Objective Statement

The objective of this report is to investigate the possibilities of Natural disaster response using swarm technology to determine the most likely locations of victims and use this information to plan optimal path for rescue workers.

Technical Solution

We will develop a swarm of aerial vehicles that are programmed to perform a collaborative mapping of a hurricane disaster site. Each vehicle will be equipped with a variety of sensors including infrared, LIDAR, and microphones. If the vehicle locates a human, the agent will inform the victim that help is one the way. Each vehicle will directly communicate with a central hub that will process and present the collected data. In addition to reporting the location of humans, an algorithm will determine regions in the search zones that are likely to contain immobile victims. Ultimately, the system will present rescue workers with an optimal path plan for finding and rescuing victims.

Technological Developments

This project is primarily a system integration problem. We can use currently existing technologies such infrared cameras, microphone, speakers, LIDAR, modules to stitch images/process map data. Notable problems include the range and type of aerial vehicles. The range is affected by battery life and radio communication. The environment will help determine the type of vehicle that is needed for the operation.

There already exists a large body of current technology that the system could draw from in order to reach the end state. The following are some of the current technologies that the system would be able to use.

- **3D Robotics**
  - 3D Robotics develops innovative, flexible and reliable personal drones and UAV technology for everyday exploration and business applications. 3DR’s UAV platforms capture breathtaking aerial imagery for consumer enjoyment and data analysis, enabling mapping, surveying, 3D modeling and more.
  
  - 3D Robotics technology is currently used across multiple industries around the world, including agriculture, photography, construction, search and rescue and ecological study. 3DR brings the power of UAV technology to the mainstream market.
Co-founded in 2009 by Chris Anderson, creator of DIYDrones.com, and Jordi Munoz, 3D Robotics is a VC-backed startup with over 180 employees in North America and more than 28,000 customers worldwide. 3DR has business offices in Berkeley, CA, engineering operations in San Diego and manufacturing facilities in Tijuana, Mexico.[1]

- **Airware**
  - Airware is a CA-based startup that specializes in the development of autopilots for unmanned aircraft systems. The company develops enterprise solutions for drones that combine autopilot hardware and flexible software architectures. Airware’s hardware and software solutions enable customers to tailor UAVs towards any commercial or military application.

- Airware’s os-Series Autopilots combines modular hardware with an open architecture, making each autopilot the ideal development platform for the rapid prototyping and cost-effective production of custom Unmanned Aerial Systems (UAS).

- These autopilots are offered in multiple form factors with features tailored for various vehicles, payloads, and applications. Each autopilot is a complete integrated solution and contains an INS/GPS with Air Data, a datalink radio, payload interfaces, and a Linux computer within one miniature package. [2]

- **AeroVironment**
  - AeroVironment, Inc. designs, develops, produces, and supports unmanned aircraft systems, and electric vehicle systems for various industries and governmental agencies.

- It offers small unmanned aircraft systems (UAS), which provide intelligence, surveillance, and reconnaissance, including real-time tactical reconnaissance, tracking, combat assessment, and geographic data to the small tactical unit or individual war fighter. The small UAS wirelessly transmit critical live video and other information to a hand-held ground control unit, enabling the operator to view and capture images.

- The company also provides spare equipment, alternative payload modules, batteries, chargers, repair services, and customer support services for small UAS. [3]

**Implications**

**Pros:**

- More efficient searching process
- Can be used for other applications
- Save money on helicopter fuel and personnel (maybe)

**Cons:**
Widespread Adoption

The widespread adoption of the system will improve the efficiency of the response during a natural disaster. The introduction of a mobile application and giving people the choice to disclose their location during the advent of the disaster will help in narrowing down the search area. The data collected from previous incidents will provide better understanding of the geographical conditions, enabling better response and knowledge about the affected area. The major focus of this machine is to identify victims in a disaster location, which would inspire research on search protocols for hidden objects [4]. It will encourage research on building integrated Unmanned Aerial Vehicles with multiple usage and better maneuverability. These will be useful in coming up with novel methods that may be used in defense sector of the country [4]. In addition, if the machine can be shared with different countries it may improve the relations with the country, since the bonding is over humanitarian prospects.

One of the only technical problems affecting cost will be the constricting flight time [5]. A possible solution would be looking into alternative energy sources. The search can be localized to the geographical location. The other option would be to increase the number of drones in the area according to the state budget. The cost of the machine is contingent on contracts with companies dealing with the different machines and the final integration is dependent on the volunteers available for the work and the requirements [6].

Strategic Planning: Training

Two levels of operational sophistication will enable a wider base of users to employ the new emergency relief drone swarm. Expert users who receive complete training will be able to use a complex graphical user interface, use all system functions, and make modifications to the system in the field. A simplified version of the interface will be available to civilian or backup users, who will not need as extensive training, but will also have fewer capabilities with the system.

The cost and logistical complexity of training programs will be minimized by working through existing disaster response organizations. Various groups already provide disaster responder training, from governmental agencies like the Federal Emergency Management Agency (FEMA) and non-profits such as the Red Cross, to religiously affiliated groups such as the United Methodist Committee on Relief (UMCOR). These organizations provide a mix of online and local training options (1, 2, 3). Online modules include readings, videos, and tests to help volunteers work through preparation material. Community Emergency Response programs and other local efforts preemptively coordinate volunteers to form teams and complete local training sessions. Online modules and local training programs developed for the emergency relief drone swarm can be offered alongside the existing programs. These modules should be developed by the system creators, in collaboration with the existing organization of choice.

For the emergency relief drone swarm, interested individuals could complete online training modules and subsequently register as qualified operators. A basic module would teach the fundamentals of the system using the simplified interface for non-experts. Further modules may be offered for particularly motivated volunteers to explore additional functions. Separating the levels allows many people to become qualified as basic users, without overwhelming them.
with unnecessary complexity or time requirements. In case of need in communities near these users, they could then be called upon to assist responders who bring the system to the area.

Communities at high risk could also elect to form a dedicated team or train area law enforcement or firefighting units in a local group training program. This would create a more formal team which could operate the system at its more complicated level without heavy assistance from outside responders.

In both cases, involving community members will introduce the system to communities before the stress of an emergency, and will involve more locals in disaster recovery efforts. Introducing new disaster response technology is a delicate task. Without proper training and standards, the novel technology could easily be misused. Thankfully, specialized courses are already offered to and recommended for individuals seeking disaster response training. The well-known FEMA (Federal Emergency Management Agency) CERT (Community Emergency Response Team) program offers training to community members so that they can be effective first responders in fire, terrorist, or search and rescue operations [7]. The swarm search and rescue technology could become an integral component of courses such as CERT. Before permitting widespread usage, the swarm technology should be taught in such courses. It should be shown that students in these courses are able to operate the technology with the aid of an experienced user within a reasonable amount of time.

There are several key points that should be communicated to swarm trainees:

1. How to use the technology.
2. When it is appropriate to use the technology.
   a. Not every situation will warrant the use of this innovation and improper use could draw resources away from more important assets.
3. Why the technology was introduced.
   a. Explaining the motivation behind the technology will encourage its use when appropriate.
4. The capabilities of the system.
   a. Trainees should be aware of the system limitations (e.g. battery life) and normal operating conditions.

**Overcoming Obstacles**

The obstacles of the 21st century will be more focused on the economic impact technology will bring to the market. This presents one of the biggest questions of all times: how much is a human life worth? Does a human life have a price? In February 6th, 1978 a Blizzard, one of the biggest storms recorded in the history, hit New England. The range were waves 10 or 12 inches, and “27.1 inches of snow in Boston (40 inches in parts of Rhode Island), 99 deaths, 4,500 injuries, 350 federal troops, $520 million dollars in damages, and 3,000 cars and 500 trucks abandoned on just an 8 mile stretch of Route 128 (The blizzard of ‘78).” “Fourteen people would die from carbon monoxide poisoning as they huddled in their snow-trapped vehicles (A look back at the Blizzard of 1978).” The swarm technology to addition to sensor and the ability to map the perimeters will help locate the victims. This will improve the access to persons that
face in this type of disasters. I will reduce the time that we spent trying to save a live. It also will reduce the cost in a long term [8].

**Conclusion**

The SWARM technology offers a new way in which the humanitarian response organizations can react to natural disasters in order to save the most lives. The largest area of concern is the implications of the system in prioritizing lives; this could cause backlash of the system. The technology involved would not be anything new because the system would be able to use current sensors and mostly rely on the integration of the sensor inputs to create an output that was useful. The idea of using SWARM technology for natural disaster response is not a new idea, however, focusing on a certain type of natural disaster may lead to a better suited system and greater results.
Bibliography


