Identifying an Evacuation Strategy for Norfolk Fire-Rescue's Highrise Operations

Drew Savage

Norfolk Fire-Rescue, Norfolk, Virginia

Certification Statement

I hereby certify that this paper constitutes my own product, that where the 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: _____

Drew R. Savage

Date: _____

Abstract

The problem was that Norfolk Fire-Rescue's (NFR) standard highrise procedures did not include a coordinated strategy for evacuation of building occupants. The purpose of this research was to identify recommended changes to NFR's standard highrise procedures and operations to address the coordinated evacuation of occupants. The research focused on three questions: (a) What problems are associated with evacuation of occupants during emergency highrise operations? (b) What are current industry recommendations for evacuation of highrise structures? (c) How do other fire departments address highrise evacuation in their policies, procedures, and incident command structure during emergency operations?

A descriptive process was used to review the current data and available case studies that reflect problems associated with evacuation of highrise buildings during emergency operations. The literature review also addressed recommendations for highrise evacuation. In support of the literature review and general research regarding evacuation practices and concerns, original research in the form of survey was conducted. This survey addressed the highrise evacuation policies, procedures, and command considerations of other fire departments during emergency operations.

Results stressed the value of an established plan for evacuation of occupants and the varied factors that complicate highrise evacuation. The literature review and survey also identified several items for NFR to implement. These recommendations included: (a) added preplan activities related to highrise systems and practices; (b) adoption of a phased evacuation strategy with defined terms and responsibilities; (c) development of scripted evacuation messages for use at emergency events.

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Introduction

The idea for this research project came from my direct observations during emergency responses for reported fires or alarms within highrise structures. On several occasions, occupants were witnessed scooting down a stairwell in a seated position with others attempting to carry walkers and other assist devices down with them. During these responses, it was noted the building was operating under a "total evacuation" model with many of the observed evacuees leaving their apartments on floors well below the reported emergency.

Based on these observations, the problem was NFR's standard highrise procedures do not include a coordinated strategy for occupant evacuation. This procedural exclusion sets the stage for an uncontrolled evacuation once the flow of occupants has begun and emergency operations are underway.

The purpose of this project was to identify recommended changes to NFR's standard highrise procedures and operations to address the coordinated evacuation of occupants. This project employed a descriptive research method to address the following questions:

1. What problems are associated with evacuation of occupants during emergency highrise operations?
2. What are the current industry recommendations for evacuation of highrise structures?
3. How do other fire departments address highrise evacuation in their policies, procedures, and incident command structure during emergency operations?

Background and Significance

The first highrise buildings were built in the United States (U.S.) in the late 19th and early 20th centuries (Bellis, n.d.). From that point, several engineering advances helped make their prevalence possible today. These advances included the invention of the elevator and air

conditioning and development of steel frames (Hassanain, 2009). Today highrise structures are common fixtures in many large and small communities throughout the United States.

According to the National Fire Protection Association (NFPA), 15,400 structure fires occurred in highrise buildings from 2007 to 2011 (Hall, 2013, p. i). Hall (2013) further reported that this number accounts for 3% of reported structure fires during that time frame causing:

- 46 civilian deaths
- 530 civilian injuries
- $219 million in direct property damage.

Within these statistics, four property use group classifications account for half of the fires in highrise buildings. These groups include:

- "apartment buildings (45%);
- hotels (3%);
- facilities for the sick (1%);
- offices (2%)" (Hall, 2013, p. 2).

As these statistics show, fires in this type of structure encompass only a small portion of the fire responses in the U.S. However, due to the building features and occupancy, these fires present unique challenges to emergent responders and occupants attempting to take protective actions and potentially evacuate. As noted by the United States Fire Administration (USFA), the two biggest priorities at highrise fires are suppression and evacuation with evacuation presenting "one of the biggest challenges to controlling the emergency" (United States Fire Administration [USFA], 1996, p. 21).

Norfolk, VA is a diverse city covering 66 square miles ("City of Norfolk Website," n.d.) with a varied mix of historical and modern architecture. Based on 2015 information, 92

buildings of various occupancy are interspersed throughout the city that meet Norfolk Fire-Rescue's highrise classification standard ("Emporis," 2015). As defined in NFR's operational procedures, any structure that is, "5 stories or greater in height" is classified as a highrise (Norfolk Fire-Rescue [NFR], 2010, p. 1). While these numbers are not staggering when compared to other U.S. cities, any fire within a highrise structure has the same challenges and risk potential to both the occupants and the responders to this non-routine event.

This research project was guided by instruction during the Executive Analysis of Fire Service Operations in Emergency Management course of the United States Fire Administration's (USFA) Executive Fire Officer Program (EFOP). The course challenged participants to address emergency events through preparatory actions and implementation of established practices to mitigate. This project addresses the goal of the course by identifying recommendations for changes to departmental policy and procedures. In addition to course goals, this project also addresses and satisfies Goal 1 of the USFA to "reduce fire and life safety risk through preparedness, prevention, and mitigation" (United States Fire Administration [USFA], n.d., p. 13).

Literature Review

Evacuation of a highrise structure presents a unique challenge. As noted by Crow (2008), "thousands of people could be in an enclosed structure from which there are very limited means of egress and in which the fire load is extremely heavy" (para. 1). In addition to the obvious challenge, multiple factors exist to complicate the process and pose hazards to the occupants and fire service personnel. To overcome these complications and reduce the risk of potential hazards requires a coordinated evacuation process with clear communication to the occupants of the structure.

Complications

Key factors that have the potential to impact all evacuation procedures are the building and the response by those that occupy the structure.

Building Use. At a high level, the type of occupancy presents several challenges and expectations. Ronchi and Nilsson (2013) noted, "the building use affects several factors concerning the egress performance of a high-rise building such as the design, the characteristics of the population, the training of the population, the staff available, the fire safety installations, etc." (pg. 4). Based on these criteria, they noted that office buildings generally present an open design which limits compartmentation; however, on site staff are available for assistance with fire protection system issues. The office setting also provides an occupant base that is ready to evacuate. Residential structures provide some compartmentation; however, occupants are not routinely prepared to leave and often reluctant to evacuate. These factors contribute to a longer pre-evacuation time. For health care facilities, the critical factors are the number of disabled occupants and the training level of staff (Ronchi & Nilsson, 2013).

Building Components. Two key building factors that the literature addresses with regard to impact on occupant evacuation are the primary egress method of stair use and the height of the building. Historically, the design of stairs for highrise structures was based on the maximum occupant load on a floor in the building or to accommodate the needed flow of evacuating a couple floors at once (Peacock, Kuligowski, & Averill, 2012). However, this design criteria does not account for factors present under emergent situations or larger scale occupant flow in response to the emergency. In addition to the physical design of the stairs and stairwell, the overall effectiveness is further impacted by factors such as the location of stairwells in the building and the number of available stairs (Peacock, Averill, & Kuligowski, 2009).

Further, the building height is also important due to the increased distance involved to safely evacuate as the number of floors increases. With this increased distance, physical limitations and fitness levels of occupants compound the effect of building height on the evacuation process (Fire Protection Association Australia [FPA Australia], 2009).

Occupant Behavior. Human behavior is a noted factor related to all fires and plays a role in emergencies within highrise structures. With regard to this observation:

> Human behavior studies indicate that the reaction of people to an emergency condition is related to a number of factors, including a person's assumed role, experience, education, and personality, as well as the emergency's perceived threat and the actions of others sharing the experience.
>
> *Assumed Role*. The role an individual plays has an impact on his or her reaction in the event of an emergency. Individuals in leadership roles will regularly take charge. Employees may follow the lead of their supervisor or a long-term employee. Visitors in a facility will typically be more passive and look for guidance from other occupants or staff.
>
> *Experience*. Previous experience in emergency situations may cause an employee to react faster than someone who has never had to evacuate a building under fire conditions.
>
> *Education*. Individuals who have participated in drills and received training in emergency response react faster and with better decision making than those without training. Investigative reports of the Peachtree 25th Building fire in Atlanta indicate that federal employees who had taken part in evacuation drills were better prepared than those from private businesses who had not participated in drills.

> *Personality*. The personality of an individual has an impact on how he or she will react in an emergency. Some individuals might attempt to fight the fire; others will attempt to escape immediately. Studies have shown that men are much more likely to attempt to fight the fire and women are more likely to leave the building as their first action.
>
> *Perceived Threat.* Before individuals begin to evacuate, they almost always seek to validate that there is, in fact, a problem. Unless there are obvious clues, such as smoke or visible flames, many people may not take immediate action in response to a fire alarm.
>
> *Actions of Others Sharing the Experience*. Individuals tend to function similarly to those they are with during the emergency. For example, if an individual panics, those around him or her are likely to do the same. Research indicates that panic appears to be very rare during emergencies, including life-threatening situations such as were found at the Beverly Hills Supper Club and MGM Grand fires. (Demers & Jones, 2001, p. 13-14)

With regard to the last factor, it has long been an expectation or assumption that humans panic during a fire. However, this assumption has been challenged as myth:

> Panic which supposes irrational behavior for a situation is rather atypical of human behavior in fire. On the contrary, people appear to apply rational decision making in relation to their understanding of the situation at the time of the fire. In retrospect, it is easy to point to some decisions that were not optimal and played a negative part on the outcome of a fire; however, at the time of the fire these decisions were rational when all factors were considered. (Proulx, 2001b, p. 2)

Proulx (2001b), stated that in the absence of occupant panic, behavior is driven by three major elements, “the occupant characteristics, the building characteristics, and the fire characteristics” with numerous subcategories of varied factors (p.3). Proulx further stressed that

determining behavior based on these characteristics is difficult because factors, “are mixed in different patterns according to each situation” (p.5).

A specific area where the factors driven by human behavior have a potential impact on the evacuation operation is the decision of occupants to respond to the suspected or reported emergency. According to Proulx (2001b), the delay to start evacuation has been studied based on drill analysis and follow-up interviews with victims of an actual event. Based on this research, delays should be expected with occupants spending time investigating and attempting to determine if the emergency is real and then engage in preparatory routines such as, “finding children, pets, or even valuables before deciding to evacuate the building” (Proulx, 2001b, p. 6).

Another factor common to case studies of fatal fires, is the prior experience of occupants with nuisance or false alarms. In 1989, 16 residents of a highrise building for the elderly perished in Tennessee. As with most incidents, the factors and conditions that allowed the fire to progress were complex; however, it was noted the building had a history of false alarms that may have caused a lack of concern and sense of urgency to evacuate (United States Fire Administration [USFA], 1989). More recently at a fatal fire in San Antonio, TX, occupants reported a lack of urgency to evacuate due to the repeated false alarms in the building ("False alarms preceded fire," 2015).

Evacuation Hazards

Hazards associated with the evacuation process of highrise buildings are varied and have implications whether occupants follow evacuation procedures or ignore provided signs and direction. The 1980 MGM Grand fire in Las Vegas resulted in fatalities on upper floors remote from the fire after delays in the alarm system sounding and people remaining on the upper floors after noting the alarm. In contrast, four fatalities occurred in the stairwell of the West 60th Street

Towers in Manhattan in 1998. These occupants came from upper floors in the building attempting to evacuate a 12th floor fire ("Evacuation message strategies," n.d.). These cases present the risks in these structures and the challenge of selecting an evacuation strategy and directing its implementation. "In MGM, perhaps more occupants would have survived had they heeded the sound from the delayed alarm and evacuated the building. In New York, the occupants were better off had they stayed in their dwelling units" ("Evacuation message strategies," n.d., para. 7). The risks related to remaining versus evacuating was also demonstrated earlier in 1985 by MacDonald (as cited by FPA Australia, 2009). This analysis was the result of a review of multiple case studies for fires in highrise structures. From this analysis, "MacDonald indicated that of 160 fatalities, 117 died attempting to evacuate and 36 died by not evacuating (the other fatalities were not able to be determined)" (FPA Australia, 2009, p. 109). In a more recent case study from New York City, one adult male died and another critically injured as they evacuated via a stairwell and encountered smoke from a fire 18 floors below their apartment (Schwitz, 2014).

Aside from documented fatalities, evacuating occupants are also at risk for injuries from common events like slips, trips, and falls. Further, those occupants with underlying health issues are at increased risk for health related events from the exertion required to exit a highrise structure (FPA Australia, 2009).

Evacuation Strategies

Depending on source, different names have been applied to a variety of strategies designed to accomplish the task of highrise evacuation. According to Harrington, "two basic occupant-protection strategies are evacuation—either total or staged—and defend-in-place" (Harrington, 2005, p. 1). Ronchi and Nilsson summarized four options for strategic

consideration, “(1) total evacuation (or simultaneous full evacuation), (2) phased evacuation, (3) defend-in-place and (4) delayed evacuation” (Ronchi & Nilsson, 2013, p. 9). As noted, sources reviewed for this research presented different variations of evacuation strategies that combined some classifications and simplified the distinction. In an effort to provide a comprehensive discussion of available strategies, four classifications are discussed.

Total evacuation. This technique was described by Hassanain (2009) as simultaneous evacuation of the structure by all occupants in response to an alarm system activation. While straightforward in nature, this strategy presents several concerns. Congestion in the evacuation routes can delay overall evacuation as all occupants attempt to reach safety at once. Further, many occupants may be leaving an area that presented no immediate hazard due to the building structure and location of the fire. Once evacuated, repopulation of the building also becomes a concern as building design does not account for all occupants arriving at one time ("Evacuation message strategies," n.d.).

Phased evacuation. A phased approach involves evacuation priority going to the most critical floors while other occupants are delayed to reduce congestion and maximize occupant flow from the building (Ronchi & Nilsson, 2013). While effective, this approach takes coordination and is reliant on additional factors such as fire protection systems to maintain compartmentalization, means of communication within the building, and building staff training levels (Luo & Wong, 2006). After the evacuation of those floors in immediate danger, continuous monitoring of the incident is critical to determine if additional floors and occupants require evacuation (Harrington, 2005).

Defend/Protect-in-Place. This strategy operates on the premise that occupants not in the compartment of origin are safer to keep their door closed and await rescuers (Ronchi & Nilsson,

2013) and includes theory tied to the phased evacuation. The Fire Protection Association (FPA), Australia noted:

> Protect-in-place is a concept of occupants not evacuating initially on being alerted of a fire, as they are not directly at risk from the fire or smoke. Protect-in-place does not mean that occupants do not exit at all. It may mean a delay in exiting until safe to do so for many occupants. For others, it may mean no evacuation as there is no requirement to do so. (Fire Protection Association Australia [FPA Australia], 2009, p. 109)

In order to implement this approach, Proulx proposed specific criteria to guide the decision-making. This criteria included:

- The building should be above 6 stories in building height since evacuation of lowrise buildings is usually faster in terms of travel distance.
- This approach should be implemented only in residential, hotel, and dormitory buildings where occupants are located in enclosed compartments. In such compartments, occupants typically have access to tools for protect-in-place activities and they have access to a telephone and a window or balcony to identify their location.
- The building should be of non-combustible construction.
- Self-closers should be installed on all entry doors.
- A central alarm system should be present to warn occupants of the occurring fire.
- Finally, a voice communication system is indispensable to inform occupants of the fire, to provide them with information on the evolution of the event and to give them tips on protect-in-place activities they should be carrying out. (Proulx, 2001a, p. 10)

With this approach fire service personnel expect occupants to be in their units and life safety is provided by buildings systems and suppression by fire service personnel (FPA

Australia, 2009). This approach provides further merit when addressing those occupants with disabilities. For these residents, staying in place or moving to a safe area limits their travel and resources required to assist. Proulx and Yung (1996) considered this concept of areas of safe refuge a variation of protect-in-place.

With regard to protect-in-place, McGrail (2007) stressed the increased value of this strategy for residential structures that offer compartmentalization over commercial structures. Due to the design features of commercial structures with a general lack of compartmentalization, more floors will need initial evacuation. For these structures, McGrail presented the "three floor rule" where evacuation includes, "three below, three above, and the top three, for a total of nine floors, initially" (McGrail, 2007, p. 230).

Dunn (2003), further broke down defend-in-place into total and partial applications of the concept. For fires in highrise office buildings, he noted agreement for partial defend-in-place based on fire location and those floors in most imminent danger. However, for residential highrise buildings, a total defend-in-place strategy is possible if the door to the unit of fire origin was closed after occupant exit. The theory being occupants are safe in their apartments and the IDLH components remain isolated within the apartment of origin (Dunn, 2003).

Delayed evacuation. Ronchi and Nilsson (2013) defined the concept of areas of refuge/rescue assistance as a separate approach from protect-in-place. With this approach there is a deliberate delay as part of the overall strategy. Based on their research, this approach is recommended for buildings with large numbers of occupants with disabilities such as health care facilities. Hassanain (2009) provided two potential variations for implementation where occupants are moved to either an adjoining safe zone on the same horizontal level or a zoned approach based on the location of emergency.

Dunn (2003) noted the horizontal evacuation of people as an effective strategy for buildings with separate fire resistive sections such as hospitals, jails, etc. If a fire occurs in one section, occupants are moved to another fire resistive section and the fire rated door closed. This approach could then progress with a later movement of people out of the building or remaining in place as dictated by the incident and conditions.

Strategy Recommendations

As noted, a variety of evacuation strategies exist with pros and cons to be considered based on the numerous factors present at a reported emergency in a highrise structure. Whatever strategy is employed it must be controlled with specific direction communicated to the occupants (McGrail, 2007).

The United States Fire Administration (USFA) provides the following reasons for relocating occupants within the structure and implementing a strategy that limits the number of occupants attempting to exit the building:

- "prolonged removal times;
- insufficient stairwell design for the occupant flow;
- reduced potential for injury to evacuees;
- efficiency of firefighting operations" (Department of Homeland Security, United States Fire Administration [DHS-USFA], 2006, p. 4-9).

To address these concerns, the USFA recommends initial evacuation of the fire floor and two floors above. Floors that are three above and those below the fire floor are directed to remain in place under these recommendations (DHS-USFA, 2006). The NFPA further stressed this practice through guidance for:

> The occupants of the fire floor and floors immediately above and below it should immediately use the exit stairs to descend to a floor level that is at least a few floors below the fire floor. The occupants can then reenter the occupied space on those safe floors to await further instructions. ("NFPA building evacuation FAQs," 2015, para. 5)

Communication

Today's highrise buildings have the potential to challenge our ability to transmit critical evacuation instruction and information to occupants. However, the value of this information cannot be overstated. McGrail (2007) noted, "this is a very important aspect of our overall operations and can truly save countless lives when factual information and instructions are communicated to building occupants, and then followed by these occupants" (p. 317).

With regard to information communicated to the occupants, it is necessary to understand what information the building's management or automatic alarm system transmitted prior to fire department arrival. This knowledge can be gained through preplan efforts and discussions with building personnel. Fire department personnel will then build on this message to keep occupants informed on progress of activities and direct their evacuation. The use of these systems gives fire department personnel, "an opportunity to provide important information and attempt to establish and maintain an orderly, systematic, and appropriate movement of building occupants" (McGrail, 2007, p. 318).

Critical information will vary with each highrise event; however, certain key elements are common to all emergencies within highrise buildings. McGrail (2007) expressed the value of building communication systems to provide direction to occupants to either evacuate or protect-in-place as well as the location of the stairwell dedicated to occupant evacuation. Despite incident variables, common communication elements exist:

> When a fire is reported on any floor, several messages need to be transmitted. The occupants of the fire floor need to be told the facts and instructed where to go. The adjacent floors need to be cleared, and thus their occupants must also be given instructions. And finally, a message must be broadcast to the "receiving" floors where the occupants of the evacuated areas are sent." (Keating & Loftus, 1977, p. 25-26)

By transmitting information and providing updates to building occupants, fire department personnel can attempt to control the evacuation. This provides value with regard to maintaining operational efficiency and also occupant safety. Further, information plays a vital role in determining occupant behavior and response to the report or suspicion of a fire or other emergency within highrise buildings. With regard to the type of information received, a verbal message through a communication system prompts a more immediate response by occupants to follow established procedures or initiate directed evacuation (Proulx, 2001b).

Further, the value of voice messaging has driven code development as well as building systems design with many building, fire, and life safety codes requiring voice systems to help guide evacuation in structures where egress could be complex ("Combining emergency and nonemergency voice systems," 2004).

Summary

The literature review identified the challenges associated with highrise evacuation and also showed the varied strategies available to address this task. As noted the building and occupancy use provide factors that both help the process and potentially hinder a smooth operation. In general, the phased approach was most common with movement of occupants either from the building or to areas determined to be safe based on the location of the emergency. This information is useful to the research given the value placed on identifying the at-risk

locations and then controlling the flow of occupants. The guidance for and value of the remaining occupants to defend-in-place was also present in the review. Most references presented scenarios where a phased evacuation employs defend-in-place as an accompanying tactic. The information obtained from this literature review will directly affect the recommendations from this research given the detail of the expected complications and common practices to take control through a phased strategy with others seeking protection in place at the time of emergency.

Procedures

Throughout this research the descriptive method was used to examine the impact of evacuation procedures on operations in highrise buildings and the recommendations and practices of other fire departments to address evacuation. Details for each of the identified research areas follow:

Question 1: What problems are associated with evacuation of occupants during emergency highrise operations?

This question was addressed through the literature review which began at the Learning Resource Center (LRC) at the National Fire Academy (NFA). Several catalog search methods were included for broad and then more specific resources. Additionally, an internet-based search was conducted using Google to again identify and review available resources and case studies from actual events. General baseline searches were conducted for highrise evacuation related topics. A search of the NFA LRC produced several items of value; however, the bulk of the resources were identified through the internet-based search using Google.

Question 2: What are the current industry recommendations for evacuation of highrise structures?

The literature review served to identify the accepted and varied evacuation strategies that are in use today. This review also provided insight regarding the advantages and disadvantages of each approach along with the recommended application based on the type of occupancy. Specific guidelines for the implementation of the varied strategies such as the specific floors to consider for evacuation and those to defend-in-place were also available in the selected literature. Further, the review included recommendations from respected fire service organizations as well as subject matter experts that are known for their expertise with regard to highrise operations.

Question 3: How do other fire departments address highrise evacuation in their policies, procedures, and incident command structure during emergency operations?

An internet search was conducted using Google to identify U.S. cities that have the largest number of highrise buildings. After the general search, the website *www.skyscraperpage.com* was selected as the reference source regarding highrise buildings in the United States. The most comprehensive listing from this resource identified the "top 25" U.S. cities based on their number of highrise structures. Based on this information, fire departments within those cities and their surrounding areas were selected for inclusion in an online survey using the website *www.surveymonkey.com*. The survey consisted of 13 questions. Several questions were general in nature and addressed the responding department's overall approach to highrise operations. These questions were intended as reference material and not for direct inclusion in the results of this research. Additional questions were specific to evacuation practices and considerations during an emergent response within this type of structure. The questions were set up for selection of direct responses such as (a) *yes*, (b) *no*, or (c) *not applicable* with space provided for additional details. Several questions were set up to only solicit open ended responses.

Respondents from the identified departments were selected based on personal contacts and a search of a fire department directory on the website *www.firefightingnews.com*. Telephone calls were made to update or confirm contact information collected from the web site. For several departments, general department email addresses had to be used after unsuccessful attempts for a direct contact. Once all respondent email addresses were collected, the survey was distributed for online participation. If the direct contact was not provided during the phone inquiries, the email notification requested forwarding of the survey to the appropriate individual to best address the survey content. 33 invitations for participation were forwarded to the selected departments. Of the 33, four came back as undeliverable and repeat contact was not successful. Based on those that were deliverable, the total survey pool for this research was 29 fire department participants. At the close of the response window, all responses were reviewed including statistical data for the direct questions and a review of all open-ended comments.

Limitations

The return rate for survey responses was low. The selection criteria was specific to those departments most likely to have experience and documented procedures for highrise operations based on the number of structures in their response area. Based on the number of return responses, an expanded pool may have provided a greater response to evaluate for the research; however, the survey results were aligned with strategies and recommendations noted in the literature review.

Results

Overall the research satisfied the selected objectives for this project. The complex task of highrise evacuation was evident in both the review of available resources and the varied ways fire departments address this challenge.

Literature Review

The literature review provided adequate coverage of the first two questions as outlined in the selected procedures. The available resources provided both a historical perspective and current view of the factors that complicate this difficult task and also those elements required to help facilitate a positive outcome. Available strategies were clearly detailed with multiple resources providing both advantages and disadvantages of each.

Fire Department Survey

Of the departments contacted for participation in the online survey, five responses were received. The survey questions provided opportunity to collect general background information related to highrise operations as well as specific information related to evacuation procedures. All respondents reported having a policy that directed operations in a highrise structure. They also reported having direction in their respective policies for a coordinated evacuation of occupants and operational considerations to accomplish this task.

Question 5 addressed the specific direction included in their policy to coordinate evacuation. All responses had a common theme with some variation in floor selection and implementation. For all responses, the floor of origin was included in initial evacuation. Several respondents included additional evacuation variations of floors in close vicinity as follow:

- fire floor and floor above;
- fire floor and 2 floors above;
- fire floor and 2 floors below.

One respondent reported a staged response beginning with the fire floor and two floors above. Additionally, any floors above or below with reported products of combustion were evacuated

and then all floors from the top down. One final respondent reported evacuation of the "affected floor."

Questions 6 and 7 addressed sheltering-in-place as part of evacuation strategies. Of the respondents, 80% reported that sheltering-in-place is addressed in their departmental policy as an option during evacuation procedures. One respondent reported that the implementation strategy is predetermined based on pre-plans and available on apparatus mobile computers. If a pre-plan were not available the plan is at the discretion of the Incident Commander. This is in line with the responses provided by the other respondents who reported the decision was at the discretion of the Incident Commander and based on the situation.

Questions 8 and 9 addressed the use of verbal announcements provided by the fire department to advise occupants of the status of the emergency and direct the evacuation plan. 60% of the respondents reported they do provide formal, scripted announcements during emergent operations in highrise buildings.

To determine how evacuation procedures factor into the operational structure at an incident, Question 10 covered personnel assigned to this task. All respondents reported that specific personnel are assigned to address the evacuation of occupants. Two respondents reported the establishment of an Evacuation Group with a supervisor responsible for the operation. Two additional respondents stated the task falls to ladder or squad companies. One of these two provided specific information that stated evacuation of the fire floor is assigned to the first arriving ladder. The final respondent reported that companies are assigned to the stairwell to assist occupants and operate under the designation Stairwell Division.

Questions 11 addressed specific policy guidance for evacuation of occupants with disabilities. 40% of the respondents reported their standard procedures address disabled

occupant evacuation. One respondent reported that their Fire Prevention Bureau works with all highrise occupancies to address methods for evacuating occupants with disabilities. During emergent operations, their procedures allow for removal by fire personnel via elevator if conditions permit. Otherwise, sheltering in the stairwell until personnel can remove is considered. Another respondent reported their actions are guided by a Special Needs List. Specific details were not provided as to whether this was a needs-based action list or building specific reporting the existence of special needs occupants.

Question 13 involved whether departments distinguish between commercial and residential structures in their policy and procedures. 80% of the respondents reported they do not make a distinction. One respondent stated that despite the lack of a determination there is a conscious effort to train personnel on the characteristics of each occupancy and the potential differences in building design. Additional details from the respondent that reported their department does distinguish between the two were not provided.

Discussion

Numerous case studies document the severity and challenge of fighting a fire in a highrise building; however, a majority of the fire service has no first-hand experience with the strenuous task of operating under IDLH conditions in this type of structure. Crow (2008) stated, “even though highrise fires can be the most challenging and dangerous, they are among the least frequent types of fires to which we respond” (para. 1). Conversely, occupants are also unlikely to have experienced a true event and their performance and actions in an emergency will be based on the complex interplay of factors that affect behavior (Proulx, 2001b).

The challenge to the fire service is to adopt the proper strategy to help facilitate a safe evacuation of the occupants and a successful operation. According to the USFA, this strategy

should be driven by policy, and "SOPs should emphasize the importance of making a decision in the early stages about whether firefighters should concentrate on suppressing the fire or helping occupants out of the building" (DHS-USFA, 2006, p. 21). In most instances, these tasks will occur simultaneously. The simultaneous challenge of these two critical tasks reinforces the necessity for a controlled and appropriate evacuation.

The concept of total evacuation presents challenges based on building factors and potentially places occupants at unnecessary risk. As noted by the USFA (2006), this evacuation could take hours. Further, the task of leaving the building may be beyond the physical capabilities of the occupants and also an unfamiliar practice. Blossom (2002) noted that building conveniences such as elevators have made stairwell use uncommon. Occupants may know where they are; however, regular use is rare. In a survey conducted by the Fire Protection Research Foundation, "just less than half of residents reported they had never walked completely out of their building" (Zmud, 2007, p. 15).

With total evacuation both impractical and potentially creating added risk, the removal of those in most danger is warranted under a phased evacuation. As noted in the survey results and supported by research, the distinction of those at most risk provided some variation for implementation. However, the majority of respondents and other sources were in line with evacuation of the fire floor, the floor above, and one below as recommended by the USFA (DHS-USFA, 2006). Variations occurred with regard to additional floor considerations for initial removal.

For those not initially evacuated, the strategy to protect/defend-in-place is a viable option. This concept has the occupants remaining in their dwelling unit and awaiting direction from the fire department or other officials (Ronchi & Nilsson, 2013). Prior training and direction for

procedures to best provide personal protection under these conditions is vital; however, self-protective measures are also intuitive when presented with IDLH conditions. Zmud (2007) noted, "if significant smoke was outside their door, two-thirds (61 percent) of respondents indicated they would not open the door to evacuate, and most would isolate themselves in a room and seal cracks to keep the smoke out" (pg. 15). With occupants safely within their units, the building features provide protection along with the activities to contain and extinguish the fire by fire department personnel (FPA Australia, 2009).

Whatever strategy is selected, communication is going to be vital to help control and manage the process (McGrail, 2007). Highrise buildings both commercial and residential should have functioning communication systems. Use of this system is vital to keep occupants informed on the status of the emergency and provide direction for evacuation. This is identified as a specific task for the supervisor responsible for the evacuation efforts under the expanded Incident Command System (ICS) for highrise operations under the National Incident Management System (NIMS) (National Incident Management System [NIMS], 2007). The amount of information and frequency of messages will depend on the incident and progress of activities related to the event. However, several key pieces of information seem logical:

- general announcement to building the fire department is on scene;
- specific details regarding the type of emergency and location within the building;
- direction for evacuation of specific floors based on selected evacuation strategy;
- direction for those occupants not directed to evacuate;
- ongoing status and repeated direction as needed;
- notification when emergency has been mitigated and building is clear (FPA Australia, 2009).

With regard to evacuation direction, McGrail (2007) notes, “of utmost importance is the need to direct occupants to the evacuation stairwell” (p. 231). This designation should be made by initial companies as directed by department policies and procedures. This specific direction will help minimize interaction between the occupants actively leaving the structure and fire personnel attempting to mitigate the emergency.

These results stress the importance of controlling the process and keeping the occupants informed with accurate information and direction to guide the operation. While each event will have variables that direct the specifics of information presented to the building occupants, the framework for initiating the evacuation process and benchmarks for occupant information are well documented. By having these components available in departmental procedures is of value to help avoid the reactive response when a true highrise event is realized. The research shows that standard strategies and implementation recommendations do exist and are supported by those entities with the knowledge and expertise in this operational area. Therefore, these results have merit for further consideration with regard to NFR’s highrise policy and procedures.

Recommendations

The purpose of this research was to identify recommended changes to NFR’s current highrise operations policy and procedures to provide direction for coordinated evacuation of these structures during emergent operations. While the research identified several areas for change, several recommendations require further discussion based on the varied approaches presented in the literature review and survey with regard to implementation of specific strategies. The following recommendations should be considered to help establish a framework for occupant evacuation during these critical, low frequency events.

Strategy Selection

The research shows that defend-in-place practices work in highrise structures. NFR should identify parameters to implement phased evacuation of highrise structures to avoid the complications of total evacuation. These parameters should outline which floors to evacuate in relation to the reported floor of origin for the emergency. As noted in the research and fire department survey results, there are multiple approaches implemented in the fire service today. NFR will need to conduct further discussion to select the appropriate strategy and implementation guidelines; however, the practice of initially evacuating the fire floor, floor above, and floor below are recommended as the basis for future discussions. These discussions should also address any variations based on occupancy. As the research showed, there are considerations specific to the occupancy that will guide operational decision-making as well as occupant response.

Terminology Awareness

In order to address evacuation procedures, common terminology needs to be in place and understood by all decision makers. Key terms for NFR's selected evacuation strategy need to be selected for inclusion in NFR's policy and procedures and defined (*i.e.,* total evacuation, phased evacuation, defend/protect-in-place, etc.). This terminology should also be clearly defined as part of the strategy through a training outlet to address approved changes to NFR's highrise operations.

Preplan Considerations

A vital component with evacuation of highrise buildings are the actions taken by occupants prior to fire department arrival. NFR currently has a robust preplan program with information available for many buildings on apparatus computers. Information specific to the

building's evacuation procedures would be helpful for inclusion in this preplan information. Specifically, whether the building practices "total evacuation" or some form of phased evacuation with other occupants defending-in-place. This information will be helpful for follow-up communication and direction by NFR personnel.

In order for NFR personnel to communicate with occupants and provide further direction, knowledge of the building's communication system is required. The type of communication system and location of the main communication controls are recommended for inclusion in preplan data gathering and dissemination.

Communication Messages

NFR should develop scripts for common scenarios during highrise operations. These scripts should address the necessary information to provide occupants to direct evacuation based on the floor of origin. These scripts should cover possible scenarios for the expansion of a phased evacuation as well as informational messages for occupant reassurance such as status of the emergency and fire department response.

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Appendix A: Fire Department Survey Results

Question 1 was for tracking and administrative purposes and omitted from this research.

Question 2

What are your initial and additional alarm responses for a fire in a highrise? Please describe below:	
Answer Options	**Response Count**
	5
answered question	**5**
skipped question	**0**

Number	Response Date	Response Text
1		See procedures to follow Alarm: 2-Engines, 1-Truck, 1-Chief Possible: 4-Engines, 2-Trucks, 1-Rescue (2 person ALS), 1-Squad (4-5 TRT), 2- Chief, 1-Command Unit
2		4 Engines, Two Trucks, Two Battalion Chiefs, One Squad, Safety Chief Greater alarms consist of the Shift Commander, 3 Engines, 2 Trucks, and 1 Battalion Chief.
3		We assign a "highrise response" to initial alarm. 3 engines 2 trucks. Once a working fire is assigned an additional 2 pumps and ladder truck.
4		AFA =2Engs, 2Trks, 2Chiefs, 1 Medic
5		Fire=3Engs,3Trks, 1Squad, 3Medics, 5 Chiefs

Question 3

Does your department have a policy or procedure for emergency operations in highrise structures?		
Answer Options	**Response Percent**	**Response Count**
Yes	100.0%	5
No	0.0%	0
answered question		**5**
skipped question		**0**

Question 4

Does your policy provide direction for coordinated evacuation of occupants?		
Answer Options	**Response Percent**	**Response Count**
Yes	100.0%	5
No	0.0%	0
answered question		**5**
skipped question		**0**

Question 5

Does your policy provide specific direction regarding which floors to evacuate (e.g., 2 floors above reported incident)?		
Answer Options	**Response Percent**	**Response Count**
Yes	100.0%	5
No	0.0%	0
If Yes, please describe below:		5
	answered question	**5**
	skipped question	**0**

Number	Response Date	If Yes, please describe below:	Categories
1		Yes 2 floors below fire floor	
2		Fire floor, 2 above fire floor, Any floors above with products of comb., Any floors below with products of comb., All floors starting at the top and moving down.	
3		Evacuation is coordinated with occupancy Floor Wardens. The evacuation stairwell is identified so that fire suppression personnel may utilize stairwells not being used for evacuation. Typically, the floor of origin, floor above, and floor below are evacuated initially. Additional floors are evacuated based on incident needs.	
4		Evacuate the fire floor and above first.	
5		Effected Floors	

Question 6

Does your policy address sheltering-in-place as an option?		
Answer Options	**Response Percent**	**Response Count**
Yes	80.0%	4
No	20.0%	1
	answered question	**5**
	skipped question	**0**

Question 7

Does your policy provide specific direction for which floors to shelter-in-place? Please describe your procedure below.		
Answer Options	**Response Percent**	**Response Count**
Yes	40.0%	2
No	60.0%	3
If Yes, please describe below:		3
	answered question	**5**
	skipped question	**0**

Number	Response Date	If Yes, please describe below:	Categories
1		Depending on the location and extent of the fire those 4 or more floors below the fire floor in a 72 story building could be asked to shelter in place. We allow our Incident Commander to make the decision.	
2		Sheltering in place is occupancy dependent based on the facility's ability to shelter people. This is pre-determined through pre-incident inspections and the plan resides on apparatus mobile computers or the shelter in place option is applied while on-scene without the benefit of a pre-incident plan.	
3		Situational	

Question 8

Does your department provide verbal announcements to direct evacuation of occupants during emergency operations?		
Answer Options	**Response Percent**	**Response Count**
Yes	60.0%	3
No	40.0%	2
answered question		**5**
skipped question		**0**

Question 9

Does your department have formal, scripted announcements for various highrise incidents?		
Answer Options	**Response Percent**	**Response Count**
Yes	60.0%	3
No	40.0%	2
If Yes, please describe the announcements and units responsible for delivering:		3
answered question		**5**
skipped question		**0**

Number	Response Date	If Yes, please describe the announcements and units responsible for delivering:	Categories
1		"Your attention please. This is not a drill. This is Firefighter Doe of the Fire Department. There is a fire on the 8th floor. The fire department is here. Please remain in your present location until the fire department instructs you to do otherwise. The Fire Department will have to use the stairwells for firefighting operations. You are in more danger if you leave your present location now."	
2		The Bureau of Fire Prevention works with every occupancy to ensure evacuation messages are appropriate. The announcements are pre-recorded, however most high rise occupancies can also provide dynamic announcements.	
3		Situational	

Question 10

Are specific resources assigned to address occupant evacuation?		
Answer Options	**Response Percent**	**Response Count**
Yes	100.0%	5
No	0.0%	0
If Yes, please describe these resources and responsibilities below:		5
answered question		**5**
skipped question		**0**

Number	Response Date	If Yes, please describe these resources and responsibilities below:	Categories
1		If needed we would establish a evacuation group and assign a supervisor an staff the group as needed.	
2		An Evacuation Group supervisor is assigned	
3		During evacuations, fire companies are assigned to the stairwells to assist occupants. The typical call sign is Stairwell Division.	
4		first arriving ladder company evacuation of fire floor, second arriving ladder company evacuation of the floor above	
5		Assigned Truck and Squad Companies.	

Question 11

Does your policy address evacuation of occupants with disabilities?		
Answer Options	**Response Percent**	**Response Count**
Yes	40.0%	2
No	60.0%	3
If Yes, please describe these considerations below:		2
	answered question	**5**
	skipped question	**0**

Number	Response Date	If Yes, please describe these considerations below:	Categories
1		The Bureau of Fire Prevention works with every high rise occupancy to educate how to evacuate people with disabilities. Elevators may be used in the firefighter mode by our personnel, however a more likely scenario is sheltering the stairwells until firefighters arrive to assist down the stairs.	
2		Via a "Special Needs List"	

Question 12

Does your department assist facilities with development of evacuation plans and strategies?		
Answer Options	**Response Percent**	**Response Count**
Yes	60.0%	3
No	40.0%	2
If Yes, please describe this process below:		3
	answered question	**5**
	skipped question	**0**

Number	Response Date	If Yes, please describe this process below:	Categories
1		Our Inspection Division is available upon request.	
2		The Bureau of Fire Prevention assists every high rise occupancy with developing evacuation plans while the Operation's division ensures that the plans are practical through annual evacuation drills.	
3		FPB	

Question 13

Does your policy distinguish between residential and commercial highrise structures?		
Answer Options	**Response Percent**	**Response Count**
Yes	20.0%	1
No	80.0%	4
If yes, please describe procedural considerations below:		2
	answered question	**5**
	skipped question	**0**

Number	Response Date	If yes, please describe procedural considerations below:	Categories
1		Any structure 4 stories or more is treated as a highrise. However, we do train to understand the different challenges that each occupancy poses and the significant differences in center-core vs center-hall design. Center-core buildings were historically commercial while center-hall were typically residential. With many high rise occupancies being converted from commercial to residential, this may not always be as apparent today though.	
2			