nodes along their paths effectively establishing an ad-hoc infrastructure for positioning, sensing and communication. Firefighters interact with this sensor network by way of wearable computing equipment and receive navigational information on e.g. a head-mounted display or over a headset."*
System to locate caller's cell-phone etc	**Rating by Area Managers** This has a medium priority rating with the benefits of "Provide more intelligence more quickly to OIC" (60.9) and "Provide more intelligence to comcen operator" (56.1). **Status in ICT Strategy** There is a project to investigate finding location coordinates from Mobile phone callers and mobile IP Phone Callers in the ICT strategy. **Literature Review** Takizawa et al (2008) devise a prototype system for pinpointing the place of an origin of a mobile phone emergency call using active RFID tags. Their method is claimed to be more precise than GPS or cell-based position method because it works in GPS blind spots (indoors or underground). In fire fighting and rescue, three dimensional position is often necessary, eg to the specific level of building the incident is in. In this proposed system, smartphones are equipped with an RFID reader and rooms of buildings have active RFID tags embedded in their ceilings (ie included as part of the smoke detector or fire alarm). In the prototype, Bluetooth is used for communication between smartphones and RFID tags but other systems are possible. In the ideal fully developed system, the user would initiate the emergency call manually, and the precise location in space the call is made from would be transmitted automatically as part of the call and appear on the comcen console.
Transmission of digital video by cameras on firefighters	**Rating by Area Managers** This is rated as medium priority with the benefit of "Improving OIC's Command and Control at Incidents (60.4)", and at a lower priority with the benefit of "Helping firefighters perform fire operations more safely and effectively (41.2)."

	Status in ICT Strategy "*Use of ... video streaming to provide real-time graphical information about the incident environment"* is identified as a "technology opportunity", but not specifically video from cameras on firefighters. **Literature Review** Bergstrand and Landren (2011) describe an explorative project aimed to study the use of live video technology in emergency response work: *"The application (LiveResponse) was designed as a secure web mash-up incorporating dynamic map services and live video support. The main feature of the application is the ability for response actors to broadcast live video from the incident site to be viewed in a matter of seconds using the web-application at the command centre.* *Videos are broadcasted using a commercial live video service from Bambuser on Nokia Navigator mobile terminals equipped with a 3.2 megapixel camera, 3G networking capabilities and A-GPS positioning. The live video service handles the live video and delivers geopositioned live streaming and archived Flash video material to the web application in seconds. The web application also provides access to traffic surveillance cameras.* *Based on the interviews with the professional responders, our analysis indicates that video from response work is seen as enhanced means of communication. Video provides complementary information to the traditional verbal reports communicated via radio or mobile phone.* *From the perspective of the people working at the command centre, the use of video enables them to have a tighter connection to the ongoing response work… the cues extracted from the video enable the command centre operator to have a form of implicit feedback loop for the activities done at the command centre in order to support the work on the site."* Bretschneider et al (2006) review the requirements for HMD display technology for firefighters, then available technology (including see through and look around technologies), and how the technology was expected to develop. An example of this is with a helmet (or otherwise) mounted camera, images can be transmitted to remote experts and at the same time the images are displayed in the HMD. The expert can indicate things in the camera's picture that is displayed on the firefighter's HMD.
Display of images and text data superimposed over real time images of emergency location	**Rating by Area Managers** This is rated as medium priority (60.4) with the benefit of "Improving OIC's Command and Control at Incidents **Status in ICT Strategy** This is recognised as a "Technology Opportunity" in the mobility field in the ICT.

	Literature Review Nilsson et al (2009) describe an "augmented reality" (AR) approach to collaborative command and control between emergency responders to a major incident. The AR system provides "organisation specific" views of the emergency to representatives of emergency response organisations. In the system, paper maps, plans, etc, are replaced with digital maps, and users interactwith the maps via a head mounted display. Participants in a reported simulation using the system thought AR has potential in training, simulation and strategy testing before an operation. The *"AR system allows all individuals to work on the same map, both individually as well as collaboratively… but the added benefit of the AR system, compared to a paper map, is that it is possible to quickly swap perspectives and follow one organisation at a time, as well as see the overall view of all available resources and their status and distribution".* Ali et al (2008) note that advances in mobile computing have enabled a new realism of visualizing 3D representation of objects on small computing devices such as cell phones or head-mounted display, but that challenges remain due to limited bandwidth and processing power on mobile devices. The authors present a "motion-aware" approach to speed up real-time retrieval of 3D objects over a wireless network. The authors claim their experiments demonstrate the effectiveness of their solution to continuous retrieval of complex spatial data in mobile settings.
Receive and analyse GPS data from public's devices	**Rating by Area Managers** This is rated as medium priority with the benefit of providing more intelligence more quickly to OIC (57.1). **Status in ICT Strategy** *"Use of GPS and video streaming to provide real-time graphical information about the incident environment"* is noted as a "Technology Opportunity". "Highlight" of Comcen Enabler: *Investigations into the ability to support other methods for the public to communicate with the Comcens, such as text messaging, the ability to send pictures or video from the incident scene, and the ability for the Comcens to utilise GPS or other such facilities to confirm the location of a caller.* **Literature Review** The current challenges of locating cell phones (see above) will ameliorate over time, due to increasing penetration of smartphones with GPS capabilities. Emergency responders will gain instant information on location of person making an emergency call. See **Section 3.3** for a review of literature on crowdsourcing of emergency information.

Bio-sensors on firefighters to measure and transmit physiological data	**Rating by Area Managers** Has medium rating (56.3) with the benefit of Improving OIC's command and control at incident and a low rating of 43.6 for helping firefighters perform fire operations more safely and effectively. **Status in ICT Strategy** ""*Use of bio-sensors to monitor fighter physiology in real-time during an incident (under research at AFAC)"* is noted as a "Technology opportunity" in the ICT strategy. **Literature Review** Colunas et al (2011) discuss the "DroidJacket", which combines the "Vital Jacket" embedded with biometrics sensors (see http://www.biodevices.pt/) with an Android-based smartphone as a base station for vital signs acquired "*enabling visualization and simple real time processing".* *"The selection of Android-based devices allowed us to adopt a modular design for our mobile base station framework, using an open source framework and to deploy this solution easily from a standard workstation to the Android mobile with no added cost, as Android development is also supported in Java. The design is highly extensible to support different protocols…and automatic detectors that can summarize the data stream features and/or generate alarms.* (The System) *monitors multiple individuals, taking advantage from the fact that most mobile operating systems now support multithreading.* *The DroidJacket integrated acquisition and processing, in a mobile device, opens new ways of personnel monitoring. However the mobile application limited screen size is not as convenient as a laptop for monitoring multiple teams."* The "Vivometrics LifeShirt" (see http://www.vivometrics.com/) is a chest strap/belt embedded with biometrics sensors, for emergency responders to wear under protective gear. It monitors respiration, ECG, blood oxygen saturation, temperature, and activity level, plus blood pressure, and other measures of health. Trainers and officers can use the standardized, statistically significant data to predict the onset of overexertion and heat stress and as a baseline when observing firefighters during physically demanding work in stressful environments. Sensor data are transmitted in real time by wireless modem to the command centre, where first responders and their working conditions are monitored. The software also supports individual "threshold zones" based on each responder's physical fitness. University of Maryland's Centre for Firefighter Safety Research and Development (Bennett, 2006) used the Vivometrics LifeShirt in a study to devise health and safety guidelines for firefighter training:

	"*The LifeShirt gathered multiple measures including blood pressure, blood oxygen saturation, respiration, EEG/EOG, periodic leg movement, temperature, end tidal CO2 and cough*." The Worcester Polytechnic Institute (WPI) "Precision Personnel Locator System" outlined above also incorporates *"physiological monitoring sensors and real time display"* refer Cavanaugh et al (2011). Kingsley et al (2004) describe Srico's "Photrode", a non-contact sensor system which uses lasers to measure the electrophysiological signals produced by the body.
Video data from cameras on fire engines	**Rating by Area Managers** Has medium rating (54.7) with the benefit of "Improving OIC's command and control at incident" and a low rating of 24.8 for "More effective post-incident reviews" **Status in ICT Strategy** *"Use of GPS and video streaming to provide real-time graphical information about the incident environment"* is noted as a "Technology Opportunity" **Literature Review** See above under **Transmission of digital video by cameras on firefighters**.
Capability to receive and analyse visual imagery of incidents at comcen **Image analysis software to analyse video for location, size and movement for command and control at incident**	**Rating by Area Managers** This has low priority rating of 37.1, for the benefit of provide more intelligence to comcen operator, and slightly higher priority for command and control at incidents (42.7) **Status in ICT Strategy** "ability to accept video and data from the public at an incident" is a "Technology Opportunity" in the ICT. **Literature Review** "Firelidar" is a portable active (ie sends a near-infrared light signal and detects its return) imaging system developed to aid search and rescue in smoke and flame environments (Billmers et al, 2007). The system is intended to augment passive thermal imaging technology by imaging *"in the presence of a thermal bloom, heavy smoke conditions"*. It enables firefighters to see objects through obscuring smoke and flames. While scheduled for development to prototype stage in 2005, it appears to not yet be on the market. Harvey (2011 a) gives advice on use of thermal imagers safely, and in Harvey (2011b) the author gives advice on using thermal imagers to detect "pre-flashover" conditions in a room. In Harvey (2010), the author suggests techniques for using a thermal imager to evaluate a structure for signs of structural collapse during a fire.

	Lombardo (2006) reviews a number of incidents in which thermal imagers were used in Buffalo, NY, to save lives, make rescues or find fires. Thermal/visual imaging technologies originally developed by NASA for use in manned spaceflight have been adapted for use by fire firefighters by Innovative Engineering and Consulting (http://www.iecinfrared.com). This thermal imaging technology is claimed to make a clear distinction between the intense heat of a fire and the lower-level thermal signatures of human bodies in search and rescues situations. The firm's products include "*infrared cameras, thermal imaging systems, non-imaging sensors and supporting subsystems*". *Visual Analytics* Kim et al (2007) present an *"efficient and interactive mobile visual analytic system for increased situational awareness and decision making in emergency response and training situations".* Here, "visual analytics" means interactive visual interfaces on mobile devices including smartphones. Visual analytics is a tool to help emergency response commanders (at the emergency location) to analyse and understand the "active emergency situation" through interactive, integrated data analysis and visualisation. There are three categories of visualisation: visualisation of sensor data, 2D and 3D visualisation on mobile devices, and visual analytics on mobile devices. The prototype system was subject to a test simulation of evacuation from a 2003 nightclub fire. Emergency response personnel who participated in the study are cited as feeling the technology would be useful for personnel training, preplanning scenarios involving site inspections. Technext (2011) describe a volumetric 3-D display technology by termed "3D VolumeViewer": *"The system… provides a radiant, high-density picture that is viewable from any angle. The ability to have a large number of simultaneous viewers is unique to true volumetric displays. The 3D VolumeViewer system provides both physiological and psychological depth cues required by the human visual system to perceive 3D objects. … 3D VolumeViewer makes 3D viewing much more intuitive and efficient, providing an excellent visual tool for mission-critical situations."* Pattath et al (2006) discuss the use of visual analytics on mobile devices to *"provide safety personnel with information for better emergency planning and guidance".* The authors define "Visual analytics" as *"the science of analytical reasoning facilitated by interactive visual interfaces. More specifically, the integration of mobile devices into the analytical process is referred to as 'mobile analytics.' Using state-of-the-art mobile devices, we can enhance the analytical process through interactive, integrated data analysis and visualization, enabling the user to extract important features necessary for rapid, actionable decision making on site.*

Capability to receive and analyse photo and video data sent by public	**Rating by Area Managers** Area managers see this has having only low potential, but this may be because of lack of awareness of what is/will be possible. The priority for NZFS would be to implement technologies at its end for analysis of video data from cameras on appliances and firefighters, then extend capability to analysing visual data provided by public. **Status in ICT Strategy** Highlight of Comcen Enabler: *Investigations into the ability to support other methods for the public to communicate with the Comcens, such as text messaging, the ability to send pictures or video from the incident scene, and the ability for the Comcens to utilise GPS or other such facilities to confirm the location of a caller.* **Literature Review** Refer to literature review on "crowdsourcing" of information useful for emergency responders in **Section 3.3** above.
Head up display of images and text data superimposed over real time images of emergency location	**Rating by Area Managers** This is perceived by managers has having a low priority (35.1) for the benefit of helping firefighters perform fire operations more safely and effectively. **Status in ICT Strategy** This is recognised as a "Technology Opportunity" in the mobility field in the ICT. **Literature Review** Wilson and Wright (2007) describe in detail the theory and practice of Head mounted Displays (HMD) for fire fighting. Two types are covered: "look around" monocular HMD in facemasks, and see through "augmented reality" displays. The author's view is that "look around" design "is generally preferred for applications such as a firefighter viewing a floor plan. It has advantages of simplicity, smaller size, lighter weight, lower power consumption and ease of viewing against bright backgrounds" Consequently, only the look around approach is subject to intensive experimental testing (refer also Wilson et al (2007)) Martins et al (2004) describe the prototype of an "augmented reality" display system. Bretschneider et al (2006) review: the requirements for HMD display technology for firefighters; the technology then available (including see through and look around technologies); and, how the technology was expected to develop.

Decision Support/Expert Systems in Command and Control	**Rating by Area Managers** Not included in Survey of Area Managers **Status in ICT Strategy** The ICT Strategy notes that *"the new generation Hazmat/Command vehicles provide incident command and control software for decision support."* **Literature Review** There has been considerable development in the field of decision support systems to help incident commanders assess, and make sound command decisions on the basis of the range and depth of data from video and other sensors the modern ITC technologies make possible (Cowlard et al, 2008). Adams et al (2011) describe the architecture and requirements of a system to support command and control in major emergencies. A "net-centric" approach is proposed that emphasizes cognitive aspects of decision support to enable decision makers to achieve "shared awareness". "*Linking knowledgeable entities effectively leads to increased speed of command and a higher tempo of operations with a degree of self-synchronization. The resulting system will decrease cognitive over-load and improve cognitive monitoring by providing a more systematic and less labour-intensive method to manage information from and for emergency responders".* Wang and Li (2011) suggest a multidimensional data model for emergency decision making that divides emergency event attributes into "structured" and "unstructured" attributes. The model finds "similar" events through application of "similarity theory", to provide references to support emergency decision-making. Xin Ye et al (2009) also address this topic; the authors propose the architecture of an Emergency Decision Support System. Chen et al (2008) present the theory of a "*mobile fuzzy decision support system for firefighter cooperation in ad hoc networks"*. This proposed decision support (expert) system involves "*path navigation, danger reminder, rescue cooperation, and extinguishing cooperation".* The authors suggest that their proposed DSS will allow firefighters to "*obtain complete situation information of the fire scene, achieve more effective cooperation, select optimum assistance alternative based on triangular fuzzy set, and increase their safety".* Wu et al (2008) present a theoretical paper suggesting a "vocabulary" for emergency events as progress towards an emergency decision support/expert system. The authors' "Ontological Event Model" consists of five "layers" - Event Layer, Phases Layer, Representation Layer, Decision-making Layer, and Action Layer. Drury et al (2009) report an experiment to test a visualisation approach to providing firefighters with "Dynamic Decision

	Support" by showing the range of simulated consequences of possible decisions. The aim is to find a "course of action" that is "robust", ie is "*not sensitive to inaccuracies in situation descriptions, and therefore more likely to succeed across a wider range of plausible futures".* Freßmann (2006) presents an overview of the European R&D project AMIRA (Advanced Multimodal Intelligence for Remote Assistance) focused on information support for time critical processes in fire service organisations. The proposed system aims to support the Incident Commander (IC) when he "*lacks information necessary for decision-making and for estimating current resources*". The AMIRA system "*focuses on supporting the IC in making requests and receiving answers by using a mobile system, which can be triggered through speech based requests*". The authors propose a "workflow approach" which "*automatically sends requests to different information sources and to stop when the search results are satisfying*". Wang (2009) introduce a formal resource-constrained decision support workflow model for emergency response; this constitutes a decision support tool to effectively manage the resources used through the phases (mitigation, preparedness, response and recovery) of an emergency, without incurring resource shortages. Zhu et al (2009) describe an "advanced" decision support system for emergency decision making that includes geographic information system (WebGIS). The authors claim their proposed system "*can provide the whole process, multi-level information services, as well as the emergency command and decision-making for all levels (of) emergency agencies*", before, during and after emergencies.

3 Other Fire Fighting Technologies

Maintain/enhance mains water supply pressure is adequate for fire fighting	**Rating by Area Managers** This is the highest priority non-ICT technology for area managers, with a rating for 59.3 for providing the benefit "help firefighters perform fire operations more safely and effectively". **Consultation** This issue arose in our consultation as it became clear that sprinkler technology (particularly domestic) can not be considered in isolation from water pressure, as sprinklers will not function correctly if water pressure is too low. We understand from consultation there is a relevant "social" trend towards water supply agencies reducing water pressure so as to reduce losses, but to the detriment of both sprinkler operation and effective fire fighting. However, if this becomes a fact of life the fire service has to live with, then it may have to adopt fire fighting technologies to maintain fire fighting effectiveness, and domestic active protection systems will also need to adapt. We have not carried out a literature review on this topic.

Compressed Air Foams delivery systems	**Rating by Area Managers** This has a rating for 46.0 for providing the benefit "help firefighters perform fire operations more safely and effectively". **Literature Review** Alan, O'Neil et al (2010) present an experimental study of the cooling capabilities of the compressed air foam system (CAFS) in fire-fighting of compartment fires: "*Two fire scenarios were considered, namely fuel- and ventilation-controlled tests. The CAFS and the traditional suppression agent (water mist) were used in both scenarios".* • *For fuel-controlled experiments, the CAFS is far superior to water mist as: a) it reduces more substantially the temperatures inside the enclosure owing to its higher heat absorption rates, and, b) it creates much less water run-off during the operations and thus minimises the water damage to buildings and the environment. Moreover, when the CAFS was applied the flashover conditions were almost completely extinguished and fire-fighters could stay inside the compartment for the duration of the operation until fire was put out, whereas when water mist was used fire-fighters had to retreat during the operation due to reduced visibility and high temperatures.* • *For ventilation-controlled experiments, little difference was observed in the suppression effectiveness between the CAFS and water mist as the temperature evolution histories by the two agents are almost identical. One of the concerns in using the CAFS is that the air in the system could accelerate the backdraft. This was not observed in the present study, which showed that the CAFS does not contribute to or cause a backdraft.* • *The present results clearly show that CAFS could be used for fire-fighting of fuel-controlled fires; however proper training and understanding of fire behaviours and the application methods are essential. The analysis of the suitability of CAFS in ventilation-controlled fires remains inconclusive and further research should be undertaken in this area."* Jourda et al (2010) conduct a real-scale test of the efficiency of two extinction techniques used by firefighters for under-ventilated fires: first impulses of finely divided water and, second, projection of CAF on the walls of the premises, in order to develop models describing thermal exchanges in the premises under both techniques. In the water droplet technique, gases are cooled by thermal exchange of droplets with the gaseous environment. In contrast, CAFS are used to create a cold surface on wall (ie foam acts as a heat sink at the surface of the wall). The authors suggest that: *"Due to new energy conservation regulations, buildings are becoming more and more heatproof. Thermal feedback of the walls on the hot gases must be taken into account by the firefighters in order to define new fire fighting techniques."*

	However, both techniques use of the latent heat of the water evaporation. Svensson (2010) describes a number of approaches for quantifying fire fighting operations, with the goal of assessing the efficient use of resources during fire fighting. The author suggests the *"focus should be on the results of such operations"* while considering the inherent complexity, measurability and outcome of fire fighting operations.
Handheld Water Mist delivery systems	**Rating by Area Managers** This has a rating for 29.7 for proving the benefit "help firefighters perform fire operations more safely and effectively". **Literature Review** Snegirev et al (2010) study the effects on water droplet size on fire suppression, via a computer simulation study. The authors note that growing use of high-pressure fine water sprays in fire suppression systems is motivated *"by the need to minimize water flow rate necessary to suppress fire. Being relatively cheap, environmentally clean, non-toxic and widely available substance, finely dispersed water (water mist) is often considered as a possible substitute for Halons prohibited by the Montreal Protocol and its subsequent revisions. Given the unbeatable thermal characteristics of water as an extinguishing agent, refinement of water spray may offer an engineering solution that will intensify water evaporation and control its delivery to the fire origin. As a result, use of fine water sprays and mists is a rapidly evolving technology of fire protection"* The authors conclude that: drop size reduction may cause faster flame suppression at lower water supply rate. This advantage of spray refinement can only be utilized if total spray momentum is sufficiently high (relative to the momentum of the flame-driven flow) and (ii) spray is directed towards the fuel.
Positive Pressure Ventilation	**Rating by Area Managers** Not in Survey of Area Managers. **Literature Review** Kerber et al (2010) review developments in positive pressure ventilation. Experiments have shown that PPV can be used with success in a variety of buildings. However, the use of PPV should be used with caution in large structures, especially structures including rooms with high ceilings and large open areas as well as structures with a complex layout. PPV works best in "tube like" areas such as hallways. PPV causes mixing in rooms with high ceilings which may disrupt the thermal layer. In rooms with large open areas the flow from the fans will clear between the inlet and the outlet. To ventilate efficiently in these rooms the outlet should be varied to entrain more smoke into the ventilation flow. In large structures there is the potential for multiple victims and extended rescue times and resources. Fans provide the ability to remove a hazardous condition from potential victims making the search and rescue process less time and labour intensive.

4 Rescue Technologies

Robots for Fire and urban search and rescue	**Rating by Area Managers** This technology was rated as a very low priority, at 15.3. **Literature Review** Burke and Murphy (2007) tests mobile robots in a Urban Search and Rescue (USR) context as a way of augmenting communication in "distributed" teams "*through a remote shared visual presence (RSVP) consisting of the robot's view. By giving all team members access to the shared visual display provided by a robot situated in a remote workspace, the robot can serve as a source of common ground for the distributed team"* The authors claim the findings of their field study suggest "*RSVP may enable distributed teams to perform as effectively as collocated teams."* Candido et al (2010) propose an algorithm for control of a team of autonomous fire fighting robots. The algorithm allows an expert, (presumably the OIC) to "inject specialized knowledge" to the robots, to helps the robots deal with "*uncertainty in both the application of actions and sensing of observations*". The algorithm is tested in simulation, not in the "real world". Liu and Lu (2009) develop AI control strategies for a group of robots to locate the source of a hazardous contaminant (or an incipient fire). The authors test their method in computer simulations, rather than build real-world robots. Naghsh et al (2008) describe pre-prototype development of interactive (ie between humans and robots) use of autonomous robots in fire emergencies. The report focuses in particular on "*a swarm of robots that are capable of supporting and enhancing fire fighting operations co-operatively and we investigate how firefighters in the field work with such a swarm".* The authors suggest the following ways a robot swarm can assist firefighters: *"1) Notifying the firefighters of possible hazards (e.g. obstacles, high temperature, chemicals);* *2) Indicating unambiguously the direction to the scene of incident or backwards to the exit point;* *3) Grouping - it is important for firefighters that the swarm stays within a relatively close range to them but also maintains its distance to the firefighters to allow them freedom of action."* Pessin et al (2007) describe simulation of a "multirobotic system" in a forest fire. They contend that the intelligent control and fire fighting strategies they develop and test could be applied to physical robots fighting real forest fires. NASA (2005) describes military robots based on technologies developed for robotic spacecraft and rovers. Designed to search dangerous or inaccessible areas, similar technologies may become available for urban search and rescue. Kumar et al (2004) develop and test an innovative variant on the theme of distributing sensors (mote) in buildings during emergency for environmental monitoring and responder location

	purposes). In this paper, the motes are deployed by camera-carrying mobile robots which can enter, explore and test spaces and routes potentially too hazardous for human firefighters. The test was only a qualified success, but gave a useful base for further development of the technology. Purohit (2011a) et al describe how The Department of Electrical and Computer Engineering, Carnegie Mellon University is developing a more modern system on the same principle, but in this case the sensors are carried by flying robots ("Sensorfly"). See http://sensorfly.sv.cmu.edu/SensorFly/Home.html; this site has videos of a prototype in action. The SensorFly system is *"controlled-mobile aerial sensor network platform for indoor emergency response application. The miniature, low-cost sensor platform has capabilities to self deploy, achieve 3-D sensing, and adapt to node and network disruptions in harsh environments".* Purohit and Zhang (2011b) describe a simulation system for testing and developing the SuperFly system, "*that incorporates a realistic indoor fire growth model (CFAST), with a radio path loss model, wireless network model, and mobility model of a controlled mobile sensor network, to achieve a more comprehensive representation of such cyber-physical systems."* An article at http://www.fireapparatusmagazine.com/index/display/article-display/1456189995/articles/fire-apparatus/volume-16/issue-11/features/drones-change-the-face-of-recon-for-fire-service.html discusses the adaptation of military-type aerial drones for reconnaissance at major emergencies. The Honeywell cDUV drone can carry optical or infrared cameras, and "chemical, biological or radiological sensors", for a flight time of 40 minutes; but is limited to flying in winds of 17 mph or less. W.S.Darley and Company's Stinger drone has a similar camera/sensor capabilities and flight time 15-40 minutes depending on payload.

5 Training Technologies

Technologies to maximise flexibility in training time/place.	**Rating by Area Managers** This is the third highest rated "technology" by area managers at 112.4 (although it is more correctly an application of technology, than a technology per se). According to NZFS's Statement of Intent 2009, the "*Training and Progression System (TAPS) umbrella. TAPS is a unit-standard-based programme that provides a well-defined career path in terms of knowledge and experience requirements. It enables firefighters to do much of their learning at their own pace, outside the work environment.*" The Fire Services has a "blended learning" policy, to provide both career and volunteer firefighters with different ways of accessing information. Most training materials are in written form, supplemented by videos distributed on DVD (pers. comm.) Bandwidth issues have restricted development of online interactive materials to date. In the literature review below we indicate "e-learning" technologies with potential for adoption at a future date when bandwidth ceases to be a constraint. That some firefighters will continue to have preference for printed over on-line materials will continue to be a challenge to cost-effective delivery of standardised training. **Literature Review** *E-learning Training Technologies* A good starting point for exploring ICT educational technologies is the (U.S.) Association for Educational Communications and Technology (AECT) at:http://aect.site-ym.com/ Christchurch-based multimedia "e-learning" company Hand Multimedia presents steps in the development of "Learning Management Systems" at http://www.hand-multimedia.co.nz/3.1.asp?mid=3.1 it Information on its e-learning product "Roleplay" is at: http://www.roleplaytraining.com/company/about_us.aspx *Course Management Systems (CMS)* "Blackboard Learn" is an education system to deliver course content which can be extended and customized to client's requirements with "building blocks". It is used for training by the (U.S.) National Association of State Fire Marshals: http://nasfm.blackboard.com/. Victoria University of Wellington use it for Learning/Course Management System: http://www.utdc.vuw.ac.nz/blackboard/ McCabe and Meuter (2011) present a study on the connection between classroom technology including Blackboard and student learning. The authors found that students enjoy using many of the course management tools, but the students "*do not see the*

	tools as highly effective at enhancing the learning experience". The authors ascribe this to inadequate use of CMS by teachers; technology should be used to "*develop innovative learning situations and make learning more active, engaging, and ultimately better for students* (so that) *students and faculty work together to create the learning process*", rather than to duplicate what has always been done in the classroom. *Virtual Worlds eg Second Life* "Virtual World" websites, most notably "Second Life" have been experimented with as vehicles for serious education and training, as well as entertainment (for example Halverson et al 2011). These could be used to for fire (and other emergency) simulation training at relatively low cost. MASA Group, a developer of Artificial Intelligence systems for sophisticated simulators for training (see below) has taken steps towards developing a fire training simulation system in Second Life, see: http://www.youtube.com/watch?v=n2UYUZDfoBU, and http://www.youtube.com/watch?v=0nxWbvixapw&feature=related A comment from MASA group on the first video is "*Our Second Life prototype is … a technical demonstration … and only follows a lot of work will be necessary to transform it into a real training tool"* Diner et al (2009) report on a University of Auckland pilot project into the feasibility and potential for multi-user virtual reality environments nursing scenarios for nursing education. The authors concluded that the simulations built in Second Life "*provide students with experiential and contextual learning in a team setting...* (our) *goals are to engage students in analysis, decision making and problem solving within a real-time team context.., through increasing collaborations with other medical educators and institutions we believe we can reduce the cost of simulation development* (and) *considerably expand the base of cases and scenarios.* See also YouTube video http://www.youtube.com/watch?v=G2jN7L80bH8&feature=related
Technologies to maximise flexibility in training and learning style (visual, auditory, read/write, kinesthetic)	**Rating by Area Managers** This is the fourth highest rated "technology" by area managers at 105.5; again it is an application of technology. **Literature Review** Leite et al (2009) test the VARK algorithm for assigning people to four learning style preferences - Visual, Auditory, Read/Write and Kinesthetic. This division is not absolute, as many people are classified as having multiple learning style preferences. The author found that as many as 36% of test subjects had all four styles. Many firefighters are believed have a "kinesthetic" learning style (source: consultation with NZFS managers, Petrakis 2003), so prefer to learn when physically active. Motion sensing input devices such as Nintendo Wii and Microsoft's Kinect for Xbox 360 could potentially be used with simulators based on games technology (see below) and lower-cost "virtual

	world" simulators (see above) for more effective training of those with a "kinesthetic" learning preference. E-learning tools built using the Course Management Systems outlined above could include materials developed to accommodate the other learning styles eg written text for those prefer a read/write style, podcasts for those with auditory preferences, and graphic and video for those with a visual preference.
Innovative live fire simulators	**Rating by Area Managers** This is the fifth highest rated technology by Area Managers, at 94.5 **Literature Review** Information on the "Compartment Fire Behavior Training (CFBT)" approach to live fire training using redundant steel shipping containers to simulate compartments, as used by UK Fire Brigades is available from http://www.transitionalfire.com/index.php and http://www.firetactics.com/COMPARTMENT-FIRE-SIMULATORS.htm Information on Kidde Fire Trainers is available at: http://www.kiddeft.com/utcfs/Templates/Pages/Template-46/0,8060,pageId%3D792%26siteId%3D385,00.html
Command and Control Simulators (physical and software, fixed or truck-mounted)	**Rating by Area Managers** This is the seventh highest rated technology by Area Managers at 87.5. **Literature Review** Toups et al (2011) take an unusual approach to training firefighters in teamwork. While the training uses computers, there is no attempt to present realistic visuals. The authors "*take a different tack, hypothesizing that a zero-fidelity approach, focusing on human-centered aspects of work practice, will improve team coordination learning".* To test this hypothesis, the authors "*develop quantitative evaluation methods for impact on team coordination learning through measures of communication efficiency and cooperative activity. Results show that participants improve cooperation, become more efficient communicators, differentiate team roles through communication, and leverage multiple communication modalities".* Lee et al (2010) describe a prototype virtual reality platform for team training that includes haptics (tactile feedback, including heat radiation equipment). The virtual environment allows the firefighter to "*navigate the environment, command firefighters, watch them according to pre-defined training scenarios and manuals, see realistic fire and smoke based on fire dynamics, feel heat stress using heat radiation equipment, and monitor the behavior of trainees as they react to changes in the environment".*

	Schurr et al (2006) describe in detail DEFACTO, *"a multiagent based tool for training incident commanders for large scale disasters (man-made or natural)"*. The system combines *"a high fidelity simulator, a human interface, and a multiagent team driving all of the behaviors. Training incident commanders provides a dynamic scenario in which decisions must be made correctly and quickly because human safety is at risk. When using DEFACTO, incident commanders have the opportunity to see the disaster in simulation and the coordination and resource constraints unfold so that they can be better prepared when commanding over an actual disaster. Applying DEFACTO to disaster response aims to benefit the training of incident commanders in the fire department".* Rocha and Boukerche (2010) describe in-development *"architecture to support the modeling of different High Level Architecture (HLA) compliant emergency management training simulations. Different ontologys (simulation, tactic, emergency, equipment, person, infrastructure and vehicle) are created to support complex simulation instantiation. Simulations can be accessed through any device that can run an X3D browser. A context database is created, which provides real life events, collected via wireless sensor networks that can be added to different simulation scenarios."*
Interactive Virtual reality fire fighting simulators (physical and software fixed or truck-mounted)	**Rating by Area Managers** This is rated by Area Managers as having medium importance (67.2) **Literature Review** Cha et al (2010) discus a Virtual reality based fire training system which seeks to portray fire behaviour accurately through *"a specialized numeric solver to generate fire dynamics data, and apply scientific visualization techniques to effectively display these data in 3D."* The authors found that *"this enabled users to easily grasp the useful information of a fire, as well as to evaluate safety achievement during training activities."* The system employs large screens which surround the (standing) trainees. Denef et al (2009) report on fieldwork studies on the *"equipment used by firefighters, practices built upon them and a set of common properties"* in order to inform design of ubiquitous computing systems (ubicomp). They conclude: *"Ubicomp for firefighters has largely neglected the complex nature of fire fighting, focusing on transferring technology for other areas of research and adapting them to fire fighting. Contrasting with that, we are focusing on creating technology reaching from the contextual nature of fire fighting towards ubicomp".* Frye (2007) reports on training firefighter students in deploying sensors, then establishing and using Wireless Sensor Networks.

	Backlund et al (2007) describes a "game based", "virtual environment" firefighter training simulator in which firefighters are surrounded by high panel screens. The author notes that: "*Sidh is based on computer game hardware and software solutions but adds a novel interaction model and gameplay specifically developed for the purpose of training firefighters. The simulator environment is a Cave where the player is interacting with the game through a set of sensors. Players move in the virtual world by movements in the physical world and a substantial physical effort is required to accomplish game tasks.* The authors contend that *Sidh is a useful complement to traditional training methods and that the subjects give very high grades on the entertainment value of the game which indicate that this form of training may be self-motivating which is an important issue for voluntary, after-hours training".* Dogra et al (2009) describe development of the "VRFire" for "immersive" 3D wildfire visualization and simulation application: This *fire spread model will be graphically illustrated on a realistically rendered terrain created from actual DEM data and satellite photography*. *We are working to improve and benefit tactical and strategic planning, and provide training for firefighter and public safety with our application".*
Command and Control Simulators (software only)	**Rating by Area Managers** This is rated by Area Managers as having medium importance (65.1) **Literature Review** Julien and Shaw (2003) describe a software-only command and control simulator which: *"allows the user to: navigate around the environment, viewing a house on fire from any angle; command firefighters and watch them execute those commands; and see realistic fire and smoke behavior reacting to changes in the environment."* However, it appears the simulator has not been further developed since 2003. Information on the CommandSim package for command simulation and training is available at: http://www.commandsim.com/products.html
Interactive Virtual reality fire fighting simulators (software only)	**Rating by Area Managers** This is rated by Area Managers as having medium importance (54.6) **Literature Review** MASA Group Limited offers two AI systems for developing simulators for training purposes. MASA LIFE is an "*Intuitive, adaptable Artificial Intelligence middleware for unparalleled simulated reality",* which incorporates technology developed for multi-player online games. MASA SWORD is "*Is a powerful aggregated simulation tool automated by MASA's cutting-edge Artificial Intelligence technology… designed to help users in the*

	military, civil security and research communities develop and deploy complex, highly-realistic training scenarios and analysis" Refer http://www.masagroup.net/products.html. Zhang (2010) outlines an approach to developing an "edutainment" package, based on a game package, for fire safety education and to teach elementary fire-fighting skills. The target market would be teenagers but the approach, if it comes to fruition, may have some value in fire fighting training. The author claims that *"Game-based learning software saves costs and points out the direction of future educational software".* Zhu et al (2010) describe a coal mine fire simulation and virtual reality system. The system can be used for research purposes – simulating mine fire development scenarios, and also for training purposes. While not specifically focusing on fire fighting training, Tan et al (2006) report on the benefits of virtual reality training that uses physically large displays rather than standard desktop monitors. Maxwel (2004) describes a PC-based prototype fire fighting simulator, which can be controlled through a "gestural interface". While the described version is standalone, it was planned to extend the system to be a scenario-driven classroom trainer.

6 Environmental Protection Technologies

Marlair et al (2004) discuss how fires affect the environment through:

- *Direct gaseous and particulate emissions to the atmosphere (fire plume)*
- *Spread of atmospheric emissions*
- *Deposition of atmospheric emissions*
- *Soil contamination*
- *Aquifer contamination*

This contamination can be due to emissions of numerous, time and product dependant effluents from the fire itself or those associated with the fire brigade activities that may even influence the nature of airborne emissions.

Techniques for the containment/removal of fire fighting water run-off	**Rating by Area Managers** This is rated by Area Managers as having low importance (27.9) **Literature Review** Pabon (2009) has explored alternative treatments of foam water effluence collected from major fire incidents. The purpose is to

	extract the AFFF foam from the water, so that the concentrate part can be incinerated. Wieczorek et al (2010) evaluated the environmental impact of automatic fire sprinklers. The fire tests were first, of an unsprinklered fire, extinguished by manual fire service intervention. The second test involved control via an automatic sprinklers and ultimate extinguishment by the fire service. The tests show clearly that environmental impacts are much lower in the latter case, on all environmental attributes evaluated (ie greenhouse gas emissions, fire damage, fire water runoff and landfill aspects).
Use of low concentration foaming agents for Class B fires	**Rating by Area Managers** This is rated by Area Managers as having low-medium importance **Literature Review** The Bio-Ex (refer http://www.bio-ex.fr/uk/) product 'Ecopol' is a fluorine-free AR foam concentrate for use on hydrocarbon and polar solvent fires. It is usable at Low, Medium and High Expansion. *"The foaming base of ECOPOL is exclusively made from copra fatty acids, a natural re-growing resource".* It is claimed to be biodegradable and *"not expected to be toxic at a rate of dilution of 600 ppm)."* Schaefer (2010) discusses an ARFF technical evaluation of synthetic foam technology that does not contain flurochemicals. Solberg Re-Healing foam RF3 (3%) and RF6 (6%) foam concentrates were found to perform best on aviation kerosene. Solberg Foam (2011) make a range of foam products: *"RE-HEALING FOAM™ products, manufactured at our production plant near Bergen in Norway are formulated using a new High Performance Synthetic Foam technology to replace the classic AFFF and AFFF/ATC foam concentrates and even older Fluor-Protein foams.* The product is claimed to be "*maximum protection to the environment as possible*". It is claimed to "improve extinguishment" of deep-seated "Class A" fires such as hydrocarbon fires and that *"Most commonly available foam aspirating equipment as well as non aspirating equipment, including standard sprinkler heads, can be used to obtain maximum results".* Solberg Foam's website is http://www.solbergfoams.com/index.php?option=com_frontpage&Itemid=1 Cortina (2008) presents a non-technical review of the environmental impacts of fire fighting foams. The author notes that all foams have environmental impacts: *"There are several types of fire fighting foams available including: Aqueous Film Forming Foam (AFFF); Alcohol-Resistant AFFF; Protein Foams; Alcohol Resistant Protein Foams; Fluoroprotein Foams; Class A Foams; Medium and High Expansion Foams;*

	Wetting Agents; Training Foams; and others." Aquatic toxicity tests showed that: *"Fluorinated surfactants are persistent chemicals that have come under increased scrutiny in recent years as a result of the perfluorooctyl sulfonate (PFOS) issue. This scrutiny has encouraged some manufacturers to supplement their range of foams to provide fluorine free products under the descriptive title of environmentally friendly alternatives to AFFF. But it is important to acknowledge that just because a foam agent does not contain fluorine; it is not necessarily safer for the environment, as illustrated by the higher aquatic toxicity of non-fluorinated foams as compared to AFFF."* Cortina (2010) again warns against the notion that fire fighting foams can be truly "eco-friendly". He observers there is a trade-off between the environmental contamination from the foam, and from run-off from the fire ground; the author claims fluorine free foams mean *"three times as much run-off to clean up"*, and that AFFF foams can be used by a wider range of equipment and that fire-fighters can be further from the fire when using them. AFFF foams are much safer for the environment than the older generation PFC foams such as PFOS. However, Cortina is Executive Director of the Fire Fighting Foam Coalition http://www.fffc.org/ so is not a disinterested researcher. This trade association lobbies in support of AFFF foams but has member that includes manufactures of fluorine-free products. Williams et al (2011) report extinguishment and burnback tests of AFFF and fluorine-free fire fighting foams, using the "MilSpec" qualification test. The fluorine-free foam tested (Solberg RF6) took 60% and 70% longer to extinguish the test gasoline fire than the two AFFF foams it was tested against, but was only slightly over meeting the MilSpec time (35 seconds rather than 30). "FireAde 2000" is a fluorine-free agent that can be used as a wetting agent or foam, and is claimed to be suited to fighting both Class A and Class B fires. It is claimed to have *"No adverse impact on the environment"*. Refer: http://fireade.com/products/view/FireAde2000 Tests on the product are reported in Schaefer (2010). In response to these claims by manufacturers and industry lobbyists, the UK Civil Aviation Authority is introducing an objective Environmental Impact System for rating fire fighting foams, based on standardised, replicable tests (Klein 2011). Foams will be rated by "*Acute Aquatic Toxicity*", and by "*Chronic effects (Persistence, Bioaccumulation, Toxicity (PBT)*)". The author notes that AFFF-type concentrates have breakdown products that are "*exceedingly environmentally persistent*", but have acute toxicity that is less than Class A foams and fluorine-free Class B foams. However, he notes the greater toxicity of Class A and fluorine-free Class B foams should not be exaggerated "*as done by some in the industry*".

	Klein (2009) discusses the use of "training" foams that are fluorine-free but not as effective as operational AFFF foams, but avoid "unnecessary" environmental contamination during training.
Use of low concentration foaming agents for Class A fires	**Rating by Area Managers** This is rated by Area Managers as having low importance (27.1) **Literature Review** While it is sometimes contended that Class A foams have little or no environmental impact beyond possible foaming in waterways, (eg Carringer (2009), Brooks (2010)), Kalabokidis (2000) has questioned this belief, but, in his study of the effects of fire fighting chemicals used for wildfire suppression, the main threats are from fire retardant chemicals, not fire fighting foams. However, Cavette (2008) observes that the concentration needed by Class A foam agents has reduced from 1% to as low as 0.1%; one effect of this is that appliances can now deliver much more finished foam. Bio-Ex (refer http://www.bio-ex.fr/uk/) manufacture a range of fire fighting chemicals. The company's 'Bio For C' and "Bio for N" wetting and foaming additives for Class A fires (and hydrocarbon fires) are both fluorine-free are used at low concentration (wetting effect 0.1-0.3%, foaming effect 0.3-0.5%). They are claimed to be biodegradable and not be toxic at 120 ppm ('Bio For C') and 240 ppm ('Bio for N'). Chemguard's Class A foam products are used at similar concentrations and claimed to be environmentally safe: http://www.chemguard.com/fire-suppression/catalog/foam-concentrates/class-a-foam/

5.4 ASSESS NEW TECHNOLOGIES IN TERMS OF POTENTIAL COST EFFECTIVENESS USING AN EVALUATION MATRIX

We have used an evaluation matrix to identify of a set of new technologies for the NZFS which are beyond the scope of this project, could usefully proceed to further evaluation. This future, more detailed, evaluation should include financial and economic benefit-cost analyses and a detailed assessment of operational implications.

This evaluation matrix indicates potential cost effectiveness in which the performance of each technology will be rated in terms of quantitative and qualitative performance criteria, and in terms of likely cost to develop and implement the technology.

Our evaluation matrix approach is based on of that used by the NZ Fire Service in evaluating projects, including those involving investments in new technology, as part of preparing business cases. Our approach is necessarily streamlined, due to the range of technologies we consider.

We have distilled five attributes for use in the evaluation matrix. These are listed below, along with the rationale for their selection:

- **Earlier intervention in the fire growth curve and better containment:** Source for this attribute is the *"Impacts"* level of the "Commission intervention logic for its outputs and their expected impacts" set out in National Fire Risk Management Plan 2010.
- **More appropriate resources deployed to fire and non-fire emergencies:** Same source as above.
- **Stage of Development** ie the current level of development of the technology.
- **Potential to achieve a net annual cost reduction for NZFS**
- **Potential to achieve national economic net benefits:** Some technology investments may be economically and socially justified by their discounted flow of benefits to the nation (ie lives and property saved, and injuries prevented) outweighing their resource costs. However, such investments may not necessarily save the Fire Service money. We presume the issue of how such investments could be funded would be left to a later stage of investigations.

The level of achievement of each attribute by each technology is summarised by/represented by a six point scale, ie the digits 0 - 5; Short description of each attribute level were prepared; these are set out in **Table 5.1** below:

We then take the average of the five individual attribute scores as a summary score, and use this to prioritise the technologies for further investigation.

5.5 PRIORITISING OF TECHNOLOGIES

We have taken two approaches to prioritising the fire technologies. First, we rank them using the index derived from the survey of Fire Service Area Managers (**Table 5.2**) and, second, we rank them using the average score from the evaluation matrix (**Table 5.3)**

Table 5.1 Attributes Used in Evaluation Matrix

Attribute	Score	Description
Earlier intervention in the fire growth curve and better containment		
	0	No performance improvement
	1	Potential for only marginal performance improvement
	2	Potential for minor performance improvement
	3	Potential for some performance improvement
	4	Potential for significant performance improvement
	5	Potential for major performance improvement
More appropriate resources deployed to fire and non-fire emergencies		
	0	No performance improvement
	1	Potential for only marginal performance improvement
	2	Potential for minor performance improvement
	3	Potential for some performance improvement
	4	Potential for significant performance improvement
	5	Potential for major performance improvement
Stage of Development		
	0	Theoretical stage of research only
	1	Laboratory testing/experiment underway
	2	Early prototyping but significant r & d still required
	3	Late prototyping, most technical challenges overcome
	4	Available but requires implementation of supporting technologies (eg "LTE" networks)
	5	Available and could in principle be implemented
Potential to achieve net annual cost reduction for NZFS		
	0	Could increase annual costs for NZFS
	1	Likely to be cost-neutral or only marginal savings
	2	Potential for minor cost savings
	3	Potential for some cost savings
	4	Potential for significant cost savings
	5	Potential for major cost savings
Potential to achieve national economic net benefits		
	0	Likely to have national net cost
	1	Likely to have cost-benefit ratio of around 1
	2	Potential for minor national net benefits
	3	Potential for some national net benefit
	4	Potential for significant national net benefits
	5	Potential for major national net benefits

Table 5.2: Prioritising of Fire Services Operational Technologies using Survey of Area Managers: Ranked 1-25

Technology	Earlier intervention in the fire growth curve and better containment	More appropriate resources deployed to fire and non-fire emergencies	Stage of Development	Potential to achieve net annual cost reduction for NZFS	Potential to achieve national economic net benefits	**Area Manager's Survey Index**	*Rank Under Area Managers Survey Index*
Reduce false alarms by encouraging building owners to modernise fire alarm systems	n/a	n/a	5	5	5	124.6	*1*
Vehicle-based Incident Information Display via IP network	5	5	4	3	5	113.3	*2*
Technologies to maximise flexibility in training time/place.	5	5	5	3	4	112.4	*3*
Technologies to maximise flexibility in training and learning style (visual, auditory, kinaesthetic)	3	3	4	3	4	105.5	*4*
Innovative live fire simulators	5	n/a	4	2	3	94.5	*5*
Integrated building management systems with IP (internet protocol) connection to comcen	5	n/a	4	3	5	94.1	*6*
Command and Control Simulators (physical and software, fixed or truck-mounted)	4	4	3	2	4	87.5	*7*
Devices on firefighters for location in structures	4	4	4	3	4	81.3	*8*
Interactive Virtual reality firefighting simulators (physical and software fixed or truck-mounted)	4	n/a	3	2	3	76.3	*9*
Sensors on firefighters to measure and transmit environmental data eg temperature, gases, smoke etc	4	n/a	4	3	4	71.6	*10*
"Intelligent" domestic fire alarms with IP (internet protocol) connection to comcen	4	n/a	4	3	4	68.6	*11*
Emergency response driver simulators (physical and software, fixed or truck-mounted)	3	3	4	2	2	67.2	*12*
Modelling/simulation to refine location of stations and/or resources	5	3	5	3	4	65.7	*13*
Command and Control Simulators (software only)	3	3	3	2	3	65.1	*14*
System to locate caller's cell-phone etc	3	3	2	3	4	60.9	*15*
Transmission of digital video by cameras on firefighters	4	4	4	3	3	60.4	*16*
Display of images and text data superimposed over real time images of emergency location	3	3	2	3	3	60.4	*17*
Enhance mains water supply pressure so it is adequate for firefighting	5	n/a	5	4	4	59.3	*18*
Receive and analyse GPS data from public's devices	2	4	4	3	4	57.1	*19*
Delivery of incident information to stations via IP (internet protocol) network	4	3	2	3	4	57.1	*20*
Video "reach back to remote experts" available from fire trucks	3	3	5	3	4	56.3	*21*
Bio-sensors on firefighters to measure and transmit physiological data	2	3	4	2	3	56.3	*22*
Video data from cameras on fire engines	2	3	4	3	4	54.7	*23*
Interactive Virtual reality firefighting simulators (software only)	2	n/a	3	2	3	54.6	*24*
Use of smart building services/technologies on fire stations	n/a	n/a	5	2	4	53.3	*25*

Table 5.2 Cont: Prioritising of Fire Services Operational Technologies using Survey of Area Managers: Ranked 26-50

Technology	Earlier intervention in the fire growth curve and better containment	More appropriate resources deployed to fire and non-fire emergencies	Stage of Development	Potential to achieve net annual cost reduction for NZFS	Potential to achieve national economic net benefits	**Area Manager's Survey Index**	*Rank Under Area Managers Survey Index*
MVA rescue techniques for hybrid and all-electric and hybrid vehicles	n/a	4	3	2	4	50.5	*26*
Emergency response driver simulators (software only)	2	2	4	2	3	46.9	*27*
Compressed Air Foams delivery systems	4	n/a	4	3	4	46.0	*28*
Techniques for the containment/removal of firefighting water run-off	n/a	n/a	5	2	4	44.5	*29*
Capability to receive and analyse visual imagery of incidents	4	4	4	3	4	43.2	*30*
Capability to receive and analyse photo and video data sent by public	2	4	2	3	4	43.2	*31*
Image analysis software to analyse video for location, size and movement	5	4	4	3	4	42.7	*32*
Integrated home security systems with IP (internet protocol) connection to comcen	3	3	4	3	4	37.0	*33*
Head up display of images and text data superimposed over real time images of emergency locatio	4	5	2	3	2	35.1	*34*
Distribute tablet computers/net books/or e readers to all firefighters for TAPS and other training materials	3	3	5	1	4	35.0	*35*
Use of low pollutant (emission) vehicles	n/a	n/a	4	2	3	33.6	*36*
Improved rope rescue technology/techniques	n/a	4	5	2	4	32.4	*37*
Normally – aspirated foam delivery systems	3	n/a	4	2	3	32.1	*38*
Integrated personal (medical) home security systems with IP (internet protocol) connection to comcen	3	3	4	2	3	30.8	*39*
Devices and techniques for 'pulling' vehicles apart at MVAs	n/a	3	3	2	3	29.7	*40*
Use of low concentration foaming agents for Class B fires	n/a	n/a	4	3	3	27.9	*41*
Use of low concentration foaming agents for Class A fires	n/a	n/a	4	3	3	27.1	*42*
Handheld Water Mist delivery systems	3	n/a	4	2	4	24.2	*43*
Influence road layout/traffic engineering solutions	3	3	5	3	3	23.6	*44*
Real time traffic information	3	3	4	4	4	22.6	*45*
Handheld reduced droplet size spray delivery systems	2	n/a	4	2	3	22.4	*46*
Control of traffic light phasing by on-board device	1	1	3	3	2	19.5	*47*
Change/improve appliance design to improve performance through traffic	1	1	4	3	2	19.0	*48*
Robots for urban search and rescue	n/a	3	2	1	2	15.3	*49*
Decision Support/Expert Systems in Command and Control	4	4	1	3	3		*n/a*

Table 5.3 Prioritising of Fire Services Operational Technologies using Evaluation Matrix: Ranked 1-25

Technology	Earlier intervention in the fire growth curve and better containment	More appropriate resources deployed to fire and non-fire emergencies	Stage of Development	Potential to achieve net annual cost reduction for NZFS	Potential to achieve national economic net benefits	Evaluation Matrix Total Score	Rank Under Evaluation Matrix
Reduce false alarms by encouraging building owners to modernise fire alarm systems	n/a	n/a	5	5	5	25.0	1
Enhance mains water supply pressure so it is adequate for firefighting	5	n/a	5	4	4	22.5	2
Vehicle-based Incident Information Display via IP network	5	5	4	3	5	22.0	3
Technologies to maximise flexibility in training time/place.	5	5	5	3	4	22.0	4
Integrated building management systems with IP (internet protocol) connection to comcen	5	n/a	4	3	5	21.3	5
Modelling/simulation to refine location of stations and/or resources	5	3	5	3	4	20.0	6
Image analysis software to analyse video for location, size and movement	5	4	4	3	4	20.0	7
Capability to receive and analyse visual imagery of incidents	4	4	4	3	4	19.0	8
Devices on firefighters for location in structures	4	4	4	3	4	19.0	9
Sensors on firefighters to measure and transmit environmental data eg temperature, gases, smoke etc	4	n/a	4	3	4	18.8	10
"Intelligent" domestic fire alarms with IP (internet protocol) connection to comcen	4	n/a	4	3	4	18.8	11
Compressed Air Foams delivery systems	4	n/a	4	3	4	18.8	12
Improved rope rescue technology/techniques	n/a	4	5	2	4	18.8	13
Use of smart building services/technologies on fire stations	n/a	n/a	5	2	4	18.3	14
Techniques for the containment/removal of firefighting water run-off	n/a	n/a	5	2	4	18.3	15
Real time traffic information	3	3	4	4	4	18.0	16
Transmission of digital video by cameras on firefighters	4	4	4	3	3	18.0	17
Video "reach back to remote experts" available from fire trucks	3	3	5	3	4	18.0	18
Innovative live fire simulators	5	n/a	4	2	3	17.5	19
Influence road layout/traffic engineering solutions	3	3	5	3	3	17.0	20
Receive and analyse GPS data from public's devices	2	4	4	3	4	17.0	21
Integrated home security systems with IP (internet protocol) connection to comcen	3	3	4	3	4	17.0	22
Technologies to maximise flexibility in training and learning style (visual, auditory, kinaesthetic)	3	3	4	3	4	17.0	23
Use of low concentration foaming agents for Class B fires	n/a	n/a	4	3	3	16.7	24
Use of low concentration foaming agents for Class A fires	n/a	n/a	4	3	3	16.7	25

Table 5.3 Cont: Prioritising of Fire Services Operational Technologies using Evaluation Matrix: Ranked 26-50

Technology	Earlier intervention in the fire growth curve and better containment	More appropriate resources deployed to fire and non-fire emergencies	Stage of Development	Potential to achieve net annual cost reduction for NZFS	Potential to achieve national economic net benefits	Evaluation Matrix Total Score	Rank Under Evaluation Matrix
Handheld Water Mist delivery systems	3	n/a	4	2	4	16.3	26
MVA rescue techniques for hybrid and all-electric and hybrid vehicles	n/a	4	3	2	4	16.3	27
Delivery of incident information to stations via IP (internet protocol) network	4	3	2	3	4	16.0	28
Video data from cameras on fire engines	2	3	4	3	4	16.0	29
Head up display of images and text data superimposed over real time images of emergency locatio	4	5	2	3	2	16.0	30
Command and Control Simulators (physical and software, fixed or truck-mounted)	4	4	3	2	4	17.0	31
Distribute tablet computers/net books/or e readers to all firefighters for TAPS and other training materials	3	3	5	1	4	16.0	32
System to locate caller's cell-phone etc	3	3	2	3	4	15.0	33
Capability to receive and analyse photo and video data sent by public	2	4	2	3	4	15.0	34
Integrated personal (medical) home security systems with IP (internet protocol) connection to comcen	3	3	4	2	3	15.0	35
Decision Support/Expert Systems in Command and Control	4	4	1	3	3	15.0	36
Normally – aspirated foam delivery systems	3	n/a	4	2	3	15.0	37
Interactive Virtual reality firefighting simulators (physical and software fixed or truck-mounted)	4	n/a	3	2	3	15.0	38
Use of low pollutant (emission) vehicles	n/a	n/a	4	2	3	15.0	39
Display of images and text data superimposed over real time images of emergency location	3	3	2	3	3	14.0	40
Bio-sensors on firefighters to measure and transmit physiological data	2	3	4	2	3	14.0	41
Emergency response driver simulators (physical and software, fixed or truck-mounted)	3	3	4	2	2	14.0	42
Command and Control Simulators (software only)	3	3	3	2	3	14.0	43
Handheld reduced droplet size spray delivery systems	2	n/a	4	2	3	13.8	44
Devices and techniques for 'pulling' vehicles apart at MVAs	n/a	3	3	2	3	13.8	45
Emergency response driver simulators (software only)	2	2	4	2	3	13.0	46
Interactive Virtual reality firefighting simulators (software only)	2	n/a	3	2	3	12.5	47
Change/improve appliance design to improve performance through traffic	1	1	4	3	2	11.0	48
Control of traffic light phasing by on-board device	1	1	3	3	2	10.0	49
Robots for urban search and rescue	n/a	3	2	1	2	10.0	50

5.6 PRIORITY TECHNOLOGIES FOR FUTURE INVESTIGATION

Based on the two rankings above, we suggest the following technologies as priorities for the Fire Service (not including technologies already being investigated under the Fire Service's ICT strategy) together with the rationale for selecting them. These are listed in a provisional descending order of priority; future, more detailed investigations could lead to this order being revised:

1. **Reduce false alarms by encouraging building owners to modernise fire alarm systems.** This emerges as a top priority for two reasons: first, false alarms impose unnecessary costs on the Fire Service, its volunteers, and on their employers. Second, most of the emerging technologies for collection, transmission and analysis of intelligence by the Fire Service itself require inputs from a smart detection system.
2. **Vehicle-based or Portable Incident Information Display via IP (internet protocol) network, eg risk plans.** The provision of intelligence/information to OICs directly to help them establish effective command and control more quickly is a clear priority. This technology is also prerequisite for the other technologies such as cameras and thermal imagers mounted on or carried by firefighters, or data received from the public's smartphones.
3. **Transmission of video by cameras on firefighters together with image analysis software to analyse video for location, size and movement.** This can include both visible light video, and thermal imagery. In the literature review above we outline how the hardware and software (algorithms) have developed to increase the power to detect flame and hotspots, and to detect persons in both fire and Urban Search and Rescue situations. There are potentially substantial benefits in more effective command and control, and in firefighter safety and effectiveness.
4. **Technologies to maximise flexibility in training time/place and in learning style** (visual, auditory, kinaesthetic). The desirability of improving training of volunteer firefighters while managing demands on their time came through strongly in our consultation in the Survey of Area Managers. In the literature above we indicated how new ICT technologies can facilitate training.
5. **Modelling/simulation to refine location of stations and/or resources.** Methodologies for refining the models used to locate fire stations and allocate resources are reviewed above. While the Fire Service's current National Resource Allocation Model (NRAM) is, according to the Fire Service's 2011/14 Statement of Intent, a major technical advance on previous procedures, developing theory in this area may mean further improvements are achievable.
6. **Devices on firefighters for location in structures.** This is important for both for purposes of firefighter safety, and for

effective fire fighting. A number of technologies for locating fires were covered in the literature review, including GPS and RFID tags, and "motes"; the latter two require investment by building owners.

7. **Innovative live fire simulators.** The reduction in real fire incidents means there is a need for live fire training and it is unlikely that computer simulations will ever entirely replace this need. We suggest the relatively low cost live fire simulators discussed **in Section 5.3** should be investigated further.

8. **Command and Control Simulators.** In the survey of Area Managers the command and control simulators for training were thought to have priority over computer (non-live fire) simulators. We suggest that further investigations be carried out into the command and control decision support methodologies covered in the literature review. Most can be used for both training and as decision systems in actual operations.

9. **Location of caller's mobile phone together with capability to receive and analyse other data on incidents.** The various means by which the public can provide useful data to the emergency services are reviewed in **Section 5.3** above; these range from the location of the calling phone (using GPS or more complex approach to locate the phone within a muti-storey structure), through images and video and eventually data from other sensors imbedded in the phone. Using Quick Response (QR) codes could be a further, future step. For example, a member of the public could scan a QR code attached to a room or building where an incident is occurring. The QR code, when received by the Fire Service, would link comcen and the responding OIC to risk plans, floor plans, etc. Further, the techniques for using video to detect fire outlined in **Section 4.3** above could be used to analyse this video transmitted by the public, providing useful intelligence to comcen and OICs. Richer, more detailed data will be able to be transmitted once 4G mobile network technologies are available n New Zealand (most likely LTE).

10. **Compressed Air Foams delivery systems.** This is an existing technology, but we were informed by Fire Service managers that the potential of CAFs for more effective fire fighting, with less polluting water runoff, have not been realised. We suggest the reasons for this be examined in more detail than we have been able to here. We also recommend a cost-benefit study be carried out on the possible wider adoption and use of CAF by NZFS.

6. CONCLUSIONS: RISKS AND OPPORTUNITIES

6.1 SCOPE OF CONCLUSIONS

In this chapter we draw the four threads of our assessment together and distil our main findings on the impacts of

- social changes;
- consumer technology changes;
- new property fire detection and suppression technologies; and
- emerging technologies for NZFS

for Fire Service operations (**Section 6.2**).

We then present an overall assessment of risk and opportunities posed for achievement of the Fire Service's National Goals and outcomes (**Section 6.3**);

6.2 MAIN FINDINGS

6.2.1 Impacts of Social Changes

Social Changes tending to Increase Fire Risk in the Community

- Modest economic growth means there is likely to be a persistent *"Lower socio- economic people"* segment of the community living in absolute (not just relative) deprivation; this group most at risk from fire will continue to be a growing challenge for fire risk management.
- Increasing population of "*Older People*" combined with government "aging in place" policies and older people's preferences means more people living alone and a growing need to maintain fire safety in the home.
- "*Maori and Pacific Island People*" will become a larger proportion of the population; their needs will need to continue to be addressed in Fire Service's community education programmes.
- Rate of owner/occupancy will continue to decline; growing numbers of "*People living in rental property*".
- Greater mobility combined with increasing importance of "virtual" communities have weakened ties to a conventional neighbourhood/community; has implications for social capital including volunteerism and other aspects of mutual support within communities.
- Increasing immigration, with more Asian and other immigrant groups without English as a first language, means increasing challenges for effective fire safety community education...
- Consumption of alcohol is increasing, and a "binge" pattern of consumption is apparent (though not necessarily increasing).

Social Changes tending to Reduce Fire Risk in the Community

- Increasing levels of education which may boost community receptiveness to more sophisticated fire safety messages and adoption of fire safety behaviours;
- Rapidly increasing use of Consumer ICT facilitating transmission of fire safety messages from NZFS to community.
- Consumer ICT facilitating two-way communication between public and emergency response organisations during emergencies.
- Trend towards more intensive urbanisation, including infill housing in suburban areas and apartment living in downtown areas.

6.2.2 Impacts of Consumer Technology Changes

- Social media and smart portable devices have great potential for improved two-way communication between the public and emergency services, and communication between private individuals and groups during recovery from an emergency.
- Smartphones (and other portable devices) have potential for "crowdsourcing" data in "routine" fire incidents, so that the Fire Service has more intelligence available prior to arrival at an incident. This data could include:
  - Mobile phone caller location giving the précised location of incident, for rescue purposes or so that risk plans, floor plans etc can be retrieved by the responding officers in advance;
  - images and video, together with data from miniaturised sensors in the smartphone (eg detection of gasses).

6.2.3 Impacts of New Property Fire Detection and Suppression Technologies

Domestic

- Technologies for improving performance of residential smoke alarms through requiring less maintenance (10 year life with no battery change), reduction in false alarms etc; interconnection of smoke alarms.
- Wireless connection of residential smoke alarms to the internet and other devices in the home.
- In particular, wireless integration of smoke and heat detectors with other personal and household security sensors including for example medic alert alarms monitored by expert systems software can detect emergency situations and provide information to security providers and emergency responders. Such systems can support "aging in place".
- Partial coverage sprinklers have potential for cost-effective reduction of fire risk.

Commercial/Industrial

- Improving "Integrated building management systems" incorporating interconnected smoke detectors and sprinklers have potential for cost-effectively improving protection of commercial and industrial buildings. These enable earlier automatic detection and suppression, and provide intelligence to responding fire officers.
- More intelligent, accurate sprinkler systems.

6.2.4 Impact of Emerging Operational Technologies for NZFS

- The development of broadband wireless connectivity – 3G and WiFi – means that it is now possible for intelligent alarm/detection systems, OICs at incidents, firefighters themselves, Comcen, and the public's smartphones to transmit rich data to support fire fighting and other emergency response options. In future, implementation of 4G/LTE networks will increase wireless bandwidth much further.
- Greater computing power on portable devices, including smartphones, mean that more processing can be carried out in the field, eg running applications to analyse visible light and thermal images, or for command and control decision support purposes.
- Miniaturisation, reduce power demand and expanded range of sensors for detecting fire, environmental conditions in a fire, fire fighters physiological status; wireless interconnection between sensors and intelligent processing and interpretation of the data flowing from sensors.
- Reduced weight and lower power demand of such sensors mean they can be mounted on firefighters (eg head mounted video cameras or thermal imagers), in building structures or on walls, in cameras for visual monitoring on in the public's smartphones.
- With data coming from sensors placed within structures, on firefighters, on vehicles and possibly from the public's smartphones there is an increased prospect of incident commanders/managers being subject to "information overload". As covered in the literature review, decision support/expert systems are being developed for use by fire/emergency responders which will help commanders/command teams identify/distil what actions to take.
- Provision of improved intelligence (plans, other images, text, and other information) at incidents, and on the way to incidents, so that officers and their teams at incidents can be more rapidly effective.

6.2.5 Trends discussed in the brief that appear to be of marginal or no significance:

- People deliberately causing events, or bystanders then actively impeding or threatening firefighters – appears to be a minor

problem, and not a new one. It is not perceived by firefighters to be a significant or growing problem for them, nor is there evidence for it in the New Zealand literature.

- Technologies to reduce travel time to incidents through controlling traffic lights etc exist and will be refined. However, the need for, or priority to be given to adopting these is not clear. The consensus seems to be that **the time for the responding crews to become effective** is more important than the response time (including travel time) per se and that there is more scope for reducing time to become effective through better information and more readily deployable and effective fire fighting tools, than via a marginal reduction in travel time.

6.3 OVERALL ASSESSMENT OF RISKS AND OPPORTUNITIES

6.3.1 Risks

The following trends tend to increase fire (and other emergency) risks:

- The "aging" of the population; in particular increasing numbers of people aged over 75 living independently in the community.
- Increasing population in other "at risk groups", including Maori, Pacific Islanders, and migrants who do not have English as a first language.
- A persistent high-alcohol consumption ("binge drinking") sub-culture, particularly among the population 16-25 (Males in this age group have an elevated risk of injury by fire refer AFAC 2009).
- If civil unrest occurs locally, social media and smartphones make it easier for crowds to assemble, which could (in principle) start fires and/or impede the Fire Service in its duties (we see this as a minor risk however).
- A constrained economy over the medium term will mean limited job growth and continuing high unemployment. This indicates, unless effective social, training and employment policies achieve otherwise, an "underclass" will persist and perhaps grow larger.
- Straightened economic conditions and house price decreases have led to households seeking to reduce debt rather than invest more in their houses. This means that households will be less inclined to take up the opportunities to reduce the risk of fire they faced by investing in interconnected "smart" domestic smoke alarms (hardwired or wireless).
- Similarly, a tight economy may mean owners of commercial/industrial properties not taking up the opportunity to invest in modern, intelligent detection or suppression systems.

6.3.2 Opportunities

On the other hand, trends that tend to create opportunities to enhance achievement of the Fire Services outcomes include:

- Falling population in younger, risk taking age groups.
- Successful road safety campaigns against drink-driving have meant a reduction in serious motor vehicle accidents, and provide a precedent for current campaign to reduce cooking while intoxicated.
- Adoption of safer home heating technologies, with portable radiant heaters and open fires being replaced by heat pumps. Government and regional incentives programmes to achieve the National Environment Standards for Air Quality are helping to promote this shift, which can be expected to have fire-risk as well as environmental benefits.
- Wireless interconnected domestic smoke alarms with long-life batteries will provide the benefits of hard-wired smoke alarms at lower cost and could therefore be taken up more rapidly by the household market. Even "stand-alone" domestic smoke alarms with 10-year battery life are a major advance on traditional types which require checking and replacement of batteries. Futher, dwellings that comply with Clause F7—Warning systems of the New Zealand Building Code, which came into effect in 2003, will be a growing proportion of the total housing stock.
- At a more sophisticated level, integrated domestic security, medical and fire safety systems wirelessly connected to security providers will become more intelligent and perhaps more affordable. These will involve multiple sensors, together with expert system software to identify situations requiring intervention/assistance and to automatically notify security providers or 111 accordingly. These systems, if adopted and installed in sufficient numbers, could partially offset the increased risk associated with an aging population. Those elderly people (for a given level of frailty) living independently, with such technology installed, will be safer than those of today.
- In commercial/industrial properties detection and suppression systems are also becoming more intelligent. Networks of sensors combined with expert system software can assess when emergency services need to be called, and this will reduce both damage from fires and the numbers of false alarms. Suppression systems, if triggered, will be more targeted and effective, and cause less water damage. An increasing proportion of new commercial/industrial buildings will be fully "intelligent". The challenge is, of course, to induce property owners to retro-fit such systems, when even the current generation of detection and suppression systems have had low rates of take-up.
- Such intelligent building systems can transmit data directly to the Fire Service comcen and responding appliances. Of course the Fire Service will need to invest in the technology to receive

and analyse this data, but, if so, they have the potential to make responding crews more effective, more quickly and so reduce fire damage, risks to fire fighters, and the environmental effects of fire-fighting.

- Decision Support/Expert systems are being developed by the Fire Service to assist Officers in Charge make more rapid and effective decisions based on the information provided to them.
- Smartphones and other consumer portable devices will carry an increasing range of sensors and be able to process the data to detect emerging situations and transmit it, along with video and images, to emergency responders. Technologies are being developed to assist emergency responders compile, analyse and interpret such "crowd sourced" data.
- Sensors on firefighters to measure environmental conditions to interact with those installed in buildings for purposes of location, combined with lighter Head mounted Displays (HMD) and biometrics have potential to make firefighters both safer and more effective.
- Existing, but not fully adopted by NZFS, fire fighting technologies such as CAFs also have potential to increase firefighter effectiveness.

6.3.3 Balance of Risks and Opportunities.

On balance, social changes are tending to increasing fire risk, and technological changes to reduce fire risk and facilitate achievement of the Fire Service's National Goals and outcomes. Technological changes have the potential to more than offset increasing risk from social changes such as population aging.

The proviso is that new and emerging active fire protection technologies are adopted by households, commercial/industrial building owners and by the Fire Service itself. In the short term, in a tight economy, investment by any of these parties is likely to be limited. The challenge to the Fire Service is to help ensure the opportunities presented by the emerging technologies are realised.

6.4 INVESTIGATION PRIORITIES

We conclude this research by identifying four high-priority topics for further investigation. While these are numbered one to four, we see these as being of approximately equal importance.

1. Research the commercial and industrial building market for modern intelligent IP connected alarm/suppression systems. The research would include:
   - building owners' awareness and perceptions of these technologies by;
   - the perceived barriers to retrofitting these in existing buildings them and how these could be overcome;
   - a financial cost-benefit assessment of these system, from the point view of building owner;

- an economic cost-benefit assessment of these system from the national perspective (benefits include savings of false alarm callouts)

2. Research the domestic market for modern smoke alarms at increasing levels of cost and sophistication, including as part of an "intelligent" integrated domestic security system. The research would investigate, *inter alia*:
   - Domestic property owner's awareness and perceptions of these technologies;
   - The perceived barriers to adopting them and how these could be overcome;
   - a financial cost-benefit assessment of these system, from the point of view of the property owner;
   - an economic cost-benefit assessment of these system from the national perspective

   There should be two target samples in the research; first, owner-occupiers, and, second, landlords of domestic rental properties, who will make the required investments. Boost sub-sample should be made of "at risk" group households.
3. Evaluate vehicle-based or portable Incident Information Display systems for receiving, analysing and displaying:
   - risk plans
   - data from smart fire alarm systems
   - location, video and other data from the public's smartphones (crowdsourcing).
4. Evaluate technologies to maximise flexibility in training time/place and in learning style. This would involve *inter alia*:
   - Surveys of career and volunteer firefighters on how they prefer to learn;
   - Case studies of use of modern ICT, including Course Management Systems and games-technology based simulators, in emergency services training (particularly involving volunteers) in NZ and internationally;
   - Assessment of the barriers to more intensive use of these technologies in NZFS (technical/financial/attitudinal) and how these could be overcome;
   - Evaluation of specific training systems.

[END]

McDermott Miller Strategies Limited
20 March 2012

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New Zealand Fire Service

Impact of Emerging Social Change and Technological Developments on Fire Service Operations

Annex A: Select Bibliography

McDermott Miller Limited

20 March 2011

ANNEX A TABLE OF CONTENTS

McDermott Miller Limited, Strategic Planning Consultants
CPO PO Box 629 Wellington New Zealand
2nd Floor 90 The Terrace Wellington
Telephone (04) 471-8500
Email strategies@mcdermottmiller.co.nz
www.mcdermottmiller.co.nz

A1. APPROACH TO SELECTIVE LITERATURE SEARCH

This Annex presents a select bibliography arising from our systematic literature search. Our approach comprised relevant bibliographic sources to search, and identifying relevant search terms.

Sources for Relevant Literature

We met the Fire Services' Information Centre Manager and Senior Information Officer to discuss our information needs. We received guidance on NZFS's library catalogue system, and links to key web sites for relevant fire research literature.

The sources of relevant literature include:

Sources for technological developments in fire service operations:

- NZFS Information Centre catalogue: as well as providing references to published literature (both scholarly and non-academic) this referenced some unpublished Fire Service reports.
- Reports provided on a confidential basis by Fire Service managers we interviewed, particularly in the ICT area on past trials with new technologies.
- Review of unpublished NZFS Incident Statistics reports provided by the Information Analyst (this confirmed that households in "deprived" areas continue to be at elevated risk of fire).
- The NZFS website - for previous CRF research reports.
- Australian, British, US & Canadian fire service and emergency agency web sites (links supplied by NZFS Information Centre Officers) for research reports etc which are not necessarily referenced in the academic literature.
- Academic journal publishers websites, eg Emerald, which index the journals they publish.
- EBSCO (link through WPL).
- Bibliographic sites accessed through National Library including Index New Zealand.
- Bibliographic sites accessed through VUW, including IEEE Xplore and Wiley Online Library.
- Web sites of publishers of relevant journals.
- Websites of producers and marketers of active fire protection and firefighting equipment.
- What's Next www.nowandnext.com for international overview of "trends in society, business, science & technology, government and the environment".

Sources for Information on Social and Economic Trends in NZ:

- Futures Thinking Aotearoa www.futurestrust.org.nz
- The New Zealand Institute www.nzinstitute.org
- Population Association of New Zealand http://panz.rsnz.org
- Enhancing Wellbeing in an Ageing Society www.ewas.net.nz.
- Ministry of Social Development.
- The Social Report 2010 www.socialreport.msd.govt.nz.
- Statistics NZ.

- New Zealand Treasury.
- Ministry of Civil Defence and Emergency Management.
- 2025 Taskforce www.2025taskforce.govt.nz.
- www.eastonbh.ac.nz.

Identifying Search Terms

Relevant Search Terms were identified:

- From terms supplied by Executive Officers in our interviews with them;
- On the basis of our McDermott Miller's previous experience in undertaking CRF research (Fire Research Report 12);
- Discussions with Fire Service Information Centre manager;
- Review of key previous Contestable Research Fund reports;

Criteria for selecting reports and articles for review

We carried out a selective review of the literature. The selection criteria used were:

- **Relevance:** After each search run, we read the titles of document discovered and their abstracts, if available. The prime criterion for selection for review was that the reference provided useful information relevant to the search terms. If the documents appeared to be sufficiently relevant we then considered the following subsidiary selection criteria:
- **Authorities of Publication:** The searches were not limited by publication type and a wide range has been considered including peer-reviewed scholarly journals, independent reports commissioned by fire services, internal fire service reports, government reports, magazines and web sites aimed at firefighters, non-peer reviewed conference papers. This was a pragmatic decision, as we considered limiting the search to the academic literature only was too limiting; and, publication generally not current enough.

  Not all material has been given equal weight. In reviewing the documents and considering the significance of their findings for the current study, we put most weight on articles in peer-reviewed journals, followed by reports and conference papers by professionally qualified authors that appear to have been prepared with a scholarly/scientific approach. Other material was used for "colour", or to glean search terms and (subject headings) for further searching.
- **Recency of Publication**: Essentially we have limited the review to documents published since 2004 (except for NZFS CRF Research reports; all were considered since the series began; other pre-2005 NZFS reports have also be reviewed), to ensure the research is current. When large numbers of documents were found in a particular search, these were sorted in descending order and we only gave titles earlier than 2000-2004 a cursory scan. Some pre – 2004 documents of particular value have been reviewed, particularly if cited in more recent papers.

  In considering social and economic trends, more weight has been given to documents published since the financial crisis of 2008, since expectations for medium to long term economic environment shifted at that point.

The development of wireless "connectivity", handheld devices and social media1 websites in both the consumer and fire technology fields has meant earlier technical reports that do not take these into account have been superseded.

- **Language:** we have only considered documents published in English.

[1] Potential for use of social media for community education under fire risk management programmes was not included in the survey, as this is the subject of UMR (2011), another study funded under the Contestable Research Fund.

A2. REFERENCES FOR CHAPTER 2 IMPACT OF SOCIAL CHANGES

MACRO-TRENDS (Refer Section 1.5)

References Cited in Report

McDermott Miller Limited Environment Bay of Plenty Air Quality Marketing Strategy. Report to Environment Bay of Plenty, 2010
Abstract: A marketing research and evaluation-based approach to development of an incentive loan package to encourage Rotorua homeowners and landlords to upgrade their home heating to environmentally "cleaner" appliances. The project involved indentifying and segmenting the relevant household market [owner occupiers and landlords], using survey based techniques, to estimate households' interest in and likely responses to the issue of air pollution in Rotorua; identifying and designing a range of possible financial incentive packages and evaluate their costs and appeal or otherwise to the market; and, devising a social marketing strategy to secure "take-up" of at least one of these packages, which in turn should help achieve Environment Bay of Plenty's objective of improving Rotorua's air quality

Other Relevant References

Boven, Rick. Environment and climate: Implications, reaction and response. 2011.
www.nzinstitute.org
Abstract: Economic growth has occurred because fossil fuels and shipping technologies allowed trade expansion. Now, with environment becoming a constraint again, and increasing concerns about climate change, new challenges are emerging for the global economy. Pressures to reduce environmental impacts are conflicting with concerns over energy security to create difficult challenges for world leaders and uncertainty for businesses. The presentation will include an overview of the implications of global environmental change, responses so far and likely, and how businesses may be affected. Environmental issues will lead to differing responses by governments, consumers and businesses. The timing and scale of those responses will affect the context within which sea transport businesses will prepare their long term strategies.

Easton, Brian. What does a multipolar world mean?. Presentation for the Wellington Branch of NZIIA AGM, 16 March 2010.

Easton, Brian. Globalisation & Trade. 2010.
http://www.eastonbh.ac.nz/?p=115

Skilling, David. The Economic effects of Climate Change: Positioning New Zealand to respond. 2007.
www.nzinstitute.org

Watson, Richard. Trends and technology timeline 2010+: A roadmap for the exploration of current and future trends (+ some predictions to stir things up). Nowandnext.com. 2010.

A2.1 ECONOMIC OUTLOOK : CONSTRAINED GROWTH.

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2025 Taskforce. Focusing on Growth: Closing the income gap with Australia by 2025. 2010.

Howitt, Peter and David N. Weil. Economic Growth. The New Palgrave Dictionary of Economics, 2nd Edition, New York: Palgrave MacMillan. 2008.
http://www.dictionaryofeconomics.com/article?id=pde2008_G000209&goto=economicgrowth&result_number=964
Abstract: Does homeownership affect individual social capital and thereby influence local outcomes? Following DiPasquale and Glaeser, a body of literature suggests that homeownership is positively related to social capital formation. Homeowners have an incentive to engage in the local community in order to preserve or enhance the value of their housing asset. Moreover, homeownership creates barriers to geographic mobility, which increases the present value of the expected stream of benefits from local community social capital. We test the homeownership hypothesis alongside other individual, household and locational determinants of social capital using unique data created by merging the 2006 and 2008 samples of the New Zealand Quality of Life survey. The measures of social capital used in our analysis include trust in others, participation in social networks, attitude The results confirm that homeownership exerts considerable positive impact in the formation of social capital in New Zealand communities. In raising accountability of local government it does, however, lead to reduced satisfaction by homeowners in the performance of local councils.

NZIER. NZIER Consensus Forecasts June 2011. NZIER. 2011.
Abstract: Incorporating returns received up to Monday 13 June 2011

The Treasury. Budget Economic and Fiscal Update (BEFU) 19 May 2011. 2011.
http://www.treasury.govt.nz/budget/forecasts/archive

Other Relevant References

2025 Taskforce. Focusing on Growth: The Second Report of the 2025 Taskforce. http://purl.oclc.org/nzt/r-1252. 2010.

2025 Taskforce. 2025 TASKFORCE REPORT 2: FOCUSING ON GROWTH: Questions and Answers. 2025 TASKFORCE. 2010.

2025 Taskforce. Focusing on Growth: Summary Report of the 2025 Taskforce. 2025 Taskforce. 2010.
Abstract: The 2025 Taskforce was set up in 2009 to provide recommendations to the Government on how to close the income gap with Australia by 2025. The Taskforce's first report in 2009 concluded that far-reaching policy changes would be required to close the gap. The Taskforce stands by the specific recommendations made in that report. We have used this second report to more fully articulate the context and framework for those recommendations. It stresses the urgent need for public policy to become focused on creating an environment conducive to strong sustained economic growth that will benefit all New Zealanders.

Boven, Rick. Opportunities for prosperity: Labour Pary Economic Seminar. 2010.

Boven, Rick; Bidois, Dan; Harland, Catherine. A goal is not a strategy: Focusing efforts to improve New Zealand's prosperity. 2010.
www.nzinstitute.org
Abstract: Economic prosperity is a worthwhile goal for New Zealand and Government has set a goal of matching Australia's GDP per capita by 2025. The dominant approach to economic development in New Zealand since the mid-1980s has been economic liberalisation. Economic liberalisation comprises a set of ten standard prescriptions that all countries are encouraged to implement to achieve economic prosperity. An alternative, termed the 'diagnostic approach' has emerged more recently. It involves identifying the binding constraints to growth and establishing policies to overcome those constraints. As the diagnostic approach "is a framework for figuring out what to do (and maybe

what not to do) in different kinds of cases and different kinds of countries" (Rodrik, 2005, p.1) it does not necessarily contradict economic liberalisation; they can be used together. New Zealand had a relatively high GDP per capita prior to the early 1970s but the United Kingdom's entry to the European Union led to a relative decline until around 1990. Despite strong doses of economic liberalisation, New Zealand's GDP per capita remains lower than the Organisation for Economic Co-operation and Development (OECD) average and much lower than Australia's. The main driver of GDP per capita is labour productivity and New Zealand's private economy labour productivity is 57% of Australia's. Labour productivity is not the only important measure of economic prosperity though. For a small trading nation exports are very important too. New Zealand's exports have grown much more slowly than the OECD average partly because global trade in commodities (where New Zealand exports are concentrated) has grown more slowly than trade in differentiated goods and services. In recent years weakening trade performance has combined with imported private debt to erode the current account balance. Now New Zealand needs to improve labour productivity and grow exports enough to reduce the debt load and increase prosperity. Lifting labour productivity depends on improving the drivers of labour productivity; entrepreneurship, innovation, skills and talent, investment, and natural resources. For some drivers New Zealand has made choices that differ from those made in other advanced economies and there is good reason to believe that those choices have eroded relative economic performance. New Zealand is fortunate that there is great potential for improving performance on the labour productivity drivers. New Zealand's most important sectors for exports are tourism, agriculture, and manufacturing. All three sectors have average or lower than average productivity so simply growing these activities without also substantially lifting productivity would not lift GDP per capita materially. Denmark is one of the world's wealthy countries. Denmark's food and agriculture exports per capita are similar to New Zealand's and Denmark's agricultural productivity performance is similarly low. But Denmark's differentiated goods and services exports are much higher and that difference explains Denmark's high prosperity. There are many opportunities in agriculture, natural resources, and tourism, and these should be pursued where competitive advantage and high value jobs are available. But information, communications and technology (ICT), and niche manufacturing, along with value-added and differentiated goods and services based on primary production, are where New Zealand should invest most aggressively. New Zealand's success at exporting differentiated goods and services has been limited by the obstacles of small domestic market size and distance from markets. Applying the diagnostic approach reveals internationalisation of businesses as a critical binding economic constraint. But over-reliance on economic liberalisation has led to New Zealand committing less effort than other small trading countries to overcome the internationalisation challenge. If the issue had been recognised sooner, and remedial action had followed, the country would be in a much stronger economic position now. Examples of successful internationalising firms from New Zealand demonstrate that success is possible. Increased efforts to develop entrepreneurs, to train managers and others to become high-skilled workers, and to ensure adequate capital supply are all possible. Other small countries are becoming prosperous by exporting differentiated goods and services and New Zealand must find a way to join them or find another strategy for success. A strategy is a reallocation of resources to achieve a valued goal. If the goal is important and the strategy is sound then the reallocation should be material; sufficient to change the outcome. A few tens of millions of dollars is not material. Competing small countries are committing hundreds of millions of dollars to efforts they regard as strategically important. Our conclusion that supporting internationalisation success for differentiated exports should be the economic strategy priority should be tested and debated. If the conclusion survives that scrutiny then a material reallocation of resources should follow.

Giesecke, James; Schilling, Chris. The economic impact of the New Zealand fiscal stimulus package. New Zealand Economic Papers. fiscal stimulus; dynamic CGE; New Zealand economy. 2010.

fiscal stimulus; dynamic CGE; New Zealand economy

Abstract: Unlike many countries affected by the global financial crisis, New Zealand did not announce a formal fiscal stimulus package. However, via a series of policy announcements beginning in October 2008, by March 2009 the government budget balance had moved towards deficit by 1.6% of 2011 GDP. We interpret this discretionary movement towards deficit as New Zealand's fiscal stimulus package. The package largely comprises three policies: cuts to personal income taxes, cuts to business taxes, and infrastructure spending. We investigate the individual and joint effects of these policies using a dynamic CGE model of the New Zealand economy. We find that the package has a small positive effect on short-run employment, but at a cost to long-run real consumption. We examine an alternative package, which generates a larger short-run employment gain, for a similar long-run real consumption cost

Gyngell, Allan; Skilling, David; Thirlwell, Mark. Australia and New Zealand in a globalising world. The New Zealand Institute. 2007.
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Jensen, Beneikte. The end of the golden weather: The financial crisis, global recession, and what this means for New Zealand. 2008.
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Lattimoer, Ralph; Le, Trinh; Claus, Iris. Stroombergen, Adolf. Economic progress and puzzles: Long-term structural change in the New Zealand economy, 1953-2006. NZIER. 2009.

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O'Donovan, Brendan. Stephens, Dominick. Gordon, Michael. Bonniface, Anne. Delbruke, Felix. Denne, Natalie. Westpac Economic Review: January 2011. 2011.

Skilling, David. Home is where the money is: The economic importance of savings. 2005. www.nzinstitute.org
Abstract: Asset ownership is increasingly important for meaningful participation in society and the economy. Ownership enhances the ability of people to access opportunities and to invest in the future – by buying a house, financing education, and so on – and allows people to cope with shocks. Assets provide greater security, control, and independence. A broad distribution of ownership also generates enhanced social cohesion at a national level, and ensures that more New Zealanders obtain the benefits of economic growth. So helping all New Zealanders acquire assets will make a significant contribution to New Zealand's economic and social future. In recognition of the increasing importance of asset ownership, many countries are introducing and expanding 'asset based policies' that assist and encourage people to accumulate wealth. Creating an ownership society, in which ownership of assets is broadly distributed through the population and in which all people are able to accumulate wealth over their lifetimes, is a policy priority across many countries. And such policies are advocated by governments and political parties from across the political spectrum; it is not a policy solely of the left or of the right. However, many New Zealanders do not have any real wealth holdings. And many New Zealanders – particularly young New Zealanders – are finding it increasingly difficult to advance financially and build an ownership stake; rising house prices and declining home ownership rates, student loan debt, and an emerging debt culture, all make wealth accumulation harder. Further, New Zealand's overall level of household wealth is substantially lower than in most other countries, and this is likely to constrain domestic investment, productivity and growth. Although New Zealand has historically had policies that assisted people to accumulate wealth – like assisted home ownership – these policies have been removed over the past two decades, and there are currently no deliberate policies that assist New Zealanders to build an ownership stake. This sets New Zealand apart from the international policy mainstream, and increasingly so as countries pursue asset based policies to encourage ownership. We have chosen 'Creating an Ownership Society' as our initial work program because increasing the number of New Zealanders with an ownership stake – and increasing the overall level of asset ownership in New Zealand - will have a profound effect on New Zealand's economic and social future. We also believe that New Zealand policy settings in this area are increasingly out of date and we want to contribute new and creative thinking to the New Zealand debate, drawing on developments in international policy and thinking. Our focus is on identifying ways in which New Zealanders can be assisted to acquire assets over their lifetime. So over the next several months, we will be releasing a series of papers examining different aspects of this issue, discussing these issues with New Zealanders, and developing recommendations as to how government, business and community organisations can assist many more New Zealanders to build an ownership stake.

Skilling, David. Choosing to compete: Increasing the magnetism of the New Zealand economy. 2006.
www.nzinstitute.org
Abstract: Recent headlines speculating about the relocation of Fletcher Building to Australia, the exit of companies like Waste Management from the NZX, and the seemingly unending news of Australian private equity firms purchasing New Zealand companies, like Hirepool and Metropolitan Glass, have generated an increasingly high profile public debate – and mounting concern – about the so-called hollowing out of the New Zealand economy.1 Is New Zealand becoming a nation of employees, increasingly owned by foreign investors? Does the hollowing out of the New Zealand economy undermine New Zealand's economic sovereignty, and ultimately compromise the performance prospects of the New Zealand economy? I will frame my remarks on these issues around the notion of making choices. National attitudes in New Zealand often seem to oscillate between complacency – New Zealand is the best country in the world and there is no need to do anything – and fatalism – New Zealand's doomed and there's nothing much we can do about it. In the context of the hollowing out of the New Zealand economy, I will argue that neither complacency nor fatalism is appropriate. In the first half of this essay, I will explain why complacency is not a reasonable response and that as a country we do need to make some deliberate choices. Current course and speed is not delivering good outcomes. And in the second half of this essay, I will make the case that fatalism is not an appropriate response either. Although the forces that are driving the hollowing out of the New Zealand economy are powerful, New Zealand has a series of choices available to us that can act to remedy this situation. We have more choices than I think we commonly recognise. In terms of the structure of this essay, I begin by defining hollowing out and then examine the scale of this issue and form a view on its significance for New Zealand. The conclusion of this analysis is that the hollowing out of the New Zealand economy is a serious issue. But in order to understand what, if anything, can be done in response, it is important to first understand the underlying dynamics of this process. New Zealand is not the only country grappling with the exit of companies to larger markets, and there is a well-developed body of international thinking and evidence on this powerful tendency towards agglomeration. It is in this context that the nature of the appropriate policy response for New Zealand is considered. In particular, I will outline the key dimensions of 'magnetic economic policy'; policy settings that are deliberately designed to attract and retain companies in New Zealand.

Skilling, David; Boven, Danielle. Dancing with the stars? The international performance of the New Zealand economy. 2005.
www.nzinstitute.org
Abstract: The New Zealand economy has performed well over the past 15 years, with economic growth rates that exceed those generated in previous decades and that compare well against the US and Australia. The challenge now is to build on this good performance, so that New Zealand's income levels converge to those of other developed countries. Sustaining high rates of economic growth into the future will necessarily involve a substantial increase in labour productivity growth. New Zealand is a small economy, and substantially raising New Zealand's labour of exporting and foreign investment by New Zealand firms. Exporting and investing offshore provides scale, growth opportunities for New Zealand's most productive firms, and great learning opportunities for New Zealand firms. New Zealand cannot achieve and sustain high rates of productivity growth without making much greater use of larger markets through international activity. However, New Zealand's international performance does not compare well against many other developed countries, and only a small number of New Zealand companies are substantially engaged in international markets in terms of either exporting or investing. New Zealand is not participating in increased international economic activity to the extent that many other countries are. Of course, New Zealand firms do face particular difficulties in terms of moving into international markets because of the small size and remoteness of the New Zealand market. It is this combination of the importance of international engagement, and the difficulties that some New Zealand firms face in going global, that provides the motivation for this project. This project is being undertaken to identify the actions and policies that will move New Zealand towards becoming a genuinely global economy, in which much more of New Zealand's national income is generated offshore and where New Zealand firms win systematically abroad. Over the next several months, we will be releasing a series of reports examining different aspects of this issue. Initial reports will describe why taking the New Zealand economy to the world is vitally important, will examine New Zealand's current exporting and international investment outcomes, and will identify some of the key reasons that New Zealand's international outcomes do not compare well against other small, developed countries. An important part of this project will be conversations with a wide range of business and political leaders about the key issues and the actions that can be taken to increase exporting and international investment by New Zealand firms. This will provide the basis for reports that focus on a range of solutions. The aim of the project is to identify the actions of government, business, and others, which are required in order to take the New Zealand economy to the world in a material and successful way. Creating a global New Zealand economy is an important but demanding challenge, and will require sustained leadership from both the private and public sectors.

A2.2 GROWING INCOME INEQUALITY

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Abstract: This inter-departmental report provides a broad range of indicators relevant to New Zealand's economic performance. This document characterises the New Zealand economy and includes discussion on how indicators provide a picture of the factors influencing economic growth. The indicators include a set on wellbeing and prosperity, along with more economic measures of productivity and income growth. The indicators used in this report vary in quality, timeliness, and robustness due to the different sources. Most indicators in this report are benchmarked against Organisation for Economic Co-operation and Development (OECD) countries.

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Abstract: This research note draws on census data to chart the course of the distribution of personal incomes in New Zealand from 1951 to 2006. Gini co-efficients (Ginis) are given for both total and Maori populations and for men and women separately

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A2.3 DECLINING "SOCIAL CAPITAL"

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Andrews, Rhys; Brewer, Gene A.. Social Capital and Fire Service Performance: Evidence from the U.S. states. Social Science Quarterly, Vol.91, Issue 2. 2010.
Abstract: The present study evaluates whether areas with high levels of social capital are likely to have better fire service performance. Utilizing Robert Putnam's 14-measure index of social capital, OLS regression techniques are applied to objective data on the rate of unintentional fire deaths in the U.S. states between 1980 and 2003. The findings show that social capital is associated with a low unintentional fire death rate, even when controlling for a range of important environmental constraints. However, the effects of social capital vary by its conceptual components. The study supports the argument that social capital is likely to be an important determinant of fire service outcomes, and suggests that the political engagement and social trust components may be the most important focus for public policies seeking to build social capital in order to reduce fire fatalities.

Roskruge, Matthew; Arthur Grimes, et al. Homeownership and Social Capital in New Zealand, Motu Working Paper 11-02 March 2011. Motu Economic and Public Policy Research. 2011.
Abstract: Does homeownership affect individual social capital and thereby influence local outcomes? Following DiPasquale and Glaeser, a body of literature suggests that homeownership is positively related to social capital formation. Homeowners have an incentive to engage in the local community in order to preserve or enhance the value of their housing asset. Moreover, homeownership creates barriers to geographic mobility, which increases the present value of the expected stream of benefits from local community social capital. We test the homeownership hypothesis alongside other individual, household and locational determinants of social capital using unique data created by merging the 2006 and 2008 samples of the New Zealand Quality of Life survey. The measures of social capital used in our analysis include trust in others, participation in social networks, attitude The results confirm that homeownership exerts considerable positive impact in the formation of social capital in New Zealand communities. In raising accountability of local government it does, however, lead to reduced satisfaction by homeowners in the performance of local councils.

Spellerberg, Anne. Social Capital in New Zealand. Social Capital Programme Team, Statistics NZ. 2001.
http://www2.stats.govt.nz/domino/external/web/prod_serv.nsf/htmldocs/Framework+for+the+Measure+of+Social+Capital+in+New+Zealand
Abstract: For several years, social capital has been of interest in New Zealand. In particular, central and local government have recognised that an understanding of social capital may contribute to a broader analysis of policy options and issues. Relevant policy areas are varied - from education, health and justice, to industrial development, productivity and economic growth. This document suggests a framework for the measurement of social capital in New Zealand. Using an operational definition of social capital, the framework draws on the work of James Coleman, a Mäori concept, and the experience of overseas field researchers to propose four structural components. These relate to behaviours, attitudes and values, population groups, and organisations. Several indicators are suggested for each component along with possible ways of measuring these indicators. This paper is intended to stimulate discussion and to inform understanding of the statistical components and measures of social capital in New Zealand

A2.4 DECLINE IN OWNER OCCUPANCY HOUSING TENURE

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Scobie, Grant; Le, Trinh; Gibson, John. Housing in the household Portfolio and Implications for retirement saving: Some initial finding from SOFIE. New Zealand Treasury. 2007. www.treasury.govt.nz

Abstract: Housing is an important sector of the economy. It has widespread implications for investment, banking, saving and employment. Home ownership has been linked to building social capital and a sense of community. Furthermore housing equity is a significant element of retirement accumulation for many New Zealanders. The Treasury maintains a programme of work related to housing, saving, wealth accumulation and retirement. The results of this contribute to Treasury's role in providing advice to the Minister and at the same time informing a wider group of external stakeholders. This paper uses unit record data from a new panel survey (SOFIE) to study housing wealth in household portfolios. It then estimates the rates of saving that would be needed to smooth consumption between pre- and post-retirement. Finally it explores the effect of some home equity withdrawal on the required saving rates. The main findings of this study are:

- 60% of households are recorded as owning a home;
- Almost half of home-owning households have no mortgage debt;
- One in six households own residential investment property;
- One in twelve households own a rental property;
- Patterns of property ownership in New Zealand are similar to those in selected comparator countries;
- Housing represents a major share of household wealth, and this share has risen in line with the increase in house prices;
- The composition of household portfolios is comparable to other selected countries except for the USA ;
- Empirical results indicate that even if households planned to draw down half of housing equity to support retirement income, the impact on the saving rate needed to smooth consumption would be modest.

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A2.5 MIGRATION AND URBANISATION

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Bräuninger, Michael. Social Capital and Regional Mobility. University of Kassel. 2002
Abstract: This paper explores the relation between social capital and regional labour mobility. Individuals live for two periods. In the first period they work and invest into regionally immobile social capital. At the end of the period there may be an income shock. In the case of a shock, individuals have to decide whether to move into another region where they can maintain their income but lose social capital, or to stay in the region, accepting the income loss but maintaining their social capital. Social capital depends on the individual's own investment as well as on that of other individuals. This gives rise to multiple equilibria. There are societies where social capital is low and, therefore, moving costs are low. In other societies everybody builds immobile social capital and, therefore, everybody is immobile
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Bedford, R.; Ho, Elsie. Immigration Futures: New Zealand in a Global Context. New Zealand Population Review,32(2):49-63 2006.
Abstract: At no other time in the past century has there been such focused and intense global interest in international migration. Never before has there been such interest, internationally, in how Australia, Canada and New Zealand manage their international migration. These countries have become models for governments elsewhere who are seeking to develop policy that has a more direct impact on the quality of the population flows into their countries. New Zealand is unusual by OECD standards in that it has a high level of emigration of citizens at the same time that it has a very high per capita rate of immigration. New Zealand's contemporary migration flows are examined briefly and it is demonstrated that the system is not nearly as dominated by migration from countries in northeast Asia as it was a decade ago. A more flexible approach to the attainment of permits to reside in a country is being adopted in most countries now. The prospective migrants take the opportunity to assess employment opportunities and the quality of life in a prospective new home (perhaps not their only home either), while working or studying on temporary permits and gaining the sort of local experience that is valued in the points-based immigrant selection systems. The paper concludes with a brief analysis of data relating to transition to residence in New Zealand.

Guerin, Pauline; Nikora, Linda; Rua, Mohi. Tuhoe on the Move: Regional Mobility. New Zealand Population Review. 32(2)65-90: 2006.
Abstract: Academic interest in geographic mobility of indigenous peoples has increased in recent years with a corresponding growth in the literature relating to Maori mobility more specifically. With this greater acknowledgement of Maori issues has also come an awareness of the need for iwi-specific research because of the diversity within and between Maori and iwi. The present research contributes to a larger project exploring Tuhoe regional mobility. In this paper, we analyse published data and unpublished census data from 2001 that relate specifically to Tuhoe regional mobility and the relationship between mobility and language. Region of residence in 1996 and 2001 were analysed in relation to age, sex, and broad language groups. Overall, this analysis found important and diverse relationships between age, sex, language, and region of residence in New Zealand among Maori who identify as Tuhoe. For example, patterns of mobility for different age groups and sex had some similarities with other research, such as a higher proportion of "stayers" in older age groups, but differences were also found, such as higher proportions of "movers" among females in some age groups. Interestingly, we found that language between "movers" and "stayers" differed depending on the region of residence. A greater proportion of "movers" were able to converse in Maori in Auckland and the Waikato, but a slightly greater proportion of "stayers" could converse in Maori in the Hawke's Bay and Bay of Plenty. These results suggest that geographic mobility among Maori, and Tuhoe more specifically, are complex and should not be overly-simplified in more aggregate analyses

Lovelock, Kirsten; Leopold, Teresa. Labour Force Shortages in Rural New Zealand: Temporary Migration and the Recognised Seasonal Employer (RSE) Work Policy. New Zealand Population Review. 33/34: 213-234, 2008.
Abstract: Contemporary economic and social change in the agricultural sector in New Zealand in conjunction with a time of full employment has ensured that labour shortages are an increasing reality for many primary producers. Increasingly too, changes in land use within this sector, especially where viticulture and horticulture have replaced sheep and beef production in some areas, have increased the demand for temporary seasonal workers. This paper explores how New Zealand immigration policy is responding to these changes in the agricultural, horticultural and viticultural sectors, paying particular attention to the use of temporary migration as a means to address labour shortages in these sectors through the Recognised Seasonal Employer (RSE) policy. The paper draws on interviews with public sector stakeholders conducted in late 2007 and early 2008 where the objective was to explore the reasons for establishing the RSE policy, the process of policy development and anticipated outcomes. This paper outlines the intentions behind this scheme, observes current research in the area and highlights the need for further research on the use of temporary migration to meet labour needs in New Zealand.

Perry, Martin; Hayward, David. Contribution of Demographic Structure to Regional Migration, 1991-2001. New Zealand Population Review. 2003.
Abstract: Shift share analysis is applied to the change in regional migration over two time periods (1991-1996 an d 1996-2001) to indicate how regional differences in age structure and the mobility of individual age cohorts influence changes in migration. Their impact is found to be important in the case of some regions but only a small part of the overall change in migration flows.

Schroder, Catherine. Attachment to Place in New Zealand. New Zealand Population Review. 33/34: 177-212, 2008.
Abstract: Attachment to place is believed to play a fundamental role in understanding residential mobility, however, there is still very little understanding of what attachment actually means, its dimensions, who is attached, and in what ways. This paper addresses each of these questions by analysing the results of a National Attachment Survey administered to 1001 people in New Zealand in 2005.1 The international literature on place attachment points to its multidimensionality. Collectively these are expressed in terms of attitudes (e.g. sentiment and satisfaction) and behaviour (formal and informal social networks). Based on the survey responses, principle components factor analysis is applied to retrieve five dimensions which are subsequently labelled sentiment, friends, relatives, participation in, and satisfaction with the community. Each of the five dimensions of attachment, are regressed on a suite of demographic variables revealing how different subpopulations are associated with different forms of attachment. Different characteristics of places were also found to invoke different dimensions of attachment, even after controlling for the characteristics of respondents. Both sets of results, for individuals and places, have important research and policy implications.

A2.6 AT RISK COMMUNITIES

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AFAC. Accidental fire fatalities in residential structures: who's at risk?. 2005.
Abstract: The 'Accidental Fire Fatalities in Residential Structures: Who's at Risk?' project is a research initiative of the Australasian Fire Authorities Council (AFAC). The project was conducted with the cooperation of Australian Fire Services and the New Zealand Fire Service. The 'Accidental Fire Fatalities in Residential Structures: Who's at Risk?' project builds on the 1998 'Fire Fatalities: Who's at Risk?" Research Report and provides further insight into the identification of 'at risk' groups, time periods of elevated risk, and major causes of fatal fires. Armed with this information, Australasian Fire Services and other associated bodies are placed in the advantageous position of being able to develop enhanced strategies aimed at reducing the total number of fire fatalities in Australia and New Zealand

AFAC. Accidental fire injuries in residential structures: who is at risk?. Australasian Fire and Emergency Service Authorities Council. 2009.
Abstract: The 'Accidental Fire Injuries in Residential Structures: Who's at Risk?' project is a research initiative of the Australasian Fire and Emergency Service Authorities Council. The project was conducted with the cooperation of Australian Fire Services and the New Zealand Fire Service. Data from rural South Australia was not available at the time this report was produced and therefore could not be included in this report. The 'Accidental Fire Injuries in Residential Structures: Who's at Risk?' project complements the October 2005 'Accidental Fire Fatalities in Residential Structures: Who's at Risk?' report providing further insight into the consequences of residential fires on people in terms of fire injuries. The report includes the identification of 'at risk' groups, time periods of elevated risk, and major causes of fires that cause injury to people. This information will assist Australasian Fire Services and other associated bodies to develop targeted strategies aimed at reducing the total number of fire injuries in Australia and New Zealand

CRESA. A Review of Existing Fire Safety in Homes. New Zealand Fire Service Commission Research Report Number 88. 2009
Abstract: This research aimed to contribute to a reduction in the incidence and consequences of unintended fires in New Zealand households by estimating the prevalence and characteristics of risk factors across a range of dwellings and household types. These findings provided a basis for developing practical risk assessment tools and delivery mechanisms for typical and hard-to-access households.

Duncanson, Mavis; Alistair Woodward; Papaarangi Reid. Social & economic deprivation and fatal unintentional domestic fires in NZ 1988 - 1998. New Zealand Fire Service Fire Research Report No. 5. 2000.
Abstract: The first report to establish a spatial correlation between social and economic deprivation and fire fatalities.

FEMA Fire Risks for Older Adults United States Fire Administration. 1999
Abstract: Older adults represent one of the highest fire risk populations in the United States. As a result of progressive degeneration in physical, cognitive, and emotional capabilities, older adults present unique challenges in the fields of fire protection, prevention, and safety. Complications associated with aging increase the likelihood that an elderly person will accidentally start a fire and at the same time reduce his or her chances of surviving it. As the nation's elderly population grows, the fire death toll will likely rise in direct proportion to that growth unless measures are taken to ameliorate the risks associated with this group. The fire safety community must address the fire safety needs of older adults or be faced with the potential for a severe public health problem.
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UMR. Effectiveness of Digital Media and Social Networking for Reaching At-risk Groups. New Zealand Fire Service Commission Research Report Number 118. 2011

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Barrett, Patrick; Twitchin, Stephen. The living environments of community-dwelling older people who become frail: another look at the living standards of older New Zealanders survey. .
Abstract: Efforts to support older people who live in the community and who become frail will be enhanced by a better appreciation of the shared characteristics of this group. This paper reports indicative findings from a re-analysis of the Living St

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Carter, Kristie; Hayward, Michael; Blakely, Tony; Shaw, Caroline. How much and for whom does self-identified ethnicity change over time in New Zealand?. Social Policy Journal of New Zealand. 2009.
Abstract: Ethnicity is often assumed to be a stable construct. However, much research in New Zealand has shown growth in the number of people reporting multiple ethnicities and changes in the ethnic composition of New Zealand, which may reflect social changes as well as changes in the construct of ethnicity. This study uses three years of data from the longitudinal Survey of Family, Income and Employment (SoFIE) to examine changes in self-identified ethnicity. Self defined ethnicity is recorded every year and participants may record multiple ethnicities. A change in ethnicity was defined as any change in the reported ethnic group(s) of an individual over the first three waves of SoFIE. Overall, 8% of respondents changed ethnicity at least once during the three waves of the survey. The strongest

predictor of changing self-identified ethnicity was Maori, Pacific and Asian ethnicity at wave 1, as well as reporting more than one ethnic group. Individuals who changed ethnicity were also more likely to be younger, to be born overseas, to live in a family with children, to belong to more deprived groups, and to have poorer self-rated health. This exploratory analysis has shown fluidity in the concept of self-identified ethnicity, but more longitudinal research is needed to further clarify the (in)stability of ethnicity over time.

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Abstract: Unattended cooking is the most common cause of house fires in New Zealand, accounting for nearly one quarter of fires nationally. This is followed by electrical failure in faulty equipment and wiring, and then deliberate firesetting. Includes a pie-chart showing proportions of fires attributed to each type of fire origin, over the period 2002-2004.

Cuthbert, Bas; Challands, Neil. FIRM facts : Social deprivation and ethnicity. BRT (Bulletin of Research and Technology), no10 (Jun 2003). 2003.
Abstract: Chart showing the number of people in each of the main ethnic groups according to their level of socioeconomic deprivation. Previous research has shown that the risk of experiencing a residential structure fire increases with rising socioeconomic deprivation

Dharmalingam, A.; Pool, I.. Population Projections: Stochastic Simulation, Techniques and Applications. NEW ZEALAND POPULATION REVIEW. 2005.
Abstract: The paper describes five ways in which stochastic population projections can contribute to policy analysis: (1) stochastic population projections provide a much richer characterization of demographic uncertainty than conventional projections; (2) stochastic projections are less likely than conventional projections to yield misleading results; (3) the results from stochastic projections are easier to explain to lay people; (4) stochastic projections permit a clear distinction between demographic uncertainty and policy options; and (5) stochastic population projections permit an appropriate division of responsibility between technical experts and policy practitioners

Duncanson, Mavis; Woodward, Alistair; Reid, Papaarangi. Socioeconomic deprivation and fatal unintentional domestic fire incidents in New Zealand 1993-1998. Fire Safety Journal 37. 2002.
Abstract: A cross-sectional study was undertaken in Aotearoa New Zealand to investigate the relationship between socioeconomic deprivation and risk of an unintentional fatal domestic fire incident. Addresses of unintentional fatal domestic fire incidents were geocoded to small area (census meshblock) level and analysed with the New Zealand index of socioeconomic deprivation. Fatal unintentional domestic fire incidents occurred disproportionately in dwellings in the most socioeconomically deprived meshblocks. Annual rates of fatal unintentional fire incidents per 100,000 households in the most deprived decile were significantly higher than rates in the least deprived decile (RR 5.6, 95%CI 1.9–16). Strategies to prevent fire related deaths must overcome barriers to household fire safety in population groups experiencing increased risk, including the socioeconomically deprived, seniors, and ethnic minorities. Specific intervention strategies relevant to risks associated with socioeconomic deprivation include improving quality and affordability of housing; increasing prevalence of installed and functioning smoke detectors; and regulation of specific characteristics of cigarettes to reduce risk of ignition from abandoned heat sources. Substantial progress awaits reduction of the underlying socioeconomic determinants of disadvantage. r 2002 Elsevier Science Ltd. All rights reserved

Finnis, Kirsten. Creating a Resilient New Zealand: Can public education and community development campaigns create prepared communities? An examination of preparedness and motivation strategies. Ministry of Civil Defence and Emergency Management. 2004.

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Abstract: Children under age 5 are almost one and a half times as likely to die in a home fire as the average person, but their relative risk has been declining over time. Adults over the age of 65 are more than twice as likely to die in home fires as the average person. Alcohol or other drugs, disabilities and age-related limitations are all factors in the risk of home fire death.

Friensen, Myron; Woodward, Lianne; Fergusson, David; Horwood, John; Chesney, Anna. Living Standards and Material conditions of young New Zealand families. .
Abstract: The purpose of this paper is to provide a descriptive profile of the personal characteristics and socio-economic circumstances of a cohort of young parents (N = 155) who had full-time care of at least one dependent child at 25 years of age.

Hurnard, Roger. Hyslop, Dean. Tuckwell, Ivan. The living standards, Incomes and Accommodation Costs of older New Zealanders Revisited. New Zealand Treasury. Living standards; material well-being; current income; accommodation costs. 2005.
Living standards; material well-being; current income; accommodation costs
Abstract: In 2001 the then Ministry of Social Policy published a comprehensive study of the living standards of older New Zealanders. The current paper revisits the estimated relationship between material well-being and the current income and accommodation costs of older people, and questions the extent to which income and accommodation costs directly affect well-being or proxy for other factors. We first extend the estimated relationship between material well-being and current income to include the source of the income as well as its level. We find that controlling for different income sources roughly halves the estimated associative effect of income on material well-being. Furthermore, for a given level of income, those with higher fractions of either employment earnings or capital investment income have significantly higher material well-being scores, while those with a higher fraction of income from benefit allowances have lower scores. One interpretation is that these factors may proxy for other causal factors, such as health and wealth effects, rather than reflecting a direct income effect. Next, we extend the original specification between material well-being and accommodation costs to, first, include property rates as an accommodation cost and, second, to control for the type of housing tenure (freehold homeowner, mortgaged, renter, and no accommodation costs). We find that, controlling for housing tenure, the estimated effect of accommodation costs (including rates) is, at most, half that originally estimated and, for some specifications, insignificantly different from zero. Furthermore, controlling for the level of accommodation costs, mortgage holders and renters have significantly lower material well-being scores than freehold homeowners. These findings suggest that understanding what influences the material well-being outcomes of older people is not as straightforward as might be suggested by the simple association of certain variables.

Jakes, Pamela; Kelly, Laura; Langer, E.R.. An exploration of a fire-affected community undergoing change in New Zealand. The Australian Journal of Emergency Management. 2010.
Abstract: In the first case study of a fire-affected community in New Zealand's rural-urban interface, researchers found evidence to support findings raised in other countries regarding evacuation, blaming behaviour and perceptions of risk. Differences were evident based on ownership tenure, including less awareness of wildfire risk and preparedness among those with shorter residency. The study also provides new evidence of wildfire highlighting or intensifying existing divisions within an affected community.

Jaslow, David; Ufberg, Jacob; Yoon, Russell; McQueen, Clay; Zecher, Derek; Jakubowski, Greg. Fire Safety Knowledge and Practices Among Residents of an Assisted Living Facility. Prehospital and Disaster Medicine. 2005.
http://pdm.medicine.wisc.edu
Abstract: Assisted living facilities (ALFs) pose unique fire risks to the elderly that may be linked to specific fire safety (FS) practices. Objective: To evaluate self-reported FS practices among ALF residents. Methods: All residents of a small ALF were surveyed regarding actual and hypothetical FS behaviors, self-perceived fire risk, and FS preparedness. Results: Fifty-eight ALF residents completed the survey. Thirty-three (58%) individuals reported one or more disabilities. Seven (12%) residents ignored the fire alarm and 21 (35%) could not hear it clearly. Sixteen (28%) residents would attempt to locate the source of a fire rather than escape from the building. Only 24 (42%) residents were familiar with the building fire plan. Twenty-three (40%) people surveyed believed that they were not at risk of fire in the study facility. Conclusion: Residents of an ALF may be at increased fire injury risk due to their FS practices and disabilities

Khawaja, Mansoor; Boddington, Bill. Too Early to Retire? Growing Participation of Older New Zealanders in the Labour Force. New Zealand Population Review. 2009.
Abstract: This paper examines key trends in the labour force participation of New Zealanders aged 65+ years during 1986-2006, their dynamics and likely determinants. While a majority of senior New Zealanders retire by the age of eligibility for New Zealand Superannuation (65 years), a growing proportion are extending their working life, either on a full-time or a part-time basis. At the 2006 Census of Population and Dwellings, 17 percent (one in six people) aged 65+ years were gainfully employed, and for those aged 65-69 years, the figure was much higher at 34 percent (one in three). In recent decades, a host of socio-economic developments have coincided, including growth of service industries, increased opportunities for part-time or contractual work, skill shortages and a more buoyant economy in the early years of the new millennium – all of which probably had a bearing on these trends. Using a range of demographic characteristics, notably age, gender, ethnicity and education, the paper also describes and compares the labour force experiences of various population subgroups in New Zealand.

Legge, Jaimie; Heynes, Anne. Beyond reasonable debt: a background report on the indebtedness of New Zealand families. Social Policy Journal of New Zealand. 2009.
Abstract: This paper reviews international literature and New Zealand data to examine the indebtedness of New Zealand families and identify circumstances and behaviours that might distinguish families who use debt well from those who do not. Some circumstances (notably being young, having children and separation) and some behavioural traits (basing aspirations on comparisons with others and being impulsive) appear to be important in determining who

gets into debt. Other circumstances (notably having low income) and other behavioural traits (having an external locus of control) appear to be important in determining who gets into problem debt. Having an external locus of control means you believe your environment or other people control your decisions.

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http://www.treasury.govt.nz
Deprivation, inequality, distribution, meshblocks, regions
Abstract: This paper presents an analysis of the distribution of socio-economic deprivation throughout New Zealand. The analysis focuses on the three census years 1986, 1991, and 1996. A summary deprivation measure is constructed which approximates NZDep96 using standard regression techniques. The paper extends a static analysis of deprivation by examining changes to the deprivation profile across time on a regional basis. Differences in the incidence of deprivation for different ethnic groups are emphasised. Maori and Pacific people are more likely to live in deprived meshblocks than their European counterparts. We also touch on the role isolation plays in determining the distribution of deprivation.

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http://www.nzma.org.nz/journal/118-1227/1779/
Abstract: Background Socioeconomic inequalities in all-cause child mortality exist in New Zealand; however the inequalities in cause-specific mortality have not been examined. This study examines child mortality inequality by household income between 1981 and 1999, by cause of death. Methods Data was used from a record linkage study of census and mortality records of all New Zealand children aged 0–14 years on census night 1981, 1986, 1991, 1996 followed up for 3 years for specific causes of mortality between ages 1–14 years. All cohorts were combined to calculate mortality rates, rate ratios, and rates differences for each cause of death. Results Socioeconomic differences in child mortality (low income compared to high income) were observed for injury (non road traffic) (RR 1.87, 1.35 to 2.58), road traffic injury (RR 1.36, 1.01 to 1.82), and 'other' causes of death (RR 1.81, 1.32 to 2.47). 'Other' and non-road traffic injury deaths together contributed 70% of the total gap in child mortality between the rich and the poor. Conclusions Socioeconomic differences existed across most broad causes of child death. The major contributors to mortality inequality are diverse, suggesting that the similar distal causes of inequality (e.g. poverty) play out through a myriad of proximal causes. Fortunately there appears to be some scope for policymakers to modify some of the proximal and distal causes of these inequalities

Smith, James. A Burning Issue: Cigarette-caused fires and burns in a population of New Zealand Smokers. The University of Auckland. 2008.
Abstract: This dissertation aims to estimate lifetime prevalence of cigarette-caused fires and burn injuries in a New Zealand population of moderate-to-heavy smokers. It examines the inequalities that arise from these fires and burns. Smoker characteristics associated with greater risk of cigarette burns or fires are also explored and the association between cigarette type (manufactured or hand-rolled) and risk of these events is estimated.

Zhanga, Guicheng; Leea, Andy; Lee, Hoe.Clintoa, Michael. Fire Safety among the elderly in Western Australia. Fire Safety Journal. 2004.
Abstract: Unsafe dwelling environments may contribute to high morbidity and mortality of residential fire among the elderly people. This study investigated the prevalence of fire safety devices and related risk factors in elderly households. A series of convenience surveys was administered at 11 council community centres within metropolitan Perth, Western Australia, between August and October 2004. A total of 1188 older adults aged 65 years or over were recruited. The results found generally low prevalence for electric safety switches (56%), fire extinguishers (18%) and fire blankets (10%), while 72% had a functional smoke detector installed. Nearly a quarter of the participants had never thought of an escape route. Logistic regression analysis based on generalized estimating equations further showed that those living alone had a significantly lower prevalence of smoke detector and functional smoke detector, with adjusted odds ratios 0.48 (95% CI: 0.34–0.69) and 0.55 (95% CI: 0.41–0.75), respectively. Similarly, elderly people living in private rental housing appeared to be less equipped against residential fire relative to those in public rental and those occupying their own homes. As expected, elderly people with home contents insurance coverage had a significantly higher prevalence of fire safety devices. These findings have important implications for the government and policy makers if community fire safety for the elderly is to be improved.

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1. What, if any, pertinent standards, laws, or recommendations exist?
2. What have other adjacent fire departments done to address this issue?
3. What factors suggest that a scene is not secure and/or there is a high potential for violence?
4. What indicators must be present to justify the use of physical force, and what are appropriate methods of self-defense?
A comprehensive literature review examined many sources, including trade journals, text books, fire department incident histories, and legal references. Research findings indicated that firefighter safety 3 issues due to violent incidents is a widespread concern. Indeed, many communities have experienced injuries and deaths to emergency personnel due to societal violence. Also, many agencies have implemented various strategies for coping with this trend, including special training, equipment, and policies. Applicable laws, standards, and recommendations were examined as they pertained to the subject. With respect to laws, the state of Oregon utilizes safety rules applied in the general sense, but were not topic-specific. The only nationally recognized standard found was NFPA 1500, which applied as a general safety guide, non-specific to responding to unknown hostile incidents. Several recommendations were developed; most revolved around training personnel for increased awareness and protection through appropriate use of policies and equipment. Some also pertained to uniform clothing, protective gear, and self-defense enhancements. Self defense issues were looked at, with the overall result being that of using incremental decision making when faced with violence, such as: 1) use caution and stay away from situations that are potentially violent, 2) retreat if possible, 3) use verbal skills to defuse situation, 4) use self defense manoeuvres as necessary for protection. The research findings were analyzed in a problem-solving mode seeking solutions for increasing personnel safety in unknown hostile situations. Conclusions were then drawn in light of currently observed field conditions and using the professional judgement of the author. Finally, the resulting recommendations from the research were: (a) implementation of the Standard Operating Guideline for Responding to Unknown Hostile Incidents as shown in Appendix A, (b) training personnel in relevant policies, procedures, and equipment, (c) assessment of protective equipment needs, (d) assuring that uniform clothing is boldly designated 4 fire department, does not include badges, and is clearly distinct from law

enforcement in appearance, (e) issuance of foam pepper spray (oleoresin capsicum) canisters to personnel, (f) seeking legal counsel, advice from law enforcement experts, and professional training prior to issuing impact weapons or firearms, and (g) that further research should be conducted on this and related topics to analyze the effectiveness of the aforementioned SOG and other recommendations.

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A3. REFERENCES FOR CHAPTER 3 IMPACT OF CONSUMER TECHNOLOGY CHANGES

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Abstract: During the recent years, several advances about smart environments are taking place. The challenge of transforming cities to 'smart' cities aims to combine competitiveness and sustainable urban development simultaneously. This is taking place through the combination of traditional urban environment, governmental and social functions with modern Information and Communication Technologies (ICT) providing e-services. At the same time, next generation technologies community puts efforts on issues associated with the development of community-based services that aim to capture and assess large amounts of data in a systematic collaborative manner. Thus, the concept of crowd sourcing becomes quite popular. In this paper we focus on discussing whether crowd sourcing can be facilitated in the contexts of smart buildings and cities in order to support a more effective and efficient integrated disaster management approach. Within this context, we exemplify the approach using few model architecture diagrams.

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Abstract: Despite the availability of the sensor and smart-phone devices to fulfill the ubiquitous computing vision, the-state-of-the-art falls short of this vision. We argue that the reason for this gap is the lack of an infrastructure to task/utilize these devices for collaboration. We propose that microblogging services like Twitter can provide an "open" publish-subscribe infrastructure for sensors and smartphones, and pave the way for ubiquitous crowd-sourced sensing and collaboration applications. We design and implement a crowd-sourced sensing and collaboration system over Twitter, and showcase our system in the context of two applications: a crowd-sourced weather radar, and a participatory noise-mapping application. Our results from real-world Twitter experiments give insights into the feasibility of this approach and outline the research challenges in sensor/smartphone integration to Twitter.

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Abstract: In this study based on the keywords of disaster prevention, social networking service(SNS), smart phones, and I consider to combine organically, to use disaster prevention "trust" and "human relations" in the deepening in the region. In the event of disasters such as earthquakes, the question of are in good to the scene of the regional information is accurate, the question of which mutual assistance among neighbors until the arrival of rescue teams, the question of which understanding the circumstance yourself to use existing disaster management system, these questions are have to resolve as background. To minimize the damage of the disaster to prepare for disasters is prevention. I hypothesize, not just disaster drill once a year, the question of which daily basis activity of neighborhood might have lead to the idea of cooperation work, the question of which the smart phones might be expected, and also smart phones are highly affinity with SNS, the idea of user -- friendly touch screen viewing in an emergency. How can I share information, consider what can be done to rescue them how to take advantage of features were verified through experiments. Index Terms: haptization, digital divide, the weak in information technology, information accessibility

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http://www.computer.org/portal/web/csdl/doi/10.1109/INCOS.2010.44
Abstract: During the past few years much effort has been put into developing community-based methods to capture and analyse a large amount of data in a systematic manner. The concept of crowd- sourcing (also known as citizen science) becomes quite popular. This is mainly due to its distributed service orientation and its group intelligence problem solving production model. Parallel to this emerging technology, Data Mashups join information from different data related services or applications available on the web for presenting a combination of functionalities among two or more services. The large amount of data generating and gathering from the client applications are hosted online and published in APIs so they facilitate an easy to integrate mechanism for future developers. Therefore, a new vision for scientists is the data information processing of Data Mashups alongside with the crowd-sourcing framework in the direction of how to store, process and benefit from collected data. In this exploratory paper we present a case-based scenario of a disaster management by highlighting how the aforementioned standards may play a significant role for solving such problems. Moreover, we discuss the emergence of paradigms and next generation technologies including Grids, Clouds and Ubiquitous and address issues related to their use in crowd-sourcing problem solver.

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Abstract: In a crisis situation, critical success factors include good preparedness, the availability of trustworthy information and reliable people, and the responders' ability to improvise with the available, functioning tools. Wikis can be used as collaborative group support systems to support these activities, especially for communities of practice that must operate as high reliability organizations. The advantages of using a wiki are especially beneficial in volatile environments, such as those in the emergency domain, where critical real-time decision making is required. An international wiki emergenciWiki.org - has been created and is being used by both practitioners and academics. The conclusions include that wiki features and functionality, which are important for safety- critical work, should add a minimum of bureaucratic overhead while helping to establish trust and a sense of purpose and community among the users, thus easing the evaluation of information reliability while strengthening ad hoc group interaction.

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Abstract: New technologies and inexpensive gear are about to create an explosion in the number of amateurs creating digital video content. In this paper we identify and discuss factors that affect the perceived goodness of video delivery platforms for amateur video distribution. The work is based on an analysis of amateur video producer categories and the types of videos that are created. We first discuss people's skills and motives to shoot and consume videos and categorize the amateur video producers accordingly. Once their work is done, people wish to present their video to some audience, either small or big. We discuss what characteristics are needed from a good Internet-based delivery

platform in order to satisfy different categories of amateur video producers. The characteristics include technological, sociological, and marketing aspects. We stress the importance of creating a sense of community in a delivery platform. This would compensate for the loss of a physical meeting and learning space that has happened due to the proliferation of inexpensive video creation tools that enable people to work on their own at their homes. Finally, we discuss the mobile future of the delivery platforms.

A3.4 COMMUNICATING WITH POPULATION IN AN EMERGENCY THROUGH SOCIAL NETWORKS

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Abstract: This paper presents the conceptual design of an emergency alert service which addresses the problem of getting help in a crowd. The design is based on the results of more than 30 years of research in social psychology on the bystander effect and it addresses the obstacles for helping by directing an alert directly to the members of the victim's social group who happen to be near the location of the emergency event. The proposed emergency recommender design combines the general availability of geo-location services with social clusters available either from the analysis of social web-sites or from communication analysis. For this purpose, two recently developed innovative clustering methods are used. The feasibility of the design is evaluated by simulating emergency events on the MIT reality mining data set.

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Abstract: The advanced capabilities for location-based services of smart phones are mostly used for travel applications, navigation or business fleet management. We motivate a social emergency alert service that makes use of the wide availability of smart phones and activates nearby social contacts in cases of emergency. Research has shown, that especially in busy urban districts help from fellow citizens is hard to receive because of the so-called bystander-effect: Nearby people often do not recognize or take responsibility for ongoing emergency situations. A simple and fast mechanism to call for help is necessary. Additional to local authorities as the police or rescue services, assistance from family or acquaintances is a valuable and fast(er) supplement. We describe the architecture of an emergency alert service providing the functionality required for the activation of social contacts and present a prototype. The distribution of tasks between mobile devices and server infrastructure and the underlying communication protocol are designed energy-efficient and privacy preserving. The central tracking of geo-positions is avoided.

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technology (ICT) could be designed to support this activity, which we refer to as megacollaboration. The goals are not only to better facilitate civilian responses to crises, but to also interface these bottom-up networks with the top-down structures of military and governmental agencies.
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Abstract: The rise of social media tools has enabled the "citizen journalist" to break news. In a crisis there are many examples of traditional news sources being bypassed as communities Tweet or use Facebook to connect. This very readable and engaging book guides emergency response agencies through the best practices in crisis media management. It applies the new media principles of engagement, speed, trust and accountability, to the crisis environment. The book outlines the role of media in a crisis, including media ethics. It guides you on the selection and use of spokespeople, including whether or not to use the CEO. The book also gives in-depth treatment to handling media interviews, from giving phone interviews or organising a press conference, to dealing with bloggers.

A3.5 USE OF MOBILE PHONES IN EMERGENCIES

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Abstract: In this paper we detail the security and privacy architecture and implementation of the HealthNet mobile electronic health monitoring and data collection system. HealthNet consists of a body sensor network embedded in clothing that communicates wirelessly to the wearer's mobile phone. The mobile phone is used to manage, store and transfer the data in a secure way. Data may be transferred to other parties, such as medical experts, emergency care and private parties trusted by the wearer himself, e.g. his family. The patient controls who may access his data. Only emergency physicians nearby the patient may access vital data without the patient's individual consent. We describe the unique security and privacy features of our architecture which may also be used to improve other telemonitoring solutions.

Chu, Liou. A RFID-Based Hybrid Building Fire Evacuation System on Mobile Phone. Intelligent Information Hiding and Multimedia Signal Processing (IIH-MSP), 2010 Sixth International Conference on, Darmstadt, 15-17 Oct. 2010 page(s): 155 - 158. DOI: 10.1109/IIHMSP.2010.46. 2010.
http://ieeexplore.ieee.org/xpl/freeabs_all.jsp?arnumber=5635989
Abstract: Building fire is a common disaster happening in our daily life that causes unfortunate casualties and deaths. Successfully escaping from fire depends on the design of evacuation route and time as most of the damage of fire is caused due to lack of evacuation equipments or poor design of the emergency route. In this research work, we designed a hybrid building fire evacuation system (HBFES) on a mobile phone using Radio Frequency Identification (RFID) techniques. The system will be implemented at Tamkang University on Lanyang campus where a central fire alarm system has been installed. Location Based Service (LBS) and several existing computer or mobile phone applications, namely Viewpoint Calculator, Path planner, and MobiX3D viewer will be used on the system to rapidly calculate the reliable evacuation routes when building fire takes place.

Duval, Sebastien; Christian Hoareau; Hiromichi Hashizume. Improving Quality of Life from Birth to Old Age with Ubiquitous Computing and Virtual Reality. 2008 International Conference on Convergence and Hybrid Information Technology, pp.371-377. DOI: 10.1109/ICHIT.2008.202. 2008.
http://www.computer.org/portal/web/csdl/doi/10.1109/ICHIT.2008.202
Abstract: Virtual reality and ubiquitous computing can significantly improve the general public's quality of life worldwide from birth to old age because they allow monitoring, awareness and support in real and digital worlds thanks to sensors, actuators, remote connections, and dedicated knowledge bases. However, age influences their usefulness and appropriateness due to growth and decline as well as changes in activities and uses of technology. Based on the cognitive, physical, physiological, and sensory characteristics of young people and older adults, we discuss dedicated systems that exploit intelligent environments, wearable computers and virtual reality. Our most significant contribution is the analysis of the potential and limits of ubiquitous computing and virtual reality to improve quality of life, taking into account all age ranges.

Hickey, K. Fire department's iPhone app can help save lives. Government Computer News. 2011.

Inoue, Y.; Sashima, A.; Ikeda, T.; Kurumatani, K.; Indoor Emergency Evacuation Service on Autonomous Navigation System using Mobile Phone. Universal Communication, 2008 . Second International Symposium on,: Osaka , 15-16 Dec. 2008 Pp 79 - 85. DOI: 10.1109/ISUC.2008.49. 2008.
http://ieeexplore.ieee.org/xpl/freeabs_all.jsp?arnumber=4724445
Abstract: Two difficult problems pertain to selection of an evacuation route according to each individual's situation. One is constant supervision of the situation of a living space and detection of dangerous situations; the other is detection of residents' respective positions. In this paper, we describe devices and systems for an indoor emergency evacuation using a mobile terminal such as a cell phone or PDA for indoor navigation. The navigation system functions autonomously: the user's device receives wireless beacon signals from the surrounding environment and can thereby detect a user's position by a mobile terminal independently. In fact, no server-side computation is necessary. Moreover,

the system is applicable to an indoor emergency evacuation system using various sensors. The emergency system navigates people to safety in the wake of a disaster. A system must detect all residents' positions and then inform them individually of routes to safety to evacuate all residents to a safe space urgently. We have developed a feasible indoor navigation system that can solve various problems arising in the application layer.

Neves, Pedro; Paulo Simoes et al. WiMAX for Emergency Services: An Empirical Evaluation. DOI: 10.1109/NGMAST.2007.61. 2007.
http://www.computer.org/portal/web/csdl/doi/10.1109/NGMAST.2007.61
Abstract: WiMAX, as a Broadband Wireless Access technology for Metropolitan Area Networks, supporting fixed and mobile terminals, is very promising for Next Generation Networks. Emergency Services can also strongly benefit from WiMAX features, allowing the exploitation of novel application scenarios and business models. This paper presents a set of scenarios, such as Environmental Monitoring, Telemedicine and Fire Prevention, defined and implemented in several European testbeds, interconnected by the European research network GEANT 2, in the framework of the WEIRD project1. In particular, we focus our attention on the scenario implemented in the Portuguese testbed Fire Prevention providing a detailed description about the testbed planning, implementation and evaluation.

Osamu Takizawa; Masafumi Hosokawa et al. Pinpointing the Place of Origin of a Cellular Phone Emergency Call Using Active RFID Tags. 22nd International Conference on Advanced Information Networking and Applications - Workshops 2008 pp.1123-1128. DOI: 10.1109/WAINA.2008.135. 2008.
http://www.computer.org/portal/web/csdl/doi/10.1109/WAINA.2008.135
Abstract: When police, fire or ambulance personnel receive an emergency call, they must pinpoint its place of origin in order to respond quickly. When such a call is made from a cellular phone, its place of origin can be determined by using GPS or a cell-based positioning method. However, these methods are sometimes inaccurate and have blind spots. We developed a system for determining location using RFID-reader-equipped cellular phones and RFID tags. We outline the prototype system here.

Pesout, Pavel; Ondrej Matustik. On the Way to Smart Emergency System. DOI: 10.1109/ITNG.2010.42. 2010.
http://www.computer.org/portal/web/csdl/doi/10.1109/ITNG.2010.42
Abstract: Thousands of people die today and every day as a result of fatal injuries during car crashes, fires, floods and other emergencies. Many of them die absolutely needlessly. They often become in few moments in so serious situation that they are unable to call emergency by dialing emergency number on their mobile phone. Price of human lives is incalculable, that is why it is necessary to look for new solutions to their saving. This solution can be the emergency system built-in directly in the mobile phone, which will analyze the surrounding and based on the interpretation of sensors and will evaluate the necessity of emergency signal transmission. Index Terms: built-in sensors, crisis definition, emergency system, mobile phone, pattern recognition

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Velez, F.J.; Carvalho, V.; Santos, D.; Marcos, R.P.; Costa, R.; Sebastiao, P.; Rodrigues, A.. Aspects of cellular planning for emergency and safety services in mobile WiMax networks. Wireless Pervasive Computing, 2006 1st International Symposium on , pp. 6 pp., 16-18 Jan. 2006. DOI: 10.1109/ISWPC.2006.1613643. 2006.
http://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=1613643&isnumber=33870

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José, Rui; Nuno Otero; Shahram Izadi; Richard Harper. Instant Places: Using Bluetooth for Situated Interaction in Public Displays. IEEE Pervasive Computing, vol. 7, no. 4, pp. 52-57, Oct.-Dec. 2008. DOI: 10.1109/MPRV.2008.74. 2008.
http://www.computer.org/portal/web/csdl/doi/10.1109/MPRV.2008.74

Matustik, Ondrej; Pavel Pesout. On New Opportunities of Saving Human Lives Using Mobile Phones. 2010 Second International Conference on Communication Software and Networks, Singapore, 2010 pp.131-135. DOI: 10.1109/ICCSN.2010.71. 2010.
http://www.computer.org/portal/web/csdl/doi/10.1109/ICCSN.2010.71
Abstract: Current technologies are helpful in many areas of human live. Focus of this article is on combination of technology and statistics with the aim of building mobile emergency system. Such system is based on evaluation of input signals to the mobile phone from its sensors, like VGA camera or microphone, and further processing with help of advanced statistical methods both in mobile phone and in the central processing machine. The purpose of this idea is to enable the mobile phone automatically alarm correct emergency process and help the person in emergency situation. The results can help thousands of people every day, when they are in crisis situation and unable to call for help. Index Terms: mobile emergency system, sensors, evaluating process, image recognition, sound recognition

A4. REFERENCES FOR CHAPTER 4 IMPACT OF NEW FIRE DETECTION AND SUPPRESSION TECHNOLOGIES

A4.1 NEW TECHNOLOGIES AVAILABLE ON THE NEW ZEALAND MARKET

References Cited in Report

McDermott Miller Limited. Environment Bay of Plenty Air Quality Marketing Strategy. Report to Environment Bay of Plenty, 2010.
Abstract: Development of an incentive loan package to encourage Rotorua homeowners and landlords to upgrade their home heating to environmentally "cleaner" appliances. The project involved indentifying and segmenting the relevant household market [owner occupiers and landlords], using survey based techniques, to estimate households' interest in and likely responses to the issue of air pollution in Rotorua; identifying and designing a range of possible financial incentive packages and evaluate their costs and appeal or otherwise to the market; and, devising a social marketing strategy to secure "take-up" of at least one of these packages, which in turn should help achieve Environment Bay of Plenty's objective of improving Rotorua's air quality.

Other Relevant References

Birch, David. Smoke alarm policy - is it working?. Fire Engineers Journal, v61 no211 (Mar 2001) p9-11. 2001.

BRANZ. Sprinklers for houses : combination domestic plumbing and fire sprinkler systems. 2002.

Bukowski, Richard W; Peacock, Richard D; Averill, Jason D; Cleary, Thomas G; Bryner, Nelson P; Walton, William D; Reneke, Paul A; Kuligowski, Erica D. Performance of home smoke alarms : analysis of the response of several available technologies in residential fire settings. 2004.
http://smokealarm.nist.gov/
Abstract: Study measuring the performance of ionisation and photoelectric types of smoke alarms and alarm installation arrangements in controlled laboratory tests, and in two types of houses. Both types of alarm systems generally provided sufficient time for occupants to escape from residential fires. Ionisation type alarms reacted earlier to flaming fires, and photoelectric alarms provided a faster response to smouldering fires. Escape times in this study were shorter than those found in a similar study conducted in the 1970s, due to a combination of factors: faster fire development times for today's products, different criteria for time to untenable conditions, and improved understanding of the speed and range of threats to tenability.

Butler, Iain. Sprinklers faster than fires. Build, Aug-Sep 2006, p100-101. 2006.
Abstract: Describes the latest New Zealand Fire Service launch of a fire safety campaign to encourage more homeowners to install home sprinklers when building or renovating. Emphasises their cost-effectiveness, reliability and inexpensiveness.

Department of Building and Housing. Amendment 7 Compliance Document for New Zealand Building Code Clause F7 Warning Systems ? Third Edition Effective 10 October 2011. Department of Building and Housing Wellington. 2011.

Department of Building and Housing. Proposed changes to the Acceptable Solution for Building Code clause F7 (Warning Systems) Appendix A Proposed amended Acceptable Solution for Warning Systems. Department of Building and Housing Wellington. 2011.

Department of Building and Housing. Compliance Document for New Zealand Building Code Clauses C1, C2, C3, C4 Fire Safety. Department of Building and Housing Wellington. 2011.

von Behrens. Home Smoke Alarms: Hard Wired and Battery Powered Systems: Summary Bulletin. Home Modification Information Clearinghouse University of Sydney. Online: 2-10-06. 2006.
http://www.homemods.info

Duncan, Christine; Colleen Wade. Cost-effective Domestic Fire Sprinkler Systems. New Zealand Fire Service Fire Research Report No. 1. 2000.
Abstract: This cost benefit study led to the development of a practical home sprinkler design and new NZFS fire safety campaign.

Firestone, James. Set and forget: why sprinklers are the best home fire protection. FPANZ Newsletter, no119 (Oct 2006) p10-11. 2006.
Abstract: Examines the design and installation of domestic home sprinklers in New Zealand homes, and their cost effectiveness for homeowners. Author is a Fire Engineer with the New Zealand Fire Service. Refers to NZ Standard 4517: 2002.

A4.2 MULTI SENSOR DETECTION, INCLUDING VIDEO

References Cited in Report

Borges, Paulo; Vinicius Koerich; Joceli Mayer; Ebroul Izquierdo. Efficient Visual Fire Detection Applied for Video Retrieval. 16th European Signal Processing Conference (EUSIPCO 2008), Lausanne, Switzerland, August 25-29, 2008, copyright by EURASIP. 2008.
Abstract: In this paper we propose a new image event detection method for identifying ?re in videos. Traditional image based ?re detection is often applied in surveillance camera scenarios with well behaved background. In contrast, the proposed method is applied for retrieval of ?re catastrophes in newscast content, such that there is great variation in ?re and background characteristics, depending on the video instance. The method analyses the frame-to-frame change in given features of potential fire regions. These features are colour, area size, texture, boundary roughness and skewness of the estimated fire regions. Because of flickering and random characteristics of fire, these are powerful discriminants. The change of each of these features is evaluated, and the results are combined according to the Bayes class to to achieve a decision (i.e. fire happens, fire does not happen). Experiments illustrated the applicability of the method and the improved performance in comparison to other techniques.

Nugrohoa; Yulianto S.; Suwarnob, Muhammad R.; Widyantob, Yanuara et al. Early Detection of Cable Fires Using Image Processing. Interflam 2010 Proceedings, Interscience Communications Ltd, London. 2010.
Abstract: Electrical fires remain one of the important sources of initial heating in domestic and industrial fires. This paper presents the experimental work on cable fires due to poor connection and overload. An experimental set-up was developed to study the early stages of self-heating and smoke release in jointing of 1.5mm2 NYA ? PVC insulated cables. The surface temperature and smoke release are closely monitored using image processing technique. In this paper a video based smoke detection using the adaptive Gaussian Mixture Model was also applied. The prediction of the model is in good agreement with the observer's interpretation of smoke area for the early stages of cable fire. The results also reveal a correlation between the surface temperature of the jointing and smoke area developed. In addition, it was found that the maximum values of the blobs areas of smoke for 15A to 17A occurred at similar surface temperatures of the jointing. Verification of outcomes from video smoke detection technique with the physical process of smoke and fire development is a great challenge in defining the level of fire risk.

Sekkas, Odysseas; Stathes Hadjiefthymiades; Evangelos Zervas. A Multi-level Data Fusion Approach for Early Fire Detection. 2010 International Conference on Intelligent Networking and Collaborative Systems, pp.479-483, Thessalonika, Greece 2010. DOI: 10.1109/INCOS.2010.64. 2010.
http://www.computer.org/portal/web/csdl/doi/10.1109/INCOS.2010.64

Verstockt, Steven; Chris Poppe; Sofie Van Hoecke, Charles Hollemeersch et al. Silhouette-based multi-sensor smoke detection: Coverage analysis of moving object silhouettes in thermal and visual registered images. Machine Vision and Applications. Published Online August 2011. DOI: 10.1007/s00138-011-0359-3. 2011.
http://www.springerlink.com/content/90j85kn52g4547n4/
Abstract: Fire is one of the leading hazards affecting everyday life around the world. The sooner the fire is detected, the better the chances are for survival. Today's fire alarm systems, such as video-based smoke detectors, however, still pose many problems. In order to accomplish more accurate video-based smoke detection and to reduce false alarms, this paper proposes a multi-sensor smoke detector which takes advantage of the different kinds of information represented by visual and thermal imaging sensors. The detector analyzes the silhouette coverage of moving objects in visual and long-wave infrared registered (~aligned) images. The registration is performed using a contour mapping algorithm which detects the rotation, scale and translation between moving objects in the multi-spectral images. The geometric parameters found at this stage are then further used to coarsely map the silhouette images and coverage between them is calculated. Since smoke is invisible in long-wave infrared its silhouette will, contrarily to ordinary moving objects, only be detected in visual images. As such, the coverage of thermal and visual silhouettes will start to decrease in case of smoke. Due to the dynamic character of the smoke, the visual silhouette will also show a high degree of disorder. By focusing on both silhouette behaviors, the system is able to accurately detect the smoke. Experiments on smoke and non-smoke multi-sensor sequences indicate that the automated smoke detection algorithm is able to coarsely map the multi-sensor images. Furthermore, using the low-cost silhouette analysis, a fast warning, with a low number of false alarms, can be given.

Verstockt, Steven; Alexander Vanoosthuyse; Sofie Van Hoecke; Peter Lambert and Rik Van de Walle. Multi-sensor Fire Detection by Fusing Visual and Non-visual Flame Features. Lecture Notes in Computer Science, 2010, Volume 6134/2010 , 333-341. DOI: 10.1007/978-3-642-13681-8_39. 2010.
http://www.springerlink.com/content/9w6n608813700577/
Abstract: This paper proposes a feature-based multi-sensor fire detector operating on ordinary video and long wave infrared (LWIR) thermal images. The detector automatically extracts hot objects from the thermal images by dynamic background subtraction and histogram-based segmentation. Analogously, moving objects are extracted from the ordinary video by intensity-based dynamic background subtraction. These hot and moving objects are then further analyzed using a set of flame features which focus on the distinctive geometric, temporal and spatial disorder characteristics of flame regions. By combining the probabilities of these fast retrievable visual and thermal features, we are able to detect the fire at an early stage. Experiments with video and LWIR sequences of fire and non-fire real case scenarios show good results and indicate that multi-sensor fire analysis is very promising.

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Arifler, D. Information Theoretic Approach to Detecting Systematic Node Destructions in Wireless Sensor Networks. Wireless Communications, IEEE Transactions on, November 2008 Volume : 7 Issue:11. DOI: 10.1109/T-WC.2008.071001. 2008.
Failure analysis, information theory, point processes , wireless sensor networks
Abstract: Hazards such as fires and floods may destroy and prevent nodes of a wireless sensor network from functioning properly and reporting measurements of interest. Destructions by hazardous events are systematic and hence different from random node and link failures, which are very common in wireless sensor networks due to the fragility of devices and the intermittent degradation in wireless link quality. An information theoretic approach is presented that may be used for detecting systematic node destructions in dense sensor deployments wherein detection by visual inspection of the destroyed sensors on a "sensor map" at a central monitoring station is hard, if not impossible. It is shown that the information theoretic approach combined with the statistical methodology presented can effectively be used for automated triggering of alarms in decision support systems to rapidly contain hazards. It is also shown that as few as approximately 20 close-proximity sensor failures could be considered "unusual" enough to detect a systematic destruction with 90% confidence in dense sensor deployments, and this is observed to be independent of deployment density. Simulations also indicate that connectivity, which is critical in wireless sensor networks for relaying measured data, is with high probability not compromised before detection takes place.

Balaschak, Andrew Durstenfeld, Bobÿ. Hazardous environment response using ""mission control"" approach. International Fire Protection, no25 (Feb 2006) p25-29. 2006.
Abstract: Describes the latest technology in hazardous chemical detection systems that uses a combination of gas, radiation detection, wireless communications, and computer systems. Outlines the benefits of the 'Rapid Deployment hazardous Environment Detection System', and its application during 2005 locomotive hazmat incident at Graniteville, South Carolina, USA.

Barrett, Roger. Measured doses. Fire Safety Engineering, v13 no2 (Mar 2006) p27-30. 2006.
Abstract: Summarises findings from test fire data illustrating the performance of carbon dioxide (CO) fire detectors. Gives examples of their successful application, and highlights their limitations. Includes definition of carbon dioxide (CO) detectors.

Bojun Li; Piyanuch Hathaipontaluk; Suhuai Luo. Intelligent Oven in Smart Home Environment. 2009 International Conference on Research Challenges in Computer Science, Shanghai, China pp.247-250. DOI: 10.1109/ICRCCS.2009.70. 2009.
http://www.computer.org/portal/web/csdl/doi/10.1109/ICRCCS.2009.70
Abstract: Smart homes are gradually becoming one of the main applications in the high technology area. The intelligent appliance is a fundamental component of a smart home environment. People tend to invest in the kitchen appliances as they will be used throughout their lifetime, therefore many manufacturers focus on making these appliance more interesting. However, majority of manufacturers focus on how to make them cook faster. Very few manufacturers pay attention on the ability to cook healthier food. In this paper we introduce an innovative intelligent oven for the healthier food choice that is woven inside smart home environment. The intelligent oven is designed for manipulating recommended healthy recipe choices to suit each family member health concerns. Moreover, its ability to interact with other smart appliances such as smart fridge, mobile phone, and smart fire alarm are beneficial. We believe that the features mentioned above will make the intelligent oven an essential component in the smart home environment.

Bruck, Dorothy. Non-awakening in children in response to a smoke detector alarm. Fire Safety Journal, v32 no4 (Jun 1999) p369-376. 1999.
Abstract: An Australian study into the extent children will awaken to a smoke detector alarm in a hallway found that of 20 children aged 6-17yrs, only 15% woke reliably when subjected to a 60dBA alarm over two nights of testing. This is compared to 100% of the adults in the study waking up when the alarm was activated. It is recommended that interconnected detectors are installed in residential dwellings so that adults are woken if a fire occurs in or near children's bedrooms.

ByoungChul Ko; Hyun-Jae Hwang; In-Gyu Lee; Jae-Yeal Nam. Fire Surveillance System Using an Omni-directional Camera for Remote Monitoring. Computer and Information Technology Workshops, 2008. CIT Workshops 2008. IEEE 8th International Conference on, Sydney, 8-11 July 2008 pp 427 - 432. DOI: 10.1109/CIT.2008. 2008.
http://ieeexplore.ieee.org/xpl/freeabs_all.jsp?arnumber=4568542
Abstract: This paper proposes new video-based fire surveillance and remote monitoring system for real-life application. Most previous video-based fire detection systems using color information and temporal variations of pixels produce frequent false alarms due to the use of many heuristic features. Plus, they need several cameras to overcome the dead angle problem of a normal CCD camera. Thus, to overcome these problems, probabilistic models of fire are generated based on the fact that fire pixel values in consecutive frames change constantly and these models are applied to a Bayesian Networks to detect real fire from videos. In our system, we use an omni-directional camera instead of a normal CCD camera to remove the dead angle problem. After then, the fire region is captured by pan-tilt camera and transferred to cell phone for remote monitoring. The proposed system was successfully applied to various fire-detection tasks in real-world environments and effectively distinguished fire from fire-colored moving objects.

Chacon-Murguia, Mario I; Francisco J. Perez-Vargas. Thermal Video Analysis for Fire Detection Using Shape Regularity and Intensity Saturation Features. Pattern Recognition, Lecture Notes in Computer Science, 2011, Volume 6718/2011, 118-126. DOI: 10.1007/978-3-642-21587-2_13. 2011.
http://www.springerlink.com/content/j477317434750k47/
Abstract: This paper presents a method to detect fire regions in thermal videos that can be used for both outdoor and indoor environments. The proposed method works with static and moving cameras. The detection is achieved through a linear weighted classifier which is based on two features. The features are extracted from candidate regions by the following process; contrast enhance by the Local Intensities Operation and candidate region selection by thermal blob analysis. The features computed from these candidate regions are; region shape regularity, determined by Wavelet decomposition analysis and region intensity saturation. The method was tested with several thermal videos showing a performance of 4.99% of false positives in non-fire videos and 75.06% of correct detection with 7.27% of false

positives in fire regions. Findings indicate an acceptable performance compared with other methods because this method unlike other works with moving camera videos.

Che-Bin Liu; Ahuja, N.. Vision based fire detection. Pattern Recognition, 2004. ICPR 2004. Proceedings of the 17th International Conference on, 23-26 Aug. 2004, p 134 - 137 Vol.4. DOI: 10.1109/ICPR.2004.1333722. 2004.
http://ieeexplore.ieee.org/xpl/freeabs_all.jsp?arnumber=1333722
Abstract: Vision based fire detection is potentially a useful technique. With the increase in the number of surveillance cameras being installed, a vision based fire detection capability can be incorporated in existing surveillance systems at relatively low additional cost. Vision based fire detection offers advantages over the traditional methods. It will thus complement the existing devices. In this paper, we present spectral, spatial and temporal models of fire regions in visual image sequences. The spectral model is represented in terms of the color probability density of fire pixels. The spatial model captures the spatial structure within a fire region. The shape of a fire region is represented in terms of the spatial frequency content of the region contour using its Fourier coefficients. The temporal changes in these coefficients are used as the temporal signatures of the fire region. Specifically, an auto regressive model of the Fourier coefficient series is used. Experiments with a large number of scenes show that our method is capable of detecting fire reliably.

Cote, Arthur E. Operation of fire protection systems : a special edition of the fire protection handbook. 2003.
Abstract: Contains 37 chapters from the Fire Protection Handbook on how fire detection, alarm, and suppression systems work, and what you need to do to keep them operational. Covers detection and alarm systems including notification appliances, fire alarm system interfaces, gas and vapour detection systems and monitors. Guidance on automatic sprinklers, water spray protection, standpipe and hose systems, an d hazards such as Microbiologically Influenced Corrosion (MIC). Facts about direct halon replacement agents, foam, and all types of extinguishing agents and systems. Aimed at fire service personnel an d facilities managers.

Davies, Stuart. Series 300 - an intelligent approach to conventional fire detection technology. Fire Safety Engineering, v8 no5 (Sep 2001) p31-34. 2001.
Abstract: Discusses the innovations of fire detection developers and manufacturers Systems Sensor Europe to conventional fire detectors. Outlines the choices of fire detection systems available and their appropriate use, with conventional systems for small installations and analogue addressable systems for large installations. Discusses the advantages of analogue systems, and how although recent technology has made them more cost effective for increasingly smaller installations, they are still not cost effective enough smaller installations. The Series 300, a new conventional system, addresses this problem, being cost effective and incorporating many of the intelligent features of analogue systems.

Davis, Simon. Smoke detection and unwanted alarms; Apartment smoke detection. FPANZ Newsletter, no92 (May 2004) p6 + no93 (Jun 2004) p2-3. 2004.
Abstract: Two articles highlighting a growing problem where smoke detectors are being covered up by apartment occupants because of nuisance activations. Detectors are being set off because cooking fumes are not being removed by the ventilation systems in kitchens. Refers to NZ Standard 4512 and clause F7 of the Building Act. Includes opinion from the Building Industry Authority about compliance, and offers possible solutions to address the problem.

Gang Hua, Ting-Yi Yang and Srinath Vasireddy. Toward a Visual Motion Based Perceptual Interface for Mobile Devices. Lecture Notes in Computer Science, 2007, Volume 4796/2007 , 39-48. DOI: 10.1007/978-3-540-75773-3_5. 2007.
http://www.springerlink.com/content/5265j25140578281/
Abstract: We present the architecture and algorithm design of a visual motion based perceptual interface for mobile devices with cameras. In addition to motion vector, we use the term "visual motion" to be any dynamic changes on consecutive image frames. In the lower architectural hierarchy, visual motion events are defined by identifying distinctive motion patterns. In the higher hierarchy, these visual events are used for interacting with user applications. We present an approach to context aware motion vector estimation to better tradeoff between speed and accuracy. It switches among a set of motion estimation algorithms of different speeds and precisions based on system context such as computation load and battery level. For example, when the CPU is heavily loaded or the battery level is low, we switch to a fast but less accurate algorithm, and vice versa. Moreover, to obtain more accurate motion vectors, we propose to adapt the search center of fast block matching methods based on previous motion vectors. Both quantitative evaluation of algorithms and subjective usability study are conducted. It is demonstrated that the proposed approach is very robust yet efficient.

Ha Dai Duong; Dao Thanh Tinh. A Novel Computational Approach for Fire Detection. Second International Conference on Knowledge and Systems Engineering, Hanoi, Hanoi Vietnam 2010, pp.9-13. DOI: 10.1109/KSE.2010.12. 2010.
http://www.computer.org/portal/web/csdl/doi/10.1109/KSE.2010.12
Abstract: This paper proposes a model for detecting fire captured in video data by combining the methods of correlation coefficient, Gaussian Mixture Model - GMM and turbulent analysis. The method of correlation efficient is used to determine movement objects. We use GMM to cluster fire-colored pixel in the RGB space. The objective of turbulent analysis is to detect the flame of fire. A model built on three above methods will be presented and the experimental results are discussed in Section III. Index Terms: Fire Detection, Correlation Coefficient, Gaussian Mixture Model

Jianjun Liao; Xiaotai Niu; Qiuping Guo; Xiaoning Li. Study of Fire Recognition System Based on Dmpster-Shafer Evidence Theory. 2010 International Conference on Multimedia Information Networking and Security, 2010 pp.945-948. DOI: 10.1109/MINES.2010.200. 2010.
Abstract: In order to improve the recognition rate of the early fire, this paper analyzed the relationship between the image resolution and fire recognition rate from the application point of view. On this basis, we have adopted the Dmpster-Shafer evidence theory and carried on the recognition experiment to the different resolution fire image under different environmental conditions. The simulation experimental results have indicated that this method can obtain the basic consistent recognition effect regardless of the resolution of fire image is high or low, and can simultaneously give dual attention to the recognition rate and the recognition efficiency.
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Laluvein, Bernard. Turn up the heat. Fire Safety Engineering, v14 no1 (Feb 2007) p30-32. 2007.
http://find.galegroup.com/itx/infomark.do?&contentSet=IAC-Documents&type=retrieve&tabID=T003&prodId=ITOF&docId=A159696365&source=gale&srcprod=ITOF&userGroupName=per_nzfs&version=1.0
Abstract: Examines how heat enhanced carbon dioxide (CO) fire detection can respond to smaller amounts of CO emission produced by these types of fires. Describes their application, identifies suitable scenarios for their installation, and highlights their drawbacks. Looks at what is available or being developed in the way of UK and European compliance codes.

Liao Jianjun; Niu Xiaotai; Guo Qiuping; Li Xiaoning. Improvement and Realization of the Fire Recognition System. 2010 Third International Symposium on Information Processing, Qingdao, Shandong China pp.506-509. DOI: 10.1109/ISIP.2010.139. 2010.
http://www.computer.org/portal/web/csdl/doi/10.1109/ISIP.2010.139
Abstract: In order to improve the recognition rate of the early fire, this paper analyzed the relationship between the image resolution and fire recognition rate from the application point of view. On this basis, we have adopted the Dempster-Shafer evidence theory and carried on the recognition experiment to the different resolution fire image under different environmental conditions. The simulation experimental results have indicated that this method can obtain the basic consistent recognition effect regardless of the resolution of fire image is high or low, and can simultaneously give dual attention to the recognition rate and the recognition efficiency. Index Terms: Fire Recognition, Dempster-Shafer Evidence Theory, Image Resolution, Recognition

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Abstract: Advanced computer technology, internet communication technology and synthesis wiring technique were used and personality requirement and living subsystem such as security defense, light control, curtain control, gas valve control, information household electric appliance and scene linkage were combined in intelligence home system. New living experience was acquired by internet intelligent control and management. System control can be come true by local control and telecontrol. Local control is to control lamp and household electric application by internet switching. Telecontrol is to control them by telecontroller, timing controller, integrated controller or telephone and computer. Intelligent home control system can realize some functions: telecontrol function, sound telephone telecontrol function, timing control function, central control function, sense function, internet telecontrol function, global internet video monitoring function and safety defense warning function. Now the research focuses of intelligence home control system are videophone, entrance guard system and safety defense warning subsystem. These subsystems are mutual independence and can't realize information share, which made setting and use inconvenience. In the paper, the new system is be studied and these control subsystem and electric apparatus will be connected by uniform central control unit to realize information share and home intelligent telecontrol.

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Abstract: This paper introduces an attribute reduction method based on the characteristics of consistent approximation space (CAS) of rough set. The proposed method can be used to fuse alarm signals from different kinds of fire sensors using decision rules derived from a sample data in CAS with the data classification features of CAS. The experiment results of an example data set show that this method can fuse different kinds of fire alarms to detect the occurrence of fire as well as the type of fires and give the confidence of the decisions. Index Terms: rough set, consistent approximation space, fire detection, information fusion, attribute reduction

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Abstract: This paper proposes a new fire-flame detection method using probabilistic membership function of visual features and Fuzzy Finite Automata (FFA). First, moving regions are detected by analyzing the background subtraction and candidate flame regions then identified by applying flame color models. Since flame regions generally have an irregular pattern continuously, membership functions of variance of intensity, wavelet energy and motion orientation are generate and applied to FFA. Since FFA combines the capabilities of automata with fuzzy logic, it not only provides a systemic approach to handle uncertainty in computational systems, but also can handle continuous spaces. The proposed algorithm is successfully applied to various fire videos and shows a better detection performance when compared with other methods.

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A4.3 SENSITIVE SENSORS BASED ON AEROSPATIAL TECHNOLOGY

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Abstract: This paper discusses the basic concept of the software interface technology of intelligent building and BMS based on EBI, explains in detail the software interface technology of intelligent building which uses the parallel integration module running on EBI and component integration module based on OPC and its application in engineering by citing one system integration project of intelligent building completed by the author, and presents two methods of developing fire fighting subsystem software interface running on EBI. One is to develop, based on AI agent theory, an agent which is running between EBI and MK7022. This agent can be used as the software interface of fire fighting subsystem and integrates the fire fighting subsystem as a parallel integration module into BMS. Another is to develop a driving COM which is called by OPC server to realize the system integration based on OPC.

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Abstract: Wireless Sensor Networks (WSN) play very important role in information and communication Technology (ICT) and have attracted a lot of attention lately. The importance of these networks are increasing exponentially due to its usage in monitoring wide variety of applications. In this paper, we propose a novel architecture for intelligent alarm generation in a wireless sensor zone. We developed a decision support system for continuous monitoring the logged data for quality assurance across the zone, to raise alerts in terms of mail or message or alarm following any violation in the safety norm in an intelligent and adaptive manner. We implemented the system, by creating a Wireless Sensor Network Zone using Crossbow Imote2 sensor nodes. The standard Zigbee 802.15.4 protocol is used for communication. Our prototype system generates alerts in terms of SMS to predefined and authenticated mobile number(s) following detection of alarm in terms of fire, light, object movement and pH, Temperature, Salinity, Dissolved Oxygen of drinking water.

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Abstract: Decision support systems (DSS) are computerized information systems used for decision making activities and management support. The importance of DSS is increasing with the advent of computerized systems. DSS has been remained one of the most important and widely researched area in disaster management. In any type of disaster either the source of these disasters is natural or human, the primary objective is always to minimize the causalities. To get this goal an efficient evacuation plan is required. Agent based technology has been remained a preferred field of research for last few decades in disaster management. There has been a problem of congestion while evacuating from large buildings with few exit points. In this article we have proposed a multi agent-based decision support system for prioritized evacuation during fire disaster. The proposed model can be implemented to validate proposed idea in evacuation to ensure the safety and quick evacuation of evacuees. The disaster points can be relocated and changed to assess the effect on the model.

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A4.5 ADVANCED SPRINKLERS INCLUDING WATER MISTS

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Abstract: In 2002, a Task Group1 to the BSI committee FSH/14/-/2 was established to develop a new set of fire resistance Tables for inclusion in the British Standard B9999 ?Code of Practice for Fire Safety in the Design, Construction and use of Buildings. The Task Group, which was made up of fire safety engineers from leading consultancies and research organisations in the UK, developed a methodology that used engineering calculations in a probabilistic way to achieve satisfactory levels of structural fire safety. Recommendations were then made for fire resistance requirements for different occupancy purpose groups based upon the use and height of the building. The probabilistic approach used a Monte Carlo statistical analysis. This type of analysis was used to simulate the development for 10,000 post flash-over fires in order to provide a spread of heating conditions in different buildings that had rooms of various type and size. The method adopted in this study was never extended to look at the ability of compartments of different size to contain the lateral spread of fire across the buildings floor plate. This is something that could easily have been done using the same Monte Carlo technique. In this paper, the same Monte Carlo method is used with the parametric fire expression given in Annex A of Eurocode 1-1-22, to measure the ability of different sized fire compartments to contain the spread of a fully developed flashover fire. The results of this statistical analysis are then used to determine permissible compartment sizes when sprinklers are used. The analysis shows that current compartments sizes in UK buildings could be increased and outlines a methodology that allows equivalent levels of fire performance to be derived when life safety and property protection sprinkler systems are used.

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Abstract: This paper describes a study to investigate the suitability of concealed and recessed pattern sprinklers for use in residential premises, particularly concerning their effectiveness and maintainability. The study involved carrying out an experimental programme of ?stylised? and ?realistic? fires and wind tunnel tests and a review of design, installation and maintenance issues. The results have provided input to the development of standards, provided Regulators with sound engineering-based results and are available to assist and support those working in the fire arena.

Klinzmann, Christoph; Hosser, Dietmar. Active Fire Protection Measures and Probabilistic System Analysis as a Basis for a National Fire Safety Concept in Germany. Interflam 2010 Proceedings, Interscience Communications Ltd, London. 2010.
Abstract: Up to now, the building codes of the German states are prescriptive, giving e. g. requirements with respect to the fire resistance class of structural members and the reaction to fire of building materials. The required properties can be guaranteed by designing the structural members according to the rules of the German standard DIN 4102 part 4 [1]. It contains tables with minimum design requirements derived from fire tests according to the standard temperature time curve. With the implementation of the fire parts of the Eurocodes in early 2010, natural fire models can be applied alternatively in structural fire design in conjunction with a fire safety concept. The German National Annex to Eurocode 1 part 1-2 [2] contains a new safety concept which will replace the informative Annex E of Eurocode 1 part 1-2 [3]. This paper concentrates on the consideration of active fire protection measures like sprinkler systems and firefighting by the fire brigade within this safety concept. The proposals in the safety concept are derived from full probabilistic system reliability analyses taking into account different fire scenarios depending on the function or malfunction of the fire protection measures. The interaction of the functional and nonfunctional protection measures is analyzed using event trees, leading to different fire scenarios. The probability of occurrence of each scenario depends on the reliability of the fire protection measures. Generally, the fire scenario with the highest contribution to the system reliability is a fully developed fire in case of malfunction of all active fire protection measures. The failure probability of the measures are considered in the conditional probability of failure of the structural fire protection measures as a basis to derive partial safety factors for the input parameters of the natural fire model. Problems can occur if some of the protection measures do not act independently from each other.

Marchant, Eric W.. The efficacy of water mist fire suppression systems for archive protection. Interflam 2004 Proceedings, Interscience Communications Ltd, London.2004.
Abstract: Water mist used as a fire suppression system has a history in the 20th Century of a high level of success in the special environments as found in both the machinery spaces and the bunk spaces aboard ships. The land based application of water mist has developed over the last 15, or so, years. Because of the nature of water mist it is an effective suppressant for vigorous flames. The use of water mist systems for parts of buildings is an important development especially because of the removal and elimination of gaseous Halon fire suppression systems. Because of the lack of a design code and the lack of a formal test protocol the relevant NFPA Code 1 recommends full scale experiments using real fuels and a real suppression system. It is noted in the Code 1 that very few systems had, up to the year 2000, been tested at full scale. Using real archival material as the fuel, 6 full scale experimental burns [tests] were carried out in an expendable building. The main outcomes of the tests were: 1/ heat activation for individual heads caused a significant and unacceptable loss of archival material; 2/ after water is released the atmosphere in the total test volume is likely to be lethal to any occupant(s); and 3/ heads activated by a signal from a smoke detector could still allow the water mist to be overwhelmed and the fire continued to grow (dependent on the materials of the shelving). After careful consideration of the performance of the water mist systems it was decided to install a gaseous fire suppression system in the archive stores.

Nilsen, Alf; Brekken, J. On the use of window sprinkler to prevent vertical fire spread. Interflam 2007 Proceedings, Interscience Communications Ltd, London. 2007.
Abstract: The use of listed window sprinklers to protect glass against thermal stress, preventing it to crack, was tested and the reliability and need for redundancy when using such systems is discussed. Experiments were done in a ISO room (W = 2.4 m, H = 2.4 m, L = 3.6 m: HW = 2 m, WW = 0.8 m) using heptane fires placed away from the window in the far side of the room. Radiant heat, temperatures and weight loss of heptane was measured. Six different setups were used; open window with and without window sprinkler, closed window with and without window sprinkler. Heat resistant glass in window frames of PVC, with a metal core, was tested to see how they react to fire. Furthermore, a test with normal glass protected by window sprinkler, using common furniture as fuel, was carried out. Temperatures in the fire room were measured to a maximum of 1300 øC. Flame heights outside the open window were visible 1.4 m above the top of the window. Water spray, dedicated to protect the glass on the inside, reduced the temperature in the flames outside the window and pushed them away. Radiant heat at the upper window was measured to a maximum of 5.4 kWm-2 when there were no windows or water. Some further discussions are made on the operational reliability of sprinkler as a safety system. Experience indicate that the reliably of sprinkler systems are greatly affected by human made faults either in the engineering design process or in the inspection of the systems. A reference to an alternative approach to risk analysis is given

Shelley, Jonathan, and M Spearpoint. Tenability comparison of detectors and sprinklers in television set fire tests. Interflam 2007 Proceedings, Interscience Communications Ltd, London. 2007.
Abstract: A series of 21 television set fires was conducted in a compartment to compare the performance of fast response sprinkler heads with several other types of fire detection devices. The television sets were ignited using a tea light candle positioned adjacent to the plastic casing. Measurements were made of temperatures, toxic gas levels and visibility to assess the tenability levels and the occupant movement speed within the compartment. The results showed that the sprinkler system did not respond well to the television fires when compared to the performance of the other fire detectors. In five of the tests, the maximum tolerable exposure time provided by the sprinkler system was exceeded by the actual exposure time during egress. Of the remaining cases, the minimum margin was just 12 seconds, and the maximum margin was only 151 seconds. On a number of occasions the sprinkler system did not operate at all and the television burned out completely.

Standards New Zealand. NZS 4515:2009 Fire sprinkler systems for life safety in sleeping occupancies (up to 2000 square metres). Standards New Zealand. 2009.
Abstract: Applies to buildings used solely as a residence. NZS 4515 includes care institutions, hostels, boarding houses, apartment buildings, motels, retirement homes, rest homes, transitional houses, and hospital ward areas. The 2009 version of the Standard places a greater emphasis on the life safety characteristics of sprinkler systems, as opposed to their property protection characteristics. This Standard recommends the use of residential sprinkler heads as a number of important benefits are derived from their rapid response and fire control.

Standards New Zealand. NZS 4517:2010 Fire sprinkler systems for houses. Standards New Zealand. 2010.
Abstract: Specifies minimum requirements for the design, material, manufacture and installation of fire sprinklers systems for domestic occupancies. This revision updates the requirements set out in the 2002 edition by providing more clarification about its scope and consideration of fire formal interpretations that have been received since the last edition was published. $77.60+GST (Members), $97.00+GST (Retail), 85 pages

Xiangyang Zhou, Stephen P. D'Aniello and Hong-Zeng Yu. Spray pattern measurements of selected fire sprinklers. Interflam 2010 Proceedings, Interscience Communications Ltd, London. 2010.
Abstract: Measurements were conducted to characterize the spray patterns of two fire sprinklers in the near field and far field of the sprinkler. A laser-based shadow imaging system was used to measure the droplet size, velocity and water volume flux in the spray. An array of pressure-transducer equipped water collection tubes and containers provided a separate set of water volume flux measurements. A large-scale traverse was constructed to move the laser optics and water collection tubes and containers to the designated measurement locations. A single K-205-Lpm/bar1/2 (14.2 gpm/psi1/2) pendent sprinkler and a single K-162-Lpm/bar1/2 (11.2 gpm/psi1/2) upright sprinkler were operating at two respective pressures in the measurements. In the near field at 0.76 m from the sprinkler, measurements were performed in a spherical coordinate at different azimuthal and elevation angles with respect to the sprinkler deflector. In the far field, the sprays were mapped out at 3.05 m and 4.57 m below the ceiling. The measurements show that the spatial distributions of water volume flux, droplet size and velocity of sprinkler sprays are strongly influenced by the sprinkler frame arms and the configuration of sprinkler deflector's tines and slots. The near-field measurements can be used to prescribe the spray starting condition in the numerical modeling of spray transport through the fire plume, and the far-field measurements can be used to evaluate the spray transport calculations.

Other Relevant References

BRANZ. Domestic fire protection. BRANZ Bulletin, no458 Feb 2005 (whole issue). 2005.
Abstract: Use, installation and maintenance of domestic smoke alarms and home sprinkler systems in New Zealand. The best fire protection is provided by a sprinkler system incorporated into the domestic plumbing . Describes the spread of smoke in a home. Earlier warning is provided by smoke detectors than by heat detectors, and this allows more time for escape. Refers to relevant standards.

Brown, Alastair R and Hans van Nieuwburg. Investigation into the use of fine water mist for protection of plastic fume exhaust ductwork against fire. Interflam 2004 Proceedings, Interscience Communications Ltd, London. 2004.
Abstract: Over the last three decades there have been a number of fires in semiconductor manufacturing facilities. In the fires where the most serious fire damage has occurred there has been a common factor, the presence of combustible ductwork, typically polypropylene. In each case, the fire and smoke spread throughout the manufacturing cleanrooms causing extensive damage to the sensitive manufacturing equipment and contamination to the cleanroom environment. The most recent fires have occurred in Europe in 2003 and in Taiwan in 1996 and 1997. In the Taiwan fires, fire damage in excess of œ150m was reported each time, with downtime for the affected cleanroom is typically in excess of 12 to 18 months. While automatic sprinkler protection is often used to protect existing plastic ductwork and prevent internal fire spread, and firesafe ducts are available that can be installed without fire protection, both can be expensive and very difficult to retrofit in an operating cleanroom. This paper explores the issues involved with plastic ductwork protection in a modern wafer fabrication cleanroom and describes fire testing that was carried out to determine if fine water mist protection could be applied successfully to the protection of plastic ductwork.

Clark, Phil and Debbie A Smith. Design fire size for fire safety systems that utilise fast or standard response sprinkler heads. Interflam 2004 Proceedings, Interscience Communications Ltd, London.2004.
Abstract: The robustness of assumptions included within a fire safety engineered design, whether it be for a small single shop unit or a large shopping complex are of direct concern to regulators, fire safety engineers, building owners, occupiers and users. That is, the selection of a design fire may be the basis of, for example, a smoke control system design, with the life safety criteria in such a case based upon the principle that the people escaping from a building will be separated from the smoke at all times. Such a requirement will only be satisfied if the fire used as the basis for the design is robust. Work has been carried out to obtain comparative data relating to the relative activation times of standard and fast response sprinklers when exposed to known rates of fire growth. This information has then been related to the heat release rates at the time of activation of the first sprinkler head to assess the potential benefits that may be derived from fast response sprinklers within fire safety design. Comparative data are also provided on the relative performances of fast and standard sprinklers on four realistic fire loads.

Communities and Local Government. A cost benefit analysis of options to reduce the risk of fire and rescue in areas of new build homes. Fire Research Series 1/2010, Department for Communities and Local Government, United Kingdom, 2010.
Abstract: The Department for Communities and Local Government (CLG) commissioned NERA
Economic Consulting (NERA) to carry out a cost benefit analysis of options for addressing the fire and community safety needs of areas of new build housing, with special reference to the Thames Gateway. Of particular interest is the issue of installing sprinklers in domestic properties, and whether or not the present costs of installing and maintaining sprinkler systems might be justified by the risk reduction that they would provide. The findings from modelling are consistent with previous studies in suggesting that the benefits of installing sprinklers in all new housing, in terms of reduced fatalities, injuries and property loss, would fall far short of the costs We find some limited and uncertain evidence that installing domestic sprinklers in new social housing could lead to similar net social benefits as providing additional FRS resources
http://www.communities.gov.uk/documents/fire/pdf/costbenefitfirenewbuild.pdf

Fire Protection Association. Development of a lower-cost sprinkler system for domestic premises in the UK Fire Research Technical Report 2/2007
http://webarchive.nationalarchives.gov.uk/+/http://www.communities.gov.uk/pub/325/22007DevelopmentofalowercostsprinklersystemfordomesticpremisesintheUKPart1of8_id1509325.pdf
Abstract: Introduces findings from the development of a cheap and easily installed sprinkler system for domestic premises in the UK. A prototype sprinkler system has been developed based on the BRANZ experience which offers system costs lower than that for traditional domestic sprinkler systems. Identifies savings in the design which will combine domestic water and sprinkler pipe distribution networks, allow exclusion of some expensive high-maintenance equipment, and rely on town mains pressure rather than an installed pump. Home sprinklers within reach. Fire Australia, Spring 2008, p11. 2008. Abstract: Highlights the new Australian standard AS 2118.5-2008 that will allow licensed plumbers to install stand-alone automatic fire sprinklers in domestic homes. Comments on economic cost benefits to homeowners.

Fire sprinkler systems for houses. NZS 4517:2010. 2010.
Abstract: Specifies minimum requirements for the design, material, manufacture and installation of fire sprinklers systems for domestic occupancies. This revision updates the requirements set out in the 2002 edition by providing more clarification about its scope and consideration of fire formal interpretations that have been received since the last edition was published.

Firestone, James. Bringing fire sprinklers into homes. Build, no121 (Dec 2010/Jan 2011) p56-57. 2011.
Abstract: Examines how domestic home sprinklers can be integrated into the domestic plumbing of New Zealand homes. Author is a Fire Engineer with the New Zealand Fire Service. Refers to NZ Standard 4517: 2010

Firestone, James. Retrofitting a home sprinkler system. Build, no116 (Feb/Mar 2010) p42-43. 2010.
Abstract: Example of a fire sprinkler system installed in a1891 native-timbered villa. Highlights the design features and access limitations encountered during installation.

Håkansson Anders; Daniel Langenbach; Patrick van Hees; Thomas Hermodsson; Bjarne P. Husted. Improvements of test method for watermist systems - CEN/TS 14972:2008. Interflam 2010 Proceedings, Interscience Communications Ltd, London. Annex A.3. 2010.
Abstract: Today's water mist systems are primarily designed on the basis of application testing. For land based applications a test called ?Office test?, or more correctly the CEN/TS 14972:2008, Annex A.3, is used. This test standard has shown not to be a particular good test standard, as there have been problems with repeatability and reproducibility of the test. This paper is an analysis of the uncertainties with respect to repeatability and reproducibility of the test method. Furthermore suggestions for an improved test method are given.

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Abstract: The NFPA guide to automatic sprinkler systems. It covers system requirements, and special design considerations for a range of occupancies and materials, including storage of plastics, rubber, and paper.

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http://www.nrc-cnrc.gc.ca/obj/irc/doc/pubs/nrcc49232/nrcc49232.pdf
Abstract: This paper reviews current research activities into the use of water-based fire suppression systems for tunnel protection, and identifies some of the challenges associated with the use of these systems

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Abstract: Aspirating systems can provide very early warning of incipient fires but until recently, have been considered too sensitive to activate suppression systems. Author examines pioneering work using fire modelling to fine tune the responses of these systems.

McGuirk, Tony. Aqua-mistÿ. Patio heater to portable sprinkler : first-ever moveable sprinklers in the UK + Portable sprinklers installed in Merseyside. Fire, v98 no1206 (Jan 2006) p30-31; Fire Prevention and Fire Engineers Journal, v66 no264 (Jan 2006) p4. 2006.
Abstract: Describes a portable sprinkler device for residential homes that can be placed in any room where an individual is most at risk. The stand-alone unit contains three extinguishers filled with water. When activated by a heat sensor a fine mist is produced that contains a fire-retardant chemical which quickly extinguishes the fire. The idea for the device was conceived by Merseyside chief fire officer, Tony McGuirk, from a patio heater and developed by Aqua-mist.

Page, Ian. Fire safety features in our homes. Build, Apr-May 2006, p38-39. 2006.
Abstract: Findings from the 2005 BRANZ survey of smoke alarms found in New Zealand homes. Looks at the number of homes with operational smoke alarms; how many alarms per house; location of alarms in the home; and other fire protection measures available in homes. Comments on the domestic fire fatality trend for New Zealand.

Perdell, Neil. Cheap not cheerful. Fire Risk Management, June 2010, p11-13. 2010.
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Persson, Henry; P Blomqvist, Fire and fire extinguishment in silos. Interflam 2007 Proceedings, Interscience Communications Ltd, London. 2007.
Abstract: A series of four silo fire experiments were conducted in an intermediate scale to provide guidelines regarding fire fighting of silo fires. The silo construction used was 1 m in diameter, approximately 6 m high and filled with approximately 3.7 m3 of wood pellets. The fire was initiated with a coiled heating wire placed centrally in the pellets bulk and after a preburn period of about 30 hours, the smouldering fire was extinguished using inert gas (N2 or CO2), and in some tests, inert gas in combination with foam. During the preburn period, the pyrolysis development and the possibilities for detection were studied. Some important conclusions of the work are that early detection is difficult to achieve with conventional gas analysis equipment, and that using injection of an inert gas is a suitable method for extinguishing a silo fire with wood pellets. Another conclusion is that it is important to keep the silo airtight during the extinguishing process. Prior to the tests, calculations of pyrolysis development and extinguishment were made using a designated computer code. The calculations predicted much of the actual fire development which was later seen in the experiments. The calculations were in this case a valuable tool in designing the experiments, but can in the future be a tool in designing safe storages.

Quintiere, James; N Schultz, Physical scaling for water mist fire suppression-A design application. Interflam. Proceedings, Interscience Communications Ltd, London.2007.
Abstract: The objective of this paper was to develop a water mist extinguishment design using physical scale modeling. The suppression scenario is combustible cargo on two covered open-bed trailer trucks subjected to a large heptane pool fire of 3 m2, as described in Maritime Safety Committee Circular MSC 914. The scaling emphasizes the preservation of flame radiation trough the fuel radiative absorption coefficient. Design development tests at a quarter scale were done with both liquid and gas simulated pool fires with noncombustible commodities. After testing several nozzle designs at small-scale, two L66-Bete swirl nozzles at 1.46 gpm (0.092 L/s) each, were found satisfactory for suppression. Compliance to MSC 914 was achieved by scaling up to two Bete-TF18 swirl nozzles at 30 gpm (1.89 L/s) each. Acceptable scaling was demonstrated for the fire and its suppression in this complex scenario.

Robin, Markÿ NFPA. Coming clean. Fire Risk Management, May 2008, p59-62. 2008.
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Abstract: Describes the retrofitting of a sprinkler system in a New Zealand rural property. Looks at the design considerations required, which included the removal of internal linings, use of side-wall sprinklers, and installation of an additional water tank.

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Utiskul, Yunyong; Wu, Neil P. Residential fire sprinklers : water usage and water meter performance study. 2011.
http://www.nfpa.org/assets/files//PDF/Research/RFWaterUsageWaterMeterPerformance.pdf
Abstract: This study looked at water issues related to residential sprinklers. It includes: 1) a study of water consumption during fire events and the resulting impact of sprinklers on the water infrastructure demand for detached one- and two-family home communities, and 2) an evaluation of the performance of water meters when used to supply residential fire sprinkler systems. This was in response to local and state authorities interest in water related issues, when considering adoption of model building codes that incorporate sprinklers. Residential sprinklers can assist with the conservation of water and the potential reduction of water infrastructure demands in communities. Water usage by fire services is expected to be significantly less for homes protected by a fire sprinkler system. Convention al water meters for combined service (i.e. domestic potable and fire sprinkler system service) can be perceived to be unsuitable for residential fire sprinkler systems based on pressure loss characteristics, flow capacity limitations, and reliability characteristics.

Wei Zhu; B Cong; G Liao; Z Huang. Experimental and numerical investigation of suppressing cup-burner frames with water vapor. Interflam 2007 Proceedings, Interscience Communications Ltd, London. 2007.
Abstract: The suppression process of a laminar methane-air diffusion flame formed on a cup burner with water vapor has been studied experimentally and numerically. The methane burned in a steel cup surrounded by a glass chimney. A mist generator produced fine mist delivered though the glass chimney with air. These fine droplets were heated into water vapor when they go though the diffuser. The suppression limit was obtained by gradually increasing the amount of water vapor to replace air in the coflowing oxidizer stream. Results show that the agent extinguishment concentration is constant over a wide range of the oxidizer velocity, showing a so-called ?plateau region?. The measured extinguishing mass fractions of agents are: (16.7 ñ 0.6) % for H2O; (15.9 ñ 0.6) % for CO2; and (31.9 ñ 0.6) % for N2. Computations used FDS developed by NIST. The simulations predict the water vapor suppression limit and the flickering frequency with good agreements with the experimental observations and, more importantly, reveal that the suppression of cup-burner flames occurred via a blow-off process (in which the flame base drifts downstream) rather than the global extinction phenomenon typical of counterflow diffusion flames. And the flame-base oscillation just before the blowoff is a key step for the flame extinction in the cup burner.

Yehuda Sinai; Chris Staples; Philip Stopford; Mike Edwards; Andy Hooper. PROGRESS ON CFD MODELLING OF FIRE SUPPRESSION BY WATER MIST. 2004.
Abstract: Sinai et al1 reported some aspects of the first stage (named Stage I) of a programme of development of CFD modelling of fire suppression by water mist. That work included multiphase flow, heat and mass transfer, thermal radiation, Eddy Break Up combustion, and coupling of pyrolysis to the fire. The modelling is being undertaken in parallel with a separate substantial experimental programme2. Stage I compared the predictions with an experiment in a 96 m3 compartment. In December 2001, Stage II was begun, with the aim of porting all that was done previously into the newer software (CFX-5), enhancing and generalising the physics, and validating against large-scale pool fire experiments. The programme of Stage II is a substantial one, involving the following:
1. Implementing transience in the Lagrangian PTM (Particle Transport Model).
2. Soot scavenging.
3. Droplet-congestion interactions.
4. Enhanced combustion modelling.
5. Soot modelling.
6. Additive effects.
7. Coupled pyrolysis.
8. Large-scale validation.
The validation is being done for a compartment pool fire with and without a metal structure above the pool (and engulfed by the fire), as well as with and without additive (AFFF). The existence of a structure within the fire can sometimes have a major influence on suppression phenomena, because its thermal inertia can continue to encourage ignition when it is hot, even when the combustion processes have been affected directly by the water spray. The validation is thus covering a wide range of conditions, and it is believed that some of these have not been addressed previously by CFD models. This paper is in the form of a progress report, and will focus on two aspects of the work: Scavenging of soot particles by water droplets on the one hand, and combustion and soot modelling on the other. The soot scavenging model has been developed because the phenomenon can affect radiation and visibility. Unfortunately, no experimental data has been found against which the model could be validated, specifically and solely regarding the scavenging process for the soot-droplet pair, and the work has identified the need for a separate-effects experiment to fill this void. In the paper, computational tests for generic, simple cases are reported. The combustion and soot activities use documented techniques, namely flamelet and soot models of Fairweather, Lindstedt and colleagues at Imperial College.

A4.6 REDUCTION OF FALSE ALARMS

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A4.7 OTHER DETECTION

Other Relevant References

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Abstract: Discusses findings from research investigating the responsiveness of older adults (65-85 years) to different emergency fire signals during sleep. Normal age-related decline in hearing ability makes it difficult to hear high pitched sounds. Recommends that high pitched signals currently found in smoke alarms be replaced by an alternative signal that will wake most of the adult population.

Bruck, Dorothy. Lowering the tone saves lives. New Scientist, no2678 (18 Oct 2008) p23. 2008.
Abstract: Briefly highlights findings from recent Australian research that found smoke alarms would save more lives if the noise they made was a little less shrill. People woke fastest when exposed to a square- wave signal with a frequency of 520 hertz plus other low tones.

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http://www.nfpa.org/assets/files/PDF/Research/alcohol&alarmsreport.pdf
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A4.8 EVACUATION

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Abstract: Two difficult problems pertain to selection of an evacuation route according to each individual's situation. One is constant supervision of the situation of a living space and detection of dangerous situations; the other is detection of residents' respective positions. In this paper, we describe devices and systems for an indoor emergency evacuation using a mobile terminal such as a cell phone or PDA for indoor navigation. The navigation system functions autonomously: the user's device receives wireless beacon signals from the surrounding environment and can thereby detect a user's position by a mobile terminal independently. In fact, no server-side computation is necessary. Moreover, the system is applicable to an indoor emergency evacuation system using various sensors. The emergency system navigates people to safety in the wake of a disaster. A system must detect all residents' positions and then inform them individually of routes to safety to evacuate all residents to a safe space urgently. We have developed a feasible indoor navigation system that can solve various problems arising in the application layer.

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Abstract: Computer simulation is a promising approach to better understand the crowd psychological dynamics. The lack of real data in crowd simulations, however, usually results in heavy dependence on assumptions, and thus hampers the confidence. This paper presents our work on the simulation of crowds under confrontation of psychological stimuli. This paper focuses on the psychological aspect of the crowd and introduces the intervention between two different relationship spaces in the crowd. Firstly, with the agent-based approach, psychometrics is employed in the construction of the individual model to improve the trustworthiness. Secondly, we describe in the model the phenomenon that individuals tend to get involved in various relationship spaces, which plays an important role in the procedure of psychological propagation. Finally, a scenario of a crowd in large-scale public activity under terrorist threat is studied, in which the workflow for psychometrics based crowd simulation is demonstrated, and the preliminary results are also discussed. Index Terms:Crowd Psychological Dynamics, Social Relationship Spaces, Psychometrics, Crowd Simulation, Multi-Agent System

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Abstract: Public lifts in high-rise buildings are traditionally seen as a means of transportation not a means of escape. Hong Kong professor explains his radical fire safety designs for lifts that are smoke and flame proof. These lifts would only stop at designated refuge floors, where people unable to walk down stairwells are required to gather in the event of a fire. Also describes his 'safety chamber' lift design, the use of computer vision-based intelligent control features, and outlines some of the obstacles to his designs.

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Abstract: Building fire is a common disaster happening in our daily life that causes unfortunate casualties and deaths. Successfully escaping from fire depends on the design of evacuation route and time as most of the damage of fire is caused due to lack of evacuation equipments or poor design of the emergency route. In this research work, we designed a hybrid building fire evacuation system (HBFES) on a mobile phone using Radio Frequency Identification (RFID) techniques. The system will be implemented at Tamkang University on Lanyang campus where a central fire alarm system has been installed. Location Based Service (LBS) and several existing computer or mobile phone applications, namely Viewpoint Calculator, Path planner, and MobiX3D viewer will be used on the system to rapidly calculate the reliable evacuation routes when building fire takes place.

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Abstract: The Vigilant QE90 Emergency Warning and Intercommunication System (EWIS) is designed to facilitate the orderly evacuation of a building in the event of an emergency. The evacuation may be initiated automatically by a fire alarm system, or by a building occupant operating an emergency call point. Integrating a flexible alarm and voice warning system with a dedicated emergency intercom system, the QE90 allows fire wardens or emergency services personnel to easily control and coordinate rapid building evacuation. QE90 meets the control and indicating equipment requirements of installation standard AS 1670.4, complies with equipment standard AS 2220.1, and supports the ISO 8201 T3 evacuation signal and strobe pattern.

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Commuters; Evacuation
Abstract: A study on building occupant characteristics in mass rapid transit (MRT) stations in Singapore is reported in this paper. The characteristics studied include age group and gender distributions, commuters' response to fire emergency alarms and their awareness of locations of exits, their walking speeds on walkways and stairs. The study took advantage of the fare card system used in Singapore to ascertain the age group spectrum of the commuters. Surveys were conducted among the MRT commuters to establish their intended response to three types of fire alarm systems, namely the fire alarm bell, the live announcement and the pre-recorded message. Commuter walking speeds were measured with the aid of video recording and on-site observation. The distributions of age groups in the MRT commuters were found to be statistically significantly different from that of general public, as there were mainly adults and fewer children and elderly in comparison to the general population. The distributions of gender groups in the MRT commuters were also found to be statistically significantly different from that of general public, as the female/male ratio among the commuters was greater than that in the general population. The survey results indicated that commuters intended more likely to respond to live announcement warning system than to the other two systems. The commuters' awareness of egress routes was poor. It was also noted that there was no statistically significant difference in the responses by the two gender groups to the three fire alarm warning systems but the study indicated the statistically significant gender difference in the awareness of fire escape routes. A significantly large proportion of commuters was found unaware of or unfamiliar with the current fire escape route provisions in the MRT stations from the survey. The unimpeded walking speed was found to be gender and age dependant and it may not be appropriate to apply one walking speed for all commuters. Weak correlations were found for linear fit of walking speeds over a wide range of pedestrian density on walkways and staircases.

A4.9 RISK ASSESSMENT

Other Relevant References

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Abstract: Technological advances have driven all aspects of Earth observation data, including improvements realized in sensor characteristics and capabilities, global data processing, near real-time monitoring, value-added products, and the distribution of global products. In particular, the growth of the World Wide Web is contributing to an increase in the global user base. The synergy of remote sensing, geographic information systems (GIS), Internet, and mobile phone technologies is revolutionizing the way in which satellite-derived information is archived and distributed to users. The Fire Information for Resource Management System (FIRMS), a NASA-funded application, is just one of many examples that illustrate the increasing ease with which Earth observation data are accessible to a broad range of users. This paper describes how the delivery of satellite-derived fire information has evolved over the last six years. By understanding user requirements and taking advantage of recent development s in areas such as information management, search, access, visualization, and enabling technologies, FIRMS has expanded the number and range of users that are able to access and utilize satellite-derived fire information. Specifically, we describe how satellite remote sensing and GIS technologies have been integrated to deliver MODIS active fire data to natural resource managers using Internet map ping services and customized e-mail alerts to users in more than 90 countries. We also describe how this web-based desktop application has been transitioned to a mobile service in South Africa to deliver fire information to field staff to warn of fires that may be potentially damaging to both natural resources and infrastructure.

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Abstract: This study explores the extent to which data mining and statistical techniques might assist the Fire Service in detecting threshold and pattern changes in its spatio-temporal fire data. Three entirely different scenarios are investigated. A post-hoc search for patterns was made of fires of suspicious or unknown cause in an area where a subsequently convicted arsonist was known to be operating. The spatio-temporal occurrence of chimney fires was compared with local climate data looking for any threshold conditions which might trigger the seasonal changes in occurrence. Finally an attempt is made to measure the effectiveness of the Firewise programme, which involves fire fighters visiting schools to instruct students in fire safety. The before and after incidence of residential fires in proximity to schools visited is assessed to determine whether the programme has had any measurable effect. Different data

mining techniques are applied to each scenario. The literature on change-point detection is reviewed and the applicability of identified techniques to real time fire data is discussed. Software options are discussed. The results suggest that fire data, especially time and location data, would be adequate for the purposes of detecting change-points but the problem under investigation must be clearly defined. Interpreted data about the fire must be accurate and unambiguous if it is to be of assistance in identifying change-points.

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Abstract: With the urbanization of China, the fire risk in urban areas is increasing. Thus an evaluation of the fire risk is necessary. This article analyzes the main factors influencing the city fire risk in China. The index system of city fire risk evaluation is constructed by various techniques. The mathematical model is established under the comprehensive assessment theory of fuzzy mathematics. The response time of fire departments corresponding to different risk regions is determined on the basis of risk evaluation. In the end the fire station coverage is calculated according to the response time. The evaluation results not only provide basic information for decision-making such as performance-based design of fire stations and city planning of fire protection, but also offer a theoretical foundation for optimizing fire fighting forces in cities.

Madrzykowski, Daniel. Kerber, Stephen. Kumar, Sunil. Panindre Prabodh. Wind, Fire & High - Rises. Mechanical Engineering, Vol. 132, Issue 7. 2010.
Abstract: The article focuses on the collaboration of the Fire Research Laboratory of the National Institute of Standards and Technology, Chicago, Illinois and New York City fire departments, and the Polytechnic Institute of New York University to analyze the dynamics of fires driven by winds. It states that the study also aims to avoid the repetition of the December 1998 accident in a New York City high-rise apartment which led to the death of three firefighters because of the wind-driven fire. It explains the various methods and experiments of the firefighters in New York and Chicago on wind-driven fires including the use of a wind control device to minimize the impact of wind, high-rise nozzle, and the usage of big portable fans to keep pressurize stairwells from combustion gases and smoke.

Massey, Curtis S D (5)ÿ. The new millennium's biggest challenge to firefighters: coming to a ""telco hotel"" near you. Firehouse (May 2001) p48-62. 2001.
Abstract: Discusses the potential for firefighter injuries in, and provides an extensive list of the fire hazards of intelligent buildings, which house large amounts of telecommunication equipment, hence ""telco hotels"".

Morgan J. Hurley. Predicting fire exposures to structures? a review of the state of the art. Interflam 2004 Proceedings, Interscience Communications Ltd, London. 2004.
Abstract: Fire resistance is typically designed into structures to protect against failure in the event of fire. The design of fire resistance of structures has historically been based on prescriptive requirements that have their basis in research conducted in the early 1900?s. These methods typically prescribe minimum fire resistance ratings for individual structural elements based on a number of building characteristics such as occupancy type and building height. While structures that are designed based on these requirements have a history of excellent performance in fires, by not considering the fire exposures to which structures might be exposed and structural response at elevated temperature, these prescriptive requirements do not provide a true measure of structural performance in fire. Additionally, it is clear from fire experience that structures built according to existing methods do not necessarily perform the same in fires.1 The most effective way to determine true structural performance in fire is through an engineering approach. The first step in engineering structural fire resistance is to determine the fire boundary conditions to which a structure could be exposed. After determining the fire boundary conditions, the thermal response of the structure can be predicted. Finally, with knowledge of the thermal response of the structure, the structural response analysis can be conducted with the use of elevated temperature material properties

Phillips, Emma Grubisich; Thomas Lyon Bradley. Understanding risk: innovation in disaster risk management : proceeds from the 2010 UR forum. 2011.
http://community.understandrisk.org/
Abstract: This event explored best practices in a variety of topics ranging from open source risk modelling to community-based risk assessments. New approaches in risk assessment were showcased, focusing on technological developments and the benefits of inclusive partnerships. The UR conference was attended by officials from government agencies, research institutions, multilateral organizations, nongovernmental organizations (NGOs) and more involved in disaster risk assessment. Prof. David Charters. A REVIEW OF FIRE RISK ASSESSMENT METHODS. 2004. Abstract: Fire regulations are increasingly being based on risk assessment. A range of fire risk assessment techniques are used to satisfy these regulations, from qualitative checklists, through points schemes to full quantification using fault and event trees and statistical analysis. It can be said that knowledge can be based on one or more of four things; superstition,

observation, measurement and/or theory. The fire risk assessment methods in use today draw their basis from these four areas to different degrees. This paper reviews the degree to which they draw on the different types of knowledge and the potential impact that this has on the assessed level of risk with respect to the actual level of risk.

Russell Thomas, National Research Council, Canada. The use of fire statistics in guiding research and code development. Interflam 2007 Proceedings, Interscience Communications Ltd, London. 2007.

Abstract: There has been a long tradition of collecting fire statistics in many countries around the world. In most cases the collection of statistics have entailed the records of the number of deaths, injuries and the total losses incurred through fire incidents. The majority of the statistics have focused upon fires in buildings, although there have also been considerable financial losses due to other types of fires that often do not get recorded or are included but without being identified as such. The statistics that do exist are, for a variety of reasons, often incomplete or contain errors of one sort or another. There is some value to be gained by these gross statistics, allowing for national comparisons of fire deaths and injuries, but these statistics are in general of little use to the research and codes communities in their current format. In order to gain useful information, researchers and codes authorities need to be able to obtain and analyze fire related statistics that reflect a greater level of detail. The major problem in obtaining statistical data on fire incidents in sufficient detail, is obtaining an unbiased sample of events and being sure that they do not include systematic biases due to the sampling techniques adopted. This paper will look at both long-term national trends and at the subsets developed to look at specific research issues. The studies will include consideration of the impact of specific regulations, such as smoke alarms and low ignition propensity cigarettes, on fire statistics. The impact of sub-reported fires that generally represent fires that did not grow to a significant size and self-extinguished or fires that were suppressed at an early stage, will also be considered. In many countries, changes to demographics are beginning to have an impact on the fire statistics. Many developed countries are starting to see the impact of the post Second World War population ?bulge? with a growing percentage of the population moving into their post 60?s. As a result many countries will over the next 30 years see a greater percentage of their elderly living longer. Concurrent with this a growing population of those less able, also a greater percentage will, exhibit difficulties with reacting promptly and appropriately to incidents, such as fires. What can the regulators and the fire community learn from the existing fire statistics that may help them prepare better for such changes and what can the research community do to develop the appropriate information and tools for the future?

Stefan Säardqvist. Cluster analysis of fatal fires. Interflam 2004 Proceedings, Interscience Communications Ltd, London. 2004.

Abstract: The number of fire related deaths in Sweden has been fairly constant during the last decade, commonly between the ranges of 100 to 150, distributed among 100 to 130 fires. Fatal fires are often regarded as unique events. When analysed they are, almost without exception, treated as a group. Data is available on the number of deaths in fires covering age, gender, first item ignited, cause of fire, time of day and day of the week. The situation is similar in many countries. This work shows that it is possible to separate fatal fires into different groups or clusters of fires. The fires show large similarities within each group and differences between the groups. Much of the statistical noise is reduced by clustering the fires and by analysing the different clusters, rather than analysing all the fires together. Thereby, patterns that have been hidden in the statistical noise are revealed, providing better opportunities for preventative measures.

United Nations. Global Assessment Report on Disaster Risk Reduction. 2011. http://www.preventionweb.net/english/hyogo/gar/2011/en/home/index.html

Abstract: This United Nations report is a resource for understanding and analysing global disaster risk today and in the future. It shows the mortality risk for all weather-related hazards continues to be concentrated in countries with low GDP and weak governance. The estimated economic loss risk associated with floods and tropical cyclones is increasing in all regions. This online version will be updated and enriched over the next few months following the Third Session of the Global Platform for Disaster Risk Reduction in Geneva in May 2011.

A5. REFERENCES FOR CHAPTER 5 IMPACT OF EMERGING TECHNOLOGIES FOR NZFS

A5.1 MODELING/SIMULATION TO REFINE LOCATION OF STATIONS AND/OR RESOURCES

References Cited in Report

Afshartous, David; Yongtao Guan; Anuj Mehrotra. US Coast Guard air station location with respect to distress calls: A spatial statistics and optimization based methodology. European Journal of Operational Research, Volume 196, Issue 3, 1 August 2009, Pp 1086-1096. Spatial statistics; Simulation; Robust optimization; Facility location; Location uncertainty. 2009.
http://www.sciencedirect.com/science/article/pii/S0377221708003731
Spatial statistics; Simulation; Robust optimization; Facility location; Location uncertainty
Abstract: We study the problem of suitably locating US Coast Guard air stations to respond to emergency distress calls. Our goal is to identify robust locations in the presence of uncertainty in distress call locations. Our analysis differs from the literature primarily in the way we model this uncertainty. In our optimization and simulation based methodology, we develop a statistical model and demonstrate our procedure using a real data set of distress calls. In addition to guiding strategic decisions of placement of various stations, our methodology is also able to provide guidance on how the resources should be allocated across stations.

Arabani, Alireza Boloori; Reza Zanjirani Farahani. Facility location dynamics: An overview of classifications and applications, Computers & Industrial Engineering. www.sciencedirect.com. Static facility location; Dynamic facility location; Location–relocation; Multi-period; Time-dependent; Stochastic. 2011.
http://www.sciencedirect.com/science/article/pii/S0360835211002877
Static facility location; Dynamic facility location; Location–relocation; Multi-period; Time-dependent; Stochastic
Abstract: In order to modify the current facility or develop a new facility, the dynamics of facility location problems (FLPs) ought to be taken into account so as to efficiently deal with changing parameters such as market demand, internal and external factors, and populations. Since FLPs have a strategic or long-term essence, the inherited uncertainty of future parameters must be incorporated in relevant models, so these models can be considered applicable and ready to implement. Furthermore, due to largely capital outlaid, location or relocation of facilities is basically considered as a long-term planning. Hence, regarding the way in which relevant criteria will change over time, decision makers not only are concerned about the operability and profitability of facilities for an extended period, but also seek to robust locations fitting well with variable demands. Concerning this fact, a trade-off should be set between benefits brought by facility location changes and costs incurred by possible modifications. This review reports on literature pointing out some aspects and characteristics of the dynamics of FLPs. In fact, this paper aims not only to review most variants of these problems, but also to provide a broad overview of their mathematical formulations as well as case studies that have been studied by the literature. Finally, based on classified research works and available gaps in the literature, some possible research trends will be pointed out.

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Goal programming; Multi-Objective modeling; Location planning; Fire stations
Abstract: The purpose of this paper is to determine where to locate fire-station facilities. The decision of where to locate depends upon a set of tangible and intangible criteria that are unique to a given problem. Thus, the traditional models that incorporate only travel times or travel distances are no longer appropriate. This paper presents a multiple criteria modeling approach, via integer goal programming, to the fire-station location problem that involves conflicting objectives. The proposed model describes the situation in which the city evaluates potential sites in 31 sub-areas that would serve these sub-areas in the year 2005. The model attempts to determine the location of fire stations, and the areas they are supposed to serve. The model considers multiple objectives that incorporate both travel times and travel distances from stations to demand sites (sub-areas). In addition, the model considers other cost-related objectives that

have been considered in previous studies. Other criteria considered are technical or political in nature, or used to satisfy certain system requirements. Further experimentation is carried out, by incorporating the results of a set-covering problem of the same situation. The results of the model indicate that the developed integer goal programming model seems to be an ideal technique that is applicable to the real-world fire-station location problem. Through extensive and direct interaction with decision-makers, model design and experimentation helps in a better understanding of the fire-station location problem. This paper includes discussions of the use of the multi-criteria model, the synergism of judgement and analysis, and ensuing recommendations that resulted. ? 1998 Elsevier Science B.V. All rights reserved

Baharin, Safiza; Suhana Kamal; Abdul Samad Shibghatullah; Zahriah Othman. Disaster Management in Malaysia: An Application Framework of Integrated Routing Application for Emergency Response Management System. 2009 International Conference of Soft Computing and Pattern Recognition, Malacca, Malaysia pp.716-719. DOI: 10.1109/SoCPaR.2009.144. 2009.
http://www.computer.org/portal/web/csdl/doi/10.1109/SoCPaR.2009.144
Abstract: Malaysia has experienced various disasters either natural or manmade disaster. One of the critical phases in Disaster Management System life cycle is response phase. In this phase, connectivity analysis such as a navigation service to help emergency rescue (ER) units reach at disaster area on time is necessary. Nowadays, commercial navigation system seems not appropriate to be used by ER units as they have different preferences. In addition, location information that is vital was not fully utilized in disaster management, especially in doing multi-task analysis. Thus, the real potential of GIS technology in managing spatial data including real-time (moving objects) data of ER units may influence the quality of the service. However, the services should be supported by a good data model. In order to eliminate inappropriate information, incomplete data, and overloaded information from Database Management System (DBMS) sent to the user, this paper will present the framework of integrated routing application for emergency response units embedded with context-aware.

Bonneu, Florent; Christine Thomas-Agnan. Spatial point process models for location–allocation problems. Computational Statistics & Data Analysis, Volume 53, Issue 8, 15 June 2009, Pp 3070-3081. 2009.
http://www.sciencedirect.com/science/article/pii/S0167947308004696
Abstract: The problem of finding an optimal location frequently occurs in geomarketing, economics and other fields: positioning a new branch of a bank, a supermarket, a fire station, a plant, designing a traffic network, etc. The optimal location of the source facility is the argument-minimum of an optimization problem parametrized by some characteristics of the clients. The random nature of some of these characteristics has already been recognized, but few stochastic models for location–allocation problems address the issue of uncertainty of the locations of the clients, and even then they do it with very naive tools. It is proposed to recognize uncertainty in the spatial positions of the clients, and possible spatial autocorrelation as well, by considering the random inputs of the optimization as one realization of a spatial marked point process. The method, called SPP location–allocation, involves fitting a point process model, simulating from the adjusted process, and solving a family of optimization problems for each simulated set of observations. The advantage of this approach over the deterministic one is twofold: it gives an indication of the spatial variability of the optimal solution, and it allows one to solve larger problems. Finally an application to the optimal positioning of a new fire station in the Toulouse area (France) is presented with some heuristic algorithms.

Challands, Neil. The relationships between fire service response time and fire outcomes. Fire Technology, v43 no3 (Jul 2010) p665-676. 2010.
http://ejournals.ebsco.com/direct.asp?ArticleID=43BDA57D4DA7DC71FF89
Abstract: Fire service response to fire is premised on the assumption that the earlier the fire is attacked the smaller will be the consequences to people and property. A simple method is shown for measuring the influence fire service response has on building fire development. The results for New Zealand are shown. The method is then extended to determining a nominal monetary benefit from rapid response and benefits in terms of other desired outcomes. The method allows the benefits of monitored fire alarms and sprinklers to be quantified. Finally the method is extended to determining the impact on fire service response of calls from cellular phones versus standard landlines. In the New Zealand circumstances the use of cellular phones does not appear on average to provide a speedier alert to the fire service and generally involves a marginally slower response owing to delays in locating incidents. This results in a measurably greater monetary loss.

Farahani, Reza Zanjirani; Maryam Steadie Seifi; Nasrin Asgari. Multiple criteria facility location problems: A survey. Location; Bi-objective; Multi-objective; Multi-attribute; Criteria. 2010.
http://www.sciencedirect.com/science/article/pii/S0307904X09003242
Location; Bi-objective; Multi-objective; Multi-attribute; Criteria
Abstract: This paper provides a review on recent efforts and development in multi-criteria location problems in three categories including bi-objective, multi-objective and multi-attribute problems and their solution methods. Also, it

provides an overview on various criteria used. While there are a few chapters or sections in different location books related to this topic, we have not seen any comprehensive review papers or book chapter that can cover it. We believe this paper can be used as a complementary and updated version.

Farahani, Reza Zanjirani; Nasrin Asgari; Nooshin Heidari;, Mahtab Hosseininia; Mark Goh. Covering problems in facility location: A review. Journal Computers & Industrial Engineering, Volume 62, Issue 1, February 2012, Pp 368–407. Facility location, Covering problem, Mathematical formulation, Survey. 2011.
http://www.sciencedirect.com/science/article/pii/S036083521100249X
Facility location, Covering problem, Mathematical formulation, Survey
Abstract: In this study, we review the covering problems in facility location. Here, besides a number of reviews on covering problems, a comprehensive review of models, solutions and applications related to the covering problem is presented after Schilling, Jayaraman, and Barkhi (1993). This survey tries to review all aspects of the covering problems by stressing the works after Schilling, Jayaraman, and Barkhi (1993). We first present the covering problems and then investigate solutions and applications. A summary and future works conclude the paper.

Indriasari, Vini. Mahmud, Ahmad. Maximal Service area problem for optimal siting of emergency facilities. International Journal of Geological Information Science, Vol.24, Issue 2. 2010.
Abstract: Geographic information systems (GIS) have been integrated to many applications in facility location problems today. However, there are still some GIS capabilities yet to be explored thoroughly. This study utilizes the capability of GIS to generate service areas as the travel time zones in a facility location model called the maximal service area problem (MSAP). The model is addressed to emergency facilities for which accessibility is an important requirement. The objective of the MSAP is to maximize the total service area of a specified number of facilities. In the MSAP, continuous space is deemed as the demand area, thus the optimality was measured by how large the area could be served by a set of facilities. Fire stations in South Jakarta, Indonesia, were chosen as a case study. Three heuristics, genetic algorithm (GA), tabu search (TS) and simulated annealing (SA), were applied to solve the optimization problem of the MSAP. The final output of the study shows that the three heuristics managed to provide better coverage than the existing coverage with the same number of fire stations within the same travel time. GA reached 82.95% coverage in 50.60 min, TS did 83.20% in 3.73 min, and SA did 80.17% in 52.42 min, while the existing coverage only reaches 73.82%.

Lili Yang, Bryan F. Jones, Shuang-Hua Yang. A fuzzy multi-objective programming for optimization of fire station locations through genetic algorithms. Location; Fire stations; Multi-objective programming; Genetic algorithm; Fuzzy programming. 2007.
http://www.sciencedirect.com/science/article/pii/S037722170600467X
Location; Fire stations; Multi-objective programming; Genetic algorithm; Fuzzy programming
Abstract: Location of fire stations is an important factor in its fire protection capability. This paper aims to determine the optimal location of fire station facilities. The proposed method is the combination of a fuzzy multi-objective programming and a genetic algorithm. The original fuzzy multiple objectives are appropriately converted to a single unified 'min–max' goal, which makes it easy to apply a genetic algorithm for the problem solving. Compared with the existing methods of fire station location our approach has three distinguish features: (1) considering fuzzy nature of a decision maker (DM) in the location optimization model; (2) fully considering the demands for the facilities from the areas with various fire risk categories; (3) being more understandable and practical to DM. The case study was based on the data collected from the Derbyshire fire and rescue service and used to illustrate the application of the method for the optimization of fire station locations.

Mokhtarian, M.N. A new fuzzy weighted average (FWA) method based on left and right scores: An application for determining a suitable location for a gas oil station, Computers & Journal: Mathematics with. MCDM; Fuzzy weighted average (FWA); Fuzzy sets; Left and right scores; Facility location selection; Gas oil station. 2011.
http://www.sciencedirect.com/science/article/pii/S0898122111002847
MCDM; Fuzzy weighted average (FWA); Fuzzy sets; Left and right scores; Facility location selection; Gas oil station
Abstract: The selection of a facility location from alternative locations is a multiple criteria decision making (MCDM) problem including both quantitative and qualitative criteria. In many real-life cases, determining the exact values for MCDM problems, and especially for facility location selection problems, is difficult or impossible, so the values of alternatives with respect to the criteria or/and the values of criteria weights are considered as fuzzy values (fuzzy numbers) such that the conventional crisp approaches for solving facility location selection problems and other MCDM problems tend to be less effective for dealing with the imprecise or vagueness nature of the linguistic assessments. In such conditions, fuzzy MCDM methods are applied for facility location selection problem and other fuzzy MCDM problems. In this paper, we propose a new fuzzy weighted average (FWA) method based on left and right scores for

fuzzy MCDM problems. Moreover, we apply the proposed method to a real application. As a result, we found that the proposed method is practical for facility location selection problems. Besides, it seems that the proposed FWA method is very accurate, flexible, simple, and easy to use when compared to other versions of the FWA method.

Murray, Alan T; Daoqin Tong. GIS and spatial analysis in the media. Applied Geography, Volume 29, Issue 2, April 2009, Pp 250-259. Location modeling; Journalism; GIS; Emergency services; Geography. 2009.
http://www.sciencedirect.com/science/article/pii/S0143622808000532
Location modeling; Journalism; GIS; Emergency services; Geography
Abstract: It is not uncommon to see maps and more advanced statistical or spatial analysis reported in the media. Geographical information systems (GIS) have no doubt facilitated access to and analysis of spatial information. This article is the outgrowth of contact by the Boston Globe and subsequent published articles examining structure fires and the location of fire stations in Massachusetts. The questions asked by the Boston Globe are important geographical ones regarding location specific urban/rural service provision issues, and to answer these questions requires the use of spatial analysis. This article focuses on the use of methods for answering the questions raised in the context of applying academic research, an issue that continues to be a challenge.

Simpson, N.C. Modeling of residential structure fire response: Exploring the hyper-project. Journal of Operations Management, Volume 24, Issue 5, September 2006, Pp 530-541. Fire hazard; Fire surrogates; Forest restoration; Fuels management; Sierra Nevada. 2006.
http://www.sciencedirect.com/science/article/pii/S0378112705004470
Fire hazard; Fire surrogates; Forest restoration; Fuels management; Sierra Nevada
Abstract: Fuel treatments have been suggested as a means to limit the size and intensity of wildfires but few experiments are available to analyze the effectiveness of different treatments. This paper presents information from a replicated, stand level experiment from mixed conifer forests in the north-central Sierra Nevada that investigated how control, mechanical (crown thinning, thinning from below followed, rotary mastication), prescribed fire, and mechanical followed by prescribed fire treatments affected fuels, forest structure, potential fire behavior, and modeled tree mortality at 80th, 90th, and 97.5th percentile fire weather conditions. Fuels Management Analyst was used to model fire behavior and tree mortality. Thinning and mastication each reduced crown bulk density by approximately 19% in mechanical only and mechanical plus fire treatments. Prescribed burning significantly reduced the total combined fuel load of litter, duff, 1, 10, 100, and 1000 h fuels by as much as 90%. This reduction significantly altered modeled fire behavior in both mechanical plus fire and fire only treatments in terms of fireline intensity and predicted mortality. The prescribed fire only and mechanical followed by prescribed fire treatments resulted in the lowest average fireline intensities, rate of spread, and predicted mortality. The control treatment resulted in the most severe modeled fire behavior and tree mortality. Mechanical only treatments were an improvement over controls but still resulted in tree mortality at severe fire weather when compared with the treatments that included prescribed fire. Restoration of mixed conifer ecosystems must include an examination of how proposed treatments affect fire behavior and effects. Variation in existing stand structures will require solutions that are site specific but the principals outlined in this work should help managers make better decisions.

Tzeng, Gwo-Hshiung; Hsin-Jung Cheng; Tsung Dow Huang. Multi-objective optimal planning for designing relief delivery systems. Earthquake; Multi-objective programming; Natural disaster; Relief distribution; Relief systems. 2007.
http://www.sciencedirect.com/science/article/pii/S1366554507000208)
Earthquake; Multi-objective programming; Natural disaster; Relief distribution; Relief systems
Abstract: The fatal earthquake on September 21, 1999 caused significant damages to Taiwan, which made the national government focus on strengthening relief systems regarding natural disasters. Disaster prevention, protection, and reconstruction are the major areas of focus to reduce human suffering and damage from disasters. A key point is the ability to enhance the distribution of relief materials effectively. In this study, we construct a relief-distribution model using the multi-objective programming method for designing relief delivery systems in a real case. The model features three objectives: minimizing the total cost, minimizing the total travel time, and maximizing the minimal satisfaction during the planning period. The first two objectives pursue the efficiency goal, whereas the third pursue fairness – making best effort to ensure relief commodity delivery to all demand points. Results of an empirical study are presented and suggestions are given for future research.

Upson, Robert; Notarianni, K. Quantitative evaluation of fire and EMS mobilization times. Worcester Polytechnic Institute, USA. 2010.
Abstract: The ability of emergency response agencies to get personnel and equipment to the scene of an emergency in a timely manner is critical. This involves effective alarm handling time and turnout time. However, comprehensive data on emergency first responder alarm handling and turnout time is largely absent from the published literature. This study provides a quantitative evaluation of fire emergency and EMS mobilization times, and identifies key factors affecting their performance. It provides a statistical analysis of actual fire emergency and EMS alarm handling and

turnout times based on data collected across a diverse representative population of North American fire service organizations.

WEI Lai, LI Han-lun, LIU Qi, CHEN Jing-yi, CUI Yi-jiao. Study and implementation of fire sites planning based on GIS and AHP. Procedia Engineering, Volume 11, 2011, Pp 486-495. 2011. http://www.sciencedirect.com/science/article/pii/S1877705811008757

Abstract: Urban fire is a hidden danger for city safety. Therefore, the overall layout of fire fighting facilities is an important part of fire control planning in cities. This study combines the method of GIS and AHP together. The paper, which fully considers the complicated data and their mutual influence, makes full use of spatial analysis, data processing and query. Planning and analysis will be more flexible and universal by utilizing this method, and the complexity of spatial location selection can be decreased considerably, which consequently may overcome the casualness and uncertainty of subjective site selection. And finally, the approach satisfies the planning requests of some related fire fighting department to a certain degree.

Wang, Shaojun; Bhaba R. Sarker; Lawrence Mann Jr.; Evangelos Triantaphyllou. Resource planning and a depot location model for electric power restoration. European Journal of Operational Research, Volume 155, Issue 1, 16 May 2004, Pp 22-43. 2004. http://www.sciencedirect.com/science/article/pii/S0377221702008032

Abstract: The purpose of this research is to develop a depot location model to manage the resources needed for efficient and economic power restoration in an area which has experienced an outage. Determining the optimal number of depots, optimal location of depots, and the optimal number of repair crews and/or equipment is of significant importance in power restoration operations. The problem is studied on two levels: first, the general problem simultaneously locates depots and determines the amount of the resources to be shipped from the depots to each point in order to minimize the total transportation cost. The second problem adds new depots to an area where depots already exist. This decision-making is a trade-off between whether or not it is necessary to establish new depots. The mathematical models for both cases are developed on an incremental basis as the problems become complex and new scenarios become apparent. An optimal solution strategy is presented following each problem. The results show that the optimal model can be used by power restoration management. For a large size problem, a heuristic can help the analysts/planners obtain an approximate optimal solution. In this investigation, a two-phase heuristic for the depot location is developed. Some computational results are discussed for both optimal and heuristic solutions.

Xiang Zhang; Jian-gang Xu; Yi Qi. Decision Support System of Fire Station Distribution and Responsible Area Zoning in Nanjing, China. Artificial Intelligence and Computational Intelligence, 2009. International Conference on , vol.4, no., pp.206-213, 7-8 Nov. 2009. DOI: 10.1109/AICI.2009.456. 2009.

http://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=5376382&isnumber=5375743

Abstract: This paper, from a theoretical perspective, to study Fire Station Distribution and Responsible Area Zoning, found that optimizing standard was fire protection response time. Using this standard, the author constructed an Optimizing Mathematic model to convert response time problem to vehicular speed of Fire Engine. Based on principles of Transportation Accessibility and Road System Reliability, this paper chose thirteen factors from three perspectives (including the urban road structure and its ability of impedance, urban land use and population density) in Nanjing downtown area. Using analysis method of multi-factors weighted-overlay and GIS software, this paper evaluated vehicular speed on the road, the intersection and urban land in different periods. Then the author constructed an Decision Support System of Fire Station Distribution and Responsible Area Zoning during the Traffic Peak Period of Nanjing based on analysis of Time Cost-weighted Distance. Results indicated that current distribution of Fire Station was not suitable and the average fire control response time was about 14 minutes, far exceeding the national standards of 5 min. Through Decision Support System, the author planned 14 new fire stations, and together with the 19 reservation fire stations in Nanjing Urban Master Planning, this distribution planning would make the average response time short to 8 minutes, and more than 50% urban area of Nanjing down area can be arrived by the Fire Engine in time(less than 5 minutes), and the average responsible area of these 46 fire stations would be about 6.2 km2. This paper was a preliminary research on analyzing Distribution of Fire Station with a raster calculating method that could be a great valuable supplement for studying the Planning of Fire Station Distribution in traditional vector network analysis and it could help the government to make decisions. However, this study had its limitations. Future study needs to focus on factor choosing an- d speed calculating.

Department for Communities and Local Government (DCLG), UK. Review of Fire and Rescue Service response times. 2009.

Abstract: Findings from new research in the UK says that response times in England have increased mainly due to rising fire and road traffic incidents over a number of years. The report looks at factors that may have contributed to the trends and identifies possible links between changes in response times, fatality rates and property loss.

Other Relevant References

Bacharach, Samÿ. Open spatial web : improves decision support. GEOWorld, (Dec 2005) p38-40. 2005.
Abstract: Discusses the benefits of geospatial information and how it can play a key role in the four stages of disaster management: mitigation, preparedness, response, and recovery. Describes an ""interoperability"" initiative by Open Geospatial Consortium (OGC) and several US agencies and companies to identify solutions to common concerns to enhance the geospatial standards platform in the USA.

Corcoran, Jonathan. Higgs, Gary. Brunsdon, Chris. Ware, Andrew. The Use of Comaps to Explore the Spatial and Temporal Dynamics of Fire Incidents: A Case Study in South Wales, United Kingdom. Professional Geographer, Vol.59, Issue 4. 2007.
Abstract: This article reports on the results from a spatiotemporal analysis of disaggregate fire incident data. The innovative analysis presented here focuses on the exploration of spatial and temporal pattern s for four principal fire incident categories: property, vehicle, secondary fires, and malicious false alarms. This research extends previous work on spatial exploration of spatiotemporal patterns by demonstrating the benefits of comaps and kernel density estimation in examining temporal and spatiotemporal dynamics in calls for services. Results indicate that fire incidents are not static in either time or space and that spatiotemporal variation is related to incident type. The application of these techniques has the potential to inform policy decisions both from a reactive, resource-allocation perspective and from a more proactive perspective, such as through spatial targeting of preventive measures.

Krisp, Jukka. Planning Fire and Rescue Services by visualizing mobile phone density. Journal of Urban Technology, Vol. 17, Issue 1. 2010.
Abstract: This paper focuses on how calculating and visualizing mobile phone density would assist fire and rescue services in Helsinki, Finland. Studying the relationship between population distributions (over time) and population density hot spots can lead to better emergency preparedness and the more efficient allocation of fire and rescue services. Current data are restricted to the administrative boundaries of census data and limited in their time dimension. Data acquired from mobile phone locations have a high temporal and spatial dimension and are better suited for the purpose of showing changing population density hotspots over time. Viewing population density as a continuous surface, using kernel density estimations, and visualizing it as a "landscape" can support the understanding of density distributions, which are of particular importance in the planning of fire and rescue services.

Leidner, Alan. The geospatial response to 9/11; Disasters stress geospatial field support; Distributed GIS and the Web provide powerful benefits; A first responder's perspective. GEOWorld, v18 no9 (Sept 2005) p26-30 + p31 + p32 + p33. 2005.
Abstract: Lessons learned from the World Trade Center attack, 11 September 2001 that focuses on the geospatial response to the incident. Discusses future requirements in this field so that a common and integrated spatial information database can be developed that is available at local and federal state emergency management levels in the event of such disasters.

Queensland Fire and Rescue Service. University of Queensland. Mapping unearths fire insights. Emergency, Aug 2006, p24-26. 2006.
Abstract: Briefly describes a new fire modelling project ('Mapping to the Rescue') that aims to enhance the capacity to model fire occurrences, intensity and magnitude of fire and associated risk factors in Queensland. Researchers from University of Queensland are developing innovative mapping techniques to analyse the spatial and temporal dynamics of fire incidences.

Smoke - keep out (2011). Fire and Rescue, no82 (2nd Quarter 2011) p45-46. 2011.
Abstract: Describes a new innovative product called the 'Butterfly Smoke Seal'. This thermal resistant smoke seal effectively prevents smoke and harmful vapours from penetrating into a room, by blocking the air space below the door and covering air leaks around doors. Refers to NFPA Code 105 and UL Standard 1784.

A5.2 IMPROVE APPLIANCE DESIGN TO IMPROVE PERFORMANCE THROUGH TRAFFIC, ON BOARD NAVIGATION

References Cited in Report

Cohen, Michael; Owen Noel Newton Fernando; Tatsuya Nagai; Kensuke Shimizu. Back-Seat Driver: Spatial Sound for Vehicular Way-Finding and Situation Awareness. Frontier of Computer Science and Technology, 2006. Japan-China Joint Workshop on , pp.109-115, Nov. 2006. DOI: 10.1109/FCST.2006.1. 2006.
http://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=4020978&isnumber=4020958
Abstract: We are exploring IDSS (intelligent driver support systems), especially including way-finding presented via spatial audio. ("Way-finding" refers to giving a driver directions, as via car navigation ["car-nabi"] GPS/GIS systems.) We have developed a networked driving simulator as a virtual-reality based interface (control/display system) featuring integration with the c Shaire rotary motion platform for azimuth-display, stereographic display for 3D graphics, and spatial audio (sound spatialization) way-finding cues. A design for a guidance system coupled with a GPS system is described, using dynamically selected HRTFs (head-related transfer functions) to directionalize arbitrary audio signals. The system is intended to provide a capability for way-finding as an audio compass or homing beacon. "Back-seat driver" is a slang expression for a passenger (often stereotypically a mother-in-law) who offers driving advice while en route. Besides this colloquialism, we also interpret the phrase literally: we have developed a double-driver (long ladder) fire-truck simulation with a "tiller" (rear steering), which can be driven via an integrated pair of our driving simulator stations. We have incorporated navigation cues into the emergency vehicle simulator, and are working to deploy such a system in a real vehicle

McGuirk, Tony, Merseyside Fire and Rescue Service. Fire motorbike launched. Fire, v98 no1202 (Aug 2005) p9. 2005.
Abstract: Describes the launch of a 12-month pilot initiative by the Merseyside Fire and Rescue Service. It will be using a fire motorbike to attend automatic fire alarm calls in a bid to beat rush hour and other congested traffic delays in the city. The fire motorbike will provide initial risk assessments at callout scenes while appliances are en route. When not operational the fire motorbike will be help with community fire safety initiatives.

A5.3 CONTROL OF TRAFFIC LIGHT PHASING BY ON-BOARD DEVICE

References Cited in Report

Butt, Brian. Traffic control systems. BRT : Bulletin of Research and Technology, no3 (Aug 1999) p3. 1999.
Abstract: Account of the trialling of 3M's "Opticom" system which allows fire appliances to trigger green lights when travelling to an emergency

A5.4 VEHICLE-BASED INCIDENT INFORMATION DISPLAY VIA IP (INTERNET PROTOCOL) NETWORK EG RISK PLANS

References Cited in Report

Dittmar, Mary Jane. Technology Roundup: Focus on Interoperability, Safety, and All-Hazards Efficiency. Fire Engineering, Vol.160, Issue 5. 2007.
Abstract: This article features information on technology in the field of firefighting. A Commanders' Radio Interface has been developed. The interface links incompatible radios, satellite phones and Voice-over Internet Protocol systems for instant communications. A personnel locator system is under development. Fireground applications include a structural stability monitor. Other new products are featured.
http://www.fireengineering.com/articles/2007/05/technology-roundup-focus-on-interoperability-safety-and-all-hazards-efficiency.html

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http://www.fieldsoft.com/newsrelease/2009/Windows_7_Compatible.html

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Prepared Response Inc, Rapid Responder® Crisis management system, Prepared Response Inc, accessed October 2011
http://www.preparedresponse.com/rapidresponder/default.html

Other Relevant References

Parker, Davidÿ. Cab computers for West Sussex. Fire, v93 no1143 (Sep 2000) p37. 2000.
Abstract: Reports on the West Sussex project to provide operational information via a mobile data system, or computer, to personnel en route to an incident. This information enables them to make better risk assessments before arrival, and to better ensure their own safety. This in turn helps the employer meet its obligations under the Health and Safety in Employment Act.

A5.5 INTEGRATED BUILDING MANAGEMENT SYSTEMS WITH IP (INTERNET PROTOCOL) CONNECTION TO OIC AND COMCEN.

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Cowlard, A; Wolfram Jahn et al. Sensor Assisted Fire Fighting. Fire Technology, 46, 719–741. DOI: 10.1007/s10694-008-0069-1. 2010.
http://www.see.ed.ac.uk/~grein/rein_papers/Cowlard_SensorFireFighting_FT08.pdf
Abstract: Fire detection and monitoring sensors, fire modelling, fire fighting and command and control are usually perceived as independent issues within fire safety. Sensor data is associated to detection and alarm and to some minor extent as a source of very basic information for building management or emergency response. The streams of data emerging from sensors are deemed to lead to a rapid information overload, so the pervasive sensor deployment (now common in modern buildings) is entirely independent of procedures associated to emergency management. Fire modelling follows a similar path because model output is not robust enough, not fast enough and the information generated by such simulations rapidly escalates in quantity and complexity so that no commander can assimilate it. Fire fighting is therefore left as an isolated activity that does not benefit much from sensor data or the potential of modelling the event. This separation is naturally induced by the complexity of a fire event and represents the biggest barrier to the useful development of sensor technology and fire modelling into emergency response. Therefore, current technology applied to fire is decades behind sensor development for other related areas like military operations or intruder security. There is no apparent use for more complex and expensive sensors. This paper describes the different processes that need to be studied to establish a path by which a collection of sensor data can be used to provide early detection, robust building management and adequate information to assist fire fighting operations

Werner, R.; Nelem Pazzi, Azzedine Boukerche, and Tingxue Huang. Implementation, Measurement, and Analysis of an Image-Based Virtual Environment Streaming Protocol for Wireless Mobile Devices. IEEE Transactions on Instrumentation and Measurement, Vol.57 No.9 Sept 2008. DOI: 10.1109/TIM.2008.919901. 2008.
http://ieeexplore.ieee.org/xpl/freeabs_all.jsp?arnumber=4497232 Abstract: Remote exploration of detailed virtual environments (VEs) on mobile devices with acceptable frame rates has become a challenging and interesting research topic. With recent advances in mobile computing devices with communication and multimedia capabilities, remote VE walk-through and real-time streaming for mobile devices have opened a new class of 3-D VE exploration-based applications such as virtual guides and malls, online gaming, training, and monitoring, just to name a few. Furthermore, emergency preparedness types of applications can benefit from mobile 3-D visualization systems to support emergency responders with critical information about the disaster area. The combination of sensor networks with VEs can provide a physical environment monitoring and measurement system with live information about the target environment that can be visualized in real time. The challenge lies in how to provide a rich and detailed 3-D VE on thin mobile devices that are known for their lack of proper resources to process large-scale 3-D geometric data. Our

approach consists of moving the demanding geometry-rendering task to a dedicated remote rendering server that streams the rendering output to a client, leaving only the displaying and certain minor image-based rendering tasks to the local, less-powerful mobile hardware. In addition, wireless networks pose significant challenges to multimedia streaming due, for the most part, to the mobility-induced changes in bandwidth and errors in the wireless channel. In this paper, we focus on the implementation, measurement, and analysis of an image-based VE streaming strategy. We define a new approach to remote rendering and interactive visualization of 3-D VEs on thin mobile devices. To this end, we propose end-to-end streaming and rate control protocols, as well as buffering and scheduling mechanisms to support the requirements of bandwidth-demanding multimedia systems. The main purpose of our proposed rate control scheme is to achieve- - both high end-to-end throughput and low frame-rate fluctuation to adapt data traffic to the frequent changes of the bandwidth and error rate present in wireless networks. We discuss the design of our proposed solutions and report on their performance evaluation through an extensive set of simulation experiments.

Wilson, J.; Bhargava, V.; Redfern, A.; Wright, P. A Wireless Sensor Network and Incident Command Interface for Urban Firefighting. Mobile and Ubiquitous Systems: Networking & Services, 2007. MobiQuitous 2007 Fourth Annual International Conference on , pp.1-7, 6-10 Aug. 2007. DOI: 10.1109/MOBIQ.2007.4450980. 2007.
http://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=4450980&isnumber=4450969
Abstract: The Fire Information and Rescue Equipment project at UC Berkeley has developed a prototype wireless sensor network (WSN) and Incident Command (IC) interface for urban and industrial firefighting and emergency response. A fixed WSN deployment in the building acts as a backbone for communication between mobile personnel and Incident Command. The Telos Sky mote 802.15.4 platform with the TinyOS operating system is used for a variety of sensing and communication tasks. These include localization, environmental monitoring, and redundant emergency communications. We describe features and performance of the system. We also share what we have learned from firefighters through interviews, usability tests, and demonstrations.

A5.6 DEVICES ON FIREFIGHTERS FOR LOCATION IN STRUCTURES

References Cited in Report

Denef, Sebastian; Leonardo Ramirez; Tobias Dyrks; Gunnar Stevens. Handy navigation in ever-changing spaces: an ethnographic study of firefighting practices. Proceedings of the 7th ACM conference on Designing interactive systems, ACM New York, NY, USA ©2008. DOI: 10.1145/1394445.1394465. 2008.
Abstract: This paper presents an ethnographic study, conducted to gain an insight of the practices around navigation of firefighters on the first line of intervention. We argue that the common approach of looking only at the technical aspects is incomplete. We show instead, that navigation of firefighters in ever-changing spaces is a collective craft or art, where technology is only one of the relevant pieces, but not the only one. Therefore design should take a deep look at existing navigation practices of firefighters. In order to identify relevant work practices, we conducted our ethnographic study to find out patterns of navigation work and based on our findings, we provide an outline of how the navigation practices can be supported by ubiquitous computing.

Fischer, Carl; Hans Gellersen Lancaster University. Location and Navigation Support for Emergency Responders: A Survey. Pervasive computing IEEE Vol 9 Issue:1 pp 38 ? 47. DOI: 10.1109/MPRV.2009.91. 2010.
http://ieeexplore.ieee.org/xpl/freeabs_all.jsp?arnumber=5342406
Abstract: As this overview of products and projects shows, preinstalled location systems, wireless sensor networks, and inertial sensing all have benefits and drawbacks when considering emergency response requirements.

Hampshire Fire and Rescue Service; Northamptonshire Fire and Rescue Service. Keeping track on the fireground; CoCon goes live with Northamptonshire Fire and Rescue Service. Fire, v102 no1326 (Apr 2010) p42-43. 2010.
Abstract: Two articles on UK Fire and Rescue Services in Hampshire and Northamptonshire investigating the use of Radio Frequency Identification (RFID) technology to track firefighters, vehicles and equipment, and to improve communication connectivity on the fireground.

Lorincz, Konrad; Matt Welsh. MoteTrack: a robust, decentralized approach to RF-based location tracking. Personal and Ubiquitous Computing archive Volume 11 Issue 6, August 2007 Springer-Verlag London, UK. DOI: 10.1007/s00779-006-0095-2. 2007.

Abstract: In this paper, we present a robust, decentralized approach to RF-based location tracking. Our system, called MoteTrack, is based on low-power radio transceivers coupled with a modest amount of computation and storage capabilities. MoteTrack does not rely upon any back-end server or network infrastructure: the location of each mobile node is computed using a received radio signal strength signature from numerous beacon nodes to a database of signatures that is replicated across the beacon nodes themselves. This design allows the system to function despite significant failures of the radio beacon infrastructure. In our deployment of MoteTrack, consisting of 23 beacon nodes distributed across our Computer Science building, we achieve a 50th percentile and 80th percentile location- tracking accuracy of 0.9 and 1.6 m respectively. In addition, MoteTrack can tolerate the failure of up to 60% of the beacon nodes without severely degrading accuracy, making the system suitable for deployment in highly volatile conditions. We present a detailed analysis of MoteTrack's performance under a wide range of conditions, including variance in the number of obstructions, beacon node failure, radio signature perturbations, receiver sensitivity, and beacon node density

Ramirez, Leonardo; Sebastian Denef; Tobias Dyrks. Towards human-centered support for indoor navigation. Proceedings of the 27th international conference on Human factors in computing systems, ACM New York, NY, USA 2009. DOI: 10.1145/1518701.1518893. 2009.
Abstract: This paper presents a new perspective for the design of indoor navigation support. In contrast to technology oriented approaches coming from Context Awareness research, we argue for a wider focus that complements the technical question of providing precise indoor location with the development of more effective navigation practices based on technology available today. Starting from research on indoor navigation conducted with the Paris Fire Brigade, we present two design concepts aimed at supporting firefighters in creating and finding their own paths, together with some of the design strategies that informed the creation of these concepts.

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Prasanna, Rajÿ King, Malcolm Yang, Lili Loughborough University, UK. Real-time resources. Fire Risk Management, Jul 2010, p38-43. 2010.
Abstract: Discusses the initial findings of a new wireless technology project called 'SafetyNet'. It will provide real-time data about buildings, hazard conditions, and a responder's location with the support of wireless sensors. It will also expand the decision-making capabilities of firefighters in areas such as life protection, incident identification, rescue support and time-critical decision-making. UK-influenced.

A5.7 SENSORS ON FIREFIGHTERS TO MEASURE AND TRANSMIT ENVIRONMENTAL DATA EG TEMPERATURE, GASES, SMOKE ETC

References Cited in Report

Bonfiglio, Annalisa; Carbonaro, Nicola; Chuzel, Cyril et al. Managing Catastrophic Events by Wearable Mobile Systems. Mobile Response Lecture Notes in Computer Science Lecture Notes in Computer Science, 2007, Volume 4458/2007, 95-105. DOI: 10.1007/978-3-540-75668-2_11. 2007.
http://dx.doi.org/10.1007/978-3-540-75668-2_11
Abstract: AB - Proetex is a European Integrated Project dedicated to micro- and nano-technology-based wearable equipment for emergency operators. During the first year of work, a careful analysis of several emergency scenarios has been carried out and has resulted in the design of a complete "smart" uniform for fire-fighters and emergency rescuers. These garments aim at monitoring both physiological parameters, position and posture of the operators and the presence of external potential sources of danger and to send these data to a remote coordinating unit. In the following, the main issues of the design flow will be described and discussed.

Cavanaugh, A.: M. Lowe: D. Cyganski: R. J. Duckworth. A Bayesian Fusion Algorithm for Precision Personnel Location in Indoor Environments. Worcester Polytechnic Institute, Worcester, Mass. 2011.
http://www.wpi.edu/Images/CMS/ECE/ION_ITM_2011_cavanaugh_itm_footnoted.pdf

Abstract: An RF-based system is being developed at WPI for tracking of first responders and other personnel in indoor environments. The system assumes no existing infrastructure, no precharacterization of the area of operation and is designed for spectral compliance and rapid deployment. A 3D location system, based on a multicarrier signal using a novel signal fusion algorithm has been previously described [1] and has demonstrated sub-meter positioning accuracy of a transmitter, even in difficult indoor environments with high multi-path, with all receivers placed outside the building. The development of new hardware supporting two-way transactions has driven development of new signal fusion algorithms, as well as allowing tight integration with information from an on-board high-quality MEMs IMU system. This paper reports on the development of new processing and filtering techniques that were designed to exploit the new hardware capabilities and that yield performance improvements in comparison with our previously demonstrated systems.

Also see:
http://www.wpi.edu/academics/ece/ppl/ (accessed November 2011)
and
http://www.fireapparatusmagazine.com/index/display/article-display/6413136915/articles/fire-apparatus/volume-16/issue-11/features/interior-firefighter-location-systems-being-refined.html

Cyganski, David R.; James Duckworth; Kathy Notarianni. Development of a Portable Flashover Predictor (Fire-Ground Environment Sensor System). FEMA AFG 2008 Scientific Report, Worcester Polytechnic Institute, Worcester, Mass. 2008.
http://www.wpi.edu/Images/CMS/ECE/WPI_AFG_2008_Fire-ground_Environment_Sensor_-_Scientific_Report.pdf

Abstract: An AFG 2008 award supported a science and engineering effort towards development of an integrated Firefighter Locator and Environmental Monitor to provide real-time flashover warning and advanced situational awareness. The goal of the one year effort was evaluation of the feasibility and impact of a new flashover warning technology. The program was designed to balance the tradeoffs between the underlying physics of ideal flashover prediction and the requirements of practical field implementation to ultimately offer firefighters a tool to save lives and enable more efficient firefighting tactics. The project included an integration effort in which the flashover prediction information was fused with a data stream from a system previously developed by WPI under AFG 2006 which provided simultaneous firefighter location and physiological information. This report focuses upon the basic scientific effort to understand the relationship between certain observables on the fireground and the event of flashover, followed by the engineering of a portable device that provides significant warning of the impending event of flashover.

See also:
http://www.fireapparatusmagazine.com/index/display/article-display/6413136915/articles/fire-apparatus/volume-16/issue-11/features/interior-firefighter-location-systems-being-refined.html

Klann, Markus; Till Riedel; Hans Gellersen; Carl Fischer et al. LifeNet: an Ad-hoc Sensor Network and Wearable System to Provide Firefighters with Navigation Support. UbiComp: Demos Extended Abstracts. 2007. Innsbruck, Austria. sensor networks, localization, navigation, wearable computing. 2007.
http://eprints.lancs.ac.uk/13037/2/2007-LifeNet.pdf
sensor networks, localization, navigation, wearable computing.

Abstract: This paper describes a concept called LifeNet for using an ad-hoc sensor network providing relative positioning and a wearable system to support firefighters at indoor-navigation under impaired visibility. We describe the concept and a first implementation.

Walters, K.; Seungyon Lee; Starner, T.; Leibrandt, R.; Lawo, M.. Touchfire: Towards a glove-mounted tactile display for rendering temperature readings for firefighters. Wearable Computers, 2010 International Symposium on , pp.1-4, 10-13 Oct. 2010. DOI: 10.1109/ISWC.2010.5665862. 2010.
http://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=5665862&isnumber=5665849

Abstract: The temperatures of objects and ambient air are important to a firefighter when fighting an indoor fire. Firefighters have difficulty sensing temperature through their protective gloves, yet the often-used practice of removing their gloves risks burning their hands. One potential solution is to add a temperature sensor outside of the glove and a tactile display inside the glove that maps the sensed temperature into varying tactile patterns. We create a two-vibrator display, mounted on the wrist, and perform two studies to determine how well different speeds of simple alternating patterns can be distinguished. Our results show that the patterns' periods should differ by more than 300ms and that age may play a significant role in a user's ability to perceive the patterns.

Other Relevant References

Ceruti , Marion G; Vincent Vinh Dinh; Nghia Xuan Tran et al, Space and Naval Warfare Systems Center, San Diego, CA. Wireless communication glove apparatus for motion tracking, gesture recognition, data transmission, and reception in extreme environments. Proceedings of the 2009 ACM symposium on Applied Computing ACM New York, NY, USA ©2009. DOI: 10.1145/1529282.1529320. 2009.
http://dl.acm.org/citation.cfm?id=1529320
Abstract: Military personnel need better ways to communicate in hostile, noisy, silence-mandated, and/or extreme environments. Typing on a keyboard is difficult and impractical while wearing comprehensive protective clothing. Wireless data gloves were researched and developed to transmit and receive ASCII code and other signals as hand gestures. Two categories of glove prototypes were constructed: gloves with and without a haptic-IO capability. All data gloves detect motion, such as gestures, using magnetic sensors. Non-haptic gloves only transmit static and dynamic gestures. Haptic gloves have vibro-mechanical devices on the fingertips for feedback about transmitted signals and for covert-signal reception. Many potential communications applications include hazardous and covert military operations, space operations, fire fighting, mining, training, underwater use, and aids for the visually and hearing impaired.

Keaton, Trish: M. Dominguez; H. Sayed. Browsing the environment with the SNAP&TELL wearable computer system. Personal and Ubiquitous Computing archive Volume 9 Issue 6, November 2005 Springer-Verlag London, UK. DOI: 10.1007/s00779-004-0316-5. 2005.
Abstract: This paper provides an overview of a multi-modal wearable computer system, SNAP&TELL. The system performs real-time gesture tracking, combined with audio-based control commands, in order to recognize objects in an environment, including outdoor landmarks. The system uses a single camera to capture images, which are then processed to perform color segmentation, fingertip shape analysis, robust tracking, and invariant object recognition, in order to quickly identify the objects encircled and snapped by the users pointing gesture. In addition, the system returns an audio narration, telling the user information concerning the objects classification, historical facts, usage, etc. This system provides enabling technology for the design of intelligent assistants to support Web-On-The- World applications, with potential uses such as travel assistance, business advertisement, the design of smart living and working spaces, and pervasive wireless services and internet vehicles.

Timm-Giel, Andreas; Koojana Kuladinithi; and Carmelita Görg. WearIT@work: Communications for the Mobile Worker Equipped with Wearable Computing. Mobile Response Lecture Notes in Computer Science Lecture Notes in Computer Science, 2007, Volume 4458/2007, 95-105. DOI: 10.1007/978-3-540-75668-2_11. Wearable Computing, User Centered Design, Application scenarios, Communication Services Module. 2007.
http://dx.doi.org/10.1007/978-3-540-75668-2_11
Wearable Computing, User Centered Design, Application scenarios, Communication Services Module
Abstract: This paper gives an overview on the requirements and the concepts to enable communications for the mobile worker using a wearable computer. Wearable computing allows a paradigm shift from working at the computer to working with the computer. The results presented are based on work performed in the framework of the wearIT@work project funded in the IST 6th Framework Programme of the EC. The project and development is based on a User Centered Design (UCD) approach and therefore considers four different user scenarios: firefighting, aircraft maintenance, car production and medical services in the hospital. The specific and general requirements on communications for wearable computing are presented and the concept and first results of integration are presented. Research topics for further investigation in the framework of the wearIT@work project are explained in the conclusion.

A5.8 SYSTEM TO LOCATE CALLER'S CELL-PHONE ETC

References Cited in Report

Osamu Takizawa; Masafumi Hosokawa et al. Pinpointing the Place of Origin of a Cellular Phone Emergency Call Using Active RFID Tags. 22nd International Conference on Advanced Information Networking and Applications - Workshops 2008 pp.1123-1128. DOI: 10.1109/WAINA.2008.135. 2008.
http://www.computer.org/portal/web/csdl/doi/10.1109/WAINA.2008.135
Abstract: When police, fire or ambulance personnel receive an emergency call, they must pinpoint its place of origin in order to respond quickly. When such a call is made from a cellular phone, its place of origin can be determined by using

GPS or a cell-based positioning method. However, these methods are sometimes inaccurate and have blind spots. We developed a system for determining location using RFID-reader-equipped cellular phones and RFID tags. We outline the prototype system here.

Velez, F.J.; Carvalho, V.; Santos, D.; Marcos, R.P.; Costa, R.; Sebastiao, P.; Rodrigues, A.. Aspects of cellular planning for emergency and safety services in mobile WiMax networks. Wireless Pervasive Computing, 2006 1st International Symposium on , pp. 6 pp., 16-18 Jan. 2006. DOI: 10.1109/ISWPC.2006.1613643. 2006.
http://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=1613643&isnumber=33870
Abstract: This work addresses cellular planning aspects for a WiMax (worldwide interoperability for microwave access) point-to-multipoint wireless network to be developed in the region of Beira Interior. It is concentrated in more detail in the district of Covilha, and, particularly, in the urban area of the city, in order to guarantee communications from the Health Science Faculty of University of Beira Interior (HSF/UBI)/ Hospital Pero da Covilha to all central urban area of the city. By having aspects related with the carrier-to-noise and carrier-to-interference ratios into account, one concluded that it is necessary to consider a cellular structure with sectorisation, and cell coverage distances around 3 km. Because this zone is very hilly, the optimization of the choice of the location for base stations is essential; the potentialities of the GIS (geographic information systems) tools were explored to optimise the existence of line of sight coverage in coverage. Future research directions regarding architectures for interoperability and mobile IP, security, and the impact of multimedia applications are also addressed.

A5.9 TRANSMISSION OF DIGITAL VIDEO BY CAMERAS ON FIREFIGHTERS

References Cited in Report

Bergstrand, Fredrik; Jonas Landgren Chalmers. Visual reporting in time-critical work: exploring video use in emergency response. Proceedings of the 13th International Conference on Human Computer Interaction with Mobile Devices and Services ACM New York, NY, USA 2011. DOI: 10.1145/2037373.2037436. 2011.
Abstract: This paper reports on an explorative project aimed to study the use of live video technology in emergency response work. The initial stage of the project aimed at enabling an emergency response organization with live video capabilities. The study covered the steps of design, development and deployment of an application for live video broadcasting. Over a 10 months period, professional responders has used the application in over 200 incidents. The study shows how short video sequences are produced as an embedded activity in order to capture small fragments of work rather than creating a complete coverage of an incident. Further, this study also shows how broadcasted video is incorporated into the work at the command center as visual reports, which open up for collective negotiations of the broader meaning of a situation.

Other Relevant References

Massachusetts Institute of Technology, USA. Going round the bend. Economist, 18-31 Dec 2010, p22. 2010.
Abstract: An innovative camera that can look round corners could be useful for doctors and firefighters. US-influenced.

A5.10 DISPLAY OF IMAGES AND TEXT DATA SUPERIMPOSED OVER REAL TIME IMAGES OF EMERGENCY LOCATION

References Cited in Report

Ali, Mohammed Eunus; Rui Zhang; Egemen Tanin; Lars Kulik. A Motion-Aware Approach to Continuous Retrieval of 3D Objects. DOI: 10.1109/ICDE.2008.4497493. 2008.
http://www.computer.org/portal/web/csdl/doi/10.1109/ICDE.2008.4497493
Abstract: With recent advances in mobile computing technologies, mobile devices can now render 3D objects realistically. Many users of these devices such as tourists, mixed-reality gamers, and rescue officers, need real-time

retrieval of 3D objects over a wireless network. Due to bandwidth and latency restrictions in mobile settings, efficient continuous retrieval of 3D objects remains a challenge. In this paper, we describe a motion-aware approach to this problem. We first introduce multi-resolution ion storage and retrieval methods for 3D data, which restrict access to only the necessary content based on the client's motion pattern. We then propose a motion-aware buffer management technique as well as an efficient index using multi-resolution representations of objects. Our experiments demonstrate the effectiveness of our solution to continuous retrieval of complex spatial data in mobile settings.

Nilsson, Susanna; Bjorn Johansson; Arne Jonsson. Using AR to support cross-organisational collaboration in dynamic tasks. DOI: 10.1109/ISMAR.2009.5336522. 2009.
http://www.computer.org/portal/web/csdl/doi/10.1109/ISMAR.2009.5336522
Abstract: This paper presents a study where Augmented Reality (AR) technology has been used as a tool for supporting collaboration between the rescue services, the police and military personnel in a crisis management scenario. There are few studies on how AR systems should be designed to improve cooperation between actors from different organizations while at the same time support individual needs. In the present study an AR system was utilized for supporting joint planning tasks by providing organisation-specific views of a shared working. The study involved a simulated emergency event conducted in close to real settings with representatives from the organisations for which the system is developed. As a baseline, a series of trials without the AR system was carried out. Results show that the users were positive towards the AR system, and would like to use it in real work. They also experience some performance benefits of using the AR system compared to their traditional tools. Finally, the problem of designing for collaborative work as well as the benefits of using an iterative design processes is discussed.

Other Relevant References

SungYe Kim; Ross Maciejewski; Karl Ostmo; Edward J. Delp; Timothy F. Collins; David S. Ebert. Mobile Analytics for Emergency Response and Training. Information Visualization March 20, 2008 7:77-88. 2008.
http://ivi.sagepub.com/content/7/1/77.full.pdf+html
Abstract: During emergency response events, situational awareness is critical in effectively managing and safe-guarding civilians and in-field personnel. To better support both command center controllers and in-field operators, we have developed a mobile visual analytics tool to help enhance situational awareness and support rapid decision making. Our mobile visual analytics tool consists of a 2D/3D visualization component, which shows personnel-related information, situational and static scene-related information, integrated multi media playback functionality for personnel outfitted with cameras, and fast-forward/rewind capabilities for reviewing events. Our current system has been employed in the evaluation of two different scenarios: a simulated evacuation of The Station nightclub fire that occurred in Rhode Island during 2003 and a testing exercise for a rescue operation in an elementary school. Our system has been deployed on a Dell Axim X51v PDA, an OQO 02, and on a Sprint PCS VisionSM smart device PPC-6700.

A5.11 BIO-SENSORS ON FIREFIGHTERS TO MEASURE AND TRANSMIT PHYSIOLOGICAL DATA

References Cited in Report

Bennett, Angela L; Brown, James; Derchak, Alex et all. Health and Safety Guidelines for Firefighter Training. University of Maryland Centre for Firefighter Safety Research and Development Maryland Fire and Rescue Institute. 2006.
http://www.mfri.org/fireresearch/hsg/healthandsafetyguidelines.pdf

Colunas, M.F.M.; Fernandes, J.M.A.; Oliveira, I.C.; Cunha, J.P.S. DroidJacket: An Android-based application for first responders monitoring. Information Systems and Technologies (CISTI), 2011 6th Iberian Conference on , pp.1-4, 15-18 June 2011. 2011.
http://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=5974243&isnumber=5974162
Abstract: The Vital Responder project aims at exploring the synergies between wearable technologies, scattered sensor network, intelligent building technology and precise localization services to provide secure, reliable and effective first-response systems in emergency scenarios. One of the components required in this technological setting is the ability to monitor biosignals from first responders in the field. In this paper we present a mobile monitoring system called

DroidJacket to address the Vital Responder requirements. DroidJacket uses a Android-based smartphone as a base station for vital signs acquired with the Vital Jacket® garment, enabling visualization and simple real time processing.

Kingsley, Stuart. A; Sriram Sriram; Andrea Pollick; John Marsh. Photrodes for physiological sensing. SRICO, Inc., 2724 Sawbury Blvd., Columbus, OH USA 43235-4579. 2004. http://www.srico.com/files/SPIE%20Photonics%20West%202004.pdf
Abstract: This paper describes a paradigm shift in the technology for sensing electro-physiological signals. In recent years, SRICO has been developing small lithium niobate photonic electrodes, otherwise called "Photrodes™" for measuring EEG and ECG signals. These extrinsic fiber-optic sensing devices exploit the extremely high electrical input impedance of Mach-Zehnder Intensity (MZI) electro-optic modulators to detect microvolt and millivolt physiological signals. Voltage levels associated with electrocardiograms are typically on the order of several millivolts, and such signals can be detected by capacitive pickup through clothing, i.e., the Photrode™ may be used in a non-contact mode. Electroencephalogram signals, which typically have an amplitude of several microvolts, require direct contact with the skin. However, this contact may be dry, eliminating the need for conductive gels. The electrical bandwidth of this photonic electrode system stretches from below 0.1 Hz to many tens of kHz and is constrained mainly by the signal processing electronics, not by the Photrode™ itself. The paper will describe the design and performance of Photrode™ systems and the challenging aspects of this new technology.

A5.12 VIDEO DATA FROM CAMERAS ON FIRE ENGINES

Other Relevant References

McCann, Denisÿ. The camera never lies. Fire, v100 no1300 (Jan 2008) p25. 2008.
Abstract: Examines an innovative wireless incident ground camera system being used by the Avon Fire and Rescue Service. Designed to relay live images of incidents to the command vehicles which are equipped with receiving, monitoring, recording and satellite equipment. Includes findings from a system test undertaken in the Severn Tunnel.

A5.13 IMAGE ANALYSIS SOFTWARE TO ANALYSE VIDEO FOR LOCATION, SIZE AND MOVEMENT FOR COMMAND AND CONTROL AT INCIDENT

References Cited in Report

Billmers, Richard I.: Elizabeth J. Billmers: Mary E. Ludwig: Edward T. Dressler and Brian McCarthy. Development of FireLidar: an active imaging system for smoke and flame environments. Proc. SPIE 5791, 128. DOI: 10.1117/12.602376. 2005. http://spiedigitallibrary.org/proceedings/resource/2/psisdg/5791/1/128_1?isAuthorized=no

Harvey, Brad. Five 'don'ts' of thermal imaging. Firehouse, v36 no2 (Feb 2011) p56, 58. 2011.
Abstract: A back-to-basics approach to fireground safety when using thermal imagers. Emphasis is on firefighter safety and regular training in a variety of scenarios to build competency and confidence. US-influenced.

Harvey, Brad. Flashover recognition. Firehouse, v36 no3 (Mar 2011) p48-51. 2011.
Abstract: Dispels common misconceptions about what thermal imagers (TI) can do in flashover situations. Emphasises that TI's won't help firefighters caught in a flashover. Its' importance lies during size-up where they can provide early visual indications of warnings signs e.g. convective velocity, thermal layering and rollovers in smoke. US-influenced.

Harvey, Brad. In living color; Thermal imaging terminology. Firehouse, v35 no3 (Mar 2010) p66, 68; v35 no6 (Jun 2010) p50-51. 2010.
Abstract: Discusses the impact of the 'Heat Indicating Colour' function when operating a thermal imaging camera. Identifies what the colours palettes mean on camera models. Comments on 'polarity inversion' and how it may affect the validity of firefighter decisions. 2nd article provides useful glossary of several key technical terms. US-influenced.

Harvey, Brad. Warning signs of structural collapse: evaluating building construction with your thermal imager. Firehouse v35 no12 (Dec 2010) p58, 60. 2010.
Abstract: Offers practical tips on how to use your thermal imager to assess building construction during preplanning or inspection activities. US-influenced.

Lombardo, Mikeÿ. Thermal imaging : real-world incidents. Firehouse, v31 no6 (Jun 2006) p77-78, 80, 82. 2006.
Abstract: Discusses lessons learned from several fire incidents in the USA where thermal imaging technology has made a significant impact in saving lives, rescues, and locating fire sources.

Pattath, A.; Bue, B.; Yun Jang; Ebert, D.; Xuan Zhong; Aulf, A.; Coyle, E.. Interactive Visualization and Analysis of Network and Sensor Data on Mobile Devices. Visual Analytics Science And Technology, 2006 IEEE Symposium On Oct. 31 2006-Nov. 2 2006 Baltimore, MD Pp 83 - 90. DOI: 10.1109/VAST.2006.261434. 2006.
http://ieeexplore.ieee.org/xpl/freeabs_all.jsp?arnumber=4035751
Abstract: Mobile devices are rapidly gaining popularity due to their small size and their wide range of functionality. With the constant improvement in wireless network access, they are an attractive option not only for day to day use. but also for in-field analytics by first responders in widespread areas. However, their limited processing, display, graphics and power resources pose a major challenge in developing effective applications. Nevertheless, they are vital for rapid decision making in emergencies when combined with appropriate analysis tools. In this paper, we present an efficient, interactive visual analytic system using a PDA to visualize network information from Purdue's Ross-Ade Stadium during football games as an example of in-held data analytics combined with text and video analysis. With our system, we can monitor the distribution of attendees with mobile devices throughout the stadium through their access of information and association/disassociation from wireless access points, enabling the detection of crowd movement and event activity. Through correlative visualization and analysis of synchronized video (instant replay video) and text information (play statistics) with the network activity, we can provide insightful information to network monitoring personnel, safety personnel and analysts. This work provides a demonstration and testbed for mobile sensor analytics that will help to improve network performance and provide safety personnel with information for better emergency planning and guidance

SungYe Kim; Yun Jang; Mellema, A.; Ebert, D.S.; Collins, T.. Visual Analytics on Mobile Devices for Emergency Response. DOI: 10.1109/VAST.2007.4388994. emergency response , mobile visualization , visual analytics. 2007.
http://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=4388994&isnumber=4388977
emergency response , mobile visualization , visual analytics
Abstract: Using mobile devices for visualization provides a ubiquitous environment for accessing information and effective decision making. These visualizations are critical in satisfying the knowledge needs of operators in areas as diverse as education, business, law enforcement, protective services, medical services, scientific discovery, and homeland security. In this paper, we present an efficient and interactive mobile visual analytic system for increased situational awareness and decision making in emergency response and training situations. Our system provides visual analytics with locational scene data within a simple interface tailored to mobile device capabilities. In particular, we focus on processing and displaying sensor network data for first responders. To verify our system, we have used simulated data of The Station nightclub fire evacuation.

Technext. Displays for 3D Imaging: 3D Volume Viewer - The glasses-free walk-around display. Technext. Accessed October 2011
http://www.genextech.com/pages/600/display.htm:

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Lameira, Ana. Real-Time Object Recognitiion using Mobile Devices. www.mendeley.com Computer and Information Science Miscellaneous Papers. 2011.
Abstract: This paper proposes an application for real-time object recognition using mobile devices that runs locally without the need to communicate with a server. Both object detection and identification algorithms are performed by the mobile device avoiding the communication with the server. The paper presents results that show the effectiveness of the proposal.
http://www.mendeley.com/research/realtime-object-recognition-using-mobile-devices

Richardson, Michael T. Thermal triage. Fire Chief, v45 no9 (Sep 2001) p24-27. 2001.
Abstract: Detailed article describing the uses of thermal imaging devices. Advocates the need for training, and the development of standard operating procedures for the thermal imaging technologies. Discusses when and how they can be useful, including as tools for incident command, as a means for identifying personnel and victims, as a means of incident triage, and for guided operations with wireless video.

Sheridan, Wes. The future of thermal imaging technology. APF Asia Pacific Fire, no. 23 (Sep 2007) p29-32. 2007.
Abstract: Outlines the historical development of thermal imaging cameras. Also comments on technological advances, both historically and in the immediate future, that will see improvements reducing size, weight, power consumption and cost.

A5.14 HEAD UP DISPLAY OF IMAGES AND TEXT DATA SUPERIMPOSED OVER REAL TIME IMAGES OF EMERGENCY LOCATION

References Cited in Report

Bretschneider, Nora; Brattke, Simon; Rein, Karlheinz. Head Mounted Displays for Fire Fighters. Applied Wearable Computing, 2006 3rd International Forum on, pp.1-15, 15-16 March 2006. 2006.
http://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=5758281&isnumber=5758270
Abstract: Head Mounted Displays have the potential to increase the fire fighter's safety and make their work more efficient. Typical applications of Head Mounted Displays in the area of fire fighting are to display thermal imaging data or tactical information such as maps or navigation information. As fire fighters work under hazardous conditions they have to wear special equipment such as helmets and breathing masks. This makes an appropriate design of a Head Mounted Display for fire fighters especially challenging. In this paper we discuss the requirements of Head Mounted Displays for fire fighters and evaluate different design options.

Martins, Ricardo; Vesselin Shaoulov; Yonggang Ha and Jannick Rollanda. Projection-based head-mounted displays for wearable computers. DOI: 10.1117/12.542778. 2004.
http://www.creol.ucf.edu/Research/Publications/1431.PDF
Abstract: The projection based head-mounted display (HMD) constitutes a new paradigm in the field of wearable computers. Expanding on our previous projection based HMD, we developed a wearable computer consisting of a pair of miniature projection lenses combined with a beam splitter and miniature displays. Such wearable computer utilizes a novel conceptual design encompassing the integration of phase conjugate material (PCM) packaged inside the HMD. Some of the applications benefiting from this innovative wearable HMD are for government agencies and consumers requiring mobility with a large field-of-view (FOV), and an ultra-light weight headset. The key contribution of this paper is the compact design and mechanical assembly of the mobile HMD.

Wilson, J.; P. Wright. Design of monocular head-mounted displays, with a case study on fire-fighting. Department of Mechanical Engineering, UC Berkeley, Center for Information Technology Research in the Interest of Society, Berkeley, California, USA. DOI: 10.1243/09544062JMES721. head-mounted display design, emergency first response, fire-fighting. 2007.
http://kingkong.me.berkeley.edu/PUBLICATIONS07_08/Design_of_monocular_head-mounted_displays.pdf
head-mounted display design, emergency first response, fire-fighting
Abstract: The paper presents a design methodology and a case study for monocular headmounted displays (HMDs), wherein a user can simultaneously and easily see the physical world by looking through and/or around the display. The design approach is user-focused because of the complexity of the human visual system, and because HMDs are very task, user, and context specific. A literature review of factors related to HMD design is given. This includes considerations for basic optical design, the human visual system, and head and neck biomechanics. General HMD design guidelines are given based on these considerations. For the specific case study on fire-fighting, it is recommended that the HMD be mounted at 15? to 45? below the Frankfurt plane, with a 15? to 40? field of view. A resolution of 20–60 px/deg should be focused at 1m or farther. The neck joint torque due to the HMD should not exceed about 1 Nm. This equates to a typical maximum weight of 0.5 to 1 kg depending on the mounting location.
See also: http://fire.me.berkeley.edu/

Other Relevant References

Bimber, Oliver. Guest Editor's Introduction: The Ultimate Display--What Will It Be?. Computer, vol. 38, no. 8, pp. 29-30, Aug. 2005. DOI: 10.1109/MC.2005.262. 2005.
http://www.computer.org/portal/web/csdl/doi/10.1109/MC.2005.262
Abstract: Future trends in display technology range from autostereoscopic and volumetric display techniques to computer-generated holography, projector-based concepts, and new rendering schemes. In this special issue, leading experts from science and industry discuss the possibilities, developments, limitations, and potential pitfalls of these emerging trends. Index Terms: display technology, autostereoscopic displays, volumetric displays, holography, 3D displays, input/output devices

A5.15 DECISION SUPPORT/EXPERT SYSTEMS IN COMMAND AND CONTROL INCLUING VISUAL ANALYTICS

References Cited in Report

Adams, K.; Wassell, A.; Ceruti, M.G.; Castro, E.; Lehan, S.F.; Mitchell, J.W.. Emergency-management situational-awareness prototype (EMSAP). Cognitive Methods in Situation Awareness and Decision Support, 2011 IEEE First International Multi-Disciplinary Conference on , pp.110-114, 22-24 Feb. 2011. DOI: 10.1109/COGSIMA.2011.5753427. 2011.
http://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=5753427&isnumber=5753422
Abstract: This paper describes the architecture and requirements of an integrated system that is needed to support command and control for the interoperability-capability focus area. The architecture is designed to enhance situational awareness during emergencies such as earthquakes, volcanic eruptions, wild fires, floods, tsunamis, mud slides, storms, tornadoes, hurricanes, extreme heat, extreme cold, massive disease outbreaks, wars, terrorist attacks, power outages, cyber-attacks on utility grids and civil unrest. A net-centric approach that emphasizes cognitive aspects, such as cognitive-information operations, in decision support ensures information superiority by networking sensors and human-factors monitoring. This enables decision makers to achieve shared awareness. Linking knowledgeable entities effectively leads to in-creased speed of command and a higher tempo of operations with a degree of self-synchronization. The resulting system will decrease cognitive over-load and improve cognitive monitoring by providing a more systematic and less labor-intensive method to manage information from and for first res-ponders at the local, tribal, state, and federal levels.

Drury, J.L.; Klein, G.; Pfaff, M.S.; More, L.D.. Dynamic Decision Support for Emergency. Technologies for Homeland Security, 2009. IEEE Conference on , pp.537-544, 11-12 May 2009. DOI: 10.1109/THS.2009.5168084. 2009.
http://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=5168084&isnumber=5168000
Abstract: To enhance support of emergency response decision making, we are investigating decision aids that use simulation models to predict the range of plausible consequences of each potential course of action. Due to the rapid pace of emergency operations, the user interface displaying the models' results needs to facilitate quick understanding of a changing landscape of possible futures. This paper describes a user test aimed at (1) determining whether a model-driven visualization was useful and (2) confirming the validity of a principled design approach for developing decision-making test situations. Two groups of participants received identical textual descriptions of situations and were asked to decide the number of emergency response vehicles to dispatch. One group also saw a visual depiction of model results. The decision-aided group's decisions were closer to the normatively correct decisions and this group's confidence was higher. Further, the decision-aided group rated the degree of decision support higher. The decision times for each of the four types of test situations differed significantly from each other, re-validating our method of developing test situations.

Fressmann. Andrea. Adaptive Workflow Support for Search Processes within Fire Service Organisations. Enabling Technologies: Infrastructure for Collaborative Enterprises, 2006. 15th IEEE International Workshops on, pp.291-296, June 2006. DOI: 10.1109/WETICE.2006.15. 2006.
http://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=4092225&isnumber=4092164
Abstract: This paper presents a brief overview about the European R&D project AMIRA (advanced multimodal intelligence for remote assistance) focused on information support for time critical processes in fire service organisations. This paper presents a requirement analysis which has analysed what the actual needs of end-user in

those organisations are. Based on that, the need for an information system is concluded, which enables search processes as short term workflows to cope with time critical processes in incident grounds

Jiacun Wang; Tepfenhart, W.; Rosca, D.. Emergency Response Workflow Resource Requirements Modeling and Analysis. Systems, Man, and Cybernetics, Part C: Applications and Reviews, IEEE Transactions on , vol.39, no.3, pp.270-283, May 2009. DOI: 10.1109/TSMCC.2009.2009125. 2009.
http://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=4806029&isnumber=4814874
Abstract: A workflow management system determines the flow of work according to predefined business process definitions. It manages the resources required to meet goals and provides monitoring facilities and control capabilities. Resources can become important decision factors when combined with control flow information. This is particularly true in an emergency response system where large quantities of resources, including emergency responders, ambulances, fire trucks, medications, food, clothing, etc., are required. In this paper, we introduce a resource-constrained and decision support workflow model. This model enables users to specify resource consumption and production when executing a task, and decision policies to choose a path at a given situation where multiple execution branches are available. The paper also presents an efficient resource requirement analysis algorithm that can be used to decide the minimum resource set that, if satisfied, the workflow can be executed along any possible path till finish without the occurrence of resource shortage. A case study is presented to show the use of the proposed approach.

Li, K.F.; Miska, E.. Fire-fighter: a decision support system for fire management. Communications, Computers and Signal Processing, 1991., IEEE Pacific Rim Conference on , pp.573-576 vol.2, 9-10 May 1991. DOI: 10.1109/PACRIM.1991.160803. 1991.
http://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=160803&isnumber=4206
Abstract: Fire-fighter acts as an intelligent assistant for the on-scene commander of a fire emergency on a naval vessel. Given a ship's model with information of the configuration, contents, fire-fighting resources, and some fire-specific knowledge, Fire-fighter will develop a fire management plan to suppress the fire. Fire-fighter is based on script-based planning. Scripts are skeleton plans which are similar in concept to contingency plans for emergencies. The known situation data is used to instantiate the skeleton plan. Fire-fighter interleaves planning, execution, and monitoring to better react to a changing environment. To measure the success of its emergency actions, Fire-fighter will monitor the progress of the plan. When actions fail or appear to be failing replanning will commence. In a hazardous environment, care must be taken to safely replan. Fire-fighter uses domain-dependent knowledge to determine why goals are not being met. Once the cause of failure is known, one can determine where to alter the plan and the appropriate steps to take

Lingyun Zhu; Wenhua Song; Qinggong Li. Construction of Emergency Decision System Based on GIS. Knowledge Engineering and Software Engineering, 2009. Pacific-Asia Conference on , pp.171-174, 19-20 Dec. 2009. DOI: 10.1109/KESE.2009.52. 2009.
http://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=5383593&isnumber=5383567
Abstract: In order to achieve quick response and scientific decision-making, it is necessary to build a distributed emergency decision-making system. In this paper, the system uses a frame structure with combination of B/S and C/S technologies, and bases on WebGIS and other technologies, which provide a technology platform for the system. This system has the ability to report the disaster situation to the command center, simultaneously, it also fast implements auxiliary decision. This article focuses on the design thoughts, key technologies, and applications, and finally an example is given for analysis and simulation to explore the system specific application in an emergency.

Liwen Wu; Li Wen; Jiangnan Qiu; Yanzhang Wang. The Study of Ontology for Emergency Event Model Based on Decision Support. Wireless Communications, Networking and Mobile Computing, 2008. 4th International Conference on , pp.1-4, 12-14 Oct. 2008. DOI: 10.1109/WiCom.2008.2532. 2008.
http://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=4680721&isnumber=4677909
Abstract: This paper presents an ontology for emergency event model based on decision support (DSE2M). The model is recommended as a means to solve problems of how to describe basic characteristics of each phase in an emergency, and decide to take corresponding actions to deal with it according to the characteristics. To obtain satisfactory solutions and detailed actions, DSE2M is stratified into five levels: event layer, phases layer, representation layer, decision-making layer, and action layer. DSE2M constructs the vocabulary as a platform of semantic integration and the common model to support emergency decision.

Xin Ye; Zailin Dai; Yanzhang Wang. Research and application of problem model of emergency decision support system. Service Systems and Service Management, 2009. 6th International Conference on , pp.789-793, 8-10 June 2009. DOI: 10.1109/ICSSSM.2009.5174988. 2009.
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Abstract: Public emergencies have various types and involve a board scope of fields. The solution methods for different emergencies may be quite different. How to build an open, comprehensive, flexible and quick response Emergency Decision Support System (EDSS), which integrates various models and methods to handle various public emergencies, has become a focus in the theoretical study and practical applications. First, the general decision process of emergency management is proposed in this paper. Then, as the starting point and the end result of decision-making, the general emergency problem model is researched in detail. This model can integrate various solution models and methods for various public emergencies flexibly. The ontology and meta framework model of emergency are also proposed for emergency problems organization and navigation. The architecture of EDSS based on problem model of emergency decision support system is proposed at last.

Yanwei Chen; Demin Li; Chenwen Wang; Jiacun Wang. MFDSSF: A Mobile Fuzzy Decision Support System for Firefighter Cooperation in Ad Hoc Networks. Network and Parallel Computing, 2008. IFIP International Conference on , pp.475-482, 18-21 Oct. 2008. DOI: 10.1109/NPC.2008.52. 2008.
http://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=4663370&isnumber=4663278
Abstract: Firefighting is a dangerous profession, which often faces complicate, variable, and uncertain situation. Only depending on conventional tools, can't the firefighters cooperate work effectively. We present a mobile fuzzy decision support system for firefighter cooperation in ad hoc networks (MFDSSF) based on the decision support architecture proposed by William J. O'Brien. The decision support system, MFDSSF involves path navigation, danger reminder, rescue cooperation, and extinguishing cooperation. By this system, the firefighters can obtain complete situation information of the fire scene, achieve more effective cooperation, select optimum assistance alternative based on triangular fuzzy set, and increase their safety. For the realization of the decision support system, MFDSSF, the interfaces' patterns are discussed in the end.

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Andrienko, Gennady; Natalia Andrienko; Martin Mladenov; Michael Mock; Christian Poelitz. Extracting Events from Spatial Time Series. 2010 14th International Conference Information Visualisation, London, United Kingdom2010 pp.48-53. DOI: 10.1109/IV.2010.17. 2010.
http://www.computer.org/portal/web/csdl/doi/10.1109/IV.2010.17
Abstract: An important task in exploration of data about phenomena and processes that develop over time is detection of significant changes that happened to the studied phenomenon. Our research is focused on supporting detection of significant changes, called events, in multiple time series of numeric values. We developed a suite of visual analytics techniques that combines interactive visualizations on time-aware displays and maps with statistical event detection methods implemented in R. We demonstrate the utility of our approach using two large data sets. Index Terms: visual analytics, event detection, time series

Boyacioglu, K.F. ; Arifler, D. Second-Order Analysis of Formation of Holes in Spatial Point Patterns: Applications in Wireless Sensor Networks. Modeling and Optimization in Mobile, Ad Hoc and Wireless Networks and Workshops, 2007.5th International Symposium on, 16-20 April 2007, page(s): 1 - 5. DOI: 10.1109/WIOPT.2007.4480074. 2007.
Abstract: Dense deployment of wireless sensors can be used for environmental monitoring applications. Natural and artificial disasters, such as floods and fires, are significant events that need to be continuously monitored and contained as fast as possible. However, such disasters may destroy sensors deployed to monitor environmental conditions and prevent reporting of critical measurements that may indicate an occurring hazard. In this paper, we present how spatial point pattern analysis techniques, which have traditionally been used to analyze clustering, randomness, or regularity, can also be employed to analyze formation of a "hole" in a point pattern, which is also of significant interest in randomly deployed sensor networks since formation of a hole might be considered as an indication of a hazard. We first outline a methodology based on an information theoretic approach that can be used in decision support systems for detecting holes wherein visual inspection of destroyed sensors on a sensor map at a central station is hard, if not impossible. We show, by means of a second-order spatial point pattern analysis, that manifestation of such holes can be detected at small spatial scales. Furthermore, second-order analysis might provide an insight into the spatial scale of the hole in the pattern. Results presented validate our observations that failure of sensors due to a systematic destruction may be inferred by decision support systems when only a small portion of the monitored area is affected.

Carver, Liz; Murray Turoff. Human-computer interaction: the human and computer as a team in emergency management information systems. Communications of the ACM - Emergency response information systems: emerging trends and technologies Volume 50 Issue 3, March 2007 Pp.33 - 38. DOI: 10.1145/1226736.1226761. 2007.

http://dl.acm.org/citation.cfm?id=1226736&picked=prox&cfid=48439105&cftoken=25558045
Abstract: Building the computer as part of the emergency management team ensures that people continue to do the things they do well, supported by the technology, not driven by it.

Clark, Martin. Intelligent rescue. Fire, v96 no1172 (Feb 2003) p34. 2003.
Abstract: Describes the research project called 'Remote Intelligent Management Support and Training' (RIMSAT) being developed by a consortium of UK and European emergency responder agencies. A knowledge-based decision tool aimed at supporting incident commanders, providing a web-based distance learning facility, and developing preplanning systems for incidents.

D'Souza, O. A Virtual Presence®, predictive analysis and pre-emptive intervention using wired and wirelessly networked, interactive, video, voice and control technology - a case study. Security Technology, 2005. 39th Annual 2005 International Carnahan Conference on , pp. 109-112, 11-14 Oct. 2005. DOI: 10.1109/CCST.2005.1594838. 2005.
http://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=1594838&isnumber=33562
Abstract: Security system configurations, especially command and control, are vital to the management of "safe and secure" environments, often delivering "reactive" capability to support investigative initiatives, post incident and not designed to perform pre-emptive tasks. In this case study, Virtual Presence® predictive analysis tools and preemptive intervention are tools used effectively to reduce the occurrences of security/safety incidents. The concept is to use pre-emptive strategies that enable the delivery of effective deterrents and logistic support, right to the "first responders", so that they are better informed and hence have a better chance of deploying counter measures to reduce the predicted risk. The use of video (visible and invisible spectra), active and passive multi-sensor arrays, software digital analysis robots (SoftBOTs), connected via a network links are part of an effective solution that facilitates "collaboration" between operatives and experts to make effective use of their time and improve efficient use of their services.

Denef, Sebastian; David Keyson; Reinhard Oppermann; Sankt Augustin. Rigid structures, independent units, monitoring: organizing patterns in frontline firefighting. Proceedings of the 2011 annual conference on Human factors in computing systems ACM New York, NY, USA ©2011. DOI: 10.1145/1978942.1979225. 2011.
Abstract: Providing firefighters working on the frontline of interventions with ubiquitous computing support remains an open challenge. Designing meaningful solutions for this complex work environment requires reflective thought and conceptual understanding of its social configuration. This paper presents organizing patterns of firefighting frontline practice as a means to inform ubiquitous computing design processes. The patterns originate from a qualitative analysis of an extensive range of user studies conducted with French and German firefighters. As the patterns show, firefighting on the frontline is based on a rigid structure that gains its flexibility through independent units whose safety is ensured by a number of monitoring activities. We conclude that the interaction between the presented patterns forms a balanced whole and needs to be recognized by ubiquitous computing design.

Doweling, Sebastian; Florian Probst, Thomas Ziegert and Knut Manske. Soknos - An Interactive Visual Emergency Management Framework. NATO Science for Peace and Security Series C: Environmental Security, 2009, Part 4, 251-262. DOI: 10.1007/978-90-481-2899-0_20. Emergency Management - Collaborative Work Environments - Semantics-Based Web Service Integration - Visual Analytics. 2009.
http://www.springerlink.com/content/u0h4xtw0281l1355/
Emergency Management - Collaborative Work Environments - Semantics-Based Web Service Integration - Visual Analytics
Abstract: Emerging Spatial Data Infrastructures and non-spatial Web Service environments allow new approaches to dynamically integrate information sources. The ability for dynamic information integration provides the basis on which an emergency management system should allow its users to create spatial, temporal and structural views on the emergency situation. Furthermore, dynamic information aggregation and generalization should allow tailoring the presented information to the users' requirements. In combining a SOA-based information processing approach with a user-centric perspective on information visualization and handling, we introduce the approach taken in the SoKNOS project to develop a new generation of emergency management systems.

French, Simon; Murray Turoff. Decision support systems. Communications of the ACM - Emergency response information systems: emerging trends and technologies Volume 50 Issue 3, March 2007 Pp.39 - 40. DOI: 10.1145/1226736.1226762. 2007.
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Hongwei Xie ; Xueli Yu ; Juanli Li ; Xiaobo Wu. Study on Ontology-Based Apriori Algorithm Applying to Emergency Decision System.. Fuzzy Systems and Knowledge Discovery, 2007. Fourth International Conference on. DOI: 10.1109/FSKD.2007.543. 2007.
Abstract: The paper proposes an optimized Apriori mining algorithm based on ontology by contrast with traditional data-mining ones, which could mine data on the high-level. The algorithm is based on the domain and background knowledge in what the ontology describes. And we use the algorithm in the fire protection emergency decision system. The experiment result shows that applying the algorithm can expose more exact certainty rules and provide more meaningful decision suggestions for decision-maker.

Houghton, Robert. Barber, Chris, McMaster, Richard. Stanton, Neville. Simon, Paul. Stewart, Rebecca. Walker, Guy. Command and control in emergency services operations: a social network analysis. Ergonomics, Vol.49, Issue 12/13. 2006.
Abstract: There is increasing interest in the use of social network analysis as a tool to study the performance of teams and organizations. In this paper, processes of command and control in the emergency services are explored from the perspective of social network theory. We report a set of network analyses (comprising visualization, a selection of mathematical metrics, and a discussion of procedures) base d on the observation of six emergency service incidents: three fire service operations involving the treatment of hazardous chemicals, and three police operations involving immediate response to emergency calls. The findings are discussed in terms of our attempts to categorize the network structures against a set of extant command and control network archetypes and the relationship between those structures; comments on the qualities the networks display are put into the contexts of the incidents reported. We suggest that social network analysis may have a valuable part to play in the general study of command and control.

Huizhang Shen ; Jidi Zhao. A Quick Group Decision-making Planning Method for Emergency Response. Intelligence and Security Informatics, 2007 IEEE, 23-24 May 2007, page(s): 25 - 31. DOI: 10.1109/ISI.2007.379514. Emergency services , Group theory , Management decision-making. 2007.
Emergency services , Group theory , Management decision-making
Abstract: To support the group decision-making in emergency response, it is important to research on how to reach consensus quickly and reliably in the procedure of group decision-making. This paper proposes a new planning method to improve the efficiency of group decision-making based on Markov chain model and uses a real case example of New Orleans Hurricane Katrina to illustrate the usefulness and effectiveness of the proposed approach. The approach is quicker than conventional process in terms of two points. (1) It minimizes the human interventions and makes the most of computer system support to speed up the interactions between the decision-maker and the system. (2) It researches into the important hidden pattern in the group decision-making process, predicts the possible decision in the future and thus further speeds up the decision-making process. The authors hope that analysis of the dynamic procedure of decision-maker's preference adjustment will assist researchers not only in better understanding of group decision-making procedure but also in better design of Group Decision Support Systems for emergency response.

Kaban, Ata. A Scalable Generative Topographic Mapping for Sparse Data Sequences. DOI: 10.1109/ITCC.2005.34. 2005.
http://www.computer.org/portal/web/csdl/doi/10.1109/ITCC.2005.34
Abstract: We propose a novel, computationally efficient generative topographic model for inferring low dimensional representations of high dimensional data sets, designed to exploit data sparseness. The associated parameter estimation algorithm scales linearly with the number of non-zero entries in the observations while still learning a truly nonlinear generative mapping. The latent variables of the model lie in a 2D space that can be used for visualisation. We discuss related work and we provide experimental results on text based documents visualisation as well as the exploratory analysis of web navigation sequences.

Keim, Daniel A.; Florian Mansmann; Jörn Schneidewind; Jim Thomas and Hartmut Ziegler. Visual Analytics: Scope and Challenges. Lecture Notes in Computer Science, 2008, Volume 4404/2008 , 76-90. DOI: 10.1007/978-3-540-71080-6_6. 2008.
http://www.springerlink.com/content/5275180h84863347/
Abstract: In today's applications data is produced at unprecedented rates. While the capacity to collect and store new data rapidly grows, the ability to analyze these data volumes increases at much lower rates. This gap leads to new challenges in the analysis process, since analysts, decision makers, engineers, or emergency response teams depend on information hidden in the data. The emerging field of visual analytics focuses on handling these massive, heterogenous, and dynamic volumes of information by integrating human judgement by means of visual representations and interaction techniques in the analysis process. Furthermore, it is the combination of related research areas including visualization, data mining, and statistics that turns visual analytics into a promising field of research. This paper aims at providing an overview of visual analytics, its scope and concepts, addresses the most important research challenges and presents use cases from a wide variety of application scenarios.

Keim, Daniel A.; Florian Mansmann; Daniela Oelke and Hartmut Ziegler. Visual Analytics: Combining Automated Discovery with Interactive Visualizations. Lecture Notes in Computer Science, 2008, Volume 5255/2008, 2-14. DOI: 10.1007/978-3-540-88411-8_2. 2008.
http://www.springerlink.com/content/56150m11q55534jt/
Abstract: In numerous application areas fast growing data sets develop with ever higher complexity and dynamics. A central challenge is to filter the substantial information and to communicate it to humans in an appropriate way. Approaches, which work either on a purely analytical or on a purely visual level, do not sufficiently help due to the dynamics and complexity of the underlying processes or due to a situation with intelligent opponents. Only a combination of data analysis and visualization techniques make an effective access to the otherwise unmanageably complex data sets possible. Visual analysis techniques extend the perceptual and cognitive abilities of humans with automatic data analysis techniques, and help to gain insights for optimizing and steering complicated processes. In the paper, we introduce the basic idea of Visual Analytics, explain how automated discovery and visual analysis methods can be combined, discuss the main challenges of Visual Analytics, and show that combining automatic and visual analysis is the only chance to capture the complex, changing characteristics of the data. To further explain the Visual Analytics process, we provide examples from the area of document analysis.

London Fire and Emergency Planning Authority. Vector Command Ltd. Command support system creates command and control revolution. Public Safety Bulletin, v6 (Aug 2008) p12-13. 2008.
Abstract: Highlights the features of a new command support system being developed by Vector Command for the London Fire Brigade. Key information will be displayed to fire commanders throughout an incident drawn from a variety of sources like GIS mapping, fire service databases, live news feeds, and other streamed video image feeds.

Moere, Andrew Vande. Beyond the Tyranny of the Pixel: Exploring the Physicality of Information Visualization. 2008 12th International Conference Information Visualisation, 2008 pp.469-474. DOI: 10.1109/IV.2008.84. 2008.
http://www.computer.org/portal/web/csdl/doi/10.1109/IV.2008.84
Abstract: This paper consists of a review of contemporary methods that map and materialize abstract data as physical artifacts. With computing technology and the access of information influencing every aspect of our everyday lives, one can question the current habit of information displays to 'simulate' real world metaphors, and whether information could instead be conveyed by approximating the analogue and tangible characteristics of our daily experiences. This paper introduces five different degrees of 'data physicality', which differ in the level of abstraction of how data is mapped and perceived by human senses: ambient display, pixel sculptures, object augmentation, data sculptures and alternative modality. This categorization demonstrates the potential of information visualization as a communication medium in its own right, which proliferates beyond the ubiquitous pixel-based, light-emitting surfaces of today. Index Terms: info-aesthetics, data sculpture, pixel sculpture, multi-modal visualization, ambient display

Morentz, J.W. Unified Incident Command and Decision Support pilots take information sharing to the real world of incident management. Technologies for Homeland Security, 2010 IEEE International Conference on, 8-10 Nov. 2010, page(s): 519 - 524. DOI: 10.1109/THS.2010.5654976. Agents , Decision Support , Homeland Security Technology , Information Sharing , Situational Awareness. 2010.
Agents , Decision Support , Homeland Security Technology , Information Sharing , Situational Awareness
Abstract: The Unified Incident Command and Decision Support (UICDS) middleware has moved through its architecture design phase, the development of a reference implementation, and now is engaged in a major pilot under the sponsorship of the Department of Homeland Security, Directorate of Science and Technology, Infrastructure and Geophysical Division. The current project will deploy pilots of the middleware in more than 20 states and approximately 100 pilot locations in order to assess the utility of the design for federal, state, and local agency use. UICDS enables ubiquitous information exchange among existing government and commercial incident management technologies for the purpose of creating one-to-many, incident-specific, agreement-based information sharing among a wide range of technologies used in incident management. This paper describes the current state of the architecture and reference implementation and offers an invitation to organization in both the government and private sectors to participate in pilots.

Morreale, Patricia; Feng Qi; Paul Croft; Ryan Suleski; Brian Sinnicke; Francis Kendall. Real-Time Environmental Monitoring and Notification for Public Safety. IEEE Multimedia, vol. 17, no. 2, pp. 4-11, Apr. 2010. DOI: 10.1109/MMUL.2010.37. 2010.
http://www.computer.org/portal/web/csdl/doi/10.1109/MMUL.2010.37
Abstract: Researchers at Kean University describe their experience developing and deploying a real-time environmental monitoring and visualization system using a mesh network of wireless sensors. Challenges they addressed in their

design of the Wireless Integrated Network Sensors (WiNS) application include issues associated with the data volume, latency, and data synchronization from individually clocked sensors. Index Terms: wireless sensors, visualization, sensor networking, data analysis

New Zealand Fire Service. New Zealand boosts command and control. Fire Australia, Summer 2010-11, p7. 2011.
Abstract: Refers to the acquisition of 17 new dual-role hazardous material/command vehicles for the New Zealand Fire Service.

Pattath, Avin; David S Ebert; T Collins; Timothy F Collins. Real Time Scalable Visual Analysis on Mobile Devices. Proceedings of SPIE (2008) Volume: 6821, Publisher: Spie, Pp.682102-682102-11. DOI: 10.1117/12.766604. 2008.
http://www.mendeley.com/research/real-time-scalable-visual-analysis-mobile-devices-3/
Abstract: Interactive visual presentation of information can help an analyst gain faster and better insight from data. When combined with situational or context information, visualization on mobile devices is invaluable to in-field responders and investigators. However, several challenges are posed by the form-factor of mobile devices in developing such systems. In this paper, we classify these challenges into two broad categories - issues in general mobile computing and issues specific to visual analysis on mobile devices. Using NetworkVis and Infostar as example systems, we illustrate some of the techniques that we employed to overcome many of the identified challenges. NetworkVis is an OpenVG-based real-time network monitoring and visualization system developed for Windows Mobile devices. Infostar is a flash-based interactive, real-time visualization application intended to provide attendees access to conference information. Linked time-synchronous visualization, stylus/button-based interactivity, vector graphics, overview-context techniques, details-on-demand and statistical information display are some of the highlights of these applications.

Rand Corporation, FEMA. Evaluating the reliability of emergency response systems for large-scale incident operations. 2010.
http://www.rand.org/pubs/monographs/MG994/
Abstract: This research draws on the fields of systems analysis and engineering to apply the concept of system reliability to the evaluation of emergency response systems. The authors describe a method for modeling an emergency response system; identifying how individual parts of the system might fail; and assessing the likelihood of each failure and the severity of its effects on the overall response effort. The authors walk the reader through two applications of this method: a simplified example in which responders must deliver medical treatment to a certain number of people in a specified time window, and a more complex scenario involving the release of chlorine gas. The authors conclude with a discussion of how this method of measuring emergency response system reliability could inform policy discussion of emergency preparedness, how system reliability might be improved, and the costs of doing so.

Roberts, Mary Rose. Nerve center. Fire Chief, v53 no6 (Jun 2009) p46-53. 2009.
Abstract: Modern US emergency operations centres are changing the nature of a fire chief's job. Looks at selected fire departments in the US that have adopted new technologies to centralise incident information from multiple sources. US-influenced.

Sagun, Aysu. Bouchlaghem, Dino. Anumba, Chinmay. A senario-based study on information flow and collaboration patterns in disaster management. Disaster, Vol.33, Issue 2. 2009.
Abstract: Disaster management (DM) is a continuous, highly collaborative process involving governments, DM organisations, responders, the construction sector, and the general public. Most research approaches to DM include the development of information and communication technologies (ICT) to support the collaboration process rather than the creation of a collaboration process to provide information flows an d patterns. An Intelligent Disaster Collaboration System (IDCS) is introduced in this paper as a conceptual model to integrate ICT into DM and the mitigation process and to enhance collaboration. The framework is applicable to the collaboration process at the local, regional and national levels. Within this context, the deployment of ICT tools in DM is explored and scenario-based case studies on flooding and terrorism—examples of natural and human-induced disasters, respectively—are presented. Conclusions are drawn regarding the differences found in collaboration patterns and ICT used during natural and human-induced disasters and the differences between currently available ICT and proposed ICT.

Schooley, Benjamin; Brian Hilton; Yousef Abed; Yoonmi Lee; Thomas Horan. Process Improvement and Consumer-Oriented Design of an Inter-Organizational Information System for Emergency Medical Response. 2011 44th Hawaii International Conference on System Sciences, Kauai, Hawaii USA pp.1-10. DOI: 10.1109/HICSS.2011.351. 2011.
http://www.computer.org/portal/web/csdl/doi/10.1109/HICSS.2011.351
Abstract: This research employs Information Systems Design Theory (ISDT) to design, develop, and assess an inter-organizational information system for Emergency Medical Services (EMS). This research takes both a goal-oriented process improvement and consumer-oriented approach to systems design. While IS development has a rich history of

focusing on improving organizational processes, the consumer- oriented approach aims to incorporate socio-psychological considerations of users. System goals include 1) improve patient information exchange from emergency responders to emergency department practitioners, and 2) develop the system in a manner that users believe to be ethical and otherwise intrinsically motivating to use. Data collection, system requirements, and system design and kernel theories are presented, design propositions are evaluated, and implications discussed on the role of consumer-oriented approaches in the development of multi-organizational, multi- consumer information systems.

Wang En-yan; Li Xiang-yang. Multi-dimension data model for emergency event and analysis of similarity. Uncertainty Reasoning and Knowledge Engineering (URKE), 2011 International Conference on , vol.2, no., pp.215-218, 4-7 Aug. 2011. DOI: 10.1109/URKE.2011.6007874. 2011.
http://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=6007874&isnumber=6007866
Abstract: In the analysis of the features of emergency decision and emergency decision support system it can find that the effective application of emergency decision and support systems must rely on the specific models and methods to achieve high efficiency and scientific decision in a short time because of the specific decision requirements and decision environment. Events retrieval is based on similarity theory in general, and it finds similar events by calculating the similarity, so as to provide reference for decision-making. Based on in-depth research of the conception and characteristics of the emergencies it proposed a multidimensional data model in this paper that divided the event attributes into different type, structured and unstructured. The model calculated attributes similarity according to different types, further analysis of the events similarity.

den Hengst, Mariëlle; Michael McQuaid; Jiang Zhu. Impact of Time-Based Visualization on Situation Awareness. Proceedings of the 37th Annual Hawaii International Conference on System Sciences - Track 1, vol. 1, Big Island, Hawaii pp.10039b 2004. DOI: 10.1109/HICSS.2004.1265150. 2004.
http://www.computer.org/portal/web/csdl/doi/10.1109/HICSS.2004.1265150
Abstract: We have developed a time-based visualization system and tested it in accordance with a well-developed theory of situation awareness during a simulation of an actual emergency. The client- server system is fed by a collaborative server, and uses linguistic parsing, suffix tree clustering, and multidimensional scaling to develop a changing picture of textual data related to an unfolding event. We provide a detailed account of situation awareness theory and use it to explain the effect of the visualization on perceptions of facts, comprehension of the situation, and projection of near term status. We developed a simulation of a tragic shooting at the University of Arizona, performing requirements elicitation of officials involved in the actual event, and preparing a repeatable scenario based on, but differing from, the event. We ran the simulation with about 200 management students, half of whom used the visualization system and half of whom used a competing text-based system, and found that the visualization system aided comprehension and projection, but had no effect on perception of facts.

A5.16 OTHER ICT

References Cited in Report

Neves, Pedro; Paulo Simoes et al. WiMAX for Emergency Services: An Empirical Evaluation. DOI: 10.1109/NGMAST.2007.61. 2007.
http://www.computer.org/portal/web/csdl/doi/10.1109/NGMAST.2007.61
Abstract: WiMAX, as a Broadband Wireless Access technology for Metropolitan Area Networks, supporting fixed and mobile terminals, is very promising for Next Generation Networks. Emergency Services can also strongly benefit from WiMAX features, allowing the exploitation of novel application scenarios and business models. This paper presents a set of scenarios, such as Environmental Monitoring, Telemedicine and Fire Prevention, defined and implemented in several European testbeds, interconnected by the European research network GEANT 2, in the framework of the WEIRD project1. In particular, we focus our attention on the scenario implemented in the Portuguese testbed Fire Prevention providing a detailed description about the testbed planning, implementation and evaluation.

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Abstract: Findings from full-scale and bench-scale fire tests identifying performance metrics and test methods relating to fire conditions and tasks performed by firefighters using thermal imaging cameras in structural firefighting scenarios.

Anderson, Leif. Reliable Communications and the Hazard Zone. Fire Engineering, Vol.163, Issue 5. 2010.
Abstract: The article highlights research conducted by the Phoenix Fire Department (PDF) of Arizona on its public radio system requirements. The PFD analyzed different technical options through actual firefighting scenarios and identified three basic radio communication paths for hazard cone communications. One of the cost-effective solutions found by the PFD for transporting analog simplex fireground trans missions to and from the incident commander and the regional dispatch center are digital vehicular repeater systems.

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Abstract: Discusses information and information communication technology as a core concern of modern government. E-government (electronically enabled government) is fundamental to the ongoing ?reinvention? of public administration. The spending of public money on ICT has led to some costly failures. Takes a critical look at policies, problems and prospects for e-government in a series of case studies. Discusses why ICT failures in the public sector occurred and what lessons they provide for the future.

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Abstract: Explains the basics of telephone communication systems. Includes chapters on internet telephony (VoIP and other systems), and wireless communications.

Manoj, B.S.; Alexandra Hubenko Baker. Communication challenges in emergency response. Communications of the ACM - Emergency response information systems: emerging trends and technologies Volume 50 Issue 3, March 2007 Pp.51 - 53. DOI: 10.1145/1226736.1226765. 2007.
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Abstract: This article discusses various issues related to new investment in high technology to better equip the fire service of the U.S. to handle a crisis caused by weapons of mass destruction. The American f ire service can be accused of many things. However, being high-technology or cutting-edge is not on the list. The challenge in implementing new technology, especially detectors and monitoring devices, is to be able to use the gear when the time comes. The manufacturers are looking for ways to make the machines user-friendly, but an agency must commit the time and money to keep people current on the training.

Shiraishi, Y. Tokyo Univ., Chiba. A User-centric Approach for Interactive Visualization and Mapping of Geo-sensor Data .4297407 . Networked Sensing Systems, 2007. Fourth International Conference on Pp 134 - 137. DOI: 10.1109/INSS.2007.4297407. geographic information system , location-based system , personalization , sensor data visualization. 2007. geographic information system , location-based system , personalization , sensor data visualization
Abstract: Sensor network applications collect and use sensor data from distributed sensor networks and databases. These real-time and time series sensor data are very useful for many location-based systems that manage and browse various kinds of personal spatial information such as digital photograph, travel diary and so on. Such location-based system for personal use requires a user-centric framework that can support intuitive query request and direct sensor data mapping. This paper proposes a user-centric approach for interactive visualization and mapping of geographically distributed sensor data. The overview of the prototype system that we are developing is briefly described. Our

approach generates a query for distributed sensor databases based on user's track log. This method produces understandable information from collected sensor data based on GIS (geographic information system) methods.

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Abstract: The Vigilant QE90 Emergency Warning and Intercommunication System (EWIS) is designed to facilitate the orderly evacuation of a building in the event of an emergency. The evacuation may be initiated automatically by a fire alarm system, or by a building occupant operating an emergency call point. Integrating a flexible alarm and voice warning system with a dedicated emergency intercom system, the QE90 allows fire wardens or emergency services personnel to easily control and coordinate rapid building evacuation. QE90 meets the control and indicating equipment requirements of installation standard AS 1670.4, complies with equipment standard AS 2220.1, and supports the ISO 8201 T3 evacuation signal and strobe pattern.

The future is calling out. Fire and Rescue, no75 (Aug 2009) p44-45. 2009.
Abstract: Looks at the latest developments in TETRA communications technology in the UK. Refers to the UK Fire and Rescue Service's new national communications network known as Firelink. Explains how the TETRA system isolates communication streams between various group members.

A5.17 COMPRESSED AIR FOAMS DELIVERY SYSTEMS

References Cited in Report

Alan O'Neill, Michael Delichatsios, Jianping Zhang. Assessment of the gas cooling capabilities of compressed air foam systems in fuel- and ventilationcontrolledcompartment fires. Interflam 2010 Proceedings, Interscience Communications Ltd, London. 2010.
Abstract: The objective of this study was to assess the cooling capabilities of the compressed air foam system (CAFS), as an alternative suppression agent to water mist, in fuel- and ventilation-controlled compartment fires. Two compartment fire behaviour training (CFBT) cells with dimensions of 12m long ? 2.4m wide ? 2.4m high and 6m long ? 2.4m wide ? 2.4m long were used, respectively, for the fuel- and ventilation-controlled experiments. Wooden pallets and chip boards were used as fuels. In addition to the CAFS, tests using water mist (the traditional suppression agent) were also conducted. Tests were video recorded and the development of temperature inside the units was also recorded using thermocouples. A comparative analysis of the results by the CAFS and water mist is conducted based on the temperature evolution histories and observations from the videos. The results indicate that the CAFS is more efficient in fire-fighting fuel-controlled fires, whereas for ventilation-controlled fires no noticeable difference is found between the CAFS and water mist. It is however noted that the CAFS does not contribute to or cause a backdraft in ventilation-controlled experiments.

Jourda, Paul; Marc Briffaud; Jeremy Hattenberger;, Jean-Pierre Vantelon et al. Simplified models of interactions of foam jets with hot smokelayers in under-ventilated fire conditions according to fullscale experiments. Interflam 2010 Proceedings, Interscience Communications Ltd, London. 2010.
Abstract: A real-scale research platform has been built in order to reproduce firefighting operations and compare the efficiency of water droplets and aqueous foam extinguishing systems. The premises are equipped with thermocouples allowing a 3D investigation of the thermal fields inside the hot gas layer. Four cases are studied. Droplets directly cooled down the hot gases. Foam creates a heat sink at the surface of the wall. The vaporization rate dictates the pressure variation inside the premises. Higher rate leads to higher depression. Results indicate that the average enclosure temperature decrease is due to the change of the gas specific heat inside the enclosure. It is possible to approximate the final temperature knowing the mass of water injected inside the premises. The increase of the average premises temperature, just after an impulse, can also be explained. It is related to the mass flow rate of outgoing hot gases and to the heat exchange between the walls and the gases.

Stefan Svensson, Ph.D. Quantifying efficiency in fire fighting operations. Interflam 2010 Proceedings, Interscience Communications Ltd, London. 2010.
Abstract: There is a great need to quantify the efficient use of resources during fire fighting operations. When addressing this problem, the focus should be on the results of such operations. This paper describes a number of approaches for quantifying fire fighting operations. Also, it identifies and discusses a number of aspects that has to be considered during such work, including inherent complexity, measurability and outcome of such operations

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Abstract: Identifies and dispels several myths about compressed air foam systems (CAFS). Includes practical advice on the selection, installation and effective application of CAFS systems.

Collette, Dominic. Class A foam and CAFS briefing: structural firefighting : Part 1-Debate on new technology; Part 2 - Finished foam and foam proportioning; part 3 - Generating Class A foam; Part 4 - Compressed air Foam Systems. Firehouse, v34 no10 (Oct 2009) p88-90; v34 no11 (Nov 2009) p106-107, 09; v34 no12 (Dec 2009) p118-120; v35 no4 (Apr 2010) p130-132. 2010.
Abstract: Series of articles giving an overview of the properties and characteristics of Class A foam and compressed air foam systems (CAFS). Explains how the extinguishing agents in firefighting foams work and when and where to apply them.

Collette, Dominic. The challenge of integrating foam into fire operations. Firehouse, v31 no2 (Feb 2006) p88, 90. 2006.
Abstract: Looks at the development of Class A and compressed air (CAFS) foam technology. Provides practical guidelines for implementing a foam technology integration strategy and action plan that covers initial research, education, equipment evaluation, specification and purchase. US-influenced.

Colletti, Dominic. Just add water : learn the capabilities and limitations of foam agents. Fire Rescue, v23 no3 (Mar 2005) p66-68, 70, 72-77. 2005.
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International Compressed Air Foam Association. Correct use of CAFS at car fires. Fire and Rescue, no79 (3rd Quarter 2010) p42, 44. 2010.
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Abstract: Examines the benefits, limitations, and application of Class A and Class B firefighting foams. Refers to NFPA Codes 18, 18A and 1145 for guidelines on wetting agents, water additives, and use of Class A foams in structural firefighting. Includes safety measures for firefighters and considerations for storing wetting agent and water additive concentrates. US-influenced.

Klassen, Keith. Fight with foam. Fire Rescue, v28 no2 (Feb 2010) p105-107. 2010.
Abstract: Discusses how to use Class A foam and Compressed Air Foam Systems (CAFS) to protect structures in wildland-urban fire incidents. US-influenced.

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Klein, Roger. Foam, foam and more foam - why regular re-evaluation is essential. Fire and rescue, 3rd Quarter 2006, p13-20. 2006.
Abstract: Examines the fire extinguishing properties of Class A and Class B foam, and describes under what circumstances they should be applied. Highlights the environmental impact of foam run-off, and outlines why fire brigades should consider alternative extinguishing methodologies for their personnel.

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Russell, Dave Angus. Fire Firefighting foam: making the right choice. Asia Pacific Fire, no28 (Dec 2008) p55-58. 2008.
Abstract: Highlights issues for consideration when selecting multipurpose firefighting foam. Identifies the current foam types available, their characteristics, application and storage requirements.

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Abstract: Findings from an Australian study identifying fluorochemical free firefighting foams capable of suppressing vapours of flammable liquid spills.

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Abstract: Reviews the current technology around firefighting foams especially for Class B flammable liquids, and Class A combustible solids applications. Includes a table listing the ten foam categories, their use, and typical application. Also highlights the overlap in performance between AFFF and high performance FFreeF (fluorine free foam) technologies.

Shelly, Craig H. Industrial-Strength Equipment for Industrial-Strength Operations. Fire Engineering, Vol.164, Issue 2. 2011.
Abstract: In the article the author discusses firefighting equipment used for industrial-strength fire services. He says that when dealing with larger scale fires, fire departments should have deck guns that ca n allow the maximum capacity flow coming from the pumper. He cites that portable around-the-pump proportioner can be used if firefighters cannot foam supplies close to the point of attack. He conclude s that fire departments should utilize the industrial technology and equipment available for them.

Whitely, Bob BFPSA. Foam fears for firefighters. Fire, v97 no1195 (Jan 2005) p26. 2005.
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Willson, Mike; Multipurpose foams for hazmat response. International Fire Fighter, no13 (Feb 2007) p45-48. 2007.
Abstract: Examines the firefighting properties of different types of foams, and highlights the latest advancements in foams used worldwide. Describes the differences between foams classified as 'Newtonian"" and ""Non-Newtonian"", foam storage requirements, and its low environmental impact.

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Abstract: Four experts (from Sweden, Australia, USA and Belgium) offer different perspectives on the type of firefighting foam predominantly used in their country to combat class B fires.

A5.18 HANDHELD WATER MIST DELIVERY SYSTEMS

References Cited in Report

Snegirev, Alexander; Alexey Lipjainen and Victor Talalov. Flame suppression by water sprays:flame-spray interaction regimes and governing criteria. Interflam 2010 Proceedings, Interscience Communications Ltd, London. 2010.
Abstract: Using the LES-based model, we demonstrate that spray refinement (droplet size reduction) facilitates extinguishment of the gaseous buoyant turbulent diffusion flame due to accumulation of total spray momentum in a narrowly focused turbulent vapour-rich jet. Necessary conditions for spray refinement to enhance flame suppression are (i) sufficiently high total spray momentum (compared to that of the rising plume) and (ii) jet orientation towards the fuel source. The dimensionless spray fineness number is suggested to distinguish coarse and fine sprays, namely the ratio of the droplet deceleration length to the distance between the nozzle and the fuel bed. The spray fineness number also determines two distinct regimes of flame-spray interaction.

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Magnus Arvidson & Tommy Hertzberg. A new methodology to evaluate the performance of total compartment water mist and water spray systems. Interflam 2004 Proceedings, Interscience Communications Ltd, London. 2004.
Abstract: Traditionally, the only parameter used to measure the performance of total compartment water mist or water spray systems during fire testing has been the time to extinguishment. However, tests conducted inside simulated machinery space compartments indicate that this measure is not adequate. The variation in ?time to extinguishment? for the same system can be of the order of several tens of percent under apparently identical conditions. Moreover, the ?ranking? of tested systems in one test compartment can be different compared to the ?ranking? when tested in another compartment, when ?time to extinguishment? is used as the only measurement parameter. This paper describes tests conducted under the VINNOVA water mist research project and defines parameters that characterise the performance of total compartment water mist and water spray systems. The methodology used is based on measurements of the Heat Release Rate of an obstructed pool fire, combustion gas concentrations and the gas temperatures inside the test compartment.

Yehuda Sinai, C Staples, ANSYS Europe Ltd and M Edwards, M Smerdon, MoD, UK. CFD modelling of fire suppression by water mist. Interflam 2007 Proceedings, Interscience Communications Ltd, London. 2007.
Abstract: The UK Ministry of Defence has recently completed a comprehensive research programme looking at water mist technologies that can be used on Royal Navy vessels. This work was initially intended to identify an alternative to Halon. The research programme led to the development of a lowpressure water mist system, Fine Water Spray (FWS) that operates from the ship's high-pressure salt water (HPSW) system at a typical operating pressure of 7 bar and AFFF at 1% concentration. As part of this programme, MoD wanted to develop a computer model that could be used as a tool to enable designers to assess the performance of the FWS system when fitted onboard ship, without the need for expensive fire testing. ANSYS Europe Ltd. was contracted to develop a Computational Fluid Dynamics (CFD) model using the ANSYS-CFX software, validate it ?blindly? against MoD's fullscale experiments, and demonstrate its application to a real vessel. The modelling is relatively advanced, and the comparison with experiments was encouraging. Whilst further developments are warranted, the authors consider the model to be a practical tool suitable for simulation of suppression of pool fires and other nominally single-phase fires by water droplets. The tool is also able to predict ventilation and thermal comfort.

Zhu Wei, W Tong, Beijing Municipal Institute of Labour Protection, L Guangxuan, University of Science and Technology of China and J Longzhe, University of Science and Technology of Beijing, PR China. Evaluation model of water mist fire suppression under forced ventilation. Interflam 2007 Proceedings, Interscience Communications Ltd, London. 2007.

Abstract: Abstract: In recent years is increasing recognized and extended during the applications with forced ventilation. A forecasting model was advanced to predict the time that surface flame was extinguished under the action of water mist. The model was depended on the combination with the relation between temperature and oxygen concentration, which could be deduced on R. Weighs' water mist fire extinguishing limit, and experiential relation of oxygen concentration descending after water mist discharging. Compared with experimental results, the forecasting results can be in good agreement with the time measured.

A5.19 POSITIVE PRESSURE VENTILATION

References Cited in Report

Kerber, Stephen; Stefan Svensson. Developments in Positive Pressure Ventilation 2010. Interflam 2010 Proceedings, Interscience Communications Ltd, London. 2010
Abstract: Positive pressure ventilation (PPV) has been used by the fire service for a number of years as a procedure to remove smoke and hot gases from a building on fire. PPV is a procedure where air is pushed into a building exposed to fire with the help of fans, consequently pushing hot air and smoke out of the building. This paper summarizes a large number of studies on PPV, draws conclusions from these studies and suggests further work in the area of safe fire attack involving PPV. Such work includes investigating impact of various wind conditions, flow path from inlets to exhausts, risk of unintentional fire spread, and combination of fire suppression efforts with PPV. Also, developing standards for testing and evaluating PPV are greatly needed as well as developing field guides for the safe use of PPV during fire fighting operations.

A5.20 PROTECTIVE CLOTHING

Other Relevant References

Cotterill, Deena; Easter, Elizabeth P. Firefighter turnout gear durability study - evaluation of visibility trim. Fire Technology, v47 no3 (3rd quarter July 2011) p601-613. 2011.
Abstract: The trim requirements on firefighter turnout gear are intended to be easily visible in both daytime and nighttime environments. This study discusses an evaluation of the reflectance, colour and fluorescence properties of high visibility trim on firefighters' used turnout gear. Refers to NFPA Codes 1851 and 1971. US-influenced.

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Abstract: Latest advances in equipment for hazmat response personnel. Looks at disposable chemical suits and their permeation performance, PAPRs (Powered Air-Purifying Respirators), monitoring and remote-sensing equipment, mobile lighting units, record-keeping systems, mobile laboratories, and advances in IT software that stores and displays data in the field.

Hummel, Alexander; Barker, Roger Lyons et al. Development of instrumented manikin hands for characterizing the thermal protective performance of gloves in flash fire exposures. Fire Technology, v47 no3 (3rd Quarter July 2011) p615-629. 2011.
Abstract: Describes the 'Pyrohands' system which is designed to measure the thermal protective performance of gloves in controlled flame exposures. US-influenced.

Mell, William E; Lawson, J. Randall; Prasad, Kuldeep. A heat transfer model for firefighters' protective clothing, continued developments in protective clothing. Fire Technology, v46 no4 (Oct 2010) p833-841. 2010.
Abstract: Additional development of the heat transfer model since the February 2000 publication of this paper. The radiant heat transfer element has been refined, and the model can now address predictions of heat transfer through wet protective clothing materials. Additionally, there has been an extension of the thermal properties database for fabric materials used to manufacture firefighters? protective clothing. These improvements have significantly expanded the capabilities of the model and provide users with a more robust tool for economically predicting thermal protective clothing performance. Refer also to Document 17039.

Rezadeh, Moein Torvi, David. Assessment of factors affecting the continuing performance of firefighters' protective clothing: a literature review. Fire Technology, v47 no3 (3rd quarter July 2011) p565-599. 2011.
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Standards New Zealand; International Standards Organisation (ISO); New Zealand Fire Service. Firefighters personal protective clothing - international standards meeting held in Wellington. Touchstone [e-newsletter], no17 (Jun 2010). 2010.
Abstract: Fire safety equipment experts from around the world recently met in Wellington to discuss international Standards for protective clothing for firefighters. Ten countries were represented at the International Organization for Standardization (ISO) Firefighters' Personal Equipment subcommittee meeting (ISO TC 94 SC 14) held 24 to 28 May 2010. New Zealand Fire Service Senior Adviser Keith Whale, a New Zealand representative on ISO TC 94 SC 14, comments on the meeting.

Feel the heat. Fire and Rescue (UK), no77 (1st Quarter 2010) p22-28. 2010.
Abstract: As protective clothing has improved, firefighters can theoretically get deeper into a fire and remain there for longer periods of time before they feel the heat and realise they should retreat. A number of experts share their thoughts on the effectiveness of protective structural clothing.

Urban search and rescue personal protective equipment specification for Scenario 2 high dust environments : Fire Research Report 6. 2010.
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Abstract: This report continues work conducted by the Health and Safety Laboratory for the Department for Communities and Local Government on Urban Search and Rescue (USAR) Personal Protective Equipment (PPE).

ROBOTS FOR FIRE AND URBAN SEARCH AND RESCUE

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Burke, Jenny; Robin Murphy. RSVP: an investigation of remote shared visual presence as common ground for human-robot teams. Proceedings of the ACM/IEEE international conference on Human-robot interaction, ACM New York, NY, USA ©2007. DOI: 10.1145/1228716.1228738. 2007.
Abstract: This study presents mobile robots as a way of augmenting communication in distributed teams through a remote shared visual presence (RSVP) consisting of the robot's view. By giving all team members access to the shared visual display provided by a robot situated in a remote workspace, the robot can serve as a source of common ground for the distributed team. In a field study examining the effects of remote shared visual presence on team performance in collocated and distributed Urban Search & Rescue technical search teams, data were collected from 25 dyadic teams comprised of US&R task force personnel drawn from high-fidelity training exercises held in California (2004) and New Jersey (2005). They performed a 2 x 2 repeated measures search task entailing robot-assisted search in a confined space rubble pile. Multilevel regression analyses were used to predict team performance based upon use of RSVP (RSVP or no-RSVP) and whether or not team members had visual access to other team members. Results indicated that the use of RSVP technology predicted team performance (ß= -1.24, p<.05). No significant differences emerged in performance between teams with and without visual access to their team members. Findings suggest RSVP may enable distributed teams to perform as effectively as collocated teams. However, differences detected between sites suggest efficiency of RSVP may depend on the user's domain experience and team cohesion.

Candido, S. ; Davidson, J. ; Hutchinson, S. Exploiting domain knowledge in planning for uncertain robot systems modeled as POMDPs. Robotics and Automation (ICRA), 2010 IEEE International Conference on 3-7 May 2010 pp 3596 - 3603. DOI: 10.1109/ROBOT.2010.5509494. 2010.
Abstract: We propose a planning algorithm that allows user-supplied domain knowledge to be exploited in the synthesis of information feedback policies for systems modeled as partially observable Markov decision processes (POMDPs). POMDP models, which are increasingly popular in the robotics literature, permit a planner to consider future uncertainty in both the application of actions and sensing of observations. With our approach, domain experts can inject specialized knowledge into the planning process by providing a set of local policies that are used as primitives by the planner. If

the local policies are chosen appropriately, the planner can evaluate further into the future, even for large problems, which can lead to better overall policies at decreased computational cost. We use a structured approach to encode the provided domain knowledge into the value function approximation. We demonstrate our approach on a multi-robot fire fighting problem, in which a team of robots cooperates to extinguish a spreading fire, modeled as a stochastic process. The state space for this problem is significantly larger than is typical in the POMDP literature, and the geometry of the problem allows for the application of an intuitive set of local policies, thus demonstrating the effectiveness of our approach. URL: http://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=5509494&isnumber=5509124

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http://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=4600675&isnumber=4600621
Abstract: In a variety of emergency settings robot assistance has been identified as highly valuable, providing remote, and thus safe, access and operation. There are many different forms of human-robot interactions, allowing a team of humans and robots to take advantage of skills of each team member. A relatively new area of research considers interactions between human and a team of robots performing as a swarm. This work is concerned with the interactive use of autonomous robots in fire emergency settings. In particular, we consider a swarm of robots that are capable of supporting and enhancing fire fighting operations co-operatively and we investigate how firefighters in the field work with such a swarm. This paper outlines some of the key characteristics of this emergency setting. It discusses possible forms of interactions with swarm robotics being examined in the GUARDIANS project. The paper addresses the use of assistive swarm robotics to support firefighters with navigation and search operations. It reports on existing firefighters operations and how human-swarm interactions are to be used during such operations. The design approaches for human-swarm interaction are described and the preliminary work in the area are outlined. The paper ends by linking current expertise with common features of emergency related interaction design.

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Abstract: This paper describes the modeling, implementation, and evaluation of RoBombeiros multirobotic system. The robotic task in this paper is performed over a natural disaster, simulated as a forest fire. The simulator supports several features to allow realistic simulation, like irregular terrains, natural processes (e.g. fire, wind) and physical constraint in the creation and application of mobile robots. The proposed system relies on two steps: (i) group formation planning and (ii) intelligent techniques to perform robots navigation for fire fighting. For planning, we used genetic algorithms to evolve positioning strategies for firefighting robots performance. For robots operation, physically simulated fire-fighting robots were built, and the sensory information of each robot (e.g. GPS, compass, sonar) was used in the input of an artificial neural network (ANN). The ANN controls the vehicle (robot) actuators and allows navigation with obstacle avoidance. Simulation results show that the ANN satisfactorily controls the mobile robots; the genetic algorithm adequately configures the fire fighting strategy and the proposed multi-robotic system can have an essential hole in the planning and execution of fire fighting in real forests.

Purohit, A.; Pei Zhang. Controlled-mobile sensing simulator for indoor fire monitoring. Wireless Communications and Mobile Computing Conference, 2011 7th International , pp.1124-1129, 4-8 July 2011. DOI: 10.1109/IWCMC.2011.5982698. 2011.
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Abstract: Indoor emergency response situations, such as urban fire, are characterized by dangerous constantly-changing operating environments with little access to situational information for first responders. In situ information about the conditions, such as the extent and evolution of an indoor fire, can augment rescue efforts and reduce risk to emergency personnel. Cyber-physical controlled- mobile sensor networks have been proposed for emergency response situations. However, cost-effective development, analysis and evaluation of such cyber-physical systems require simulation frameworks that simultaneously model its many computational and physical components. Existing multi-sensor/robot simulation environments are inadequate for this purpose. This paper presents a simulator that incorporates a realistic indoor fire growth model (CFAST), with a radio path loss model, wireless network model, and mobility model of a controlled-mobile sensor network, to achieve a more comprehensive representation of such cyber-physical systems. A detailed example simulation scenario is presented along with analysis to illustrate the capabilities of the framework.

Purohit, A.; Zheng Sun; Mokaya, F.; Pei Zhang. SensorFly: Controlled-mobile sensing platform for indoor emergency response applications. Information Processing in Sensor Networks (IPSN), 2011 10th International Conference on , pp.223-234, 12-14 April 2011. 2011.
http://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=5779040&isnumber=5779036 Abstract: Indoor emergency response situations, such as urban fire, are characterized by dangerous constantly-changing operating environments with little access to situational information for first responders. In-situ information about the conditions, such as the extent and evolution of an indoor fire, can augment rescue efforts and reduce risk to emergency personnel. Static sensor networks that are pre-deployed or manually deployed have been proposed, but are less practical due to need for large infrastructure, lack of adaptivity and limited coverage. Controlled-mobility in sensor networks, i.e. the capability of nodes to move as per network needs can provide the desired autonomy to overcome these limitations. In this paper, we present SensorFly, a controlled-mobile aerial sensor network platform for indoor emergency response application. The miniature, low-cost sensor platform has capabilities to self deploy, achieve 3-D sensing, and adapt to node and network disruptions in harsh environments. We describe hardware design trade-offs, the software architecture, and the implementation that enables limited-capability nodes to collectively achieve application goals. Through the indoor fire monitoring application scenario we validate that the platform can achieve coverage and sensing accuracy that matches or exceeds static sensor networks and provide higher adaptability and autonomy.

Vijay Kumar; Rus, D.; Sanjiv Singh. Robot and sensor networks for first responders. Pervasive Computing, IEEE , vol.3, no.4, pp. 24- 33, Oct.-Dec. 2004. DOI: 10.1109/MPRV.2004.17. 2004.
http://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=1369158&isnumber=29960
Abstract: The need to collect, integrate, and communicate information effectively in emergency response scenarios exceeds the state of the art in information technology. This emergency response problem provides an interesting and important test bed for studying networks of distributed mobile robots and sensors. Here, we describe the component technologies required to deploy a networked- robot system that can augment human firefighters and first responders, significantly enhancing their firefighting capabilities. In a burning building at a firefighting training facility, we deployed a network of stationary Mote sensors, mobile robots with cameras, and stationary radio tags to test their ability to guide firefighters to targets and warn them of potential dangers. Our long-term vision is a physical network that can sense, move, compute, and reason, letting network users (firefighters and first responders) Google for physical information - that is, information about the location and properties of physical objects in the real world.

Zhenzhang Liu; Tien-Fu Lu. Multiple robots plume-tracing in open space obstructed environments. Robotics and Biomimetics, 2009 IEEE International Conference on , pp.2433-2439, 19-23 Dec. 2009. DOI: 10.1109/ROBIO.2009.5420742. 2009.
http://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=5420742&isnumber=5420381
Abstract: Plume-tracing mobile robots have the potential to detect emissions caused by dangerous sources, such as early stage fire, toxic gas and explosives, without endangering human life during the detection and source localization process. So far, most researchers have focused on odour source localization using a single mobile robot; however, using a single robot to locate an odour source has limitations. In this study, multiple robots were adopted and cooperated with a supervisory program to locate an odour source in open space, wind-varying, obstructed environments. The supervisory program collected information from individual robots and designated different control commands to individual robots. Based on the information provided by individual robots, the supervisory program was able to determine a region where the odour source was located. A series of simulations has been conducted and the simulations outcomes showed that the proposed strategies for multiple robots are successful in locating an odour source.

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Atanasov, Atanasko; Andrea Kulakov; Vladimir Trajkovic; Danco Davcev. Testbed Environment for Wireless Sensor and Actuator Networks. 2010 Fifth International Conference on Systems and Networks Communications, Nice, France 2010 pp.1-6. DOI: 10.1109/ICSNC.2010.8. 2010.
http://www.computer.org/portal/web/csdl/doi/10.1109/ICSNC.2010.8
Abstract: The Wireless Sensor and Actuator Networks (WSAN's), defines collaborative operations between the sensors and the actuators, enabling distributed sensing of a physical phenomenon. In this paper, an integrated testbed consisted of wireless sensor network, server station and robot system is proposed. Our main contribution is in the design and development of the server and actuator tier software modules and the communication protocols between them. We provide new applications where actuators are part of the network and perform actions based on the information gathered by sensors. We describe some test scenarios for the potential use of the system. We envision that WSANs will be an integral part of the systems such as battlefield surveillance, nuclear, biological or chemical attack detection, home automation, and environmental monitoring. Our platform offers reusability, modularity and simplicity to the user. Furthermore, it is designed with cheap and off- the- shelf components. Index Terms: Wireless Sensor and Actuator Networks, mobility, monitoring, path planning, navigation

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Penders, Jaques. Alboul, Lyuba. Witkowski, Ulf. Naghsh, Amir. Saez-Pons, Joan. Herbrechtsmeier, Stefan. El-Habbal, Mohamed. A Robot Swarm Assisting a Human fire fighter. Advanced Robotics, Vol.25, Issue 1/2. 2011.
Abstract: Emergencies in industrial warehouses are a major concern for fire-fighters. The large dimensions, together with the development of dense smoke that drastically reduces visibility, represent major challenges. The GUARDIANS robot swarm is designed to assist fire-fighters in searching a large warehouse. In this paper we discuss the technology developed for a swarm of robots assisting fire-fighters. W e explain the swarming algorithms that provide the functionality by which the robots react to and follow humans while no communication is required. Next we discuss the wireless communication system, which is a so-called mobile ad-hoc network. The communication network provides also the means to locate the robots and humans. Thus, the robot swarm is able to provide guidance information to the human s. Together with the fire-fighters we explored how the robot swarm should feed information back to the human fire-fighter. We have designed and experimented with interfaces for presenting swarm-based information to human beings.

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A5.21 MOTOR VEHICLE ACCIDENTS RESCUE

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Abstract: Since 2010, the body structure of new vehicles have increasingly being made from advanced and ultra high strength steels. Identifies some European late model vehicles that require high standards of extrication techniques. Illustrated showing the use of cutting tools, rams and spreaders especially around the B-post area. UK-influenced.

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Abstract: Identifies extrication and tactical concerns for firefighters responding to hybrid and electric vehicle fires. Looks at suppression technologies, access to the vehicle and emphasises the importance of power battery isolation.

Dalrymple, David. New tricks for old tools. Fire Engineering, v163 no3 (Mar 2011) p26-40. 2011.
Abstract: Discusses several vehicle extrication techniques for motor vehicle rescue operations. Emphasises the importance of a powerful hydraulic cutter, and a reciprocating saw with good rescue blades. Describes how the roof tent evolution involves the widening of the rear window opening, reclining the seat of the patient and sliding the patient up a long spine board for removal. Also includes guidelines for performing the upper rail roll evolution. US-influenced.

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Abstract: Series of articles exploring the features of the all-electric drive 2011 Chevrolet VOLT motor vehicle. Seen from an emergency responder perspective, discusses vehicle construction and design, and operating features and battery information. Includes guidelines for rescue and extrication protocols for this vehicle model type. US-influenced.

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A5.22 OTHER NON-FIRE EMERGENCY TECHNOLOGIES

Other Relevant References

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A5.23 TECHNOLOGIES TO MAXIMISE FLEXIBILITY IN TRAINING TIME/PLACE.

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Diener, Scott; John Windsor; David Bodily. Design and Development of Clinical Simultions in Second Life. University of Auckland, 2009.
Abstract: Physical classrooms in tertiary education have changed little with the introduction of technology. To an extent, the interactive dynamics of teaching have been limited by educational technology, for instance moving around the classroom interacting directly with individual students. Powerpoint based teaching too often ties teachers to a menu-driven podium, and ever-increasing class sizes have cast students into even larger 'seating batteries' where they can be fed. We can do better. The design of physical learning spaces has started to undergo change in recent years

(see http://www.jiscinfonet.ac.uk/infokits/learning-space-design), but can we apply these same concepts to virtual spaces such as Second Life? The Medical faculty at the University of Auckland currently utilises trained actors, called standardised patients, to give participants a realistic clinical encounter, including taking a history, discussing the likely differential diagnoses, and making management decisions. A wide range of problems can be presented to the students in this manner, although there is significant cost associated with the development of these real-world simulations. This paper presents the virtual world pilot environment developed by the Academic and Collaborative Technologies Group and Faculty of Medical and Health Sciences at the University of Auckland within Second Life to explore the potential of bringing the same actors into a very low-cost virtual world. The paper further describes the conceptual design and construction details of the University's Second Life simulation island, which provides an environment for varied clinical and student-oriented simulations.
https://researchspace.auckland.ac.nz/bitstream/handle/2292/4305/4305.pdf?sequence=2
See also YouTube video:
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McCabe, Deborah Brown; and Matthew L. Meuter. A Student View of Technology in the Classroom: Does It Enhance the Seven Principles of Good Practice in Undergraduate Education?. Journal of Marketing Education August 2011 33: 149-159. 2011. doi:10.1177/0273475311410847
Abstract : There has been an explosion of classroom technologies, yet there is a lack of research investigating the connection between classroom technology and student learning. This research project explores faculty usage of classroom-based course management software, student usage and opinions of these software tools, and an exploration of whether or not the use of classroom-based course management software enhances student perceptions of learning based on the Seven Principles of Good Practice in Undergraduate Education. The authors find that although students enjoy using many of the course management tools, they do not see the tools as highly effective at enhancing the learning experience. When designing courses and considering if or how to use course management tools, it is critical for faculty to consider the connection between the Seven Principles for Good Practice in Undergraduate Education and the specific technology tools. Implications of the research findings and suggestions for improved use of classroom management software tools are provided.

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Abstract: The delivery of marketing education seems to be rapidly shifting toward pedagogy rich in experiential learning and strongly supported with educational technology. This study integrates and extends previous research efforts and investigates the simultaneous effects of multiple influences of technology and nontechnology factors on learning outcomes. Responses were obtained across a marketing curriculum with technology-accustomed students. The findings suggest that the use of preferred instructional methods will enhance each of the three different measures of learning outcomes, while encouraging supportive class behaviors can increase self report performance and course grade. Regardless of the dependent outcome measure, only one of the five instructional technology variables proved significant, suggesting that in contrast to previous studies that examined technology in isolation, when analyzed relative to other learning factors, technology's influence is secondary. Implications are discussed with practical suggestions for the classroom and direction for further investigation.
http://jmd.sagepub.com/content/25/2/130.short

A5.24 TECHNOLOGIES TO MAXIMISE FLEXIBILITY IN TRAINING AND LEARNING STYLE (VISUAL, AUDITORY, READ/WRITE, KINESTHETIC)

References Cited in Report

Leite,Walter L; Marilla Svinicki; and Yuying Shi. Attempted Validation of the Scores of the VARK: Learning Styles Inventory With Multitrait–Multimethod Confirmatory Factor Analysis Models. Educational and Psychological Measurement, April 2010; vol. 70, 2. 2009
Abstract:The authors examined the dimensionality of the VARK learning styles inventory. The VARK measures four perceptual preferences: visual (V), aural (A), read/write (R), and kinesthetic (K). VARK questions can be viewed as testlets because respondents can select multiple items within a question. The correlations between items within testlets are a type of method effect. Four multitrait—multimethod confirmatory factor analysis models were compared to evaluate the dimensionality of the VARK. The correlated trait—correlated method model had the best fit to the VARK scores. The estimated reliability coefficients were adequate. The study found preliminary support for the validity of the VARK scores. Potential problems related to item wording and the scale's scoring algorithm were identified, and cautions with respect to using the VARK with research were raised.
http://epm.sagepub.com.helicon.vuw.ac.nz/search/results?fulltext=Validation+of+the+Scores+of+the+VARK&submit=yes&journal_set=spepm&src=selected&andorexactfulltext=and

Petrakis, John G.. Firefighter learning styles and training: beyond the slide presentation. Fire Engineering v156 no 10. 2003.
Abstract: Fire service educators strive to provide sup-erior training exercises and skill-enhancing instruction to their students. Unfortunately, not every student learns in the same way; each student has his own learning style. This article examines three basic student learning styles: (1) visual—through examining pictures or images; (2) auditory—through listening; and (3) kinesthetic—through practical application. In addition to the learning style, an instructor/training officer should consider the type of learning environment most conducive to the student's retention and understanding of information. Fire service instructors often overlook their students' different learning styles. Just as there are different methods through which people effectively retain information in a particular learning environment, there are different instructional methods and audiovisual aids instructors can use to convey this information. Instructors should also discover the environment in which their students learn best. In every instructional session, instructors should identify

and appropriately address the needs of the visual, audible, and kinesthetic learners within their training programs. Instructors who comprehend the physiology and fundamental philosophy of learning will better understand the effectiveness of assorted instructional techniques and coordinate them with the various students' learning environments. Training officers and instructors often overlook variations in learning styles when preparing training outlines and assume that most firefighters gain knowledge in the same way. If instructors do not recognize the varied learning styles, students may not achieve the instructional program objectives designed to ensure the highest learning potentials for later relevance.
http://www.fireengineering.com/articles/print/volume-156/issue-10/features/firefighter-learning-styles-and-training-beyond-the-slide-presentation.html

Other Relevant References

Clark, Ruth. Give your training a visual boost. T D, v63 no4 (Apr 2009) p36-38. 2009.
Abstract: Tips on using visual literacy in training materials. Considers the effect of decorative visuals which add interest but don't enhance instruction. Refers to a study of sample lessons that omitted interesting visuals which led to better student comprehension results. Discusses how to use explanatory visuals that illustrate content relationships. US-influenced.

Edmondson, Jada. Let's be clear: how to manage communication styles. T D, v63 no9 (Sep 2009) p30-31. 2009.
Abstract: Lists the four basic communication styles - expressive, systematic, sympathetic, and direct. Explains how these styles are perceived by people. US-influenced.

Hayes, Christine Golding, Barry Harvey, Jack NCVER. Adult learning through fire and emergency service organisations in small and remote Australian towns. 2004.
http://www.ncver.edu.au/research/proj/nr2L03.pdf
Abstract: Investigates the impact literacy levels may be having on the ability of volunteers in Australian fire services to meet the changing demands and training requirements arising from community expectations and legal pressures. Explores the communication skills and other literacies needed by members of these organisations, and the role the organisations have in developing the skills of people in rural and remote communities. Produced by the National Centre for Vocational Educational Research, following a survey of fire brigades and state emergency services in small and remote communities across five Australian states.

Laugh, Michael. Closing the generation gap. T D, v63 no5 (May 2009) p20. 2009.
Abstract: Findings from a recent survey suggests that the value of evaluating workplace behaviours solely on the basis of age is no longer acceptable. Comparisons were made from the four most identifiable age groups - Generation Y, Generation X, baby boomers, and traditionalists. Believes that prevailing assumptions about what each generation values are misguided.

McClincy, William D. Instructional methods for public safety. 2011.
Abstract: A comprehensive overview of emergency services instruction. Tailored specifically for emergency services personnel, this resource offers new and experienced instructors clear, detailed direction on course design, along with concise guidance on evaluation and assessment tools. It also provides a concise overview of educational theories, and looks at the use of multimedia and technology in learning and instruction. It is based on the current National Guidelines for Educating EMS Instructors by National Highway Traffic Safety Administration (NHTSA) and encompasses the recommendations of the US EMS Education Standards.

A5.25 INNOVATIVE LIVE FIRE SIMULATORS

Other Relevant References

Brady, Don T. Safe and scorching. FEPN : Fire / EMS Product News (supplement to Fire Chief), v8 no1 (Jan-Feb 2006) p1, 4-5. 2006.
Abstract: US fire departments are finding that gas-fueled, computer-controlled live fire training systems provide a viable solution with several advantages over conventional training. Describes how the gas systems work, and what types of fire scenarios are used during training. Refers to NFPA code 1402 for guidelines on the installation and maintenance of these systems.

Brammer, David; Wise, Stephen. Fire Brigade flashover training simulator; Letters to the Editor. Fire Australia, (Nov 2002) p8-13 + (Feb 2003) p17-19. 2002.
Abstract: Computer modelling was used to investigate the safety of a flashover training simulator in Australia following concerns when a firefighter experienced excessive temperatures during an exercise. Describes the use of Computational Fluid Dynamics (CFD) which studied a venting arrangement recreating the effect of flashover within an enclosed space. Includes recommendations for conditions of use and some structural changes to the simulator. + Feedback to the Editor in response to Brammer and Wise article on fire behaviour simulators.

Butterfield, Johnÿ. Going underground. Fire and rescue, no58 (second quarter 2005) p31-33. 2005.
Abstract: Describes the Hagerbach Test Galleries simulation facility in Flums, Switzerland. This facility allows firefighters and emergency crews to experience the real-life limitations of confined space rescue fires. The facility can also simulate road accident or train derailment tunnel rescues. Briefly covers case studies of significant tunnel fires such as the Mont Blanc Highway tunnel fire 1999, Channel Tunnel fire 1996, and London's King's Cross Underground Station fire,1987.

Klein, Roger. Training with foam - a cost-benefit analysis. Fire and Rescue, no74 (May 2009) p20-22. 2009.
Abstract: Discusses how the chemical makeup and intended operational usage of firefighting foam determines the types of training foams used by fire brigades.

Musselwhite, Chris Kennedy; Sue Probst, Nancy; Best practices for facilitating simulations. T D, v64 no8 (Aug 2010) p26-28. 2010.
Abstract: Examines best practices for trainers facilitating simulation exercises in an interactive learning environment. The experience should deliver significant knowledge that can be assimilated into work processes and lead to real behaviour change. Covers preparing, selecting, delivering, and debriefing of a simulation exercise. US-influenced.

Rice, Curtis; Clark, Bruce. Maximizing training evolutions in an acquired structure. Fire engineering, v163 no4 (Apr 2010) p97-106. 2010.
Abstract: Discusses step by step live fire training options for an acquired wood-frame structure. Training involved simulations of forcible entry, cutting padlocks, ladder placement, and venting windows among other scenarios. Includes photos with captions. US-influenced.

Rodriguez, Pedro Sapeurs-Pompiers de Paris. Paris Brigade acquires state-of-the-art fire trainers. Fire and rescue, 3rd Quarter 2006, p33-34. 2006.
Abstract: Describes two new simulation training facilities built for the Paris Fire Brigade. Highlights some of the design solutions that took into account building codes and regulations, constraints of the building land, and fire service requirements.

Turnbull, Aidan; High-rise training. Fire and rescue, no67 (Jan 2007) p12-13. 2007.
Abstract: The Gatwick Airport Multi-Training facility includes a simulator that provides training in high-rise firefighting. The simulator allows for different high-rise and climbing scenarios and allows firefighters to practice flashover and backdraught techniques in a safe environment.

Waterbus, Aaron; Best behaviour. Fire Prevention and Fire Engineers Journal, Nov 2006, p44-45. 2006.
Abstract: Describes the New Zealand Fire Service's first compartment fire behaviour training facility (CFBT) located at the fire service's new national training centre at Rotorua.

White, Sam. What a disaster. Fire Chief, v51 no6 (Jun 2007) p54-58, 61. 2007.
Abstract: Describes a 52-acre training facility complete with full-scale, collapsible structures designed to simulate various wreckage. As home of the Emergency Operations Training Center, Disaster City is just one portion of a larger emergency response training facility that includes the Brayton Fire Training Field. Brayton Field is the largest training facility of its kind in the United States and includes buildings, towers, tanks, industrial plant structures and a ship that are used during lifelike, live-fire training simulations.

Live fire training as simulation. 2010.
Abstract: Examines how compartment fires in the training environment differ from those found in emergency operations. Identifies the key elements of simulation 'fidelity'. Emphasises the importance of defining intended learning outcomes and the critical elements of context required during training. Refers to NFPA Code 1403 'Standard on Live Fire Training'. US-influenced.

A5.26 COMMAND AND CONTROL SIMULATORS (PHYSICAL AND SOFTWARE, FIXED OR TRUCK-MOUNTED)

References Cited in Report

Jaikyung Lee; Moohyun Cha; Byungil Choi; Taesung Kim. A team-based firefighter training platform using the virtual environment. Proceedings of the 9th ACM SIGGRAPH Conference on Virtual-Reality Continuum and its Applications in Industry ACM New York, NY, USA 2010. DOI: 10.1145/1900179. 2010.

Abstract: The increasing complexity of modern buildings, such as high-rise buildings and underground subway stations, has brought about an increase in the scale of potential hazards, which in turn requires changes in firefighter training. Due to cost, time, and safety requirements for the trainee, it is impossible for firefighters in training to experience a real fire. In additional, repeated training is impossible if real fire were used. We proposed a team-based firefighter training platform using the virtual environment for complex buildings. The platform provides training and evaluation of firefighting and mission-based team training. To achieve an immersive virtual environment, VR, AR and haptics technique is adopted. A numerical analysis method is used to model real fire phenomena.

Rocha, Rafaela V.; Regina B. Araújo ; Márcio R. Campos ; Azzedine Boukerche. HLA Compliant Training Simulations Creation Tool. Proceedings of the 2009 13th IEEE/ACM International Symposium on Distributed Simulation and Real Time Applications IEEE Computer Society Washington, DC, USA ©2009. 2009.

Abstract: This paper presents an architecture to support the modeling of different High Level Architecture (HLA) compliant emergency management training simulations. Different ontologies are created to support complex simulation instantiation. Simulations can be accessed through any device that can run an X3D browser. A context database is created, which provides real life events, collected via wireless sensor networks that can be added to different simulation scenarios. A use case is described using our proposed architecture.

Schurr, Nathan; Pratik Patil; Fred Pighin; Milind Tambe. Using multiagent teams to improve the training of incident commanders. Proceedings of the fifth international joint conference on Autonomous agents and multiagent systems ACM New York, NY, USA ©2006. DOI: 10.1145/1160633.1160924. 2006.

Abstract: The DEFACTO system is a multiagent based tool for training incident commanders for large scale disasters. In this paper, we highlight some of the lessons that we have learned from our interaction with the Los Angeles Fire Department (LAFD) and how they have affected the way that we continued the design of our training system. These lessons were gleaned from LAFD feedback and initial training exercises and they include: system design, visualization, improving trainee situational awareness, adjusting training level of difficulty and situation scale. We have taken these lessons and used them to improve the DEFACTO system's training capabilities. We have conducted initial training exercises to illustrate the utility of the system in terms of providing useful feedback to the trainee.

Toups, Zachary O.; Andruid Kerne; William A. Hamilton; Nabeel Shahzad 2011. Zero-fidelity simulation of fire emergency response: improving team coordination learning. Proceedings of the 2011 annual conference on Human factors in computing systems ACM New York, NY, USA ©2011. DOI: 10.1145/1978942.1979226. 2011.

Abstract: Fire emergency responders rely on team coordination to survive and succeed in high-stress environments, but traditional education does not directly teach these essential skills. Prior simulations seek the highest possible fidelity, employing resources to capture concrete characteristics of operating environments. We take a different tack, hypothesizing that a zero-fidelity approach, focusing on human-centered aspects of work practice, will improve team coordination learning. Such an approach promotes simulation focus by developing an alternative environment that stimulates participants to engage in distributed cognition. The costs of simulation development are reduced. To supplement preparation for burn training exercises, 28 fire emergency response students played the Teaching Team Coordination game (T2eC), a zero-fidelity simulation of the distributed cognition of fire emergency response work practice. To test our hypothesis, we develop quantitative evaluation methods for impact on team coordination learning through measures of communication efficiency and cooperative activity. Results show that participants improve cooperation, become more efficient communicators, differentiate team roles through communication, and leverage multiple communication modalities. Given the context of the study amidst the educational process, qualitative data from the students and their expert instructor supports the ecological validity of the contribution of the T2eC zero-fidelity simulation to fire emergency response education.

Other Relevant References

Brennan, Christopher. Fireground tactical decision making. Fire Engineering [e-newsletter], v164 no4 (Apr 2011) p81-88. 2011.
Abstract: Introduces the 'Boyd Loop' also known as the 'OODA Loop' which is a decision making concept used in the US military. The concept enables people to develop their abilities to interpret their environment, gather information relevant to their situation, and use that knowledge to make decisions and plot their actions. Author believes this training idea can be applied to fire service tactical decision making on the fireground. US-influenced.

Corley, Jack ; Dan Lejerskar. Simulation for emergency response: homeland defense center network - capitalizing on simulation, modeling and visualization for emergency preparedness, response and mitigation. Proceedings of the 35th conference on Winter simulation: driving innovation Winter Simulation Conference ©2003. 2003.
Abstract: Emerging simulation, modeling and 3D visualization technologies (3D-SMV) could be used to dramatically improve how we prepare for, respond to and recover from disaster across federal, state, and local lines. It is now possible, at low-cost, to: Address 3D-SMV needs with seamlessly integrated, commercial, scalable, networked solutions; Provide unique flexibility to reuse 3D-SMV content across PC, laptop, or mobile devices via CD, LAN or Internet.; Portray fully interactive 3D-SMV on multi-wall display and, without change, on monitors with optional accessories including head-mounted displays, haptic gloves, 3D glasses. In the Homeland Defense Center Network, ATI is teamed with Eon Reality and University-based Homeland Defense Centers. Each Center has unique expertise in applying 3D-SMV to: urban assessment; surveillance; sensor simulation; critical infrastructure; scalable training; firefighting; and HAZMAT. This paper describes efforts to use these centers to capitalize on 3D-SMV for training and decision support throughout the emergency life-cycle.

Kastros, Anthony. Mastering Fireground Command: 10 Commandments of Command. Fire Engineering, Aug2011, Vol. 164 Issue 8, p53-67, 11p. 2011.
Abstract: The article discusses the incident command system (ICS) formula and the 10 Commandments of Command and the templates that can be used by firefighters for multifamily dwellings like duplexes, townhomes and apartments. It suggests the splitting of the interior functions into a Fire Attack Group and a Rescue Group. It cites the questions that should be considered to determine the level of tactical expertise. It explores the advantages of conducting simulation training.

Ponder, Michal; Bruno Herbelin; Tom Molet; Sebastien Schertenlieb et al. Immersive VR decision training: telling interactive stories featuring advanced virtual human simulation technologies. Proceedings of the workshop on Virtual environments 2003 ACM New York, NY, USA ©2003. DOI: 10.1145/769953.769965. 2003.
Abstract: Based on the premise of a synergy between the interactive storytelling and VR training simulation this paper treats the main issues involved in practical realization of an immersive VR decision training system supporting possibly broad spectrum of scenarios featuring interactive virtual humans. The paper describes a concrete concept of such a system and its practical realization example. Based on the premise of a synergy between the interactive storytelling and VR training simulation this paper treats the main issues involved in practical realization of an immersive VR decision training system supporting possibly broad spectrum of scenarios featuring interactive virtual humans. The paper describes a concrete concept of such a system and its practical realization example.

Shapter, Chrisÿ. Promoting the best in New South Wales. Vector Command, no9 (Spring 2004) p8. 2004.
Abstract: Describes the VectorCommand simulation system used by the New South Wales Fire Brigade. Looks at its use in the professional development and training of station officers and executive officers covering areas such as incident command, risk control and communication coordination. Also offers familiarisation and practical drill programmes for firefighters.

VectorCommand Ltd; New Zealand Fire Service. NZFS National Training Centre, Rotorua. Incident command training delivered with kiwi ingenuity. Emergency Command System Bulletin, no15 (Summer 2009) p13. 2009.
Abstract: Highlights the incident command simulation training for New Zealand firefighters using mobile incident management training vehicles.

A5.27 INTERACTIVE VIRTUAL REALITY FIREFIGHTING SIMULATORS (PHYSICAL AND SOFTWARE FIXED OR TRUCK-MOUNTED)

References Cited in Report

Backlund, P.; Engstrom, H.; Hammar, C.; Johannesson, M.; Lebram, M.. Sidh - a Game Based Firefighter Training Simulation. Information Visualization, 2007. 11th International Conference , pp.899-907. DOI: 10.1109/IV.2007.100. 2007.
http://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=4272085&isnumber=4271944
Abstract: This paper presents Sidh-a game based firefighter training simulator developed in cooperation between the University of Skvde and the Swedish Rescue Services Agency. Sidh is based on computer game hardware and software solutions but adds a novel interaction model and gameplay specifically developed for the purpose of training firefighters. The simulator environment is a cave where the player is interacting with the game through a set of sensors. Players move in the virtual world by movements in the physical world and a substantial physical effort is required to accomplish game tasks. Sidh has been used in a feasibility study where 31 firefighter students have been playing the game and the performance of these students as well as their reflections from using the game have been analyzed. Results from this study show that Sidh is a useful complement to traditional training methods and that the subjects give very high grades on the entertainment value of the game which indicate that this form of training may be self-motivating which is an important issue for voluntary, after-hours training.

Denef, Sebastian; Leonardo Ramirez; Tobias Dyrks. Letting tools talk: interactive technology for firefighting. Proceedings of the 27th international conference extended abstracts on Human factors in computing systems ACM New York, NY, USA 2009. DOI: 10.1145/1520340.1520681. 2009.
Abstract: In this work-in-progress report we present the results of a preliminary analysis of a set of fieldwork studies conducted in collaboration with a firefighter school and a firefighter brigade. To inspire the design of ubiquitous computing systems, we provide a description of the equipment used by firefighters, practices built upon them and a set of common properties.

Dogra, S.; Manna, S.; Banik, A.; Maiti, S.; Sarkar, S.K.. A novel approach for RFID based fire protection. Emerging Trends in Electronic and Photonic Devices & Systems, 2009, International Conference on , pp.198-201. 2009.
http://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=5441139&isnumber=5441033
Abstract: Every year lot of properties and lives are lost in fires. When the firefighters start extinguishing fires, they have to enter the fire affected region, but the main problem is that in most cases the firefighters don't have an overall knowledge of inside scenario of progress of fire. Sometime it can lead to death of firemen. As for example nationwide, of the roughly 100 firefighters who die on duty each year, a quarter loses their lives in fires, according to the U.S. fire administration.Nearly half the deaths are the result of heart attacks or other health-related problems. So, when a firefighter loses his life in the line of duty, it is a reminder of the complexity and peril of the profession, despite a dedication to improved equipment and training in recent years. So, if the firefighters have a prior knowledge about the nature of progress of fire within the building/premises, they can plan their action and movement accordingly. In this paper we have proposed a scheme for planning of fire fighting that will help the firefighters to extinguish the fire more effectively.

Frye, Lisa M. Wireless sensor networks: learning and teaching. Proceedings of the 8th ACM SIGITE conference on Information technology education ACM New York, NY, USA ©2007. DOI: 10.1145/1324302.1324360. 2007.
Abstract: There have been many response deficiencies cited regarding a fire department's ability to fight a structure fire. The attacks on the World Trade Center on 9/11 highlighted many of these problems and demanded the attention of the world. Wireless Sensor Networks (WSN) can benefit fire fighters as they bravely enter a structure fire. WSNs are networks consisting of many small sensors or nodes. The sensors can monitor a variety of data, such as the environment, movement and patient health readings. There has been much research completed in the area of WSNs but most of this research is proven via simulations with little actual experimentation or deployment of devices. Wireless sensor networks is an exciting and a new area of research; it has captured the interest of many researchers. The intrigue easily attracts the attention of students as well. With the help of various students, a wireless sensor network will be deployed in a fire training center to test a deployment in a structure. The primary measurement will be the performance of the sensors and the sensor network. Several students have been utilized to assist in writing the necessary programs, and more will continue to contribute to the project. This project will maintain research in utilizing WSNs in a fire fighting scenario and will continue to employ students to get them excited about learning and research.

Moohyun Cha; Jaikyung Lee; Byungil Choi. Fire training and evaluation through the scientific visualization of fire phenomena. VRCAI '10 Proceedings of the 9th ACM SIGGRAPH Conference on Virtual-Reality Continuum and its Applications in Industry ACM New York, NY, USA ©2010. DOI: 10.1145/1900179.1900224. 2010.
Abstract: Virtual reality based fire training enables the provision of emergency response training through a computer-created fire environment. Because the accuracy of fire behavior can play a very important role in the training and evaluation process, we can utilize a specialized numeric solver to generate fire dynamics data, and apply scientific visualization techniques to effectively display these data in 3D. With the exception of volume rendering, typical scientific visualization methods pose an obstacle for people to understand and experience fire behavior in an intuitive manner in the virtual reality environment. We present an approach that enables the use of scientific visualization for fire training and evaluation through the real-time volume rendering of various physical quantities in fire dynamics. We found that this enabled users to easily grasp the useful information of a fire, as well as to evaluate safety achievement during training activities.

Other Relevant References

Boosman, Martijn. Dynamic virtual reality training - at a realistic cost. Fire International, no188 (Aug 2001) p20-21. 2001.
Abstract: Describes the virtual reality software package DiaboloVR designed by E-Semble as a training package for emergency personnel, including firefighters, police and ambulance. The company has worked with emergency personnel to develop this low cost training tool which can simulate an unlimited number of incidents and emergency scenarios. Instructors can choose to customize scenarios. The responses of the trainees are recorded throughout the session and a statistical feedback function is under development and soon to be realised.

Pope, Nick Coley, Gary Davies, Garry Molloy. A dynamic approach to safety; Realistic fire training. Fire Prevention, no356 (May 2002), p33-36 + no364 (Jan 2003) p12-13; Fire Engineers Journal, no356 (May 2002), p33-36 + no364 (Jan 2003) p12-13. 2003.
Abstract: Describes the use of computer simulations to model the behaviour of fire and smoke to discover what was wrong with a flashover training simulator. Discusses the methods of fire modelling using computational fluid dynamics. Also describes the flashover training simulator and its problems with insufficient airflow. + Instructors from the UK Fire Service College criticises the conclusions of author Nick Pope and clarify some inaccuracies in his article.

Tate, D.L.; Sibert, L.; King, T.. Using virtual environments to train firefighters. Computer Graphics and Applications, IEEE , vol.17, no.6, pp.23-29, Nov/Dec 1997. DOI: 10.1109/38.626965. 1997.
http://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=626965&isnumber=13642
Abstract: Using virtual environments for training and mission rehearsal gives US Navy firefighters an edge in fighting real fires. A test run on the ex-USS Shadwell measured the improvement. The results suggest that virtual environments serve effectively for training and mission rehearsal for shipboard firefighting. VE training provides a flexible environment where a firefighter can not only learn an unfamiliar part of the ship, but also practice tactics and procedures for fighting a fire by interacting with simulated smoke and fire without risking lives or property. These tests proved a successful first step in developing a new training technology for shipboard firefighting based on immersive virtual environments. The tests also indicated potential areas for improvement, requiring additional research. User interaction techniques for manipulating objects in VEs need further study, along with usability studies to determine their effectiveness or utility. Other areas that could enhance VE training systems include more natural and intuitive I/O devices such as 3D sound, speech and natural language input, integrated multimedia and hypermedia instruction, and multi user interaction

A5.28 COMMAND AND CONTROL SIMULATORS (SOFTWARE ONLY)

References Cited in Report

Julien, Tazama U. St.; Chris D. Shaw. Firefighter command training virtual environment. Proceedings of the 2003 conference on Diversity in computing ACM New York, NY, USA 2003. DOI: 10.1145/948542.948549. 2003.
Abstract: The Firefighter Command Training Virtual Environment is being developed at Georgia Tech in collaboration with the Atlanta Fire Department. The VE allows the user to: navigate around the environment, viewing a house on fire from any angle; command firefighters and watch them execute those commands; and see realistic fire and smoke

behavior reacting to changes in the environment. The VE user is a commanding officer trainee who instructs teams of virtual firefighters to perform different actions to help put out virtual fires. The correct sequence of commands will successfully extinguish the flame with the least amount of danger to the firefighters and the least amount of damage to the home. This simulation was developed using the Simple Virtual Environment (SVE) library, an extensible framework for building VE applications. This is the first example of a firefighter training environment that combines representations of animated firefighters with a reasonable simulation and animation of smoke and fire.
See also: http://www.cc.gatech.edu/vwlab/projects.html.

Other Relevant References

Davenport, Thomas H. How to design smart business experiments. Harvard Business Review, v87 no2 (Feb 2009) p68-76. 2009.
Abstract: The author believes the best way to support decision making on potential innovations is to design a valid experiment, act on the facts, and make testing a normal part of the organisation's training and infrastructure. Refers to readily available software that will enable non-experts in statistics to oversee rigorous experiments and analyse results. Encourages leaders to adopt a 'test and learn' culture so that costly mistakes are avoided. US-influenced.

Su Lin, H Chuanping, Q Xinggui, Shanghai Fire Research Institute, PR China. Research on numerical simulation comparing with experiments for water mist fire-extinguishing process of oil pan fire in large space. Interflam 2007 Proceedings, Interscience Communications Ltd, London. 2007.
Abstract: In this paper, we use simulation software for fire dynamics---FDS (Fire Dynamics Simulator) to simulate the fire-extinguishing process for oil pan fire of water mist system in large space. For water mist whose particle size is much smaller than water spraying, we use two kinds of fire-extinguishing calculation models to carry out the numerical simulation of the water mist fire-extinguishing process for oil pan fire and compare it with the physical experimental results with the purpose of analyzing the effectiveness and accuracy of the numerical simulation of the fire-extinguishing process with water mist system.

A5.29 INTERACTIVE VIRTUAL REALITY FIREFIGHTING SIMULATORS (SOFTWARE ONLY)

References Cited in Report

Hongqing Zhu; Bingwen Zhao; Yongchao Wang; Minbo Zhang. Mine Fire Simulation and Virtual Reality Technology Study. Software Engineerings, 2010 Second World Congress on , vol.1, no., pp.148-151. DOI: 10.1109/WCSE.2010.58. 2010.
http://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=5718283&isnumber=5718248
Abstract: Coal mine fire simulation system can reproduce the mine scenes, and achieve particle and numerical simulation of underground fire process of beginning, spreading and destroying. It has a significant meaning for the coal mine fire control, the effects analysis of disaster relief technical and disaster reproduce in the safety training. The MultiGen Creator software has been adopted by this system as the primary modeling tool, Vega Prime API as a simulation programming language, the Visual C + +.NET of Microsoft corporation as system software development platform, coupling numerical simulation and graphics rendering technology, and two types of smoke simulation have been applied. Fire scenes reproduction, rapid development simulation and smoke numerical simulation shows in the particular circumstances have been achieved by this system. It also contributes to scientifically forecasting the disaster evolution and analyzing the fire damage effects and scope under different conditions, and provides intuitive support for the accident investigation, disaster reproduction, and emergency decision.

Maxwel, Douglas. Simulators for training firefighters. Linux Journal archive Volume 2004 Issue 122, June 2004. 2004.
Abstract: Fewer real fires means we need more fake fires for training. Behind the scenes at a Navy/New York Fire Department simulator. Tan Desney, S; Darren Gergle; Peter Scupelli; Randy Pausch. Physically large displays improve performance on spatial tasks. ACM Transactions on Computer-Human Interaction (TOCHI) TOCHI Homepage archive Volume 13 Issue 1, March 2006 ACM New York, NY, USA. 10.1145/1143518.1143521. 2006.
Abstract: Large wall-sized displays are becoming prevalent. Although researchers have articulated qualitative benefits of group work on large displays, little work has been done to quantify the benefits for individual users. In this article we present four experiments comparing the performance of users working on a large projected wall display to that of users working on a standard desktop monitor. In these experiments, we held the visual angle constant by adjusting the viewing distance to each of the displays. Results from the first two experiments suggest that physically large displays,

even when viewed at identical visual angles as smaller ones, help users perform better on mental rotation tasks. We show through the experiments how these results may be attributed, at least in part, to large displays immersing users within the problem space and biasing them into using more efficient cognitive strategies. In the latter two experiments, we extend these results, showing the presence of these effects with more complex tasks, such as 3D navigation and mental map formation and memory. Results further show that the effects of physical display size are independent of other factors that may induce immersion, such as interactivity and mental aids within the virtual environments. We conclude with a general discussion of the findings and possibilities for future work.

Zhang, Guilli. The Design and Development of Fire Edutainment Software and its Application Research. Information Technology and Applications), 2010 International Forum on , vol.3, no., pp.57-60. DOI: 10.1109/IFITA.2010.298. 2010.
http://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=5634721&isnumber=5634634
Abstract: During fire education, because of the particularity of the fire scene, learners are difficult to truly grasp and apply the relevant knowledge. This study which selecting the fire of knowledge as the main content, and making the teenagers as the target public, use of game engine to develop game-based educational software. It is difficult to present the fire scene in real life. But the technology of 3D and simulation can reproduce the scene possible, making the exposure to fire-fighting visually. The learners can better grasp the fire-fighting skills in a more real scene. Game-based learning software saves costs and points out the direction of future educational software. The software has been small-scale trials carried out among young people to verify the balance of teaching and entertaining in the game-based learning software.

Other Relevant References

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Abstract: Discusses the latest technological developments in simulation training in the area of large-scale incidents involving mass-casualty, CBRN, and terrorism.

McLennan, Jim; Pavlou, Olga Klein; Philip Omodei, Mary. Using video during training to enhance learning of emergency incident command and control skills. Australian Journal of Emergency Management, v20 no3 (Aug 2005) p10-14. 2005.
Abstract: Discusses training issues for Australian emergency services in the areas of incident command and control skills. Describes the use of head-mounted video equipment by fire officers to aid with reflective self-appraisal during incident command training simulation exercises.

Wu, Zhaohui; Zhou, Zhong; Wu, Wei. Realistic Fire Simulation: A Survey. Computer-Aided Design and Computer Graphics, 2011 12th International Conference on, pp.333-340. DOI: 10.1109/CAD/Graphics.2011.26. 2011.
http://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=6062811&isnumber=6062747
Abstract: As fire is one of the basic elements of nature, realistic fire simulation plays a significant role in fire control, film special effects, military emulation, and virtual reality. Fire simulation has been being an eternal theme in the field of computer graphics, because of the anisotropic shape and complex physical mechanism of the fire. This paper presents a survey on the development of flame simulation, with a detailed introduction to the different kinds of methods applied in the field. The methods can be classified into several different kind, mainly include texture mapping method, particle system method, mathematical physics-based method, cellular automation method, image based tomographic reconstruction, and other methods. This paper analyzes the performance of different methods from real-time, reality, spatio-temporal complexity, edit ability, and interactivity. Finally, in connection with issues in the present research and possible future direction of development, the paper puts forth a number of theoretical and technical problems, hoping they can be resolved in the future.

Xiuting Gao; Xiaohu Ma. Simulation of fire based on improved particle system and texture rendering. Image Analysis and Signal Processing , 2010 International Conference on , pp.587-590. DOI: 10.1109/IASP.2010.5476049. 2010.
http://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=5476049&isnumber=5476039
Abstract: The simulation of the irregular objects is a difficult and attractive problem in computer graphics. Flame simulation is of a great challenge because of the variability of the shape of fire. A new method of flame simulation based on the improved particle system and texture rendering is proposed in this paper. This model is introduced to study structured particle and the performance of the random process of wind. It can generate flames with different details. To reduce the number of the particles in the calculation process, we use the multi-texture technology. This overcomes the defects of large calculation scale for particle system. Experimental results show that the proposed method can meet the requirements of real time and reality.

A5.30 OTHER TRAINING

Other Relevant References

Attewell, Alex. Participation of New Zealand Fire Service volunteer firefighters in a Training and Progression System. New Zealand Fire Service 2009.
Abstract: In 2007 Alex Attewell surveyed 24 volunteer brigades for their views on the Training and Progression System (TAPS). TAPS was introduced in 2004 for volunteers, and a revised version for career firefighters was implemented in 2007. This survey found that volunteers were generally satisfied with both the content and delivery of the programme. There are some suggestions for improvement. These include the importance of a blended learning approach that would involve a variety of delivery methods, scaffolding of the knowledge required at each rank, and to improve training materials with less text and more diagrams and images. This is a report produced by the author as part of his Massey University course.

Baran, Benjamin; Scott, Cliff. Organising Ambiguity: A grounded theory of leadership and sense making within dangerous contexts. Military Psychology, Vol.22. 2010.
Abstract: Leaders in high-reliability organizational contexts such as firefighting, emergency medicine, and law enforcement often face the challenge of making sense of environments that are dangerous, highly ambiguous, and rapidly changing. Most leadership research, however, has focused on more stable conditions. This study analyzed 100 reports of "near-miss" situations in which firefighters narrowly escape d injury or death, drawing upon sensemaking and high-reliability organizational theories to provide a grounded theory of leadership processes within extreme events. Themes related to direction setting , knowledge, talk, role acting, role modeling, trust, situational awareness, and agility were key categories. Further abstraction of the data revealed the higher-order categories of framing, heedful interrelating, and adjusting as key characteristics of the overall social process of leadership within dangerous contexts, labeled organizing ambiguity. These findings highlight leadership as a collective sensemaking process in which ambiguity is reduced and resilience promoted in the face of danger via interaction among and between leaders and followers.

Catherwood, Di; Sallis, Geoff; Edgar, Graham; Medley, Andrew. Understanding fireground 'situation awareness'. Fire, v103 no1333 (Jan 2011) p27-29. 2011.
Abstract: New research findings elaborate on how errors in decision-making can occur in stressful and changeable situations. Of interest is how the fireground is 'scoped' - that is, whether people work from a broad span of information or focus on a small part of the available data. Discusses how these findings can support fireground training.

Fleming, Gary. Compartment firefighting: carbonaceous or LPG systems. Fire and Rescue (UK), no79 (3rd quarter 2010) p34-35. 2010.
Abstract: Author weighs the pros and cons of two primary systems for simulated compartment fire training in the UK. The two systems generally deployed tend to be carbonaceous (wood based) or LPG (gas based). Comments on their environmental impact, training that focuses on skills, and safety measures for firefighters.

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Abstract: Non-technical skills are the cognitive and social skills required for efficient and safe operations, often termed Crew Resource Management (CRM) skills. Borrowing from high-risk work settings such as aviation, the military, health care and firefighting, this book examines how these skills contribute to safety. The skills are situation awareness, decision-making, communication, teamwork, leadership, managing stress, and coping with fatigue. Includes chapters on both training for, and assessing these skills.

Fredholm, Lars; Göransson, Anna-Lena. Emergency response management in today's complex society. Swedish Civil Contingencies Agency. 2010.
Abstract: This collection of readings looks at how the command of emergency response operations can be improved in an increasingly complex global society. The editors describe society as a socio-technical system, which emphasises relationships between people, and between people and technical/physical environments. Since the end of the cold war, society has become more complex, and there are different societal risks. They note increased collaboration by response agencies, both nationally and internationally. In this context, the book covers many aspects of emergency response management, including incident command, human behaviour, leadership, and command support. The intention of this book is to stimulate reflection by leaders and managers in emergency response agencies.

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Abstract: Examines how incident commanders make decisions while under stress. Determines that the conventional decision-making process is not suitable for emergency incidents. Instead recommends the recognition-primed decision-making process as this is more flexible. Identifies three levels of situational awareness and discusses how incident officers perform different actions at each level. US-influenced.

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Abstract: Examines the dangers that vehicle fires represent for responding firefighters in view of developments in automotive technology. Identifies examples of possible hazards to firefighters such as: the possibility that compressed-gas lifting struts and bumper struts would shoot out and injure firefighters; air bag inflators could blow out through the car roofs and burst into shrapnel; and plastic fuel tanks may melt and spill hot gasoline on the feet of firefighters. US-influenced.

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http://www.frsito.org.nz/newsletters/frsito_reports.html
Abstract: This report presents NZIER?s findings from the first stage of a study into volunteer-related training in emergency services. The study has been commissioned by FRSITO, is a collaborative venture between FRSITO and other industry training organisations (ITOs) which cover emergency services, and is part-funded by the Tertiary Education Commission.

Pells, Sharon. Volunteer-related training in emergency services: improving training outcomes findings from qualitative research. report to FRSITO. NZIER. 2008.
http://www.frsito.org.nz/newsletters/frsito_reports.html
Abstract: This report presents NZIER?s findings from the second (and final) stage of a study into volunteer-related training in emergency services. The study has been commissioned by FRSITO, is a collaborative venture between FRSITO and other industry training organisations (ITOs) which cover emergency services, and is part-funded by the Tertiary Education Commission. The study identifies three broad motivations for volunteering in general. The consumption motivation is concerned with the current satisfaction received by the volunteer from the act of volunteering. The investment motivation is when the individual invests volunteer hours out of current available leisure for future rewards (primarily in the labour market). The public goods/altruism motivation is a genuine selfless act for the benefit of others. The report goes on to look at the implications that these three strands of motivation have on the delivery and uptake of training.

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Stanley, Peter. Seven steps to incident command. Fire, v102 no1324 (Feb 2010) p16-18. 2010.
Abstract: Introduction to the 'Seven Steps' command methodology that offers a practical approach to forming good command habits for fire incident commanders. UK-influenced.

A5.31 TECHNIQUES FOR THE CONTAINMENT/REMOVAL OF FIREFIGHTING WATER RUN-OFF

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Abstract: The present study examines the relationship of automatic fire sprinkler technology to environmental sustainability. Large-scale fire tests were conducted using identically constructed and furnished residential living rooms. In one test, fire extinguishment was achieved solely by fire service intervention, and in the other, a single residential automatic fire sprinkler was used to control the fire until final extinguishment was achieved by the fire service. Comparisons of the total greenhouse gas production, quantity of water required to extinguish the fire, quality of water runoff, potential impact of wastewater runoff on groundwater and surface water, and mass of materials requiring disposal between the two tests were made. The results show that in addition to providing life safety and limiting property damage, the use of automatic fire sprinklers is a key factor in achieving sustainability.

Marlair, Guy . Margaret Simonson and Richard G. Gann. Environmental concerns of fires : facts, figures, questions and new challenges for the future. Interflam 2004 Proceedings, Interscience Communications Ltd, London. 2004.
Abstract: The effect of fires on the environment has been increasingly in the public eye since the chemical warehouse accident in the Sandoz facility in Schweizerhalle in November 1986. This paper presents a discussion of this accident together with a representative sample of other environmentally important case studies related to fires. Modes of interaction with the environment and potential transfer mechanisms are discussed. The impact of fire effluents in both the short and long terms and activities on the quantification of the environmental effect of fires are also presented. Some of the current environmental debates that are interacting with fire prevention and fire firefighting techniques are also discussed, outlining challenging remaining issues. Finally, insight on international action in response to these incidents and related standardisation activities under progress is presented.

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http://www.hemmingfire.com/news/fullstory.php/aid/671/Martial_Pabon,_PhD:_Design_of_a_Mobile_Post-treatment_Unit_for_Water_Used_During_Fire_Extinguishment_Operations.html

A5.32 USE OF LOW CONCENTRATION FOAMING AGENTS FOR CLASS B FIRES

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Cortina, Tom. Environmental impact of foam. Fire Safety Engineering, v15 no3 (Apr 2008) p33-35. 2008.
Abstract: Examines the different types of foams and systems available for extinguishing and suppressing fuel pool fires. Compares their 'green' credentials and their environmental impact.

Klein, Roger A.. New foam labeling system: foam for ARFF operations: why we need the environmental impact system and qualified products list.(aviation rescue and fire fighting. Fire and Rescue (March 2011): p24(4). 2011.

Klein, Roger. Training with foam--a cost-benefit analysis: the chemical makeup and intended operational usage of firefighting foam dictate the types of training foams used by fire brigades. Fire and Rescue (May 2009): p20(3). 2009.

Tom Cortina. Can firefighting foam be "eco-friendly"?. Fire and Rescue (Nov 2010): p29(1). 2010.

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http://www.nfpa.org/assets/files/PDF/Proceedings/SUPDET11WilliamsPaper.pdf
Abstract: The fire extinguishment and burnback performance of three foams were tested on four low flash point fuels: gasoline, commercial grade heptane, iso-octane (2,2,4-trimethylpentane), and methylcyclohexane. The final three fuels have flash points in a range between -9°C and -4°C, compared to gasoline which has a typical flash point of -40°C. Gasoline and heptane represent, respectively, the current and the possible future fuels for the MilSpec qualification test for AFFF. Iso-octane and methylcyclohexane were chosen because they have similar flash points but different surface tensions; AFFFs have difficulty forming film on iso-octane but can easily form film on methylcyclohexane. We observed that the AFFFs had diminished fire extinguishment performance with fire extinction times of 5 to 12 seconds longer in cases where they could not form film. The non-fluorinated foam performed as good as or better than the AFFFs on iso-octane. Significant differences were found between fuels in burnback performance (the time for fire to spread across a

foam-covered pool). These fuel differences in burnback were consistent for all three foams studied, and did not correlate with fuel flash point or film formation. Other properties of the fuels, and their interaction with foam components, must be responsible for the differences in fire suppression performance. The rate of fuel passage through the foam layer measured in laboratory studies correlates with burnback performance.

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Schaefer, Ted H.; Dlugogorski, Bogdan Z.; Kennedy, Eric M.. Protecting the environment while optimising the performance. Fire Australia, Spring 2008, p48-51. 2008.
Abstract: Discusses the latest developments in firefighting foam technologies. Highlights environmental concerns regarding its use and looks at what manufacturers are doing to reduce emissions and bio-accumulations.

Willson, Mike. Fluorotelomer based foams - are they safe for continued use?. 2010.
Abstract: Summarises key findings from a recent study into fluorotelomer-based firefighting foams. Explores the relative merits of modern fluorine free foams, the envrionmental impacts of foam types, firefighter safety, and waste treatment issues.

A5.33 USE OF LOW CONCENTRATION FOAMING AGENTS FOR CLASS A FIRES

References Cited in Report

Brooks, Neal. Break Out the Bubbly. Fire Chief (Oct 1, 2010). 2010.
Abstract: Without question, the use of Class A foam has become more popular, given its advantages in knockdown time, firefighter safety and environmental impact compared with untreated water. [..] the department must have a working knowledge of fuel classifications and the correct foam for that usage.

Carringer, Rod. Foam factors. Fire Chief, v53 no3 (Mar 2009) p70-74. 2009.
Abstract: Addresses several common misconceptions about firefighting foam and its application. US-influenced.

Cavette, Chris. A new look at foam. Fire Chief, v52 no3 (Mar 2008) p82-84. 2008.
Abstract: Discusses recent changes in foam concentrates, flammable liquid hazards and foam proportioning systems that have altered foam firefighting. Comments on their effectiveness against ethanol-blended fuels for motor vehicles. US-influenced.

Kalabokidis, K.D. Effects of wildfire suppression chemicals on people and the environment – a review. Global Nest: The International Journal 2(2):129-137. 2000.
http://www.gnest.org/journal/vol2_no2/01_kalabokidis.pdf
Abstract: Fire agencies worldwide apply millions of gallons of fire suppression chemicals on a broad array of ecosystems. These chemicals are considered to have minimal effects on the health of people who might be exposed to them. Only incidents of skin and eye irritation have been reported as a result of prolonged fire retardant and firefighting foam contact. Fire suppression chemicals have minor toxicological or ecological effects and, as a result, do not generally harm terrestrial ecosystems. Major impacts, suppression chemicals have on the environment, may be through the adverse effects on water quality, and subsequently to aquatic ecosystems. Retardants may encourage eutrophication and, in some cases, contribute to fish kill when applied on watersheds, or if accidentally applied directly to water bodies. Foams are generally more toxic than retardants to aquatic biota, but they are applied in much smaller quantities. Application of retardants increases the total amount of smoke and airborne particulate produced, but air

quality implications are minimal since additional smoke emission by the retardant is insignificant compared to the major output by the wildfire. Recommendations are offered for mitigation of potential human health and environmental impacts from the use of fire suppression chemicals, nevertheless, risks must be assessed on a site-by-site basis

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Klassen, Keith. All about 'A'. Fire Rescue, v28 no2 (Feb 2010) p122-123. 2010.
Abstract: Reviews specific safety measures when using class A foam in firefighting operations, especially in rural firefighting. US-influenced.

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Abstract: Fluorosurfactant firefighting foams are environmentally persistent, with degradation products now existing in the air and water. Explains how the management of these foams is essential to minimising environmental risk.

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OTHER ENVIRONMENTAL

Other Relevant References

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Abstract: Discusses several 'daylighting' features on sustainable ('green') buildings encountered during fire operations and inspections. Cites several innovative design concepts, new construction practices and efficient illumination devices ideal for green building construction. Identifies several design concerns for fire chiefs and fire protection engineers, such as atria and sawtooth roofs. US-influenced.

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VOLUNTEERING

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Abstract: Annotated bibliography listing abstracts of articles, reports, and conference proceedings about volunteer-based fire services and recruitment and retention of volunteers from non-English speaking and culturally diverse backgrounds. Looks at both fire service and general volunteering by people from NESB and CALD backgrounds, and NESB and CALD minorities in the career emergency services, defence and policing. Also focuses on these groups' attitudes and knowledge on fire safety and risk .

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Abstract: Western Australian Government project for the International Year of Volunteers, 2001. Explores the current views and aspirations of Baby Boomers and the ways, and extent to which they may volunteer in the future.

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Abstract: Brief summary of four key priority areas for the reform of volunteers and their organisations which were identified at the 2005 Emergency Management Volunteers Summit in Australia. The issues covered legal protection, funding, recognition, incentives, retention and training. Highlights areas of concern such as increasing competition for volunteers' time, rural decline, and changing demographics in rural and regional areas. See Document 25744 for the full report.

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Abstract: Commissioned by Emergency Management Australia (EMA), this report is based on findings from a national survey of volunteers in the emergency sector. It profiles the volunteers who responded in terms of age, gender, income, motivations, and factors inhibiting volunteering. Frequency of activation, and training are also discussed, with a major focus on the costs of volunteering. It concludes with some strategies for offsetting volunteer costs.

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Abstract: Considers how the different settings, within which voluntary welfare associations are organised, can act to facilitate or constrain the development of active citizenship. Points out that governments are making increasing efforts to promote volunteering, while on the other hand, the drive to professionalism and regulatory procedures may be actively discouraging volunteerism. Focuses on the tensions voluntary associations face between organisational growth and restructuring in order to provide good quality services on one hand, and the positive engagement with volunteers and empowerment of local people on the other.

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http://www.ocvs.govt.nz/work-programme/encouraging-participation/volunteering-research/mahiaroha.html
Abstract: This research identifies motivators and cultural drivers for Maori, which contribute to maintaining mana for the whanau, hapu- and iwi. This research indicates that Maori volunteering is based significantly on the notion of whanaungatanga (kinship). Mahi aroha is the term that most closely translates to the concept of voluntary work. The report notes the different world view that Maori have, the complex motivations for mahi aroha, and the range and depth of commitment Maori have to unpaid work. For many Maori, mahi aroha carried out for the benefit of whanau, hap□ and iwi is often seen as an essential part of fulfilling their cultural obligations to the wider collective. It is also central to their own sense of identity and for maintaining their culture and traditions. Maori language and culture, incorporating principles of tikanga, mana, manaaki and whanaungatanga, provide a rich framework for understanding Maori perspectives on and motivations for undertaking mahi aroha.

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Pells, Sharon. Volunteer-related training in emergency services- improving training outcomes. Findings from qualitative research. NZIER 2008.

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http://www.fire.org.nz/Research/Publishsed-Reports/Pages/DescribingtheValueoftheContributionfromtheVolunteerFireBrigade.aspx
Abstract: This research examines the economic and social value of volunteer fire brigades in small remote communities in New Zealand. Based on desk research, a survey and interviews, the paper demonstrates three key reasons that volunteer fire brigades (VFBs) contribute to the ongoing sustainability of small remote towns. Firstly, a VFB provides security and protection for the property and person of residents in these areas by substantially reducing response times to fire, medical and accident emergencies. The economic valuation of this benefit is conservatively estimated at $79 million annually. Secondly, the research describes how these brigades contribute to social cohesion and act as the social glue for retaining the community identity and spirit. Thirdly, participating in a brigade assists in sustaining the quality of life for volunteers and their families by providing social opportunities and personal intrinsic value.

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http://www.victoria.ac.nz/fca/research-services/documents/managers-matter-full-report.pdf
Abstract: This survey fills a gap identified by Volunteering New Zealand, and helps identify training needs and career paths of volunteer managers. In partnership with Volunteering New Zealand, Victoria University of Wellington undertook a nationwide survey of volunteer managers between December 2009 and February 2010. Over 800 individuals participated from a diverse range of sectors. Section 2 of the report presents a profile of those managing volunteers and the organisations for which they work. Sect ion 3 looks at the roles they perform, their paid or unpaid employment status, wages and salaries, and individuals? previous experiences in volunteer management. Section 4 considers what work is like for managers; including job satisfaction, volunteer management challenges, and the support they receive from their organisation. Section 5 provides an analysis of training needs, and section 6 looks ahead at respondents? future career plans. The final section (7) draws out the key conclusions from the research.

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Abstract: Describes issues surrounding volunteering in emergency services. Discusses the enormous contribution that volunteers make to emergency services, and looks in particular at the Country Fire Service and the State Emergency Service of South Australia. Discusses the relatively new issues of management and effective and efficient use of volunteer personnel in emergency services, including management of services, administration of services and support for volunteers, and describes the role s of the Volunteer Support Officer in South Australia. Concludes with a discussion of recruitment issues.

Tamasese, Taimalieutu; Kiwi Parsons; Tafaoimalo Loudeen; Sullivan, Ginny; Waldegrave, Charles. A qualitative study into Pacific perspectives of cultural obligations and volunteering: a research project carried out by the Pacific Section and the The Family Centre Social Policy Research Unit. 2010.
http://www.familycentre.org.nz/Publications/index.html
Abstract: This research aims to explore the concepts of cultural obligation, volunteering and unpaid work amongst Pacific people living in New Zealand. It looks at definition(s) of ?volunteering?, which is not a concept used by Pacific people. There are however, traditional cultural activities that are closely associated with concepts of caring, service, and support for the community. There is an absence of literature and research which compares the practice of volunteering with fulfilment of cultural obligation. It was therefore decided to carry out research into the concepts of cultural obligation, unpaid work and volunteering amongst Pacific people living in New Zealand, first of all, by completing a literature review; secondly, by conducting research amongst Pacific groups within New Zealand through case studies of six projects of pride, and analysing people's contributions and motivation; and thirdly, by inviting people to take part in Faafaletui of focus groups in order to deepen discussion and understanding of it

Volunteering Australia. National survey of volunteering issues. 2009.
http://www.volunteeringaustralia.org/files/CFBMHJNYX5/FINAL_National_Survey_of_Volunteering_Issues.pdf
Abstract: This survey has been running since 2006. It is a general survey across all sectors, but does include a significant number of emergency services respondents. It has used a consistent line of questioning, so that trends and changes can be tracked since the first survey. Some of these include: a lack of public policy involvement in volunteering issues; organisations struggling to retaining volunteers; volunteers? continued commitment; and volunteering as a way of increasing the health, wellbeing

Wilson, Carla. The changing face of social service volunteering: A literature review. Ministry of Social Development, 2001.
Abstract: Reviews the changing nature of social service volunteering by looking at New Zealand and overseas. Looks at the impact of contracting in the social service sector, and economic, demographic and social changes which may affect the level of such volunteering in New Zealand.

McDERMOTT MILLER Strategies™

New Zealand Fire Service

Impact of Emerging Social Change and Technological Developments on Fire Service Operations

Annex B: Survey of Area Managers

McDermott Miller Limited

20 March 2011

ANNEX B TABLE OF CONTENTS

McDermott Miller Limited, Strategic Planning Consultants
CPO PO Box 629 Wellington New Zealand
2nd Floor 90 The Terrace Wellington
Telephone (04) 471-8500
Email strategies@mcdermottmiller.co.nz
www.mcdermottmiller.co.nz

LIST OF EXHIBITS

B1. SURVEY PURPOSE, OUTLINE AND SPECFICATIONS

B1.1 SURVEY PURPOSE

This survey is part of the research project *Impact of Emerging Social Change and Technological Developments on Fire Service Operation* which McDermott Miller were commissioned to undertake by New Zealand Fire Service Commission, under the Contestable Research Fund (2010/11 round). Discussion on the scope of research and methodology is presented in Section 1 of the main report.

In the research proposal, McDermott Miller undertook to

4.1 Consult with NZFS managers and executive officers on perceived problems with, and limitations of, existing technologies used to obtain information about structures before and during rescue and fire fighting operations.

4.2 Extend the face to face and telephone consultation with an email survey of a wider range of national and fire region managers and officers. The list of those to include in the survey will be agreed with the National Director Fire Risk Management.

This present volume is the report on this email survey.

B1.2 SCOPE OF SURVEY

The original intention of was the email survey would focus on operation technologies; McDermott Miller raised the possibility of broadening the survey to ask respondent's views on social changes affecting fire risks, but the panel of NZFS managers advising on the research confirmed that the survey should focus on technological matters only.

The panel also advised that the survey population should be assistant area managers and area managers. Accordingly, the Principal Risk & Project Advisor, National Community Safety Group provided us with contact details for 69 of these managers; this list formed the sample frame for the survey.

B1.3 OUTLINE OF QUESTIONNAIRE AND THIS ANNEX

There are two sections to the questionnaire:

- The purpose of the first section is gauge managers' views on the priorities the potential benefits of new technologies. These benefits are as follows:
  - Reduce response time
  - Provide more intelligence to comcen operator
  - Provide more intelligence more quickly to OIC

- Improve command and control at incident
- Help firefighters perform fire operations more safely and effectively
- Help firefighters perform rescue operations more safely and effectively
- Easier and more effective training
- Manage demands on volunteers
- Easier and more effective post-incident reviews
- Reducing environmental pollution from firefighting

Respondents indicated the importance of these ten benefits by allocating points across them so that the total of all numbers in the left hand column adds to 100. An open-ended question gave respondents the opportunity to add comments.

- Analysis of the first section of the questionnaire is presented in **Section 2: Prioritising Benefits** of this Annex.
- In the second section, respondents were presented with screens on each of the above benefits in turn. On each screen was a list of technologies which could provide the benefits. Respondents were able to add to this list presented to them. Each technology was then **Table 5.2** of the main report extracts the technologies from the tables in Section 3 above with indices in the "Overall Weighted Index" columns of these tables, and rank the technologies in descending order of this index, labelled the "Area Manager's Survey Index.
- prioritised as "High", "Medium" or "Low" (Don't Know and N/A responses were also available). An open-ended comments question was also provided on each screen.
- Analysis of the second section of the questionnaire is presented in **Section 3: Rating Technologies** of this Annex. The method for rating technologies is discussed at the beginning of this Section B3.

B1.4 SURVEY SPECIFICATIONS

The **Sample Universe** for the online survey of NZFS managers was NZFS managers identified by the National Community Safety Group as relevant to the research project. A **Sample Size** of 42 interviews was obtained following a 61% response rate.

The **Data Collection Methodology** was online interviews. The Survey was conducted by McDermott Miller Limited.

Quality Control was assured by close management of field administrators by a Senior Consultant.

The survey was conducted from 2-22 August, 2011. An e-mail survey invitation was sent to the sample universe. An email reminder was sent on 9 August to all manager's who had not yet completed the survey. No incentives were offered.

The **Margin for error** for the online survey of NZFS Managers survey is a maximum of plus or minus 15.1% at a 95% level of confidence.

B2. PRIORITISING BENEFITS

B2.1 INTRODUCTION

The purpose of the first section of the survey is gauge managers' views on the priorities the potential benefits of new technologies. These benefits are as follows:

- Reduce response time
- Provide more intelligence to comcen operator
- Provide more intelligence more quickly to OIC
- Improve command and control at incident
- Help firefighters perform fire operations more safely and effectively
- Help firefighters perform rescue operations more safely and effectively
- Easier and more effective training
- Manage demands on volunteers
- Easier and more effective post-incident reviews
- Reducing environmental pollution from firefighting

Respondents indicated the importance of these ten benefits by allocating points across them so that the total of all numbers in the left hand column adds to 100. An open-ended question gave respondents the opportunity to add comments.

B2.2 RESULTS

Table BB2.1 presents the results this prioritisation of potential benefits of new technologies. For example, 18 respondents allocated between 1 and 5 points inclusive to the benefit "Reduce Response Times"

Table BB2.1 Number of Respondents Allocating Points to Indicate Importance of Potential Benefits of New Technologies

	Points out of 100 allocated								
Potential Benefit of New Technology	**0**	**1-5**	**6-10**	**11-15**	**16-20**	**21-25**	**26-30**	**>31**	**Total**
Reduce response times	8	18	5	4	4	1	2		42
Provide more intelligence to comcen operator	5	18	11	5	3				42
Provide more intelligence more quickly to OIC	2	8	13	7	8	2	1	1	42
Improve command and control at incident	1	6	16	11	6			2	42
Help firefighters perform fire operations more safely and effectively	3	7	23	5	3		1		42
Help firefighters perform rescue operations more effectively	6	16	13	4	3				42
Easier and more effective training	3	8	21	4	3	1		2	42
Manage demands on volunteers	1	7	9	10	9	2	4		42
Easier and more effective post-incident reviews	8	22	9	2	1				42
Reducing environmental pollution from firefighting	9	17	8	3	4	1			42

Source: McDermott Miller Survey of Area Managers

In **Table BB2.2** ranks the responses summarised in **Table BB2.1** above.

- An initial ranking of the benefits is calculated using mean points allocated to each response. Under this measure:
  - "Manage demands on volunteers" is the highest ranked benefit, with a mean of 14.6 points; followed by
  - "Improve command and control at incident" with mean of 1B3.5 points;
  - "Provide more intelligence more quickly to OIC" with a mean of 13 points.
- Use of the mean to prioritise benefits could potentially give a prioritisation skewed by a few respondents allocating most of their points to a single benefit. We have therefore prioritised the benefits on the basis of median as well as mean responses; as shown in **Table BB2.2** the prioritisation is the same.

Table BB2.2 Mean and Median Importance Rating of Potential Benefits of New Technologies

Short Name	**Potential Benefit of New Technology**	**Mean %**	**Median**	**Rank**
Volunteer	Manage demands on volunteers	14.6	15	1
CommControl	Improve command and control at incident	13.5	10	2
Intel OIC	Provide more intelligence more quickly to OIC	13.0	10	3
Training	Easier and more effective training	11.8	10	4
FireOps	Help firefighters perform fire operations more safely and effectively	10.2	10	5
ReduceResp	Reduce response times	8.6	5	6
RescueOps	Help firefighters perform rescue operations more effectively	7.8	5	7
IntelComcen	Provide more intelligence to comcen operator	7.6	5	8
Environ	Reducing environmental pollution from firefighting	7.3	5	9
Review	Easier and more effective post-incident reviews	5.6	5	10
	Total	**100.0**		

Source: McDermott Miller Survey of Area Managers

B2.3 OPEN-ENDED RESPONSES

In this section we present the open-ended comments associated with each potential benefit. Tables are ordered in descending order of mean points allocated to their associated potential benefit.

Table BB2.3 Comments on Potential Benefit of New Technologies: Manage demands on volunteers

As 80% of our fire service is volunteers time needed to record all activities already restrictive
Demands on volunteers for not only response, but training, auditing, OSM, checks needs to be managed
More assistance and resources
Need to continue to make volunteering easier (especially CFO & DCFO admin management roles)
Quicker turnaround times to reduce volunteer time
So they only need respond the Volunteers that the call would require. Medics to Med calls etc.
Yes, reduce volunteer time commitment

Source: McDermott Miller Survey of Area Managers

Table BB2.4 Comments on Potential Benefit of New Technologies: Improve command and control at incident

Improve officership to more effectively engage with tactical requirements
Improve training
Information is power to act effectively with the "aim" readily at hand
relates to safety and better fire outcomes
Training & role playing more essential

Source: McDermott Miller Survey of Area Managers

Table BB2.5 Comments on Potential Benefit of New Technologies: Provide more intelligence more quickly to OIC

For safety advice first, for identifying value based priorities next
Improve data
Information is power to act effectively
Mapping and operational plans available electronically on appliances
PFA info maybe. the sate of the evacuation and exact location and spread. Smart sprinklers
Will enable more effective decision making which will directly impact on operational outcomes
Will improve analytical decision making

Source: McDermott Miller Survey of Area Managers

Table B2.6 Comments on Potential Benefit of New Technologies: Easier and more effective training

Improve training
Largest part of maintenance activity
safety
Technology to assist training is where we should put our effort. Computer based Distance learning
Training (even OSM) is taking up considerable time with volunteers
Training needs to be more effective without low-level repetitiveness.
Training of our staff in all aspect of their job far out weighs any other of these benefits

Source: McDermott Miller Survey of Area Managers

Table B2.7 Comments on Potential Benefit of New Technologies: Help firefighters perform fire operations more safely and effectively

As Above
Communications, Training and supervision are the keys to safety
Reduces injury, lost time and employment costs
Safety
Safety & health of fire fighters

Source: McDermott Miller Survey of Area Managers

Table B2.8 Comments on Potential Benefit of New Technologies: Reduce response times

Any gains would be minimal as the travel time component is pretty much a constant.
Early detection and suppression of fires contributes more than response times
Improve Volunteers recruitment
Response time is becoming less important with changing nature of work.
Technology can speed up the call processing time but not the distance from the station to incident

Source: McDermott Miller Survey of Area Managers

Table B2.9 Comments on Potential Benefit of New Technologies: Help firefighters perform rescue operations more effectively

As above
Rapid detection location and deployment will improve victim survival
Rare demand in fire situations
Rescues are time critical in most instances- seconds count..

Source: McDermott Miller Survey of Area Managers

Table B2.10 Comments on Potential Benefit of New Technologies: Provide more intelligence to comcen operator

Better communication
By providing more intelligence to comcen operators, dynamic resourcing decisions may be possible
Greater information to Comcen may provide better data to OIC and improve C&C
Information is power
Reduces the number of wrong address responses + more flexibility in response of resources
Will impact on response requirements

Source: McDermott Miller Survey of Area Managers

Table B2.11 Comments on Potential Benefit of New Technologies: Reducing environmental pollution from firefighting

An emerging and critical area for attention
Needs to be considered as part of contributing to resilient sustainable communities
Sustainable fire firefighting practices increasingly more important
Very important

Source: McDermott Miller Survey of Area Managers

Table B2.12 Comments on Potential Benefit of New Technologies: Easier and more effective post-incident reviews

Agreed
Essential to learning but not as higher priority
Learning form what we got wrong to futher develop our training is also valuable
Reviews can be more effective

Source: McDermott Miller Survey of Area Managers

B3. RATING TECHNOLOGIES

In the second section of the questionnaire respondents were presented with screens on each of the above benefits in turn. On each screen was a list of technologies which could provide the benefits. Respondents were able to add to this list presented to them. The potential of each technology to provide the benefits was then rated as "High", "Medium" or "Low" (Don't Know and N/A responses were also available). An open-ended comments question was also provided on each screen.

METHOD

Rating the potential of technologies to providing each benefit

- In **Table BB3.1** below for example, 29 respondents rated the technology *"Modelling/simulation to refine location of stations and/or resources"* as have "High" potential to achieve the benefit "reducing response times". This is 69% of the total of 42 respondents.
- We have made allowance for those rating a technology as "Medium" priority by applying a 25% weighting to those responding "Medium". For the above technology, this is 25% of 12 ie 3; adding this to the 29 rating "High" gives a score of 32, or 76% expressed in % terms.

Overall Rating of Technologies

The values "Weighted High/Medium %" columns in the tables below present a rating of each technology for providing the associated benefit. In order to derive overall priorities for all technologies ie across all the benefits, we apply the prioritisation of benefits in **Table B2.2** above as follows:

- Mean points allocated to "Reducing Response" times (**Table B2.2**) is 8.6
- Multiplying the values in the "Weighted High/Medium" column of **Table BB3.1** by 8.6 and dividing by 10 gives values in the "Overall Weighted Index" column ie 65.7 for the technology *"Modelling/simulation to refine location of stations and/or resources".*

Table 5.2 of the main report extracts the "Overall Weighted Index" from the tables below, and ranks the technologies in descending order of this index, labelled the "Area Manager's Survey Index.

Table BB3.1 ReduceResp - How would you rate the following technologies for Reducing Response times?

	High	Med	Low	Don't Know	N/A	Total	Weighted High/Medium %	Overall Weighted Index
Modelling/simulation to refine location of stations and/or resources	29	12	1			42	76%	65.7
Influence road layout/traffic engineering solutions	8	14	19	1		42	27%	23.6
Real time traffic information	7	16	19			42	26%	22.6
Control of traffic light phasing by on-board device	7	10	24		1	42	23%	19.5
Change/improve appliance design to improve performance through traffic	5	17	20			42	22%	19.0

Source: McDermott Miller Survey of Area Managers

Table B3.2 How would you rate the following technologies for Reducing Response times? - Other

Access to operational plans electronically
Acknowledgement of volunteer response
Address route directions and risk information on computer screen in front of OIC
Alerting system
Appliances go faster than my (Exec) car The only option is to reduce call processing time.
Automatic Vehicle Location
Automatic Vehicle Location technology integrated with CAD to select nearest appliance
Automatic Vehicle location that allows for the closest resource to be sent
better matching response to risk
capturing feed back from volunteers at the station on their anticipated ETA when called out
Change in the attitudinal status of career staff from disinterest to wishing to improve performance
Continual look at visual and audio effectiveness systems
Do not give details of incidents to volunteers; they prioritise what and how they respond to the fir
Dynamic placement of appliances so the resources are in the right place at the right time.
Early accurate detection/location of emergencies at their source
Electronic mapping showing incident location and other responding appliances
improve appliance visibility to other drivers
Improve information provided to crews before they respond
Improve time for volunteers travelling from their home to the fire station to respond
introduce alternative vehicles that perform a rapid response role (motorbike or 2 person ute)
Mapping software available on appliances
On board cameras
On board navigation systems
On board route information
On board sensory tools - object distance - cornering roll over limiting devices
On board, dynamic Alternate route suggestions via NavMan type mapping for congested routes
On screen location of other appliances
provide targeted training to Fire Service drivers
Reduce time from alert to when crews leave the station
reliable, single provider of timebound alerting (replacing pager technology)
Review H&S restrictions on running to appliances and dressing+seatbelts before leaving station
Smaller, lighter 1st response vehicles.

Source: McDermott Miller Survey of Area Managers

Table B3.4 How would you rate the following technologies for Reducing Response times? - Comments

As this is response based, we are doing the 'Ambulance at the bottom of the cliff' phase. Reducing response times does very little for fire outcomes due to significant fire involvement upon arrival. As one person said to me we often are clearing a carpark once we arrive. In larger cities these technologies may have impact, but not in towns or rural centres
Automated "On-board" mapping / GPS is overdue. Relieving the OIC of navigational issues releases him / her to concentrate on information concerning the incident i.e. radio messages / risk plans / make-ups....
Have used traffic light phasing in the past. Drivers still need to proceed through intersection at a speed they can stop in an emergency.
I don't consider this a major issue
I think there is significant risk to other road users and ourselves to manage traffic lights out of sequence.
It is already known, traffic has little bearing on the overall outcome of a fire or incident(in normal every day traffic situations) It may however be more prudent to have stations better located having regard to the various hazards an emergency response vehicle is likely to face even on a normal day (eg: CBD, busy connecting intersections and routes of travel)
Technologies need to reduce the incidence and consequence of fire and other emergencies. Occupiers need to know they have an emergency first and be able to evacuate safely while the potentially dangerous environment is managed automatically/robotically. This information needs to be relayed to responders quickly and accurately
The gains are not to be made in call processing or speed of response from a station to an incident. The only gains will be by anticipating where the calls will be at any given time (Day / Night) and positioning the appliances close by.

Source: McDermott Miller Survey of Area Managers

Table B3.5 Intelcomcen - How would you rate the following technologies for Providing more intelligence more quickly to ComCen operator

	High	Med	Low	Don't Know	N/A	Total	Weighted High/Medium %	Overall Weighted Index
System to locate caller's cell-phone etc	29	8	4	1		42	74%	56.1
Automated Vehicle Location/Automated Vehicle Monitoring	28	8	6			42	71%	54.3
Receive and analyse GPS data from public's devices	25	9	5	2	1	42	65%	49.3
Extended Alarm Data- Transmission of intelligent building sensors and panel data to comcen	22	16	2	2		42	62%	47.0
Integrated building management systems with IP (internet protocol) connection to comcen	17	16	7	2		42	50%	38.0
Capability to receive and analyse visual imagery of incidents	18	10	12		2	42	49%	37.1
"Intelligent" domestic fire alarms with IP (internet protocol) connection to comcen	17	10	12	3		42	46%	35.3
Interoperable communication with other emergency responders (via Digital LMR)	13	22	6	1		42	44%	33.5
Capability to receive and analyse photo and video data sent by public	13	17	10	1	1	42	41%	31.2
Integrated home security systems with IP (internet protocol) connection to comcen	9	8	22	3		42	26%	19.9
Integrated personal (medical) home security systems with IP (internet protocol) connection to comcen	6	11	21	2	2	42	21%	15.8

Source: McDermott Miller Survey of Area Managers

Table B3.6 How would you rate the following technologies for Providing more intelligence more quickly to ComCen operator - Other

callers' details automatically entered into ICAD
Dynamic visual presentation (Hologram like) of Building management Systems (IP) direct to appliances
Integrated building management systems with IP (internet protocol) connection to appliances.

Source: McDermott Miller Survey of Area Managers

Table B3.7 How would you rate the following technologies for Providing more intelligence more quickly to ComCen operator - Comments

I don't think the COMCEN is the most appropriate place to receive most of this information. Make it available at the sharp end Using AVL to determine quickest response thus removing the need for beat lists
Many of these technologies are associated with domestic home owners and I don't think that is the best bang for our buck. WE most certainly do not need comcen using visual imagery to do incident analysis. There is no command function associated with our
Photo and video from public could be a double edge sword - it will need some filtration if it is to be beneficial
The closer and more quickly technology can bring remote observation to an actual emergency the quicker the correct level of response can be actioned and also altered when necessary
The ComCen operator is a non decision maker for an incident. The key is to get the data direct to the OIC Fire in such as way that it can be used easily and assimilated quickly. ComCens need only tell "what type of incident and where". The rest is an Ops Officer function.

Source: McDermott Miller Survey of Area Managers

Table B3.8 IntelOIC - How would you rate the following technologies for providing more intelligence more quickly to OIC

	High	Med	Low	Don't Know	N/A	Total	Weighted High/Medium %	Overall Weighted Index
Vehicle-based Incident Information Display via IP (internet protocol) network eg risk plans	35	7				42	88%	113.3
Communication of integrated building management systems data to OIC	29	6	7			42	73%	94.1
Extended Alarm Data- Transmission of intelligent building sensors and panel data to OIC	26	11	4	1		42	68%	88.7
Interoperable communication with other emergency responders (via Digital LMR)	18	21	2	1		42	55%	71.7
Communication of "intelligent" domestic smoke detector/fire alarm data direct to OIC	19	13	10			42	53%	68.6
System to directly locate caller's cell-phone etc	16	15	8	2	1	42	47%	60.9
Delivery of incident information to stations via IP (internet protocol) network	14	18	10			42	44%	57.1
Directly receive and analyse GPS data from public's devices	15	14	11	2		42	44%	57.1
Capability to directly receive and analyse visual imagery of incidents sent by public	9	20	12	1		42	33%	43.2
Communication of integrated home security systems data direct to OIC	10	8	24			42	29%	37.0
Communication of integrated personal (medical) home security systems to OIC	7	12	21		2	42	24%	30.8

Source: McDermott Miller Survey of Area Managers

Table B3.9 How would you rate the following technologies for providing more intelligence more quickly to OIC - Other

Water supply information displayed in vehicle

Source: McDermott Miller Survey of Area Managers

Table B3.10 How would you rate the following technologies for providing more intelligence more quickly to OIC - Comments

Once again, possible application in larger centres, but very low in rural and towns where cell-phone/IP systems don't operated 50% of the time they are on the road or in location
Risk of "swamping" the OIC with data / information.....however, if by OIC you also mean an Incident Commander / Controller, then all the above relevant information / data needs to be interrogated and used in developing the Incident Action Plan (IAP). The Hazmat / Command vehicles are the perfect platform for this "planning & intelligence" assimilation.
some technologies would not fit with our expectations and the realities of incident ground functions. There is clear definition of roles played by our operations and our coms staff which is a pretty comfortable fit. You can get information overload and therefore paralysis by analysis in the field
The more information available to the OIC the better the decision making will be based on hard facts and data

Source: McDermott Miller Survey of Area Managers

Table B3.11 CommControl - How would you rate the following technologies for Improving command and control at incident

	High	Med	Low	Don't Know	N/A	Total	Weighted High/Medium %	Overall Weighted Index
Integrated communication with other emergency responders	26	14	2			42	70%	95.0
GPS devices on firefighters for location in structures	21	17	4			42	60%	81.3
Sensors on firefighters to measure and transmit environmental data eg temperature, gases, smoke etc	18	17	7			42	53%	71.6
Transmission of digital video by cameras on firefighters	13	23	6			42	45%	60.4
Display of images and text data superimposed over real time images of emergency location	14	19	6	3		42	45%	60.4
Video "reach back to remote experts" available from fire trucks	14	14	11	3		42	42%	56.3
Bio-sensors on firefighters to measure and transmit physiological data	12	22	8			42	42%	56.3
Video data from cameras on fire engines	11	24	7			42	40%	54.7
Image analysis software to analyse video for location, size and movement	8	21	8	5		42	32%	42.7

Source: McDermott Miller Survey of Area Managers

Table B3.12 - How would you rate the following technologies for Improving command and control at incidents Other

At lager incident video footage shot by trained staff of incident over time would be very useful
Command and Control software that is easily usable and integrated with the C2 process
integrated IAP platform with other emergency responders
Reach back of telemetry from DIM and video equipment to a remote SME with voice coms between
Table computer platform for Sector Commanders, linked to ICU showing dynamic changes and sitreps

Source: McDermott Miller Survey of Area Managers

Table B3.13 How would you rate the following technologies for Improving command and control at incidents - Comments

A balance needs to be struck between good, safe & effective control structures at an incident i.e. sectors / sector commanders on the ground and attempts at "remote-control" C&C from behind a desk somewhere....
Challenge would be developing robust equipment that is cost effective.
OICs with limited callouts to large scale events would struggle to remember how to use much of this equipment
Some nice to haves here but not all realistic in medium term
The reachback of video and HazMat DIM (Detection and ID) equipment to a remote SME (HazSubs advisor etc) with voice coms between is a biggie which would supply expert advice to the incident ground by having on call a very small number of contracted SME's

Source: McDermott Miller Survey of Area Managers

Table B3.14 FireOps - How would you rate the following technologies for helping firefighters perform fire operations more safely and effectively

	High	Med	Low	Don't Know	N/A	Total	Weighted High/Medium %	Overall Weighted Index
Digital Radio Communications in BA	35	5	2			42	86%	87.7
BA Telemetry including head up display of data	24	14	4			42	65%	66.6
GPS devices on firefighters for location in structures	22	16	3	1		42	62%	62.9
Maintain/enhance mains water supply pressure is adequate for firefighting	21	14	5	2		42	58%	59.3
Sensors on firefighters to record environmental data eg temperature, gases, smoke etc	17	18	7			42	51%	52.0
Compressed Air Foams delivery systems	15	16	9	2		42	45%	46.0
Bio-Sensors on firefighters to record physiological data	13	20	9			42	43%	43.6
Video data from firefighters	11	24	6	1		42	40%	41.2
Head up display of images and text data superimposed over real time images of emergency locatio	11	14	12	5		42	35%	35.1
Normally – aspirated foam delivery systems	7	25	9	1		42	32%	32.1
Handheld Water Mist delivery systems	5	20	12	4	1	42	24%	24.2
Handheld reduced droplet size spray delivery systems	4	21	12	4	1	42	22%	22.4

Source: McDermott Miller Survey of Area Managers

Table B3.15 How would you rate the following technologies for helping firefighters perform fire operations more safely and effectively - Other

electronic display of FF skills for OIC

Source: McDermott Miller Survey of Area Managers

Table B3.16 How would you rate the following technologies for helping firefighters perform fire operations more safely and effectively - Comments

Ease of use required as volunteers in smaller brigade would only use this technology sparingly
Have rated fire fighting tools (CAF, Foam etc) as medium because all these options have potential in the right situation. All tools in the toolbox.
Mist systems are just another tool useful in only a small percentage of cases and compressed foam has proven to be disastrous
Not sure what the mains water question refers to? Access to and knowledge of main size and flow is critical information that should be available to first arriving crews....water is their ammunition!
Water will remain the cheapest and most effective fire fighting medium for some time. Specialist applications require specialist training that can be difficult to deliver and maintain especially in remote volunteer sectors. BA wearing is one of the more hazardous activities undertaken during fire fighting so the more data on location and state of wearers would be beneficial. Special applications of fire fighting media need to simple to set up and use.

Source: McDermott Miller Survey of Area Managers

Table B3.17 RescueOps - How would you rate the following technologies for helping firefighters perform rescue operations more safely and effectively

	High	Med	Low	Don't Know	N/A	Total	Weighted High/Medium %	Overall Weighted Index
MVA rescue techniques for hybrid and all-electric and hybrid vehicles	24	13	5			42	65%	50.5
GPS devices on firefighters for location in structures	23	13	6			42	63%	48.7
Improved rope rescue technology/techniques	13	18	11			42	42%	32.4
Devices and techniques for 'pulling' vehicles apart at MVAs	12	16	13	1		42	38%	29.7
Robots for urban search and rescue	4	17	17	4		42	20%	15.3

Source: McDermott Miller Survey of Area Managers

Table B3.18 How would you rate the following technologies for helping firefighters perform rescue operations more safely and effectively - Other

Better Thermal Image cameras (Lighter smaller in helmet)
GPS tracting software so a search can be monitored and managed by tracking progress on a screen
Lighter, small more powerful vehicle extrication tools
More specialist training and equipment fro use underground.better monitors and detectors
More specialist training/ equipment in rural scenerios-silos etc
Quick nutritious (hot when necessary) food and beverages on scene quickly

Source: McDermott Miller Survey of Area Managers

Table B3.19 How would you rate the following technologies for helping firefighters perform rescue operations more safely and effectively - Comments

No responses

Source: McDermott Miller Survey of Area Managers

Table B3.20 Training - How would you rate the following technologies for easier and more effective training

	High	Med	Low	Don't Know	N/A	Total	Weighted High/Medium %	Overall Weighted Index
Innovative live fire simulators	32	7	3			42	80%	94.5
Command and Control Simulators (physical and software, fixed or truck-mounted)	28	13	1			42	74%	87.5
Interactive Virtual reality firefighting simulators (physical and software fixed or truck-mounted)	24	13	4	1		42	65%	76.3
Emergency response driver simulators (physical and software, fixed or truck-mounted)	20	16	6			42	57%	67.2
Command and Control Simulators (software only)	19	17	5	1		42	55%	65.1
Interactive Virtual reality firefighting simulators (software only)	15	18	7	2		42	46%	54.6
Emergency response driver simulators (software only)	13	15	13	1		42	40%	46.9
Distribute tablet computers/net books/or e readers to all firefighters for TAPS and other training materials	8	18	14	2		42	30%	35.0

Source: McDermott Miller Survey of Area Managers

Table B3.21 How would you rate the following technologies for easier and more effective training - Other

Interactive computer programs for TAPS and other learning

Source: McDermott Miller Survey of Area Managers

Table B3.22 How would you rate the following technologies for easier and more effective training - Comments

Core skills need to be delivered on site relevant to Brigades
Have rated all items as high because these are all key factors in training and development of firefighters and officers.
Our simulation training units need to as close as possible to realistic because of the types of personnel we have. Generally simulation has proven partially useful at best and can never take the place of real-time experiences.
Simulation and e-learning are the keys
This is technology set at the 'high end' of the training that is needed. We need to ensure we have the right training for our most common ranks RFF, FF, QFF and SFF, and ensure we are using the best training material and technology to make their training
With decreasing actual or "real" fire frequency, simulation must make up the competency formula....i.e theory / training / simulation / hands on operations = competence

Source: McDermott Miller Survey of Area Managers

Table B3.23 Volunteer - How would you rate the following technologies for managing demands on volunteers

	High	Med	Low	Don't Know	N/A	Total	Weighted High/Medium %	Overall Weighted Index
Sensors on firefighters recording environmental data eg temperature, gases, smoke etc	15	18	9			42	46%	26.1
Recording and storage of digital video by appliance mounted cameras	14	18	10			42	44%	24.8
Transmission, recording and storage of digital video by cameras on firefighters	13	22	7			42	44%	24.8
Image analysis software to analyse video recordings for location, size and movement	11	17	10	4		42	36%	20.4
Display of images and text data superimposed over images of emergency location	10	20	10	2		42	36%	20.1
Bio-sensors on firefighters recording physiological data	9	22	11			42	35%	19.4

Source: McDermott Miller Survey of Area Managers

Table B3.24 How would you rate the following technologies for managing demands on volunteers - Other

Auto TXT fire safety messages to mobile phones
Compressed air foam to put fires out quicker and get back to work
determine a tiering structure for brigades that is meaningful and realistic
Mandatory hardwired smoke alarms in residential housing
Provide 10 year life smoke alarms in bulk to volunteer brigades with targeted installation programme
reduce compliance for less busy brigades
STAFF rather than technologies to deliver training at right time evening and weekends
Technologies to capture report data quicker and more effective. Save time demands writing up reports
Turnout paging system alternatives that give better info ob call type etc

Source: McDermott Miller Survey of Area Managers

Table B3.25 How would you rate the following technologies for managing demands on volunteers - Comments

Efficient reliable fire alarm systems would free up 40% of activity time and save on fuel and wear and tear of appliances.
Infill paging is an old technology that has shown high limitations in its current application. In truth its a bloody nightmare!
Many building in volunteers areas are not as modern in their construction or alarm systems but that is reality and for some brigades any callout is a good callout with social benefits. Targeting the trouble ones is more like it. technologies for training delivery are to be encouraged
Much of the demand is also with administration. The technology we use works against us in this currently. Many issues with computers in rural areas frustrate volunteers.
Pagers need to be replaced by smart phones asap.....
There is a fundamental flaw with our current thinking on reducing PFA "false alarms" It is not about encouraging building owners. The NZFS has this completely wrong!!!!!!! Who is the expert in fire alarms? the alarm company. Who is the expert installer???

Source: McDermott Miller Survey of Area Managers

Table B3.26 Review - How would you rate the potential of the following technologies for easier and more effective post-incident reviews?

	High	Med	Low	Don't Know	N/A	Total	Weighted High/Medium %	Overall Weighted Index
Sensors on firefighters recording environmental data eg temperature, gases, smoke etc	15	18	9			42	46%	26.1
Recording and storage of digital video by appliance mounted cameras	14	18	10			42	44%	24.8
Transmission, recording and storage of digital video by cameras on firefighters	13	22	7			42	44%	24.8
Image analysis software to analyse video recordings for location, size and movement	11	17	10	4		42	36%	20.4
Display of images and text data superimposed over images of emergency location	10	20	10	2		42	36%	20.1
Bio-sensors on firefighters recording physiological data	9	22	11			42	35%	19.4

Source: McDermott Miller Survey of Area Managers

Table B3.27 How would you rate the potential of the following technologies for easier and more effective post-incident reviews? - Other

Recording of eIAP info and relating that to synchronized video data real time playback
Recording of voice traffic
Software to manage debrief and review process
Trained Staff only for video use and on Command appliances

Source: McDermott Miller Survey of Area Managers

Table B3.28 How would you rate the potential of the following technologies for easier and more effective post-incident reviews? - Comments

A bit of a wish list
Most of the above technology records the consequences of decisions made by the OIC / Incident Controller.....monitoring and tracking the decision making processes would be much more effective i.e. timeliness of eIAP's / Risk Assessments / Safe Person considerations / sitrep regularity / accessng risk plans.....

Source: McDermott Miller Survey of Area Managers

Table B3.29 Environ - How would you rate the following technologies for reducing environmental pollution from firefighting

	High	Med	Low	Don't Know	N/A	Total	Weighted High/Medium %	Overall Weighted Index
Use of smart building services/technologies on fire stations	29	6	5	1	1	42	73%	53.3
Techniques for the containment/removal of firefighting water run-off	22	14	6			42	61%	44.5
Use of low pollutant (emission) vehicles	15	17	10			42	46%	33.6
Use of Compressed Air Foam	14	15	12	1		42	42%	31.0
Use of low concentration foaming agents for Class B fires	11	20	9	2		42	38%	27.9
Use of low concentration foaming agents for Class A fires	10	22	8	2		42	37%	27.1

Source: McDermott Miller Survey of Area Managers

Table B3.30 - How would you rate the following technologies for reducing environmental pollution from firefighting Other

Environment efficiency design for all new fire stations

Source: McDermott Miller Survey of Area Managers

Table B3.31 How would you rate the following technologies for reducing environmental pollution from firefighting - Comments

Foams have to be used in some situations but generally the environmental impacts can be more disastrous than the fire situation
Hazmat technologies and effective deployment of Hazmat equipment is relevant here. Every fire is also an environmental hazard / polluter.
Knock the fire quickly and contain the run-off
The current foam used in CAFS and foaming agents are an environmental pollutant. Developing a neutral and still effective foam and then re-deploying the technology makes more sense
While all these would meet the outcome of the question, they are not foremost in our thoughts. Smart buildings would be great, but not affordable on most volunteer stations

Source: McDermott Miller Survey of Area Managers