



EXPLORE FLIGHT

WE'RE WITH YOU WHEN YOU FLY

Autonomy in Aviation: Human Roles and Responsibilities

Kelley Hashemi, NASA Airspace Operations and Safety Program

NASA Aeronautics – Vision for Aviation in the 21st Century



ARMD continues to evolve and execute the Aeronautics Strategy
<https://www.nasa.gov/aeroresearch/strategy>

6 Strategic Thrusts



Safe, Efficient Growth in Global Operations



Safe, Quiet, and Affordable Vertical Lift Air Vehicles



Innovation in Commercial Supersonic Aircraft



In-Time System-Wide Safety Assurance



Ultra-Efficient Subsonic Transports



Assured Autonomy for Aviation Transformation

U.S. leadership for a new era of flight

ARMD PROGRAMS

Airspace Operations and Safety
Program



Advanced Air Vehicles
Program



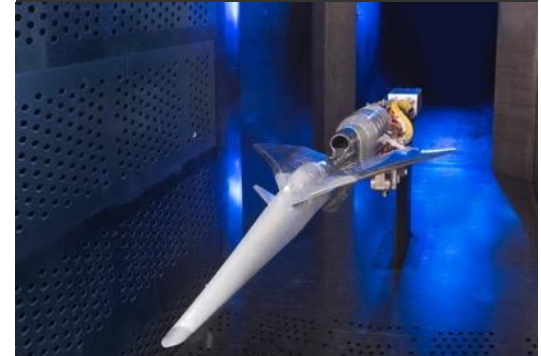
Integrated Aviation Systems
Program



Transformative Aeronautics
Concepts Program



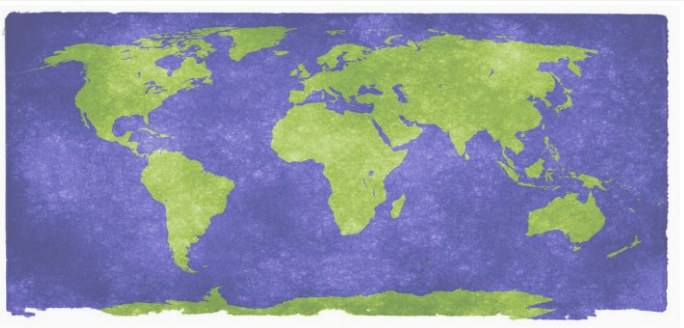
Aerosciences Evaluation and
Test Capabilities Portfolio



Drivers of airspace design

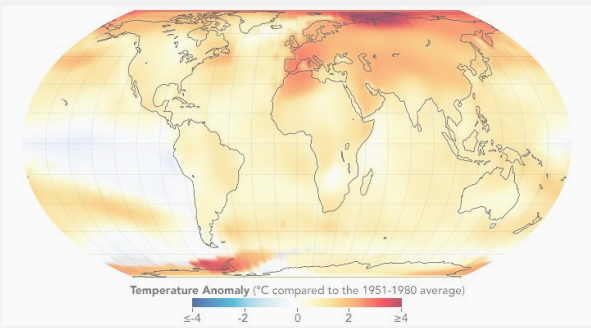
Complex ecosystem of social and technical needs

US Economic Growth



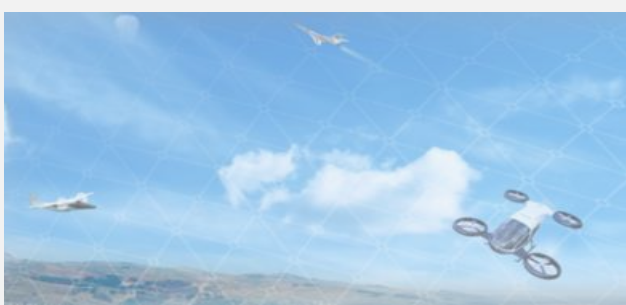
- *Global competition*
- U.S. Leadership ~\$9T UAM mkt by 2050¹

Sustainability



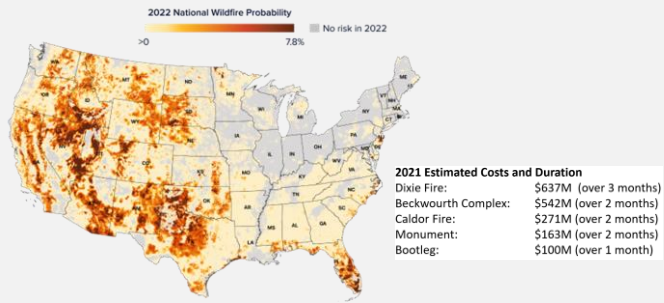
- *Climate change*
- Meet U.S. Net Zero 2050 Goals

Greater Mobility



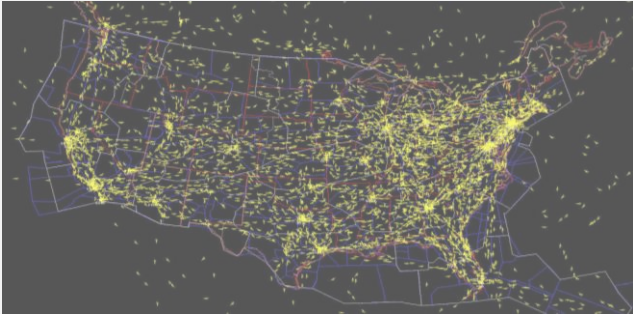
- *Slow pace in meeting market demand*
- Diverse, scalable mobility solutions

Public Benefit



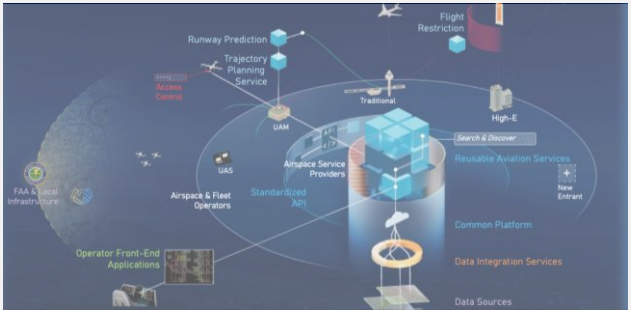
- *Inability to leverage aviation capabilities*
- Unleash new humanitarian solutions

Maintain Safety



- *Growing complexity threatens safety*
- Develop next generation of safety

Emerging Innovation



- *Integration complexity delays benefits*
- Adapt at the pace of innovation

2050: Sky for All

A vision for the future airspace



Sustainable Aviation

Seamless Skies



Ubiquitous Resilient Operations

Operator Empowerment



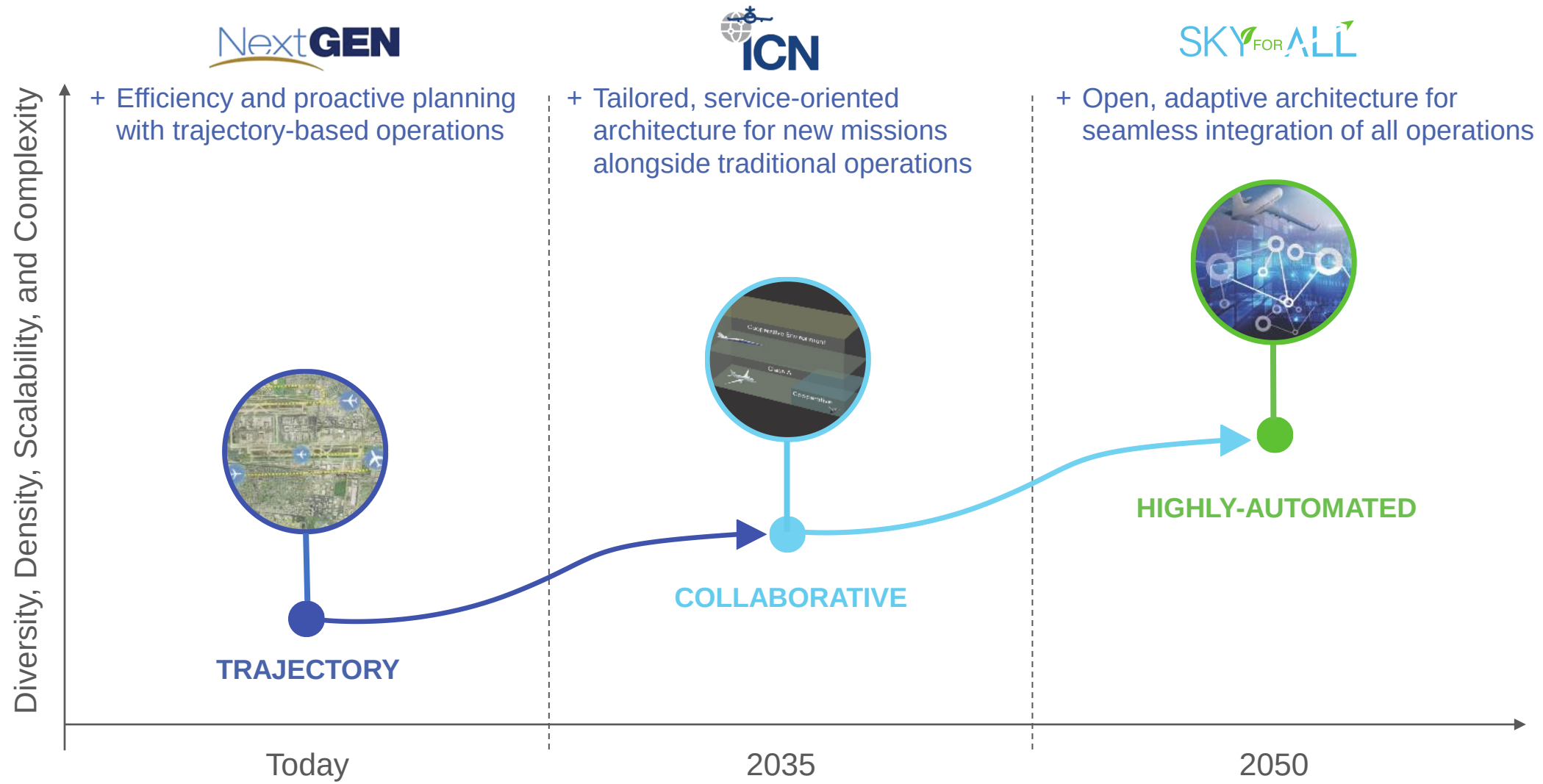
Learning-Based System of Systems

SKY^{FOR}ALL

- NASA-led effort to gather inputs from the aerospace community and FAA
- Co-developed vision of a mid-21st century shared airspace that is agile, scalable, optimizable, accommodating of diversity, and equitable
- Evolution from trajectory-based operations to collaborative and highly automated operations

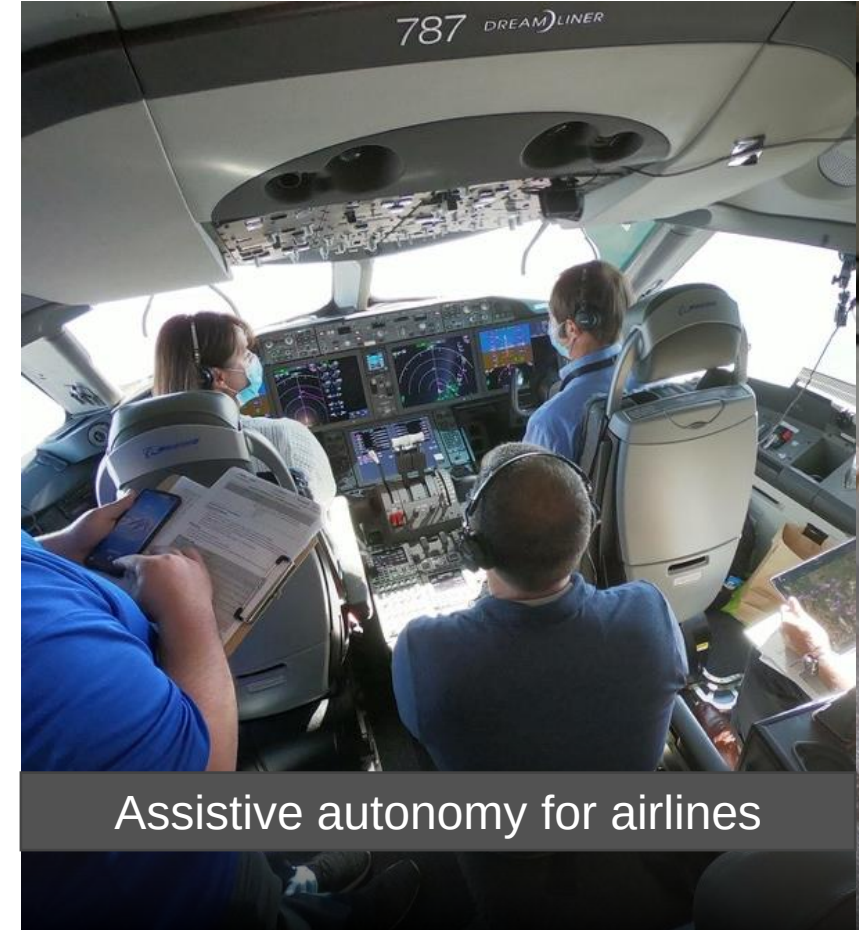
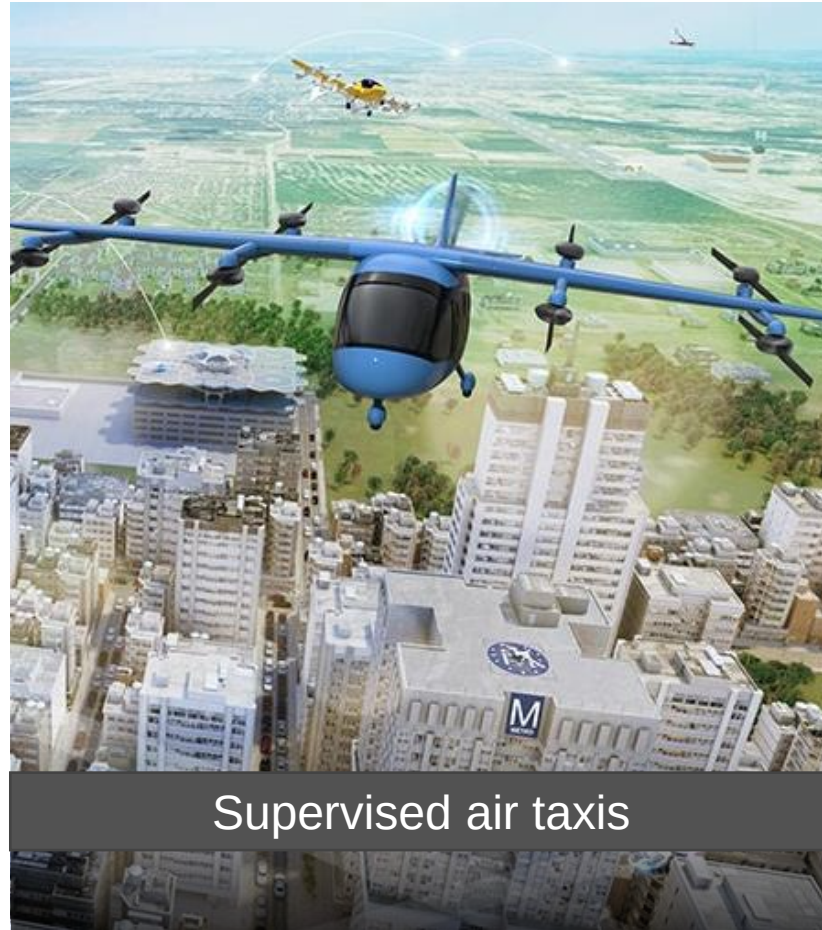
Path to Sky for All

Building from airspace advancements underway



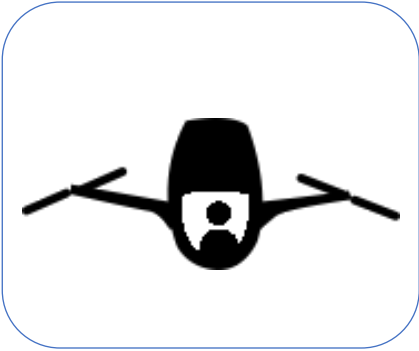
What does autonomy look like?

Level and timeline vary by use case

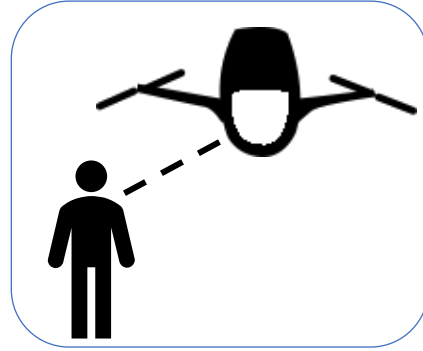


Operational modalities

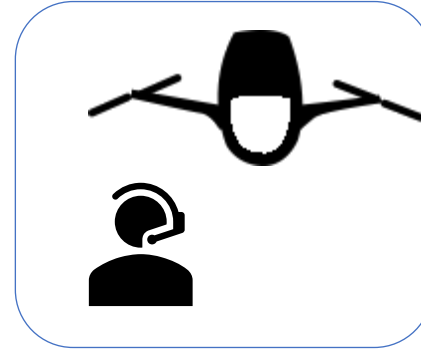
Facilitates range of autonomy levels



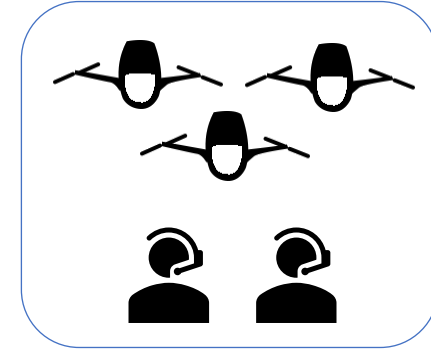
Piloted with simplified operations



Remotely piloted



1:1 Remotely supervised



m:N Remotely supervised

- Human always remains a part of the system
- Teaming modalities not exhaustive—look to industry for desired ConOps
- Not a strict progression

R&D on R&R

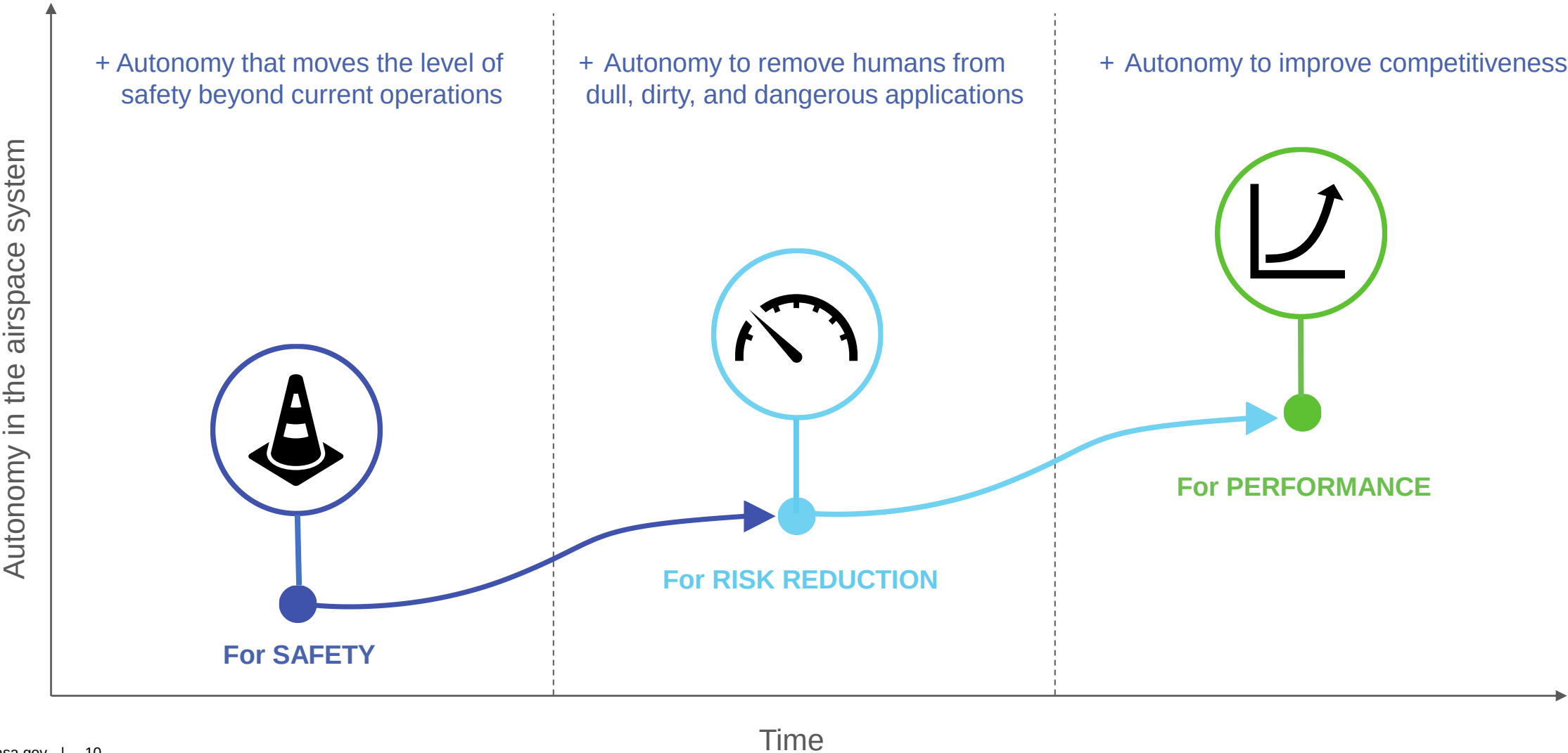
What informs appropriate human roles and responsibilities?

- Foundational human-autonomy teaming research
 - Trust calibration
 - Shared mental models
 - Bi-directional communication
- Workload
- Multi-vehicle (m:N) operations
 - Communication and handoff procedures
 - Displays
- Human contributions to safety
- Collective autonomy
- Vehicle technology
 - Contingency management
 - Perception, DAA
- Airspace integration
 - Communications
 - Spacing and separation
 - Cooperative procedures
- Safety and regulations



Path to increasing autonomy

Consider the benefit of implementation



Parting thoughts

Level of autonomy is a product of task complexity, environment, and technology.

- Consider the airspace operations ecosystem
 - **Services** and **infrastructure** also facing human/autonomy questions
 - Broad autonomy adoption leads to **system of systems** considerations
- **Heterogeneous operations** will be the norm
 - E.g. Level of autonomy, use case, ConOps
 - Segregation is not a desirable solution
- Autonomy is not just a technology problem



Questions?

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