Problem Definition

Jacob Knaup

Team 24: MATES  
EGR401

# I. INTRODUCTION

My team is working for Dr. Redkar by competing in a University Design Challenge hosted by the Air Force Research Lab (AFRL). The challenge is to design a device to be used by first responders for locating people in an active threat or disaster situation. Our device will be judged on a number of criteria, but the main challenge is locating humans who are trapped under debris or hiding in buildings etc.

# II. PROBLEM

In order to define our problem we consulted a number of sources. We began with the assignment documents provided by the class in order to get an overview of what the problem definition was and what specific requirements it had [1]. Then we examined the competition solicitation provided to us by AFRL [2]. This provided us with a description of what the competition hosts were interested in and what they would be looking for in our product. This document was able to answer many of the questions raised by the problem statement assignment such as the nature of the problem and how often it occurred. We identified assumptions and constraints by critically examining our view of the project and how we would pursue it. This allowed us to objectively identify several factors that we were currently assuming that were important to the success of the project. We also identified several of the ways in which the project was most likely to go wrong and the underlying causes of those issues generated our constraints.

We have developed the following problem statement to describe our challenge. *Active threat situations where first responders are unable to prevent victim injuries and casualties occur, despite emergency responder trainings and technologies. We are proposing a study which investigates active threat situations and identifies the root cause and possible resolutions.*

We are assuming that our device will need to transmit information in real time, accurately position targets, and have a high quality user interface. We also assume that we will need to research and test our sensors prior to the finalized design, purchase hardware and test early, and finish a functioning prototype and have it tested before our competition. Finally, we are assuming all team members are honest about their technical skill sets and are willing to learn. We are constrained by our budget, our timeline before the AFRL competition, the number of sensor solutions we can test within our time and budget limits, our class and project schedules, our access to equipment and facilities, and our knowledge/abilities to use the technology.

# III. SCOPE

To scope our project my team first imagined what our ideal competition entry would be capable of. We then identified the most essential aspects of this ideal entry selected what we thought we could reasonably accomplish in two semesters. For example, we decided that we would need to focus our time on integrating solutions rather than developing our own technologies from scratch. This led to the decision to consider creating new sensing technology to be out of scope.

This process resulted in the conclusion that the scope of our project was to design a device used for active threat situations, test the hardware for this device (including sensors and user displays) individually, create a functional prototype integrating these components, and finally test the prototype. We decided to declare creating new sensor or display technologies to be beyond the scope of our project. This project is dependent upon our ability to obtain high-end sensing technologies and the AFRL competition itself.

# IV. REQUIREMENTS

To develop the project’s requirements, we examined the judging criteria provided to us by AFRL [3]. This seemed like the most logical source from which to extract our requirements since it gave us the specific criteria and categories on which our project would be judged. Since our goal is to win the competition, logically our requirements should be driven by how to score well in the competition.

We concluded that the project needs to be mobile, therefore it must be lightweight and small in size so that it is easy to carry and stow. It also must be useful in the field; therefore, it needs to be able to “see” through walls and debris. It also needs to be wirelessly remote controlled so that it can be used remotely. It must have a simple and clear design, so that it can be easily implemented. It needs to be easy to use so that new users can quickly be trained. It must be safe to operate. Finally, the user interface must clearly display human detection to the operator.

We had to critically evaluate their scoring criteria in order to distill some of their broad category descriptions into specific and concise requirements. For example, one of the categories is Usability, from which, we extracted the requirement of a detailed user display. Our project requirements, if met, will ensure our project is able to effectively mitigate the problem described in our problem statement. That is to say, the requirements ensure our device will be useful for first responders in an active threat or search-and-rescue application.

# V. SPECIFICATIONS

We developed our specifications using the same scoring criteria document we used to develop our specifications [3]. However, we had to distill our requirements into measurable specifications. We did this by looking at aspects of the requirements that could be measured and that were associated with specific functions the device would perform.

Our project must meet the following feature specifications. It needs to have accuracy to detect people in different obstructed environments. It must be under 7 lbs. and less than 27”x21”x14” in size. It should have a detection distance of 25-30ft, and its cost must be under $5000.

# VI. SUCCESS CRITERIA

We selected our success criteria by determining the most objectively measurable and the heaviest weighted categories from the scoring document [3]. For example, while safety was a very important scoring criteria, it did not seem very measurable, so instead we chose the category of remote use as one of our success criteria.

Table I

Success Criteria

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Criteria** | **Threshold**  **(*Halt & Review*)** | **POR**  **(*Plan of Record*)** | **Stretch**  **(*Design Stop*)** | **POR**  **Risk**  **(H,M,L)** | **Comments** |
| Identifying humans through walls | No wall | Thin interior wall | Thick exterior wall | H | Needs to work in cluttered environment |
| Identifying humans at distance | Thru wall: Under 5ft  Open space:  100ft | Thru wall:  5-15 ft  Open Space:  100-400ft | Thru wall:  15+ ft  Open Space:  400+ ft | M | Needs to work in spacious environments at range |
| User Interface | Binary detection info | Low resolution 1D map | High resolution 2D map | M | Needs to convey results to user |
| Prototype Cost | $5000+ | $3000-$5000 | Under $3000 | L | Entire Design and prototype is less than AF budget |
| Remote Use | Short-distance (1’)  wired communication | Short distance (1’) wireless communication | Long-distance (>400’)  wireless communication | M | Information transmission distance between sensor and UI |

REFERENCES

[1]

“Project Definition and Scope Document,” p. 2.

[2]

M. Lazalier and M. Wright, “Air Force Research Laboratory’s (AFRL) Center for Rapid Innovation (CRI) 2019 University Design Challenge (UDC) and Service Academy Challenge (SAC) Problem Statement: Mobile Active Threat Emergency System (MATES).” .

[3]

M. Lazalier, “2019 AFRL University Design Challenge Competition Setup Scoring Criteria and Schedule.” 19-Sep-2018.