Aerial Assistance for Search and Rescue

Team F

Meet the team

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Sponsor:
Near Earth Autonomy

Draft Functional Requirements

The system shall

1. Autonomously navigate through a set of provided waypoints
2. Explore the surroundings around each waypoint
3. Collect perceptual data while navigating
4. Process the data to identify human signatures
5. Analyze the identified signatures to accurately estimate human location
6. Navigate to the rescue location
7. Drop the “rescue” package

Functional Requirements

The system shall

1. Autonomously navigate through a set of provided locations of interest
2. Complete the search within limited time
3. Explore the surroundings around each location of interest
4. Collect perceptual data while navigating
5. Process the data to identify human signatures
6. Analyze the identified signatures to accurately estimate human location
7. Navigate to the rescue location carrying the rescue package
8. Drop the rescue package

Draft Performance Requirements

The system will

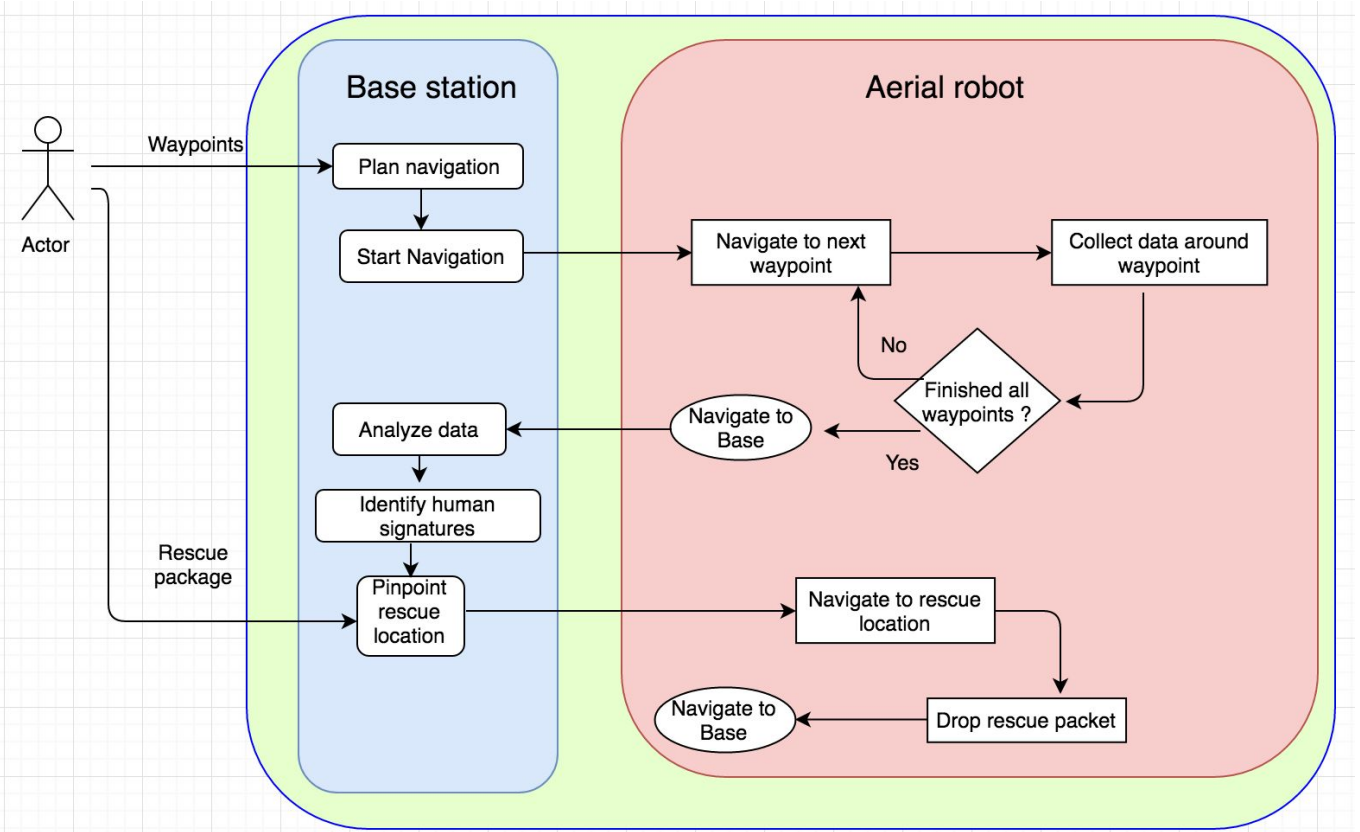
1. Operate in a search area with dimensions 200m x 200m and no occlusion
2. Complete one iteration of search in less than 25 minutes
3. Cover areas around the waypoints with 20% tolerance
4. Collect perceptual data limited to 3-4 (?) types
5. Identify 3-4 (?) human signatures
6. Estimate human location with 80% confidence and +-10m tolerance
7. Carry a “rescue” package weighing ~100g
8. Drop the package at the rescue location with a tolerance of +-5m

Performance Requirements

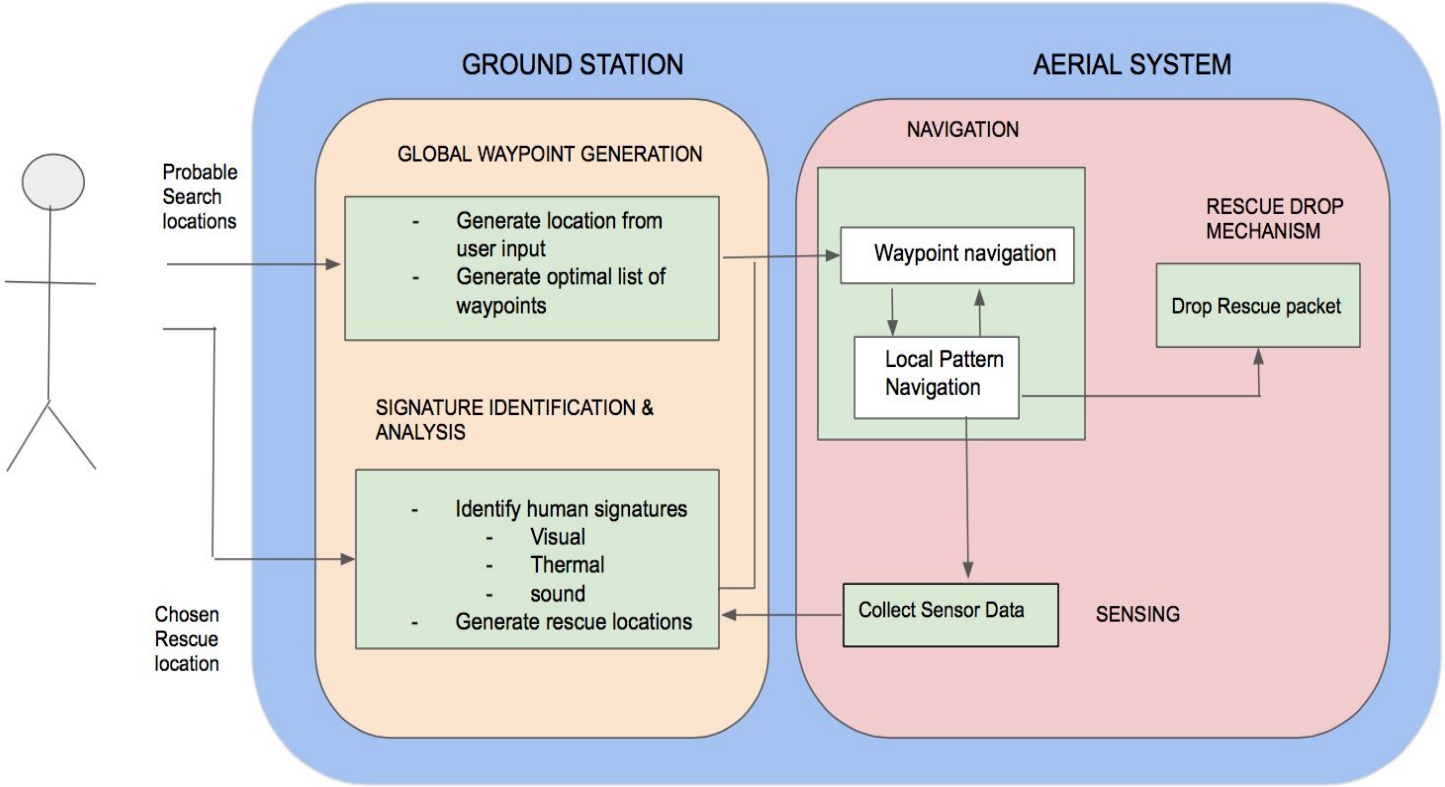
The system will

1. Accurately reach the locations of interest with a tolerance of +-5m
2. Complete one iteration of search in an un-occluded operating area of 200m x 200m in <25 minutes
3. Attain up to 80% coverage of the desired local search areas around each location of interest
4. Collect perceptual data limited to 3 types - IR radiation, visual imagery, and sound
5. Identify potential human signatures with at least 80% recall and 60% precision
6. Estimate potential human signature location with +-5m tolerance
7. Carry a rescue package weighing 100g
8. Drop the package at the rescue location with a tolerance of +-5m

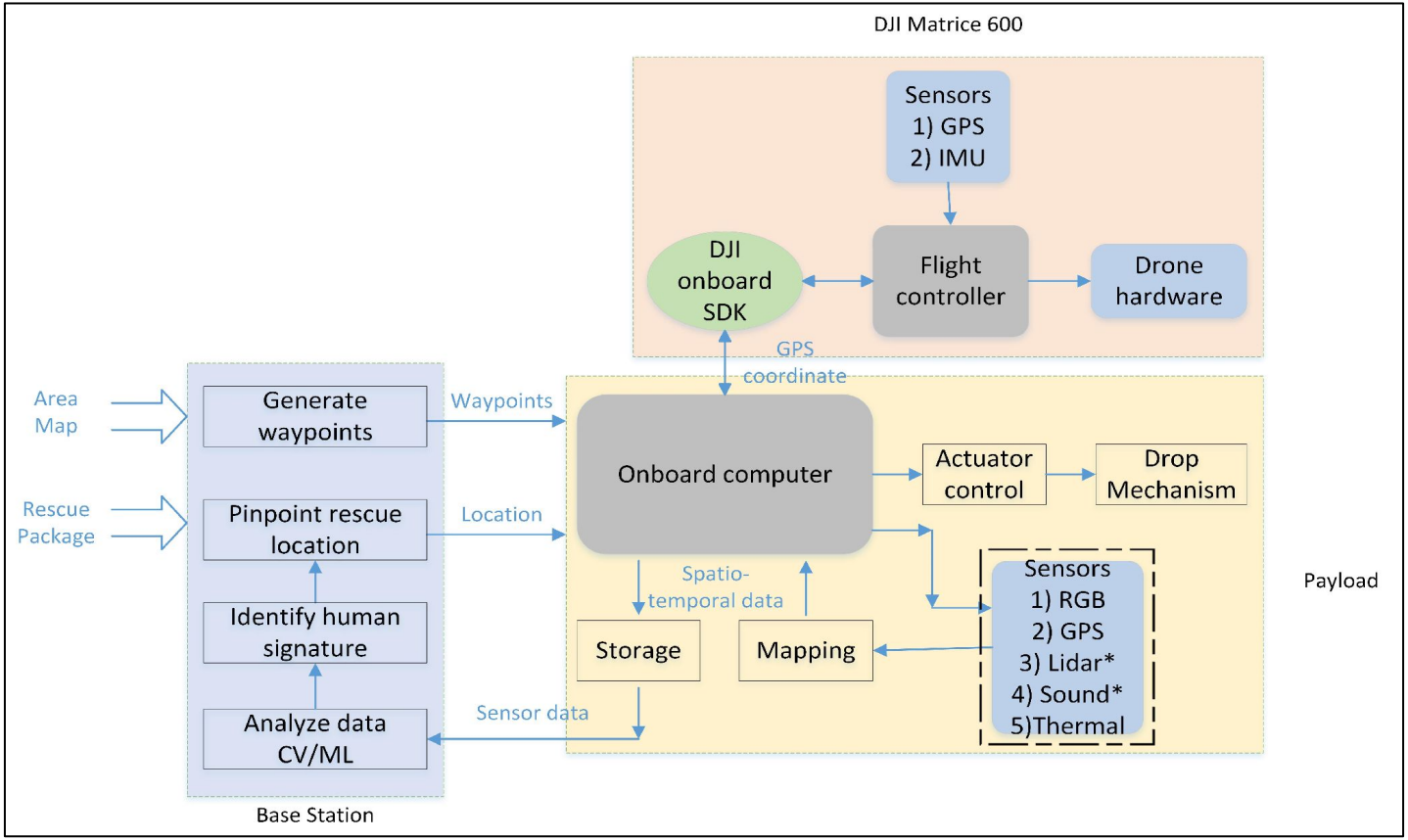
Draft Functional Architecture



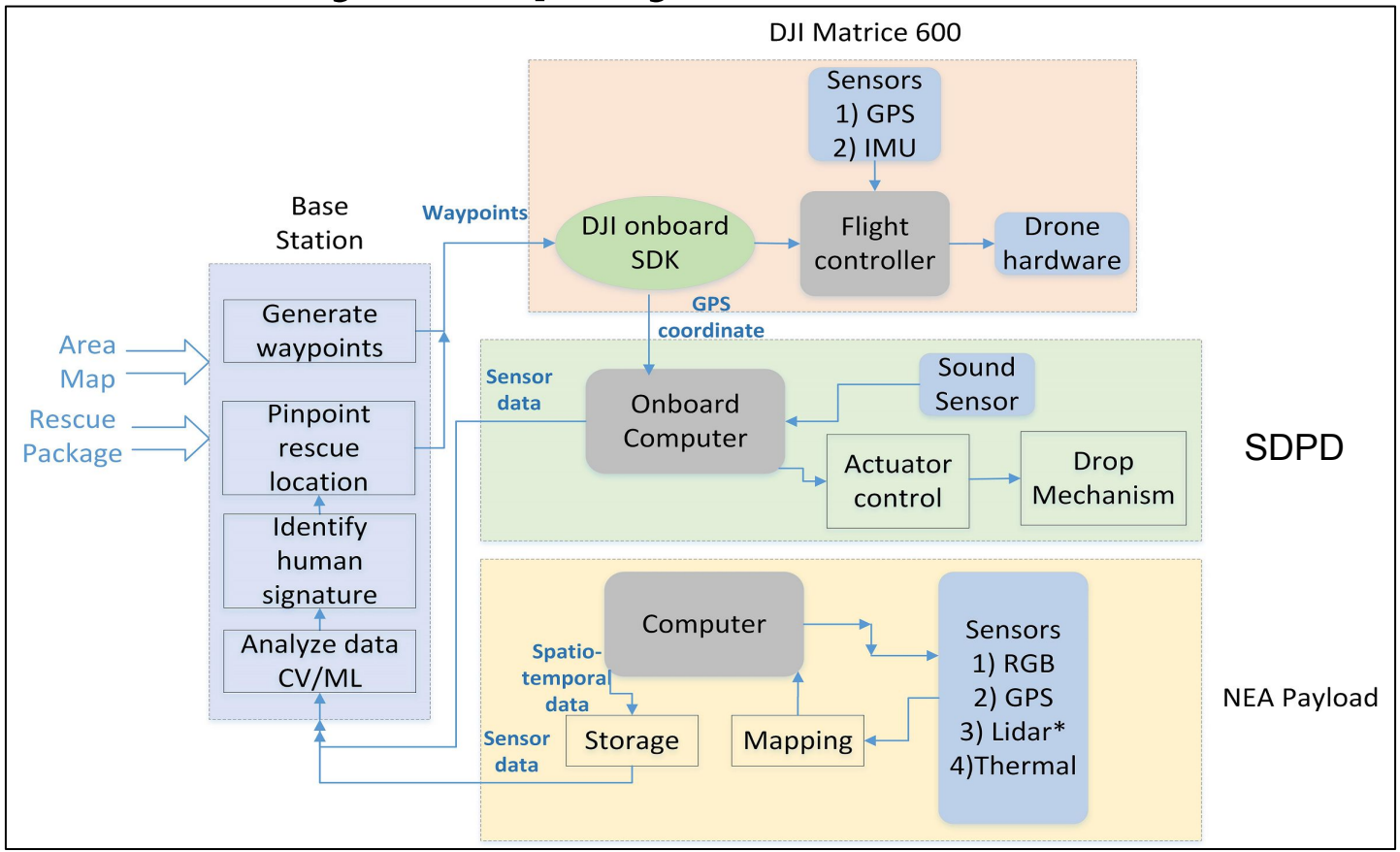
Functional Architecture



Draft Cyberphysical Architecture



Revised Cyberphysical Architecture



WBS

1. Autonomous Flight System

1.1. Set up Matrice 100

- *1.1.1. Assembly*
- *1.1.2. Test simulator*
- *1.1.3. First teleoperated flight*
- *1.1.4. Test basic autonomous flight*

1.2. Set up Matrice 600

- *1.2.1. Assembly*
- *1.2.1. Test simulator*

1.3. Implement autonomous waypoint navigation

- *1.3.1. Software for waypoint navigation*
- *1.3.2. Test on Simulator*
- *1.3.3. Test on external site*
- *1.3.4. Software to autonomously determine likely search locations*
- *1.3.5. Revise software for waypoint navigation*
- *1.3.6. Test on Simulator*
- *1.3.7. Test on external site*

1.4. Implement Local Search strategy

- *1.4.1. Design basic strategy*
- *1.4.2. Software to implement basic strategy*
- *1.4.3. Test on simulator*
- *1.4.4. Test on external site*
- *1.4.5. Software to plan local search with high quality sensor coverage*
- *1.4.6. Software to plan rescue operation*
- *1.4.7. Test on simulator*
- *1.4.8. Test on external site*

2. Sensing

2.1. Finalize sensors

- *2.1.1. RGB camera*
- *2.1.2. Thermal camera*
- *2.1.3. Sound sensor*

2.2. Test individual sensor performance

- *2.2.1. RGB camera*
- *2.2.2. Thermal camera*
- *2.2.3. Sound sensor*

2.3. Software: process NEA payload data

2.4. Software: process specific sensor data

- *2.4.1. RGB camera*
- *2.4.2. Thermal camera*
- *2.4.3. Sound sensor*

2.5. Design sound sensor mounting

3. Rescue assembly system

3.1. Mechanical structure

- *3.1.1. Design*
- *3.1.2. Prototype*
- *3.1.3. Fabricate*

3.2. Actuation system

- *3.2.1. Finalize actuation method*
- *3.2.2. Finalize actuators*
- *3.2.3. Finalize electronic components needed*
- *3.2.4. Develop actuation mechanism*
- *3.2.4. Interface actuator with SDPD computer*
- *3.2.5. Test drop mechanism*

3.3. Integrate mechanical structure & actuation system

4. Signature detection and analysis

4.1. Finalize human signatures to detect

4.2. Basic visual signature detection

- *4.2.1. Literature study/Datasets*
- *4.2.2. Implementation (SVR)*
- *4.2.3. Debugging/Improvements (FVR)*

4.3. Visual+Thermal signature detection

- *4.3.1. Literature study/Dataset (SVR)*
- *4.3.2. Implementation (SVR)*

4.4. Human sound detection

- *4.4.1. Literature study/Dataset (SVR)*
- *4.4.2. Implementation (SVR)*

4.5. Optimize/scale Performance

5. System Integration and Testing

5.1. Test flight

- *5.1.1. Waypoint navigation; NEA payload*
- *5.1.2. Waypoint navigation + basic hover; no payload*

5.2. Build SDPD payload; integrate

- *5.2.1. Schematic for PDS*
- *5.2.2. Layout for PDS*
- *5.2.3. PCB Fabrication for PDS*
- *5.2.4. Interface sound sensor with drone and onboard computer*
- *5.2.5. Form SDPD payload; integrate into the system*

5.3. Data collection pipeline: UAV to base

5.4. Test end to end system

- *5.4.1. Navigation + search; NEA payload*
- *5.4.2. Whole operation*

6. Project Planning

6.1. Initial Planning

- *6.1.1. Define project scope/requirements*
- *6.1.2. Conduct trade studies*
- *6.1.3. Develop functional and cyber-physical architectures*

6.2. Project Continuity

- *6.2.1. Develop and maintain project website*
- *6.2.2. Design Fall and Spring demo*
- *6.2.3. Procure RGB sensor*
- *6.2.4. Procure Thermal sensor*
- *6.2.5. Procure Sound sensor*
- *6.2.6. Procure Matrice 100*
- *6.2.7. Procure material for drop assembly*
- *6.2.8. Fall demo preparation*
- *6.2.9. Field Tests*
- *6.2.10. Spring demo preparation*

6.3. Project Delivery

- *6.3.1. Deliver Conceptual Design Review*
- *6.3.2. Deliver Preliminary Design Review*
- *6.3.3. Deliver Critical Design Review*
- *6.3.4. Fall Demo*
- *6.3.5. Spring Demo*

6.4. Risk Management

- *6.4.1. Risk analysis and mitigation plans*
- *6.4.2. Execute risk mitigation plans*

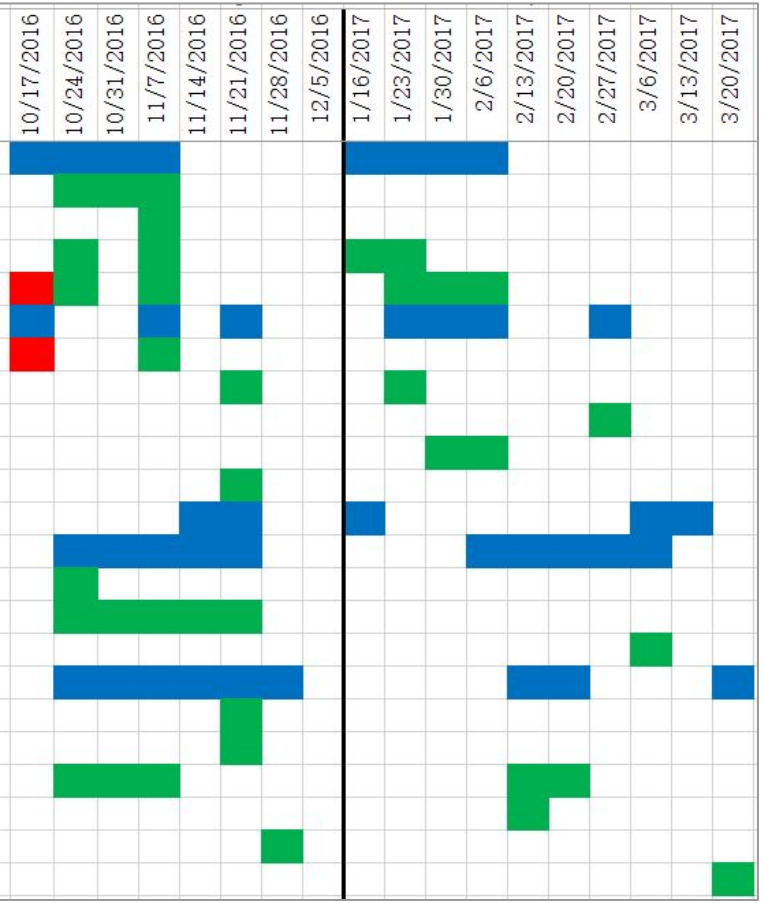
Fall 2016

Spring 2017

Both

Schedule

	Tasks	Sems	Hours
1	**Autonomous Flight System**		**117**
1.1	Matrice 100 setup	FV	17
1.2	Matrice 600 setup	FV	5
1.3	Implement autonomous waypoint navigation		46
1.4	Implement Local Search strategy	SV	49
2	**Sensing**		**110**
2.1	Finalize sensors		20
2.2	Test individual sensor performance		18
2.3	Process NEA payload data	SV	16
2.4	Process specific sensor data		48
2.5	Design sound sensor mounting	FV	8
3	**Rescue assembly system**		**70**
4	**Signature detection and analysis**		**150**
4.1	Finalize human signatures to detect	FV	10
4.2	Develop basic visual signatures' detection algorithm	FV	60
4.4	Performance optimizations/scaling (as per SVR)	SV	20
5	**System Integration and Testing**		**107**
5.1	Test flight: waypoint navigation; NEA payload	FV	10
5.2	Test flight: waypoint navigation + basic hover; no payload	FV	10
5.3	Build SDPD payload; integrate into the syatem		51
5.4	Data collection pipeline from UAV to base	SV	6
5.5	Test end to end system: waypoint navigation + search; NEA pay	SV	10
5.6	Test end to end system for the whole operation	SV	20

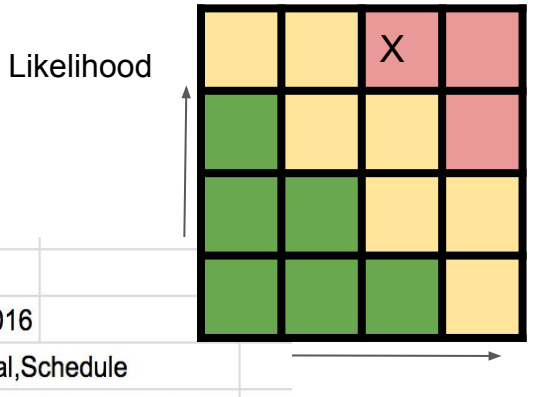


Schedule

Plan
Not finished
Finished

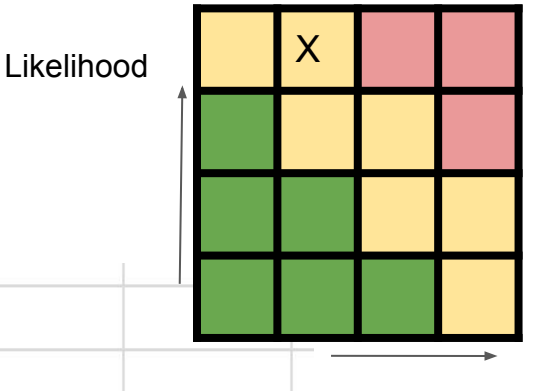
	Tasks	Sems	Hours	10/17/2016	10/24/2016	10/31/2016	11/7/2016	11/14/2016	11/21/2016
1.1	Matrice 100 setup	FV	17						
1.2	Matrice 600 setup	FV	5						
1.2.1	Assembly	FV	2						
1.2.1	Test simulator	FV	3						
1.3.1	Software for waypoint navigation	FV	8						
1.3.2	Test on Simulator	FV	2						
1.3.3	Test in external site	FV	4						
1.4.2	Software to implement basic strategy	FV	6						
1.4.3	Test on simulator	FV	2						
1.4.4	Test on external site	FV	4						
2.1.1	RGB camera	FV	4						
2.1.2	Thermal camera	FV	4						
2.1.3	Sound sensor	FV	12						
2.2.1	RGB camera	FV	6						
2.5	Design sound sensor mounting	FV	8						
3.1	Design mechanical system	FV	16						
3.2	Prototype mechanical system	FV	6						
3.3	Procure mechanical/electronic components	FV	4						
4.1	Finalize human signatures to detect	FV	10						
4.2	Develop basic visual signatures' detection algorithm	FV	60						
4.2.1	Literature study/Datasets	FV	20						
4.2.2	Implementation (SVR)	FV	30						
4.2.3	Debugging/Improvements (FVR)	FV	10						
5.1	Test flight: waypoint navigation; NEA payload	FV	10						
5.2	Test flight: waypoint navigation + basic hover; no payload	FV	10						

Risks and Mitigation



RISK SUMMARY				
Title	Unavailability of drone for frequent testing		**Date Submitted**	10/19/2016
Owner	Karthik/Sumit		**Risk Type**	Technical,Schedule
Description	Sponsor requires drone to remain in their premise and may not be able to schedule flights frequently			
Consequence	Will impact ability to iterate quickly on various navigation strategies/sensing evaluation and rescue strategy			
RISK MITIGATION				
Action	**Date**	**Success criteria**		**Risk level**
Order dev drone	10/25/2016	Ability to test and run navigation strategies iteratively		60
Validate using sensor payload manually to generate data	11/10/2016	Ability to generate sensor data very similar to aerial flight		50
Use data from flights scheduled for other projects	11/10/2016	Validate if data matches what we expect		40
Device sensor mounting strategy for dev drone	11/20/2017	Ability to use rgb and thermal camera for sensing on dev drone		30

Risks and Mitigation



RISK SUMMARY				
Title	Inability to achieve high accuracy in signature detection		**Date Submitted**	10/22/2016
Owner	Juncheng/Sumit		**Risk Type**	Technical
Description	Sensor data especially sound might be very noisy and could generate inaccurate results			
Consequence	Will impact accuracy with which system can detect signatures			
RISK MITIGATION				
Action	**Date**	**Success criteria**		**Risk level**
Evaluate design for suspended microphone sensor	1/20/2017	Ability to suspend microphone 10 feet below the drone and fly the drone safely		10

Thank you