

**Knowledge Leading to Action:**

*Examining obligations to incorporate current scientific understanding of the modern fire environment and fire dynamics into Ottawa Fire Services training and practice.*

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## **EXECUTIVE SUMMARY**

In the context of the Ottawa Fire Services, this paper explores how firefighters in the City of Ottawa are exposed to recent developments in the understanding of the science of fire behaviour (fire dynamics), and how this knowledge is maintained and updated. Making linkages to occupational health and safety legislation, professional standards and relevant guidelines, the paper examines how fire services are legally obligated to provide appropriate training, and explores risk management and accreditation obligations internal to the City of Ottawa. In so doing, the paper demonstrates the need to develop and maintain a level of fire literacy adequate to protect firefighters from the inherent dangers of their working environment. Current demographics and training practices are discussed while referencing case studies that illustrate the dangers of not providing firefighters with the guidance required to make fire scene decisions grounded in evidence-based science. The paper recognizes the recency of developments in fire dynamics research and knowledge, and, while acknowledging that steps have been taken to develop and deliver such training in Ottawa, argues that these steps remain inadequate without further commitment. Recommendations are presented to ensure that assurances are in place to complete and maintain a validated, evidence-based fire dynamics program.



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## Chapter 1

### Introductory Comments

*The mission of Ottawa Fire Services is to protect the lives, property and environment for the residents of, and visitors to, the City of Ottawa. Its vision is to be a modern and integrated fire service that operates seamlessly, employs highly-productive and highly-motivated people, uses innovative practices and technology and strives to improve every day.*

- Ottawa Fire Services 2014 Annual Report

*We've always done it this way.*

- Anecdotal refrain heard throughout the fire service

The Ottawa Fire Services (OFS) is a large, composite fire department, serving approximately 950,000 residents of the City of Ottawa across a geographic area of 2,796 square kilometres, with a suppression division made up of more than 850 full-time firefighters staffing 29 stations in the urban core, 500 paid on-call firefighters operating from 16 stations in the rural areas<sup>1</sup>, and full-time communications, prevention, maintenance and training divisions. The OFS is tasked with not only the traditional firefighting activities of fire suppression and prevention, but also with specialized rescue operations such as water/ice rescue, vehicle extrication, high-angle rescue, trench rescue and hazardous materials responses, to name a few. In order to develop and maintain the most effective response capability and to remain compliant with applicable legislation, training across all disciplines must be current, ongoing, relevant, consistent and comprehensive, and it must incorporate both theoretical and practical components.

This paper examines one aspect of fire suppression training and on-scene emergency operations. Specifically, it explores how firefighters in the City of Ottawa are taught to

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<sup>1</sup> The OFS' 2014 Annual Report indicates totals of 863 career personnel in Operations/Special Operations and 487 paid on-call personnel (OFS, 2015:7).

understand the science of fire behaviour (fire dynamics), and how this knowledge is maintained and updated. The paper makes links to requirements set forth under Ontario's Occupational Health and Safety Act as well as to professional standards and guidelines that apply to firefighting practices in Ontario, addressing how fire services are legally obligated to provide appropriate training, and applies an enhanced risk management approach to the topic, exploring the obligations that internal City of Ottawa processes require in relation to firefighter training and development, as well as to service delivery. In so doing, gaps between these requirements and practice are identified, and recommendations are made to mitigate these gaps in the context of the OFS in terms of the development, delivery and ongoing support for an appropriate fire dynamics training program. The paper includes a contextualization of the issue, recognizing the emergence of concerns and the very real consequences of maintaining the status quo.

## **Chapter 2**

### **Contextualizing the Issue**

Traditionally, North American fire services have used a predominately experience-based approach to firefighter training and development, incorporating little scientifically validated fire dynamics instruction and few evidence-based firefighting procedures (Campbell, 2014; Kerber, 2013; 2014; McBride, 2009; Svensson, 2010). While this may have been considered adequate in the past, and while anecdotal experience remains extremely important, changes to the modern fire environment combined with legislated worker protections and employer responsibilities expose weaknesses to this approach.

### **Fire Dynamics**

Fire dynamics is the study of how chemistry, fire science, and the engineering disciplines of fluid mechanics and heat transfer interact to influence fire behaviour, or, simply put, how fires start, spread and develop (NIST, 2016a). As a firefighter, understanding fire dynamics means not only comprehending the processes influencing fire growth and development, but also having the ability to evaluate fire conditions and potential hazards in order to choose appropriate mitigations (strategies and tactics) while understanding how those mitigations will affect fire development, the structural integrity of fire buildings and exposures, firefighter safety and overall operations.

Modern building construction materials and techniques result in larger homes, with more open spaces and void areas. Construction materials and increased content fuel loads, consisting of synthetic materials such as plastics, alter the modern fire environment, producing far greater heat release rates when burning than the mostly natural materials found in fuels in the past. The result is much faster fire propagation and rapid changes in fire behaviour, including shorter time

to extreme fire events, shorter escape times, shorter time to structural collapse and an increased potential for dangerous rapid fire development. Additionally, the transition from fuel-controlled fires to ventilation-controlled fires<sup>2</sup> is often much more rapid, creating significantly more dangerous conditions for first-arriving firefighters than in the past. Traditional suppression tactics often no longer apply under these circumstances, and anecdotal experience may not provide for appropriate responses (Bolton, 2014; Cagala, 2014, Kerber, 2014; McBride, 2009).

### **Demographics and Experience**

Also impacting fire literacy<sup>3</sup> in the fire service is a decrease in the total number of fires encountered combined with a demographic shift in staffing. Many fire services have experienced, or are experiencing, significant retirements, resulting in overall firefighter experience levels decreasing. As such, even when it is found to be useful and applicable, fire services are losing years of experience without adequate knowledge replacement. Ottawa is no exception. Approximately 1/3 of OFS firefighters have less than 5 years of operational experience, and with an average of just over 3000 structure fires each year shared across 4 shifts, opportunities to learn through direct experience are limited. Relying on emergency incidents for fire training and development without conducting adequate, validated live-fire training scenarios is not acceptable given these circumstances. Compounding these problems, technological advances in personal protective equipment enable firefighters to undertake operations further into buildings under hazardous fire conditions, allowing firefighters to potentially advance into more dangerous situations than in the past.

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<sup>2</sup> A fuel-controlled fire is dependent upon available fuel for further development; a ventilation-controlled fire is dependent on available oxygen for further development.

<sup>3</sup> Fire literacy in this context refers to an overall understanding of fire dynamics and fire science.

To summarize, firefighters are now capable of advancing deep into well developed fire situations without the benefit of extensive incident experience, using strategies and tactics often based on non-validated anecdotal information emerging from a previous generation of firefighters operating under very different fire conditions and who may have misunderstood exactly what was occurring to benefit or hinder their mitigations (McBride, 2009:64). Many firefighters do not have a well developed knowledge of modern fire dynamics on which to base tactical decisions, and so are in danger of making mistakes with potentially deadly consequences (McBride, 2009:61).

### **Recent Incidents**

Within the past several years, several notable Canadian incidents have occurred during firefighting operations which highlight the need to address this reality. These include the death of a captain with the service de sécurité incendie de Montréal in January, 2006, the deaths of two captains with Winnipeg Fire Paramedic Service in February, 2007<sup>4</sup> and the deaths of two volunteer firefighters in Listowel, Ontario in March, 2011. Specific to the City of Ottawa, in February of 2007 five OFS firefighters were critically injured after being forced by fire conditions to jump out of 4<sup>th</sup> storey windows during a structure fire. In each of these incidents, rapid fire progression and changes to fire behaviour occurred. Subsequent investigations identify inadequate scene size-up, risk assessment, operational guidelines and fire dynamics evaluation as factors contributing to critical injuries and fatalities (Bolton, 2015; City of Winnipeg, 2007; King, 2012; McBride, 2009). To prevent similar tragic events, modern fire services such as the OFS must evolve and incorporate a scientifically validated understanding of fire dynamics into training and practice.

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<sup>4</sup> Note that while this paper was being completed, Winnipeg Fire Paramedic Service was involved in a structure fire resulting in burn injuries to 3 firefighters. No report on this April 23, 2016 fire has been released at this time.

In the United States, firefighter injury and fatalities paint a similar picture<sup>5</sup>. Despite a wide range of initiatives undertaken by fire services aimed at increasing firefighter safety in North America, including programs related to incident management, personnel accountability, rapid intervention teams, and health and wellness, the National Institute for Occupational Safety and Health (NIOSH) notes that “each year an average of 100 fire fighters die in the line of duty” (NIOSH, 2016). NIOSH conducts investigations into firefighter line of duty deaths and issues summary reports and recommendations for the prevention of future similar events. In those recent investigations related directly to structure fires, recommendations consistently and across multiple jurisdictions include integrating current fire behaviour (fire dynamics) research findings into firefighter training and operations, citing recent studies conducted by the National Institute of Standards and Technology (NIST) and Underwriters Laboratories (UL)<sup>6</sup> (Bolton, 2015; McBride, 2009; see for example NIOSH 2010; 2013a; 2013b; 2013c; 2014; 2015a; 2015b; 2016b<sup>7</sup>). Although much of the research is relatively recent, and as such investigators previously lacked the tools or the terminology to make appropriate recommendations, a cursory review of earlier investigations (prior to approximately 2006) indicates a lack of understanding of fire dynamics by firefighters in many of those incidents as well<sup>8</sup>.

Simply put, firefighters have been and are being injured and killed as a result of inadequate fire literacy. Fireground practices must reflect current research; these practices and

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<sup>5</sup> While it is acknowledged that data from the United States reflect some differing jurisdictional realities, similarities in construction techniques, material use, societal standards and firefighting practices allow for comparisons to be made with relative confidence. Additionally, firefighting standards across North America are closely interrelated (for example, North American fire services rely heavily on the National Fire Protection Association (NFPA) for professional qualification standards; Ontario specifically adopted the use of these standards in 2014).

<sup>6</sup> NIST and UL remain at the forefront of North American research into fire development and fire behaviour, undertaking multiple and ongoing studies related to the modern fire environment.

<sup>7</sup> Additional example reports are available online (NIOSH 2016a).

<sup>8</sup> These earlier reports describe on-scene actions that are contrary to those that would be expected given a comprehensive understanding of modern fire dynamics; however, they do not reference the terminology as such, as it was not, at the time of the reporting, fully developed or communicated to the fire service or NIOSH. Indeed, it is the newness of this information and its recent dissemination that serves as the impetus for change described in this paper. Now that we know, the argument is made that we must now act on that knowledge.

the science behind them must be taught to all firefighters, from the new recruit through to Chief Officers. This instruction must include both theoretical and practical components, and fire services need to support initial and ongoing training in order to adequately protect firefighters.

## Chapter 3

### Legal Obligations, Guidelines and Standards

#### Occupational Health and Safety Legislation

Managing structural firefighting operations is complex and challenging. Structural fires are among the most potentially hazardous incidents that firefighters encounter, both in terms of the high levels of exertion required during operations and the potential for injuries or death from burns, smoke exposure, structural collapse, disorientation, and falls. Mitigating the risk involved is difficult at best; eliminating this risk when interior firefighting operations are required is essentially impossible. Indeed, this is acknowledged in Part V, Section 43 of Ontario's *Occupational Health and Safety Act (OHSA)*, which stipulates that when danger is "inherent in the worker's work or is a normal condition of the worker's employment" or "when the worker's refusal to work would directly endanger the life, health or safety of another person", firefighters do not retain the right to refuse or stop unsafe work (OHSA, R.S.O. 1990, c.0.1, s.43). Obviously, this applies to firefighters operating at a structure fire. Despite this caveat, however, municipalities as employers also have a duty under Part III of the *OHSA* to "take all reasonable precautions, under the particular circumstances, to prevent injuries or accidents in the workplace" (OHSA, R.S.O. 1990, c.0.1, s.25). That is to say that Part V s.43 of the *OSHA* does not remove the legal requirement to provide appropriate training and supervision to firefighters expected to operate at structure fires simply because there is inherent danger involved. Reasonable precautions must be taken, and these include providing appropriate training for fire service supervisors and workers to guide actions and decision-making on a fireground. A summary of the *OHSA*, Part III, pertaining to general duties of employers, is provided here, with emphasis placed on areas deemed applicable to this discussion:

**An Ontario employer, who is covered by the OHSA, has a range of legal obligations, including the obligation to:**

- **instruct, inform and supervise workers to protect their health and safety** [clause 25(2)(a)]
- assist in a medical emergency by providing any information—including confidential business information—to a qualified medical practitioner and other prescribed persons for the purpose of diagnosis or treatment [clause 25(2)(b)]
- **appoint competent persons as supervisors [clause 25(2)(c)]. “Competent person” is a defined term under the Act. A “competent person” is defined as one who must:**
  - **be qualified—through knowledge, training and experience—to organize the work and its performance**
  - be familiar with the Act and the regulations that apply to the work being performed in the workplace
  - **know about any actual or potential danger to health and safety in the workplace**

An employer may appoint themselves as supervisors if they meet all three qualifications [subsection 25(3)].

- inform a worker, or a person in authority over a worker, about any hazard in the work and train that worker in the handling, storage, use, disposal and transport of any equipment, substances, tools, material, etc. [clause 25(2)(d)]
- help joint health and safety committees and health and safety representatives to carry out their functions [clause 25(2)(e)]
- not employ or permit persons, who are under the prescribed age for the employer’s workplace to be in or near the workplace [clauses 25(2)(f) and (g)]
- **take every precaution reasonable in the circumstances for the protection of a worker** [clause 25(2)(h)]

*(Excerpt from Ontario Ministry of Labour, 2016c, emphasis added)*

As of 2004, the *Criminal Code of Canada (CCC)* further emphasizes this legal obligation of employers, creating a criminal offence under Section 217.1 that requires that “every one who undertakes, or has the authority, to direct how another person does work or performs a task is under a legal duty to take reasonable steps to prevent bodily harm to that person, or any other person, arising from that work or task” (CCC R.S.C. 1985, 217.1). Section 22.1 of the CCC further imposes criminal liability on organizations and its representatives for negligence (CCC R.S.C. 1985, 22.1).

## Section 21 Guidance

The Ontario Fire Service Advisory Committee on Occupational Health and Safety operates under Section 21 of the *OHSA*, and exists to advise and make recommendations on matters relating to firefighter occupational health and safety in Ontario. With the support of the Ontario Ministry of Labour (MOL), the committee develops Guidance Notes and a Guidance Manual for fire services, to allow fire services to compare procedures against recommended practice, in compliance with the intent and provisions of the *OHSA*. MOL inspectors refer to the Guidance Notes and Guidance Manual to determine if reasonable precautions for the protection of a worker are being taken under clause 25(2)(h) of the *OHSA* when they carry out enforcement duties (Ontario Ministry of Labour, 2013). While these Guidance Notes are not statements of law, they can and have been used to support claims of compliance or non-compliance with the *OHSA*.

Several Guidance Notes apply to providing appropriate training in the fire service as it pertains to this discussion. For example, *Guidance Note #7-2, 'Training Requirements'*, refers specifically to *OSHA* Section 25(2)(a), and states that “the employer shall provide training and instruction for all fire department members commensurate with the duties and functions that they are expected to perform” (Ontario Ministry of Labour, 2007). The City of Ottawa expects firefighters to perform interior firefighting as required to save lives and salvage property. Revised in February of 2016, *Guidance Note #7-6 'Hazardous Fire Conditions – Rollover, Flashover and Backdraft'* refers to dynamic fire events, and states that “employers need to provide their personnel with the appropriate information, instruction, and supervision to ensure that firefighters understand the various hazardous fire conditions to which they may be exposed, as well as the controls required for them to protect their health or safety” and recommends key

elements to be included in training programs (Ontario Ministry of Labour, 2016a). *Guidance Note #6-6 'Rapid Fire Progression'* has yet to come into effect, but the draft document expected to be released imminently notes that:

Fire departments should develop training in fire dynamics for suppression personnel. Fire suppression personnel should be aware of the combustibility of modern contents and how they can impact compartment fire behavior and rapid fire progression events.

This training should include information on identifying ventilation flow paths and understanding how fire suppression activities can influence a flow path that could result in rapid fire progression.

There are critical differences between fuel-limited and ventilation-limited fires, and correspondingly, different hazards. Generally, the opportunity for injury and the greatest hazard to fire suppression personnel is present during ventilation-limited compartment fires, which could lead to roll-over, flash over, back draft, or any rapid fire progression event.

- Ontario Ministry of Labour, 2016b

These Guidance Notes reflect recent developments in the understanding of modern fire dynamics; fire services in Ontario will be expected to follow suit and institute measures to maintain compliance with *OHS*A requirements.

### **Professional Standards**

In 2014, Ontario began the transition from Ontario Fire Service Standards to National Fire Protection Association (NFPA) Professional Qualifications Standards, taking advantage of the NFPA's recognized ability to provide certification to firefighters in particular skills (OFMEM, 2014). Much of OFS' professional development, policies and procedures are based on NFPA standards (OFS, 2014c), which align with *OHS*A requirements and *Section 21 Guidance Notes* as well as requirements of the *Ontario Fire Protection and Prevention Act (1997) (FPPA)*<sup>9</sup>. For example, NFPA 1500 determines much of OFS' occupational health and safety

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<sup>9</sup> Under Part III, Clause 9(2)(d) of the *Ontario Fire Protection and Prevention Act (1997)*, it is the duty of the Ontario Fire Marshal to develop training programs and evaluation systems for persons involved in the provision of fire protection services and to provide programs to improve practices relating to fire protection services. The Office of the Fire Marshal had developed a core curriculum around fire suppression operations, and OFS had adopted this

program, including the safety requirements for members involved in fire suppression and related activities, including firefighter training, and NFPA standards 1401-1452 are established standards for fire service training.

In August of 2015, NFPA established a *Technical Committee on Fundamentals of Fire Control Within a Structure Utilizing Fire Dynamics*, to develop material for *NFPA 1700: Guide for Structural Fire Fighting*, which is currently in development (NFPA, 2016b). This decision again reflects the recency of the research and the immediacy of incorporating validated materials into professional standards. As NFPA Standards are used by the OFS to develop policies and procedures, this new standard can be expected to be adopted as well.

Taken together, the NFPA standards, Section 21 Guidelines, and the *OHSA* dictate what the City of Ottawa is expected to do with respect to the training and supervision of firefighters; in this instance, as that relates to OFS training programs, and, specifically, to the incorporation of existing and evolving fire dynamics knowledge into training and practice.

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Ontario Curriculum for performance based training while adapting it to local requirements. As this transition occurs, NFPA standards become the accepted standards which OFS follows.

## Chapter 4

### City of Ottawa – Internal Considerations

The City of Ottawa itself has internal obligations to provide appropriate training and development to firefighters independent of the previously discussed legal aspects. Examples are included here.

#### *Enhanced Risk Management*

Since 2010, the City of Ottawa has had in place an Enhanced Risk Management (ERM) Policy (2013a). This policy identifies management of risk as a shared responsibility of all City levels, requiring all employees to demonstrate risk-aware thinking and for managers to be aware of and act on risk management concerns. Risk management is explicitly required at “all strategic, corporate and operational levels including projects and work activities where risk is inherent” and identifies as objectives to:

- Embed risk management into the culture of the City
- Reduce events or conditions that create uncertainty
- Ensure that unplanned events are managed effectively
- Provide common and consistent risk management processes and practices.

*City of Ottawa Enhance Risk Management Policy, Revised December 11, 2013.*

In the context of this discussion, risk management includes the avoidance and/or mitigation of hazards, the management of uncertainty and the harnessing of opportunities. “Employees are expected to promote and facilitate appropriate risk control techniques to manage the risks to the public and employees’ health, safety and security, mitigate liability and protect corporate assets against loss and damage”, and managers are required to manage identified risks appropriately (Ibid).

While this policy is often directed towards financial and legal risk management of routine corporate activities, it explicitly applies across all aspects of City operations; as such, ERM applies to both the training and operations levels within the OFS, and must be taken into account when developing not only non-emergency management policies and procedures but also be embedded in training and on-scene emergency response activities.

### **Applying ERM in this Context**

Current levels of knowledge of fire dynamics within the OFS result in significant risks to the Corporation of the City of Ottawa. Assessment tools identified in the ERM policy and through the City of Ottawa Corporate Risk Management Framework allow us to identify the following existing risk as applicable to this discussion. The use of inappropriate suppression tactics and/or misidentification of hazards during firefighting due to a lack of understanding of fire dynamics introduce the following risks:

1. Risk of firefighter/civilian death, significant permanent disability or critical injury;
2. Economic risk – high dollar loss – i.e. legal fees, law suits, death benefits, economic losses due to fire loss, etc.
3. Legal liability – as related to the *OHSA* as well as property law;
4. Criminal liability – as related to the *Criminal Code of Canada*.

*Appendix A: Enhanced Risk Assessment – Fire Dynamics* applies the aforementioned risk management tools (templates/matrices/maps), categorizing the combined risk as ‘high’<sup>10</sup>. That is to say the risk combines potential high impact (severity) events with at least mid-range probability (likelihood) of occurrence. According to City policy, ‘high’ risks require a mitigation strategy (City of Ottawa, 2013b:6).

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<sup>10</sup> The City of Ottawa Enhanced Risk Management (ERM) Framework provides direction on conducting risk assessments and evaluating results.

### *Commission on Fire Accreditation International*

Overseen by the Center for Public Safety Excellence (CPSE), the Commission on Fire Accreditation International (CFAI) administers a comprehensive self-assessment and evaluation program, enabling fire services to examine past, current, and future service levels and internal performance and compare them to industry best practices (CPSE, 2016). In August of 2014, OFS received accreditation with CFAI, making it one of fewer than 200 agencies worldwide to achieve International Accredited Agency Status. The distinction signifies that OFS has measured up to industry standards and best practices in all aspects of its business including operations, prevention, training, communications and administration. In order to achieve this designation, the OFS appraised its ability to meet performance indicators, and has either met certification requirements or has demonstrated a plan to meet the requirements of each indicator. The OFS has made a commitment to maintain this accreditation, and is required to be re-assessed every 5 years, ensuring compliance and continuous updating to industry best practices (OFS, 2015:8-9). As standards and practices evolve, so will the requirements.

In terms of fire literacy, the following *Table 1: CFAI Category 8 Training and Competency – Commitments that will require incorporation of modern fire dynamics* has been developed by the author to provide examples of training performance indicators which must be addressed by incorporating modern fire dynamics into policies and procedures in order to maintain compliance<sup>11</sup>.

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<sup>11</sup> This is not an exhaustive list, as many CFAI performance indicators outside of training and competency, especially those involving occupational health and safety, are also impacted by the need to recognize recent developments in the understanding of fire dynamics; however, Table 1 serves to provide an overview of many of the needs requiring consideration. It focuses on those reflective of this discussion, emphasizing training obligations and delivery needs.

**TABLE 1: CFAI Category 8 Training and Competency –  
Commitments that will require incorporation of modern fire dynamics**

Performance Indicator <sup>12</sup> (Stipulated by CFAI)	Steps required to maintain CFAI compliance relative to recent developments in the understanding of modern fire dynamics
8B.1 A process is in place to ensure personnel are appropriately trained	The OFS will continue to ensure that personnel are appropriately trained, meeting all legislative requirements and industry best practice. Research and development and current trends will augment training. As recognized Standards and Guidance Notes evolve to recognize modern fire dynamics, legal requirements under the <i>OHSA</i> will require that OFS act on these changes. This commitment indicates a need to acknowledge and incorporate recent research as well as current trends in fire dynamics training. A validated fire dynamics curriculum will need to be delivered to personnel.
8C.1-CC Available training facilities and apparatus are provided to support the training needs of the agency	In order to deliver an adequate practical fire dynamics training curriculum, live-fire tools will be required as well as suitable locations in which to conduct training evolutions. Existing OFS training sites are inadequate for appropriate fire dynamics training.
8C.2 Instructional personnel are available to meet the needs of the agency	Trained instructional personnel will be required to deliver a validated fire dynamics curriculum. The OFS will need to provide innovative solutions to training needs, including the use of e-learning platforms, and time will need to be allotted to train instructors and maintain currency.
8C.3 Instructional materials are current, support the training program, and are easily accessible	Current curriculum materials reflecting modern fire dynamics will be required, and delivery must be planned and maintained.
8C.7-CC Training materials are evaluated on a continuing basis and reflect current practices	As fire dynamics curriculum materials become available, OFS will be required to adopt and deliver them.

**Current Training Practices**

Professional firefighters are expected to take action to save lives and protect property from fire. As such, they are expected to be ‘experts’ in their field. In many ways, OFS firefighters are indeed accomplished experts, especially in relation to operating firefighting apparatus and equipment, managing victims and applying known strategies and tactics. An enormous amount of training goes into sustaining this expertise; however, time spent on the

<sup>12</sup> Performance indicators are taken from the OFS CFAI Self-Assessment Manual (OFS, 2014c).

study of fire dynamics, arguably what firefighters should be most expert in, is inadequate. Indeed, the amount of time spent dedicated to the study of fire dynamics is woefully small.

OFS conducts initial training for all of its new recruits over a ten to twelve week period. Out of this, the time dedicated to instruction in fire dynamics totals a mere 3.5 to 5 hours (personal communication with OFS Training Officers, January 2016), and is covered under the headings of fire behaviour, fire control and size-up. Much of it is based on Chapter 5 of the International Fire Service Training Association's Essentials of Firefighting (IFSTA, 2013), which contains information and skills required for NFPA 1001: Standard for Fire Fighter Professional Qualifications. While this information meets this NFPA minimum standard, it does not reflect the evolving needs of firefighters to understand modern fire dynamics, nor is it likely to meet evolving standards such as NFPA 1700 (in development). Additional discussion of fire dynamics takes place throughout this training period during various practical evolutions such as live-fire training and flashover training as well, which is useful and encouraging, but this is not dedicated fire dynamics instruction.

Ongoing training on the topic is minimal as well, with no required recertification in fire dynamics related topics over the course of a career. Certainly, fire behaviour is discussed during various practical training evolutions, smoke reading and fire control training sessions, but this again is not dedicated fire dynamics training, and so there is little evidence of accurate knowledge transmission to firefighters (see also discussions on fire behaviour, risk assessment, and training in McBride, 2009). As such, it is unlikely that many OFS firefighters can be considered 'experts' in the study of fire dynamics<sup>13</sup>. Given this lack of expertise, it is argued that the OFS does not meet the standards required under NFPA 1500 nor its requirements under the

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<sup>13</sup> Individual OFS firefighters and officers have taken additional training and education, often at their own expense, and have become well versed in modern fire dynamics; however, this is far from the norm in the OFS.

*OHSA and Section 21 Guidance Notes.* With an obligation to provide appropriate knowledge for a worker to remain safe in their work environment and to provide competent supervision, a validated and measurable level of expertise is required. The bottom line is this: if the City of Ottawa and the OFS are to meet their legal, professional and internal obligations, a validated fire dynamics program must be adopted for, delivered to, and maintained for, its front-line personnel.

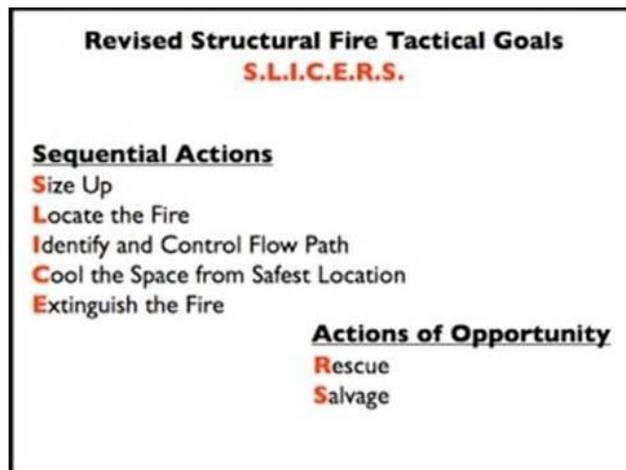
## Chapter 5

### Current Initiatives

OFS acknowledges the desire to incorporate modern fire dynamics research into its activities, and takes steps to educate and train personnel. While not yet embedded sufficiently into training and operations, current initiatives are described here.

#### SLICE-RS

SLICE-RS is an acronym developed to operationalize fire dynamics research concepts, enabling first-arriving firefighters to methodically apply knowledge and make tactical decisions based on validated science and observed conditions. It rethinks older tactics and incorporates recent research. Developed by the International Society of Fire Service Instructors (ISFSI), and incorporating NIST and UL research and scientific analysis of fire in the structural firefighting environment, the SLICE-RS process has been vetted by industry subject matter experts and involved researchers and has their endorsements (Reeder and Milan, 2014; Modern Fire Behavior, 2016). The SLICE-RS acronym is outlined here:



- Image taken from Modern Fire Behavior, 2016.

In 2015, two OFS training officers and approximately 20 firefighter paratrainers were trained as instructors in the delivery of the SLICE-RS program. To this point, these instructors have delivered the one-day classroom SLICE-RS program to approximately 90% of full-time firefighters and officers and are in the process of delivery to the paid on-call personnel in Ottawa's rural areas. While the acronym itself is a useful on-scene tool, the science behind it and the changes in the understanding of fire dynamics delivered during the course are significant with respect to increasing fire literacy in the OFS. The SLICE-RS program is one step towards a more complete understanding of fire dynamics, and embedding SLICE-RS into operational procedures<sup>14</sup> helps enable firefighters to draw on that understanding to make appropriate tactical decisions.

SLICE-RS is not comprehensive, however, serving as an introduction to the applicable theory. It does not provide the practical training required to apply the lessons learned from the research, nor does it provide a complete picture of what one encounters on the fireground. For example, it advocates appropriate 'Size-up', but does not go into detail about reading smoke and other indicators<sup>15</sup>. Further training is required to cover specifics, and practical evolutions are needed to provide firefighters with the appropriate knowledge and abilities to operate in their working environment; this training must be competency-based to ensure mastery of principles is achieved<sup>16</sup>.

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<sup>14</sup> The 2016 OFS Operational Guide was released on April 29, 2016, and formally embeds SLICE-RS into the actions of first-responding firefighters at structure fires. The Guide states that it "has been developed using the combined knowledge of OFS personnel, supplemented by credible external sources of information and research. Agencies such as Underwriters Laboratories (UL), National Institute of Standards and Technology (NIST) and the International Society of Fire Service Instructors (ISFSI) have been referenced and applicable information has been incorporated into this document" (OFS, 2016b:1).

<sup>15</sup> A realistic overview of firefighting operations is beyond the scope of this paper; examples such as this are simply provided as contextualization of the discussion points.

<sup>16</sup> Competency-based training has replaced traditional training in the fire service as the best-practice to develop skills and achieve mastery of required knowledge. See, for example, the presentation by Weider (2007) or the description of competency-based learning in Fire Service Instructor: Principles and Practice (NFPA, IAFC and ISFSI, 2009).

### ***From Knowledge to Practice – Fire Dynamics Curriculum Project***

In 2013, a team of OFS firefighters, under the direction of Division Chief of Safety and Innovation Peter McBride, applied for and received a 1.2 million dollar grant from the Canadian Safety and Security Program (CSSP), led by Defence Research and Development Canada's Centre for Security Science, to undertake a project alongside partners from the Calgary Fire Department, Halifax Regional Fire & Emergency and the service de sécurité incendie de Montréal to develop and deliver a comprehensive, evidence-based fire dynamics curriculum. In addition to the CSSP's commitment, the project receives widespread support from the Canadian and international fire service communities, totalling almost 3 million dollars of in-kind contributions (OFS, 2014:14).

Titled *From Knowledge to Practice (FKTP)*, the project brings together a diverse group of subject matter experts from around the world, including scientists and practitioners, incorporating international research into modern fire dynamics, best practices, and innovative firefighting techniques to develop theoretical and practical competency-based learning materials. Project manager Chief McBride is a recognized expert in the field, instrumental in the characterization of many emerging fire dynamics concepts through his research and participation on many international technical and advisory committees directly related to the subject, including the aforementioned *NFPA Technical Committee on Fundamentals of Fire Control Within a Structure Utilizing Fire Dynamics*. International instructors have been selected to deliver the initial curriculum materials to OFS personnel, who will become fire dynamics instructors and in turn be capable of delivering the curriculum to Ottawa firefighters as well as representatives from fire services across Canada. The National Research Council (NRC) of

Canada is a contracted partner, providing validation expertise and a suitable training development location at its fire labs in Mississippi Mills, Ontario.

The impetus for this project was the aforementioned 2007 incident resulting in critical injuries to 5 Ottawa firefighters. Known as the Forward Avenue Fire, this incident led to the 2009 release of The Workers' Report - Critical Injuries: Forward Avenue Fire, Ottawa Fire Services Incident # 07-8038<sup>17</sup>. The report, commissioned by the Ottawa Professional Fire Fighters Association (OPFFA) and authored by Chief McBride, provides an example of the emergence of modern fire dynamics research, accurately describing fire behaviour and many associated concepts as they relate to fire ground operations. It contains 85 recommendations intended to prevent similar occurrences, including that the:

- OFS develop, implement and maintain a comprehensive fire dynamics course for all operational personnel.
- OFS instructors undertake... Compartment Fire Behaviour Training (“CFBT”) in order to deliver it within the department.
- OFS engage subject matter experts in all phases of program development wherever possible.
- OFS develop, implement and maintain curriculum directed at firefighter, officer and chief officer development that encompasses knowledge (theory), skills (application) and abilities (evaluation) in its design.
- OFS undertake a feasibility study for the construction of a new purpose built, all season, multi-discipline training facility.
- OFS integrates... Compartment Fire Behaviour Training (“CFBT”) within structural firefighting operational training
- OFS immediately discontinue the practice of delivering abridged versions of training courses.
- OFS undertake a comprehensive review of all current fire suppression training materials and courses to establish their efficacy with respect to procedural context and operational realities.

- *McBride, 2009:4-5; see also Bolton, 2015.*

Importantly, the OPFFA is highly supportive of the FKTP project, and has made considerable contributions to its success, not only financially but also by negotiating with the City of Ottawa to allow union members to participate under adjusted labour and remuneration conditions. The

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<sup>17</sup> Commentary on the release of this report is available online here: <http://www.fireengineering.com/articles/2010/08/forward-ave-report.html>. The full report is available online here: [http://www.ottawafirefighters.org/items/ForwardAvenue\\_GOLD\\_1\\_Mar\\_11.pdf](http://www.ottawafirefighters.org/items/ForwardAvenue_GOLD_1_Mar_11.pdf).

development of a fire dynamics curriculum can be seen as a win-win situation in that both labour and management have demonstrated agreement that it should go forward, and are providing a positive example of what can be accomplished by working together. Certainly, both management and the union recognize that the FKTP project addresses many of the key recommendations of the Forward Avenue Report<sup>18</sup>.

This multi-year project is currently under way, and curriculum materials will be ready for dissemination this fall<sup>19</sup>. The curriculum incorporates an e-learning component as well as a week-long theoretical classroom component and practical evolutions using standardized, validated teaching props and live-fire enclosure fire dynamics training simulators. As such, it goes beyond the outline provided by SLICE-RS, to provide a thorough understanding of the science of fire dynamics, and includes tactical options and evaluation tools<sup>20</sup>, as is required by the previously discussed obligations binding the City of Ottawa. NFPA has committed as well, through its development of NFPA 1700, to incorporate the findings and practices of the final curriculum into its standards, demonstrating the value placed on the project by the industry.

Primary funding for the project has come from the Government of Canada, with the OFS providing in-kind contributions of equipment and time to allow approximately 20 firefighters to complete initial training over a two-week period at the NRC in 2015 towards becoming instructors. While this contribution is considerable, measures must be taken to ensure that

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<sup>18</sup> It should be noted that partner firefighter unions are also supportive of the project, providing sponsorship and publicly encouraging the development and adoption of deliverables. Again, this support demonstrates the value placed by all interested parties on such a curriculum.

<sup>19</sup> Curriculum materials will be made available to all interested parties. A key component of FKTP is that deliverables are accessible free of charge to firefighters across Canada. While OFS leads the way in terms of instructor training and development, efforts will be made to ensure all firefighters can benefit from the knowledge and tools. In this way, the City of Ottawa and OFS lead by example, placing emphasis on worker safety, education, and efficacy.

<sup>20</sup> While, as previously mentioned, SLICE-RS is a start, the FKTP project goes into detail about the components required to ensure adequate knowledge transmission, and includes tactical options based on observed conditions. The curriculum also includes necessary details regarding training hygiene practices, training tool development, training requirements as required under NFPA standards, and ongoing recertification.

additional resources are provided to complete instructor training. For practical evolutions, developing instructors will require hundreds of hours of time using the fire dynamics tools to become safe and proficient. This requires significant investment from the OFS. Furthermore, the delivery of the curriculum to nearly 1400 OFS firefighters and ongoing recertification will require a commitment from the highest levels of management. The commitment to complete instructor training appears to be in place, given the investment already made in the project; however, no formal commitment has been made to deliver the final curriculum across the OFS with ongoing support for recertification.

## Chapter 6

### Recommendations

Given the arguments presented here based upon the requirements to manage risk, comply with standards, maintain professional accreditation, and act in accordance with applicable legislation, the City of Ottawa and Ottawa Fire Services are advised to act on the following recommendations:

***Recommendation 1: Maintain current levels of support for the FKTP fire dynamics curriculum project until such time as the project is completed.***

- Current in-kind support for this project is adequate based upon the scope of the project. Should additional resources be required to complete the project, OFS is encouraged to consider allowing these resources, within reason.

***Recommendation 2: Provide resources to ensure OFS fire dynamics instructor-candidates are able to complete practical training.***

- As resources for the additional hours required for OFS instructor-candidates to become safe and proficient in conducting the practical training evolutions are beyond the scope of the FKTP project budget itself, OFS must provide those resources.

***Recommendation 3: Provide resources to ensure OFS personnel receive the FKTP curriculum, in its entirety.***

- Upon completion of the FKTP curriculum, OFS must provide for the initial instruction of all front-line personnel to ensure the requirements of knowledge and competency are met.

***Recommendation 4: Provide resources to ensure OFS personnel receive ongoing fire dynamics training.***

- Subject to curriculum requirements, OFS front-line personnel must be allowed to be recertified in fire dynamics training on a regular basis, in order to maintain competency and remain current on best practices and scientific understanding.

***Recommendation 5: Develop a suitable training location with adequate, maintained resources to conduct live-fire fire dynamics training scenarios, including hygiene and rehabilitation capabilities.***

- Live-fire training must be conducted regularly on a dedicated site, using validated and maintained teaching props and live-fire enclosure fire dynamics training simulators. In order to meet NFPA requirements relating to training and safety, and to adhere to applicable occupational health and safety legislation, resources must be available to conduct appropriate rehabilitation and hygiene practices.

***Recommendation 6: Develop a plan to maintain fire dynamics instructor levels adequate to service OFS front-line personnel.***

- Ongoing fire dynamics training is required; instructor levels must be maintained to ensure capacity.

***Recommendation 7: Incorporate the FKTP curriculum into OFS recruit training.***

- All OFS firefighter recruits must complete fire dynamics training in order to meet the aforementioned obligations to workers.

***Recommendation 8: Incorporate the FKTP curriculum into the OFS Operational Guide.***

- As the recently released OFS Operational Guide is considered a living document, knowledge and tactics identified in the FKTP curriculum must be incorporated in order to establish consistency between training and practice.

***Recommendation 9: Incorporate the FKTP curriculum into applicable OFS policies and procedures.***

- As with the Operational Guide, knowledge and tactics identified in the FKTP curriculum must be incorporated into applicable OFS policies and procedures in order to establish consistency between training and practice.

## Chapter 7

### Concluding Remarks

This paper demonstrates the need to develop and maintain a level of fire dynamics understanding adequate to protect firefighters from the inherent dangers of their working environment, as related to structure fires. The modern fire environment is different from the fire environment out of which many OFS policies and procedures were developed, and changing demographics result in a loss of experience that needs to be addressed through better and more accurate training. Health and safety legislation, MOL Guidance Notes and professional standards as well as internal risk management and professional accreditation requirements clearly indicate the need to establish training that enables City of Ottawa firefighters to “know about any actual or potential danger to health and safety in the workplace” and to demonstrate that OFS has taken “every precaution reasonable in the circumstances for the protection of a worker”. Reports on firefighter deaths and critical incidents consistently recommend fire dynamics instruction for front-line firefighters and officers.

While steps have been taken to ensure such training is developed and occurs in Ottawa, commitments to complete and maintain a validated, evidence-based fire dynamics program are required. If the OFS wishes to complete its mission and be seen as a “modern” fire service, using “innovative practices and technology... strive[ing] to improve every day”, it will embrace the recommendations presented here and move forward as an informed, safe and competent fire service.



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**APPENDIX A: Enhanced Risk Assessment – Fire Dynamics**

<b>ACTIVITY</b> Structural Firefighting – The use of inappropriate suppression tactics and/or misidentification of hazards during firefighting due to inadequate knowledge of fire dynamics	<b>BRANCH</b> Ottawa Fire Services	<b>RISK RATING</b> HIGH
	<b>DEPARTMENT</b> Emergency and Protective Services	<b>DATE</b> January 2013 Revised April 2016

**DESCRIPTION OF POTENTIAL RISKS**

1. Risk of firefighter / civilian death, significant permanent disability or critical injury;
2. Economic risk – high dollar loss:  
I.e. legal fees, law suits, death benefits, economic losses due to fire loss, etc.
3. Legal liability – as related to the *OHS*A as well as property loss;
4. Criminal liability – as related to the *Criminal Code of Canada*.

Many firefighting procedures are based more on tradition than on research into fire dynamics. While firefighter professionalism, skill, and experience often mitigate this situation, a lack of scientific understanding places firefighters, the public, property and critical infrastructure at risk during operations. Furthermore, retirement demographics are resulting in the loss of considerable legitimate experiential knowledge, requiring better live-fire simulation training and pedagogical approaches. The City is obligated under the *OHS*A to provide knowledge of dangers and to take every precaution reasonable in the circumstances for the protection of a worker. Post incident investigations identify inadequate size-up, risk assessment, fire dynamics evaluation, tactics and live fire training as contributing factors to injuries, deaths and property losses.

Corporate risks include financial costs due to legal action (relating to obligations under *OHS*A, *CCC*; and relating to law suits related to property loss) along with life-safety risks to employees.

**RECOMMENDED MITIGATION PLANS**

Directing investment into evidence-based training is economically responsible and sustainable.

Through the development, delivery and ongoing support of evidence-based fire dynamics training, using safe, realistic live fire training tools, the OFS can reduce social, economic, environmental, legal and life-safety risks and impacts due to fire. This will confront a wide range of existing, inaccurate and potentially dangerous assumptions and replace them with complex, often non-intuitive research findings in a valid and reliable way. This addresses capability gaps and enhances safety, informing training and operational policies and procedures, and represents a necessary investment decision. As the burden of local fire loss rests disproportionately on Ottawa’s citizens, reducing such social, economic and environmental losses improves community safety, wellbeing and economic sustainability. This, in turn, increases public confidence.

Current high risk practices will be reduced through innovative, science-based controls. Improved tactics will mitigate extensive social, environmental and economic losses, along with civilian and firefighter injuries and deaths. Obligations related to relevant *OHS*A legislation will be met, and City corporate risks will be mitigated.

## RISK MANAGEMENT MITIGATION PLAN

RISK	Likelihood (1-5)	Impact (1-5)	Risk Score
Tactical Mistakes	4	5	20

### Risk Assessment Map (Likelihood vs. Risk Impact)

<b>Likelihood</b>	<b>5</b>	M	M	H	H	H
	<b>4</b>	L	M	M	H	H
	<b>3</b>	L	M	M	M	H
	<b>2</b>	L	L	M	M	M
	<b>1</b>	L	L	L	L	M
	<b>0</b>	<b>1</b>	<b>2</b>	<b>3</b>	<b>4</b>	<b>5</b>
<b>Risk Impact</b>						

Current Risk Assessment: **HIGH**. (4/5 Likelihood, 5/5 Risk Impact)

**CONCLUSION:** Strategy Required

- **Risk Impact** difficult to address
- Must instead address **Likelihood** in order to reduce the Risk Assessment Score
- **Recommend:** improve training to reduce likelihood