

Evaluation of a Radically Revised ATC Interface

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Abstract

A radically revised ATC (Air Traffic Control) interface, developed from that described at HCI-Aero98, has been evaluated by trials using 26 postgraduate students (native French speakers). Twenty-four out of 26 students were able to control traffic at a nominal rate of 200 aircraft per hour after about one hour of training. All but two of 1620 potential conflicts were resolved correctly. All but five of 10468 aircraft left the simulated area at exactly the time position and height planned. The interface is briefly discussed, and the underlying assumptions and implications are suggested.¹

Introduction

ATC evolved in response to technological innovations in an incremental, largely unplanned fashion. An exercise, initially intended to re-design the controllers' display facilities, led to an 'ab-initio' redesign of the Air Traffic system, employing satellite based navigation, and satellite communications (Dee, 1995). This system does not employ beacons, routes or sectors, and allows very large areas to be controlled from one center. This system would provide aircraft with conflict-free direct routes, using data-link communications to modify flight plans and monitor adherence to plans. The demonstrator employed for these trials (which has been named 'TROTSKY') does not include an actual data-link, or the voice synthesizers that would be used in a real system to allow controllers and aircrew in the aircraft addressed and in adjacent aircraft to monitor events. Equally, the fallback system to solve conflicts safely (but not efficiently) is not provided, nor are other potentially useful attention-maintaining features. After some preliminary experimentation, a 'coplanar' display, as described in Wickens (2000) was chosen. (In practice, it is not possible to present four-dimensional information using the available pseudo-3D displays without ambiguity.) This display presents aircraft as icons showing their relevant characteristics. Where there are potential future conflicts, the aircraft involved are linked with lines increasing in conspicuity

as the conflict becomes more urgent. In this model, any future conflicts are detected on entry. (A system could be arranged so that aircraft were only accepted after their clearance had been established.)

An aircraft in the most urgent conflict is selected, and its profile is shown on the same scale, with comparable symbols. As the controller constructs a solution, it is immediately reflected on the screen, after each keystroke. Remaining conflicts and wrong exit points are explicitly identified symbolically. If the controller accepts a solution that leaves unresolved conflicts or incorrect exits, the system will ask for explicit confirmation.

Evaluation

In order to evaluate the usability of the system, an initial trial was carried out during 1999, (David and Bastien, 2000) This trial showed up some faults in the original interface, as described in that report, which were rectified in this second trial, which took place from November 2001 to March 2002 (David and Bastien, 2002). The traffic capacity is such that direct comparisons with the existing system are impractical, since a workload that would exhaust an expert controller using the existing system would be so trivial, even for a novice, with the revised system as to be boring.

Participants. Twenty-six students (8 male, 18 female) taking the "Information Ergonomics" course at the Université Paris V - René Descartes took part in the experiment. Most of the students had a four years university background in psychology. None of them had any knowledge of air traffic control before this experiment. No student was a native English speaker. They were not rewarded for participation.

Background Familiarization. All participants attended a familiarization lecture on Air Traffic Control, including a presentation of the ODID III (Prosser et al. 1993) video record, a discussion of Air Traffic controllers' tasks and a description of the current evolution of ATC equipment. They were briefed on the underlying theory of the revised interface, given a step-by-step description of its operation and provided with an opportunity to ask questions about it.

Training Simulations Each participant then ran twenty short training scenarios. They were coached in the

use of the interface during these scenarios, and encouraged to explore alternative methods of solution.

Measured Simulations Each participant then carried out two complete simulations, each corresponding to one hour of elapsed time. Each simulation involved the simultaneous presence of forty aircraft in random flight. Forty aircraft initially entered at random intervals during the first five minutes. These were immediately replaced on leaving the area, during the simulated hour. The simulation was continued after the end of the simulated hour until all remaining potential conflicts had been resolved, or actual conflicts had been completed. All remaining aircraft were then simulated until their flights had been completed, to provide complete information for each flight. Different, or similar but slower, solutions to initial conflicts made it impossible for some subsequent new aircraft to enter as originally occurred, leading to a rapid divergence of simulations.

Results

Performance

(The following figures represent mean values per exercise unless otherwise stated.)

Traffic. 201.3 aircraft were treated per exercise. (Most of these aircraft followed their original flight plan without interference.) The mean actual time of flight per aircraft was 13.07 minutes, corresponding to 65.76 Nautical Miles flight distance. The planned time and distance, corresponding to a direct route, were 13.07 minutes and 65.73 Nautical Miles. The total additional time flown was negligible. The total extra distance flown was 7.12 NM, representing the additional distance flown due to vectoring (changes in heading), corresponding to approximately 31 meters additional flight per aircraft. The mean actual exercise time was 13.89 minutes, 4.7 minutes of active conflict resolution and 9.2 minutes of inactivity (at six times real time). There were no statistically significant differences between participants or between first and second exercises in these measures. The planned traffic contained an average of 13 climbs and 14.4 descents, which increased to 34 climbs and 36 descents during exercises. These numbers varied significantly between participants, although not between first and second exercises overall. (These differences represent 'style' differences, discussed in the full report.)

Conflict Resolution. The mean number of potential conflicts was 33.08 per exercise. There were no significant differences between participants or by order. (The mean number of accepted orders was 30.35, mean time 14 seconds. There were also 10 cancelled orders, mean time 14.3 sec.) The mean time for the resolution of a conflict (measured from its initial presentation to the acceptance of an order solving it) was 22.8 seconds. This mean time was statistically significantly greater for the first run (24.3 sec vs. 21.2 sec), and between

individuals, varying from less than 15 sec to more than 30 sec.) The mean time between a conflict being resolved and its expected start time was 1765 seconds (29.4 minutes). There were no statistically significant differences between participants or by order.

Errors (overall) There were two unresolved conflicts in separate exercises. In addition, five aircraft left at the wrong height, of which one was at the wrong time and place, and another at a wrong time. (Participants were instructed to allow an aircraft to leave at a wrong height if it would otherwise be in conflict at the exit position.)

Discussion

The students participating in this experiment operated a simple interface, making essentially simple judgments. They were not burdened with other ATC tasks, or with the awareness that a wrong decision could cost hundreds of lives. It would be wrong to assume that an improvement in the controller-system interface would eliminate the need for high professional standards. Removing the unnecessary difficulties and dangers imposed by the present system would not remove the need for conscientious application of the system.

This study has established the capacity in terms of conflict resolution, and has shown that the workload generated by boundary coordination is negligible. Further work is in progress to quantify the system capacity using queuing theory, employing more traffic in more realistic traffic patterns, and developing symbology for compliance monitoring.

Conclusion

It is possible to develop a system for Air Traffic Management, based on currently available technology but requiring a radical revision in the way control is exercised, that would be cheaper, safer, easier to operate, more efficient and more flexible than the existing system.

References

- David, H. and Bastien, J-M. C. 2000. Initial Evaluation of a Radically Revised Interface for En-route Air Traffic Control, EEC Report No. 360, Eurocontrol Experimental Centre, Bretigny, France.
- David, H. and Bastien, J-M. C. 2002. Second Evaluation of a Radically Revised Interface for En-route Air Traffic Control. EEC Report No. (to be allotted), Eurocontrol Experimental Centre, Bretigny-sur-Orge, France.
- Dee, T.B. 1995. An Illustrated Re-Design Of The Air Traffic Controller's Human/Computer Interface, In Proceedings of the Eighth International Symposium on Aviation Psychology, April 1995, Eds. Jensen R.S. and Rakovan L.A. Vol. 1, pp 369-374.
- Prosser M., David, H., Clarke, L. 1991. ODID III Real-Time Simulation, EEC Report No. 242, Eurocontrol Experimental Centre, Bretigny-sur-Orge, France.
- Wickens, C.A. 2000. The When and How of using 2-D and 3-D Displays for Operational Tasks. In Proceedings of the IEA2000/HFES 2000 Congress, San Diego California USA.