



WORKING PAPER

ASSEMBLY — 40TH SESSION

EXECUTIVE COMMITTEE

Agenda Item 26: Other high-level policy issues to be considered by the Executive Committee

NEW OPERATIONAL CONCEPTS INVOLVING AUTONOMOUS SYSTEMS

(Presented by the International Coordinating Council of Aerospace Industries Associations (ICCAIA))

EXECUTIVE SUMMARY

The continuous improvement in automation, the development of digital technologies and the increasing robustness of artificial intelligence are paving the way for more and more autonomous systems. These new technologies introduce new operational concepts, such as single pilot operations (SPO), reduced crew operations (RCO), high altitude pseudo-satellites (HAPS) operations, and partially or fully autonomous operations.

Action: The Assembly is invited to:

- a) acknowledge the rapid development of digital technologies, and the increasing automation in aircraft systems, with a strong trend towards autonomous operations;
- b) request that ICAO further liaise with industry in order to establish an inclusive dialogue at strategic level that will encourage further collaboration in this area;
- c) request ICAO to explore the options for allowing industry, and other stakeholders, to address emerging operational concepts such as single pilot operations, reduced crew operations, HAPS operations, and partially autonomous operations; and
- d) request ICAO to coordinate actions for defining a safe and orderly approach to the autonomy concept in aviation and request the Council to urge the Legal Committee to consider a study on the legal implications of autonomy.

<i>Strategic Objectives:</i>	This working paper relates to all Strategic Objectives.
<i>Financial implications:</i>	The activities referred to in this paper will be subject to the resources available in the 2020-2022 Regular Programme Budget and/or from extra budgetary contributions.
<i>References:</i>	Doc 10115, Report of the Thirteenth Air Navigation Conference (AN-Conf/13), Corrigenda Nos. 1 and 2, and Supplement No. 1. Doc 10075, <i>Assembly Resolutions in Force (as of 6 October 2016)</i>

¹ Arabic, Chinese, English, French, Russian and Spanish versions provided by ICCAIA.

1. INTRODUCTION

1.1 Automation has improved the operational efficiency of the airplane and safety at the same time. Moreover, and thanks to the high level of investment in Automotive and Information Technology industries, autonomy technologies are becoming more and more available and reliable. Consequently, industry will continue to add automation. This will improve the resilience of aircraft systems and functions, as well alleviating pilots' tasks in some phases of flight. The evolution of the operational concepts in cockpit will be accompanied by a similar transformation of Air Traffic Management (ATM).

1.2 The industry is facing an unprecedented demand for pilots that may lead to a pilot shortage if no action is taken. Increased automation can be a way to handle that issue, with the adequate training and with the right human-machine interactions design. Automation is one enabler to reduce workload and fatigue. It could allow reducing the number of flight crew required at controls, starting by optimizing crew composition on long-haul flights and operations without passengers (cargo and pseudo-satellites for example), or, for ATM, optimizing the number of operators per time interval.

2. DISCUSSION

2.1 From an automation point of view, we can distinguish four generations of aircraft. The first two generations – the early commercial jets and those with basic integrated auto-flight systems - are disappearing. The third and fourth generations, with glass cockpits and flight management systems (FMS), and the latest with fly-by-wire flight envelope protection, are demonstrating that the additional automation is reducing the fatal accident rate. If we examine the data, improved safety is coming largely from reducing the loss of control in flight for which flight envelope protections in the latest generation plays a significant role. Hence the numbers are showing that automation is increasing safety, and we know why; it's not a statistical anomaly.

2.2 All aviation stakeholders should be justifiably confident in the safety and security of these innovations. Some of the key questions that the aviation stakeholders will need to answer are: what should be the role of the human; what are the consequences of the presence of only one crew in the cockpit or even none for some specific vehicles; how to cover the possibility of that crew to be incapacitated at some point in the flight; what is the impact of automation on the workflow for air traffic control (ATC) operators; and how to best use new technologies like “machine learning” in this field?

2.3 Moreover, leveraging the high level of investment in automotive and information technology industries, autonomy technologies are becoming more and more available, including machine learning algorithms. Image processing to navigate runway and taxiway markings will be integral to autonomous taxi, take-off and landing. Image processing to detect road obstacles would enable to detect obstacles on the taxiway, the runway and even in flight. Voice processing akin to a personal assistant could greatly help the pilot understands Air Traffic Controller speech and could be a component of new human-machine interface (voice command). The ability to read and understand text (typically the operational manuals) could help the crew analyse a situation.

2.4 Consequently, industry will continue to add automation for this will improve the resilience of aircraft systems and functions. Similar innovations can be found in ground systems, to facilitate the work of ATC operators and airport operators.

2.5 The industry is facing an unprecedented demand for Pilots that may lead to a pilot shortage if no action is taken (<https://www.icao.int/Newsroom/Pages/ICAO-Addresses-Shortage-of-Skilled-Aviation-Professionals.aspx>). One means to address this issue is through the use of emerging operational concepts, such as single pilot operations (SPO) (one crew in the aircraft for the whole flight), Reduced Crew Operations (RCO) (one crew at controls during the cruise phase), remotely piloted aircraft system (RPAS) (operated from the ground), and fully autonomous aircraft (tasked with a mission and not actively humanly-operated during the flight).

2.6 Focusing the flight crew on mission management while automation is managing the machine will also change the type of competences that will be required from the flight crew and possibly open the field to additional people. In a similar manner, increased automation in ATC centres increases the efficiency of operators, allows the machine taking in charge more repetitive tasks while letting the human more time to dedicate to essential tasks. This globally increases the situation awareness of ATC operators and therefore the level of safety. In any case, the adequate training with the right human-machine interactions will need to be thoroughly defined.

2.7 For these reasons, the industry is inviting the Assembly to acknowledge the rapid development of digital technologies, and the increasing automation in aircraft and ATC systems, with a strong trend towards autonomous operations.

2.8 For the foreseeable future, the Industry is convinced that humans remain better than any machine at taking strategic decisions – like a diversion or managing an “unknown-unknown” situation, e.g. the case we “don’t know what we don’t know.” Humans are better provided that the system provides them with sufficient time and the right level of information to assess the situation. Depending on the vehicle (from large passenger airplane to high altitude pseudo satellite), and depending on the ATM centre (en-route, approach, airport), the level of human engagement is an open question.

2.9 A likely answer for passenger airplane is to keep at least one human in the loop and on-board. Aviation regulations have not been designed with this in mind and will require review. The risk that a single human could become incapacitated (incapacitation definition: any degradation of psychophysiological crew state due to psychological, physiological or medical events) and that the airplane is de facto either autonomous or commanded from the ground is also questioning current regulation.

2.10 To build this confidence in emerging operational concepts, the industry is convinced that ICAO must act and is requesting ICAO to review existing Standards and Recommended Practices (SARPs) and manuals to address such emerging operational concepts on board and on the ground.

2.11 To build this justifiable confidence in emerging operational concepts, all aviation stakeholders must move forward and be coordinated: aviation safety agencies and associated standardization bodies, air traffic control and airport authorities in case of crew incapacitation or for fully autonomous vehicles and platforms, airlines and training schools for training and selection of crew, as well as aircraft and systems manufacturers.

2.12 The industry is forecasting three new situations impacting air and ground traffic control flying in the same airspace as other aircrafts: commercial aircrafts with an incapacitated crew, remotely piloted aircraft systems, and fully autonomous vehicles. These operations are likely to evolve step-by-step and demand a mandatory review of ATM rules and practices.

2.13 The role of cockpit crew is thus likely to evolve, and some new ground crew roles are likely to appear. A transition from current competences to future ones will need to be managed too. Airlines and training schools will have to review their curriculum and even to create new ones. To some extent, the future career path of crews should be anticipated including transition between multiple crew and single crew cockpits along the career of a pilot.

2.14 Automation (through for example, flight envelope protections) has significantly increased safety, but can be seen as altering the balance of responsibilities between the crew and the manufacturers. Depending on the role of any ground crew, the balance of rights and duties may change too.

2.15 Coordination is needed among all aviation stakeholders. The industry is convinced that ICAO must act to coordinate actions for defining a safe and orderly approach to the autonomy concept in aviation and consider a study on the legal implications of autonomy.

3. CONCLUSION

3.1 The continuous improvement in automation, the development of digital technologies, and the increasing robustness of artificial intelligence, pave the way for more and more autonomous systems and thus overall, more autonomy. These new technologies introduce new operational concepts, such as SPO, RCO, High Altitude Pseudo-Satellites (HAPS) operations, and partially or fully autonomous operations. The industry is convinced of the safety and efficiency benefits of these emerging technologies and concepts. The industry is also convinced that this is the right time for ICAO to lead and coordinate all stakeholders so that everybody continues to be justifiably confident in the safety and security of aviation.

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