

From the Knowledge-based Digital Platform (KbDP) Concept for Advanced Air Mobility Research to a Preliminary Prototype

Forum: TPAT December 7, 2022
Presenters: Nipa Phojanamongkolkij, NASA Langley Research Center
Lead Systems Engineer, ATM-X UAM Subproject
Ian Levitt, NASA Langley Research Center
Principal Engineer, ATM-X UAM Subproject
Braxton VanGundy, NASA Langley Research Center
Software Developer



Purpose

Describe the Knowledge-based Digital Platform (KbDP), its preliminary prototype, and get feedback from TPAT

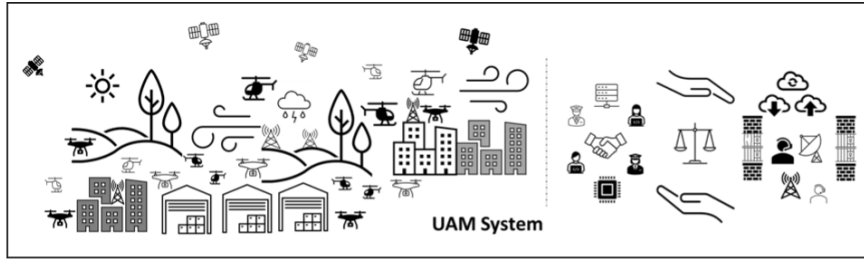


Outline

- Background (15 min)
- Proposed Solution – the KbDP (15 min)
- Preliminary Prototype
 - User Story 1, Demo, Discussion (20 min)
 - User Story 2, Demo, Discussion (10 min)
 - User Story 3, Demo, Discussion (15 min)
 - User Story 4, Demo, Discussion (10 min)
 - User Story 5, Demo, Discussion (5 min)



Background – Draw from the Previous TPAT Forum



UAM Airspace Research Roadmap

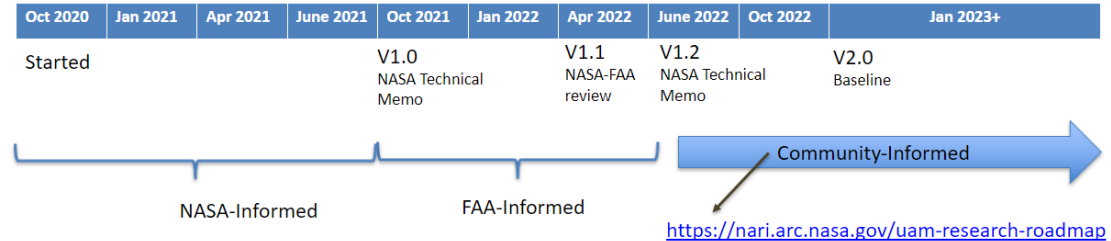
Forum: TPAT June 6, 2022
Presenter: Ian Levitt, NASA Langley Research Center
Principal Engineer, ATM-X UAM Subproject



UAM Airspace Research Roadmap

A living document that describes how research informs the progression of UAM airspace capabilities

High-level requirements
Assumptions
Constraints



UAM System of Systems

partially decomposed into capabilities that cover the airspace system

- Airspace Mgmt
- Airspace Design
- Regulations & Policies
- Communications
- Navigation
- Secured Airspace
- Separation Services
- Surveillance
- Vertiport Operations
- Weather

Progress of Time

- Research Assumptions will
- Research Requirements shall/should
- Operational and Functional
- TBR

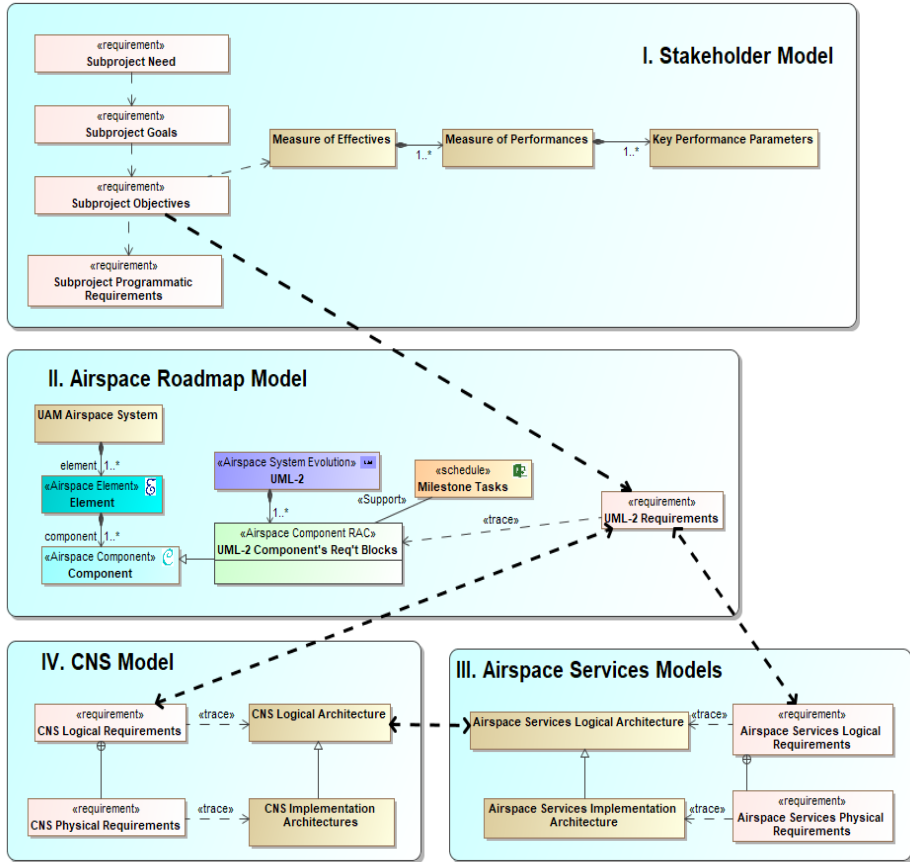
Roadmap and system engineering (SE) methodology

For latest info, see [Roadmap Rev 1.2](#)

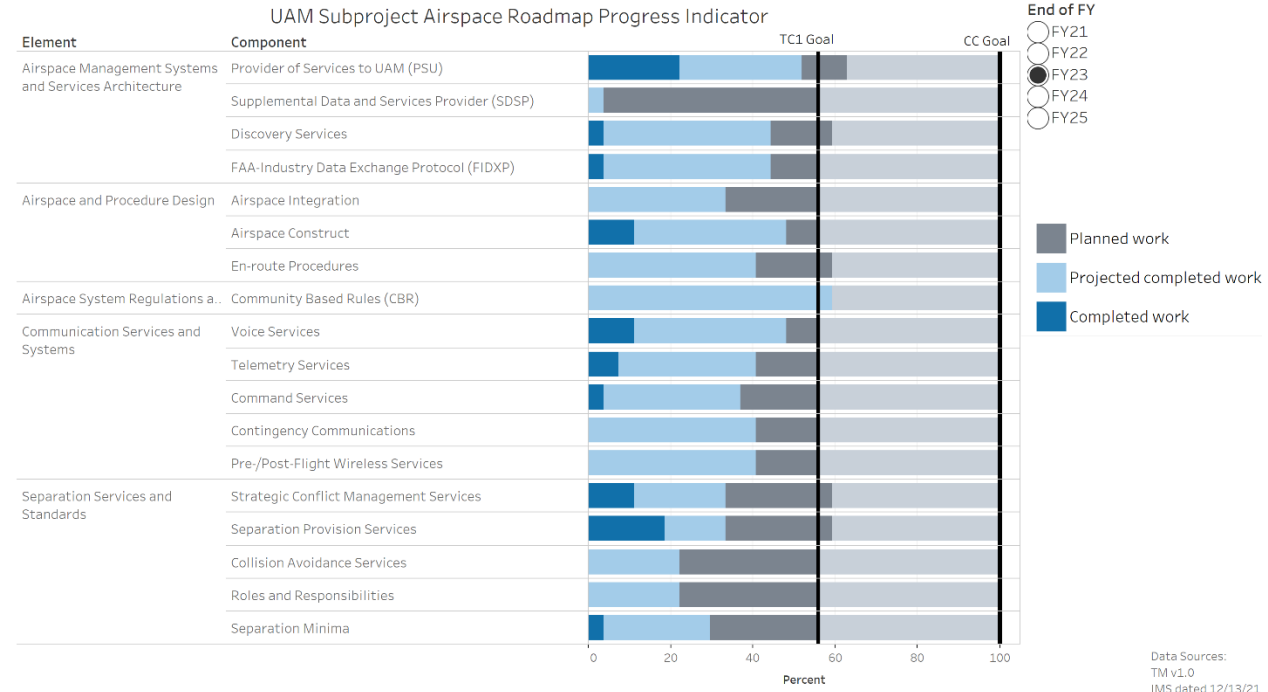


Under-the-hood System Engineering

Digital Engineering methodology



Lower-level requirements
 Inter-dependency traces
 System analysis
 Dashboard reports




Phojanamongkolkij, N., Levitt, I., Barnes, P. "Overview of Model-Based Systems Engineering Efforts to Evolve the Airspace Research System Roadmap," 2022 AIAA Aviation Forum, June 2022

Cheng, A., Witzberger, K., Phojanamongkolkij, N., and Levitt, I., " Urban Air Mobility (UAM) Airspace Research Roadmap Systems Engineering Approach to Managing Airspace Evolution Towards UML-4," 2022 AIAA Aviation Forum, June 2022



Identifying Airspace Research Gaps beyond UAM Subproject

NASA/TM-20220008917

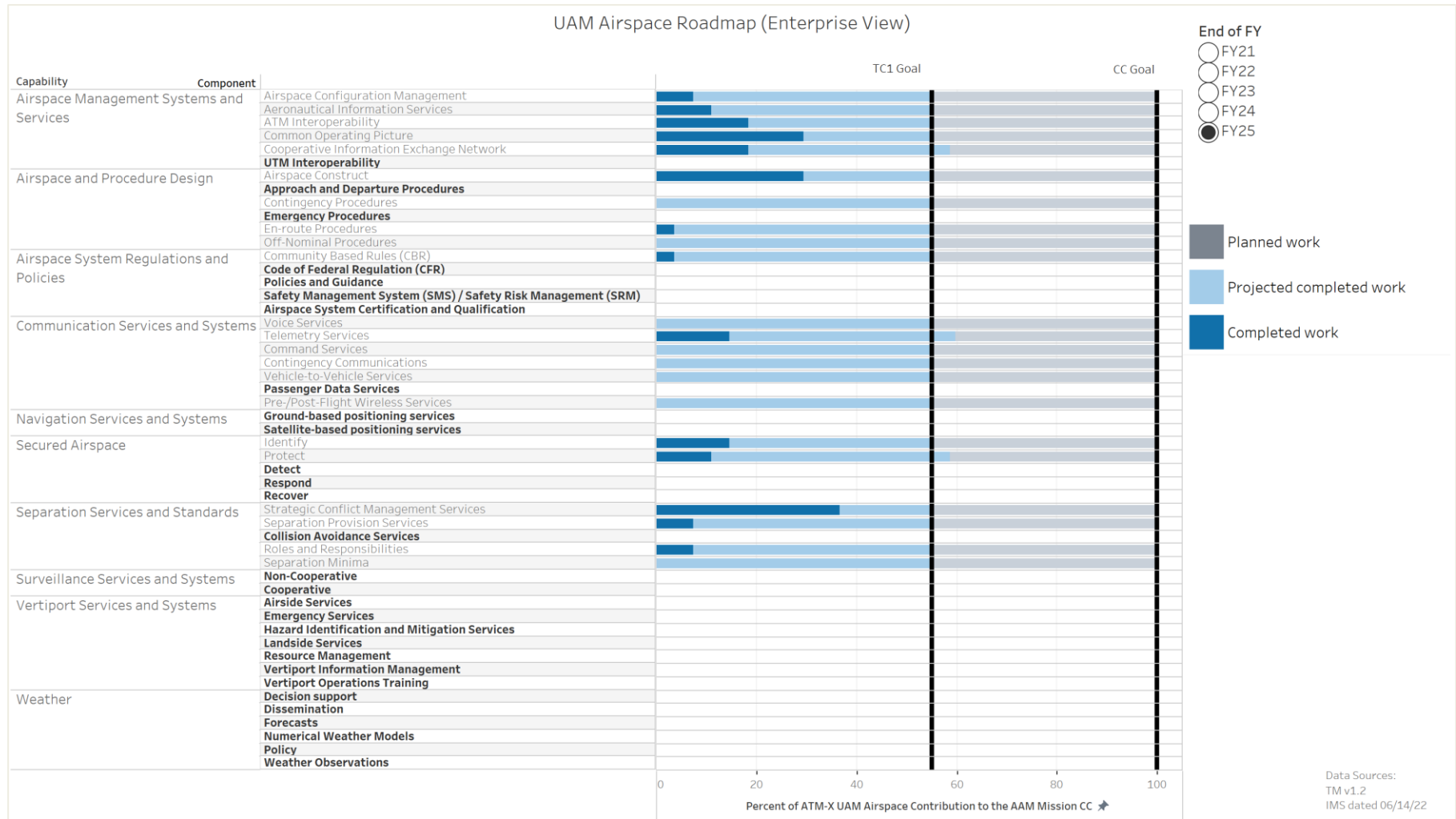


UAM Airspace Research Roadmap
Rev 1.2

*Ian Levitt, Nipa Phojjananongkolksj, Adam Horn
Langley Research Center, Hampton, Virginia*

*Kevin Witzberger
Ames Research Center, Moffett Field, California*

June 2022



Significant gaps to Advanced Air Mobility (AAM), National Airspace System (NAS), or the National Transportation System (NTS)

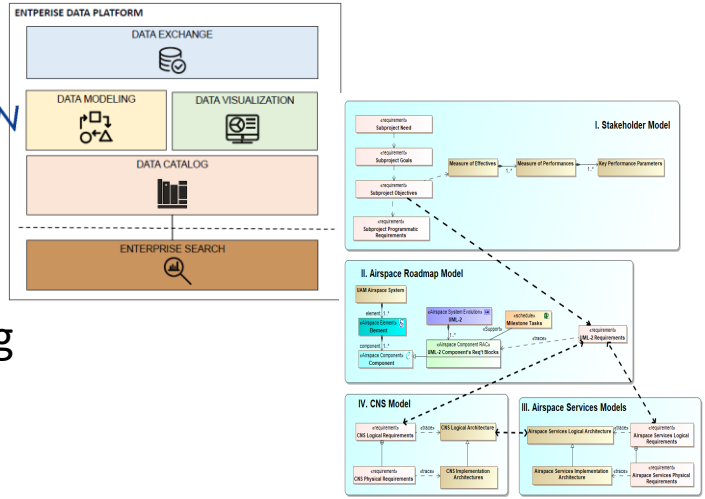


Problem Statement

- Stove-piped R&D across the aerospace and transportation community
- Lack of integrated research strategies and research outcomes
 - leads to inefficient research investment decisions and tech transfers of limited utility
- Lack of complete enterprise understanding of the problem
 - makes enterprise-level challenges (e.g., sustainability, supply-chain) intractable
 - leads to sub-optimal solutions that have not considered the entire problem space



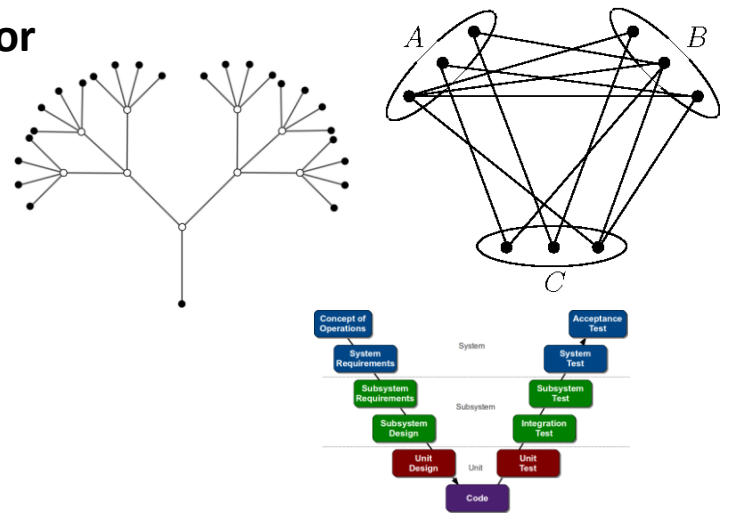
Elements of the Proposed Knowledge-base Digital Platform (KbDP)



- MBSE
- Digital Engineering
- Machine Learning

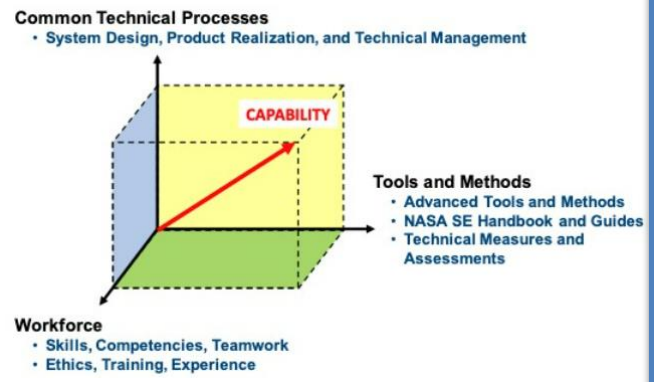
Mathematical Rigor

- Graph Theory
- Data Science
- System Engineering



Change Management

- Researcher, Project Manager, and System Engineer
- Building coalition



NASA Procedural Requirements (NPR) [7123.1C](#), 2020

Technology Transfer

- Research pipeline with Industry and FAA
- Technical readiness and operational readiness

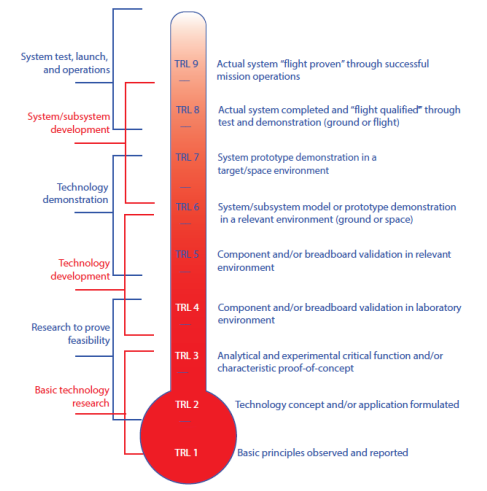
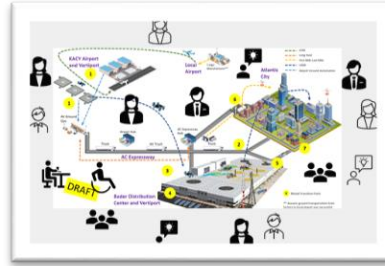


FIGURE G.4-1 Technology Readiness Levels

NASA Systems Engineering Handbook Revision 2, [Appendix G](#), 2020



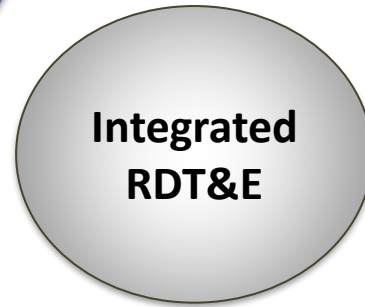
An Innovation Ecosystem for Transportation



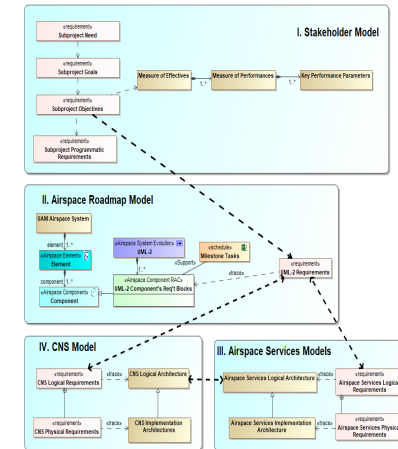
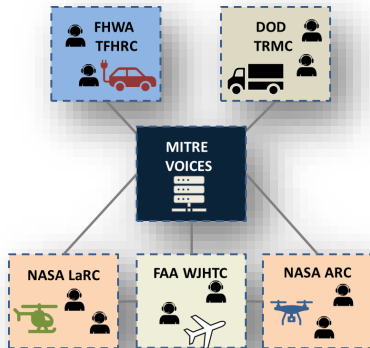
Stakeholder Engagement

Discover

Explore



Capture



Live, Virtual, Constructive (LVC) environment

Digital Engineering

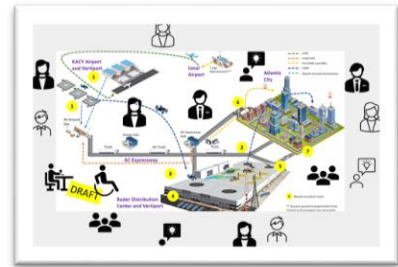


An Innovation Ecosystem for Transportation



Aligns with non-IT Agile best practices and processes

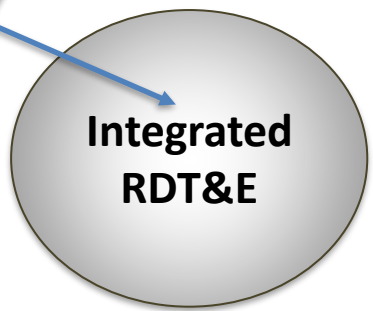
Recognized by NextGen as 10% of the TBO problem



Who's **NOT** at the table?

Stakeholder Engagement

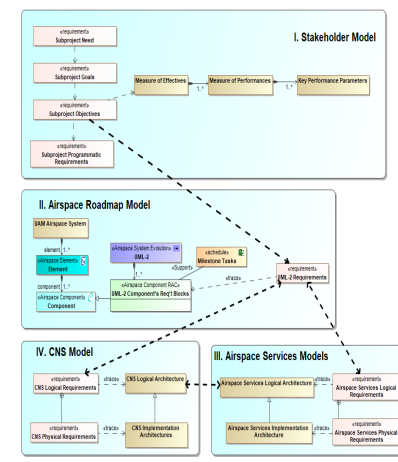
Discover



Explore

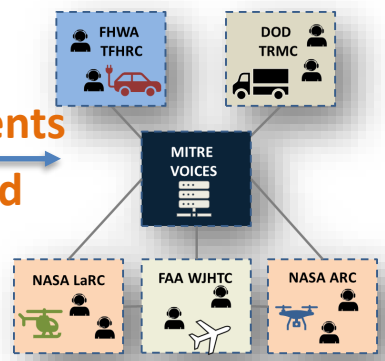
MBSE efforts are necessary, but not sufficient

Must be enterprise-level



Capture

Agreements Needed



Live, Virtual, Constructive (LVC) environment

Digital Engineering

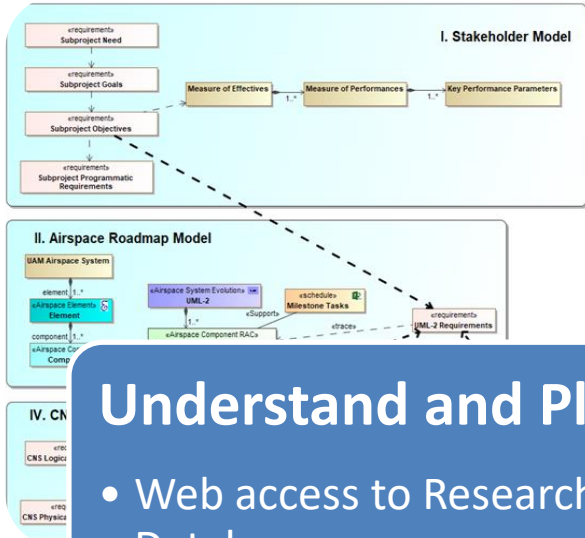


Exploration Workflow

Digital Engineering

Stakeholder Engagement

LVC Environment



Understand and Plan

- Web access to Research Database
- Provide necessary detail

Discuss and Define

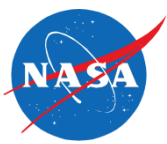
- Scenario-based discovery
- Inclusive and diverse
- Detailed exploration

Build and Execute

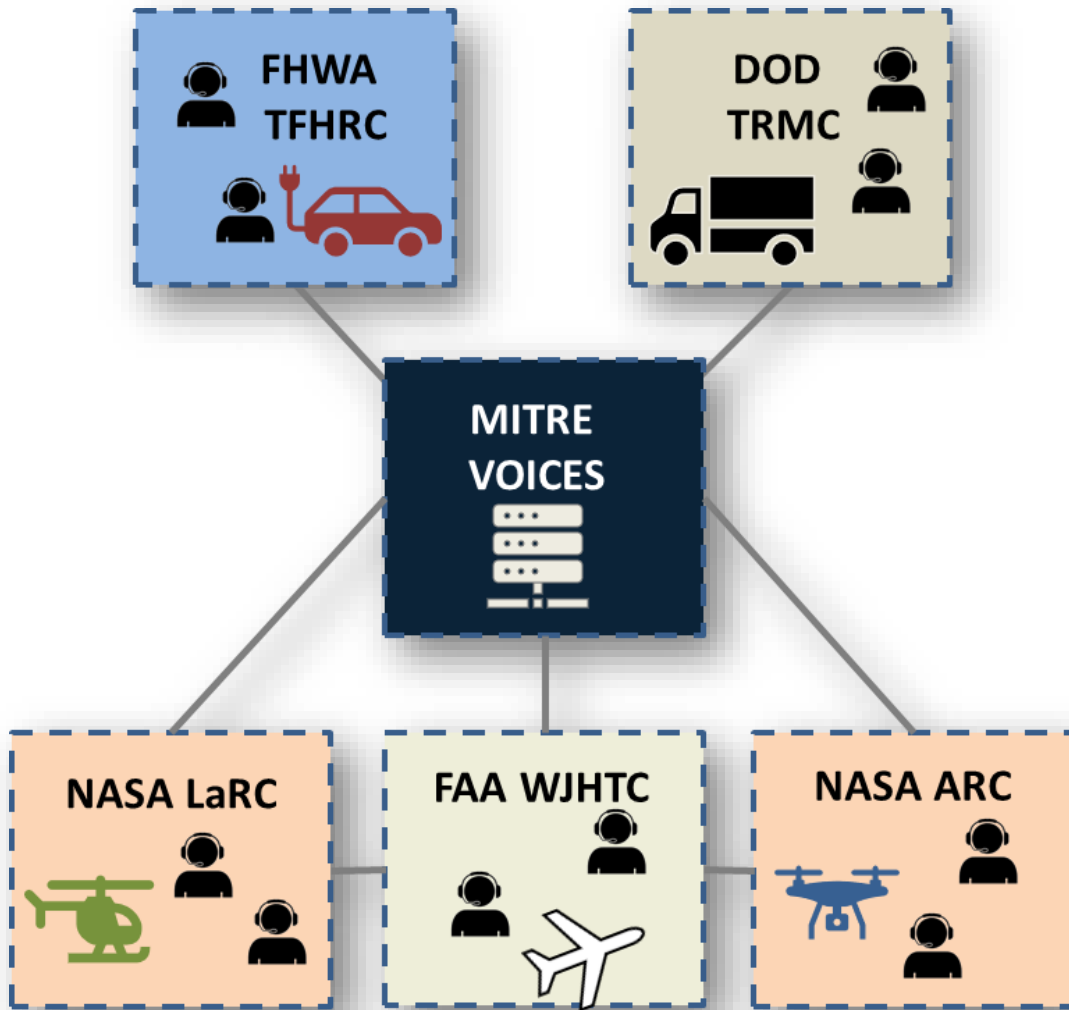
- Learn by Doing
- Info-Centric Sandbox
- Safety and Performance

Goal to reduce cycle from **years to months**





LVC Environment



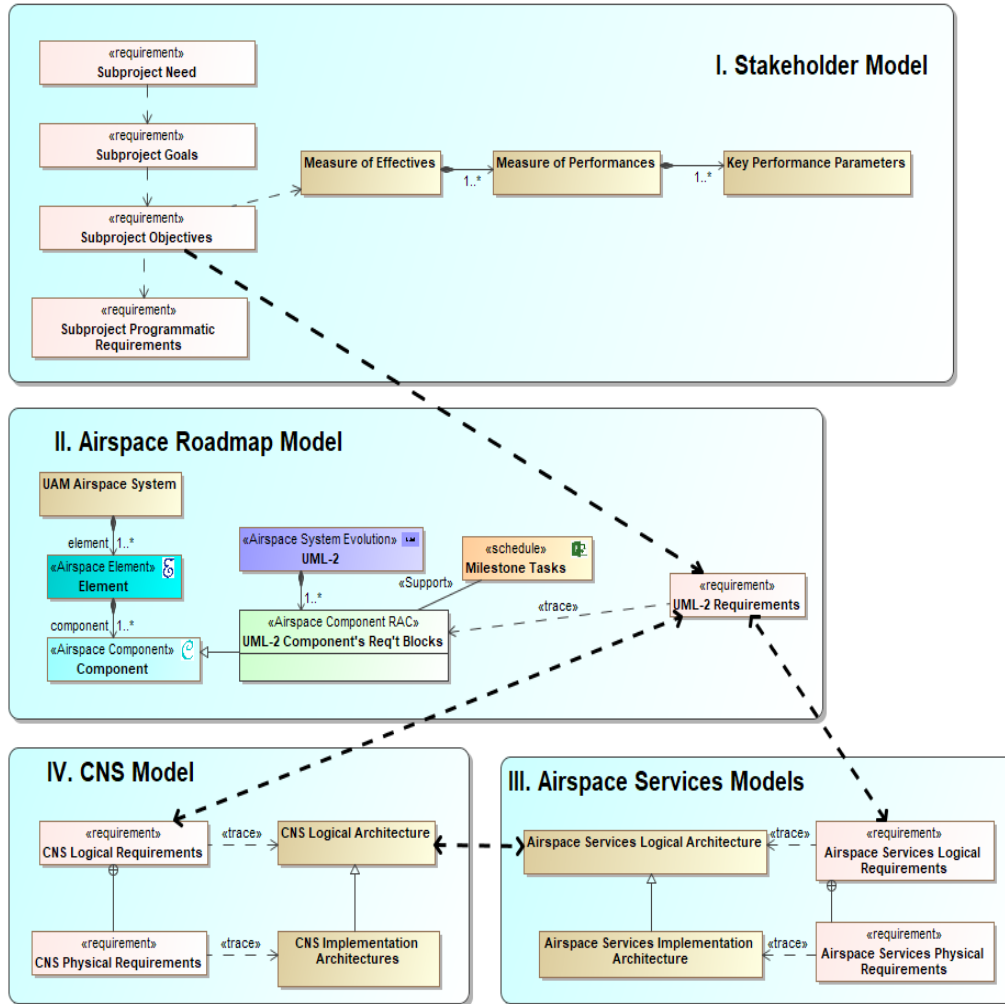
Proposed Distributed Simulation Capability

- Persistent, info-centric sandbox capability
- Explore data exchanges, operational procedures, human-machine roles
- Collect safety and performance info, feed decision-making
- Public / Private ownership, access and governance



Digital Engineering

Knowledge database of integrated research results, with web-based user interface for RDT&E



- Proof of Concept with early prototype established for UAM Airspace
- Lightweight process to formalize learnings, enabled by AI/ML
- User Stories include standards and literature search; research planning; scoping assumptions; and certification support
- Public/Private model that compliments the LVC
- Low-TRL NASA technology, could be ready for transfer in 5-7 years



Vision

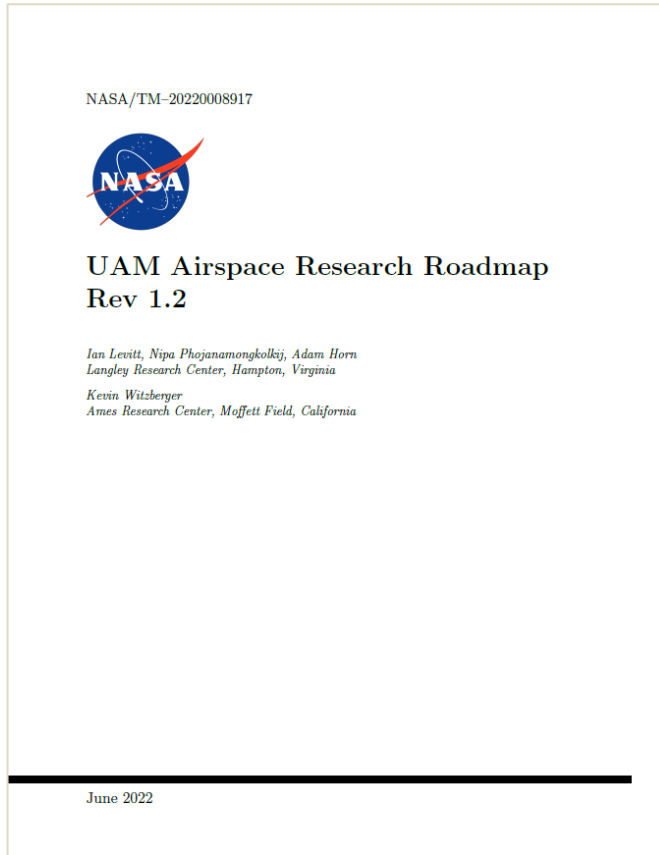
A future transportation system evolved to ... (safe, equitable, resilient, sustainable, competitive) ... that enables ... (peace, prosperity, societal change)



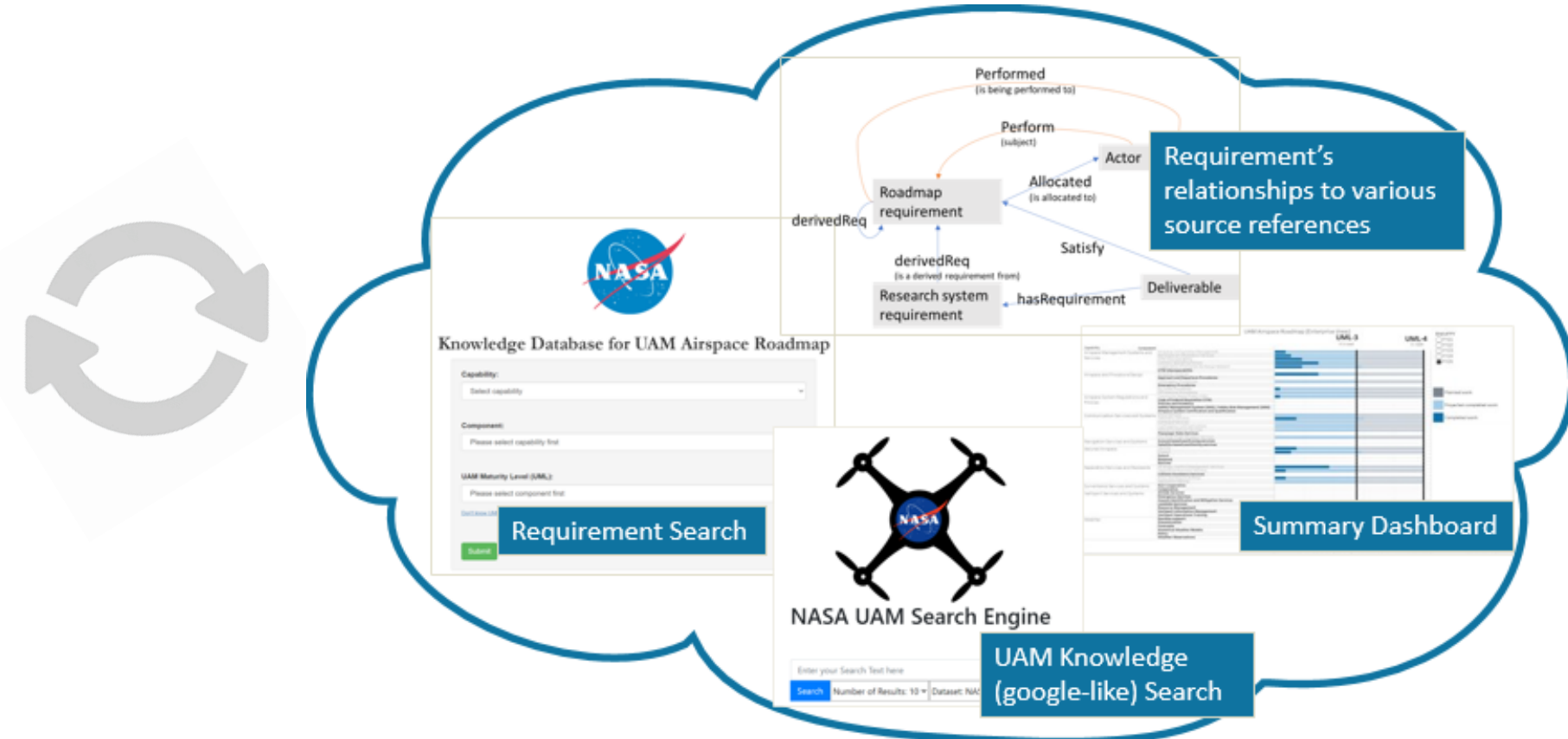


Current KbDP Strategy

From Document-based



To Digital/Cloud-based

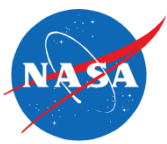


Tools and Methods:

Systems Engineering: SE processes, SysML

Data Science: graph theory and algorithm, machine learning, data visualization, experimental design

Software Development and Infrastructure: web/software development, Google Cloud Platform, Amazon Web Service

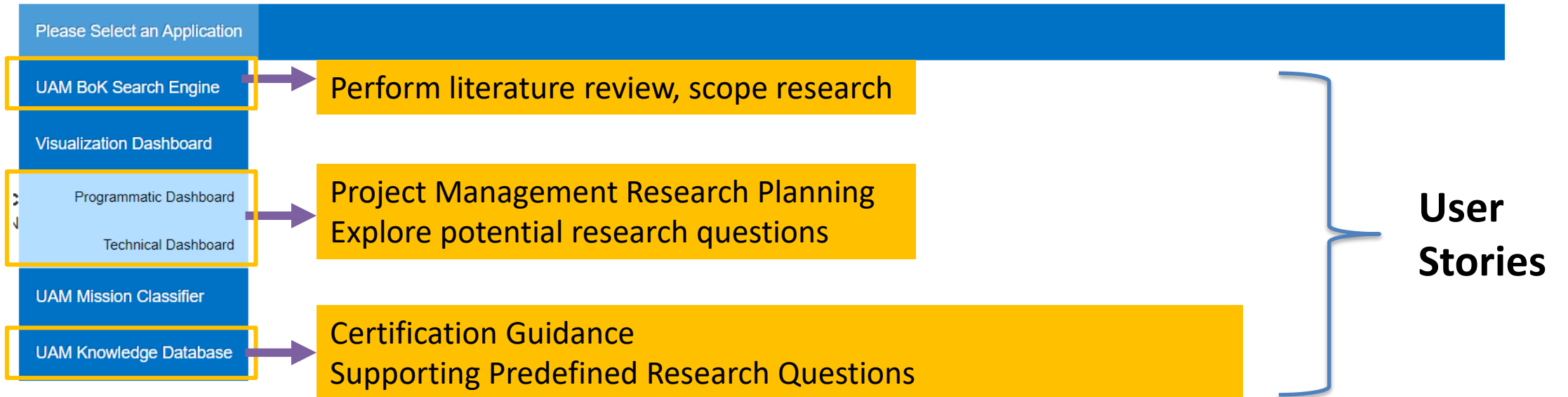


Early Prototype Web-service

Prototype web-service: [UAM Knowledge Database \(nasa.gov\)](https://nasa.gov)



Knowledge Database for UAM Airspace Research





DEMO



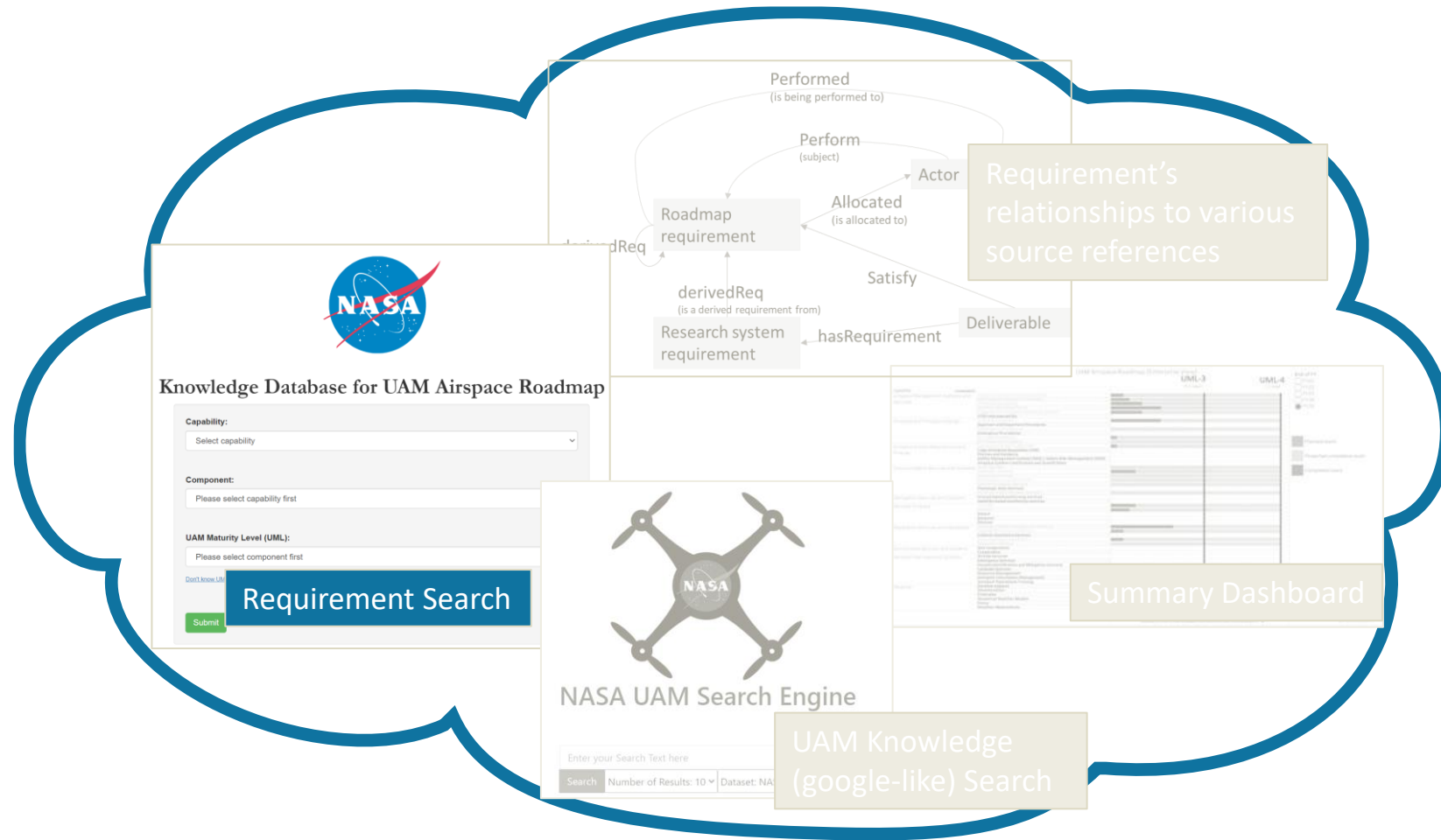
Discussion

- Does this user story make sense?
- Does the web-application support the story?
 - What works?
 - What doesn't work?
- How to improve the user experience?



User Story 2 – Supporting Predefined Research Questions

Individual researcher is planning a research activity, and wants to identify prior research, research gaps, areas of need, relevant requirements and assumptions.



Tools and Methods:

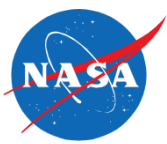
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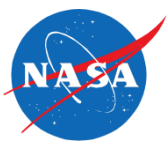


DEMO



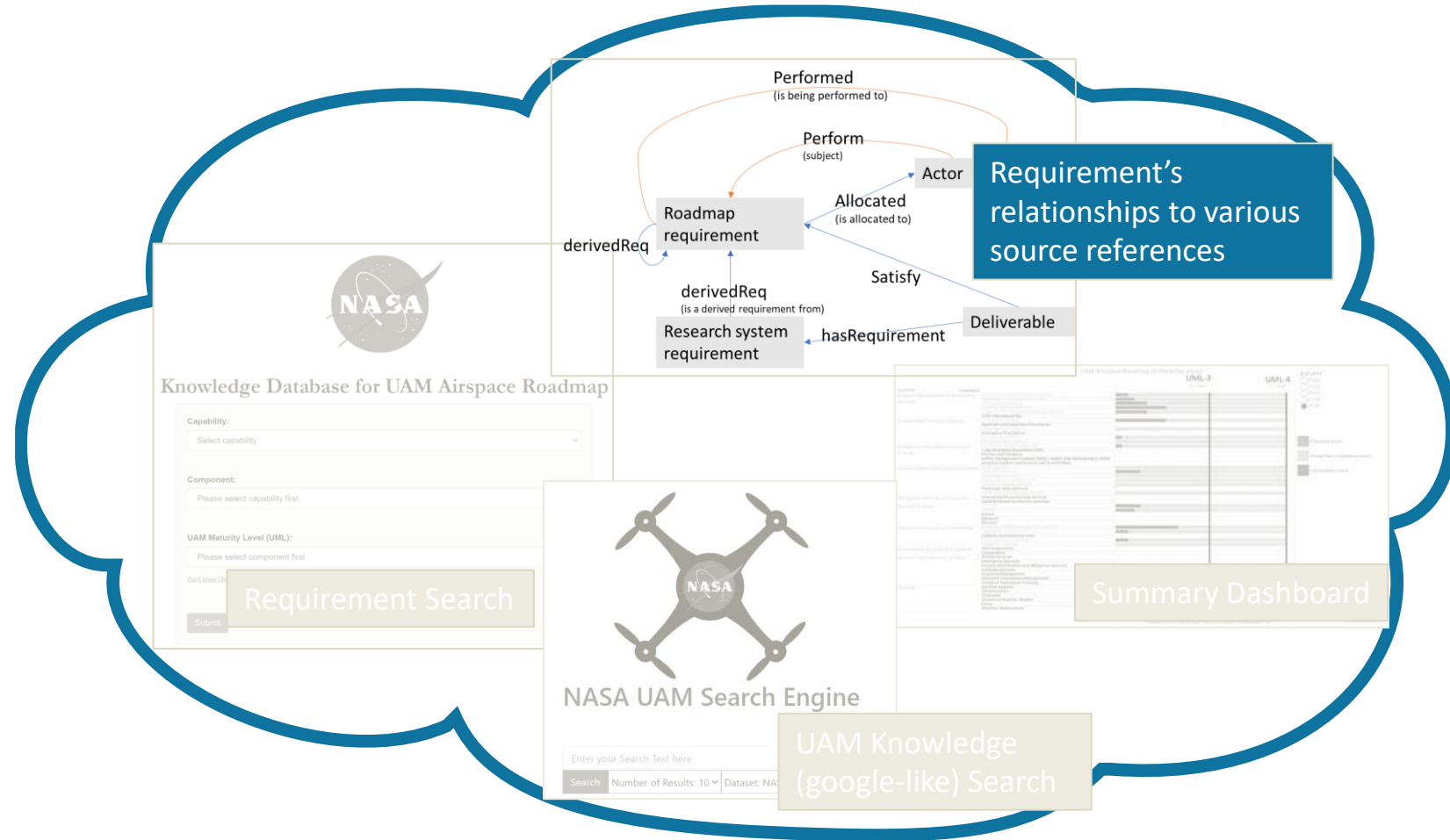
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User Story 3 – Research Insights

Researchers would like to explore dependencies among system of systems. They can visualize the dependencies to understand the “what” and can drill down to dependent requirements to understand the “why and how”.

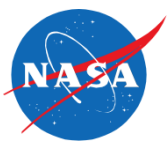


Tools and Methods:

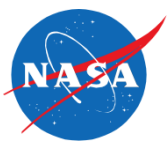
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DEMO



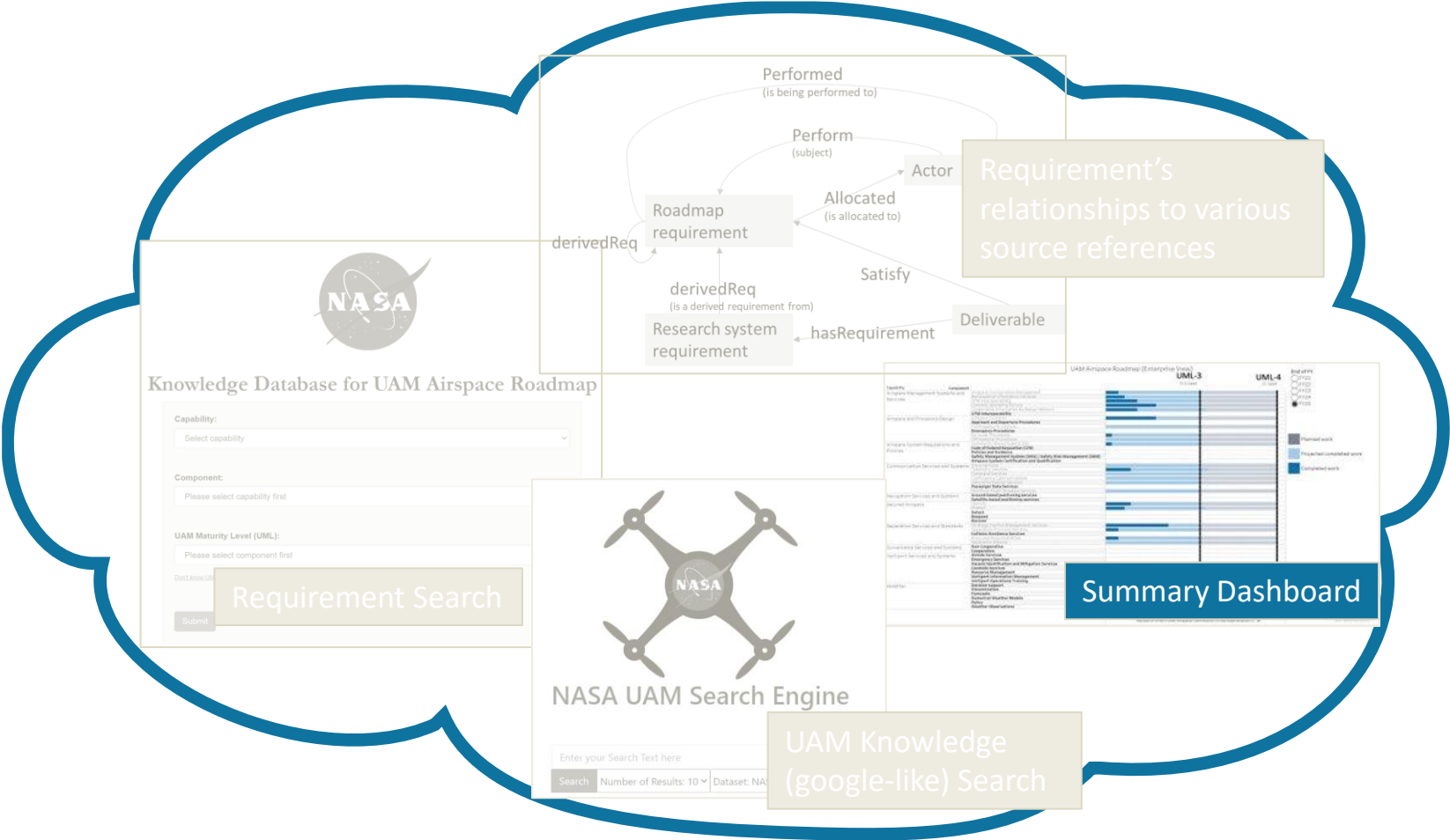
Discussion

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User Story 4 – Project Manager Research Planning

Project Manager and Principal Engineer are planning research for the next few years. They would like to visualize the research gaps, and where research is most needed, dependencies and opportunities with other projects.

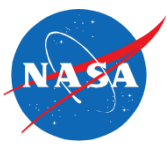


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DEMO



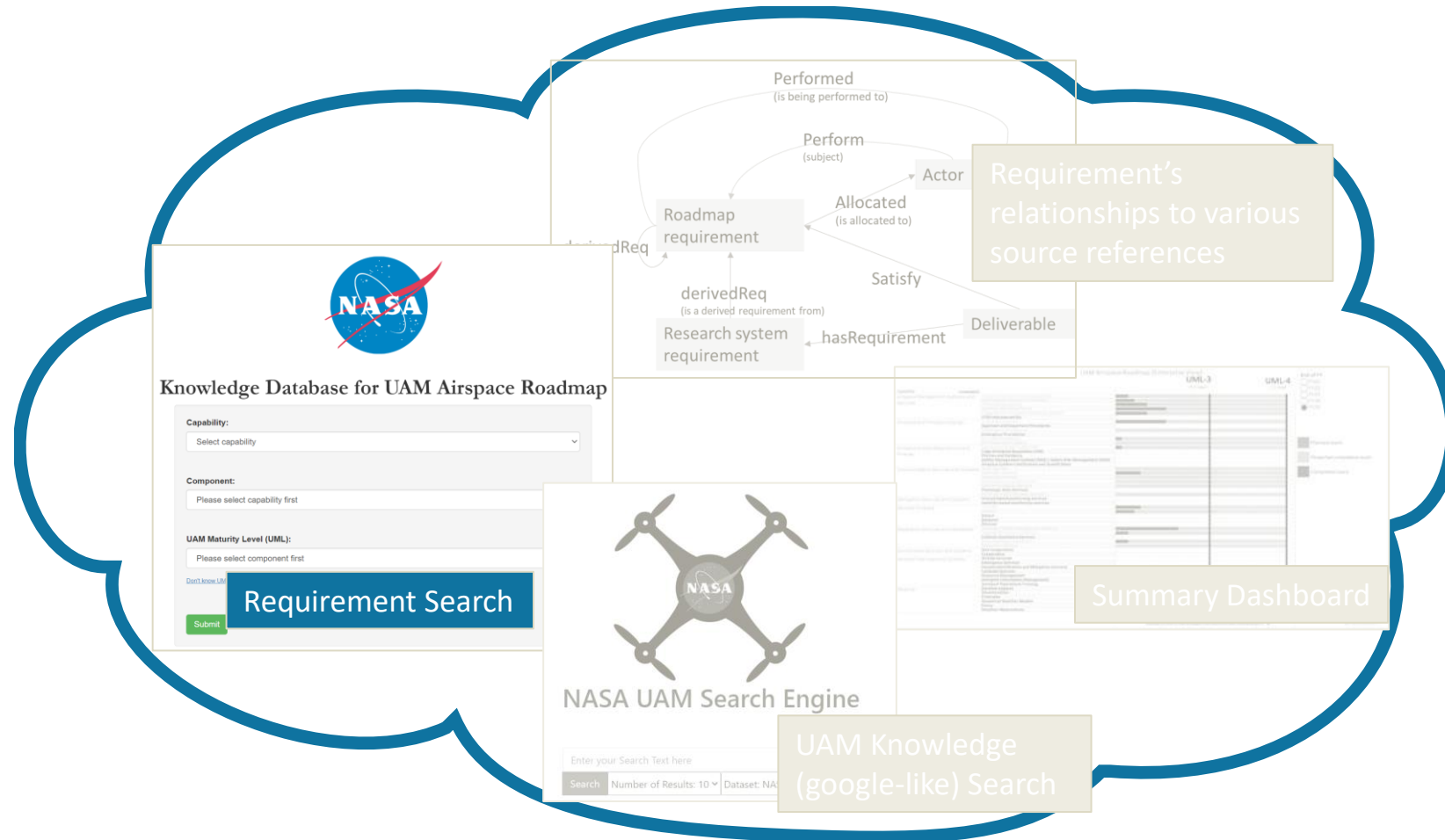
Discussion

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User Story 5 – Certification Guidance

A Service Provider (e.g., PSU) has decided to prepare for the certification for a given service (e.g., conformance monitoring) at UML-2 (or UML-3/4). The SP would like to get a list of UML-2 requirements that are used for the certification process.

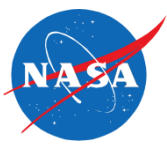


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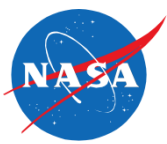


DEMO



Discussion

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- Does the web-application support the story?
 - What works?
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- How to improve the user experience?



Conclusions and Next Steps

Have accomplished:

- Proof of Concept with early prototype established for UAM Airspace
- Lightweight process to formalize learnings, enabled by AI/ML
- User Stories include standards and literature search; research planning; scoping assumptions; and certification support

Path forward:

- Address feedbacks and suggestions



BACKUP



UAM Airspace Research Roadmap

A living document that describes how research informs the progression of UAM airspace capabilities

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