Organizational Learning from Post-Incident Analyses

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Certification Statement

I hereby certify that this paper constitutes my own product, that where language of others is set forth, quotation marks so indicate, and that appropriate credit is given where I have used the language, ideas, expressions, or writings of another.

Signed: _____

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Abstract

The problem studied for this applied research project was that the Montgomery County Fire and Rescue Service (MCFRS) had endured seven fireground Mayday incidents, resulting in ten significant firefighter injuries since the implementation of the *Standard Operating Procedures for Safe Structural Firefighting Operations* in 2005. The purpose of this applied research project was to determine if MCFRS is learning the lessons needed to prevent critical fireground injuries and death. The descriptive research method was used, which included a literature review and a meta-analysis of MCFRS post-incident analyses published over the past six years. The research questions were: how did MCFRS's post-incident analysis process compare to national standards and best practices, what were the causes of the Maydays and resulting firefighter injuries, what warnings were indicated in previous post-incident analyses, and what recommendations were made in the previous post-incident analyses that may have averted the Mayday incidents and resulting firefighter injuries? The literature review developed into a comparison matrix to compare the MCFRS process with other processes. The meta-analysis produced quantifiable data for analysis on the causes of Maydays and fireground injuries, and the warning signs and recommendations from previous post-incident analyses. The results showed that MCFRS meets NFPA standards for post-incident analysis and is comparable to FEMA guidelines, but needs to integrate other best practices. Failure to maintain crew integrity and failure to recognize the fire conditions and effects on structural components are the causes of the Maydays and resulting injuries. There were adequate warning signs and recommendations in previous post-incident analyses that could have averted the aforementioned Maydays. It is recommended that MCFRS update its post-incident analysis process based on best practices. Additionally, MCFRS needs to integrate a culture of risk assessment into its initial fireground operations.

Table of Contents

List of Figures

List of Tables

Organizational Learning from Post-Incident Analyses

Peter Senge asserts “at the heart of a learning organization is a shift of mind… from seeing problems as caused by someone or something out there to seeing how our own actions create the problems we experience” (1990, pp. 12-13). The Montgomery County Fire and Rescue Service (MCFRS) has endeavored to embrace Senge’s work on *organizational learning* by analyzing critical fireground incidents, in attempts to improve incident command and fireground operations. The 2002 revision of the MCFRS *Incident Command System* includes the requirement for the incident commander to conduct and publish a *Post-Incident Analysis* after major incidents. This approach is what Gist describes as “aggregating, validating and disseminating” (2010a, ¶ 12) lessons learned from emergency incidents to all levels of the organization.

The problem is that the MCFRS has endured seven fireground Mayday incidents which have resulted in ten significant firefighter injuries since the implementation of the *Standard Operating Procedures for Safe Structural Firefighting Operations* in 2005. These firefighter injuries led to hospitalizations, disability retirements, and monetary losses. Even though MCFRS has made progress in the area of organizational learning, significant fireground injuries still occur in what can only be called close-call, near-fatal incidents. Left unchecked, the pervasiveness of the underlying causes of these Maydays and injuries may lead to firefighter fatalities. With 42 firefighter fatalities in the United States this year (United States Fire Administration [USFA], 2010b), MCFRS and its individual members must successfully learn from previous mistakes and implement steps to prevent needlessly adding to the death toll.

Therefore, the purpose of this applied research project is to determine if MCFRS is learning the lessons needed to prevent critical fireground injuries and death from occurring. The research not only examines the root causes of recent fireground Mayday incidents that resulted in critical firefighter injuries, but also more importantly examines the problem areas and recommendations for improvement from previous MCFRS post-incident analyses. Armed with this knowledge, the researcher as an Executive Fire Officer will have the ability and opportunity to improve upon the post-incident analysis process, and improve fireground operations and incident command competencies, with the ultimate goal of preventing future firefighter injuries and death.

For this applied research project, the descriptive research method will be used, including a literature review and a meta-analysis of MCFRS post-incident analyses published over the past six years. The research questions are: how does the Montgomery County Fire and Rescue Service's post-incident analysis process compare to national standards and best practices, what did the post-incident analyses determine to be the causes of the Maydays and resulting firefighter injuries, what significant warnings were indicated in previous post-incident analyses, and what recommendations were made in the previous post-incident analyses that may have averted the subsequent Mayday incidents and resulting firefighter injuries?

Background and Significance

Throughout its history, the MCFRS has not suffered a line of duty death on the fireground. This distinction is due to the existence of institutionalized safety practices, exceptional training programs, and effective incident command. Yet since the implementation of the *Standard Operating Procedures for Safe Structural Firefighting Operations,* MCFRS has incurred seven fireground Mayday incidents resulting in ten significant firefighter injuries.

MCFRS could be considered overdue for a firefighter fireground fatality, because statistically there are between 2.8 and 4.5 firefighter fatalities per 100,000 incidents nationwide over the last decade (USFA, 2010a).

As background to the analysis of this problem, MCFRS has several policies and procedures applicable to its combined career and volunteer fire service that are considered the cornerstones of firefighter injury and mortality prevention. The first of these, the *Incident Command System* was implemented with the stated purpose to "assure safe and effective emergency incident control efforts" (Montgomery County Fire and Rescue Service [MCFRS], 2002, p. 2) and to "promote maximum safety of fire and rescue personnel...during emergency incidents" (p. 1). The *Incident Command System* reflects the mandates of the *National Incident Management System* (NIMS) published by the United States Department of Homeland Security. But it does need to be updated to the 2008 NIMS revision in order for MCFRS to be interoperable with other fire service agencies within the Metropolitan Washington Council of Governments (COG) and the COG's Fire *and Rescue Services Mutual Aid Operational Plan*.

As though it was an afterthought, a *Post-Incident Analysis Package* is included as an attachment to the *Incident Command System,* with no further reference in the body of the policy. This attachment requires that after every major incident the incident commander "develop a post-incident analysis to determine strengths, weaknesses, and lessons learned about the incident operations" (MCFRS, 2002, p. Attachment 1). *Major incidents* are defined as a building fire with three or more rooms damaged by fire, a civilian or firefighter fatality, or a fire with a firefighter injury requiring hospitalization (MCFRS, 2002). From an organizational learning perspective, this process becomes a critical tool in passing on lessons on strategic decision-making and operational effectiveness. The MCFRS Operations Division Executive Officer is responsible for

collation and distribution of these post-incident analyses through an online Lessons Learned Center. Since the *Post-Incident Analysis Package* is not mentioned in the body of the policy, there is debate amongst the career and volunteer command officers as to whether or not the *Incident Command System* mandates that they complete a post-incident analysis after every major incident as a matter of policy. Thus, organization learning is diminished when post-incident analyses are not conducted or published. The impact of this on the organization is clear; if these analyses are not timely and effectively distributed, then the current lessons will be lost and mistakes are sure to be made again in the future, and ultimately the service will suffer a firefighter fatality.

The *Injury Investigation Team Procedures* (MCFRS, 1991) establishes the procedures used by an Injury Investigation Team to investigate incidents where a critical firefighter injury or fatality occurred. The end-product of this investigation is an Injury Investigation Report that includes the unsafe acts, hazardous conditions and management failures that led to the injury, and recommendations to prevent recurrence of the conditions that led to the injury. The Injury Investigation Report is meant, in part, to supplement the Incident Commander's post-incident analysis.

Another cornerstone document, the *Standard Operating Procedures for Safe Structural Firefighting Operations,* provides for standard response assignments for structure fires to ensure "operational safety, effectiveness and efficiency" (MCFRS, 2005, p. 1). This document outlines the standard operating procedures (SOPs) for initial fireground operations at structure fires, as well as procedures for structure fires in areas without municipal water supply, for high-rise building fires, and for residential basement fires. This SOP includes detailed procedures for initial fireground operations for the entire first alarm assignment including size-up; initial

communications; initial command; transfer of command; initial entry and stand-by team functions (29 CFR 1910.134 *Respiratory Protection Standard*); rapid intervention team functions; and detailed fireground assignments for units, unit officers, and crews.

An additional section on firefighter Mayday procedures is included in this SOP, with a *Mayday* defined as "an emergency distress signal indicating that one or more fire/rescue personnel need emergency assistance to escape an immediately dangerous to life and health (IDLH) atmosphere, or other life threatening situation" (MCFRS, 2005, p. 3). This section describes conditions that necessitate a firefighter Mayday, procedures on how to declare a Mayday, and incident commander actions during the Mayday. The procedures require firefighters to declare a Mayday when:

1. "A firefighter has become entangle, trapped or pinned;
2. Personnel have fallen through a roof or floor and cannot be accounted for or have become injured;
3. Personnel are caught in a flashover;
4. Personnel are off a hose line or tag line in a large/open area with zero visibility;
5. A low air alert activates, and personnel cannot immediately find an exit; or
6. A firefighter believes the safety of a crew or a crew member may be at risk" (p. 9).

This SOP became effective for the MCFRS on December 1, 2005. Since that time, there have been seven separate fireground Mayday incidents (see listing in Appendix A), which resulted in ten significant firefighter injuries. The following represents a brief synopsis of each Mayday event:

South Leisure World Boulevard Apartment Fire

On December 3, 2005, at 1900 hours, Battalion 4 units were dispatched for an apartment fire in a high-risk senior citizen community (Gallo, 2005). The first engine, truck, ambulance and battalion chief arrived to find heavy smoke from the open corridor of a two-story, garden-style apartment building. The truck officer advised that an occupant was re-entering the apartment of origin, and that his crew would attempt a rescue. The engine crew followed with a hose line. Five minutes after arrival on the scene, a flashover occurred in the apartment and the truck officer declared a Mayday (Carr, 2005), indicating only that a firefighter was trapped in the apartment. During attempts by the incident commander to control fireground communications and manage the Mayday, the trapped firefighter self-rescued (Carr). The firefighter received medical attention for burns caused by the flashover. The time during and immediately following the Mayday were consumed with the medical care of the injured firefighter and rescue of victims from the front of the apartment building.

Due to high winds, a rapidly spreading fire, and delays in fire suppression from the Mayday and rescues, this fire grew to all exposures and was eventually brought under control after four alarms. The occupant who had re-entered the apartment building had walked through the apartment and exited through the rear patio doors, and was uninjured. The civilian fatality was the occupant of a second floor exposure apartment. Neither the post-incident analysis nor the review panel report listed the extent of the firefighter injuries; although a press release indicates that the firefighter was treated and released from a burn center (Montgomery County, 2005). The cause of the fire was listed as accidental; as the occupant of the fire apartment left food cooking the kitchen stove

unattended, igniting combustible materials near the stove (Gallo. 2005). The fire caused $1.6 million dollars in property damage (Gallo. 2005).

Goshen Road House Fire

On November 12, 2006, at 1946 hours, Battalion 5 units were dispatched for a fire in a greenhouse which was attached to a single-family house (Korenblatt, 2006). The first arriving engine found a large greenhouse fully involved in fire, and began a defensive, exterior attack. During the initial fire attack, a crew member from the first engine entered a garage attached to the greenhouse, without notifying his officer or the incident commander. The firefighter became disoriented in the heavy smoke. While trying to crawl to an exit, a large file cabinet fell over on top of him. Now trapped, the firefighter was unable to reach his portable radio to signal a Mayday, so he remained still until his integrated Personal Alert Safety System (PASS) device activated. About twenty minutes into the incident crews entering the garage from the opposite direction heard the PASS and called a Mayday (Reid, 2006). Nearby crews quickly rescued the trapped firefighter, and he was transported him to the closest trauma center. This firefighter has lost extended time at work due to his injuries.

Claridge Road Duplex Fire

On July 19, 2007, at 0433 hours, Battalion 4 units were dispatched for a fire in a residential community of duplex homes (Kinsley, 2007). The first arriving engine company officer reported that there was smoke showing from a two-story house and established command in the attack mode. A secondary report indicated that there was a baby trapped upstairs. The first due engine and aerial tower crews entered the building with a hose line to conduct rescue operations on the second floor. As the officer of the

aerial tower ran up the interior stairs, the stairs collapsed, dropping him and his partner into the basement below. The aerial tower crew landed amongst the charred stairway components, now exposed again to oxygen and free-burning. The nozzleman also fell through the hole on the stairs, but was able to pull himself back up the hose line.

The aerial tower officer, struggling in pain, attempted to call for help on the wrong radio talk-group (Kinsley, 2007). The Emergency Communications Center (ECC) heard the call for help, but did not respond or advise command. Fortunately, the engine company officer was able to call for a Mayday. The incident commander properly instituted the SOP for Maydays and sent the arriving Rapid Intervention Company to the basement to rescue the downed firefighters. All three firefighters were rescued and received medical care within six minutes of the Mayday (Tippett, 2007). Injuries to the firefighters included third degree burns and musculoskeletal trauma. All three were transported to the regional burn center. Significant time was lost from work, as one firefighter had orthopedic surgery and another had multiple skin grafts. The most seriously burned firefighter has been off work for over three years and recently retired on disability.

The cause of the fire is officially listed as undetermined. The location of the fire was on top of and underneath the interior stairs, with a secondary fire on a mattress in bedroom on the second floor. The baby, it turns out, was an adult daughter of the home owner, and was not at home during the time of the fire.

Twinbrook Parkway Apartment Fire

On May 3, 2008, Battalion 3 units were dispatched for an apartment fire at 0046 hours (MCFRS, 2010). The first arriving aerial tower company positioned to the rear of

the building and reported fire from the second floor and extending to the third floor of a three-story garden apartment. What that officer described as a three-story apartment from the rear was actually a two-story apartment building with walk-out basement apartments. A command officer arrived just behind the tower and established command, requesting a second alarm.

The first arriving engine company positioned at the front of the apartment building and reported multiple victims in need of rescue on second floor balconies (MCFRS, 2010). The officer ordered a leader line deployed to what he believed to be the fire apartment. His objective was to place a hose line between the fire and the trapped occupants. As the crew entered the apartment, they encountered high heat and heavy smoke. The crew flowed water as they continued to the back bedroom of the apartment, but the heat continued to intensify. As the crew began to exit the apartment due to the high heat, the floor beneath them suddenly collapsed, dropping all three firefighters into the free-burning fire in the apartment below.

The engine company officer immediately radioed a Mayday, which was acknowledged by the incident commander (MCFRS, 2010). The incident commander partially followed the SOP for Maydays, but failed to conduct an accountability check, which led to some confusion during rescue efforts. The engine company officer found a window and jumped out of the apartment. The second firefighter jumped headfirst out of a window at the rear of the apartment. The third firefighter was trapped in debris, but still had hold of the nozzle and flowed water on the fire. When his low-air alarm activated, he disentangled himself and quickly found the exit. He walked out of the first floor apartment as other firefighters where pushing in to search for him.

All three injured firefighters were treated on the scene by paramedics and transported to the regional burn center (MCFRS, 2010). The engine company officer received orthopedic injuries, internal trauma and burns. The other two firefighters had various burn injuries. All three lost time, but are currently back to work. The cause of the fire is listed as undetermined.

Frederick Avenue House Fire

On October 2, 2008, at 0127 hours, a single engine company from Battalion 3 was dispatched for a transformer fire at the 200 block of Frederick Avenue (Goldstein, 2009). Upon arrival, the engine crew found a fire in the basement of a single family house and called for the full house fire assignment. Prior to interior firefighting operations, it was reported to the incident commander that this was a vacant house. The first due engine company crew positioned a hose line at the top of the interior stairs to the basement, per the SOP. The second due engine company crew found an exterior entrance to the basement, and positioned for a fire attack through that entrance while the first engine company protected the first floor from fire extension.

Twenty-five minutes into operations, a weak Mayday transmission was made that was not acknowledged by the incident commander (Goldstein, 2009). The officer of the first due truck company heard what he thought was the dining room floor cracking, and then a voice saying that someone was “burning up” (p. 47). He then called a Mayday because he believed that a firefighter had fallen thought the dining room floor into the fire below, and had several firefighters unaccounted for. The firefighter who fell was the driver of the rescue squad, who had entered the structure without a partner to perform a search. He saw flames blowing up from the basement on the exterior of the structure, and

ordered other nearby firefighters to exit the structure. While walking out across the dining room, he fell feet first into a hole in the floor. He eventually sank down into the basement, into the fire that had just been suppressed by an engine crew. After struggling to self rescue through a basement window, he managed to get his upper body out of the window, where he was discovered and pulled out of the basement by a firefighter on the exterior of the structure.

The injured firefighter was treated on the scene for burns by paramedics and transported to the regional burn center for second degree burns on 35% of his body. The burn injury was listed as "caused by compression of the air space in the PPE after it had been exposed to excessive heat" (Goldstein, 2009, p. 162). The cause of the fire was documented as still under investigation.

Castle Boulevard Apartment Fire

On May 9, 2009, Battalion 1 units arrived on the scene to find fire on the top floor and burning through the roof of this four story garden apartment building (Jones, 2009a). This two-alarm fire would consume seven apartments on three floors of this building. While conducting operations in the fire apartment on the forth floor, the ceiling collapsed onto a firefighter. A Mayday was called for the injured firefighter, but on the wrong radio talk-group. The ECC heard the Mayday, but did not pass this on to the incident commander. Eventually, the Mayday was called on the proper radio talkgroup, as the firefighter was being assisted out of the building. The firefighter was treated on the scene for burns and musculoskeletal injuries, and then transported to the regional burn center. The firefighter lost significant time off work. There were two other firefighter injuries, unrelated to the Mayday.

The cause of this fire was determined to be electrical, with the kitchen as the area of origin. Damage to the building and contents was estimated to be 1.6 million dollars.

Piney Branch Road High Rise Fire

On July 11, 2009, this high rise building fire was dispatched at 1933 hours. First arriving units provided an initial on-scene report of heavy fire showing from the top floor of this twelve-floor building (Jones, 2009b). Twenty-three minutes into the incident, an engine company crew was low on breathing air and decided to exit the fire floor and relocate to a stairwell outside of the IDLH atmosphere (Jones, 2009b). The firefighter and officer became separated and took different egress routes. Realizing that he was lost in the fire apartment and low on air, the firefighter called a Mayday. After three and one-half minutes, both crew members found exits from the building and were accounted for. The report states that two firefighters were injured on this fire, but it is unclear if the Mayday firefighters were the ones injured.

This two-alarm fire was caused by an overloaded or faulty power cord, from un-permitted construction within the apartment in an attempt to subdivide. Thirty-six apartments were affected, causing over six hundred thousand dollars damage to the structure.

An applied research project examining this problem is past due. Based on the synopses from the Mayday incidents, sufficient evidence exists from past experiences to justify this research from an organizational perspective. Since there have been ten firefighters injured in the past where firefighters have found themselves in life-threatening situations on the fireground, a meta-analysis is needed to understand the underlying organization deficiencies that continue to plaque MCFRS fireground operations. Firefighters on several of these Mayday incidents came

close to losing their lives in the line of duty. The organization must take steps to ensure that these events do not reoccur.

Currently there is an effort under way by MCFRS to revise the *Standard Operating Procedures for Safe Structural Firefighting Operations*, based on the common problems and recommendations from three of the Mayday incidents: South Leisure World Boulevard, Claridge Road and Frederick Avenue. The stated intent was to extract the Mayday and Rapid Intervention Team sections into separate policies and then update the SOP. However, that process has floundered over the past eighteen months, and meanwhile two more Mayday incidents have occurred (Castle Boulevard and Piney Branch Road). Should the Mayday incidents persist, MCFRS will certainly continue to see significantly injure firefighters on the fireground, and ultimately suffer the tragedy of a fireground fatality. It is irresponsible for any organization to have information from post-incident analysis but not rapidly and appropriately to act on that information when it could save lives. Results and recommendations from this applied research project could be used as a basis for developing a revision to the SOP.

This applied research project is consistent with the United States Fire Administration's (USFA) new operational objectives, most significantly to "improve the fire and emergency services' capability for response to and recovery from all hazards" (USFA, 2009, p. II-2). The USFA's *Strategic Plan* (n. d.) further details this goal to suggest a "well-trained, prepared, and coordinated local response to an all-hazards incident" (p. 14) and promote "a culture of health, fitness, and behavior that enhances emergency responder safety and survival" (p. 20). The results and recommendations of this applied research paper could be used to improve the response capability of the MCFRS and improve firefighter safety and survival on the fireground. With

publication of this applied research project, other fire service organizations will have the opportunity to share in this knowledge.

This applied research project is also consistent with the Executive Fire Officer course *Executive Leadership*. The goal of *Executive Leadership* is to "develop the ability to conceptualize and employ the key processes used by executive-level managers" (Federal Emergency Management Agency [FEMA], 2005, p. v). This applied research project represents the Executive Fire Officer's application of learned leadership abilities to "describe the current situation [and] gather data to facilitate the decision making process" (p. 1-4) in order to solve critical, department-wide problems and manage the change required to implement those solutions. Examples of practical skills application from *Executive Leadership* lessons include the ability to perform analysis and exercise judgment; to make decisions; to manage the decision-making process, and to promote and manage change (FEMA, 2005).

Literature Review

During the literature review it was noted that there are multiple terms used in the fire service, the United States Armed Services, and the business world to describe a *post-incident analysis*. *Incident critique, after action report, after action review, lessons learned report,* and *critical incident analysis,* or variations of these terms, are all similar forms of formal or informal review of operational actions. It was also noted that a *significant injury incident report,* or variations of this term, also produces some of the same information. For this applied research paper, the term *post-incident analysis* will be the standard term used to describe the process of critical human thinking to objectively review incident operations for the purpose of organizational learning, and the subsequent physical documentation of that process in the form of

a published report. No matter the name, the desired end result is the same: “positive changes in behavior; constant operational improvement” (Bailey, n.d., p. 5).

For the first research question, on the national standards and best practices for conducting a post-incident analysis, multiple authors were found who have published related applied research projects at the National Fire Academy’s Learning Resource Center (LRC). Most of the recent applied research papers have a very similar thesis, so a few older, yet more relevant sources had to be used. For the most part, those authors compared their local version of a post-incident analysis to national standards and best practices of similar fire service organizations. There is some consensus on the sources of national standards, primarily from the National Fire Protection Association (NFPA) and the Federal Emergency Management Agency (FEMA). Most post-incident analysis procedures presented in these applied research projects as best practice examples were either related back to one of these national standards or to procedures from neighboring jurisdictions.

English (2000) confirms the benefits from post-incident analysis program. He reports that the post-incident analysis process gives organizations a “mechanism to direct change” (p.21). His research shows that this change includes improvements in fireground SOPs, better communication, better rapid intervention team process, improved incident command procedures, improved tactical execution, and an overall improvement in job performance. English’s work supports the argument that the organization can learn and change based on the post-incident analysis process.

Rodriguez (2003) conducted a literature review for his applied research project and found that the majority of written post-incident analysis procedures were based on one or more of the following national standards: NFPA 1500 *Standard On Fire Department Occupational Safety*

And Health Program, Occupational Safety and Health Administration's (OSHA) *Hazardous Waste Operations And Emergency Response* (29 Code of Federal Regulations 1910.120), International Society of Fire Service Instructors' (ISFSI) *Incident Critique Guide*, FEMA's *Special Report: the After-Action Critique: Training Through Lessons Learned*, or the quality improvement techniques from Dr. W. Edwards Deming. The benefits of following a national standard are made clear in Rodriguez's work: "when organizations closely followed adopted national standards and have clear and concise checklists in place for performing the [post-incident analysis] process, overall results were enhanced" (2003, p. 22). As for the results of the post-incident analysis, Rodriguez recommends communicating the lessons learned to the entire work force because "sharing of vital information…begins the thought process of change" (p. 15) through updated procedures and improved training programs.

In 2003, Ward conducted a survey of 100 fire departments in the United States, to compare post-incident analysis programs to the requirements of NFPA 1500. Ward reports that most fire departments require post-incident analyses for multiple alarm fires, hazardous materials incidents and technical rescues. However, only 40% of fire departments with procedures requiring post-incident analyses to be conducted actually developed a written post-incident analysis for those events (2003). As provided in Table 1, Ward offers his recommendations for elements to include in the post-incident analysis based on his research findings. Summarizing his research, Ward advises that "after information is gathered and lessons learned developed from [the post-incident analysis], it is important to incorporate this information into the department's operating procedures, training lesson plans, and distribute it to the members" (2003, p. 31).

Table 1

*Recommend Elements for Formal Post-Incident Analysis (*Ward, 2003*)*

Dispatch and Response Times
Building Structure / Site Layout
Rescue Operations
Communications
Safety Sector
Investigations
Review of Fire Code History
Site Operations
Staging
Support Functions
Accountability
Goals and objectives of the analysis
Appropriate policies and procedures
Reports from personnel on the incident
Recommendations
Review of the conditions present and actions taken
Effect of the conditions and actions on the safety and health of members

Wong (2004) reviewed the San Francisco Fire Department's post-incident analysis procedures, which uses a continuous quality improvement (CQI) model. This CQI methodology is based on Dr. W. Edwards Deming's work in quality management, such as his *14 Points for Management* first published in *Out of the Crisis* in 1982. Another CQI tool used by the San

Francisco Fire Department to examine poor incident performance and implement performance improvements is the *FOCUS-PDCA* method (see Table 2). Based on these principles, the San Francisco Fire Department now uses the term *post-incident educational session* to "identify and evaluate the elements of discovery and to use the evaluation to identify and correct errors, identify procedures requiring modification, validate and encourage positive actions, and enable a common understanding of all elements of the incident" (pp. 12-13).

Table 2

FOCUS-PDCA (Wong, 2004, p. 9)

F	Find a process to improve
O	Organize a team that knows the process
C	Clarify current knowledge of the process
U	Understand or uncover the sources of process variation
S	Select the process improvement
P	Plan the improvement and continued data collection
D	Do the improvement, data collection and analysis
C	Check and study the results
A	Act to hold the gain and to continue to improve the process

Hall questioned Executive Fire Officer Program (EFOP) participants in his 2009 applied research project. Ninety percent of respondents "indicate a preference for increased utilization of [the post-incident analysis], either formal or informal, for all multiple-trauma incidents, working structure fires, and hazardous materials incidents where technician-level deployment occurs" (2009, p. 31). Yet 70% of those same respondents prefer an immediate, informal post-incident analysis at the company or shift level because "to wait for a formal [post-incident analysis] to be

developed would result in a loss of interest and little learning would take place after the necessary delay" (p. 32). Hall also found from his literature review that multiple NFPA standards referenced the post-incident analysis (see Table 3).

Table 3

NFPA Standard Referencing the Post-incident Analysis

NFPA 450	*Guide for Emergency Medical Services and Systems*
NFPA 1026	*Standard for Incident Management Personnel Professional Qualifications*
NFPA 1143	*Standard for Wildland Fire Management*
NFPA 1201	*Standard for Providing Emergency Services to the Public*
NFPA 1250	*Recommended Practice in Emergency Service Organization Risk Management*
NFPA 1403	*Standard on Live Fire Training Evolutions*
NFPA 1500	*Standard on Fire Department Occupational Safety and Health Program*
NFPA 1521	*Standard for Fire Department Safety Officer*
NFPA 1600	*Standard on Disaster/Emergency Management and Business Continuity*
NFPA 1620	*Standard for Pre-Incident Planning*

Williams (2009) reviewed post-incident analysis policies from six fire departments, representing a broad cross section of the fire service in the United States. For his research, he developed a consensus for "trigger mechanisms to start" (p. 18) the post-incident analysis process (see Table 4). His findings also show that recommendations from the post-incident analysis should be "based on established procedures, focus on lessons learned, and distributed throughout the department" (p. 25), and he urges leaders to have the "commitment to follow through with the recommendations" (p. 26). As a result of his research, Williams created a new standard operating procedure for post-incident analysis for the Rochester Fire Department.

Table 4

Trigger Mechanisms to Start Post-incident Analysis (Williams, 2009, pp. 18-19)

Any incident in which an unusual event occurs such as an explosion, collapse, etc.
A building fire in which three or more rooms are severely damaged by fire, or where unusual extinguishing problems existed
Any fire resulting in a fatality
Any fire resulting in injury serious enough to necessitate admission to a medical facility
Any close call incident where firefighter could have been seriously injured
Any mass casualty incident involving four or more seriously injured patients
At the incident commander's discretion, or at the direction of a senior officer
Large scale wildland fires involving three or more units
Specialty rescue operations
Special events that require department involvement such as festivals, parades, etc.
Mock incident participation
Any emergency preparedness incident whether natural or man-made
Events that tax the department's ability such as weather incidents, multiple fires, etc.

Finucane (2209) sent a survey to Commission on Fire Accreditation International (CFAI) accredited fire departments. He discovered that 74% of departments surveyed require a post-incident analysis for certain incidents and 72% have a written standard operating procedure for conducting a post-incident analysis. Finucane shows that there are benefits to conducting a post-incident analysis, including the "ability to share/communicate lessons learned" (p. 49). Most (97%) of respondents to his survey agreed that the post-incident analysis "allows their department to effectively identify and communicate areas of sustainment, improvement and

lessons learned that result in a positive impact on future operations" (p. 52) and 90% of respondents indicate that "conclusions from [the post-incident analysis] did serve as a basis for revising [or] updating [standard operating procedures]" (p. 51).

Based on the findings from these applied research projects, more information was collected from the LRC on some of the specific national standards. NFPA 1021 *Standard for Fire Officer Professional Qualification*s requires that the fire officer be able to "conduct a post-incident analysis…so that all required critical elements are identified and communicated" (2008, p. 13). NFPA 1500 *Standard on Fire Department Occupational Safety and Health Programs* states that fire departments "establish requirements and standard operating procedures for a standardized post-incident analysis of significant incidents or those that involve serious injury or death" (2006, p. 26).

Directed towards the safety and health of firefighters, NFPA 1500 lists components of the post-incident analysis to include "the conditions present, the actions taken, and the effects of the conditions and actions on the safety and health of members" (p. 26). Recommendations from the post-incident analysis should include "any action necessary to change or update any safety and health program elements to improve the welfare of members" (p. 26) and lead to an action plan that "include[s] the change needed and the responsibilities, dates, and details of such actions" (p. 26).

NFPA 1521 *Standard for Fire Department Safety Officer* requires that the incident safety officer participate in the post-incident analysis and prepare a written report that includes "pertinent information about the incident relating to health and safety issues" (2007, p. 11). The report must include a review of the incident action plan, the incident safety plan, all issues related to protective clothing and equipment, all issues related to the personnel accountability

system, firefighter rehabilitation operations, and other issues affecting the safety and health of firefighters on the scene (p. 10). Although not part of the requirements of NFPA 1521, a safety officer's post-incident analysis checklist is included in the appendix of the standard, as well as a list of required sections for the written report: introduction, sequence of events, safety issues, hazards, injuries, safety violations, discussion, and recommendations.

Ockershausen (2008) has published guidelines on the after-action critique through the FEMA/USFA Technical Report Series Project. These FEMA guidelines list the events that would trigger an after-action critique, which include multiple alarm fires, hazardous materials incidents, fires with injuries or a fatality, fires that exceed a predetermined dollar loss, technical rescues, incidents with unusual circumstances or unexpected development, fires in high-risk buildings, and incidents in structures where fire protection features influenced event outcomes. Ockershausen underscores that "experiences and lessons are [usually] limited to those who were involved directly in responding" (p. 1) and warns that "unless feedback on incident response is shared with other personnel in the fire department, a valuable learning opportunity can be lost" (p. 1). He recommends using the formal critique "to reconstruct an incident to determine if the fire department had an appropriate tactical plan and procedures and if they were followed, as well as how effective they were in mitigating the incident" (p. 6) and to "add a section on who would be responsible to address needed change and when and how the proposed improvements will be implemented" (p. 7). This report also lists FEMA's recommendations for sections of a formal report from the post-incident analysis.

At this point, the literature review has influenced this applied research to use the NFPA and FEMA guides as the basis for a comparison of the MCFRS post-incident analysis procedures to national guidelines. The best practices reviewed by other authors described in the literature

review all point back to these national standards, or the practices of other agencies that have similar recommendations to these national standards. This led to a literature review beyond the typical fire service approach for best practices. Fortunately, it was discovered that the United States Armed Forces use approaches that could easily be adopted by the fire service.

After-Action Reviews were developed by the United States Army's National Training Centers (NTC) to "capture lessons from…simulated battles" (Garvin, 2000, p. 1). According to the Department of the Army, the after-action review compares the actual outcome of a process with the intended outcome of the process, and thus has three objectives: to correct deficiencies, to sustain strengths, and to "focus on [the] performance of specific mission essential objectives" (1993, p. ii). This process became so successful in training exercises at the NTC that it has been incorporated into all phases of Army operations, including actual combat operations in order to "capture and disseminated critical organizational knowledge" (p. 1).

Using the Army approach to after-action review, training or combat team members meet immediately after their mission to "review assignments, identify successes and failures, and look for ways to perform better" (Garvin, 2000, p. 1). Four questions are asked during the review: 1) what did we set out to do, 2) what actually happened, 3) why did it happen, and 4) what are we going to do next time? (p. 1). Breaking these questions down further, the after-action review evaluates the key tasks of the mission and acceptable standards for success; facts not only from team members conducting the mission, but also from observers and information technologies; cause and effect relationships and the underlying causes for successes and failures; and focuses on lessons learned, specifically to the processes that can be fixed rather than process beyond team members' immediate control.

Not surprisingly, the National Wildfire Coordinating Group (NWCG) uses the Army's after-action review technique as a best practices approach to post-incident analysis of wildfire incidents. According to the consulting group Mission-Centered Solutions (2008), the NWCG has developed a list (see Table 5) of topics to be included in a formal after-action review based on this approach.

Table 5

NWCG After-Action Review Subjects (Mission-Centered Solutions, 2008, p. 2)

Technical performance	Equipment performance
Techniques used	Lessons learned
Planning	Procedures adherence
Communication of directions, events, changes	Environmental attributes or changes
Perception of events	Coordination
Communication	Attitude impacts
Environmental problems	Safety concerns
Stress impacts	Roles and responsibilities
Fatigue impacts	Environmental indicators
Organizational issues or cultural problems	Adapting

The Army isn't the only military service that uses the after action review. For over fifty years, United States military pilots of all branches of service have been using a debriefing technique described in Murphy's book *Flawless Execution* (2005). This technique has resulted in a reduced pilot mistake rate, and decreases in both casualties and losses of aircraft. Murphy describes this debrief as a best practice approach to be used in the business world, where

information is fed back into the system so that organizations can "learn from their experiences and react in real time" (p. 134). Military pilots conduct this debrief immediately upon landing from their missions, much the same way that fire companies perform the informal critique known as a "hot wash" immediately upon return to quarters. Murphy's *STEALTH* pneumonic (see Table 6) is used as a step-by-step process to conduct this debrief, when a review of the execution of the mission determines if the objectives were "*clear, measurable, achievable, and supportive of the organization's vision*" (p. 140). Participants in this debrief painstakingly reconstruct the sequence of events of the mission to determine if they accomplished the mission objectives. This produces a list of errors and successes, each analyzed for causes and root causes. According to Murphy, root causes are typically categorized as: leadership, organizational, teamwork, communications, and discipline. From each of the root causes of errors and successes, a clear list of lessons-learned forms. Unlike the fire service methods, the STEALH debrief rarely uncovers a mistake "so fundamental that the entire organization has to change" (p. 157). When there is a "true, systemic root cause [discovered], it [then] becomes an organizational issue" (p. 157) that is communicated to the entire organization with a specific series of actions to take.

Table 6

STEALTH Debrief Technique (Murphy, 2005, p. 140)

S	Set Time/Location/Preparation Phase
T	Tone – Nameless/Rankless
E	Execution versus Objectives
A	Analyze Execution
L	Lessons Learned
T	Transfer Lessons Learned
H	High Note Ending

Since these two techniques from the United States Armed Forces have obvious fire service applications, they are used as the basis for best practices comparisons with the MCFRS post-incident analysis process in lieu of fire service examples already covered by other applied research projects.

To continue the literature review of relevant work on the other three research questions about MCFRS's post-incident analyses, another search was conducted through the LRC database. Unfortunately, there have been no other published applied research projects on MCFRS Maydays or post-incident. Nor were there any other recent studies by similar organizations at the meta-analysis level. Most of the relevant and recent research on post-incident analysis at the LRC has been centered on the problem of not having a post-incident analysis policy and the recommendations on how to create one.

Looking internally to MCFRS, there have been two relevant, yet unpublished studies on the topic: a lecture presentation on *Common Threads and Missing Links* from the current MCFRS Fire Chief and a data compilation from the 2009 work of the *Standard Operating Procedures for Safe Structural Firefighting Operations Review Panel*. As they are relevant and timely, both of these serve as the basis for the remainder of the literature review.

Bowers and Collins (2010) have researched several fireground incidents in the Maryland and Virginia region that have caused significant firefighter injuries and fatalities. These include the Leisure World Boulevard, Claridge Road, Twinbrook Parkway, and Frederick Avenue fires in Montgomery County, Maryland; the 2008 Meadowood Court fire in Louden County, Virginia; and the 2008 Marsh Overlook Drive fire in Prince William County, Virginia. Bowers and Collins developed a lecture series on the *Common Threads and Missing Links* between these fires.

Each fire was examined based on critical incident factors, the firefighter Mayday situation, and the resulting firefighter injuries and death. Commonalities among critical incident factors that led to the Maydays include the existence of lightweight building construction and materials; rapidly changing fire conditions, including rapid fire spread or flashover; and early structural compromise and failure (Bowers and Collins, 2010). The Mayday scenarios also shared some commonalities including occurrence early during initial company operations; a sudden change in fireground conditions such as a floor collapse; not having a fully functional rapid intervention group in place; firefighters self-rescuing or attempting a self-rescue; and poor personnel accountability and crew integrity maintained prior to Mayday. It is also noted that all of the Maydays occurred early in fireground operations, prior to the assembly of an effective firefighting force and prior to a well established incident command team.

The physical toll on firefighters from these five Mayday incidents reveals one firefighter fatality (Marsh Overlook Drive) and thirteen firefighters with significant burns and musculoskeletal injuries. As a result of these fires, there were also two service-connected disability retirements and one firefighter who resigned after a single year of service.

There are similarities among the Mayday events presented by Bowers and Collins. The recognition of such is evidence to suggest that there may have been early indicators, or warning signs, that the Maydays and resulting injuries and death would occur. This had a profound influence on this applied research project, as it suggested that the research questions were on target and would produce some interesting results from the MCFRS data.

In early 2009, the MCFRS Fire Chief formed a panel of command officers and subject matter experts for the purposes of updating the *Standard Operating Procedures for Safe Structural Firefighting Operations*. The directions given by the Fire Chief were to review

previous MCFRS Mayday fires, and incorporate the recommendations into an updated SOP. At the time, only three post-incident analyses were published from Mayday incidents: the Leisure World, Claridge Road, and Frederick Avenues fires. Panel members reviewed all three post-incident analyses and produced a compilation of recommendations under the following categories: operations, incident command, communications, training, and equipment. The recommendations were cataloged by the time frame required for implementation: immediate, short-term and long-term. Immediate recommendations under each category are generalized in Table 7.

The information from the *Standard Operating Procedure for Safe Structural Firefighting Operation Review Panel* confirmed the value in reviewing the published MCFRS post-incident analyses, and collecting data on the recommendations. There is evidence to suggest a cause and effect relationship surrounding these Mayday incidents. Had MCFRS followed these recommendations, subsequent Maydays and injuries may have been avoided. However, the nature of some of the recommendations presented by the panel from MCFRS indicates that these may simply be long-standing opinions of the panel members, and not necessarily based on facts presented in the post-incident analyses.

Table 7

Review Panel Recommendations (MCFRS, 2009)

Operations
▪ mandate crew integrity ▪ create a doctrine to allow deviations from standard procedures ▪ units officers need to communicate task status up to incident command ▪ create procedures for abandoned or vacant structures ▪ implement the incident management team concept ▪ include procedures for risk/benefit analysis ▪ revise basement fire attack procedures ▪ update policy to comply with NIMS ▪ improve personnel accountability procedures ▪ update rapid intervention team procedures to include ALS units
Incident Command
▪ improve communications between incident command and attack crews ▪ assign full-time aides to the battalion chiefs ▪ encourage incident commanders to quickly lower their span of control
Training
▪ revise criteria and methods to conduct a post-incident analysis for all significant events ▪ limit the number of observers or firefighter candidates allowed to ride apparatus
Communications
▪ conduct a study on the reliability of the communications system ▪ eliminate bidding on incidents ▪ eliminate switching talk-groups immediately following a Mayday ▪ allow incident commander to declare radio silence during a Mayday ▪ reduce the amount of communications on the tactical talk-group.
Equipment
▪ equip all primary units with one portable radio and one SCBA per riding position ▪ equip all primary units with a thermal imaging camera ▪ require all personnel to carry a hand-light

Procedures

This applied research project uses the descriptive research method to assemble information about the MCFRS post-incident analysis process as it compares to national standards and best practices, and to review the results accumulated over six years of conducting the post-incident analysis process on Mayday events and other major incidents. The underlying purpose of this research is to determine if MCFRS is learning the lessons needed to prevent critical fireground injuries and death from occurring.

For the first research question on how the MCFRS post-incident analysis process compares to national standards and best practices, a literature review was conducted at the LRC. A keyword search was performed via the online catalog at http://www.lrc.fema.gov/ using the keywords *post-incident analysis, after-action review,* and *incident critique*, and variations of thereof to find recent publications on best practices and references to national standards. This was followed by a site visit to the LRC to obtain documents not available online for download. Specific fire service references found at the LRC, including the NFPA standards, FEMA/USFA guides, IFSTA manuals, the Center for Public Safety Excellence (CPSE) accreditation guidelines, and OSHA regulations were searched for applicable standards on the post-incident analysis process. Much of the information gathered on the post-incident analysis process is presented in the literature review section of this applied research project.

Next, the *Post-Incident Analysis Package* from the *Incident Command System* (MCFRS, 2005) and the *Injury Investigation Team Procedures* (MCFRS, 1991) were retrieved from the MCFRS Policies and Procedures Manual. Both documents were also available online at the websites listed in the reference section. These two documents were reviewed as the basis of comparison to the national standards and best practices.

Since most fire service examples of best practices to the post-incident analysis process were based on NFPA and FEMA publications, the procedures progressed to comparing the MCFRS process directly with the applicable NFPA and FEMA guidelines. Additionally, non-fire service organizations including the United States Army and the United States military air forces have developed guidelines of their own for post-incident analysis process. These guidelines were used as the examples of best practices for the comparison with the MCFRS process.

Four points were established as the basis of comparison: 1) who conducts the post-incident analysis, 2) when a post-incident analysis is required, 3) what significant factors are analyzed, and 4) how recommendations are presented. A comparison matrix was created with these four points on the row heading and the NFPA, FEMA, and MCFRS sources on the column heading. The matrix was completed by filling in the answers to the four points for each of the four organizations. Next, a second comparison matrix was completed using the United States Army and United States military aviation forces sources on the column heading. These matrixes are provided in the results section, but have been reformatted to fit the page.

There are limitations to the procedures for the first research question. First, there is a source of uncertainty with the references, since there is no true national consensus standard for conducting a post-incident analysis. What is available from the NFPA is geared more towards the occupational safety and health of firefighters, rather than an analysis of the command and control of fireground operations, and its related strategy, tactics, and tasks. While the purpose of this applied research project was firefighter safety-oriented, an analysis of the entire fireground operation is needed to uncover the root causes of safety issues. The FEMA guidelines published by Ockershausen do provide for a better analysis of fireground operations. Second, it was difficult to find unique fire service-based best practice examples of post-incident analysis

programs, since most simply reflect the contents of the NFPA or FEMA examples. Therefore the research turned to successful post-incident analysis programs, notably from the United States military. These programs are excellent examples of best practices from non-fire service sources, but they are structured for a more immediate review of the action, rather than a detailed and structured process which would include a written report and presentation to the entire organization.

For the second research question on what the post-incident analyses determined were the causes of the seven MCFRS Maydays and resulting firefighter injuries, all published documents (see Appendix A) on the MCFRS Mayday events were reviewed. These documents were found in the archive files maintained by the MCFRS Operations Division Executive Officer and on the MCFRS Lessons Learned Center webpage at http://www.montgomerycountymd.gov/Content/firerescue/swsj/operations/pia/. Summary statements about the cause of each Mayday situation and resulting injuries are provided in the results section. Relevant data to the causes and contributing factors of the Mayday events and the resulting injuries were extracted from each document and entered into an Excel spreadsheet in the form of text. Next, these data were reviewed and correlated to one or more of the following generalized categories in order to facilitate analysis: *failure to maintain crew integrity, fire conditions and effect on the structure, freelancing, IDLH operations without stand-by team, IDLH operations without team-mate, improper fireground operations, inadequate unit staffing, incident size-up, Mayday procedures, misuse of SOPs, personal protective equipment, radio use and fireground communications, situational awareness, situation status reports,* and *unit and personnel accountability*. This final data set was then analyzed using the *table* and *chart* functions of Excel, and presented in the results section.

For the third research question on what the significant warnings indicated in previous MCFRS post-incident analyses were, 48 published post-incident analyses (see Appendix B) on other MCFRS major structure fire incidents dating back to January, 2005 were reviewed. These documents were found in the archive files maintained by the MCFRS Operations Division Executive Officer or at the MCFRS Lessons Learned Center at http://www.montgomerycountymd.gov/Content/firerescue/swsj/operations/pia/. Data relevant to the issues or problems discussed in each of the post-incident analyses were then extracted from each document and entered into an Excel spreadsheet in the form of text. From the post-incident analyses 198 lines of data were extracted. Next, this raw data was reviewed and correlated to one or more of the following generalized categories: *accountability, building familiarization, command and control, communications, convergence, crew integrity, delayed response, fire conditions/structural compromise, freelancing, IDLH operations without stand-by team, IDLH operations without team-mate, improper fireground operations, inadequate staffing, incident size-up, mayday procedures not followed, radios, risk/benefit analysis, situational awareness, SOPs not followed,* and *weather*. This final data set was then analyzed using the *table* and *chart* functions of Excel, and presented in the results section.

For the final research question on what recommendations were made in the previous post-incident analyses that may have averted subsequent Mayday incidents and resulting firefighter injuries, 48 published post-incident analyses (see Appendix B) on other MCFRS major structure fire incidents dating back to January, 2005 were reviewed. Data relevant to the recommendations made in each post-incident analysis were extracted from each document and entered into an Excel spreadsheet in the form of text. From the post-incident analyses 136 lines of data were extracted Next, this raw data was reviewed and correlated to one or more of the

following generalized categories of recommendations: *anticipate rapid fire spread and structural failure, assign/maintain stand-by team/entry team in IDLH, conduct thorough initial incident scene size-up, enforce/modify/train on SOPs, enhance dispatch information, ensure firefighter safety, improve fireground operations/tactics/tasks, improve incident command function, improve pre-fire planning, improve staffing levels/competencies, improve/maintain unit/personnel accountability, improvements/additional equipment, maintain crew integrity, proper use of PPE, provide situation status reports to command, reduce span of control, staff battalion chief aide positions*, and *training on radio system/fireground communications*. This final data set was then analyzed using the *table* and *chart* functions of Excel, and presented in the results section.

The limitation for the last three research questions is that the original data are subjective. Subjective data are a result of the researcher's personal beliefs and judgments. As with the nature of subjective data, the authors of the original post-incident analyses unwittingly injected their personal opinions in their presentations of the facts. Ideally, with a structured, written post-incident analysis there should be strictly objective data from which conclusions are drawn, such as that needed to establish cause and effect relationships. Not all of the reports reviewed provide direct objective data, such as the root cause(s) for the Maydays and resulting injuries or data-supported recommendations to avoid future firefighter injuries. There is, however, enough evidence in the reports to extrapolate contributing factors to the Mayday events and other issues suggestive of warning signs of firefighter injury. The limitation, and challenge, arises when attempts are made to objectively analyze the data for this descriptive research.

Results

How does the Montgomery County Fire and Rescue Service's Post-Incident Analysis process compare to national standards and best practices? The NFPA process (see Table 8) when combined with the FEMA process (see Table 9) as national standards, are very similar in structure and purpose to the MCFRS process (see Table 10).

Table 8

Comparison Matrix – NFPA

	NFPA 1500 - *Standard on Fire Department Occupational Safety and Health Programs* (NFPA, 2006)
Who conducts the post-incident analysis?	Determined by local fire department, but must involved the fire department safety officer
When is a post-incident analysis required?	Determined by local fire department
What are the significant factors analyzed?	1. Conditions present 2. Actions taken 3. Effects of the conditions and actions on the safety and health of members
What is done with the recommendations?	Identify actions necessary to change or update any safety and health program elements in the form of a standardized action plan to include changes needed and the responsibilities, dates and details of such actions

	NFPA 1521 - *Standard for Fire Department Safety Officer* (NFPA, 2007)
Who conducts the post-incident analysis?	Incident safety officer
When is a post-incident analysis required?	When a post-incident analysis is conducted per NFPA 1500
What are the significant factors analyzed?	Review of: 1. Incident action plan 2. Incident safety officer's incident safety plan 3. Issues related to protective clothing and equipment 4. Issues related to the personnel accountability system 5. Rehabilitation operations 6. Other issues affecting the safety and welfare of personnel at the incident scene
What is done with the recommendations?	Written report for the post-incident analysis

Table 9

Comparison Matrix – FEMA

	FEMA - *Special Report: The After-Action Critique: Training Through Lessons Learned* (Ockershausen, 2008).
Who conducts the post-incident analysis?	Incident Commander
When is a post-incident analysis required?	Determined by local fire department, but suggested to include: 1. Multiple alarm fires 2. Hazardous materials incidents 3. Fires with injuries or fatalities 4. Fires that exceed a predetermined dollar loss 5. Technical rescues 6. Incidents with unusual circumstances or unexpected development 7. Fire in high-risk buildings 8. Incidents in structures where fire protection features influenced event outcomes
What are the significant factors analyzed?	1. Incident Command 2. Fire suppression 3. Dispatch/fireground communications 4. Logistics/fleet maintenance 5. Public information 6. Code enforcement 7. Fire Investigations 8. Emergency medical services 9. Hazardous materials Written report to include: 1. Basic information on the incident 2. Key aspects of incident in greater detail (conditions confronting crews, problem encountered by crews, life safety issues, and strategic and tactical operations) 3. Lessons learned 4. Management approved action plan to adopt lessons learned
What is done with the recommendations?	Action plan to adopt lessons learned submitted to fire department management

Table 10

Comparison Matrix – MCFRS

	MCFRS - *Post-Incident Analysis Package* (MCFRS, 2005)
Who conducts the post-incident analysis?	Incident Commander
When is a post-incident analysis required?	1. A building fire in which 3 or more rooms are severely damaged by fire, or where unusual extinguishing problems existed 2. Any fire resulting in a fatality 3. Any fire resulting in injury to firefighters serious enough to necessitate admission to a medical facility 4. Any hazardous materials incident at the recommendation of the HazMat Officer 5. Any mass casualty incident involving 8 or more victims 6. At the Incident Commander's or senior officer's discretion
What are the significant factors analyzed?	1. Building structure 2. Fire code history 3. Communications 4. Pre-emergency planning 5. On-scene operations 6. Staging 7. Support functions 8. Safety group 9. Accountability 10. Investigations 11. Lessons learned 12. Overall analysis of incident
What is done with the recommendations?	Forwarded to the Fire Chief through the chain of command

	MCFRS - *Injury Investigation Team Procedures* (MCFRS, 1991)
Who conducts the post-incident analysis?	Injury Investigation Team ▪ Safety Officer ▪ Deputy Safety Officer ▪ EMS Duty Officer ▪ Fire Prevention Officer ▪ Bargaining Unit Member ▪ Division Chief
When is a post-incident analysis required?	Firefighter fatality or Critical injury (i.e., requires hospitalization and/or extensive recuperation time)
What are the significant factors analyzed?	1. Nature of injuries 2. Characteristics of the firefighter involved 3. Description of the incident 4. Characteristics of equipment being used 5. Tasks being performed at the time of death/injury 6. Time factors 7. Protective equipment used/preventive measures taken 8. Summary of applicable laws, standards, policies, procedures 9. Unsafe acts, hazardous conditions, management failures 10. Recommendations to prevent recurrence 11. Weather conditions
What is done with the recommendations?	Forwarded to the Fire Chief and may be disseminated to personnel via a Training or Safety Bulletin

The first point of comparison shown in the matrices is the individual responsible for conducting the post-incident analysis. The MCFRS and FEMA processes both require that the incident commander conduct the post-incident analysis. The NFPA standards state that the individual should be appointed by the local jurisdiction, but the fire department safety officer must also be involved. NFPA 1521 *Standard for Fire Department Safety Officer* requires that the analysis be conducted by the incident safety officer and the fire department's health and safety officer, which then contributes to the post-incident analysis conducted per NFPA 1500 *Standard on Fire Department Occupational Safety and Health Programs*. This is an analogous arrangement to that of MCFRS, where the safety officer leads a team to investigate significant fireground injuries or deaths per the *Injury Investigation Team Procedures* (1991), which inputs into the post-incident analysis being conducted by the incident commander.

For the second point of comparison on when a post-incident analysis is conducted, the NFPA leaves that determination to the local jurisdiction. The MCFRS has developed a list of incidents that required a post-incident analysis, which are similar to those described by Ockershausen for FEMA. Both the guidelines from FEMA and the MCFRS require post-incident analysis to be conducted for fire with fatalities or significant injuries, fires with unusual circumstances, and certain hazardous materials incidents. MCFRS requires the post-incident analysis for fires involving three or more rooms in the structure, while the FEMA guide states this differently as multiple alarm fires. The FEMA guide requires a post-incident analysis for more types of structure fires including those that reach a predetermined dollar loss, those in high-risk buildings, and those where built-in fire protection features contributed to the outcome.

For the third point of comparison shown in the matrices on what significant factors are analyzed, the NFPA standards are clearly concerned with conditions, action plans, and issues

related to firefighter safety, as are the MCFRS *Injury Investigation Team Procedures.* The FEMA guide has more in common with the MCFRS *Post-Incident Analysis Package,* in that they both consider other common fireground operations.

For the forth point of comparison what is done with the recommendations, both the MCFRS and FEMA processes have written reports with recommendations presented the fire chief or fire department management. The NFPA standards, again more concerned with firefighter safety, use the recommendations to update safety and health program elements and SOPs, while the FEMA guidelines require that a detailed action plan be developed to implement the recommendations that include needed changes and the responsibilities, dates and details of those changes.

In summary, the combination of both parts of the MCFRS post-incident analysis process, the *Post-Incident Analysis Package* and the *Injury Investigation Team Procedures,* are very similar to the standards from the NFPA that reference the post-incident analysis process. A reasonable statement would be that the MCFRS meets the NFPA standards. The FEMA guidelines are also comparable to those of the MCFRS, and could be used as the basis for revising the MCFRS processes.

Table 11 shows the comparison matrix for the United States Armed Forces (Army and military air forces) after-action and debriefing techniques held as examples of best practices. There are some significant differences between the formal MCFRS post-incident analysis process and the after-action techniques used by the United States Armed Forces. Yet the military processes seem to work well, as exemplified by the NWCG adoption of the after-action process.

Table 11

Comparison Matrix – Best Practices

	US Army ***A Leader's Guide to After-Action Reviews*** (Department of the Army, 1993).
Who conducts the post-incident analysis?	Operation/training commander
When is a post-incident analysis required?	After each operation/training event
What are the significant factors analyzed?	1. Operation/training objectives 2. Commander's mission and intent 3. Opponent's mission and intent 4. Review of events in operation/training (intelligence, maneuver, fire support, mobility, counter-mobility, survivability, air defense, combat service support, command and control, fratricide, flexibility) 5. Optional issues (soldier/leader skills, tasks to sustain/improve, statistics) 6. Force protection (safety) issues
What is done with the recommendations?	Commanders use recommendations to immediately retrain troops and revise standard operating procedures

	United States military aviation forces ***Flawless Execution*** (Murphy, 2005)
Who conducts the post-incident analysis?	Mission leader
When is a post-incident analysis required?	Immediately after mission (45 minutes after landing)
What are the significant factors analyzed?	1. Execution of mission versus objectives of mission (was the objective clear, measurable, achievable, supports vision of success?) 2. Analysis of execution of mission (execution errors/successes, cause of each error/success, root cause analysis of each error/success) 3. Lessons learned
What is done with the recommendations?	Written lessons learned transmitted to commanding officer

Few similarities exist between the MCFRS and the United States Armed Forces processes. The commander in charge of the event, whether it is for a fireground incident, training exercise, or combat mission, conducts the analysis. For the United States Army, the after-action process is conducted after every training operation and combat mission. Similarly for the United States military air forces, the debrief takes places immediately after pilots land from their missions. For MCFRS, the post-incident analysis is not conducted after every incident, but rather conducted only when one of the trigger events occur. However, outside of policy, MCFRS fire

companies and battalions frequently conduct a *hot wash* or informal critique in manner similar to the United States Armed Forces after-action process. The significant factors analyzed in the United States Armed Forces processes focus on the objectives, how well the objectives were accomplished, the issues and errors in accomplishing the objectives, the root causes of the issues and errors, and the lessons learned on how to avoid those issues and errors in the next mission. Standard operating procedures are updated and combat forces are immediately retrained in order to carry out the next mission. This differs in the MCFRS process, as the focus is more on safety issues and functional areas.

What did the MCFRS post-incident analyses determine were the causes of the Maydays and resulting firefighter injuries? There are various documented contributing factors that led to each of the Maydays incidents and Mayday rescue operations. The review of the Mayday documents shows that the contributing factors of the Mayday incidents can be classified into the categories as shown in Table 12 and Figure 1. Having to assign a single factor as the cause of the Mayday is a subjective task. But after reading all of the narratives and consideration of the possible causes, it can be subjectively stated that the main causes of the Mayday incidents include: *fire conditions and resulting effect on the structure* in five of the seven (71%) Maydays and *failure to maintain crew integrity* in two of the seven (29%) Maydays. The injuries that resulted from the Mayday situation include: seven out of ten (70%) were caused by *firefighters falling from a height*, two out of ten (20%) were caused by *an object falling on the firefighters*, and one out of ten (10%) was a *firefighter caught in a flashover*. Eight of the ten firefighters (80%) also received *burns* significant enough to be treated at a regional burn center.

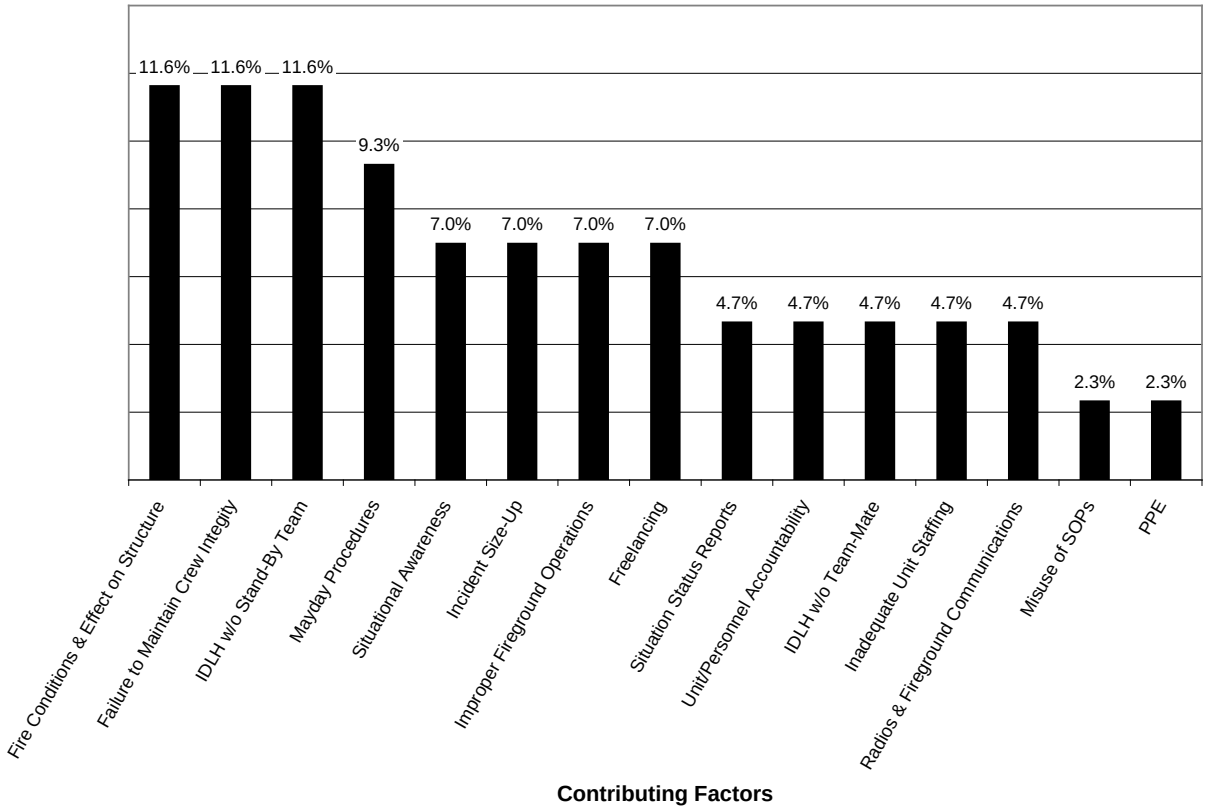
Table 12

Factors Contributing to Mayday Incidents

	South Leisure World	Goshen Road	Claridge Road	Twinbrook Parkway	Frederick Avenue	Castle Boulevard	Piney Branch Road
Failure to Maintain Crew Integrity	x	x	x		x		x
Fire Conditions and Effect on the Structure	x		x	x	x	x	
Freelancing			x	x	x		
IDLH Operations w/o Stand-By Team	x	x	x	x	x		
IDLH Operations w/o Team-Mate		x			x		
Improper Fireground Operations			x	x	x		
Inadequate Unit Staffing		x			x		
Incident Size-Up		x	x	x			
Mayday Procedures	x	x	x	x			
Misuse of SOPs		x					
PPE			x				
Radios and Fireground Communications		x	x				
Situational Awareness	x		x	x			
Situation Status Reports		x		x			
Unit/Personnel Accountability				x	x		

Figure 1

Contributing Factors to Mayday Incidents



In order to support the statements above about the main causes of the Mayday incidents, the following summaries are provided:

South Leisure World Boulevard

The Mayday at the South Leisure World Boulevard (Gallo, 2005) was most significantly caused by the *fire conditions and effects on the structure*. Firefighters entered the building to conduct a search, and became separated and trapped from exiting the fire apartment when the fire reached flashover conditions, most likely due to the introduction of oxygen through the front door opened by the firefighters or the patio door left open by the occupant they were searching for. Contributing to the Mayday was the

fact that first arriving firefighters did not maintain a situational awareness of the rapidly growing fire and failed to maintain crew integrity following the flashover. The crew assigned as the stand-by team did not carry out this assignment and was not in direct contact with the initial entry team when the flashover occurred.

Goshen Road

The Mayday at the Goshen Road fire (Korenblatt, 2006) was most significantly caused by a *failure to maintain crew integrity*. One of the firefighters from the first arriving engine company split off from the rest of his crew members, who were performing exterior defensive fire attack. This firefighter entered an attached structure, without a partner and without the knowledge of his supervisor. This firefighter became disoriented in the IDLH atmosphere and trapped when he accidentally pulled a heavy file cabinet on top of himself. He was unable to reach his portable radio to call for a Mayday, so he relied on his PASS to activate. There was no stand-by team established, so no crew was in direct contact to affect a rescue.

Claridge Road

The Mayday at Claridge Road (Kinsley, 2007) was caused by the *fire conditions and effects on the structure*, as the interior stair components were compromised by fire conditions. Firefighters ran into the smoke-filled occupancy to affect rescue, disregarding basic firefighting principles of crawling in an IDLH atmosphere while sounding for footing, and failing to maintain crew integrity when first entering the structure. Three firefighters fell through the damaged stairway into the basement below. The designated stand-by team was freelancing by performing other exterior firefighting operations

instead of maintaining direct contact with the initial entry team, thus causing a delay in rescue.

Twinbrook Parkway

The Twinbrook Parkway Mayday (MCFRS, 2010) was caused by the *fire conditions and effects on the structure*. A rapidly growing fire in a first floor apartment weakened the floor structure of the apartment above. The first engine crew entered to attack the fire, but due to poor incident size-up and situational awareness, they mistakenly entered the floor above the fire. The floor collapsed, dropping three firefighters into the free-burning fire below. Again, there was no stand-by team in place maintaining direct contact with the initial attack crew, and therefore unable to effect an immediate rescue.

Frederick Avenue

The Mayday at the Frederick Avenue (Goldstein, 2009) was also caused by *fire conditions and effects on the structure*. This free-burning basement fire weakened the structural components of the floor above, allowing a partial floor collapse and dropping a firefighter into the fire below. Here, fireground operations was a major contributor to the Mayday, as it was broadcast by the first arriving engine company that this was a vacant structure, yet interior operations continued. The firefighter who fell through the floor into the basement had entered the IDLH atmosphere without a team-mate or the knowledge of his supervisor, thus failing to maintain crew integrity and freelancing are contributors to this Mayday situation. The crew assigned as the stand-by team did not take this assignment, and there was no rapid intervention team assigned by the incident commander.

Castle Boulevard

The Castle Boulevard Mayday event (Jones, 2009a) was caused by a ceiling collapse onto a firefighter during fire suppression, therefore *fire conditions and effects on the structure*. This situation was resolved quickly, as a Mayday was called and the firefighter rescued almost immediately.

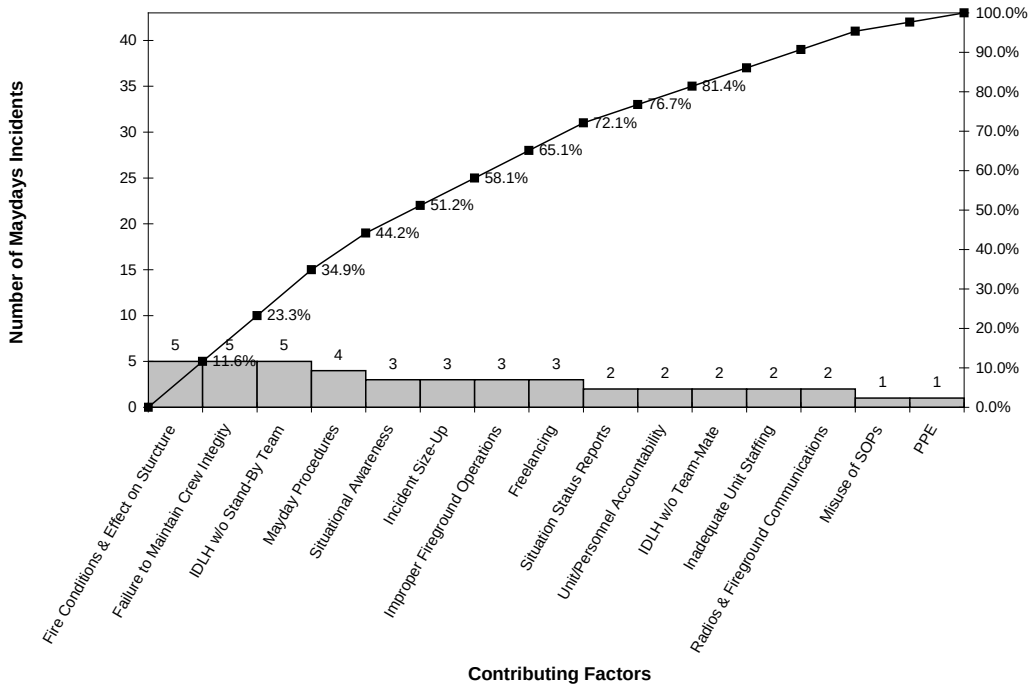
Piney Branch Road

The Piney Branch Road Mayday (Jones, 2009b) was caused by *failure to maintain crew integrity*. When an engine company officer and his firefighter ran low on air, they properly agreed to exit the structure. However, they got separated from each other when they followed different hose lines out of the fire floor. Believing he had a missing firefighter, the officer transmitted a Mayday to the Incident Commander.

In order to objectively analyze the contributing factors of the MCFRS Mayday incidents, a Pareto analysis was conducted. This analysis is based on the Pareto principle (i.e., 80-20 rule), whereby a majority of the problems are produced by a minority of causes. While a Pareto analysis is more useful when there are a large number of variables, the resulting chart (see Figure 2) assists in placing the data into perspective. According to this Pareto analysis, the major factors (i.e. less than 80% cumulative) contributing to Mayday events include 1) *fire conditions and effects on the structure*, 2) *failure to maintain crew integrity*, 3) *IDLH operations without stand-by team*, 4) misuse of *Mayday procedures*, 5) failure to maintain *situational awareness*, 6) failure to conduct an adequate *incident size-up*, 7) *improper fireground operations*, 8) *freelancing*, 9) failure to provide adequate *situation status reports* to the incident commander and 10) failure to maintain *unit and personnel accountability*.

Figure 2

Pareto Analysis of Factors Contributing to Mayday Incidents



Were significant warnings indicated in previous post-incident analyses? From the 48 post-incident analyses reviewed, which cover an almost six-year period from January, 2005, there were 198 issues identified. These issues span the 22 general categories as assigned to facilitate objective data analysis. Many of these issues (see Table 13, Figure 3, and Figure 4) can be thought of as warnings of impending fireground Mayday situations, as all can cause or contribute to a fireground injury or fatality. These are the warning signs indicated in previous MCFRS post-incident analyses.

Table 13

Issues from MCFRS Post-Incident Analyses

Issue or Problem	Frequency of Occurrence	Percent of Total Number of Occurrences (n=198)	Number of Incidents	Percent of Total Incidents (n=48)
Accountability	7	3.5%	7	14.6%
Building Familiarization	2	1.0%	2	4.2%
Command and Control	12	6.1%	11	22.9%
Communications	10	5.1%	10	20.8%
Convergence	1	0.5%	1	2.1%
Crew Integrity	9	4.5%	6	12.5%
Delayed Response	2	1.0%	2	4.2%
Fire Conditions/Structural Compromise	15	7.6%	13	27.1%
Freelancing	17	8.6%	8	16.7%
IDLH w/o Stand-By Team	15	7.6%	6	12.5%
IDLH w/o Team-Mate	3	1.5%	2	4.2%
Improper Fireground Operations	30	15.2%	20	41.7%
Inadequate Staffing	6	3.0%	3	6.3%
Incident Size-Up	15	7.6%	9	18.8%
Mayday Procedures not Followed	13	6.6%	3	6.3%
PPE	1	0.5%	2	4.2%
Radios	16	8.1%	11	22.9%
Risk Benefit Analysis	1	0.5%	1	2.1%
Situation Status Reports	2	1.0%	2	4.2%
Situational Awareness	6	3.0%	3	6.3%
SOPs Not Followed	11	5.6%	9	18.8%
Weather	4	2.0%	4	8.3%

Figure 3

Incidents with Issues from MCFRS Post-Incident Analyses

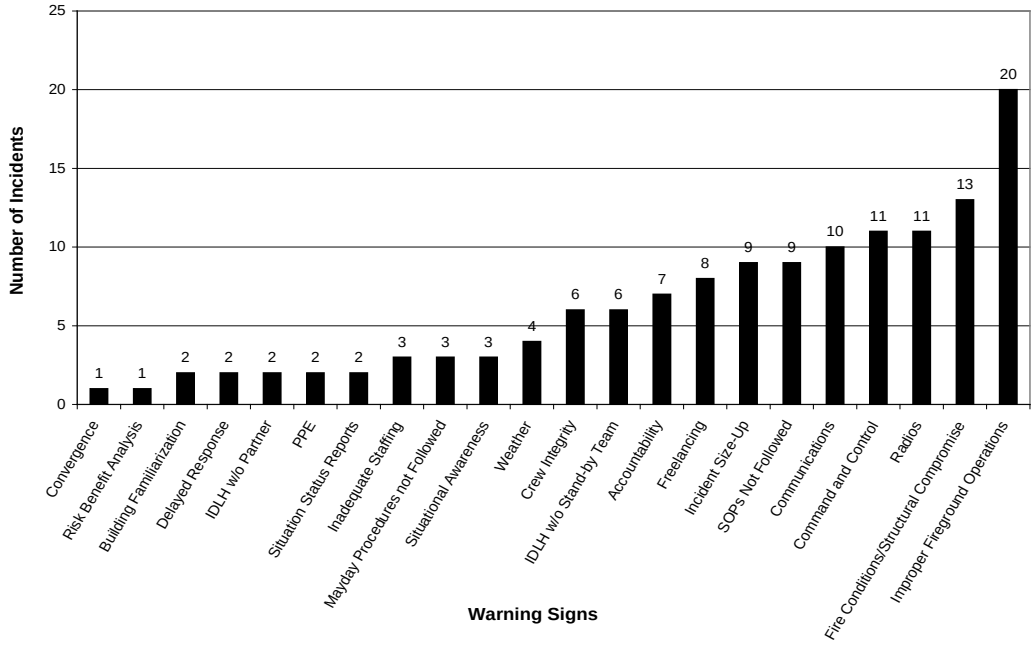
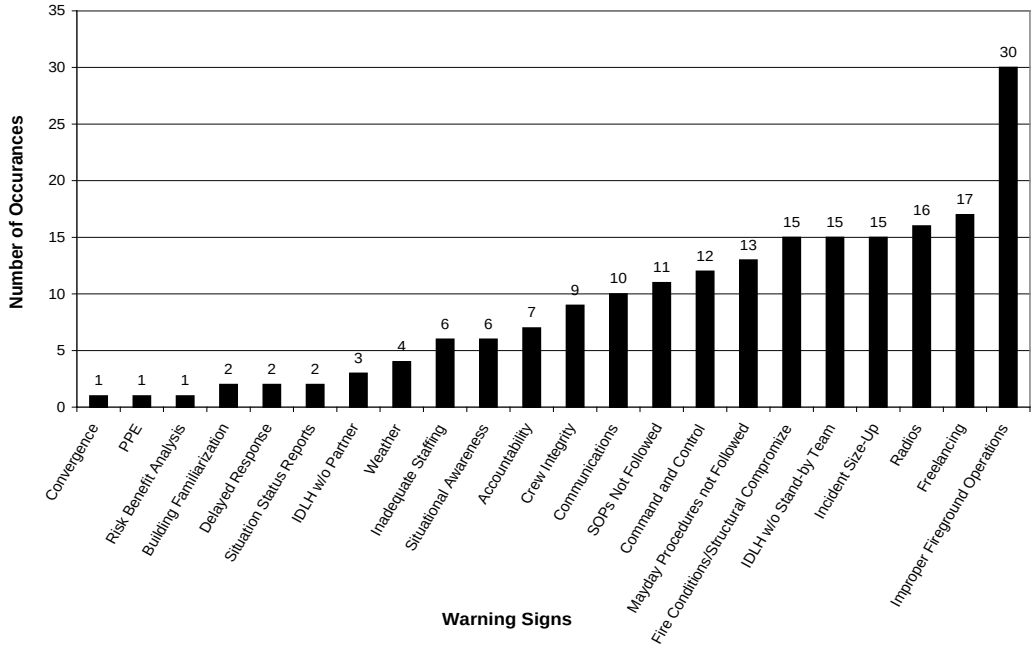


Figure 4

Frequency of Issues from MCFRS Post-Incident Analyses

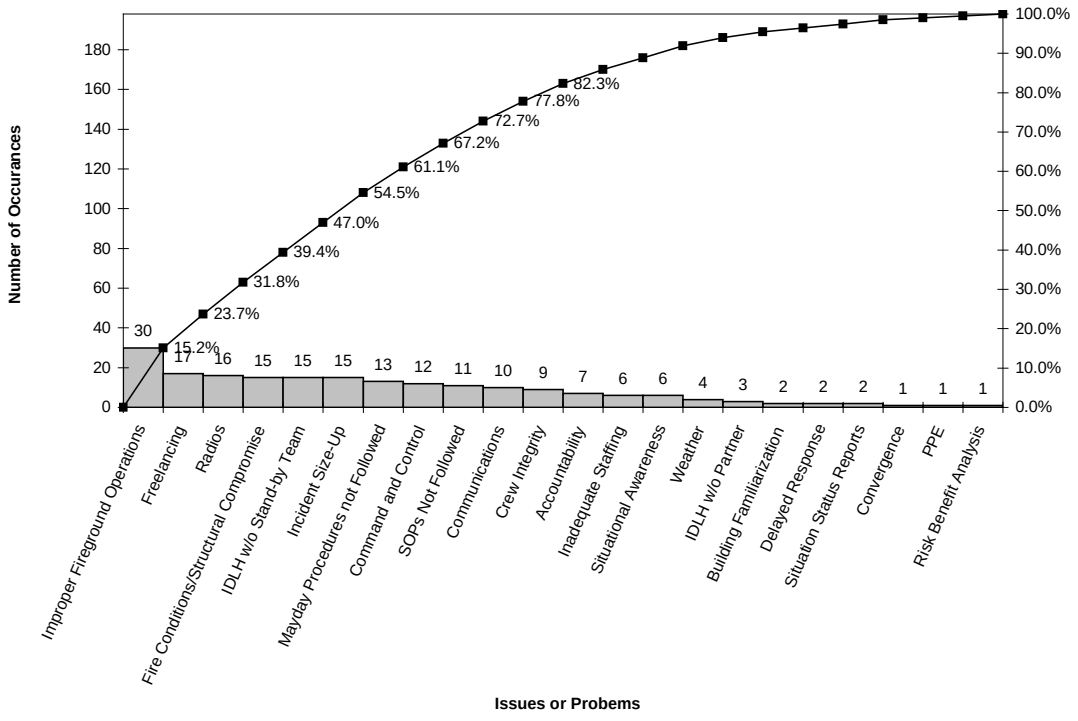


The most significant issue or problem discovered in the research was under the category of *improper fireground operations,* which occurred in 20 (41.7%) of the post-incident analyses. When the data is examined based on frequency of occurrence (i.e., how many times an issue or problem has been identified in a post-incident analysis), the most frequent issue is still *improper fireground operations.* This issue has been identified 30 times altogether (15.2%), more than twice that of any other identified issues.

The Pareto analysis (see Figure 5) shows the issues or problems that statistically occur a majority of the time on major structure fires run by MCFRS. This Pareto analysis shows the most important categories of issues or problems. These are the warning signs that MCFRS must take seriously and change organizational practices in order to avoid fireground injuries and fatalities.

Figure 5

Pareto Analysis of Issues from MCFRS Post-Incident Analyses



The data presented in the tables and figures shows that there were warnings made in previous post-incident analyses that may have averted the subsequent Mayday incidents and resulting injuries. The conditions of the fire and resulting structural compromise were the most significant contributors in 71% of the Maydays. This issue occurs in 13 out of the 48 (27.1%) post-incident analyses. Twenty-nine percent of the Maydays were most significantly contributed to by personnel not maintaining crew integrity. The issue of *crew integrity* occurs in 6 of 48 (12.5%) post-incident analyses. Table 14 presents a cross-walk of the contributing factors of the Maydays compared to the warnings from the post-incident analyses.

Table 14

Comparison of Contributing Factors of the Maydays to Warnings

Contributing Factor of Mayday	**Warnings from Post-Incident Analyses**
Crew Integrity	Crew Integrity
Fire Conditions and Effect on Structure	Fire Conditions and Structural Compromise
Freelancing	Freelancing
IDLH w/o Stand-By Team	IDLH w/o Stand-by Team
IDLH w/o Team-mate	IDLH w/o Partner
Improper Fireground Operations	Improper Fireground Operations
Inadequate Staffing	Inadequate Staffing
Incident Size-Up	Incident Size-Up
Mayday Procedures	Mayday Procedures not Followed
Misuse of SOPs	SOPs not Followed
Radios and Communications	Communications Radios
PPE	PPE
Situation Status Reports	Situation Status Reports
Situational Awareness	Situational Awareness
Unit/Personnel Accountability	Accountability

What recommendations were made in the previous post-incident analyses that may have averted the subsequent Mayday incidents and resulting firefighter injuries? Table 15 lists the recommendations from the 48 post-incident analyses reviewed. The data is broken down by the number of incidents the recommendations occurs in (see Figure 6) and by overall frequency of occurrence (see Figure 7). A Pareto analysis (see Figure 8) of the frequency at which these recommendations occur confirms the most significant recommendations.

The data presented in the tables and figures shows that there were recommendations made in previous post-incident analyses that may have averted the Mayday incidents and resulting injuries. The *fire conditions and effects on the structure* contributed to 71% of the Maydays. The direct recommendation for firefighting crews to *anticipate rapid fire spread and structural failure* only occurs in 1 out of the 48 (2.1%) post-incident analyses. However, the related recommendation to *conduct a thorough initial incident scene size-up* occurs more frequently, appearing in 8 out of 48 (16.7%) of post-incident analyses. Twenty-nine percent of the Maydays were most significantly contributed by *personnel failing to maintain crew integrity*. The issue of *crew integrity* occurs in 7 out of the 48 (14.6%) post-incident analyses. Table 16 presents a cross-walk of the contributing factors of the Maydays compared to the recommendations from the post-incident analyses.

Table 15

Recommendations from MCFRS Post-Incident Analyses

Recommendation	Number of Incidents (n=48)	Percent of Number of Incidents	Frequency of Recommendation (n=137)	Percent of Total Number of Recommendations
Anticipate Rapid Fire Spread and Structural Failure	1	2.1%	1	0.7%
Assign/Maintain Stand-by Team/Entry Team in IDLH	5	10.4%	7	5.1%
Conduct Thorough Initial Incident Scene Size-Up	8	16.7%	9	6.6%
Enforce/Modify/Train on SOPs	10	20.8%	15	10.9%
Enhance Dispatch Information	7	14.6%	7	5.1%
Ensure Firefighter Safety	7	14.6%	6	4.4%
Improve Fireground Operations/Tactics/Tasks	12	25.0%	14	10.2%
Improve Incident Command Function	12	25.0%	13	9.5%
Improve PreFire Planning	7	14.6%	8	5.8%
Improve Staffing Levels/Competencies	2	4.2%	2	1.5%
Improve/Maintain Unit/Personnel Accountability	6	12.5%	6	4.4%
Improvements/Additional Equipment	5	10.4%	7	5.1%
Maintain Crew Integrity	7	14.6%	7	5.1%
Proper Use of PPE	3	6.3%	3	2.2%
Provide Situation Status Reports to Command	3	6.3%	3	2.2%
Reduce Span of Control	2	4.2%	2	1.5%
Staff Battalion Chief Aide Positions	9	18.8%	10	7.3%
Training on Radio System/Fireground Communications	12	25.0%	16	11.7%

Figure 6

Recommendations from MCFRS Post-Incident Analyses

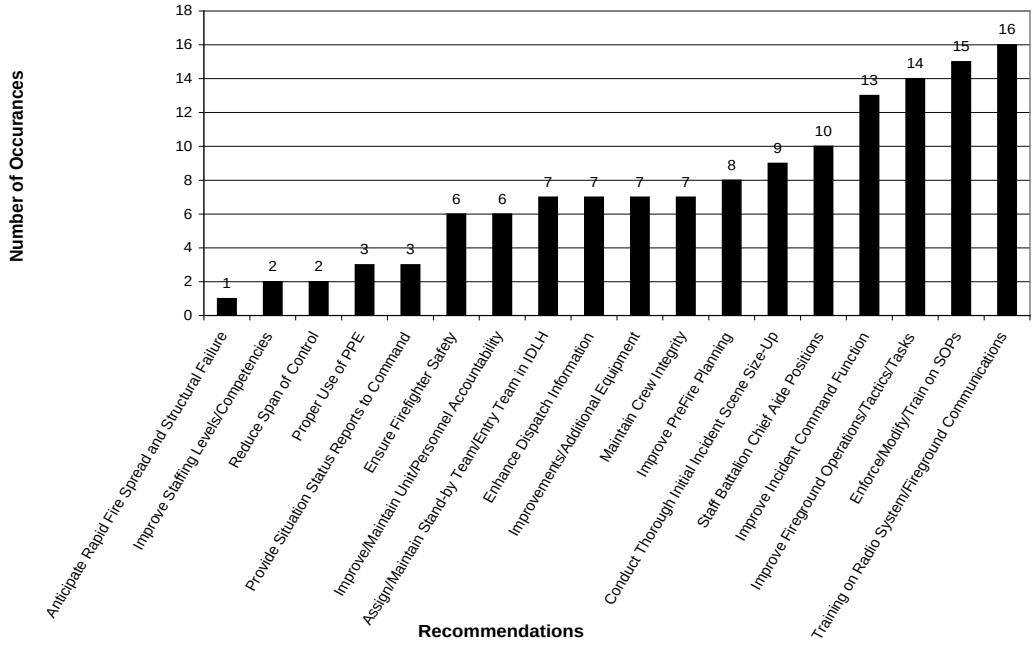


Figure 7

Frequency of Recommendations from MCFRS Post-Incident Analyses

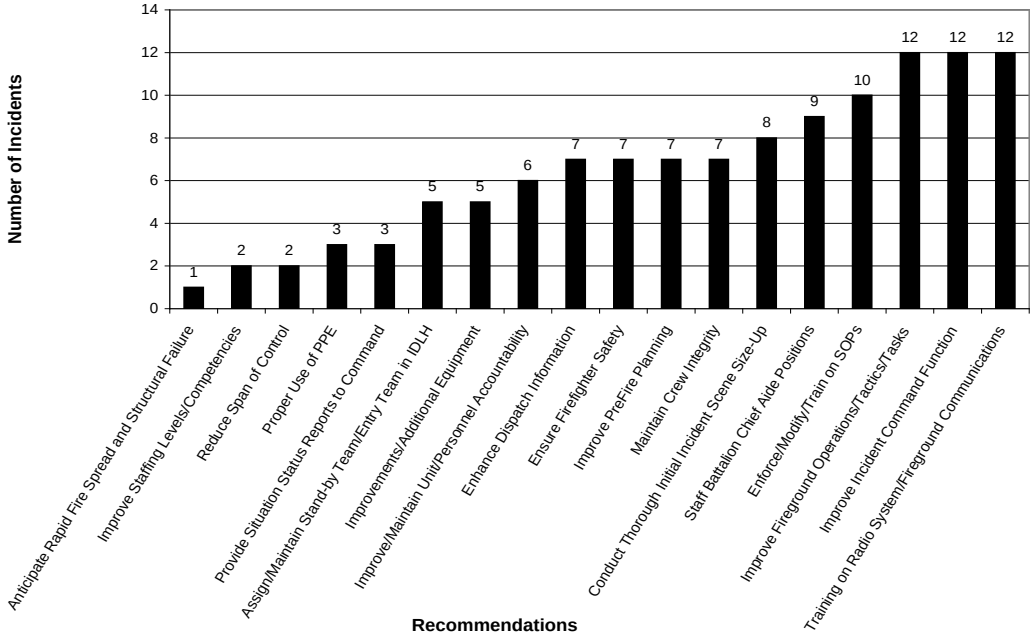


Figure 8

Pareto Analysis of Recommendations from MCFRS Post-Incident Analyses 2005-2010

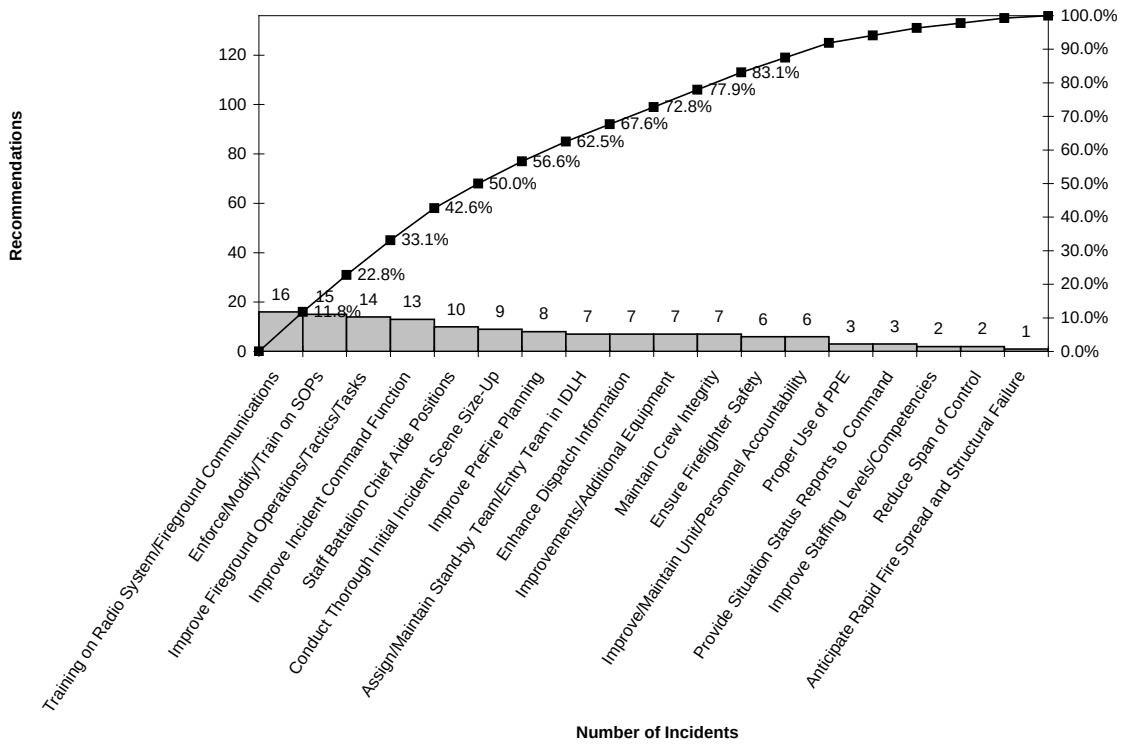


Table 16

Comparison of Contributing Factors of the Maydays to Recommendations

Contributing Factor of Mayday	**Recommendations from Post-Incident Analyses**
Crew Integrity	Maintain crew integrity
Fire Conditions and Effect on Structure	Anticipate rapid fire spread and structural failure
Freelancing	Maintain crew integrity
IDLH w/o Stand-By Team	Assign/maintain stand-by/entry team in IDLH
IDLH w/o Team-mate	Assign/maintain stand-by/entry team in IDLH
Improper Fireground Operations	Enforce/modify/train on SOPs Improve fireground operations/tactics/tasks
Inadequate Staffing	Improve staffing levels/competencies
Incident Size-Up	Conduct thorough initial incident scene size-up Anticipate rapid fire spread and structural failure
Mayday Procedures	Enforce/modify/train on SOPs
Misuse of SOPs	Enforce/modify/train on SOPs
Radios and Communications	Training on radio system/fireground communications
PPE	Proper use of PPE
Situation Status Reports	Provide situation status reports to command
Situational Awareness	Anticipate rapid fire spread and structural failure Conduct thorough initial incident scene size-up
Unit/Personnel Accountability	Improve/maintain unit/personnel accountability

Discussion

The purpose of this applied research project is to determine if MCFRS is learning the lessons needed to prevent critical fireground injuries and death. The motivation behind the research was to explore the idea that MCFRS was evolving into a learning organization, based upon the effectiveness of the post-incident analysis process.

The results from English's applied research project on post-incident analysis programs reaffirm this overall thesis on organizational learning. English aptly describes the post-incident analysis as a "mechanism to direct change" (2000, p.21) and goes on to provide the specific data

on successful organizational learning. Another description of the post-incident analysis is that it is an organizational learning tool, used as a "process of change" (Rodriguez, 2003, p. 15). Finucane describes this as the ability to "effectively identify and communicate areas of sustainment, improvement and lessons learned that result on a positive impact on future operations" (2009, p. 52). Certainly the concept of the post-incident analysis process has merit and is working to solve the problems experienced by other fire departments. For MCFRS, a properly structured post-incident analysis tool may be the key to help solve its problems of frequent Maydays and severely injured firefighters.

The comparison matrixes in the results section show the requirements for conducting a post-incident analysis from NFPA 1500 *Standard on Fire Department Occupational Safety and Health Programs* and NFPA 1521 *Standard for Fire Department Safety Officer*. The MCFRS process, using the *Post-Incident Analysis Package* together with the *Injury Investigation Team Procedures* meets these requirements of the NFPA standards when used for evaluating safety issues from fireground operations. Both processes are led by the incident commander and incident safety officer, conducted under circumstances as determined by the fire department, review the effects of actions and conditions on fireground safety, and result in recommendations for improvement of firefighter safety. Thus, the MCFRS post-incident analysis process meets applicable NFPA standards and would be considered an appropriate organizational learning tool to use.

Rodriguez (2003) discovered that most fire departments he reviewed base their written post-incident analysis programs on national standards such as NFPA 1500 and NFPA 1521. Thus the NFPA standards are not only the national standards for fire service post-incident analysis, but the basis for best-practice comparisons. In his 2003 research, Ward explains that even though fire

departments require post-incident analysis per NFPA 1500, most do not actually complete the process after the requisite major incidents. This fact is troubling, as the data collected for this applied research project was pulled only on the completed MCFRS post-incident analysis. As mentioned in the background section, there is disagreement among MCFRS command officers as to whether the post-incident analysis is mandatory component of the *Standard Operating Procedures for Safe Structural Firefighting Operations*. The unknown factor is how many MCFRS post-incident analysis should have been completed since the process was mandated in 2005, and has valuable organizational knowledge been lost.

Hall (2009) provides insight as to why there may be missing post-incident analysis. He discovered that even though there are no less than ten NFPA standards that mention a written post-incident analysis, most fire department personnel prefer not to conduct a formal post-incident analysis, opting for an immediate, informal review at the company level. These requirements from the NFPA are adequate for assessing the safety issues on the fireground, but for the post-incident analysis process to work in aiding organizational learning, it must be consistently applied. The MCFRS must assure that all appropriate major incidents are being reviewed using the established post-incident analysis process.

The MCFRS post-incident analysis process is comparable to the FEMA guidelines for post-incident analysis written by Ockershausen in 2008. These guidelines go beyond the safety implications of the NFPA standards, and focus review on most aspects of fireground operations, including incident command functions. The MCFRS *Post-Incident Analysis Package,* while older than the FEMA guidelines, has similar qualities in that both describe the specific conditions when a post-incident analysis is to be performed, and exactly what factors need to be

analyzed. The end-result is an action plan for the fire department leadership to formally adopt lessons learned.

There is similarity in the research results provided in the literature review. Williams' 2009 applied research project determined a consensus list of factors that would trigger a post-incident analysis, as does the FEMA guide and the list from MCFRS. Ward (2003) offered his recommendations as to the elements necessary for a comprehensive post-incident analysis, again similar to the FEMA guide and the list from MCFRS. Furthermore, Finucane (2009) shows that most fire department officials agree that conclusions from the post-incident analysis should form an action plan as the basis for revising SOPs. The MCFRS post-incident analysis process is similar in these aspects, but to provide maximum opportunity for organizational learning, the information from Williams, Ward, Finucane and others, along with the FEMA guidelines, might be considered when revising the MCFRS process to maximize data gathered during this learning process.

The United States military has a different take on the post-incident analysis, one seemingly adaptable by the fire service as done by the NWCG. The after-action reviews conducted by the United States Army and the after-action debriefing technique conducted by the various United States air forces are standardized processes used immediately after every combat, flight or training mission. Much like the fire department "hot wash," these after-actions reviews do not result in a formal, written analysis, but rather result in an immediate implementation of lessons learned via change in behavior on an individual, company and battalion-wide basis.

While the United States military after-action techniques differ from the formal MCFRS post-incident analysis process, the objectives are the same. Both set out to determine what was supposed to happen, what actually happened, why it happened, and how it will happen better

next time (Gavin, 2000). The STEALTH technique described by Murphy (2005) illustrates the root cause analysis process of an after-action review, where team members reveal errors and successes, determine causes and root causes, and then plan for improvement in the process for the next mission. Since the NWCG has taken the United States military approach and adapted it for the fire service, the MCFRS should evaluate further the merits of this technique as an alternative or concurrent approach to organizational learning. Certainly, if companies and battalions take it upon themselves to conduct a "hot wash" immediately after an active incident in an effort of self-improvement, then proven guidelines can be incorporated to assure the individual and organizational learning takes place.

The implication of these research results for MCFRS is that while meeting the NFPA standards and having similar characteristics to the FEMA guidelines, there is still room for process improvement. There are situations when a formal post-incident analysis is warranted, and the process needs to be updated and standardized. But the military-style after-action review is a tool with utility. It could be standardized into the MCFRS culture and taught to company-level and command officers, to supplement the formal post-incident analysis or injury investigation process. To enable organizational learning, the tools provided must be used constantly, when there are failures, as well as when there are successes.

After examination of the seven Mayday incidents in Montgomery County since 2005 for this applied research project, a considerable list of factors was produced that may have contributed to the Maydays and resulting injuries. The bar chart and Pareto analysis in the results section reveal that the most significant contributing factors include *fire conditions and effects on the structure, failure to maintain crew integrity,* and firefighting crews conducting *IDLH*

operations without a stand-by team in place, each taking place at 11.3% of the MCFRS Maydays.

The difficulty in producing and analyzing this data lies in the fact that the post-incident analyses and the injury investigation reports present mostly subjective data based on the authors' opinions. For this applied research project, the subjective data had to be categorized in order to conduct an objective analysis. After categorization, it was relatively easy to produce a list of contributing factors based on rate of occurrence in the Maydays. However, there was insufficient data and analysis provided in the reference documents to drill down to the actual root causes. This had to be left to a subjective interpretation of the narratives from the post-incident analysis and injury investigation reports. Thus, the direct causes of the Maydays can be stated to be *fire conditions and effects on the structure* at 71% of the MCFRS Maydays and *failure to maintain crew integrity* at 29% of the MCFRS Maydays.

The presentation by Bowers and Collins (2010) cited in the literature review was based on four Mayday events in Montgomery County and two Mayday events in Northern Virginia. The commonalities presented include the existence of lightweight building construction and materials; rapidly changing fire conditions, including rapid fire spread and flashover; and early structural compromise and failure. These three factors building upon one another in sequence (i.e, the building has lightweight construction, thus when a fire starts it spreads rapidly and leads to early structural failure). This chain of events is presented as the cause of the Maydays. This is similar to the 71% of the MCRFS Mayday events determined to be caused by *fire conditions and effects on the structure.* These findings together indicate that firefighters are entering residential structures where the fire has grown rapidly and compromised the integrity of the structure, leading to structural failure, firefighters falling through structural components or structural

components falling on firefighters, and thus firefighter injuries. The other most significant cause of MCFRS Maydays is *failure to maintain crew integrity*, and to a lesser extent *freelancing* and *poor unit and personnel accountability*. Bowers and Collins (2010) confirm this finding by reporting that one of the shared commonalities is poor personnel accountability and crew integrity prior to the Mayday.

Bowers and Collins (2010) also allude to the injury pattern of firefighters involved in these Mayday incidents. They cite that there was one firefighter fatality and thirteen firefighters with significant burns and musculoskeletal injuries. The results from this applied research project indicate that firefighters are receiving both musculoskeletal injuries and significant burns, due to injury causes of falling from a height (through compromised structural members), being struck by a falling structural member, and being caught in a flashover. The injury patterns confirm the discussed causes of Maydays as being most significantly *fire conditions and effects on the structure*, which lead to the burns and musculoskeletal injuries.

After reviewing the 48 MCFRS post-incident analyses from 2005 to 2010, a pattern emerges that is similar to the results found in the review of the MCFRS Mayday incidents. The intent behind this review was to determine if there were warning signs present from previous incidents that might have indicated impending Mayday incidents and firefighter injuries. There is evidence to suggest that some of the Maydays might have been avoided had these warning signs been heeded.

The most recurrent warning sign in the MCFRS post-incident analyses is *improper fireground operations*, which occurs in 20 out of 48 (41.7%) of the incidents and at a frequency of 30 times out of 198 warnings (15.2%). Other related warning signs mentioned include *SOPs not being followed* (18.8% of incidents) and *IDLH operations without stand-by team* (12.5% of

incidents). These were mentioned in the Mayday post-incident analyses as contributing factors to the Maydays and resulting injuries. Therefore, a significant amount of data exists, suggesting that these warning might have averted at least five of the Maydays.

The next most recurrent warning sign in the MCFRS post-incident analyses is *fire conditions and effects on the structure* (27.1% of incidents). This was the direct cause of five of the seven Mayday incidents. Other related warning signs are found in the post-incident analyses reviewed, including inadequate incident size-up, poor situational awareness, command and control issues, crews not familiar with buildings, poor risk/benefit analysis, and poor situation status reports to the incident commander. Collectively, these issues comprise 26.8% of the warnings signs found in the post-incident analyses, and should have been heeded to prevent the Mayday incidents. These warnings suggest that poor risk assessment and improper decisions by initial firefighting crews are placing them in harm's way, especially in fires that have compromised the structural components of buildings.

There were also issues related to *crew integrity* found in the review of post-incident analyses. *Crew integrity*, *accountability issues*, and *freelancing* occur in 16.6% of the collective warning signs. These warnings are also related directly as the cause of two of the seven Mayday incidents.

Not surprisingly, the recommendations made in the previous post-incident analyses did correlate with the warning signs and issues listed. Since *improper fireground operations* was the most frequently occurring issue, then a causal relationship leads to the recommendation to *improve fireground operations/tactics/tasks*, which is the most frequent recommendation. *Improve fireground operations/tactics/tasks* was in the top three recommendations. However, the most frequently occurring recommendation was *training on radio systems/fireground*

communications, which was not identified as a significant issue in either the Mayday reports or other post-incident analyses. Along with the recommendation to *improve fireground operations/tactics/task,* which constituted 25% of all recommendations, there were other related recommendation categories including improve incident command function at 25% occurrence and enforce/modify/train on SOPs at 20.8% occurrence.

The *fire conditions and effects on the structure* was listed as the most common cause of the Mayday events. However, the recommendation to *anticipate rapid fire spread and structural failure* was the least frequently occurring recommendation, at a 2.1% occurrence rate. This was surprising, given the fact that *fire conditions and effect on the structure* was listed as an issue 30 times and in 27.1% of incidents reviewed. There was one other related recommendation: to *conduct thorough initial incident scene size-up*. This should have directed the organization towards improvements in the risk assessment function prior to initiating interior, offensive fire suppression activities.

The *Standard Operating Procedure for Safe Firefighting Operations Review Panel* (MCFRS, 2009) was charged with reviewing previous Mayday incidents and incorporating those recommendations into an updated SOP. It may have been an error for this group not to include a review of all of the other previous post-incident analyses, which would have provided much information in the form of warning signs and recommendations to prevent Maydays from occurring again. However, the panel did list in its recommendations to mandate crew integrity and improve personnel accountability procedures, in addition to including procedures for a risk/benefit analysis.

There are significant implications for MCFRS in these findings. The pattern developing can place a root cause at the residential construction in Montgomery County. Not all of the

Mayday events involved fires in light-weight construction, but they did involve a rapidly growing fire that had consumed enough of the building components to causes structural failures at the moment firefighters have entered to conduct suppression operations. Therefore the root cause of this problem might not be the legacy issues of the building itself, but rather the inopportune time and reasons firefighters choose to enter the building. Firefighting has its risks, but it is the responsibility of the first arriving crews and the incident commander to perform an adequate size-up of the structure and fire situation; determine the need to enter the structure for rescue, confinement, and extinguishment; conduct a risk/benefit analysis prior to initiating tactical operations; and maintain a situational awareness of the effects the fire and suppression efforts are having on the building.

The results and discussion presented here bear a resemblance to the subject matter of the International Association of Fire Chief's (IAFC) Rules of Engagement Project (2010). *The Rules for Engagement of Firefighter Survival* are presented in Table 17, while *The Incident Commander Rules of Engagement for Firefighter Safety* are presented in Table 18. The Safety, Health and Survival Section of the IAFC produced these consensus model procedures in an effort to reduce firefighter fatalities and injuries. The underlying principle behind the rules is the "integration of the firefighter into the risk assessment decision making process… while still marinating command unity and discipline" (¶7). Even a cursory examination of these principles shows an alignment with the issues and recommendations pulled from the MCFRS post-incident analyses over the past six years. Examples of these correlations include conducting size-up of the incident, conducting a risk assessment, maintaining crew integrity and personnel accountability, and having a rapid intervention team in place. Certainly, the results of this applied research project prove the Rules of Engagement Project to be valid.

Table 17

The Rules for Engagement of Firefighter Survival

1.	Size-Up Your Tactical Area of Operation.
2.	Determine the Occupant Survival Profile.
3.	Do Not Risk Your Life for Lives or Property That Can Not Be Saved.
4.	Extend Limited Risk to Protect Savable Property.
5.	Extend Vigilant and Measured Risk to Protect and Rescue Savable Lives.
6.	Go in Together, Stay Together, Come Out Together
7.	Maintain Continuous Awareness of Your Air Supply, Situation, Location and Fire Conditions.
8.	Constantly Monitor Fireground Communications for Critical Radio Reports.
9.	You Are Required to Report Unsafe Practices or Conditions That Can Harm You. Stop, Evaluate and Decide.
10.	You Are Required to Abandon Your Position and Retreat Before Deteriorating Conditions Can Harm You.
11.	Declare a Mayday As Soon As You Think You Are in Danger

Table 18

The Incident Commander Rules of Engagement for Firefighter Safety

1.	Rapidly Conduct, or Obtain, a 360 Degree Size-Up of the Incident.
2.	Determine the Occupant Survival Profile.
3.	Conduct an Initial Risk Assessment and Implement a Safe Action Plan.
4.	If You Do Not Have The Resources to Safely Support and Protect Firefighters – Seriously Consider a Defensive Strategy.
5.	Do Not Risk Firefighter Lives for Lives or Property That Can Not Be Saved – Seriously Consider a Defensive Strategy.
6.	Extend Limited Risk to Protect Savable Property.
7.	Extend Vigilant and Measured Risk to Protect and Rescue Savable Lives.
8.	Act Upon Reported Unsafe Practices and Conditions That Can Harm Firefighters. Stop, Evaluate and Decide.
9.	Maintain Frequent Two-Way Communications and Keep Interior Crews Informed of Changing Conditions.
10.	Obtain Frequent Progress Reports and Revise the Action Plan.
11.	Ensure Accurate Accountability of All Firefighter Location and Status.
12.	If, After Completing the Primary Search, Little or No Progress Towards Fire Control Has Been Achieved, Seriously Consider a Defensive Strategy.
13.	Always Have a Rapid Intervention Team in Place at All Working Fires
14.	Always Have Firefighter Rehab Services in Place at All Working Fires

There is a solution to the problem of MCFRS having endured seven fireground Mayday incidents which have resulted in ten significant firefighter injuries since the implementation of the *Standard Operating Procedures for Safe Structural Firefighting Operations* in 2005. Initial arriving firefighters must follow the *Rules for Engagement of Firefighter Survival* by performing an adequate size-up of the building and situation upon arrival, by determining the occupant survival profile, by performing a risk/benefit analysis, by maintaining crew integrity, and by maintaining a constant situational awareness.

Recommendations

Gist provides an appropriate global recommendation for MCFRS to embrace, "to redefine ourselves as…learning organization, one that constantly transforms itself by systematically promoting the learning and growth of its members with respect to its mission... [moving] beyond planning and response to embrace each encounter as an opportunity to get better and grow stronger" (2010b, ¶ 26). The motivation behind this applied research project was to explore the idea that MCFRS was evolving into a learning organization, based upon the effectiveness of the post-incident analysis process. Unquestionably, the post-incident analysis is an appropriate tool to aid MCFRS in this pursuit.

Based on the results and discussion of the research presented, the following recommendations are made for MCFRS, or any other fire service organization experiencing similar problems:

1. The MCFRS should conduct a critical review and revision of its post-incident analysis process. This end result should be a stand-alone procedure, a *Standard Procedure for Conducting a Post-Incident Analysis*. This new procedure would be comprehensive, objective, and valid. It would assure that weaknesses as well as successes are identified.

The FEMA *Special Report: The After-Action Critique: Training Through Lessons Learned*. (Ockershausen, 2008) should be used as a guide.

2. The MCFRS should establish a Post-Incident Analysis Review Panel to conduct a peer review of each post-incident analysis before publication, much like the Executive Fire Officer Applied Research Project evaluation or peer-review for a medical or scientific journal. This would help eliminate bias, prejudices and unrelated opinions from surfacing, and assure objective, evidenced-based conclusions and recommendations from the author.
3. There are numerous NFPA Standards addressing or referring to a post-incident analysis, but not a single source reference for how a fire department should conduct a post-incident analysis. Therefore, the MCFRS should use its newly revised procedure as a model to lobby the NFPA to create a new NFPA standard, the *Standard Procedure on Fire Department Procedures for Conducting a Post-Incident Analysis*.
4. The after-action review process has been shown to be a valuable tool for the United States Military. And it has been adopted for use by the NWCG. Therefore, this informal process should be institutionalized into the MCFRS culture as a technique for company officers and battalion chiefs to perform “hot washes” after every incident.
5. The method of implementing recommendations from post-incident analysis needs to be standardized. Only actionable recommendations that will improve key processes should be accepted. These recommendations should be aimed at operational strategy and tactics, policies and procedures, and training. Each recommendation should be assigned to a senior staff officer, with a clear guidelines and a deadline established for implementation.

6. The method by which MCFRS shares its published post-incident analyses needs to be improved to assure that all MCFRS members not only have easy access to the documents, but also the ability to discuss the merits of the documents with peers. This would include sharing these valuable lessons-learned with other fire service organizations. Internet-based file sharing services and knowledge management systems, as well as social media services should be evaluated as possible solutions.
7. The results from this applied research project show the deficiencies in fireground risk assessment and risk/benefit analysis. The MCFRS should institute training programs and policy that assures compliance with the risk assessment portions of NFPA 1500 *Standard on Fire Department Occupational Safety and Health Program* and NFPA 1561 *Standard on Emergency Services Incident Management System*.
8. The MCFRS should re-direct the work of the *Standard Operating Procedures for Safe Structural Firefighting Operations Review Panel* with a focus on revising the SOP to include stronger mandates on conducting fireground size-up, risk assessment, risk/benefit analysis and preservation of crew integrity and personnel/unit accountability.
9. The MCFRS should incorporate into its doctrine and culture *The Rules for Engagement of Firefighter Survival* and *The Incident Commander Rules of Engagement for Firefighter Safety*. The IAFC Rules of Engagement Project provides solutions to the problems identified in this applied research project. First arriving firefighters must conduct an adequate size-up of the incident and a risk/benefit analysis based on an occupant survival profile prior to entering a structure for interior fire attack and rescue; they must have a rapid intervention team in place prior to entering the structure; they must maintain crew integrity and personnel/unit accountability while inside the structure; they must maintain

constant situational awareness of the fire, its effects on the building, and effects of fireground operations; and they must be ready to declare a Mayday when they are in danger.

10. The MCFRS should incorporate risk assessment into its command officer training programs and command officer competency testing programs. This training and testing is based upon the previous three recommendations: compliance with NFPA risk assessment standards, a revised *Standard Operating Procedures for Safe Structural Firefighting Operations* with an improved risk assessment component, and the adoption of the IAFC Rules of Engagement Program as MCFRS doctrine.

Based on the results and discussion in this applied research project, it becomes evident that more research needs to be conducted in the topic of post-incident analyses. It is recommended that future research include:

1. Evaluating the fire service organization's post-incident analysis process with the four comparison points used in this research to compare the MCFRS process with national standards and best practices. Those points include: 1) who conducts the post-incident analysis, 2) when a post-incident analysis required, 3) what significant factors are analyzed, and 4) how recommendations are presented.
2. Conducting a mega-analysis of other fire service organizations' post-incident analyses and National Institute for Occupational Safety and Health (NIOSH) *Fire Fighter Fatality Investigation Reports* to determine if the issues identified correlate to the key points of the IAFC's Rules of Engagement Program.

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Appendix A

Montgomery County Fire and Rescue Service

Mayday Incidents

December 2, 2005	3221 S. Leisure World Boulevard	Garden Apartment Fire
November 12, 2006	20720 Goshen Road	House Fire
July 19, 2007	12012 Claridge Road	Duplex House Fire
May 3, 2008	12819 Twinbrook Parkway	Garden Apartment Fire
October 2, 2008	219 Frederick Avenue	House Fire
May 2, 2009	14147 Castle Boulevard	Apartment Fire
July 11, 2009	8830 Piney Branch Road	Residential High-Rise Fire

Appendix B

Montgomery County Fire and Rescue Service

Post-Incident Analyses

January 27, 2005	2329 London Bridge Road	House Fire
March 23, 2005	1412 Hampshire West Court	Apartment Fire
April 14, 2005	1220 East West Highway	Residential High-Rise Fire
June 29, 2005	9204 Fall River Lane	House Fire
September 18, 2005	3417 Beret Lane	House Fire
November 5, 2005	28055B Ridge Road	House Trailer Fire
December 2, 2005	3221 S. Leisure World Boulevard	Garden Apartment Fire
December 8, 2005	3506 Taylor Street	House Fire
March 28, 2006	11924 Darnestown Road	Garden Apartment Fire
August 4, 2006	12851 Clopper Road	Commercial Structure Fire
August 7, 2006	2305 Georgian Way	Garden Apartment Fire
November 12, 2006	20720 Goshen Road	House Fire
November 15, 2006	18903 Lindenhouse Road	House Fire
December 4, 2006	243 Congressional Lane	Apartment Fire
January 16, 2007	11629 Drumcastle Terrace	Townhouse Fire
January 29, 2007	19568 Fisher Avenue	Townhouse Fire
February3, 2007	9819 Connecticut Avenue	House Fire
February 6, 2007	309 Market Street	House Fire
Febraury7, 2007	2437 Parallel Lane	House Fire

March 14, 2007	11202 Kennilworth Avenue	House Fire
May 7, 2007	3920 Baltimore Street	House Fire
June 26, 2007	106 Coydon Court	Apartment Fire
July 15, 2007	10334 Royal Woods Court	Townhouse Fire
July 19, 2007	12012 Claridge Road	Duplex House Fire
October 8, 2007	4988 Boiling Brook Parkway	Commercial Structure Fire
November 6, 2007	17121 Queen Victoria Court	Apartment Fire
November 7, 2007	5480 Wisconsin Avenue	Residential High-Rise Fire
November 30, 2007	5225 Pooks Hill Road	Apartment Fire
December 10, 2007	17804 Muncaster Road	House Fire
December 27, 2007	9132 Bobwhite Circle	Townhouse Fire
January 23, 2008	15 Gibson Place	House Fire
February 1, 2008	37 Cherry Bend Court	Townhouse Fire
May 3, 2008	12819 Twinbrook Parkway	Garden Apartment Fire
August 16, 2008	101 Odendhal Avenue	Residential High-Rise Fire
October 2, 2008	219 Frederick Avenue	House Fire
December 2, 2008	4806 Jamestown Road	House Fire
January 26, 2009	101 Walsh View Terrace	Apartment Fire
March 1, 2009	13248 Country Ridge Drive	Townhouse Fire
May 2, 2009	14147 Castle Boulevard	Apartment Fire
June 14, 2009	10237 Arizona Circle	Townhouse Fire
June 29, 2009	10109 Lorain Avenue	House Fire
July 11, 2009	8830 Piney Branch Road	Residential High-Rise Fire

August 17, 2009	324 E. Diamond Avenue	Apartment Fire
August 21, 2009	2025 Featherwood Street	Townhouse Fire
October 11, 2009	310 University Boulevard West	Church Fire
December 5, 2009	6822 New Hampshire Avenue	Commercial Structure Fire
December 8, 2009	13311 Woodruff Court	Townhouse Fire
April 5, 2010	9863 Brookridge Court	Townhouse Fire