FAA's Approach to Unmanned Aircraft Systems (UAS) Concept Maturation, Validation & Requirements Development

Presented to: V&V Summit

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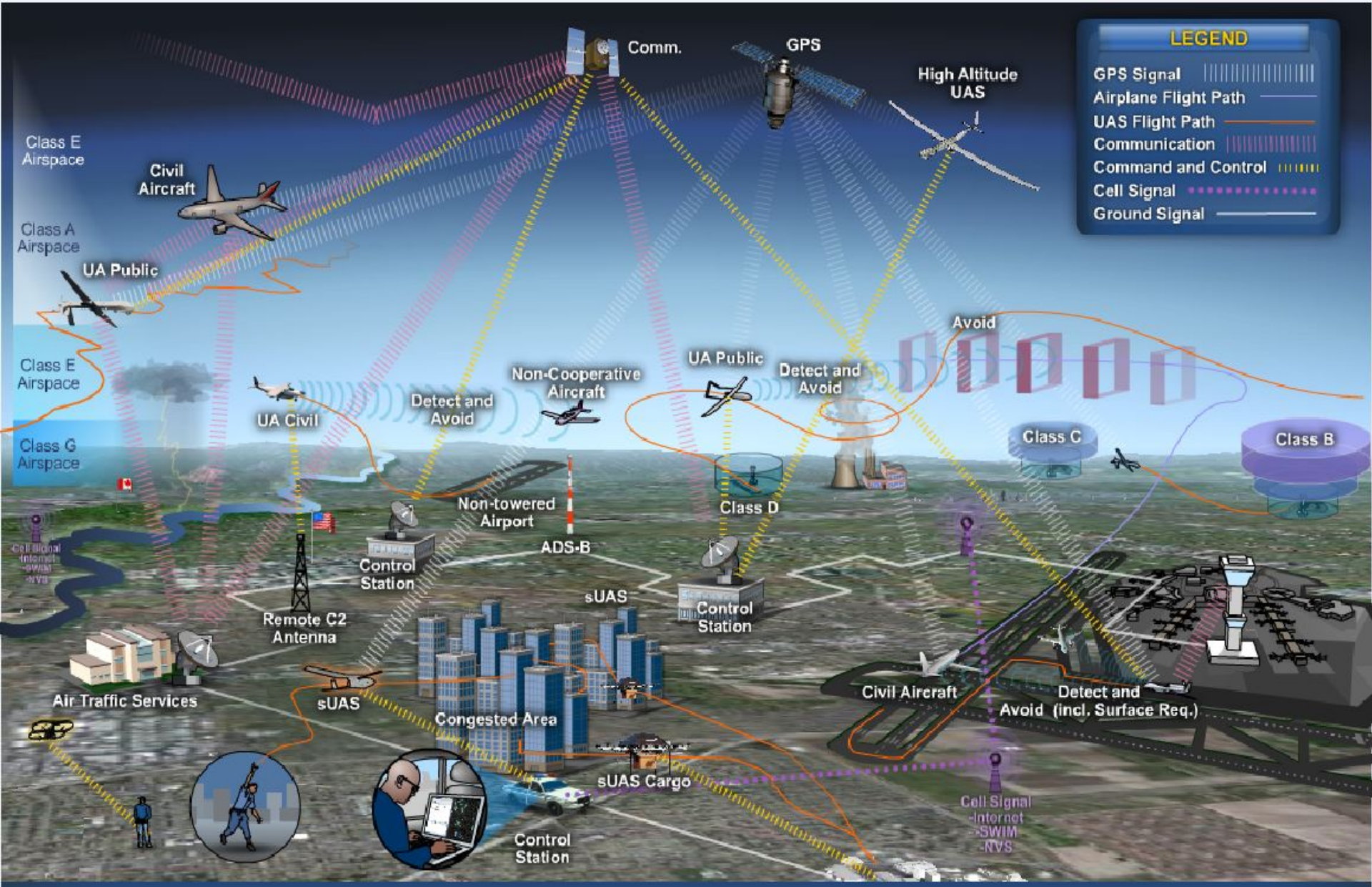
ATO/ANG UAS Concept Maturation Team

Date: September 24, 2015

Briefing Objectives

- **Provide a history of FAA concept development and maturation efforts conducted to date towards achieving UAS integration into the National Airspace System (NAS) and the associated drivers for initiating the work**
- **Describe the systematic approach and process employed by the FAA ATO/ANG UAS concept maturation team to identify proposed UAS concept maturation/validation needs**
- **Demonstrate cross line of business, cross-organizational collaboration**
- **Highlight strategic plans for moving forward**


LEGEND
GPS Signal
Airplane Flight Path
UAS Flight Path
Communication
Command and Control
Cell Signal
Ground Signal
Comm.
GPS
High Altitude UAS
Class E Airspace
Civil Aircraft
Class A Airspace
UA Public
Class E Airspace
Class G Airspace
UA Civil
Detect and Avoid
Non-Cooperative Aircraft
UA Public
Detect and Avoid
Avoid
Class C
Class B
Class D
Non-towered Airport
ADS-B
Control Station
Remote C2 Antenna
Air Traffic Services
sUAS
Congested Area
sUAS
Control Station
Civil Aircraft
Detect and Avoid (incl. Surface Req.)
sUAS Cargo
Control Station
Cell Signal
-Internet
-SWIM
-NVS
Policies and Procedures
Roles and Responsibilities
Standards and Rulemaking
Performance and Equipage
Design Specifications Certification

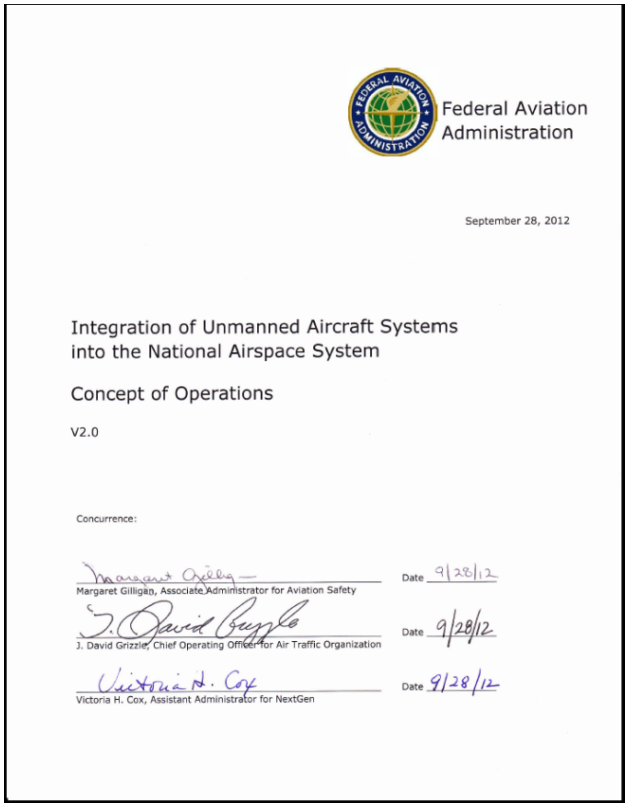
FAA UAS ConOps

Overview
Development Approach
Concept Assumptions
Operational Scenarios

2011-2012: High-Level UAS ConOps Development

- Developed FAA UAS Concept of Operations (ConOps) for mature state integrated UAS operations, due to growing interest and demand for UAS access to airspace

- FAA Modernization & Reform Act (February 2012), mandating that FAA integrate UAS into the NAS by 2015, further stressed importance and priority of FAA UAS concept and requirements development efforts



Federal Aviation Administration

September 28, 2012

Integration of Unmanned Aircraft Systems into the National Airspace System

Concurrence:

Margaret Gilligan, Associate Administrator for Aviation Safety — Date 9/28/12

J. David Grizzle, Chief Operating Officer for Air Traffic Organization — Date 9/28/12

Victoria H. Cox, Assistant Administrator for NextGen — Date 9/28/12

ConOps Objectives

- Begin the systems engineering process of identifying operational and system-level requirements necessary to achieve integration
- Establish framework for alignment of UAS efforts across FAA (roadmaps, research plans and activities) to validate and inform path to integration
- Identify touchpoints and interactions with NextGen systems, capabilities, and operational improvements
- Document FAA expectations of UAS operators, in terms of operations, performance, and airworthiness, and identify pre-requisites to integration at an appropriate level

Concept does not address small UAS (aircraft weighing less than 55 lbs) operations conducted exclusively within visual line of sight of the flight crew

ConOps Development Approach

- Established multi-organizational team of FAA subject matter experts (SMEs) to encompass air traffic, safety, and system perspectives and foster early internal stakeholder acceptance of the vision
- Developed concept narrative and mature state operational scenarios, primarily from an air traffic perspective
  - Defined assumptions about certification, operating rules, and the operating environment
  - Described operations by phase of flight and airspace class (A-E, G)
- Assumed
  - All required policies, regulations, procedures, technologies, and training are in place to support integrated UAS operations (both civil and public) in the NAS
  - NextGen capabilities, enabling technologies, and operational concepts have matured
  - Timeframe is milestone-driven

Summary of Key Integration Assumptions

- UAS are aircraft and behave in a manner similar to manned aircraft. This includes meeting the performance and equipage requirements established for the airspace class and/or route in which they are operating.
- Certification of airworthiness and a capability analogous to that required under “see and avoid” requirements of 14 CFR Part 91 are pre-requisites to NAS integration.
- UAS adhere to current and future ATC procedures, requirements, and instructions using standard phraseology. The FAA creates no new airspace classes specifically to support UAS.
- Autonomous operations are not authorized. The Pilot in Command (PIC) can always assume direct control of the aircraft during normal operations. There is a 1-to-1 relationship between the PIC and the UA.
- ATC remains responsible for separation services as required by airspace class and flight plan type using applicable separation minima.
- FAA policy, guidelines, and automation support priority for individual flights, and equitable access to airspace and air traffic services.

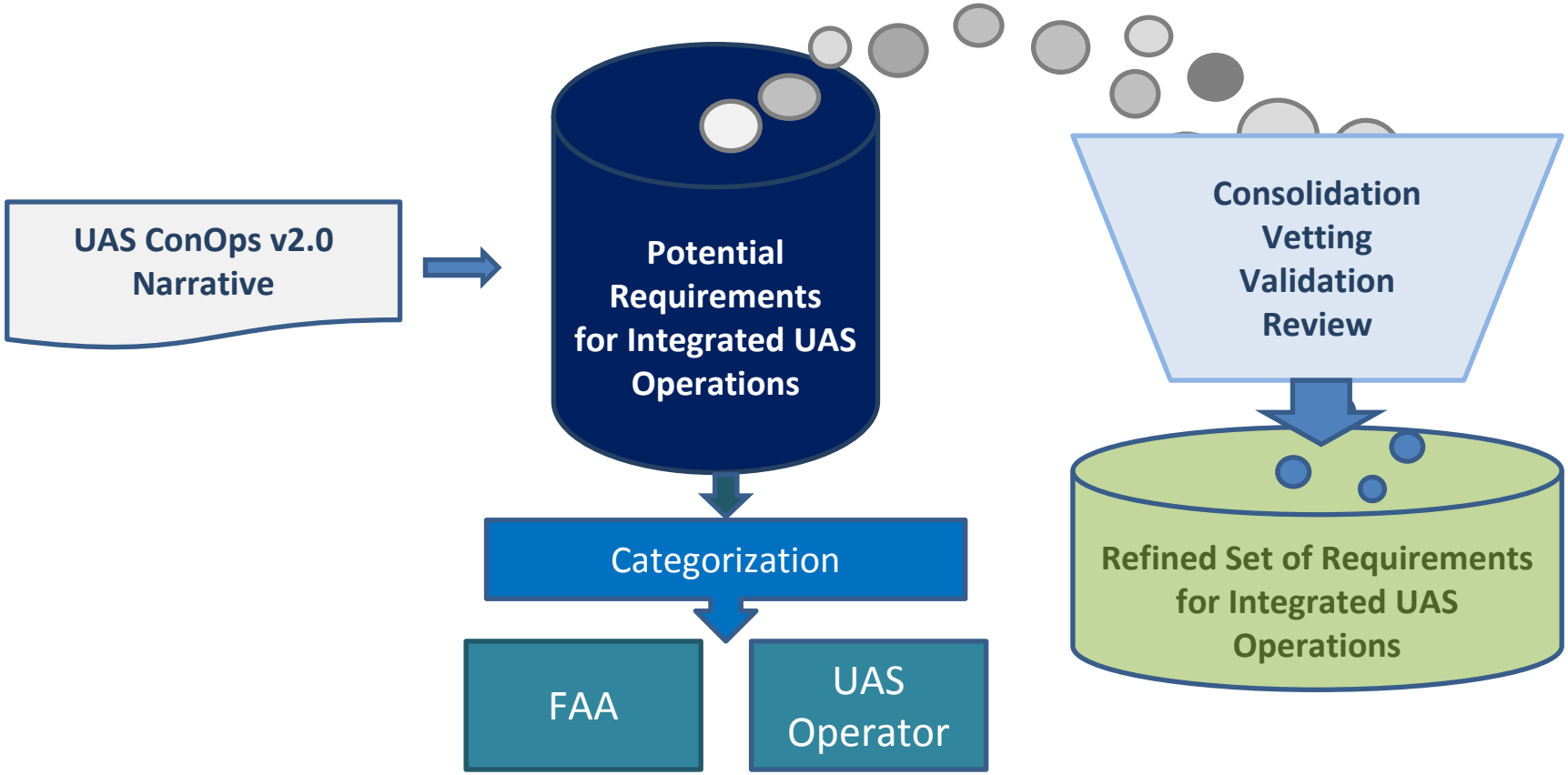
Summary of Mature State Operational Scenarios

Scenario Name	Flight Plan	Airspace	Purpose of Flight	Aircraft	Mature State Highlights
Flight Planning	IFR	All	Any where IFR flight plans are appropriate	All	Negotiation of flight plan prior to departure and updates during flight. Define “unique.”
Surface Operations	N/A	Class C or Class D	N/A	All	For ground movement on towered airports. Interact with other traffic and ATC on the surface.
Border Patrol/ Monitoring	IFR	Class C arrival/departure, aerial work in Class A and Class E	Border patrol	Predator-B	Planned maneuver and unplanned deviation. Negotiated delay in return to airport. Go-around.
Atmospheric Monitoring (HALE)	IFR	Class A, Class E high altitude	Environmental Sensing	HALE	Slow transition through Class A. Long-endurance above FL600.
Search and Rescue	Notify	Class G	Survey at night	ScanEagle	Survey operations in Class G airspace.
Traffic Monitoring	IFR	Class D departure, Class B aerial work	Media and traffic reporting	Fire Scout helicopter	Follow defined route. Hovering operations.
Environmental Sampling	IFR	Class E with Class B transition	Monitor coal plant air emissions	Aerosonde	Class B transition, operations grid pattern in Class E. 4D trajectory operations. Early termination for weather.
Cargo/Mail Delivery	IFR	Class D departure, Class E en route and arrival	Cargo delivery	Cessna Caravan	ATM weather reroute and pilot weather deviation.
Oceanic Cargo/Mail Delivery	IFR	Class A oceanic, Class B arrival	International cargo	B747	Oceanic high altitude point-to-point operations. In-trail climb procedure. High-density airspace operations to include OPD.
Delegated Separation Environmental Sampling	IFR	Class E	Exploration in class E	Shadow	IFR flight with delegated separation for exploration in Class E airspace
Lost Link	IFR	Class A	Demonstrate what Known and Predictable means	Any UA certified to operate in Class A	Talks about LL profile, Standardized LL Contingency Plans, LL recovery plans and procedures

UAS Requirements Development

ConOps Decomposition
FAA
UAS Operator

ConOps Decomposition

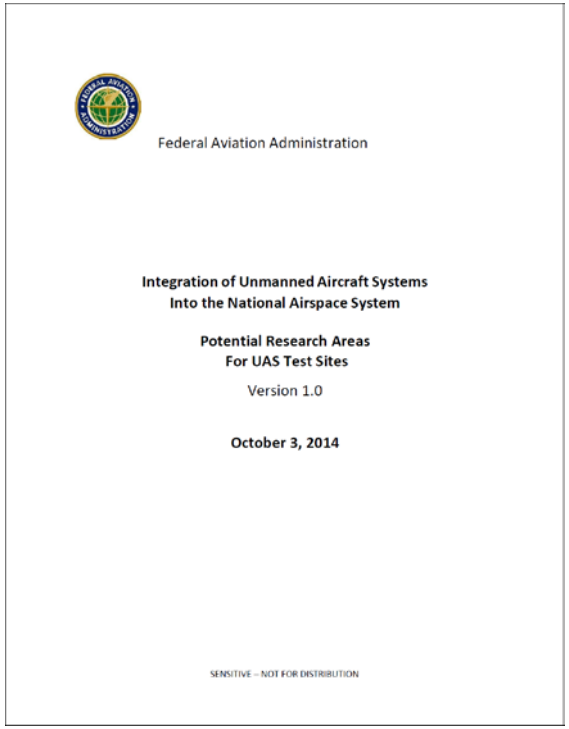


FAA Requirements

Rqmt #	Category	Shortfall	Shortfall #	FAA Requirement	Mid Term?	Concept maturation area(s) of interest, if any.	Status of Requirement & Shortfall
1-126	Operations - Contingency	Standard UAS contingency procedures [associated with lost link] that require ATC interaction have not been established. Air traffic procedures in the terminal domain do not include airspace or fixes that support lost link events.	S1.13	Airports routinely serving UAS shall designate a fix or volume of airspace for lost link containment and/or flight termination. Airports routinely serving UAS may designate a fix or volume of airspace for lost link containment.	Y	**AJV-7 Support/Consult** [R1.13 - ATC Procedures and Phraseology for Lost Link Events] Concept Maturation Questions: ☐What ATC procedures are required during lost link events in the en route and terminal domains? o For designating a fix or volume of airspace for lost link containment o For handling UAS flight termination events if link cannot be regained ☐What phraseology is required for use by controllers during lost link events? ☐Are the proposed ATC procedures and phraseology adequate to support lost link events?	
1-89	Flight Planning	The current flight plan does not support the full range of UAS operations. The number of characters within a flight plan route string does not support every type of UAS operation.	S4.1.1	The FAA shall increase (currently at 1000) the number of characters in a flight plan route string. The FAA will assess and establish an appropriate number of characters (currently 1000) that may be needed to support UAS flight plans.	Y	**AJV-7 Lead** [R4.1.1 - Increasing Flight Plan Route Elements and Characters] Concept Maturation Questions: ☐Is it necessary to increase flight plan route elements and characters within a route string to support every type of UAS operation? What types of operations need to be supported? o Will the planned increase in characters within a flight plan route string (from 1000 to 3000 via ERAM Sector Enhancements) be sufficient to support UAS operations? If not, what is the target number that needs to be established for implementation? o Will the increase in flight plan route elements (from 48 to approximately 250, enabled by the planned increase in characters) be sufficient to support UAS operations? If not, what is the target number that needs to be established for implementation? ☐What are the technical limitations associated with the number of flight plan route elements and characters automation is able to process? ☐If automation's technical limitations do not support target numbers of flight plan route elements and characters required for implementation, what are potential work-arounds (e.g., filing multiple flight plans for different segments of flight)?	Requirement and shortfall allocated to ERAM Sector Enhancements

UAS Operator Requirements

- **Shared with UAS test sites in 2014 in form of 'Potential Research Areas'**



Federal Aviation Administration

Integration of Unmanned Aircraft Systems Into the National Airspace System

Potential Research Areas For UAS Test Sites

Version 1.0

October 3, 2014

SENSITIVE – NOT FOR DISTRIBUTION

Category	Research Consideration	ConOps Section
Certification - Communications	**UAS will comply with voice and data communications latency requirements (which may vary by class of airspace) between the flight crew and ATC.** Includes research to validate standards for one or more acceptable thresholds for communications latency.	4.4.1.2

Category	Research Consideration	ConOps Section
Operations - Sense & Avoid	**The UAS PIC will obtain ATC approval prior to performing a self-separation maneuver outside the IFR clearance issued in controlled airspace.** **Note: In Class A airspace, self-separation maneuvers should not be performed.** Includes research to develop capabilities or validate standards to use Sense and Avoid system to self-separate from one or more other aircraft as approved by ATC.	4.5

UAS Concept Maturation

UAS Steering Group (USG)
Mid-Term Operational Scenarios
Scenario Service/Responsibility Allocation Tables

UAS Steering Group (USG)

Mission

- Provide executive level direction on maturation and validation of UAS operational concepts
- Provide a forum to
  - Review and provide input to concept maturation products at a working level
  - Gain agreement/consensus regarding scenarios' narratives, objectives, outcomes, and requirements
  - Recognize and consider interdependency of issues and anticipated changes needed

Participants

- Air Traffic (ATO), Safety (AVS), & NextGen (ANG) organizations- Directors & Chief Scientist
- Participants engaged in various FAA UAS efforts - to ensure continuity of UAS integration planning

2013-Present: Concept Maturation

Drivers & Objectives

- **Drivers of activity included air traffic management (ATM) automation lead times to incorporate changes and uncertainty surrounding specific dates when significant commercial UAS operations are anticipated**
- **Multi-year, cross-organizational, integrated work plan developed *with scenario-based approach* to further:**
  - Identify policy, procedural, regulatory, and other issues
  - Address issues/questions associated with the ConOps and detailed scenarios

Products & Outputs

- **11 detailed, vetted mid-term scenarios, based on mid-term environment assessment**
- **11 updated, detailed, vetted, mature state scenarios**
- **Updated operational requirements based on mid-term scenarios**
- **Initial shortfalls and operational requirements to inform Concept & Requirements Definition & Investment Analysis Readiness Decisions (CRDRD & IARD) of planned investments**

Summary of Mid-Term Operational Scenarios

Scenario Name	Flight Plan	Airspace	Purpose of Flight	Aircraft	Mid-Term Highlights
Flight Planning	IFR	All	N/A	All	Negotiation of flight plan prior to departure and updates during flight. Define "unique."
Surface Operations	N/A	Class C or Class D	N/A	All	Assumptions only. For ground movement on towered airports. Interact with other traffic and ATC on the surface.
Border Patrol/ Monitoring	IFR	Class D arrival/departure, aerial work in Class A	Border patrol	Predator-B	Planned maneuver and unplanned deviation. Go-around.
Atmospheric Monitoring (HALE)	IFR	Class A, Class E high altitude	Environmental Sensing	HALE	Slow transition through Class A. Long-endurance above FL600.
Search and Rescue	IFR	Class E, TFR	Search and Rescue at night	Scan Eagle	Search operations Class E airspace.
Agricultural Monitoring	Notify	Class G, D	Agriculture mapping	Trimble UX5	Survey of farmer's land to provide detailed information to the farmer about his crops.
Pipeline Surveillance	Notify	Class G, transition Class D	Pipeline monitoring	Scan Eagle	Designated route specifically for UAS (under 500 ft. AGL).
Accident Scene (HazMat Investigation)	Notify	Class B	Monitoring specific situations on the ground	Small – Shadow Hawk Aeryon Scout	Control in and around urban areas. Flyaway in terminal area
Maritime Surveillance	IFR	Class A oceanic	Surveillance	Global Hawk	Oceanic high and low altitude.
Offshore Surveillance with Due Regard	IFR	Oceanic off-shore, Class A, Class D airport	Surveillance Due Regard Operations off-shore	Scan Eagle	Oceanic Due Regard off-shore operations picking up IFR flight plan back into airport in Class D.
Lost Link	IFR	All	Demonstrate LL procedures for Terminal and En-route	All	Lost link/contingency route activation with & without TOS/ABRR capability, ground-ground CPDLC, procedural changes

Scenario Responsibility Allocation Tables – EXAMPLE

FAA USG Final – 4/24/2015

Mid-Term Scenario Category:
Low Altitude Operations in Sparsely Populated Areas – Allocated Airspace or Structured Route

Example Applications

- Agricultural Monitoring
- Livestock Management
- Power Line Inspection
- **Pipeline Surveillance**
- Oil Field Security/Monitoring
- Canal Monitoring/Inspection

Operational Domain: Low altitude, primarily uncontrolled airspace without radar coverage; allocated airspace volume or route	
UAS Type	Small
Altitude Range	Low (<2,000' AGL)
Aircraft Endurance	Medium (hours)
Expected Traffic Density	Very low
Aircraft Range	Variable, beyond visual line of sight
Conditions	Day
Potential Airspace Classes	D/E/G
Operational Limits	Route defined by ground features; Sparsely populated areas

Pipeline Surveillance

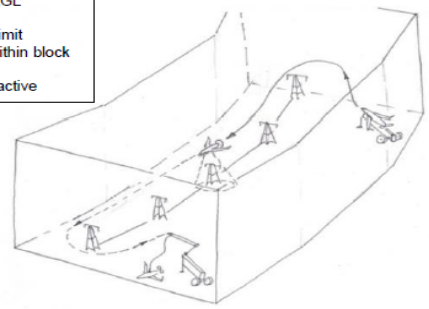
Scenario Synopsis: UAS launches and recovers off airport and operates (in uncontrolled airspace) within a designated "UAS Route" that is NOTAM'd when active. The PIC obtains clearance from ATC to transit Class D airspace that includes a short segment of the allocated route.

Red text in scenario tables indicate shortfalls that need to be addressed

Traceable to Application Option D (Low Alt, Non-Urban, Static)

UA Route
Fixed airspace block
Width = 1 mile
Height = to 2,000 ft. AGL (clear of terrain)
Length < UAV range limit
Launch & Recovery within block
DAA not required
Route NOTAM when active

UA route, Remote Launch (Pipeline/Power line mission)



Note: Detect & Avoid (DAA) options in the mid-term limit operational alternatives.

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Scenario Responsibility Allocation Tables (cont'd) - EXAMPLE

Pipeline Surveillance

Class D

Service/Responsibility	Allocation				Explanatory Notes
	ANSP	PIC		N/A	
		UAS	Manned		
Separation					
Aircraft (general)					
IFR aircraft – IFR aircraft	X				Applies to those UAs on an IFR flight plan.
IFR aircraft – VFR aircraft		X	X		Shared responsibility among UAS and manned aircraft. UAS use currently acceptable means of DAA.
VFR aircraft – VFR aircraft			X		
UA from manned aircraft while on UR route				X	Procedural. UR route is designed and authorized for UA use only.
UA – UA (within allocated route)		X			For multiple UA aircraft on the same UR route, separation assurance is pre-coordinated as part of flight approval.
Airspace					
All aircraft from allocated (and active) route	X	X	X		Procedural. Controller instructs participant aircraft to remain clear of UR route when active.
Collision avoidance (between all aircraft, including UAs)		X*	X		Shared responsibility among UAS and manned aircraft. UAS use currently acceptable means of DAA. *Pipeline UAS not capable.
UAS may accept instructions & clearances with a visual component when the requirements for the specific visual application ar e satisfied.					
Hazard Avoidance					
Terrain avoidance / obstacle clearance					
IFR aircraft, including IFR UAs					
For T/O & initial climb on departure, transition to landing		X	X		
Upon effectiveness of the clearance on departure, and until at DH or MAP while on arrival route	X				Cleared route of flight meets IFR criteria for MEA, MOCA, MVA.
VFR aircraft, UAs that are approved to access the airspace		X	X		
Weather avoidance		X	X		
Advisories					
Wake turbulence advisories	X				Where applicable.
Traffic advisories	X				Workload permitting. Excludes advisories between participating aircraft authorized to operate within allocated airspace.
Weather advisories	X				Workload permitting.

Pulling it all together

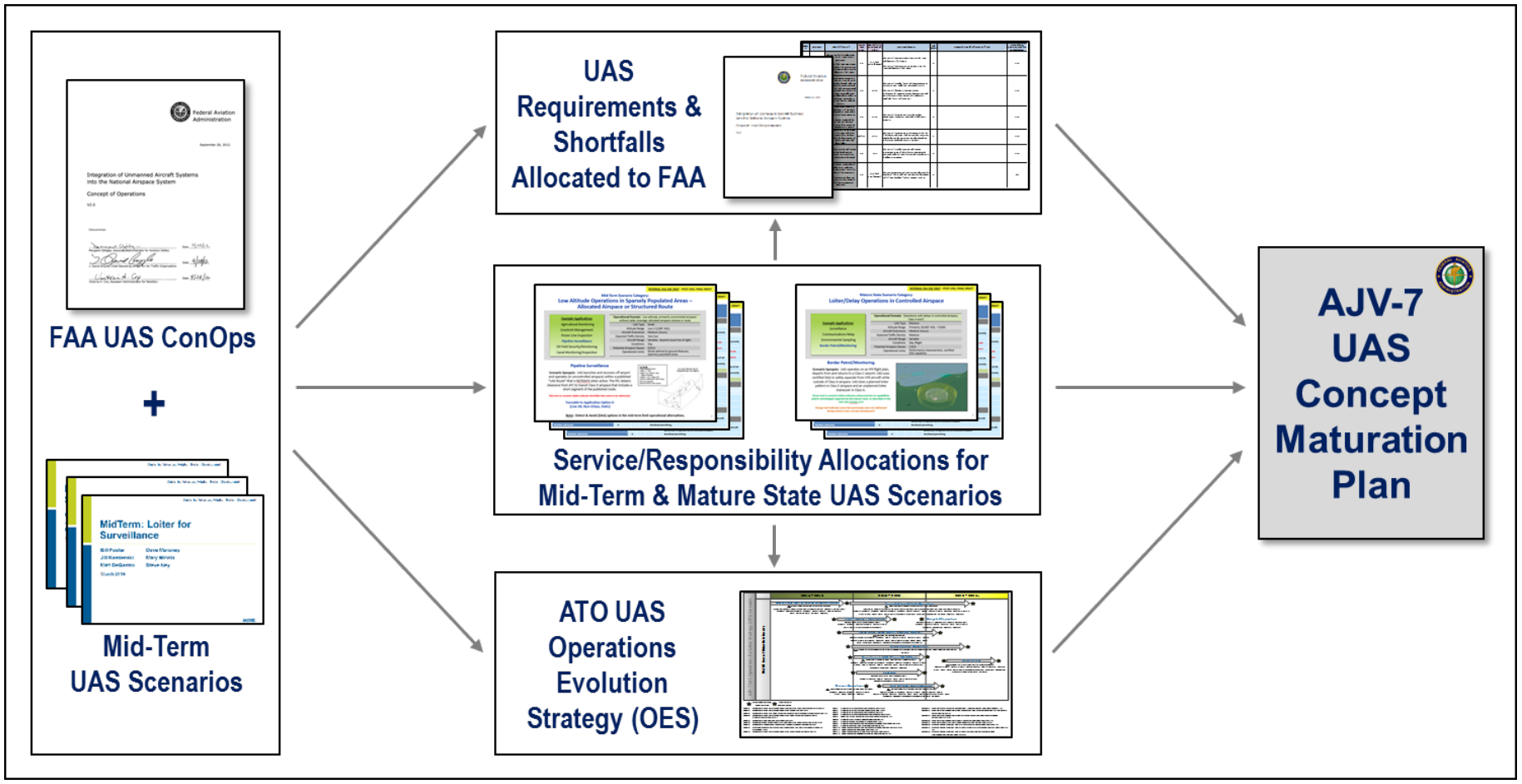
Types of UAS Operations & Supporting Products

Small commercial UAS operations within visual line of sight and outside busy airspace	Specified and routine operations within visual line of sight over populated areas and expanded visual line of sight in rural environments	Beyond visual line-of-sight UAS operations in segregated airspace over low populated areas	Beyond visual line-of-sight UAS operations in segregated airspace over populated areas	Integrated UAS operations
Part 107 – Small UAS Rule	Near-Term Strategy -Pathfinders Mid-Term Scenarios Service / Responsibility Allocations Shortfalls Potential Operational Requirements	Near-Term Strategy -Pathfinders Mid-Term Scenarios Service / Responsibility Allocations Shortfalls Potential Operational Requirements	Mid-Term Scenarios Service / Responsibility Allocations Shortfalls Potential Operational Requirements	UAS ConOps 2.0 Mature State Scenarios Service / Responsibility Allocations Shortfalls Potential Operational Requirements

Strategic Plans for Moving Forward

Concept Maturation & Validation
External Stakeholder Engagement

Concept Maturation Plan



Concept Maturation Prioritization - EXAMPLES

Activity ID	Concept Maturation Activity	Associated Shortfall	Associated FAA Req(s)	Priority
R1.16	ATC Obtainment of Lost Link Contingency Route Information	S1.16	1-120	High
R4.1.1	Increasing Flight Plan Route Elements and Characters	S4.1.1	1-89, 1-102	High
R4.6	Incorporating UAS Type Designations and Performance Characteristics into ATC Automation	S4.6	1-129	High
R1.10	Impact of UAS Performance Limitations in the Terminal Domain	S1.10	1-133	High
R4.2	Trajectory Modeling of Unique (Planned and Unplanned) UAS Flight Profiles	S4.2	1-7, 1-91	High
R1.15.1	Thresholds for Lost Link Duration	S1.15.1	1-65	High
R4.3	Conflict Detection and Resolution for Unique UAS Flight Profiles	S4.3	1-92	High
R4.8	Impact of Proposed Control Link and Communications Latency Thresholds on ATC	S4.8	1-51, 1-70	High
R4.12	UAS Flight Data for Flight Object	S4.12	1-68	High
R1.19	Impact of Communications Latency Exceeding Acceptable Thresholds on ATC	S1.19	1-108	High
R2.2	Radar Detection, Differentiation, and Tracking of Non-Cooperative UAS with Small Radar Cross Sections	S2.2	TBD	High
R5.12	ATC Interaction with Airborne DAA	S5.12	1-111	High
R4.1.3	Flight Planning Capabilities for Long Duration Flights	S4.1.3	1-6, 1-93	Medium
R4.1.4	Flight Plan Feedback for UAS	S4.1.4	1-8, 1-78	Medium
R4.1.6	Incorporating UAS 4D Trajectory Data into Flight Plans	S4.1.6	1-97	Medium
R1.5	Impact of Long Duration UAS Operations on ATC	S1.5	1-96	Medium
R4.5	Automation Support for Demand and Capacity Balancing	S4.5	1-134	Low
R4.9	Data Communications for UAS	S4.9	1-42	Low
R4.4	Incorporating Operational Priority Assignments into ATC/TFM Automation	S4.4	1-44, 1-123	Low
R4.1.5	Processing Flight Plans with Fixes in Latitude/Longitude Format	S4.1.5	1-132	Low
R4.1.2	Identifying UAS Type Designations and Performance Characteristics	S4.1.2	1-80, 1-105	N/A (Addressed)
R4.11	Lost Link Beacon Code	S4.11	1-114	N/A (Addressed)

External Stakeholder Engagement

- Inform public and civil UAS stakeholders of FAA's concept maturation work completed to date addressing air traffic concepts for managing UAS operations
- Walk through operational scenarios – covering applicable range of potential UAS missions, and corresponding Air Navigation Service Provider (ANSP) services and UAS operator responsibilities
- Solicit input to develop a more comprehensive perspective on UAS operational concepts for mid-term and mature state operations
- Ensure accurate and adequate coverage of mission and business objectives

Continue efforts to safely & systematically integrate UAS into the NAS!!

Questions?