A UAV MISSION HIERARCHY

C. E. NEHME
M.L. CUMMINGS
J. W. CRANDALL

MASSACHUSETTS INSTITUTE OF TECHNOLOGY*

PREPARED FOR CHARLES RIVER ANALYTICS

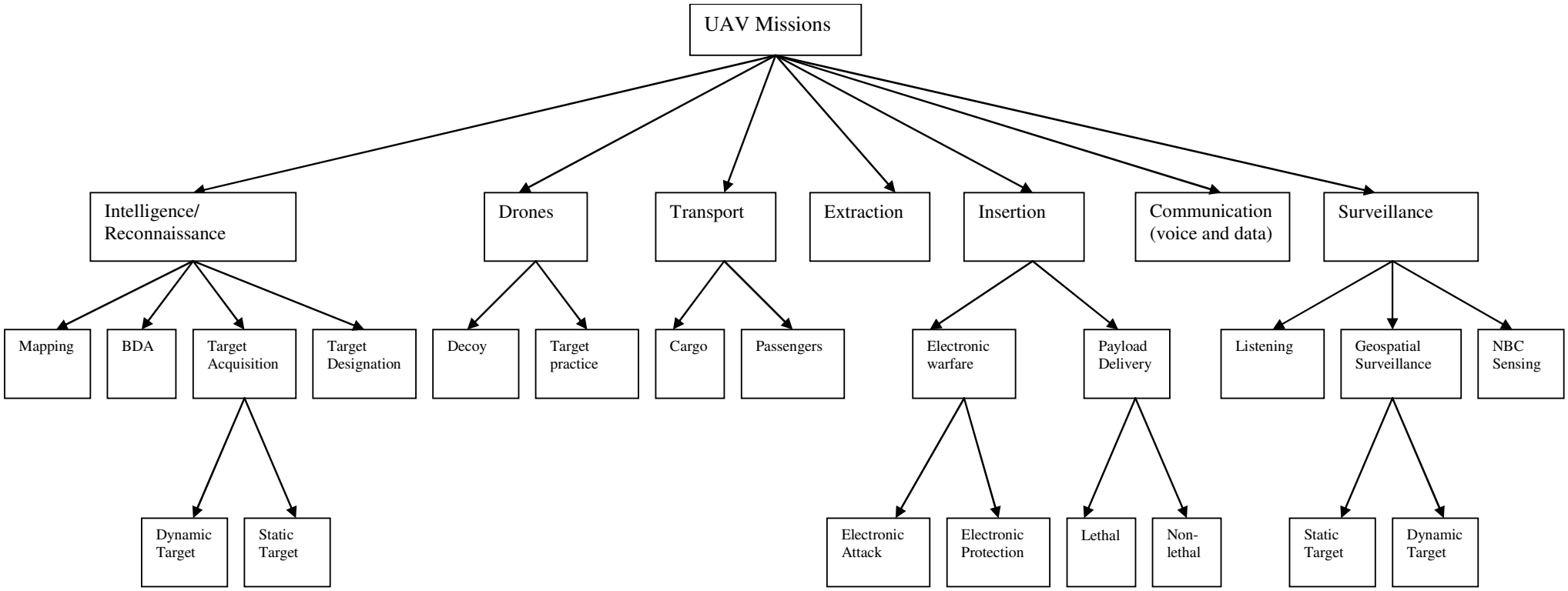
HAL2006-09

DEC, 2006

http://halab.mit.edu e-mail: halab@mit.edu

*MIT Department of Aeronautics and Astronautics, Cambridge, MA 02139

UAV High Level Task Overview*



*These tasks/missions generally have both military and commercial applications. The missions are not necessarily mutually exclusive as one UAV can conduct multiple missions (e.g., the Predator which can conduct surveillance and strike capabilities in a single mission.)

Terms

- **Intelligence:** a military discipline that focuses on the gathering, analysis, protection, and dissemination of information about the enemy, terrain, and weather in an area of operations or area of interest.
- **Reconnaissance:** an inspection or exploration of an area to gather information.

    - **BDA (**battle damage assessment)**:** the act of measuring, either quantitatively or qualitatively, the status of a target. Also known as BDI (Battle Damage Imagery)
- **Drones:** UAVs can also be used to imitate fighter aircraft for several purposes.
    - **Target Practice:** An imitation of a hostile target for training purposes.
    - **Decoy:** An imitation in any sense of a person, object, or phenomenon which is intended to deceive enemy surveillance devices or mislead enemy evaluation.
- **Transport:** the movement or transference of passengers or cargo from one location to another.
- **Surveillance:** the process of monitoring the behavior of people, objects or processes for conformity with expected or desired norms.
    - **NBC sensing:** Nuclear, biological and chemical sensing**.**
- **Communications:** links between units, including connections to a higher command.
- **Extraction:** Payload extraction from a specified target. In the military, insertions typically involve cargo and/or personnel (search and rescue would fall here).
- **Insertion:** Payload delivery to a specified target. In the military, insertions typically involve weapons (although not necessarily lethal) and can include, for example, the rendering of facilities inoperable (electronic jamming), and the elimination of targets. Commercial applications of strike would include crop dusting and emergency supplies drops.
    - **Electronic Attack** (EA)**:** the active use of the electromagnetic spectrum to deny its use by an adversary. Most EA activity is in the form of jamming or electromagnetic deception. EA can also include the use of devices that employ electromagnetic or directed energy weapons in order to destroy enemy vehicles and incapacitate or kill opposing infantry forces. An older term for EA is Electronic countermeasures (ECM).
    - **Electronic Protection** (EP)**:** all activities related to making enemy EA activities less successful by means of protecting friendly personnel, facilities, equipment or objectives. EP can also be implemented to prevent friendly forces from being affected by their own EA. Active EP includes technical modifications to radio equipment (such as frequency-hopping spread spectrum), while passive EP includes education of operators (enforcing strict discipline) and modified battlefield tactics or operations. Older terms for EP are Electronic protective measures (EPM) and Electronic Counter Counter Measures (ECCM).

Generalized Operator Functions

In the following sections, each of the primary missions are decomposed into mission planning, management, and replanning segments in order to identify what the primary functions a human operator will need to perform. The goal is to understand what tasks/functions are common across different UAV missions and platforms in order to map the generalizability of any particular research project.

Intelligence/ Reconnaissance	Mapping	BDA	Target Acquisition	Target Designation

Mapping:

	Phase Goals	**Functional/Information Requirements**
Mission Planning	- Planning path of area to be mapped - Scheduling of health and status reports	- Threat area information - No fly zone information - Scheduling mechanism - Decision support for path planning (including loitering)
Mission Management	- Tracking progress of UAVs and of health and status reports - Image (map) analysis	- Health and status indicators - Image analysis tools (zoom, panning, filtering)
Mission Replanning		
Operator Functions	- Monitoring health and status of UAV - Optimal[1] position supervision - Perceiving/interpreting images - Analyzing images	

BDA:

	Phase Goals	**Functional/Information Requirements**
Mission Planning	- Assessing targets and routes - Scheduling of order of assessments if more than one - Scheduling of health and status reports	- Threat area information - No fly zone information - Scheduling mechanism - Decision support for path planning (including loitering)
Mission Management	- Tracking progress of UAVs and of health and status reports - Analyzing BDA results	- Health and status indicators - Image analysis tools (zoom, panning, filtering)
Mission Replanning	- Resource allocation	- Asset coverage re-plan decision support
Operator Functions	- Monitoring health and status of UAV - Perceiving/interpreting images - Analyzing images - Monitoring network communications - Resource allocation & scheduling - Path planning supervision - Notifying relevant stakeholders	

[1] Optimal implies that some type of decision support is needed

Target Acquisition (Static and Dynamic):

	Phase Goals	**Functional/Information Requirements**
Mission Planning	- Path planning (areas to search and waypoints to the area of interest) - Scheduling of health and status reports	- Threat area information - No fly zone information - Scheduling mechanism - Decision support for path planning (including loitering)
Mission Management	- Tracking progress of UAVs and of health and status reports - Analyzing EO imagery - Image/sensor matching (e.g., ATR) - Position tracking (only for dynamic)	- Health and status indicators - Support for viewing results and storing results - Support for sensor matching - Support for tracking position of target (only for dynamic) - Signal detection - Predictive path planning (only for dynamic)
Mission Replanning	- Path Replanning	- Replanning decision support - Rescheduling decision support
Operator Functions	- Monitoring health and status of UAV - Optimal position supervision - Perceiving/Interpreting other sensor data - Analyzing other sensor data - Positive target identification - Tracking target (only for dynamic) - Notifying relevant stakeholders	

Target Designation:

	Phase Goals	**Functional/Information Requirements**
Mission Planning	- Perceiving location of target to be designated - Scheduling of assessments and of health and status reports	- Threat area information - No fly zone information - Scheduling mechanism - Decision support for path planning
Mission Management	- Tracking progress of UAVs and of health and status reports - Monitor designation	- Health and status indicators - Feedback on completion or failure of designation - Active communication
Mission Replanning	- Designation replanning (cancelling designation, or designating another target) - Rescheduling transmission of health and status reports	- Replanning decision support - Rescheduling decision support
Operator Functions	- Monitoring health and status of UAV - Negotiating with other stakeholders - Positive identification (Combat ID)	

Drones	Decoy	Target Practice

Decoy:

	Phase Goals	**Functional/Information Requirements**
Mission Planning	- Scheduling of health and status reports - Choosing area for deployment	- Threat area information - No fly zone information - Scheduling mechanism - Decision support for choosing loiter location
Mission Management	- Tracking progress of UAVs and of health and status reports	- Health and status indicators
Mission Replanning	- Redesignate area of deployment	- Path planning
Operator Functions	- Monitoring health and status of UAV - Path planning supervision	

Target Practice:

	Phase Goals	**Functional/Information Requirements**
Mission Planning	- Scheduling of health and status reports - Choosing area for deployment	- Threat area information - No fly zone information - Scheduling mechanism - Decision support for choosing loiter location
Mission Management	- Tracking progress of UAVs and of health and status reports	- Health and status indicators
Mission Replanning	- Re-designate area of deployment	- Path planning
Operator Functions	- Monitoring health and status of UAV - Path planning supervision	

Transport	Cargo	Passengers

Cargo:

	Phase Goals	**Functional/Information Requirements**
Mission Planning	- Path planning (route from origin to destination) - Scheduling of health and status reports	- No fly zone information - Scheduling mechanism - Decision support for path planning
Mission Management	- Tracking progress of UAVs and of health and status reports	- Health and status indicators - Alert management to alert when something is off nominal
Mission Replanning	- Re-routing by modifying waypoints to account for update traffic and weather information	- Replanning decision support
Operator Functions	- Monitoring health and status of UAV - Path planning supervision	

Passengers:

	Phase Goals	**Functional/Information Requirements**
Mission Planning	- Path planning (route from origin to destination) - Scheduling of health and status reports	- No fly zone information - Scheduling mechanism - Decision support for path planning
Mission Management	- Tracking progress of UAVs and of health and status reports	- Health and status indicators - Alert management to alert when something is off nominal
Mission Replanning	- Re-routing by modifying waypoints to account for update traffic and weather information	- Replanning decision support
Operator Functions	- Monitoring health and status of UAV - Monitoring health and status of passengers - Path planning supervision	

Surveillance	Geo-spatial Surveillance	Listening	NBC Sensing

Listening:

	Phase Goals	**Functional/Information Requirements**
Mission Planning	- Path planning (location of target to be or area to be monitored) - Scheduling of health and status reports	- Threat area information - No fly zone information - Scheduling mechanism - Decision support for path planning (including loitering)-
Mission Management	- Track progress of UAVs and of health and status reports - Listening to transmissions - Interpreting transmissions	- Health and status indicators - Listening support - Audio Signal Detection - Alert management - Signal analysis decision support
Mission Replanning	- Maintaining flexibility for changing goal states	- Re-plan decision support for optimal position
Operator Functions	- Monitoring health and status of UAV - Optimal position supervision - Monitoring for sensor activity - Perceiving/interpreting other sensor data - Analyzing other sensor data - Notifying relevant stakeholders	

Geo-spatial (dynamic and static):

	Phase Goals	**Functional/Information Requirements**
Mission Planning	- Path planning (location of target to be or area to be monitored) - Scheduling of health and status reports	- Threat area information - No fly zone information - Scheduling mechanism - Decision support for path planning (including loitering)
Mission Management	- Monitoring health and status reports - Interpreting transmissions	- Health and status indicators - Alert management - Resource (sensor) allocation
Mission Replanning	- Maintaining flexibility for changing goal states	- Re-plan decision support for optimal position
Operator Functions	- Monitoring health and status of UAV - Optimal position supervision - Resource allocation - Path planning - Target tracking (dynamic) - Perceiving/interpreting images	

	- Analyzing images - Notifying relevant stakeholders - Negotiating with other stakeholders

NBC sensing:

	Phase Goals	**Functional/Information Requirements**
Mission Planning	- Path planning (location of target to be or area to be sensed) - Scheduling of health and status reports	- Threat area information - No fly zone information - Scheduling mechanism - Decision support for path planning (including loitering)
Mission Management	- Tracking progress of UVs and of health and status reports - Monitoring for nuclear, biological or chemical indicators - Taking action if something is sensed	- Health and status indicators - Nuclear, biological, chemical signal detection - Alert management - Active communication to alert proper authorities when NBC sensed
Mission Replanning	- Maintaining flexibility for changing goal states	- Re-plan decision support for optimal position
Operator Functions	- Monitoring health and status of UAV - Optimal position supervision - Monitoring for sensor activity - Notifying of relevant stakeholders	

Communication

Communication:

	Phase Goals	**Functional/Information Requirements**
Mission Planning	- Scheduling of health and status reports - Choosing area for deployment - Picking nodes to be connected	- Threat area information - No fly zone information - Scheduling mechanism - Decision support for choosing loiter parameters - Decision support for connecting nodes
Mission Management	- Tracking progress of UVs and of health and status reports - Monitoring communication availability	- Health and status indicators - Alert management when communication fails
Mission Replanning	- Changing nodes being connected	- Replanning decision support
Operator Functions	- Monitoring health and status of UAV - Monitoring network communications - Notifying of relevant stakeholders of anomalies (e.g., communication loss)	

Extraction

Extraction:

	Phase Goals	**Functional/Information Requirements**
Mission Planning	- Scheduling of health and status reports - Pick areas to extract from - Path Planning (to target location and from target location back to base or alternate point) - Scheduling of targets if multiple extraction points	- Threat area information - No fly zone information - Scheduling mechanism - Decision support for path planning (including loiter locations)
Mission Management	- Tracking progress of UVs and of health and status reports - locating extraction location - Monitoring completion of extractions	- Health and status indicators - Alert management when under threat
Mission Replanning	- Changing extraction points	- Replanning decision support
Operator Functions	- Monitoring health and status of UAV - Path planning supervision - Positive target identification (could include image/sensor interpretation & analysis) - Resource allocation & scheduling - Negotiating with other stakeholders - Notifying relevant stakeholders	

Insertion	Electronic warfare	Payload Delivery

Electronic Warfare:

	Phase Goals	**Functional/Information Requirements**
Mission Planning	- Scheduling of health and status reports - Picking areas to strike - Path planning (routes to strike locations) - Scheduling of targets if multiple targets - Sensor attack plan	- Threat area information - No fly zone information - Scheduling mechanism - Decision support for choosing loiter location - Decision support for connecting nodes
Mission Management	- Tracking progress of UAVs and of health and status reports - Monitoring sensor operation	- Health and status indicators - Alert management - Optimal sensor usage decision support
Mission Replanning	- Modifying target list (order of strikes) & sensor plan	- Replanning decision support
Operator Functions	- Monitoring health and status of UAV - Optimal position supervision - Monitoring for sensor activity - Resource allocation and scheduling - Negotiating with other stakeholders - Notifying relevant stakeholders	

Payload Delivery:

	Phase Goals	**Functional/Information Requirements**
Mission Planning	- Scheduling of health and status reports - Pick areas to strike - Path planning (routes to strike locations) - Scheduling of targets if multiple targets	- Threat area information - No fly zone information - Scheduling mechanism - Decision support for path planning (including loiter locations)
Mission Management	- Tracking progress of UAVs and of health and status reports - Monitoring information coming from BDAs - Weapon choosing	- Health and status indicators - BDA information channels - Command interface with weapon selection support
Mission Replanning	- Modifying target list (order of strikes)	- Replanning decision support
Operator Functions	- Monitoring health and status of UAV - Path planning supervision - Monitoring weapons status - Positive target identification (could include image/sensor interpretation & analysis) - Resource allocation & scheduling	

	- Negotiating with other stakeholders - Notifying relevant stakeholders

Operator Functions vs. Mission Types

	Intelligence/ Reconnaissance	Drones	Transport	Surveillance	Communications	Extraction	Insertion
Monitoring weapon status							X
Monitoring network communications					X		
Monitoring health and status of Passengers			X				
Monitoring health and status of UAV	X	X	X	X	X	X	X
Monitoring for sensor activity				X			X
Negotiating with other stakeholders	X			X		X	X
Notifying relevant stakeholders	X			X	X	X	X
Optimal position supervision	X			X			X
Path Planning supervision	X	X	X	X		X	X
Perceiving/interpreting images	X			X			X
Perceiving/interpreting other sensor data	X			X			X
Analyzing images	X			X			X
Analyzing other sensor data	X			X			X
Positive Target Identification	X					X	X
Resource allocation and scheduling	X			X		X	X
Tracking target	X			X			

Operator Functions vs. Mission Types (individual)

	Intelligence/ Reconnaissance				Drones		Transport		Surveillance			Comm.	Extra-ction	Insertion	
	Mapping	BDA	Target acquisition	Target designation	decoy	Tar-get	Cargo	Passenger	Geo-spatial	Listening	NBC sensing			Electronic warfare	Payload delivery
Monitoring weapon status															X
Monitoring network communications		X										X			
Monitoring health and status of Passengers								X							
Monitoring health and status of UAV	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Monitoring for sensor activity										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	
Path Planning supervision		X			X	X	X	X	X				X		X
Perceiving/interp reting images	X	X							X						
Perceiving/interp reting other sensor data			X							X					
Analyzing images	X	X							X						

Analyzing other sensor data			X							X					
Positive Target Identification			X	X									X		X
Resource allocation and scheduling		X							X	X			X	X	X
Tracking target			X						X	X					