International Civil Aviation Organization

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WORKING PAPER

FOURTEENTH AIR NAVIGATION CONFERENCE

Montréal, Canada, 26 August to 6 September 2024

Agenda Item 4: Hyper-connectivity of air navigation system
4.1: Connected aircraft concept and associated challenges

CONNECTED AIRCRAFT CONCEPT AND NEXT STEPS

(Presented by the Secretariat)

EXECUTIVE SUMMARY

Air traffic management (ATM) concepts are aimed at improving operational safety, efficiency and capacity, as well as accommodating the needs of traditional aviation and new entrants. They are heavily dependent on the collection, processing and use of information, and require extensive information exchange between the aircraft and other aviation stakeholders on the ground. ICAO has been working on the development of a concept that illustrates the benefits of connected aircraft functions and outlines a framework for the use of performance-based communication links to accommodate the expected growth in demand for the aforementioned information exchange. The paper presents the summary of the draft connected aircraft concept and proposes the next steps.

Action: The Conference is invited to agree to Recommendation 4.1/x — Evaluation, standardization and implementation of the connected aircraft concept in paragraph 3.

Strategic Objectives:	This working paper relates to the Safety, Air Navigation Capacity and Efficiency, and Environmental Protection Strategic Objectives.
Financial implications:	*Impact for the aviation community:* Considerable opportunities are associated with the implementation of the connected aircraft concept, which provides lower-cost alternatives relative to traditional aviation data links. The aviation community at large will benefit from the development of a regulatory framework necessary for the safe, globally harmonized and interoperable implementation of the concept. *Impact for ICAO (relative to the current Regular Programme Budget resource levels)*: The ICAO activities referred to in this working paper will continue over the next triennia and no additional resources are required.
References:	Doc 9750, *Global Air Navigation Plan* Doc 9854, *Global Air Traffic Management Operational Concept*

1. INTRODUCTION

1.1 The guiding principles for the *Global Air Traffic Management Operational Concept* (Doc 9854) explicitly identified the dependence of the air traffic management (ATM) community on system-wide sharing of information. This information sharing includes airborne elements as an essential part of the fully integrated, interoperable and robust ATM system as reflected in the several threads of the Aviation System Block Upgrade framework in the *Global Air Navigation Plan* (Doc 9750). A connected aircraft concept has been developed, with the support of the Air Traffic Management Requirements and Performance Panel (ATMRPP) and other relevant expert groups, and has reached the necessary maturity for soliciting global direction for the next course of action.

2. DISCUSSION

2.1 Overview of the concept

2.1.1 Air-ground communications today via voice and data link are limited to concise information that supports air traffic services and aeronautical operational control. The need for a connected aircraft concept is driven by the increasing demand for air-ground connectivity, which is forecasted to exceed the capacity of existing aeronautical communication systems. Many aircraft operators have already found value in connectivity to improve operations and the passenger experience. Airframe and aircraft system original equipment manufacturers see value in obtaining real-time information to monitor the performance of their products (e.g., engines, avionics), allowing them to address maintenance and performance issues quickly and effectively. Emerging uses for information in ATM (e.g. trajectory-based operations) also require an increased level of connectivity to handle information exchanges between the aircraft and other stakeholders on the ground.

2.1.2 As the global air transportation data and information exchange vision has matured, along with the performance-based framework (e.g., performance-based communications and surveillance (PBCS)), technological advances specifically related to Internet Protocol (IP)-based communications and mobile computing have significantly increased the number of service offerings and future possibilities. The introduction and proliferation of IP-based aircraft links have led to the availability of multiple communication links. These additional communication links represent an extension to the data link continuum and offer new capabilities for aviation. These provide options for air-ground exchanges, available bandwidth and levels of performance from which to select.

2.1.3 As depicted in Figure 1, the connected aircraft concept describes a future in which a range of options will be available to meet the air-ground communications and information exchange needs of airspace users (flight crew and operational control centre), ATM services providers, aerodrome operators and other third-party information suppliers (e.g., weather services). The concept is envisioned to: a) complement human-to-human communication with machine-to-machine interaction between the aircraft and ground parties; b) improve data distribution and accessibility; and c) enable the exchange of a richer set of information via aviation and non-aviation communication links with the aircraft to improve operational awareness and decision-making. More details on the concept, including use cases for manned[1] and unmanned aircraft, including new entrants[2] as well as technical and regulatory considerations can be found in the latest draft of the connected aircraft concept on the AN-Conf/14 site under the Reference Documents page at: https://www.icao.int/Meetings/anconf14/Pages/Reference-Documents.aspx.

[1] Manned Aircraft – Existing airspace users, including commercial, business, and general aviation aircraft.

[2] New Entrants – New airspace users, such as advanced air mobility (AAM) aircraft, unmanned aircraft systems, supersonic aircraft, or high-altitude platform systems (HAPS).

2.2 Technical and operational validation considerations[3]

2.2.1 Part of the draft connected aircraft concept, namely information exchange using performance-based links, has been considered technically and operationally during the development of ICAO provisions concerning the flight and flow — information for collaborative environment (FF-ICE) services (refer to AN-Conf/14-WP/11). These activities, regardless of their scope and scale, have proven to be excellent opportunities to bring together various stakeholders and familiarize them with a new concept. In addition, the results of the activities have identified areas that require further investigation and discussion, ultimately contributing to an enhanced quality in the ICAO provisions and guidance material. In this regard, ICAO, with the support of States and industry stakeholders, wishes to continue these activities as part of progressing the work concerning the FF-ICE services focused on post-departure air-ground and ground-ground communications, and information exchange.

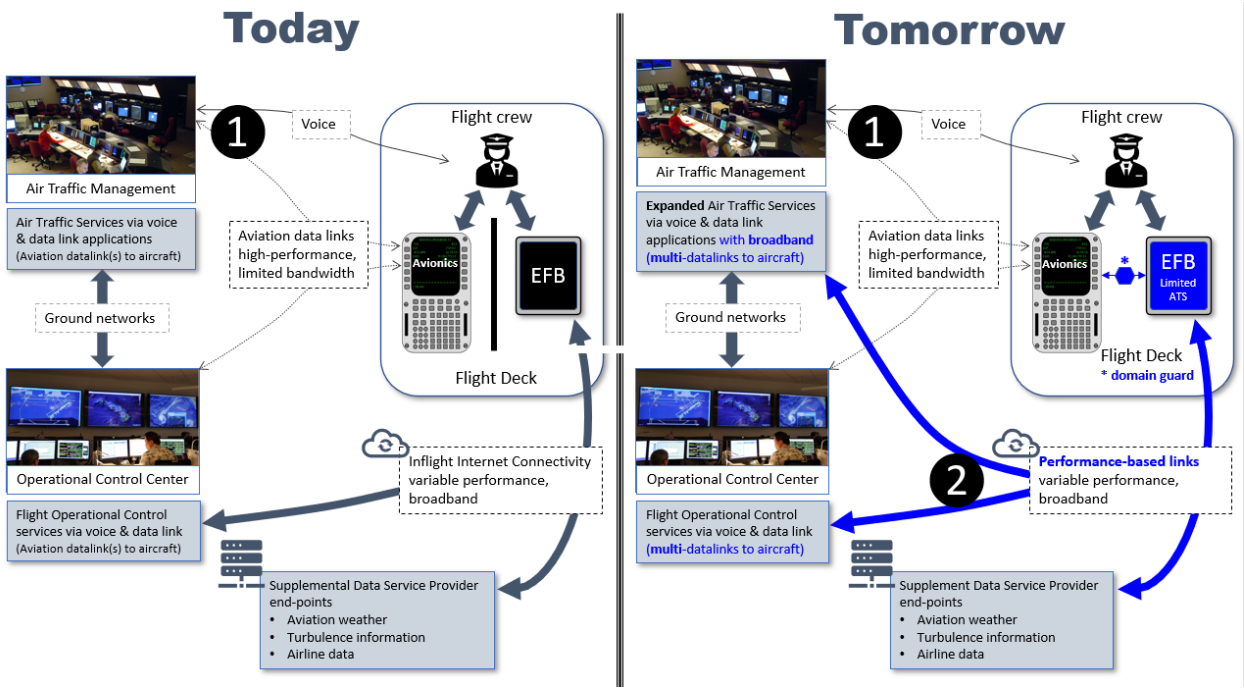

Figure 1. Air-ground information exchange paths

2.3 Further investigation to identify global standardization needs

2.3.1 Advancement of several key ICAO work programmes will eventually contribute to the implementation of the connected aircraft concept. These include the tasks concerning post-departure FF-ICE services (2.2.1 refers), air-ground system-wide information management, PBCS framework, aviation cybersecurity and trust framework. Concerning aeronautical frequency spectrum usage and the possible use of commercial services in frequency bands regarded by the International Telecommunication Union as non-safety spectrum, appropriate safety assessments have to be performed, knowing that it must be avoided to set any precedent that implies that aviation does not need access to safety spectrum and the advantages the use of such spectrum brings. Furthermore, tasks to address cyber threats and risks to the civil aviation sector, as described in AN-Conf/14-WP/14, are also required.

[3] focuses on industrial research and validation, includes: the proof-of-concept validation, standalone prototyping implementation and test, testing and prototyping in a representative environment, and the full engineering feasibility demonstration in actual system application.

2.3.2 However, to ensure a safe, globally harmonized and interoperable implementation of the concept, and to determine the need and appropriate level of standardization through ICAO provisions, further investigation in other subjects (i.e. comprehensive gap analysis) is also necessary:

2.3.2.1 ***Interoperability and end-to-end performance requirements***. Mixed aircraft equipage (aviation data link and performance-based link), individual aircraft operator choices selected from available performance-based links, and variable deployment across flight information regions will necessitate the global requirements to ensure interoperability. Any new performance-based links supporting ATM operations predicated on a required communication performance and/or required surveillance performance specification would require analysis and appropriate allocations assigned within the overall desired specifications. New functions enabled by the concept will call for an assessment of the required performance, including the required level of safety, and allocations based on both human and technical performance aspects. Additional mechanisms may be warranted to ensure the use of the "correct" pathway whose end-to-end performance meets the requirements of the given function.

2.3.2.2 ***Evolution of the electronic flight bag (EFB)***. The EFBs play a notable role in the concept by providing a potential interface to take advantage of additional efficiency, flexibility and cost-effectiveness in the delivery and display of certain kinds of information. This supplements and enhances the information provided by the aircraft avionics (e.g. flight management system). These new functions call for an assessment of both the suitability of an EFB and the nature of associated information exchanges (safety-critical or not) between the ground, EFB and aircraft avionics. In addition, because the concept brings more information to the flight deck, the evolution of EFB or the introduction of other novel solutions is expected to ensure the flight crew can safely and effectively manage the flight and make the best use of the additional information.

2.3.2.3 ***Human factors and operational procedures***. The concept still involves human-machine interactions through the devices to be used by the human actors (e.g. pilots and controllers). Therefore, it is essential to consider the role of humans in both system integrity and system operation. In addition, the system design and operational procedures should also consider potential system abnormalities and expected responses from humans.

2.3.2.4 ***Aircraft avionics certification and operational authorization.*** The concept does not envision changes to the integrity or certification methods for aircraft avionics. The allocation of functions may change between aircraft avionics and commercial off-the-shelf equipment, but the resulting architecture shall maintain acceptable integrity commensurate with the target level of safety for operations. The complexity of the air-ground networks and subnetworks and any potential changes to the allocation of functions will be a key driver for the level of scrutiny necessary in the operational authorization process.

3. CONCLUSION

3.1 ATM concepts are aimed at improving operational safety, efficiency and capacity, as well as accommodating the needs of traditional aviation and new entrants. They are heavily dependent on the collection, processing, and use of data and information, and require extensive exchange between the aircraft and aviation system participants. The connected aircraft concept illustrates the benefits of connected aircraft functions. It also outlines a framework for the use of performance-based links to accommodate the expected growth in demand for data and information exchange between the aircraft and relevant aviation stakeholders. Several ongoing ICAO work programmes are expected to support the safe, globally harmonized and interoperable implementation of the concept. However, there is still more work to be done by Member States, industry stakeholders and ICAO.

3.2 In light of the above, the Conference is invited to agree to the following recommendation:

Recommendation 4.1/x — Evaluation, standardization and implementation of the connected aircraft concept

That States:

a) evaluate the technical and operational aspects to further mature the draft connected aircraft concept together with industry stakeholders, and provide ICAO with the results;

that ICAO:

b) update the draft connected aircraft concept, and relevant threads of the Aviation System Block Upgrade framework in the Global Air Navigation Plan to guide the development of ICAO provisions and guidance material, as necessary, taking into account input from the Conference and the results of the States' evaluation;

c) conduct a comprehensive gap analysis to identify areas requiring ICAO provisions and guidance to support the safe, globally harmonized and interoperable implementation of the connected aircraft concept, taking into account input from the Conference; and

d) update relevant ICAO provisions and guidance material based on the updated draft connected aircraft concept and the comprehensive gap analysis above, as necessary.

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