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The Ground Station Operator in Single Pilot Operations – Active or Passive Role?

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ABSTRACT

The introduction of single pilot operations (SPO) in commercial aviation for large passenger aircraft will require new operational procedures and the implementation of technical innovations on the ground and in the cockpit. Most concepts under investigation assume ground support at all times to monitor and support the onboard single pilot (SP). The question remains on the level of involvement of the ground station operator (GSO) in nominal situations in two phases of highest workload: departure and arrival. Current operational procedures of two-piloted aircraft assume a distribution of tasks and responsibilities between the pilot flying (PF) and the pilot monitoring (PM). In SPO the pilot will remain the pilot flying (arguably with more support from automation), but automation, the GSO or even the SP, will need to take over the tasks traditionally delegated to the PM. The extent of the support provided by the GSO depends on the chosen operational concept and the expected level of engagement. We present an analysis of the allocation of tasks for an active as opposed to a more passive role of the human operator on the ground during the departure and arrival phases, complementing the analyses conducted in previous research.

Keywords: Single pilot operations, Operational concept, Ground station operator

INTRODUCTION

For almost two decades research has been underway to explore the feasibility of implementing single pilot operations (SPO) in commercial airlines (Comerford et al. 2013; Harris 2007). It is expected that in the longer term, these operations would lead to economic benefits, more efficient crew scheduling and better aircraft availability (Malik and Gollnick 2016). Two major areas of research within SPO include its technical feasibility and concept of operations (Schmid and Korn 2018). Stanton et al. (2016) argue that existing technology already allows SPO; consider, for example, the maturity and increasing levels of safety reached by general aviation, military aviation and Unmanned Air Vehicles. In addition, all commercial aircraft can already be flown by only one pilot (e.g., in case of pilot incapacitation; EASA 2015).

Nevertheless, commercial airline operations are currently required to have two pilots in the cockpit: the pilot flying (PF) and the pilot monitoring (PM). Once one pilot is removed from the cockpit, some of the advantages of having a second pair of eyes disappear. In particular, some redundancy is lost, including error checking functions (for example, data entry into the Flight Management System), and other aspects such as workload management (through task delegation), support in building Situation Awareness and boredom prevention (Vu et al. 2018).

Most concepts of operations under consideration for SPO assume that a ground station would need to be established to assist the single pilot (SP) during periods of high workload and in case of non-nominal and emergency situations (Bilimoria et al. 2014; Lachter et al. 2017; Stanton et al. 2016). The ground station operator (GSO) would also be expected to intervene and take over control of the aircraft in case of pilot incapacitation. Several different configurations of task allocation to GSO have been considered, but they can be separated in two main modes of support (Lachter et al. 2017): the GSO is either assigned to one single aircraft (dedicated support view) or to several (multiple-aircraft support view). In one study addressing operating procedures, Schmid and Korn (2017) proposed to have a ground station supporting several SP by request during cruise (when workload is normally relatively low) and dedicated departure and arrival remote co-pilots with expert knowledge about the airport, including current weather conditions. However, the extent of the involvement of the dedicated GSO during take-off and landing is still unclear. According to ICAO (2013) these are critical phases, with the highest workload, and hence those in which the absence of a PM is felt the most. In this paper we investigate two constellations: One where the GSO's tasks are similar to those of a co-pilot or PM, and one where the GSO would be less involved.

Within the European project SAFELAND, a future concept for SPO in the event of pilot incapacitation is being developed (see Martins et al. 2021 for more information). Even though the coverage of SPO in normal conditions is out of scope for SAFELAND, in order to derive a concept for dealing with pilot incapacitation it was necessary to discuss the operational concept for nominal conditions and, in particular, the role of the GSO. This paper describes two possible constellations of GSO involvement discussed and the conclusions reached[1].

TASKS OF THE GROUND STATION OPERATOR

In a 2007 report prepared for NASA, Norman (2007) analyzed the impact of reduced crew operations on the responsibilities and duties traditionally assigned to the PM. For this paper, an initial selection of these functions was done, assuming that these would be transferred to the SP, to the GSO or to automation. Since the main focus of our analysis is on highlighting the differences between the two constellations (i.e., an active versus a passive GSO providing dedicated support), some of the traditional duties of the PM were not included. In particular, we consider that in both cases the GSO would always have the possibility to assume the role of pilot flying as required

[1]The views expressed in this paper are those of the authors and do not necessarily reflect those of the other project partners.

Table 1. Tasks delegated to automation.

Task	Reasoning
Radio Frequency changes	Automated change in frequencies, speech recognition.
Checklists	Checklists presented to the SP in a display and if some item is not executed, automation provides a warning (already implemented in some aircraft).
Verbal callouts for speeds, altitudes, configuration states	Verbal callouts conducted by automation (e.g., takeoff rotation, 50 feet altitude, as well as any deviations).
Check altitudes, headings and speeds against current clearances	Automation can check the values and issue a warning if the actual value deviates from the cleared value.
Aircraft Configuration (e.g. landing gear and flaps setting)	Automation can execute the setting of flaps, landing gear, landing lights etc. with the single pilot monitoring and intervening, if necessary.

(especially in case of pilot incapacitation) and would be monitoring aircraft systems to detect any abnormal or emergency situations.

The next step was to identify which tasks or functions would be automated or not necessarily require manual inputs from a human operator. This is mainly the case for tasks that can be described by consistent, rule-based behavior without the need for further cognitive processing or decision-making, such as changing radio frequencies (e.g. between sectors) or setting the flaps and the landing gear (at least during normal operating procedures). The selection was also done considering current research taking place within SESAR and NextGen (Brooker, 2008). Table 1 presents these tasks, together with a short explanation on how they could be executed in a single-piloted aircraft by onboard automation. It is assumed that the pilot would still be monitoring automation at all times and be asked to confirm some of the actions before they are executed.

The next step was to allocate the remaining PM tasks to the GSO in both constellations under study. Even though the cruise GSO is out of scope for this paper, they are presented in Table 2 below for comparison purposes. Recall that in the concept of operations being assessed, the cruise GSO supports several aircraft concurrently (multi-support), whereas during take-off and landing the GSO is handling exclusively one aircraft. The dedicated GSO would also have an open-channel to communicate with the SP, unlike the cruise GSO. Therefore, general Situation Awareness is expected to be higher and reaction times lower for the dedicated GSO. Table 2 below describes the task distribution between these three roles.

From the initial list of ten tasks, three should remain with the SP. To handle a potential pilot incapacitation during take-off and landing, these would most probably be performed by a highly automated system, thus requiring that flight guidance, autopilot and autothrottle configuration remain with the pilot. Arguably, the tasks of the cabin crew would also need to be adapted, with

Table 2. Tasks of the multi-aircraft support GSO for cruise, passive dedicated GSO and active dedicated GSO.

Task	Cruise GSO	Passive GSO	Active GSO
Configure Flight Guidance, Autopilot and / Autothrottle system modes	No. Remains with the SP		
Monitor External Hazards, including visual contact in Instrument Meteorological Conditions (possibly complemented by a system that detects objects of interest, such as a runway)	No. Remains with the SP		
Cabin Crew Management	No. Remains with the SP		
Communication with Flight Dispatch, AOC	Yes	Yes	Yes
Monitor Weather Conditions	Yes	Yes	Yes
System Monitoring including pressures, temperatures, voltage, as well as fuel balance, engine power, etc.	Yes	Yes	Yes
Monitor pilot mental state, overall judgment of actions (complemented by a pilot monitoring system)	No	Yes	Yes
Communication with ATC	No	No	Yes
Record flight information received via radio or the datalink system, for future recall (e.g., transmissions involving weather, NOTAMs, clearances, fix reporting requirements, etc.)	No	No	Yes
Configure a/c navigation systems including planning and executing routes, route and runway changes, etc.	No	No	Yes

at least one crew member having more responsibilities regarding passenger management and coordination with the SP, or even the possibility to directly contact the GSO, bypassing the SP in some specific situations (e.g. hijacking). Finally, a GSO can never directly replace the SP in the detection of external hazards due to their remote location and reduced access to sensory cues, even with the help of sensors and cameras.

In contrast, four of the tasks could be transferred to the ground without affecting overall safety levels or the ability of the pilot to perform the higher-level functions of aviate and navigate. In fact, one of these tasks correspond to the management of aircraft systems and engine, which has the lowest priority of the four levels (the remaining being communicate). In addition, even though the pilot will most likely have an onboard weather radar and access to ground-based weather services like today, the dedicated GSO will have already supported other SP in the previous hour or so and can report on any difficulties experienced due to the weather conditions. In the same way, the GSO can aid the SP by handling all communications with Flight Dispatch and the Airline Operation Center (AOC). Lastly, the task of monitoring the SP will also certainly need to remain with the GSO, most probably complemented by an onboard pilot health monitoring system.

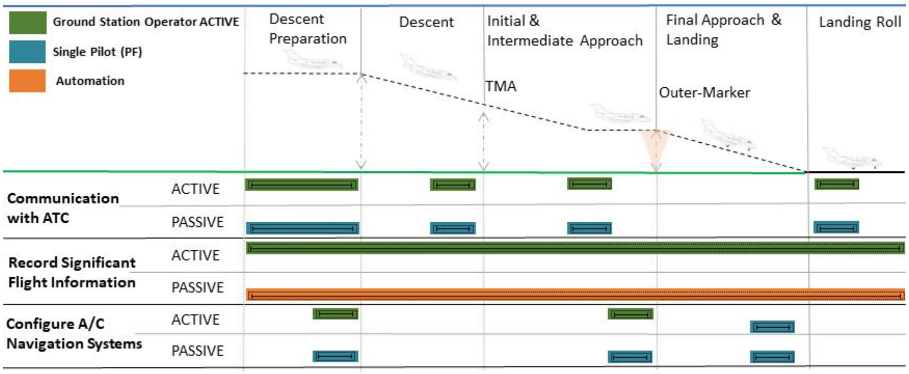

Figure 1: Task allocation diagram for the three selected tasks in both constellations (active and passive).

Three final tasks were identified that could eventually be displaced to the ground (active GSO), but which arguably should remain with the SP (passive GSO). The advantages/disadvantages of each and the implications are discussed in the next section.

TASK ALLOCATION DIAGRAM

In order to visualize the differences in task allocations for the two GSO constellations, a task allocation diagram was developed. This diagram is based on the Social Organization and Cooperation Analysis Contextual Activity Template (SOCA-CAT), a method for visualizing function allocations in socio-technical systems (see e.g., Friedrich et al. 2017). In a SOCA-CAT, the functions are mapped against the different situations that a work system experiences. For each function and situation, it is marked, if (1) the function is active in the respective situation and (2) who is involved in its execution. Figure 1 shows the developed task allocation diagram for the descent, approach and landing flight phases and for each of the three tasks, including the active GSO, SP and Automation. The passive GSO is not included, because they are not involved in these tasks, which are performed by either the SP or automation.

In current operations, communication with Air Traffic Control (ATC) is an important source of workload for the pilots, especially during take-off and landing when they are busy with other important tasks. Thus, one possibility would be to transfer this task to the (active) GSO, while the SP listens in to the exchange, potentially reducing pilot workload and improving levels of situation awareness of the GSO in case of an emergency. However, given the physical distance between them, it would be difficult for the GSO to initiate any communication/request without specific instructions from the SP. At the end of each exchange, the GSO would also need to confirm with the SP whether the clearances were understood and are accepted. In current operations this acknowledgement would take place through simple body language. On the other hand, if communication with ATC remains in the cockpit, the implementation of new technology regarding datalink systems (e.g. LDACS, L-band Digital Aeronautical Communications System, ICAO, 2019) would allow new clearances to be uploaded directly to the aircraft and ultimately to be transmitted to the appropriate navigation systems onboard, pending approval by the SP. For this reason, in the diagram above, the task "*Record Significant Flight Information"* is allocated to automation when communication with ATC is under the responsibility of the SP, and not of the GSO. The active GSO could also be supported by such a system, but it is not required.

Finally, all "*Configure Aircraft Navigation System*" tasks could also be transferred to the ground to be performed by an active GSO, instead of the SP. In particular, planning and inserting the new route into the flight guidance computer can be done during climb so that the SP can concentrate of flying the aircraft. In the same way, if there is a runway change during the first phase of descent, the GSO can also update the FMS. However, as the aircraft approaches the airport, any such change would need to remain with the pilot due to the limited reaction time left during final approach and landing.

CONCLUSION

Starting from a list of tasks traditionally allocated to the PM in current operations, this paper presents an analysis of the allocation of these tasks to an active, as opposed to a more passive GSO during the departure and arrival phases. There are potentially other ways of allocating the tasks, which can also vary by aircraft and operator, but we focused on two of them. We considered that since there is already a dedicated GSO available, this support should be used to the greatest extent possible. In general, the aviate component should remain in the cockpit in nominal operations. In the concept of operations under study, we also consider that monitoring tasks associated with management of the aircraft systems could be transferred to the GSO. It is on the higher-level navigate and communicate functions that there is more room for argument in how to make this distribution. Regarding the two constellations described here, the question remains whether a more active GSO during take-off and landing reduces pilot workload levels at the expense of the pilot's situation awareness and general safety levels (if communication with ATC and update of aircraft navigation system are done by the GSO). It is also not clear whether in case of pilot incapacitation the active GSO is able to react and take over the aircraft faster compared to the passive GSO (recall that take-off and landing would be fully automated to prepare for a sudden pilot incapacitation event). Therefore, we think that a more passive role for the GSO during take-off and landing would be more feasible.

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