Firefighter's Locator and Communicator (FiLAC)

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1. Introduction

The problem we face today involves the complex problem of providing safety measures for a firefighter. We need a firefighter monitoring and tracking device which will provide communication, locations of the firefighters in real time, and monitors of vital signs such as their heart rate as well as surrounding factors such as air quality. We are looking to prevent deaths of the brave, selfless, valuable men who make up a firefighting squad. The #1 cause of firefighter death during an emergency call is heart attack. We can easily prevent this if we had a system which matches the specifications of what we have outlined below.

This system should be able to minimize those risks a firefighter takes to a great extent. The fire chief coordinator needs additional functionalities which will help him to communicate to firefighters various information such as their location in the building, a safe exit path from the building, and the situation around the firefighter’s position.

We need a device attached to each rescue worked that could do this and serve as an alternate communication channel to his or her voice radio. This system must provide the following:

- The ability to monitor, track, and archive each firefighter’s location and vital signs (heart rate, oxygen levels, temperature).
- Location information must include the entire path each firefighter took to achieve his/her current position.
- A 3D real time visualization of the incident scene, including the location of floors, walls, dangerous areas, firefighters, and victims.

Including these functionalities in our system would provide our users, three major advantages:

- Location: Incident Commanders, back-up personnel and the Responders themselves will always know their precise position
- Monitoring of vital signs and environment: pulse rate, body temp, air temp, CO gas, etc. are sensed and communicated to nearby monitoring stations
- Back-up two-way communications: panic button and other important information can be communicated as an alternate, robust path to the standard voice radio.

The firefighters face a number of obstacles and put their lives on the line to protect other lives, it is important that they are given all the safety precaution and reassurance that we can protect them from all possible dangers. Even though there are some current solutions that put into use many emerging technologies, they are not quite complete. When it comes to lives of our people, no matter how many precautions we take, it might still prove to be less. Hence we are trying to build a system that is complete, i.e one which will allow us to tackle all the challenges that the current systems face.
In this document, we will discuss current solutions to the problem and highlight their shortcomings. We will detail what the proposed device must do and how it will “fill in the gaps” left by the other emergency/first-responder safety tools. We’ll also acknowledge that no computerized solution can completely replace the human intervention and that is why this device should be used in conjunction with them. We will end the document by discussing plans that we have for future releases.

**2. History/Current Systems:**

Back before the modern age, there were no methods of tracking the vital signs and locations of firefighters and it was almost impossible to relay information to the firefighter due to poor communication methods. With the advancement of technology, we have more options. Stronger signals and lighter devices mean there are ways to build the device we are proposing. Today there are number of technologies that can be deployed to overcome these out-dated deficiencies.

**2.1 GLANSER: A Firefighter locator**

GLANSER is the Geospatial Location Accountability and Navigation System for Emergency Responder, a tool that lets incident commanders locate and track first responders inside enclosed areas. This portable tracking device comprises a microwave radio, battery and navigation technology. The commander can plug a USB powered base station into a laptop that transmits and receives signals; the more fire trucks with base stations the better the accuracy.

The GLANSER system can track approximately 500 firefighters simultaneously in a 50 story building and is accurate to as little as three feet. Accuracy of GLANSER can be increased further to pinpoint the fire fighter.

**2.2 The Star Trek-style PHASER**

Rather than a weapon, PHASER is like a recorder for firefighters. PHASER is the Physiological Health Assessment System for Emergency Responders program that is being developed by the Department of Homeland Security’s Science and Technology Directorate in conjunction with researchers from UCLA. It monitors the pulse, body temperature and blood pressure of a firefighter and then relays his or her vitals back to the base. While PHASER will let the commander know a firefighter is in trouble, fellow firefighters will still need to locate him or her. So PHASER can’t be used independently and some tracking device should still be used to form a complete system.
2.3 WISPER 'bread crumbs'

PHASER uses a 900-MHz frequency, and due to its portable size, it needs a boost or it could be stopped by a wall or wall of trees in a wildfire. So it works with WISPER to achieve that boost and get the signal to the commander in spite of obstructions. The Wireless Intelligent Sensor Platform for Emergency Responder (WISPER) relays a firefighter's vital signs back to the fire truck so that the base can monitored them and track him through a fire. But again it would take time to get these products commercialized. So in spite of these products being powerful, they haven’t been implemented due to their high cost.

None of the existing solutions provide an “all-in-one” approach and tackle all aspects of a locator/communicator system. Even though each of these existing systems tackles individual challenges, putting them into use separately cannot provide a total solution to the problem in hand. Integrating several devices into one single system with interfaces would be more efficient. This is the sort of device we are looking for.

3. Objectives / Goals

Many of the existing systems provide unique functionalities yet cannot individually satisfy all the needs. The goal is to build a system that enhances the safety of our users, protecting them from grave dangers. The device should be able to:

- Monitor the Vital signs of firefighters
- Detect the presence of poisonous gases and its concentration levels.
- Measure the temperature in the surroundings.
- Trace the path taken by each firefighter, keeping track of his location in a building.
- Capture a 3D view of the building that can be sent to the responders.
- Provide a user friendly interface for easy access.
- Support reliable communication among peers.

4. Relevance and Quality of Life

If a firefighter is equipped with the proposed device, it would improve the quality of his life by providing him with several safety measures in addition to his own training. It displays his vital signs on the central device, from which the operation coordinator can analyze if he in danger. The chief would then be able to divert the firefighter from dangerous scenarios, and could monitor his chances of having a heart-attack. By tackling these major causes of firefighter
deaths and injuries, we can provide much assurance to him. By mapping the interior of a building with information from the firefighter’s devices we can also see a 3D mapping of the building. This image gives us hotspots so the firefighters going inside the building would know the whereabouts of the safe areas and the areas to be avoided.

Having the danger button would help the co-fighters and the fire chief to know who are in distress and can coordinate resources as he sees fit to provide a solution for whatever is occurring inside the burning building. Having air composition sensors (mainly to detect the level CO) can help the firefighter know before-hand with what they are dealing with. The chief can continuously monitor the carbon monoxide levels inside the rooms where firefighters are working. If the heart rate of a firefighter is above normal limit, then the chief could give him directions to move out of the building with the safest path as possible. The rescue team could help the firefighter trapped inside the building and rescue him from danger.

Having radio communication would help chief controller to communicate with other firefighter would help to calm the situation down and help the chief controller to assess the situation for response. Radio communication would also help firefighters to save each others life.

The danger associated with this profession would drastically decrease. Loss of lives happens due to poor communication, poor teamwork and lack of safety supplies. With this system being deployed, all the shortcomings could be covered and that could lead to a successful system.

5. Functional Requirements

5.1 Firefighters Locator Device

For each firefighter, we need to monitor several variables which will measure his condition and his environment. This information should be sent to central where the information is monitored and displayable by the main user/fire chief). We want to be able to know the following about a firefighter’s situation:

- Firefighter’s Physical Condition:
  - Heart Rate
  - Body Temperature

- Firefighter’s Environmental Condition:
  - Temperature Sensor
  - Carbon Monoxide Sensor
  - Natural Gas Sensor
This device can not be intrusive. It must be lightweight and integrate easily with the firefighter’s current outfit. Excessive wiring or components is not what we are looking for. If the device inhibits the firefighter from performing his current duties then it is not worth it.

5.2 Communications Devices

This device should also serve as a communication medium between himself, other firefighters, and the fire chief. Particularly the fire chief should be able to hear every firefighter and see what they can see.

- Firefighters’ Outgoing Communications
  - Video feed from firefighter’s helmets
  - All of the above, outlined monitors (output to central device)
  - Firefighter’s vocal/radio communications
  - “Danger Button” – signals a dangerous area to the central user (i.e. fire chief)
  - “Rescue Button” – signals an area which needs additional attention

- Firefighters’ Incoming Communications
  - Radio Communication from chief
  - Radio Communication from other firefighter’s

5.3 Central Receiver/Device

We need a central device that will be used by the rescue coordinator or the fire chief. The central device performs communications tasks and will relay all incoming information to the computer.

- Central Receiver
  - Receive all firefighter communications
  - Radio communication to all firefighters

- Central Device
  - Create a map of the building as firefighters enter and explore the scene
  - Manage all incoming communication from firefighters

5.4 User Interface

The user software must have a very simple layout. Any clutter on screen could cause confusion and distraction for the central user. This is not acceptable because in emergency situations it can cost lives.

- Display
  - Map of all firefighter’s positions
  - Basic information about each firefighter (e.g. heart rate and surrounding temp.)
○ Ability to view more in-depth information for any particular firefighter or location
○ Ability to view one or more firefighter’s helmet cameras

● Map Features
○ 3D view of all firefighter’s locations and any danger areas
○ Backtrace/Escape route highlighted for each firefighter as they enter
○ Areas can be marked by firefighters’ Danger or Rescue buttons

6. User Profile / Deployment Environment

6.1 Who uses the system
The system can be used by all the first responder systems who perform tasks of similar significance as the firefighters. The users include:
● Firefighters/Rescue Personnel
● Miners
● Police Forces
● Military Forces

6.2 User Profile/ Deployment Environment
The proposed device will be used by firefighters when they go inside buildings to rescue people caught up in fire. Since firefighters wear uniforms, our proposed device would be embedded inside the uniform in such a way that it will be possible to monitor all the entities in our design. The device should keep sending data to all the other devices within the range of a given device.

As the firefighters are doing the needful, they will be represented as 3D images at the main responders side, where the data from the device would be continuously sent, monitored and coordinated with.

A similar setup can be constructed for miners and armed forces. The miners would have the device fitted into their costumes and sent into mines and information on all the changes in the miners vital signs can be noted and attended to by the main coordinators. In the armed forces, the soldiers would be the users to whom these devices are fitted to and based on the changes in their vital signs, reinforcements can be sent to soldiers who need them the most.

Hence the deployment environment would be:
● Burning buildings
● Mines/Quarries
7. Constraints

7.1 User Cost
In past solutions, high costs to the user have prevented widespread use. So, costs to the user need to be kept low enough to promote use. Main reason is that product needs different platform interfaces to get the readings from various tools and hence this is a costly procedure on money and as well as time. One way of reducing the costs could be by using the smart phones, which is capable of reading all this tools (i.e thermometer, gas analyzer, camera etc). Thus this would definitely bring down the costs.

7.2 Range Limitation
Creating an ad-hoc network on the go is really tricky and can go wrong horribly quickly. Even after 8-10 years of research on ad-hoc networks, there is no solid foundation to create a solid ad-hoc network. Hence establishing a reliable communication channel among the firefighters who are spread out throughout the building is a technical challenge which needs to be addressed.

7.3 Accuracy
One of the major concerns of such a system is the accuracy of tracking the firefighter’s location, heart rate, vital signs. If this is not accurate, most of the functionality will be lost. It will do no good to provide safe passage from the firefighter’s current position if that position is not accurate. This is a technical challenge that must be addressed completely.

8. Proposed Solution:
Our solution would include making of a device which could be integrated with the firefighter’s suit and serve as a multipurpose device. This device would enable firefighter to communicate to the main responder or chief coordinator, it would help monitor the vital signs of the firefighter and it would send the live video feed to the main coordinator so that he can see what’s going on in the building and command appropriately to the firefighter depending on the situation.

This device can be integrated with the suit.
We also propose to simulate the environment on the computer through OpenGL in visual studio. We propose to make a map of the building in OpenGL and mark the location on the map according to the location of the firefighter. The software used in the project would give the vital signs of the firefighter such as heart rate, pulse rate and it would also give the temperature of the room to assess the danger. It can be modified for other purposes and for other domains such as in police, military, first response, etc. so that they can track the positions and vital signs of their personal.

Some of the major technical hurdles we will come across include establishing a communication path among the devices, battery backups (kicks in when the firefighter is inside for a long time), synchronizing all the devices, using/implementing Wi-Fi Direct in the devices, trying to reach a device which is out of the range from the central coordinator and 3D imaging.

A brief overview of the design is as shown below: 

![Proposed Device Diagram]
9. Deliverables

Upon completion of the project, we expect the following:

- A detailed documentation of the product.
- A website which provides basic help and customer service

9.1 Instruction Manual

This document should be a succinct manual that can be delivered to any customer upon request. It is intended to provide a complete walkthrough for how the device operates. A detailed description of all the functionalities of the product and the interfaces should be included. It should also provide a phone number and website for technical support as well as customer service.

9.2 Website

The website is the hub of activity concerning the device and the community of users. On the site, users can access a forum where they can communicate with other users and provide feedback on the device. Customer support and technical support will be accessed through here as well as an instructional brochure. Additionally, a FAQ should be maintained to facilitate smoother customer support.