THE IMPACT OF SINGLE CONTROLLER OPERATION VS. DUAL-OPERATOR SETUPS ON WORKLOAD IN AIR TRAFFIC CONTROL

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Abstract

The air traffic control system is a complex network that relies on highly trained personnel to manage the movement of aircraft through airspace. Air traffic outside the vicinity of airports is organised into control sectors that define the vertical and lateral boundaries of a specific part of the airspace. In Europe, these sectors are typically controlled by a team of two air traffic controllers (ATCO), each with distinct tasks. The radar controller is instructing the pilots to prevent unauthorised proximity between aircraft or to the sector boundaries. Meanwhile, the planner controller coordinates with other units to optimize traffic flow and minimize congestion around sector interfaces. By deploying two air traffic controllers, air navigation service providers are able to offer a higher flight throughput per sector than would be possible and allowed due to workload and safety with one air traffic controller alone. Thereby, the sectors can be designed just as large as operationally necessary to allow effective conflict resolution and traffic handling within each sector. This efficient use of human resources has contributed significantly to meet the demand for growth of air traffic in Europe. However, an increasingly high demand for air traffic (services), stringent applicant skill requirements, and demographic changes have led to significant staff shortages across almost all European air navigation service providers in recent years. These conditions force air navigation service providers to impose capacity limits on accepted traffic, leading to increased delays, cancellations, and detouring of flights, which ultimately impact airlines and passengers. To address these challenges, DLR proposed the Single Controller Operation (SCO) concept, where only one air traffic controller is deployed per sector on a planned basis, taking over tasks from both air traffic controller roles and supported by additional automation. While this approach may seem like an obvious solution to staff shortages, it also poses significant risks if not implemented carefully. The workload experienced by a single air traffic controller can be substantially higher than that of an air traffic controller team, which could compromise safety if not managed properly.

The current study validated the single controller operation concept using a system with additional support functionalities. Twelve air traffic controllers evaluated the system using a 2 x 2 within subject design. The participants conducted human-in-the-loop real time simulations under single controller and air traffic controller team conditions each for two traffic volumes above 80% of the defined maximal capacity of the sector used for the validation. Here, we show the assessment of the impact of the setup and traffic on air traffic controller workload as assessed by the NASA-TLX and Instantaneous Self-Assessment (ISA). While subjective ratings of workload did not significantly differ between team and SCO, response time to ISA queries was significantly higher during SCO. However, considering same traffic increase within team setup and single controller setup separately, the latter causes less increase in workload. A 10% traffic increase within air traffic controller team setup results in a 14% (mean) increase in workload, whereas in single controller operation setup the same traffic increase results in 10% increase in workload. It becomes even clearer, if considering single controller operation setup as an equivalent traffic increase per air traffic controller compared to team setup. Interpolating results to a 10% traffic increase shows only 2-3% increase in workload from team setup to single controller setup. Our findings suggest that single controller operation has substantial potential as a solution to staff shortages in air traffic control without impacting on air traffic controller workload critically. Furthermore, this approach could pave the way for further capacity increases with the introduction of a digital air traffic controller as team member of the single air traffic controller or enabling same capacity with consideration of climate-optimized trajectories. This would not only address the pressing issue of staff shortages but also enable more efficient and sustainable air traffic management in Europe. In the context of global air transportation, the successful implementation of single controller operation could serve as a model for other regions facing similar challenges.

In conclusion, our study suggest that single controller operation offers a promising solution to staff shortages in air traffic control, and its implementation could have far-reaching benefits for the entire aviation industry.

Keywords

air traffic control, single controller operation, human in the loop study, workload