Assessing pilots' situation awareness on Future Systems Simulator

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SUMMARY

The present paper reports the results of a trial investigating pilots' situation awareness in the Future Systems Simulator (FSS). Both PF and PM positions and accompanying tasks in the simulator are considered. Moreover, a follow-up session with current airline pilots in the study provides perspectives on the practical application of the FSS.

KEYWORDS

Aviation Safety, Flight Operations, Human-Computer Interaction

Introduction

Modern technologies have paved the way to the ability to recreate very realistic flight scenarios in the safe environment of a laboratory. Developments and research in flight simulation technology have resulted in the Future Systems Simulator (FSS), which is a digital, touch-screen display simulator which can model all types of advanced aircraft. While it shows many promises, one must consider human-computer interaction (HCI) challenges and pilots' situation awareness (SA) (Carroll & Dahlstrom, 2021). The aim of this short paper is to assess HCI and focus on pilots' SA of the FSS for two different roles within the simulator, pilot flying (PF) and pilot monitoring (PM). Moreover, practical applications from a HCI standpoint are discussed to assess the utility of the FSS.

Methods

This experiment involved fifteen participants aged 21 to 53 years (*M* = 27.67, *SD* = 10.38). They were either pilots or collegiate aviation students. Out of fifteen participants, ten (66.6%) are male and two (13.33%) are current airline pilots. Because of their experience, they will take part in a follow-up session to provide insight into the practical application of the system from a HCI standpoint. Ethical approval was provided by the Cranfield University Research Ethics System (CURES/14773/2021). All participants provided their informed consent.

Each participant performed two landing scenarios in the FSS, acting once as PF and as PM. In the role of PF, participants were instructed to use the Instrument Landing System (ILS) and primary flight display (PFD), while noting airspeed, altitude, vertical speed, and visual alignment with the runway. As PM, participants were responsible for setting the target speed for the Auto throttle, running through appropriate checklists, and monitoring the aircraft's speed and altitude, calling out the altitude to the PF. On completion of the pre-landing checklist, the PM also monitored approach.

A survey hosted online immediately after the simulation was used to collect data on participants' demographics and cockpit position (PF or PM). Moreover, SA was assessed using the Situation Awareness Rating Technique (SART-10) which contains ten questions, each of which need to be assessed on a seven-point scale (1 = Low, 7 = High). The SART includes three domains on Supply, Demand and Understanding (Taylor, 1990).

Results

A repeated measures ANOVA with SART total score, Demand, Supply and Understanding as dependent variables and position as within-subject factor (PM/PF) has shown a significant main effect of position, $F(3, 12) = 4.447$, $p = .025$, , $\eta^2 = .526$. Univariate follow-up tests show non-significant effects of position on Supply, $F(1, 14) = .055$, $p = .818$, $\eta^2 = .004$, and on Understanding, $F(1, 14) = .029$, $p = .868$, $\eta^2 = .002$, but significant and strong effects of position on the total score, $F(1, 14) = 6.458$, $p = .024$, $\eta^2 = .316$, and on Demand, $F(1, 14) = 10.106$, $p = .007$, $\eta^2 = .419$. The mean total SART scores of PM and PF are 22.60 and 19.27 respectively, while the mean Demand scores are 9.60 and 13.07 respectively.

Discussion

The present findings indicate that there are differences in perceived SA between the position of PM and PF. In terms of overall SA, the PM experiences higher levels of SA than the PF. However, greater demands were put on attentional resources in the role of PF than as PM. Perhaps these differences are because the PF remains occupied throughout the landing sequence, while the PM performs more duties related to monitoring.

In the follow-up session looking into the practical application of a system like the FSS, the current pilots believe the FSS can reduce costs, but poses challenges from an operational perspective. First, the full use of touch screens eliminates any physical levers in the flight deck (except for the thrust levers), which reduces weight. This will transfer to a fuel saving cost, provided that additional computing power does not demand more weight. Furthermore, replacement costs of mechanical parts are thought to be substantially lower. Moreover, the pilots feel training costs will be lower as controls to match different flight decks can be manipulated. This can benefit both manufacturers, when they release a new aircraft type, and individual airlines, to suit their Standard Operating Procedures. This could create standardisation across multiple fleets, reducing time and costs for conversion courses between fleets within airlines.

Moreover, both pilots feel that although information was clearly presented on the screens, important controls were initially difficult to find, especially when the layout of the flight-deck changed between PF and PM set-ups. However, as the simulation progressed, the pilots found these controls easier to locate. They also felt that selecting flaps and gear requires more cognitive attention when using touch screens compared to conventional levers, hence monitoring of the aircraft may temporarily be compromised. Also, extra time was required to ensure the correct selection was made as PM, and the selection was correctly identified when completing checklists as PF. This extra time detracts from time spent monitoring during important phases of flight. It should also be noted that the experiment was performed in a normal operational environment, yet turbulence could exacerbate the problems listed above.

References

Carroll, M., & Dahlstrom, N. (2021). Human computer interaction on the modern flight deck. *International Journal of Human–Computer Interaction, 37*(7), 585-587. https://doi.org/10.1080/10447318.2021.1890495

Taylor, R.M. (1990). Situational Awareness Rating Technique (SART): The development of a tool for aircrew systems design. In *Proceedings of Situational Awareness in Aerospace Operations Conference* (no. 478, pp. 1-17). Neuilly Sur Seine, France: NATO - AGARD