



WORKING PAPER

ASSEMBLY — 41ST SESSION

TECHNICAL COMMISSION

Agenda Item 31: Aviation Safety and Air Navigation Standardization

DEVELOPING A CAPABILITY MATURITY METHODOLOGY FOR AUTONOMY

(Presented by Singapore and the Flight Safety Foundation)

EXECUTIVE SUMMARY

This paper provides an overview of a methodology for evaluating automation functions proposed by the Flight Safety Foundation (FSF) Advanced Air Mobility (AAM) Working Group. It is designed to discover the technical and regulatory readiness for aircraft automation and operational automation functions, including the clearly defined role of the human for normal and degraded operational modes.

Action: The Assembly is invited to:

- a) note the work progressed by the FSF AAM Working Group of the Foundation’s Autonomous and Remotely Piloted Aviation Capabilities (ARPAC) Advisory Committee; and
- b) encourage ICAO to engage with member States and international organizations, including FSF, when addressing increasing levels of automation and autonomy, and consider the work of the FSF AAM Working Group on the capability maturity matrix and gated process.

<i>Strategic Objectives:</i>	This working paper relates to the Safety Strategic Objective.
<i>Financial implications:</i>	This paper has no significant financial implications.
<i>References:</i>	<ol style="list-style-type: none">1) NASA AAM Ecosystem Working Group (WG) Presentation: Capability Maturity Model for Automation – Original Author: Wes Ryan, Feb 22, 2022 NASA NARI, https://aam-cms.marqui.tech/uploads/aam-portal-cms/originals/da85f1b4-b18d-48aa-8db6-b3b0df85c99f.pdf, Recording: https://youtu.be/516FwOrNZbg2) ASTM AC377 Technical Report #1 “Technical Report (TR) 1, Autonomy Design and Operations and Aviation Terminology and Requirements Framework.”3) ICAO, HLCC 2021-WP/123, Human Factors and Safety Considerations in Increasingly Automated Aviation Systems, October 2021.

1. INTRODUCTION

1.1 Increasing automation with the goal of future autonomy has been a constant focus of the global aviation community for many years. However, increasing automation toward autonomy has proven to be an elusive goal in applications where a high level of safety for civil trustworthiness must be demonstrated. Recent events have shown even highly experienced system designers and civil authorities struggle to implement new automation capabilities that are resilient in service. This will become an even greater challenge for highly automated systems that move from aircraft-system-level automation, which is primarily assistive in nature (for the pilot on board the aircraft), and push toward operational autonomy. A methodical and robust process for achieving automation capability maturity and for evaluating potential gaps in technology, data sources and the governing civil regulations must be applied throughout the design, development, testing, certification, operational approval and airspace integration of any new automation capability.

1.2 To address this challenge, Flight Safety Foundation (FSF) and the United States National Aeronautics and Space Administration (NASA) have conceptualized an automation toolkit that proposes a capability maturity model (CMM) structure and a gated automation evaluation process. Both are intended to provide a common structure under which the aviation industry can honestly evaluate the technical and regulatory maturity of automation functions being proposed for aircraft automation and operational autonomy.

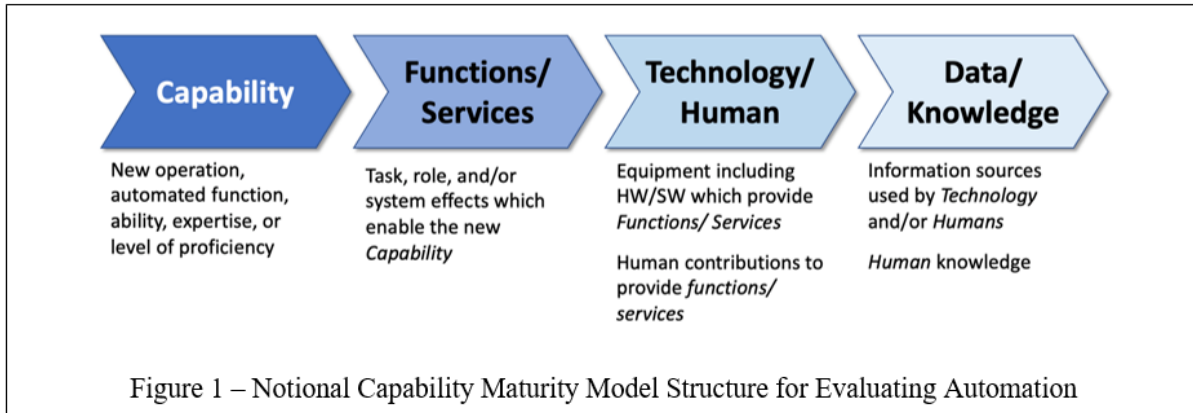
1.3 Though aircraft automation and operational integration are inextricably tied to each other, they are often evaluated separately, and in a serial manner, during design and development and during certification. This is partially because of the challenge of designing a system and then evaluating how it works in operational service, and because the aircraft and its operational certification are often evaluated by separate parts of civil authorities with different and often mutually exclusive processes. This presents a growing challenge for the human-machine interface and resilient design of automation that replaces traditional pilot functions, particularly as this automation is envisioned to perform capabilities tied to operational integration that are the legal responsibility of air traffic controllers, dispatchers, pilots and other human elements in the system.

2. DISCUSSION

2.1 The development of any new automation capability must be evaluated in the context of the type of aircraft, its operational mission, the specific elements or segments of that intended mission, the airspace in which it is intended to fly, the clearly defined role of the human (for normal and abnormal operating conditions) and the level of expected safety that must be achieved to be accepted by civil aviation authorities charged with protecting the public. Therefore, one must assess the maturity, as well as the accuracy, availability, integrity, continuity and coverage of data sources and technology to implement an intended function in support of a new capability.

2.2 Figure 1 shows the notional FSF/NASA proposed CMM structure. The model ties the proposed automation capability (a new operational concept, a new aircraft/system function, or other) to the functions and services that will enable the new capability. These functions and services are tied to the core technology that will enable them, and to the clearly defined role of the human regarding their expected contribution to the function or service. The technology that enables the proposed functions or services is in turn driven by data and information sources that are required for the technology to perform its intended function. Without this entire thread being evaluated and clearly understood, it is possible to envision new

automation capabilities whose intended functions cannot be supported by current technologies and data sources. It may also be possible to envision new automation capabilities that are beyond the knowledge or skill for a human to perform the necessary role to safely team with the new automation capability.



2.3 To implement the CMM concept, a gated evaluation process is proposed (see Figure 2). The intent of the gated process is to evaluate both the technical and the regulatory maturity required to enable a new automation capability. Often technology is ready at a prototype level, causing companies to speculate how a new functional capability enabled by that technology might be used in service. However, until these capabilities are shown to have reached a level of civil readiness that is acceptable to civil regulators, they may not be allowable under current regulation. It is unusual for a regulation to be changed to support a new capability before the enabling technology is proven to be mature to a level acceptable to civil authorities.

2.4 The proposed gated process steps are as follows:

2.4.1 Gate 0: Identify an intended function for automation including the context — intended use (e.g., operational context and/or phase of flight, and functional interfaces/dependencies).

2.4.2 Gate 1: Explain the potential benefits or incentives of automating the proposed function (e.g., safety enhancement, operational enhancement and economics). Identify any potential risks, limitations or barriers to automating the proposed function. Perform a risk analysis on the intended function in context of its intended use.

2.4.3 Gate 2: Define how the intended function is currently completed/accomplished in operations and describe how it would be completed/accomplished once automated. Include human responsibilities and authority, including how both could change for normal or degraded system function, with consideration to changing system interfaces or dependencies.

2.4.4 Gate 3: Define the required information, processing and outputs necessary to automate the function.

2.4.5 Gate 4: Identify candidate example technology products that may be capable of automating the function.

2.4.6 Gate 5: Identify gaps in the current technology products to perform the intended function, and what operations the current technology could enable now.

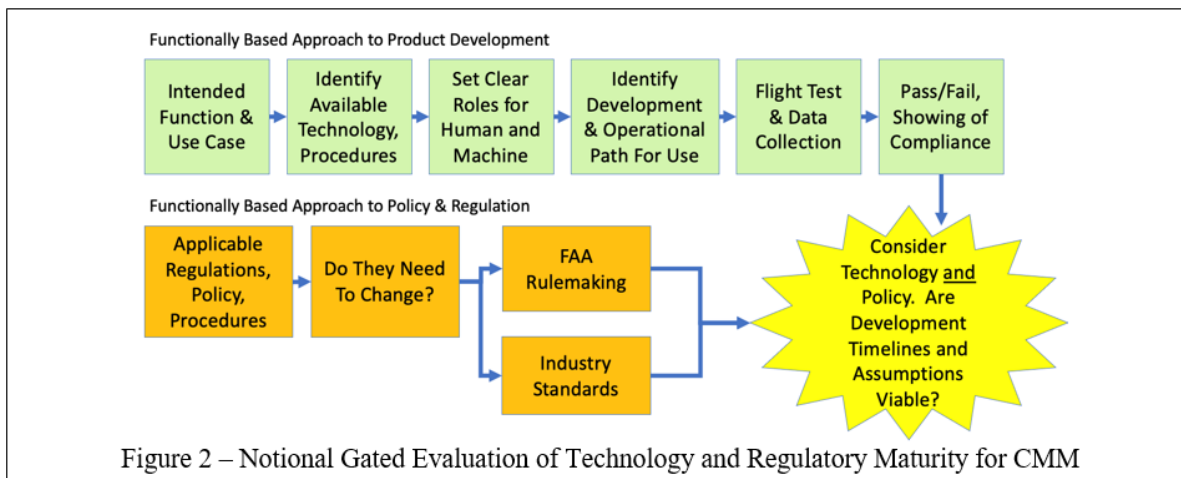


Figure 2 – Notional Gated Evaluation of Technology and Regulatory Maturity for CMM

2.4.7 Gate 6: Identify the required maturity level of a technology product for it to achieve the intended function. Describe any differences in the level of maturity that may be appropriate, depending upon aircraft size (i.e., normal category, transport category), kind of operation (i.e., cargo, passenger-carrying), or any other appropriate risk consideration.

2.4.8 Gate 7: Identify a path from current technology capabilities to the future technology capabilities necessary to achieve the identified maturity level(s).

2.4.9 Gate 8: Identify the applicable regulations/policy/standards/guidance (i.e., aircraft certification, operational, airman, ICAO) related to the current function.

2.4.10 Gate 9: With reference to Gates 2 and 8, identify what regulations/policy/standards/guidance may need revision and where new regulations/policy/standards/guidance may need to be developed to certify an aircraft with the technology and authorize/enable its use in operations.

3. CONCLUSION

3.1 The FSF seeks to engage with ICAO Member States to evaluate the proposed CMM and gated automation evaluation steps. The goals of these discussions are to: 1) gain support for the CMM concept and have it applied to emerging automation concepts to evaluate its validity; 2) formalize the methods being used to evaluate automation capabilities to identify a path to automation maturation and integration strategies leading to safe aircraft automation, operational automation and future autonomy; and 3) encourage Member States and industry to consider adopting the CMM and gated evaluation processes formally into their automation efforts toward future autonomy.