Project Phoenix

CS 6750 HCI - P1

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OVERVIEW

It takes a lot to be a firefighter. While most of us run away from the sight of danger, firefighters are trained to go into life threatening situations to save human lives and properties. Even though the number of firefighter fatalities are statistically low compared to the number of civilian lives saved, we still lose many firefighters each year in the United States. In 2008, the number of on duty firefighter fatalities is 128; This year, from beginning of January to end of August, the number of on duty firefighter fatalities has been reported to 67 [6]. When the problem regarding firefighters fatalities was brought up, we all agreed that firefighters held a very important role in the society and firefighter losses should be avoided at any cost.

The unofficial motto of firefighters is ″we are ready to risk a life to save a life″. In our project, the goal is to reduce this risk, and thereby save both firefighters and civilian lives. We aim to do this by providing critical information to firefighters when they are dealing with fire emergencies. Several interviews were conducted with different firefighters to understand their current needs and difficulties. A list of common concerns gathered form the interviews are visibility, time and hazardous materials. Based on users′ needs, we would like our system to capture the following information: building blueprints, interior layout, hazardous materials and critical times.

In fire emergencies, visibility is relatively low inside burning structures due to smoke, which can spread faster and further than fire. Currently, firefighters use a device called Thermal Imaging Camera (TIC) to see through dense smoke. TIC outlines objects and people using infrared heat instead of light. In addition to information coming from TIC, knowing building blueprints and interior layouts will be extremely helpful to navigate inside burning structures.

Hazardous materials was one of the major concerns brought up in the interviews. There are numerous hazardous materials that can impede firefighting operations; these are divided up into the following categories: radioactive, poison, combustible, explosive and flammable [8]. Response, planning, and prevention training for hazardous materials (HAZMAT) are all part of fire department operations. A preventive effort is to document hazardous materials in public places such as hospitals, chemical research buildings and waste plants. Hazardous materials are also stored in private homes but they are not inspected by trained personnel. Thus when firefighters go into private homes, they require specific information about hazardous materials to prevent accidents from occurring.

Another critical piece of information that we will capture in this system is time. Many firefighters we have spoken to had identified the importance of time. Responsive time is very critical and a one minute delay can cause a matter of life and death. Our system will notify fire-

fighters of critical times and will collect data. The data will also help fire departments analyze potential patterns and generate reports for government audits.

Overall, the scope of our project is large. The primary aim is to improve visibility by using information from existing technology (TIC), from prevention reports, and generated during real-time encounters. Knowing that firefighters operate in very stressful environments will be a central design consideration for our system. In the section below, we'll begin by describing the important characteristics of the users.

USER ANALYSIS

The National Fire Protection Association (NFPA) governs the requirements required for becoming a firefighter. Our focus is on land-based commercial or residential fire/rescue based operations. The expected personal dispatched for these operations are Firefighters Level I and II, drivers and fire officers. The requirements for these are laid out in NFPA 1001 - Standard for Fire Fighter Professional Qualifications,NFPA 1002 - Standard for fire apparatus driver/operator professional qualifications, NFPA 1021 - Standard for Fire Officer Professional Qualifications and NFPA 1500 - Standard on Fire Department

Occupational Safety and Health Program. NFPA 1001[2002 edition] is our main point of reference as it contains the requirements of our main user groups, Firefighters I and II.

firefighters II assume additional responsibilities on top of the ones for firefighter I. We cannot assume the user has reached this level of proficiency or training. Instead the base level of proficiency provided by the firefighter I track will be assumed.

Physical and Age requirements

NFPA §1001.4.1 state that the physical and age requirements of firefighters shall be determined by the authority having juristrisction over the incident.

In Georgia, a firefighter must be [1]

- 18 years of age
- Posses a high school diploma or general education development equivalency within 12 months after initial employment
- Be in a good physical condition (defined by a medical examination)
- Pass the Georgia Basic Firefighter training course. Requirements for this course are defined in NFPA 1001
- All Georgia firefighters are Emergency Medical Technicians(EMT) [2]

These requirements change per Juristrisction, in the city of Dayton, Tennessee, among the requirements are

- Successful completion of Fire department Emergency driving course
- First responder level of medical care

• Physically able perform heavy work, including exerting over one hundred pounds of force. Certification by an M.D. is required

General Skill requirements

To be in compliance with NFPA regulations, firefighters are required to successfully perform a number of tasks, these include, but are not limited to[NFPA §1001.5]:

- The ability to don personal Protective Clothing within one minute; doff personal protective clothing; hoist tools and equipment
- The ability to successfully communicate with external agents.
- Initiate the response to a reported emergency, informing dispatch centers, receive business telephone calls and transmit and receive radio messages
- Performing activities necessary to ensure life safety, fire control and property
- Use of SCBA(Self Contained Breathing Apparatus)
- Correct use of personal protective equipment
- Use of traffic and scene control devices
- Knowledge of potential hazards involved in operating on emergency scenes
- Be able to force entry into a structure
- Ability to transport and operate hand and power tools and force entry through doors, windows and walls
- "Exit a hazardous area as a team, given vision-obscured conditions, so that a safe haven is found before exhausting the air supply, others are not endangered, and the team integrity is maintained." [NFPA §1001.5.3.5]
- Correctly set up a ladder
- Handle a passenger vehicle fire as part of a team
- Extinguish exterior Class A material fires(Ordinary combustibles)
- Conduct a team based search & rescue
- Handle an interior structure fire operating as a team member
- Perform horizontal and vertical ventilation on a structure

- Check a fire scene, ensuring structural integrity is uncompromised, all hidden fires are discovered and extinguished
- "Conserve property as a member of a team" [NFPA §1001.5.3.14]
- Connect a hose to a water supply or fire department pumper
- Extinguish nascent Class A(ordinary combustibles), Class B(Flammable Liquids), Class C(Electrical Fires) using a fire extinguishers
- Illuminate emergency scenes
- Handle a ground cover fire operation as a member of a team
- There are no requirements for performing rescue operations
- Perform safety surveys,maintenance & prevention activities and safety briefings to visitors

Although not separately mentioned in the NFPA regulations,throughout the document a large emphasis is laid upon the fact that teamwork is an essential for firefighters to complete their tasks.

TASK ANALYSIS

Characteristics of the Tasks

Firefighting operations rely heavily on team work and organization. All team members are assigned responsibilities that they will have to perform during emergencies. The leader of each team is the officer. He is the one that gives out order to the team during fire situations. Standard operating procedures are followed closely to make sure fire operations are effective and efficient. The effectiveness of teamwork places a critical role in the outcome of the situation. Due to the time sensitive nature of a fire, the victims become increasingly hard to save and risk more injuries the more time drags on. This danger is imposed on the firefighters as they pursue the rescue.

Only knowledge of the area can compensate for time lost. This is done through more strategic allocation of resources and time which can later reduce the amount of time it takes to suppress the fire. Knowledge of the area also assists firefighters in avoiding situations that will later place them in danger. As an example fires originating from the basement make the floor structure weaker. Advanced knowledge of this will allow firefighters to avoid these dangers as they appear and react accordingly. Thus the dynamic nature of the situation becomes a consideration when attempting to suppress the fire.

Characteristics of the Environment

The characteristic of the work environment is diverse and unpredictable. Firefighter work shifts vary depending on their agencies. Sometimes they are required to work up to 24-hours per shift and then off for 48-hours. In other cases, they work 8-hour day shifts or 14-hour night shifts [5]. Many firefighters work more than 50 hours per week [4].

Most of the time, firefighters are at the fire station doing administrative tasks such as writing incident reports, reading up on fire literature, practicing fire drills and maintaining equipments [4]. Fire stations are setup like dormitories so that firefighters can stay there for a long period of time. The work environment during these times are very laid-back.

However, during emergencies, firefighters can be dispatched to work in any types of environments such as metropolitan areas, rural areas with grasslands and forests, airports, chemical plants and other industrial sites [4]. One of the most dangerous environment firefighters work in is dealing with forest fire. In order to combat forest fire, extra methods are employed to deal with the massive nature of the task. These include parachuting from airplanes to reach inaccessible areas, cutting down trees and removing any combustible vegetation in the path of

the fire [4].

Most of the emergencies firefighters respond to, however, are medical calls. According FEMA, 57.7% emergencies are EMS and Rescue in the South. They are relatively low-risk but requires certified Emergency Medical Technician (EMT) presence. Fire emergencies accounts for only 8.7% of incidents [9].

Structured Task Analysis

Firefighters always work as a team and follow a very structured set of procedures when responding to a fire. Duty of each team of firefighters is determined by whether they work for the engine company or the ladder company. The engine company is responsible for putting out the fire (defense) and the ladder company's primary goal is search and rescue (offense).

The following is the sequence of events that take place from when the fire is reported to when the fire is put out by the firefighters.

SCENE: Medium fire on a two-story suburban house/private dwelling.
GROUP: First Ladder Company (usually 1 officer and 5 firefighters)
TEAM: Inside Team
TIME: Early morning

SETUP:

A. Roll Call

Each ladder company is made up of two teams: an inside team and an outside team. The inside team is responsible for handling floor level operations and the outside team is in charge of upper level operations. The Ladder Company assignments are given to each member by on-duty officer during roll call [10]. On top of assigning positions, the officer also provides information of hazardous conditions, street closings, safety issues, Department orders, and other relevant information to the team [10].

B. Dispatchment

The operator receives the call from 911 and finds the nearest fire station and alerts the station. The operator then pulls up various information about the location of the fire, such as presence of any hazardous chemicals, etc on record and blueprints of the building (if available). Documentation of blueprints are only available for public buildings. Hazardous materials on the other hand, can be either documented or not. As an example extremely hazardous material

such as high levels of gasoline, must be documented. Oxygen tanks used for medical purposes are considered hazardous, but are not documented.

C. TASKS:

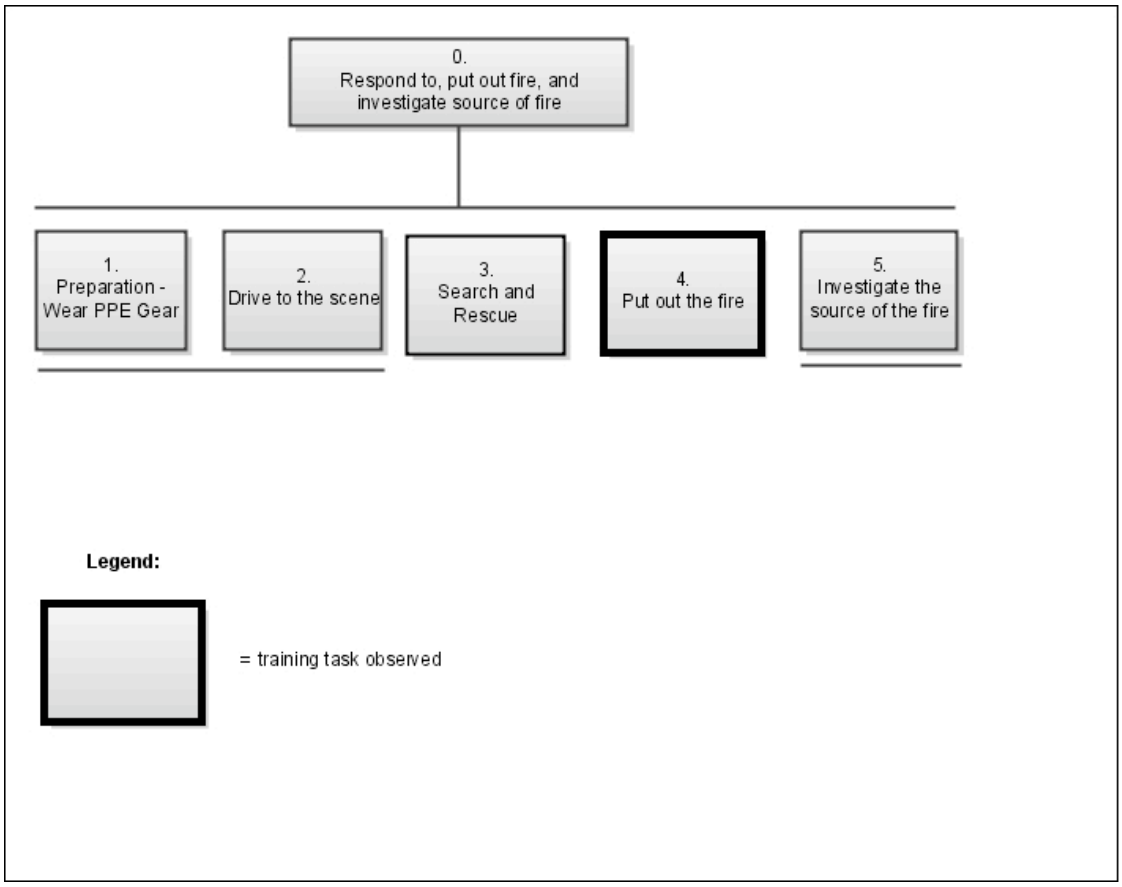

Figure 1: Overview of firefighter tasks

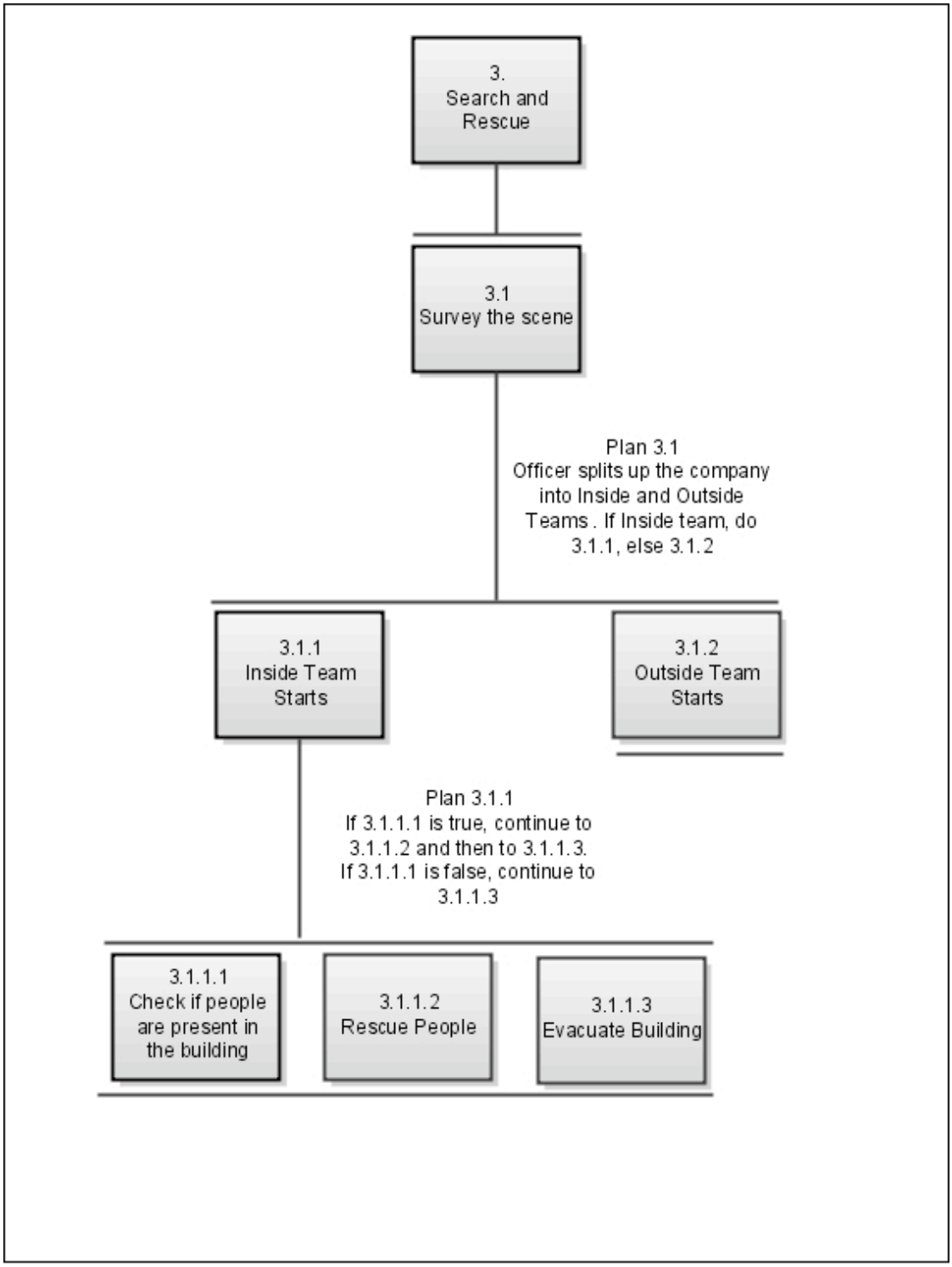

Figure 2: Search and Rescue Subtask

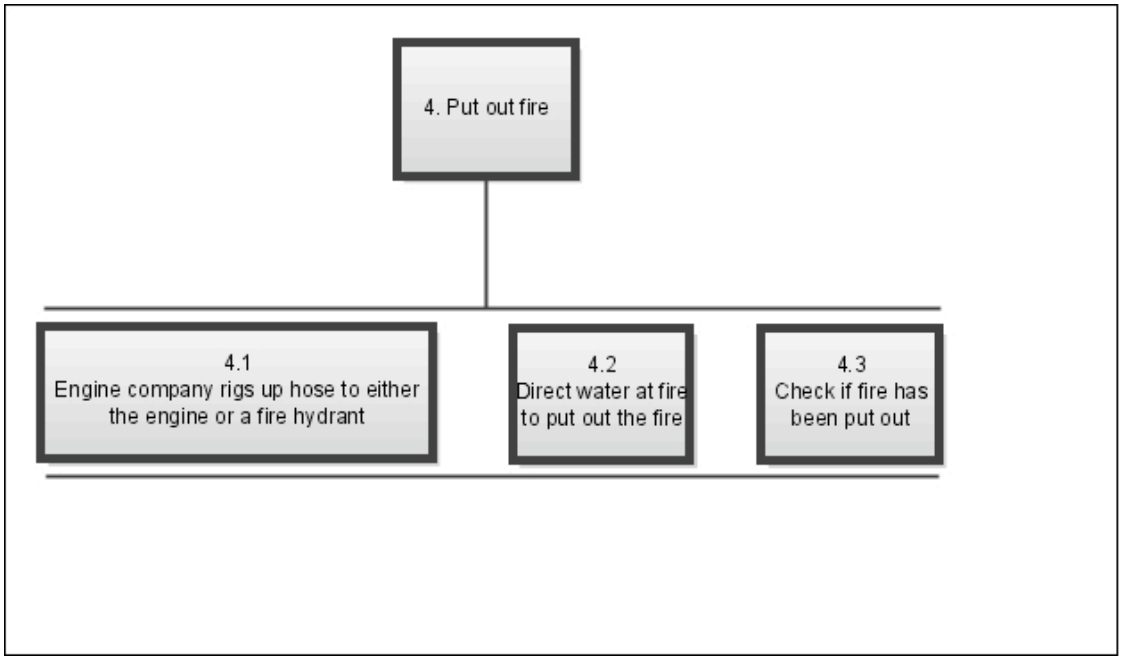

Figure 3: Put out fire Subtask

1. Preparation

After receiving the dispatch call, firefighters prepare by donning their Personal Protection Equipment (PPE). This includes wearable equipment such as fire suits, flashlights, and other types of equipment relevant to their duty.

2. Drive to the scene

3. Search and Rescue

3.1. Survey the Scene (Figure 2.)

The officer is always the first to be on the scene to do a quick analysis of the situation (assisted by TIC), determines location of the fire, and gives out order to members in the team.

3.1.1. Inside Team Starts

When the officer have a general knowledge of the situation, he will dispatch the forcible entry firefighter and extinguisher firefighter to perform their tasks.

Forcible Entry firefighter make sure the floor entrance to fire building is cleared and accessible. They will ensure the fire does not damage the vital entrance and stairs that lead to second floor. If called upon by the officer, the Forcible Entry firefighter may assist in search and rescue.

The primary duty of the Extinguisher firefighter is to make sure fire does not get to other firefighters, ventilate the building and assist both Forcible Entry firefighter and officer in their tasks.

3.1.1.1. Check if people are present in the building

The primary goal of the inside team is to search and rescue people who might be trapped inside the building. In this case, since the fire emergency occurred during early morning, the inside team will check the bedroom first and skip areas such as the living room and dinning room.

3.1.1.2. Rescue people

If occupants are located, the extinguisher firefighter will cover the officer as he moves to rescue them. The extinguisher firefighter must not try to put out the fire directly(e.g. by trying to put out a fire in a fully involved room using the extinguisher), as this has a very minimal effect [10]. Once search and rescue is accomplished, the officer and everyone will move out of the building.

3.1.1.3. Evacuate Building

3.1.2 Outside Team Starts

4. Put out the fire (Figure 3.)

4.1. Engine company rigs up hose to either the engine or a fire hydrant

The officer communicates to the engine company through radio, letting them know the location of the fire. The engine company advances to the line.

4.2. Direct water at fire to put out the fire

4.3. Check if fire has been put out

5. Investigate the source of the fire

6. Write incident report

Firefighters write an incident report describing the actions taken in responding to the fire. They also include critical values like response time.

EXISTING SYSTEMS

Many of the basic procedures and tools of firefighters have more or less remained the same over many years. Firefighters still end up taking the same risks that many of their predecessors did.

The following sections will attempt to describe some of the tools that firefighters use and the general procedures that they follow today.

Tools:

All firefighters deployed in emergency fire situations must pass a stringent training course and be certified for such situations. Thus all users in our problem space are proficient and familiar with the tools they carry into a fire. These tools are called include "Personal Protective Equipment" (PPE) or turnouts (due to the nature of them being normally turned inside out for quick deployment).

1. Thermal Imaging Camera (TIC):

The TIC is a hand-held infrared camera. It is a rather bulky hand-held device though. It has a small screen which shows the heat signatures of objects that it is pointed at in a grayscale gradient. The hottest objects are shown in complete white and the coldest in black.

Image 1. Thermal Imaging Camera

The thermal imaging camera makes it possible for firefighters to find a person in a fire in-spite of very low visibility available and the far stronger heat signature of the fire. The firefighters we spoke to were very happy with the device. The TIC is also useful for figuring out the general shape of various furniture, etc using the TIC.

One TIC is present in each large fire-truck. The TIC is quite an expensive piece of equipment. When the fire department we interacted with acquired it, it cost around $30,000 each, though it has since then reduced in cost to around $15,000.

2. Mobile Data Terminal (MDT):

The MDT is basically a rugged laptop fitted into the fire-truck in the passenger seat position on a movable arm. It is also detachable and can be carried around if necessary. Two of its most common functions are:

a. to provide information about the location of a fire on a map to make it easy for the firefighters to find location of the fire.

b. to provide a way of entering reports while on the road.

A recent development is also having the MDT have a timer that will record the time it took between when the dispatcher sent the call to when the fire engine reached it's location. From our interviews, we were told that their introduction is fairly new, yet a very welcome one.

3. PASS (Personal Alert Safety System):

Every firefighter has a little alarm system fitted into this suit. This little alarm system starts to make a sound if the firefighter has been found to not be moving for more than 30 seconds thus making it easy for other firefighters to locate him.

4. Radios:

The firefighters stay in constant contact with each other using a radio when responding to an emergency. This is very important in helping the firefighters to organize themselves.

Image 2. Mobile Data Terminal (MDT)

5. Flame Retardant suit, Fire Helmet and Self Contained Breathing Apparatus (SCBA) (Oxygen mask and tank):

The flame retardant suit, fire helmet and the SCBA can be classified as needing the least amount of technical knowledge to operate. Due to the inherent thickness of the suit and the accumulation of water and sweat the weight of the suit increases even further. The weight alone is not the only aspect of PPE technology that must be considered. The thickness of the layers becomes a large impediment on movement. Sight is also impeded by the visor. Though this technology does have these drawbacks, it is a very robust item whose effects must be incorporated into our design.

Strong Points of the existing system

1. Tried, tested and refined procedures
2. TIC is effective at helping firefighters navigate the smoky confines of a burning building
3. The flame-retardant suit, fire helmet are very effective at protecting the firefighters from the heat of the fire.

Deficiencies of the existing system

1. Information about the layout of most private buildings not available, and hence firefighters need to figure out the layout of the building at the scene. Doing this when visibility is so poor and in an emergency situation is extremely difficult.

2. Also no information is available about the presence/absence of people in the building, and hence firefighters either need to rely on information from other people or go in and check.

3. No information is available about the presence of dangerous chemicals in the atmosphere and in the apartments.

TECHNICAL AND SOCIAL CONTEXT

Social

The largest social consideration for our design is that the environment firefighters are working in is private space. This not only extends to fires in private homes, but also those in public spaces and offices. Each of these spaces carries a higher level of inherent privacy. This even extends within the same building. An example being that a living room or family room is considered less private than a bedroom. Thus, whatever information firefighters take from their environment must either be dynamic enough to take varying levels of information or adhere to the highest level of privacy and apply it to all environments.

For our design this extends to two portions of a firefighter's duties. The first is the information obtained while the fire is trying to be contained and suppressed. This includes pictures taken of the house, analysis of chemicals in their home, and the disclosure of the information. For our design, this limits the type of information we can collect and how it is distributed. The second portion of a firefighter's duties that this affects is after the fire has been suppressed; once the origins of the fire and the causes of its spread are being investigated. The social implications of the information collect become a larger issue during the investigation because during this time firefighters are given access to a large amount of private information. Also, the type of information gained during the investigation is much larger than during the fire: the pictures may tell more about the victim's private area, chemical analysis will be clearer without the smoke, and firefighter's, and distribution is shared amongst more departments who help with the investigation.

Another social portion of the environment that our design interacts with is that the actions taken by firefighters should remain within what the victim is comfortable with in their homes or offices. Certain cases supersede this, especially when the life of a firefighter or a victim is in consideration. An example is a current procedure firefighters undertake before entering a hazardous situation. A team is initially in charge or surveying the outside of the house and removing obstructions from possible emergency exits. This ranges from small obstructions such as barbecues covering a rear door, to removing theft protection bars off windows. Because firefighters are given the discretion of choosing when these measures are appropriate, a social responsibility should be to minimize the necessity for this when necessary.

Though both the privacy and property of the victim are considerations for firefighters, these aspects will always be a secondary priority to saving lives. Each firefighter we spoke to described this as always being the central consideration of their job and the portion of the job that allows for minimal compromise. As stated by one firefighter, material possessions can

always be replaced, yet a life will be lost forever. This extends to both sides of our design: the victim, who is in a very dangerous situation with little chance of survival without assistance, and the firefighters, who risk their own lives in order to save who and what they can.

Technical Context

A variety of contextual aspects affect how a firefighter does their job. A primary feature is that firefighters are civil servants. This entails a certain level of service to the public that makes the position unique. This is best put into terms by a mantra that was repeated many times during our interviews: ″we will risk a life in order to save a life″. An advantage of working for the government is the stability of a firefighter′s job. With the United States government being the largest employers in the country and firefighters filling a direly needed role, there is a high demand for servicemen in this area. In addition, the training required of firefighters before they actually enter a dangerous situation makes further dwindles the pool of potential firefighters. All of these factors are secondary to the degree of danger inherent to the position. Saving a life thus becomes is only a source of great satisfaction from being a firefighter, but one earned through great risk.

Though being a government employee has its benefits, economic situations have their affect on a firefighter′s job. A current issue voiced from our interviews was the extent of current budget cuts. Though it has not left firefighters with insufficient equipment to do their job safely, it has hindered the distribution of newer and more effective technology. The most prominent example being the distribution of Mobile Data Terminals (MDTs). Though the system has been used nationwide for years, it was only recently that Atlanta fire stations began getting these tools. This gives some clues as to how familiar firefighters are with the technology and its probably audience.

An dual edged sword facing firefighters from an administrative side is their cooperation with other civil agencies. This includes police officers and the local government offices. The common role police officers fill in a fire is to keep the area clear and control possibly dangerous situations outside of the fire. With local government offices, firefighters gain access to information and resources that help them do their job, ranging from communication with other fire stations to financial assistance. The negative aspects of this collaboration comes from maintenance of this communication. During every stage of a fire, a large amount of information is required for later paper work. This includes noting how long it took firefighters to get to the site, what steps were taken during the fire, and later investigation. The necessary paperwork accumulates and was voiced as a tedious task by some of the firefighters we spoke to. In addition, this paperwork is not digitized, which makes it even more tedious to file and report. This

internal lack of organization for paperwork, both on the filing and accessing side, has created a large problem space that many firefighters would welcome a better solution for.

USABILITY PRINCIPLES AND EVALUATION CRITERIA

Our system will be used by firefighters to navigate inside burning buildings, contact fellow firefighters (inside or outside the building), locate all persons inside the building contact persons outside the building etc. This means that the system has to be very usable and should require minimum effort from the firefighter to use. It should not encumber the firefighter in any manner.

Following are some of the usability principles that we would want to incorporate in our design and the prototype that should be tested for.

Learnability:

Firefighters are not necessarily a tech savvy group. Some of the older firefighters may have minimal exposure to technology. That being said we expect that the users of our system will be personnel who will have had undergone specialized training to use the system. However the system in consideration should require minimal learning time. So that it may be used on the field faster.

Predictability:

High predictability will lead to quicker understanding of all the capabilities of the system. It will also lead to lower operation time (due to lesser cognitive load) when the users are learning to use the system as well as when they are using it in the field. Hence predictability is an important attribute that we will incorporate into our system.

Familiarity:

High familiarity should be a critical attribute of our system. Use of familiar metaphors and existing knowledge of firefighters will lead to ease of use in the field.

Consistency:

Since the system we design will be used for specific tasks in specific scenarios we will aim to have a consistent method of interaction with the system as long as the task or the scenario of usage does not change.

Flexibility:

The users of our system are specially chosen persons with typical demographics. However even in this niche group there are variations of age and experience.

Dialog initiative:

Ideally we would like the system to be aware of its surroundings, user and be able to provide relevant information. This said the system will allow the user to request any information or perform any task using the system. The key here will be to ensure that neither one of the the dialog methods hinders the user using the other in the field.

Multithreading:

Firefighters will be using the system when they may be dealing with multiple tasks to be performed simultaneously such as knowing about the lay out of the room they are in while scoping for victims and knowing the intensity of heat in the various parts of the room. Hence we plan to design the the final product with the view to allow the user to do multiple tasks simultaneously.

Browsability:

High browsability coupled with high predictability will allow users to learn how to use the system quickly and will build trust in the system which will result in high performance.

Responsiveness:

Since the system is used in a scenario where the user has to make split second decisions, every extra moment spent may mean a lost life, as a result the system we design should be highly responsive.

Comfort:

User comfort is very important for our system design. The system cannot in any way encumber the user while they are in a hazardous environment, because this may affect the efficiency of the user and may result in the failure of an operation.

DESCRIPTION OF OUR SOURCES OF INFORMATION AND A JUSTIFICATION OF THE METHOD USED TO GATHER DATA

For this project we interviewed firefighters on two occasions. In the first occasion, we visited a firefighter job fair at Atlanta fire station no.4 and interviews 4 people. Later we visited the Fire Awareness Campaign on the Georgia Tech campus and interviewed 2 additional people. The people we interviews have diverse responsibilities, 2 firefighters, 1 fire chief, 2 fire department administrators and 1 fire marshall. For all of these interviews we used the open ended interview technique. These were exploratory interviews that were directed towards gaining information about a broad range of activities in which firefighters are involved. Recordings of each interviews were made for follow up reviews.

After the interviews. We discuss the implication of being a firefighter and narrowed down our problem space to working with actual fire and focus the users to firefighters. Additional sources of information are collected based on knowledge obtained from interviews.

DESIGN IMPLICATIONS

Since the aggregated information must be made available to the firefighters; it implies that the system we design will have to be carried by the firefighters. Following are some of the design implications that we have come up with during the process of gathering information in part 1 of the project.

- The system needs to have a self-contained power-source that will allow operation over the expected average duration of active engagement of the firefighter plus a safety margin.
- The system should not fail or power down when a firefighter is inside a hazardous environment.
- The system should be over-engineered in this regard to be considered reliable.
- The system needs to be able to withstand rough treatment, shocks and impact forces. This is a necessity because of the extreme hazardous conditions firefighters are likely to be in.
- It needs to be able to withstand small to medium sized G-loads. Sudden movements and small impacts should not damage the device, as these are to be expected.
- The system needs to be able to able to deliver information to the user in low-visibility, noisy and hazardous environments.
- The system also may be able to required to communicate with other systems in the same environment.
- It has to be able to withstand extreme temperatures unless it is designed to be fitted inside the suit.
- The system should be waterproof as there is a lot of water used for dousing fires.
- It should be able to readily integrate with equipment on the fire truck. e.g.. if it records a video of whatever the firefighter sees or whatever is around the firefighter then it should be able to link to some equipment on the fire truck and dump the data after the fireman returns from the firefighting operation.

CONCLUDING REMARKS

Interviewing and watching firefighters in action has gone miles in showing us not only the strengths and limitations of our selected user group, but also the burning passion and bravery in each individual firefighter. On one hand, we were able to see where firefighters excel. Their stringent training regime forges many skills that are essential in the field. Teamwork is perhaps the firefighter's largest safety device. This is not only accentuated in training manuals and protocols, but from our interviews this was stressed as the largest factor in insuring that every firefighter that enters a building comes out alive. The second strongest asset to firefighters is their equipment and proficiency with it. This includes equipment such as their Personal Protection Equipment (PPE), fire hoses, Mobile Data Terminals (MDT), and Thermal Imaging Camera (TIC). Each of these items has continuously proven itself in the field. Of particular attention are the more modern technological artifacts: the TIC and MDTs. As the clearest identifier for finding humans as well as displaying fires within or behind walls, the TIC is perhaps the largest piece of technology that has changed how firefighters do their jobs. The second largest piece of assistive technology has been the MDT. With it's mobile capabilities as well as giving critical information to firefighters, the MDT has quickly found its place as the foremost information regulating device for firefighters today. The strengths of these systems provide a basis for what has been effective in the field. Thus, implications for our design should seek to either incorporate these systems as a means of increasing effectiveness or using the concepts inherent to their success and cornerstones.

Coupled with these strengths are the inherent dangers and weaknesses of the systems firefighters regularly work with. From our usability analysis, two major points were derived as implications for the direction of our future design. This includes difficulties inherent from the fire suit. The weight of the suit encumbers firefighters, which further increases the possibility of fatigue due to the heat of the fire and stress of the situation. The suit also limits dexterity and tactile senses because of the large gloves and thickness of the materials. Thus our design must at the very least not utilize a small traditional control scheme using small buttons, and considering the type of situation, it must be able to withstand the heat. The second design implication comes from the environment firefighters work in. The overwhelming smoke that accumulates during most fires usually renders the insides of homes with little to no visibility. Coupled with the standard procedure of firefighters entering burning houses via a crawl and the lower angle further reduces visibility. With visibility hampered to this extent, finding not only the source of the fire but also any survivors in a timely matter becomes a task that requires compromises to safety in order to complete. What this implies for our design is that regaining as much visibility back to firefighters, or even conveying more visual information

than they would have in clear situation, is an effective direction as well as having large benefits for both victims and firefighters.

Superseding both the strengths and weaknesses of the systems firefighters carry into fires is strength of their spirit and passion. Every firefighter we interviewed stated the same line when asked about their views towards risking their lives in every situation; ″we will risk a life in order to save a life.″ Considering that saving a life would require the potential loss of the whole team, this may be expected to be a flight of reckless behavior from the firefighters we interviewed. Yet every protocol we examined, whether it was in the Atlanta area, State wide, or National, regulated the saving of a life as a pinnacle responsibility and duty of firefighters. With both stakeholders facing the possibility of death, we see the area of obtaining and disseminating information that will help firefighters save lives as the future direction of this project. Aiding us in making the most effective design for doing so will be our constant consideration of the environment firefighters are put in so as to not further encumber them and understanding the tools and techniques that will make them effective for years to come.

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