



# Aerospace Cognitive Engineering Lab (ACEL)

## Automation Enabled Pilot (AEP) Series

Michael Feary, NASA  
[michael.s.feary@nasa.gov](mailto:michael.s.feary@nasa.gov)  
John Kaneshige, NASA  
Kimberlee Shish, NASA  
Loran Haworth, SJSUF at NASA Ames  
Amber Villa, NASA  
Thomas Lombaerts, KBR Wyle Services LLC  
Kevin Monk, NASA  
Nelson Iwai, ASRC  
John Archdeacon, ASRC  
Mieczyslaw Steglinski, KBR Wyle Services LLC  
Barth A. Baron Jr, SJSUF at NASA Ames

# Aerospace Cognitive Engineering Lab



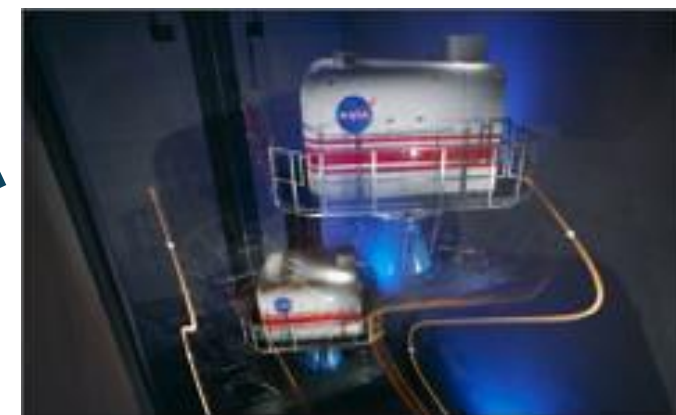
Analysis and Modeling



Desktop Simulation  
Development  
(FlightDeckZ, Advanced  
control and display  
development, Immersive  
environment development)



ACCEL-RATE  
Fixed Based  
Immersive Simulator



NASA Vertical Motion  
Simulator

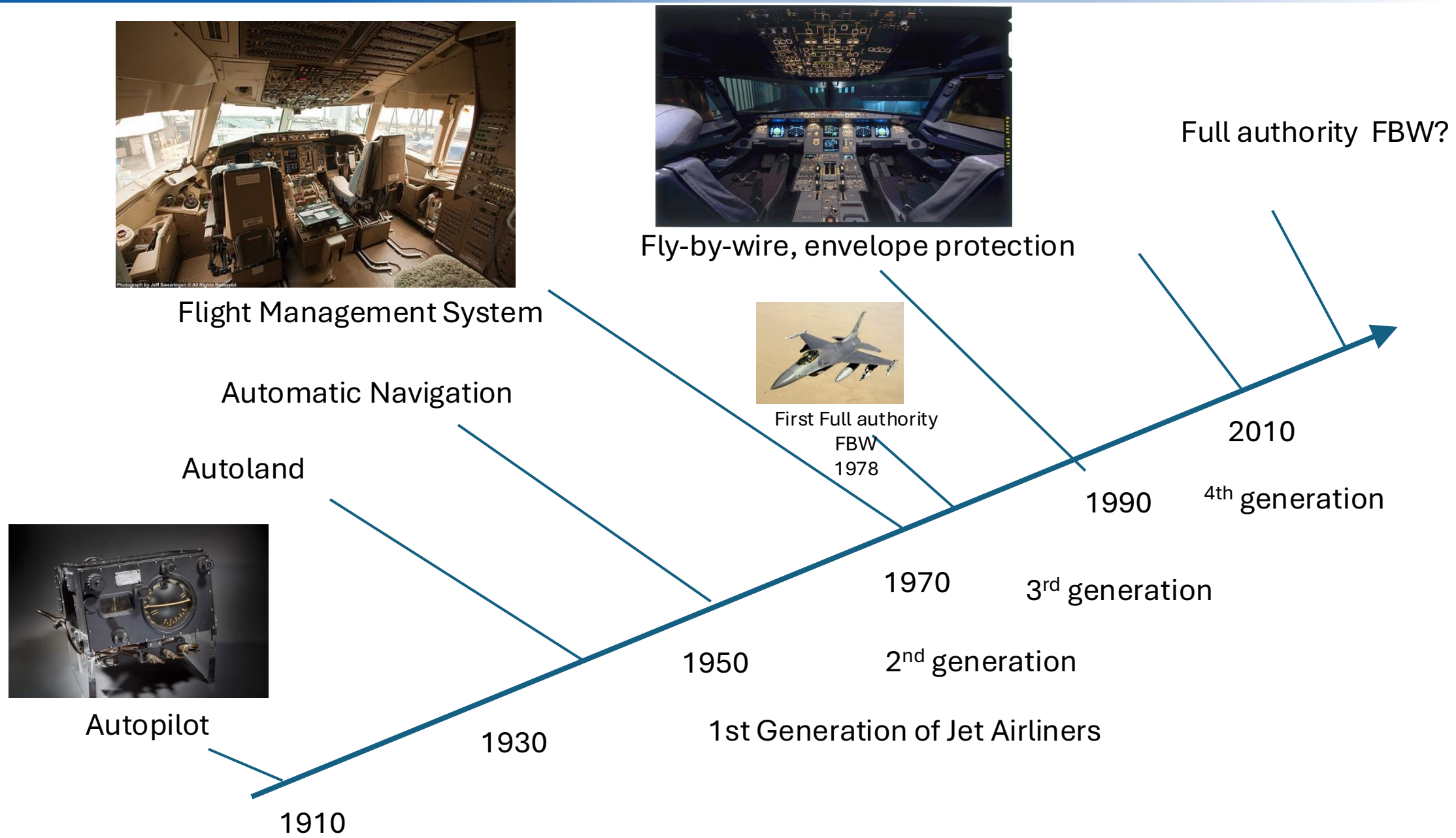
# Advanced Air Mobility (AAM)



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



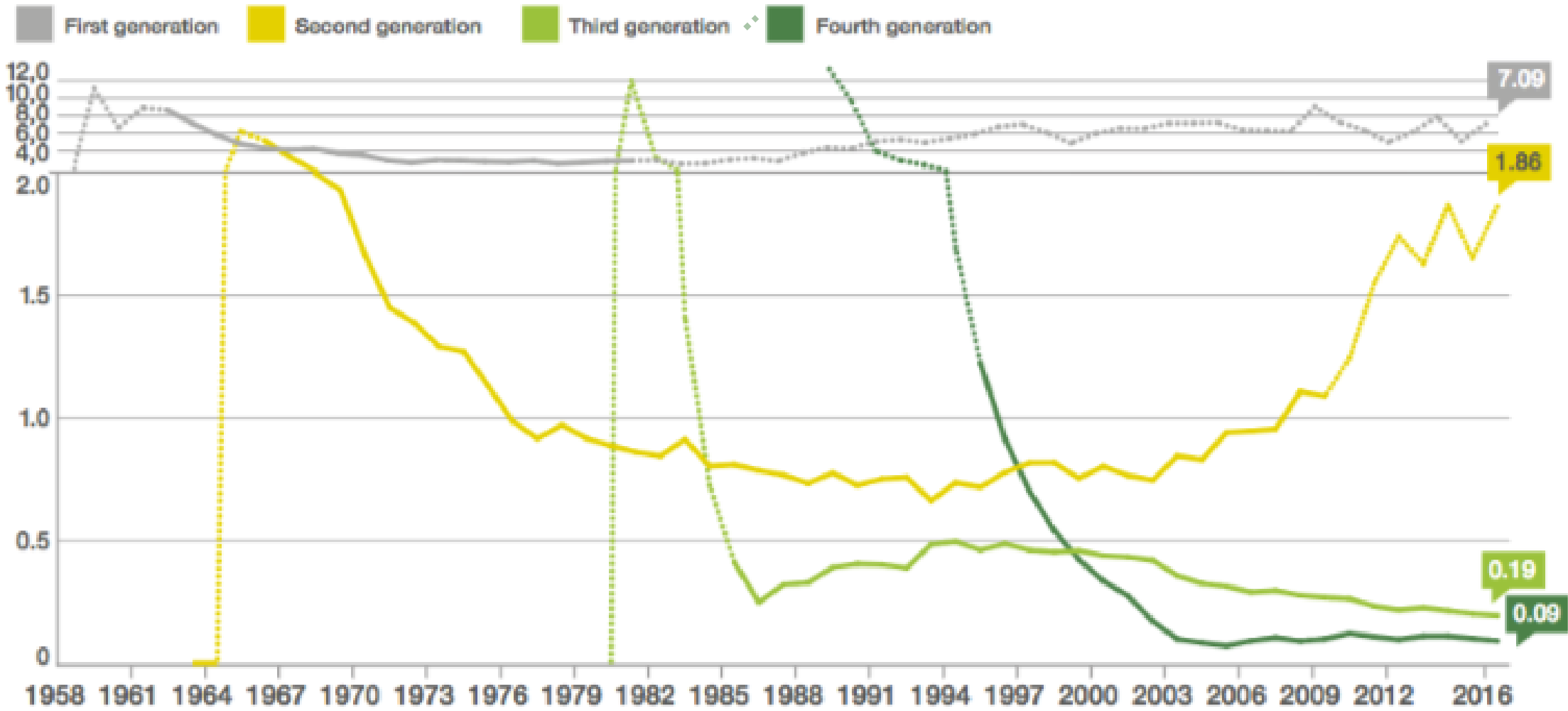
# Aviation Automation: A Brief History





# Fatal Accident Rates and Technology Adoption

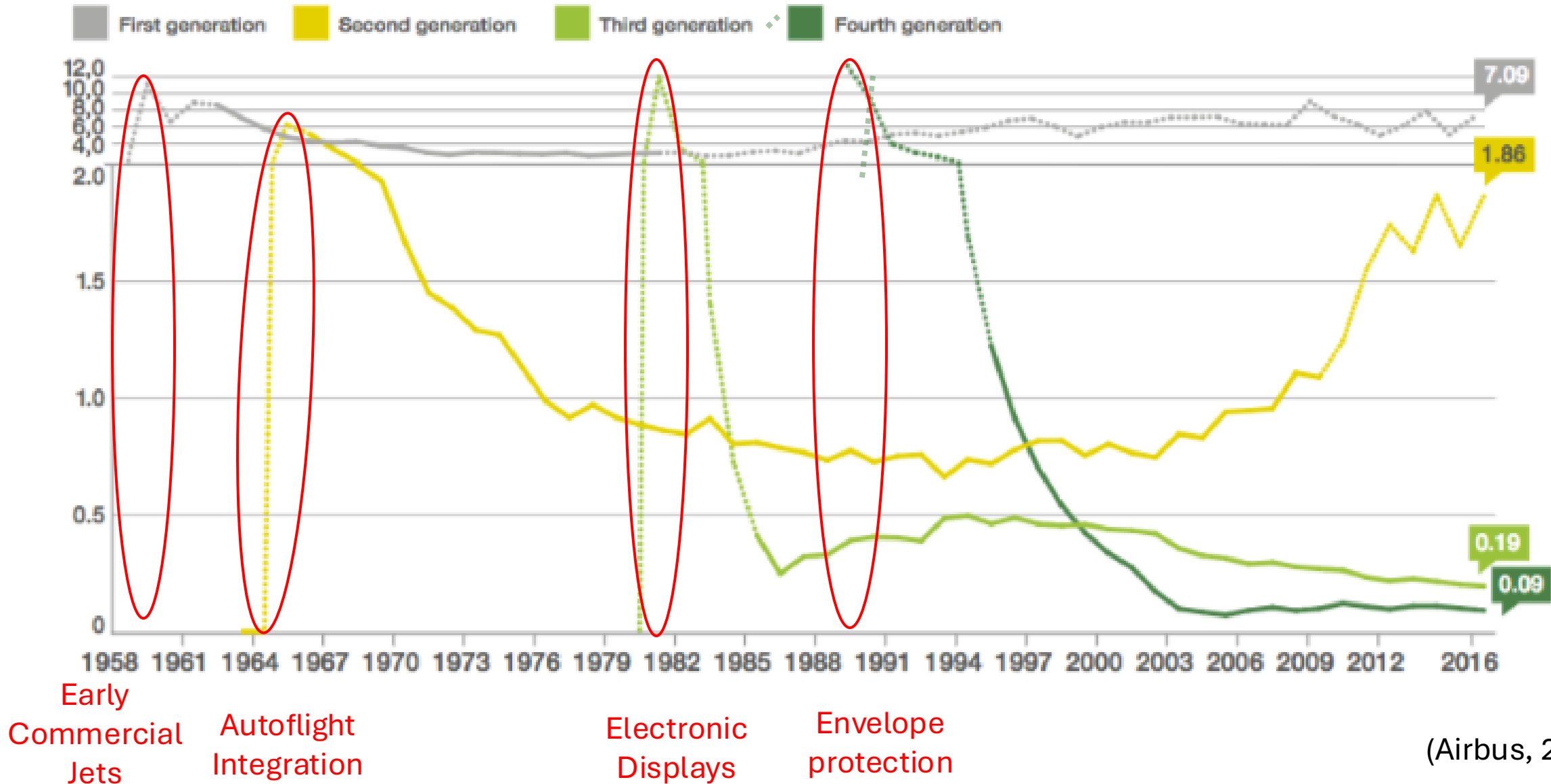
Accidents per million flight departures





# Fatal Accident Rates and Technology Adoption

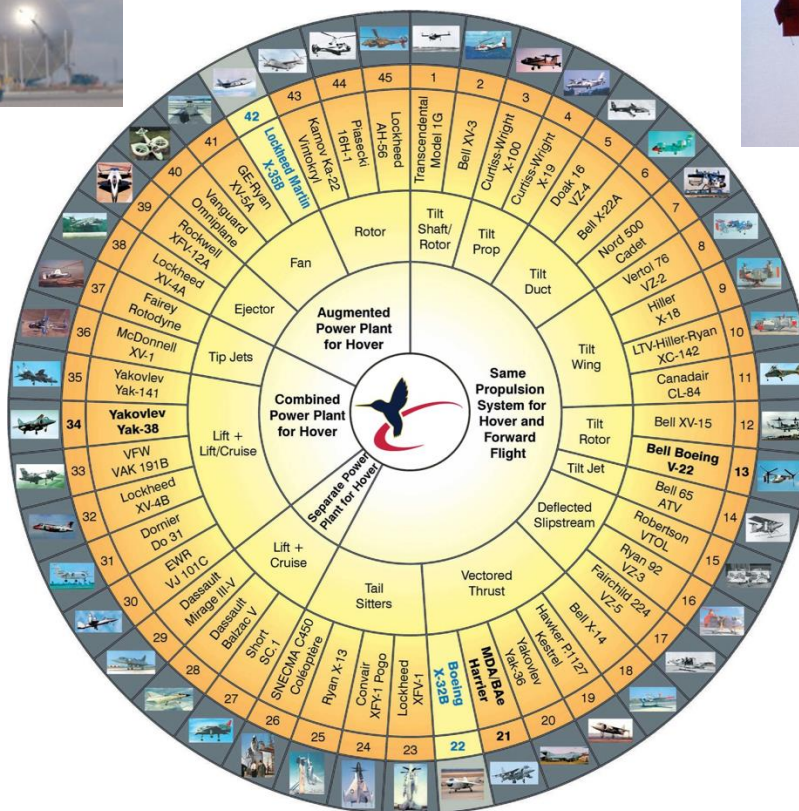
Accidents per million flight departures



(Airbus, 2018)

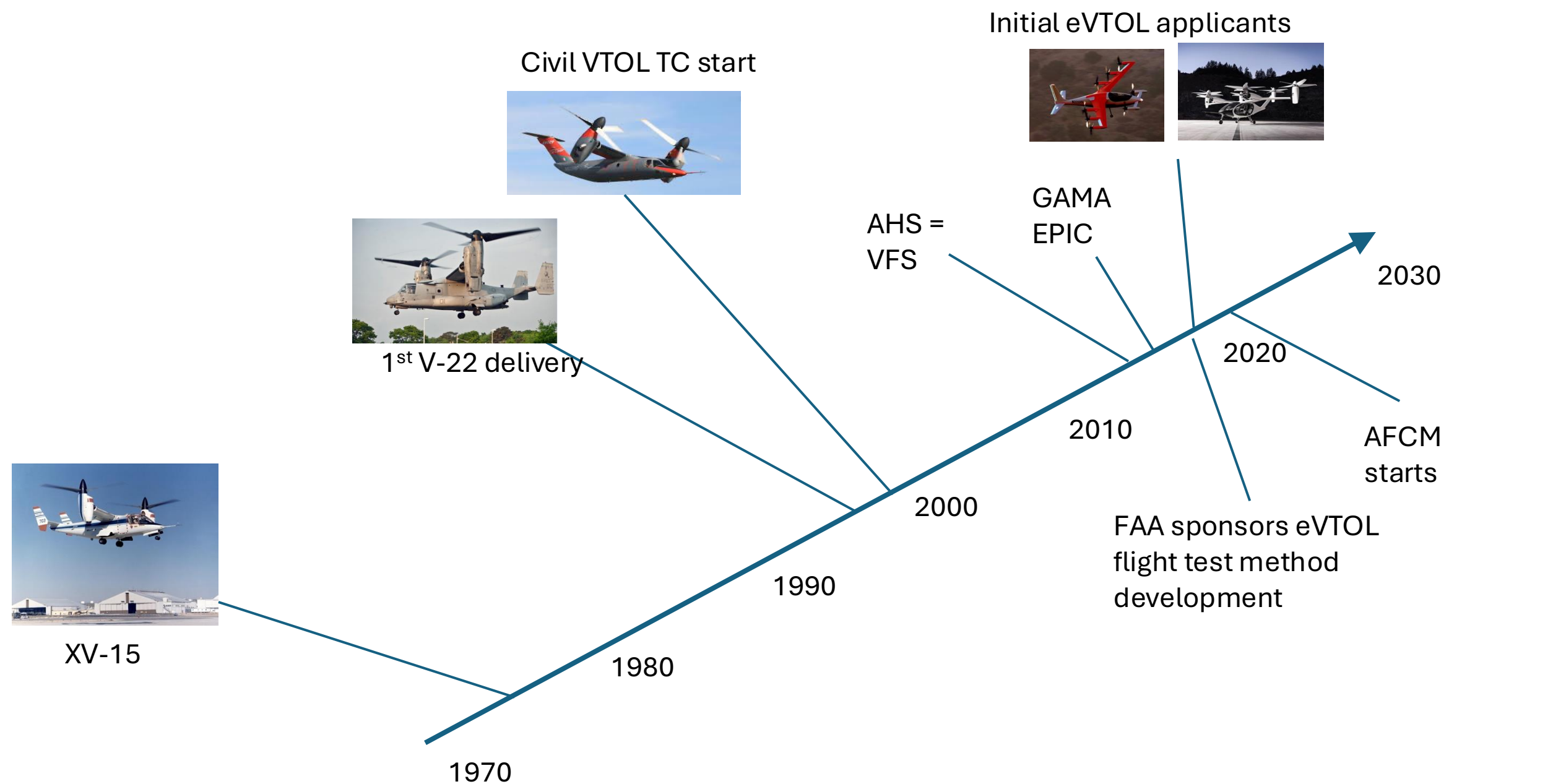


# Background: Powered Lift Aircraft





# A Very Brief History of Powered Lift





# Background

---

VSTOL aircraft control is a challenge

- Indirect Flight Controls viewed as the solution
- Stability and workload considerations different from airplane operations

”Simplified Vehicle Operations” introduced as a term to describe how to overcome challenge

- Implication is to reduce training

No consensus on eVTOL operations

- SVO is actually ”Simplified Vehicle Control” (SVC)

NASA term “Automation Enabled Pilot”

- New operations, new tools, new challenges



# Mission Oriented Handling Quality Evaluation

- Adapted from Military ADS-33, now MIL-DTL-32742
- Focus on the defining the Mission/Operational Concept
  - Determine performance criteria, environment
- Criteria do not change for the different vehicle configurations
- Criteria do not change for varying automation capabilities or configuration
  - Scalable from today's operational concept to m:n operations



Precision



Aggressiveness

| MTE                           | RE-<br>QUIRED<br>AGILITY | ROTORCRAFT CATEGORY |       |         |       | EXTER-<br>NALLY<br>SLUNG<br>LOAD |
|-------------------------------|--------------------------|---------------------|-------|---------|-------|----------------------------------|
|                               |                          | ATTACK              | SCOUT | UTILITY | CARGO |                                  |
| Tasks in GVE                  |                          |                     |       |         |       |                                  |
| Hover                         | L                        | ✓                   | ✓     | ✓       | ✓     | ✓                                |
| Landing                       | L                        | ✓                   | ✓     | ✓       | ✓     |                                  |
| Slope Landing                 | L                        | ✓                   | ✓     | ✓       | ✓     |                                  |
| Hovering Turn                 | M                        | ✓                   | ✓     | ✓       | ✓     |                                  |
| Pirouette                     | M                        | ✓                   | ✓     | ✓       | ✓     |                                  |
| Vertical Maneuver             | M                        | ✓                   | ✓     | ✓       | ✓     | ✓                                |
| Depart/Abort                  | M                        |                     |       | ✓       | ✓     | ✓                                |
| Lateral Reposition            | M                        |                     |       | ✓       | ✓     | ✓                                |
| Slalom                        | M                        | ✓                   | ✓     | ✓       | ✓     |                                  |
| Vertical Remask               | A                        | ✓                   | ✓     |         |       |                                  |
| Acceleration and Deceleration | A                        | ✓                   | ✓     |         |       |                                  |
| Sidestep                      | A                        | ✓                   | ✓     |         |       |                                  |
| Deceleration to Dash          | A                        | ✓                   | ✓     | ✓       |       |                                  |
| Transient Turn                | A                        | ✓                   | ✓     | ✓       |       |                                  |
| Pullup/Pushover               | A                        | ✓                   | ✓     | ✓       |       |                                  |
| Roll Reversal                 | A                        | ✓                   | ✓     | ✓       |       |                                  |
| Turn to Target                | T                        | ✓                   | ✓     |         |       |                                  |
| High Yo-Yo                    | T                        | ✓                   | ✓     |         |       |                                  |
| Low Yo-Yo                     | T                        | ✓                   | ✓     |         |       |                                  |
| Tasks in DVE                  |                          |                     |       |         |       |                                  |
| Hover                         | L                        | ✓                   | ✓     | ✓       | ✓     | ✓                                |
| Landing                       | L                        | ✓                   | ✓     | ✓       | ✓     |                                  |
| Hovering Turn                 | L                        | ✓                   | ✓     | ✓       | ✓     |                                  |
| Pirouette                     | L                        | ✓                   | ✓     | ✓       | ✓     |                                  |
| Vertical Maneuver             | L                        | ✓                   | ✓     | ✓       | ✓     | ✓                                |
| Depart/Abort                  | L                        |                     |       | ✓       | ✓     | ✓                                |
| Lateral Reposition            | L                        |                     |       | ✓       | ✓     | ✓                                |
| Slalom                        | L                        | ✓                   | ✓     | ✓       |       |                                  |
| Acceleration and Deceleration | L                        | ✓                   | ✓     |         |       |                                  |
| Sidestep                      | L                        | ✓                   | ✓     |         |       |                                  |
| Tasks in IMC                  |                          |                     |       |         |       |                                  |
| Decelerating Approach         | L                        | ✓                   | ✓     | ✓       | ✓     | ✓                                |
| ILS Approach                  | L                        | ✓                   | ✓     | ✓       | ✓     |                                  |
| Missed Approach               | L                        | ✓                   | ✓     | ✓       | ✓     |                                  |
| Speed Control                 | L                        | ✓                   | ✓     | ✓       | ✓     |                                  |

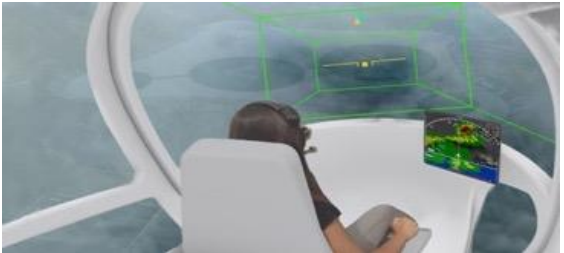
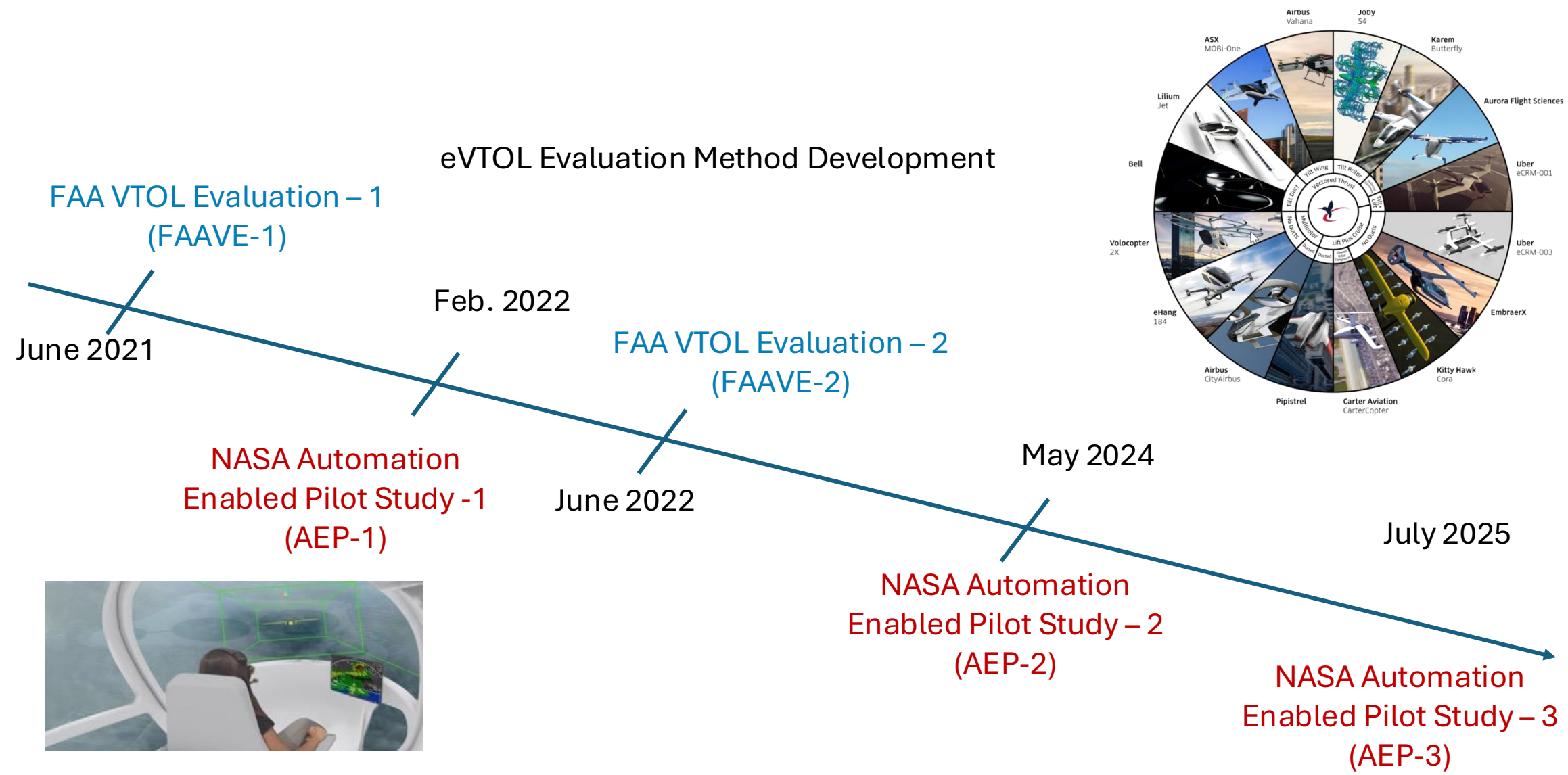
Notes: ✓ = Suggested maneuvers to apply with appropriate performance standards.

L = Limited agility

MTE maneuvers, ADS-33E-PRF (1996)



# eVTOL Automation Studies Background





# NASA Automation Enabled Pilot (AEP) Research

- **Goal**
  - Develop and evaluate representative electric Vertical Take-Off and Landing (eVTOL) aircraft automation to support the development of methods for compliance for novel control and pilot interface concepts
- **Objectives**
  - Identify automation challenges associated with flying representative eVTOL vehicles in AAM operational environments
  - Develop methods for characterizing and assessing automation enabled pilot/vehicle performance
    - For increasing levels of automation
    - Under nominal and off-nominal conditions
    - For various concepts of operation
  - Understanding Pilot requirements for increasingly automated systems
- **Approach**
  - Simulate eVTOL industry representative aircraft design concepts
  - Develop representative control and advanced automation technologies for enabling safe and efficient Aircraft Handling and Operations (AHO)
  - Evaluate eVTOL vehicle operations based on Integrated Piloting Requirements (IPR)





# Pilot Automation Interaction (PAI) Framework

