HUMAN FACTORS ISSUES
IN THE USE OF
ARTIFICIAL INTELLIGENCE
IN
AIR TRAFFIC CONTROL

October 1990 Workshop

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ACKNOWLEDGEMENTS

1. EXECUTIVE SUMMARY OF CONFERENCE PROCEEDINGS

A report by participants in the Human Factors/AI/ATC Workshop at California Polytechnic State University, San Luis Obispo, October 3 through 5, 1990.

Executive Summary

The objective of the workshop was to explore the role of human factors in facilitating the introduction of Artificial Intelligence to advanced ATC automation concepts. The workshop was a follow-up to a previous AI/ATC workshop sponsored by the FAA held at NASA Ames Research Center, February 9 and 10, 1989.

"Artificial Intelligence" is an umbrella term which is continually expanding to cover a variety of techniques where machines are performing actions taken based upon dynamic, external stimuli. AI methods can be implemented using more traditional programming languages such as LISP or PROLOG, or they can be implemented using state-of-the-art techniques such as object-oriented programming, neural nets (hardware or software), and knowledge based expert systems.

As this technology advances and as increasingly powerful computing platforms become available, the use of Artificial Intelligence to enhance Air Traffic Control systems can be realized. Substantial efforts along these lines are already being undertaken at the FAA Technical Center, NASA Ames Research Center, academic institutions, industry and elsewhere.

Although it is clear that the technology is ripe for bringing computer automation to ATC systems, the proper scope and role of automation are not at all apparent. The major concern is how to combine human controllers with computer technology. A wide spectrum of options exists; ranging from using automation only to provide extra tools to augment decision making by human controllers to turning over moment-by-moment control to automated systems and using humans as supervisors and system managers.

Across this spectrum, it is now obvious that the difficulties that occur when tying human and automated systems together must be resolved so that automation can be introduced safely and effectively. The focus of the workshop was to further explore the role of injecting AI into ATC systems; and to identify the human factors that need to be considered for successful application of the technology to present and future ATC systems.

The workshop opened with an address by Joseph Del Balzo, Executive Director for System Development of the FAA. The

workshop participants represented government, academia and industry in Canada, France, the US, and Yugoslavia. After presentations and discussion of several papers on (i) applications of AI to ATC functions and concepts and (ii) identification of air transportation issues with high potential for AI applications, the participants divided into three working sub-groups to consolidate the findings and recommendations of the workshop. The topic areas of the three sub-groups were:

1) Task allocation between humans and computers and the limits of automation;

2) Simulation and testing of AI/ATC systems; and

3) ATC problems to be addresses by AI.
Brief summaries of the groups' conclusions follow.

Task Allocation Between Humans and Computers: The Limits of Automation

The proposed role of the human operator of AI/ATC systems must be evaluated at all stages of ATC system/subsystem design and development. In particular, this evaluation should take place at the beginning of systems development cycles, where systems or operational protocols are being conceived.

The FAA should develop a formal means to insert human factors research and applications early on, and this should continue throughout the design and deployment phases of new or modified ATC systems. The FAA should consider establishing an office with Human Factors specialists who must be in the review cycle of automation design for ATC systems. Projects, whose principal goal is to provide cognitive and perceptual aids for human controllers, should include human factors experts in the design team.

Scientific knowledge about cognitive processes, including their limits and strengths, should be examined to determine which functions should be assigned to humans and those which could be assigned to computers. Reliable information is steadily accumulating identifying the mental operations that people can or can not perform well. Existing tools for modeling human cognition should be employed to characterize the cognitive demands imposed upon human operators by ATC tasks. These tools can be used to guide the collection of objective performance data to ATC tasks.

The FAA should also support research refining and extending cognitive modeling techniques (the mental process by which knowledge is acquired) in ways that tailor them to the ATC domain.

The FAA should support the development of improved methods for analyzing and evaluating new AI applications and techniques in ATC proposals. Specifically, the FAA should support the development of:

1) Guidelines based upon knowledge about human capabilities.

2) Rapid-prototyping tools for developing and testing new Computer-Human Interfaces iteratively.

3) Analysis techniques based on formal cognition models.

Simulation and Testing of Artificial Intelligence in the Air Traffic Control System

The role and limitation of AI in the ATC system needs to be evaluated by complementary applications of simulation and testing in an AI/ATC simulation test-bed. An assessment should be made of the various communities involved in human factors research to determine how the technology and results from independent research experiments can be shared and used in concert.

A critical first step in this process is to identify the nature and requirements of experiments that are designed to assess ways in which AI can positively impact the ATC systems. Evaluation criteria must be identified for each experiment to provide a means of assessing the effects of incorporating AI in ATC.

It is recommended that the FAA identify and implement a process for the verification, validation, and accreditation of experimental AI techniques that have high payoff potential for the ATC system. This process should involve a complementary mix of simulation and test activities.

The simulation and test activities should be compared to a common library of FAA accredited scenarios that can serve as a baseline to measure independent experiment results. In this manner a multi-disciplinary ATC community (including human factors experts, system engineers, pilots, controllers, and the entire cross section of ATC professionals), can reach concurrence on the merit of proposed AI techniques. The simulation and test methods should define common interfaces that allow maximum use of available technical and operational resources for experimentation.

Finally, it is recommended that the FAA establish a working group that meets frequently. This working group would serve as a forum to present and review research on AI for ATC, and would develop a common set of standards or guidelines that could be used to

assess the effectiveness of AI techniques as applied within the ATC system.

ATC Problems To Be Addressed by AI

One of the themes in this group was to break away from the notion that the FAA needs to begin with grand schemes for using very sophisticated AI techniques to automate the entire ATC system. The AI techniques used need not necessarily be "hard" AI as the term is customarily used. Standard programming languages and hardware may be appropriate, or it may be desirable to integrate special AI components into standard computing environments.

In this early stage of development, the FAA should also be looking for ways to select small and medium-scale problems that are separable and can be treated reasonably independently from each other (see list below). The experience gained in creating, implementing, and--perhaps most importantly--using these systems will refine the technical approaches and will build confidence in automated systems in the user community. As controllers experiment with automated AI components, and as feedback from their use is assimilated in the laboratory, systems can be augmented and eventually increase in complexity.

Event histories should be carefully studied to verify the condition under which system operation is required. Special care should be given to identifying "rare" events critical to safe operation.

In an effort to focus energy in the research and application of AI in ATC, several areas were identified that were considered ripe for investigation. The list includes both smaller manageable problems for immediate attack and larger, long term issues on how future ATC systems could be configured. These areas are listed here:

Maintenance: Particularly the maintenance of equipment in remote areas.

Monitoring: Particularly of equipment subject to maintenance.

Surface Control Management: Taxiing, crossing active runways, etc.

Scheduling and Planning: Particularly of longer-term tasks.

Modeling the Controller: With emphasis on implicit perceptual and cognitive activity, not merely overt actions.

<u>System Function Allocation:</u> Especially between air and ground systems in the data link environment.

<u>Data Fusion:</u> Integration, interpretation, and use of data presented from various sensors with varying levels of quality.

*   *   *   *

To summarize results from the three working groups, it is important that the FAA identify areas where AI can positively impact the ATC system starting with small-scale programs and gradually evolving to larger-scale efforts. Definitive methods of verification, validation and accreditation of new AI methods should be developed to provide evidence that will allow the development of confidence in the new AI technologies.

Finally, the research and development of AI for application to the ATC system should include the participation of human factors experts. These experts should focus their expertise on the development of powerful, flexible tools and analytic techniques that can assess the effectiveness of injecting AI into the ATC system.

2. LISTING OF CONFERENCE ATTENDEES

The following list contains the alphabetic listing of persons who attended the October 1990 workshop. Points of contact (addresses, phone, FAX and e-mail information) are included in the listing of those requesting copies of the Proceedings.

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* Al Lee did not attend the last day of the workshop and therefore did not participate in the drafting or signing of the letter to Joe Del Balzo.

3. POST WORKSHOP ACTIVITIES

Semi-Annual Progress Report:

A Semi-Annual Progress Report covering the period of January 1, 1991 through June 30, 1991, was delivered to Thomas Walsh,

APPENDIX A

LISTING OF ATC HUMAN FACTORS and/or AI PROFESSIONALS

This listing contains the names and addressed of human factors
and artificial intelligence professionals who were invited to
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** Dr. Bird wrote that he was no longer in this field.

APPENDIX B

THE PROCEEDINGS

(under separate cover)

Advanced Computer Technology
for
National Airspace System

Human Factors Issues
in the Use of
Artificial Intelligence
in
Air Traffic Control