Autonomous Aerial Assistance for Search and Rescue

Team F

System Design Review

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Team Rescue Rangers
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Sponsor:
Near Earth Autonomy
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Project Description

Motivation

Existing SAR Approaches:

- Require Skilled personnel and Helicopters
  - Expensive
  - Risk of human lives
- Teleoperated drones with minimal autonomy

Objective

Develop an autonomous aerial system to make Search and Rescue operations:

- Speedier
- Cheaper
- More reliable

http://www.carson.org/government/

http://store.dji.com/product/

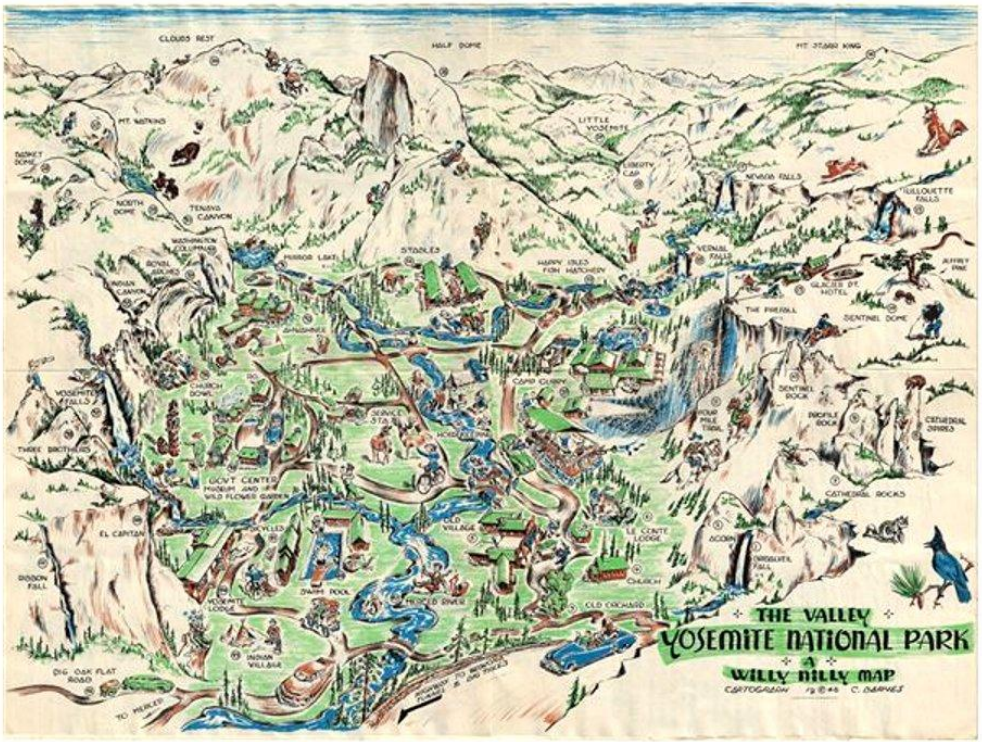
Use Case (Context)

Yosemite National Park (2012)

- Land Mass: 748,036 acres
- Designated Wilderness: 94.45%
- 53,679 overnight hikers
- 800 miles of trail
- 216 Search and Rescue operations

Yosemite Search and Rescue (YOSAR) team

- Well-equipped: 90% of big-wall rescues (~24) require a helicopter
- Rescuers: solid alpine skills required
    - Salary $ 23-34 per hour



http://www.yosemite.ca.us/library/maps/yosemite_valley_map_1946_barnes.jpg

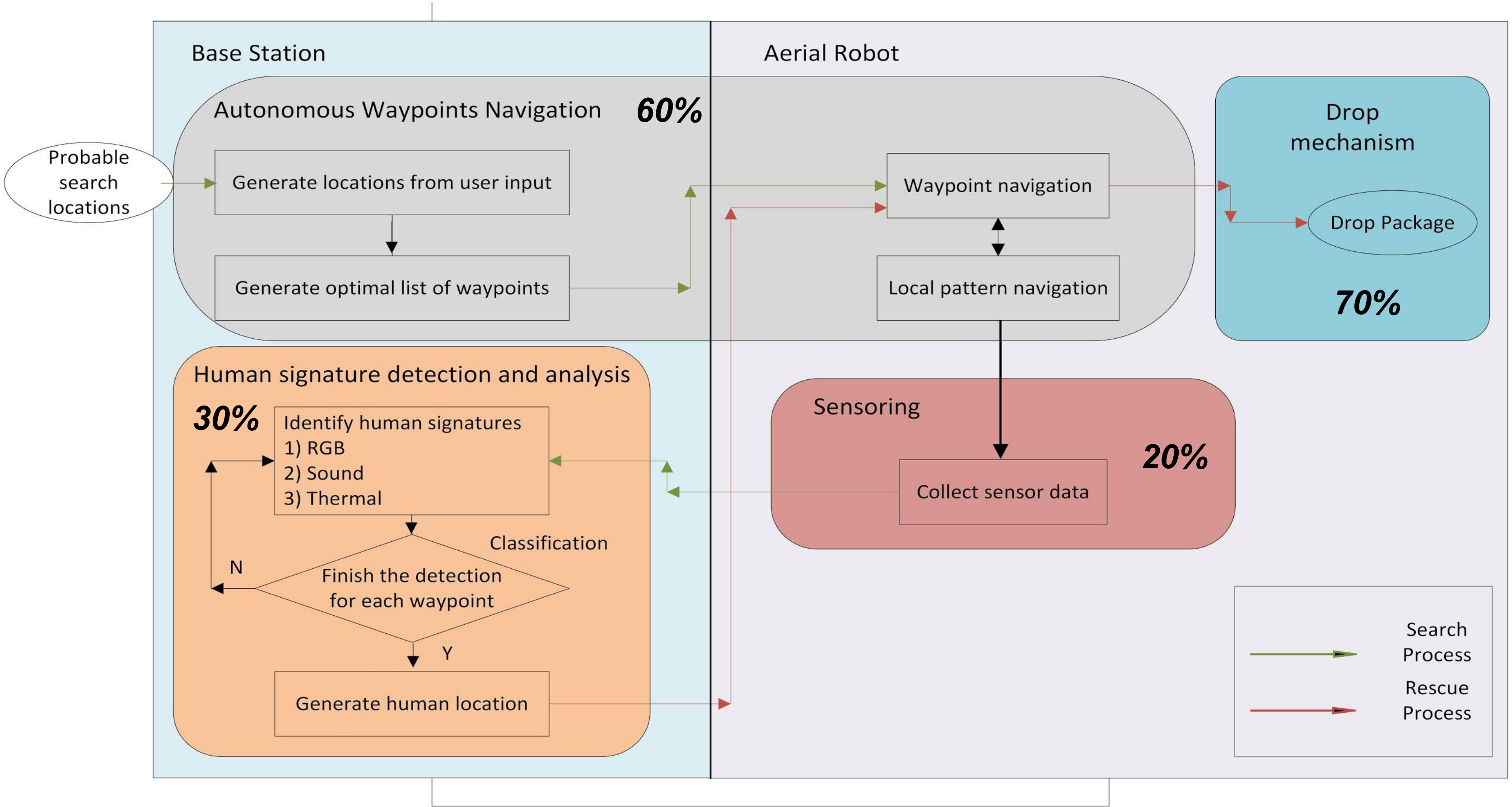
Use Case

… buys RescueRangers drone

Requirements

Functional Requirements The system shall:	**Performance Requirements** The system will:
M.F.1. Autonomously navigate through a set of provided locations of interest	**M.P.1.** Accurately reach the locations of interest with a tolerance of **+-5m**
M.F.2. Complete the search within limited time	**M.P.2.** Complete one iteration of search in an un-occluded operating area of **200m x 200m in <25 minutes**
M.F.3. Explore the surroundings around each location of interest	**M.P.3.** Attain up to **80%** coverage of the desired local search areas around each location of interest
M.F.4. Collect perceptual data while navigating	**M.P.4.** Collect perceptual data limited to 3 types - IR radiation, visual imagery, and sound
M.F.5. Process the data to identify human signatures	**M.P.5.** Identify at least **75%** of the locations with human signatures
M.F.6. Analyze the identified signatures to estimate human location	**M.P.6.** Estimate potential human signature location with **+-5m** tolerance
M.F.7. Navigate to the rescue location carrying the rescue package	**M.P.7.** Carry a rescue package weighing **100g**
M.F.8. Drop the rescue package	**M.P.8.** Drop the package at the rescue location with a tolerance of **+-5m**

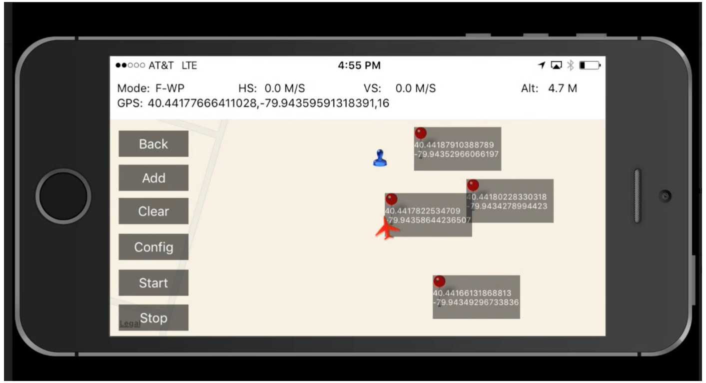
Functional Architecture



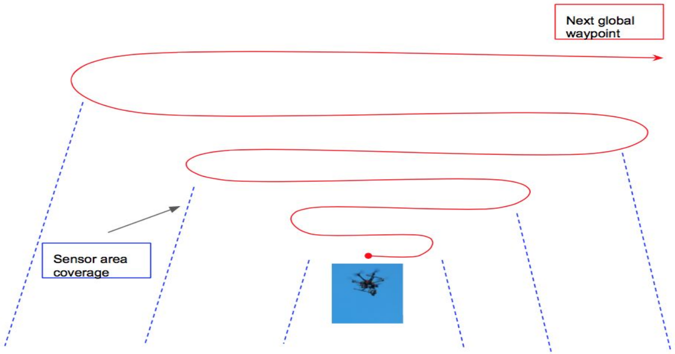
Current Status

Autonomous Navigation

- **Waypoint navigation - 90%**
  - Generate Location of Interest
  - Generate Waypoints
  - Validate ability to reach given GPS waypoints through screenshots taken during the flight



- **Localized Search - 30%**
  - Defining the navigation strategy



- **Port to M600 - 0%**

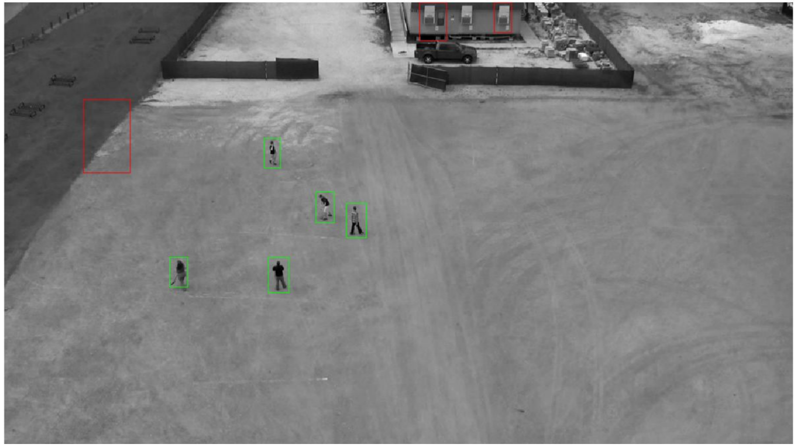
Signature Detection

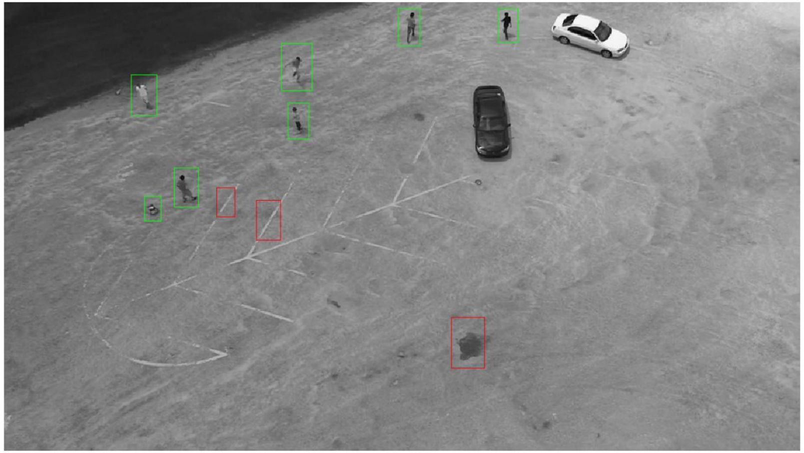
- **RGB - 60%**
  - Implement a HOG+SVM algorithm
  - Achieve over 60% accuracy of detecting humans

- **Thermal - 15%**
  - Literature Study

- **Sound - 30%**
  - Preliminary tests to detect human voice from sound samples

- **Fusion - 0%**





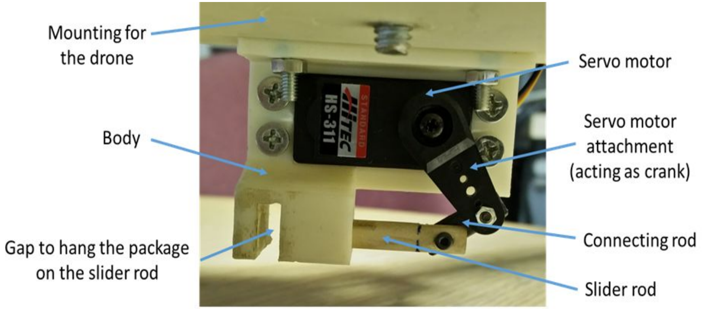
Sensing

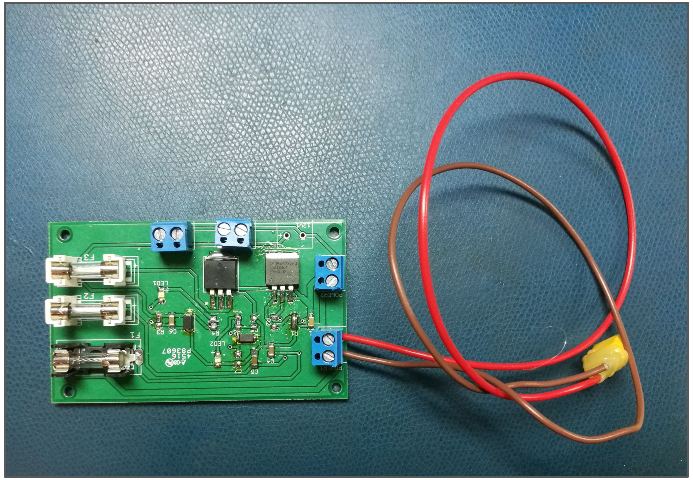
- **RGB - 20%**
  - Collected RGB image data by using Gopro and 360fly

- **Thermal - 0%**
- **Sound - 20%**
  - Collected samples using iPhone with the drone flying at few feet above
- **Plan for data collection with NEA payload in place**

Package Drop Mechanism

- **Package drop - 80%**
  - A prototype for the dropping mechanism
  - Validation on the mechanism
- **Sensor mounting - 0%**
- **PDB - 80%**
  - Design and fabricate a PDB with all desired functions





Pending Tasks/Challenges

Pending Tasks *...according to our requirements*

Autonomous Flight System

- Local pattern implementation integration
- Validation on Matrice 600

Sensing subsystem

- Data collection and processing using NEA payload

Package Drop

- Determine precise package drop location based on imagery
- Autonomous drop at specified GPS location

Signature Detection

- RGB signature detection improvements
- Thermal signature detection
- Sound Signature detection using VAD
- Fusion of various detection results

Integration

- Sound sensor and payload mount
- End to end system integration
- Testing/Validation at Final demo site

Challenges

Inability to get sufficient flight time with Matrice 600:

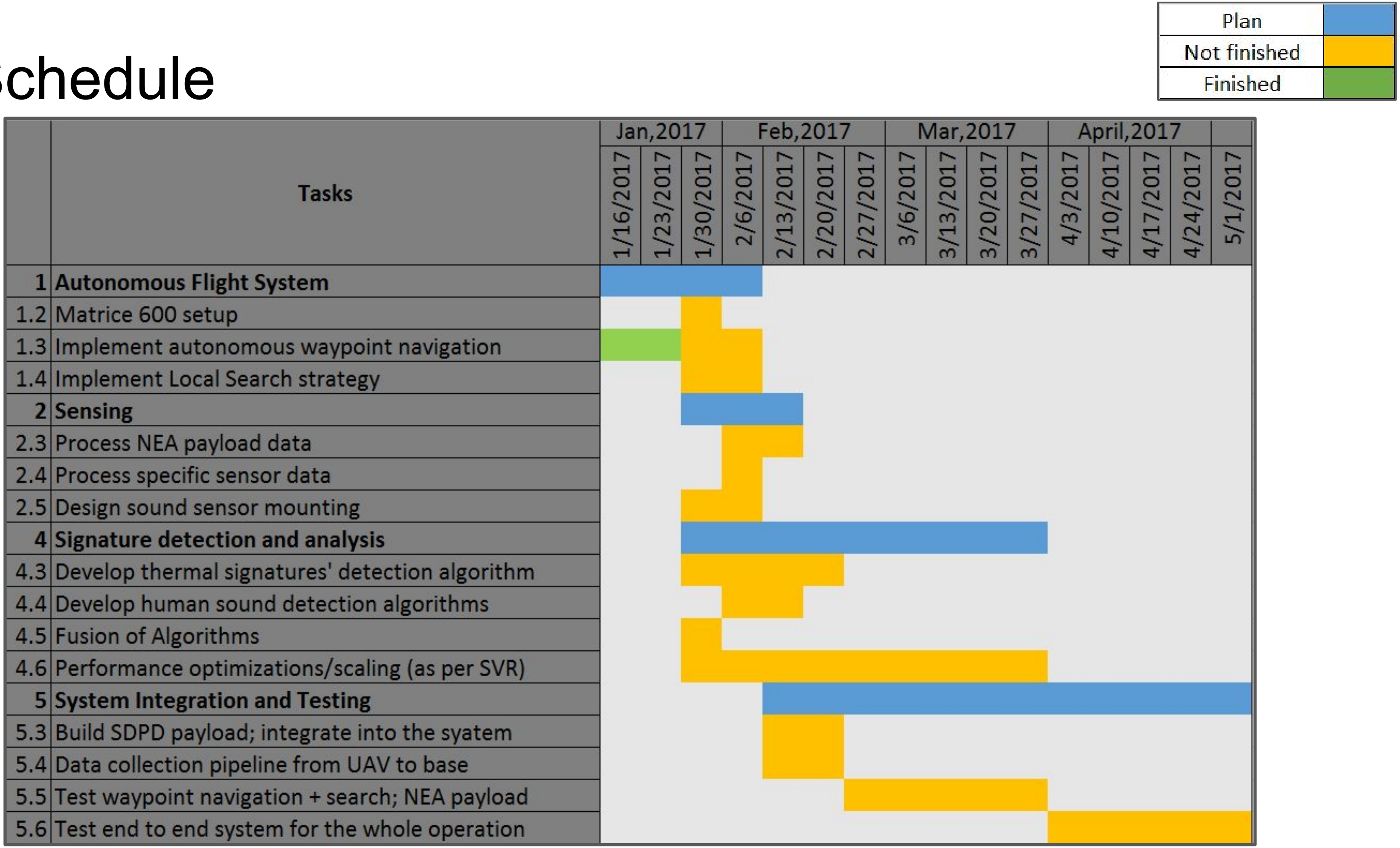
- Affects testing and validation of waypoint navigation and data processing
- Collecting datasets - Plan to buy our own RGB and Thermal cameras as backup - by the end of week

Improve quality of Signature Detection

- Accuracy of signature detection.
- Ability to detect different types of signatures.

Schedule/Test plans

Schedule


Plan
Not finished
Finished
Tasks
Jan,2017
Feb,2017
Mar,2017
April,2017
1/16/2017
1/23/2017
1/30/2017
2/6/2017
2/13/2017
2/20/2017
2/27/2017
3/6/2017
3/13/2017
3/20/2017
3/27/2017
4/3/2017
4/10/2017
4/17/2017
4/24/2017
5/1/2017
1 Autonomous Flight System
1.2 Matrice 600 setup
1.3 Implement autonomous waypoint navigation
1.4 Implement Local Search strategy
2 Sensing
2.3 Process NEA payload data
2.4 Process specific sensor data
2.5 Design sound sensor mounting
4 Signature detection and analysis
4.3 Develop thermal signatures' detection algorithm
4.4 Develop human sound detection algorithms
4.5 Fusion of Algorithms
4.6 Performance optimizations/scaling (as per SVR)
5 System Integration and Testing
5.3 Build SDPD payload; integrate into the syatem
5.4 Data collection pipeline from UAV to base
5.5 Test waypoint navigation + search; NEA payload
5.6 Test end to end system for the whole operation

Spring 2017 Milestone/Test plan

Milestone	***Date***	***Capability***
PR 7	**Feb 1**	- Finalize NEA data collection flight plan
PR 8	**Feb 15**	- Waypoint navigation on Matrice 600 - Test the collected data - Test local search on Matrice 100 - Preliminary test of sound detection algorithm
	Feb 20	- Preliminary test of revised RGB-based human detection algorithms - Preliminary test of Thermal signature detection algorithms
PR 9	**March 1**	- Test microphone mounting - Test SDPD payload mounting for Matrice 600 - Test sound detection algorithm on data collected during flight
	March 10	- Test thermal/RGB detection algorithms - Test software to collect and process NEA payload data
PR 10	**March 22**	- Rigorous test: all subsystems
PR 11, 12	**April 5, April 17**	- Test end-to-end system for the whole operation

Spring Validation Experiment 2017

Test D: Full system test (1/3)

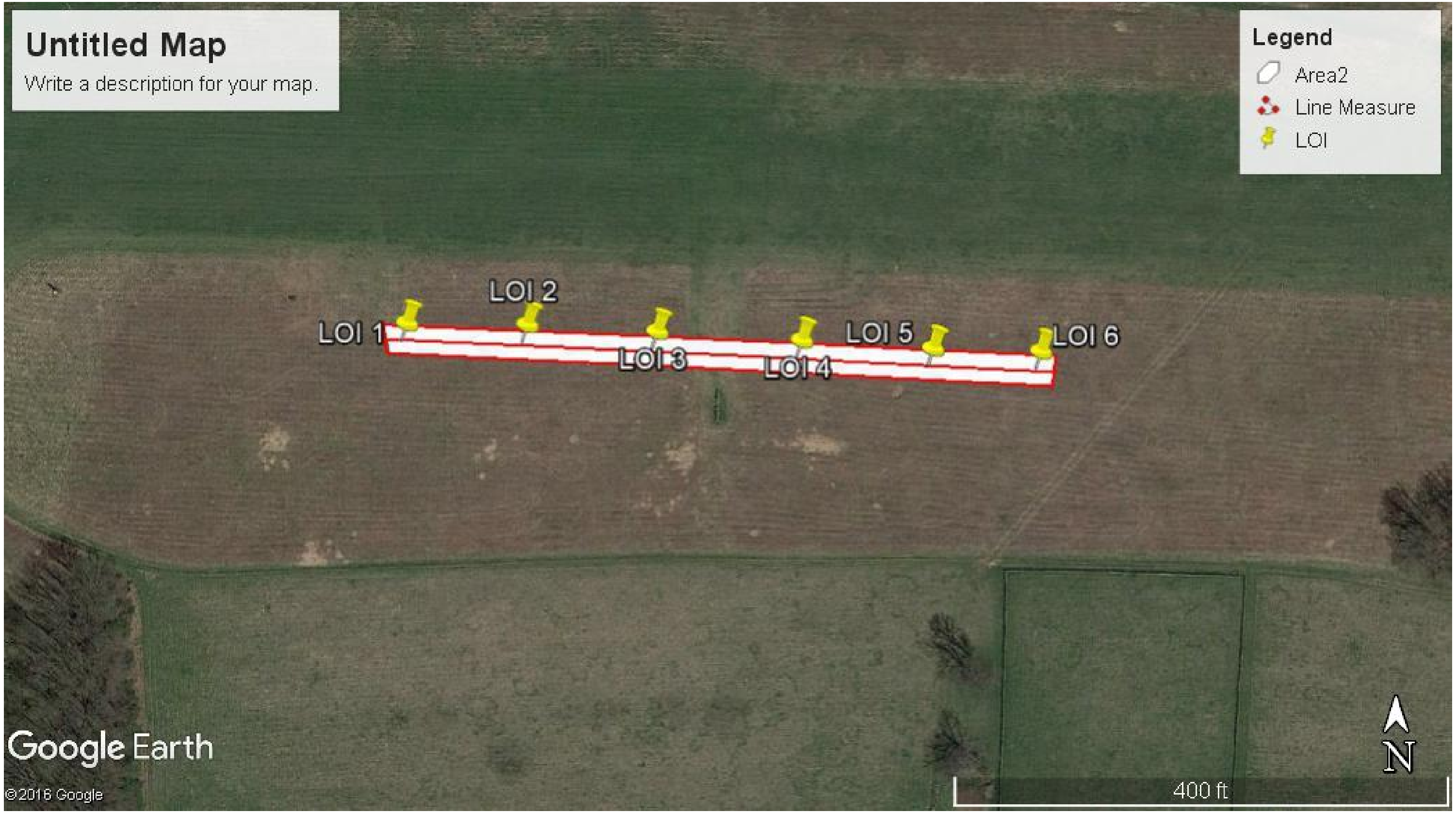
Objective:

To validates the system's ability to autonomously search for a human in a search and rescue scenario and also dispatch a rescue package

Test conditions:

Location	Open 200m x 200m area with GPS access and normal wind (hopefully, Nardo Airport site)
Equipment	UAV; Laptop; Rescue package; Representations of human signatures: 4 humans, tent, air mattresses, stove, backpacks

Spring Validation Experiment 2017



Spring Validation Experiment 2017

Test D: Full system test (2/3)

Steps	*Step Description*	*Performance Measures*
D.1.	Place UAV on the ground. Feed GPS locations for 8 LOIs	
D.2.	UAV takes off and reaches the desired altitude for navigation	Accuracy in reaching desired height (+-1m tolerance)
D.3.	UAV reaches the first LOI and performs localized search	Accuracy in reaching the LOI (+-5m tolerance)
D.4.	UAV Flies from one LOI to another performing localized search	- Accuracy in reaching the LOI (+-5m tolerance) - 80% coverage of the planned search area
D.5.	UAV flies back to the starting point after covering all the waypoints	Accuracy in reaching the starting point (+-5m tolerance)

Spring Validation Experiment 2017

Test D: Full system test (2/3)

Steps	*Step Description*	*Performance Measures*
D.6.	Transfer data from the UAV to base station	Ability to collect the three types of perceptual data
D.7.	Process the data to identify any human signatures	Ability to identify at least 75% of the locations with human signatures
D.8.	Based on the identified human signatures, select correct location for rescue	Ability to identify at least one correct location for rescue
D.9.	UAV flies to the selected rescue location	Accuracy in reaching the rescue location (+-5m tolerance)
D.10.	UAV releases the rescue package	Ability to safely release the package
D.11.	UAV flies back to the base station	Accuracy in reaching the starting location (+-5m tolerance)

Budget

Part List 1 , Sponsor Provided

Description	Manufacturer	Model	Unit	Weight (g)	Cost
LWIR	FLIR	Tau 2	1	72	$7000
RGB Camera	Pointgrey	Grasshopper	1	520	$2,399
Lidar	Velodyne	VLP-16	1	590	$7,999
Flying platform	DJI	Matrice 600	1	9,600	$4,599
Panorama video camera	360fly	360fly 4k video camera	1	172	$399

Part List 2, Not provided by Sponsor

Description	Manufacturer	Model	Unit	Weight (g)	Cost
Aerial Platform	DJI	Matrice 100	1	680	$3250
Battery Heater	DJI	Inspired 1	1	100	$20
Battery Sticker	DJI	Inspired 1	1	0.2	$2

Summary

- Total Budget = $5000
- Total Cost = $3272
- Percentage spent to date = 65.4%

Additional Purchases

- Shotgun Microphone ~ $ 200
- RGB/Thermal camera for testing on Matrice 100 ~ $ 800
- Redundant Battery ~ $200

Thank you!