
National Aeronautics
and Space Administration
NASA
AAM Ecosystem Working Groups (AEWG)
Workshop
March 23, 2022
11:00AM – 3:15PM ET / 8:00AM – 12:15PM PT

Agenda (Day 2)

March 23, 2022			
Time (ET)	**Topic**	**Speaker**	**Location**
General Session			
11:00AM – 11:15AM	**Opening**	• Davis Hackenberg, NASA	YouTube Live Stream [YouTube Day 2 Link Here]
11:15AM – 11:45AM	**Later Ecosystem Goals (UAM Maturity Levels (UMLs) 3 & 4) Overview**	• Ken Goodrich, NASA • Steve Bradford, FAA	
11:45AM – 12:45PM	**Panel:** Later UMLs & the Future of Autonomy **Moderator:** Wes Ryan, NASA	• Erick Corona, Wisk • Maxime Gariel, Xwing • Terik Weekes, Elroy • Todd Petersen, Ellis & Associates • Victor Wicklund, FAA	Conferences IO [Conferences IO Link Here]
Quick Break & Transition to Breakout Session #3 (20 minutes)			

Agenda (Day 2)

Breakout Session #3			
1:05PM – 2:05PM *(Choose one)*	**Topic #1 (Aircraft):** Automated Flight & Contingency Management	• Ken Goodrich, NASA	MS Teams [MS Teams Link Here]
	Topic #2 (Airspace): UAM Procedures, Airspace Architectures & 3rd Party Services	• Annie Cheng, NASA	MS Teams [MS Teams Link Here]
	Topic #3 (Community Integration): Initial Infrastructure Deployment	• Nancy Mendonca, NASA	MS Teams [MS Teams Link Here]
	Topic #4 (Crosscutting): High Capacity UAM Ports	• Marcus Johnson, NASA	MS Teams [MS Teams Link Here]
	Topic #5 (Crosscutting): Integrated System-Wide Safety Tools & Methods	• Kyle Ellis, NASA	MS Teams [MS Teams Link Here]
Transition to Breakout Session #4 (5 minutes)			

Agenda (Day 2)

Breakout Session #4			
2:10PM – 3:10PM *(Choose one)*	**Topic #1 (Aircraft):** Scaled Vehicle Production	• Parimal Kopardekar, NASA	MS Teams [MS Teams Link Here]
	Topic #2 (Airspace): Comm Architecture Requirements	• Casey Bakula, NASA	MS Teams [MS Teams Link Here]
	Topic #3 (Community Integration): Multi-Modal Integration	• Nancy Mendonca, NASA	MS Teams [MS Teams Link Here]
	Topic #4 (Crosscutting): Integration of Automated Systems	• Wes Ryan, NASA	MS Teams [MS Teams Link Here]
	Topic #5 (Aircraft): Advanced Urban Capable Aircraft	• Carl Russell, NASA	MS Teams [MS Teams Link Here]

Logistics

- **General Session** *(11:00AM – 12:45PM ET / 8:00AM – 9:45AM PT)*
  - **Platform:** YouTube Live Stream
    - Go to the AEWG Portal or workshop agenda for the link
  - **Q&A:** Conferences.io
    - Enter https://arc.cnf.io/sessions/cc22/#!/dashboardinto your browser
    - Questions will be addressed *if times permits or at the facilitator's discretion*
- **Breakout Sessions** *(1:05PM – 3:15PM ET / 10:05AM – 12:15PM PT)*
  - **Platform:** MS Teams
    - To access the individual breakout rooms, use the MS Teams meeting links in the agenda
    - The agenda is accessible at the following URL: [INSERT AGENDA SHORT LINK]
  - **Q&A:** MS Teams microphone, chat, and "Raise your hand" functions
    - Leave your cameras/webcams off to preserve WiFi bandwidth
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    - Say your name and affiliation before you begin speaking

Connectivity Issues

Slow, delayed, poor connection or video feed:

- Move closer to your WiFi router
- Disconnect any devices you are not actively using from the WiFi
- Close any applications or internet browsers that you are not actively using on the device
- Disconnect from your organization's VPN
- Connect your device directly to the router using a Cat-5 ethernet cable

No Internet Connection:

- Restart your modem and router (i.e., disconnect and reconnect to the power source)

NOTE: *If there is a service outage in your area or region, you will need to contact your internet service provider directly.*

Need Help?

If you need logistical or technological assistance throughout the workshop, you can reach out to the NARI support team through the following platforms:

General Session:

- Enter your comment or question in the conferences.io platform
- Email your comment or question to arc-cal-nari@mail.nasa.gov

Breakout Sessions:

- Enter your comment or question in the MS Teams chat box
- Email your comment or question to arc-cal-nari@mail.nasa.gov

Later Ecosystem Goals

AEWG March 2022 Workshop

Steve Bradford, Chief Scientist, FAA NextGen Office

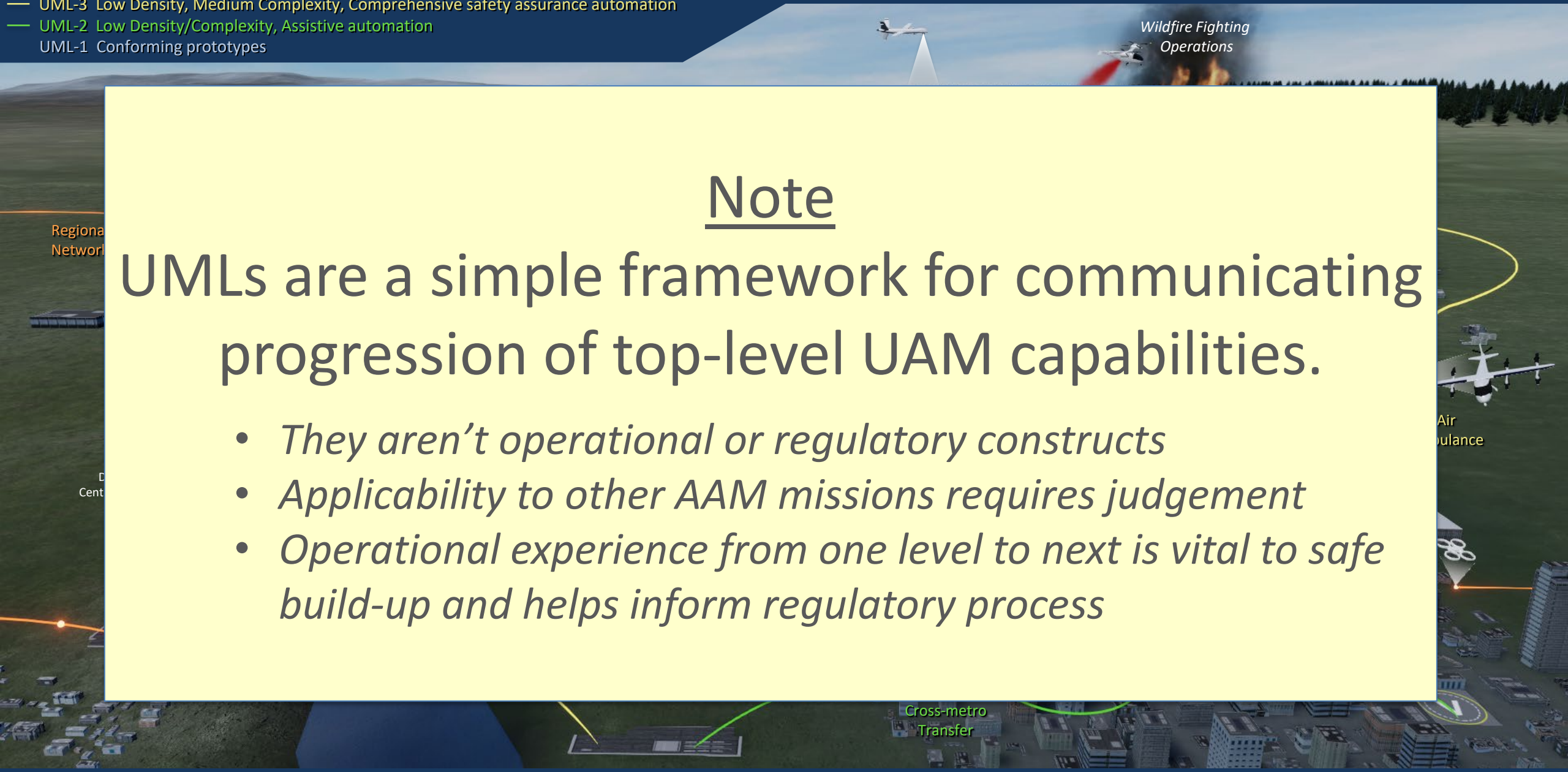
Ken Goodrich, NASA AAM Project, Deputy Project Manager for Technology

March 22, 2022

Advanced Air Mobility (AAM) Mission

UAM Maturity Levels (UML)

- UML-4 Medium Density/Complexity, Collaborative and responsible, automated systems
- UML-3 Low Density, Medium Complexity, Comprehensive safety assurance automation
- UML-2 Low Density/Complexity, Assistive automation
- UML-1 Conforming prototypes



Note

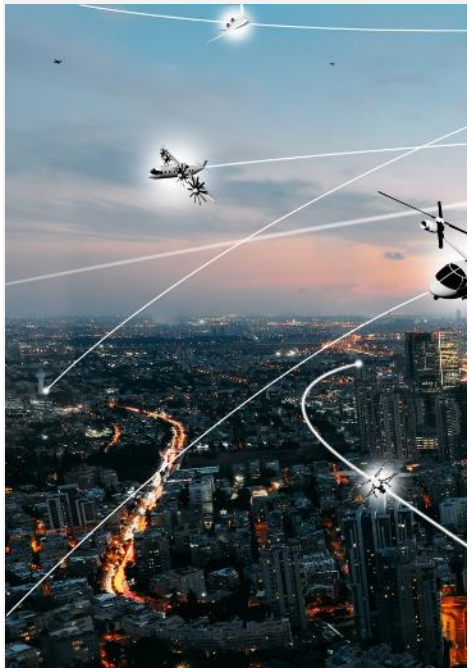
UMLs are a simple framework for communicating progression of top-level UAM capabilities.

- *They aren't operational or regulatory constructs*
- *Applicability to other AAM missions requires judgement*
- *Operational experience from one level to next is vital to safe build-up and helps inform regulatory process*

Safe, sustainable, affordable, and accessible aviation for transformational local and intraregional missions

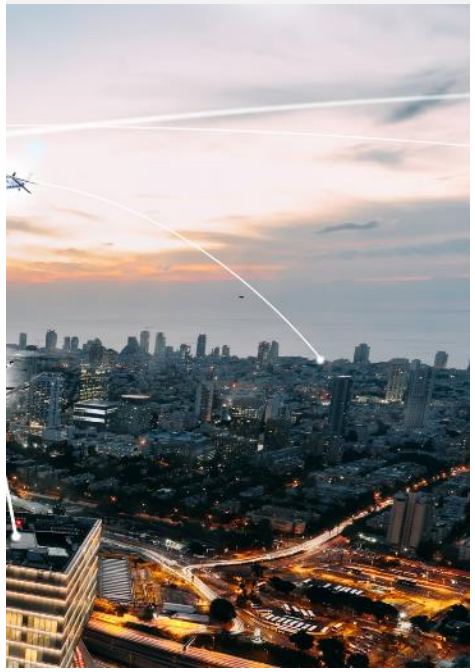
Ecosystem Goals Organized by Vehicle, Airspace, Community, & Overarching

Vehicle Development and Operations



Airspace Design and Operations

Community Integration



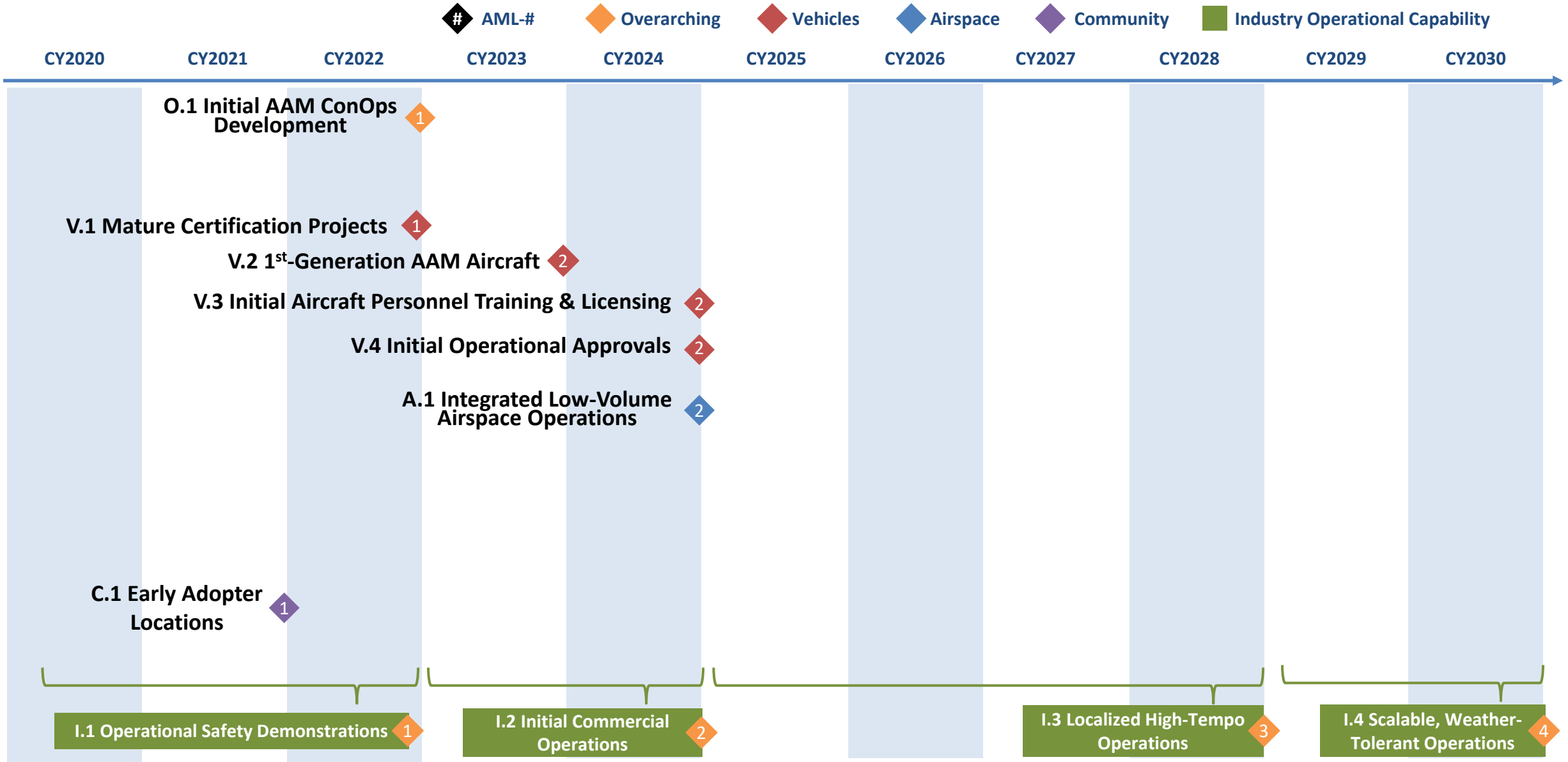
NASA and partners collectively take on the most difficult technical and mission challenges to enable AAM services and industry to flourish by 2030

- System concepts & architectures
- Technologies
- Standards
- Policy

- Products and services
- Public benefit

NASA's goal is to deliver long term technical solutions, system architectures, and recommended requirements for the industry and regulatory communities

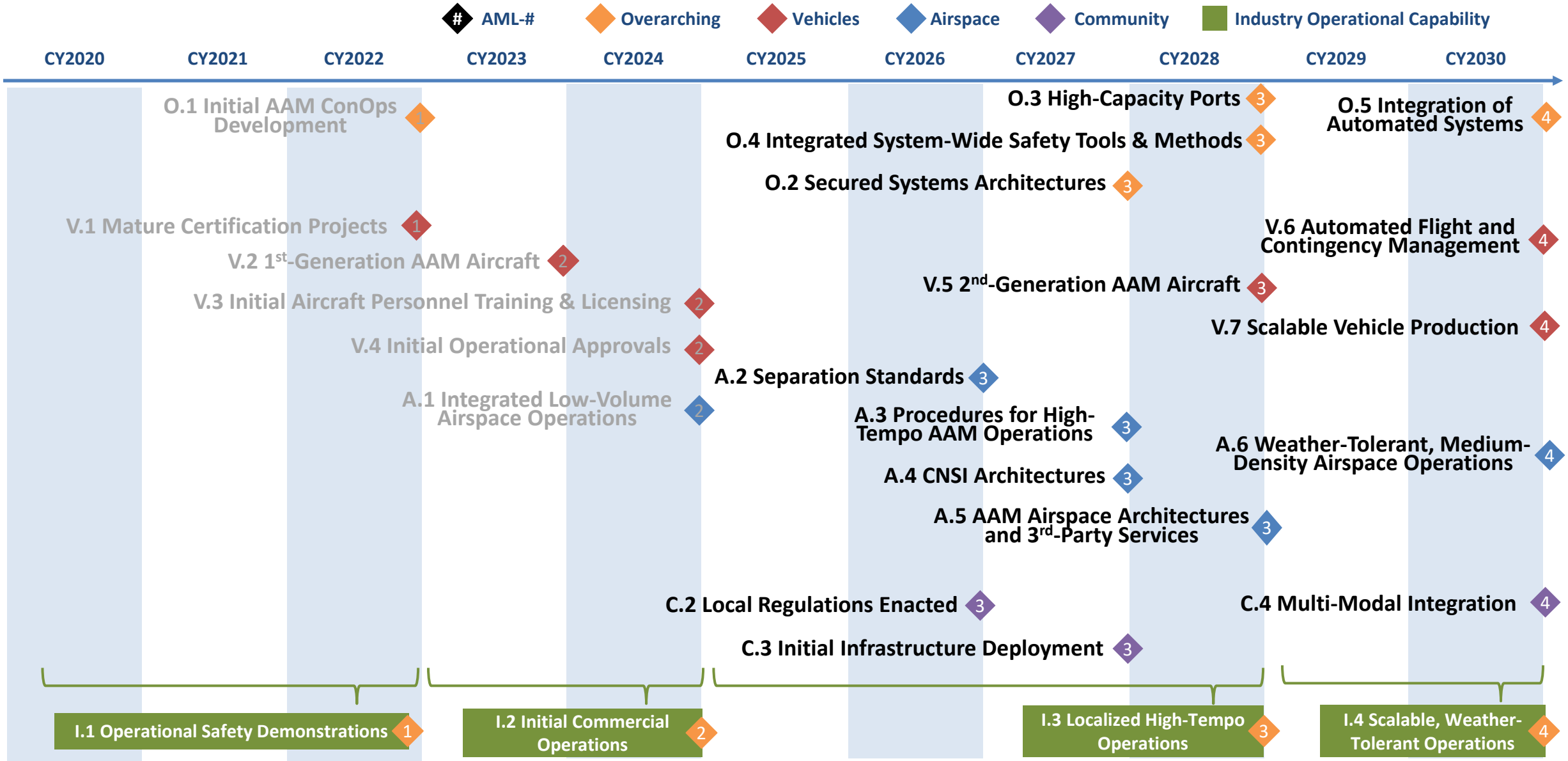
Ecosystem Goals Through UML-2[1]



[1] Based on a range of publicly available industry projections; not a consensus view; aggressive

CNSi: Communication, Navigation, Surveillance, Information
AML: AAM Maturity Level

UAM Ecosystem Goals UML 3-4[1]



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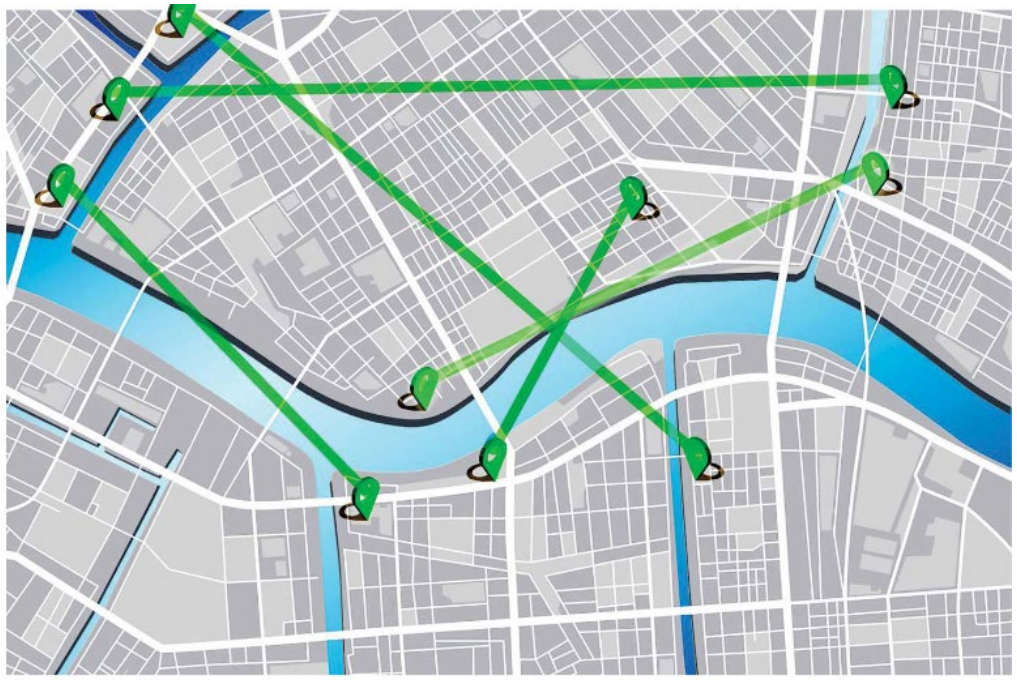
UAM Maturity Levels 3-4

UML 3: Early Adopter Markets, Initial Fleet Operations

(<100 operations, <10 vertiports)

- Early adopter cities with favorable conditions
- Operations *from within* urban areas
  - Satisfactory noise/annoyance (vehicles and fleets)
  - Fly away (or land) from any 1st failure
  - Demonstrated operational safety
- Simple route network
  - E.g., point-to-point, limited interactions
- Initial NAS accommodations
  - UAM corridors managed by PSUnet, CBRs
  - Routine coordination with ATC is automated/voiceless
- Increasing tempo & throughput
- Operational integration and validation of technologies need for UML4
  - Experience and data supports future rule making



NextGen UAM ConOps V1.0

UAM Maturity Levels 3-4

UML 4: Scalable, Weather-Tolerant Operations for Most Cities

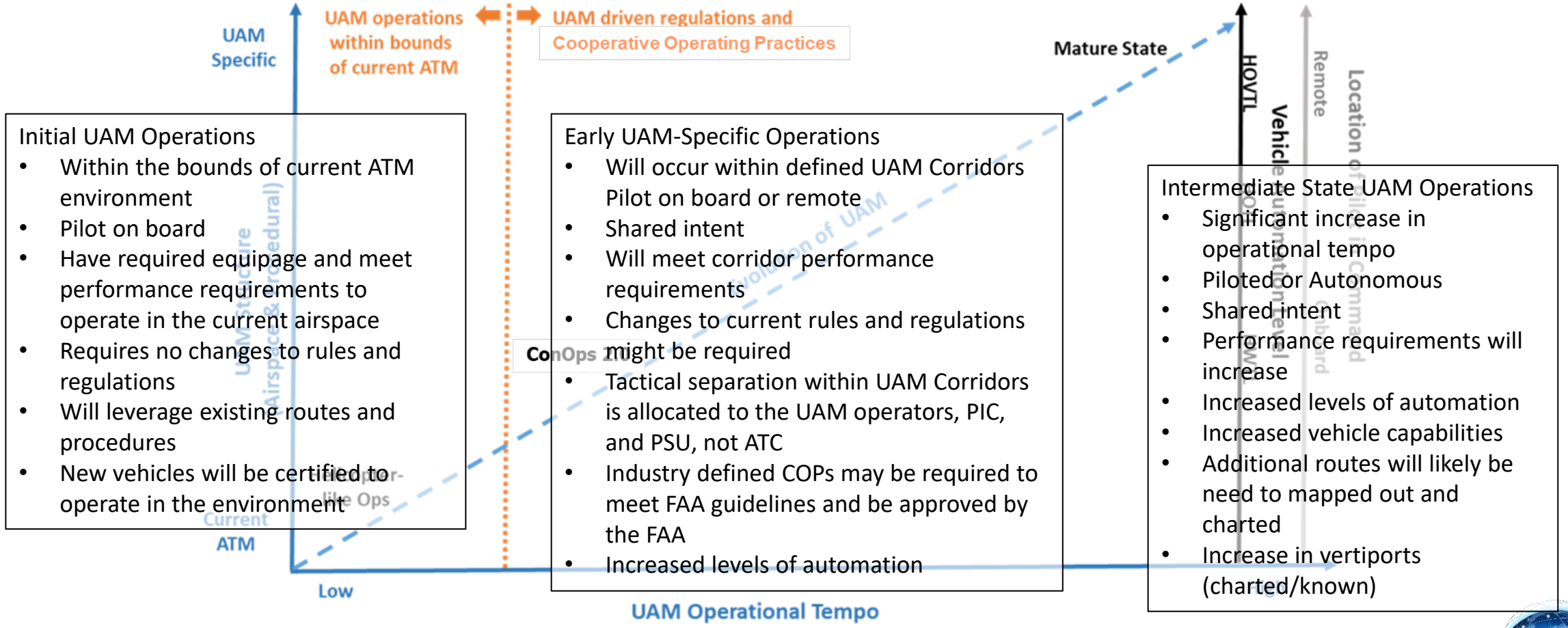
(100s of operations, 10s of vertiports)

- Scalable
  - Any city
  - Flexible routing between 10's of ports
  - Human bottlenecks eased (pilot, ATM)
  - Operations in low-visibility (no-visibility?)
  - Other types of weather tolerance
  - CNSI infrastructure
- Significant regulatory challenges
  - Traffic management & separation in IMC
  - Flight Procedures & operations in IMC
  - Pilot responsibility, qualifications
  - Interoperation of piloted and remotely supervised AC
- High tempos & rigorous resource scheduling
  - Vertiports
  - Intersections

Operations & Airspace Integration

Steve Bradford

UAM Operations *Evolution*



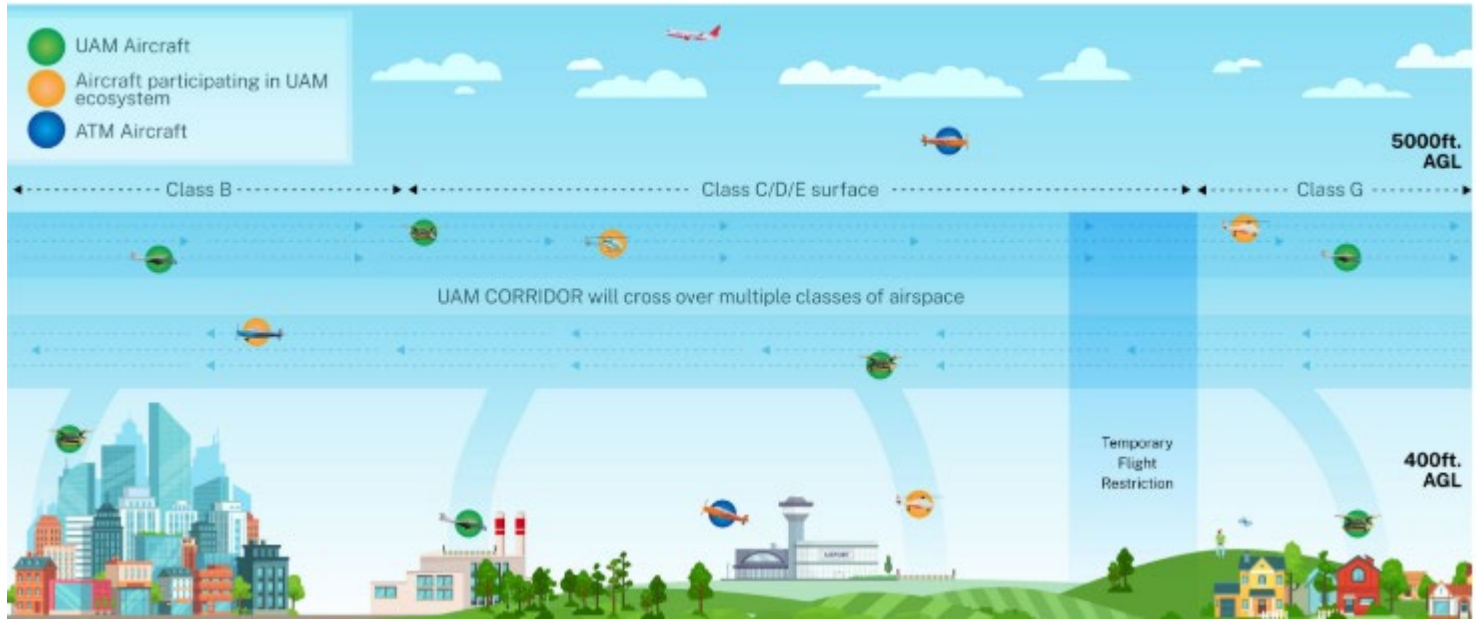
Initial UAM Operations
- Within the bounds of current ATM environment
- Pilot on board
- Have required equipage and meet performance requirements to operate in the current airspace
- Requires no changes to rules and regulations
- Will leverage existing routes and procedures
- New vehicles will be certified to operate in the environment

Early UAM-Specific Operations
- Will occur within defined UAM Corridors Pilot on board or remote
- Shared intent
- Will meet corridor performance requirements
- Changes to current rules and regulations might be required
- Tactical separation within UAM Corridors is allocated to the UAM operators, PIC, and PSU, not ATC
- Industry defined COPs may be required to meet FAA guidelines and be approved by the FAA
- Increased levels of automation

Intermediate State UAM Operations
- Significant increase in operational tempo
- Piloted or Autonomous
- Shared intent
- Performance requirements will increase
- Increased levels of automation
- Increased vehicle capabilities
- Additional routes will likely be need to mapped out and charted
- Increase in vertiports (charted/known)

Original UAM Concept Overview

- UAM Operations defined as the transport of people or goods from one vertiport to another using UAM Corridors
- UAM Corridors exist in all Airspace Classes
- Any aircraft using or crossing a UAM Corridor participates in the UAM Ecosystem by obtaining a confirmed Operational Intent from a PSU
- Aircraft operating within a UAM Corridor must meet the performance and participation requirements of the UAM environment



While a good starting point, UAM Corridors in all airspace classes with a requirement to fully participate becomes restrictive

FAA *ConOps 2.0 Engagement*

- Key Differences from ConOps 1.0
  - Corridors implemented only as needed on an airspace-by-airspace class basis
  - Varied participation requirements for crossing traffic - depending on airspace class
  - Alternate mitigation strategies for crossing traffic
- Impacts to non-UAM – Reduced overall impact
  - Reduced participation requirements for crossing UAM Corridors
  - Fewer UAM Corridors required overall
  - More interaction between UAM/non-UAM outside UAM Corridors
- Impacts to UAM – Greater Flexibility
  - More flexibility in UAM Corridor design
  - Allocation of greater tactical separation responsibilities to UAM Ecosystem
  - More interaction between UAM/non-UAM outside UAM Corridors

Guiding Principles *Categories*

- **Cooperative Traffic Management Operations** – Responsibilities of operators in their role to safely conduct operations
- **Regulatory Authority** – Roles and responsibilities of the FAA
- **Airspace Organization** – Attributes of the airspace where cooperative traffic management operations may occur
- **Fully Integrated Information Environment** – Information environment and key attributes necessary to effectively achieve the future state vision of information exchange between stakeholders
- **Scalability** – Principles associated with the scalability of the airspace and systems necessary to accommodate the types and tempo of operations envisioned in the future

AAM separation future?

- In high density operational areas ATC provides separation unless there are strategic provisions – VFR corridor
- Strategic provision can limit the requirements on tactical separation – airspace, design capacity balancing, synchronization
- The separation value depends of the separation provider
  - If strategically de-conflicted and we still need higher density do we need a new flight rule **AFR** in which the "system" is the separation provider
    - In AFR the system can be the "detect and avoid"?

Summary, Later Ecosystem Goals

- **Crawl -> Walk -> Run**
- Scaling and return on investment
  - Benefits to localities and public demonstrated
  - Technology and policies for expansion into any location
- Operational experience and data inform rulemaking
  - Ecosystem always considering next steps

National Aeronautics and Space Administration

AAM Ecosystem Working Groups (AEWG) Workshop

LATER UMLs & THE FUTURE OF AUTONOMY

Moderator: Wes Ryan, NASA

Panelists: Erick Corona, Wisk; Maxime Gariel, Xwing; Terik Weekes, Elroy; Todd Petersen, Ellis & Associates; Victor Wicklund, FAA

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AAM Ecosystem Working Groups (AEWG) Workshop

BREAK & TRANSITION TO BREAKOUT SESSION #3

12:45PM – 1:05PM ET / 9:45AM – 10:05AM PT

National Aeronautics
and Space Administration

AAM Ecosystem Working Groups (AEWG) Workshop

BREAKOUT SESSION #3

1:05PM – 2:05PM ET / 10:05AM – 11:05AM PT

To access the individual breakout rooms, use the MS Teams meeting links in the agenda accessible here:

[INSERT AGENDA SHORT LINK HERE]

AAM Ecosystem Working Groups (AEWG) Workshop

Breakout Session #4, Topic #1:

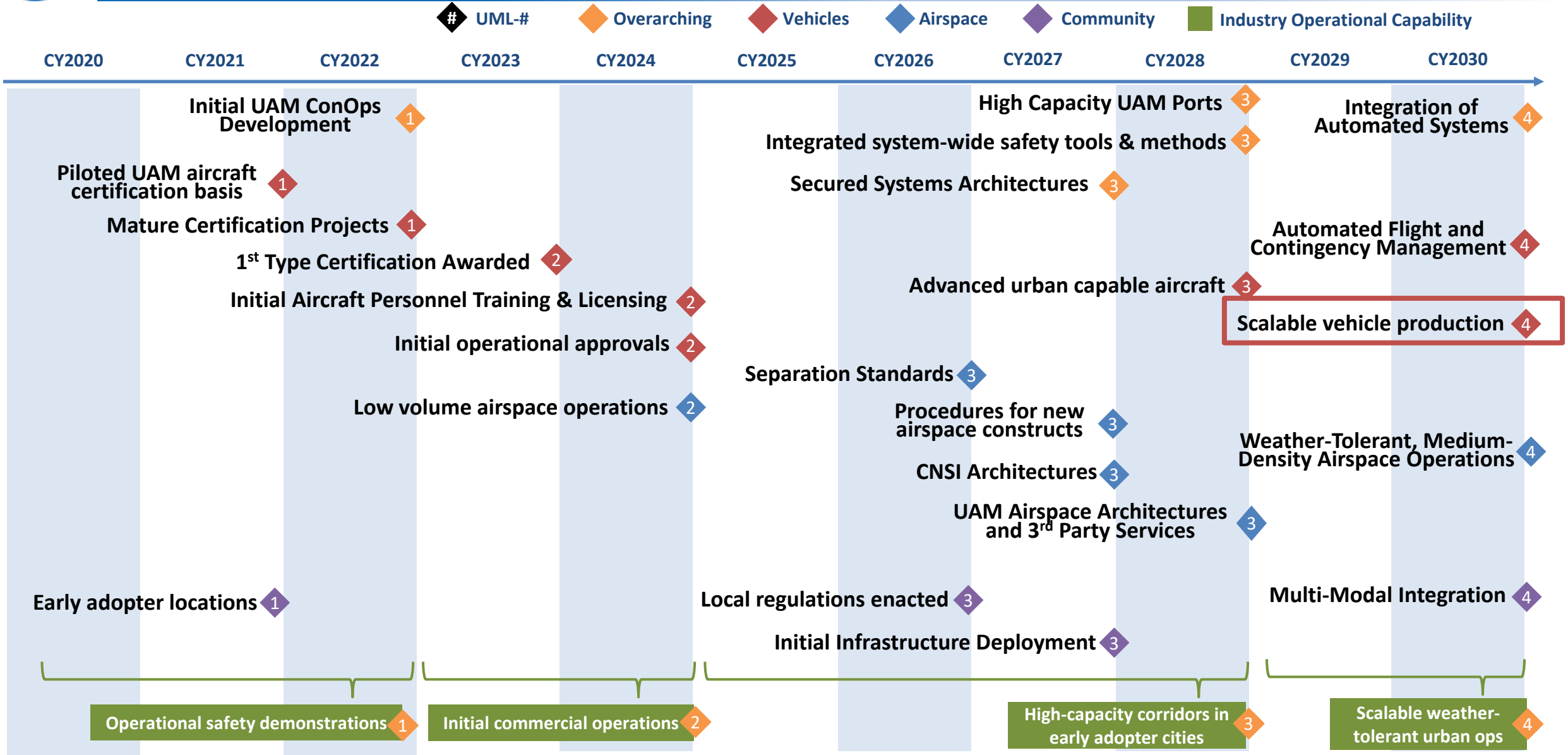
Scalable Vehicle Production

March 23, 2022

Breakout Session Objectives

- Review the Ecosystem Goal **definition**
- Discuss the **major barriers** associated with the Goal
- Define the different ecosystem **stakeholder roles** (e.g., academia, industry, government, etc.) associated with achieving the Goal
- Suggest the **priorities and sequencing** for achieving the Goal

Urban Air Mobility (UAM) Ecosystem Goals[1]



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UML: UAM Maturity Level

AAM Ecosystem Goal Definition:
Scalable Vehicle Production

Ecosystem Goal	Ecosystem Goal Statement
V.8 Scalable Vehicle Production	Develop cost-effective, critically scalable, certifiable, and sustainable manufacturing capabilities coupled with a robust supply chain for UAM aircraft manufacturing and maintenance/sustainment.

WG Notes/Feedback:

"AAM Ecosystem Goal" Definition: Significant capability or achievement by leading ecosystem entities marking advancements in the maturation of AAM capabilities towards medium density medium complexity operations. Ecosystem Goals are achieved through one or more Objectives.

Barriers to the AAM Ecosystem Goal:
Scalable Vehicle Production

AAM Ecosystem Goal Barriers				
	Description of Barrier	What Needs to be Addressed (Gap)	How Can it be Addressed	When Does it Need to be Addressed
Barrier n				

Nov 18, 2021 Poll Results

Response	Upvotes		Response (cont'd.)	Upvotes
Certified production process	7		standardized ground-based training system	2
Rapid production techniques	6		Cradle-to-grave metrics for entire vehicle production (ie minimize env. impact)	2
Automotive-like assembly line	5		part-number, subcomponent standardization	2
Consideration for new production and material qualification techniques, with the appropriate oversight in production cert for the level of risk	5		Would it also include maintenance/repair parts and not just the parts needed for initially producing the vehicle?	2
Affordability	4		Standard/expected set of support services to be selected as linefit options	1
Certified materials	3		Repairability standards (Self, O-level, I-level or OEM)	1
Interchangeability	3		Recall capability (safety bulletins and or component upgrade)--configuration control at the manufacturing level	1
standardized cockpit	2		Strategic Materials (like the rare-earth material mentioned for chips); There are more....	1
Market size to support scaled production.	2		Production training at the apprentice level (match the educational standards where it is, not where you wish it would be)	1

Ecosystem Goal Responsibilities: Scalable Vehicle Production

Order based on relevance to milestone, most relevant on top.

Partner	Recommended Responsibility
NASA	Role to deliver NASA R&D products aligned with critical industry needs aligned with NASAs areas of expertise. Focus areas include concepts, technology development, simulation, flight test, requirements, architectures, standards, etc.
FAA	Role of FAA as primary regulator and other responsibilities for leadership, R&D, Air Traffic Management, Safety, and Policy, etc.
Industry	Description of what the commercial UAM Industry must accomplish including technologies, standardization, certification, and operations.
SDOs	Role of SDOs in technical standards development.
OGAs	Role of critical OGAs including Excom members (FAA, NASA, OSD, DHS, DOC, DOJ) and their affiliated programs and efforts (Agility Prime).
States and Localities	Role of state and local governments to fill in the gaps of national policy, conduct initial analysis, and partner with industry to support initial development and deployment.
Other	Role of any other entity. Note, add new rows as needed to capture other partners.

Include as many or few partners as relevant to the milestone

Ecosystem Goal Roadmap: Scalable Vehicle Production

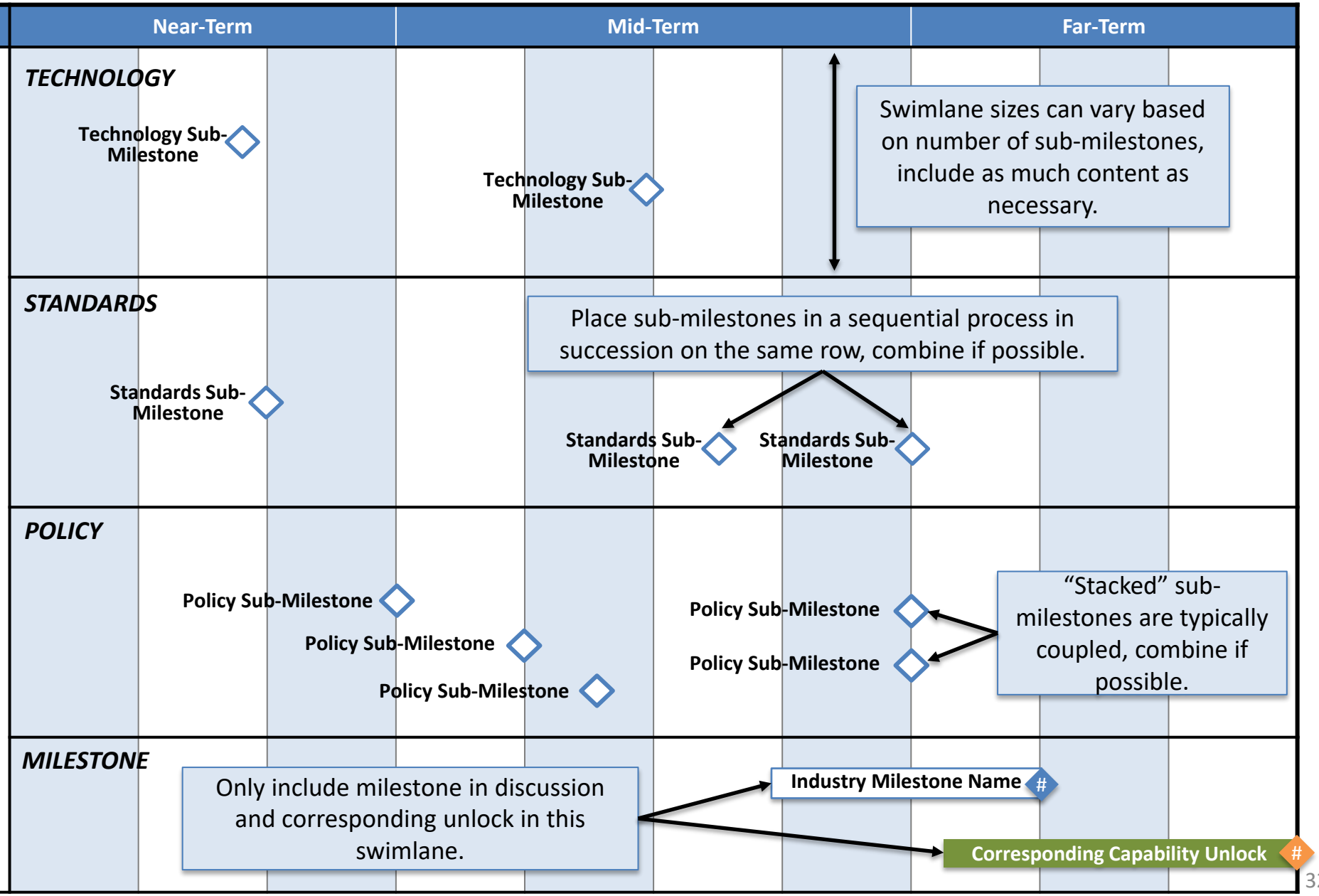
Ecosystem Goal:
V.8 Scalable Vehicle Production

Operational Objective:

Develop cost-effective, critically scalable, certifiable, and sustainable manufacturing capabilities coupled with a robust supply chain for UAM aircraft manufacturing and maintenance/sustainment.

Target Year:

2030



Thank you for joining the AEWG Workshop Breakout Session #3!

Send additional questions or comments to:
arc-cal-nari@mail.nasa.gov

Breakout Session #4 starts in 5 minutes.

To access the session #4 breakout rooms, use the MS Teams meeting links in the agenda accessible here:
[INSERT AGENDA SHORT LINK HERE]

AEWG Breakout Session

UAM Procedures, Airspace Architecture & 3rd Party Services

Annie Cheng, ATM-X UAM Sub-Project, Lead Systems Engineer for UAM

March 23, 2022

Objectives for this breakout session

- ❑ Review the Ecosystem Goal definition
- ❑ Discuss major barriers associated with the goal
- ❑ Define the different ecosystem stakeholder roles (e.g., academia, industry, government, etc.) associated with achieving the goal
- ❑ Suggest priorities and sequencing for achieving the goal

Disclaimer: FAA participation in NASA forums and AAM community/stakeholder programs does not constitute FAA approval or endorsement.

AAM Ecosystem Goals (Two for this session)

A.3 Procedures for New Airspace Constructs (2028): Develop operating rules, roles, procedures, and airspace management Concepts of Operation that enable safe and efficient operations in moderately poor weather conditions compatible with high operational tempos in urban environments that are interoperable with the existing ATM and UTM operations.

A.5 UAM Airspace Architectures & 3rd Party Services (2028): Develop a practical, feasible, flexible, scalable, equitable, and federated airspace design and implementation for UAM operations that includes the interoperability of diverse missions, pilot configurations, and vehicle types.

Quick Poll

What group do you represent?

- Academia
- Industry
- FAA
- NASA
- States and Localities
- Other

GOAL A.3: PROCEDURES FOR NEW AIRSPACE CONSTRUCTS

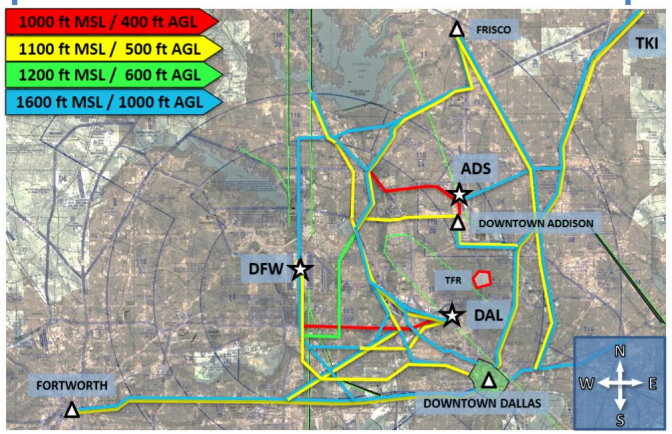
Procedures for what?

What are we trying to do?

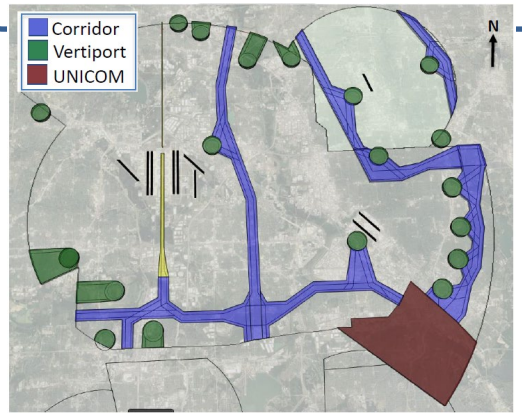
A.3 Procedures for New Airspace Constructs (2028): Develop operating rules, roles, procedures, and airspace management Concepts of Operation that enable safe and efficient operations in moderately poor weather conditions compatible with high operational tempos in urban environments that are interoperable with the existing ATM and UTM operations.

Existing helicopter routes, low-density VFR patterns.

ATC and PIC will be involved in contingencies.

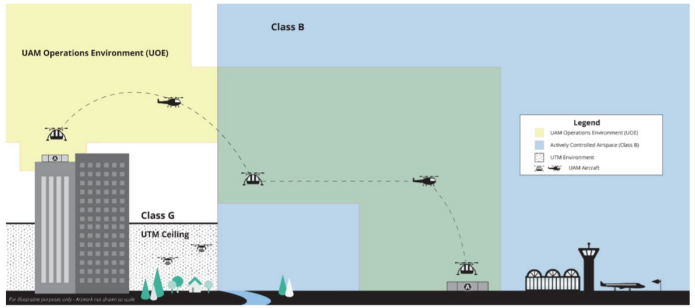


Airspace constructs, approach and departure procedures, with reduced separation minima and associated performance requirements approved by ANSP.



Scalable airspace constructs

More needs to be understood as the characteristics of airspace construct utilized by UAM depends on the regulatory approach taken



Note: The progression are examples taken from the UAM Airspace Research Roadmap
https://ntrs.nasa.gov/api/citations/20210019876/downloads/NASA-TM-20210019876Final.pdf

Brainstorm

A.3 Procedures for New Airspace Constructs (2028): Develop operating rules, roles, procedures, and airspace management Concepts of Operation that enable safe and efficient operations in moderately poor weather conditions compatible with high operational tempos in urban environments that are interoperable with the existing ATM and UTM operations.

Rules:

- 5 minutes to jot down your thoughts, come back after time is up
- There is no wrong answer, all ideas welcomed

Question 1: Is this goal clear? If not, how can it be made clearer?

Question 2: What are the major barriers (e.g., technology, regulatory, community) you see to achieving this goal?

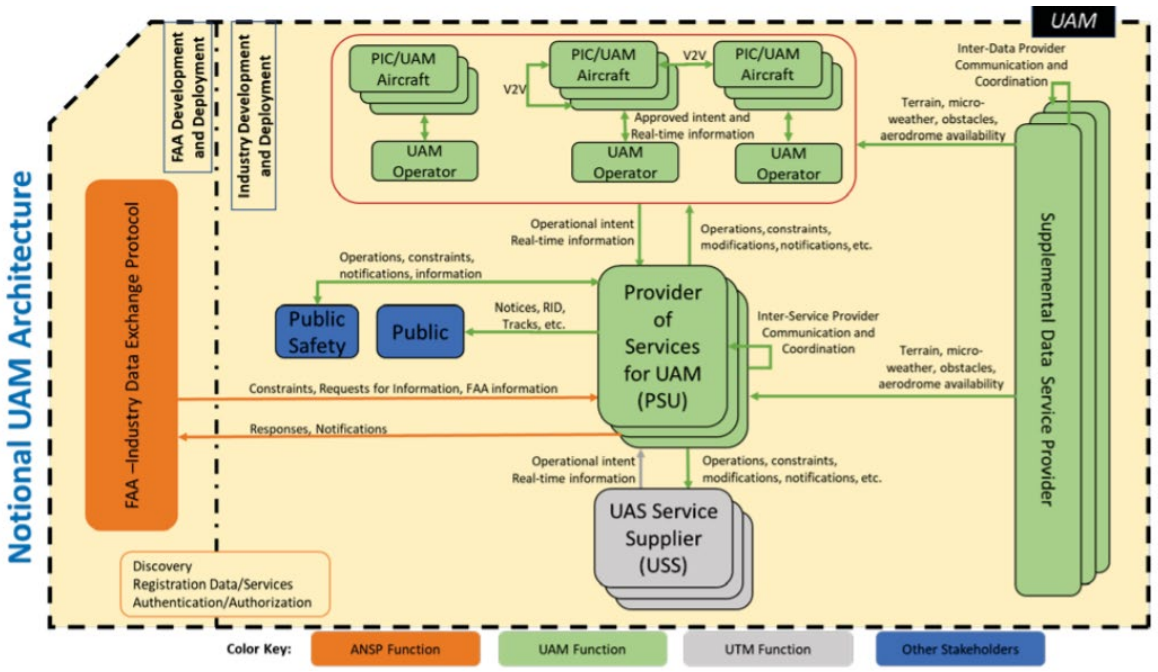
Question 3: What role does / can your group play in achieving this goal?

GOAL A.5: UAM AIRSPACE ARCHITECTURES & 3RD PARTY SERVICES

Architecture and services for what?

What kind of architecture?

A.5 UAM Airspace Architectures & 3rd Party Services (2028): Develop a practical, feasible, flexible, scalable, equitable, and federated airspace design and implementation for UAM operations that includes the interoperability of diverse missions, pilot configurations, and vehicle types.



Federated management of the airspace is not a novel concept, it is used in the NAS today. Nor is distributed separation, as it is executed in NAS today through VFR operations.

As we advance through UMLs 2-4, we need insight and input into how the management of the airspace will work

The Provider of Services for UAM (PSU) is a key airspace component of the UAM ecosystem, but it depends on other necessary services and matures through increasing levels of automation

Vehicle to Vehicle capabilities, such as Detect and Avoid (DAA), will also mature through increasing levels of automation, enabling distributed separation provision, reduced separation minima, greater scalability, and higher operational tempo

Brainstorm

A.5 UAM Airspace Architectures & 3rd Party Services (2028): Develop a practical, feasible, flexible, scalable, equitable, and federated airspace design and implementation for UAM operations that includes the interoperability of diverse missions, pilot configurations, and vehicle types.

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Question 3: What role does / can your group play in achieving this goal?

National Campaign 1 Simulation ("X4 Strategic Conflict Management")

X4 is a current activity and one of the key collaborative NASA/industry demonstration activities to develop and test UAM airspace architecture and services in a simulated environment.

What airspace concepts are being demonstrated in X4?

- **UAM Airspace Procedures and Design:** Using experimental procedures leveraging route structure (modified helicopter routes) designed to be deconflicted from ATM traffic
- **Airspace Architecture:** Building out the airspace architecture focused on the PSU (specific functions are noted in blue box on right)
- **Conflict Management:** Teasing out one of the services that support conflict management (i.e., demand-capacity balance DCB)

How are they demonstrated?

- Common system architecture, with defined requirements and standardized APIs
- Develop Community-Based Rules (CBRs) for cooperative traffic management with industry
- Demonstrate NASA- and industry-developed technologies through execution of three scenarios: nominal operation, airspace constraint management, off-nominal and contingency operation

PSU Functions in X4

Communication and Information Exchange

- Coordinates with other PSUs, via Discovery and Synchronization Service (DSS)
- Shares operational intent and states with the PSU Network, nominal and contingencies
- Obtains and distributes information about airspace constructs (e.g., corridor, routes, vertiports)
- Obtains and distributes information about airspace constraints
- Communicates with FAA (includes authorization)

Air Traffic Management

- Provides operation planning services for UAM Operators
- Checks validity of the operational plan, including performance requirements
- Monitors conformance against filed 4D operational intent
- Supports cooperative air traffic management, through demand-capacity balance (DCB)
- Manages operations in response to airspace constraints

X4 focused on initial UML-3 operations; X5 will focus on separation provision, concepts to be refined.
Validated requirements and findings from these demonstration activities will be incorporated into future updates of the UAM Airspace Research Roadmap

Stakeholder Roles

Stakeholder	Procedures for New Airspace Constructs	Architecture and 3rd Party Services
NASA	• Leverage policy to develop operating rules, roles, procedures and policy for separation standards compatible with safe and scalable operations in diverse weather operations • Lead collaboration efforts with stakeholder and regulatory committees to achieve consensus for mutually beneficial and safe concepts of operations for all anticipated UAM environments and conditions. • Collaborate with industry and SDOs on developing concepts and data to inform standards development • Lead flight-test and system integration to validate ConOps	• Develop UAM ConOps with the FAA and industry for airspace architectures and services managed by 3rd party service providers leading to a UML-4 unlock. • Partner with industry (esp. 3rd party service providers) to model, simulate, and flight-test airspace architectures to evaluate the viability of 3rd party services. • Partner with SDOs (if relevant) and the FAA to develop simulation and flight-test research findings to inform the development of standards and policy for 3rd party service providers.
FAA	• Develop rules and standard procedures to enable scalable and safe operations in diverse weather operations	• Develop UAM ConOps with NASA and industry for airspace architectures and services which will be managed by 3rd party service providers leading to operationalization. • Develop policies for delegation of responsibilities, evaluation and training for 3rd party service providers.
Industry	Description of what the commercial UAM Industry must accomplish including technologies, standardization, certification, and operations.	• Provide inputs for ConOps development and assessment of 3rd party service providers that can be conducted in UML-3 and beyond.
States and Localities	Role of state and local governments to fill in the gaps of national policy, conduct initial analysis, and partner with industry to support initial development and deployment.	
Other	Role of any other entity. Note, add new rows as needed to capture other partners.	

Next Steps

- Thank you all for participation!
- Additional questions and/or feedback can be sent to arc-cal-nari@mail.nasa.gov.

REFERENCE

Architecture and Services

UAM Operator obtains all airspace management services from ATC where applicable.

Vertiport Operators should provide services to the UAM Operator to manage surface constraints (e.g. landing reservation times).

UAM Operators, PSUs, Vertiport Operators, ANSP, and other UAM Community stakeholders should use standardized data sources for weather, terrain and obstacle, and airspace structure information

PSU supports cooperative decision making among UAM Operators. PSU monitors operational conformance, detects strategic conflicts and provides resolution(s) to UAM Operator.

FIDXP provides a means for the FAA to distribute airspace constraints to PSUs in real-time, and for the PSU to notify FAA of non-conforming and contingency operations.

UAM Operator / PIC should use assistive separation provision services like assistive DAA to keep UAM vehicle away from other UAM and ATM traffic

PSU makes cooperative decisions with other PSUs in order to equitably allocate existing capacity to the UAM Operator demand for airspace resources, provides some safety critical services to the UAM Operator, including conflict management.

UAM Operator / PIC should use collaborative and responsible separation provision services like DAA to keep UAM vehicle away from other UAM and ATM traffic. Services will be highly automated.

Role of other 3rd party service providers need to be better understood.

Note: The progression are examples taken from the UAM Airspace Research Roadmap https://ntrs.nasa.gov/api/citations/20210019876/downloads/NASA-TM-20210019876Final.pdf

Thank you for joining the AEWG Workshop Breakout Session #3!

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arc-cal-nari@mail.nasa.gov

Breakout Session #4 starts in 5 minutes.

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[INSERT AGENDA SHORT LINK HERE]

AAM Ecosystem Community Integration Working Group: Breakout – Initial Infrastructure Deployment

Agenda

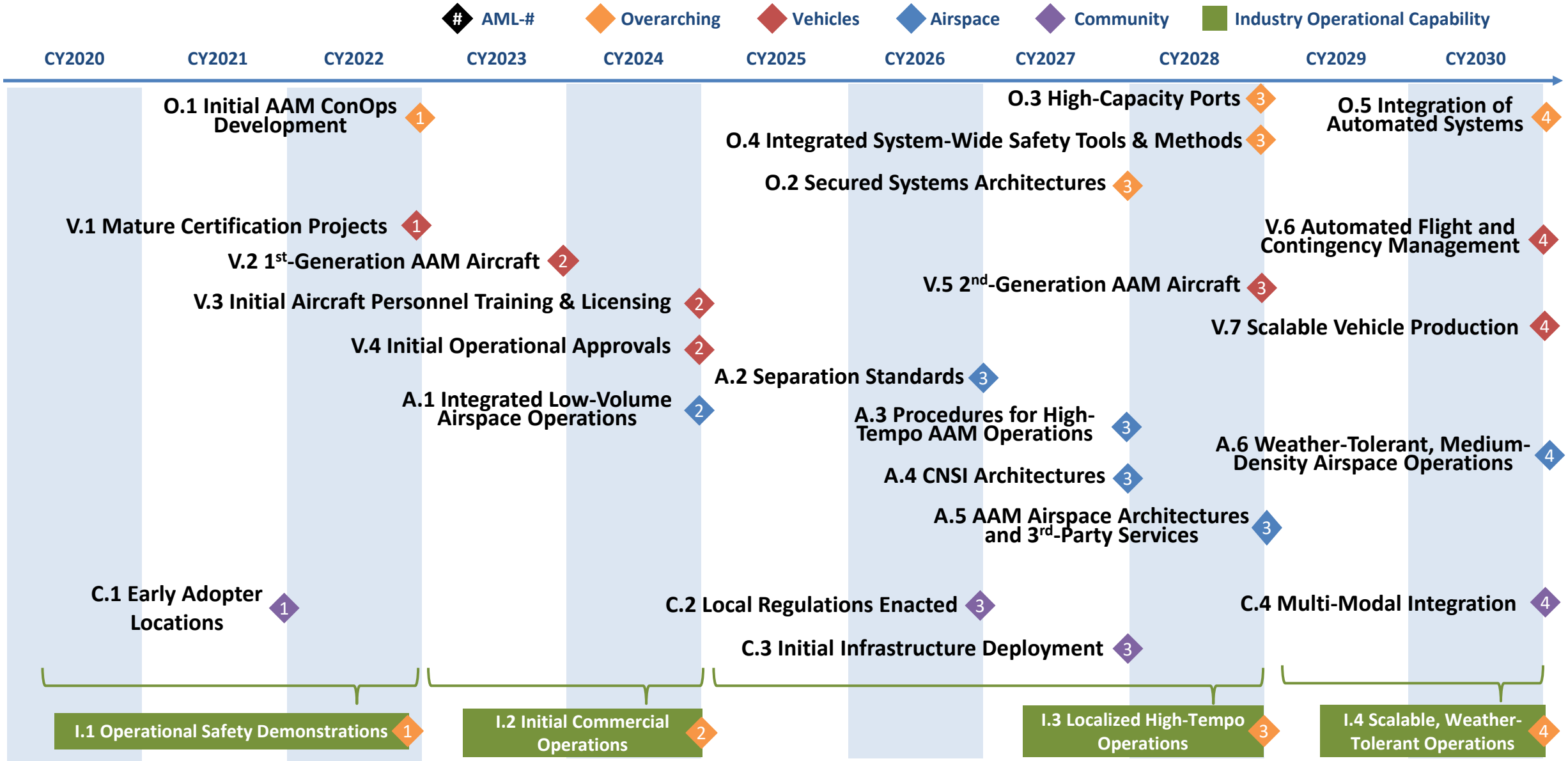
- Meeting Goals
  - Across the 4 community breakouts
  - For the **Initial Infrastructure Deployment** breakout
- Current Goal Chart
- Brainstorming Ground Rules
- Breakout Discussions

Meeting Goals

- Across the 4 Community Breakouts
  - Validate 4 Community Goals
  - Validate each community Goal Statement (definition) Intent
  - View the breadth of “needed” activities – barriers and objectives associated with each goal
  - Identify Goal Gaps

- Each Goal
  - Validate / modify Organizational Breakdown
  - Validate / modify Major Stakeholders
  - Validate / modify / add Objectives organized by Breakdown list/stakeholder
  - Look at goal time phased objectives

Proposed Advanced Air Mobility (AAM) Ecosystem Goals[1]



[1] Based on a range of publicly available industry projections; not a consensus view; aggressive

CNSi: Communication, Navigation, Surveillance, Information
AML: AAM Maturity Level

Brainstorming Ground Rules

Background

- Assuming most folks will attend all 4 community breakouts or one of the initial breakouts, so the 2nd, 3rd a 4th breakouts will spend less time on the upfront materials
- The initial barriers were compiled by the NASA UCAT
- Additional objectives can be submitted via e-mail after the breakouts with the view of presenting a consolidated collection of slides at a future CIWG.

Brainstorming Ground Rules

- There are no bad ideas
- Just looking to identify additional barriers, stakeholders and potential objective phasing
- Will be grouping by stakeholders to manage the number of objectives
- Objectives can be submitted verbally, via chat, whiteboard function, e-mail,
- Meeting – 60 min
  - 5 min logistics, intro
  - 5 min on goal and goal statement
  - 10 min organizational breakdown and stakeholders
  - 35 min on objective identification and time phasing
  - 5 min wrap up

Breakouts will be recorded for internal use only - so we don't lose your comments and inputs

Breakout Discussions

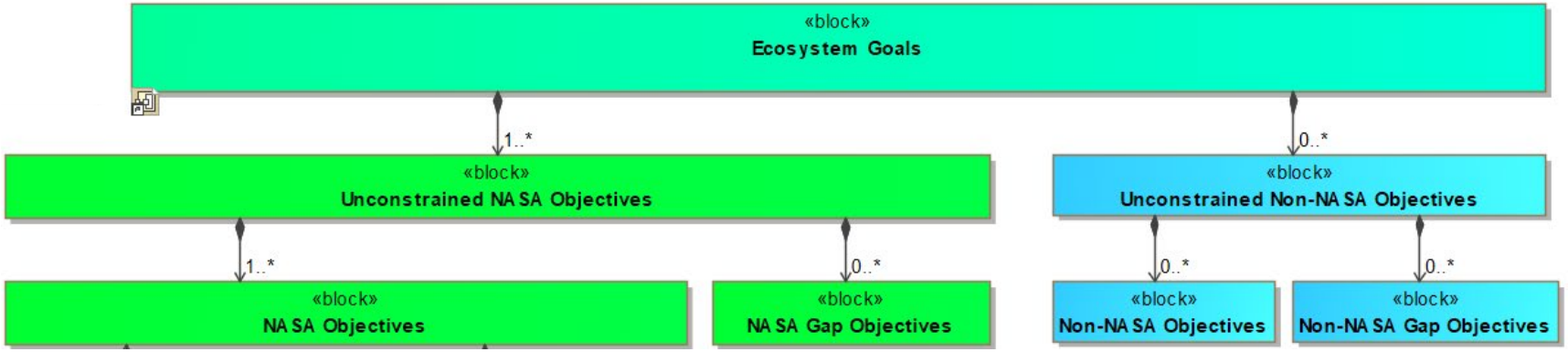
5 min

Initial Infrastructure Deployment

Statement: Design and implement initial supporting infrastructure for integrating AAM operations into localities, including novel vertiports, modifications of existing airports/heliports, and energy generation, distribution, and storage infrastructure.

Organizational Breakdown & Stakeholders

- Community
  - State
  - Local
  - Tribal
- Federal Government
  - DOT/FAA
  - DHS/TSA
  - NASA
- Industry
  - Vehicle Manufacturers/Vehicle Operators
  - Providers of Services (PSUs)
  - Vertiport Operators
  - Utilities - Electrical
- Other
  - Academia
  - Consulted Stakeholders
  - Informed (cognizant) Stakeholders



1 Option
Note: Used this option for the 4 breakouts

Community Objectives – Initial Infrastructure Deployment

- Community
  - State
  - Tribal
  - Local/regional
    - 1st year
    - 2nd year
    - 2nd & 3rd year
    - 4th year

Environmental review/NEPA is not listed in this goal timeframe; however, where it is mentioned (slide 12) it is captured within the first year. And while it's not unreasonable for FAA to complete environmental review in 3 years (the current CEQ regulations set a time limit of 1 year to complete an EA and 2 to complete an EIS), it's far too early for FAA to have a true sense of the level of effort needed for such a review.

Assume a 5-year time span from start to "achieving goal"
Start overlaps with 4-year time span Local Regulations Enacted Goal

Federal Government Elements

- Federal Government
  - DOT/FAA
  - DHS/TSA
  - NASA

Industry Elements

- Industry
  - Vehicle Manufactures/Vehicle Operators
  - Providers of Services (PSUs)
  - Vertiport Operators (includes airports with a vertiport)
  - Utilities – Electrical

Remember this is their activities related to this Community Goal

Other Elements

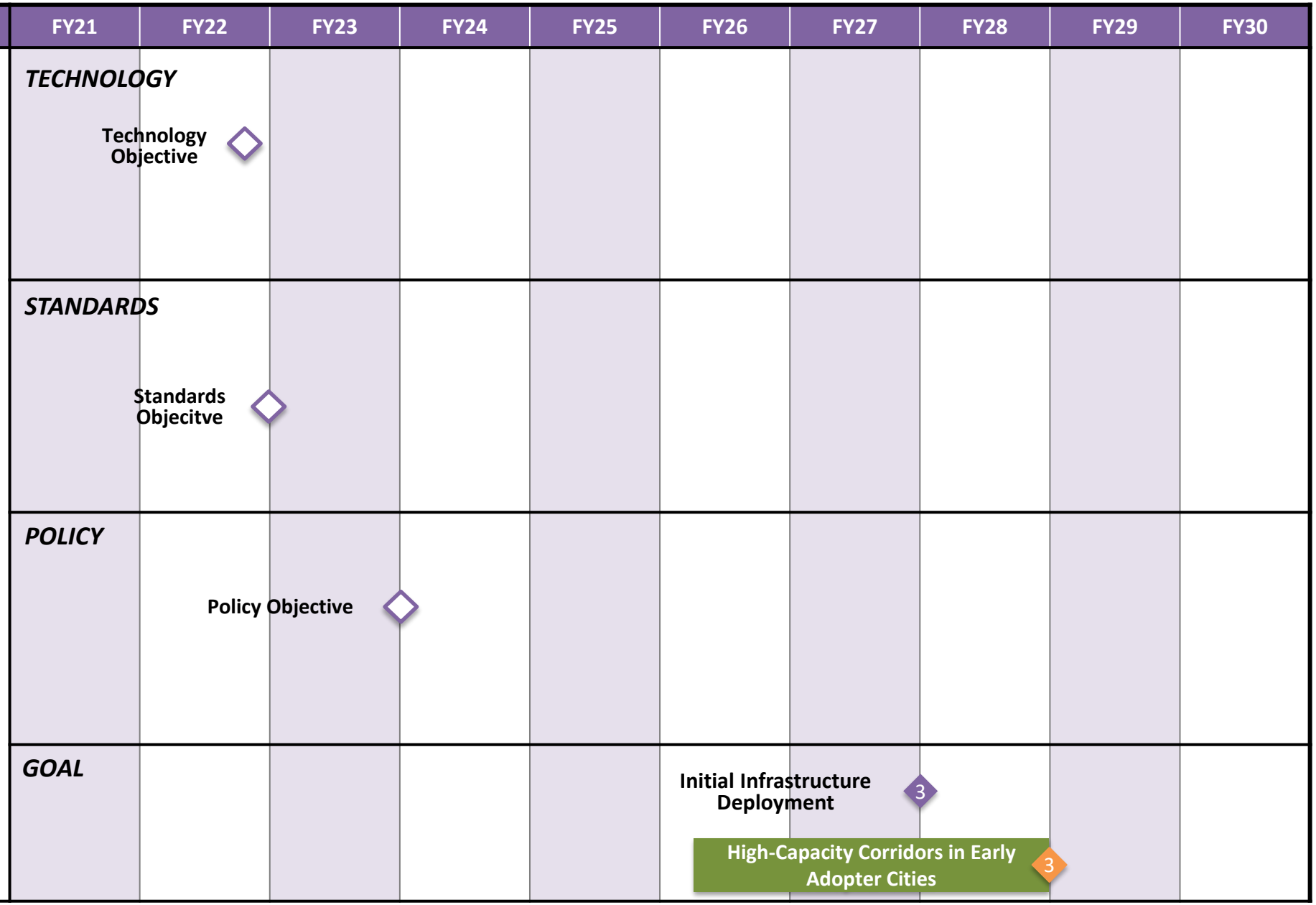
- Other
  - Academia
  - Consulted Stakeholders
    - Adjacent AAM Planning teams –
  - Informed (cognizant) Stakeholders

Initial Infrastructure Deployment Roadmap

Industry Milestone:
Initial Infrastructure Deployment

Operational Objective:

Develop and implement the required supporting infrastructure for integrating UAM operations into metropolitan areas, including vertiports, energy and supporting infrastructure.



Looking Forward

Looking forward

- March – April
  - Compile inputs from Breakouts and e-mails
- May
  - Present at CIWG
- Annual
  - Host CIWG session to update materials and assess progress

Back Up

Thank you for joining the AEWG Workshop Breakout Session #3!

Send additional questions or comments to:
arc-cal-nari@mail.nasa.gov

Breakout Session #4 starts in 5 minutes.

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[INSERT AGENDA SHORT LINK HERE]

AEWG Breakout Session
High Capacity UAM Ports

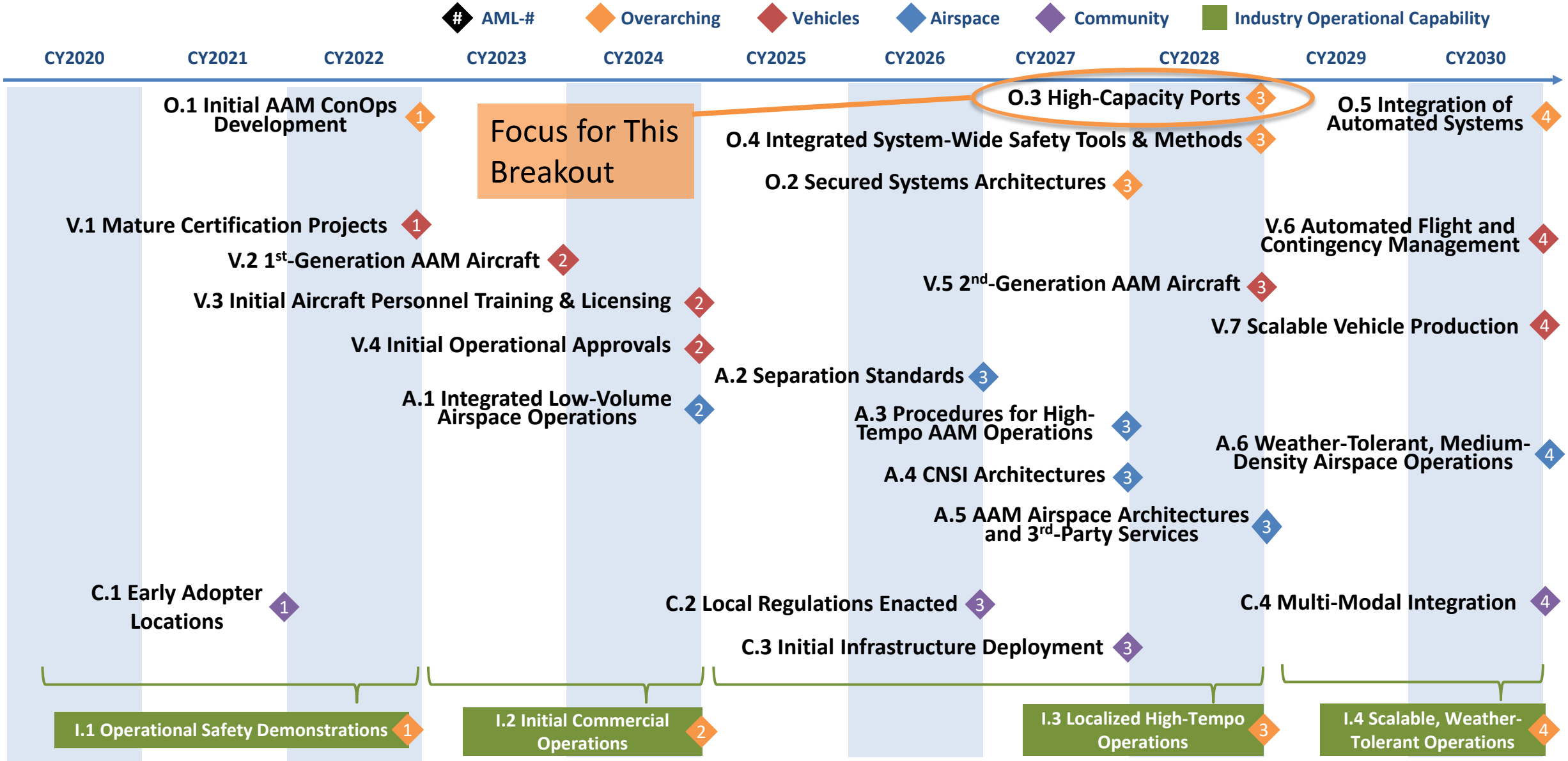
Dr. Marcus Johnson
marcus.johnson@nasa.gov

Introduction

Objective for this Breakout Sessions

- ❑ Review the Ecosystem Goal definition
- ❑ Discuss the major barriers associated with the Goal
- ❑ Define the different ecosystem stakeholder roles (e.g., academia, industry, government, etc.) associated with achieving the Goal
- ❑ Suggest the priorities and sequencing for achieving the Goal

Advanced Air Mobility (AAM) Ecosystem Goals[1]



[1] Based on a range of publicly available industry projections; not a consensus view; aggressive

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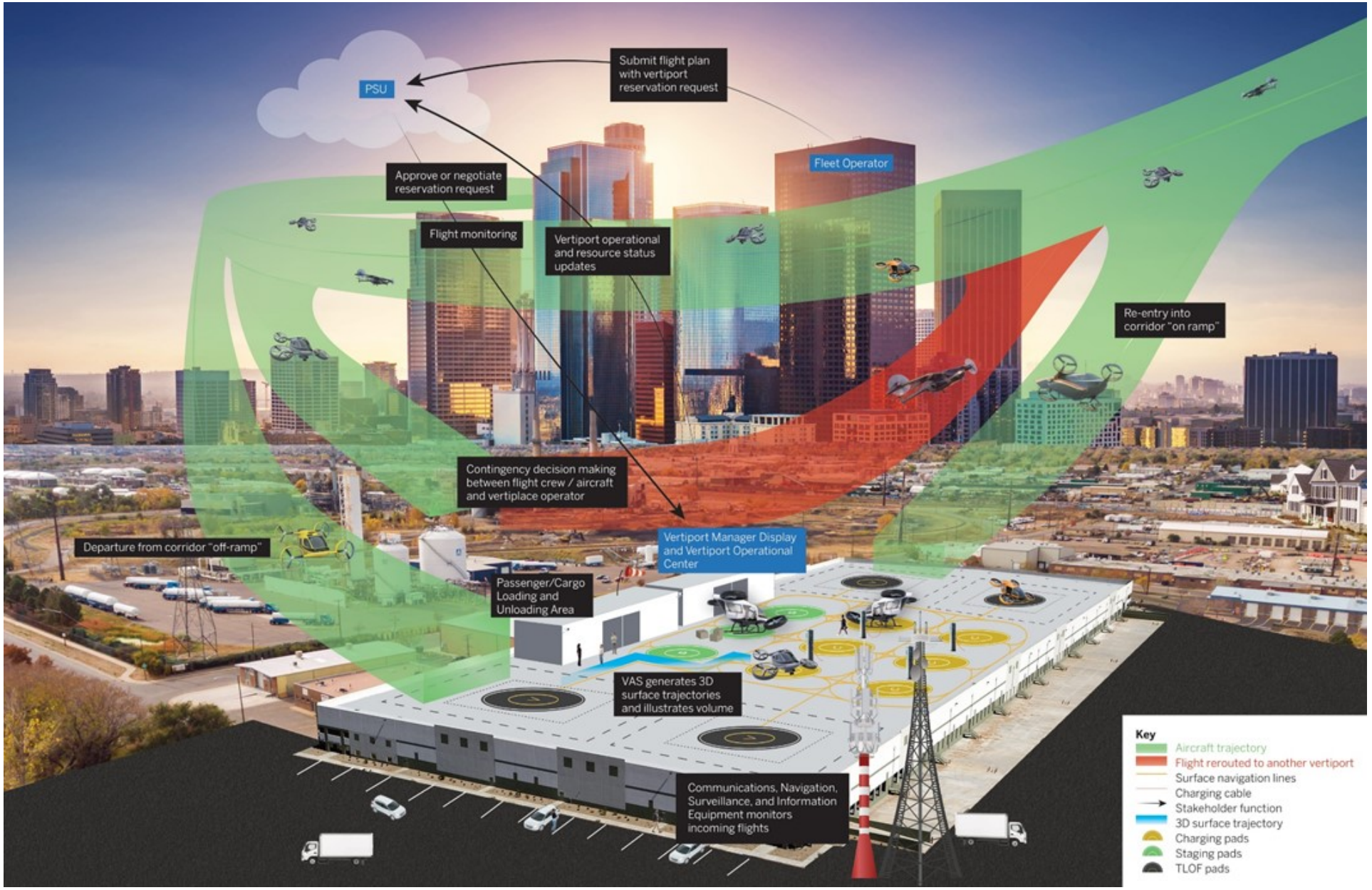
Example Operational View



Ecosystem Goal Definition

AAM Ecosystem Goal Definition

Ecosystem Goal	Ecosystem Goal Statement
High Capacity UAM Ports (2028)	Develop vertiport automation technology and associated standards that when integrated into the broader UAM system (e.g., physical vertiport infrastructure, airspace design and management, supplemental data service providers, individual aircraft flight and operations management, etc.) facilitate safe and efficient vertiport operations, including takeoff, landing, and surface operations, in near all-weather conditions.

"AAM Ecosystem Goal" Definition: Significant capability or achievement by leading ecosystem entities marking advancements in the maturation of AAM capabilities towards medium density medium complexity operations. Ecosystem Goals are achieved through one or more Objectives.

AAM Ecosystem Goal Definition

Ecosystem Goal	Ecosystem Goal Statement
High Capacity UAM Ports (2028)	Develop vertiport automation technology and associated standards that when integrated into the broader UAM system (e.g., physical vertiport infrastructure, airspace design and management, supplemental data service providers, individual aircraft flight and operations management, etc.) facilitate safe and efficient vertiport operations, including takeoff, landing, and surface operations, in near all-weather conditions.

Example Progression…

Vertiport Design
- Existing Infrastructure
- Low capacity VFR operations
- Multi-use facilities

Vertiport Communication, Navigation, Surveillance and Information
- Information Sharing
- Moderate capacity VFR & IFR operations
- Vertiport Manager Role
- Terminal Airspace Procedures

Vertiport Automation and Scalability
- *Vertiport and surface management services*
- *Terminal airspace structure and procedures*
- *Supplemental data services*
- *Contingency management capabilities*
- *Vertiport Manager Role*
- *High Capacity VFR & IFR Operations*

AAM Ecosystem Goal Definition

Ecosystem Goal	Ecosystem Goal Statement
High Capacity UAM Ports (2028)	Develop vertiport automation technology and associated standards that when integrated into the broader UAM system (e.g., physical vertiport infrastructure, airspace design and management, supplemental data service providers, individual aircraft flight and operations management, etc.) facilitate safe and efficient vertiport operations, including takeoff, landing, and surface operations, in near all-weather conditions.

Rules:

- 5 minutes to jot down your thoughts, come back after time is up
- There is no wrong answer, all ideas welcomed

Question 1: Is this goal clear? If not, how can it be made clearer?

Question 2: What are the major barriers (e.g., technology, regulatory, community) you see to achieving this goal?

Question 3: What role does / can your group play in achieving this goal?

AAM Ecosystem Goal Definition

Ecosystem Goal	Ecosystem Goal Statement
High Capacity UAM Ports (2028)	Develop vertiport automation technology and associated standards that when integrated into the broader UAM system (e.g., physical vertiport infrastructure, airspace design and management, supplemental data service providers, individual aircraft flight and operations management, etc.) facilitate safe and efficient vertiport operations, including takeoff, landing, and surface operations, in near all-weather conditions.

Summary of Ecosystem Goal Feedback :

"AAM Ecosystem Goal" Definition: Significant capability or achievement by leading ecosystem entities marking advancements in the maturation of AAM capabilities towards medium density medium complexity operations. Ecosystem Goals are achieved through one or more Objectives.


National Aeronautics
and Space Administration
NASA
M
METRO

Barriers

Barriers to AAM Ecosystem Goal

What technologies are needed to support initial commercial operations at private-use vertiports in the next 5 years?	
Upvotes	**Response**
11	Charging Infrastructure and Standards
10	Weather systems
7	C2 Links/Networks
7	Reservation and Scheduling Services
5	Air traffic integration and separation capabilities
5	CNS service around vertiports
4	Security Screening
4	Dynamic Separation Standards
3	UTM
2	Passenger Safety Systems and Coordination
2	Vehicle technology - navigation, separation, operations management, integrated with ground-based systems
2	Fire Safety technologies for lithium-ion batteries

Data from AEWG Vertiport Series Discussion: Public-use vs Private-use (July 1, 2021)

Question 2: What are the major barriers (e.g., technology, regulatory, community) you see to achieving this goal?

Barriers to the AAM Ecosystem Goal

AAM Ecosystem Goal Barriers				
#	Description of Barrier	What Needs to be Addressed (Gap)	How Can it be Addressed	When Does it Need to be Addressed
1				

AAM Ecosystem Goal Definition

Ecosystem Goal	Ecosystem Goal Statement
High Capacity UAM Ports (2028)	Develop vertiport automation technology and associated standards that when integrated into the broader UAM system (e.g., physical vertiport infrastructure, airspace design and management, supplemental data service providers, individual aircraft flight and operations management, etc.) facilitate safe and efficient vertiport operations, including takeoff, landing, and surface operations, in near all-weather conditions.

Summary of Barriers:

"AAM Ecosystem Goal" Definition: Significant capability or achievement by leading ecosystem entities marking advancements in the maturation of AAM capabilities towards medium density medium complexity operations. Ecosystem Goals are achieved through one or more Objectives.

Stakeholders and Roles

Stakeholder Roles

Partner	Recommended Responsibility
NASA	• Develop High Density Vertiport CONOPS, Vertiport Automation Architecture Concepts, and provide R&D towards exploring vertiport automation concepts and technologies. • Partner with the FAA, industry and SDOs to align research with operational needs and constraints.
FAA	• Partner with the NASA and industry to develop UAM CONOPS that includes high capacity terminal operations. • Provide policies and guidance for vertiport design and automation to support high capacity port operations.
Industry	Description of what the commercial UAM Industry must accomplish including technologies, standardization, certification, and operations.
SDOs	Role of SDOs in technical standards development.
OGAs	Role of critical OGAs including Excom members (FAA, NASA, OSD, DHS, DOC, DOJ) and their affiliated programs and efforts (Agility Prime).
States and Localities	Role of state and local governments to fill in the gaps of national policy, conduct initial analysis, and partner with industry to support initial development and deployment.
Other	Role of any other entity. Note, add new rows as needed to capture other partners.

Priorities & Sequencing

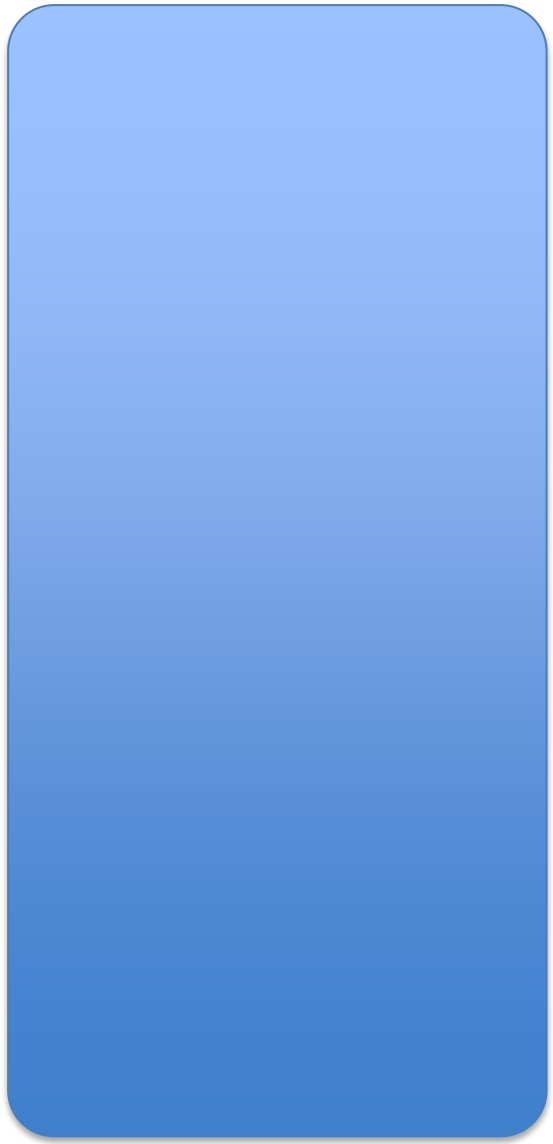
Discussion on Priorities

Technology

Standards

Policies

Milestones



Ecosystem Goal Roadmap: High Capacity UAM Ports

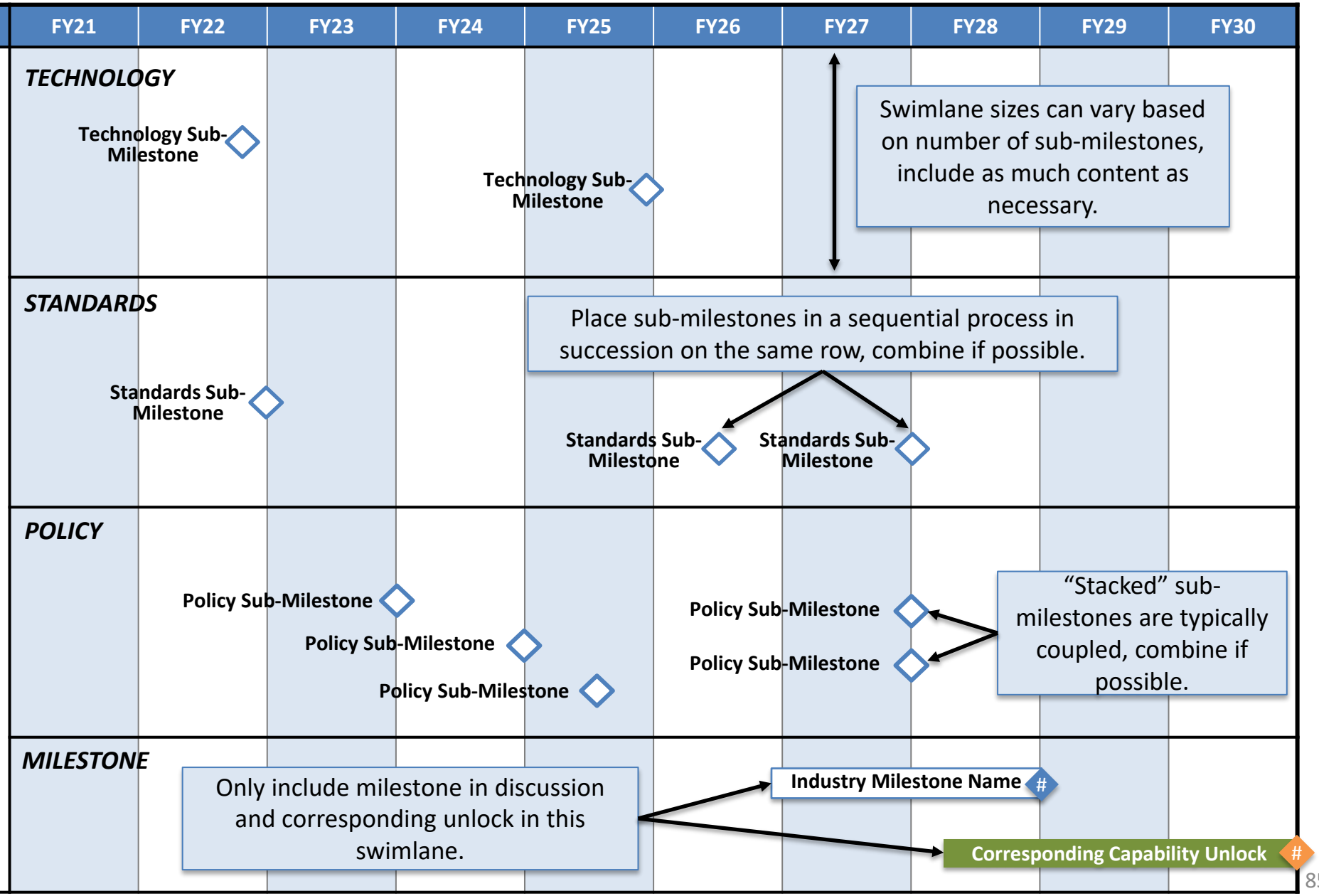
Industry Milestone:
O.3 High Capacity UAM Ports

Operational Objective:

Develop vertiport automation technology and associated standards that when integrated into the broader UAM system (e.g., physical vertiport infrastructure, airspace design and management, supplemental data service providers, individual aircraft flight and operations management, etc.) facilitate safe and efficient vertiport operations, including takeoff, landing, and surface operations, in near all-weather conditions.

Target Year:

2028



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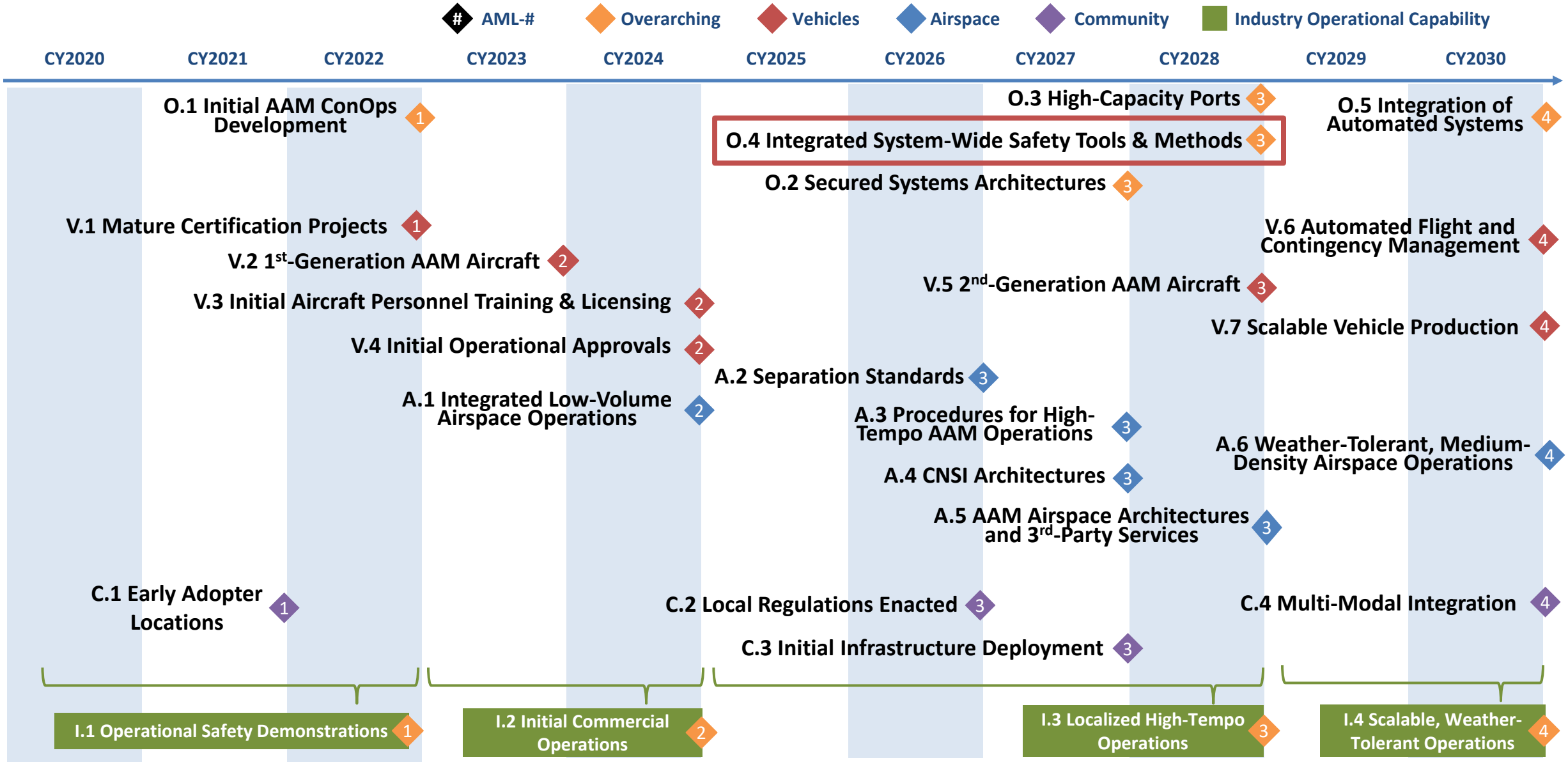
[INSERT AGENDA SHORT LINK HERE]

Integrated System-Wide Safety Tools and Methods

Objective of Breakout Sessions

- **Review the Ecosystem Goal definition**
- **Discuss the major barriers associated with the Goal**
- **Define the different ecosystem stakeholder roles** (e.g., academia, industry, government, etc.) **associated with achieving the Goal**
- **Suggest the priorities and sequencing for achieving the Goal**

Advanced Air Mobility (AAM) Ecosystem Goals[1]



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Transformed Airspace
An Economic Growth Opportunity

- **Increased number of traditional commercial operations (Part 121)**
- **Accessible to all with new aviation applications**
- **Environmentally sustainable**

- **Digital Transformation –> InfoCentric NAS**
- **AAM – New vehicle types and new operations (Part 135, 91, 107)**

Medium Density and Complexity Operations with Collaborative and Responsible Automated Systems (UML-4)

100s of simultaneous operations; expanded networks including closely spaced high throughput aerodromes; many UTM-inspired ATM services available, simplified aircraft operations for credit; low-visibility operations

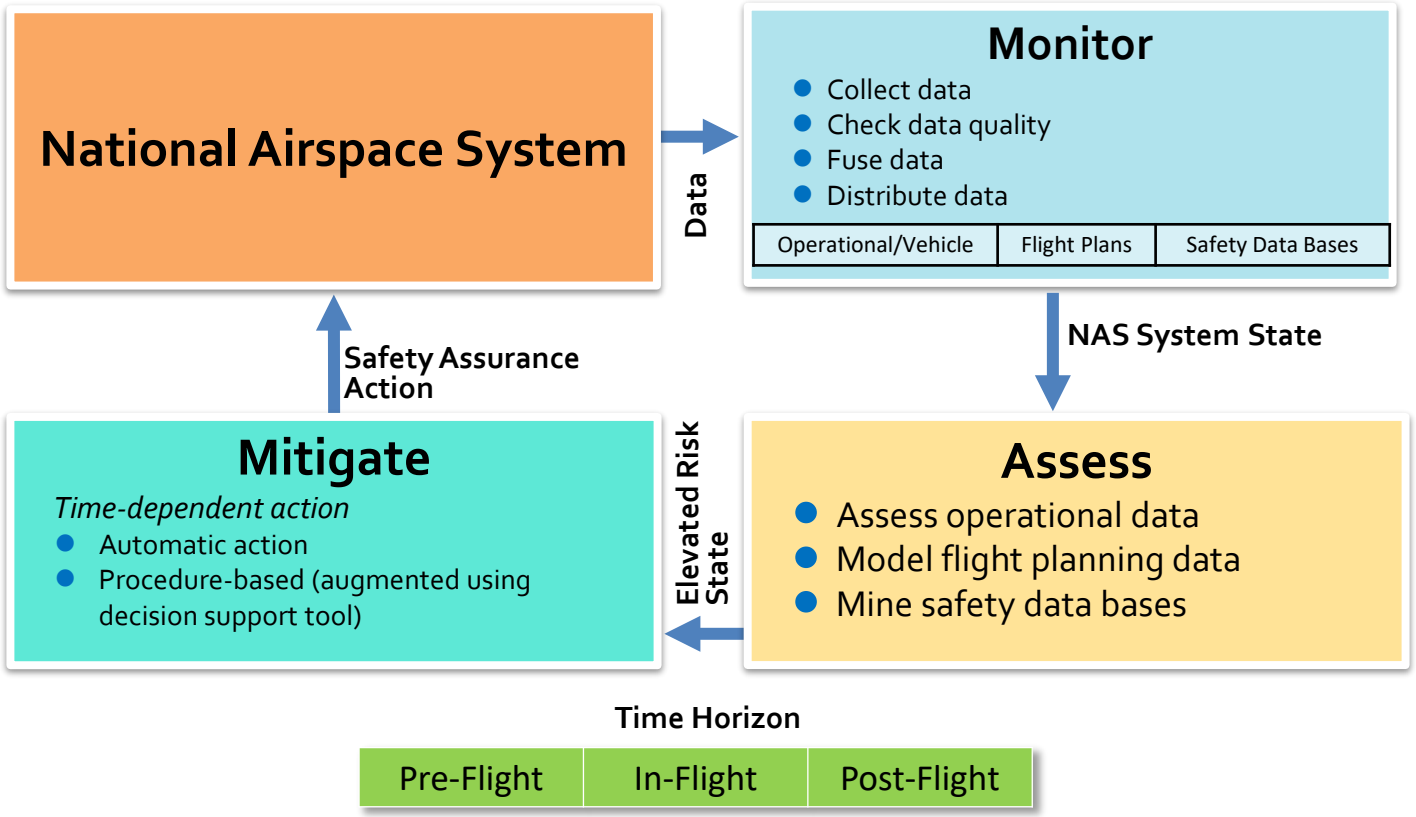
Transformed Airspace
A Complex Challenge

- More Operations = Increased Risk Potential
- New Missions = Increased Integration Complexity
- Sustainability = New Constraints

- Digital Transformation – Changes to Existing Systems and Integration of New Systems
- AAM – Certification Paths Needed for both Airworthiness and Operations
- Automation and Autonomy Central to Managing Operations and Safety of the Future Airspace

AAM Risks and Integrated System-Wide Safety

In-Time System Wide Safety Assurance



Risks

- **Flight outside of approved airspace**
- **Unsafe proximity** to air traffic, people on the ground, terrain or property
- **Critical system failures** (including loss of link, loss or degraded positioning system performance, loss of power, flight control failure and engine failure
- **Loss-of-Control** (i.e., envelope excursions)
- **Physical/Environment Related Risks**
  - Weather encounters (including wind gusts)
  - Threat by person—malicious
- **Cyber-security** related risks
- Those we have **not yet identified…**

AAM Ecosystem Goal Definition

Ecosystem Goal	Ecosystem Goal Statement
Integrated System-Wide Safety Tools & Methods, 2028	Develop and implement an in-time aviation safety management system (IASMS) that continuously monitors safety-related vehicle and airspace operational concerns and deviations in the NAS, assesses the collected data, and recommends or initiates safety assurance actions as necessary.

Barriers to the AAM Ecosystem Goal

	Description of Barrier	What Needs to be Addressed (Gap)	How Can it be Addressed	When Does it Need to be Addressed
Barrier 1	Increased risk potential from more operations	Dense airspace, closer proximity, increasingly variable ops envelopes	In-time risk mitigation by leveraging increasingly real-time data for SRM	
Barrier 2	Integration complexity from new missions	Silo'd SFCs, scalable architecture, IP concerns	Standards (informed by SDOs)	
Barrier 3	New constraints to sustainability (low tolerance for accidents)	Safety threat management, target level of safety	Regulatory-industry partnerships	
Barrier 4	Labor intensive – limited ability to process increasingly large quantities of data	Current processes highly reliant on humans	Augment humans with automation & ML/AI analytics to inform/execute mitigation strategies	
Barrier 5	Limited ability for SMS to scale	Processes currently tailored for current (Part 121) commercial ops (not 135)	Enable safe scalability and interoperability of systems across all operational domains	
Barrier 6	Not fast enough – risk of becoming increasingly reactive	Inability to quickly monitor and assess large data sets	Systems to monitor and integrate large digital data sets. Predictive analytics	
Barrier 7				
Barrier 8				
Barrier 9				
Barrier 10				

Responsibilities for Integrated System-Wide Safety Tools & Methods, 2028

Partner	Recommended Responsibility
NASA	Role to deliver NASA R&D products aligned with critical industry needs aligned with NASAs areas of expertise. Focus areas include concepts, technology development, simulation, flight test, requirements, architectures, standards, etc.
FAA	Role of FAA as primary regulator and other responsibilities for leadership, R&D, Air Traffic Management, Safety, and Policy, etc.
Industry	Description of what the commercial UAM Industry must accomplish including technologies, standardization, certification, and operations. Define specific missions/use cases
SDOs	Role of SDOs in technical standards development. (Standards for Assurance of Autonomy (G34), RTCA SC-228, ASTM F38…)
OGAs	Role of critical OGAs including Excom members (FAA, NASA, OSD, DHS, DOC, DOJ) and their affiliated programs and efforts (Agility Prime).
States, Localities and Tribal Gov	Role of state and local governments to fill in the gaps of national policy, conduct initial analysis, and partner with industry to support initial development and deployment.
Academia	Cutting-edge research on machine learning and artificial intelligence for predictive analytics.
Other	Role of any other entity. Note, add new rows as needed to capture other partners.

Lead Organizations for Barrier R&D

	Description of Barrier	How Can it be Addressed	When Does it Need to be Addressed	Lead Organization	Supporting Organizations
Barrier 1	Increased risk potential from more operations	In-time risk mitigation by leveraging increasingly real-time data for SRM		NASA	
Barrier 2	Integration complexity from new missions	Standards (informed by SDOs)		SDOs	
Barrier 3	New constraints to sustainability (low tolerance for accidents)	Regulatory-industry partnerships		FAA (PPPs?)	
Barrier 4	Labor intensive – limited ability to process increasingly large quantities of data	Augment humans with automation & ML/AI analytics to inform/execute mitigation strategies			
Barrier 5	Limited ability for SMS to scale	Enable safe scalability and interoperability of systems across all operational domains			
Barrier 6	Not fast enough – risk of becoming increasingly reactive	Systems to monitor and integrate large digital data sets. Predictive analytics			
Barrier 7					
Barrier 8					
Barrier 9					
Barrier 10					

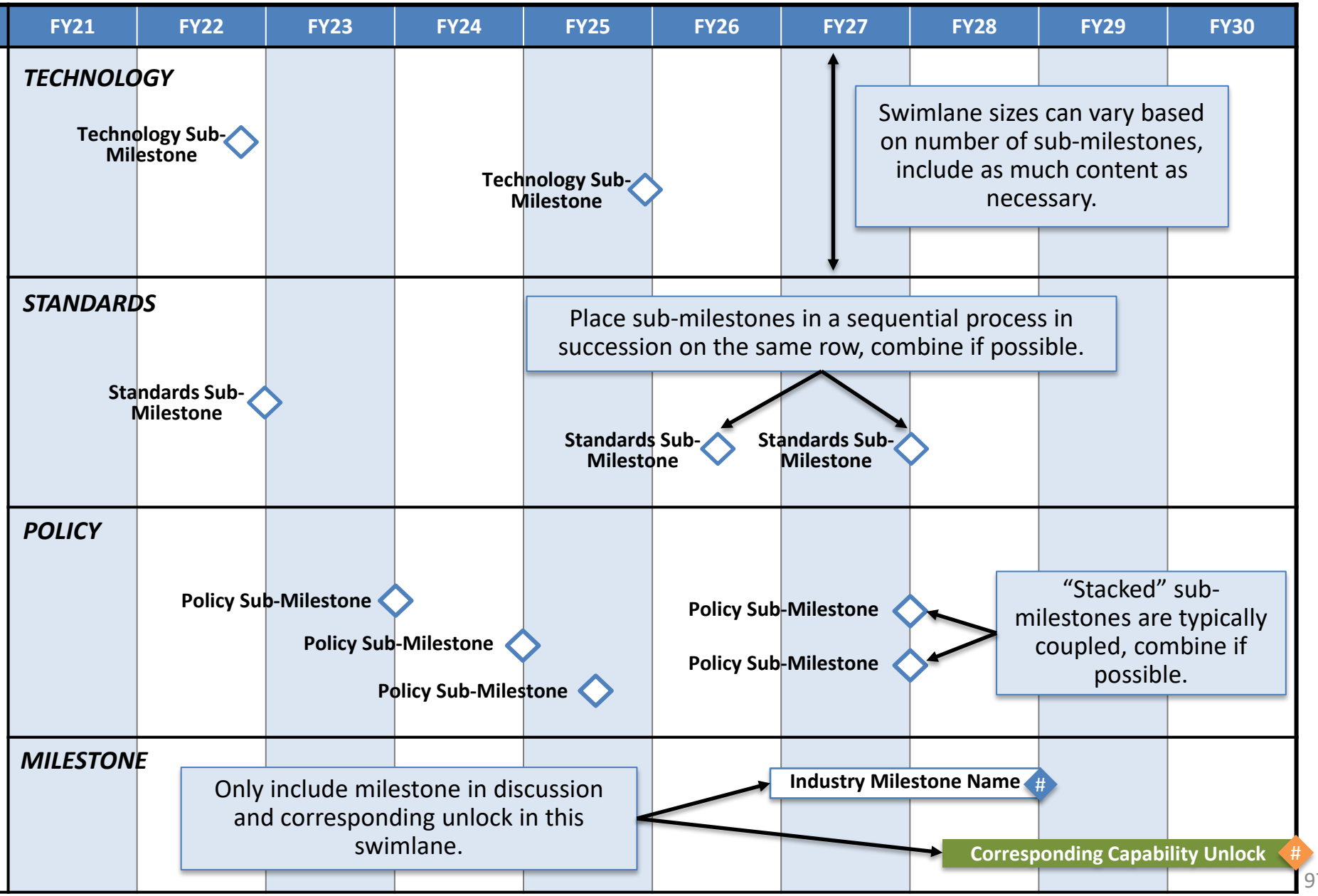
Integrated System-Wide Safety Tools & Methods Roadmap

Industry Milestone:

Integrated System-Wide Safety Tools & Methods, 2028

Operational Objective:

Operational Objective that industry must achieve to unlock the specific operational capability needed to advance UAM.



Transformed Airspace
Integrated System-Wide Safety Tools and Methods

- Tomorrow's airspace is foreseen as increasingly complex with dynamic changes in scale and variety of operations.
- Safety Management Systems must adapt and evolve to analyze larger and highly variable sets of data.
- Advanced data analytics identify risks and inform or execute safety assurance actions in-time to mitigate risks and prevent incidents and accidents.
- New safety technologies and concepts offer an opportunity to augment existing SMS processes and enable them to be increasingly predictive and timely, while also improving accessibility to more operators large and small.

Thank you for joining the AEWG Workshop Breakout Session #3!

Send additional questions or comments to:
arc-cal-nari@mail.nasa.gov

Breakout Session #4 starts in 5 minutes.

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National Aeronautics
and Space Administration

AAM Ecosystem Working Groups (AEWG) Workshop

BREAKOUT SESSION #4

2:10PM – 3:10PM ET / 11:10AM – 12:10PM PT

To access the individual breakout rooms, use the MS Teams meeting links in the agenda accessible here:

[INSERT AGENDA SHORT LINK HERE]

AAM Ecosystem Working Groups (AEWG) Workshop

Breakout Session #4, Topic #1:

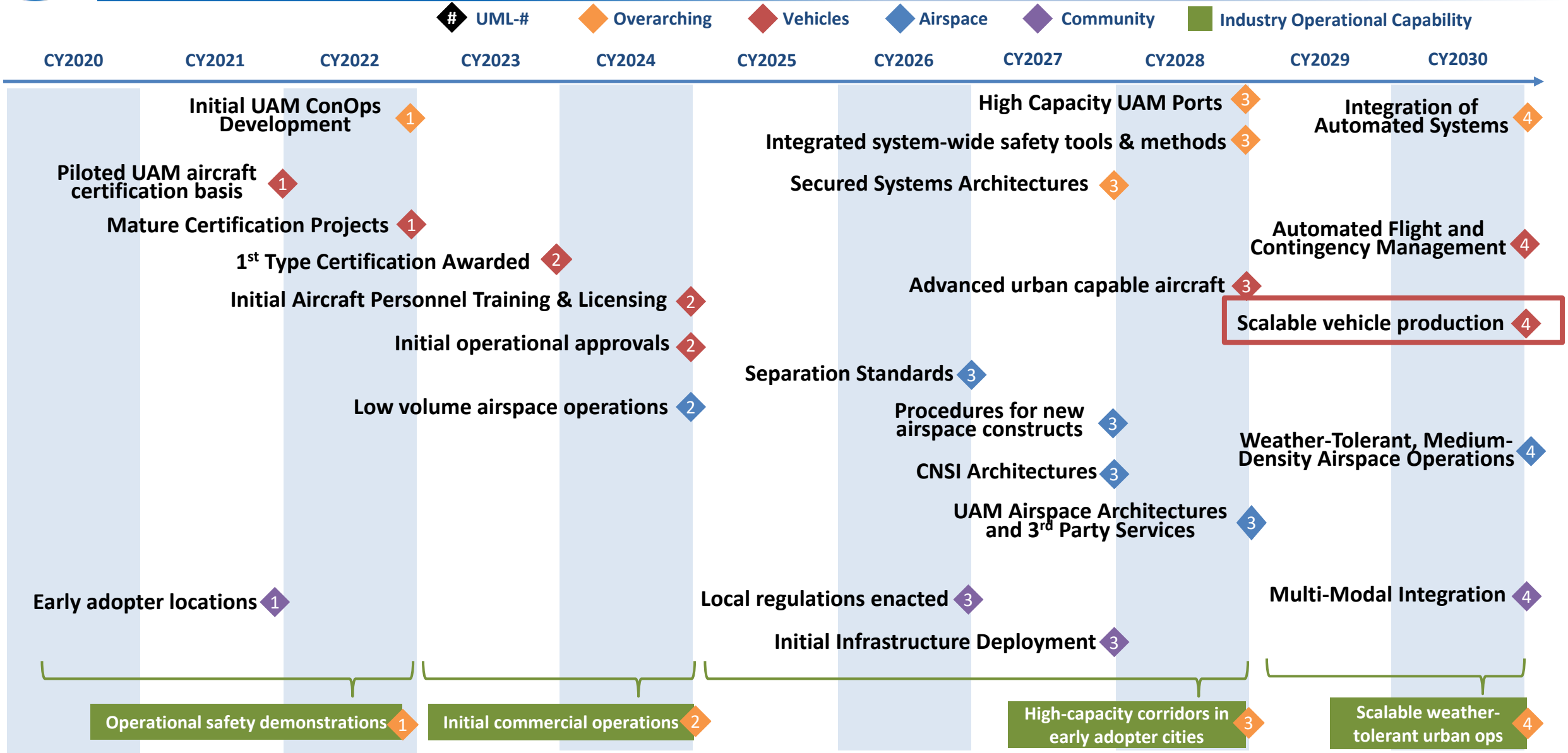
Scalable Vehicle Production

March 23, 2022

Breakout Session Objectives

- Review the Ecosystem Goal **definition**
- Discuss the **major barriers** associated with the Goal
- Define the different ecosystem **stakeholder roles** (e.g., academia, industry, government, etc.) associated with achieving the Goal
- Suggest the **priorities and sequencing** for achieving the Goal

Urban Air Mobility (UAM) Ecosystem Goals[1]



[1] Based on a range of publicly available industry projections; not a consensus view; aggressive

CNSI: Communication, Navigation, Surveillance, Information
UML: UAM Maturity Level

AAM Ecosystem Goal Definition:
Scalable Vehicle Production

Ecosystem Goal	Ecosystem Goal Statement
V.8 Scalable Vehicle Production	Develop cost-effective, critically scalable, certifiable, and sustainable manufacturing capabilities coupled with a robust supply chain for UAM aircraft manufacturing and maintenance/sustainment.

WG Notes/Feedback:

"AAM Ecosystem Goal" Definition: Significant capability or achievement by leading ecosystem entities marking advancements in the maturation of AAM capabilities towards medium density medium complexity operations. Ecosystem Goals are achieved through one or more Objectives.

Barriers to the AAM Ecosystem Goal:
Scalable Vehicle Production

AAM Ecosystem Goal Barriers				
	Description of Barrier	What Needs to be Addressed (Gap)	How Can it be Addressed	When Does it Need to be Addressed
Barrier n				

Nov 18, 2021 Poll Results

Response	Upvotes		Response (cont'd.)	Upvotes
Certified production process	7		standardized ground-based training system	2
Rapid production techniques	6		Cradle-to-grave metrics for entire vehicle production (ie minimize env. impact)	2
Automotive-like assembly line	5		part-number, subcomponent standardization	2
Consideration for new production and material qualification techniques, with the appropriate oversight in production cert for the level of risk	5		Would it also include maintenance/repair parts and not just the parts needed for initially producing the vehicle?	2
Affordability	4		Standard/expected set of support services to be selected as linefit options	1
Certified materials	3		Repairability standards (Self, O-level, I-level or OEM)	1
Interchangeability	3		Recall capability (safety bulletins and or component upgrade)--configuration control at the manufacturing level	1
standardized cockpit	2		Strategic Materials (like the rare-earth material mentioned for chips); There are more....	1
Market size to support scaled production.	2		Production training at the apprentice level (match the educational standards where it is, not where you wish it would be)	1

Ecosystem Goal Responsibilities: Scalable Vehicle Production

Order based on relevance to milestone, most relevant on top.

Partner	Recommended Responsibility
NASA	Role to deliver NASA R&D products aligned with critical industry needs aligned with NASAs areas of expertise. Focus areas include concepts, technology development, simulation, flight test, requirements, architectures, standards, etc.
FAA	Role of FAA as primary regulator and other responsibilities for leadership, R&D, Air Traffic Management, Safety, and Policy, etc.
Industry	Description of what the commercial UAM Industry must accomplish including technologies, standardization, certification, and operations.
SDOs	Role of SDOs in technical standards development.
OGAs	Role of critical OGAs including Excom members (FAA, NASA, OSD, DHS, DOC, DOJ) and their affiliated programs and efforts (Agility Prime).
States and Localities	Role of state and local governments to fill in the gaps of national policy, conduct initial analysis, and partner with industry to support initial development and deployment.
Other	Role of any other entity. Note, add new rows as needed to capture other partners.

Include as many or few partners as relevant to the milestone

Ecosystem Goal Roadmap: Scalable Vehicle Production

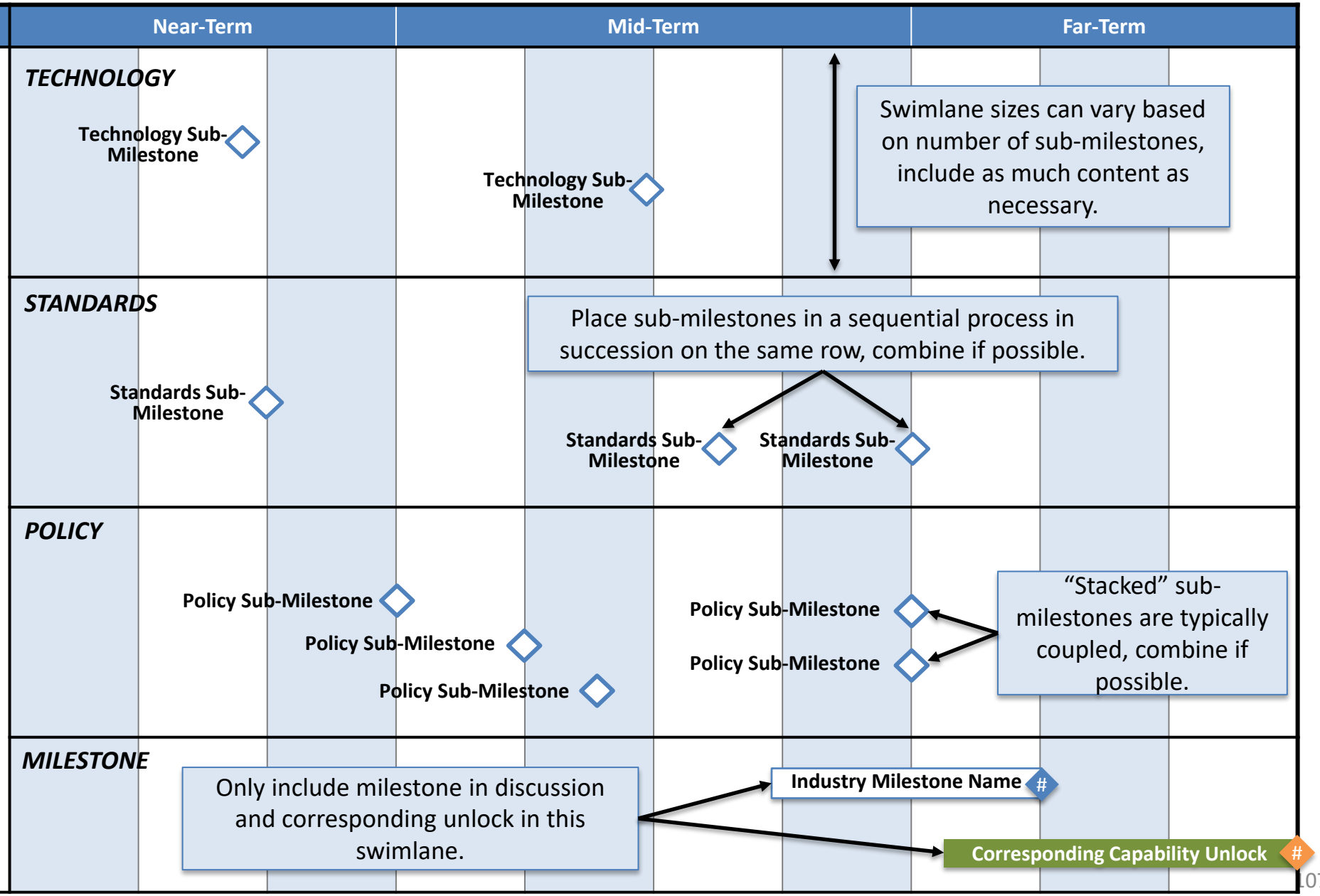
Ecosystem Goal:
V.8 Scalable Vehicle Production

Operational Objective:

Develop cost-effective, critically scalable, certifiable, and sustainable manufacturing capabilities coupled with a robust supply chain for UAM aircraft manufacturing and maintenance/sustainment.

Target Year:

2030



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Mar. 23, 2022, AEWG Workshop:

Topic #2 (Airspace) Comm. Architecture Requirements

Moderated by Mr. Casey Bakula, ATM-X UAM CNS Lead

Review AAM Ecosystem Goal Definition

Ecosystem Goal	Ecosystem Goal Statement
A.4 CNSI Architectures, 2027	**Develop and implement sufficient, resilient, and secure CNSI (communications, navigation, surveillance, and information) and control facility infrastructure including spectrally efficient communication links, navigation services, weather surveillance near the ground, ability to account for non-cooperative vehicles, and functionality in complex environments, such as in urban canyons or other areas with interference and/or sparse coverage.**

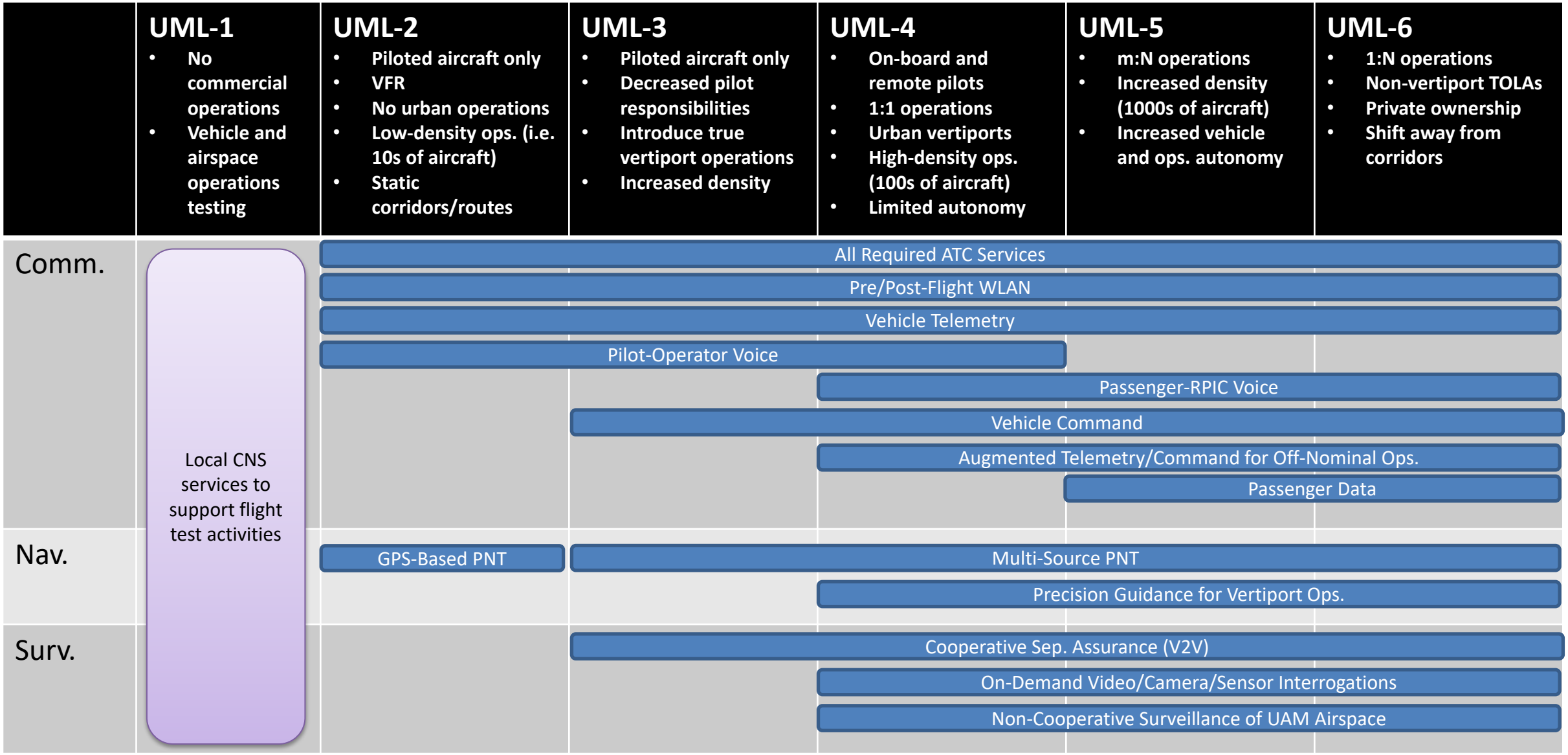
Focus on Comm. Architecture Requirements…subset of this Goal Statement

"AAM Ecosystem Goal" Definition: Significant capability or achievement by leading ecosystem entities marking advancements in the maturation of AAM capabilities towards medium density medium complexity operations. Ecosystem Goals are achieved through one or more Objectives.

Review of UAM Communications Needs

- “Standard” C2 Services
- ATC Services
- UAM Vehicle-to-Operator Voice for On-Board Pilots or Passengers
  - Use cases? Contingency only vs. nominal operations
- Enhanced Data Services for Contingencies
  - Video?
- High-Rate Pre/Post-Flight Wireless Network
- V2V Communications
  - Coop. separation assurance
  - Other V2V use cases?

Preliminary CNS Data Service Roadmap



Barriers to the AAM Ecosystem Goal

AAM Ecosystem Goal Barriers				
#	Description of Barrier	What Needs to be Addressed (Gap)	How Can it be Addressed	When Does it Need to be Addressed
1	Lack of agreement on comm. requirements/needs			
2	Spectrum access or bandwidth limitations			
3	Feasibility and/or acceptance of using non-aviation comm. services (e.g., 5G, satellite Internet, etc.)			
4	SWaP/HW integration on UAM vehicles			
5	Maintaining comm. in urban environments			
6	Cybersecurity			
7	Means of compliance			
8	Equipment certification processes			
9	Economic viability of privatized UAS comm service industry			
10	Others?			

Industry Milestone Responsibilities

Partner	Recommended Responsibility
NASA	Possible roles: Foster industry and gov't collaboration, develop system-level concepts and requirements, integration and testing, develop R&D products aligned with critical industry needs aligned with NASAs areas of expertise. Other roles?
FAA	Role of FAA as primary regulator and other responsibilities for leadership, R&D, Air Traffic Management, Safety, and Policy, etc. CNS-Specific: Oversight of private comm service providers?
Industry	*Service-oriented* approach to providing CNS options to UAM operators versus product-oriented.
SDOs	Which SDOs should be the most engaged? What types of standards should be developed? Where do we need interoperability?
OGAs	Besides NASA and FAA, which OGAs could/should be involved and how?
States and Localities	Role of state and local governments to fill in the gaps of national policy, conduct initial analysis, and partner with industry to support initial development and deployment.
Other?	

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AAM Ecosystem Community Integration Working Group: Breakout – Multi-Modal Integration

Agenda

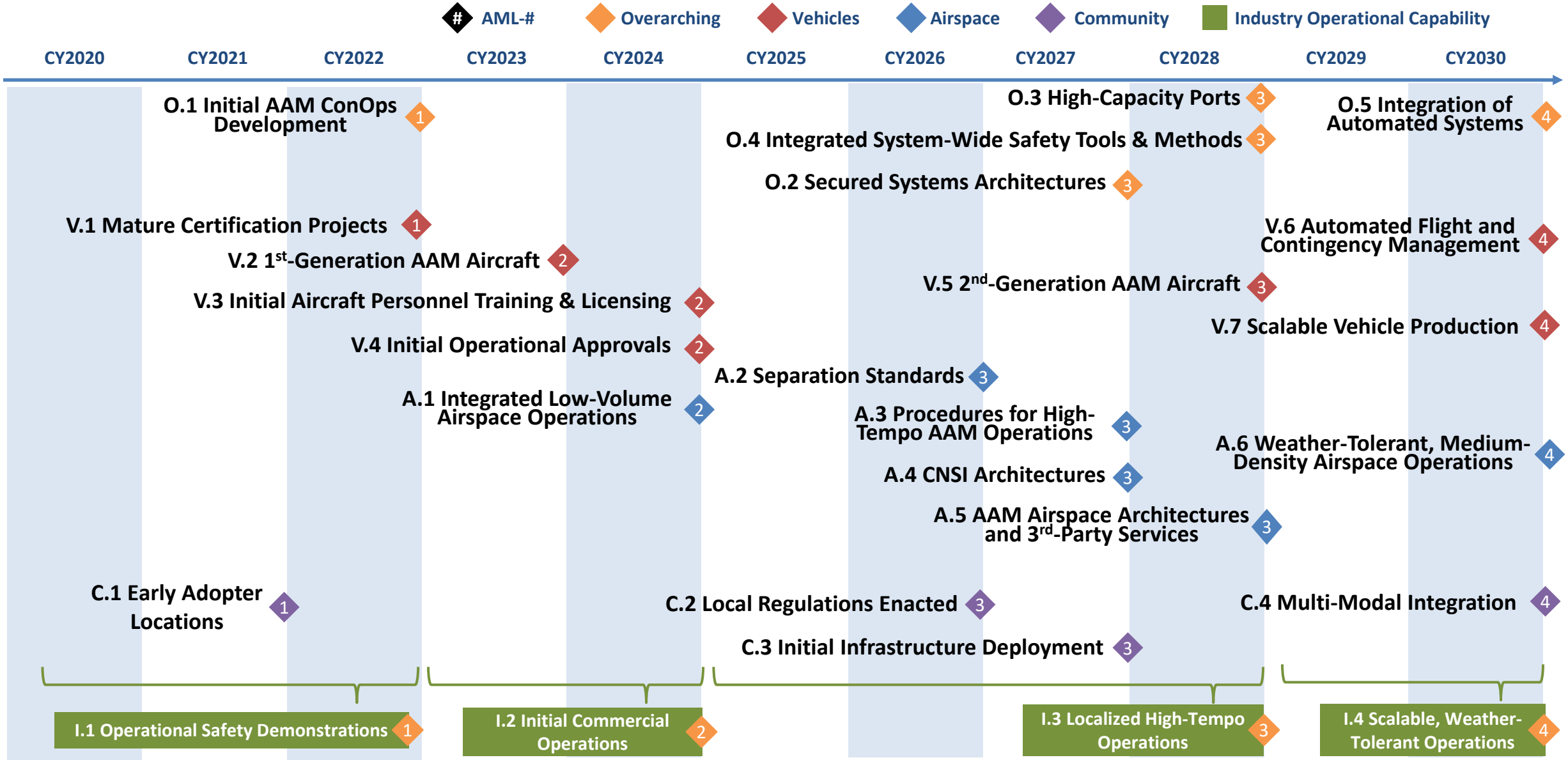
- Meeting Goals
  - Across the 4 community breakouts
  - For the **Multi-Modal Integration** breakout
- Current Goal Chart
- Brainstorming Ground Rules
- Breakout Discussions

Meeting Goals

- Across the 4 Community Breakouts
  - Validate 4 Community Goals
  - Validate each community Goal Statement (definition) Intent
  - View the breadth of “needed” activities – barriers and objectives associated with each goal
  - Identify Goal Gaps

- Each Goal
  - Validate / modify Organizational Breakdown
  - Validate / modify Major Stakeholders
  - Validate / modify / add Objectives organized by Breakdown list/stakeholder
  - Look at goal time phased objectives

Proposed Advanced Air Mobility (AAM) Ecosystem Goals[1]



[1] Based on a range of publicly available industry projections; not a consensus view; aggressive

CNSi: Communication, Navigation, Surveillance, Information
AML: AAM Maturity Level

Brainstorming Ground Rules

Background

- Assuming most folks will attend all 4 community breakouts or one of the initial breakouts, so the 2nd, 3rd a 4th breakouts will spend less time on the upfront materials
- The initial barriers were compiled by the NASA UCAT
- Additional objectives can be submitted via e-mail after the breakouts with the view of presenting a consolidated collection of slides at a future CIWG.

Brainstorming Ground Rules

- There are no bad ideas
- Just looking to identify additional barriers, stakeholders and potential objective phasing
- Will be grouping by stakeholders to manage the number of objectives
- Objectives can be submitted verbally, via chat, whiteboard function, e-mail,
- Meeting – 60 min
  - 5 min logistics, intro
  - 5 min on goal and goal statement
  - 10 min organizational breakdown and stakeholders
  - 35 min on objective identification and time phasing
  - 5 min wrap up

Breakouts will be recorded for internal use only - so we don't lose your comments and inputs

Breakout Discussions

5 min

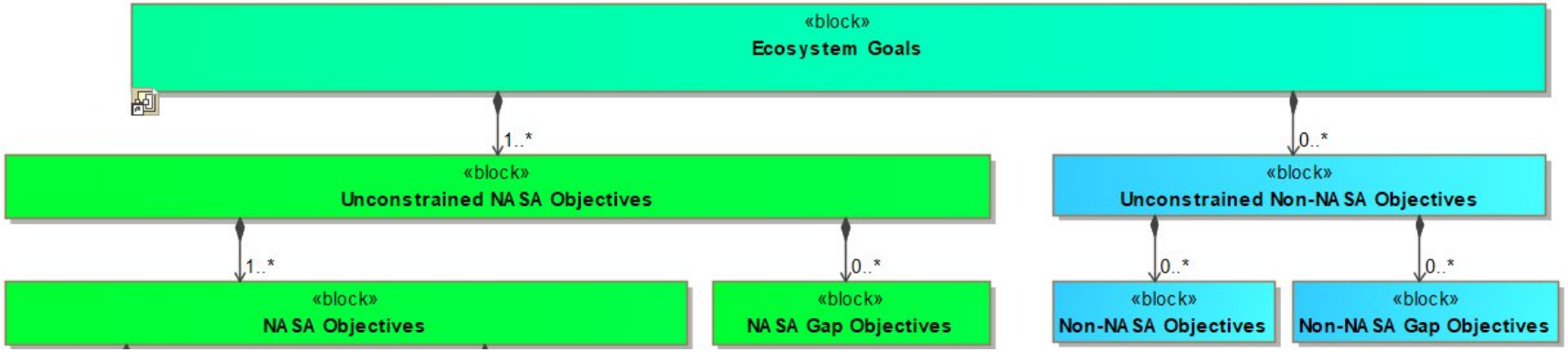
Multi-Modal Integration

Statement: Integrate AAM into a multi-modal transportation system to enable seamless transitions between modes for passengers and cargo and to ensure that the broader transportation system could still operate if AAM or other parts of the broader transportation system are impacted. Address operations-related community impacts, including passenger/cargo safety and security, sustainability, and equity.

Organizational Breakdown & Stakeholders

10 min

- Community
  - State
  - Local
  - Tribal
- Federal Government
  - DOT/FAA
  - DHS/TSA
  - NASA
- Industry
  - Vehicle Manufacturers/Vehicle Operators
  - Providers of Services (PSUs)
  - Vertiport Operators
  - Utilities - Electrical
- Other
  - Academia
  - Consulted Stakeholders
  - Informed (cognizant) Stakeholders



Use this slide for buy in on which organizational breakdown and get help adding stakeholders

1 Option
Note: Used this option for the 4 breakouts

Community Objectives – Multi-Modal Integration

- Community
  - State
  - Tribal
  - Local/regional
    - 1st year
    - 2nd year
    - 2nd & 3rd year
    - 4th year

30 min – 4 slides

Use this and the next 4 slides to get help identifying the things that “should” happen within each organizational group.

Assume a 6-year time span from start to “achieving goal”
Start overlaps with 5-year time span of Initial Infrastructure Deployment Goal

Federal Government Elements

- Federal Government
  - DOT/FAA
  - DHS/TSA
  - NASA

Scott – I can make some recommendations for you all here – presented at major forums, etc but I think you all own this one.

Industry Elements

- Industry
  - Vehicle Manufacturers/Vehicle Operators
  - Providers of Services (PSUs)
  - Vertiport Operators
  - Utilities - Electrical

Remember this is their activities related to this Community Goal

Other Elements

- Other
  - Academia
  - Consulted Stakeholders
    - Adjacent AAM Planning teams –
  - Informed (cognizant) Stakeholders

Multi-Modal Integration Roadmap

Industry Milestone:
Multi-Modal Integration

Operational Objective:

Implement multi-mode transportation integration to ensure that the transportation system could still operate if UAM of other parts of the system are impacted. Progressively address operations-related community impacts, including passenger/cargo safety and security, protection from malicious use of vehicles and denial of service attacks as technology and concepts of operations evolve.

	FY21	FY22	FY23	FY24	FY25	FY26	FY27	FY28	FY29	FY30
TECHNOLOGY				Assessments of requirements and trade-space for vertiport locations ◇				Technology development required to enable safe multi-modal integration ◇		
STANDARDS									Updated Infrastructure Standards ◇	
POLICY									◇	
GOAL										Multi-Modal Integration 4
										Scalable Weather-Tolerant Urban Ops 4

Looking Forward

Looking forward

- March – April
  - Compile inputs from Breakouts and e-mails
- May
  - Present at CIWG
- Annual
  - Host CIWG session to update materials and assess progress

Back Up

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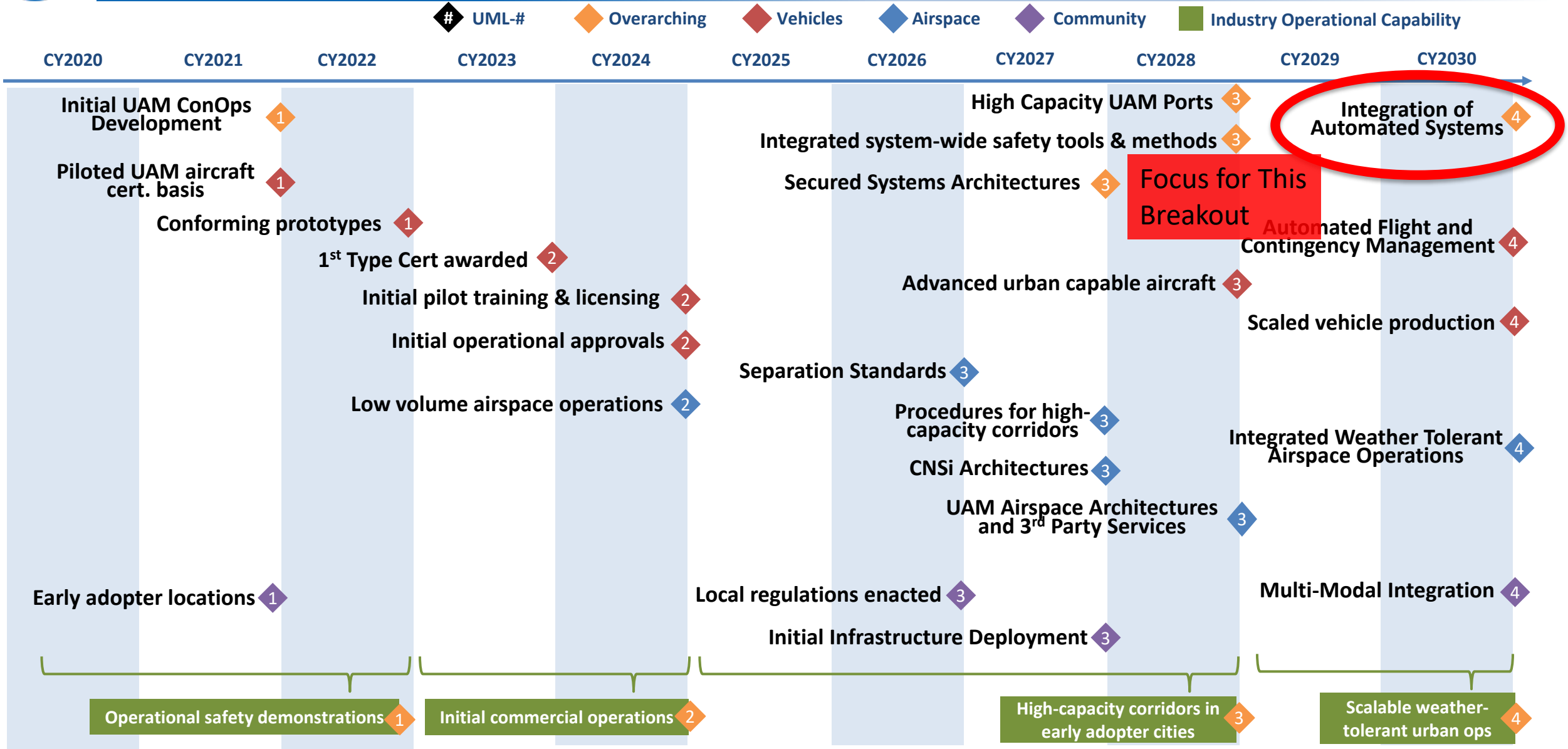
Ryan Slides for March AEWG
Breakout Session #4, Topic #4
Integration of Automated Systems

Moderator – Wes Ryan
3/23/22
2:10PM – 3:10 PM ET

Objective of Breakout Sessions

- Review the Ecosystem Goal definition
- Discuss the major barriers associated with the Goal
- Define the different ecosystem stakeholder roles (e.g., academia, industry, government, etc.) associated with achieving the Goal
- Suggest the priorities and sequencing for achieving the Goal

Urban Air Mobility (UAM) Ecosystem Goals[1]



[1] Based on a range of publicly available industry projections; not a consensus view; aggressive

CNSi: Communication, Navigation, Surveillance, Information
UML: UAM Maturity Level

Review of AAM Ecosystem Goal Definition

Ecosystem Goal	Ecosystem Goal Statement
O.5 Integration of Automated Systems, 2030	Progressively integrate, test, and operationalize systems across vehicle, airspace, and infrastructure to ensure UAM automated systems are safe, optimized, and economically beneficial.

"AAM Ecosystem Goal" Definition: Significant capability or achievement by leading ecosystem entities marking advancements in the maturation of AAM capabilities towards medium density medium complexity operations. Ecosystem Goals are achieved through one or more Objectives.

Factors to Consider for our Discussion

New concept, ability, expertise, or proficiency

Task, role, and/or system effects which enable a *Capability*

Equipment including HW/SW which enables *Function/ Service*

Information sources used by *Technology*

Must assess maturity, integrity, reliability, availability, etc. of data sources & technology to implement an intended function in support of a new capability

What are the major barriers to achieving the Goals?

Flight Testing in “Real World”

Data & V2V Data Sharing

FAA Acceptance

Safety/Resiliency

Cyber Security & Nefarious Agents

Industry Agreement on Functions/Capabilities

Standards

Means of Compliance

Achieving Safe Operation

Human/Machine Teaming

Design and Certification Best Practices

Organizational Maturity/Viability

Barriers to the AAM Ecosystem Goal

AAM Ecosystem Goal Barriers				
	Description of Barrier	What Needs to be Addressed (Gap)	How Can it be Addressed	When Does it Need to be Addressed
Barrier 1				
Barrier 2				
Barrier 3				
Barrier 4				
Barrier 5				
Barrier 6				
Barrier 7				
Barrier 8				
Barrier 9				
Barrier 10				

Capture barriers that inhibit the ability to achieve the ecosystem goal. What needs to be addressed, how to address it, and when to address it.

What Role Does NASA, FAA, Industry, and Academia Play in Resolving These Barriers?

Milestone Responsibilities

Partner	Recommended Responsibility
NASA	Role to deliver NASA R&D products aligned with critical industry needs aligned with NASAs areas of expertise. Focus areas include concepts, technology development, simulation, flight test, requirements, architectures, standards, etc.
FAA	Role of FAA as primary regulator and other responsibilities for leadership, R&D, Air Traffic Management, Safety, and Policy, etc.
Industry	Description of what the commercial UAM Industry must accomplish including technologies, standardization, certification, and operations.
SDOs	Role of SDOs in technical standards development.
OGAs	Role of critical OGAs including Excom members (FAA, NASA, OSD, DHS, DOC, DOJ) and their affiliated programs and efforts (Agility Prime).
States and Localities	Role of state and local governments to fill in the gaps of national policy, conduct initial analysis, and partner with industry to support initial development and deployment.
Other	Role of any other entity. Note, add new rows as needed to capture other partners.

Integration of Automated Systems Responsibilities, 2030

Partner	Recommended Responsibility
NASA	NASA will need to lead simulation from a domain perspective and integrate flight test assets to perform complex technology and operation assessments.
FAA	The FAA will need to develop policy and certification procedures around automation and autonomy.
Industry	Industry will need to develop critical technologies to enable automated flight technology that augments pilots in a connected ecosystem with 3rd party services.
SDOs	N/A
OGAs	OGAs will need to lead efforts such as Autonomous Prime to accelerate the potential market for automated and autonomous flight operations.
States and Localities	N/A
Other	N/A

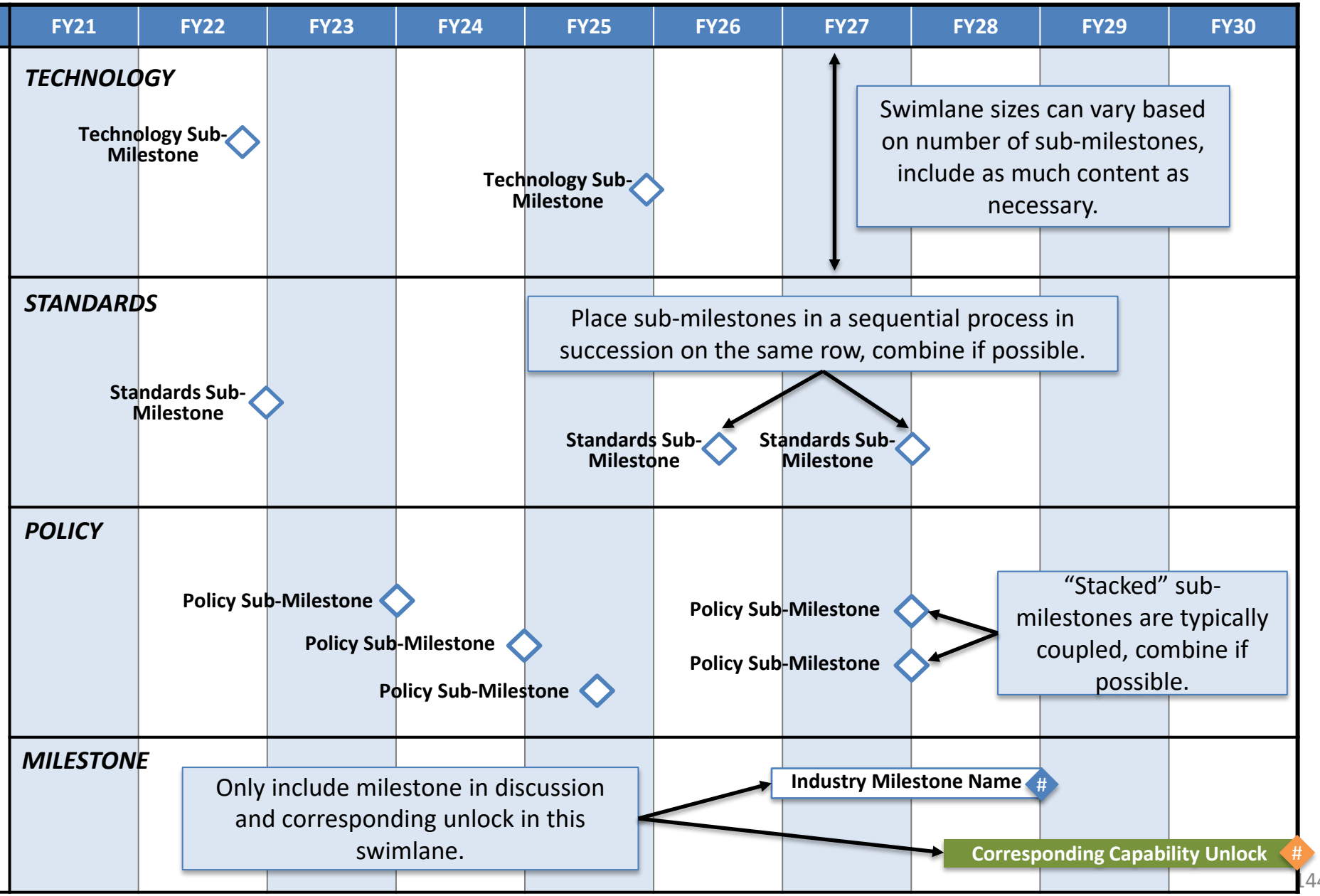
What logical priorities, sequencing, and dependencies exist for achieving the Goal?

<Industry Milestone Name> Roadmap

Industry Milestone: <Industry Milestone Name>

Operational Objective:

Operational Objective that industry must achieve to unlock the specific operational capability needed to advance UAM.



Integration of Automated Systems Roadmap (Simplified)

Ken Goodrich

Industry Milestone:
Integration of Automated Systems

Operational Objective:

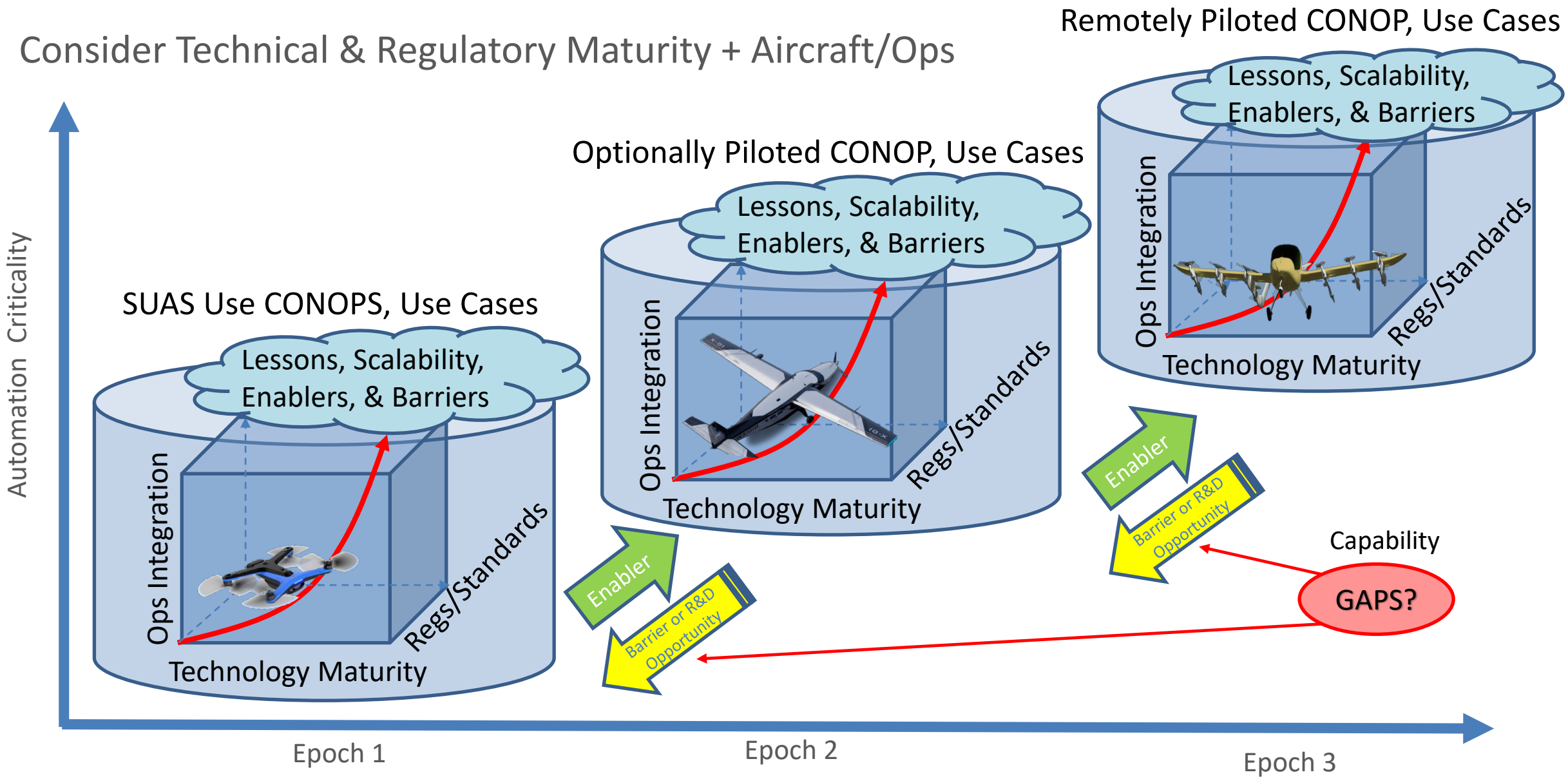
Progressively integrate, test, and operationalize systems across vehicle, airspace, and infrastructure to ensure UAM automated systems are safe, optimized, and economically beneficial.

	FY21	FY22	FY23	FY24	FY25	FY26	FY27	FY28	FY29	FY30
TECHNOLOGY		Advisory Technology		Assistive Technology	Mature Technology		For Operational Credit Technology			Responsible Technology
STANDARDS			Standards Sub-Milestone							
POLICY				Policy Sub-Milestone						
MILESTONE									Integration of Automated Systems 4	Scalable Weather-Tolerant Urban Ops 4

Supporting Slides

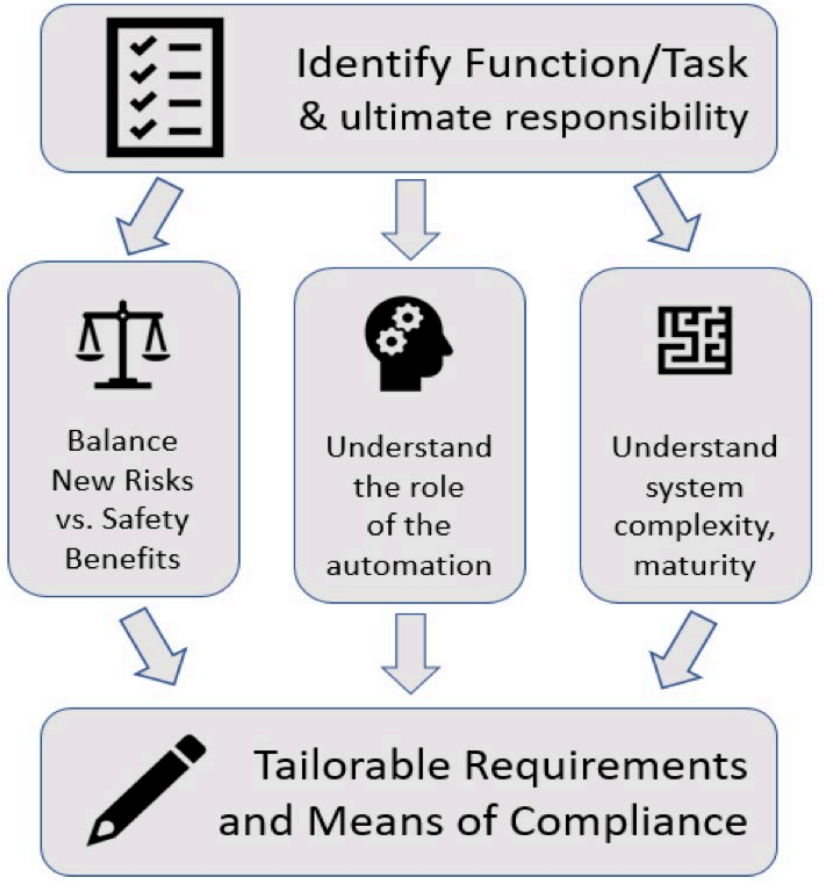
Different Timeline/Path for Different Use Cases?

Consider Technical & Regulatory Maturity + Aircraft/Ops



Automation Maturation – Industry Example

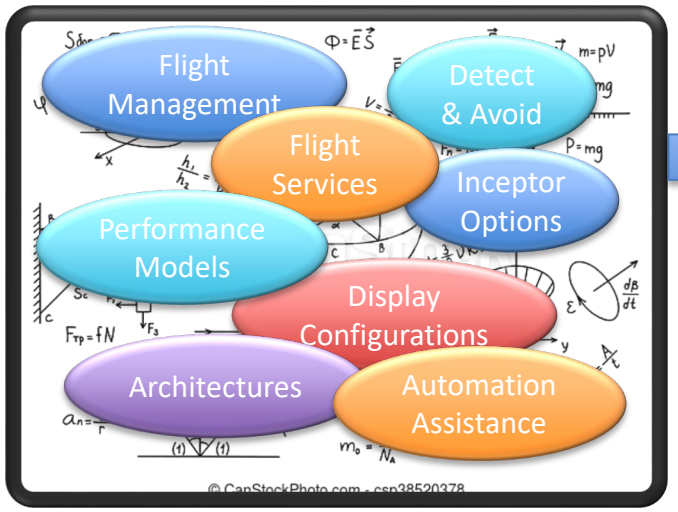
- Introduce Automation In Low-Risk Use Cases First, Where Appropriate
- Collect Data & Use Data to Develop/Validate Models
- Analyze Models for Higher Risk Safety Cases to Evolve
- “Build a Little, Test a Little” - Iterative Loop
- Models for Physical Problems Easier to Develop/Mature Than Models for Decision Making and Perception Functions
- Move Technical Maturity Forward for Specific Functions – Combine Functions to Reach Specific Operational Goals for Autonomy



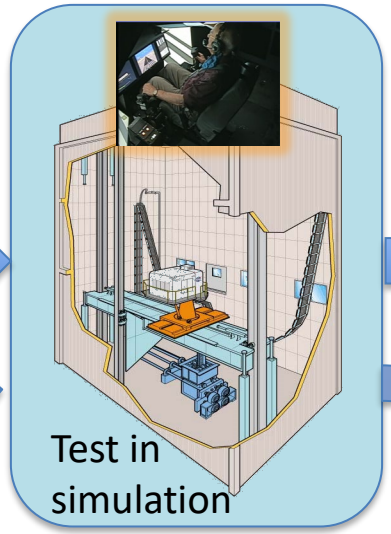
From ASTM AC 377 TR

Automation Maturation Process – NASA Example

Technical Challenge:
Develop and evaluate an initial, integrated suite of key automation functions to enable simplified piloting in urban environments and propose recommendations to enable certification and approvals for the selected concepts.



Use industry-representative models & technologies



Validate in flight

Capture Requirements

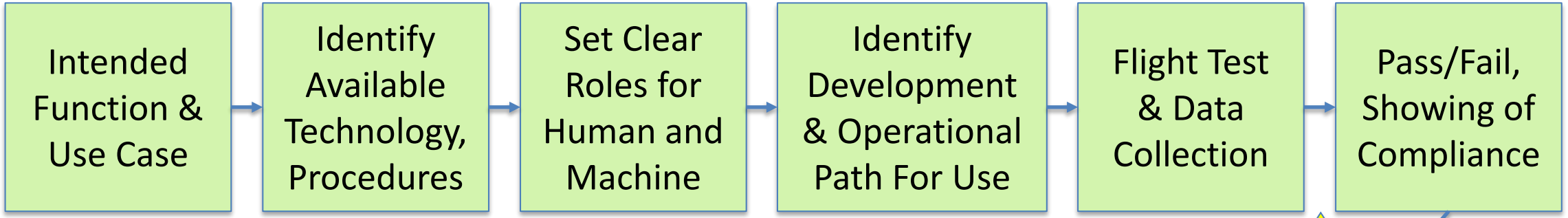
Identify common techniques for evaluation of performance, handling and safety

Deliver findings to inform development of System Concepts, Standards, Certification requirements and Means of Compliance

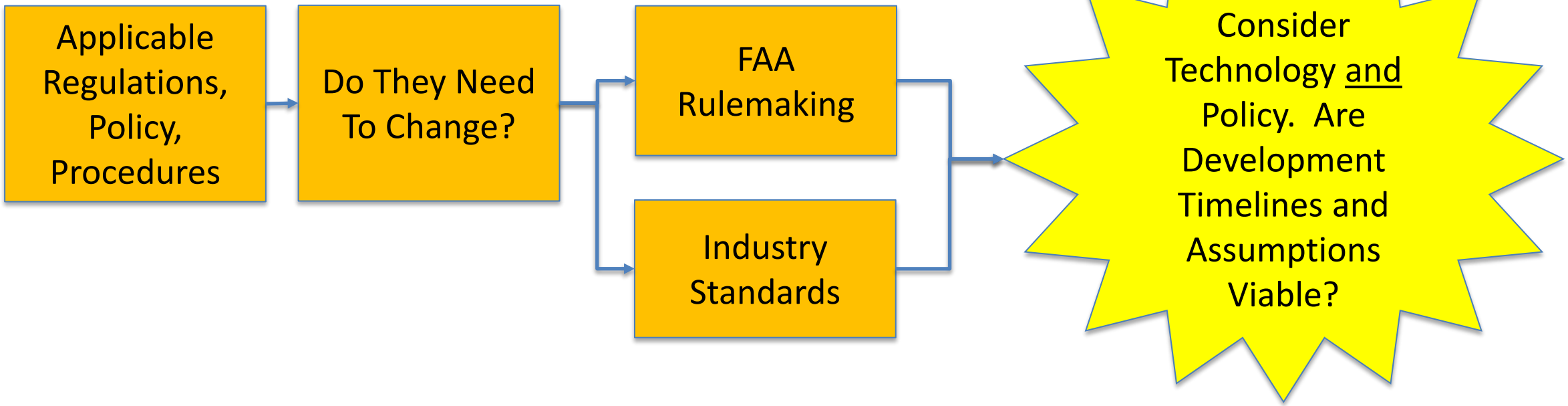
National Campaign (NC)/Integrated Automated Systems (IAS)

Deconstruction of Functional/Technology Capability

Functionally Based Approach to Product Development



Functionally Based Approach to Policy & Regulation



Proposed Gated Process for Evaluating Capability/Function/Technology/Data

Gate	Action/Evaluation
0	Identify an intended function for automation including the context – Intended use (e.g. operational context and/or phase of flight, and functional interfaces/dependencies)
1	Explain the potential benefits or incentives of automating the proposed function (e.g. safety enhancement, operational enhancement, and economics). Identify any potential risks, limitations, or barriers to automating the proposed function
2	Define how the intended function is currently completed/accomplished in operations and describe how it would be completed/accomplished once automated. Include human responsibilities and authority and how they could change and other system interfaces or dependencies when comparing.
3	Define the required information, processing, and outputs necessary to automate the function.
4	Identify candidate example technology products that may be capable of automating the function
5	Identify gaps in the current technology products to perform the function, and what operations the current technology could enable now
6	Identify the required maturity level of a technology product for it to achieve the intended function. Describe any differences in the level of maturity that may be appropriate depending upon aircraft size (i.e., normal category, transport category), kind of operation (i.e., cargo, passenger-carrying), or any other appropriate risk consideration.
7	Identify a path from current technology capabilities to the future technology capabilities necessary to achieve the identified maturity level(s).
8	Identify the applicable regulations/policy/standards/guidance (i.e., aircraft certification, operational, airman, ICAO) related to the current function.
9	With reference to Gates 2 and 8, identify what regulations/policy/standards/guidance may need revision and where new regulations/policy/standards/guidance may need to be developed to certify an aircraft with the technology and authorize/enable its use in operations.

Capability Maturity Challenges for UML-4 (NASA)

UML 1 & 2

Initial certifications, revenue operations

Goals: Certify base aircraft, approval for and initiation of revenue ops.

Assumptions: Highly experienced pilots. Low-tempo ops, VFR/VMC, current ATC

Challenges

- Define standards and methods of compliance for initial, highly-augmented aircraft
- Pilot requirements for add-on eVTOL rating must be developed
- Develop flight procedures compatible vehicle performance and automation

UML 3

Technology and operational maturation

Goals: Local network expansion in early markets while developing, maturing, validating technology/procedural foundations for scalable ops

Assumptions: Experienced pilots, locally-medium densities, VFR/VMC, NextGen UAM ConOps

Challenges

- Initial integration of flight path manage-ment automation with service provider network for strategic deconfliction and scheduling
- Maturation of 4D RNP TBO and automation for urban operations
- Development of comprehensive hazard perception and avoidance (HPA) for safety and airborne separation mang.
- Introduction of automated monitoring and management of mission and contingency planning to support pilot decision making, automate execution

UML 4

Scalable systems and operations

Goals: Scalable operations in IMC and util-zing less experienced pilots. Validate technology & standards for remote-PIC

Assumptions: Ab-initio commercial pilots, locally dense ops, IMC, UML-4 ConOps

Challenges

- Community consensus on scalable ConOps, architecture, interoperability
- Harmonization of aircraft automation standards, interfaces, assurance for nationally/ internationally scalable UAM
- Development of visibility independent flight rules and operations supported by integrated, air and ground automation
- Development of revised minimum pilot qualifications for UAM operations employing min. automation capabilities
- Validation of automation capabilities, standards, assurance, and human-interaction consistent with remote-PIC

Highlights indicate areas where Capability/Functions/Technology/Data and Regulatory Maturity are still unknown.

Capability Maturity Challenges for UML-4

Airspace Operations

Identify and implement future UAM requirements to airspace and air traffic modernization programs such as airspace design, flow management, trajectory-based operations, performance-based navigation, and procedures and standards.

CNS Infrastructure

Partner with appropriate stakeholders to develop and validate requirements and integrate the full life-cycle of UAM- enabling Communication, Navigation, and Surveillance, (CNS) and other UAM NAS infrastructure.

Information Exchange

Incorporate UAM requirements and concepts into ATO automation and data modernization activities as part of a UAM enabled information centric NAS.

Ecosystem Engagement

Collaborate with local, state, municipal and tribal government entities, industry, academic and international stakeholders to address the challenges of UAM, coordinate on strategies and approaches, and communicate progress to build a coordinated approach to UAM Airspace integration.

Workforce & Staffing

Build, empower, and retain adaptive talent to effectively anticipate and address evolving UAM workforce needs.

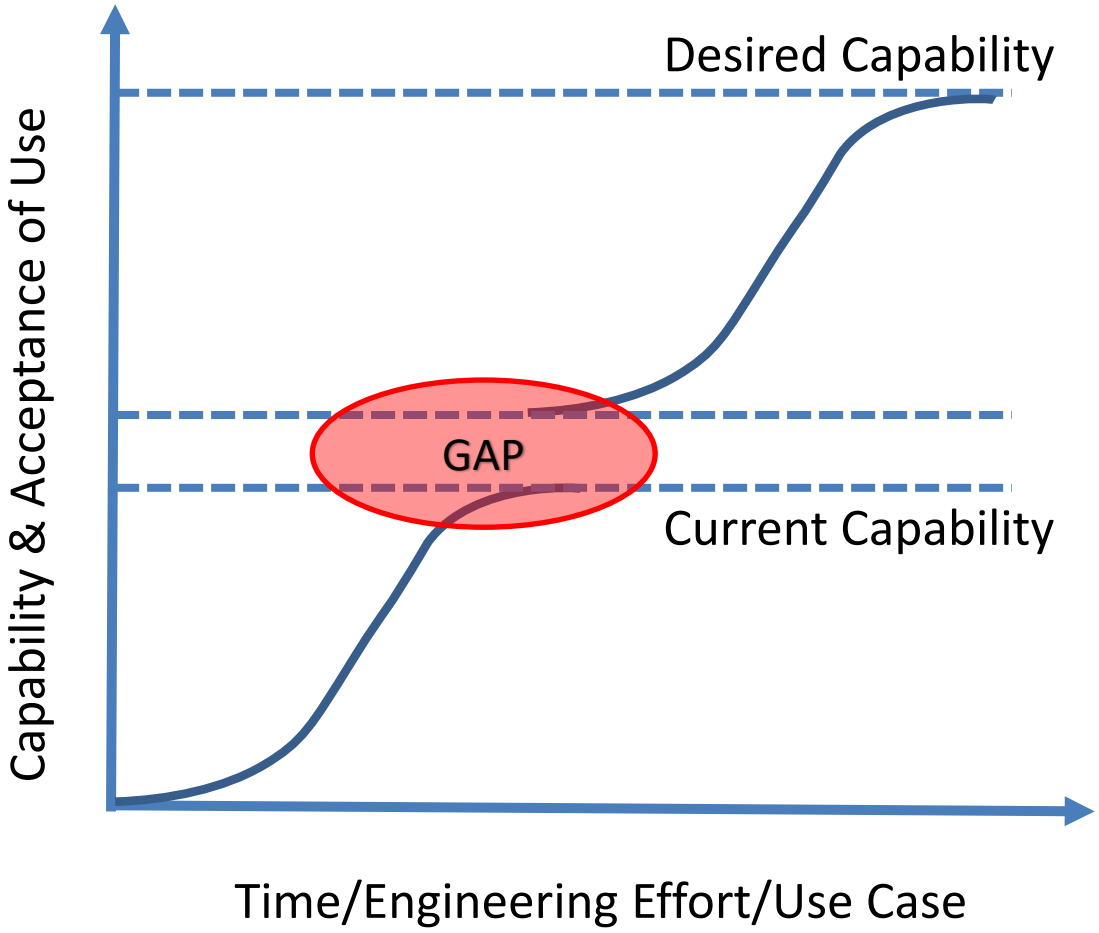
Policy & Regulation

Identify, develop, and publish timely, iterative, policy and regulation to enable the safe implementation of UAM.

Highlights indicate areas where Capability/Functions/Technology/Data and Regulatory Maturity are still unknown.

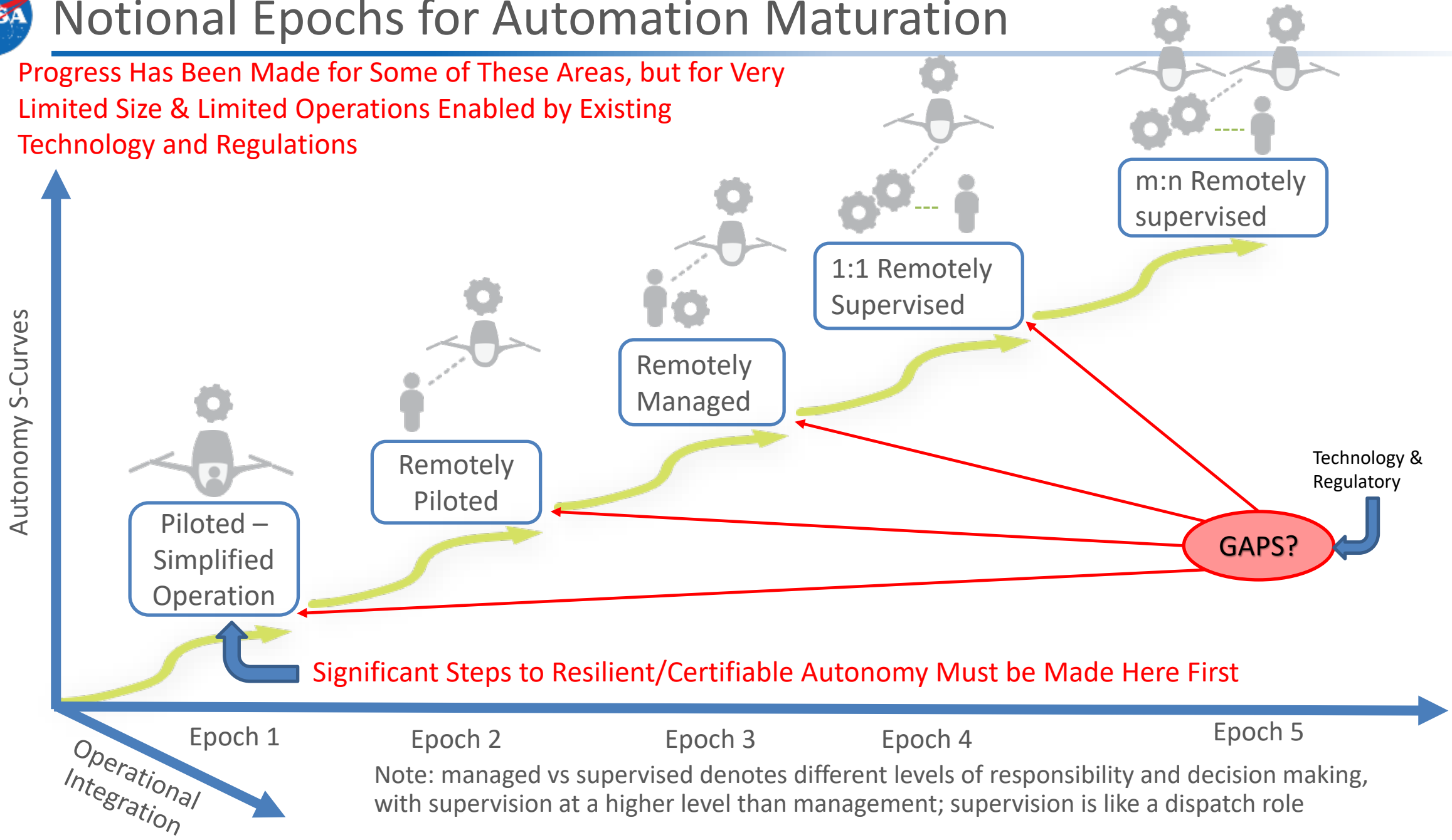
S-Curve Epochs – Maturity & Discontinuity

- Gaps in Capability May Limit Growth Towards Ultimate Goal/Use Case
- Gaps Can Exist in Technology, Regulation, and/or Operational Capability
- Consider the Level of Expected Integration vs. Demonstrated Capability
- Technology Gaps Must be Overcome by Data Collection and Demonstration in Real-World Scenarios – Catch 22
- Regulatory Gaps Present Similar Challenge - Overcome by Data



Notional Epochs for Automation Maturation

Progress Has Been Made for Some of These Areas, but for Very Limited Size & Limited Operations Enabled by Existing Technology and Regulations



Note: managed vs supervised denotes different levels of responsibility and decision making, with supervision at a higher level than management; supervision is like a dispatch role

Industry Challenge – Separate Efforts

- Many Solely Focus on Technology Readiness and Concern About Regulatory Readiness
  - Regulatory Change Requires Data - Change Needed Before Some Concepts Can Be Certified.
  - Assurance And Trustworthiness – What Role Would Surrogate Aircraft Play In Technology/Operational Maturation?
  - Current Design/V&V Practices May Need To Evolve
- Each is Working To Design Task-based Automation Towards Future Autonomy for their Use Case
  - How To Methodically Evolve to New Roles for Humans Envisioned for UML-4, 5, 6?
  - Architecture And Resilient Proficiency – How To Design Architectures Where The Human Is No Longer Critical
  - Design for Unforeseen Circumstance –Design for “Mission-Intent Level Outcomes”

Focus on Behavior/Rule Based Outcomes

- Pass/Fail Criteria for Specific Tasks
- Focus on Intended Function
- Build In, Test Proficiency & Robust Function
- Criticality Only Increases as S-curve Reaches Maturity

Scenario–based Training With Instructor + Repetition + With Expected Outcomes/Behavior

Human

Student Pilot	Private Pilot	Commercial Co-Pilot	Commercial Pilot
Initial Aptitude and Skill	Basic Proficiency	Resilient Proficiency	Civil Trustworthiness

Simulation & Flight Test to Demonstrate Readiness for Intended Use, Type of Operation, Task Criticality

System

Experimental Prototype	Advisory System	Assistive System	Safety Critical System
Initial "Aptitude and Skill" in System Function	Proven Basic Proficiency	Proven Resilient Proficiency	Proven Civil Trustworthiness

Must Work-up to Resilient/Robust Behavior in Automation Designs

Thank you for joining the AEWG Workshop Breakout Session #4!

Send additional questions or comments to:
arc-cal-nari@mail.nasa.gov

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AAM Ecosystem Working Groups (AEWG) Workshop

Breakout Session #4, Topic #5:

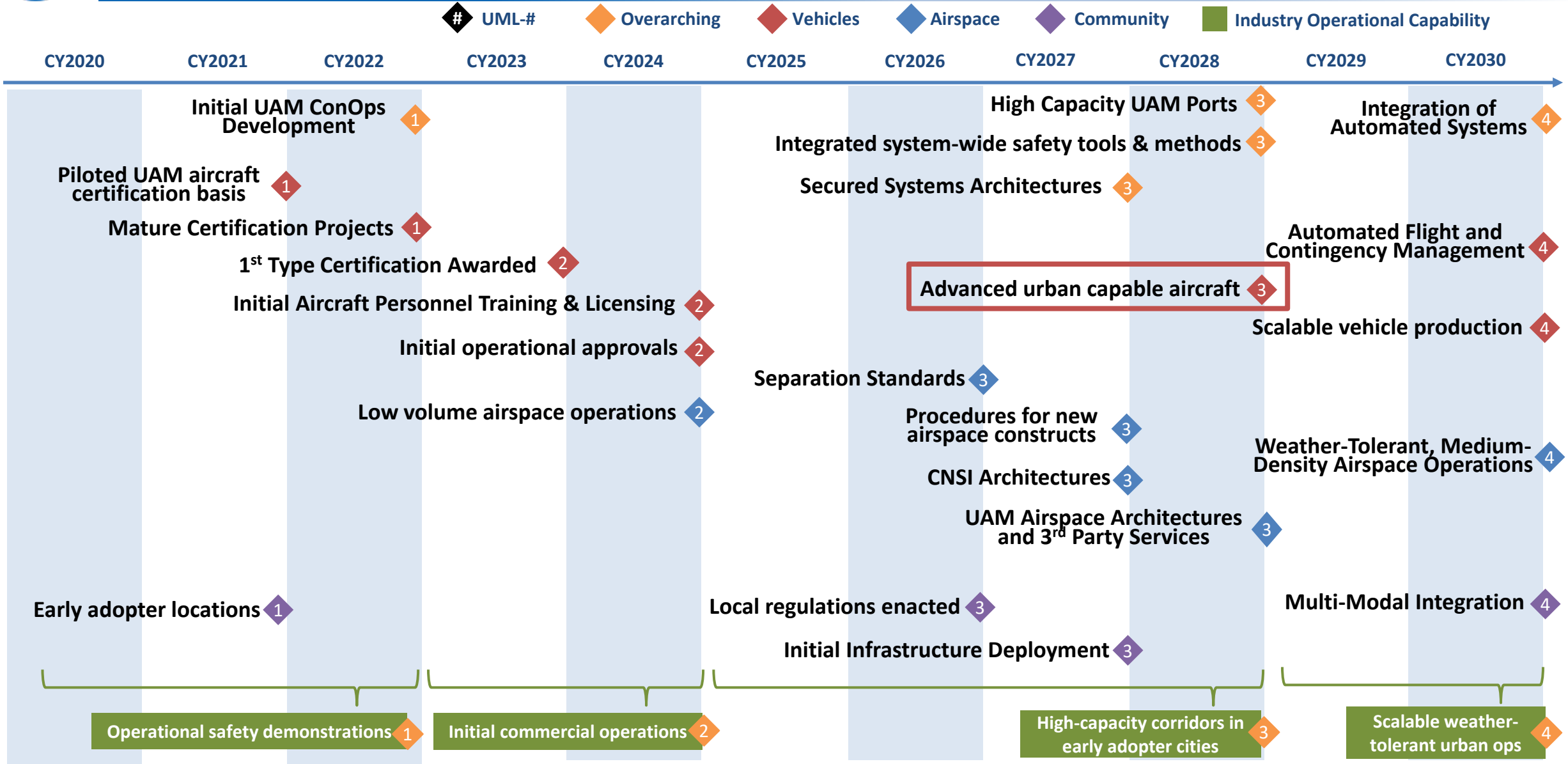
Advanced Urban Capable Aircraft

March 23, 2022

Breakout Session Objectives

- Review the Ecosystem Goal **definition**
- Discuss the **major barriers** associated with the Goal
- Define the different ecosystem **stakeholder roles** (e.g., academia, industry, government, etc.) associated with achieving the Goal
- Suggest the **priorities and sequencing** for achieving the Goal

Urban Air Mobility (UAM) Ecosystem Goals[1]



[1] Based on a range of publicly available industry projections; not a consensus view; aggressive

CNSI: Communication, Navigation, Surveillance, Information
UML: UAM Maturity Level

AAM Ecosystem Goal Definition:
Advanced Urban Capable Aircraft

Ecosystem Goal	Ecosystem Goal Statement
V.6 Advanced Urban Capable Aircraft	Type-certified and commercially operational second-generation UAM aircraft with capabilities suitable for advanced, sustainable operations in dense urban environments that have improvements over first-generation UAM aircraft in noise, range, weather tolerance, aircraft turn-around time, and energy storage systems.

WG Notes/Feedback:

"AAM Ecosystem Goal" Definition: Significant capability or achievement by leading ecosystem entities marking advancements in the maturation of AAM capabilities towards medium density medium complexity operations. Ecosystem Goals are achieved through one or more Objectives.

Barriers to the AAM Ecosystem Goal:
Advanced Urban Capable Aircraft

AAM Ecosystem Goal Barriers				
	Description of Barrier	What Needs to be Addressed (Gap)	How Can it be Addressed	When Does it Need to be Addressed
Barrier n				

Nov 18, 2021 Poll Results

Response	Upvotes		Response (cont'd.)	Upvotes
Comfortable ride	6		Maneuverability is a cluttered environment	2
10^-9 reliability	5		Matched separation standards and navigation/surveillance requirements for low separation operations.	2
Very low noise	5		Integration with infrastructure, procedures and automation to permit high intensity unscheduled operations.	2
Gust response	5		Backup safety systems (to mitigate catastrophic failures; e.g., full-aircraft parachutes, deployable energy absorbing systems, etc.)	2
Extensive flight test program	4		standard or universal vehicle control system	1
Sustainability	4		Ability to vacate (disperse) from a declared no-fly zone	1
Community Acceptance	3		"hardened" to avoid RF interference	1
We don't really know yet. Urban will come way later than Rural and Sub-urban.	2		Certification process that allows for rapid incorporation of safety improvements that has a cost comparable to the benefit provided	1
Very low operating cost	2		high precision navigation capabilities in tight urban areas (with multipath interference, degraded GPS capabilities, etc.)	1
Potential need for proven operation in lower risk use cases prior to "Urban" use	2		in-flight mission change/re-tasking	1
ADA Compliance	2			

Ecosystem Goal Responsibilities: Advanced Urban Capable Aircraft

Order based on relevance to milestone, most relevant on top.

Partner	Recommended Responsibility
NASA	Role to deliver NASA R&D products aligned with critical industry needs aligned with NASAs areas of expertise. Focus areas include concepts, technology development, simulation, flight test, requirements, architectures, standards, etc.
FAA	Role of FAA as primary regulator and other responsibilities for leadership, R&D, Air Traffic Management, Safety, and Policy, etc.
Industry	Description of what the commercial UAM Industry must accomplish including technologies, standardization, certification, and operations.
SDOs	Role of SDOs in technical standards development.
OGAs	Role of critical OGAs including Excom members (FAA, NASA, OSD, DHS, DOC, DOJ) and their affiliated programs and efforts (Agility Prime).
States and Localities	Role of state and local governments to fill in the gaps of national policy, conduct initial analysis, and partner with industry to support initial development and deployment.
Other	Role of any other entity. Note, add new rows as needed to capture other partners.

Include as many or few partners as relevant to the milestone

Ecosystem Goal Roadmap: Advanced Urban Capable Aircraft

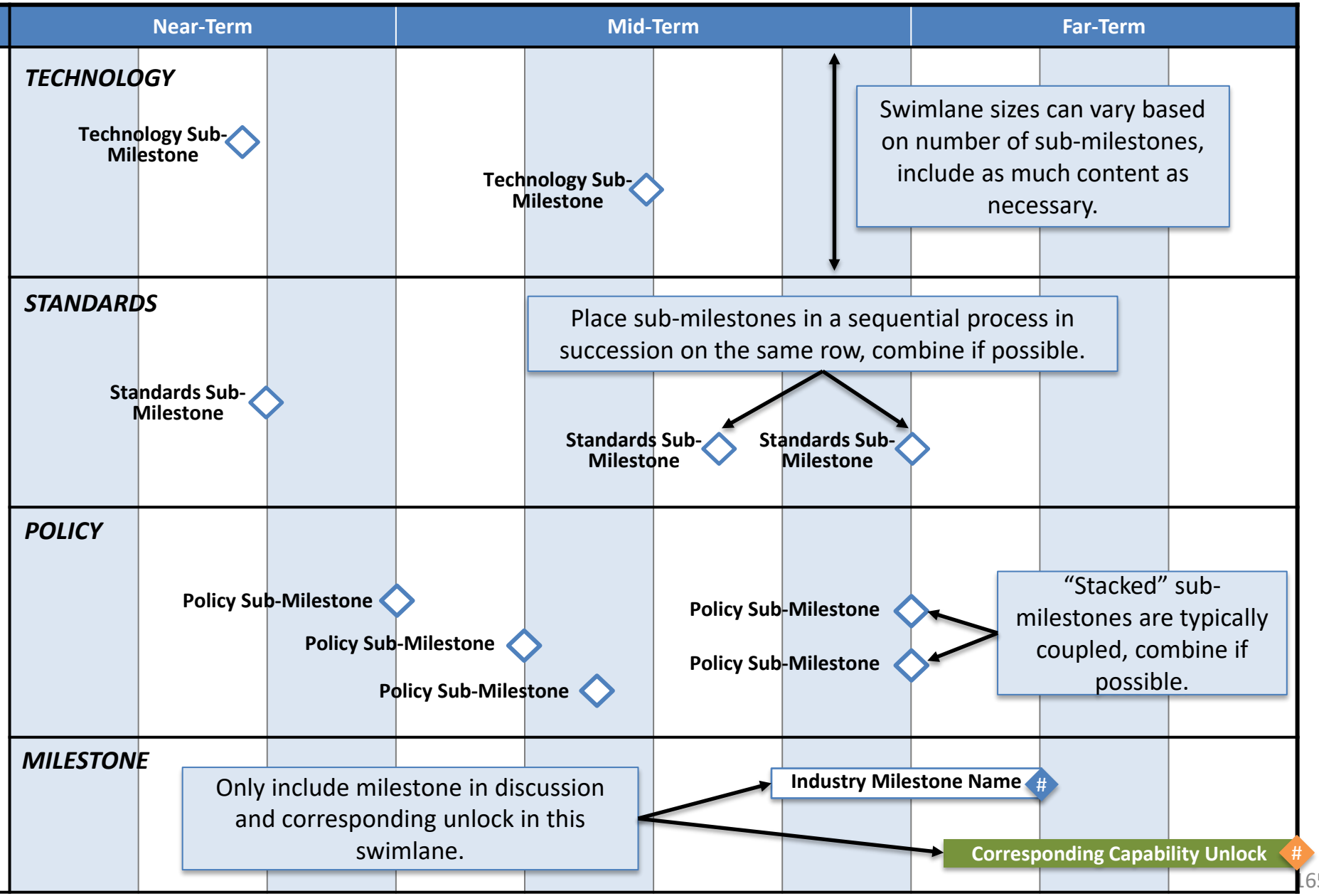
Ecosystem Goal:
V.6 Advanced Urban Capable Aircraft

Operational Objective:

Type-certified and commercially operational second-generation UAM aircraft with capabilities suitable for advanced, sustainable operations in dense urban environments that have improvements over first-generation UAM aircraft in noise, range, weather tolerance, aircraft turn-around time, and energy storage systems.

Target Year:

2028



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