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A Workload-Centered Perspective on Reduced Crew Operations in Commercial Aviation

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Abstract We introduce a novel conceptual approach to managing reduced crew operations (RCO) in commercial aviation, namely the tripartite concept of a remote co-pilot center. We adopt a workload-centered perspective. Functions are allocated on a higher-level analysis along the different flight phases.

Keywords: remote copilot center, remote copilot, tripartite concept, mental workload, commercial aviation.

1 Mental Workload as a Function of Phase of Flight

Mental workload of a pilot, in short workload, depends on various characteristics of different accumulated tasks on the flight deck. Exogenous task demands and endogenous supply of attentional or information processing resources determine workload [1]. Performance is expect to drop if the demand exceeds the available resources of the pilot. Expertise and experience modulate the endogenous supply of resources like perceiving, updating memory, planing, making a decision, and executing and processing a response. Subsequently, workload manifests in performance variables, subjective experience, and physiological parameters [2]. This is how we can summarize workload very briefly to introduce a model of RCO, also referred to as single-pilot operations (SPO), in commercial aviation. It is based on workload as a function of phase of flight. A review of workload as important cognitive construct in aviation is given by Martins [3]. As described there, the number of current regulations reflects management of workload on the flight deck.

The Annex I (Definitions) of the Regulation (EU) 965/2012 on air only defines following phases of flight as "critical": take-off run, take-off flight path, the final approach, the missed approach, the landing, including the landing roll, and any other phases of flight as determined by the pilot-in-command or commander [4]. If we consider the ICAO's definitions of phases of flight we can conclude that all the previously stated phases take place during arrival and departure [5]. The task requirements and thus workload are the highest during those phases [6]. Workload itself is included in airworthiness standards in the following regulation. The EASA CS 25.1523 refers to the minimum flight crew as sufficient for safe

operations considering three dependent variables: the workload of the individual crew members, the accessibility and ease of operation of necessary controls by the appropriate crew member, and the kind of operation authorized under CS 25.1525 [7]. Appendix D to CS 25 elaborates the basic workload functions and workload factors. Thus, workload determines the minimum flight crew.

If we consider RCO in commercial aviation we have to take into account this distribution of task- and workload during flight. The basic workload functions of CS 25 are flight path control, collision avoidance, navigation, communications, operating and monitoring of aircraft engine and systems, and command decisions [7]. They have to be re-established in RCO. The single-pilot is pilot-in-command and is supported by a remote-copilot in high workload situations, off-nominal and emergency situations. Taken together, we propose a tripartite concept of support to handle workload factors which can arise during flight.

2 The Tripartite Concept of a Remote-Copilot Center

The *tripartite concept of a remote-copilot center* establishes a support of the single-pilot according to workload as a function of flight phases. For that the phases of flight are grouped into three higher-level phases: departure, cruise, and arrival. Details of the whole concept and a review of previous research is already published [8]. During departure and arrival a mandatory support is needed. A *departure remote-copilot* and an *arrival remote-copilot* provide flight planning and navigation support to single-pilots successively. They have a special expertise in airport dependent environmental variables: specific departure and arrival routes, taxiways, weather, and the current situation at the airport. In off-nominal and emergency situations the remote-copilot can take over the command and control of the aircraft relying on his/her flying skills. The arrival support is constructed in the same way. Hence, a pilot incapacitation in critical flight phases can be handled by the remote-copilot.

In cruise optional support can be requested. A cruise dispatcher sorts and forwards the requests to a specialist or specialized support teams of following areas: operations and procedure support, system error support, medical incident support, and external incident support. External incident refers to malicious and terroristic activities. New automation tools are taken into consideration to overcome the issue of pilot incapacitation. A pilot health monitoring system should detect an adverse condition of the single-pilot critical to flight safety. On the ground side a dedicated system should cope with emergency situations, e.g. an automatic landing system. Additionally, the procedures have to be re-defined. Some of them can be allocated to ground, others might be automated as well. After this higher-level function allocation has provided a basic concept for RCO, further steps in research are planned.

Next, a cognitive work analysis will be conducted [9]. The tripartite concept of a remote-copilot center should be described and modeled in comparison to the current two crew member option. On this base, workload functions are reallocated to the human and non-human agents of the tripartite remote-copilot

center: single-pilot, the different remote-copilots, on-board automation, automation mirror, ATC, and cruise operators. Furthermore, automation tools are specified and procedures can be redefined. Subsequently, the ground station of the remote-copilot should be set up and evaluated in terms of flight performance variables, situation awareness, and mental workload.

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