

# An Operator Function Taxonomy for Unmanned Aerial Vehicle Missions

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# Motivation

- UAVs being asked to perform more and more missions
  - Military
  - Commercial
- Makes it hard to keep up with GCS needs
  - Rapidly evolving systems
  - Dynamic human operator cognitive needs
- Need a taxonomy of UAV missions & associated operator functions



Predator UAV



Shadow UAV



# Why a Taxonomy?

UAVs are being used for multiple missions

- MQ-1 Predator can perform both reconnaissance and weapons delivery missions

Missions may not have the same interface/information requirements

- Heterogeneity of tasks and vehicles will require an operator manage dissimilar tasks



UAV imagery during a search for survivors of Hurricane Katrina  
(credit: Safety Security Rescue Research Center)





# Why a Taxonomy?

If we know operator functions of a “new” task, we can leverage research findings/designs from other tasks with similar operator functions

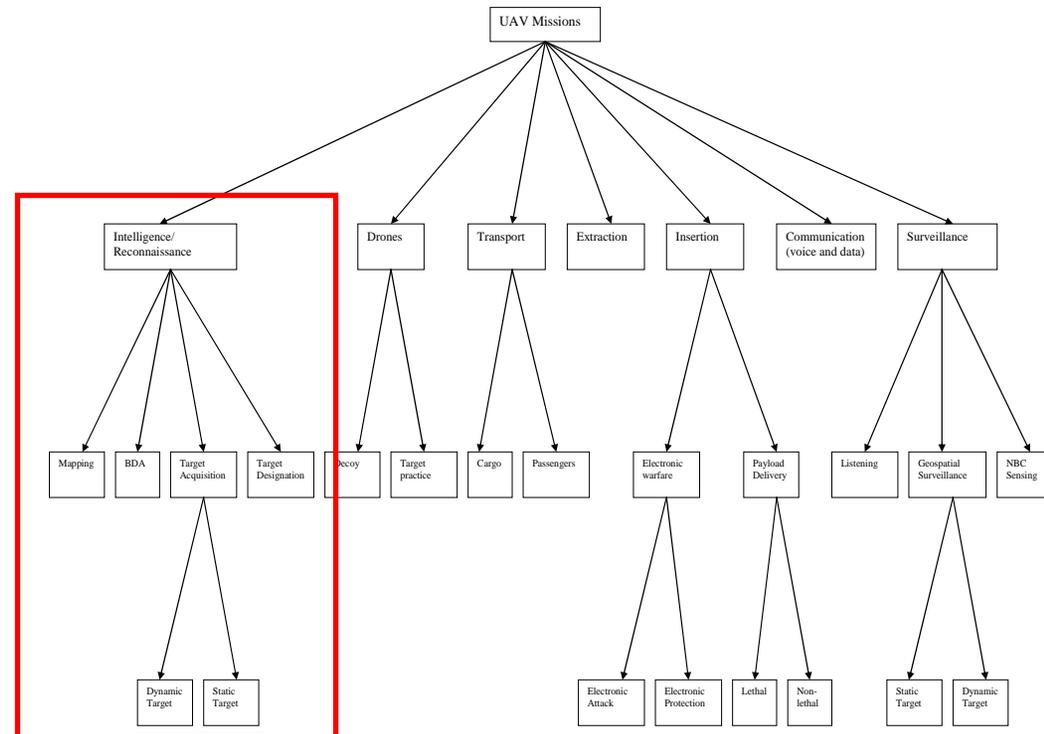
- So the taxonomy needs to specify common operator functions across different missions
- The common functions lead to a common set of information requirements





# UAV Mission Taxonomy

- Three tiers
  - Mission types more specific with tree depth
- Taxonomy generic
  - Military
  - Commercial
- Extendable
- Missions closer together have similar characteristics

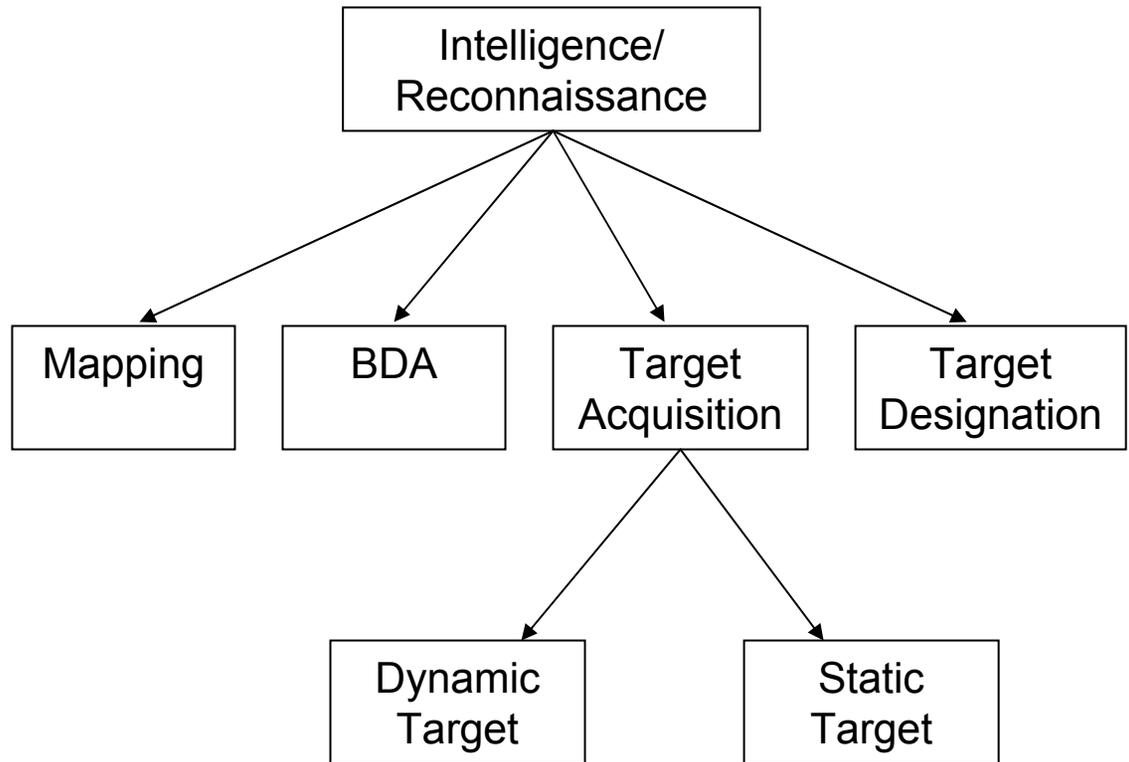




# UAV Mission Taxonomy

Level 1: General Mission Types

More specific





# Functional/Information Requirements

<b>Mapping</b>		
<b>Mission Phases</b>	<b>Phase Goals</b>	<b>Functional/ Information Requirements</b>
<b>Planning</b>	<ul style="list-style-type: none"><li>- Scheduling of health and status reports</li></ul>	<ul style="list-style-type: none"><li>- Threat area information</li><li>- Planning path of area to be mapped</li><li>- No fly zone information</li><li>- Scheduling mechanism</li><li>- Decision support for path planning (including loitering)</li></ul>
<b>Management</b>	<ul style="list-style-type: none"><li>- Tracking progress of UAVs and of health and status reports</li><li>- Image (map) analysis</li></ul>	<ul style="list-style-type: none"><li>- Health and status indicators</li><li>- Image analysis tools (zoom, panning, filtering)</li></ul>
<b>Replanning</b>	<ul style="list-style-type: none"><li>- Resource allocation</li></ul>	<ul style="list-style-type: none"><li>- Asset coverage re-plan decision support</li></ul>





# Interoperability

- Missions with similar functional/information requirements have higher interoperability
  - We might be able to use the same interface

Example 1:

BDA



Credit: <http://www.fleximage.fr>

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Mapping



More interoperable



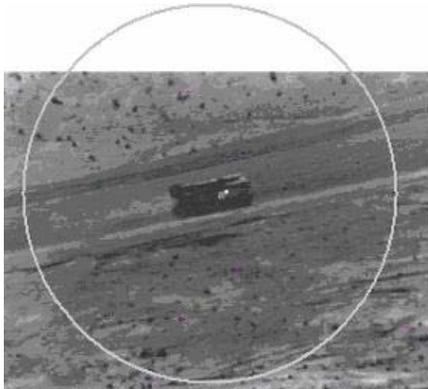


# Interoperability

- Missions with similar functional/information requirements have higher interoperability
  - We might be able to use the same interface

Example 2:

Target Acquisition



Credit: www.cardiofx.com

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Mapping



Less interoperable



# Operator Functions

- Operator functions specify the responsibility of the human operator in the UAS
- They do *not* specify *how* the human operator will implement these functions

<b>BDA</b>		
<b>Mission Phases</b>	<b>Phase Goals</b>	<b>Functional/ Information Requirements</b>
<b>Planning</b>	<ul style="list-style-type: none"><li>- Assessing targets and routes</li><li>- Scheduling of order of assessments if more than one</li><li>- Scheduling of health and status reports</li></ul>	<ul style="list-style-type: none"><li>- Threat area information</li><li>- No fly zone information</li><li>- Scheduling mechanism</li><li>- Decision support for path planning (including loitering)</li></ul>
<b>Management</b>	<ul style="list-style-type: none"><li>- Tracking progress of UAVs and of health and status reports</li><li>- Analyzing BDA results</li></ul>	<ul style="list-style-type: none"><li>- Health and status indicators</li><li>- Image analysis tools (zoom, panning, filtering)</li></ul>
<b>Replanning</b>	<ul style="list-style-type: none"><li>- Resource allocation</li></ul>	<ul style="list-style-type: none"><li>- Asset coverage re-plan decision support</li></ul>
<b>Operator Functions</b>	<ul style="list-style-type: none"><li>- Monitoring health and status of UAV</li><li>- Analyzing images</li><li>- Monitoring network communications</li><li>- Resource allocation &amp; scheduling</li><li>- Path planning supervision</li><li>- Optimal position supervision</li><li>- Notifying relevant stakeholders</li></ul>	



# Carry-over

- Research on missions with similar operator functions can be leveraged

Example 1:

Target Acquisition



Credit: [www.cardiofx.com](http://www.cardiofx.com)



Listening



<http://webschoolsolutions.com>

More Carry-over





# Carry-over

- Research on missions with similar operator functions can be leveraged

Example 2:

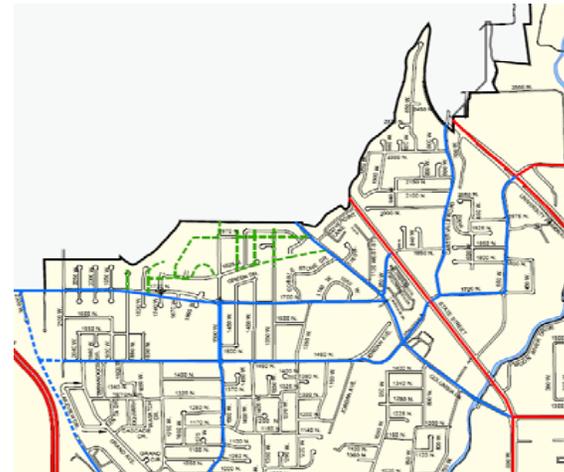
## Payload Delivery



Credit: <http://www.1000pictures.com>

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## Mapping



Less Carry-over





# Carry-over = Interoperability?

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- Missions with common functional/ information requirement also have many operator functions in common
  - Both derived from the same phase goals





# Table of Operator Functions

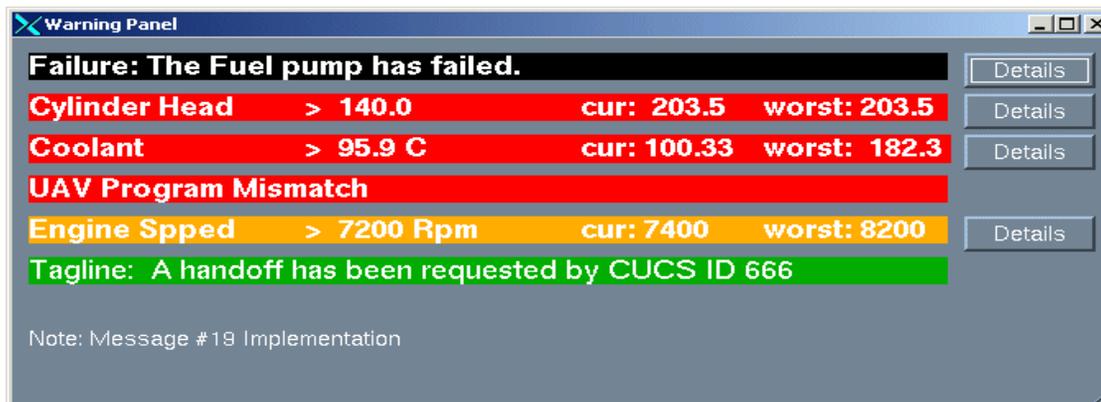
	Intelligence/Reconnaissance				Drones		Transport		Surveillance			Comm	Extra-ction	Insertion	
	Mapping	BDA	Target acquisition	Target designation	Decoy	Target	Cargo	Passenger	Geo-spatial	Listening	NBC sensing			Electronic warfare	Payload delivery
Monitoring payload status								X							X
Monitoring network communications		X										X			
Monitoring health & status of the UAV	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Monitoring for sensor activity			X							X	X			X	
Negotiating with other stakeholders				X					X				X	X	X
Notifying relevant stakeholders		X	X						X	X	X	X	X	X	X
Optimal position supervision	X	X	X						X	X	X			X	X
Path planning supervision	X	X			X	X	X	X	X				X		X
Analyzing images	X	X	X						X				X		
Analyzing other sensor data			X							X					
Positive Target Identification	X		X	X						X			X		X
Resource allocation and scheduling		X	X	X					X	X			X	X	X
Tracking target			X						X	X					





# Most Common Operator Functions

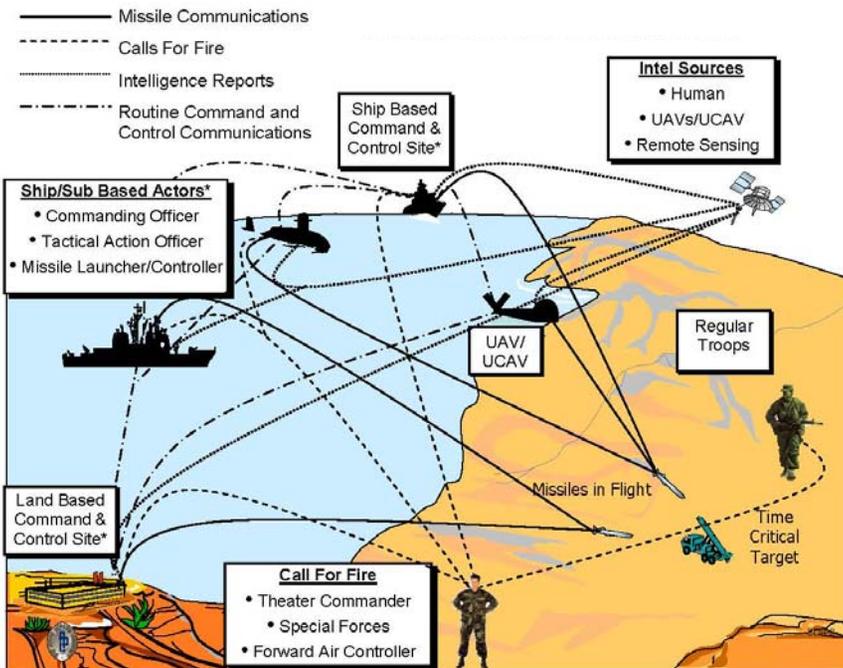
- **Monitoring health and status of UAV**
  - In every mission
  - Should not subsume operator attention
  - Humans not very good at it (max 30 mins)
  - Robust decision support should be developed that leverages automation strengths





# Most Common Operator Functions

- **Notifying relevant stakeholders**
  - Essential that UAV operators can communicate with others

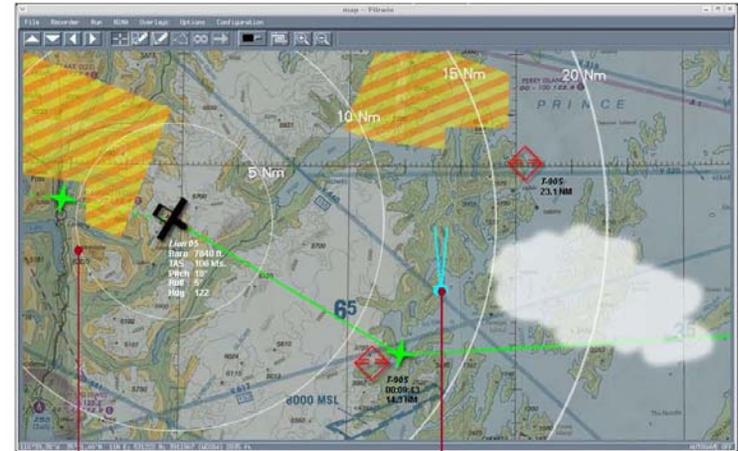




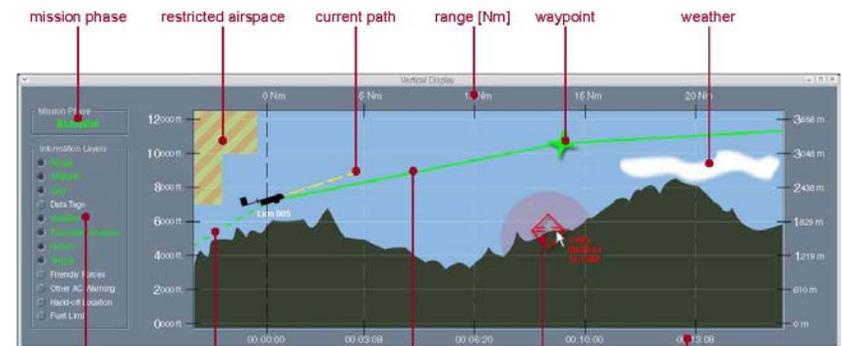
# Most Common Operator Functions

- **Optimal position supervision**

- Both in the vertical and the horizontal
  - Also need to consider both current and projected position
- Need robust automation
  - Interactive decision support tools



range circles Ground Control Station

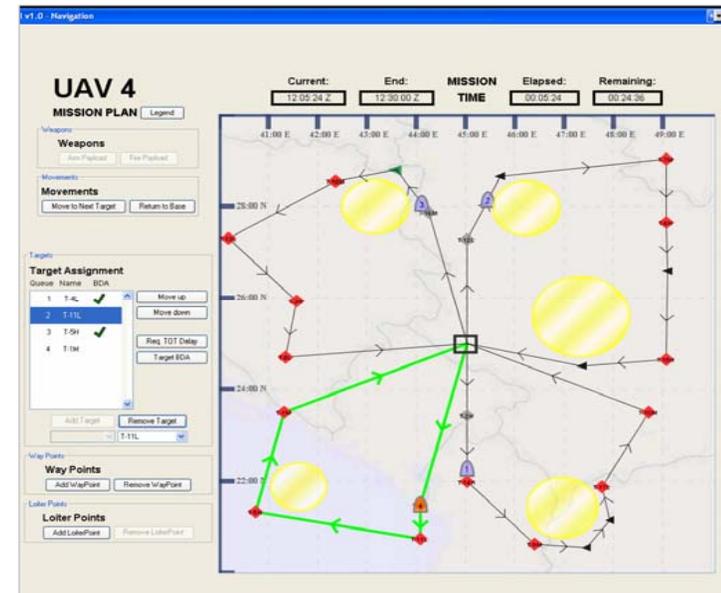


information toggles history path planned path target range [min]



# Most Common Operator Functions

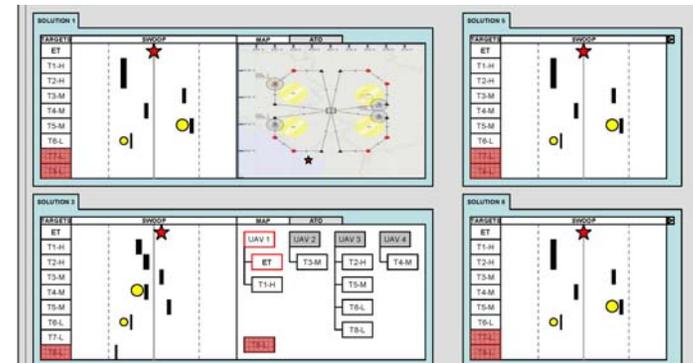
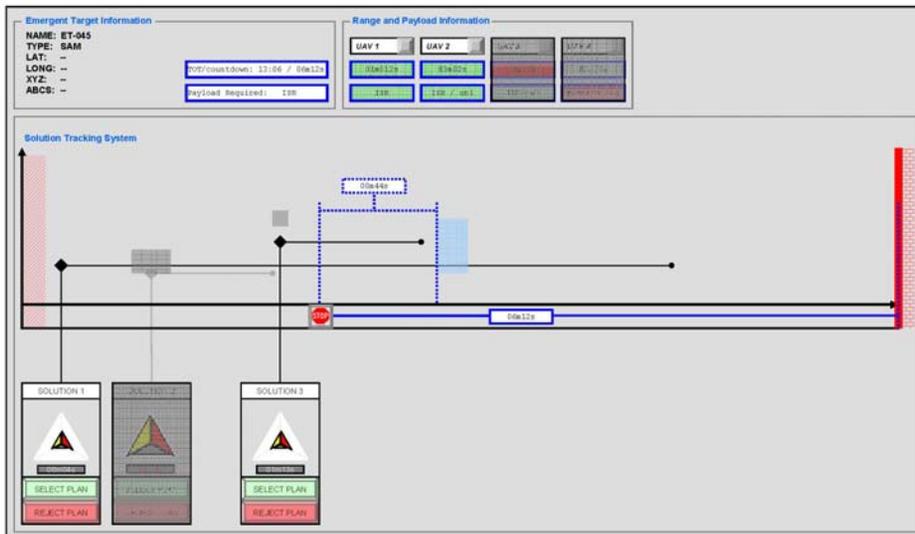
- **Path planning supervision**
  - Due to limited cognitive resources, need automated path planners
  - But users need to be able to interact with them
    - Artificial intelligence path planning algorithms can be “brittle”





# Most Common Operator Functions

- **Resource allocation and scheduling**
  - Computationally complex
  - Humans may not perform these tasks well
  - Need automated schedulers humans can interact with





# Summary

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- We have introduced a taxonomy of UAV missions
- Across missions, the taxonomy includes:
  - Information/functional requirements
  - Operator Functions
- Can potentially be used to
  - Leverage designs & research from one domain to another
  - Identify interoperability between UAV missions