In-Time Aviation Safety Management Systems

IASMS

Examining The Changing Roles and Responsibilities of Humans

NASA

System-Wide Safety

CROWN
AIR MOBILITY. ADVANCED.

Lawrence J. Prinzel III, Ph.D.
Senior Technical Advisor
NASA System-Wide Safety Project
May 19, 2021

This is a prerecorded presentation for the 21st International Symposium on Aviation Psychology

Examining The Changing Roles and Responsibilities of Humans in Envisioned Future In-Time Aviation Safety Management Systems

Lawrence J. Prinzel III, Ph.D.
Kyle K. Ellis, Ph.D.
John H. Koelling

Langley Research Center
Hampton, VA

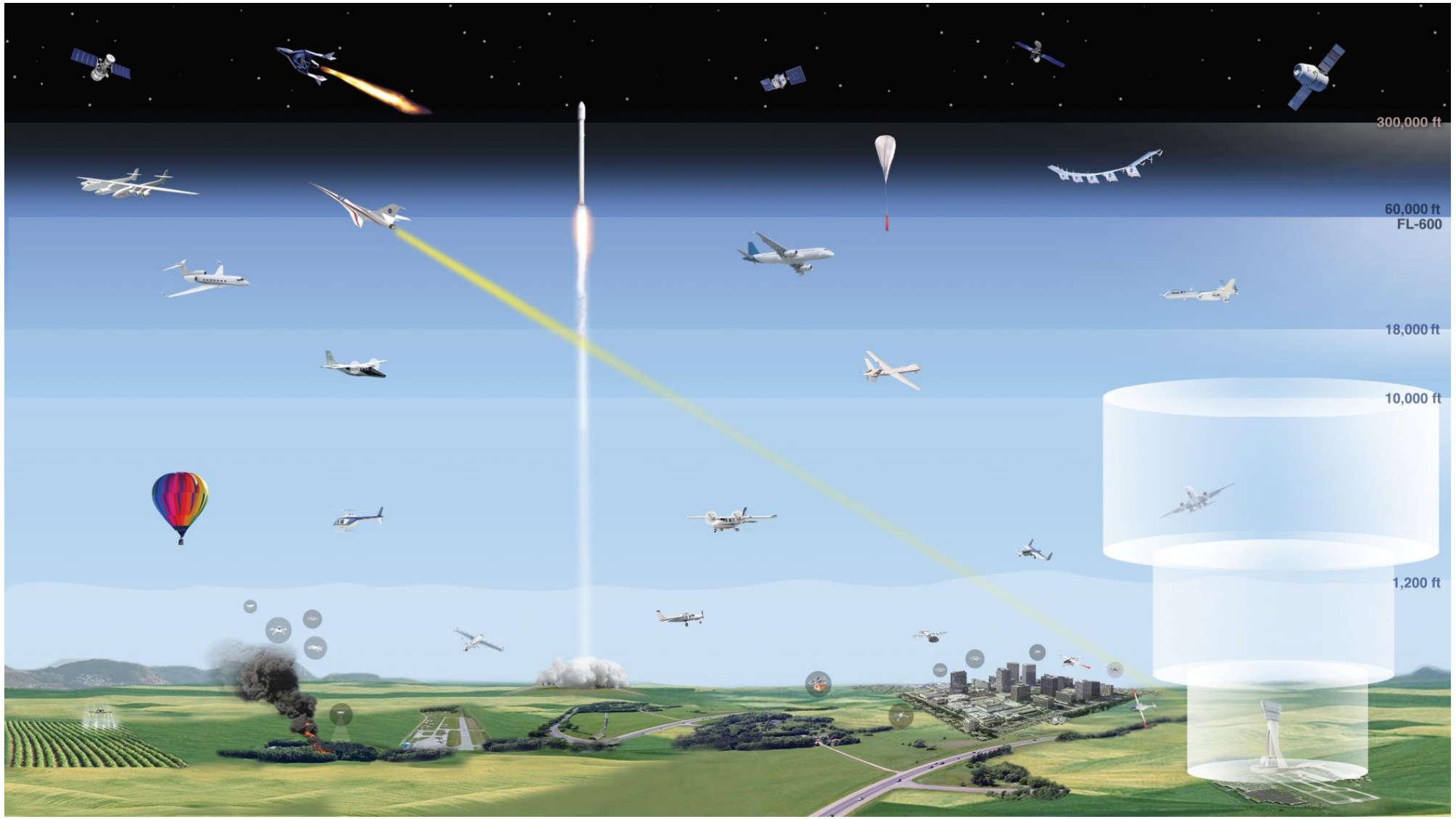
Paul Krois, Ph.D.

Crown Consulting, Inc.
Aurora, CO

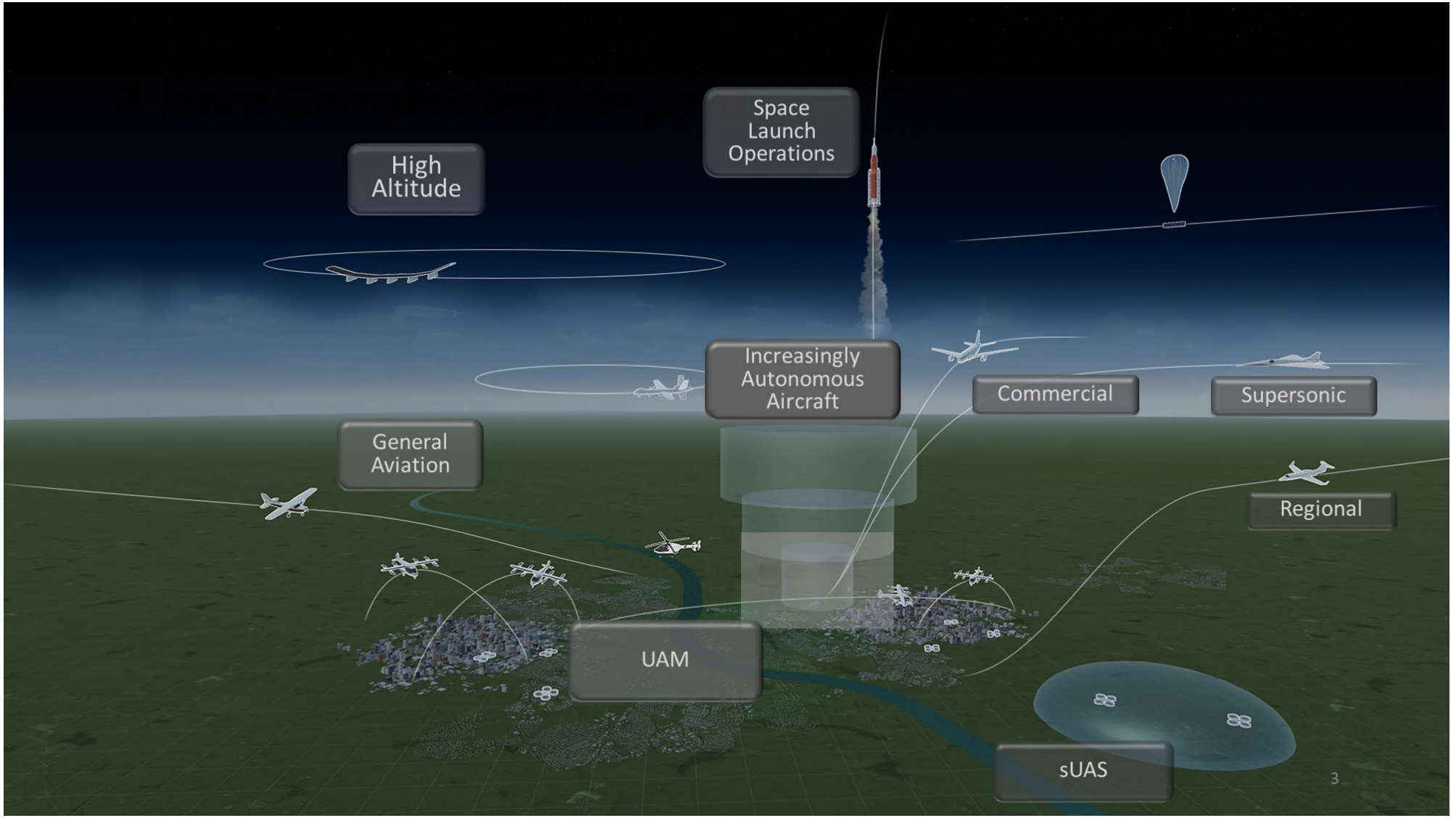
Misty D. Davies, Ph.D.
Robert W. Mah, Ph.D.

Ames Research Center
Moffett Field, CA

Air Transportation System Vision



Future Airspace Increasingly Diverse Operations

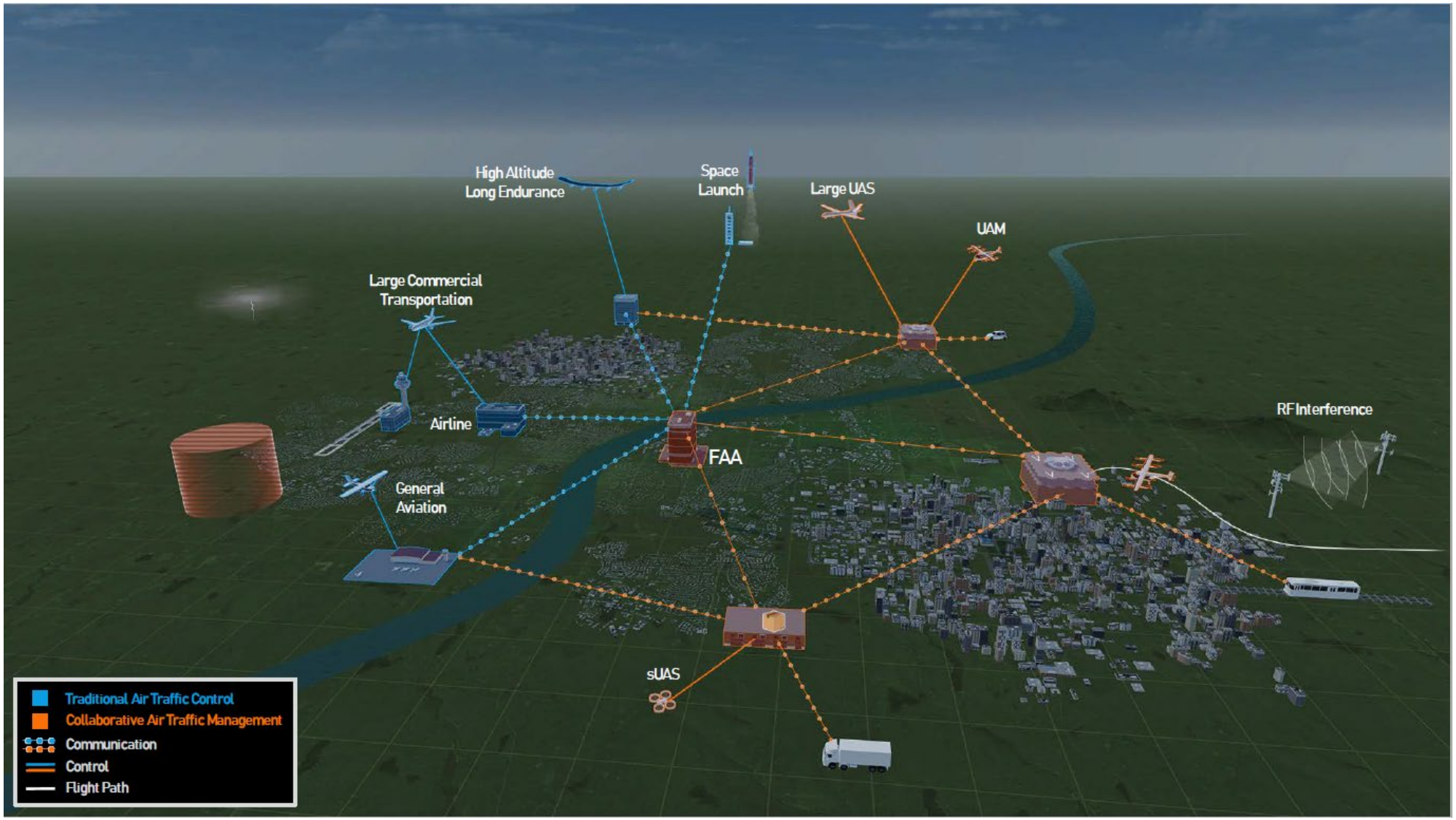


Advanced Air Mobility

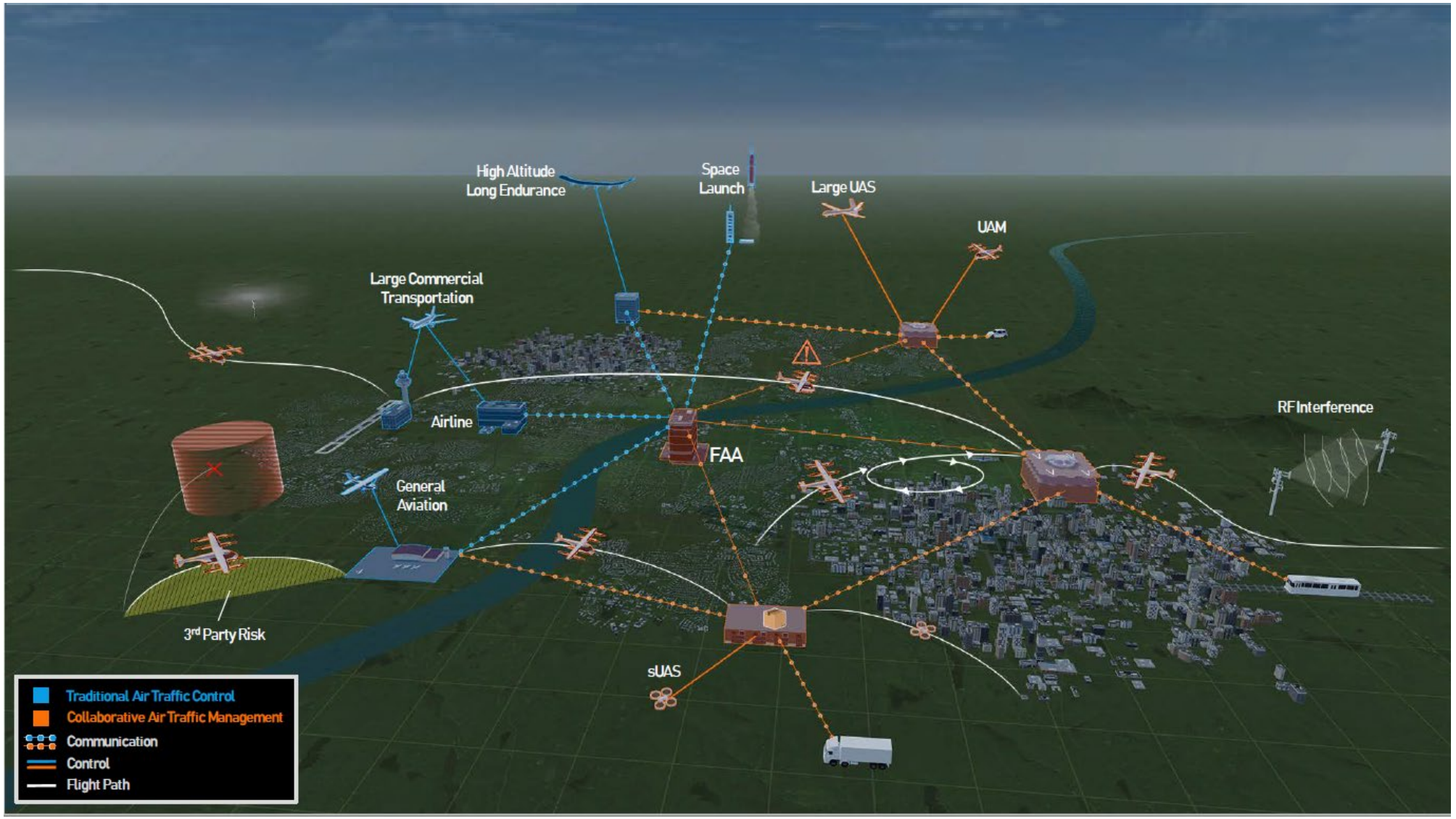
Advanced Air Mobility

Air Traffic System Today

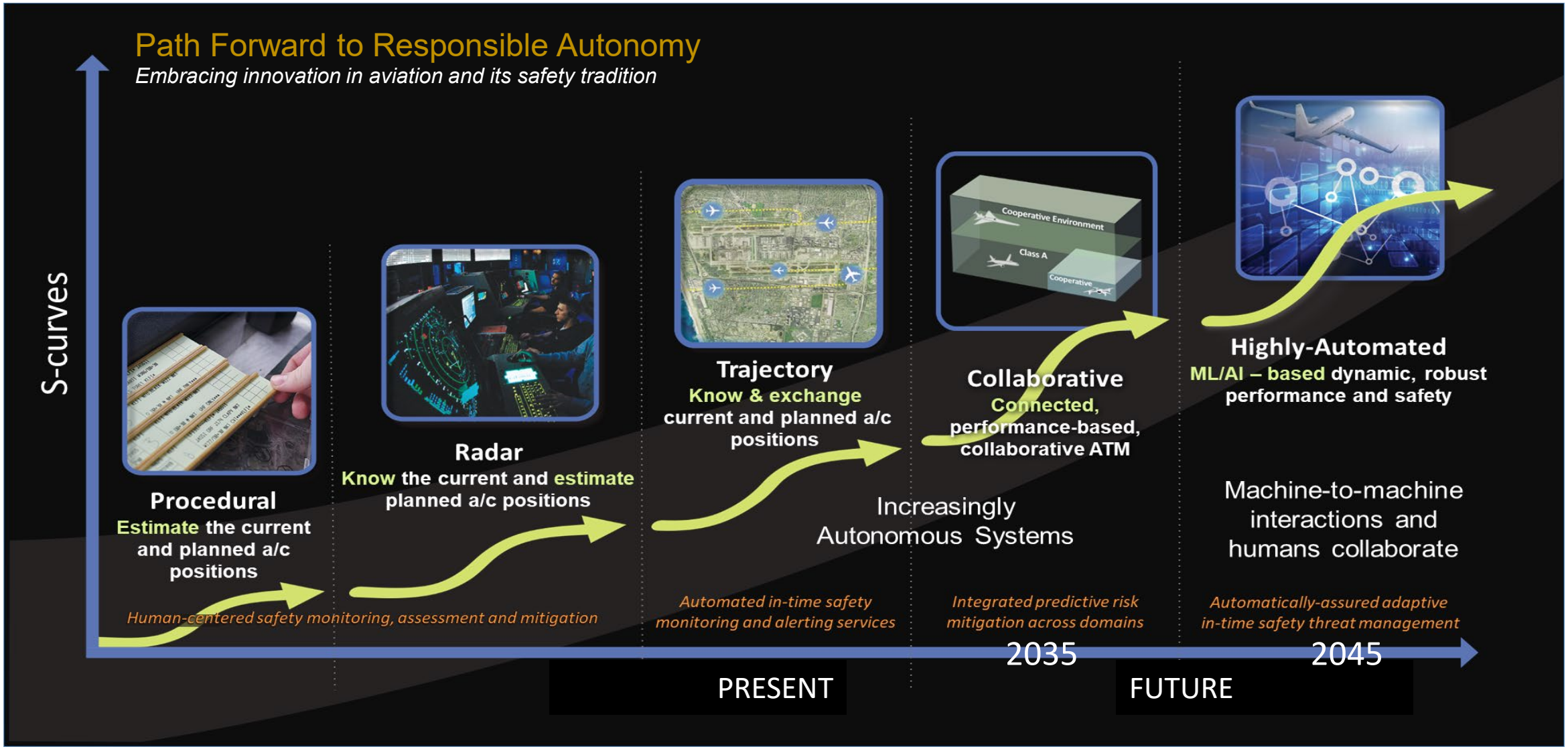
Collaborative Air Traffic Management



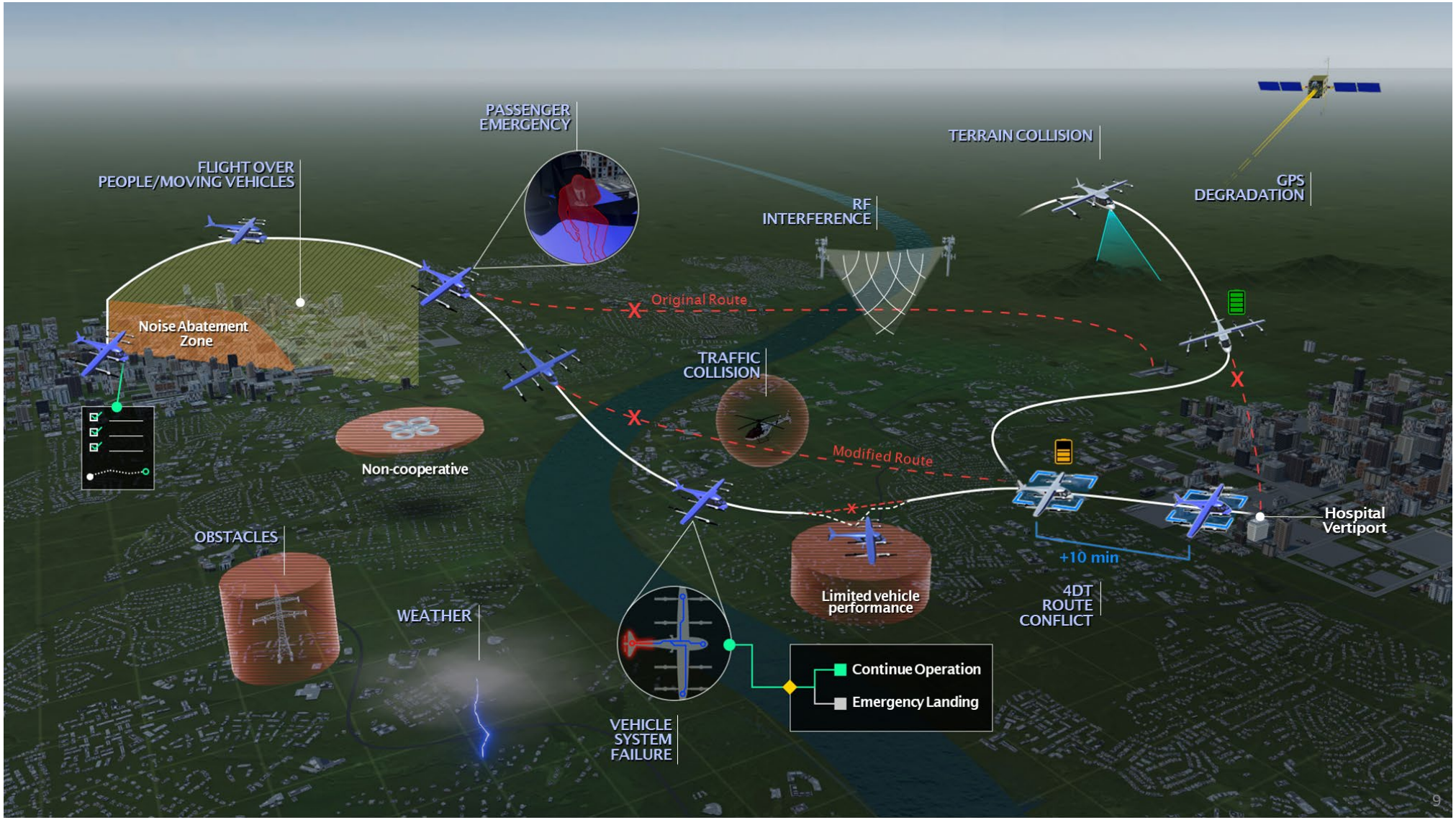
Collaborative Air Traffic Management



Enabling The Future Air Transportation System

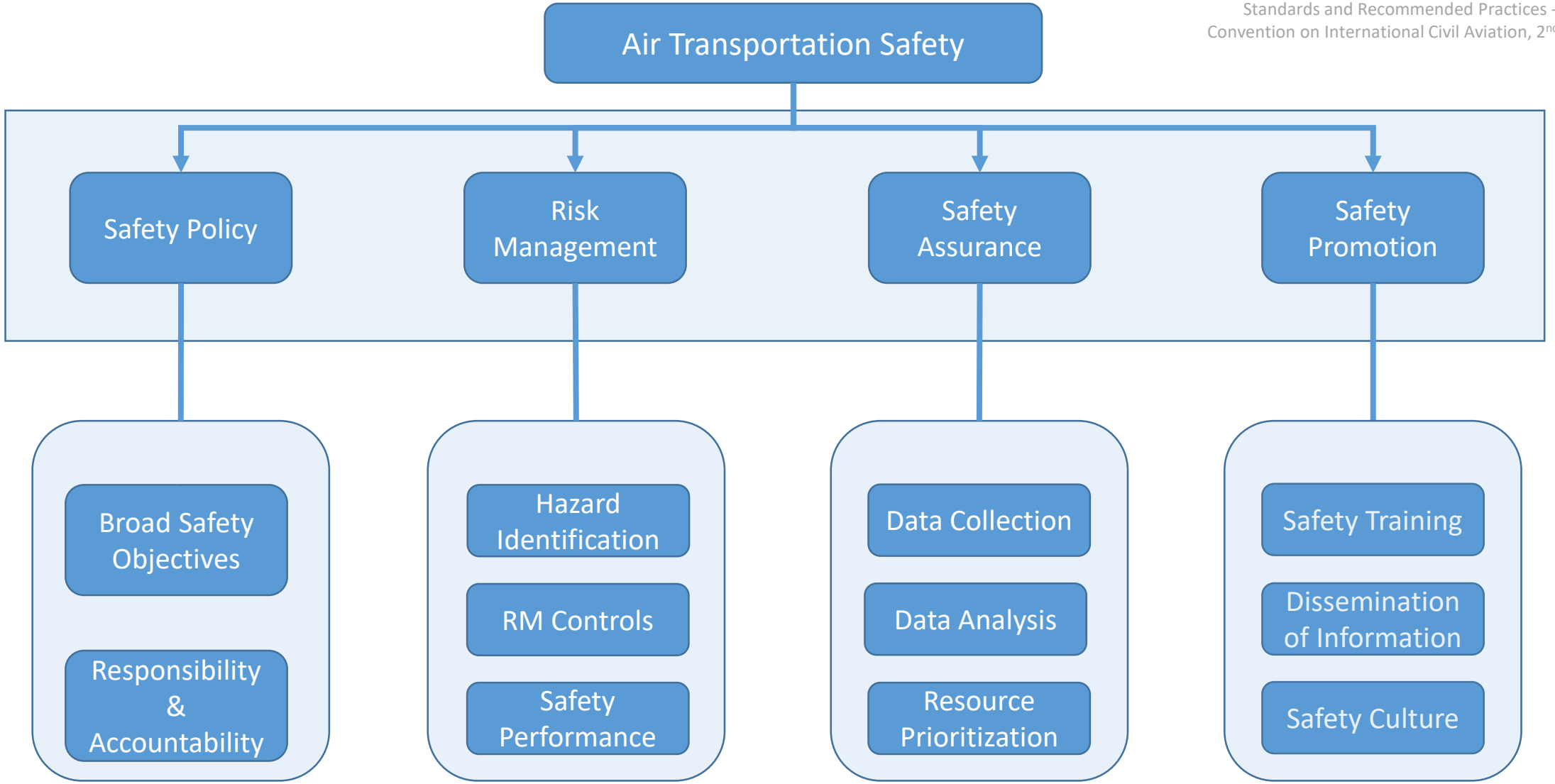


Complexities, Risks, and Constraints



Safety Management Systems

International Civil Aviation Organization, "Safety Management, Standards and Recommended Practices - Annex 19," in Convention on International Civil Aviation, 2nd Edition, 2016



From Reactive to Proactive to Predictive

[1] https://www.faa.gov/about/initiatives/sms/explained/basis/

Responds to events that have already happened, such as incidents and accidents

REACTIVE (Past)

Actively seeks the identification of hazardous conditions through the analysis of the organization's processes

PROACTIVE (Present)

Analyzes system processes and environment to identify potential/future problems

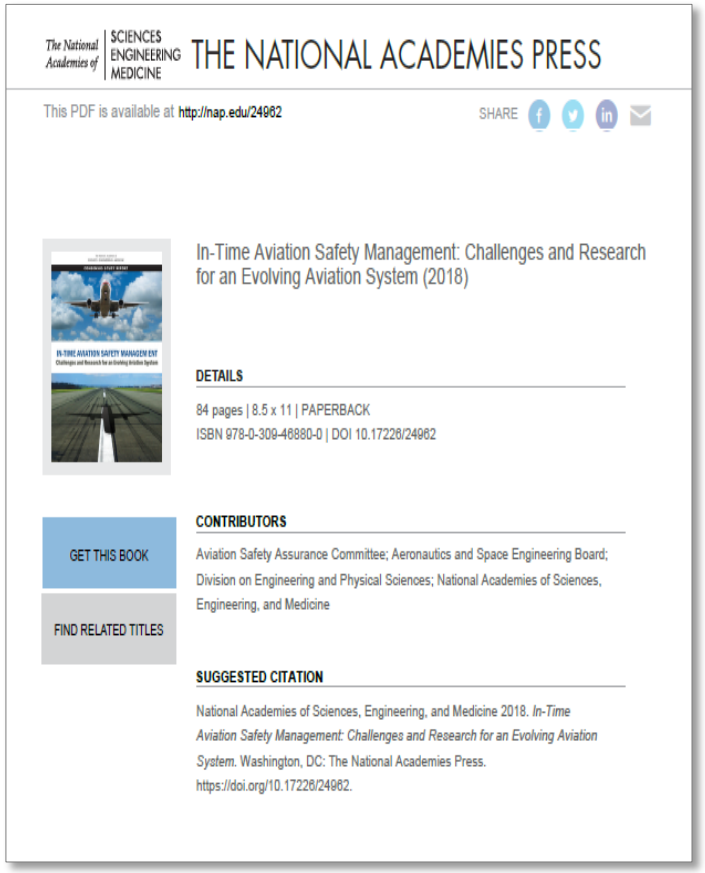
PREDICTIVE (Future)

Adapted FAA Graphic[1]

Enabling Vision 2035/2045

Automatically-assured adaptive
in-time safety management

In-Time Aviation Safety Management



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In-Time Aviation Safety Management: Challenges and Research for an Evolving Aviation System (2018)

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84 pages | 8.5 x 11 | PAPERBACK
ISBN 978-0-309-46880-0 | DOI 10.17226/24962

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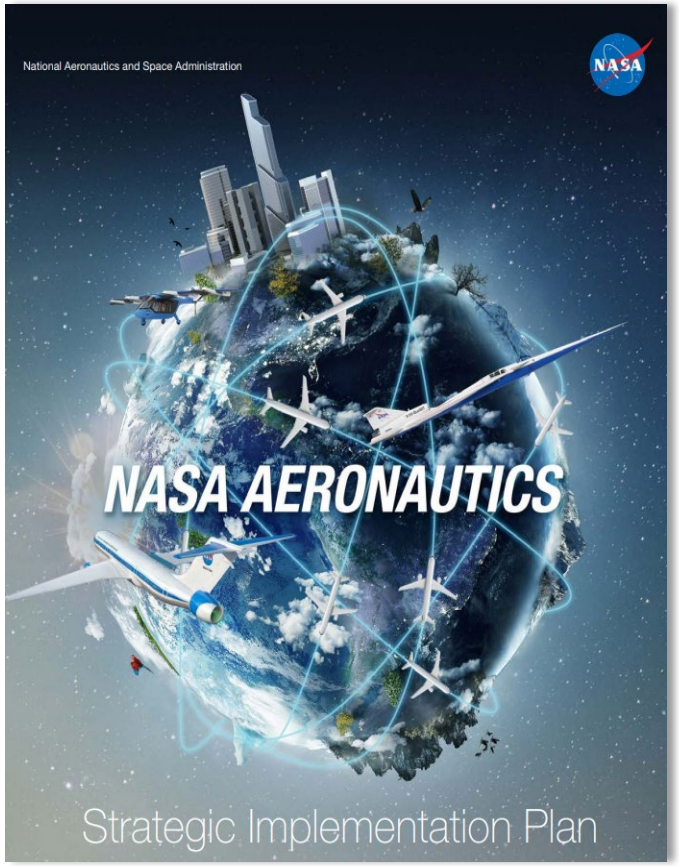
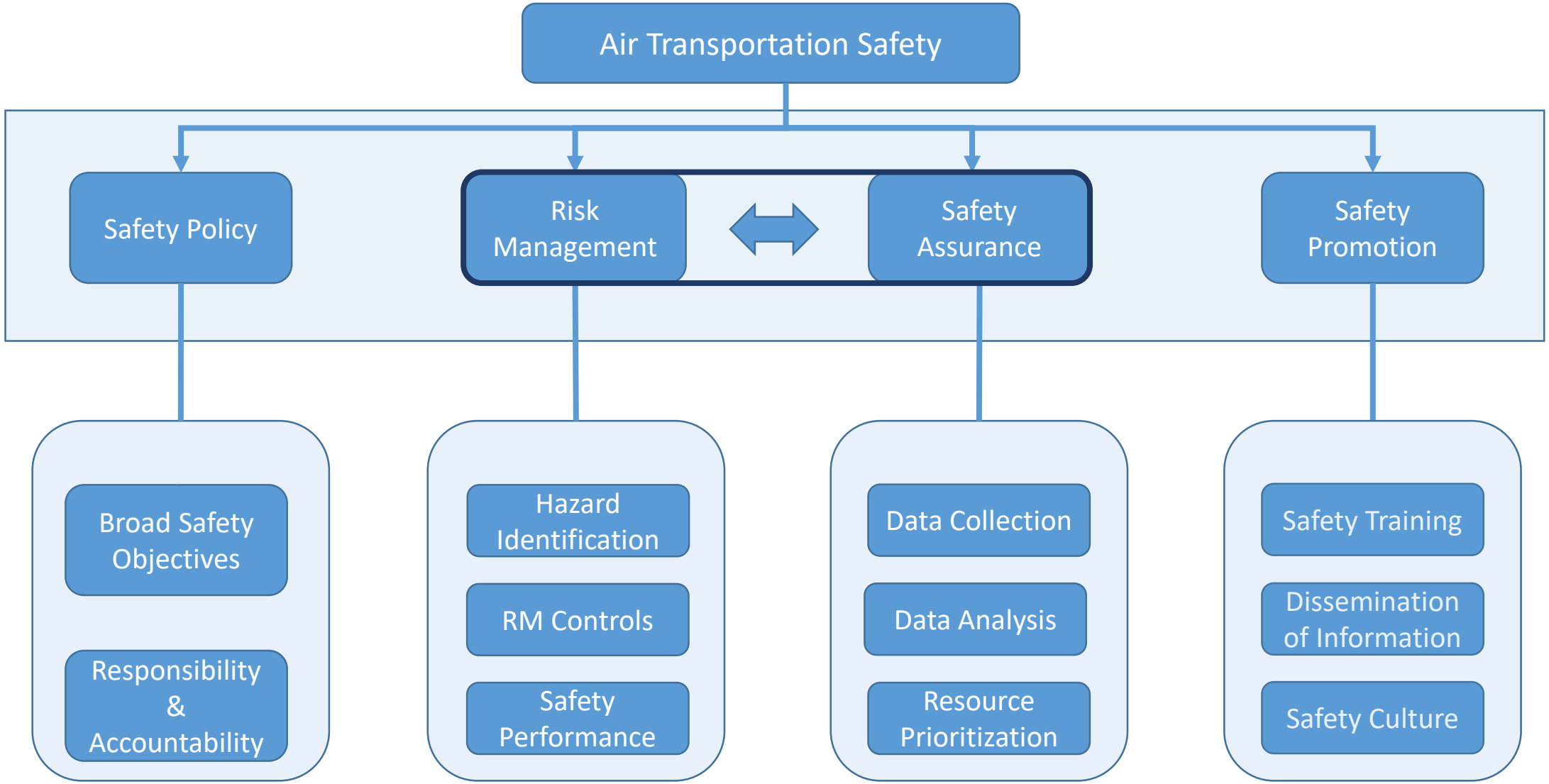


In-Time System-Wide Safety Assurance



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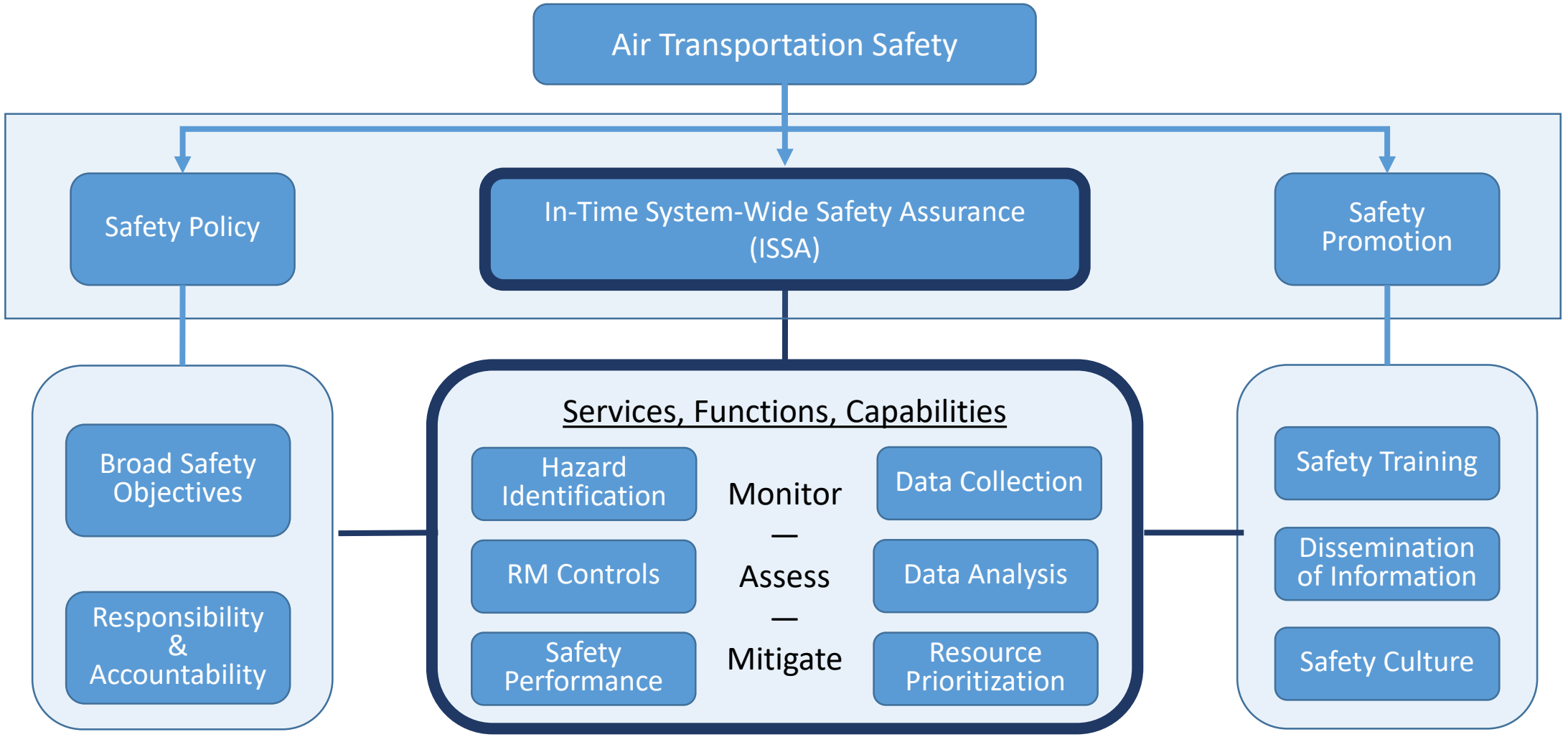
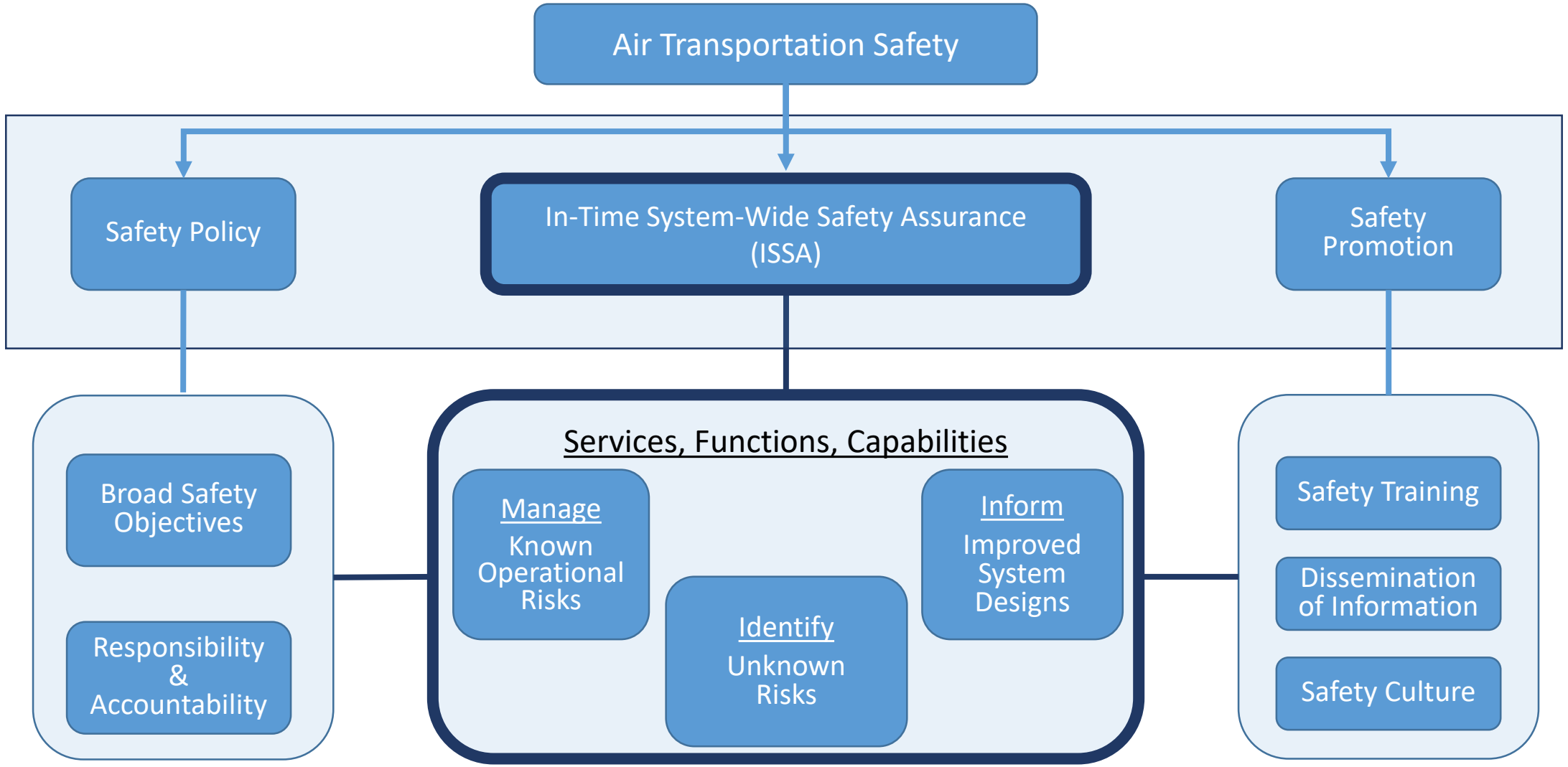
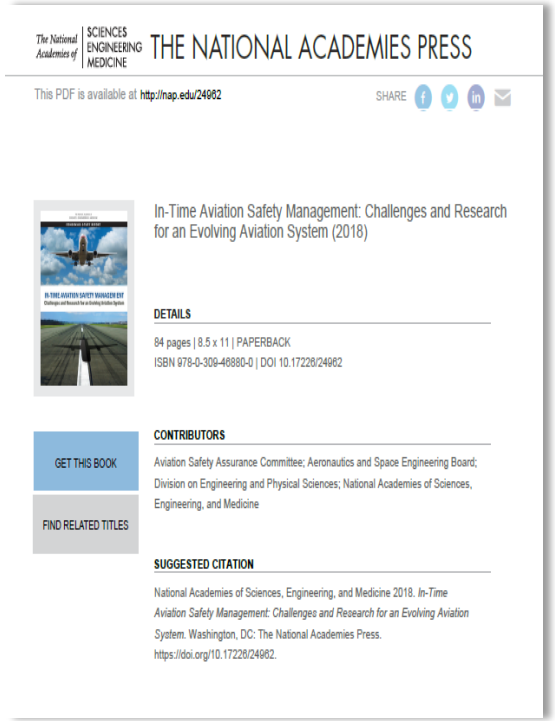


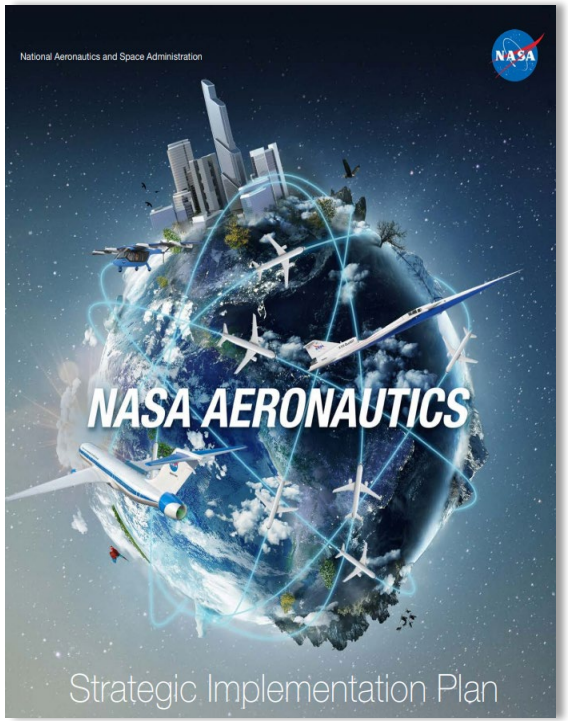
In-Time Aviation Safety Management



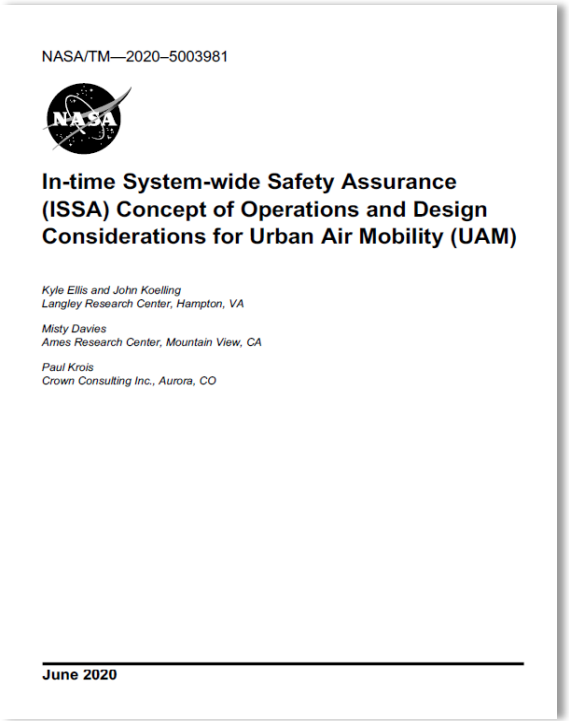
Progress Toward In-Time Aviation Safety Management



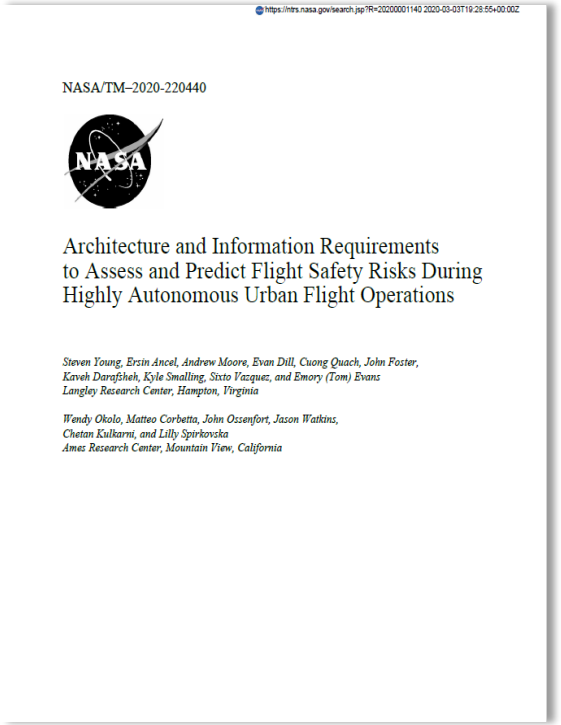
National Academies Report



NASA Strategic Implementation Plan



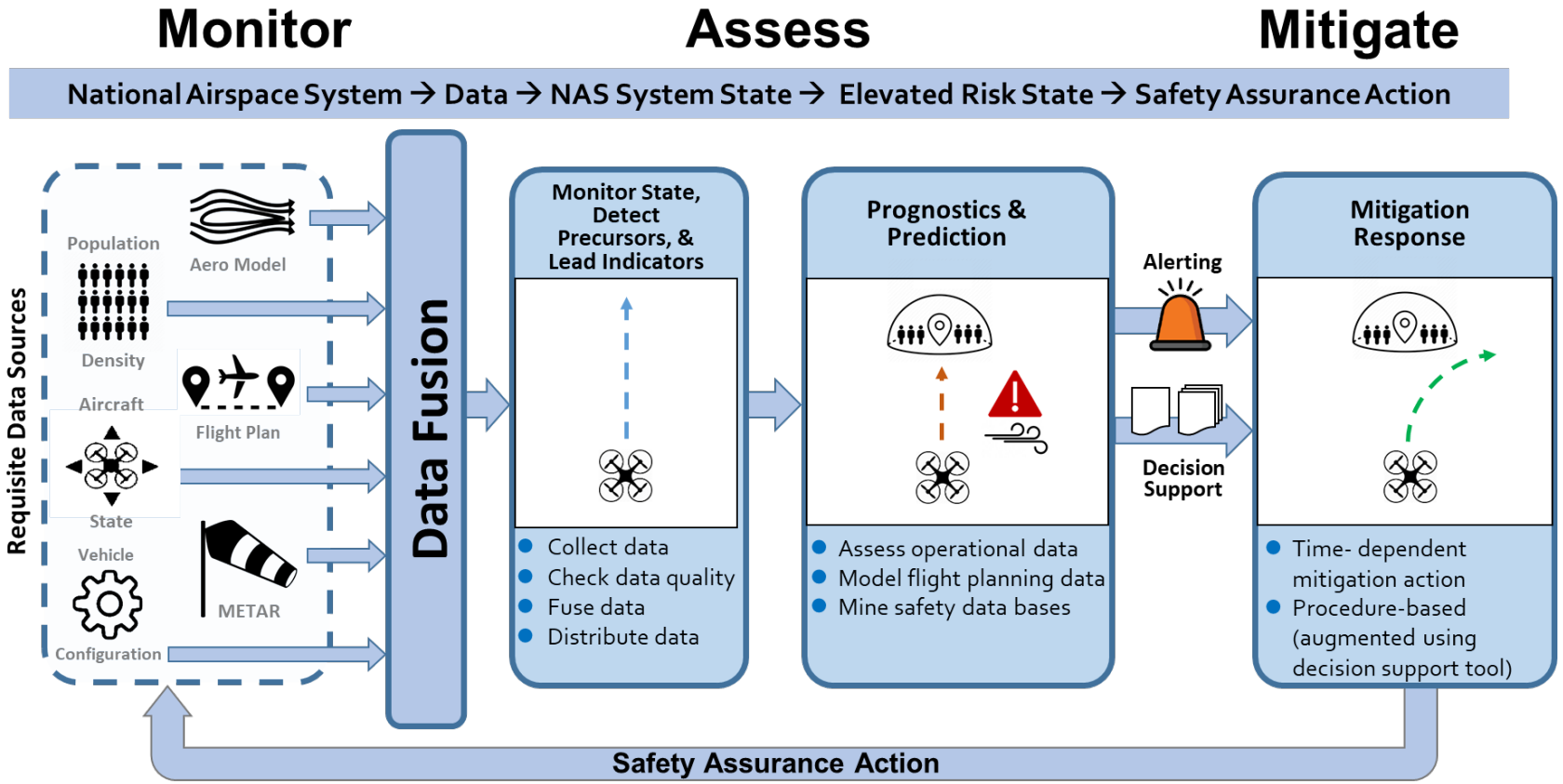
IASMS ConOps



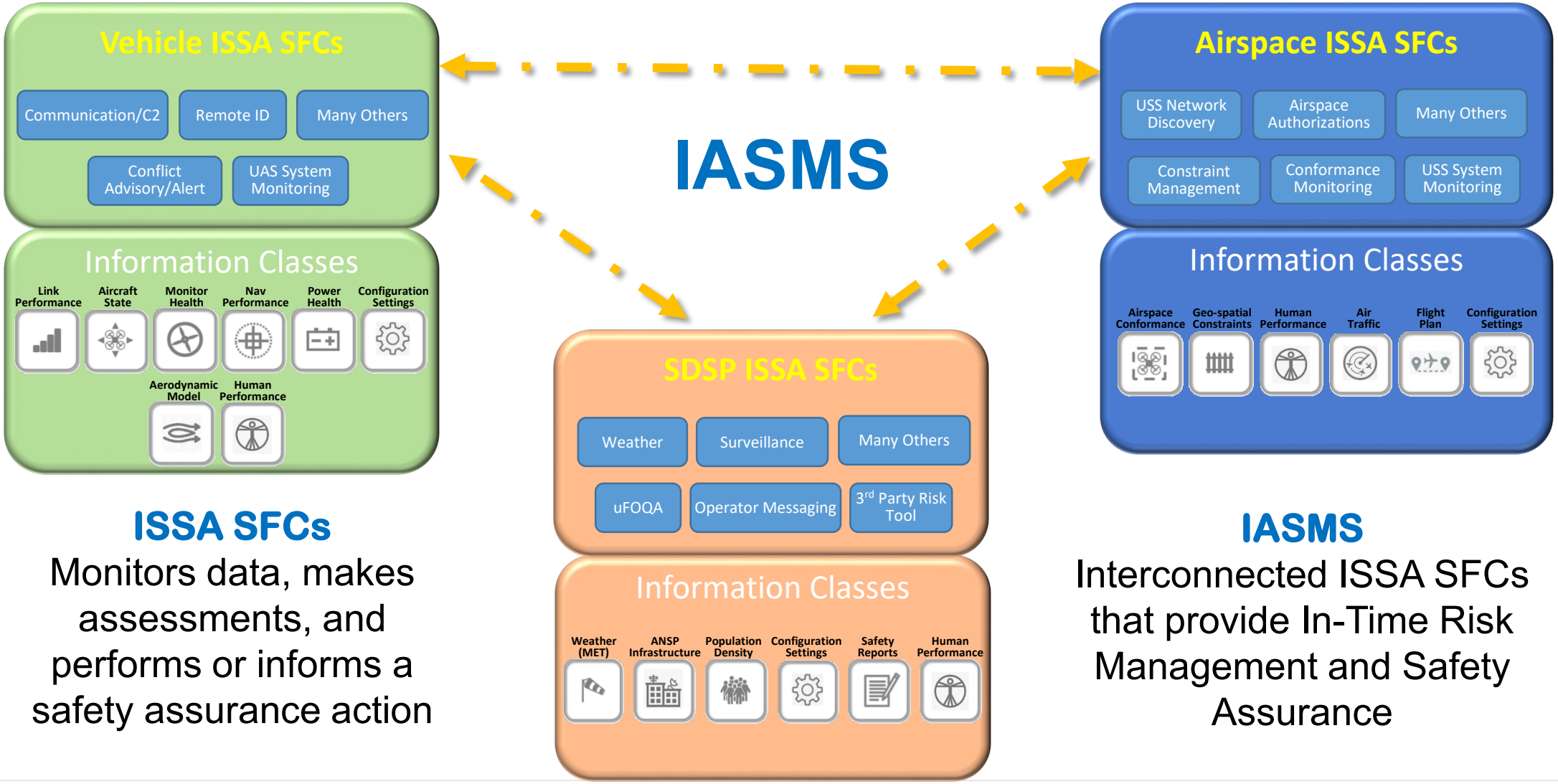
Architecture and Information Requirements TM

In-Time Aviation Safety Management Systems (IASMS)

- Domain Specific In-time Safety Monitoring and Alerting Tools
- Integrated Predictive Domain Level Application
- Adaptive Real-time Safety Management



Services, Functions, & Capabilities



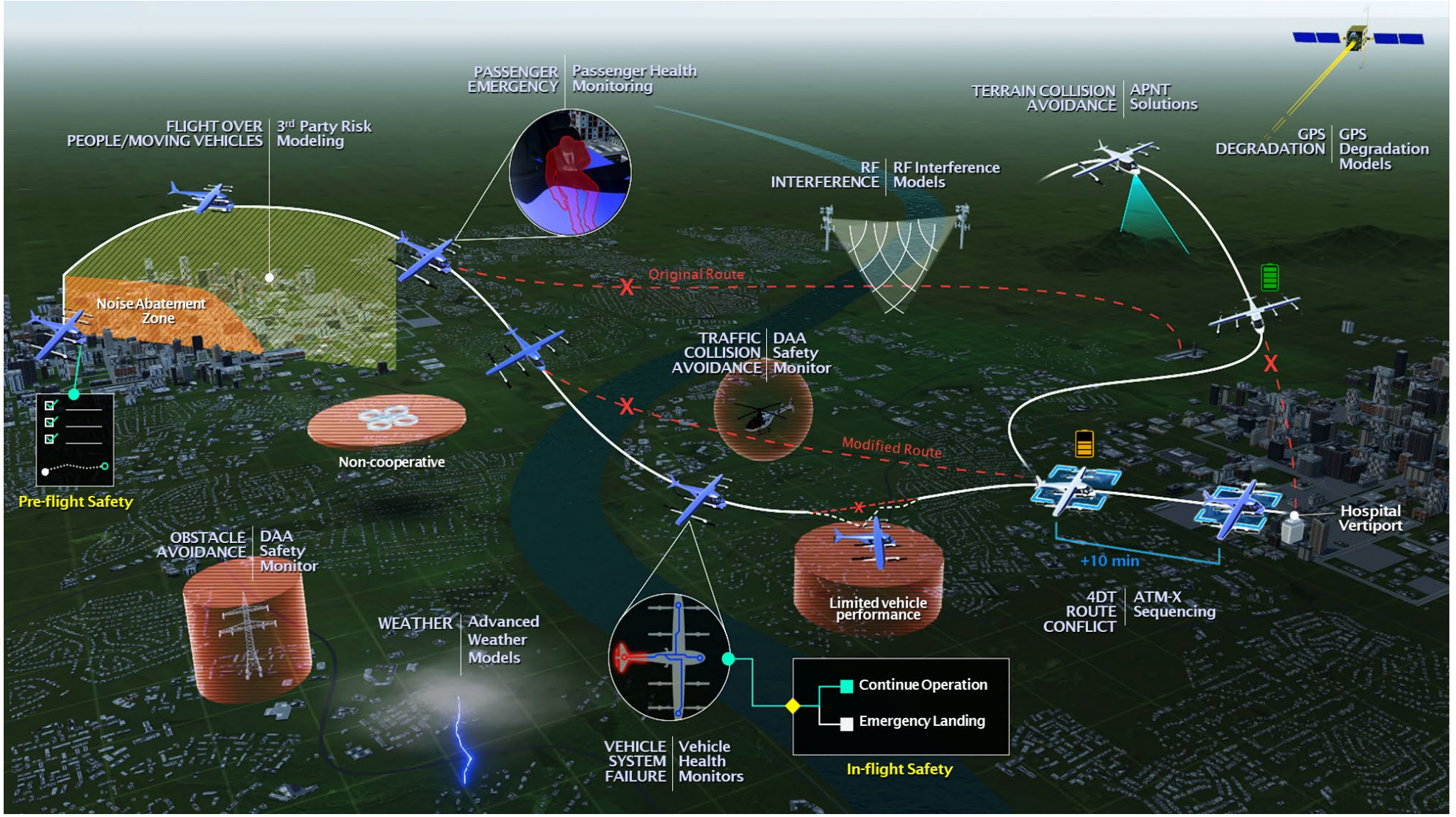
ISSA SFCs

Monitors data, makes assessments, and performs or informs a safety assurance action

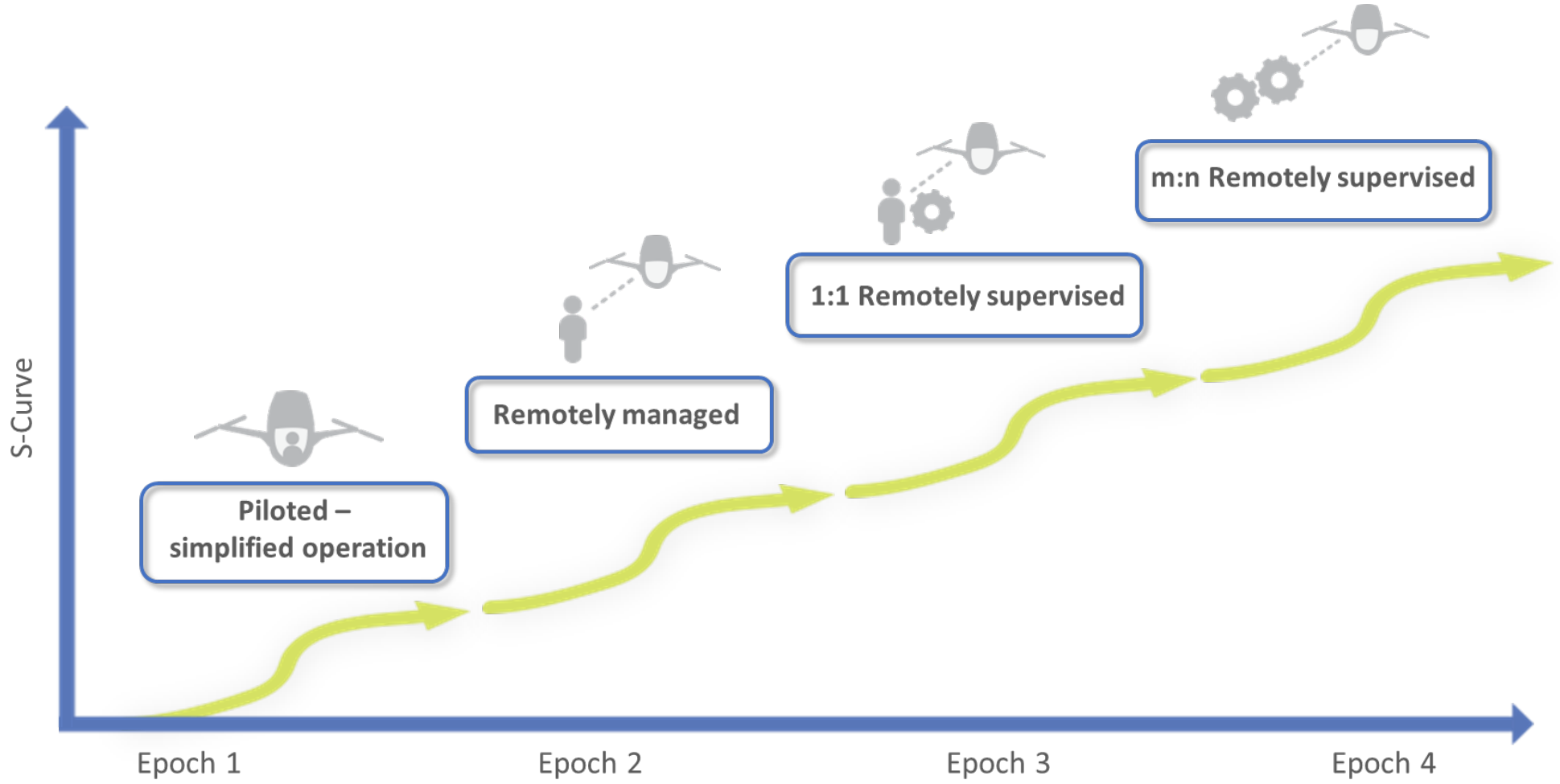
IASMS

Interconnected ISSA SFCs that provide In-Time Risk Management and Safety Assurance

Integrated, Service-Oriented Architecture



Envisioned New Roles and Responsibilities



Human Roles Defined From Functions Performed

	ROLES			
LEVEL OF AUTOMATION	MONITORING	GENERATING	SELECTING	IMPLEMENTING
Manual Control	Human	Human	Human	Human
Action Support	Human/Computer	Human	Human	Human/Computer
Batch Processing	Human/Computer	Human	Human	Computer
Shared Control	Human/Computer	Human/Computer	Human	Human/Computer
Decision Support	Human/Computer	Human/Computer	Human	Computer
Blended Decision Making	Human/Computer	Human/Computer	Human/Computer	Computer
Rigid System	Human/Computer	Computer	Human	Computer
Automated Decision Making	Human/Computer	Human/Computer	Computer	Computer
Supervisory Control	Human/Computer	Computer	Computer	Computer
Full Automation	Computer	Computer	Computer	Computer

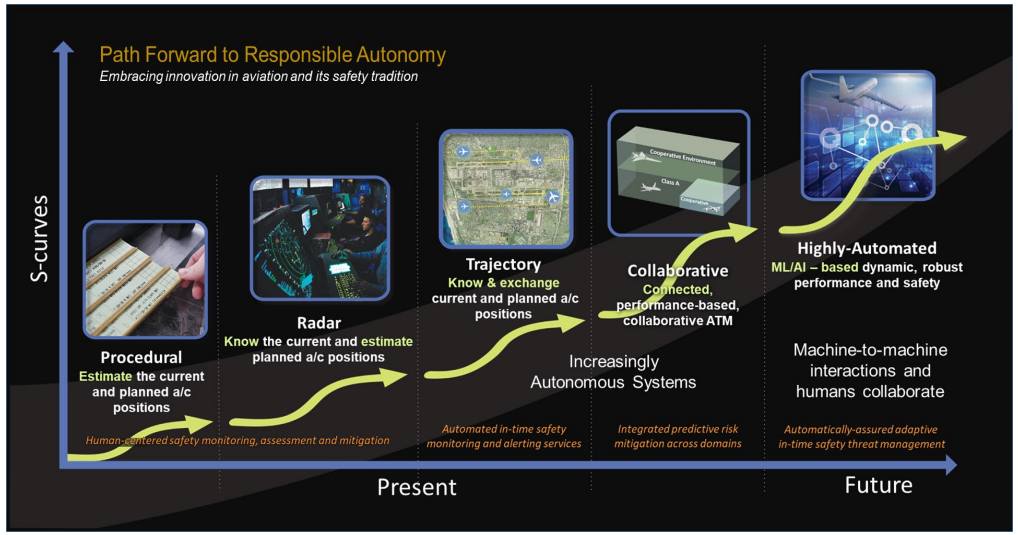
Level of Automation Taxonomy Example (from Endsley & Kaber, 1999)

Paradox of Automation — ? → Autonomy

Boeing 737-800 Flight Deck

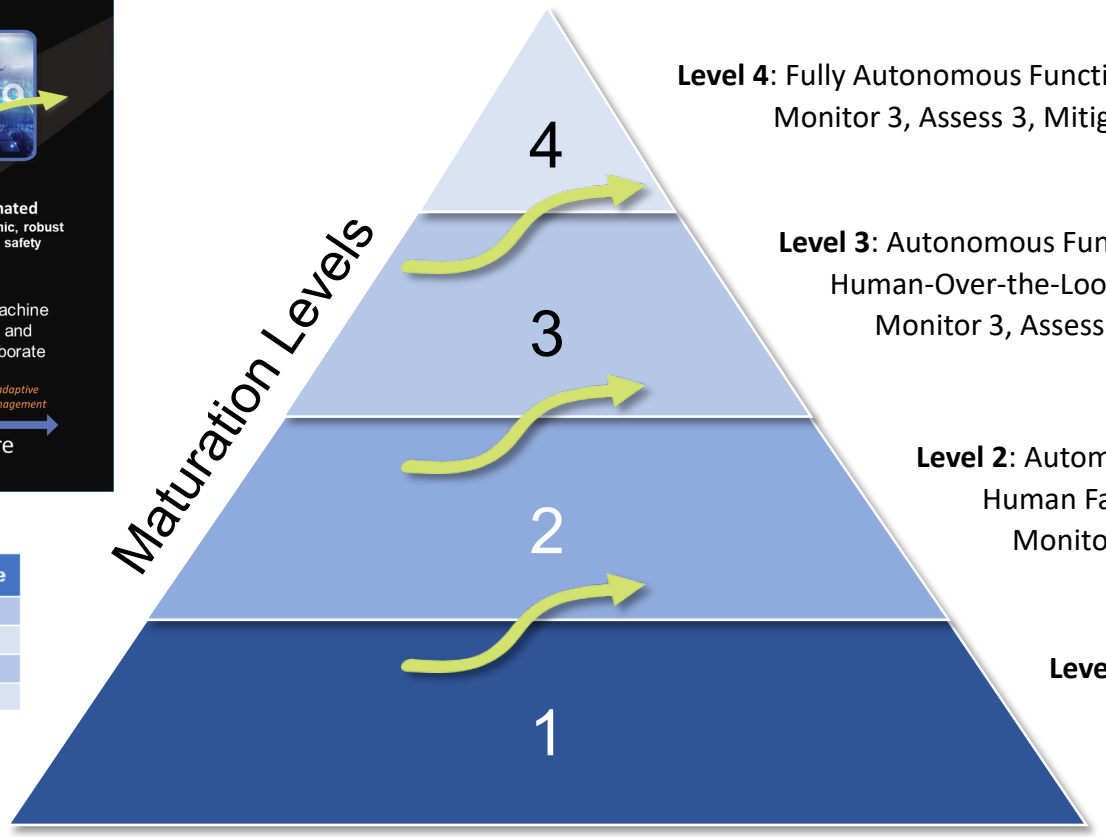
IASMS[1] Services, Functions, Capabilities Maturation

[1]In-time Aviation Safety Management System



Maturity Level	Maturity Description	Monitor	Assess	Mitigate
4	Fully Autonomous Functionality	3	3	3
3	Autonomous Functionality with Human Over-the-Loop	3	3	2
2	Automated Function with Human Fallback (On-the-Loop)	2	2	1
1	Alerting Function for Human	1	1	0

The Monitor-Assess-Mitigate numbers signify notional increases in capability



Level 4: Fully Autonomous Functionality
Monitor 3, Assess 3, Mitigate 3

Level 3: Autonomous Functionality with Human-Over-the-Loop
Monitor 3, Assess 3, Mitigate 2

Level 2: Automated Function with Human Fallback
Monitor 2, Assess 2, Mitigate 1

Level 1: Alerting Function for Human
Monitor 1; Assess 1, Mitigate 0

Exploring Human Roles and Responsibilities

Maturity Level	Maturity Description	Monitor	Assess	Mitigate
4	Fully Autonomous Functionality	3	3	3
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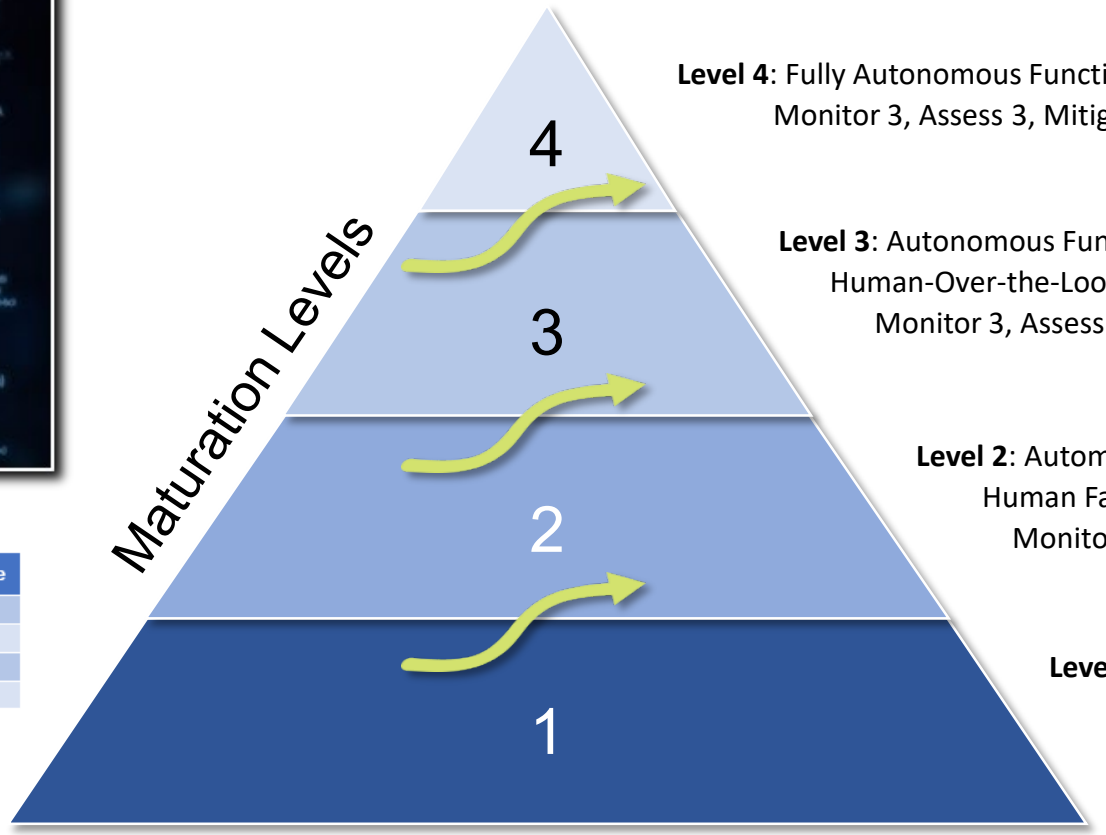

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Monitor 3, Assess 3, Mitigate 3

Level 3: Autonomous Functionality with Human-Over-the-Loop
Monitor 3, Assess 3, Mitigate 2

Level 2: Automated Function with Human Fallback
Monitor 2, Assess 2, Mitigate 1

Level 1: Alerting Function for Human
Monitor 1; Assess 1, Mitigate 0

Advances in Technology Changes The Possible

- "...a listing of those respects in which human capabilities surpass those of machines must, of course, be hedged with the statement that we cannot foresee what machines can be built to do in the future"[1]

- "... less and less qualities are uniquely human, and the overall balance of humans and machines promises to set the profile of our future as a technology-dependent species." [2]

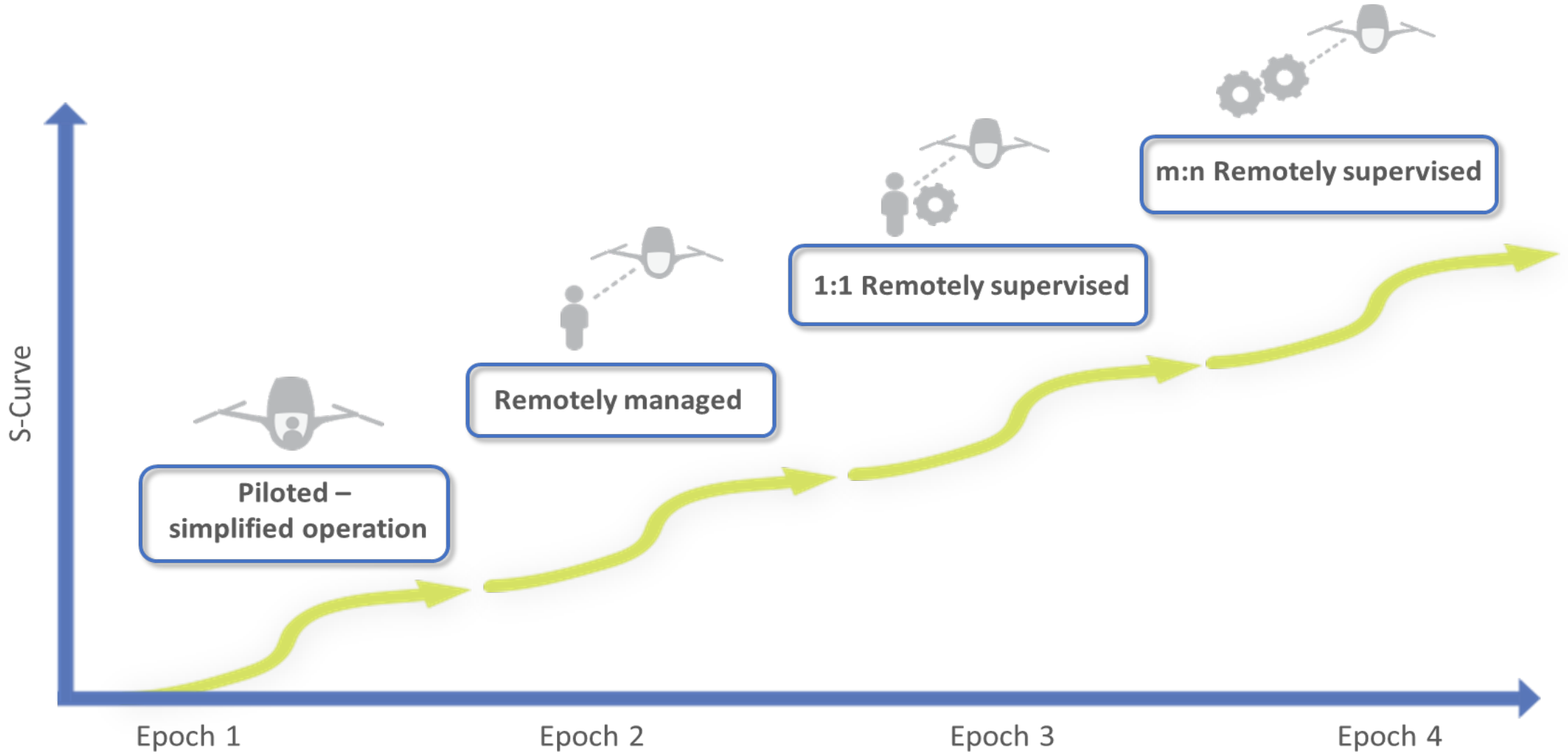
AlphaGo

[1] Fitts, P. M. (Ed.) (1951). Human engineering for an effective air-navigation and traffic-control system. Washington, DC: National Research Council

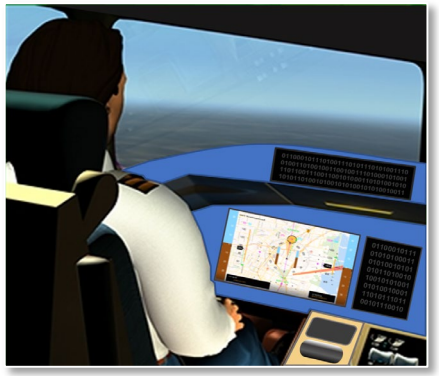
[2] J.C.F. de Winter and P.A. Hancock / Reflections on the 1951 Fitts List: Do Humans Believe Now that Machines Surpass them? Procedia Manufacturing, 3, 5334 – 5341

New Human-System Interactions May Be Possible

Challenge and Opportunity of the Envisioned



Challenge and Opportunity of the Envisioned



S-Curve

Piloted – simplified operation

Remotely managed

1:1 Remotely supervised

m:n Remotely supervised

Epoch 1

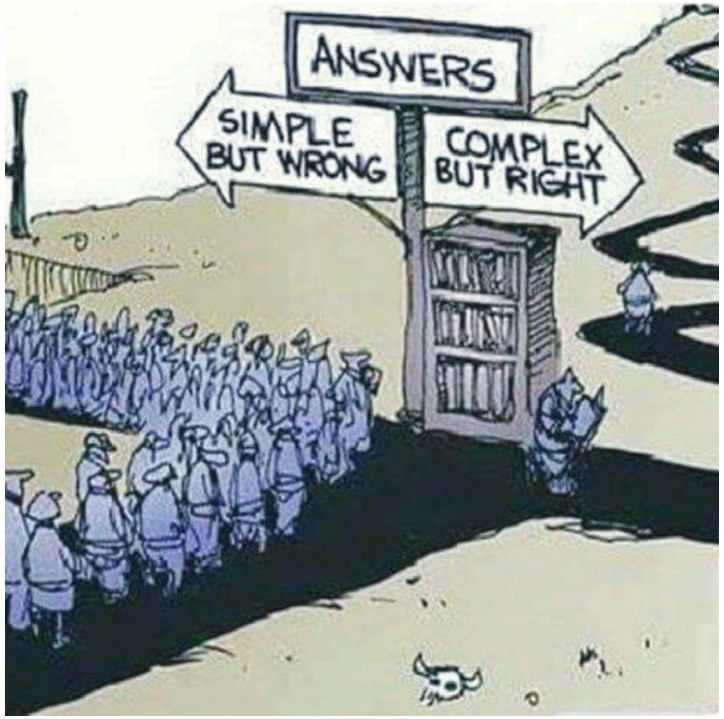
Epoch 2

Epoch 3

Epoch 4

Autonomous Systems —?→ New Science

- New Models and Frameworks
- New Methods
- New Tools & Techniques
- More Research
- ... Lot More Papers



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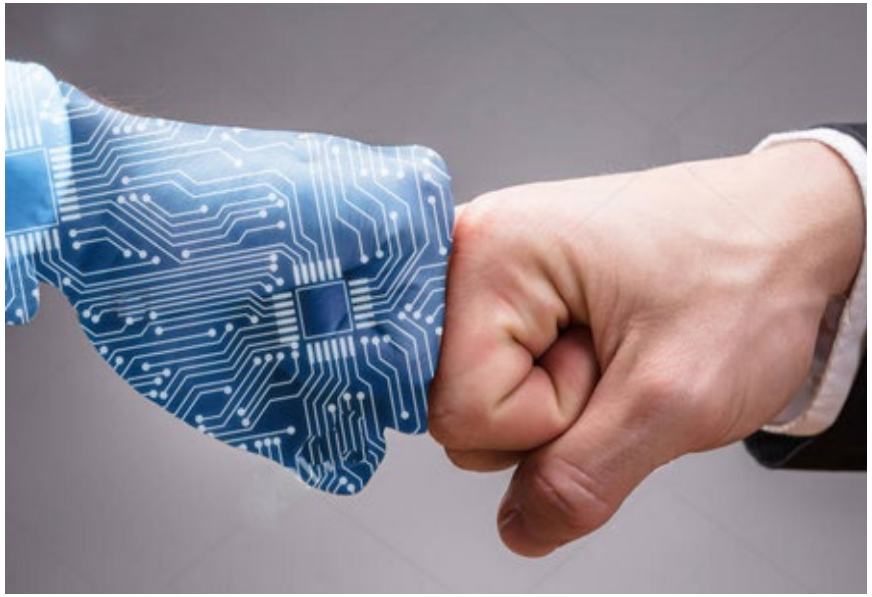
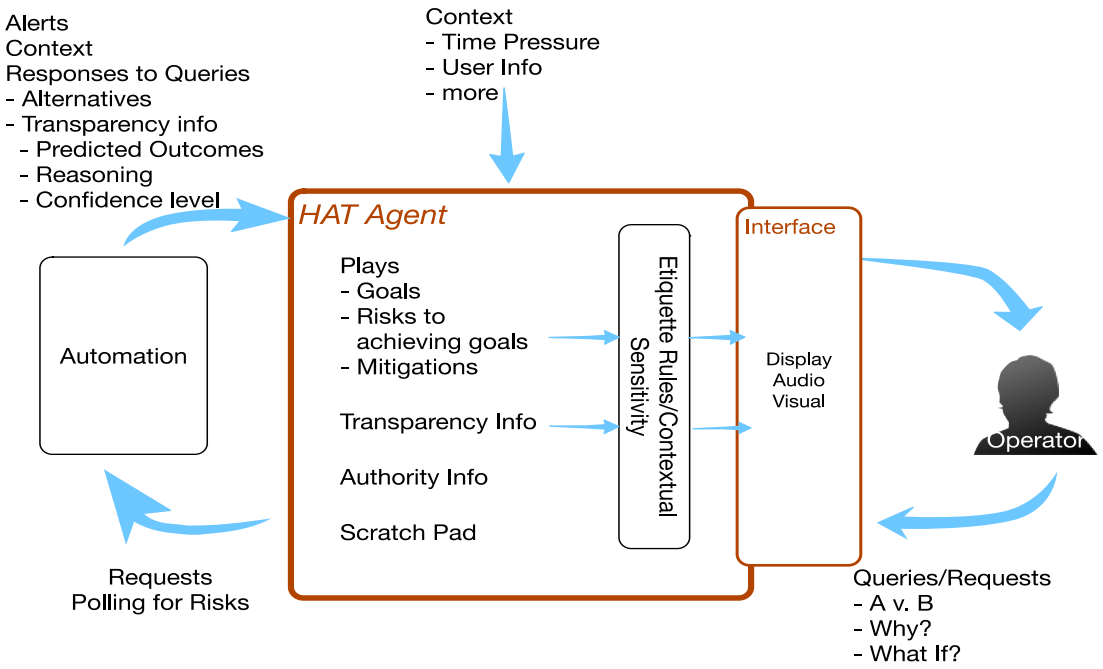


“Better Together”

Toward IASMS Through Use Cases

[1] J. Shively (2020). AAM Human Factors Issues.64th Annual Meeting of the Human Factors and Ergonomics Society. San Antonio: HFES. Note: Human-

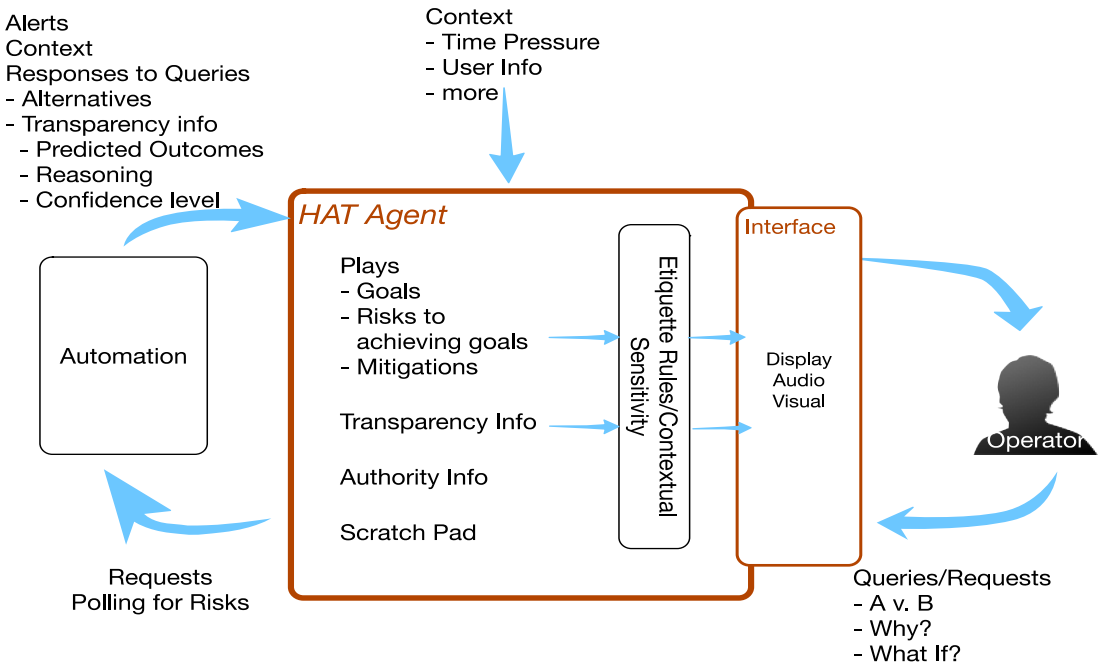


Human-Autonomy Teaming Model[1]

Wildfire Management Response

Toward IASMS Through Use Cases

[1] J. Shively (2020). AAM Human Factors Issues.64th Annual Meeting of the Human Factors and Ergonomics Society. San Antonio: HFES. Note: Human-

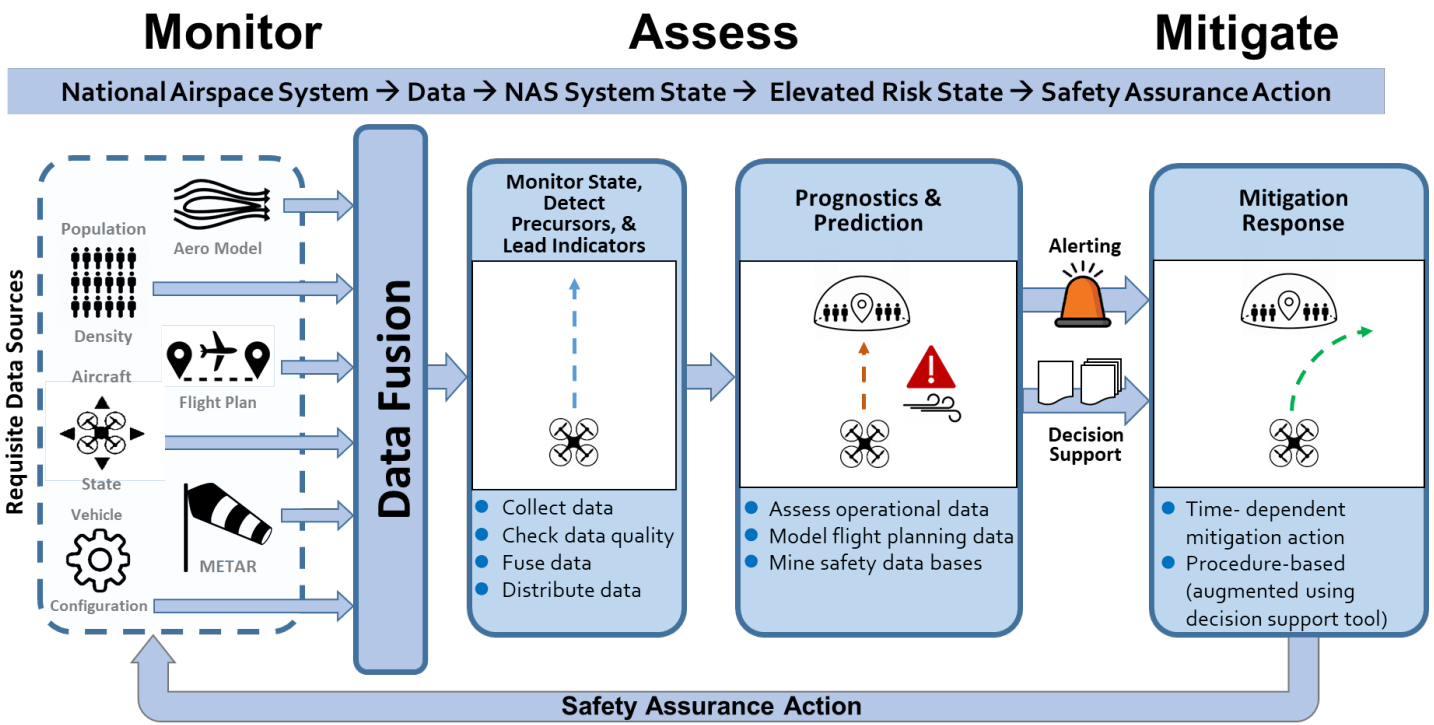


Human-Autonomy Teaming Model[1]

Services, Functions, Capabilities Required

Addressing Risks and Constraints

[1] O'Neill T, McNeese N, Barron A, Schelble B. Human–Autonomy Teaming: A Review and Analysis of the Empirical Literature. Human Factors. October 2020. doi:10.1177/0018720820960865



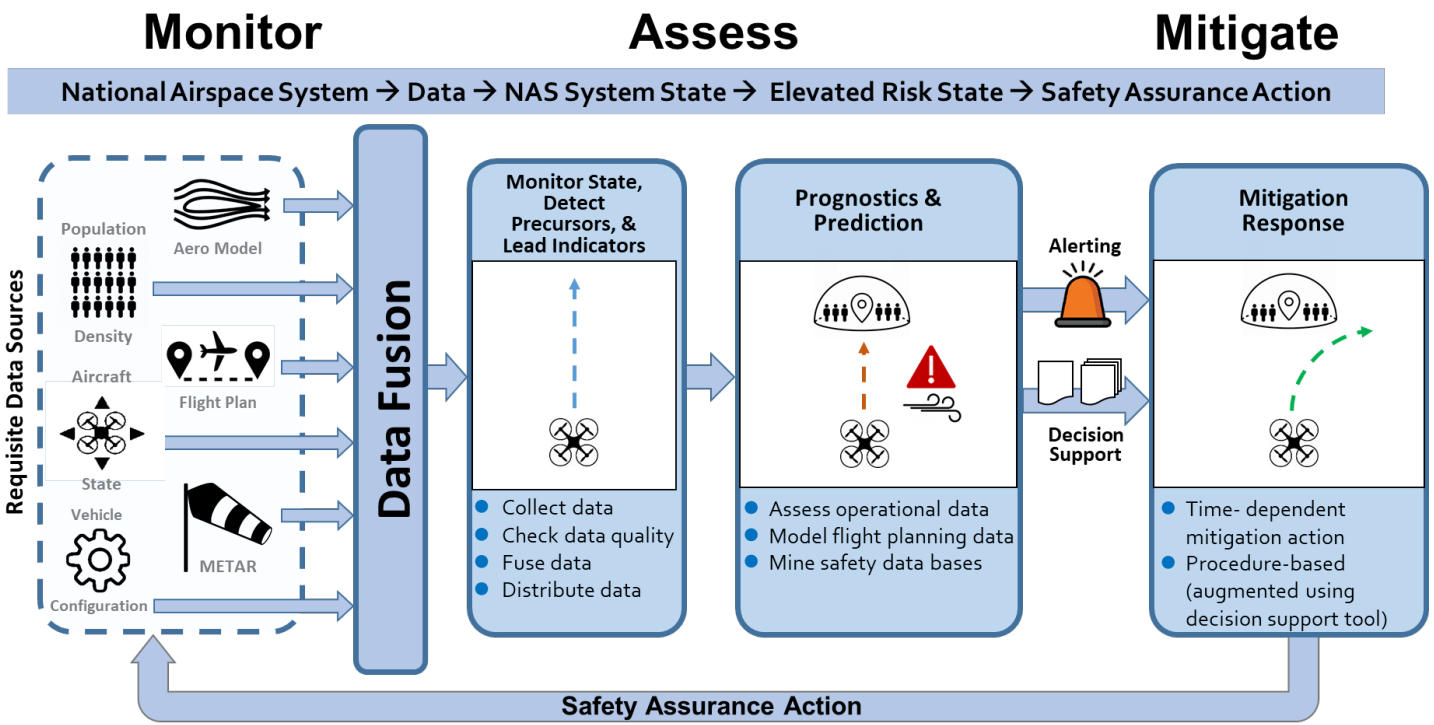
"There currently exists almost no empirical longitudinal research on HAT dynamics, or field research" [1]

Risks and Constraints

- **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 our predictive and prognostic SFCs have **not identified yet…**
- ?

Building Reference SFCs

[1] O'Neill T, McNeese N, Barron A, Schelble B. Human–Autonomy Teaming: A Review and Analysis of the Empirical Literature. Human Factors. October 2020. doi:10.1177/0018720820960865



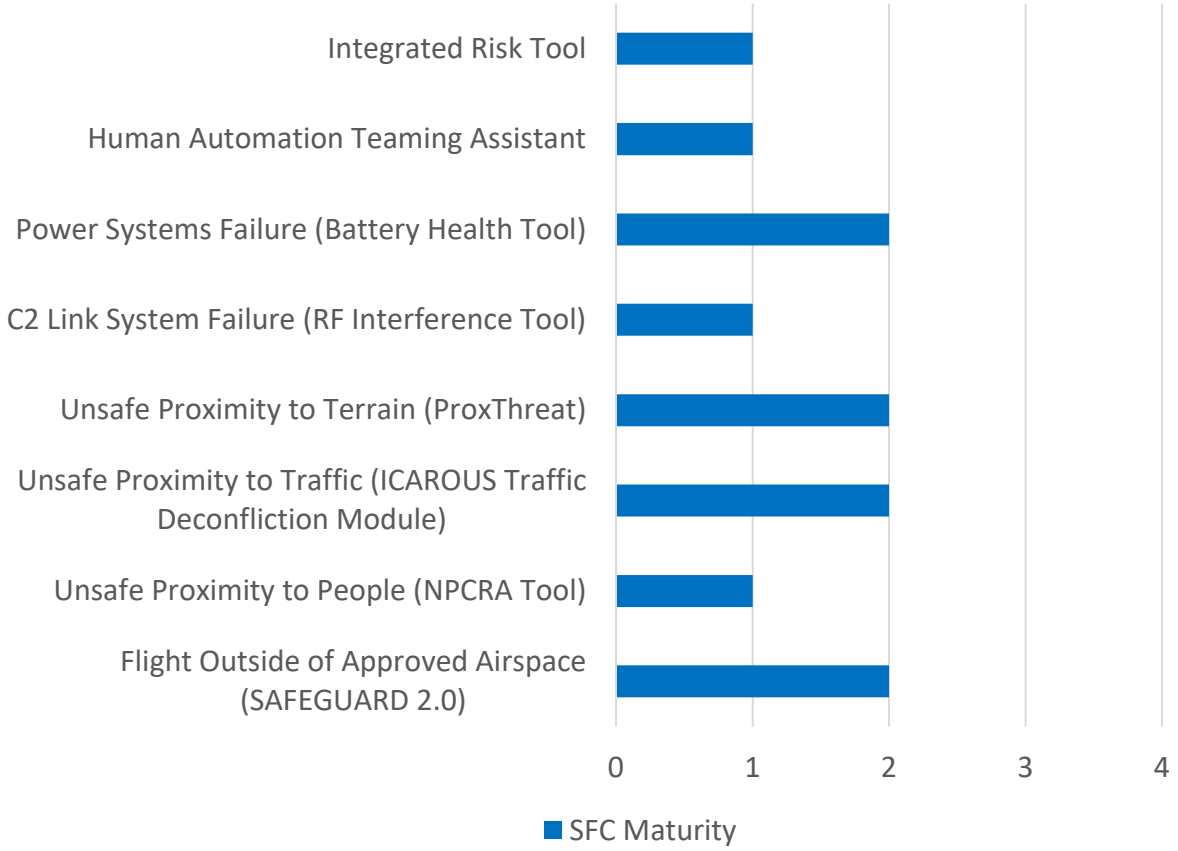
"There currently exists almost no empirical longitudinal research on HAT dynamics, or field research" [1]

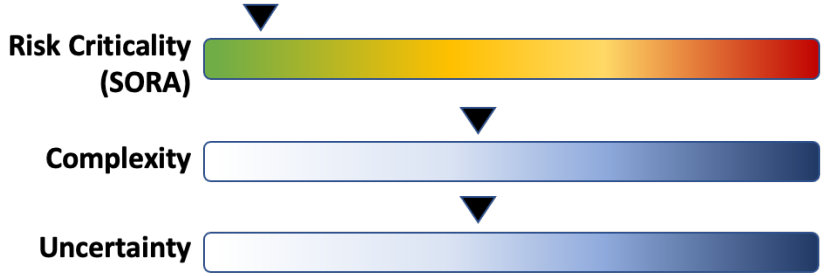
Example Reference SFCs

- SAFEGUARD
- Proximity to Threat Service, Non-participant Casualty Risk Assessment, ICAROUS, Safe2Ditch
- RF Interference Modeling
  GPS Degradation Modeling
  APNT Services (alternatives to GPS)
  Battery Health Prognostics
  Command and Control Link Monitor
- Hyper-local weather modeling → Climacell (SDSP example)
  Vehicle-as-a-sensor services
- Adaptive security procedure development
- Industry-developed Cyber-security solutions and protocols
- Multiple Kernel Anomaly Detection (MKAD)
- ?

Exploring Human-Autonomy Teaming for IASMS Application

SFC Maturity Levels for Key Risks

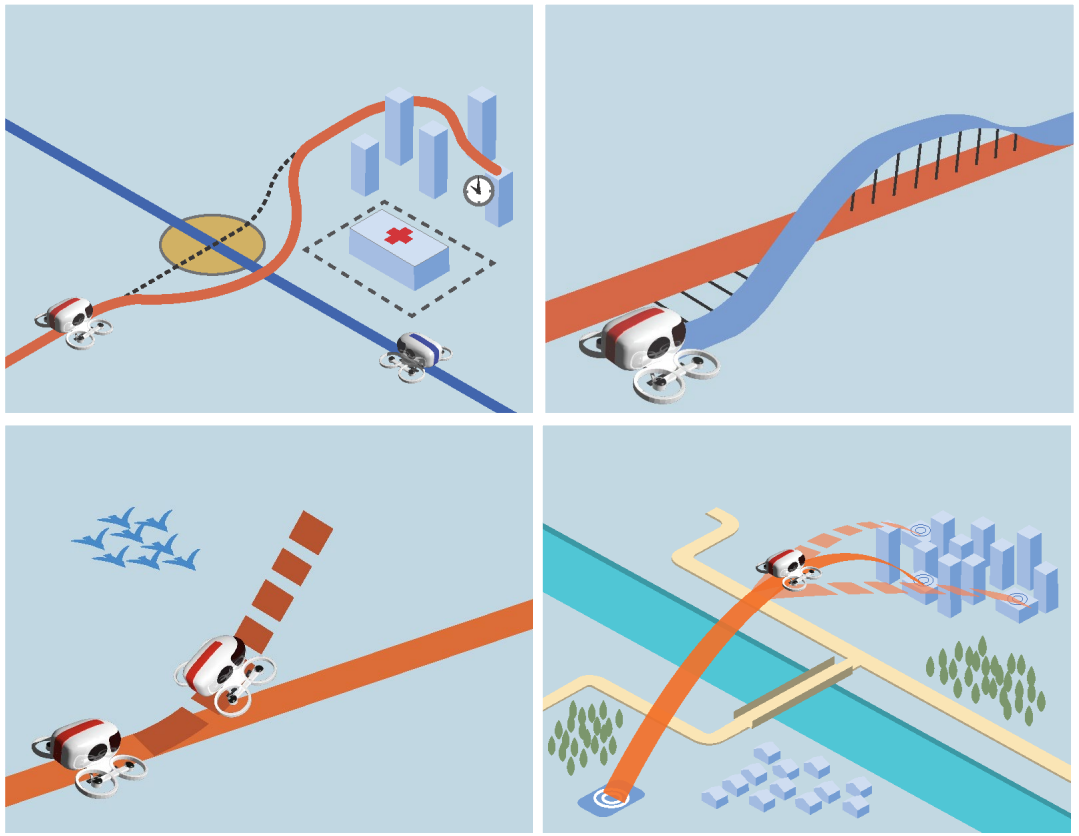




Contingency Management

- Future challenges includes understanding the information requirements for human operators and how those change with diverse and increasingly complex levels of autonomy and contingency management capabilities

- In-time safety assurance SFCs must be developed with these considerations that may be significantly different dependent upon the concept of operation employed



Summary

- Human-Autonomy Teaming approaches may need to scale as the architecture of SFCs, use of inter-dependent automated systems, and operational environments evolve toward greater complexity

- The multi-dimensional space for design of IASMS has implications for the envisioned changing roles and responsibilities of the human operator

- The IASMS Monitor-Assess-Mitigate functions can inform design decisions about what information the human operators should monitor, when they need to make assessments, and how they need to intervene

System-Wide Safety