International Civil Aviation Organization

WORKING PAPER

RPASP/7-WP/xxxx
WG-7
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REMOTELY PILOTED AIRCRAFT SYSTEMS PANEL (RPASP)

SEVENTH MEETING

Montréal, Canada 13 to 17 March 2017

Agenda Item xx: Agenda item text

Autonomy and Automation

(Presented by Jay Shively)

SUMMARY

A significant level of debate and confusion has surrounded the meaning of the terms “autonomy” and “automation”. Automation is a multi-dimensional concept, and we propose that RPAS automation should be described with reference to the specific system and task that has been automated, the context in which the automation functions, and other relevant dimensions. In this paper, we present definitions of “automation”, “pilot in the loop”, “pilot on the loop” and “pilot out of the loop”. We further propose that in future, the RPASP avoids the use of the terms “autonomy” and “autonomous” when referring to automated systems on board RPA.

WG7 proposes to develop, in consultation with other workgroups, a taxonomy of “Levels of Automation” for RPAS.

Priority: urgent, routine

1. INTRODUCTION

At RPASP5, Work Group 7 undertook to prepare a working paper on autonomy and automation. The goal of this paper is to clarify the terms "autonomy" and "automation" for the ICAO RPAS panel and provide practical definitions of the terms. It is not intended to represent a scholarly treatment of these terms, rather it is intended to provide a framework that will minimize misunderstandings by standardizing the use of these terms.

2. DISCUSSION

2.1 Autonomy is defined in the Merriam-Webster dictionary as "the quality or state of being self-governing" and "self-directing freedom". This means that a system with autonomy can operate free of outside restrictions and set its own goals. Taking a broad and colloquial interpretation of this definition, neither today's RPAS, nor any in the foreseeable future, fall into this category. Therefore we propose that the ICAO RPAS Panel should not use the term "autonomy" or "autonomous" when referring to capabilities of today's RPAS.

The first use of the term “automation” was in a Scientific American article in 1952. The definition has evolved as technology has evolved. Automation has been defined as "The performance by equipment, of a function that might otherwise be performed by a human." (RTCA, 2013, p. B4) and "The full or partial replacement of a function previously carried out by the human operator." (Parasuraman, Sheridan and Wickens, 2000, p. 287). In the past, automation has been used to replace physical labor, but current automated systems are more likely to replace mental labor. Therefore, RPAS tasks that might otherwise have been performed by the human (remote pilot) but that are now performed by a computer are said to have been automated or to have a certain level of automation.

2.2 Levels of Automation: Levels of automation (LOA) have been discussed with respect to general human-automation interaction since the late 1970s. Sheridan and Verplank (1978) defined ten levels, from fully autonomous to fully manual. Many other conceptualizations of LOA have been proposed, however they have received criticism for being overly simplistic and/or not useful as design guidance. Various LOA descriptions have been refined and adapted for specific applications. For example, U.S. National Highway Transportation Safety Administration (2016) adopted a LOA taxonomy developed specific specifically for automobiles by SAE (2016). There are many points of view with respect to RPAS relevant to this discussion and therefore it is proposed that an RPAS working group be established to adapt/define LOA specific to RPAS and ICAO.

2.3 Multi-dimensionality: A source of much confusion and miscommunication is the practice of referring to an RPAS (as a complete entity) as automated or autonomous. RPAS, like all aviation systems, have numerous capabilities; navigation, communication, caution and warning systems, etc. Further, each of these capabilities is (from a human operator point of view) a collection of tasks, each of which may have a different level of automation. For example, an RPA performing waypoint to waypoint navigation may be said to be performing at a certain level of automation. However, the communication may still be performed manually. To refer to this RPA as either manual or automated is imprecise and misleading.

Further, RPAS may employ different levels of automation for the same task in different contexts. For example, an RPA may navigate with a level of automation in the cruise phase of flight, but may be manually controlled during take-off and landing. In fact, many RPA are operated in this way.

In addition, Parasuraman, Sheridan and Wickens (2000), have posited that automated tasks may have different stages corresponding to stages of human information processing (e.g. information acquisition, information analysis, decision and action) and that the LOA may vary across stages. Note: Even this further breakdown has been criticized as being too simplistic.

These examples show that we need to discuss the level of automation that an RPAS has with respect to the specific system, tasks and context that we are discussing. We need to speak with this level of precision to ensure full communication.

2.4 Pilot in, on, and out of the loop.

RTCA (2013) has defined Human-in-the-loop as: "A control mode in which a function is either under direct control of the human, or under the control of automation that requires periodic human intervention to operate as desired." (p.B14). In the context of an RPAS, Pilot-in-the-loop (PITL) generally refers to the remote pilot's direct, physical engagement of the RPS command and control interface to perform a manoeuvre. The Pilot in Command (PIC) is responsible for determining what manoeuver to command and for physically commanding that manoeuvre to the aircraft through the RPS command and control/navigation interface. That command could be in the form of a manual flight control input, the selection of a new heading or waypoint, or anything in between.

RTCA (2013) defined Human-on-the-loop as "A control mode in which a function is under the control of automation, where the human monitors performance and can exert control over the automation as desired. Under normal conditions, the automation will be capable of performing the function without human intervention." (p.B14). Within the context of RPAS, Pilot-on-the-loop (POTL) generally refers to the PIC's supervision or management of aircraft systems.

RTCA (2013) defined Human-out-of-the-loop as "A control mode in which an automated system executes a function where human intervention is not possible." (p.B14). Within the context of RPAS, Pilot-out-of-the-loop could refer to a system that is explicitly designed to not require real-time intervention by the PIC. This could include functions designed to operate during a loss of link.

2.5 Summary

We propose the following for the ICAO RPAS panel:

2.5.1 No use of the term autonomy or autonomous with respect to RPAS.

2.5.2 Automation is defined as: RPAS tasks that might otherwise have been performed by the human (remote pilot) but that are now performed by a computer.

2.5.3 Describe the RPAS automation with respect to the specific system, tasks and context and/or other relevant dimensions.

2.5.4 Adopt the pilot in the loop, on the loop and out of the loop definitions.

2.5.5 Workgroup 7 (Human in the System) will, in consultation with other Workgroups, adapt or define relevant and specific levels of automation (LOA).

2.6 References

National Highway Traffic Safety Administration (2016). Federal automated vehicles policy. Washington DC: Author.

Parasuraman, R., Sheridan, T. B. & Wickens, C. D. (2000). A model for types and levels of human interaction with automation. IEEE Transactions on systems, man and cybernetics -Part A: Systems & Humans, 30(3), 286-97.

RTCA (2013). Operational and functional requirements and safety objectives (OFRSO) for Unmanned Aircraft Systems (UAS) standards. DO-344 Vol 2. Washington DC: Author.

SAE (2016). Taxonomy and definitions for terms related to driving automation systems for on-road motor vehicles. Surface vehicle recommended practice, J3016. Warrendale, PA: Author.

Sheridan, T. B. & Verplank, W. L. (1978). Human and computer control of undersea teleoperators. Cambridge, MA: Man-Machine Systems Laboratory, Department of Mechanical Engineering, Massachusetts Institute of Technology.

2.7 ACTION BY THE RPASP

2.8 The RPASP is invited to:

a) note and review the contents of this working paper;

b) endorse the proposed line of action in paragraphs 2.3; and

c) agree that WG7 continue its work on this proposal, with a view to finalization during the next meeting of the RPASP.

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