Security Engineering
Fall 2015

Lecture 08 – UTM Scenario

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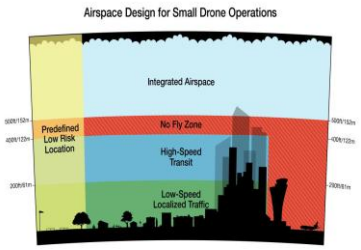
UTM, UAS and all that

- ***A bit of terminology***
  - Unmanned Aerial Vehicles (UAV)
  - Unmanned Aerial System (UAS)
  - UAS Traffic Management (UTM)
- ***What should UTM do?***
  - "The UTM will provide authentication, airspace design, airspace corridors, and dynamic geofencing, weather integration, constraint management (congestion prediction), sequencing and spacing as needed, trajectory changes to ensure safety, contingency management, separation management, transition locations and locations with NAS, and geo-fencing design and dynamic adjustments.» (NASA/TM—2014–218299)
- ***Why?***
  - "Many civilian applications of Unmanned Aerial Systems (UAS) have been imagined ranging from remote to congested urban areas, including goods delivery, infrastructure surveillance, agricultural support, and medical services delivery.
  - […] However, key infrastructure to enable and safely manage widespread use of low-altitude airspace and UAS operations therein does not exist." (NASA/TM—2014–218299)

The Airspace Classification

- ***Class A Airspace***
  - above 18,000 feet including the airspace overlying seas within 12 nautical miles
- ***Class B Airspace***
  - from the surface to 10,000 feet above the nation's busiest airports
- ***Class C Airspace***
  - from surface to 4,000 feet above airports with operational control tower, serviced by a radar approach control, and sizeable operations or passengers.
- ***Class D Airspace***
  - from the surface to 2,500 feet above airports that have an operational control tower.
- ***Class E airspace***
  - None of the above but still controlled (eg military areas)
- ***Class G Airspacw***
  - Unregulated one. Typically below 1,200 feet from surface and 5+ miles away from airports
- ***ATC clearance is required for all aircraft to operate in Class A, B Airspace and must be able to fly an instrumented flight [for "clear of clouds might run a visual_flight for B areas]***
- ***Two way radio communication with ATC, control tower prior to entry and while in Class C and D***

The AirSpace Zones (UAS «owner» view)



Amazon PrimeAir. Revising the Airspace Model

Which Model of UTM?

UTM «service provider» View Point

- ***Portable UTM System:***
  - Arrive, set-up, operate, and leave
    - be able to move from one location to another
  - Support humanitarian, agricultural and other applications
- ***Persistent UTM System:***
  - Sustained, real-time, and continuous operations
  - Sample application
    - Manage national parks
    - Good transportation between cities
    - Small goods transportation in urban areas

UAS «owner» viewpoint

- ***Remotely piloted vehicle***
  - «normal» airplane
  - pilot is just going to an office instead of boarding the plane
- ***Remotely piloted fleet***
  - Separation and Management control automated
    - vehicle-to-vehicle communications
    - vehicle-to-service communication
    - Most routing, separation management, congestion optimization automated
  - Operators only intervene in off-nominal cases
    - Emergency, national security

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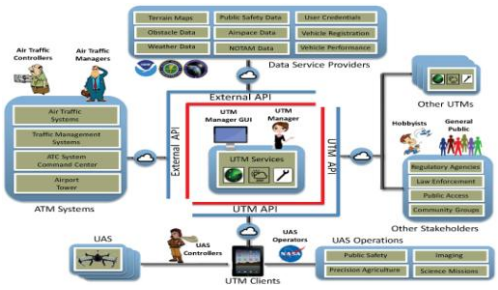
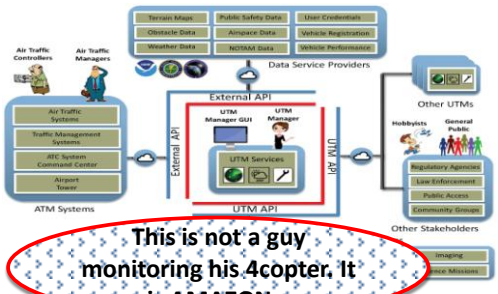
NASA Notional Architecture



NASA Notional Architecture: the «mistake»



This is not a guy monitoring his 4copter. It is AMAZON…

Current Problem with UAVs

- ***Lost Link***
  - Happens frequently even on military grade aircrafts
  - Key requirements is predictability of what happens after that
- ***Latency***
  - Both Link latency and operator latency
- ***Levels of automation***
  - Low automation makes difficult to predict what happens after link is lost
  - High automation makes difficult to predict what happens if some gear is malfunctioning
- ***Measured response***
  - UAV similar to Manned in time
    - takes time for the operator to react
  - BUT Lack «sense of place»
    - E.g. fly upside down and don't understand that
- ***Detect and avoid***
  - So far similar to manned (see above)

UTM Service Operational Requirements

- ***Airspace management and zone separation***
  - reduce risk of accidents, impact to other operations, and population's concerns
  - Vertical and horizontal
- ***Integration of Meteo data***
  - Avoidance of severe weather/wind areas
- ***Congestion management (and possibly prediction)***
  - Currently done with routes negotiations and centralized air traffic management
- ***Maintain safe separation (mission safety)***
  - Avoidance of terrain and man-made artifacts
  - Avoidance of other aircrafts (classical notion of separation)
- ***Authenticated operations***
  - avoid unauthorized airspace use
- ***See NASA Memo***

Role of UAS «fleet manager»

- ***Cloud-based UTM Service***
  - UAS manger accesses through internet
- ***Initial Set-up***
  - Generates and files a nominal trajectory
  - adjusts trajectory in case of other congestion or pre-occupied airspace
  - Verifies for fixed, human-made, or terrain avoidance
  - Verifies for usable airspace and any airspace restrictions
  - Verifies for wind/weather forecast and associated airspace constraints
- ***Run-time control***
  - Monitors trajectory progress and adjust trajectory, if needed
  - Supports contingency – rescue
- ***Allocated airspace changes dynamically as needs change***
- ***See NASA memo for details (does it conforms with Amazon View?)***
  - Not clear who manages contingencies yet

Role of UTM «service provider»

- ***Authentication***
  - Similar to vehicle identification number, approved applications only
- ***Airspace design, adjustments, and geo-fencing***
  - Corridors, rules of the road, altitude for direction, areas to avoid
- ***Communication, Navigation, and Surveillance***
  - Needed to manage congestion, separation, performance characteristics, and monitoring conformance inside geo-fenced areas
- ***Separation management***
  - May require sensing infrastructure and avoidance infrastructure
  - Part of this infrastructure maybe on aircrafts
- ***Weather integration***
  - Wind and weather detection and prediction for safe operations
- ***Contingency Management***
  - Not in NASA scenario but somebody must do it

UTM Services according to NASA

Regulatory Services

- ***Security Services:***
  - Vehicle Registration
  - User Authentication
  - Flight Monitoring
  - System Health Monitoring
- ***Flight Services:***
  - Flight Planning
  - Scheduling and Demand Management
  - Separation Assurance
  - Contingency Management
- ***UAS fleet owner is bound by response***

Information Services

- ***Information Services:***
  - Airspace Definition
  - Weather Information
  - Terrain and Obstructions
  - Traffic Operations
- ***UAS fleet owners use them to optimize its plan***

Reading List

- ***«Requirements documents»***
  - NASA technical memo - NASA/TM—2014–218299
  - Amazon memorandum – «Revising the Airspace Model for the Safe Integration of sUAS", July 2015
- ***«Background documents»***
  - Some presentations from NASA
  - Articles describing incidents due to failures of normal ATM and problems with current «remotely piloted» UAVs
  - A Upenn BSc Thesis surveying Drones