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REACHR

Reconnaissance and Emergency Aircraft for Critical Hurricane Relief

Department of Mechanical and Aerospace Engineering

North Carolina State University

Faculty Advisor: Dr. Felix Ewere

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Meet the Team

Tobias Hullette (Team Lead)
Aerospace Engineering
Senior

Brian Shi
Aerospace Engineering
Senior

Caleb Kebede
Aerospace Engineering
Senior

Sebastian Perna
Aerospace Engineering
Senior

Jose Vizcarrondo
Aerospace Engineering
Senior

Lucas Andrews
Aerospace Engineering
Senior

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Team Advisor

Dr. Felix Ewere
Associate Teaching Professor

Introduction

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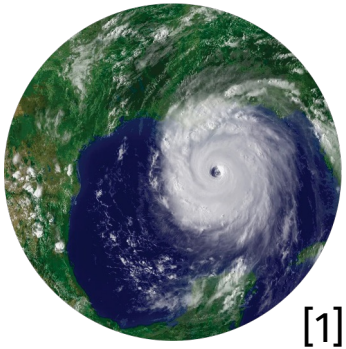
Background



[1]

Hurricanes

- Winds over 100 mph
- Atlantic coast, pacific islands, and Caribbean islands are most affected

[2]

Flooding

- Storm surges over 20 ft
- Rainfall over 6 in

[3]

Response

- Hurricane Katrina in 2009 caused 196.3 billion dollars in damage
- Only 54% of people obey mandatory evacuation

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Current Systems

[4]

FEMA

- Preparation
- Response
- Recovery
- Hurricanes, storms, winds, tornados, tsunamis

[5]

First Response

- Navigation surveys
- Disaster imagery
- Pollution assessment
- Data Analysis
- Victim assistance

[6]

Drones

- Hunting hurricanes
- Collecting wind speed, temperature, pressure and humidity data,

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Current Systems Analysis

- Examples of current systems costs
  - Over $700,000 spent on dropsondes per hurricane season
  - $1,000 - $10,000 for small landscape imagery drones
  - FPL Air One, larger fixed-wing imaging drone priced at $1.2 million
  - FEMA spent $92 million on search and rescue teams after Hurricane Harvey
- Drones are necessary for recovery operations but are often one dimensional
- REACHR is purposed to be more cost efficient and multifunctional

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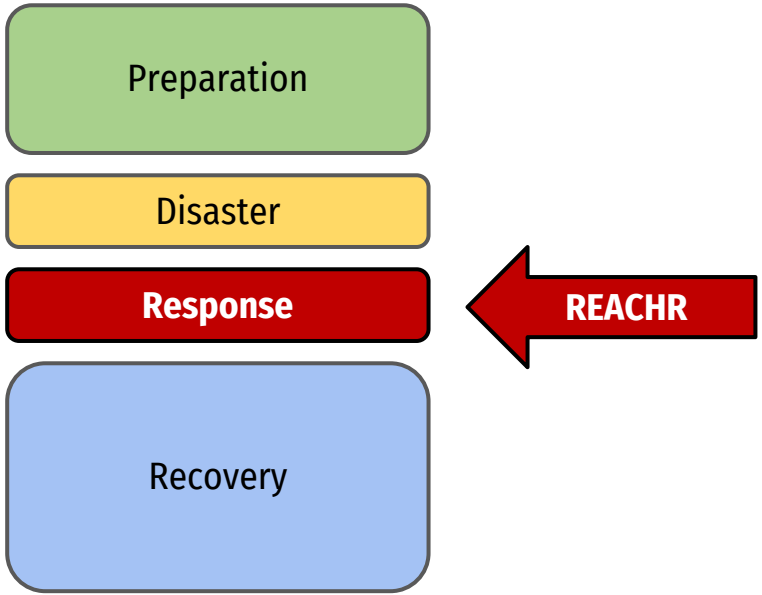
Use Case

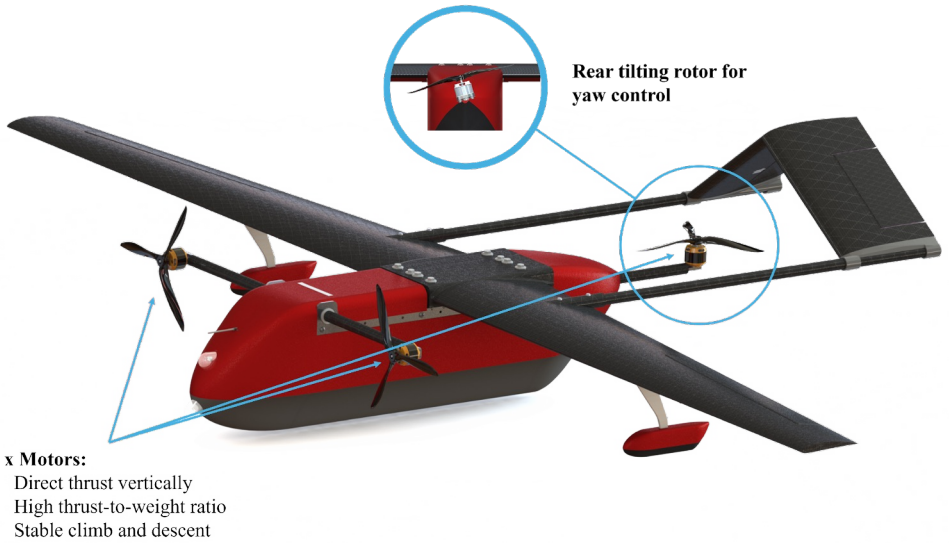
- In support of hurricane response, the UAS will
  - Conduct surveillance of flooded areas
  - Identify stranded individuals in need of assistance
  - Provide direct victim support with emergency supplies.
  - Provide indirect victim support by relaying critical data to first responders.
- With the UASs operability in the air and on water, this system can also revolutionize flood disaster response operations



Design Solution

Multi-Mode UAVs

- Fleet of versatile fixed wing UAVs with multiple flight modes.
- Conventional flight for long distance travel and large surveillance area
- Hover flight so UAV can access areas with dense debris and perform more thorough searches.
- Hull like body to allow UAV the ability to land in the water and give necessary support to stranded individuals.



REACHR Prototype

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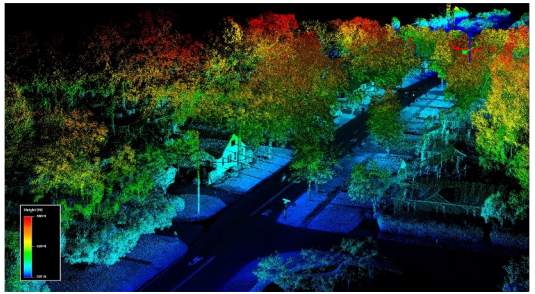
Advanced Imaging

Advanced imaging technology will assist in surveillance and data collection

LiDAR

- Generate 3D maps of affected areas.
- Assist with obstacle avoidance and optimizing first responder rescue paths.
- Bathymetric LiDAR to map underwater topography.



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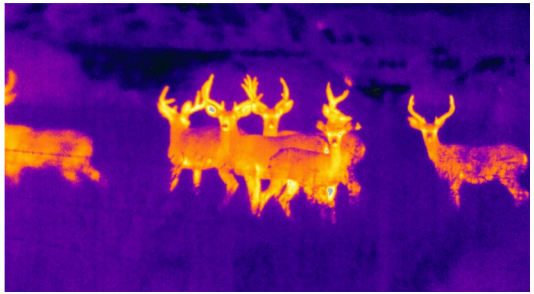
FLIR

- Detect heat signatures and visualize temperature variations.
- Can be very beneficial in low-light conditions.
- Many cameras already developed small enough to fit on drones.



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NASA FINDER

The NASA FINDER can locate survivors through obstructions, expanding the surveillance capabilities of the system.

- Utilizes microwave radar to identify survivors by detecting their heart beats and respiration.
- Capable of :
  - Seeing through rubble and dirt
  - Differentiating human survivors from noise
- Commercialized by the SpecOps Group
  - Reduced weight
  - Larger batteries
  - Better UI
- Deployed to the Bahamas after Hurricane Dorian in 2019

[10]

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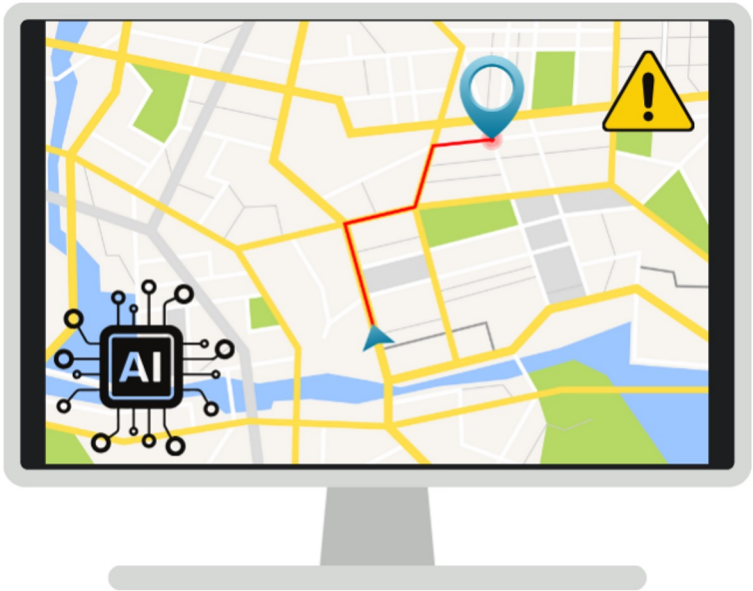
AI Route Planning

Advanced imaging technology will assist in surveillance and data collection

- Autonomously navigation and identify optimal routes for emergency response missions.
- In flooded areas, will identify road blockages, areas with shallow water to avoid, and fastest route to stranded individuals.
- Improves decision making and saves time in possibly life threatening situations.



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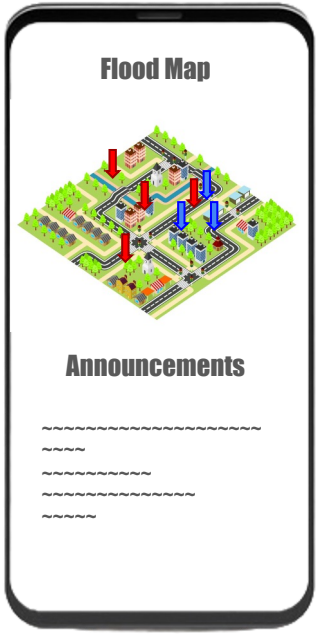
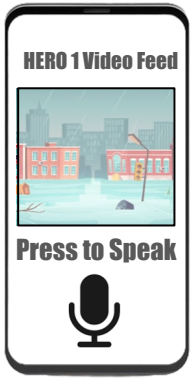
Communications Via Web Application

9/11 Public Discourse Project - communication during Hurricane Katrina was a classic failure of command and control as it had no unified incident reporting system to coordinate the efforts of local, state, and federal agencies.



- Unified reporting system.
- Information is clearly and efficiently communicated between agencies.
- Where route planning will be presented to first responders.

- Connect to specified UAVs that have landed near stranded individuals to give direction and emotional support.
- Map of affected area projected on home screen, highlighting areas of importance and known locations of stranded individuals.



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Solar Enhanced Battery

Sustainable, clean energy is a major feature of the REACHR system, empowering technological advancement and implementation with a negligible carbon footprint.

- The power supply of the REACHR UAS will be supplemented by solar panels attached along the top of the UAVs wing and body to increase the duration of flight and aerial coverage.
- Increasing the UAVs endurance directly increases it ability to provide important services during the critical hours and days of first response.
- Solar power increases it self sustainability as it has less reliance on existing infrastructure such as the electric grid.

[11]

Helios Prototype proving solar powered capabilities.

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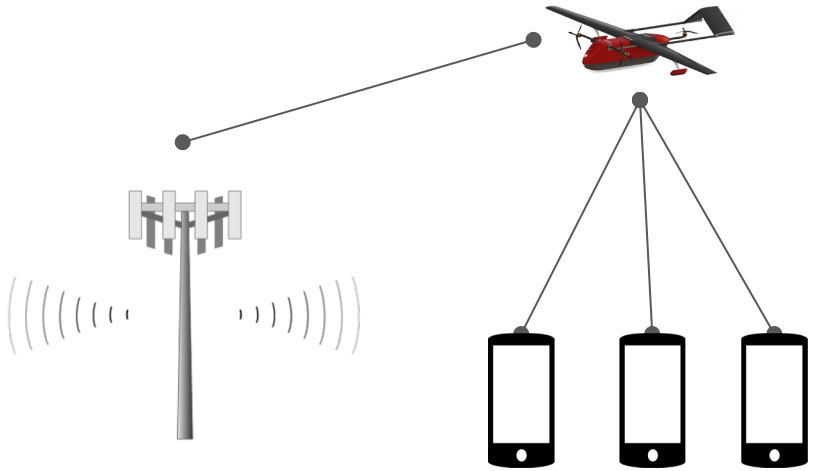
Aerial Signal Relay Station

Aerial relay capabilities will provide internet access and critical information to stranded survivors.

- Increases the range and accessibility of working 5G cellular networks or as a local source of wifi.
- Can quickly reach dead spots until more permanent solutions are brought in.
- Provides ease of mind to survivors by allowing them to directly contact emergency services or with friends, family, etc.



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Satellite Based Data Uplink

LEO satellites provide world-wide reliable internet access regardless of local or local infrastructure.

- Satellite based data uplinks allows critical operational and survivor data to be transmitted to centralized operations centers regardless of where the UAV is located.
- A Lightweight, low-power module that only sends critical information in short-burst data transmissions.
- Similarly, this allows response teams to always have reliable internet.

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Equipment Suite Specifications

Module	Vendor	Size	Weight	Cost	Power Usage
FLIR VUE Pro 640	Teledyne FLIR	2.26 x 1.75 in	4 oz	$3,895.00	2.1 W
FINDER MK4	SpecOps Group	22 x 14 x 9 in	8.3 lb	N/A	0 W
C60 Solar Cell	Full Battery	5 x 5 in	0.23 oz	$3.00	3.6 W
D-LINK DWR-2101	D-LINK	4.7 x 2.8 x 1 in	0.51 lb	$540.00	0 W
SkyLink 7100	Skytrac	5 x 8 x 1.25 in	1.6 lbs	$3500.00	7 W
RockBLOCK 9603	Ground Control	1.8 x 1.8 x 0.6 in	1.27 oz	$280.00	0.45 W

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System Integration And Expanded Analysis

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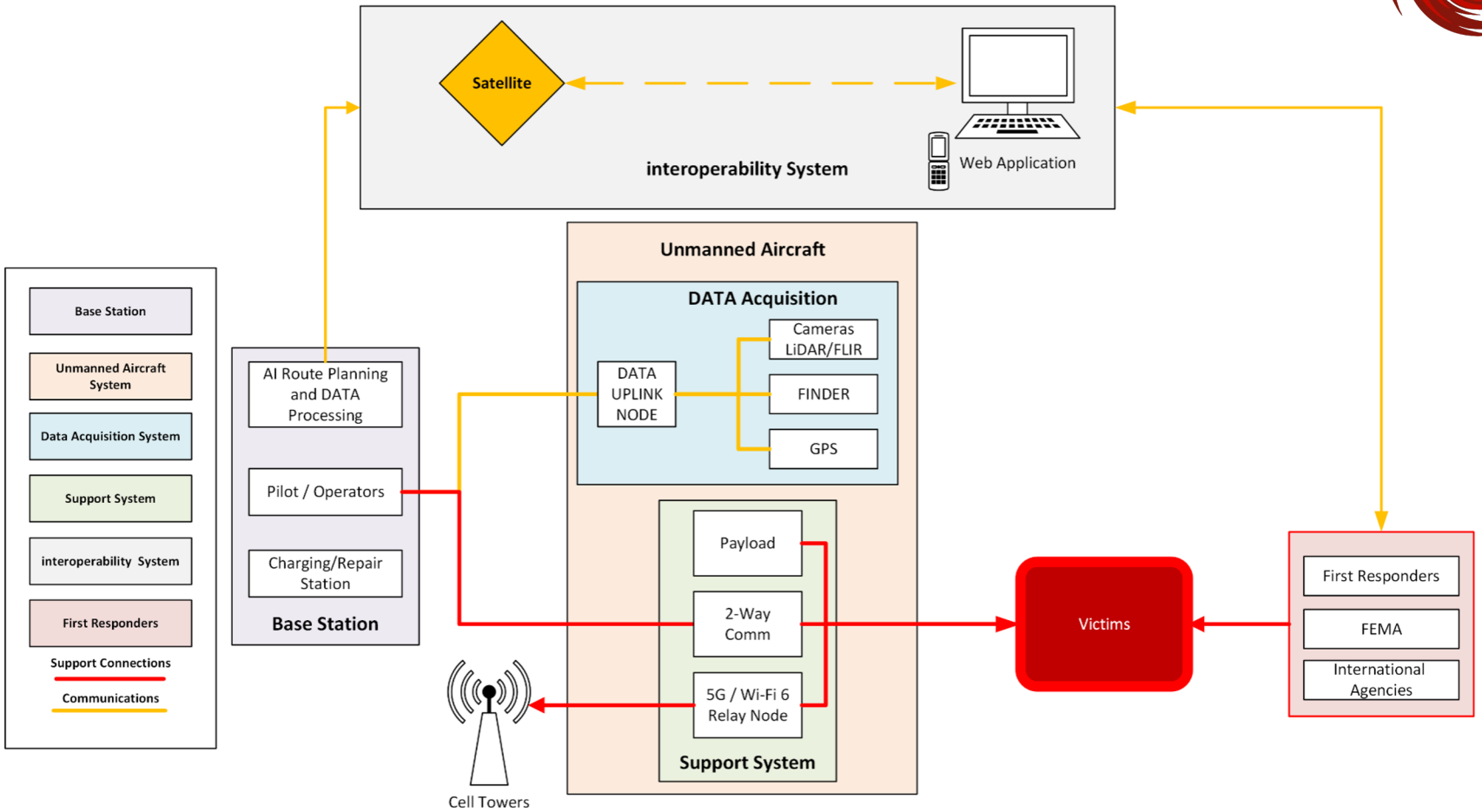
System Block Diagram



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UAV Sizing Analysis

Estimates are based on the payload, mission, and regulatory requirements of the REACHR UAV

Weight

- The UAV needs to stay below 55 lbs in order to be classified as a "medium-sized" UAV
- Will likely be around **40-45 lbs** empty with around 10 lbs of payload for either survivor rescue supplies or the NASA Finder

Power

- The power-to-weight ratio would range between 50 W/lb to 200 W/lb.
- Assuming maximum takeoff weight, power from the propulsion ranges from **2750 W** to **11000 W**.
- Power requirements of other systems negligible.

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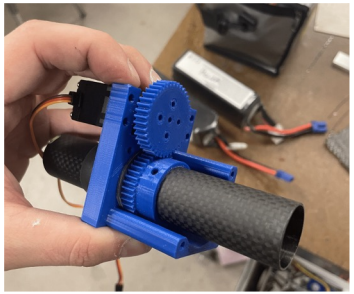
Prototyping

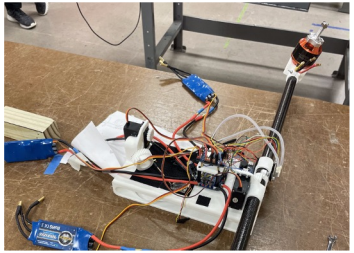
Prototype designed and built as a half-scale proof of concept for the REACHR UAV

Major Specifications

- $1,500 Maximum budget
- Deconstructs into a 5 x 3 x 2 ft box
- 22.5 lbs (50% scale, by weight, version of the production full-scale UAV)
- 10 ft foam core composite wing
- Tri-tiltrotor system
- Inverted V-tail
- Waterproof fuselage

Build Images





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Functional Prototype

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Prototyping and Testing

Hover Testing (VTOL): Proved the aircraft could produce the necessary vertical thrust

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Prototyping and Testing

Cruise Flight: Proved the aircraft is capable of low power, energy saving, forward flight

Prototyping and Testing

Water Operations: Proved the aircraft's amphibious capabilities

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Prototyping and Testing

Water Flight: Proved the aircraft's ability to take off and land on water

Conceptualization of Implementation

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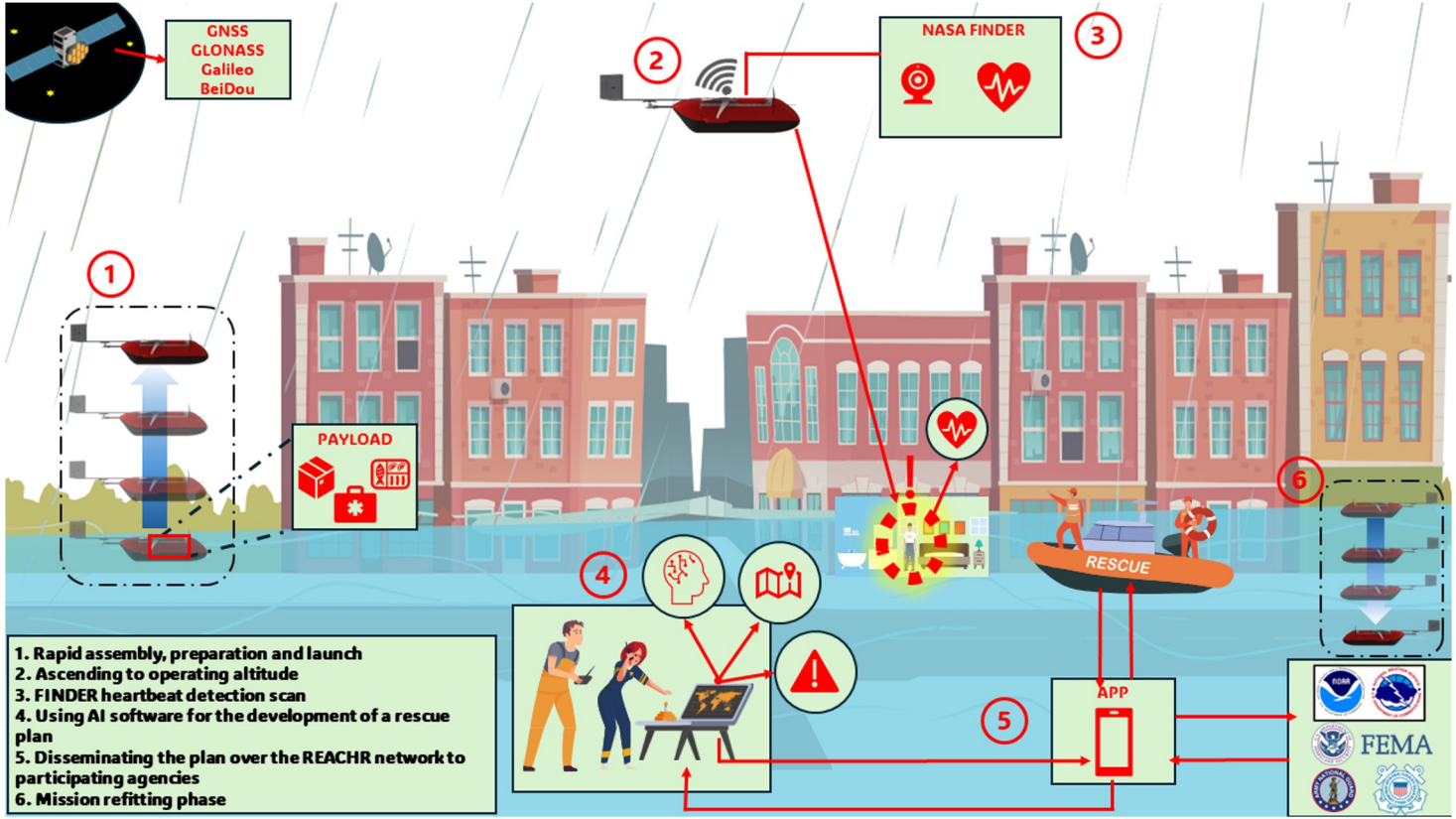
Concept of Operations



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Major Considerations

We have evaluated several major considerations for this hurricane response system

Simplicity of Adoption

- AI to minimize need for human input
- Modularity
- Training programs

Support Systems

- GCU (Ground Control Unit)
- Computer
- Operator
- Training program

Cost and ROI

- Response studies by REACHR reduce the cost of recovery
- Reduces current maintenance and operational costs
- Helicopters cost around $500,000 and have operation costs around $600/hr
- REACHR's UAS estimated to have an overall cost of under $100,000
    - UAV's estimated to cost about $10,000 with negligible operational cost

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Major Considerations

We have evaluated several major considerations for this hurricane response system

Connectivity Constraints

- Backup data storage
- Solar Cells

Environmental Conditions

- Waterproofing
- Multiple options of reconnaissance technologies
- Cellular relay only impeded slightly
- VTOL to navigate wind and debris

Interoperability

- AI facilitated flight and data processing
- Provision of rescue plans, routes, hazard locations
- Status updates

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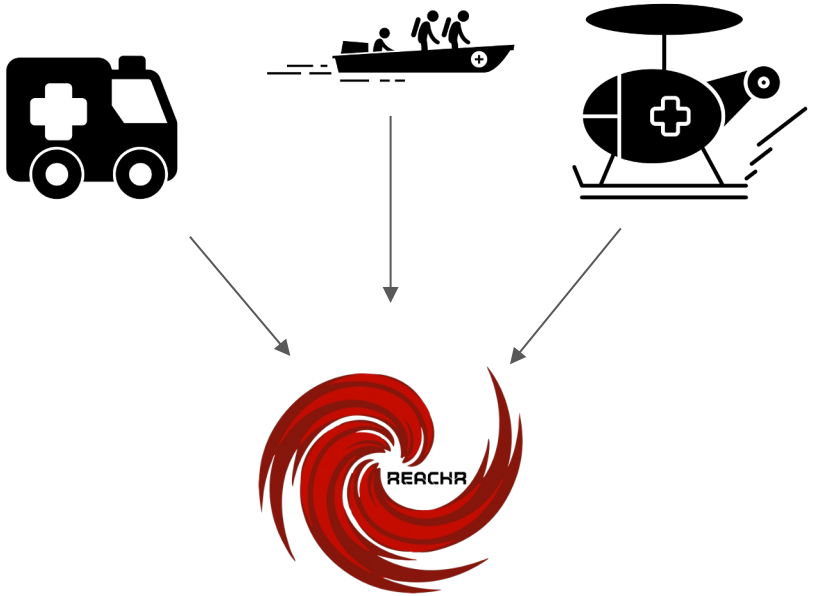
Major Considerations

We have conceptualized a system that significantly improves, consolidates, and simplifies hurricane response operations

Expected Improvements

- Time of response
- Reconnaissance technology for any situation
- Improved first responder's situational awareness
- Modular and Lower cost
- Minimization of damage
- Improved risk management
- All-in-one solution



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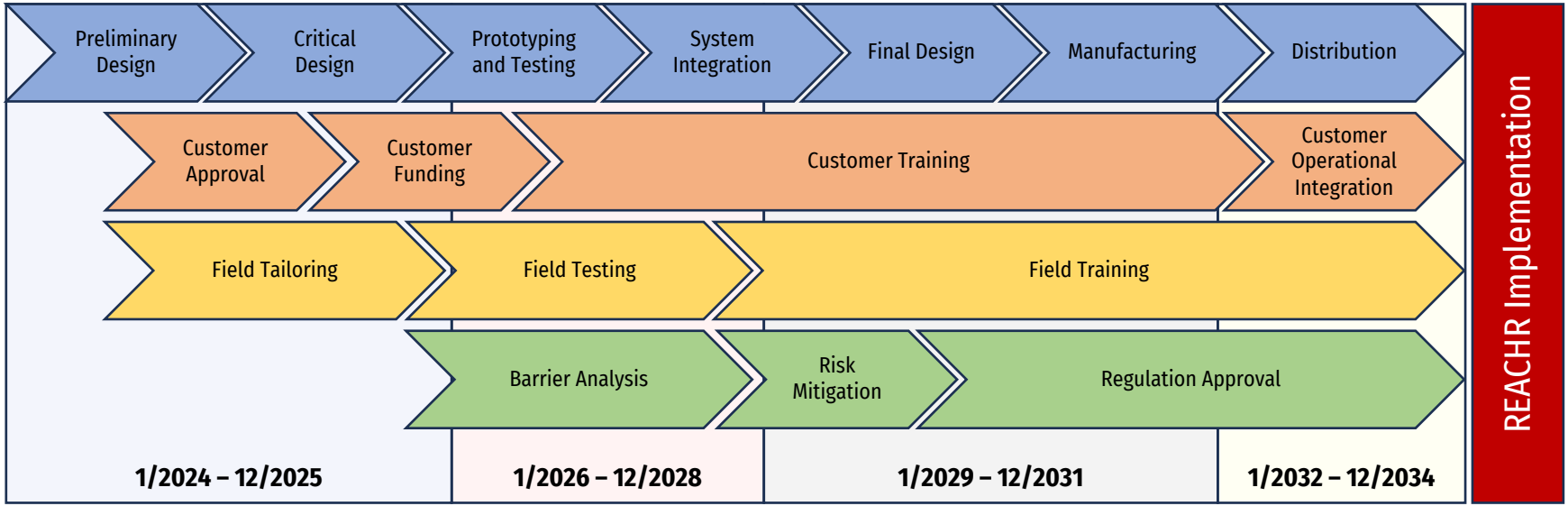
Path to Deployment



Path to Deployment

Done

- Technology specification and integration plan
- Preliminary System Design
- Preliminary UAV design
- Preliminary prototype and testing

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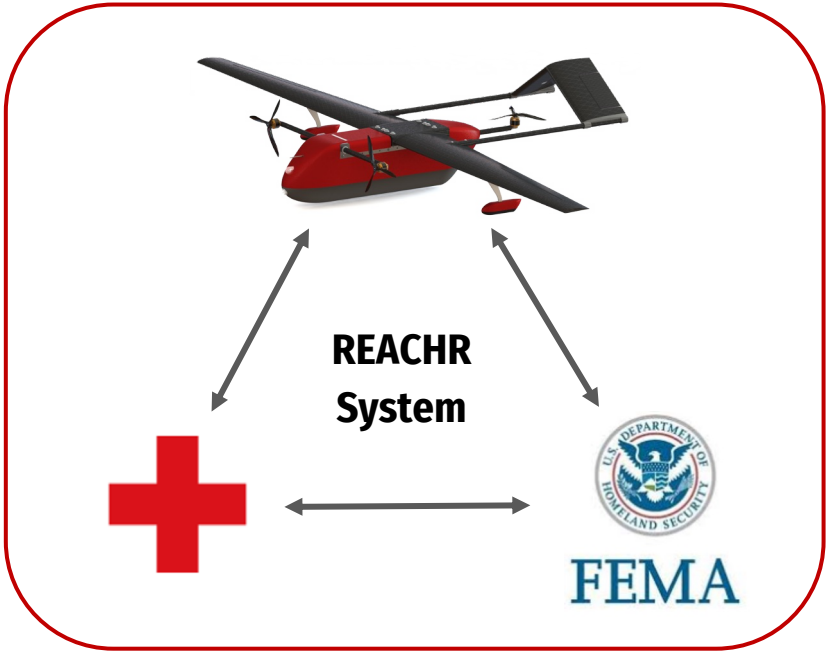
Path to Deployment

To Do

- Approval and Funding
- Analysis and Design
- Testing and Training
- Manufacturing and Verification
- Approval and Distribution



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Conclusion

We have designed a revolutionary hurricane response system, integrating state-of-the-art search, rescue, and communications technologies bolstered by a multi-mode UAV swarm capable of finding hurricane and flood victims and providing them with communication, supplies, and an optimized escape plan faster, cheaper, and more efficient than ever before.

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Thank you!

Questions?