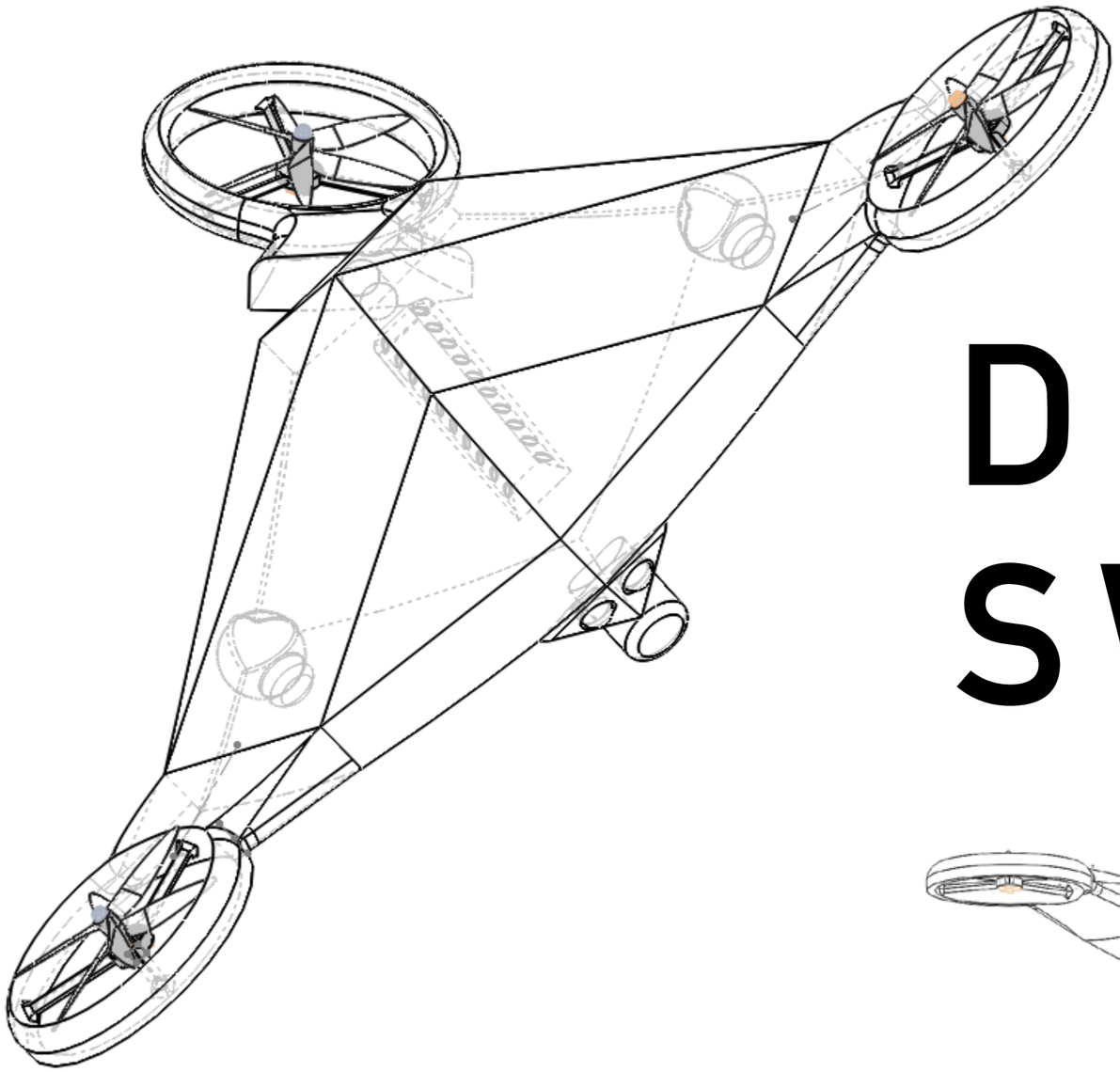
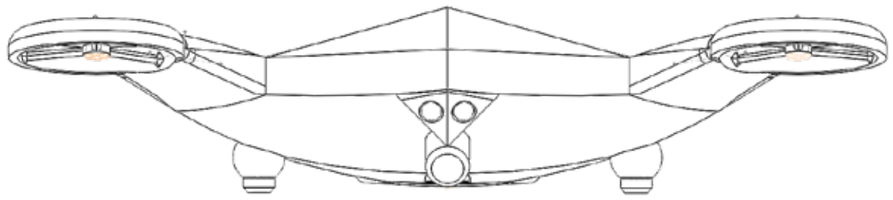


DAWN SWARM



Dawn: Improving Hurricane Response for Citizens and Local Governments

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Abstract
Weather-related disasters have the potential to cause devastating impact on community infrastructure, families, and lives. In this pictorial we propose *Dawn*, a local weather information collection tool that improves the process of information retrieval and city-wide recovery from hurricanes for citizens, as as well as federal and local governments. Through drone swarm surveillance operations, local EMA (Emergency Management Agency) operators are able to efficiently assess damages on a large scale to be sent to the Federal Emergency Management Agency (FEMA) for accelerated relief distribution to the affected city. Drone swarms are released by these operators before and after the hurricane to analyze risk pre-storm, and evaluate damages post-storm on individual properties throughout the city.

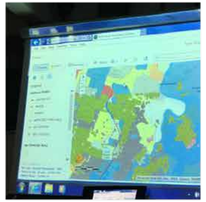
Authors Keywords
Drones; Disaster relief; Evacuation; Information collection; Information visualization.

ACM Classification Keywords
H.5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous. See: http://www.acm.org/about/class/1998/ Mandatory section to be included in your final version.

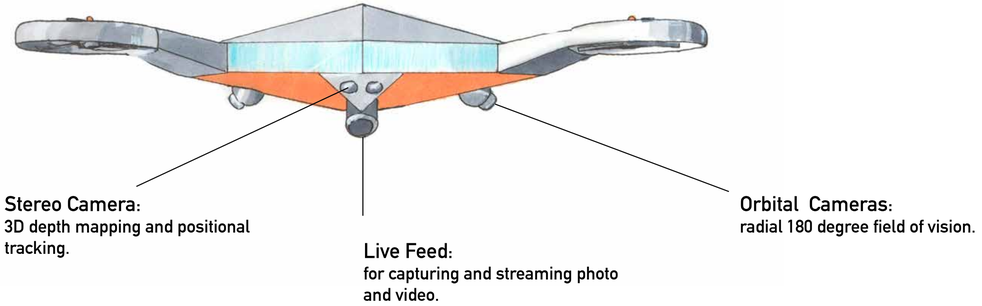
Introduction
Over one billion people in the world live in low-lying coastal regions. Hurricanes in particular present a huge threat to the world's population as they form over warm ocean waters near the equator. However, many problems exist in both stages of overall hurricane relief from both the citizen and government perspective; these problems range from the ambiguous and confusing information experience regarding storm preparation, to unoptimized repair protocols for infrastructure damage.
In our design we attempted to target some of the main problems found in primary and secondary research regarding hurricane preparation and relief.

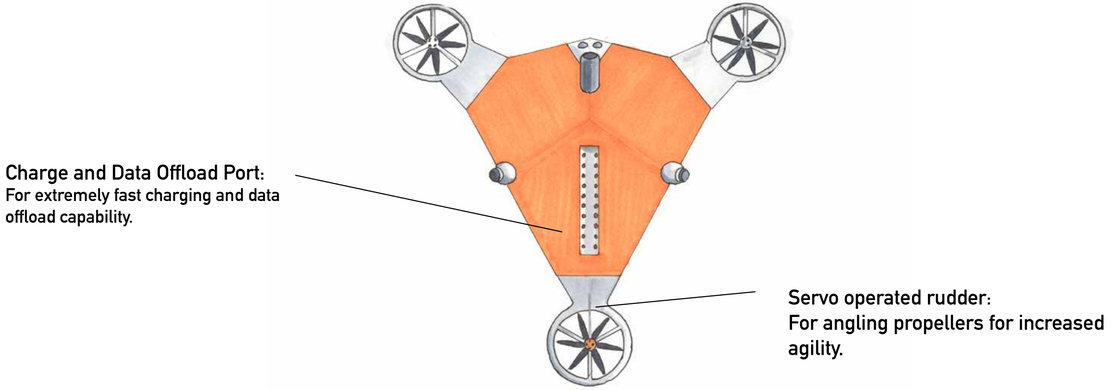
Background
Local EMAs are equipped with internal web-based tools such as WebEOC and ArcGIS to help assess city-wide damages and repair costs on individual properties and coordinate with federal governments for relief distribution. WebEOC (Web Emergency Operations Center) is an online platform that combines all of a local emergency organization's data sources into one location, aimed at local EMA specialists and public safety officials to efficiently manage disaster information. ArcGIS is a Geographic Information System (GIS) designed to work with assigning data to map addresses. While these tools succeed in providing an aggregated list of all local emergency-related operations in one place, the process of collecting local damage information is still relatively slow as it is done manually. When taking the additional time that FEMA takes to assess the damage information from the city before distributing relief into account, the time saved by expediting this process would have large benefits to citizens and the local government.

Design Process
8 one-on-one interviews and 60 intercept interviews were conducted regarding the subject of overall hurricane preparation and recovery. Due to Savannah's humid subtropical climate and two recent storm hits from Hurricane Matthew and Irma, we were lucky to have a large amount of input from locals, American students, international students, and CEMA. We asked questions pertaining to preparation, aftermath, challenges, and recovery from hurricanes. Some of our key insights from these interviews are summarized below.
- According to CEMA, the key to city-wide disaster recovery lies in the fastest damage information assessment on an individual property level. The faster FEMA gets the numbers, the faster federal aid can be distributed.
- Proper situational awareness comes from effective and efficient identification and understanding of the effects of a disaster from both citizens and local government perspectives.
- Many citizens feel frustrated when generalized weather forecasts do not provide information relevant to their specific needs.

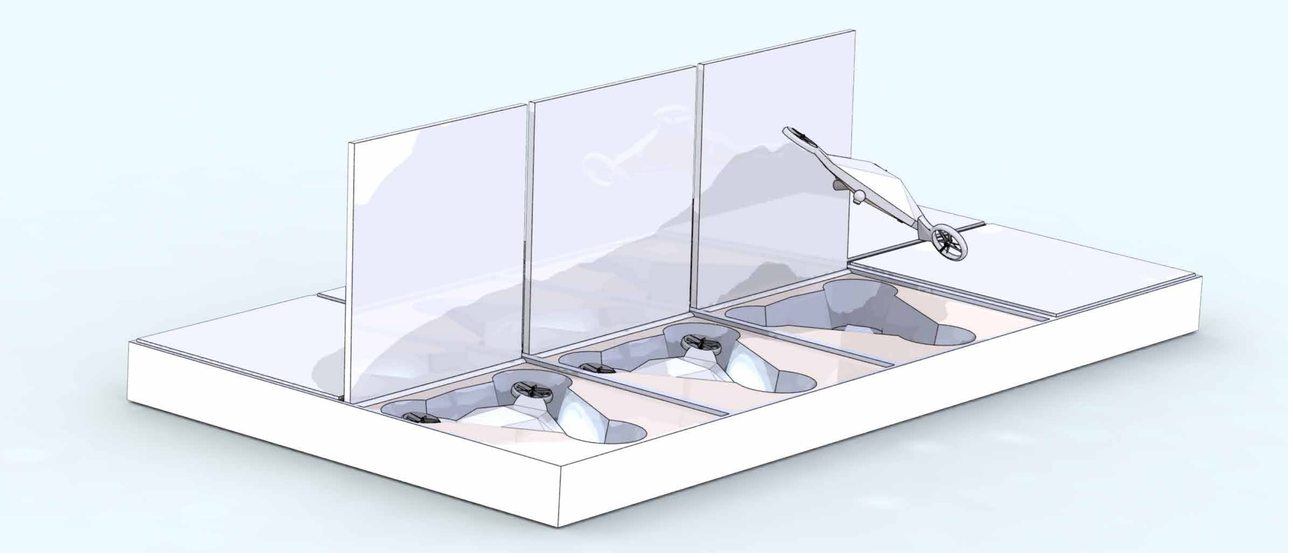

Evaluation
As we continued to develop our design concept, we had the opportunity to visit Savannah's Chatham Emergency Management Agency (CEMA) in order to get usability feedback on a few prototypes as well as validation of the feasibility and practicality of our concept. The EMA specialists we spoke to were given small tasks to operate the information retrieval interface and talk through their opinions.
According to those we spoke with, the information and data collected from the large-scale surveillance should integrate with CEMA's existing ArcGIS property parcel system. Key structures such as schools, hospitals, police buildings, and government halls should be important for EMAs to reference and should be highlighted.
After a few rounds of user testing with CEMA, we continued to develop our overall concept and design of Dawn. In this pictorial we will outline the key functionalities and features of the design.



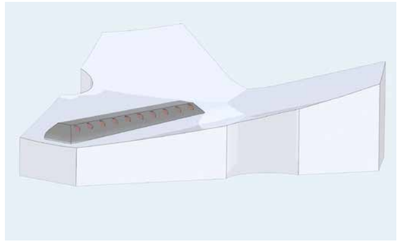


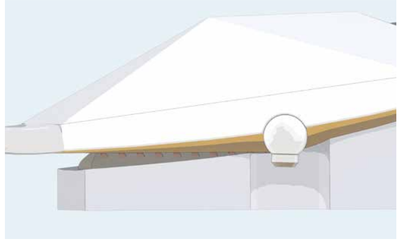
With a focus on visual data collection, imaging peripherals are of the utmost importance for these drones. The front of the drone contains a high output LED strip for operating in darkness, a large main camera for live photo and video feed as well as a stereo camera for capturing 3D depth mapping and positional tracking.

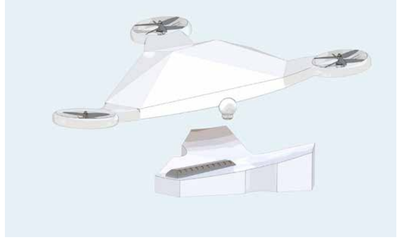
These technologies would allow for the drone to not only have spatial awareness but to be able to spatially map the environments their surveying to better understand post disaster situations. The two orbital cameras can also be directed downward in tandem to be used as a second depth-capturing device.



The idea would be to construct a housing that can attach to the roof of an emergency weather response truck. The housing would host multiple docking stations for drone storage as well as charging and data offload capabilities. The drones would stream any live feeds to the truck from a distance.

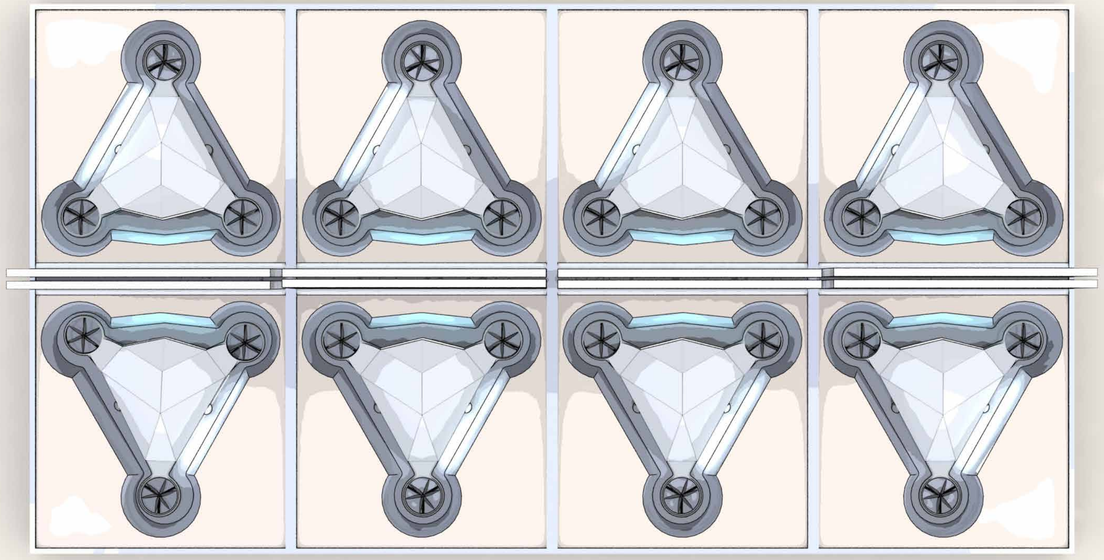






Battery Life

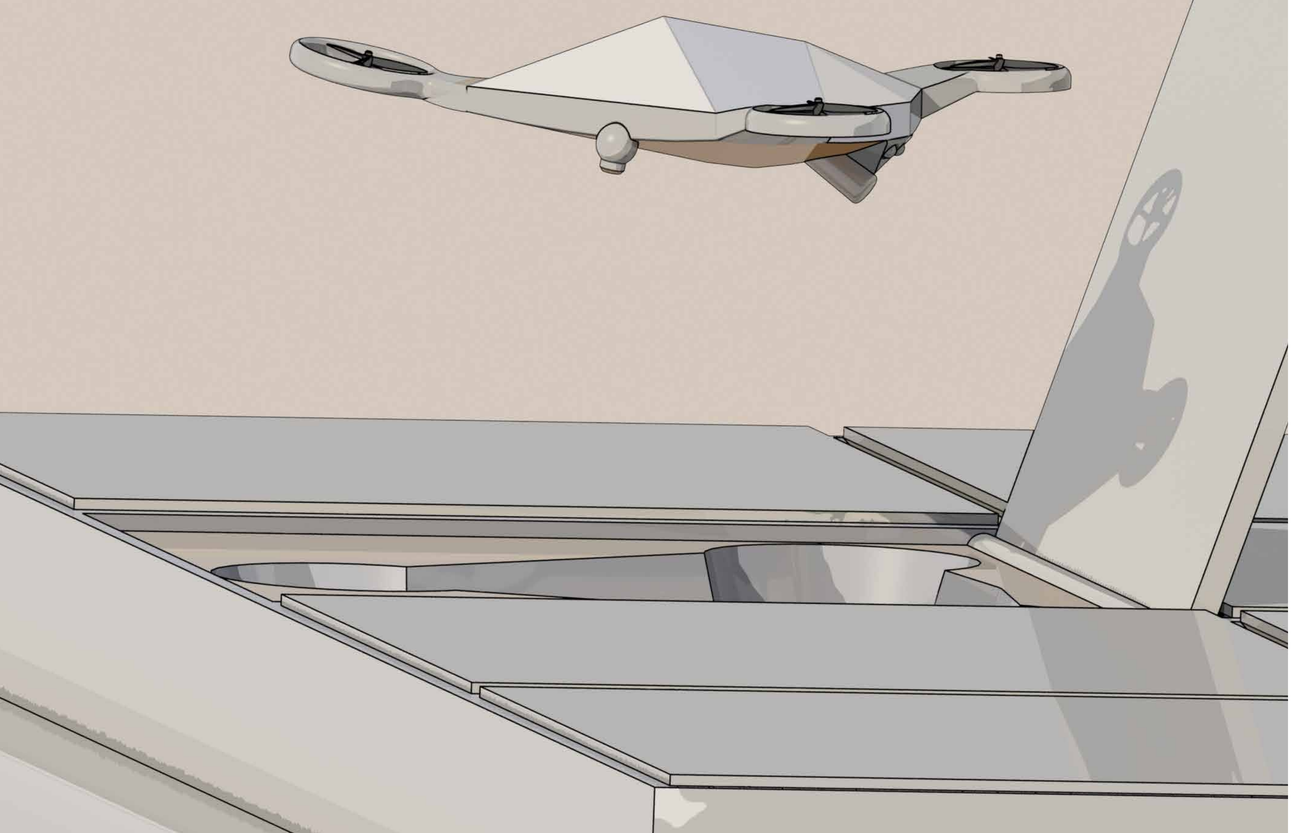
The biggest concern with relying on drones on a consistent basis is battery life, especially in the scope of surveying larger areas. It would be pertinent to not only have a large battery capacity to extend the range of a single drone, but to provide a home base for a swarm to cycle from.

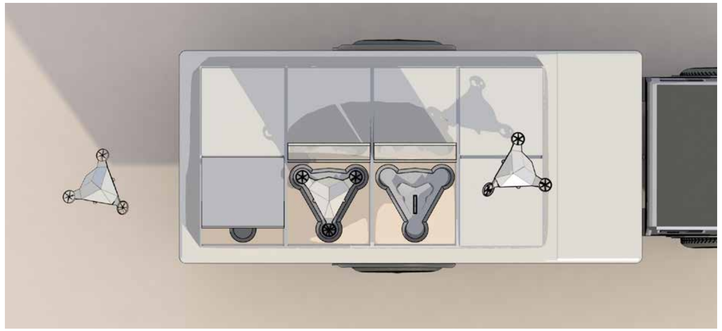


The rear rotor pivots in order to turn and swivel with acrobatic excellence.

The housing would host a fleet of eight drones attached to the roof of a vehicle, six for field use and two for backup. Drones would be released in swarms of three, every 45 minutes in a rotating cycle with flight time and charge time being identical.

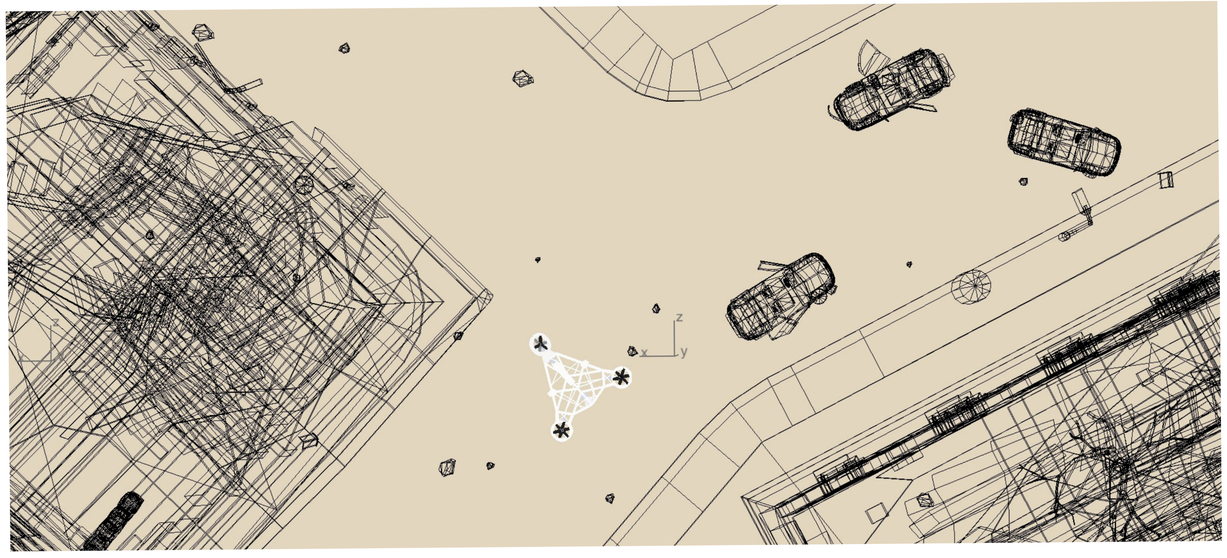
This would allow the truck to release a new swarm as the previous swarm returns to the hive, ensuring efficient data collection.





Weather response trucks are already equipped with a vast amount of technology, so by keeping them local to the truck you not only extend the capabilities of the swarm but furthermore the capabilities of the truck.

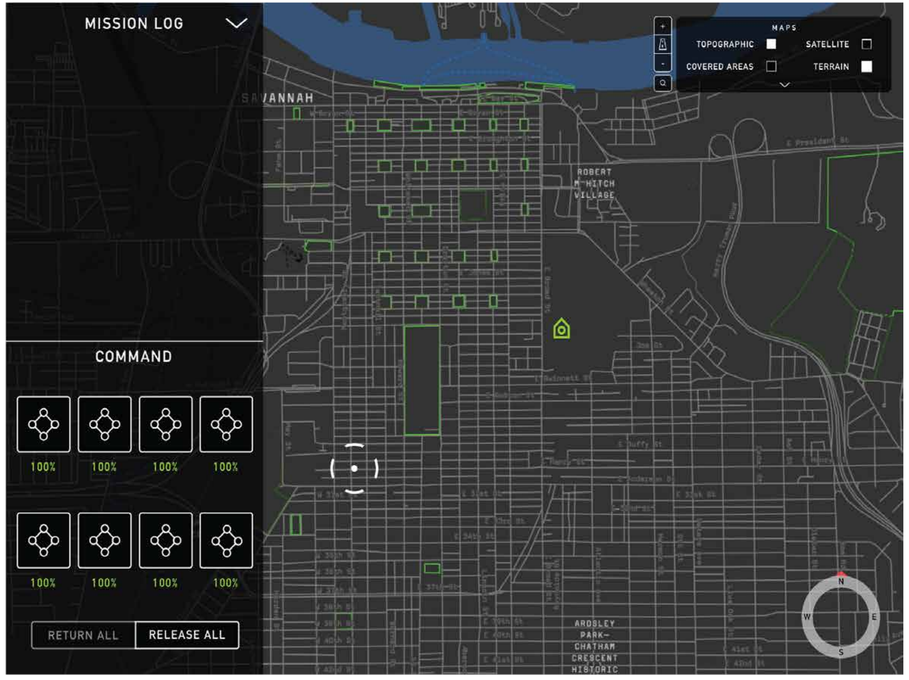
The drones would stream any live feeds to the truck from a distance, but most of its collected data would be offloaded at the end of its cycle to preserve battery life thus extending the lifetime of a cycle. Swarm data would be offloaded directly into a server in the truck cabin, so it can immediately be reviewed by emergency response personnel.



Operator Interface

The user interface for the EMA Operator includes an orthographic map of the city, a pull-out mission log menu (left), a compass (bottom right), and a map view toggle menu (top right).

The home icon on the map indicates the weather truck site where the drones are launched and charged.

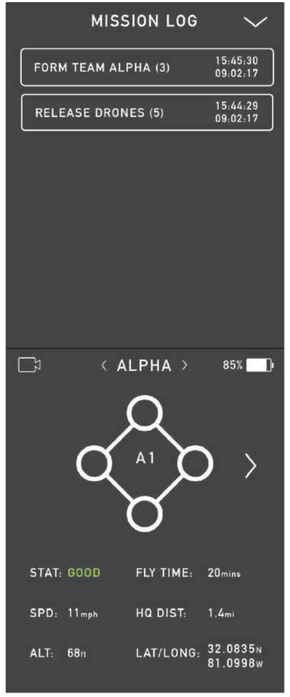


G. EMA Operator Control Interface

Interface Controls

The Map View menu allows the operator to zoom, search, and toggle visibility of different terrain types, visibility of critical facilities, and hazards on the map.
The pull-out Mission Log menu contains the bulk of command operations from the mission log, as well as details on the selected drone including status, fly time, speed, distance from launch site, altitude, battery life, and coordinates. The video icon can be clicked to view a video feed of the selected drone for more detailed surveying.

H. Map View Toggle Menu

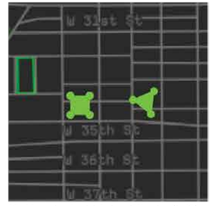


I. Mission Log submenu

Drone Status

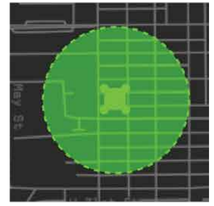
Unselected drones are uncircled and can be selected by dragging the cursor to select. Square drones are at a high-altitude, while triangular drones are at a low-altitude or street-level.
Once selected, the drones are circled in a solid green line. Drones that are on an assigned task are indicated with dotted bounding circles.

J. Dragging to select group of idle drones



K. Unselected high-altitude (left) and low-altitude (right) drone

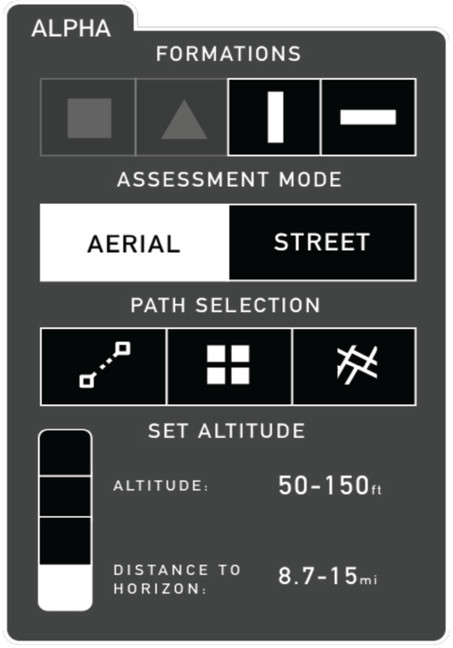
L. Selected drone (solid circle)



M. Tasked drone (dotted circle)

Drone Submenu Controls

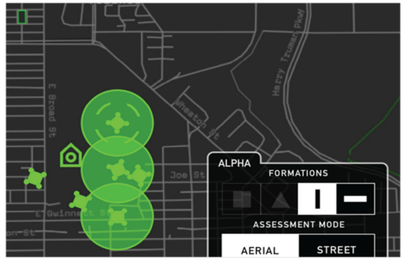
The operator can right click an individual drone or swarm to pull up a submenu of additional controls. The drone submenu allows the operator to alter swarm formations, switch assessment modes and altitudes, and select the survey path methods.



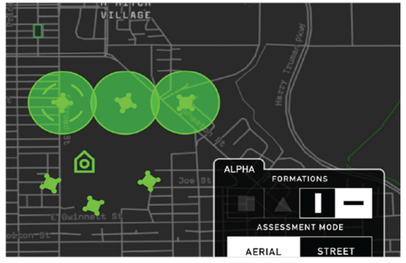
N. Drone Submenu

Swarm Formations

The drone submenu allows the operator to alter swarm formations.



O. Vertical line formation



P. Horizontal line formation

Survey Path Selection

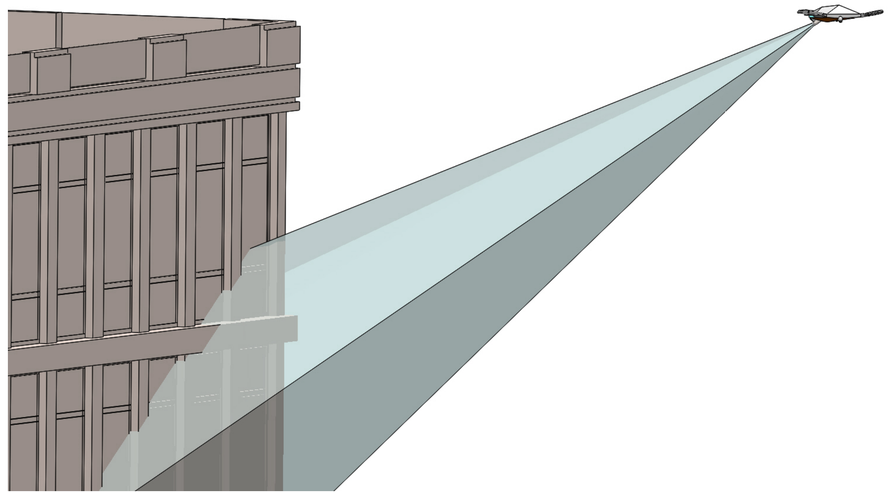
The operator can select different surveillance paths from the submenu depending on the task at hand.
Street path surveying allows the drones to survey selected streets, and block selection surveying selects blocks to survey. Custom area selection surveying allows the operator to select a custom by dropping pins to survey the area bounded by the dropped pins.

Q. Path selection options in the Drone submenu: Custom area selection (left), Block selection (middle), and Street selection (right)

R. Street path surveying

S. Custom area selection surveying

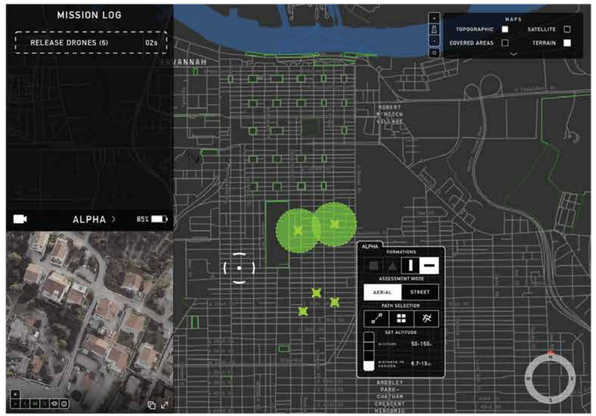
The stereo depth cameras allow the drone to have a full 360-degree field of vision to capture imaging data below, beside and above the drone body that can be used to create full scale 3D depth maps of devastated areas



T. Altitude control in the Drone submenu: High (left), Medium (middle), Low (right)

Controlling Altitude

Aerial (100-450 ft) or Street (altitudes between 10-15 ft) modes be selected in the submenu. If the video icon is selected in the Mission Log menu, a video preview of the selected drone can be viewed. The operator can select the video assessment to survey more closely at low altitude if needed.

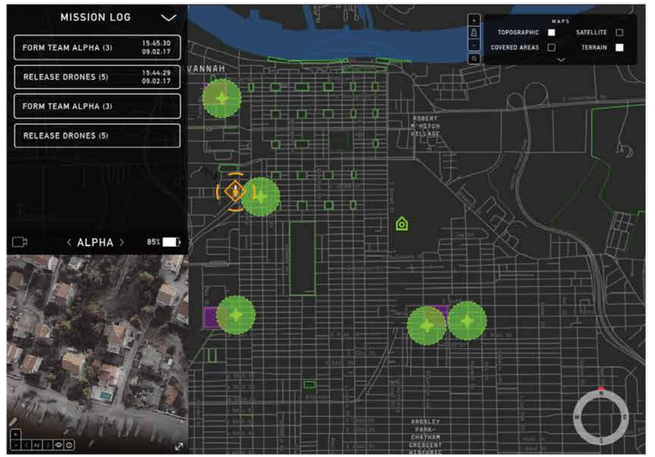


U. Aerial survey mode and video feed preview in the Mission Log menu (bottom left)

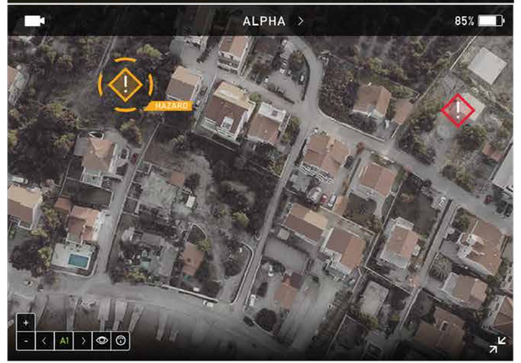
V. Video low-altitude view for street-mode assessment

Hazard Assessment

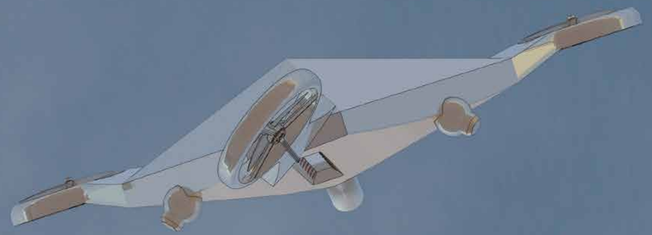
Before the storm, operators assess areas for potential hazards for pre-storm risk analysis. After the storm, operators mark hazards and footage for damage repair cost estimates to be sent to FEMA for federal relief distribution. Hazards can be marked on a both Aerial and Street mode.



W. Marking hazards on Aerial mode



X. Marking hazards on Street mode



DAWN

Conclusion

Overall, Dawn provides a more efficient and effective experience for the hurricane preparation and recovery process by addressing two of the key problems found in our research: indigestible information presentation and ineffective federal relief distribution. Since several federal government technicalities exist within general disaster recovery protocols, we tried our best to focus on designing a tool that could could be scaled to have macro-level effects through micro-level implementations within local EMAs. The process of designing this project offered an immensely valuable look into the process of hurricane relief from both the citizens' and government's perspective. With the rapid growth of autonomous data collection and communication operations in technology, one can hope for the future of disaster recovery to offer a variety of solutions to effectively inform and prepare people and mitigate the devastating effects of natural disasters.

Acknowledgements

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