FAILING TO PLAN IS PLANNING TO FAIL: CAPTURING THE PRE-INCIDENT PLANNING NEEDS OF FIREFIGHTERS

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In a fire suppression operation, seconds can mean the difference between a fatality or successful incident management. There have not been many recent studies that examine the information, tools, and technologies firefighters rely upon to gather facts about the incident scene *before* arrival. We conducted an international, web-based survey in which 50 firefighters of varying ranks characterized the benefits and challenges of using *pre-incident plans*, *documents that assist firefighters in understanding information about a facility during an emergency*. Our analysis showed that despite demographic differences in regions and the size of the population served, most departments reported severe challenges in accessing and retrieving planning information. Based upon participant feedback, we shed light on the problems with existing user interfaces and provide a path forward for the human factors community to build robust technology for first responders operating in dangerous and unpredictable environments.

INTRODUCTION

On June 14, 2017 more than 250 firefighters and 70 fire engines responded to one of the worst structure fires in history (Gorse & Sturges, 2017). The Grenfell Tower tragedy is a high-profile example of structure fire, a fire that involves the architectural or physical components (e.g., walls, roof, contents) of a residential, industrial, or commercial building. Due to the severity of the Grenfell fire, the engineering, construction, and safety industries across the world are emphasizing prevention and risk management by levering new technologies and gathering data to support fire prevention goals. Regular inspections were identified as a strategy for risk mitigation as a result of the Grenfell incident (Gorse & Sturges, 2017). Firefighters conduct inspections on existing buildings to familiarize themselves with the facilities in their response areas before emergencies happen. This inspection process results in the creation of **pre-incident plans (PIPs)**, *documents (paper or electronic) that contain information about a facility that would be necessary in the event of an emergency*.

RELATED WORK

Pre-incident planning developed from a need for firefighters and first responders to understand the critical elements of a structure and to develop incident or tactical decisions based upon anticipated conditions. Thus, pre-incident planning transitioned from a *recommended practice* to a National Fire Protection Association (NFPA) *standard*, requiring departments to identify elements in the environment to assist in forecasting future problems or hazards, ultimately preventing fatalities and property loss (NFPA, 2003).

Recent work emphasizes the value of assessing and understanding firefighter needs from an information, communication, and goal-oriented perspective in the design of new technology and systems (Dawkins et al., 2018; Gasaway, 2009; Prasanna et al., 2009). Although there have been efforts to create more effective pre-planning systems, there are relatively few published studies that capture end-user requirements directly from firefighters (Nadal-Serrano, 2010; Baker, 2011). Consequently, there is a gap in the literature that focuses on understanding how firefighters collect and use information about response areas ***prior*** to an emergency. To address the gap in the literature related to current *pre-incident practices*, we employed a qualitative approach grounded in prior field studies (Kapalo et al., 2018). We also consulted two subject matter experts (SMEs) to assist in the development of the survey questions and provide feedback. In our study, 50 firefighters of all ranks answered 33 questions regarding pre-incident planning practices in their departments. The goal of this study is to illustrate where human factors issues impact the resiliency of *current* pre-incident planning systems and technologies. Where other studies have looked at implementing the design of a new tool or system on the scene of an emergency, this study emphasizes how departments and individuals leverage planning information before setting foot on the fireground. Our approach emphasizes the need for information about what crews do ***before*** they get to the scene of the fire and how this information is applied to the fireground during the "*size up*," initial incident assessment phase prior to tactical operations. Armed with an understanding of current practices and procedures, we can better identify capability gaps and points of failure, ultimately leading to better user interface (UI) design and a safer working environment for firefighters of all ranks.

METHOD

Recruitment and Data Collection

We used an approach focused on qualitative methods to improve our understanding of how firefighters collect, access, retrieve, and use PIP information. Barriers to data collection included time, convenience, and anonymity. To minimize disruptions to firefighter schedules, the survey was administered via an online platform, Qualtrics, also ensuring that participants felt they could be as candid and honest as possible, without fear of admitting non-compliance. IRB approval was obtained prior to the survey deployment. Data was collected from April 2018 to August 2018. Inclusion criteria for partaking in the study required that the participant must be 18 years of age or older and must be a current or recently retired (< 6 months) firefighter. These participation criteria ensured that the participants were proficient in current, state-of-the-art practices and standards within their respective departments. Participants in the final count of 50 were

recruited nationwide, with representation from 22 states and two participants from the United Kingdom.

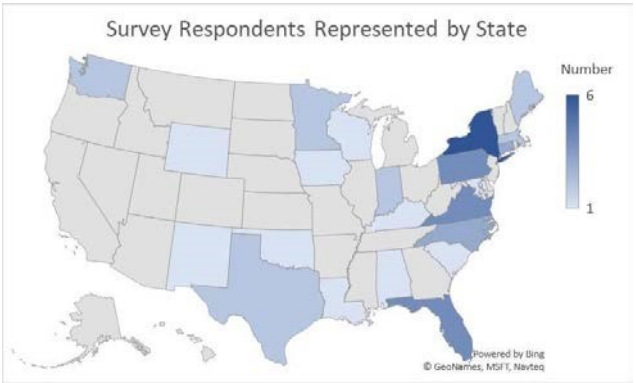

Figure 1. Number of participants surveyed by state. **Please note, this visualization does not include two international participants representing the United Kingdom

In addition to participant location, the demographics related to participant rank are listed in Table 1**.** We captured specific demographic information that could potentially affect pre-incident planning circumstances (e.g., state, number of citizens served, etc.) but we also wanted participants to share their experiences candidly and without fear of retaliation for non-compliance. Participants completed the web-based survey via a link that was posted online in several LinkedIn groups. A prerequisite for membership in the groups required all potential members to validate their status as active public safety officials, ensuring that the data came from actual firefighters and eliminating survey fraud. The survey was hosted on Qualtrics, a web-based survey platform. Participants read the consent document and proceeded with the survey.

Table 1. Participant Counts by Rank

Rank	Participant Count
Fire Marshal/Inspector	2
Chief	10
Captain	8
Lieutenant	3
Senior Firefighter	3
Firefighter	21
Other (1 participant did not report rank)	3

Data Analysis Approach and Survey Questions

We chose to structure the survey in such a way as to solicit qualitative data from participants. This approach has been successfully employed in other studies assessing firefighter perceptions of emerging technologies (Weidinger, et al., 2018). Thirty-three questions were developed with the assistance of two subject matter experts (two fire officers with 15-20 years of experience). The survey measured several dimensions of pre-incident planning, including how information is gathered, used, retrieved and stored. Data was exported from Qualtrics survey platform and cleaned. Overall, 68 responses were collected, but due to missing data, technical failure, or partially missing data, only 50 responses were completely recorded. The goal of this survey was to produce information that captured the current perception of PIPs from the perspective of all firefighter ranks. While incident commanders and company officers typically use these plans, other firefighters may be involved in data collection processes or may update these plans. Therefore, they are also stakeholders that are involved in accessing, storing, retrieving, and updating the information. The first portion of the survey collected participants' demographic information. The second portion of the survey required them to report information on:

- Frequency of use
- Incidents or calls in their response areas that required PIPs
- Collection and storage of PIP information
- Frequency of inspections
- Estimates of how long it takes to find specific information on the PIPs
- Systems used to access PIP data
- Free response

RESULTS

The tables below depict the demographic information of surveyed participants by department and agency type (see Tables 2 and 3).

Table 2. Participants by Department Type

Type of Department	Participant Count
Career	20
Volunteer	17
Combination	13

Participants ranged from 1 to 40 years of experience in the fire service, with a mean experience of 13.18 years (SD=10.59).

Table 3. Participants by Agency Type

Type of Agency	Participant Count
Municipality	35
County	6
Other (private industry, a federal agency, a non-profit private organization, combination rural and municipality, etc.)	9

The Big Picture

Sixty-eight percent of participants reported that their department uses a consistent template for gathering PIP information. However, only 34% of the respondents stated that their department or agency regularly trains using these plans. More importantly, only 10 participants indicated that they regularly used PIPs during a "size-up," the initial assessment phase in incident response, due to various barriers to accessing the plans which will be discussed in further detail.

Our findings report that locating the plan itself takes on average ***more than 60 seconds***. In addition to locating the plan, making sense of the information takes additional time. *Almost all firefighters in this study (90%) reported using the PIP to locate hazardous materials*. Only 5 reported that they do not use pre-incident plans for hazardous materials. More importantly, it still took them considerable amounts of time (30-60 seconds) to locate building occupancy and between 10-30 seconds to locate information about auxiliary appliance

features such as standpipes, sprinkler systems, etc. This information is captured in Table 4.

Table 4. Estimated time (self-reported) to locate specific plan and/or information

Time	Find Plan	Hazardous Materials	Building Occupancy	Auxiliary Appliances
10-30s	10	15	14	16
30-60s	**13**	**16**	**17**	9
>60s	**16**	**11**	**9**	**17**
Other	4	1	1	1
Did not use	**7**	**7**	**9**	**7**

What information do firefighters need on the fireground?
Based upon responses, *76% of participants reported that they used PIPs when responding to structure fires specifically.* Other types of incidents in which PIPs are commonly used include hazardous materials/chemicals, residential fires in large buildings (e.g., apartments or assisted living facilities), commercial buildings, industrial buildings, and schools. Table 3 captured the most common fire-type calls answered by responding units. We note that emergency medical services do not fall under this category and are excluded from this survey, unless they have direct relation to the fire call (e.g., trapped firefighter, citizen injured in structure fire, etc.). Twenty-six percent of participants felt that the *floorplan or layout* of the building contained in the PIP was most useful. One participant indicated that was the most important piece of information for the responding unit:

"Site map. We put all important symbols on our site map" (CAPT, 10)

Other important information included hydrant and fire department connections (FDCs) (24%), fire alarm panel locations, lock box information (also known as a "Knox Box"), utility shut offs, and contact/facility information.

"Blueprints/floorplans - any notes from the occupant that can be useful to us, location of fire pump/FACP [fire alarm control panel] risers, etc. as well as hazmat/special considerations." (CHIEF, 41)

Participants also captured that the information is useful, but at different relevant points in time depending upon the incident scene:

"All of it is useful, but it is all situationally dependent." (FF, 23)

"Honestly it should be bare-bones, you don't need to filter thru fluff when stuff is going sideways." (CHIEF, 19)

This observation details the importance of understanding how to display and present multimodal information effectively, without overloading the responding officers and units.

How do firefighters access the PIP data they need?

Over a third (36%) of participants indicated that they rely on a Mobile Data Computer (MDC) for access to the plans. A mobile data computer (MDC) or mobile data terminal (MDT) are computers that are mounted in-vehicle and are often not easily transported around an incident scene. In addition to MDC access, some departments still rely upon paper copies of these plans, creating even more of a challenge (26%). These paper copies are stored in the vehicle in three-ring binders. As you can imagine, pulling up the plan is a challenge when searching through multiple volumes of information. And another 38% of departments rely on a combination of paper and electronic copies, making it challenging for them to locate the right plan when needed and sometimes requiring multiple updates. Of the data reported, only 2 participants indicated that they had access to the plans via a tablet on scene.

Interestingly, the departments were almost equally divided on whether dispatchers in the area had access to pre-incident plans. 42% reported that dispatchers did have access, 42% reported dispatchers did not have access and 16% did not know whether dispatchers had this capability. This can impact operations since dispatchers may be able to assist in relaying more detailed information. Additionally, this can be useful for a multiple alarm fire in which the second or third due officer can request further information from dispatch related to the PIPs. This capability is typically more useful in the case of severe emergencies involving many victims (mass casualty incidents), such as a hospital, school, or assisted living facility.

When and how are PIPs updated?
Ten participants (20%) reported that PIPs for their department were only updated occasionally. Two participants indicated the plans were never updated on a regular basis. Two participants indicated that the plans were updated between every 1-3 years, suggesting that some departments might not have access to the most current information regarding facilities in their response areas. Designated shifts are how 38% of the departments in the study update their PIPs. Most other departments reported that company officers or other designated personnel will conduct the PIP inspections, but a few departments reported that these are conducted by fire inspectors or other risk assessment stakeholders (6%). Two participants reported that there was no existing procedure in place for PIP updates.

What are the barriers to successful information capture?
Respondents were asked to summarize what they perceived to be the most prominent barrier to both successful information capture and use of PIPs. Below we describe the five categories that participants illustrated as being the biggest issues in their respective departments: ***time, type of facilities, staffing/administration, attitudes, and inadequate user interfaces/technology limitations.***

Time. Of all respondents, 24% indicated that time was a major barrier. It was one of the most frequently reported barriers:

"Lack of time is huge in the fire service now days. Administrations and governments have adopted the "do more with less attitudes and that can only go so far. Tasks have been reassigned and extra tasks given and the responsibility of running calls first and preparing for the worst has gotten lost in bureaucratic busy work." (CAPT, 1)

"Time is likely the largest barrier, as these pre-incident plans are updated by volunteers." (FF, 13)

"Time to gather, create, and update pre-plans is the biggest barrier to our pre-plan program." (CAPT, 8)

"Time/Staffing to properly implement a true building information recon plan and deploy it to the field." (CHIEF, 2)

Although time may be correlated with other sociotechnical factors such as leadership, budget, and administrative policies,

it is evident from this study that crews struggle to collect timely information, to find the time to update this information, and more importantly, they struggle to use this information on scene.

Type of Facilities. The location of the department or agency poses a challenge to crews. For example, one participant below summarized the challenges of responding to multiple types of structures with limited resources:

"Living in a suburban area, preplanning is challenging because the first due area includes everything from seven story commercial buildings to farmhouses and barns. Preplanning every single structure (especially as a volunteer department) is not an option." (OTHER, 37)

Additionally, some of the smaller departments establish agreements for response with other departments (known as mutual aid). The idea is to best serve the citizens by responding to the most common emergencies, and then pulling in support units when necessary. This is evident in the participant's response below, where a department will handle calls that involve the same common types of structures in the area.

"As may be discerned, we use pre-set mutual aid for automatic dispatch and greater alarms. Our fire load is chiefly single-family residential, type V structures, as such, most responses are similar." (CAPT, 24)

As such, it is important to consider department needs. For single- family homes, there are no PIPs. These plans are typically only used in the case of multi-family residential areas or other types of structures like commercial and industrial buildings.

Staffing and Administration. For some firefighters in this study, staffing represented a major challenge to successful PIP creation and maintenance, risking safety and the wellbeing of responding units:

"I had to contain my laughter on some of these [questions]. Maybe one day we'll have enough people to do the job correctly." (FF, 47)

"We are severely understaffed/underfunded so it is difficult to integrate them in a timely fashion. Pre-plans used to be done on paper, we are slowly creating all new ones through our new CAD [Computer-Aided Dispatch] system." (FF, 38)

Although this may seem like a temporary inconvenience, it does represent a bottleneck. Updating a CAD system can take upwards of a few months to several years depending upon agency resources. It can be challenging for crews to switch back and forth between different types of plans based upon response areas.

User Interface and Technology Limitations. In the case of emergency technology, resilience of systems is a primary need. Without access to working computers, firefighters struggle to obtain the information they need. This can cause added stress and increase response times if important information is missed due to the location or functionality of the device.

"MDT [Mobile Data Terminal] functionality - it often does not work as it should and our current system is fixed in the vehicle - tablet computers should the next step." (LT, 28)

This problem with MDC functionality was cross cutting among all the participants, both nationally and internationally:

"Currently, half of our plans are on paper and half are on the computer. System is being updated and plans are being revamped." (FF, 46)

Because of the failing and unreliable computer systems, some participants expressed that they felt more comfortable using paper plans. Despite the challenge of carrying around binders full of these plans, one participant noted that paper plans allowed for more interaction. Since it can be difficult to plan tactical operations, sometimes it is most practical to markup a plan by hand.

"Paper maps are great; you can draw on them." (LT, 49)

Often, there are several disparate systems or sources of information required to record everything necessary:

"The hardest part of pre-plans is actually gathering the information and then updating regularly. The easiest method I've found for getting square- footage information is from the GIS [Geospatial Information System] tax map for the county. Thankfully, my county allows users to get the public information online, so that is a big help when calculating fire flows on a structure." (CHIEF, 42)

Some participants recommended solutions:

"Upload [the data] to a state register for easy access." (FF, 50)

Attitudes. Leadership and crew attitudes impact the success of PIPs in the field. If the pre-planning process is not prioritized, it can be detrimental to not only the department, but also citizens in the response area. One participant expressed frustration regarding leadership's attitudes towards PIPs:

"Getting the chief and officers to embrace the concept of pre-planning as a fire prevention and incident management tool [is one of the biggest barriers]." (FF, 33)

Some participants described PIPs more like an available tool as opposed to essential information, since they did not regularly trust or rely upon pre-plan information:

"We are more comfortable with having information readily available to response personnel and ICs [incident commanders]." (CHIEF, 14)

And one participant felt that PIPs did not support his job functions, expressing frustration that resulted in lack of use:

"The fact that they're worthless [in their present state] is a pretty big barrier." (FF, 25)

DISCUSSION

We extracted the major human factors issues associated with current pre-incident planning practices and outline further design implications surrounding these issues. We identified the major bottlenecks that slow down current operations, from the perspective of the end user.

User Interface Challenges

In our survey, we identified issues related to connectivity, inaccurate information, interoperability, and ineffective interaction design. This leads to frustration on the

end-user, resulting in potentially missed information or lost time. While we contend that this finding may not be novel in nature, we do point out that there are devices that already exist to help with this problem. However, most volunteer departments lack the funding to be able to afford such technology. While the solutions to these problems may not be straightforward with regard to budget and administration, the goal of this study was to identify the breakdowns in the current technology to better serve the public safety community. As a result, we contend that further studies to determine the most effective interaction design are necessary to better support these responding units. Additionally, we contend that efforts need to be directed to create systems that support both the community and the firefighters using these PIPs, we elaborate further below by explaining the importance of systems that can be used by several user groups (citizens, public safety officials, first responders, etc.)

Community Risk Reduction (CRR) Approaches

In addition to accessing the information on scene, most departments reported issues related to collecting and updating plan information. The workforce in this industry is often forced to juggle multiple tasks and running calls on top of creating and maintaining current PIPs, making it difficult for them to do careful and detailed inspections. Perhaps even more frustrating than not having access to accurate information, is spending time to access a plan only to realize the information is overcome by events that cause it to be outdated or no longer valid (e.g., a restaurant is converted into another type of business). This creates frustration on the responding units since they are required to maintain static and dynamic information from the fireground simultaneously. This increases workload and may distract the incident commander from successfully planning tactics due to the valuable resources that are tied up from checking multiple sources of data and conducting a thorough inspection upon arrival. More importantly, this poses interesting implications for future designs. As departments transition from paper to electronic plans, there are currently no standards or guidelines for electronic-based systems, excluding the information contained in the NFPA 1620 standard. Therefore, more research needs to be conducted to determine how to effectively design PIPs that incorporate emerging technologies, and more importantly, needs to factor in the current risks associated with modern construction (Baker, 2011; Hamins et al., 2015). Perhaps even more pressing, most structure fires occur at the scene of a residence (Evarts, 2018). As illustrated by the participants, PIP data is typically not collected for single family residents, homes, etc. This poses unique challenges for firefighters who may be responding to areas where homes have been renovated or converted into structures where multiple families occupy a dwelling. Efforts have been made to collect this information, but significant changes in current pre-incident planning systems and practices would be necessary to allow firefighters the opportunity to leverage this data and incorporate this information with newly emerging technology.

CONCLUSION

While not all incidents are preventable, we do acknowledge the importance of risk reduction as a key factor in incident success. Because of this, the goal of this paper is to illustrate the need to evaluate the role of information provided to the incident commander and responding units *prior to arrival*. By ignoring this information, there is a missed opportunity for designers and human factors researchers to consider firefighter safety and training in the collection, fusion, and monitoring of data related to *pre-incident plans*. When combined with experimental data, our ability to reduce firefighter workload, design effective interfaces, and capture user experience is enhanced. This paper contributes to the literature by providing qualitative data that can be coupled with future experimental data to inform the design of more effective pre-incident planning systems.

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