ICAO

INTERNATIONAL CIVIL AVIATION ORGANIZATION

A UN SPECIALIZED AGENCY



Lessons from the Initial Evaluation of STPA Applied to Advanced Air Mobility Ecosystem

on behalf of the ICAO Advanced Air Mobility Study Group

ICAO

Advanced Air Mobility Study Group (AAM SG)

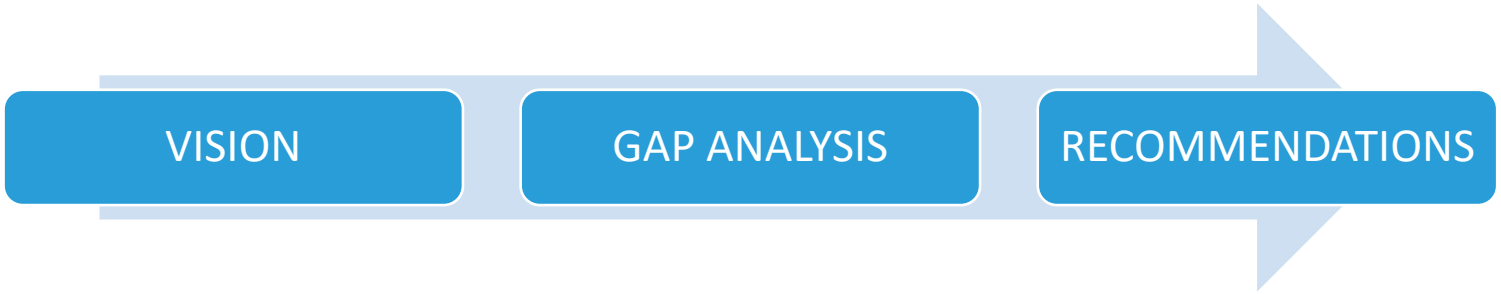
Terms of Reference refers

The ICAO Assembly recognized that the rapidly evolving AAM ecosystem calls for work to be undertaken by ICAO and agreed to establish an expert group to develop a holistic vision and framework, as well as to advise ICAO on activities in this area.

Objectives:

- to perform an assessment of the enablers such as Unmanned Aircraft System Traffic Management (UTM), automation and autonomy, information and data management, artificial intelligence, etc., and the outline of a global regulatory framework
- to perform a **gap analysis** and make **recommendations** for future work

To perform these tasks, the AAM SG should develop a clear understanding of the AAM ecosystem, its components, the interaction among said components, as well the interaction with other airspace users, from a global perspective (Vision).



Initial Evaluation of STPA for AAM

As decided by the AAM Study Group

Objective: The activity aimed to investigate the benefit of using systems theory-based methods such as STPA in gaining confidence in the completeness of the AAM ecosystem as described in the VISION document.

Methodology: Preparatory work has been done with the support of an expert practitioner. The initial evaluation was conducted through three virtual workshops (March 21, 24, and April 2, 2025), each lasting two hours.

Participants: Average of 15 experts from the Advanced Air Mobility Study Group (AAM SG) and the ICAO Safety Management Panel (SMP).

STPA starting elements for the AAM workshops

Goals

The overall objective is to support a safe, secure, efficient, and environmentally sustainable integration of Advance Air Mobility operations, and to facilitate the development of the AAM ecosystem.

Losses

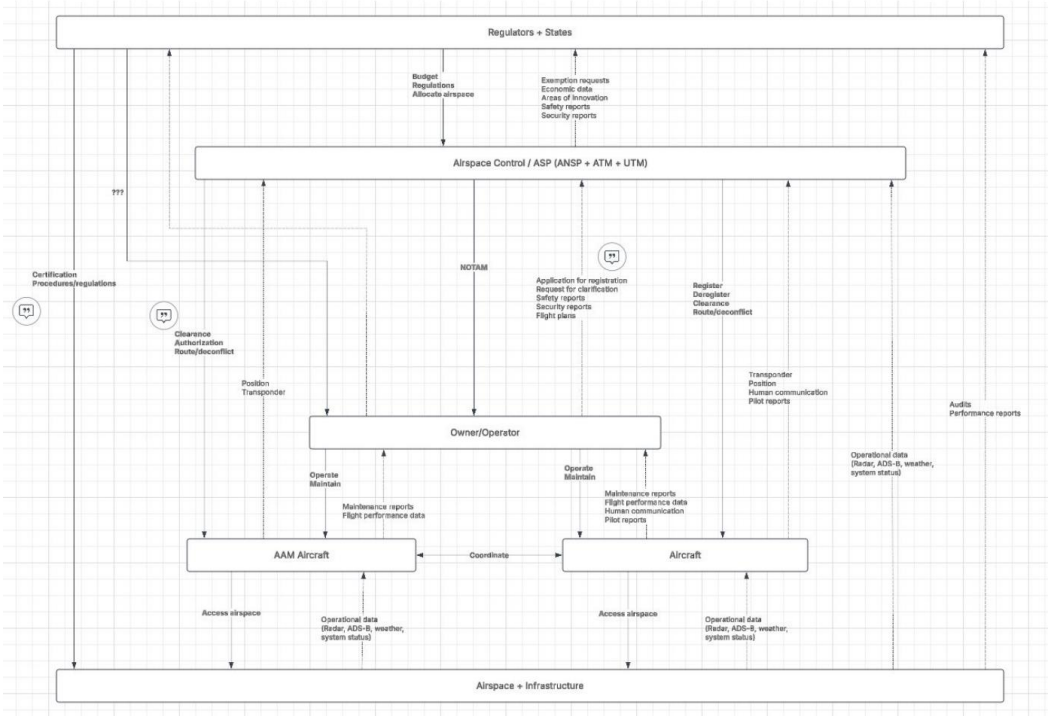
- **L1:** Loss of Safety, Security, Efficiency, or Environmental Sustainability due to inadequate integration of AAM operations
  - L1.1: Loss of human life or serious injury
  - L1.2: Damage to aircraft, infrastructure, or third-party property
  - L1.3: Environmental harm due to emissions, noise pollution, or hazardous material spills
  - L1.4: Airspace inefficiency leading to congestion, delays, or operational conflicts
  - L1.5: Security breaches (such as cyberattacks or unauthorized access)
- **L2**: Showstoppers to International AAM Ecosystem Development
  - L2.1: Loss of public trust
  - L2.2: Mission failure due to lack of technological, regulatory, or operational readiness
  - L2.3: Economic losses from disrupted operations or high operational costs
  - L2.4: Lack of international harmonization and standardization hindering scalability
  - L2.5: Data breaches or leaks compromising sensitive operational or personal information

STPA AAM workshops

System-level Hazards: For both passenger-carrying and non-passenger-carrying AAM operations:

- H1: Inadequate physical separation leading to collision
- H2: Insufficient physical integrity or robustness
- H3: Inadequate ground and airspace infrastructure
- H4: Regulatory and governance issues affecting public trust

After establishing an initial skeleton of the control structure in the first session, subsequent workshops focused on identifying and analyzing UCAs.



ICAO

Findings

The evaluation of STPA to the AAM ecosystem revealed both opportunities and challenges:

- **Finding the right level of abstraction**: The primary challenge throughout this process was determining the optimal level of abstraction that would effectively manage the inherent complexity of the AAM ecosystem while still yielding actionable insights. Even simplified models of the AAM ecosystem reveal substantial complexity when introducing change within highly integrated aviation systems.
- **Goals**: One challenge was to simultaneously consider critical safety losses along with losses of public trust, and sustainability as they are of different nature.
- **Role of the moderator** : STPA's structured methodology requires skilled facilitation to guide productive discussions and maintain analytical rigor. STPA effective application benefited from a skilled moderator to guide the process and facilitate productive discussions.
- **Iterative approach**: The analysis must evolve alongside AAM development, requiring refinement and updates. The evolution from human-operated systems to more automated processes creates additional complexity, particularly were responsibilities and interfaces overlap.

Conclusions

From the AAM SG based on an initial familiarization

The initial evaluation of STPA confirmed STPA's utility for analyzing systems challenges inherent in AAM integration, particularly in identifying control structure elements and unsafe control actions that might not be apparent through traditional safety analysis methods.

While challenges exist due to the evolving nature of the AAM ecosystem, the structured approach provided some initial valuable insights into system-level interactions and potential safety concerns.

The AAM SG agreed to recommend to ICAO to consider the application of Systems-Theoretic Approach as a future recommendation for work to be performed alongside the development of the global regulatory framework for AAM.

In addition, ICAO is exploring the use of STPA in other topics (e.g. the study on Cross-border transferability and by the Dangerous Goods Panel on the transportation of lithium batteries).



Thank You!

ICAO

What is the International Civil Aviation Organization (ICAO)

- ICAO is a specialized agency of the United Nations. It was created with the signing on 7 December 1944, of the Convention on International Civil Aviation
- Our goal is to foster safe, secure and sustainable air connectivity to promote peace and socioeconomic development
- As the global forum for international civil aviation, ICAO works closely with its 193 Member States to develop international Standards and Recommended Practices that govern civil aviation.



ICAO