



The Role of Regulation in Access to Civilian Airspace: Paths Forward for Unmanned Aerial Systems

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Outline

- Motivation
- Regulatory Framework: Conventionally Piloted Aircraft
- Current UAS Regulation: Sample International Perspective
- Path Forward: Operations Oriented Approach
- Summary Thoughts

UAS Market Projections

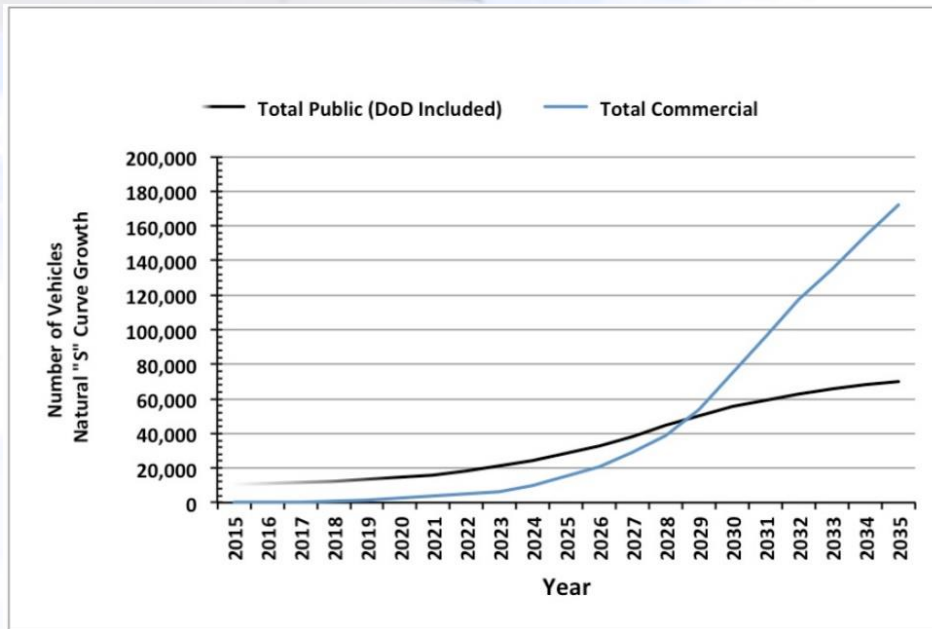
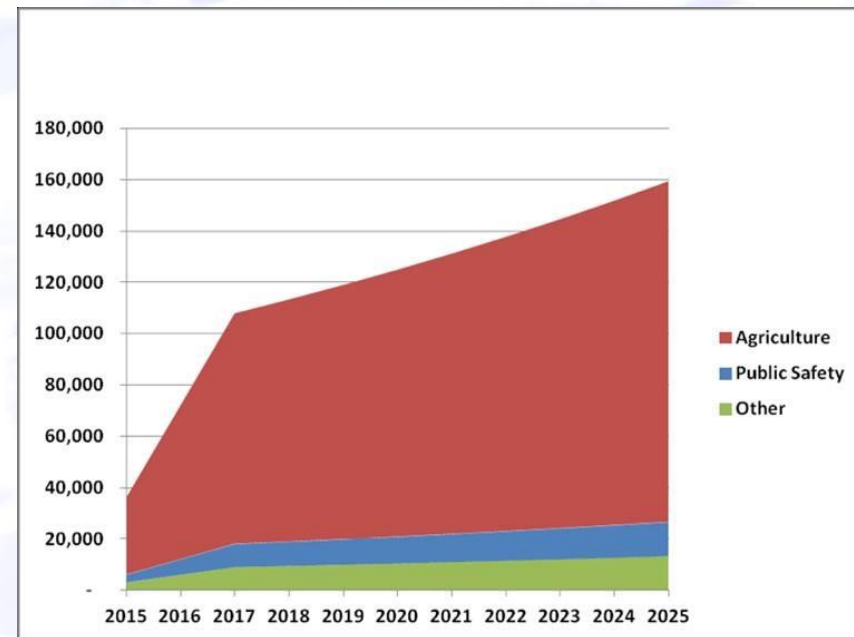


Figure ES-3 - Total UAS Forecast 2015 - 2035

Projected UAS growth in Commercial Market [1]



UAS Sales by Sector [2]

Barriers

- Lack of Assurance Arguments for Commercial Off The Shelf Components (COTS) in safety critical roles
- Lack of Component (e.g., sensors, actuators) Quality Assurance Data
- Lack of airspace/operator rules
 - Different mission (e.g., loiter)
 - Different performance envelope
 - Different equipment (see vs. sense)
- Lack of Operator/Ground Crew Standards
- Security and Privacy Issues
- **Lack of Explicit Consideration for UAS in Regulatory Framework**

A view from an airplane window showing the wing and a cloudy sky. The wing is visible in the upper left corner, and the sky is filled with white, fluffy clouds. A small airplane is visible in the distance, flying horizontally across the sky.

REGULATORY FRAMEWORK: CONVENTIONALLY PILOTED AIRCRAFT

Regulatory Framework

- Regulation of aircraft in civilian airspace occurs through the application of (legally codified) rules
 - e.g., 1998 CASR, 14CFR, EC No 216/2008, ICAO...
- Guidance for compliance is detailed in supplementary documentation (Soft Law)
 - Advisory Circulars (AC), Acceptable Means of Compliance and Guidance Materials (AMC-GM), etc.
- Standards Documents referenced in AC/AMC-GM provide detailed processes for showing acceptable means of compliance
 - e.g., DO-178C/ED-12C, DO-264/ED-78a etc.

Regulatory Framework: Certification

- We use the general concept of a CAA for this section to avoid restricting the discussion to any particular country's regulatory approach.
- A National Civil Aviation Authority (CAA) regulates access to civilian airspace (e.g., FAA, CASA, CAA etc.).
- One key aspect of regulation is certification:
 - Airworthiness Certification
 - Crew Certification
 - Instructions for Continuing Airworthiness
 - Air Operator Certification
- *Air Traffic Management (ATM), Air Navigation Service Provider(ANSP), Ground Infrastructure, and Aerodromes are regulated internally by the CAA.*

Airworthiness Certification

Airworthiness: Aircraft's fitness for flight operations, in all possible environments and foreseeable circumstances for which aircraft or device has been designed. [3]

- **Type Certificate (TC)**

- Properly designed and meets required standards /regulations

- **Production Certificate (PC)**

- Properly manufactured to type design

- **Airworthiness Certificate**

- Required for each tail number to gain access to the airspace



Crew Certification

- **Pilot Certification**

- Levels: student, sport, recreational, commercial etc.
- Category Rating: airplane, rotorcraft, glider, etc.
- Class and Type Rating: As required for category.
- Ratings can also be obtained wrt equipment: instrument vs. visual, single vs. multi-engine etc.

- **Aircrew: Supplementary Flight Crew, Cabin Crew etc.**

- **Ground Crew: Maintenance Technician, Flight Dispatcher, etc.**

Continuing Airworthiness

- Applies to aircraft, engine, propeller or part
 - Complies with airworthiness requirements
 - Remains in condition for safe operation of aircraft
- Based on initial type certification, maintenance and operational regulatory approvals → Instructions for Continuing Airworthiness (ICA). For example:
 - Operator's approved maintenance data
 - Conformance to original Type Design
 - Record keeping and reporting...


Air Operator Certificate

- Air Operator Certificate establishes requirements and procedures for commercial operation of aircraft
 - Details type of equipment, where and when you will operate, crew training requirements etc.
 - Development of operations and maintenance manuals
 - Includes business plan, system safety process, and reporting procedures
- Directly influences continuing airworthiness



Perspectives (I)

- CPA Framework may not be suitable as-is for UAS:
 - Model of operation for UAS may differ from CPA(& cost)
 - Vehicle and ground infrastructure must be considered for airworthiness, including communications links
 - UAS Airframe manufacturers do not have airworthiness responsibility for fielded platform
 - UAS operators require different skills than conventional pilots
 - Air Operators/Service Providers may take larger role in gaining and maintaining airworthiness of platform based on services offered

The background of the slide is an aerial photograph of a bright blue sky filled with white, fluffy clouds. In the upper left corner, the white wing of a large aircraft is visible, extending towards the center. In the middle distance, a small, dark silhouette of an aircraft is flying horizontally. In the lower right corner, another small, dark silhouette of an aircraft is visible, flying away from the viewer.

CURRENT UAS REGULATION: SAMPLE INTERNATIONAL PERSPECTIVE

Australia [4]

- Civil Aviation Safety Regulation (CASR) Part 101 was first operational regulation for UAS released in 2002; deals with Remotely Piloted Aircraft Systems (RPAS)
 - Currently being updated with ACs, Notice of Proposed Rulemaking
- UAS in controlled airspace are treated as IFR flights, must be equipped with SSR and a collision avoidance or forward vision system, and have filed flight plan with contingencies
- Operation BVLOS, BRLOS requires abort/termination procedures to be filed with ATC authority
- RPAS operator must have ground training applicable for IFR rating

Canada [5]

- Establishes 2 classes: under 2 kg, between 2-35 kg with max airspeed <87kts
 - Requires VLOS, prohibits use of visual observers to extend LOS, and relay stations to extend RLOS
 - Operate below 300 ft in class G airspace, and 5 nmi from aerodrome/urban area, minimum clearance of 500 ft with all obstacles/persons
 - Pilot must be 18, and completed pilot ground school
- All other UAS must certify as CPA do, though individual exemptions may be sought

European Union [6]

- EASA regulates UAS and RPAS ≥ 150 kg used for civil applications, all other UAS regulated by member nation CAAs
 - “Airworthiness Certification of Unmanned Aircraft Systems (UAS)”
- Concept of Operation for Drones
 - Three categories: **Open, Specific and Certified**
 - **Open** does not require authorization for flight, but must stay within defined boundaries
 - **Specific** requires risk assessment to gain Operations Authorization with specific limitations
 - **Certified** requires airworthiness certification

EU UAS under 150 kg

- UK [7] divides into two categories, ≤ 20 kg, and $>20 \< 150$.
 - Under 20kg, no airworthiness approval or registration for VLOS RPAS, below 400 ft, in class G airspace, or within 50 ft of people.
- Germany [8] prohibits operation of any UAS over 25 kg, or beyond LOS, or above 100 m
 - Commercial operation of a UAS or UAS over 5 kg requires license
 - UAS under 5 kg can receive limited permit for operations up to 100 m, within LOS for repeated use, but not over crowds
- France [9] has two decrees governing UAS use:
 - Aircraft Decree classifies UAS into 7 categories, C(mass, function)
 - Airspace Decree outlines 4 operational scenarios
 - (Category, Operational scenario) pairs determines level of oversight

Japan [10]

- Commercial use of unmanned helicopters for agriculture in Japan since 1980s
- Japan Agricultural Aviation Association sets standard (Ministry of Agriculture, Forestry and Fisheries)
 - Pilot Training
 - Aircraft Registration
- Operators must have valid Maintenance Operator License, and be registered, as well as meet structures, flight performance and maintenance standards
- Aviation Regulations only require that any UAS fly below 150 m and 9 km away from airports

US [11]

- 2 Part 21.25 Restricted category type certificates to Puma and ScanEagle for Arctic Operations
- Section 333 of FAA Modernization and Reform Act allows case-by-case exemption
 - FAA will grant COA for flights at or below 200ft to 333 exemption holders for weight <55 lbs, VFR, VLOS and stay fixed distance from airport → Can operate anywhere except over urban areas and restricted airspace
- Proposed small UAS rule for <55 lbs, max airspeed 100 mph, max altitude 500ft, VLOS, no overflight of persons
 - Allowed with permission in B,C,D,E airspace
 - Visual observers may be used, but not First Person Camera View

Perspectives (II)

- Other than in Australia, little formal regulation exists specifically to grant access to UAS larger than ‘small’ weight class
- Commercial UAS (even small) are often not granted access (except in Japan) and face regulatory burdens which may be disproportionate (enormous added cost)
- Beyond VLOS/RLOS operations are rarely enabled

The background of the slide is a high-angle aerial photograph of a sky filled with white, fluffy clouds. In the upper left corner, the white wing of a large aircraft is visible, extending towards the center. In the middle distance, another smaller aircraft is seen flying horizontally across the frame. In the bottom right corner, a small silhouette of a person or object is visible against the clouds.

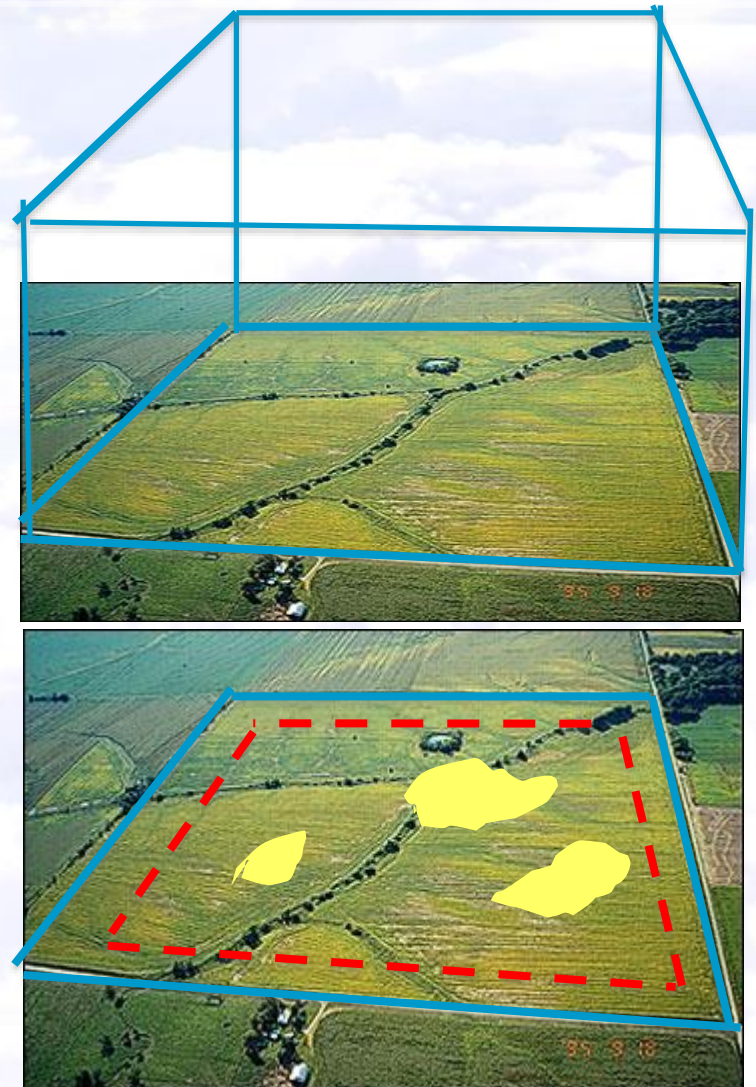
PATH FORWARD: OPERATIONS ORIENTED APPROACH

Motivation for Approach

- Wish to enable airspace access for class of commercial applications whose vehicle platform is not ‘small’ , and/or who may wish to operate BVLOS
- Several commercial application domains have been identified:
 - Precision Agriculture, Inspection/Surveillance, Mapping/Surveying
- Each of these applications may present a restricted set of operational hazards whose mitigation may be sufficient to form a type certification basis
- This will enable a ‘starting’ certification basis for (Operational Concept, Platform) pair.

Define Concept of Operations [12]

- Clearly define:
 - Operational Scenarios
 - Operational Environment
 - Assumptions
 - Functional Performance
 - Anticipated Safety Considerations
- Also Relevant: economic considerations



Vehicle Selection [13]

- Relevant Vehicle characteristics
 - e.g., range, endurance, speed
- Relevant Safety Concerns
 - Autorotative capability, etc.
- Economic Considerations



An aerial photograph of a white aircraft wing extending from the top left towards the center. The background is a bright blue sky filled with soft, white clouds. The title 'Hazard Analysis' is centered in the upper half of the image.

Hazard Analysis

- For the clearly defined Conops, an Operational Hazard Assessment (in conjunction with the selected vehicle) will yield relevant hazards
 - Evaluate wrt severity
- Vehicle specific hazards (that are evinced in operational context) are then aggregated
 - Controllability, maneuverability, etc.
- In the context of operational and environmental assumptions, this forms the set of hazards to be mitigated (airworthiness, operational, training...)
 - Ground Station, Operator, Communication Links, etc.

Develop Type Certification Basis

- Can develop regulation for each hazard that will result in desired level of mitigation
 - Can use available regulation for conventional hazards
 - Can modify available regulation to fit similar hazards in new context
 - Develop regulation for aspects of vehicle/operation that is novel
 - e.g., Communications Link , Containment Area

Assured Containment Concept [14]

- Containment system independent of the UA autopilot and avionics
- Redundant means of enforcing the containment boundaries
 - Doesn't use vehicle's sensors, actuators or computational platform
- No single failure in UAS autopilot results in an automatic failure of the containment system
 - limit the UA's physical location in the presence of such failures.
- Extensible through:
 - Vehicle Types, Operational Environments, Application Domains

Perspectives (III)

- Enabling access to airspace for a wide class of vehicles and applications will require either:
 - Case by case evaluation or
 - Reuse of assurance concepts to form a common certification basis across vehicles and operational concepts or
- Cost outlay required to meet possibly unduly burdensome standards will act to drive which approach is taken

Summary Thoughts

- Enabling UAS access into the airspace must be done in an Efficient (time and cost), Safe and Secure, as well as Non-disruptive manner in order to ensure the economic benefit of this enabling technology is fully realized
- Regulatory impediments remain the largest barrier to UAS access of airspace
- Use of operationally driven type certification bases may provide relief while maintaining safety, and begin to build a foundation for certification over classes of operations and vehicles



Questions?

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**Visit the DP-14 in the NASA
Integrating UAS into the NAS Booth at
AUVSI**

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- [14] Kelly J. Hayhurst, Jeffrey M. Maddalon, Natasha A. Neogi, and Harry A. Verstynen, “A Case Study for Assured Containment”, ICUAS 2015, to appear.