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Building Theory to Impact Practice

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The *International Fire Service Journal of Leadership and Management (IFSJLM)* is composed of peer-reviewed articles focusing exclusively on fire leadership and management topics. **To our knowledge, it is the only academic journal with this focus in the world.** *IFSJLM* is published by Fire Protection Publications (FPP) at Oklahoma State University (OSU). FPP is part of the College of Engineering, Architecture, and Technology at OSU and is the leading publisher in the world of fire-related education and training materials.

IFSJLM would not be possible without the financial support of the Dean of the College of Engineering, Architecture, and Technology and FPP. Their support represents a commitment to the continued professionalization of the American fire service.

As a further indication of the support of FPP to the international fire community, all issues of the *IFSJLM*, except the two most recent years, are available for reading **free of cost** at the Journal's website. Please go to http://www.ifsjlm.org/PastEditions.htm to read and/or download previous issues of the Journal.

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State University of New York Binghamton and Public Safety Management Consultant

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Superintendent
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Dr. Lori Moore-Merrell

Assistant to the General President
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Dr. Anne Eyre

Trauma Training Consultant
Coventry, United Kingdom

Dr. John Granito Award for Excellence in Fire Leadership and Management Research

The Dr. Granito Award

Fire Protection Publications (FPP) and the *International Fire Service Journal of Leadership and Management (IFSJLM)* headquartered on the campus of Oklahoma State University (OSU) are proud to announce the creation of the **Dr. John Granito Award for Excellence in Fire Leadership and Management Research (the Dr. Granito Award)**. The award will be presented at the *IFSJLM* Research Symposium that supports the Journal held annually in July at the IFSTA Validation Conference. The award honors Dr. John Granito. John is one of the premier fire and public safety consultants in the United States. Just a few of his many Fire, Rescue, and Emergency Services research projects include: Oklahoma State University-Fire Protection Publications Line of Duty Death Reduction project (3 years); Centaur National Study (3 years); Research Triangle Institute/National Fire Protection Association/International City/County Management Association project (4 years); Fire Department Analysis Project (FireDAP) of the Urban Fire Forum (13 years); *Combination Department Leadership* project, University of Maryland, Maryland Fire & Rescue Institute (4 years); Worcester Polytechnic/International Association of Fire Fighters/International Association of Fire Chiefs/ National Institute for Occupational Safety and Health *Fire Ground Performance Study* (current). He has participated in more than 400 fire department studies. John also has strong ties to academia. He served in a number of academic positions for almost 30 years, including 16 years at the State University of New York at Binghamton. He is Professor Emeritus and Retired Vice President for Public Service and External Affairs at SUNY Binghamton, which is consistently ranked in the top public universities by *U.S. News and World Report*. John has published numerous articles, chapters, and technical papers, served as co-editor of the 2002 book published by the International City/County Management Association entitled, *Managing Fire and Rescue Service*, and is a Section Editor of the NFPA® 2008 *Fire Protection Handbook.* Dr. Granito was the first recipient of the award that honors him and his service to the fire service and to academia. Each year the recipient of the Dr. Granito Award will present the Keynote Address at the annual *IFSJLM* Research Symposium.

Nomination Form

Fire Protection Publications (FPP) and the *International Fire Service Journal of Leadership and Management (IFSJLM)* headquartered on the campus of Oklahoma State University (OSU) are accepting nominations for the **Dr. John Granito Award for Excellence in Fire Leadership and Management Research (the Dr. Granito Award).** The award is presented at the Research Symposium that supports the *International Fire Service Journal of Leadership and Management (IFSJLM)* held annually in July at the IFSTA Validation Conference.

The nominee should have made a significant contribution to the advancement of fire leadership and management through his/her scholarly/academic writing. The Dr. Granito Award is not necessarily a life-time achievement award, although such individuals certainly should be in a prominent position to be nominated. The nominee can be a person who, although early in their career as a practitioner/scholar or academic, has made a seminal contribution to the fire leadership and management literature.

To nominate an individual for the Dr. Granito Award, please submit by 15 January of the symposium year: (1) this form (or a copy of it), (2) no more than a one-page single-spaced letter explaining why you believe the person is deserving of the award, and (3) a copy of the nominee's resume or curriculum vitae. Send the materials to: Dr. Granito Award, Dr. Bob England, Editor, *International Fire Service Journal of Leadership and Management*, Department of Political Science, 237 Murray Hall, Oklahoma State University, Stillwater, Oklahoma 74078.

I nominate ____ for the **Dr. John Granito Award for Excellence in Fire Leadership and Management Research.** To support the nomination, I have included a letter of recommendation and a resume or curriculum vitae (CV) of the nominee. (A nomination is not accepted without the supporting letter and resume/CV.)

Nominator Name: ____

Address: ____

____

Zip/Postcode: ____

Contact Information:

Telephone: ____

Email: ____

Message from Dr. Robert England

Editor, *International Fire Service Journal of Leadership and Management (IFSJLM)* and Professor of Political Science at Oklahoma State University

Welcome to Volume 7 of *IFSJLM*. This issue marks the third year of our transition from a biannual to an annual issue of the "Red Journal." Typically, readers should expect to see the annual edition released in September or October. When the issue goes to press, however, is largely dependent on when external peer reviewers accept four or more articles for publication. Regardless of the number of articles, the volume will be available no later than the end of the calendar year.

Fifth Annual Dr. John Granito Award for Excellence in Fire Leadership and Management Keynote Address presented at Research Symposium 2012 (RS12) by **Daniel Madrzykowski**, Fire Protection Engineer, National Institute of Standards and Technology

Fire Dynamics: The Science of Fire Fighting

Abstract

Fire dynamics can provide a fire officer or a firefighter with means to understand how a fire will grow and spread within a structure and how best to control that growth. Researchers have generated experimental results and computer models to explain how fire dynamics taken at the most basic level, the fire triangle, applies to the fireground. This paper will provide a brief overview of the research that demonstrates the impact that changes in fuel and construction methods have had on the fire environment. These changes have altered the model of fire behavior taught to the fire service for decades. In addition, firefighter protective equipment has also changed over the years. All these factors lead to an assessment that fire-fighting tactics may need to evolve in order to keep in balance with the changing conditions on the fireground.

These findings are the result of research conducted in conjunction with the fire service. The overarching objectives were to increase the safety and the effectiveness of firefighters. These studies were designed to focus on research results that had application on the fireground. In order for these studies to occur, it took leadership within the fire service to question the status quo. Leadership will be required in every fire department to educate the fire service as a whole and implement needed changes to the current fire-fighting practices, which have been shown to make fire conditions worse before fire control and rescue can be achieved. Leadership is needed to embrace the knowledge of fire dynamics, employ a size-up of every fire scene, and then choose the fire-fighting tactics and task assignments based on that assessment.

Introduction

In the United States (U.S.), a fire department responds to a fire every 23 seconds (National Fire Protection Association® [NFPA®], 2011). Each of these fires occurs under different conditions, hence the fire service mantra — *Every fire is different*. Yet from a science perspective, most fires share some basic similarities. The fire-heat release is due to exothermic, gas-phase, chemical reactions that produce heat and light, and they require three components to sustain the chemical reaction — fuel, oxygen, and heat. This information has been taught to fire service personnel for many decades. Only during the past 12 years or so, fire experiments and computer models have been used to explain how the fire triangle applies to the fireground and affects the design of protective equipment and the choice of fire-fighting tactics.

This article provides a brief overview of research that demonstrates how changes in fuel and construction methods have affected the fire environment. These changes, taken separately and in combination, have altered the model of fire behavior taught to the fire service for decades. All these factors lead to an assessment that fire-fighting tactics and firefighters' protective gear must evolve to correspond with fire dynamics on the modern fireground.

Fire Dynamics

Fire dynamics is the field of study that encompasses how fires start, spread, develop, and extinguish. To characterize fire behavior meaningfully, fire dynamics must incorporate the interaction of chemistry and material science and the engineering disciplines of fluid mechanics and heat transfer. In addition, one must also consider the interactions of fire with structures, materials, and people in order to fully understand the fire dynamics of a given fire incident.

The paper "Microstratigraphic evidence of in situ fire in the Acheulean strata of Wonderwerk Cave, Northern Cape province, South Africa" (Berna, 2012), which was published in April of 2012, shows that Homo erectus used fire productively about 1 million years ago, more than 300,000 years earlier than previously thought. Since that time, hunters, farmers, cooks, scientists, chemists, engineers, and firefighters have studied one aspect of fire or another. Each group focused on its specific area of interest in or the use of fire. For example, some studied the use of fire to form metal while others analyzed the combustion of fuel as a means to optimize the use of fuel in boilers, automobiles, aircraft, etc. For more than 100 years, National Institute of Standards and Technology (NIST), Underwriters Laboratories (UL®), and Factory Mutual Global (FM Global), and other organizations have studied how to protect buildings from fire by examining the fire resistance of columns and walls with furnace tests (Gross, 1991). Yet it was not until 1985 that the first textbook on fire dynamics was written (Drysdale, 1985).

In response to the 1973 report, "America Burning" (National Commission on Fire Prevention and Control, 1973), Congress passed U.S. Public Law 93-498, the "Federal Fire Prevention and Control Act of 1974." The Act called for the establishment of (1) National Fire Prevention and Control Administration (now the U.S. Fire Administration [USFA]), (2) National Academy of Fire Prevention and Control (now the National Fire Academy [NFA]), and (3) Center for Fire Research at the National Bureau of Standards (currently NIST). The Act gave NIST the mission of performing and supporting research on all aspects of fire, with the aim of "providing scientific and technical knowledge applicable to the prevention and control of fires" (Public Law 93-498, p.1546). More specifically, the Act required NIST to conduct research on "the dynamics of flame ignition, flame spread and flame extinguishment" (Public Law 93-498, p.1546). As the result of U.S.-based research programs conducted and supported by NIST in the 1970s and 1980s, as well as a significant level of fire-research activity in Canada, Japan, and the United Kingdom, a body of knowledge developed on fire chemistry, fire plumes, compartment fires, and simple models of fire phenomena. This information provided a foundation for fire-protection engineers to consider fire dynamics when designing buildings and reconstructing fires.

Changes on the Fireground

While fire researchers were making gains on understanding fire dynamics in the laboratory, the hazards on the fireground and fire dynamics that accompanied them were changing. For example, the construction techniques and materials used to build and furnish a house have changed significantly over the last 50 years.

Engineered wood products have been incorporated into the design and construction of modern structures. Engineered wood joists and trusses enable longer spans and open areas (less compartmentation) for improved use of living space in homes. Since the 1970s, the median size of a single-family home in the U.S. has increased. According to data from the U.S. Census, in 1973 the median size was 1,600 ft^2. By 2008, the floor area of the median house had increased by more than 50% to 2,500 ft^2 (U.S. Census, 2011).

In order to increase the energy efficiency of houses, insulation has improved, walls are wrapped in plastic to limit infiltration of air and water, and multi-pane windows are now the norm. When a fire occurs in an energy-efficient house, the insulation works to keep the heat and combustion products from the fire trapped in the house and limits the amount of outside air that can be drawn inside to complete the fire triangle, provided that no doors or windows are open. As a result, fires have less oxygen. We can describe this in either of two ways: a ventilation-limited or a fuel-rich fire condition.

The objects and materials inside homes have changed as well. The design and construction of furnishings have evolved dramatically in the past 50 years. In the 1950s, a wide range of synthetic materials called *polymers* became available for use in clothing, furniture, interior finish, and insulation. Within a few years of their commercial introduction, the use of polyester, nylon, and polyurethane foam became commonplace in homes. Durability, comfort, and economics all play a role in the design and manufacturer of furnishings that people choose to buy. Today, flexible polyurethane foam is one of the most common materials in upholstered furniture. According to industry statistics, more than 1.7 billion pounds of polyurethane foam are produced and used every year in the U.S. (Polyurethane Foam Association, 2007).

These new materials, energy efficiencies, and construction methods have led to changes in the fire environment that a firefighter must face. Have fire departments added staffing, altered their training, or modified their tactics to respond to these changes?

Protective Equipment

Firefighters use protective equipment to increase their safety and effectiveness on the fireground. New materials and advances in technology offer improved protection to the firefighter from thermal hazards and toxic gases. Since the 1960s, new materials, such as aramid fibers (Nomex® and Kevlar®) and polybenzimidazole (PBI), have been introduced that do not melt and have a high resistance to ignition. These materials are now in common use as part of firefighters' protective clothing and equipment.

The evolution of the self-contained breathing apparatus (SCBA) to include lighter materials, increased air supply, electronic monitoring, and warning devices has made working in a smoke-filled building safer. Continued developments in the fields of electronics and sensing have produced improvements in situational awareness for firefighters, mainly through the use of thermal imaging. However, over the last decade, we have learned that electronic safety devices, such as Personal Alert Safety System (PASS) devices, radios, and polycarbonate SCBA facepieces are not as thermally robust as other fire-fighting personal protective equipment (PPE) components. The National Institute of Occupational Safety and Health (NIOSH) documented a series of line-of-duty deaths (LODDs) involving specific types of protective equipment. Thereafter, NIST worked with NFPA® and with equipment manufacturers to improve the standard test methods and requirements in order to improve the thermal resistance of the equipment and, thereby, to improve firefighter safety. Even with these improvements, conditions in a fully developed compartment fire can still exceed the capabilities of the best protective equipment.

These changes on the fireground bring us to a very disturbing trend. Between the late 1970s and the late 2000s, the annual number of structure fires in the U.S. decreased by more than 50%. During the same period, the overall annual number of firefighter LODDs also declined. However, the rate of firefighter deaths due to traumatic injuries on the fireground increased during the same period from 1.8 deaths to 3.0 deaths per 100,000 fires (Fahy, 2010). This is an increase of more than 60% at a time when firefighters have access to the best equipment and technology ever available.

As I close this section about changes on the fireground, it is worth noting that during this time of change, the typical firefighter is getting less fire-fighting training, less fire-fighting experience, and less understanding of the technology that he or she rely on to keep him or her safe.

Fire Behavior

Typically, firefighters have been taught about fire behavior in structures with pen and ink drawings and a simple graph (see **Figure 1**). The idealized, qualitative graph shows that the fire begins with ignition. The fire is then in the growth phase, where the heat-release rate increases until the fire is fully developed. In a compartment fire, the transition from the growth stage to the fully developed stage may involve a flashover. *Flashover* is a transition in the development of a contained fire. In flashover, surfaces exposed to thermal radiation from fire gases in excess of 600°C (1,100°F) reach ignition temperature more or less simultaneously. Fire spreads rapidly through the compartment, with burning from floor to ceiling. Without an intervention, the fire transitions to the decay stage as the fuel is depleted. This ideal curve is best suited for describing a fuel-controlled fire, in other words, a fire that has all of the oxygen it needs to sustain the heat-generating chemical reaction with the fuel. In such cases, the peak heat-release rate is limited by the amount of fuel available for combustion, and the decay stage is typically related to the reduced amount of fuel available for burning. Heat-release-rate curves from free-burn sofa fires with no compartmentation effects are shown in **Figure 2**. For a typical, residential-scale room with a doorway approximately 0.9 m (3 ft) wide by 2.0 m (6.6 ft) high, the minimum heat-release rate required to flashover the room is about 2,000 kW. You can see from

Figure 1: Traditional idealized fire-behavior graph showing a typical fuel-controlled fire.

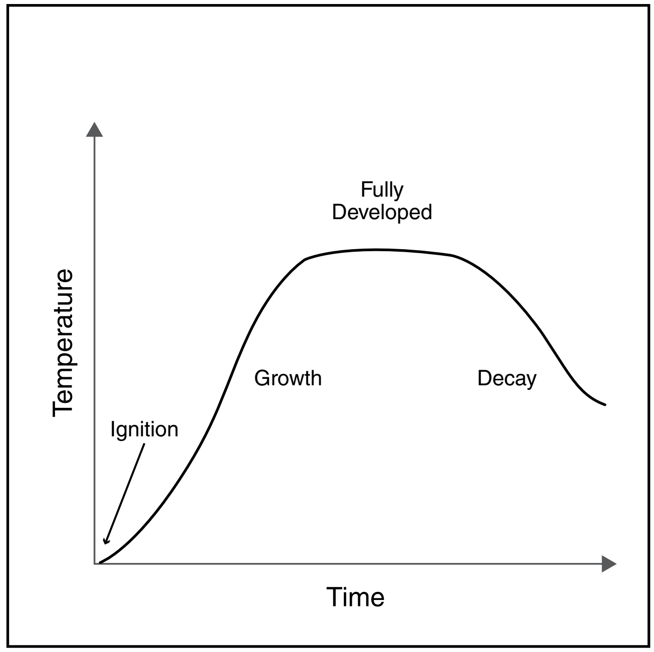


Figure 2: Heat-release rate time history from sofa "free burns."

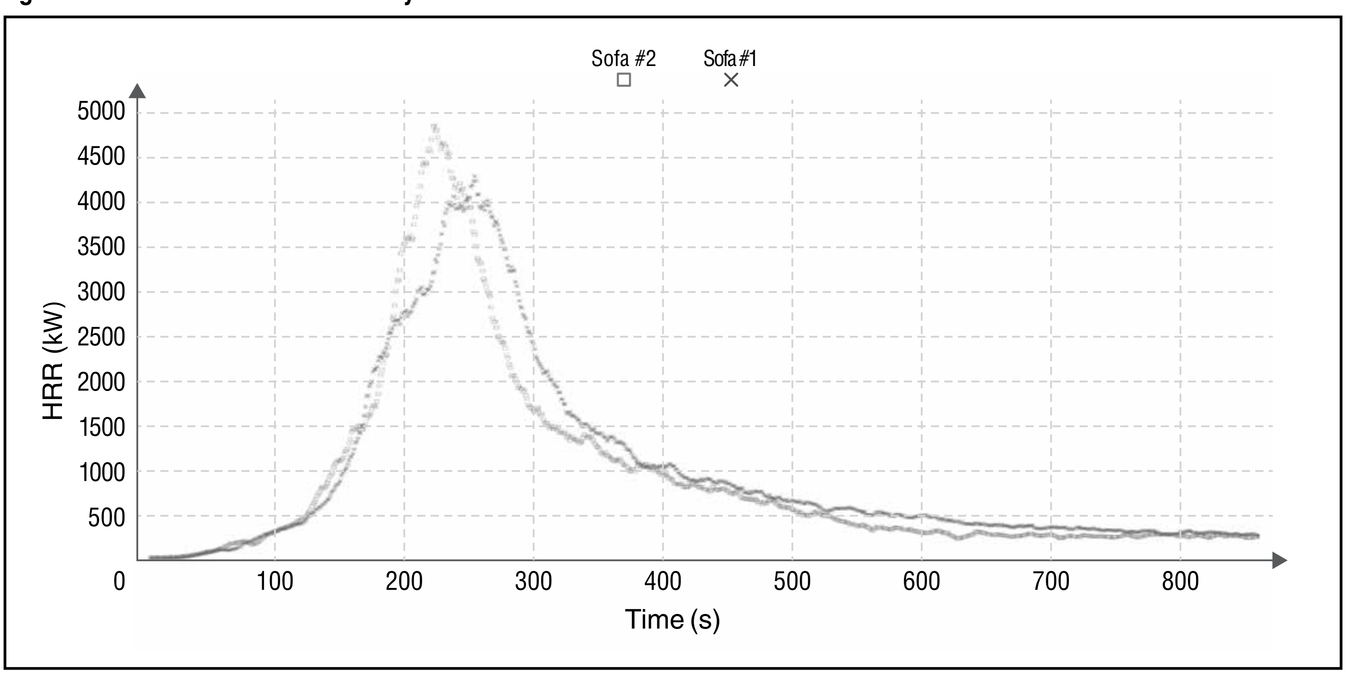


Figure 3: Temperature time-history curves from a furnished room fire with an open doorway.

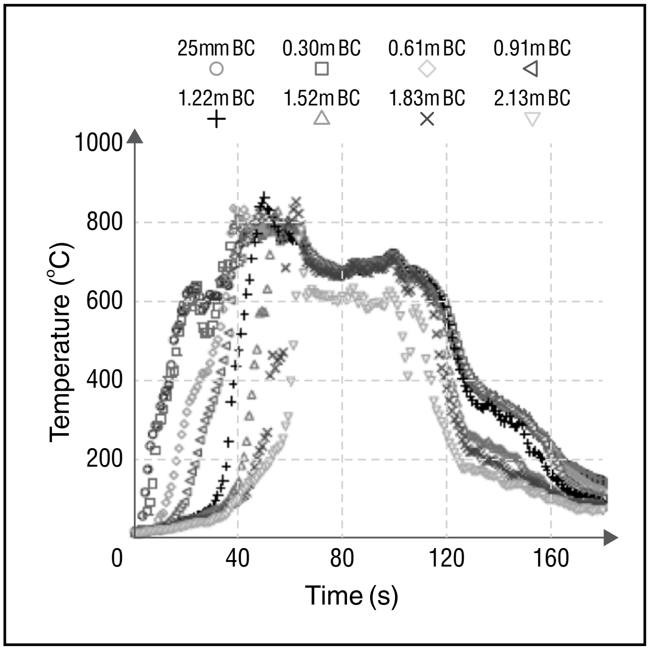


Figure 2 that a sofa has twice the peak heat-release rate needed to flashover the room. **Figure 3** is a graph of temperature vs. time-history curves shown from a sofa fire in a compartment with an open doorway, which allows for the continuous flow of oxygen from the outside of the compartment to the fire. Notice that in each case, the free burn and the open-room burn, the fuel-controlled pattern pertains: basic growth, fully developed, and decay.

As new homes retain heat and the gaseous fuels better than old homes and as synthetic fuels burn faster than wood and cotton, the probability of arriving to a preheated, fuel-rich fire environment has increased in recent years. As a result, fires are controlled by the amount of oxygen available to them. An idealized curve of a ventilation-controlled fire is shown in **Figure 4**. As in the fuel-controlled case, the fire begins with ignition and the growth stage. As the high-heat-of-combustion fuels burn in the nearly air-tight house, fire begins a decay stage due to limited availability of oxygen for the combustion process. As the available oxygen decreases, the heat-release rate of the fire decreases, along with the gas temperatures in the house. If a door or a window is opened while the fire is still burning, although at a reduced level, and if additional fuel is available, the introduction of outside air can result in a rapid increase in the heat-release rate of the fire and may enable enough energy generation to flashover the room. This transition has been referred to as a *ventilation-induced flashover*. Once enough oxygen has been made available to allow the fire to reach the fully developed stage, it may become fuel-controlled again until decay or until suppression by the fire department.

NIST has had the opportunity to measure this type of fire behavior many times while conducting fire experiments in acquired structures. For example, NIST had the opportunity, with the Chicago Fire Department, to burn several townhouses after equipping the structures with fire-monitoring instruments. Each townhouse was furnished with a sofa, upholstered chairs, a futon, wooden bookcases, a dinette set, kitchen cabinets, and bedroom furniture. In one case, a small flame ignited the sofa, which was on the first floor in the living room. All of the exterior doors and windows were closed. Within 120 seconds after ignition, flames from the sofa impinged on the living room ceiling, and combustion products spread to every first- and second-floor room with an open door. By 210 seconds after ignition, smoke was down to the floor throughout the open areas of the townhouse, and the fire was in a decay stage due to the reduced level of oxygen inside the townhouse. At approximately 215 seconds after ignition, the front door was opened. This action resulted in a bidirectional flow at the front door. Hot, higher-pressure fire gases were flowing out of the top of the doorway and cool, lower-pressure outside air was being entrained into the fire room through the lower portion of the doorway. Smoke near the floor in the living room cleared, and the fire began to increase in heat-release rate and in physical size. At 250 seconds after ignition, the living room window was vented by a firefighter. The window glass was completely cleared from the window frame within 20 seconds. Given the hot, fuel-rich conditions in the living room, the additional ventilation resulted in flames coming out of the window and doorway by 280 seconds after ignition. A full transition through flashover in the living room occurred within a minute of venting the living room window.

Figure 4: Idealized fire-behavior graph showing a typical ventilation-controlled fire.

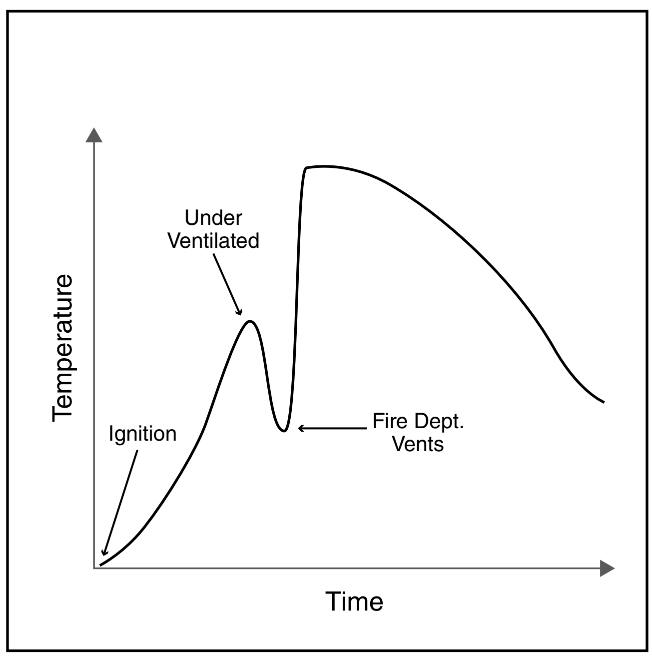


Figure 5 shows the temperature in the living room during the experiment described in the previous paragraph. Notice the shape of the temperature curves with respect to time: fire growth, followed by decay, or a decrease in heat-release rate, which is then followed by a significant and rapid increase in heat-release rate and gas temperature because of the increased availability of oxygen to the fuel-rich environment of the fire room.

Flow Path

Flow path is another concept central to fire dynamics in structures. The *flow path* is the volume between an inlet and an exhaust that allows the movement of heat and smoke from a higher-pressure area within the fire area towards lower-pressure areas accessible via doors, windows, and other openings. Depending on its configuration, a structure can have several flow paths. Operations conducted in the flow path, between where the fire is and where the fire wants to go, places firefighters at significant risk due to the increased flow of fire, heat, and smoke toward their positions. This risk is true for natural-ventilation cases with or without wind. In cases with the potential for wind to affect the heat-release rate and the movement of the fire, it is important to keep the wind at your back and to attack the fire from the upwind side.

Several LODDs have occurred where quite literally the difference between life or death depended on whether or not a glass window broke. In effect, death occurred due to a change in ventilation, while firefighters worked in a space between the fire and a lower-pressure area where the fire wanted to go — the path of least resistance. This was the case with the three Fire Department of New York City (FDNY) firefighters who lost their lives in the Vandalia fire in Brooklyn (Madrzykowski & Kerber, 2009), the two Houston firefighters who lost their lives in a ranch house fire (Barowy & Madrzykowski, 2012), and the two San Francisco firefighters who were killed in the Diamond Heights fire (San Francisco [CA] Fire Department, 2011).

NIST conducted measurements to examine the impact of flow path and wind on fires in a mock-up apartment built in its laboratory. The fires were ignited in the bedroom of the apartment. Prior to the failure or venting of the bedroom window, which was on the upwind side of the experimental apartment, the heat-release rate from the fire was on the order of 1 megawatt (MW). Once the bedroom window was opened, the heat-release rates from post-flashover structure fires were typically between 15 MW and 20 MW. When the door from the apartment to the corridor was open, temperatures in the corridor area near the open doorway, 0.9 m (3 ft) above the floor, exceeded 600°C (1,112°F) for each of the experiments. The heat fluxes measured in the same location, during the same experiments, were in excess of 70 kW/m². Even in full protective gear, a firefighter cannot survive these extreme thermal conditions. These conditions occurred within 30 seconds of the window failure. The study also found that application of water from the exterior through the vent on the upwind side significantly cooled the fire gases and suppressed the fire (Madrzykowski & Kerber, 2009).

Figure 5: Temperature time-history curves from a furnished room fire that was initially closed and then vented to the outside by opening the front door and venting the living room window.

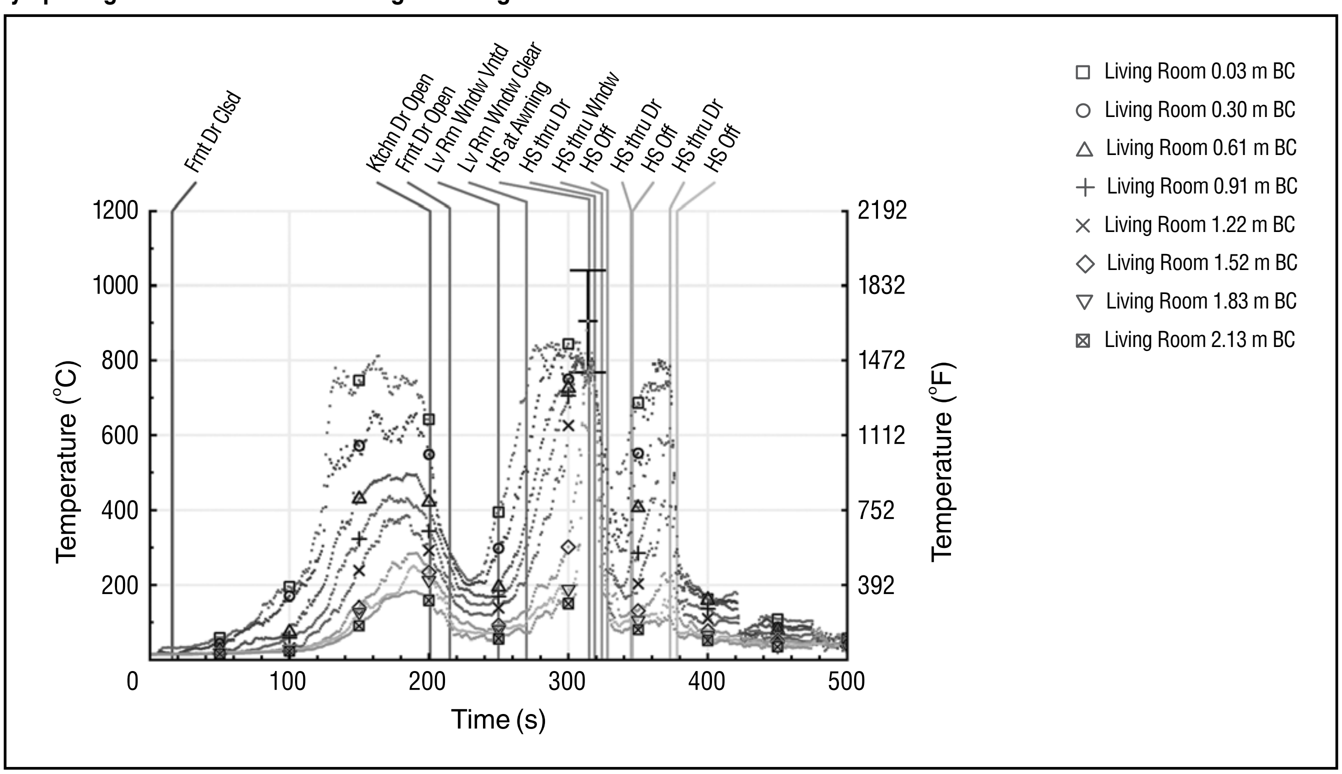
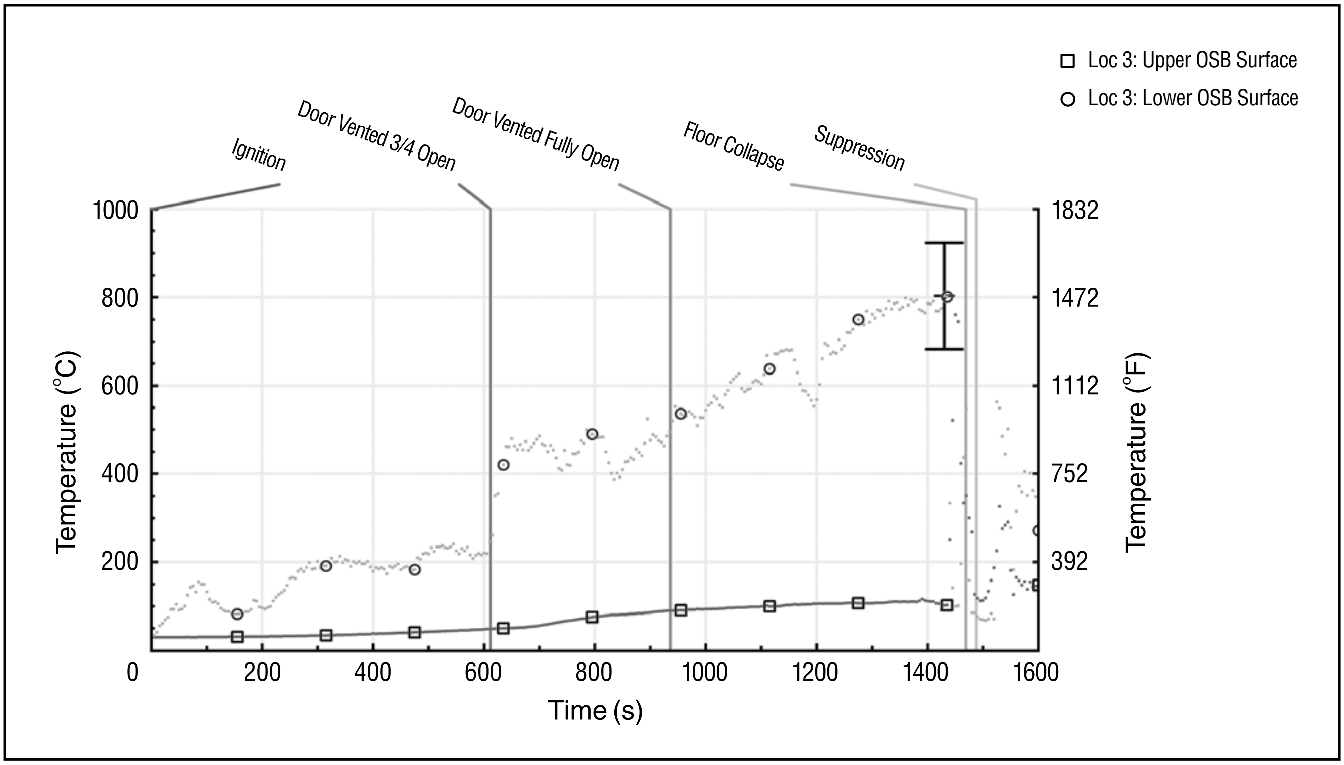


Figure 6: Temperature time-history curves comparing the temperature of the fire-compartment (lower) side of oriented strand board (OSB) subflooring and the temperature of the upper-level room side of the OSB. The measurement locations are separated only by the OSB, which is approximately 18 mm (0.75 in) thick.



Operating Above the Fire

Fire operations above a fire in a wood-framed structure with an unprotected engineered wood-floor assembly bring together several of the risk factors that we have been discussing. In a basement fire, the exposed wood-floor assembly is a sufficient and well-placed fuel load that can support rapid-fire growth and the transition through flashover if there is enough ventilation available. Due to the excellent insulation capabilities of wood-based subflooring and floor coverings, even firefighters with thermal imagers might be unaware that a post-flashover fire burns below them and that the structural integrity of the floor on which they are standing is compromised until they fall through it. The thermal imager can only sense increased temperature due to heat flow through the floor and floor coverings. During basement fire experiments, NIST has measured temperatures in excess of 800°C (1,400°F) on the lower (fire side) of the floor assembly while the temperature on the upper side of the flooring was 100°C (200°F) or less just prior to the collapse of the floor as shown in **Figure 6** (Madrzykowski & Kent, 2011).

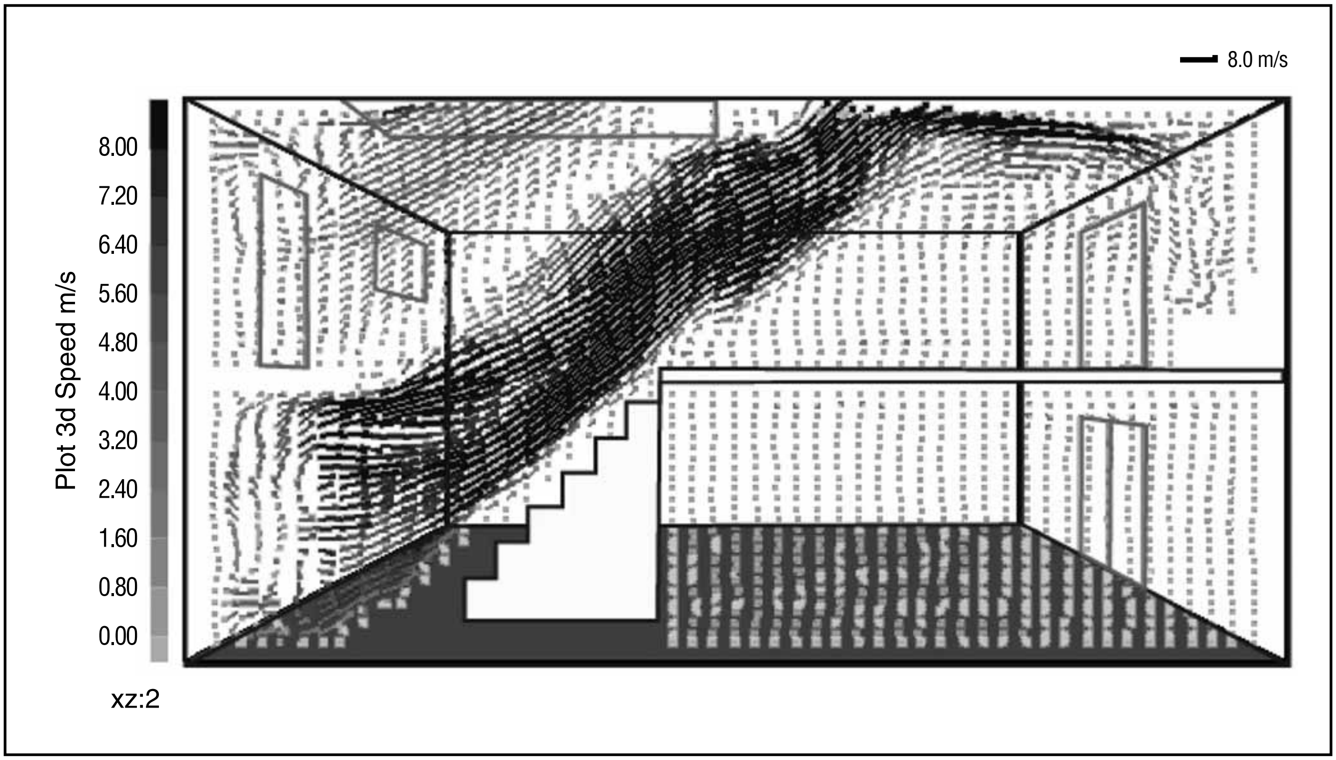
In basement fires, current practice calls for firefighters to fight their way down the stairs to suppress the fire. If the firefighters survive crawling on a floor assembly that may be burning underneath them, they will find the stairway and place themselves in the flow path between the fire in the basement (high temperature/high pressure area) and the open front door (exhaust vent to lower temperature/lower pressure area) through which they entered the house. In other words, the firefighters are trying to work their way down the chimney of a burning fireplace. This is a high-hazard location with the potential for high convective heat transfer. This scenario is similar to the one that claimed two firefighters' lives in the Cherry Road fire in Washington, DC (Madrzykowski & Vettori, 1999). The flow path from the post-flashover fire in the basement up the stairs is shown in **Figure 7**.

What approach works with this difficult fire scenario? Is it water applied from the exterior through a basement window or door? This exterior offensive tactic is known by many names: *early water, blitz attack, resetting the fire, softening the target,* and *hitting it hard from the yard*, to name a few. In basement-fire experiments NIST conducted with FDNY and UL®, flowing a hose stream into a basement window for 60 seconds reduced the temperatures from 900°C (1,700°F) to 150°C (300°F) in the basement. The temperatures at the top of the stairs leading to the basement decreased from 300°C (600°F) to 100°C (200°F). In addition, the temperatures throughout the rest of the townhouse also decreased due to the exterior hose-stream application. Applying water through the window did not push or spread the fire, and no excess steam was forced throughout the structure. Applying water through the window into the fire area quickly mitigated the hazard. **Figure 8** shows this example in graphic form.

Research Summary

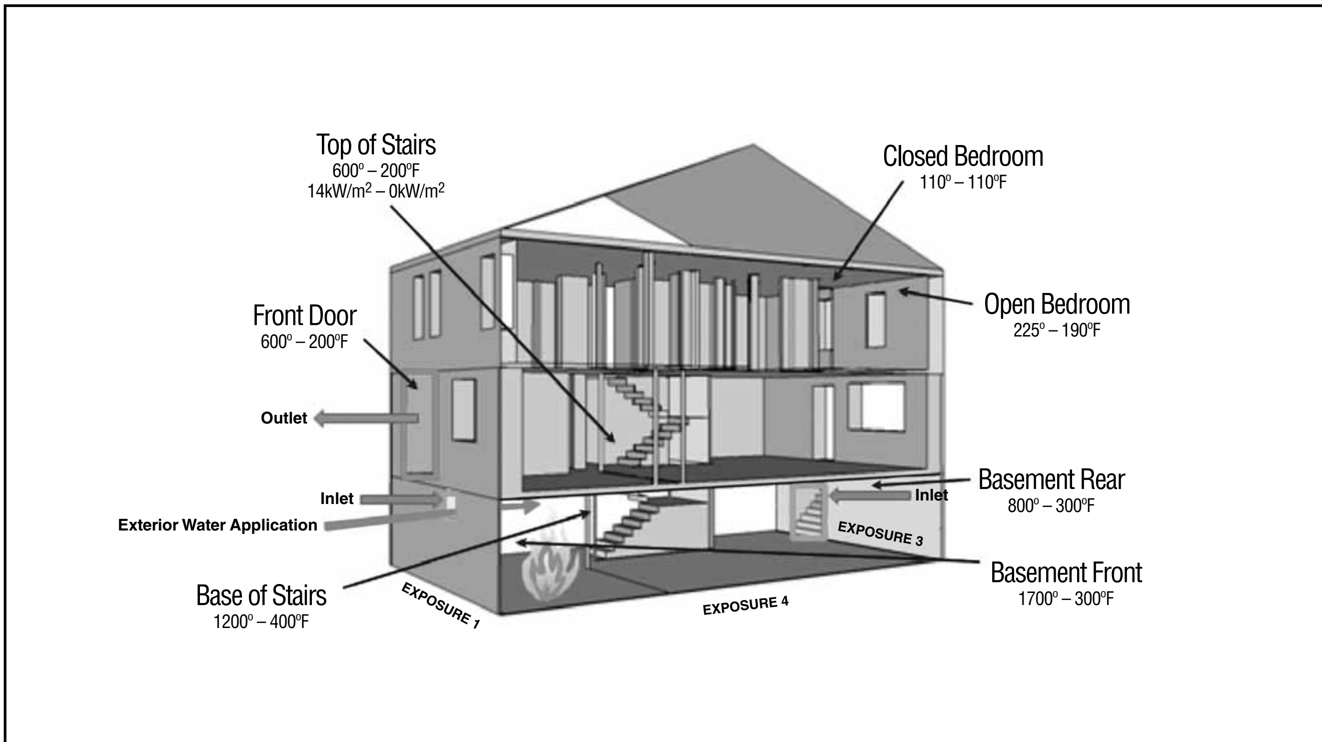
Many of the fire-dynamic applications on the fireground presented earlier were intuitive. Some were not.

Figure 7: The flow path of high-momentum fire gases going up the stairs can be seen in this NIST Fire Dynamics Simulator model of the Cherry Road fire. The firefighter victims were all working in the room at the top of the stairs.



While many in the fire service recognized some of the increased hazards in residential fires individually, few understood the synergy between the synthetic fuel loads, reduced compartmentation, and the lightweight and energy-efficient construction. Fire-test results have shown that the synthetic-fuel fire is more reactive to the introduction of oxygen than are fires fueled by wood and cotton. For the fire service, this fact means that synthetic-fuel fires are less forgiving in terms of how quickly conditions on the fireground can change. The thermal conditions generated by a fire can exceed the material limitations of firefighters' personal protective equipment (PPE) by more than 500°C (1,000°F). Of course, human thermal limitations are significantly

Figure 8: The impact of flowing a hose stream into a basement fire through the basement window at 180 gpm for 60 seconds.



lower than that. To escape harm, firefighters must understand the capabilities and the limitations of their PPE.

Given the firefighter fatality and injury rates and the challenges faced, fire department leaders need to consider revising their tactics to improve firefighter safety and effectiveness. Controlling the oxygen leg of the fire triangle through door and flow-path control and controlling the heat side of the fire triangle through early suppression from the exterior must be considered, even if these tactics go against current practice.

Firefighters at all levels need to be armed with improved knowledge about fire dynamics, their workplaces, and the equipment that they use to protect themselves. For example, smoke is fuel, venting does not always equal cooling, and most structure fires are ventilation-limited (fuel-rich) and therefore very reactive to additional oxygen.

Fire officers need to locate and assess the fire and then consider all available tactics before directing their crews, using the safest and most effective tactics possible. This option is good not only for the firefighters but also for victims trapped in the building. What are some of these tactical options? Keep the wind at your back, and stay upwind of the fire. Identify and control potential flow paths by managing ventilation (i.e., open doors and windows). An exterior direct attack on the fire from the burned side may be the best option. Use all available options to prevent firefighters from working above a fire with an unrated floor assembly.

Leadership and Implementing Change

Now that research has elevated our understanding of fire dynamics within structures, fire service leaders must use the data to develop educational and training tools and to share information across the ranks and generations of firefighters. Standard operating procedures (SOPs) must be revised to incorporate our new understanding. All of the elements of training, certification, and practice must be coordinated to make the most effective use of the knowledge.

As a result of the assistance of the U.S. Department of Homeland Security/Federal Emergency Management Agency (DHS/FEMA) to firefighter research and development grants, more high-quality research is being conducted with the fire service than at any other time in history. The research yields not only reports and numerical data but also experiment videos useful for educating the fire service. Producers of training materials such as the International Fire Service Training Association (IFSTA) are incorporating the research results in its manuals and online training apps.

Fire service leaders must embrace research-based tactics in order to motivate their instructors and get buy-in from their staffs. Annual training needs to be conducted and SOPs need to be revised so that all members of the fire department, not just the new candidates, are aware of flow-path hazards and the new technology capabilities. It will also be important to work with mutual-aid fire departments to ensure that they understand that you have added new tools and options to your department's playbook.

Implementation

Being a leader in changing the status quo requires knowledge, fortitude, and diplomacy. It will require hard choices in times of lean resources to dedicate effort to revising SOPs and to developing and providing additional training for your seasoned firefighters. Change is best accepted in a supportive environment when leadership is leading by example.

A great example of implementing change is available from the largest fire department in the U.S.: FDNY. FDNY had a history of injuries and deaths in wind-impacted fires in high-rise buildings. They embraced researchers and representatives from fire departments across the country and around the world to understand the problem and possible solutions. They supported real-scale fire experiments in a high-rise building as a means to find a better way of fighting a high-rise fire (Madrzykowski & Kerber, 2009; Kerber & Madrzykowski, 2009).

Once the findings from the NIST laboratory and high-rise studies were presented to them, the leadership in FDNY moved swiftly to implement changes to improve the safety of their firefighters. They started a pilot program in two areas of the city. The firehouses in these areas received additional training and new equipment such as positive-pressure ventilation fans, wind-control devices, and high-rise nozzles. A DVD-based training program was developed on the hazards of wind-impacted fires and the use of flow-path control, positive-pressure fans, and exterior hose streams. That program was distributed across the department. For annual training day, a program was developed in which firefighters conducted hands-on training evolutions with the new equipment and learned about the fire dynamics behind the new tactics. Then FDNY installed the *Diamondplate* system, computer kiosks in all firehouses that allow the department to push training materials on a weekly basis to the firefighters. FDNY partnered with Polytechnic Institute of New York University (NYU-Poly) to develop an interactive computer-based training program, ALIVE, on wind-driven fires based on the FDNY materials and the NIST reports (NYU-Poly Fire Research Group, 2008). Within 18 months after the completion of the experiments on Governors Island, NY, FDNY firefighters were using the new tools and tactics and saving their own.

FDNY then reexamined their ventilation practices on non-wind-impacted fires, based on what was learned about the modern fire environment and flow paths from the wind-driven study and additional research conducted with NIST and UL®. As a result, a new ventilation bulletin has been issued by the department that is based on and incorporates the science of fire fighting (FDNY, 2013).

Summary

These findings are the result of research that has been conducted in conjunction with the fire service. The overarching objective of all of the studies was to increase the safety and the effectiveness of firefighters. These studies were designed to focus on research results that had application on the fireground. In order for these studies to occur, it took leadership within the fire service to question the status quo. It took leadership to engage the researchers and ask the hard questions. Now that researchers and members of the fire service have a better understanding of the fire dynamics of a structure fire, that information must be shared. Now that the reports, data, videos, and training materials are available, that information must be taught. Leadership will be required in every fire department to educate the fire service as a whole and to implement needed changes to current fire-fighting practices that make fire conditions worse before fire control and rescue can be achieved. Now is the time to embrace the knowledge of fire dynamics based on chemistry and physics, employ a size-up of every fire scene, and then choose the fire-fighting tactics and task assignments based on that assessment.

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“Fireground News” contains research presented at the *International Fire Service Journal of Leadership and Management (IFSJLM)* Research Symposium (RS) held annually in July at the International Fire Service Training Association (IFSTA) Validation Conference. These reports offer information useful to the well being, safety, and /or professionalization of the fire service. As editor of *IFSJLM*, I decide which reports are presented at the Research Symposium and subsequently which are published in the *Journal*. The following article was presented at Research Symposium 2012 (RS12) on July 14, 2012.

Ronald Jon Siarnicki, Executive Director, National Fallen Firefighters Foundation (NFFF)

Vulnerability Assessment Program

Abstract

Firefighters in the United States (U.S.) die in the line-of-duty at an unprecedented rate — in the past decade, about 100 individuals a year. Another 70,000 or more suffer significant injuries. The number of near-misses is unknowable. Investigations by local and federal authorities routinely discover that the vast majority of these injuries and deaths were preventable if known risks had been mitigated. The National Fallen Firefighters Foundation (NFFF), in coordination with the U.S. Fire Administration (USFA) and Honeywell Corporation, is developing a vulnerability assessment tool that will provide fire departments with easily accessible real-time data to help evaluate risks and gaps in service that lead to firefighter injuries and worse. The Vulnerability Assessment Program (VAP), which will be free to registered fire-department users, will give fire departments the information they need to develop operational and strategic plans that implement risk-reduction strategies, thus hopefully reducing or eliminating predictable causes of line-of-duty injuries and fatalities.

The self-assessment tool will be offered as an interactive online survey that chiefs, fire officers, and safety teams will use to evaluate their community risks and resource capabilities (including health and safety programs) to identify areas of vulnerability that represent historically predictable and preventable risks. At the end of the assessment process, VAP users will receive a customized report identifying their departments' areas of vulnerability. Each report will contain links to low-cost resources and suggestions for risk-reduction strategies specific to the identified vulnerability and will identify industry standards that address the identified problems.

This new and historic approach to confronting firefighter risk represents a partnership between over 25 service organizations and private industry — all committed to making sure ***Everyone Goes Home****.*

Background

In 1992, the National Fallen Firefighters Foundation (NFFF) was created by the United States (U.S.) Congress and charged with the mandate to honor the nation's fallen firefighters and provide their survivors with resources they need to rebuild their lives.

In 2004, under the direction of its Board of Directors, the NFFF expanded its mission to include the prevention of firefighter injuries and deaths. That year, the NFFF coordinated the first Firefighter Life Safety Summit in Tampa, FL, where all major fire-service constituencies gathered to strategize ways to better understand risks to firefighters. As an outcome of this meeting, 16 Firefighter Life Safety Initiatives (FLSIs) were identified as targeted strategies for reducing firefighter injuries and deaths. The **Everyone Goes Home®** (**EGH®**) program was also created, and the NFFF was given the task of its management. Under the *EGH®* umbrella, the NFFF and its fire-service partners develop and deliver training courses, advance health and safety initiatives, and support research that will ultimately result in increased firefighter safety.

In 2010, Kelvin Cochran, then U.S. Fire Administrator, requested that the NFFF oversee the development of a risk-assessment tool for fire departments that would reduce firefighter line-of-duty deaths (LODDs) and injuries. Chief Cochran's vision was to design a Vulnerability Assessment Program (VAP) for evaluating exposures and risk-control techniques in fire departments nationwide, which would give fire chiefs and agency administrators, municipal governments, and others a process with which to assess risks to firefighters and leverage resources to address those risks. Chief Cochran's vision was as follows:

- A fire chief, fire officer, or firefighter answers questions on line about his or her fire department.
- The VAP tool provides an assessment of the vulnerabilities in that fire department that could lead to a firefighter injury and/or death.
- The VAP tool provides a report that summarizes the vulnerabilities and connects the user with actionable information and resources to address these vulnerabilities.
- The results of this survey will give chiefs and administrators the actual data they need when they identify needs and seek resources.

The NFFF accepted the task of developing the VAP, which aligns within the mission of the *EGH*® program, and specifically addresses FLSI 3 that states: "*Focus greater attention on the integration of risk management with incident management at all levels, including strategic, tactical, and planning responsibilities*" (NFFF, 2013).

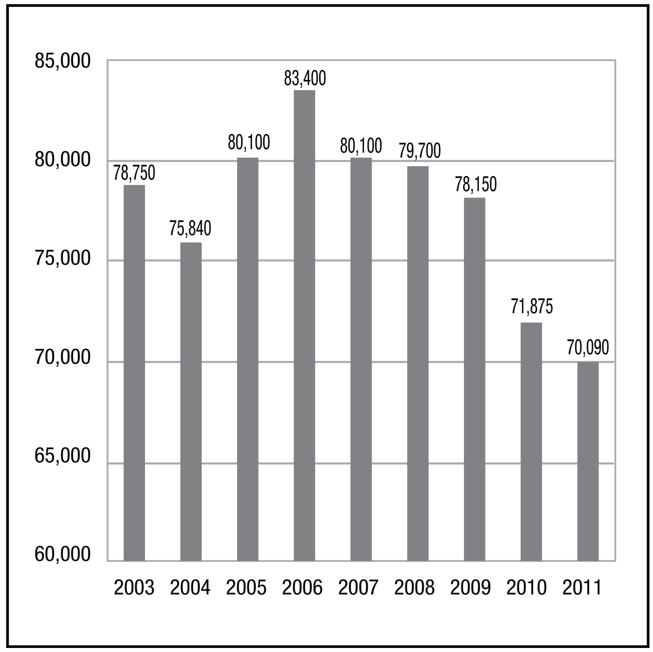
Development of the VAP has been given the highest level of support from the U.S. Fire Administration (USFA). A five-year timeline has been established for its development and implementation. Initially, the VAP was funded through a generous grant from the USFA to the NFFF. In December of 2010, Honeywell Corporation made the significant financial commitment to support further development of the VAP and provide corporate expertise to the project in the domains of industrial and firefighter health and safety, risk management, and marketing. Under the leadership of Allen Fritts and his team at Honeywell's Fire Systems Group, the VAP project has been significantly refined and advanced.

Firefighter Fatalities and Injuries

Fire fighting is one of the nation's most hazardous occupations. Each year in the U.S., more than 70,000 firefighters are injured, 10,000 of them very seriously, while fulfilling their mission to save lives and property in their communities (see **Figure 1**). Injuries are costly to firefighters, their families, their departments, and their communities. Costs include medical expenses, workers' compensation payments, and other insured medical expenses, including long-term care, lost productivity, and administrative costs of insurance, to name a few. Although figures vary, relevant economic studies estimate the cost to the nation of firefighter injuries to be between $2.8 and $7.8 billion per year (National Institute of Standards and Technology [NIST], 2005).

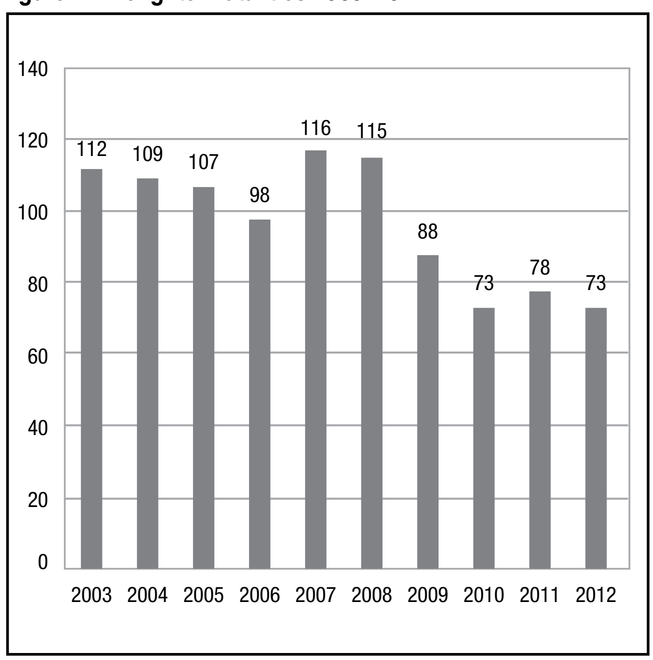
Over the last three decades, the industry has averaged about 100 LODDs per year (see **Figure 2**). Until relatively recently, the loss of a firefighter was considered by many in the industry to be an acceptable risk of operational activity. Firefighter fatalities take an enormous human toll on the family and the department. They are also costly — medical expenses, psychological counseling to the family and surviving firefighters, workers' compensation costs, death and/or disability benefits for the family, the loss of a primary breadwinner, costs of investigations, loss of productivity, and other related expenses adversely affect everyone involved.

Figure 1: Firefighter Injuries 2003–2011.



Source: National Fire Protection Association

Figure 2: Firefighter Fatalities 2003–2012.



Source: National Fallen Firefighter Foundation

Fortunately, many firefighter deaths and injuries are preventable. Often, identifiable vulnerabilities and unaddressed exposures to risk precipitate the injury or fatality. While the industry has made positive inroads in reducing fatality rates over the last few years, these preventable deaths continue to occur. Too often, fire chiefs and officers were not aware of the potentially harmful outcome of policies, procedures, misuses of equipment, or negative cultural norms in the department.

In other instances, they were cognizant of the vulnerability but were unable to leverage the resources needed to mitigate the risk.

What has been lacking until now is a systematic process by which fire chiefs and officers could identify and mitigate risk BEFORE a near-miss or injury occurs. By assessing the department in totality, clearly demarcating risks and providing actionable resources to correct them, the VAP will prevent or reduce minor injuries, career-ending injuries, and fatal injuries. In addition, the VAP will provide scientifically based documentation of existing departmental risks that can be used to prioritize expenditures that advance firefighter health and safety.

It is good business for the fire-service industry as a whole to support the development and widespread adoption of the VAP. Lost-time injuries will be fewer in number, which will reduce financial strains on jurisdictions and budgets. Local, state, and national government entities will be positively impacted because there will be fewer LODD survivors who require resources. There will be reductions in potential litigation, insurance payments to survivors, and lower insurance rates for fire departments. For municipalities, the inherent cost savings alone should support the implementation of strategies that are recommended by the VAP.

The NFFF, together with the USFA and Honeywell Corporation, has defined the long-term objectives of the VAP as follows:

- To provide a tool that will be credible with firefighters, public officials, and risk managers
- To develop a vulnerability assessment model recognized by all national stakeholders
- To create an effective tool for assessing exposures and risk (gaps in capabilities) associated with line-of-duty injuries and deaths
- To develop operational plans to address low- to no-cost exposures: policies, procedures, and work-practice controls
- To educate elected and appointed officials on fire-department capabilities and limitations
- To educate the public on risks and exposures to gain community support for preventing LODDs and injuries
- To provide a tool that is easy to use and has value for both large and small fire departments
- To develop strategic implementation plans at the federal, state, and local levels
- To educate firefighters on risk potential and areas of exposure
- To develop joint risk-reduction initiatives between labor and management at the national and local levels
- To evaluate efforts toward prevention after LODDs and injuries occur
- To establish the tool as a criteria for Center for Public Safety Excellence (CPSE) fire-department accreditation

VAP Development Team/Steering Committee and Fire Service Stakeholders

The NFFF Executive Director and a project manager oversee the VAP development and design team. In addition to NFFF staff, the NFFF has contracted FACETS LLC Consulting to coordinate project design. A core steering committee is consulted on day-to-day issues as they arise.

The VAP development team engaged potential stakeholders in the project development process from the very beginning, knowing that creating a credible tool would require buy-in from its end users. Representatives of most major fire service organizations (called the *VAP Fire-Service Partners*) were invited and encouraged to participate in the development process (see **Table 1**). In addition, individuals representing insurance companies, equipment and vehicle manufacturers, standards-making bodies, accreditation organizations, and educational institutions were involved (see **Table 2**). Active and retired fire chiefs, fire officers, and firefighters were also engaged in the process.

Table 1: Fire Service Organizational Partners.

National Fallen Firefighters Foundation	International Association of Fire Fighters
United States Fire Administration	International Association of Women in Fire & Emergency Services
Fire Department Safety Officers Association	National Association of Hispanic Firefighters
International Association of Arson Investigators	National Fire Protection Association®
International Association of Black Professional Fire Fighters	National Volunteer Fire Council
International Association of Fire Chiefs	North American Fire Training Directors

Table 2: Other Organizational Partners.

Insurance Industry (including ISO,VFIS and Provident Agency, Inc.)	Center for Public Safety Management (International City/County Management Association
Fire Apparatus Manufacturers Association (FAMA)	Oklahoma State University (Fire Protection Publications)
Fire and Emergency Manufacturers and Services Association (FEMSA)	Chief Douglas Barry, retired, Los Angeles (CA) Fire Department
United States Forest Service	Deputy Commissioner Henry Costo, Philadelphia (PA) Fire Department
United States Navy Fire & Emergency Services Command	Chief Charlie Dickinson, retired, Pittsburgh (PA) Fire Department
Fire Fighter Fatality Investigation and Prevention Program (National Institute for Occupational Safety and Health)	Chief William Pessemier, retired, Littleton (CO) Fire Department
Center for Public Safety Excellence	Chief Jim Tidwell, retired, Ft Worth (TX) Fire Department

Stakeholder meetings have been held regularly throughout the development process, and regular communications among all the entities provide a flow of information to and from all partnering organizations. The consistent involvement of stakeholders has enabled the development team to gain support throughout the process from organizations potentially affected by the VAP and solicit participation from committed individuals and organizations. Their continued interest and involvement also illustrate the widespread support that the fire service has demonstrated for the VAP.

Development of the VAP

The VAP development process is being completed in the following five steps over a five-year period:

- **Phase I** — Conduct research and analysis of existing best practices, models, and tools for risk and vulnerability assessment.
- **Phase II** — Review and confirm LODD contributing factors; develop VAP questions and decision trees, and gather fire service specific resources.
- **Phase III** — Perform needs assessment and gather requirements for software-development process; create request for qualifications (RFQ) document and distribute it to potential vendors/ development teams.
- **Phase IV** — Review RFQ respondents; create and distribute request for technical proposals (RFTPs); select/contract software development and project management teams; and develop and test web-based VAP application.
- **Phase V** — Deploy the VAP tool and begin data collection.

Phase I: Conduct Research and Analysis of Existing Best Practices, Models, and Tools for Risk and Vulnerability Assessment.

Phase I consisted of data collection and literature review. The depth and scope of research into firefighter risk and mitigation was neither entirely clear nor centrally available when the VAP project began. From the start, the VAP steering team mandated that all material ultimately offered to departments must be grounded in the most reliable research available.

Data Collection

The first step in the development process was to identify and/or create a database of information that could be utilized to specify factors contributing to a fire department's risk of experiencing firefighter near-misses, injuries, and deaths. In terms of methodology for data inclusion, the design team chose to assess fire departments holistically and to perform a broad, interdisciplinary assessment of organizations rather than narrowing the scope and targeting only operational vulnerabilities.

Numerous fire service databases were examined, but no single existing data collection effort fit the needs defined by the design team. One obvious possibility, explored early in the process, was to utilize information collected by the insurance industry related to firefighter injuries and deaths. However, insurance representatives cited difficulties that individual providers as well as the NCCI (National Council on Compensation Insurance, Inc.) would have in providing data that would be deemed acceptable for developing a risk-assessment profile. Several problematic issues were highlighted as follows:

- Inconsistent differentiation between health insurance and workers' compensation claims
- Different state requirements for workers' compensation benefits
- Antitrust laws that prohibit sharing of information
- Differences between companies in terms of identifying and classifying causal factors
- Distortions of data caused by 24-hour (postshift) coverage policies
- Difference between organizational definitions of workers' compensation, short-term disability, and long-term disability
- Providers lacking or using different methods of identification of activity vs. emergency call claims
- Each provider having a different model for assessing fire departments
- Self-insurance by larger departments

Without an existing database of relevant information, the question remained of how to create a model that utilizes behavioral assessment and review of managerial practices to assess risks. Clearly the database for the VAP would have to be developed by the design team through a large-scale literature review, which would incorporate information gleaned from fatality and injury reports, near-miss reports, and analyses of previous National Fire Protection Association® (NFPA®) injury data and National Institute for Occupational Safety and Health (NIOSH) regulations that could be used to infer factors that influence fatalities.

There is very little peer-reviewed literature on firefighter safety and fire-service risk-reduction techniques, except for a handful of journals (most notably the *International Fire Service Journal of Leadership and Management*). In creating the database for the VAP, anecdotal reports were viewed as unreliable and were eliminated. The search for reliable data had to be conducted almost entirely outside the fire service per se but was restricted to disciplines that are allied with the fire service — such as health and wellness institutions, risk-management groups, airlines, etc. The search for evidence-based best practices led the design team far and wide, resulting in a strong database, undoubtedly the most unique that exists in the fire service to date.

Literature Review

Since there was not an existing database, the development team embarked on a large-scale literature review whose purpose was two-fold:

1. To identify contributing factors to organizational vulnerability in fire departments
2. To identify risk-analysis methods and practices with potential to inform the overall VAP project

The VAP project team reviewed 3,373 peer-reviewed academic journal articles. From these, they selected 509 from 78 journals that had potential VAP applicability, with a median Impact Factor (IF) of 2.397. In addition, the researchers also reviewed the following documents:

- 513 reports from the Centers for Disease Control and Prevention (CDC), NIOSH Fire Fighter Fatality Investigation and Prevention Program (FFFIPP); see www.cdc.gov/niosh/fire/
- 24 NFPA® reports; see www.nfpa.org/categoryList.asp?categoryID=15&URL=Research
- 34 USFA reports; see www.usfa.fema.gov/statistics/
- 6 annual reports from the National Fire Fighter Near-Miss Reporting System; see www.firefighternearmiss.com/index.php/main-resources/142
- 137 doctoral dissertations and graduate theses indexed by the USFA/National Fire Academy (NFA) Learning Resource Center (LRC); see www.lrc.fema.gov/dissertation.html
- 6 USFA/NFA/LRC fire service bibliographies; see www.lrc.fema.gov/pathfinders.html

The bibliography for the VAP at the completion of Phase I of project development represented a thorough overview of the available literature as of September, 2011. Obviously, fire-science research continues to evolve. This database will need to be amended regularly throughout the life of the VAP.

The transitional step between Phases I and II was to determine a methodology for organizing and attributing risk factors within the VAP. Based on the findings from the literature review, specific factors were identified as contributing to a fire department's risk of experiencing firefighter near-misses, injuries, and deaths.

Phase II: Review and Confirm LODD Contributing Factors; Develop VAP Questions and Decision Trees, and Gather Fire Service Specific Resources.

It was very important in Phase II to organize the research yielded in Phase I. In other words, the VAP needed an organizing framework within which to develop the survey questions. The initial recommendation from the development team (in agreement with the steering committee and fire-service partners) was to utilize the NFFF's categorization scheme of firefighter fatality *root causes* as a means of structuring the VAP research data. These six root causes of firefighter fatalities were initially identified just prior to the 2004 Firefighter Life Safety Summit in Tampa and agreed upon by the participating organizations as the *causal factors* most attributed to a firefighter LODD.[1] NFFF staff and contract employees had been tasked with conducting a complete literature review of firefighter fatality reports. Using data gleaned from these documents, they were then able to isolate the common factors and identify six root causes of firefighter fatalities. These factors would then serve as a way to classify and assign causality in LODDs as well as serving as starting points for future LODD-prevention efforts through the *EGH*® programs and 16 FLSIs.[2]

The LODD root causes are the organizational and individual situations, behaviors, and attitudes that are the true causal factors of the fatal incident. Although it is important to note that the majority of firefighter fatalities and/or serious injuries have multiple identifiable root causes, these are recognizable primary causes nonetheless:

1. Ineffective policies/procedures
2. Ineffective decisions
3. Lack of preparedness
4. Ineffective leadership
5. Lack of personal responsibility
6. Extraordinary/unpredictable circumstances

To validate the relevance and applicability of the root causes as a categorization scheme for the VAP, NFFF personnel in 2011 undertook a similar review of 1,252 firefighter LODD reports for fatalities that occurred between 1999 and 2010.[3] A retired chief officer from the Prince William County (VA) Department of Fire and Rescue was contracted to review each fatality report in its entirety. He assigned an initial designation as to the one or more root causes that would be attributed to the case. A second reviewer, a retired chief fire officer from the Fort Worth (TX) Fire Department, reviewed files where the first reader found disputed causal factors. In the end, between the two readers, a final determination was reached.

Besides being examined for applicability to the organizational methodology of the VAP, the data collected from this study was examined to assess current trends. *Ineffective decisions* led to the highest number of LODDs followed by *ineffective policies/procedures*. I*neffective leadership and lack of personal responsibility* were next, followed by *lack of preparedness and extraordinary/unpredictable circumstances*. In the majority of LODD events (as had been found previously), it was determined that two or more causal factors contributed to the fatality. Most fatalities were associated with at least three root causes, while others included five. It should also be noted that the only category that was attributed as a single factor was *Extraordinary/unpredictable circumstances*.

Using the data collected from the literature review, the VAP design team defined and articulated *contributing factors* for firefighter fatalities, which were then assigned to a root cause (see **Figure 3**). Obviously grouping together contributing factor sources into VAP root causes is a subjective way to structure the program. Interestingly, these variables (that ultimately will determine the risk profile for the department or agency) are never seen by the end user because they are integrated into the model.

It is important to note that many of the interrelationships between issues and contributing factors have not been explored in the literature, so at this point there are currently no academic studies to reiterate our findings. However, in the future, the data gleaned from actual end users of the VAP could be a source of primary data to support these connections, and changes may be made to the VAP organizational structures that reflect this data.

With an organizational framework in mind, the VAP team began to draft questions to address the specific risk factors identified within the literature review. In July of 2012, the initial pilot testing of the VAP questions was distributed to 20 fire departments. This number was a broad sampling, representing a cross section of departments in terms of composition, size, and region of the country. As scalability-of-question focus is an important factor in the VAPs ultimate integration into the fire service, it was important that agencies of all configurations be included at this stage.

Initially during the development process, the end users of the VAP were assumed to be fire chiefs. However, through extensive discussions at stakeholder meetings, this assumption was challenged and found to be not always true. An equally likely scenario is that the fire chief may delegate portions of the assessment to other individuals, including company officers, training officers, and safety officers. Therefore, the initial sample group was broadened.

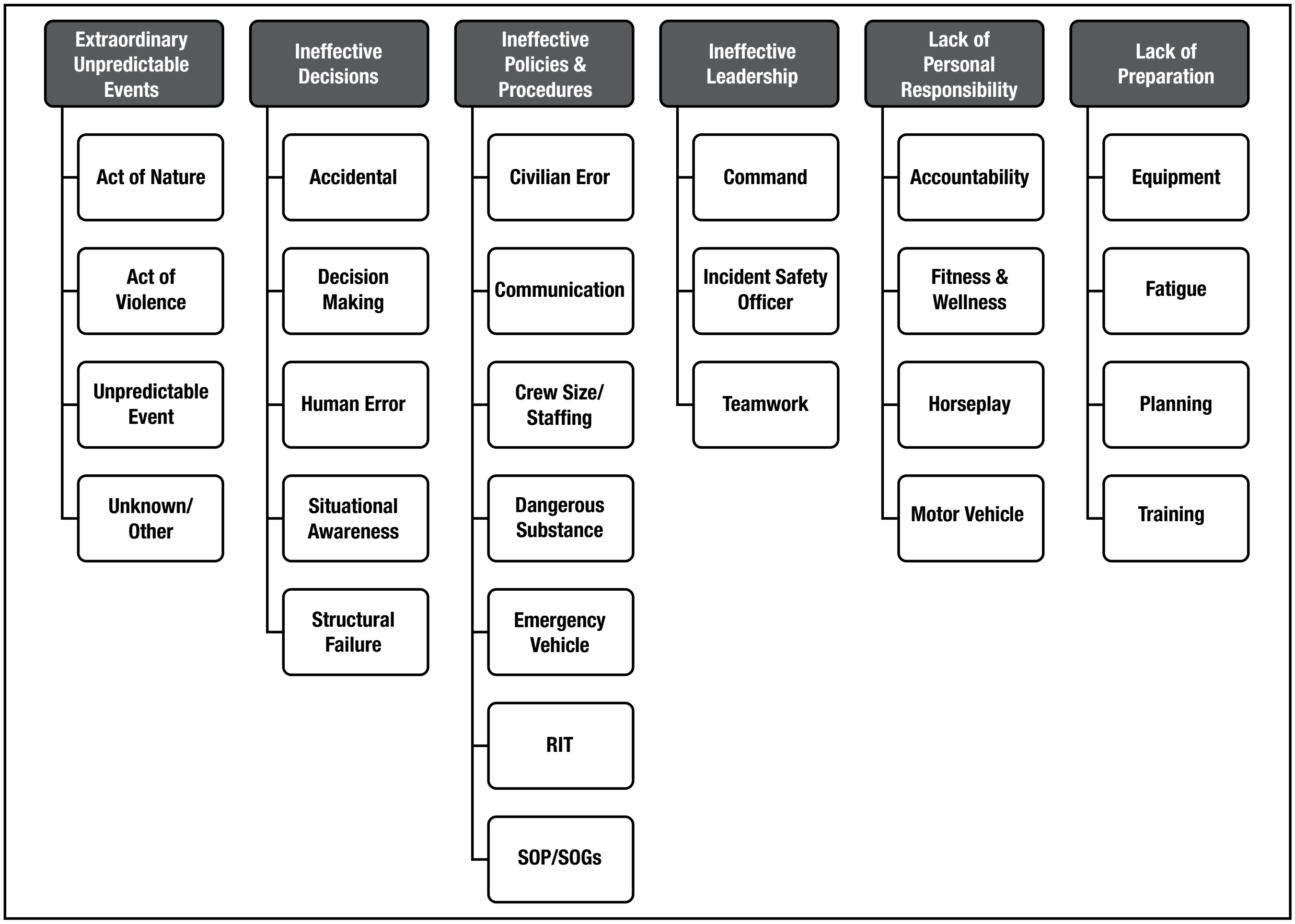
The first version of the drafted list of VAP questions included over 300 questions. Respondents were asked the following questions about each VAP question:

- How easy is it to understand this question?
- Is this question invasive or insensitive?
- Do you have any recommendations on wording or format?
- Do you have any other comments, suggestions, or concerns regarding this question?

The design team received the following feedback:

- Eleven questions were considered invasive or insensitive.
- Three-hundred comments addressed issues such as errors, wording, questions, or approval.
- Sixty-one questions were rated difficult to understand.
- No additional questions were suggested.
- Additional work was noted as being needed to standardize nomenclature.

Figure 3: LODD Contributing Factors — Root Causes.



Because there was some confusion in this early test, it was recommended that the VAP utilize IFSTA's *Fire Service Orientation and Terminology* as the guiding document for defining fire-service-specific words and terms. Subsequent iterations of the VAP may have a *mouse-over* capability to reveal specific words and terms.

Within the development of the questions, readers from the stakeholder groups have worked diligently in the refinement process. The CPSE, for example, who is potentially planning to align the VAP with its accreditation processes, has requested that questions identify whether or not consistent, evidenced enforcement of policies and procedures are in place. The CPSE requested that more weight be given in the survey to a policy that is enforced over one that exists on paper only.

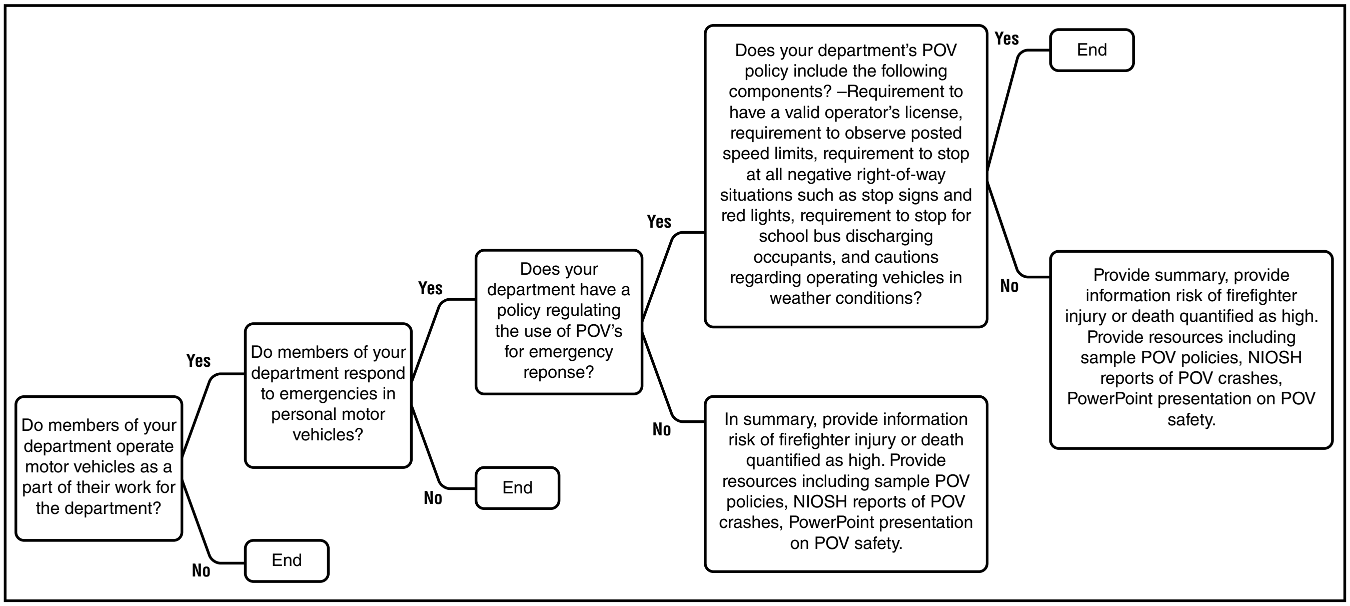
The most immediate benefit of the VAP will be in educating fire departments about their vulnerabilities and exposures and defining ways they can modify and reduce risk. While in the future the VAP will be able to be integrated with consolidated risk assessment (CRA) tools, the focus in its first iteration will be to identify the risk factors that can be controlled at the departmental level and to provide the free and easily accessible resources that can assist departments in doing so. In terms of the VAP, these are referred to as *actionable resources*. Resources will be assigned in the final report according to where the user stops in the question tree path while answering each VAP question (see **Figure 4**).

The VAP will identify actionable resources and can continue to populate the resource database as new information becomes available. Materials that will be provided in the VAP reports can include, but are not limited to the following:

- NFPA® standards
- NFFF educational materials
- USFA educational materials
- Partner organizations' educational materials, for example Fire Apparatus Manufacturers Association (FAMA)/Fire and Emergency Manufacturers and Services Association (FEMSA) manuals
- Allied industries educational materials
- Interdepartmental networks

Whenever possible, these resources will be made available free of charge and will be accessible immediately. It will take years to feel comfortable that the VAP has obtained all reasonable corrective action material. However, plans for the future include regular input from end users and from traditional research efforts.

Figure 4: Sample Question Tree.



Phase III: Perform Needs Assessment and Gather Requirements for Software-Development Process; Create RFQ Document and Distribute it to Potential Vendors/Development Teams.

Design simplicity will be critical for the user interface for the VAP because the greatest challenge will be to create something that departments trust and use. Ultimately, it must be a tool that can be used without technical training by the end user and by personnel at any level — department, company, and/or individual firefighter. A RFQ was published in January, 2013.

Briefly, the potential vendors were asked to address the following attributes in their proposals:

- Include a broad array of reporting requirements and capabilities;
- Design it to be completed at the department level, but reporting will be used by administrative officials;
- And clearly define the gap between what the department is asked to do and what it is capable of doing.

An RFTP was requested in May of 2013.

Phase IV: Review RFQ Respondents; Create and Distribute RFTPs; Select/Contract Software Development and Project Management Teams; and Develop and Test Web-Based VAP Application.

Vendor selection occurred in June of 2013. Phase IV focused on software development, testing, training, and marketing the VAP.

Phase V. Deploy the VAP Tool and Begin Data Collection.

The VAP will be deployed in a nationwide rollout in early 2014. Early on in the VAP-development process, Honeywell's Health, Safety and Environment Management Systems group gave an overview of its risk-control methodology for the VAP stakeholders. By implementing high standards of industrial safety through an operational policy of identifying and prioritizing risks, stakeholders have been able to achieve predictive performance. It was also noted that within their facilities, comprehensive performance standards and individual accountability at all levels leverage expertise and resources where they have the greatest impact.

In other words, the formal, integrated processes of risk assessment and strong management policies drive the safety culture of the company. This process is clearly analogous to the use of the VAP to identify and reduce risk within fire-service departments and to incentivize policies and procedures that will effectively institutionalize the safety culture of an organization.

In addition to increasing firefighter safety, the VAP will also be a decision support system that can be used to align community expectations with department capabilities. The VAP will focus on the gaps that most put firefighters at risk and, with a given amount of resources, will determine what the operational capabilities for reducing risk are. Output in terms of actionable resources will be prioritized in terms of what can and should be implemented first.

The insurance industry can promote use of the VAP by using cost-benefit analysis as a marketing tool. Governments can justify the VAP by assigning a potential cost savings to reduced insurance premiums resulting from risk-reduction efforts enacted by the individual department.

The concept of vulnerability assessment is a critical process that all fire departments should utilize as a way to identify, assess, and overcome vulnerabilities that could, or already have, cost firefighters and emergency medical technician (EMT) responders their lives. Clearly, there are compelling reasons for why the VAP is greatly needed. It is a **real-world solution** that will enable a fire department to address and mitigate risk issues in a conclusive and streamlined manner. For the first time, chiefs and other fire-department managers will have real data to defend budget requests.

To date, the VAP has received some very important endorsements. The U.S. Conference of Mayors, led by Mayor Joseph P. Riley, Jr. from Charleston, South Carolina (SC) has issued a Resolution of Support for adoption of the VAP by its constituent municipalities. The CPSE has issued a formal Resolution of Support for the VAP and also anticipates that the VAP will be incorporated into standards for fire-department accreditation. In the spring of 2012, the Congressional Fire Service Institute's National Advisory Committee (representing over three-dozen fire-service organizations) approved a Resolution supporting the VAP. For further information on the VAP, or to join our mailing list, please contact Dr. JoEllen Kelly, jkelly@everyonegoeshome.com

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National Institute of Standards and Technology (NIST). (2005). *The economic consequences of firefighter injuries and their prevention.* Gaithersburg, MD: U.S. Department of Commerce, Building and Fire Research Laboratory, NIST. The full report is found at http://www.fire.nist.gov/bfrlpubs/NIST_GCR_05_874.pdf

Endnotes

[1]Over 3,000 LODD records upon which recommendations on the root causes were suggested had been examined prior to 2004.

[2] This classification method for root causes is utilized by the USFA and the NFFF and its associated programs. Other fire-service organizations that write and/or review LODD reports may utilize a different nomenclature system to define root causality.

[3] The first-responder deaths caused by terrorist attacks on 9-11 were excluded from this analysis.

About the Author

Ronald Jon Siarnicki, Executive Director of the National Fallen Firefighters Foundation (NFFF), began his career as a firefighter with the Prince George's County Fire/Emergency Medical Services (EMS) Department in 1978 and, over 24 years, progressed through the ranks to Chief of the Department. In this position, he served as the Chief Executive Officer responsible for the fire, rescue, and EMS Department of Prince George's County, Maryland. Prior to joining the Prince George's County Fire/EMS Department, he served as a volunteer firefighter with the Monessen Volunteer Fire Department, Hose House No. 2, in western Pennsylvania. In doing so, he followed a family tradition — both his father and grandfather were volunteer firefighters.

In July 2001, he retired from the Prince George's County Fire/EMS Department to take the position of Executive Director of the NFFF. In addition, he oversees the development and direction of the *Everyone Goes Home®* (*EGH®*) Program designed to reduce the number of firefighter LODDs and injuries that occur each year in the U.S.

Chief Siarnicki delivers presentations at fire and emergency conferences and meetings across the country, increasing awareness of the Foundation, the efforts of its prevention work, and support for the families of the fallen. In recognition of his outstanding leadership with the Foundation and the fire service as a whole, he has been recognized by various groups and organizations to include: The Fire Engineering Lifetime Achievement Award: 2010; Alan Brunacini Fire Services Executive Safety Award from the International Association of Fire Chiefs: 2007; Metropolitan Fire Chiefs' Presidents Award of Distinction: 2007; and the 2012 Everett E. Hudiburg Award from IFSTA. In 2013, he was the recipient of the Congressional Fire Services Institute (CFSI)/Motorola Solutions *Mason Lankford Fire Service Leadership Award*.

A strong proponent of higher education, he earned both his bachelor's and master's degrees from the University of Maryland University College (UMUC) and served as a UMUC faculty member for the Fire Science Curriculum. Chief Siarnicki can be contacted at **rsiarnicki@firehero.org**

Since Volume 1, Issue 1, of the *International Fire Service Journal of Leadership and Management* (*IFSJLM*), the "Red Journal" has featured a number of articles written by our friends in the United Kingdom (UK) and Canada. Similarly, this issue of *IFSJLM* contains an article coauthored by Viv Brunsden, Rowena Hill, and Kevin Maguire, all housed at Nottingham Trent University (NTU) in Great Britain. **However, Volume 7 is a benchmark issue offering for the first time an article from a Continental European nation — Belgium**. Given that the first word in the title of the Red Journal is *International*, we urge authors studying fire leadership and management issues from around the world to submit their articles (written in English and following the current APA style) to *IFSJLM* for peer review.

Viv Brunsden, Nottingham Trent University
Rowena Hill, Nottingham Trent University
Kevin Maguire, Nottingham Trent University

Putting Fire and Rescue Service Stress Management Into Context: A United Kingdom (UK) Informed Perspective

Abstract

Fire and rescue service personnel can experience high levels of exposure to both occupational and post-traumatic stress, with the interplay between these generating a range of complex stress responses. The nature and cultural context of fire service work can, in turn, impact the take up and effectiveness of stress interventions. The development of appropriate processes for the prevention of, and responses to, stress exposure is therefore a crucial managerial issue. A consideration of such issues is presented, alongside an evaluation of the likely success of various stress interventions.

Fire and Rescue Service Research: Time for a More Honest Contextualisation of Findings?

The Fire and Rescue Service (FRS) provides a complex occupational environment for both personnel and management. Frontline responding means that personnel are routinely exposed to unusual and traumatic stressors not seen in many other organisations; whilst they are simultaneously also subjected to the usual stressors seen in most other organisations. This interaction of occupational stress, generated both by general and occupationally specific stressors, and traumatic exposure can create a highly complex, unique pattern of stress responses. This pattern in turn can generate particular stress responses and coping behaviours, and these then interact with the broader social intraorganisational context and interemployee relationships. These effects can also extend beyond the organisation to create occupationally specific family-work patterns and relationships. The FRS context and its unusual patterns of work and family relations can reduce the potential for employing preventative stress strategies because of the inevitable stress exposure involved in emergency responding. Successful stress management strategies therefore tend to be responsive, postexposure interventions that can take account of the unique occupational context.

A key problem with the global research literature into the FRS is that it is only rarely treated as a population in its own right, instead being conflated with other emergency services — specifically the police force and those working in emergency medicine such as paramedics. In the case of the latter, the situation is further complicated by the presence of dual-role fire services in some countries; for example, the United States (US) and Republic of Ireland amongst others. These dual-role services respond to both fire-related and medical emergencies. The complexity across the roles provided by the FRS globally can make research conducted in one country less relevant for another. There can also be other key differences between the FRS working across countries. Further, all FRSs reflect the characteristics and context of the wider culture in which they are embedded. It is therefore important that where appropriate a regional or national context is acknowledged before placing any research considerations into a wider global context. This article will therefore, whilst taking a global focus wherever possible, largely consider the practices of and aligned literature around the UK FRS. It is hoped that this clear acknowledgement of a particular national context will allow those in other countries to consider the relevance, or not, for their own local contexts.

Stress in the Fire and Rescue Service (FRS)

That FRS personnel are subject to a wide variety of stressors, both psychological and physiological, is well recognised in the literature (see Hill & Brunsden, 2003; Brown, Mulhern, & Joseph, 2002; Baker & Williams, 2001; and Regehr, Hill, & Glancy, 2000; for just some examples). Despite awareness of such research, there can be a reticence to acknowledge and discuss stress within the FRS itself (Beale, 2003). Within the research literature, the main focus has been on traumatic stress and, given the nature of the incidents that FRS personnel attend, this focus is perhaps unsurprising. However the relative neglect of other origins of stress may be problematic, because personnel are also exposed to a wide variety of nontraumatic stressors; for example, physical stressors such as chemical and biological hazards (Markowitz, 1989; Malek, Mearns, & Flin, 2003), bad-weather conditions (Beale, 2003), extreme heat (McLellan & Selkirk, 2006; Brenner, Shek, Zamecnik, & Shephard, 1998), and protracted or nighttime operations (Beale, 2003). Further, there is a need for shift working to ensure 24-hour responding (Ernst, Jiang, Krishnamoorthy, & Sier, 2004), and this requirement can act as a stressor in itself as well as creating additional problems such as tiredness and sleep disturbances (Courtney, Francis, & Paxton, 2010; Holmes, 2003; Murphy, Beaton, Cain, & Pike, 1999). Stress may also arise from a variety of standard occupational stressors as encountered in any other organisation (e.g., see Brunsden, Woodward, & Regel, 2003; Brough, 2002; Brown, Fielding, & Grover, 1999); and there is some evidence that the presence of occupational stress can outweigh traumatic stress despite the emphasis on trauma in the literature (Brunsden et al., 2003). Such nontraumatic stressors generate stress in and of themselves. They are also likely to further complicate incidence of traumatic stress where this does occur. Its presence must also be acknowledged because all emergency services personnel are necessarily subject to this stress through their attendance at distressing emergency events (see Hill & Brunsden, 2003; Brown et al., 2002; Beaton, Murphy, Johnson, Pike, & Corneil, 1999). Their traumatic stress is unusual relative to other traumatised populations however in that the FRS traumatic exposure is expected and routine, whereas most traumatic stress exposure is unexpected and unpredictable. Such a notion of "expected and routine" exposure has led to recent suggestions of a need for a new diagnostic category of post-traumatic stress, specifically that of duty-related traumatic stress (Paton, 2006). The occupational implications of such a categorisation could be profound, given that a survey of UK FRSs found a psychologist-to-staff ratio of only 1:2600 (Durkin, 2006).

A further source of stress for FRS personnel can arise from aggressive encounters with the general public (see Brunsden, Hill, McTernan, & Shuttlewood, 2011; Brunsden, 2007). An analysis of British Crime Survey data suggested that protective-service occupations such as the FRS are the most at risk of experiencing violence at work (Webster, Patterson, Hoare, & O'Loughlin, 2007). However, this is not an issue unique to the UK. US research has also found that it is not unknown for firefighters to experience violence when responding. Grange and Corbett (2002) in a study conducted in California found violence toward responders in 4.5% of calls, with half of these involving physical attacks. Mechem, Dickinson, Shofer, and Jaslow (2002) found a strikingly similar rate of 4% in Philadelphia. Whilst these rates are relatively low, the issue is a serious one, with medical attention being sought in 81% of the incidents and with the health consequences being serious enough to generate sickness-related absenteeism in over 30% of cases (Mechem, Dickinson, Shofer, & Jaslow , 2002). Even when aggression is manifested as verbal abuse rather than physical violence, it can still create stress and anxiety (Brunsden, et al., 2011; Communities & Local Government, 2006).

Studies related to stress in the FRS have tended to focus on operational staff (i.e., those who actually attend the emergency events); however, these members are not the only emergency service personnel who are exposed to stress. Control-room staff can also suffer stress through standard occupational and organisational factors (see Brunsden, Robinson, Goatcher, & Hill, 2012; Brunsden et al., 2003); but they may also experience traumatic stress vicariously through staying on the phone with distressed callers during incidents and hearing their description of events. Because of their close working relations with operational personnel, control staff members may also be vulnerable to stress crossover — a form of stress contagion whereby an individual assumes the stress of another because of role obligations and commitments (Wethington, 2000). Control staff members are also vulnerable to distress arising from hoax calls and may also receive sexually harassing calls (Brunsden, et al., 2011; Brunsden & Goatcher, 2009). As yet, however, this occupational group has received little attention from academic psychologists (Brunsden, et al., 2012; Brunsden, Woodward & Regel, 2003).

Despite the obvious increased stress exposure occurring for FRS personnel, it should be noted that whether such exposure *necessarily* leads to heightened detrimental responses is highly debatable. For example, Pendleton, Stotland, Spiers, and Kirsch (1989) found that firefighters reported lower strain levels than non-emergency public-sector workers; and firefighters have repeatedly been found to experience high levels of job satisfaction (Smith, 2007; North et al., 2002; Guidotti, 2000). Despite this finding, the UK FRS's own audits have repeatedly found raised detrimental stress levels in personnel (e.g., see Brunsden et al., 2003; Regel, Woodward, Horsley, & Brunsden, 2001; Woodward, Brunsden, & Regel, 2000). There is also evidence of stress being an issue for firefighters in other countries, for example, the US and Canada (Murphy, S.A., Bond, Beaton, Murphy, & Johnson, 2002); Malaysia (Malek, Fahrudin, & Kamil, 2009); Brazil (Vargas de Barros, Martins, Saitz, Bastos, & Ronzani, 2012); and Japan (Saijo et al., 2008).

Stress and the Organisational Culture of the FRS

Organisational culture is a crucial issue to consider in that it directly impacts on both stress and the take up of stress interventions. Despite recruitment drives, which have targeted women and ethnic minorities, the FRS's operational personnel remain dominated by white males (Hashem & Lilly, 2007). This male dominance is possibly exacerbated by notions of "the Brotherhood" and fraternity (see Crosby, 2007), which despite having many positives in terms of solidarity, may act as an implicit deterrent to female potential applicants. It has also been found that FRSs can be organisationally poor at evaluating their own equality policies and initiatives (Scaife & Lilly, 2007). This gender imbalance creates a particular form of organisational culture — one that can detrimentally impact on stress initiatives. Wester and Lyubelsky (2005) note that males are reluctant to publicly share, instead generating and maintaining barriers to help-seeking. The almost exclusively male population, combined with the perception of FRS work as *heroic*, can lead to a macho organisational culture. This culture has been referred to as the three Ts of "testosterone, tattoos and taut-biceps" (Beale, 2003, p. 29). The pseudo-military nature of the emergency services also has an influence here. In the UK recent modernisation processes have been implemented with an intention to remove militaristic tones from the FRS; for example, a shift from rank to role, the loss of militaristic uniforms, and a change in language such as the replacement of *brigade* with *service*. However, despite these efforts, the cultural similarities between the military and the FRS still persist (Sanderson & Brunsden, 2012). This matters because military culture has also been found to be an important barrier to help-seeking (Sanderson & Brunsden, 2012; Greenberg, Langston, & Scott, 2006); and military personnel can reject any notions of interventions perceived to be therapeutic in nature (Smith & Johnson, 2012). Certainly, a similar problem has been found to exist within the UK FRS, particularly in relation to the self-reporting of stress (Lawrence, 2003).

A further cultural issue of significance within the UK is that of industrial relations. The Fire Brigades Union (FBU) could be described as the UK's strongest single-occupation public-sector trade union; and a strong collective identity has formed within this union (Brunsden & Hill, 2009). The FBU enjoys almost total membership amongst firefighters, and the membership is active and willing to strike. Although national strikes are exceptionally rare, with only two ever having occurred in the UK, strikes at the local level take place far more often within individual FRSs. Following the 2002–2003 UK national strike, a modernisation process took place that changed many of the working conditions within the service in line with recommendations in the Bain report (Bain, Lyons, & Young, 2002). This change process acted as a significant stressor, the repercussions of which are continuing. Similarly, the strike itself could be seen as a traumatising event that has continued to generate stress reactions long after its end (see Brunsden & Hill, 2009). The politicised context of the FRSs working can also affect the stress-intervention strategies offered to personnel; for example, it has been argued that fatigue-management programmes, widely used in other high-risk industries such as aviation and the petrochemical industry, are rarely implemented in the UK FRS because the stress-inducing factors of sleep loss and tiredness are necessarily entwined in issues of work hours, pay, and secondary employment (Holmes, 2003).

The nature of UK FRS industrial relations means that audits can become highly politicised activities. Conducting stress audits necessarily requires the cooperation of both management and workers. During our own audits (e.g., Brunsden et al., 2003; Eyre & Brunsden, 2003; Regel et al., 2001; Woodward et al, 2000; Maguire & MacPherson, 1997), variously commissioned by both FRS management and trade unions, it became clear that without both sides' cooperation, the auditing would fail. Management necessarily had to approve the work to enable access, whereas the union necessarily had to endorse the initiatives in order to get any reasonable participation rate. Both sides have different agendas regarding the outcomes of any auditing. It is inevitably in management's interests that audits show low levels of stress and high levels of job satisfaction. Conversely, if audits show high stress and low satisfaction, trade unions can use these data to their own advantage in confronting management. This adversarial difference in advantage may lead both sides to exert pressure on personnel, consciously or unconsciously, to provide answers that skew the data in particular ways. The situation is then further complicated if participating personnel do not trust that their individual responses will not somehow be fed back to management. If this fear persists, regardless of whether it is founded in any actuality, then personnel may wish to represent their psychological health more positively than is actually the case. The vested interests of these various parties potentially render findings of audits as artefactual, saying more about the processes by which they were carried out than offering any indication of genuine levels of stress. Despite this issue, audits are still worthwhile exercises because, even if their findings are taken very conservatively, the discovered rates and their negative implications are still concerning.

Establishing stress levels in FRS personnel is important not only for the health of the personnel themselves, but also because of their roles in the safety of the communities they serve. Stressed and traumatised individuals cannot perform their occupational roles to the best of their abilities and when the public depends on that occupational role. Even small percentages of affected personnel constitute a serious risk to public safety. Such an effect is evident, given the detrimental consequences of stress on job performance (Srivastava & Krishna, 1991) and on crucial factors in emergency service working such as the performance of complex tasks (Berkun, 2000), and the ability to accurately judge risk (Quartermain, Stone, & Charbonneau, 1996). Stress-prevalence rates reported in fire service audits have varied, but figures have been found as high as 19.3% showing clinical signs of traumatic stress and 8% meeting all post-traumatic stress disorder (PTSD) diagnostic criteria (Brunsden et al., 2003; Regel et al., 2001). Other researchers have found even higher rates of 20% of serving firefighters having PTSD (e.g., see Durkin, 2006). Stepping away from trauma to occupational stress and related issues such as anxiety and psychological distress, the figures become even higher. Joseph, Brown, & Mulhern (2003) found that one-fifth of their sample of Irish firefighters showed high levels of psychological distress and suggested that this figure could be an underestimate of what might be found in the wider FRS population, given that the most distressed individuals also tend to be the most avoidant. This avoidance is likely to be further exacerbated by FRS culture and the reluctance to self-refer on grounds of stress (Lawrence, 2003). This is supported by Brunsden et al. (2003) who found that 76% of their UK fire service sample reported physical ill-health symptoms associated with stress-related illnesses but that only 3.8% attributed those symptoms to stress.

The Impact of Occupational Identity

Within the FRS literature there is evidence for a strong occupational identity (Fannin & Dabbs, 2003; Lee & Olshfski, 2002). This identity not only contains a clear commitment to the occupational role but also a commitment to the way in which that role is carried out, as well as how the role is viewed by members of the public. For example, firefighters have been found to have such strong role identity that they are never actually off duty (Lee & Olshfski, 2002). It has been suggested that FRS personnel in operational roles have a need for control, a need to be needed, and a need to rescue (see Brown et al., 2002; Regel et al., 2001). In addition, emergency personnel can have high empathy levels (Mitchell, 1983) and a denial of their own needs for assistance (Lawrence, 2003). Where this role identity is threatened or prevented from operating in some way (for example, during change processes or industrial disputes), there can be negative and detrimental consequences for the firefighter (Brunsden & Hill, 2009). Consideration should therefore be given to the ways in which such a strong role identity can affect firefighters', and other FRS personnel's, experience of stress. For example, if this identity leads personnel to experience a sense of enhanced responsibility, an increase in guilt, or a sense of failure as has been suggested elsewhere (Hill & Brunsden, 2009), these factors will have a confounding effect on stress symptoms. This strong group identity may also generate resistance towards stress interventions delivered by those seen as outsiders.

The strong role identity is complicated further by the well-reported observation that all emergency services are under-represented within their membership on diversity issues such as sex and race (Sigurdsson & Dhani, 2010), and thus the emergency-service identity could be said to reflect a white-male identity with all the concomitant characteristics of that identity. Certainly, this white-male dominance has led to accusations of a self-replicating, self-protectionist culture (Archer, 1999), which can be argued to be present within the FRS. Although dated, Bennett and Greenstein's (1975) work is still relevant to the FRS in terms of their conceptualisation of self-replication through the socialisation model (becoming similar through performing the job) and the predisposition model (being attracted to a job to find similar people to oneself). In order to increase the person-environment and person-role fit, recently appointed and trained FRS personnel try to replicate the behaviours, attitudes, and attributes of colleagues in their immediate contact. The predominance of male-dominated, collective identities and tight coworker networks existing within the FRS (Brunsden & Hill, 2009; Beaton et al., 1999; Nixon, Schorr, Boudreaux, & Vincent, 1999), has lead to claims that women can subvert themselves — imitating male behaviours in order to become accepted into groups and to maintain their role within those groups (Archer, 1999). Such imitation is problematic where women ape unhealthy male behaviours such as the well-recorded evidence for male reluctance to seek or accept help (Galdas, Cheater, & Marshall, 2005). This behaviour may then detrimentally affect any interventions promoted by occupational health teams.

Members of groups try to maintain their status and role within the group and find that sharing honest accounts of stress levels and psychological health difficulties are not conducive with such an attitude because of the stigma attached to the *stress* label. Occupational-health practitioners should consider the impact of stigma on both self-referral rates and the uptake of offered interventions (Hill & Brunsden, 2009; Lawrence, 2003). Having to access or report stress in a public or known way may create avoidance of interventions. To illustrate, an anecdotal story relayed to the authors was of an occupational health unit being placed in a location whereby it could be accessed only by passing the Chief Fire Officer's door. Such visibility to management would prevent any effective health-promotion initiatives or interventions. Privacy in accessing interventions should clearly be considered regarding the reporting of health issues. Similarly if stress audits are to be fed back to or worse still *through* managers, regardless of assurances of confidentiality, then the noncompliance of individuals should be given due consideration.

Stress and Family Culture

Members of the FRS become very close. The tight coworker network that forms both an operational and emotional team not only engenders the formation of a specific individual occupational identity but also that of a collective identity (Brunsden & Hill, 2009), and the creation of a fictive family. For example, the term *the brotherhood* is in wide use internationally to describe firefighter fictive families and the strong coworker loyalties that exist (Regehr, Dimitropoulos, Bright, George, & Henderson, 2005). These close correlations generally act as a stress buffer through the provision of strong social support (see Regehr, 2009); however, they can themselves become an additional stressor in certain circumstances — for example if a colleague is injured or killed at work (Hill & Brunsden, 2003, 2009). They can also lead to a reluctance to access interventions with a commonly cited excuse that the team does not need this help because they instead use each other as counsel. Varvel et al. (2007) suggests that coping can then become seen as the province of the team exclusively, thereby excluding other sources of support such as actual family members. However, they also note that this may be a forced situation as a result of shift work; a firefighter may not see his or her spouse or children for extended periods during shift work (depending on local rostering arrangements). It may be, therefore, that this inevitable distancing from the family becomes another reason for the reliance on coworkers, rather than the coworker relationship being the reason for excluding family members. Certainly, a reliance on the immediate occupational team members is reflected in other research (e.g., see Bacharach, Bamberger, & Doveh, 2008). However, as Parkinson (1993) points out, this peer support is usually merely defusing and acts only as social support rather than a coherent stress intervention per se.

In a seminal paper, R. H. Moos and B.S. Moos (1976) suggested that different types of social environments and living conditions can develop family processes, which allows fictive families to be considered in the same ways as “traditional” families. If this situation is accepted, then there becomes an obvious need for managers to understand family processes within their teams as well as for families of FRS personnel to share their experiences in order to support and cope with the occupational demands that impact on family life (Jackson and Maslach, 1982). Such notions can be taken further to suggest that FRS personnel, their close occupational teams, and their families form interrelated systems (Schumm, Bell, and Resnick, 2001). The actual families and fictive families, and their various stresses, thus become intertwined into a complex single system. This system is a premise that FRS management and occupational health teams need to consider carefully because it will not only likely impact on the uptake of interventions but also on the groups that require and participate in these.

The complex family relations, created from the blend of actual and fictive families, and the nature of the resultant social interactions therefore requires consideration before any attempts to manage FRS stress. These work-family issues change the nature of the stress that requires attention as well as affecting the likely populations who are in need of stress-management initiatives. There has been some focus on the everyday effects of work on family life (Barling, 1990; Repetti, Wang, & Saxbe, 2009; Bumpus, Crouter, & McHale, 1999), which suggests that work experiences can affect the relationships of all family members and that work stressors and spillover can affect both marital and parental functioning. Families can suffer through shift work, alterations in family dynamics, stress contagion, and the effects of fictive families (Regehr et al., 2005; Kirschman, 2004). The detection of traumatic reactions within the families of emergency service personnel has also begun to be explored (Pfefferbaum et al., 2006; Menedez, Molloy, & Magaldi, 2006). Families can be exposed to mood swings, grumpiness, unwarranted aggression, and emotional unpredictability from their emergency-service working relatives (see McFarlane, 1987, for examples); and such mood disturbances have been argued to be so shocking and disturbing as to generate levels of traumatic reaction in family members (Repetti et al., 2009). However, such reactions should not be considered in terms of PTSD or even acute stress disorder because these are the very extremes on the scale of traumatic reactions. Indeed, it is rare that firefighters themselves experience such a high level of reaction (despite the large focus on PTSD within the research literature); therefore, expecting to see such high levels of reactions within families would be naive. What is clear, however, is that there can be negative and detrimental emotional, practical, and physical impacts on the relatives of FRS personnel. Given that families can absorb the consequences of FRS personnel working, it then merits consideration as to whether FRS managers should implement stress interventions that incorporate families. Where health interventions include or are aimed at families, these should be concerned with relatives’ low-level vicarious traumatic reactions and with supporting the family members to support their firefighter relative. Aside from traumatic stress, relatives are also affected in other ways (e.g., by the FRS’s daily working practices) (Family Safety and Health, 2006; Demerouti, Geurts, Bakker, & Euwema, 2004). Family relations can be disrupted by irregular work hours as well as the depletion of their loved one’s resources in terms of energy, mood, and coping ability (Hill & Brunsden, 2006).

The support that families provide to FRS personnel should not be underestimated. Landsman et al. (1990) suggested that family and social support should always be considered in any post-traumatic interventions. Other research has supported this suggestion and highlighted the importance of social support (see Regehr, 2009). Families can feel a responsibility to protect the organisation's interests, having been found to take on the strong role identity shared by firefighters and to see themselves as also *belonging* to the employing FRS (e.g., see Hill & Brunsden, 2006; Lasky, 2004). Family members promote personnel's operational capabilities by diffusing and debriefing their relatives' stresses, by buffering negative health issues before they become problematic. Families could, therefore, be seen as providing a vital function for the FRS, even being seen to work for the FRS as unpaid occupational health workers who crucially provide naïve stress interventions and shore up personnel's resilience levels. The need for a congenial home life is obviously beneficial to firefighters because it is where they obtain their primary source of social support (Regehr, 2009), but it may have even greater benefits for the employing organisation. The social support that relatives provide is an essential part of increasing and maintaining resilience, reducing stress, and maintaining occupational effectiveness. Such support makes a cogent argument for expanding management's duty of care to include personnel's families — even beyond those cases where personnel are seriously or fatally injured.

The issue of relatives' need for support, because of their loved ones' specific organisational role, is clearly relevant for the FRS regardless of nation. Fire services and researchers in the US (see Greene, Kane, Christ, Lynch, & Corrigan, 2006; Pfefferbaum et al., 2006; Pfefferbaum, North, Bunch, Wilson, & Schorr, 2002), Canada (Regehr, Goldberg, Glancey, & Knott, 2002), Australia (Cowlishaw, Birch, McLennan, & Hayes, 2012), and the UK (Hill & Brunsden, 2006, 2008; Hill & Woods, 2007) have all begun to explore this issue. However, these are largely exceptions with a notable lack of interest having been shown towards FRS families. The FRS itself also appears to have little appetite for concerning itself with the stresses imparted to families. Certainly, the UK FRS has not thus far included the families of personnel in their interventions or health-promotional practices, likely because of the associated financial costs. There is also a nervousness that extending the duty of care and then perhaps not delivering to satisfaction could lead to negligence claims. However, work by Hill and Brunsden (2008) concludes that this situation is not expected or foreseen by legal professionals. Given the functional, albeit naïve, occupational health roles that families fulfil, FRS management may benefit from developing stress initiatives that incorporate families as well as developing specific information and guidance to prepare and train those who provide support to relatives.

Strategies to Manage Stress Exposure

Strategies open to use by FRS managers can be differentiated into therapeutic treatments (the province of the healing professions) and reactive interventions (precursory actions in an attempt to prevent serious stress, which if it later emerged would require therapeutic treatment); of course, reactive interventions might also involve members of the healing professions. In terms of reactive interventions related to critical incidents and traumatic stress, Jeannette and Scoboria (2008) identified three levels: (1) critical incident stress debriefing (CISD), (2) one-to-one debriefing, and (3) informal discussion. CISD, sometimes called *psychological debriefing*, is the intervention most associated with the FRS. It is often considered as just one part of a critical incident stress management (CISM) approach, which is generally regarded to be more effective than CISD alone (see Regel, 2007; Mitchell, 2004). It is important to note, however, that CISD and the CISM process, in which it is nested, are neither a therapy nor a substitute for one (Blaney, 2005, 2009; Mitchell, 2004). The origins of CISD and CISM lie in crisis-intervention theories dating back to 1944 (Regel, 2007) or even earlier (see Mitchell 2004). Regel (2007) describes CISM as a:

> comprehensive, systematic and integrated multi-component crisis intervention package that enables individuals and groups to receive assessment of need, practical support and follow-up following exposure to traumatic events … it facilitates the early detection and treatment of post-trauma reactions and other psychological sequelae. (p. 411)

Regel (2007) gives three elements in CISM that precede the CISD and one element that follows CISD. The precedents are precrisis education, assessment, and defusing; and the element following is treatment (i.e., therapeutic intervention) if PTSD should still occur. However, Mitchell (2004) went further in his detailing of CISM, listing twelve components rather than Regel's five. This confusion as to the exact nature of CISM, and indeed CISD, is common within the literature. Mitchell notes that "everyone talks about *debriefing* and means something different" (2003, p. 56). Certainly different authors and practitioners use this term to describe what can be very different practices (Brunsden et al., 2003).

Confusion is complicated further by the same practices also being referred to by different names. For example, Devilly and Cotton (2003, p. 144) refer to psychological debriefing as "emotional first aid," and Dyregov (1989) talks of psychological debriefing and CISD as if they were interchangeable terms. Regel (2007), however, shows preference for the term *psychological debriefing* over CISD, claiming the support of the British Psychological Society for this term. Other preventative programmes that appear to be CISD include psychological first aid (Vernberg et al., 2008), which has the slight distinction of being applied in the field and in being intended for children as well as adults; in all other ways, psychological first aid closely resembles CISD. The UK military's programme called *Trauma Risk Management* (*TRiM*) has similar echoes but is designed to be delivered individually as well as in a group (Greenberg et al., 2010). Mitchell (2004) states that CISD is not the most frequently used intervention;

however, it is the most prominent and visible and is also strongly associated with the emergency services.

Bearing in mind the differences already mentioned between the differing forms of intervention described as CISD, there are a number of principles that generally seem to characterise the interventions. There is an agreement that the group debriefed should be homogenous so that there is a greater shared understanding of the experience(s), with an implied likelihood of preparedness to listen, empathise, inform, and therefore to make progress. Consequently, CISD tends to be carried out on a holistic group who have attended, or dealt with, a specific potentially traumatic event, for example, a single watch who had attended the same fire involving fatalities. Early intervention is also agreed as a general principle, but the actual timing varies. Psychological first aid described by Vernberg et al. (2008) aims to intervene as soon as possible. Dyregov (1989) states that CISD should not occur on the same day as the traumatic event. Regel's (2007) review found that it can be held anytime between 3 and 14 days after the event. Greenberg, Langston, and Scott (2006) identify the number of sessions as a key difference between CISD and TRiM, stating that TRiM entails multiple sessions whereas CISD consists of a single session only. However, their position is discordant with the views of Mitchell who can be considered the originator of CISD; he stated in 2004 that single-session debriefings are *not* appropriate for CISD and goes on to list a host of organisations that do not endorse or approve single-session CISD, including the International Critical Incident Stress Foundation. This is an important point as Jones, Roberts, and Greenberg (2003) highlight research that suggests one-off sessions can cause more harm than good.

One characteristic that remains unresolved is who should deliver the intervention. Traditionally interventions have been delivered by occupational health personnel or external consultants. However, in recent years there has been a shift towards approaches that utilise trained peers, certainly in the UK FRS if not globally (see Brunsden & Lawrence, 2012; Durkin, 2006; Barber, 2003). Such a shift has benefits in that trained peers can identify psychological risk factors that non-peers might not notice or appreciate (Jones, Roberts, & Greenberg, 2003). Jones et al. (2003) also note that external practitioners lack in-depth organisational understanding that results in employee hostility to outsiders and poor receipt of interventions. The situation is then exacerbated by the unusual nature of the occupational role in terms of the sights, sounds, and smells that personnel have to face and deal with — limiting the discussions they feel they can have with someone who has not shared similar experiences (Brunsden & Lawrence, 2012). This unwillingness to discuss can be because of a disbelief that someone without such an experience could ever truly empathise or understand; but also because of an unwillingness to burden others with what they themselves have faced. In the UK the suspicion and distrust of external practitioners is further complicated not only by a strong role identity but in the culture of suspicion created by their unusual industrial relations.

Because interventions that use trained peers are becoming increasingly popular within the UK FRS, there has also been increased usage of the TRiM process (Greenberg et al., 2010), which was specifically designed to be delivered by trained peers. However, FRSs are also developing their own versions of CISD and CISM, adapting and modifying these to fit their own local organisations. One example is what has been termed the *Tyne and Wear approach* (see Brunsden & Lawrence, 2012; Lawrence & Barber, 2004; Barber, 2003), which originated in the UK's Tyne & Wear Fire & Rescue Service but which has subsequently been adopted more widely. In this approach, trained peers (the Trauma Support Team or TST) provide both the initial diffusing and the debriefing following a traumatic event. However, as well as having access to these peer-led interventions, there is also support available from chaplains, occupational health workers, a psychologist, and a psychiatrist. This additional support can be accessed by the whole group by agreement, or individuals can self-refer, or the peer supporters can refer specific individuals for therapeutic treatment if required (effectively acting as a triage team).

The TST also offers support to one another. Team members meet to consider case studies, to explore best practice, and also to act as debriefers for one another in order to prevent the development of secondary trauma or burnout. The peer trauma team participants are recruited through voluntary applications but go through a rigorous selection process. They then undergo extensive training, which is partly in-house from the occupational health team but also externally through the involvement of a local university. This training also enables the peer supporters to achieve relevant formal qualifications. This approach has had considerable success. It has reduced sickness following traumatic exposure, de-stigmatised traumatic responses whilst also normalising rather than pathologising reactions (Brunsden & Lawrence, 2012). It has also been found to build resilience and to facilitate help-seeking, largely through its generation of cultural change and particularly the minimising of *macho* culture (Brunsden & Lawrence, 2012).

Even such highly successful forms of CISD are not without their critics however, with concerns being raised about CISD in both its original and modified formulations. Raphael, Meldrum, and MacFarlane (1995) noted that CISD had rarely been systematically evaluated with no randomised controlled trials (RCTs) being reported. However, whether RCTs are either appropriate or ethical in the case of CISD is highly debateable. The different formulations of CISD mean that different intervention processes are being confused and would suffer unfair comparison if RCTs appeared to provide an authoritative voice on the matter. Further, the real-world conditions mean that the allocation of groups are hardly random and are certainly not controlled. This predicament is self-evident given that CISD is employed because of unpredictable and chaotic events (Deahl, 2000). Deahl (2000) also notes the ethical problems in having the nonintervention group required by RCTs because denying one group the opportunity for debriefing may be detrimental, particularly given that many individuals find it subjectively helpful at the time. This position is supported by Jeannette and Scoboria (2008) who found that, while there can be different preferences for intervention according to the seriousness of the event, some level of intervention is wanted by all. Where attempts have been made at using RCTs to evaluate CISD, these have been less than successful in terms of achieving robust RCT criteria. For example, Regel (2007) discusses two studies where there were no equivalent group memberships at pretest. Regel (2007) also notes that evaluations of CISD have been focussed on the degree to which they prevent the development of PTSD and that they have been evaluated as a stand-alone intervention. Such evaluations mistake the intentions of CISD, which is just one part of a psychological support strategy, and does not intend to prevent PTSD but instead has more general outcomes in terms of minimising an event's effects (Blaney, 2009).

Much of the criticism of CISD stems from the Cochrane Review (Rose, Bisson, & Wessely, 2002). However, as Devilly and Cotton (2003) note, this review evaluated only single-session interventions, meaning it did not consider the majority of CISD programmes or reflect CISD as originally intended (Mitchell, 2003). It is fundamental to any rigorous evaluation to compare like with like, but this situation has rarely been the case with CISD evaluations. The varying names and definitions do not help and even where the same names are used, very different processes may be being referred to. These differences are crucial, because they are highly likely to impact on outcomes. Such differences can include the timing of the intervention; its location (specifically whether delivered at, or away from, the event); whether it was peer-led or professional-led; and who were the populations being helped. The latter point is highly relevant in terms of CISD and the emergency services, given that Jacobs, Horne-Moyer, and Jones (2004) have argued that whilst CISD can do little good or may even harm accident survivors, it can have highly beneficial effects when conducted with emergency service personnel. This contention is important because in the UK there is a legal obligation not to withhold interventions that are believed to be beneficial (Wheat, 2002); even in other countries where this legal imperative is not in place, there will still be an ethical imperative not to withhold potentially useful treatment.

Aside from trauma interventions, the FRS also needs to manage other stressors and strain. This includes not only the types of stress seen in any organisation but also those peculiar to the FRS working. Within the FRS, even those stressors seen in other organisations take on additional significance because they can ultimately lead to harm in the field, risking the safety of both firefighters and the communities they serve. Thus, stressors have greater importance and urgency than among other working populations, and it therefore behoves the FRS to look carefully at issues such as support, workload, and communication. Removing and reducing generic stressors also reduces the effect that the work-peculiar stressors will have (see Fletcher, 1991). It is, however, incredibly difficult to manage out strain in FRS working, perhaps even impossible. This is because conventional control over both the workplace and workplace equipment cannot be achieved (Ash & Smallman, 2008). Certainly in terms of person-environment fit theory (Caplan 1987), it is impossible to remove the fire or road collision from the firefighter (despite efforts in areas such as fire-prevention and road safety). The FRS therefore tends to rely on a combination of developing coping strategies, including greater control latitude (thus making personnel more *stress* resilient); actively reducing strain levels (*de-stressing* initiatives); and monitoring for, and responding to, early identification of strain.

Stress Prevention

Notions of stress resilience focus interventions on preparing the firefighter for stress encounters by way of appropriate personnel selection, instruction, and training as exemplified by FRS's efforts to create the "safe worker" (Ash & Smallman, 2008). Training reduces cognitive load (Mayer & Moreno, 2003; Paas, 1992), and so general training for regular activities can help as well as training specific to the work stressors faced by emergency service personnel. The latter form of training carries twin benefits of developing specific strategies for coping with those particular stressors and automatising responses (although greater problems can then arise if these automatised responses are disrupted by the nature of the emergency: see Hill & Brunsden, 2003). Research suggests that this strategy development gives greater choice to the worker, with planning increasing control (Prenda & Lachman, 2001; Karasek, 1979), especially when tasks are of a highly complex nature (e.g., see Dodd & Ganster, 1996). Such training then leaves more cognitive capacity to face other less predictable challenges. For example, N. I. Kagan, H. Kagan, and Watson (1995) found that training in interpersonal coping and developing interpersonal awareness (both important in emergency situations) were associated with lower levels of anxiety and depression. Similarly, Michie and Williams (2003) found that problem-solving training helped reduce strain levels. Training and personal development can also help personnel to become more stress-resilient in other ways. Feelings of self-esteem are interlinked with the self-perception of competence (Johnson & Blom, 2007; Warr, 1987), and training can help to develop this sense of self-awareness and empowerment. Training can therefore be seen as an important stress-management tool; however, it should also be remembered that training for FRS personnel poses special challenges since, if it is to be realistic, training can in itself be a source of danger (Cooper & Cotton, 2000).

There is a growing literature on the "stress-buffering" effect of leisure activity. The Iwasaki, Mannell, Smale, and Butcher (2002) study of 200 Canadian emergency response personnel found that the use of leisure was associated with lower levels of stress, and the Blaney (2005) study of Canadian firefighters found a preference for exercise as a buffer against stress. Iwaski (2006) further found that leisure coping counteracted the impact of stress, suggesting long-term benefits. However, such findings may not necessarily transfer to other countries; for example, Blaney replicated her work with UK firefighters and found no such preference (Blaney, 2009). The macho culture of the emergency services may also impact on what types of leisure activities could be promoted. For example, although researchers such as Jin (1992) have found strain reduction after activities such as tai chi and meditation; these kinds of activities can be perceived as soft and feminine in contrast to macho forms of exercise such as weight-lifting and boxing. Given this perception, promoting such activities to FRS personnel could prove difficult as such suggestions may not necessarily be well received.

Stress monitoring, the minimum required by UK law, has been an important plank in FRS's intervention strategies. However, because there are no rigorously precise ways for an employer to assess levels of strain, legal standards are rarely specified. Advice from the UK's Health and Safety Executive (HSE) is that employers, as well as encouraging symptom reporting, should check sickness records (Health & Safety Executive [HSE], 1999). This managerial monitoring allows the identification of patterns across shifts and watches, as well as individual problems. There is also less formal but continual monitoring by way of the continual interaction of colleagues and family who can notice small changes. Allied with referral processes to get affected individuals to the correct professional, these informal strategies can be highly effective. Any consequent reactive help from healing professionals might also improve later stress resilience. It should, however, be kept in mind that, regardless of preexposure stress-management strategies, exposure is still inevitable and post-exposure interventions are likely to always dominate stress policies within the FRS.

Conclusion

It is clear that environmental exposure, the cultural context and the resultant coworker, and interfamilial and intrafamilial relations all interact to affect the success (or otherwise) of interventions within the UK FRS. Whilst the specific issues and cultural context of the UK FRS may not be isomorphic with those of FRS in other countries, it is reasonable to assume that there will at least be some resonance across these various issues. It has been suggested that the only successful way to understand a culture is to live in it, thus allowing understanding of linguistic nuances and practices (Gomm & Hammersley, 2001). Where external practitioners enter the FRS to explore stress as outside consultants or *external experts*, they need to ensure that they are able to appreciate that organisation's specific context and gain an understanding of that before blithely attempting to conduct audits or administer interventions. Without this deeper knowledge, there is the potential not only to alienate the workforce but also to obtain inaccurate audit data. This is an important issue for FRS management to consider as, certainly in the UK, external consultants are routinely used for auditing; and their use may well be generating artefactual results. Similarly, using external therapists to deliver interventions risks effecting more harm than good. This situation offers a serious challenge to FRS management who may be lacking in the psychological understandings necessary to facilitate sound decision-making around the development of appropriate stress support and prevention mechanisms.

In terms of trauma support, the UK's Tyne & Wear approach may be a model that offers some assistance here for FRS in other countries, not only for traumatic stress but for other forms of stress also. This approach takes account of the specific organisational culture and appropriately incorporates professionals and trained peers, whilst first utilising natural organisational coping processes. Finally, it is crucial that stress researchers reviewing, utilising, and building upon FRS research globally should maintain an active engagement with notions of cultural and geographic context in order to more appropriately frame their own understandings.

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The Process of Decision-Making in a Fast-Burning Crisis Situation: A Multiple-Sequence Approach of Decisiveness

Abstract

Many firefighters are confronted with decision-making under extreme time pressure in harsh conditions. Earlier research on decision-making indicates that prior experience and training help them to assess the dynamic risks in a split second while making a professional judgement under extreme stress. However, the question could be raised how firefighters make the right decisions under the same extreme conditions without the ability to rely on prior experience-driven or thought responses.

This research paper examines the decision-making process of a Belgian firefighter crew before and during a building collapse. The results indicate that contrary to existing views on decision-making in fast-burning crisis situations, multiple subsequent processes are at play. Firefighters act on multiple sequences, and in each of these a different form of decision-making is in use. The rationale for switching between particular decision-making processes is anchored to the type of interaction, the firefighter's perception and conception of the situation, and the type of knowledge used to tackle the problem. Based on these findings, recommendations for practical implementations, such as training and development, and directions for further research in the domain of decision-making in fast-burning crisis situations are offered.

Preface

This paper is based on a case in Antwerp, Belgium. The article is also based on the past and current education, training, and procedures of firefighters in Belgium. **As such, the case has to be interpreted from this point of view**. Fire education in Belgium (as well as in most of mainland Europe) varies from region to region and is in the process of an important reform. The reform will bring an important improvement of the education of firefighters and commanders. However, in the Antwerp region it was only about 15 years ago that a fire school was formed. Before that time, firefighters (and the commanding subofficer in the presented case) had been trained in their own stations by colleagues with more experience, but training was not based on a standard approach.

Nowadays in the standard education of firefighters the main focus is on techniques and knowledge of fire. Belgian firefighters score very high on knowledge of fire and have good hands-on skills in fire fighting. On the other hand, tactics and procedures are only just finding a way into the fire service, hence they are not yet included as a standard part of education and training. Live fire training was introduced about seven years ago, but is not yet standard and obliged for each firefighter. Moreover, the set of standard operating procedures (SOPs) that is valid for the whole of Belgium is very limited. Although there are a few local initiatives, most of the time they are not shared. In the concrete case in this paper, the commanding subofficer did not have, for example, a valid and trained standard procedure on "holding the stairs" (see Angemi, 2012).

In addition to the differences in training and education, the reader also has to take in account a possible difference in building structure and architecture between his or her own country or region and mainland Europe. In the latter case, buildings are predominantly built strong and stable. A lot of concrete and bricks are being used, and the collapse of a standard building is possible in Europe but not common in fires. Not many firefighters have ever seen a building on fire collapsing.

Introduction

The fire brigade of Antwerp (Belgium) is a fully professional fire department in a city of over 500,000 inhabitants and the second largest port and petrochemical cluster of Europe. On February 23, 2012, at 5:24 p.m. the fire service received several calls for a house fire in the south of the city. Several units were dispatched, among them a unit with crew manager Frank Van Meerbeeck, a senior fire subofficer with more than 30 years of active duty. Once the crew arrived on the scene, they faced a heavy fire on the first floor of an old building; and it was unclear whether anyone was trapped inside the building. Together with five firefighters and a second subofficer, Frank immediately attacked the fire. Two other crews and a senior officer were on their way but were stuck in heavy traffic. Frank decided to enter the building with four other firefighters (two crews of two men). According to procedure, the second fire subofficer took command of outside operations, water supply, and the organisation of further reinforcements.

Inside the building, Frank decided to proceed to the first floor, as there was nothing showing on the ground floor. On the first floor he ordered his team to wait and cover him.[1] He was even more specific by giving them the clear order to wait on the stairs. He then went further up the stairs to check the second floor. A couple of seconds after this command, and 6 minutes after arrival, the building collapsed without any prior warning or sign. The roof, the second floor, and the first floor caved in; and the ground floor was covered with debris. The five firefighters were trapped inside the building.

Less than a minute before the collapse, the second subofficer who was operating outside the building observed the first signs of instability such as the movement of the roof and suspicious cracks in the walls. He tried to warn Frank's team inside, but the radio connection was weak and he failed to warn the subofficer or any other firefighter inside. As the crew outside witnessed the building coming down, they immediately began search and rescue operations. At that very moment, the second crew arrived and assisted in the search for their trapped colleagues. After a few minutes, the five firefighters miraculously found their way out of the ruins. During the collapse, the crew was still on the stairs, which is the strongest part in this type of building. The stairs did not collapse together with the rest of the building, and all five men were unharmed.

In an attempt to uncover how Frank succeeded in making the right decision seconds before the devastating collapse, we first examine the existing literature on the key aspects of decision-making under extreme stress. We then benchmark the decision-making process of other fire commanders based on the same scenario. Subsequently, we will explore the sequences of action and decision-making as experienced by the crew that survived the collapse of that particular building. Finally, all findings will be linked to the literature and recommendations for both practice and further research will be provided.

Naturalistic Decision-Making (NDM)

By the late eighties, it became apparent that people in general, and fireground commanders in particular, did not always make decisions based on optimal algorithmic strategies (Tversky & Kahneman, 1974; Kahneman, 2003). They did not generate alternative options, estimate probability and chances, nor compare systematically options. Naturalistic Decision-Making (NDM)[2] researchers wanted to find out how people make decisions in complex real-world settings.[3] Different NDM theories all found that people use prior experiences to categorise situations as a means to make decisions (Klein, 2008). NDM researchers studied people in field settings, including firefighters, nuclear power plant controllers, Navy officers, Army officers, highway engineers, and other populations (Kahneman & Klein, 2009). Subsequently, Klein and his colleagues investigated how the commanders could make good decisions without comparing options (Klein, Calderwood, & Clinton-Cirocco, 2010). That investigation is how a main theory within the NDM frameset, the Recognition-Primed Decision (RPD) model, became well known and implemented by firefighters (Klein et al., 2010). As a matter of fact, the theory of the RPD model has become the central theory to explain the decision-making process of fire commanders in the United Kingdom (UK) (Tissington, 2004). The Dutch and Belgian Fire Brigades have also adopted this theory (Brandweer Vereniging Vlaanderen ([BVV]/Flemish Firefighters Association, 2010).

The core concept of RPD making is that in critical situations, fireground commanders make decisions based on a process of recognition of key elements in the situation that are linked to previously encountered situations stored in memory (Tissington, 2004). Consequently, the RPD model is a blend of intuition and analysis; whereas, commanders make decisions using pattern matching and mental simulation to determine whether the decision could work in the current situation (Lipshitz, Klein, & Orasanu, 2001; Klein, 2008). Pattern matching is the intuitive part; and by using pattern matching, people can quickly match the current situations to patterns they know (recognition) and hence generate solutions and decisions. Miller (1996) compares this pattern matching to a slide carousel. A fireground commander compares the actual situation with the slides he has in his slide carousel. The richer his collection of slides, the better, faster, and more accurate his decisions in complex real-life situations are. This process of analysis is based on a mental simulation in which an outcome probability is simulated in a kind of story building. Thanks to mental simulation, commanders are able to determine whether a decision could work. As most fireground commanders share a similar range of experiences, they do not generate very divergent options or rational decisions in critical circumstances. They look at the situation and choose a recognised — and thus satisfying — solution, without comparing all the alternatives. Based on in-depth interviews with fireground commanders, Klein and his colleagues found that 80 to 90 percent of their decisions were based on RPD strategies (Klein et al., 2010). Nevertheless, the fireground commanders that took part in the research did not consciously realise that they were making decisions based on recognition. Moreover, fireground commanders often do not even realise that they are making decisions at all during the process of dealing with a complex incident (Tissington, 2004).

In the Belgian case, as described earlier, one might expect that Frank made his decisions based on the RPD model. The actor and the situation were both marked by the key elements determining a complex real-world setting as described by the NDM theory (Klein & Klinger, 1991). Frank is a very skilled commander with experience in similar fires and buildings. The situation was very dynamic, uncertain and changing rapidly. Moreover, there was serious time pressure, the tasks were ill-defined, and the stakes high. Yet, contrary to the standard training of fire commanders in Belgium, Frank did not choose the known or expected solution for this situation. The standard training stipulates how a commander has to give orders to do a search and recovery starting on the first floor. In this case, Frank started with a classic fire approach but changed his strategy while moving in the house. Probably during the process of fighting the fire, he noticed new elements and changed his mind as to how to tackle the situation. The question could be raised whether known or unknown environmental signals alerted Frank or whether he was making sense of the changing and highly dangerous environment, prompting him to adapt his initial plan into a new strategy.

Sensemaking and Situational Awareness

It could be argued that Frank had been changing his decision in the process by choosing not to follow the standard approach to the fire. He did this without any hesitation or time to reflect on the situation. He just carried on commanding the team without interruption. Weick describes this behaviour as *enacted sensemaking* where an individual basically has no time to stop and reflect but reflects in action while adopting a new story that is more suitable to the present context (Weick, 1993). Enactment means that "when people act, they bring events and structures into existence and set them in motion" (Weick, 1988; p. 306). Sensemaking happens when people build a story around what is happening, because they want to make sense of the situation. Therefore, enacted sensemaking is the act of people who are dealing with a crisis or complex situation, probing actively while looking for plausible stories that explain the situation (Weick, 2010) by producing "structures, constraints, and opportunities that were not there before they took action" (Weick, 1988; p. 306).

Analysing the Mann Gulch disaster in 1949, Weick explained the importance of sensemaking for firefighters (Weick, 1993). In this case a team of smokejumpers (forest firefighters) led by foreman *Wag* (Wagner) Dodge was confronted with a sudden change of wind that caused a deadly change in the direction of the fire. Dodge was one of the only survivors because he did something nobody had ever done before: He lit a fire in front of himself and laid down in the ashes of his escape fire (for more details, see Weick, 1993). Unfortunately, Wag Dodge did not succeed in convincing his subordinates to do the same, and so most of his team died in the fire. According to Weick, there are two main reasons for this tragic event. On the one hand, the team was disintegrated and did not follow orders. The team aspects, however, are not in the scope of this paper. On the other hand, they were convinced they were dealing with a small fire. By the time they realised they were not dealing with a small fire, the wind had turned. They were too late to make an escape. It could be argued that the team and the leading officer were not able to make sense of the situation and both lacked situational awareness. This argument, however, does not mean they did not have alertness. Alertness of the situation means that one has perception of the situation as anomalies were noticed but not necessarily understood. Thus, alertness can be seen as the conception of the situation in which anomalies are noticed and given a meaning (Weick, 2010).

In the firefighter study, Klein and Klinger describe four elements that are taken into account when giving meaning and creating situational awareness: (1) expectancies, (2) plausible goals, (3) relevant clues, and (4) typical actions (Klein & Klinger, 1991). Tissington and Flin (2005), however, showed that these elements are not relevant for fireground commanders. Their analysis indicates four specific underlying factors for a fireground commander: (1) crew safety, (2) the extent to which casualties need to be rescued, (3) time pressure, and (4) the degree to which the incident is contained.

In our case, it could be argued that Frank also had to deal with this problem of sensemaking and situational awareness. He started the intervention thinking he was dealing with a standard domestic fire; but during the process, the situation changed. He had to make sense of the situation, thus creating situational awareness, and had to make a quick decision to guarantee crew safety. It is still not clear how he made this assessment and what elements were at the basis of his crew-safety assessment. Analysing this particular case, we can observe elements of RPD making as well as components of enacted sensemaking in the decision-making process. But neither RPD making, nor sensemaking, provides a suitable explanation to Frank's decision to keep his team at that position, knowing that there were no signs of an imminent collapse. Hence the question could be raised: What was steering Frank's decision to keep his crew safe? Was there a factor of luck involved or were other elements at play that might explain his decision?

From a Neuroscience Perspective

The analysis of Frank's attitude and behaviour seconds before the collapse of the building indicates he was not acting according to what he had learned in fire drills or real-life situations. This unconventional decision saved his life and that of four other firefighters. Nobel Prize winner and renowned neuroscientist Gerald Edelman (2006) indicates how every individual's history and set of brain events is unique; and by regulating them in terms of intention and behaviour, we are undermining the richness of the brain and mind. This mindset is what he calls "naturalistic fallacy" (Edelman, 2006; p. 84). We therefore contend that seconds before the collapse something happened in Frank's brain that made him make the right decision. The questions that could be raised are as follows: Was this decision a conscious or an unconscious process? Was it based on reason or on emotion? What exactly happened in Frank's brain milliseconds before the collapse? And why did the four firefighters in Frank's team accept his orders, despite the divergent view acquired in prior training?

A renowned study by Dutch psychologist Ap Dijksterhuis (2006) indicates how individuals make good choices without huge amounts of information. On the contrary, once they are overwhelmed by fact sheets and a large number of objective facts, the participants of Dijksterhuis' (2006) experiment made the wrong choices predominantly. According to neuroscientist Antonio Damasio (2012), it indicates how individuals quite often make unconscious decisions based on a conscious gut feeling. Although it is still not clear what exactly is happening in the brain while making an unconscious decision, Damasio argues that

> there is an important reasoning process going on non-consciously, in the subterranean mind, and the reasoning produces results without the intervening steps ever being known […] it produces the equivalent of an *intuition* without the "aha" acknowledgement that the solution has arrived, just a quiet delivery of the solution. (Damasio, 2012; p. 276)

In earlier research, Damasio (2006) clearly indicated how emotion is in the loop of reason and that emotion could assist the reason process rather than disturb it. This finding, known as the *somatic marker hypothesis*, demonstrates how rational decision-making is basically a decision made by emotionally influenced reasoning. We can therefore assume that Frank's reaction was primarily based on unconscious emotions and not on cogitative or conscious reasoning. Research by Dillon and Tinsley (2008) points out how two distinct information-processing systems dissociate the strategic use of information from decision-making under stress. They argue that individuals have two general information-processing systems: (1) an associative one and (2) a rule-based one (Dillon & Tinsley, 2008). The associative system is based on emotions, feelings, and interpretations, while the rule-based system operates according to formal rules of reasoning and evidence. Dillon and Tinsley claim "perceived risk is the product of the associative system processing […] that influences behavior" (Dillon & Tinsley, 2008; p. 1437). Interestingly, Dillon and Tinsley's empirical research was focused on National Aeronautics and Space Administration (NASA) employees, of whom one could presume they are trained to deal with risks based on a cognitive evaluation of evidence and calculated risk statistics and not on emotions and feelings (Marynissen & Ladkin, 2012). The same level of training and risk awareness might be expected from professional firefighters as well. According to van Gaal, de Lange, and Cohen (2012), unconscious information, which the associative information-processing system is dealing with, has an effect on various brain regions, including areas in the prefrontal cortex. This unconscious neural activation is capable of influencing many perceptual, cognitive, and decision-related processes (van Gaal, de Lange, & Cohen, 2012).

It is widely accepted that the prefrontal cortex (PFC), which is the part of the brain where our consciousness is located, is responsible for recalling, memorising, understanding, and deciding (Rock, 2009). Therefore, the role of the PFC seems to play a key role in answering the question of what exactly happened in Frank's brain immediately before the collapse.

Research by neuroscientists Miller and Cohen (2001) discovered that this particular part of the brain is not only aggregating new information, it directly activates and modulates other parts of the brain as well. To fulfil this task, the PFC has to consume energy such as sugar, oxygen, norepinephrine, and epinephrine. However, resources are limited (Rock, 2009). These energy resources seem to be activated in a split second when the PFC requires them, like in stressful situations that need deep thinking or quick decision-making. Recent experimental research by Huang and his colleagues (2010) indicates how professional firefighters, once they are in fire-fighting modus and challenged to make tactic decisions, not only have a higher heart rate, they also have elevated norepinephrine and epinephrine levels. *Norepinephrine* is a hormone released by the adrenal medulla and the sympathetic nerves and functions as a neurotransmitter. Epinephrine is commonly called *adrenaline* and is responsible for increasing rates of blood circulation, breathing, and carbohydrate metabolism and preparing muscles for exertion. This hormone is typically secreted by the adrenal glands in conditions of stress. These hormones thus fire the neurotransmitters into activating other parts of the brain. The only issue here is that it is still not known why these neurotransmitters sometimes decide to turn on parts of the right hemisphere and end up with an insight or decide to restrict its search to the left hemisphere and arrive at a solution incrementally or not at all (Miller & Cohen, 2001; Lehrer, 2009).

Going back to Frank's situation, immediately prior to the collapse, we could argue that he was just lucky that his neurotransmitters reached the right hemisphere and offered him the insight not to proceed with the inspection of the first floor. Apparently, Frank was able to look past his fear and expand the possibilities of his thought process as he considered remote mental associations that he had never contemplated before (Lehrer, 2009). According to Miller and Cohen, Frank must have had really high prefrontal function (Miller & Cohen, 2001).

Concerning the behaviour of Frank's team members, an answer can be found in two phenomena that stem from social psychology: social motivation and obedience to authority. *Social motivation* is the individual's desire to be liked and understood by others. It is one of the most profound motives to individual change or to adapt behaviour (Lieberman, 2005), and it moves individuals to neglect individual aspirations or beliefs in order to conform to group behaviour. A second phenomenon, *obedience to authority*, can in this particular situation be perceived as both detached and supportive to the team members' reaction. It was Milgram (1963) who did one of the most classic studies in the early days of social psychology with his work on obedience to authority. In his study, Milgram (1963) indicated how individuals were willing to give high-voltage shocks to strangers when a scientific researcher pressed them to do so. Although we live in a different era in which firefighters are trained for collaborative action, based on respect and knowledge sharing (Weick & Sutcliffe, 2007), the role of authority is still dominant among fire teams and especially for fire teams in action. Strict obedience to the leader can save lives in critical situations confronting firefighters.

More recently, Nummenmaa and his colleagues (2012) indicated with brain research, based on functional MRI (Magnetic Resonance Imaging), how shared emotions might facilitate the understanding of another individual's intentions and actions. They came to the conclusion that "negative valence synchronises individuals' brain areas support emotional sensations and understanding of another's actions" (Nummenmaa et al., 2012). In other words, the negative power of the various impulses that are processed in the brain somehow supports an emotional circuit that helps to understand others. In this case, the present danger of entering a building that is on fire, in combination with the sound, smell, heat, and smoke (that might be interpreted as *negative valence* or unpleasant experiences), improved the team members' acceptance level of atypical orders. Somehow, their brains were on the same level of understanding.

Methods

In an attempt to uncover what was driving Frank's decision-making process that kept his crew alive, two research actions were undertaken. Prior to in-depth interviews with members of the fire-fighting crew that survived the building collapse, a survey was sent to 30 commanders of large fire departments in Belgium. The mail explained the objective of the research, guaranteed full anonymity of the participants, and aimed for participation of the fire subofficers in their team. The survey described the situation that lead to the building collapse, without referring to the actual collapse itself, nor did the scenario describe the actions that were undertaken in the real situation by the firefighters or the fire subofficer. The participants were asked to answer the following questions:

- What actions do you take?
- What commands do you give to your team?
- Have you ever experienced a similar situation as a firefighter or as an officer?

In total, 24 fire subofficers (23 male, 1 female) from 15 different departments responded to the survey. The average age of the participants is 46.3 years, and on average they have 23 years of experience as a firefighter. Their mean amount of years as team commander is 6. The majority (17) hold the rank of *sergeant* (crew manager), 7 have the rank of *adjudant* (station manager), and 18 respondents (or 75%) declared they once experienced a similar situation. Two fire subofficers (or 8.3% of the respondents) declared they would do exactly the same as Frank did. Surprisingly, one respondent was a 29-year-old sergeant with 5 years of experience as a team commander who declared to have been in a similar situation before. The other respondent was a 44-year-old adjudant with 27 years of experience, 13 of which was as a team commander, with no prior experience of comparable situations. The survey was analysed by an experienced fire officer who looked at possible survival based on the suggested actions. If the suggested action was similar to Franks' action, or the command to not enter or leave the building immediately, the survival of the team was likely. When the suggested action was to enter the room of the first floor, probably the crew would have been injured or killed in the collapse.

The qualitative part of the research was done by in-depth interviews with four of the members of the firefighter crew who survived the building collapse in Antwerp (Belgium) on February 23, 2012. First, one of the researchers did a standard full debriefing with Frank, the senior fire subofficer who led the team that went into the house. This type of interview is part of a learning process for the members of the Antwerp Fire Department. Secondly, the second researcher had individual semistructured interviews with Frank and three members of his crew. In these interviews, the researcher was probing for elements that could be linked to various theories such as intuition; sensemaking (interpretation of clues and cosmology episode [Weick, 1993]); recognition-primed decision making (prior experiences and training, mental framing [Kahneman & Klein, 2009]); and naturalistic decision-making (role of memory, sensemaking, and situational assessment [Lipshitz et al., 2001; Weick, 1993]).

Findings

The results of the survey support our hypothesis: Frank made a decision that is atypical for this kind of fire. Not only is it the opposite of what is taught at the fire academy, also only a small minority (8.3%) of experienced fire subofficers indicated they would take similar action seconds before the building collapses.

After questioning the 24 fireground commanders, we noticed only 2 of them made a different decision and probably would have managed to get their team out alive. Remarkably, one of them would have made exactly the same decision as Frank did. The other would have evacuated his team from the burning building earlier. The majority of respondents formulated exactly what they were taught at fire academy.

Analysis of the four firefighters' interviews involved in the house collapse in Antwerp indicates that contrary to existing views on decision-making in fast-burning crisis situations, multiple subsequent processes are at play. In this case, the firefighters have been acting on multiple sequences, and in each of these sequences, a different form of decision-making has been in use. In each interview, five distinct phases of the intervention were described: (1) the way to the place of the incident, (2) the inspection of the burning house, (3) the intervention itself, (4) the recovery phase after the intervention, and finally (5) the interpretation of the event 9 months later. As indicated in **Figure 1**, all of these phases are based on collective action and interpretation of the ongoing actions, except the third phase, which is the intervention itself. Here, almost no verbal communication is feasible and thus each firefighter has a very distinct individual view of the given commands (predominantly in the form of signals), the decisions made, and the outcome. Or as one crew member described it:

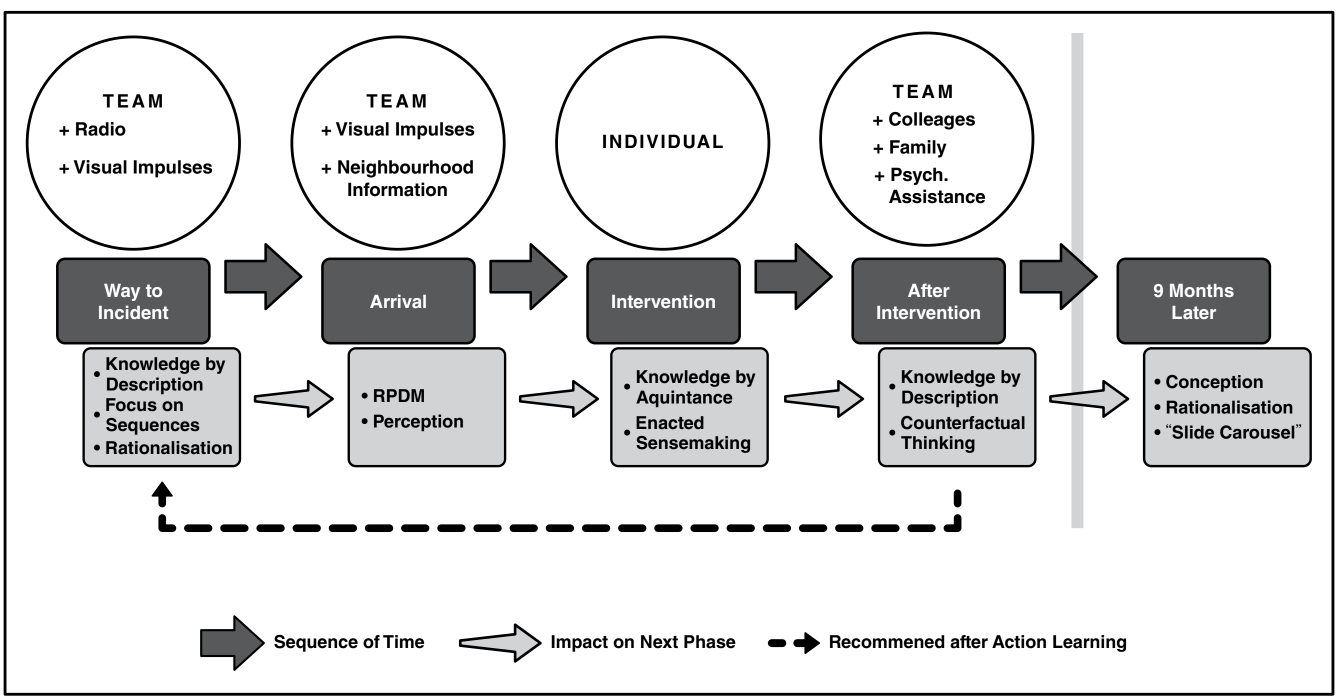
> *"Communication in a burning house is based mainly on loud shouting, and not being too far apart from your mate. You just need a mutual understanding of knowing what needs to be done."*

In the first sequence during the drive to the place of the incident, all crewmembers receive information from the control room over the radio. Although all of them individually absorb these facts concerning the incident — the witnesses, the dense traffic, the position of the second crew, and the severity of the fire — they have brief interactions concerning the probable situation they might encounter once they arrive. Based on this information, they individually put labels on this information (Weick, 1993) that have an impact on their individual perceptions once they arrive at the scene of the incident. An illustration is the commander's recall about the severity of the situation:

> *"Based on the messages over the radio, we knew we would be confronted with a blaze. The control room received multiple calls, so we knew the situation was severe for sure. […] It was between five and half past six, that's rush hour. On our way, we were told of a second house that would be affected by the fire. Once we arrived in the street, I saw nothing in the way of smoke or similar signs, which I found very odd. Once I saw the house, you could tell immediately something was terribly wrong. The first floor and the attic were burning. The ground floor was nothing to worry about."*

As the firefighters were informed about a *blaze* and several incoming calls in the control room concerning the burning house, they put the label *severe for sure* on the upcoming job. Their conceptions about being confronted with heavy traffic and additional messages about a possible fire in an adjoining house created the second label *something terribly wrong*. These labels have a significant impact on perception (Weick, 2011) as they discretely impact the way the firefighters see unpredictable events. Thus, these events are approached with certain recognised-primed decisions. It is notable how the three other firefighters in this case described in more or less the same wordings how they collectively interpreted the visual information on the appearance of the burning house.

Figure 1: Schematic representation of the multiple subsequent processes during the intervention by the Antwerp firefighters.



In this second sequence, the arrival at the burning house, the information assimilated by the firefighters comes from visual impulses and testimonials from neighbours at the scene. They all describe elements that are well in line with the RPD model strategy by taking advantage of their tacit knowledge as they were able to draw on their repertoires to anticipate the fire (Kahneman & Klein, 2009). Ferre, one of the firefighters in this team, described this shift from knowing what needs to be done to interpretation of the situation:

"We do what we normally do in these situations: three people deal with the pressure inside, the adjudant, the corporal, and me. The stairs were burning a bit, the first floor was on fire. We approached the room at the front of the first floor, which was ablaze. My colleague and I started to extinguish. The adjudant stood on the stairwell; on a mezzanine […] At that very moment we had the same insight, namely to not go further into the room because it was too tricky. It was burning far too hard and you couldn't see a thing. We signalled to each other to stay put."

According to the work of Baron and Misovich (1999), this shift bridges the gap between knowledge by description and knowledge by acquaintance; whereas, the latter starts with active exploration to take action. This active exploration involves "bottoms-up, stimulus-driven, on-line cognitive processing" (Weick, 2011; p. 23) to coordinate collective action.

This form of coordinated action, based on "discrete but shared concepts on a continuous perceptual flow" (Weick, 2011; p. 23), becomes the matrix of situational awareness that leads to enacted sensemaking (Weick, 1993; 2010) in the intervention phase. In an attempt to answer the question why this situation was "too tricky," Ferre answered:

"That's a tough question. You can feel it. There was too much noise, not that the noise level was different from any other fire. When the first beam fell you could hear creaking, but it was already happening. I cannot consciously say what gave me that feeling. In a different situation I would have gone into the room to extinguish the fire. This time I didn't. Whether it was my experience, a feeling, or intuition, I can't put my finger on it. I think it's a combination of factors. You simply get a weird feeling, it's not an exact science."

These comments illustrate how this firefighter was able to look beyond his fear and how his high prefrontal function picked up mental associations he had never contemplated before (Lehrer, 2009).

The very moment of the building collapse, all the interviewed firefighters recall how they tried to make sense of the situation, the condition their colleagues were in, and the next steps they had to take to get out alive.

"When I was on the way down, everything collapsed, and I fell on the floor, close to the person in the doorway. Suddenly there was a cloud of dust. You couldn't see anything and all you could hear were crackles. We waited until everyone came together, counted, and then we all went out together. There was no panic, as we soon knew that nobody was injured." (David, firefighter)

"There was a part on the top floor that was difficult to approach. I told my men to wait until the ladder arrived. At that very moment, the whole thing collapsed. The facade and the staircase were more or less intact. But as the staircase was connected to the roof, a lot of debris fell on me. My first idea was: Shit, my men! Luckily everyone was okay, just a little confused and frightened. I told them to leave everything and to get out as quickly as possible." (Frank, inside commander)

"I was standing outside and saw that all the beams of the ceiling were on fire. I shouted to say the building was about to collapse, but due to a technical failure the team inside the building did not receive this message. When the ladder arrived, the house collapsed. My task was to immediately scale up." (Jan, outside commander)

This attempt of making sense of a sudden new situation happened on an individual level. They had no means to communicate with each other, nor did they know whether their colleagues were still alive or not.

Immediately after the collapse, which put a brutal end to the intervention, the firefighters moved into the *after-intervention* phase. Their actions were now based on descript knowledge, things they learned at fire training and fire school. Elements such as *scaling up, to leave everything as fast as possible*, and *counting* are illustrative for this type of knowledge and subsequent decision-making. A second element that characterises this phase is the act of counterfactual thinking, which is thinking what might have happened (Morris & Moore, 2000). It has been indicated how counterfactual thoughts are most frequently provoked by negative events that are most likely to have a harmful impact on individuals (Roese & Olson, 1997). In this case, all interviewees indicated the presence of older, and thus more experienced firefighters as a positive or even lucky fact.

"They were lucky that older firefighters were inside, and no one stepped into the room. If younger men had been on duty that day, they would have entered the burning room for sure. Older firefighters are more careful. With this type of intervention I always have to stop younger colleagues when it gets dangerous. Luckily we only had one young guy in the team who had joined the brigade two weeks earlier. This was his first fire, so he had no intention of being a hero." (Jan, outside commander)

In most fire brigades it is standard procedure to have a team debrief in the presence of a senior officer and/or a psychologist. During these debriefings, they can overtly discuss the intervention, the actions taken, and the decisions made. This so-called *after action learning* (Garvin, 2000) is reported back to the entire brigade as lessons learned and as a basis for further improvement of operations. In this case there was a psychological but no technical debriefing, and thus a missed opportunity to learn.

The final phase in this case was clearly the time lapse between the intervention (February, 2012) and the interviews (November, 2012). It became apparent how all the team members rationalised their common experience. After 9 months, all of them had a kind of mental slide carousel (Miller, 1996) in which they recalled polished memories of a past action that are eventually turned into a concept of a collapse, not in the lessons learned of a collapse. Each of the four interviewed firefighters gave a slightly different description of the arrival on the scene. Although all vividly remembered the collapse, each of the four firefighters had a different perception of the decisions that were made and the instructions that were given.

Discussion

This research clearly indicates that in a fast-burning crisis situation various sequential processes are at play, both on a collective and an individual level. These processes are influenced by individual recognition of patterns stored in the memory (Kahneman & Klein, 2009), the level of knowledge by acquaintance and of knowledge by description (Baron & Misovich, 1999), coordinated collective interactions between team members (Weick, 2011), and enacted sensemaking (Weick, 1993). In other words, the rationale for switching between particular decision-making processes is anchored to the type of interaction, the firefighter's perception and conception of the situation, and the type of knowledge used to tackle the problem.

Although we did not research the interviewees' neurological conditions, we found multiple indications that support various findings in the field of cognitive neuroscience. All the interviewed firefighters referred to how shared emotions of fear helped them to understand others' actions and intentions. Recently, Nummenmaa and his colleagues indicated how networks of brain areas "tick together" in participants who were viewing similar emotional events (Nummenmaa et al., 2012). Although this research was based on functional MRI images, we found clear indications among the interviewed firefighters that support this finding outside a medical lab and based on a real life-threatening experience. Furthermore, two of the firefighters indicated unfamiliar feelings seconds before the collapse. It was an eerie intuition they could not put a label on. This is what Damasio calls "the equivalent of an intuition without the 'aha' acknowledgement that the solution has arrived" (Damasio, 2012; p. 276). Weick as well, who analysed the firefighters' (lack of) sensemaking behaviour in a disaster, calls this intuition "a cosmology episode, or something that feels like 'vu jàdé', the opposite of déjà-vu" (Weick, 1993, p. 633). However, Weick based his findings on a secondary source (the book *Young Men and Fire* by Norman Maclean, 1992) that recalls the experiences of the survivors of the Mann Gulch Disaster. Our findings are based on interviews of the firefighters who experienced the collapse of a burning house.

Finally, three out of four interviewees mentioned a common experience, more than twenty years ago, when they barely escaped from a severe blaze in a large hangar. Although they described the circumstances as being completely different to the recently experienced collapse, the similarities in their story concerning this earlier disaster were surprisingly similar. This similarity might support our earlier findings concerning NDM, enacted sensemaking, activity in the prefrontal cortex in extreme stressful situations as well as coordinated collective interactions between team members.

Recommendations for Practice

Our findings indicate how firefighters act on multiple sequences, and how in each of these a different form of decision-making is in use. Nowadays, future fire commanders (including Belgium and other European countries) are trained only to handle a limited set of standard fire situations and a limited set of decision models (mostly rational decision-making). Other knowledge on decision-making is gathered through trial and error. Only real-life experiences do not compensate for the lack of required expertise, because most of the fires are deemed *standard* fires; and the ones that are outliers and thus can be labelled as *vu-jàdé* (Weick, 1993) are not experienced and are the most dangerous.

Therefore, fire authorities and schools need to incorporate a comprehensive approach to fireground commanders' training. Decision-making training has to be included, but cannot be limited to RPD or rational decision-making only. A recent focus on "reading a fire" (Lambert & Baaij, 2011) and compartment fire-behaviour training in Belgian fire schools are excellent examples of such enrichment. These kinds of courses can make a difference for the classic training of fireground commanders by changing the focus from just the rational decision-making process to creating situational awareness through active observation of complex situations such as the building structure, the smoke, the heat, the ventilation, and the flames. Subsequently, observations have to be discussed, interpreted, and tested. Having a broader look for best practices in fire tactics and decision-making might give Belgian (as well as other European) fire authorities and schools helpful insights. A well-trained standard operating procedure (SOP) (see Angemi, 2012) in "holding the stairs" for example could have given Frank's team an advantage in the presented case. This example also means that fire authorities all over the world have to strive toward openness and sharing knowledge.

Miller (1996) compares the knowledge and experience of a commander with a slide carousel that is built up with mental pictures. He suggests performing several hands-on trainings and simulations as well as chalk trainings and case studies on a continuous basis and even outside classic training periods. In combination with Tissington's (2004) four underlying factors that should be included in the assessment of a situation (crew safety, the extent to which casualties need to be rescued, time pressure, and the degree to which the incident is contained) and based on our findings, we suggest to implement these factors continuously in the training of fireground commanders and in debriefings. Action research could even result in a training module based on this assessment.

Moreover, these trainings have to include the concept of a multiple-sequence approach of decisiveness, knowledge concerning the type of interaction, insights into the firefighter's perception and conception of the situation, and the type of knowledge used to tackle problems. And finally, fire authorities and schools, as well as individual fireground commanders, are able to improve their decision-making processes by being aware of the investment in the training of fireground commanders, conducting structured debriefings of complex incidents (after-action learning), and providing leadership and decision-making training and literature in the fire station.

Limitations and Recommendations for Further Research

Although the conclusions in this paper are based on a thorough review of the available literature and in-depth interviews with firefighters who experienced the event first-hand, this article is nevertheless based on a single case study. The case study started approximately six months after the incident, and the last interview was conducted 9 months after the incident. This timing means that the firefighters involved had a lot of time to rationalise their experiences and that some details have been forgotten.

The case study did not focus on the importance of team integrity in the decision-making process. The main difference between Frank's team and the team described by Weick in the Mann Gulch Disaster (Weick, 1993) is the integrity of the team. When Frank communicated the decision (not to enter the room), nobody in the team had the intention to disobey this order. The Mann Gulch team on the other hand had no clear leader and purpose and was a disintegrated team. That factor is, according to Weick (1993; 2010), why the Mann Gulch team neglected a similar life-saving decision by Dodge. Therefore, we recommend focusing on further research on the relationship between decision-making in fast-burning crisis situations and team integrity in the fire service.

The study also didn't focus on the primary situation-awareness problem with Frank. Since the building collapsed 6 minutes after arrival, one could say that Frank missed some indicators of an instable building before he entered the building. Since the focus was on the underlying reasons for the decision right before the collapse, this important question was not taken in account. It is obvious, however, that there are important lessons to be learned on behalf of situational awareness in this case.

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Endnotes

[1]A firefighter can never go into a burning room on his or her own without a team with a hose covering his or her way out.

[2]The study about decision-making in real-world settings.

[3]Klein & Klinger (1991) define a complex real-world setting as a situation marked with the next key features: ill-defined goals and ill-structured tasks, uncertainty, shifting and competing goals, dynamic and continually changing conditions, action-feedback loops (real-time reactions), time stress, high stakes, multiple players, and organizational goals and norms.

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Examining Firefighter Decision-Making: How Experience Influences Speed in Process and Choice

Abstract

The objectives of this study were to identify relationships among firefighter experience and the decision-making processes, by determining if experienced firefighters singularly review alternatives, review less alternatives, or make more expedient decisions than novice firefighters. Research results, utilizing the highest resolution computerized virtual reality (VR) system in the world, do not support the empirical evidence suggesting that experienced firefighters review and act upon their first alternative and that experienced firefighters review less information in less time.

Introduction

Some decisions are routinely made every day (e.g., what to eat, what to wear, and which route to take to work) and, based on our choice, possess relatively little in the way of consequences. However, there are certain occupations that require much more of people in the way of decision-making (e.g., air traffic controllers, military commanders, and race car drivers). Poor decision making in these arenas can have both drastic and dramatic results. Fire fighting should be considered one of those occupations; "the fire service continues to make life-and-death decisions every day throughout this country at fires and emergencies" (Dunn, 2008, p. 1). Regarded by some to hold "one of the most dangerous civilian occupations" (Fiedler, 1992, p. 5), firefighters often live on the edge of harm or death, where "loss of life is always a possibility" (Vaughan, 1997, p. 1; see also U.S. Department of Agriculture [USDA] and U.S. Forest Service [USFS], 2005).

Though the total number of annual structure fires continues to decline (Foley, 2003) and steps have been taken to dramatically increase safety, the fire service has been unsuccessful in eliminating the hundreds of firefighter fatalities occurring every decade on the fireground (Fahy, LeBlanc, & Molis, 2009). Even with significant safety improvements in equipment, clothing, and protocol — recognized and supported by fire personnel — firefighter death and injury statistics continue to remain unchanged (Paulson, 2008). Emphasizing the critical concern over fireground firefighter injuries and fatalities, researchers from both the National Institute of Standards and Technology (NIST) (1998) and the National Fallen Firefighters Foundation (NFFF) (2005, June), have suggested that firefighters can keep themselves out of harm's way by *making good decisions* [emphasis added]. In this high-risk environment, optimal fireground decisions are vital to successful front-line fire suppression, but because of their importance they can create what Useem, Cook, and Sutton (2005) described as a "decision making burden on fire leaders" (p. 467).

Incident commanders — positions that could be filled by any level of firefighter — are typically more experienced firefighters who take charge of the incident when arriving at the scene. The role of an incident commander is often assumed by the firefighter or fire officer sitting in the front passenger seat of the first-arriving apparatus. Whether that individual retains command or transfers it to a more senior officer is dictated by department protocol. Thus, a firefighter may perform as an incident commander, but an incident commander is always considered a firefighter. Regardless, incident commanders often shoulder the additional burden of knowing that the crucial decisions they initially make could either quickly resolve or exacerbate a situation. Vincent Dunn (2008), a 42-year fire-fighting veteran and retired chief of the Fire Department of New York, writes:

> The fireground commander responding with the first alarm is the person who makes the most life-and-death decisions. The life-and-death decisions made in the first few minutes of the fire are the most important. These decisions lay the groundwork for the entire firefighting operation. (p. 3)

Decisions made by incident commanders influence the fate of many others, because they are charged with weighing the risk and benefit of every operational decision and managing resources; and they are looked towards for decision-making guidance and direction by the firefighters inside burning buildings. For those reporting to the incident commander, it is important that they have confidence that, when risking their lives fighting a fire, the firefighter outside guiding them (i.e., the incident commander) is making the right decisions (Observer, 2008).

Naturalistic Decision Making (NDM)

Since 1989, a new branch of behavioral decision making has developed to study how people really make decisions in chaotic, uncertain, and rapidly changing environments (Klein, Orasanu, & Calderwood, 1993). Entitled *naturalistic decision making (NDM)*, this theory's framework focuses on cognitive functions that emerge in natural settings and take forms that are not easily replicated in the laboratory. Researchers know that success with NDM processes depend on one's skill with decision making utilizing limited cognitive resources (Todd & Gigerenzer, 2001). Decision making under uncertainty, time-pressure, and stress — often encountered by the likes of military commanders and firefighters — occurs where there is not always time for careful consideration of each criterion for each alternative choice. This type of decision making requires learning and expertise to routinely choose feasible courses of action without analyzing all or even part of the options.

When studying how people actually make decisions, Klein (1998) found that traditional models of decision making could not accurately describe this rapid decision making under uncertainty. After retrospectively interviewing experts in their natural environment, Klein (1993, 1998) began to theorize what has become known as the "prototypical NDM model" (Lipshitz et al., 2001, p. 335). Following extensive analysis of personal testimonials from firefighters, military leaders, and others from occupations that often require rapid decisions, he discovered that the first course of action initiated and developed by experienced decision makers was usually the one that adequately solved the problem at hand. According to his Recognition-Primed Decision (RPD) model, experienced decision makers conduct a *singular evaluation process* (a process where each alternative is evaluated on its merit) rather than conducting a comparative evaluation approach (i.e., comparing evaluations across multiple courses of action) (Wolgast, 2005).

Expertise

Klein (1998) confirmed that RPD functions well under conditions of time pressure, when only partial information is available and goals are poorly defined, but is less likely to be used by those lacking *expertise* (Lipshitz, 1993). Extensive experience among decision makers is needed in order to correctly recognize the salient features of a problem and model solutions because failures of recognition and modeling in unusual or misidentified circumstances may lead to poor decisions. For fire fighting, where it is "imperative that decision making is at an expert level," the ability to generate a rapid series of cognitive responses that lead to quick decision making seems ideal (Hintze, 2008, p. 26) and ensures that "experienced personnel can better predict fire behavior and make decisions to maintain personal safety" (Horn, 2006, p. 7). Research suggests that situation recognition, either from prior knowledge or expertise, can lead to expedient decision making by recalling analogous situations, identifying relevant cues, and implementing the standard course of action (Warwick, McIlwaine, Hutton, & McDemott, 2001). The absence of prior relevant experience weakens the capacity for making effective decisions (Useem, Cook, & Sutton, 2005).

According to research, the differences between experts and novices quickly reveal themselves when presented with reoccurring situations because experts evaluate problems differently from novices (Horn, 2006). Experienced people are able to *generate quicker decisions* because the situation may match a prototypical situation previously encountered. Thus, experienced decision makers are better able to recognize important features of a problem and to directly retrieve appropriate actions or solution techniques. Novices lack this experience and must cycle through different possibilities; they tend to use trial-and-error mechanisms. Unable to recognize a form of pattern matching, recognize multiple cues, or correlate the pragmatic information with key observations, novices tend to employ an analytical approach, systematically comparing multiple options (Larkin, McDermott, Simon, D., & Simon, 1980; Klein, 1993). Experts, unlike novices, perceive similarities in terms of fundamental laws or principles in a domain rather than in terms of superficial features (Chi, Feltovich, & Glaser, 1981). Omodei (2006), while observing wildfire firefighters, found that experienced firefighters tend to look at smoke color for additional information about how a fire is burning, while less experienced firefighters simply consider flame height.

In cognitive psychology, developmental research based on detailed comparisons of experts and novices in specific domains began with de Groot's (1978) classic study of chess masters. This study was soon followed by Chase and Simon's (1973) comparison of masters to less expert players. A chess master's skill at reconstructing meaningful chess configurations is attributed to the fact that, through experience, they have come to perceive the game in terms of highly familiar patterns. As individuals gain knowledge, they hone their abilities to categorize information, recognize familiar patterns, and address critical indicators while ignoring less important features (Means, Crandall, Salas, & Jacobs, 1993). Likewise, Klein, Calderwood,

& Clinton-Cirocco (1986) and Lipshitz (1989) both reported that fireground commanders and Israeli army officers, respectively, reacted to situations in terms of highly familiar patterns associated with certain actions. Decision making in these environments appeared to be determined by the "nature of the individual's experience, the patterns recognized, and associations between patterns and actions" (Means et al., 1993, p. 312).

Camerer and Johnson (1991) suggest that an "expert is a person who is experienced at making predictions in a domain and has some professional and social credentials" (p. 196). To create a more functional definition, it requires the assembly of several researchers' thoughts on expertise. Experts, as opposed to others, exhibit a deeper, functional understanding of a problem (Anzai, 1991), consider the effects of sequencing and timing of events (Sefaty, MacMillan, Entin, E. E., & Entin, 1997), and know and can do what others cannot (Anderson, 1983). Klein & Militello (2004) suggested several additional categories of knowledge related to expertise, including those that:

- Hold increased perceptual skills.
- Possess a broader, deeper knowledge and experience, leading to increased ability to simulate mental models.
- Carry a large repertoire of patterns that allow them to recognize situations as typical.
- Know more facts and more details.
- Spend relatively more time analyzing a situation than deliberating a course of action.
- Better self-monitor for mistakes and limitations, leading to superior self-knowledge.

How should expertise be conceptualized as it relates to this study? It would not be uncommon to find that many firefighters spend the first seven to ten years as firefighters *learning the ropes*, so to speak, all the while learning the nuances of the job and preparing themselves for upcoming promotions to company officer.

Because of the "decision making burden on fire leaders…. optimal leadership decisions are no less vital for successfully suppressing a fire" (Useem et al., 2005, pp. 462–476). On-the-job training is very common in the fire service, with little formalized company officer development occurring in most departments. Thus, promotions to company officer are often sought after and achieved only by *seasoned* veterans who have vast experience and knowledge to draw from. However, more formal efforts to improve decision making, such as courses provided by the fire service (Federal Emergency Management Agency [FEMA], 2009) and the latest work in decision-making simulators such as FLAME-SIM Software (2010), are prescriptive in nature and do not address the root cause of poor decisions. If suboptimal decision-making events are occurring in the fire service, it is surprising that few studies exist of how and why firefighters make choices. To address "the human consequences of suboptimal decisions by fire leaders" (Useem et al., 2005, p. 462), it is crucial to understand how and why firefighters, specifically incident commanders, make their decisions (Observer, 2008). Researchers have recognized that command and control decision making has received little detailed and systematic study (Brehmer, 2000). While several theories have been proposed to explain how these decisions are made, they have not been tested experimentally under realistic conditions. Due to lack of information-capturing technology, no previous means have been developed to evaluate real-time firefighter decision making under naturalistic conditions. However, as technology has evolved, possibilities for measuring decision making have changed.

Virtual Reality (VR)

Compared to "live-fire training," simulations offer an attractive alternative. Besides the risk associated with live-fire training, simulations can provide repeated practice problems that are adapted to the student in terms of difficulty level and instructional purpose in an artificially compressed time that can lead to recognition of patterns (Means et al., 1993). For example, in an air-intercept task (Schneider, 1985), computer graphic simulations and time compression were used to give prompt feedback and eliminate passive time that would certainly occur when training individuals under real-world conditions. Interactive simulations have been found to be "particularly effective" (Payne, Bettman, & Johnson, 1993, pp. 235–247) in evaluating and training the decision-making skills; so much so that many influential organizations are highly recommending its use be integrated into firefighter incident-commander training (Government Technology, 2003). The NFFF (2005, June) suggested that there is a substantial need for effective integration of simulation into training to help firefighters identify the most critical and commonly encountered issues from actual incidents, and developing virtual reality (VR) training scenarios would be the most appropriate method. Based on this need, the United States Fire Administration (USFA) (2008) began working with NIST to develop a computer-based firefighter training tool "to improve training opportunities while lowering the cost and risk of death and injury" (p. 1). Even with the recognized potential, "The use of simulators is very limited in the fire service and there is substantial opportunity for enhancement" (NIST, 2000, July, p. 35).

VR has been defined many different ways and can range from simple software programs presented on a laptop computer to fully immersive multisensory environments experienced with complicated head, vision, tactile, or haptic-related instruments (Ausburn, L. J. & Ausburn, 2004). When utilizing a three-dimensional computer-generated graphics system encompassing a majority of the user's visual field, VR can mimic a natural setting while preserving the risk-free and uncontaminated qualities offered by controlled laboratory environments. Controls allow users to interact with the system, creating a virtual world allowing users to feel fully encapsulated and more involved in the decision-making process. The result is a "simultaneous stimulation of participants' senses that gives a vivid impression of being immersed in a synthetic environment with which one interacts" (Brown, 2001). While still being a fairly recent innovation, "research-based implementation of VR systems in industrial training … have a clean slate on which to write unique literature all their own" (Ausburn, L. J. & Ausburn, 2004, p. 7).

Because NDM methodology does not always adhere to the standards of rigor appropriate for laboratory-based experiments, it has been criticized as being "soft" (Yates, 2001). Therefore, balancing the desire to study decision making in the natural environment of the decision maker, while still minimizing and/or eliminating the uncertainties and biases that laboratory studies introduce, has been a challenge. Iowa State University's Virtual Reality Application Center (VRAC) offers a unique opportunity to meet this challenge by employing highly immersive VR technologies in a rigorous experimental lab environment. Utilizing human-computer interactions, in conjunction with the development and implementation of a cutting-edge decision-tracing technology for emergency-response simulations, represents a breakthrough in command and control decision-making research. The use of VR allows for (1) development and utilization of a sophisticated real-time decision capturing algorithm to trace decision-making processes; (2) implementation of an array of virtual environments for firefighter interaction within a computerized automated VR room where all six walls are utilized to establish the highest level of immersion; and (3) digitally recording of simulations in the VR environment.

However, as Winn et al. (1997) explain, for VR to successfully be used in this research, two areas must be addressed: (1) immersion and (2) presence. VRAC utilizes the C6, an automatic virtual environment, to provide the illusion of *immersion* into a full-scale virtual world through projection of stereo images on the walls and floors of the room-size cube. The C6 system provides users with an unprecedented degree of immersion through full enclosure within six 10 feet by 10 feet screens, isolating participants within its field of view. The C6 is the highest resolution VR system in the world — more than double that of any other similar system. Each screen projects representations with a resolution of 4,000 × 4,000 pixels, which is over twice the resolution of high definition television (Iowa State University, 2008). By successfully isolating the user from the real environment and by creating realistic sensory inputs, full immersion into the virtual environment occurs. *Presence* means that users feel as though they are inside, interacting with the virtual environment — even a part of the virtual world. Users view the environment with shutter glasses, creating a high level of realism. Active stereo is used to control the perception of a participant's position and body in the virtual environment. Custom graphics programs, called *shaders*, were developed to render photorealistic objects and scenes in real time to further increase a participant's presence. These items all synergistically create an environment that provides a high level of immersion and presence for the participants.

Hypotheses

The following hypotheses were tested in this study:

- **Hypothesis 1:** According to the RPD model, experienced decision makers conduct a singular evaluation process and utilize the first course of action initiated and developed that can adequately solve the problem at hand.
- **Hypothesis 2:** Novice decision makers employ an analytical approach, systematically comparing more options than experienced decision makers.
- **Hypothesis 3:** Experienced decision makers tend to make quicker decisions.

Methods

To test the previous hypotheses, simulated fire-fighting scenarios in VR were utilized. Decisions were captured via computerized decision-tracing process technology entitled *VirtuTrace*. The next five subsections further break down this study by participants, procedures, fire-fighting scenario, instruments, and dependant variables.

Participants

To test these hypotheses, Iowa-based career fire-department personnel (3 Fire Chiefs, 3 Chief Officers, 3 Captains, 9 Lieutenants, and 24 firefighters) took part as voluntary participants in this experiment. Participants (41 men and 1 female; mean age 28.5 years) were selected by means of a convenience sample from the Ames and surrounding Des Moines metro-area fire departments. All 42 firefighters were individually tested during the months from April, 2010, until April, 2011, after ensuring appropriate consent procedures. None of the participants had partaken in a similar experiment before.

Procedure

This study was administered in a fully immersive VR environment at the VRAC of Iowa State University. Following a general oral introduction about the subject of the study, subjects provided signed informed consent. Participants were briefly coached in the procedures for operating and navigating through the VR simulator.

Participants completed two training scenarios with a research technician to learn how to control the randomized decision matrix and navigate through the virtual environment. The firefighter completed a third training scenario alone. After this third training scenario, each participant began moving the fire-fighting scenarios (described in the following section). Following completion of these scenarios, the firefighter completed an anonymous online survey, consisting of several demographic, scenario-specific, and opinion questions regarding the scenario's complexity, difficulty, and realism.

Fire-Fighting Scenario

A prebackdraft scenario was chosen to best capture the essence of extreme firefighter decision making. During this prebackdraft scenario, participants are "transported," as a firefighter in an incident-commander role, to the front of a single-family residential house with varying cues (see **Figure 1**) meant to imply potential backdraft (i.e., smoke-stained windows, glowing red doorknob, smoke pushing from windows or doors cracks, and the absence of flames).

Figure 1: Prebackdraft Scenario.

This scenario was carefully chosen to reflect the fact that backdraft is a familiar and yet challenging scenario encountered by firefighters (Cote, 2004). Of the firefighters who are killed by smoke inhalation, approximately 26% are caught in a rapidly spreading fire, backdraft, or flashover. Of those who die, secondary to burns received from a structure fire, approximately 45% are caught in or trapped by a backdraft or flashover (Foley, 2003).

Instruments

For this study a computerized decision process-tracing methodology, VirtuTrace, was utilized to record the participant's decision processes. Here, a decision matrix was used to ascertain participant choices reviewed, the order they reviewed them, the time they took to evaluate the choice, and the actual final decision. The decision matrix consisted of a 4 × 4 matrix with vertical columns representing possible decision choices and horizontal rows providing information in a series of *bins*. The matrix was projected into the virtual environment as a transparent floating window on top of the simulation (see **Figure 2**). Participants physically requested the matrix to appear with the touch of a button on a wand (i.e., remote-type control) and made subsequent choices in the same way. The matrix included non-trivial information in bins that was revealed audibly upon physical command by the participant. To increase immersion and presence, this audible information was heard over *walkie-talkies* utilized in actual live-fire communication. When ready, firefighters declared their final choice on the matrix.

Figure 2: VirtuTrace Decision Matrix.

Upon selecting the final choice (*attack the fire*, for example) the VirtuTrace verified and recorded the participant's selection. To help control for any biases introduced by the order in which alternatives and dimensions are presented, the design included several presentations of the scenario with the manipulation of different sequences of alternatives and dimensions. To maintain independent observations, participants and their scenarios had no impact or interaction with the previous or subsequent participants and their scenarios.

VirtuTrace is a technological method of recording (1) the sequence in which firefighters acquire information in the decision matrix, (2) the number of items that firefighters view for every alternative line of action along each dimension, (3) the amount of time elapsed from the time respondents begin the task until they make their choice, (4) when and how long information bins have been reviewed, and (5) the alternative that was selected. VirtuTrace analyzes data collected and presents a subject's *decision portrait*. The portrait included calculated information search indices for each of the decision process dimensions and alternatives, amount of information reviewed, time spent in distribution throughout the decision task, and cognitive maps that are used to identify decision strategies.

Dependent Variables

The dependent variables in this study consisted of three process-tracing parameters of decision making: (1) whether the first course of action (or item reviewed) was the final alternative selected, (2) the amount of information reviewed (based on the number of matrix selections reviewed), and (3) the time to final decision. One-way analysis of variance (ANOVA) and *t*–tests were used to determine whether there were statistically significant main effects of each of the treatments separately on each dependent variable. An alpha level of $p < .05$ was used for accepting significance (Johnson & Wichern, 2007; Neter, Kutner, Nachtsheim, & Wasserman, 1996).

Results

Each of the following five topics — Virtual Reality, Experience as a Continuous Variable, Preference for Selecting First Option, Amount of Information Reviewed, and Final Time to Decision — contain detailed descriptions of the results of this study.

Virtual Reality (VR)

As mentioned in the Procedure section, participants completed a postexperiment survey that addressed demographic characteristics and experience with the VR. For experience with VR, a 5-point Likert scale was used to rank experience, where 1 indicates Strongly Disagree, 2 indicates Disagree, 3 indicates Neutral, 4 indicates Agree, and 5 indicates Strongly Agree. **Table 1** provides a summary of experience in VR.

Experience as a Continuous Variable

Average years of service for all firefighter participants were 8.81 years, with a standard deviation of 5.1. Regression analyses were performed to examine the relationships between the dependent variables, amount of information reviewed (AIR) and final time to decision (FTD), and the independent variable (years of experience) as a continuous variable. Equations 1 and 2 provide the formulas for simple linear regressions, the correlation level, and the significance of the slope for AIR and for FTD, respectively:

$$\text{Equation 1: AIR} = 11.4 - 0.19^* \text{ [Years Exp]},\ R^2 = 0.0044,\ p_{slope} = 0.358$$

$$\text{Equation 2: FTD} = 317.1 - 5.3^* \text{ [Years Exp]},\ R^2 = 0.1007,\ p_{slope} = 0.1501$$

The results indicated that years of experience can explain at most 11% of the variance in FTD and less than 1% for AIR. Furthermore, the slope of the line was found insignificant for both independent variables. Therefore, experience was treated as a categorical variable.

Repeated analyses detected 10 years of service as a cutoff threshold for experience-inexperience. The firefighter group with 10 or more years of experience was termed *experienced or veterans*; the group with less than 10 years of experience was the *novice group*. Average years of experience in the novice group (N = 20) was 5.1 years, with a standard deviation of 2.6 (Skewness = -0.28, Kurtosis = -1.22). In the experienced group (N = 22), the average experience was 18.1 years, with a standard deviation of 5.1 (Skewness = 0.348, Kurtosis = -1.05).

Table 1: Survey results pertaining to experience in virtual reality.

Item	M	SD
The auditory aspects of the environment helped me feel involved.	4.33	0.42
The sound helped enhance the experience.	4.5	0.55
I was visually able to survey and search the environment.	4.08	0.94
The visual display quality did not distract me from the environment.	4.03	0.85
My general experiences in the virtual fire environment seemed consistent with my real-world experiences.	3.80	0.79
My ability to identify fire-condition indicators was consistent with my ability to identify these indications in real-life scenarios.	3.80	0.85
The decision table provided information that I typically obtain to make real-life decisions during line of action.	4.15	0.70
I was able to adjust easily and quickly to working in the virtual reality environment.	3.8	0.82

Preference for Selecting First Option

The first item the experiment assessed was whether firefighters have a preference for selecting the first alternative (or item reviewed) as their ultimate course of action. For these results, we used a two-way, cross-tabulation table as the hypothesis test for the difference in the proportion of successes in two or more groups or a relationship between two categorical variables. We looked at two separate categorical variables: (1) experienced/novice firefighter (represented as *E* or *N*) and (2) the selection of the first option reviewed (with a success being a yes = 1). Using a chi-square test, the null and alternative hypotheses for this two-way cross tabulation are stated as follows:

H_o: $\pi_E = \pi_N$ (No difference exists between the experienced and inexperienced proportion selecting their first option.)

H_a: $\pi_E \neq \pi_N$ (A difference exists between the two proportions.)

Experienced (greater than 10 years of documented fire-fighting experience) firefighters ultimately selected their first option 48% (standard deviation = 0.51) of the time. Novice firefighters ultimately selected their first option 24% (standard deviation = 0.44) of the time. This difference was not statistically significant ($p = 0.1074$ with 1 degree of freedom, and the computed chi-square statistic of $2.59 < 3.84$ the critical value of chi-square). There is insufficient evidence of a difference between experienced and novice firefighters in the preference for selecting the first option reviewed, possibly because there is high variance as seen in the standard deviation.

Amount of Information Reviewed

To analyze for differences between the two groups by determining whether a significant difference exists in the population means, we used a pooled-variance *t*–test to *pool* the sample variance of each group into one estimate of the variance common in the two groups. Using this pooled-variance *t*–test, the null and alternative hypotheses for this test is stated as follows:

H_o: $\mu_E = \mu_N$ (The two population means are equal, and there is no difference between the mean amount of information reviewed by experienced participants and that reviewed by novices.)

H_a: $\mu_E \neq \mu_N$ (A difference exists between the mean amount of information reviewed by experienced participants and that reviewed by novices.)

The amount of information reviewed (based on the number of matrix selections reviewed) significantly increased for firefighters with more experience. Two-tailed *t*–tests support a difference in means, with the computed *t*–statistic of 2.21 (which is greater than 2.021, the critical value of *t*–cal) and associated *p*–value of .0332 ($p < .05$). Firefighters with greater than 10 years of documented fire-fighting experience reviewed 7.81 (standard deviation = 4.42) items before reaching their decision, while novice firefighters reviewed only 5.23 (standard deviation = 2.99) items before selecting a final choice. These results suggest that novice firefighters review significantly less information than experienced firefighters.

Final Time to Decision

To analyze for differences between the two groups by determining whether a significant difference exists in the population means, we used a pooled-variance *t*–test to *pool* the sample variance of each group into one estimate of the variance common in the two groups. Using this pooled-variance *t*–test, the null and alternative hypotheses for this test is stated as follows:

H_o: $\mu_E = \mu_N$ (The two population means are equal, and there is no difference between the amount of time taken to reach a decision by experienced participants and that reviewed by novices.)

H_a: $\mu_E \neq \mu_N$ (A difference exists between the amount of time taken to reach a decision by experienced participants and that reviewed by novices.)

Veteran firefighters used a mean of 219.4 seconds (standard deviation = 86.99) to reach a decision, while novice firefighters took only 169.6 seconds (standard deviation = 59.94) to choose an alternative ($p = 0.0369$, *t*–cal = 2.16 > 2.021, the critical value of *t*–cal). Thus, the results suggest that there is a significant difference between the time taken to reach a decision by experienced firefighters compared to novices.

Hypothesis 3, that experienced decision makers tend to make quicker decisions, was not accepted. An ANOVA test revealed statistically significant differences between the means of the FTD and experience levels ($F [1, 40] = 4.66$ [$p < .05$]).

Discussion

Recall that Hypothesis 1 for this study was that experienced decision makers conduct a singular evaluation process and utilize the first course of action initiated and developed that can adequately solve the problem at hand. Our results suggest that experienced firefighters showed no significant preference for selecting the first alternative as their ultimate course of actions. This result suggests that the characteristics of recognition-primed decisions (RPD) are not necessarily typical to experienced firefighters. More explicitly, experienced participants did not show preference for making final selections using their first alternative, compared to any subsequent alternative reviewed.

The concept of the familiarity of decision makers with the decision problem has attracted significant attention in the literature. The effect of familiarity of the decision makers with the decision task on their decision strategy was tested by Mintz (2004) with high-ranking military officers. The results demonstrated that when they are familiar with the decision task, decision makers are more prone to employ an alternative-based information acquisition strategy. However, the results also strongly support the conclusion that in familiar decision-making settings, although a more typical alternative-based information process may have been used, a noncompensatory mechanism (which is a dimension-based process) of decision making was utilized early in the decision task to minimize the set of alternatives to a set that exceeds the minimal threshold on the critical dimension.

The results do not support Klein's *singular evaluation approach* (1998). It is important to note though, that Klein recognizes that proof is needed as to whether decision makers actually do compare alternatives subconsciously (Klein, 1998, p. 297). Shields (1980) also found differing results when he demonstrated that as the complexity of a decision task increases, experts responded by utilizing a noncompensatory strategy.

Hypothesis 2 of this study was that novice firefighters employ an analytical decision-making approach, systematically comparing more options than experienced decision makers. Our findings suggest that there is a difference in the amount of information reviewed between novice and experienced firefighters. Past research has also found that novice decision makers employ analytical approaches that compare more options than experienced decision makers (Larkin et al., 1980). However, our experiments produced statistically significant results that are in opposition to this empirical research. Firefighters with 10 or less years of career experience (novices) reviewed significantly *less* information than that reviewed by experienced (> 10 years) firefighters. Again, this fire-fighting scenario did not factor in time pressure for participants, and it can be generally considered that people utilize less information in making their choice when under pressure to make a choice in a restricted period of time (Wright, 1974; Rothstein, 1986). But this theory does not account for the differences between the experience level in the participants.

One explanation for this result could be that novice firefighters are more unaware of the consequence of their actions and thus feel more comfortable making a decision with less information. Whereas, more experienced firefighters understand the potential outcomes of a wrong decision and desire greater levels of information when making a decision under little-time pressure. Another theory would be that it is uncommon for the average person to be afforded the opportunity to partake in a virtual world, making it possible for participants to succumb to decision-making tendencies that possibly prolong the decision task, in attempts to continue the virtual experience. Also, when choices are presented in visual form, as in the decision matrices, participants could feel compelled to review more information than they otherwise might outside the virtual environment.

Finally, our third hypothesis stated that experienced firefighters make quicker decisions than novice firefighters. We found that there is a difference in the time taken to reach a decision between novice and experienced firefighters. Research has suggested that experienced decision makers tend to make quicker decisions (Klein, 1993). However, our results were contrary. Here, it was actually novice firefighters who made quicker decisions. After initial statistical analysis, further hypothesis suggests that the FTD in seconds, from the time of scenario initiation to time of alternative selection, is positively correlated with the number of items reviewed. Thus, it stands to reason that experienced participants, who reviewed more information, would also take longer to make a final decision.

The regression analysis showed an R-square value of .2302 ($p = 0.0013$), meaning 23% of the variability in the time to decision can be explained by the number of items reviewed. Constructing a confidence interval based on the parameter estimate and the standard error ($b_1 \pm t * SE_{b1}$), we can be 95% confident that for each additional item reviewed, the time to reach a decision will increase between 3.93 and 14.99 seconds.

Conclusion

When considering the inherently dangerous occupation of fire fighting, where more than 100 fatalities and 85,000 injuries occur annually in the United States (NFFF, 2005), it is imperative that optimal decision making transpire routinely. The significant results found in this study emphasize that firefighters, regardless of experience level, do not show preference for ultimately selecting, as their final choice, the first item they reviewed. Experienced firefighters also showed significant tendencies to review more information than their less-experienced peers and to take significantly longer in making a decision.

Because none of the results of this study support previous empirical research, this topic should be studied further. The study should be replicated using career firefighters from other fire departments. Further research is needed to determine if suboptimal decision making is taking place among novice firefighters, who appear to make quicker decisions with less information, even when time pressure is not a variable in the scenario design. Additional research should also focus in the area of time pressure and its effect on decision making. Implications of findings presented here are significant, and new policies and training could lead to the acceleration in the development of expertise among novice firefighters. Our expectations are to increase the understanding of a mechanism underlying the increased risk for injuries in fire fighting and lead to the development of interventions to reduce the risk of firefighter death and injuries.

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The Role of E-Government in Selected Fire Services of Taiwan and the United States: A Comparative Analysis

Abstract

Electronic government has now become a necessity in governments throughout the world. The literature has shown that there are six stages of e-government development: (1) information dissemination, (2) two-way transactions, (3) multipurpose portals, (4) portal personalization, (5) clustering of common services, and (6) full integration. This research addressed to what extent selected fire departments in the United States and Taiwan have followed such development. Employing content analysis, findings showed that none of the fire-department websites completely satisfied all six stages, although larger fire departments had more fully developed websites.

Introduction

The image of *electronic government* (e-government) invokes one sitting in front of a computer and interacting with one or several government agencies in the quest for better governmental service. For example, downloading building permits, paying fees, or scheduling appointments are all integral components to a customer-oriented e-government website. In fact, e-government has become commonplace in the daily lives of people and has gained universal acceptance. Yet, if questioned as to its date of origin, most would probably guess in error.

Only a few decades ago, the term e-government was somewhat of an enigma. Kamensky (2001) notes the term "electronic government" was first used in 1993 by a task force created to reform the United States (U.S.) Federal Government. The National Performance Review's shibboleth of "works better, costs less" became one of the most successful government endeavors in American history (Misra, 2007). Today e-government refers to, according to West (2004, p. 16), "internet delivery systems [that are] nonhierarchical; nonlinear, two-way and, available 24 hours a day, seven days a week."

E-government initiatives have progressed through numerous phases of development, and several key principles define an efficient e-governmental website. In a study of the role of electronic service delivery in the fire service in the United Kingdom (U.K.), Donnelly & McGuirk, (2005) identify the following four key principles:

1. Building services around its citizens
2. Ensuring government services are more accessible
3. Effective use of information, and
4. Maintaining equality between those with access to electronic media and those without (p. 29).

The first three principles are well within the realm of e-government possibilities and can be incorporated with great care and planning in website development. The fourth principle defines what is generally called the *digital divide* and is much harder for government entities to realize, especially if those without access to electronic media do not have the means (e.g., financially or literacy) to access agencies on line.

Since its emergence, e-government has taken on its own identity and has found its way into all municipal government departments, the fire service included. Much like other departments in municipal and county governments, e-government has an essential role in the day-to-day operations of the fire service. Whether securing permits, booking an inspection, or simply posing a question, the benefits of multistage e-government have now become a mainstay in government at all levels: federal, state, and local. More than a decade ago, research showed that municipal governments have "shifted their thinking from the traditional bureaucratic paradigm to the e-government paradigm" (Ho, 2002, p. 438). Furthermore, many cities have departed from departmental "boundaries" and adopted a one-stop shopping approach by centralizing communication (Ho, 2002, p. 438). An example of this approach is the clustering of common services, discussed in greater detail in the sections that follow.

The purpose of this article is to examine the extent to which large fire departments in both the U.S. and Taiwan deliver e-government services to their constituents. Content analysis of a fire-department's website serves as the methodology used to determine e-government services provided to local residents. While a large number of studies examine e-government initiatives among nations, federal, state, and local governments, research to date has not systematically examined e-government policies in fire departments.

Literature Review

The literature focusing on e-government is rich in both quality and quantity. In her seminal article entitled "What is e-Government?" published in *Parliamentary Affairs* in 2001, Rachel Silcock provided a concise definition of the term. She wrote, "e-government is the use of technology to enhance the access to and delivery of government services to benefit citizens" (Silcock, 2001, p. 88). She continued that e-government is a "partnership" between governments and citizens. Building on previous research conducted by Deliotte Research (2000), Silcock (2001) introduced the six stages of e-government, which guide the analysis that follows. The stages are as follows:

1. Information publishing/dissemination
2. "Official" two-way transactions
3. Multi-purpose portals
4. Portal personalization
5. Clustering of common services, and
6. Full integration and enterprise transformation (pp. 89–90).

Three years later, West (2004) similar to Silcock, outlined four general stages in e-government:

1. Billboard stage
2. Partial-service-delivery stage
3. Portal stage
4. Interactive stage (p. 17)

West's first stage purported that there is little citizen interaction or two-way communication between the government and its citizenry. Stage 2 allows users to search out information that they want, rather than seeing information that only the government wants them to have. The third stage represents one-stop portalization. Here all government agencies are integrated with one another and fully executable services are available to the citizens. In the last stage, government sites move beyond the service-only mode and offer web personalization to users. West (2004), like other researchers both before and after him, pointed out that all government sites do not go though these stages, nor do they follow this particular order.

Moon (2002) writes that e-government includes "four major internal and external components:

1. The establishment of a secure government intranet and central database for more efficient and cooperative interaction among governmental agencies
2. Web-based service delivery
3. Application of e-commerce for more efficient governmental transaction activities, and
4. Digital democracy for more transparent accountability" (p. 425)

Internally e-government is used as a management tool for collecting, organizing, managing, and storing data. Externally, electronic government is the government's interaction with its citizens.

Moon (2002, p. 427) also asserts that stage development is just a "conceptual tool" to examine the evolution of e-government. The adoption of such practices may not follow a true linear progression; e-government stages do not necessarily follow a chronological or a hierarchical order.

Additional e-government stage-development studies include research by West (2005), Siau and Long (2005), Layne and Lee (2001), Westcott (2001), Baum and Di Maio (2000), Ronaghan (2001), and Hiller and Berlanger (2001). As Siau and Long (2005, p. 523) note, "all [stage development studies] purport to describe what might be considered the 'normal' evolution of e-government from its most basic element (a rudimentary governmental presence on the World Wide Web) to fully developed e-government."

More recently, Jungwoo Lee (2010) offered a qualitative meta-synthesis of 12 previously published e-government stage-development articles. His analysis distilled nine stages of e-government development. They are: "(1) information — presentation of government information via the web, (2) interaction — two-way communication, (3) transaction — service and financial transactions via the web, (4) integration — integration of service or databases, (5) streamlining — correct processes that are inadequate for information technology, (6) transformation — transformation into new types of government operations, (7) participation — consultation with public for opinion and surveys, (8) involvement — active involvement in political decision making, and (9) process management — configurable system for process management" (Lee 2010, p. 228).

To date, stage-development research offers similar stages focusing on similar concepts such as website presence, transaction, interaction, two-way communication, and participation. The analysis of fire-department websites in the U.S. and Taiwan employs the seminal stage development work of Silcock (2001). Specifically, Silcock's (2001, pp. 89-91) six stages of e-government development that are analyzed include the following:

Stage 1: Information Publishing/Dissemination: Municipal and county departments and agencies establish individual websites. This first step requires at least one-way communication that allows citizens, for example, to download information from the site. The site may be also two-way, whereby citizens can pose questions concerning the information available.

Stage 2: *Official* Two-Way Transactions: In this stage, citizens can engage in transactions such as paying bills or securing permits. Scheduling an inspection, and other interactions, would be as easy as booking a flight reservation and choosing your seat on an aircraft.

Stage 3: Multi-purpose Portals: Citizens can, through a single point of entry, access several municipal departments, thereby saving time. For example, citizens can, usually by way of a drop-down menu, contact departments such as police, building, or the mayor's office.

Stage 4: Portal Personalization: More frequent users could customize their own portals with a personal user name and subsequent password. This process might be as easy as signing in to an email account. Frequent users could store their information and previous transactions and revisit them without starting from the beginning every time they sign in to the website.

Stage 5: Clustering of Common Services: In this stage, each government website would consolidate particular services along common tasks to benefit the user. For example, in the case of the fire department, building a house would involve the services of the building department for plan review, electrical department for wiring review, and water, sewer, and similar departments. By posing a question something such as "What do I need from the city to build a house?" one could not only access all the necessary departments but know what is required from each department. This process is based on the idea of *one-stop shopping*.

Stage 6: Full Integration and Enterprise Transformation: At this stage "old walls," as Silcock (2001, p. 90) calls them, would be broken down, and bridges constructed among departments ensuring smooth navigation throughout the municipality's website, much like Stage 5. In addition, there is the issue of customer service and feedback, which is best exemplified by some avenue for feedback. For the purposes of this research, the opportunity for the user to submit some form of electronic commentary about the site was the criterion for the survey.

Methodology

The methodology used in this study is content analysis. As Remler and VanRyzin (2011, p. 76) explain, content analysis is the "process of coding and analyzing qualitative data." As such, we analyzed the website of each U.S. or Taiwanese fire department included in the study. For each fire department, the coders (the authors) said "yes" the fire-department website included the features outlined in each of Silcock's e-government stages or "no" the website did not include the features describing the stage. More specifically, for each of Silcock's Stages 1–6, the following questions were answered based on a thorough analysis of the website.

- **Stage 1, Question 1:** Does the fire-department website provide for *one-way* communication only? YES — Aside from the ability to download something (forms, laws, etc.), there is **no two-way** communication offered on the website. For example, the user cannot submit a question. NO — The site allows the user to download material or pose a question. There is interaction between the user and the fire-department website.
- **Stage 2, Question 2:** Can the *user engage in transactions* such as paying bills or securing permits from the fire department? YES — The user can book an appointment, pay a fee, etc. NO — The user cannot conduct any transactional business.
- **Stage 3, Question 3:** Can the user, through a single point of entry (i.e., the fire-department website), *access other municipal departments?* YES — In this instance, for example, is there a drop-down menu to access other municipal departments like water, building, or electrical). NO — The user cannot access any other city department. Note: The presence of fire-related websites such as the National Fire Protection Association® (NFPA®) does not qualify the fire department for a *YES* code.
- **Stage 4, Question 4:** Can users employ *portal personalization?* YES — The user can use a screen name and password to gain access to the site, for example, logging into an email account. NO — There is no personal access to the site.
- **Stage 5, Question 5:** Does the website have a *clustering of common services?* YES — The fire-department website has a way to pose a question regarding *how to do* something, which might involve several municipal departments. NO — There is no such clustering.
- **Stage 6, Question 6:** Does the site offer user **feedback?** YES — The user can submit comments, suggestions, or feedback to the site. NO — There is no avenue for the user to submit comments, suggestions, or feedback to the fire department.

Universality and replication are ensured since all of the data used in this research are readily available over the Internet. Fire-department information was obtained through the United States Fire Administration (USFA), the Taiwanese Government, and the National Fire Department Census Database. Population statistics came from the U.S. Department of Commerce, U.S. Census Bureau, and Taiwan's Ministry of the Interior (2012). All data are free to the public.

Fire-department websites analyzed came from metro-sized fire departments located in the U.S. and Taiwan. A metro-sized fire department is a department that staffs over 400 personnel. Of the 97 American departments that meet this criterion, 50 were matched to ensure conformity with the fire departments in Taiwan. The breakdown is as follows:

- Seven cities serving a population over one million,
- Twenty cities serving populations between 500,000 and one million,
- Eleven county fire departments serving greater than one million,
- Eight county fire departments serving a population between 500,000 and one million, and
- Four county departments serving a population less than 500,000.

Taiwan is an island republic approximately 14,000 square miles (36,193 km^2), roughly the size of the Commonwealth of Massachusetts. Unlike Massachusetts, whose population claims about 6 million people, Taiwan's population is just over 23 million. Its population density is 1,664 people per square mile (Ministry of Interior, Taiwan, 2012). There are a total of 22 fire departments in the country of Taiwan. Three departments were omitted from the study because of their small size and location; they were not located on the main island. The other departments in the study included the following:

- Five city departments serving a population over one million
- Three departments serving a population between 500,000 and a million
- Two county fire departments serving a population greater than one million
- Six county departments serving a population between 500,000 and one million
- Three county fire departments serving a population less than 500,000

Considering the vast literature on e-government and the availability of the fire-department websites, there were no specific limitations to this research. Delimitations were the choice to survey only 50 of the 97 metro-sized fire departments in the U.S. to better correlate with the demographics of fire departments in Taiwan. As for the Taiwanese fire departments, as stated earlier, three small-island departments were excluded from the survey because of their size. The numbers of firefighters for these three departments are 31, 69, and 158. Of note, the population served on these islands ranges between 11,000 to 100,000 people.

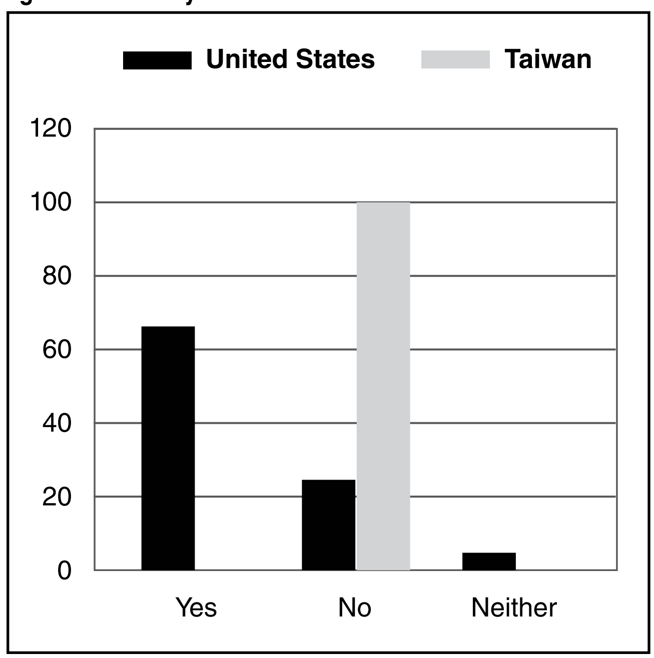
Results

Findings presented next are summarized according to each e-government stage.

Stage 1, Question 1: One-Way Communication

The first question assessed whether or not the fire-department's website allowed for more than one-way communication; can the user contact the department or is she or he restricted to just downloading material from the site. Analysis of the websites showed that 68% of the U.S. fire departments allow for only one-way communication (see **Figure 1**). Twenty-six percent of the departments provided for some aspect of two-way communication such as allowing the user to pose a question. Six percent of the agencies allowed for neither obtaining information nor contacting the fire department. None of the Taiwanese fire departments are restricted to one-way communication; a user can communicate with the department (e.g., by posing a question, downloading statistics, and reporting violations to the department).

Figure 1: One-Way Communication.



Stage 2, Question 2: Transactions

The second question addressed the ability of the user to engage in a transaction (as opposed to just downloading information) with a fire department. The results show that just over a quarter of the American fire departments surveyed (28%) provided a means for conducting two-way business with a customer, while 72% did not allow customers to conduct business with the department (see **Figure 2**).

All of the fire departments in Taiwan allowed for a form of transaction. This transaction came in the way

Figure 2: Transactions.

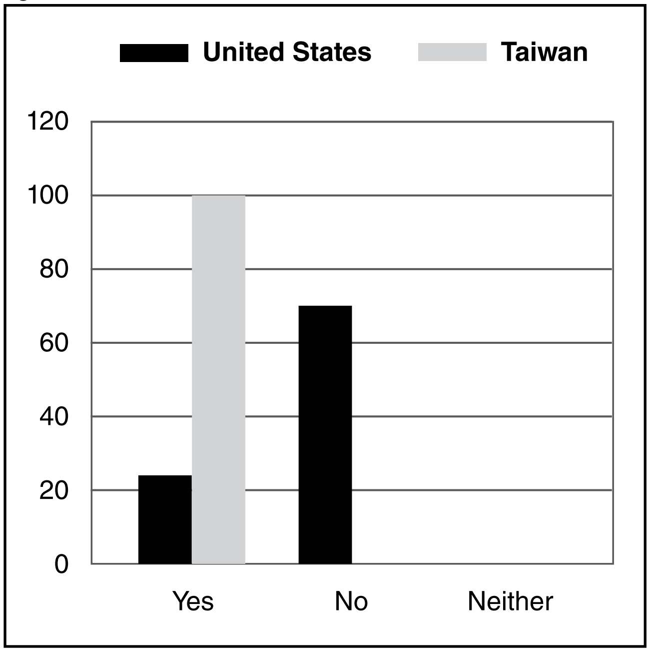
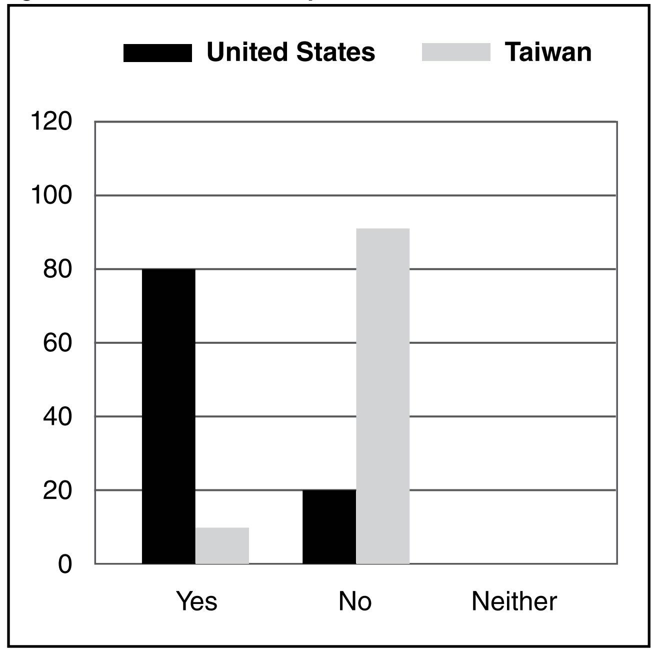


Figure 3: Access to Other Departments.



of a fire-inspection online application system that was created by the Taiwanese National Fire Agency, Ministry of Interior. The system allows the following applications: fire safety equipment drawings review, building completion inspection, inspection and reporting, company fire management plan, and drill documentations. The system is restricted, however, for professional fire inspectors to use, rather than regular civilians.

Stage 3, Question 3: Access to Other Departments

The third question assessed whether other municipal departments could be accessed from the fire-department website as opposed to having to navigate outside of the department site to enter another municipal agency's (e.g., public works) portal. Eighty percent (80%) of the U.S. fire-department websites allowed the user to connect to another municipal department without exiting the fire-department website, usually in the form of a drop-down menu (see **Figure 3**). As for Taiwan, only 2 out of 19 fire-department websites provided access in their sites to another municipal website. The two departments were located in Taipei City (population: 2,650,968) and New Taipei City (population: 3,916,451). These two fire departments are in the largest and most metropolitan cities in Taiwan. As a result of the size of these two departments, civilians have the most access to websites; and, therefore, these two departments' websites provide more functions.

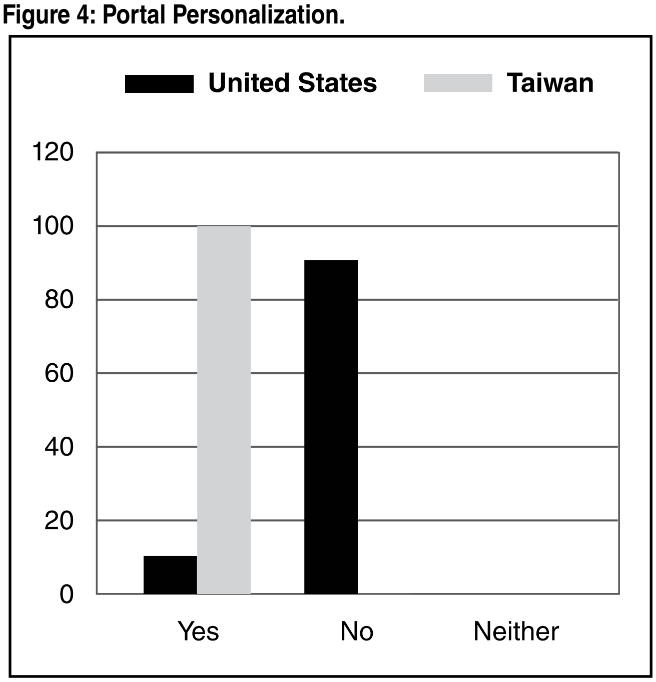
Stage 4, Question 4: Portal Personalization

Much like commercial websites, the ability of frequent users to sign in to a personal portal allows them, for example, to view previous transactions or store useful information for future reference. Because of the ability to purchase items or book a flight reservation (from Amazon to Expedia websites for example), portal personalization has become a necessary element to those who visit and use a website on a regular basis. Results show that only 10% of the American fire-department websites have incorporated some form of portal personalization into their websites (see **Figure 4**).

As noted earlier, all of the fire departments in Taiwan provide a fire inspection online application system. This system allows particular professional users, like fire inspectors, to have their own portal personalization. However, the regular population has no access to personalization.

It is important to note that fire inspectors in Taiwan are civilians who acquire a certificate in fire inspection and work closely with the department. For example, when a construction company builds a house, it needs to hire a professional fire inspector to check for code

Figure 4: Portal Personalization.



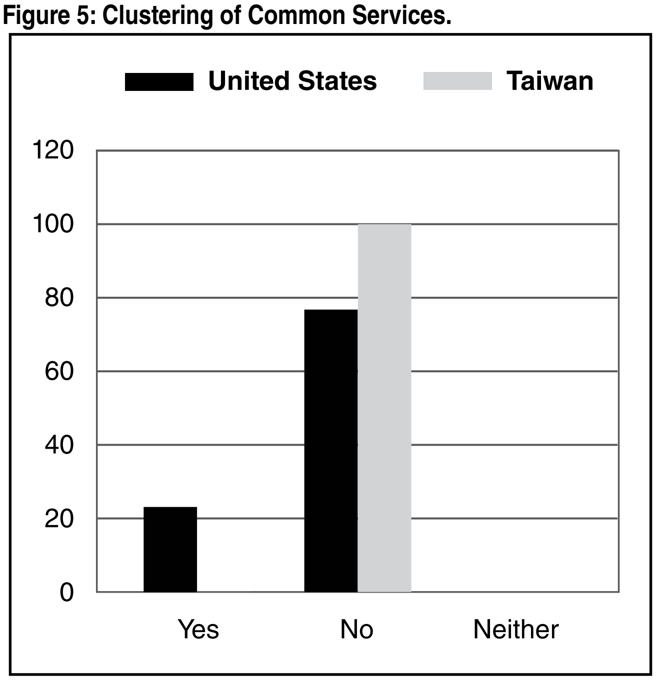
compliance; unlike in the U.S. where such inspections are carried out by city/town officials, including the fire department. In Taiwan, once the building passes inspection, the inspector then sends the application to the fire department. Staff at the fire-prevention division will then check the paperwork and confirm all regulations are met. After this stage, the construction company receives permission from a fire department to sell or begin using the building.

Stage 5, Question 5: Clustering of Common Services

Clustering of common services (especially within the fire service) is a practice that is more complex and involved for several reasons. First, there is the subject selection of what service to include. In the case of fire departments, for instance, constructing a building would involve several city or town departments such as building, electrical, public works, and others. The construction of such a website service would first be based on identifying the particular activity and second gaining the permission of other municipal departments for inclusion. As would be expected, a small minority of the U.S. fire departments' websites analyzed provided this opportunity to its customers. Only 22% had at least one common service cluster on its site, while 78% provided no access to other cognate departments (see **Figure 5**).

No fire department in Taiwan provided for the clustering of common services. This stage is not to be confused with the previous survey question where civilian fire inspectors perform a variety of inspections for the fire department. There are no means by which a user can search out specific multidepartment requirements for a particular need or task.

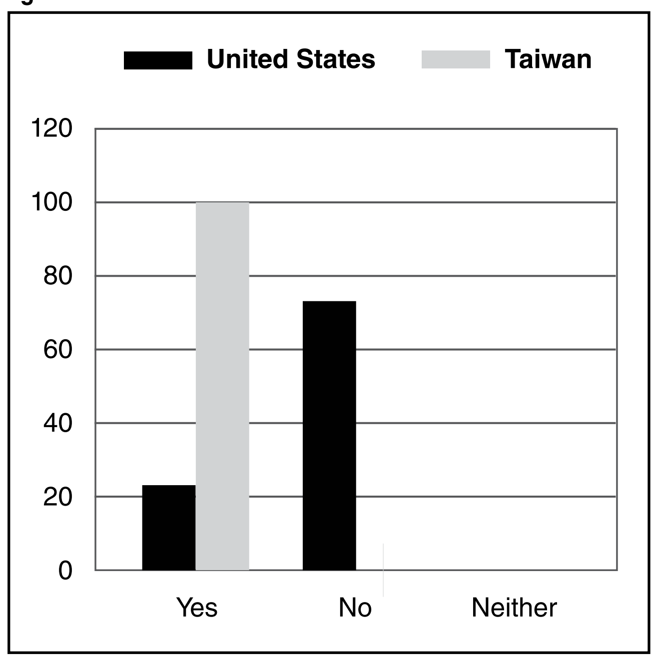
Figure 5: Clustering of Common Services.



Stage 6, Question 6: Feedback

The last feature of the analysis of the fire-department websites in the U.S. and Taiwan assessed the extent to which users could offer feedback to the agencies. Such a feature is a relatively common practice among commercial websites, offering patrons the opportunity to rate the site and/or offer a critique. Only 26% of the U.S. fire departments in the survey offered some mechanism for feedback (see **Figure 6**). Recall that simply providing a user the opportunity to provide their email address did not qualify for a yes (the site offers feedback) code. To receive credit for offering feedback, the citizen had to have the ability to electronically submit questions to a fire department. Every fire department in Taiwan provided some means for direct feedback and two departments, ChangHua County and Hualien County, provided a survey users could complete if they so desired to do so.

Figure 6: Feedback.



Discussion

A large literature has developed dedicated to an understanding of the stage development of e-government. Several authors contend that there is no particular sequence of progress; stages can appear in any order. West (2004) writes that, "categorization does not mean that all government Web sites go through these steps or that they undertake them in this particular order" (p. 17). Determining whether fire departments followed a specific sequential order of development is not the intention of this research; rather, the purpose was to account for the presence of each stage.

Overall, it appears that Taiwanese fire departments are more customer-oriented as exemplified by data shown in Figures 2 and 6. For example, in contrast to

U.S. fire departments, *every* Taiwanese fire-department website provided some way for citizens to send feedback to the agencies.

Data shown in Figure 1 showed that three-quarters of the American fire departments do not provide the opportunity for users to pose questions or communicate with the department; the communication is one-way only. In contrast, every fire department in Taiwan provides a means for customers to contact the particular department and obtain information from it.

Lee (2010) notes that 9 of the 12-stage development models in his meta-analysis incorporate *interaction* or two-way communication as a stage in e-government evolution. A two-way transaction stage allows the user (citizen) to conduct business with the fire department. Twenty-eight percent of the U.S. fire departments provide for transactional business, while 26% of the departments allowed for interaction. All of the Taiwanese fire departments provided for both interaction and transaction, but this finding is a bit misleading. A customer transaction is limited to civilian fire inspectors. Licensed inspectors are allowed to submit their final inspection reports for review to the fire department through the department website. These are the only constituents who engage in the two-way transaction feature on the Taiwanese websites.

Today's fire service is not just about emergency services. It plays a major role in nonemergency customer service. Fire departments are part of the municipal government structure; hence, they must provide customer service. Considering the technical advances in other municipal services such as the police where, for instance, violators can pay tickets online. Fire departments must provide better customer service for their citizens. Similar to attaching a document to an email, fire-department websites have to be able to make information available to those who must transact with the department. Likewise, following the lead of other municipal agencies, there must be means available for customers to conduct business with the fire department.

To what extent do fire-department websites allow a customer to directly navigate to another municipal government agency? Figure 3 showed that 80% of the U.S. departments built this feature into their web designs. Including links in a website is not a novel idea. Examining the numerous fire websites revealed two types of links: The first was dedicated to other government departments, which was the subject of the website analysis. The other link, common to many fire departments, was dedicated to other fire-related sites such as the National Fire Protection Association® (NFPA®) or Federal Emergency Management Agency (FEMA). Only two of the Taiwanese fire departments (Taipei City [population: 2,650,968] and New Taipei City [population: 3,916,451]) provided its users the ability to contact with other municipal departments by way of the fire-department website.

The analysis presented here (see Figure 5) found that portal personalization, which offers customers the opportunity to sign in using a screen name and password, is very common to most commercial websites, but it is in its infancy with respect to fire-department websites. Only 10% of the U.S. fire departments analyzed offered this feature to their customers. The same percentage held true for Taiwan where only certified fire inspectors can employ portal personalization.

The concept of clustering common services is certainly more detailed and involves the participation of several municipal departments and requires interagency cooperation. Clustering services is not as much of an information-technology issue as it is a service-delivery issue, where service-related department heads must collectively identify the needs of their citizens and assemble the necessary information to address a particular need of the consumer such as building a house. Data in Figure 5 showed that this stage in e-government is not found frequently in the U.S. and not at all in Taiwan fire departments.

A prominent feature of a democracy is the ability of government institutions to seek and respond to citizen input. In the case of U.S. fire departments, efforts in this area are lacking. Roughly one quarter of the American fire departments offered a place in its website for a customer to make suggestions and/or rate the site (i.e., provide feedback; see Figure 6). All of the fire departments in Taiwan provided a means for its users to submit feedback; although of note, only two departments provided an actual survey.

Recommendations

The value of this research was not exclusively due to its uniqueness rather that it revealed both the strengths and the limitations of the selected fire departments in Taiwan and the U.S. with respect to e-government stage development. None of the websites analyzed satisfied fully or completely all six stages of e-government identified in the literature. One may conclude, however, that fire departments serving larger populations offered more stages and features.

In general, websites both in the U.S. and Taiwan should provide more information for their users. The simple addition of one-way information (i.e., the fire department as a billboard) such as statistics and reports would provide citizens with useful, even essential, information. For example, one area where the Taiwanese websites can offer a greater service for its citizens is in education and fire prevention. With the greater frequency of earthquakes and typhoons on the island, the ability to download related information is critical to the safety of the Taiwanese population. Fire records show that carbon-monoxide-related problems associated with the use of indoor hot-water heaters has become a critical, large issue in Taiwan. Being able to secure information about fire prevention would provide a priceless tool in educating the population as to its dangers.

Next, simple transactions could be built into the site such as the opportunity to pay for permits or book inspections online. For example, a quick visit to other municipal websites will reveal the opportunity for customers to pay traffic violation fines or pay city taxes. American fire departments should include these features now in use in other municipal departments in their websites; they should provide for two-way communication and transactional business. For example, having the opportunity to electronically submit ambulance reports, necessary for private life insurance, would offer a more efficient and streamlined way to conduct business in Tiawan. At present, civilians can only download the application form from a website, after which they have to personally present it to the fire department. Having the ability to electronically submit such a report would, like here in the U.S., free personnel from clerical duties. The same can be said for the ability to download reports and statistics. Both countries must allow their users to obtain such information via their websites.

While e-government stages are not sequential, Stages 1 and 2 generally occur first and second in the sequence. Of equal, or maybe greater, importance is customer feedback. Democracy requires open-government institutions. Citizens should be able to contact fire-department officials, offer suggestions for improvement, or simply rate the department's website in terms of adequacy. While portal personalization and clustering of common services are important, both are essential to fewer **but** more-frequent users. Nevertheless, it is recommended that both features be included in website design and be part of future improvements.

Fire-department websites in both countries can learn much from each other. Moreover, they can learn even more from the vast literature available. An understanding of the six stages of e-government discussed prominently in the literature provides a solid model upon which to build their respective sites. The hard part is completed. All that is required is the application of the stages. As Osborne and Gaebler wrote in 1992, today's government service must be customer-based. It is up to fire departments in Taiwan and the U.S. to ensure that this feature is a fact and not an exception. Fire departments, regardless of size or structure, should communicate with the citizens they serve, in part, through excellent websites. These websites are mandatory for good government and should be required for every fire department to benefit the citizenry.

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