Canadian Fire Community of Practice:

Report on Intermediate Science and Technology Priorities of Canadian Fire Services

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IMPORTANT INFORMATIVE STATEMENTS

Canadian Fire Community of Practice

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Executive Summary

1. This report is designed to contribute to the mission of the Canadian Safety and Security Program (CSSP) to enhance Canada's emergency resilience infrastructure. The CSSP created the Centre for Security Science in 2006 to help coordinate Canada's efforts to build and reinforce our public safety and security infrastructure. The Centre for Security Science has subsequently organized a series of Communities of Practice to help implement that mission.

2. The Canadian Fire Community of Practice (Fire CoP) was created in 2012 to focus on threats to our communities normally handled by fire service agencies. The membership of the Fire CoP consists of subject-matter experts in fire-related matters such as firefighting, prevention, recovery, education and instruction, research, and engineering. As with the other Communities of Practice, its goal is to enhance our well-being by identifying areas of risk and associated capability gaps.

3. A goal of the Fire CoP "is to identify the required knowledge and technology that will reduce the personal, socio-economic and environmental impacts of fire (and all emergencies) through the anticipation, prevention and mitigation of hazards." One way to achieve this is by identifying science and technology (S&T) methods and solutions directed toward threats from incendiary incidents and related events.

4. This report is to help verify and hone a set of strategic priorities that the Fire CoP identified in its business plan as intermediate research needs. The current document is not designed to set specific research priorities but, instead, to inform the Fire CoP leadership what other senior professionals in the field are considering.

5. This report consists of three components. The first outlines a survey that asked senior Canadian fire professionals to rank the priority areas identified by the CSSP. It also involves generating ranked listings of elements within those priority areas. The second component is an analysis of the "qualitative" results of that survey where respondents identified items they considered important but had been omitted from the structured survey. The third component consists of an environmental scan of research priorities set by other countries facing similar resilience challenges to Canada, and by other organizations concerned with fire-related issues.

6. The overall findings of this report suggest that a strong consensus exists in Canada's senior professional fire services community over the key priorities identified by the Fire CoP. The results of the environmental scan also suggested there were a limited set of ancillary issues that the Fire CoP might wish to consider as complementing their identified priorities.

Purpose of the Project

The purpose of this report is to help verify and hone a set of strategic priorities that members of the Canadian Fire Community of Practice (Fire CoP) have identified as intermediate research needs relating to science and technology (S&T). It is one of the community development projects outlined in the Fire CoP business plan prepared in February 2013.[1] As background, this document is not designed to set specific research priorities but, instead, to inform the Fire CoP leadership what others in the field are considering. As noted in the Fire CoP business plan, decisions are to be made by consensus whenever possible.

This report consists of three components. The first presents the results of a survey that asked Canadian fire professionals to rank the priority areas that had been identified by the Canadian Safety and Security Program (CSSP) and set by the Fire CoP during its inaugural meeting in Calgary. The first component also involves generating ranked listings of elements within those priority areas.

The second component is an analysis of the "qualitative" results of that survey where respondents identified items they thought were important but had been omitted from the structured survey.

The third component consists of an environmental scan of research priorities set by other countries facing similar resilience challenges to Canada,[2] and by organizations such as the International Association of Fire Chiefs and the Society of Fire Protection Engineers.

The overall findings of this report suggest that a strong consensus exists among Canadian senior professionals in the fire services community over the key priorities the Fire CoP identified. The results of the environmental scan also suggested there were a limited set of ancillary issues the Fire CoP might wish to consider.

The material presented in this document should assist the Fire CoP to further refine its S&T research priorities to help strengthen Canada's resilience infrastructure.

Background

This report is designed to contribute to the mission of the CSSP to enhance Canada's emergency resilience infrastructure. The CSSP is a federal program led by Defence Research and Development Canada`s Centre for Security Science,[3] whose mandate is to improve Canada's ability to prepare for, respond to, and recover from natural and other forms of disaster. The CSSP aims to do this through the integration of science and technology with elements of policy, operational effectiveness and intelligence.

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[1] Canadian Safety and Security Program (2013) Business Plan: Fire Community of Practice.
[2] Those countries consisted of Australia, the United Kingdom, the United States and New Zealand.
[3] See http://www.drdc-rddc.gc.ca/en/science-tech/safety-security.page

The Centre for Security Science was set up in 2006 as a mechanism for horizontally integrating Canada's efforts to build and reinforce our public safety and security infrastructure. As such, it draws together expertise in a range of disciplines and practices. Previously, our country's broad security concerns were handled by multiple agencies in numerous jurisdictions that had varying degrees of integration or collaboration. A goal of the centre is to provide broad and evidence-based advice and guidance to support planning, decision-making, operations and the development of public safety and national security strategies and policies.

Operationally, the aim of the CSSP is to enhance Canadian public safety by addressing security vulnerabilities and capability gaps. According to the program mandate, "these gaps are identified through risk and vulnerability assessments, and consultation with communities of practice, as well as central agencies, and policy, operational and intelligence entities."

The CSSP created the Fire CoP in 2012 to focus on threats to our communities normally handled by fire service agencies.[4] The membership of the Fire CoP consists of subject-matter experts in fire-related matters such as firefighting, prevention, recovery, education and instruction, research, and engineering.[5] As with the other Communities of Practice, its goal is to enhance our well-being by identifying areas of risk and associated capability gaps.

According to its business plan, the goal of the Fire CoP "is to identify the required knowledge and technology that will reduce the personal, socio-economic and environmental impacts of fire (and all emergencies) through the anticipation, prevention and mitigation of hazards." One way the Fire CoP is achieving this is by identifying S&T methods and solutions directed toward threats from incendiary incidents and related events.

As a first step, the Fire CoP is establishing a broad-based S&T research agenda. That agenda, however, is consistent with the six overall priorities of the CSSP.

Those priorities are:
- Implementable policy and strategy;
- Protected and connected practitioners;
- Rapid technology assessment and insertion;
- Resilient infrastructure;
- Secure but open borders; and
- Alert and resilient communities

In their first meeting in February 2013, Fire CoP membership was asked to consider what they considered to be Canada's critical science and technology research strategic priorities for the fire service. The focus was on near- to mid-term requirements (three to five years forward). The six items outlined by the CSSP were considered in detail, along with a "blue sky" category of unidentified but potentially crucial emerging areas. Ultimately, the CSSP would likely fund several research proposals under the priorities identified by the Fire CoP.

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[4] At the time, the Centre for Security Science created three new communities of practice, ones for fire, police and paramedics.
[5] For details on the Fire CoP mandate, see: Fire Community of Practice (2013) *Business Plan*, Ottawa: Canadian Safety and Security Program, Centre for Security Science.

The Fire CoP membership addressed two issues. The first was to ensure that key, short-term S&T research needs were identified, with a specific focus on elegant and near-ready solutions. The second was to rank those items in order of priority. To start the process, the Fire CoP had a brainstorming session in June 2013 to identify items relating to each of the six priority areas specified by the CSSP.

Once they identified those items, the Fire CoP decided to conduct a survey of senior fire professionals to verify and rank the items. The survey would validate their framework and also help identify any critical emerging or unidentified items. The overall CSSP priorities and the related items identified by the Fire CoP are presented in the next section.

A secondary task undertaken to complement the CoP survey involved an environmental scan of existing priorities of other major agencies outside Canada.

The purpose of these exercises was to provide more background information to enable the Fire CoP to decide the near-term S&T research priorities. The exercises were not meant to set the priorities in and of themselves.

Survey of Fire Professionals

Using the material generated at the Fire CoP meeting, we constructed and distributed an online questionnaire during September 2013. There are about 3,000 fire departments in Canada, of which about 80 per cent are volunteer. About one third, or slightly less than 1,000 of those departments, have membership in the Canadian Association of Fire Chiefs (CAFC).

A link to the questionnaire was emailed to the CAFC membership, which constituted the prime survey population. The questionnaire, a background statement and instructions for completing the questionnaire were provided in both official languages. The CAFC also posted the link on its website. Two mailings were sent out to illicit responses. Ultimately, we received a response from 311 individuals. This rate of response is not uncommon, even for targeted samples.[6]

In the emails sent to the fire professionals, respondents were informed of the connection to the CSSP and that the focus was on short- to medium-term S&T research needs. When the respondents linked to the SurveyMonkey website, they were provided with a reminder of the survey's purpose.

The specific priorities as set by the CSSP and the related items identified by the Fire CoP are presented below. The respondents were presented with each CSSP category sequentially, and asked to identify the top three related items they believed were top research priorities. Once the respondents completed each of the first seven items, they were asked to rank the CSSP's categories.

[6] Marsden, P.V. and J.D. Wright (2010) *Handbook of Survey Research*, Emerald: Bingley, UK

The analysis consists of a ranking of the items based on the survey. Those results are then compared with a set of key priorities set by the Fire CoP.

Beside each item the survey included an "other" option and a text box in which respondents could write their answers. At the end of the survey, the respondents were also given the opportunity to enter any additional material they thought was important but had not been identified in the survey.

The results of the survey were downloaded in October 2013. Quantitative analyses were conducted on the questions presented below. The percentage of answers selected for each CSSP category is presented in Table 2 through Table 8. Because the respondents were allowed to select more than one response within each category, the percentages do not sum to 100.

The write-in material for the "option" category was reviewed and reported separately.

Fire CoP Survey Items

1. Policy and Strategy
   a. Building code issues and standards
   b. Local government legislation and bylaws and determining service levels
   c. National-level reporting, data, statistics, metrics: understanding policy impacts
   d. Education for fire services personnel
   e. Jurisdictional issues
   f. The impact of environmental change
   g. System sustainability and economic support

2. Practices among Fire Service Professionals
   a. Interconnections between practitioners
   b. Training methods in fire dynamics and fire literacy
   c. Communications and interoperability (both equipment and practice)
   d. Industrial health factors (both physical and psychological)
   e. Advanced hazardous materials (hazmat) equipment
   f. Fitness and wellness of firefighters

3. Rapid Technology Assessment and Insertion
   a. The threats and impacts of new materials and technologies
   b. How to better and more quickly implement new technologies
   c. Greater use of controlled laboratories
   d. Whether to follow NFPA standards or develop Canadian standards (for example, length of response time)
   e. Information-sharing protocols between first responders and other jurisdictions
   f. Impact of technology: effort and maintenance
   g. How to increase capacity to push and pull knowledge in the community

4. Resilience Infrastructure
   a. Understanding fire for emerging classes of infrastructure (for example, e-commerce and cyber infrastructure)
   b. Risk assessment related to infrastructure and building codes
   c. Need for backup power and other infrastructure during catastrophic events
   d. "Black Swan" scenarios to anticipate future complex situations

5. Secure and Open Borders
    a. Border-crossing issues (for example, opportunity with new Windsor-Detroit bridge to discover new technologies and approaches, and potential for projects and exercises)
    b. Internal provincial border choke-point issues
    c. Cross jurisdictional agreements/arrangements
    d. Collaboration with other security agencies

6. Communicating and Communities
    a. Technology and communications for educational purposes
    b. Getting public to take more "ownership" or responsibility
    c. How to encourage greater responder self-support
    d. Sustaining or finding alternatives for volunteers, including recruitment and retention issues
    e. Effective communications and planning with the private sector

7. "Blue Sky" or Cutting-edge Technologies
    a. Throwaway sensors
    b. GPS location of staff, or other tools
    c. Restructuring what and how fire services are delivered (for example, merging with other services, focus on EMS, or full-tie and volunteer staff)
    d. Financial sustainability of fire services

Analysis of Survey Results

The survey was intended to elicit both high-level and detailed perceptions of the CSSP policy dimensions. The high-level question asking respondents to rank the general research areas was placed at the end of the survey, when respondents would have already addressed the detailed questions and would have a better feel for each area's specific issues.

The average rankings of the general research areas are presented in Table 1. While there are some differences in the rankings of the specific items, it is clear that the variation is small. As might be expected, the "other" category was ranked the least important. This is not unusual in this type of survey; "other" categories are typically not ranked high unless a survey omits an extraordinary issue around which there is a high degree of agreement.

Among the seven key dimensions, "practices among fire services professionals" was considered the most important, while "secure and open borders" was ranked the least important. Beyond those two extremes, there were no statistically significant differences in the rankings of the other items. This could be interpreted as meaning that, overall, the CSSP has done a good job of identifying the range of critical policy dimensions relating to research needs.

Table 1

Q. Please rank the following general research areas.	
Answer Options	**Score**
Practices among fire services professionals	4.4
Alerting and communicating with communities	4.2
Public policy and strategy	4.1
Resilience infrastructure	3.9
Rapid technology assessments and insertion	3.8
"Blue sky" or cutting-edge technologies	3.8
Secure and open borders	3.2
Other	2.9

While few differences appeared in the perceived importance of the CSSP's main dimensions, there was substantial variation in the specific items raised by the Fire CoP groups within each policy area.

Below, each of the strategic categories outlined in Table 1 is examined in detail. Within each table, the key priorities identified by the Fire CoP are outlined in grey. A final ranking of all the survey items is presented in Appendix I.

Public Policy and Strategy

The first question in the survey related to the general topic of public policy and strategy. Respondents were asked to select three top priorities from the Fire CoP's seven potential priority areas. The responses fell into two groups. Five priority areas were selected by 43 to 60 per cent of the respondents as one of the top three priorities, while less than 10 per cent of the respondents ranked the other two items – or "other" – in the top three,

Perhaps what is most interesting about these results is that one of the lowest ranked items, "the impact of environmental change," appeared as one of the major concerns outlined in our environmental scan of other jurisdictions and agencies.

As can be seen from Table 2, "local government legislation and bylaws and determining service levels" was ranked as the most important research priority by a substantial margin. About 60 per cent of the respondents identified this as one of the top priorities. A second cluster for importance included "education for fire services personnel," "building code issues and standards," "system sustainability and economic support," and "national-level reporting, data, statistics, metrics: understanding policy impacts."

Table 2

Q1. In the area of public policy and strategy, what would you consider to be the top research priorities? Select up to three.	
Answer Options	**Per cent**
Local government legislation and bylaws and determining service levels	60.3
Education for fire services personnel	54.8
Building code issues and standards	52.6
System sustainability and economic support	43.2
National level reporting, data, statistics, metrics: understanding policy impacts	41.6
Jurisdictional issues	9.4
The impact of environmental change	6.1
Other (please specify)	3.9
Note: Percentages do not sum to 100 per cent because of multiple responses. Key Fire CoP priorities are outlined in grey.	

As indicated, environmental issues and "jurisdictional Issues" were not perceived as being highly important research issues by most respondents.

"System sustainability and economic support" and "national-level reporting, data, statistics, metrics" are considered high priority items by the Fire CoP. Although not ranked the highest in the survey, it is clear there is strong agreement among the respondents that these are important issues.

Practices among Fire Service Professionals

The second set of questions related to practices among fire service professionals. As indicated in Table 1, this overall topic area was identified by respondents as having the highest overall priority.

Under this dimension, "communications and interoperability" was identified as the primary research issue, with almost 75 per cent of the respondents selecting this as one of the top three research priorities. "Training methods" and "fitness and wellness of firefighters" were the next two highest ranked research priorities. The remaining items were not as highly ranked, although there was some support for "interconnections between practitioners."

Table 3

Q2. In the area of practices among fire service professionals, what would you consider to be the top research priorities? Select up to three.	
Answer Options	**Per cent**
Communications and interoperability (both equipment and practice)	74.9
Training methods in fire dynamics and fire literacy	59.9
Fitness and wellness of firefighters	50.8
Interconnections between practitioners	39.8
Industrial health factors (both physical and psychological)	27.4
Advanced hazardous materials (hazmat) equipment	11.7
Other (please specify)	2.0
Note: Percentages do not sum to 100 per cent because of multiple responses. Key Fire CoP priorities are outlined in grey.	

Again, the two greyed items in Table 3, "training methods in fire dynamics and fire literacy" and "industrial health factors (both physical and psychological)" were identified by the Fire CoP as being of particularly high priority. While not ranked the highest by the respondents, there is clearly a consensus that these are important items, particularly the item relating to training methods.

Rapid Technology Assessment and Insertion

Under the rapid technology assessment and insertion rubric, respondents ranked "the threats and impacts of new materials and technologies" as the most important research area. However, it is clear from Table 4 that there was little difference in perceived importance among the top five items. Although new materials and technologies stand out somewhat, those items ranked from two to five form a fairly tight cluster.

What is evident from Table 4 is that capacity to push/pull knowledge in the community, and the use of controlled laboratories, are not perceived as major needs. The controlled laboratories item was ranked particularly low with only about 4 per cent of respondents placing this in the top three. As an aside, it may that the value of research in this area is not immediately evident to most of those surveyed, since the impact of laboratory work is not as clearly linked to the needs of first responders. Furthermore, many of the content areas or substantive issues that are studied in controlled laboratories are implicitly included in other items, such as changes to building codes.

Table 4

Q3. In the area of rapid technology assessment and insertion, what would you consider to be the top research priorities? Select up to three.	
Answer Options	**Per cent**
The threats and impacts of new materials and technologies	53.2
How to better and more quickly implement new technologies	47.8
Information-sharing protocols between first responders and other jurisdictions	45.8
Whether to follow NFPA standards or develop Canadian standards (for example, length of response time)	45.1
Impact of technology: effort and maintenance	41.0
How to increase capacity to push and pull knowledge in the community	28.8
Greater use of controlled laboratories	4.1
Other (please specify)	1.7
Note: Percentages do not sum to 100 per cent because of multiple responses. Key Fire CoP priorities are outlined in grey.	

The top three items in Table 4 were also identified by the Fire CoP as being particularly important research priorities. The survey results clearly support or verify those rankings. The use of controlled laboratories was also identified as a priority item by the Fire CoP but, as mentioned previously, did not garner significant support from the survey respondents. The lack of first-hand experience with controlled laboratories, and the fact that their output is often not directly linked to the matériel or procedures of line personnel, may have had an impact here.

Resilience Infrastructure

Within the resilience infrastructure category, one item stands out: "risk assessment related to infrastructure and building codes." The need for research into backup power and research into emerging classes of infrastructure followed, although in a clearly secondary position.

A broader consideration of key factors relating to resilience infrastructure appeared in responses to the "other" category, which will be discussed in detail later. It might be argued that some "other" responses, particularly relating to research into improved structural materials and sprinkler systems, relates to this issue.

"Risk assessment related to infrastructure and building codes" was also the only item ranked as a key priority by the Fire CoP within this dimension. Again, the survey results are consistent with the Fire CoP's initial views on this matter.

Table 5

Q4. In the area of resilience infrastructure, what would you consider to be the top research priorities? Select up to three.	
Answer Options	**Per cent**
Risk assessment related to infrastructure and building codes	84.4
Need for backup power and other infrastructure during catastrophic events	58.3
Understanding fire for emerging classes of infrastructure (for example, e-commerce and cyber infrastructure)	45.1
"Black Swan" scenarios to anticipate future complex situations	29.8
Other (please specify)	3.7

Note: Percentages do not sum to 100 per cent because of multiple responses. Key Fire CoP priorities are outlined in grey.

Security and Open Borders

The survey respondents ranked the issue of secure and open borders as the lowest of the priority areas identified by the CSSP. In some ways, this result should not be unexpected. While most of the other CSSP areas have a clear S&T orientation, this area appears only tangentially related. A strong argument could be made that, while this area is not unimportant, it is more an issue of improved policy analysis rather than an S&T problem. Improvements in the area rely more on improved methods of collaboration rather than the implementation of technological solutions.

Among the items identified under this issue, however, there was a clear divide. Research into cross-jurisdictional issues and collaboration with other security agencies were differentiated from border-crossing issues and provincial border choke-point issues. In retrospect, it appears the respondents likely saw the two top issues as being variations on the same theme: broader cross-agency collaboration. Similarly, the two lowest ranked items relate to variations on cross-border issues.

More broadly, it might be suggested that all of the items specified in Table 6 could be addressed through more detailed analyses into improving inter-agency – including cross jurisdictional – collaboration.

Table 6

Q5. In the area of security and open borders, what would you consider to be the top research priorities? Select up to three.	
Answer Options	**Per cent**
Cross-jurisdictional agreements/arrangements	77.1
Collaboration with other security agencies	72.2
Border-crossing issues (for example, opportunity with new Windsor-Detroit bridge to discover new technologies and approaches (potential for projects and exercises)	28.5
Internal provincial border choke-point issues	27.1
Note: Percentages do not sum to 100 per cent because of multiple responses. Key Fire CoP priorities are outlined in grey.	

It is also noteworthy that the Fire CoP did not rank any items in this dimension as constituting key priorities. The low overall ranking of this dimension (as the least important of the seven initial dimensions) by the respondents would seem to validate the Fire CoP's view of this matter.

Alerting and Communicating with Communities

The survey respondents ranked this general area the second most important overall. The item "sustaining or finding alternatives for volunteers, including recruitment and retention issues," which was ranked most highly by the respondents, was also identified by the Fire CoP as a key priority. This is obviously a key issue, with close to 80 per cent of Canada's fire departments being supported by volunteer personnel. High rates of turnover plague many of those departments, and a lack of experienced personnel is a challenge to building effective human resilience infrastructure. Research into why this is an issue and how best to address it is clearly a priority within the Fire CoP and the broader professional community.

In many respects, however, the content of this dimension presents similar problems to those identified with the "security and open borders" issue. With the exception of the item "technology and communications for educational purposes," it is not as clear in the other items what the underlying *science or technological* matter is within the traditional definition of S&T. Ultimately, the respondents believed the issue of alerting and communicating with local communities to be an important one, worth an investment of research resources. What the Fire CoP might do is to reconsider the focus of the area.

The items identified in Table 7 deal more with human and social issues rather than technological ones. Again, this is not to suggest there is not a need to investigate these matters in their own right: they clearly impact resilience infrastructure.

There are, however, specific existing technological problems or challenges in alerting communities in emergency situations. Particularly in mass disaster situations, current technological implementations have not improved much since the 1960s. In fact, some effective mass warning systems have been decommissioned (recall the old "air raid" or civil defense sirens). Present warning and communications systems still rely heavily on commercial radio and television announcements.

Table 7

Q6. In the area of alerting and communicating with communities, what would you consider to be the top research priorities? Select up to three.	
Answer Options	**Percent**
Sustaining or finding alternatives for volunteers, including recruitment and retention issues	63.9
Getting public to take more "ownership" or responsibility	62.8
Technology and communications for educational purposes	51.4
Effective communications and planning with the private sector	47.6
How to encourage greater responder self-support	22.0
Other (please specify)	1.4
Note: Percentages do not sum to 100 per cent because of multiple responses. Key Fire CoP priorities are outlined in grey.	

Current technologies, however, allow for communications through internet and cellular linkages. For example, many university and college campuses have systems that broadcast messages onto faculty and student computers in the event of an active shooter or similarly dangerous situation on campus. Warnings are also sent as SMS messages to registered cell phones. While this technology exists for specific implementations, research into their broader use might be appropriate. In a broad call for proposals in the area, other specific technologies and implementations might be identified.

"Blue Sky" or Cutting-edge Technologies

To complement the six areas identified by the CSSP, the Fire CoP identified a seventh category specifically targeting emerging or cutting edge technologies. It is perhaps not surprising that this was one of the lower ranked areas overall, as it can be difficult to assess the value of cutting-edge technologies until one has experience with their implementation. One example of this is the personal computer and its offshoots (for example, "smart phones") that are today commonplace. When they were initially introduced as consumer goods, their adoption was slow as few consumers were fully aware of either their capabilities or their potential.

As seen in Table 8, the top response, "financial sustainability of fire services," is again important from a policy perspective but is not specifically an S&T issue. The next two items, however, are clearly more technologically related. "Restructuring fire services . . ." can be seen as a broader logistical issue, and GPS tools are self-evidently technological matters.

Table 8

Q7. In the area of "blue sky" or cutting-edge technologies, what would you consider to be the top research priorities? Select up to three.	
Answer Options	Percent
Financial sustainability of fire services	83.7
Restructuring what and how fire services are delivered (for example, merging with other services, focus on EMS, greater mix of full-time and volunteer staff)	73.6
GPS location of staff, or other tools (for example, to locate personnel or equipment in buildings or underground)	63.7
Throwaway Sensors	5.4
Other (please specify)	2.4
Note: Percentages do not sum to 100 per cent because of multiple responses. Key Fire CoP priorities are outlined in grey.	

In considering the results of this question, the Fire CoP might wish to bear in mind the summary of "other" responses detailed below. Several of the "other" responses identified potential areas that might warrant consideration, such as the need for enhanced GPS locating abilities, non-absorptive protective gear, and other items.

A summary ranking of all of the items from Tables 2 through 8 is presented in Appendix I.

Responses in the "Other" Category

For each of the seven general areas identified, the questionnaire allowed for "other" responses. Many participants took the opportunity to make comments. What follows is a summary of some key or unique points made in those submissions.

While most of the comments were insightful and valid, many clearly did not relate to the current context. That is to say, they did not raise issues specifically related to the S&T focus of this survey. Several respondents, for example, referred to labour policy, the recruitment and retention of volunteers, and other matters that are more related to human resource policy. A few respondents suggested that technology issues were not the primary challenges facing fire services. Again, this is not to say those comments did not have merit, but they are outside the mandate of the current analysis.

There were also some grey areas that fell between strictly technological issues and broader policy issues. For example, one respondent mentioned the need for the "greater engagement and awareness in the fire service of security matters, ranging from collaboration in 'taking down' clandestine drug labs to engagement in counter-terrorism activities and fire protection involvement in 'tactical' events along with police and EMS." Others referred to the need to better use social media to inform and engage the public in disaster situations.

Most of the remaining comments identified very specific examples of technologies or technological issues that fell under the umbrella of S&T issues – such as the need for the development of three-dimensional GPS locators that could work either above or below grade or the need for more or better automatic detection and suppression systems.

Among the "other" responses that might be of interest to the Fire CoP were the following.

- Matters relating to sprinkler systems: better and more varied systems; broader inclusion in local codes.
- Better protective gear, especially improving the chemical barrier performance of PPE to reduce chemical absorption through the skin.
- National databases on such issues as fire incidents, arsonists and health-related matters. Allied with this was a call for more standardization in reporting criteria and performance metrics within Canadian fire services.
- Automatic sensors linked to detection and suppression systems.
- Development of better spatial tracking equipment, ranging from dispatch and routing systems to three dimensional GPS locators. Combined with this was a request for better in-field CAD displays.
- More research into the incendiary characteristics of materials and structures and related suppression technologies.
- Smarter communications equipment such as better ways to set call priorities, standardized communications protocols across and within responder services, and a more integrated national 911 service.

Many "other" comments were clearly meant to highlight potentially serious rare or one-off events that could have a high cost associated with them. Other comments were directed toward providing more richness or specificity to the general items listed in the body of the survey.

Environmental Scan

Sometimes when we focus on the day-to-day challenges we face, identifying emerging issues is difficult. Unfortunately, most truly important issues become obvious only in retrospect. It is occasionally possible, however, to "get ahead" of those challenges by examining what is happening elsewhere.

To do this, we conducted an environmental scan that consisted of a review of research priorities set by other countries facing similar resilience challenges to Canada, as well as by related professional organizations. We reviewed available fire service agency documents from Australia, New Zealand, the United Kingdom, and the United States.

We also reviewed either implicit or explicit priorities identified by the International Association of Fire Chiefs and the Society of Fire Protection Engineers.

The range of priorities identified by the groups surveyed was broad. Those relating to financial, human resource, general management and social policy issues were excluded. We also limited our attention to issues that had an actual or apparent operational bent, as opposed to questions of "pure science." While the latter are clearly important, it was judged that fundamental or pure research issues would likely have a longer horizon to implementation.

Within that focused range of issues, most of the concerns identified by those organizations paralleled the items identified by the Fire CoP and survey respondents. However, the environmental scan identified three major issues that did not appear to have a high priority among our Canadian respondents: 1) threats from environmental events, 2) risks to isolated and high- risk assets, and 3) the need for predictive modeling.

Environmental Threats

For many outside jurisdictions, a prime cause of human and asset loss is environmental factors. Those include items such as forest or wilderness fires, and devastation due to floods and major storms. Not only are these issues seen as immediate threats, but many perceive them to be matters that will likely increase in scope and severity over time due to global warming or other sources of environmental change.

The theme is a recurrent one in the United States and Australia, and even agencies in the UK expressed concerns regarding brush fires. Interestingly, this issue was not identified as a crucial or highly important priority by the survey respondents (see the "Impact of Environmental Change" section).

Some needs identified within this area are improved technological capabilities in responding to:

- wilderness and forest fires
- the urban-wilderness fire interface
- major storms
- occasional flash or systemic flooding

Isolated and High-risk Assets

Under this rubric, the material reviewed identified assets that are not normally part of the challenges faced by most brigades or departments. These included oil platforms, ship and planes. We often see the environmental space in which some of these assets are found or operate as posing unique challenges. Thus, location problems (challenging or isolated environments) and the intrinsic nature of the asset (small spaces, proximity to dangerous commodities or difficult material challenges) are seen as posing challenges to the standard "toolbox" available to most responders.

Although it was recognized that responders have tailored procedures and equipment to respond to risks to those assets, the relative rarity or uniqueness of those events typically resulted in limited

research efforts to address the related challenges. We have already seen, for example, that fires on oil platforms or train disasters can pose significant threats to humans, and also major dollar losses and environmental degradation.

Developing Better Risk Models

This is a broad category, but it essentially involves constructing risk models or algorithms to predict locations or circumstances with a high likelihood of becoming an incendiary incident. The complement to predictive models is being able to construct models that better estimate actual or potential losses. Although listed as a separate technology, these sorts of models provide the underlying basis of many other S&T priorities identified previously. It is perhaps noteworthy that the development of better risk models and a greater focus on risk management was also mentioned in the "other" responses to the survey.

Among some specific items that would fall under this category is research into generating better:

- prediction models for fire threats
- logistics and dispatch models, or queuing models
- risk and loss models
- models for understanding how people contribute to and respond to risks

Underlying the technology here is the need for more and better fire statistics, since data are at the heart of all valid and reliable models. Many items within this priority would also require linking fire data to other data sources. For example, the US National Institute of Standards and Technology suggested the need to improve "the understanding of how vegetation, topography, climate and construction cause structure ignition and spread of fires."

Conclusions

This review was commissioned by the Fire Community of Practice in order to validate or cross-check the strategic science and technology research priorities outlined by the group in February 2013.

Overall, the results of the survey appear to reflect the items identified by the Fire CoP. There are, however, two matters the Fire CoP might wish to consider. First, it is evident that survey respondents placed a lower emphasis on some priority areas than others. For example, improving fire service practices, communications, and cross-agency collaboration were ranked as important. There is also significant concern for responder health and safety issues, based on the results of the survey and some of the comments in the "other" category. This would suggest that research into improving overall wellness along with advances in safety gear should be considered.

On the other hand, the need for new technologies related to strictly border issues was ranked less highly. There was also not a great deal of focus on the need for research into advanced resilience infrastructure and insertion.

Attention should also be paid to priorities identified both in the "other" category responses and within our scan in other jurisdictions. While research into environmental threats was not a high priority in the survey results, it is clearly a significant priority item elsewhere in the world. The Fire CoP might wish to reconsider this topic when outlining its final list. It is possible the survey results did not signify this as a high priority item because of the focus of the respondents. Since the survey was anonymous, we have no way of knowing the respondents' level of experience or exposure to environmental challenges.

The environmental scan also identified a need to focus on technologies to handle isolated and high-risk assets and the development of better risk models. Typically, incendiary and related incidents with high-risk assets tend to be rare events, but often serious ones. Good examples here are the consequences of "100-year" floods, and fires relating to oil platforms, pipelines and, increasingly, railways.

The development of better risk models is a broad rubric that affects many of the survey items and is reflected in some of the "other" category suggestions. Risk models can be used to analyze everything from the health and well-being of fire service professionals, to the better determination of needs for asset mix or dispatch models, to where to focus prevention programs. For these to be developed successfully, however, it is essential that a broad and integrated data infrastructure be put into place. Again, a focus on this need for data was one of the items identified and emphasized by some respondents in their "other" responses. It is also consistent with the "national-level reporting, data, statistics, and metrics" item that was identified and ranked highly in Table 2.

Appendix I

Survey Responses and Rankings

Answer options are ranked from highest to lowest.

Question	Answer Options	Per cent
4	Risk assessment related to infrastructure and building codes	84.4
7	Financial sustainability of fire services	83.7
5	Cross jurisdictional agreements/arrangements	77.1
2	Communications and interoperability (both equipment and practice)	74.9
7	Restructuring what and how fire services are delivered (for example, merging with other services, focus on EMS, greater mix of full-time and volunteer staff)	73.6
5	Collaboration with other security agencies	72.2
6	Sustaining or finding alternatives for volunteers, including recruitment and retention issues	63.9

7	GPS location of staff, or other tools (for example, to locate personnel or equipment in buildings or underground)	63.7
6	Getting public to take more "ownership" or responsibility	62.8
1	Local government legislation and bylaws and determining service levels	60.3
2	Training methods in fire dynamics and fire literacy	59.9
4	Need for backup power and other infrastructure during catastrophic events	58.3
1	Education for fire services personnel	54.8
3	The threats and impacts of new materials and technologies	53.2
1	Building code issues and standards	52.6
6	Technology and communications for educational purposes	51.4
2	Fitness and wellness of firefighters	50.8
3	How to better and more quickly implement new technologies	47.8
6	Effective communications and planning with the private sector	47.6
3	Information-sharing protocols between first responders and other jurisdictions	45.8
3	Whether to follow NFPA standards or develop Canadian standards (for example, length of response time)	45.1
4	Understanding fire for emerging classes of infrastructure (for example, e-commerce and cyber infrastructure)	45.1
1	System sustainability and economic support	43.2
1	National level reporting, data, statistics, metrics: understanding policy impacts	41.6
3	Impact of technology: effort and maintenance	41.0
2	Interconnections between practitioners	39.8
4	"Black Swan" scenarios to anticipate future complex situations	29.8
3	How to increase capacity to push and pull knowledge in the community	28.8
5	Border-crossing issues (for example, opportunity with new Windsor-Detroit bridge to discover new technologies and approaches, and potential for projects and exercises)	28.5
2	Industrial health factors (both physical and psychological)	27.4
5	Internal provincial border choke-point issues	27.1
6	How to encourage greater responder self-support	22.0
2	Advanced hazardous materials (hazmat) equipment	11.7
1	Jurisdictional issues	9.4
1	The impact of environmental change	6.1
7	Throwaway sensors	5.4
3	Greater use of controlled laboratories	4.1

Note: Response indicates percentage of respondents who indicated item was one of the top three issues within each question category.

Methodological Note

The purpose of this report is to serve as a background document to help the Fire CoP in setting its S&T research objectives. The individuals surveyed are a select group of fire service professionals – primarily fire chiefs – who were assumed to have a reasonable awareness of the technological challenges facing fire services and future short-term S&T needs. This limitation in the target groups should be kept in mind when considering the results. Other groups of fire service professionals might have quite different perspectives .

The overall response rate to the survey was about 30 per cent. This is not inconsistent with other surveys of this type. With this rate of response, there is always the question of representation bias if the purpose of the survey is to assess the target group's true attitudes with a high degree of accuracy. As indicated, however, the purpose of the survey was to gain some insight into the group's views of S&T priorities for the Fire CoP to consider in formulating a research agenda.

As a sample survey of opinions at a given place and point in time, the results represent *estimates* and not exact values. Resurveying the groups would likely result in some variation in outcomes. It is possible to estimate what the range of variation in results might be over a potential series of surveys. Specifically, we can estimate what the amount of variation might be for the percentage responses. For example, if an item elicited a 50 per cent response, we can estimate that the range of values would be 50 per cent plus or minus 5.4 percentage points in 19 out of 20 surveys. Another interpretation is we can be 95 per cent certain the actual response will be between 44.6 and 55.4 per cent. The level of certainty around the estimates varies with sample size and the proportion or percentage of respondents selecting an item.

Per Cent Responding	Plus or Minus (Percentage Points)	95 Per Cent Confidence Interval	
		Lower Limit	Upper limit
10	3.3	6.7	13.3
20	4.4	15.6	24.4
30	5.1	24.9	35.1
40	5.4	34.6	45.4
50	5.6	44.4	55.6
60	5.4	54.6	65.4
70	5.1	64.9	75.1
80	4.4	75.6	84.4
90	3.3	86.7	93.3

To simplify the presentation of the tables, estimates of the confidence intervals around the estimated results were omitted. Those interested, however, may use the table above to determine the probable ranges. These estimates are based on a 95 per cent level of certainty based on the number of responses obtained. Higher levels of certainty would generate wider confidence intervals, while lower levels of certainty would generate narrower ones.

Author Biographical Information

Paul Maxim obtained his MA in criminology at the University of Ottawa and his PhD in sociology at the University of Pennsylvania where he specialized in criminology and research methods. He is currently a professor in the Department of Economics and the Balsillie School of International Affairs at Wilfrid Laurier University in Waterloo, Ontario. His primary areas of research interest are population and labour economics.

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The purpose of this report is to help verify and hone a set of strategic priorities that members of the Canadian Fire Community of Practice (Fire CoP) have identified as intermediate research needs relating to science and technology (S&T)

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Le but de ce rapport est d'aider à vérifier et parfaire un ensemble de priorités stratégiques que les membres de la communauté canadienne de prévention des incendies de pratique (CoP de feu) ont identifiés comme des besoins de recherche intermédiaires relatives à la science et la technologie (S & T).

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