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AN INVESTIGATION OF
AIR TRANSPORTATION TECHNOLOGY
AT THE
MASSACHUSETTS INSTITUTE OF TECHNOLOGY

1992 - 1993

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SUMMARY OF RESEARCH ACTIVITIES

1. INTRODUCTION

One completed project and two continuing research activities are under the sponsorship of the FAA/NASA Joint University Program as the 1992-93 period ends. There were a number of publications during the year which are referenced in this report. A brief summary of the continuing research project is provided.

The completed project was:

1. Liu, Manly, "Tracking Aircraft around a Turn with Wind Effects", MIT Flight Transportation Laboratory Report, FTL 93-4, June 1993.

The active research projects are:

1. ASLOTS - An Interactive Adaptive System for Automated Approach Spacing of Aircraft.
2. Alerting in Automated and Datalink Capable Cockpits.

2. REVIEW OF CONTINUING RESEARCH ACTIVITIES

2.1 ASLOTS - Interactive, Adaptive Spacing on Final Approach

This research is aimed at providing ATC controllers concerned with approach spacing at busy airports with a decision support system which is:

- 1) Integrated across multiple simultaneous approaches
- 2) Interactive (so that they can direct its operation)
- 3) Adaptive (it adapts continuously to the real world situation).

The ASLOTS concept was described in last year's report. The effort during 1992-93 has been aimed at creating a high fidelity ATC simulation environment called ATCSIM. This simulation will provide realistic motion of aircraft under typical representation of errors from various navigation, guidance, surveillance, and ground tracking systems, as well as the time and spatial variation of winds. It has two components: an airborne simulation for arriving and departing aircraft, and a ground simulation of aircraft moving on the surface of the airport. A schematic of ATCSIM functionalities is shown in Figure 1.

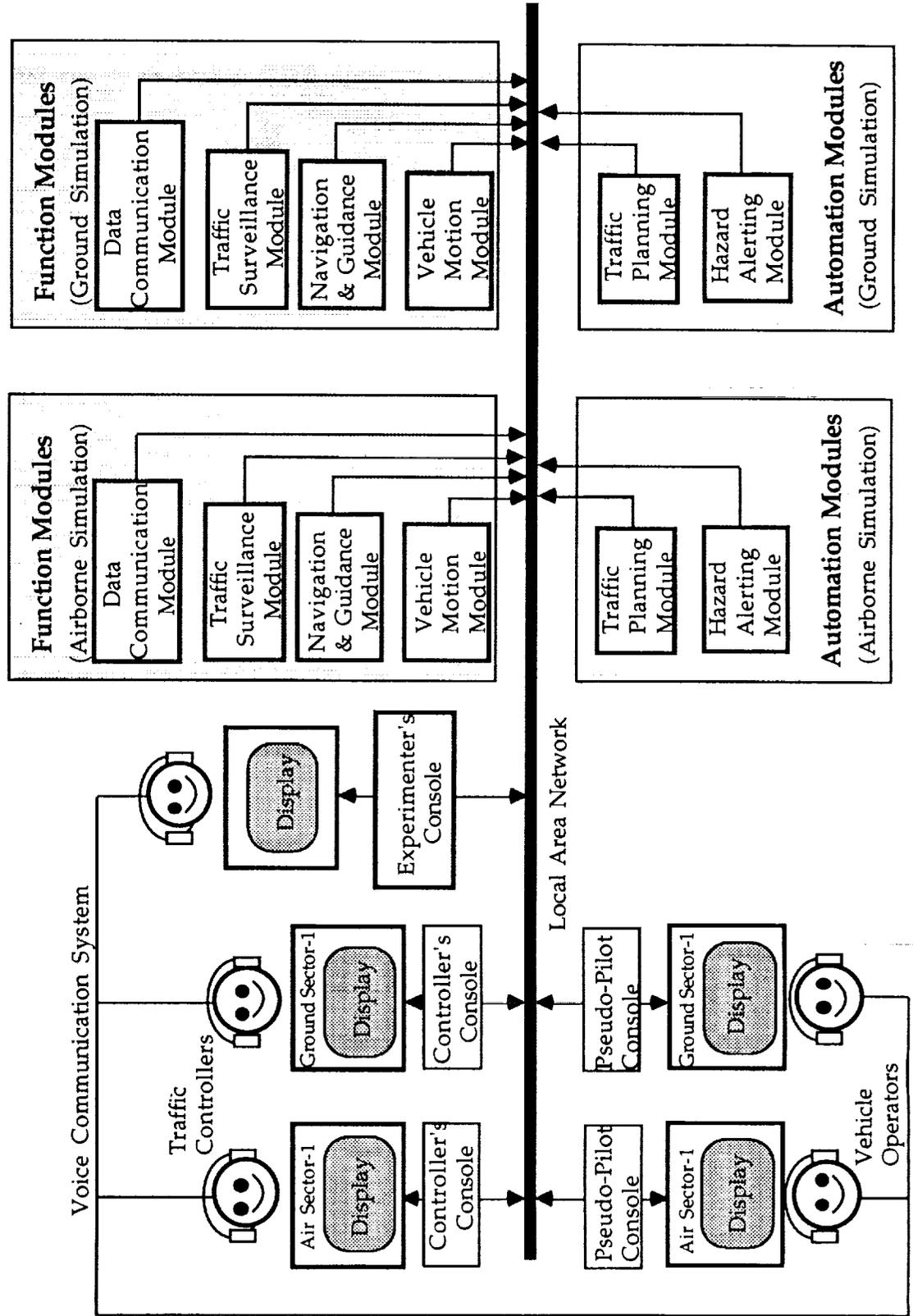
ATCSIM is designed using a generalized, modular software approach which can be easily adapted to new scenarios, and thereby provide a flexible, rapid-experimentation

tool for researchers interested in automation of ATC processes and Human Factors issues in ATC automation. It applies distributed processing using common workstations on a high speed local area network, and an object-oriented, modular approach to configuring the software which allows rapid reconfiguration of the traffic controller's console, its display formats, and its automation functions. It is written in standard ANSI C, uses X-windows for its graphics, Ethernet with TCP/IP protocol, and is currently in UNIX (AT&T System 5.3). This combination allows a variety of workstations to be used. ATCSIM will accommodate several ATC controller consoles (each with its pseudo-pilot station).

The modularity is indicated in Figure 1 where separate modules exist for communications, navigation and guidance, surveillance and tracking, and vehicle motion which provide realistic representation of the flight and ground paths followed by aircraft as they are controlled. Figure 1 also indicates that various modules for automating any or all of the various ATC processes (e.g., Conformance, Separation, Congestion Management, Hazard Alerting, etc.) can be developed separately. ATCSIM runs in real-time using a fixed script of arriving traffic, or can use Traffic Generators which construct a description of randomly arriving traffic with control over the longer term values for the mix of types, arrival rates, altitudes or gates, etc. Once a script is created it can be used by the experimenter for a series of tests. It is possible to "replay" any test run in fast-time, or "fast-forward" to any situation which is interesting. Such situations can then be the starting point for real-time experiments, and can be "doctored" to cause certain desired traffic situations to occur.

While the major effort in 1992-93 has been on creating ATCSIM, attention has now been returned to implementing ASLOTS. Current work is aimed at implementing its features (Feasible Slot Range, Auto Rearward Shift, Centerline Adaptation, Constrained Pattern Parameters, etc.) in an environment which will allow multiple runway approach and landings.

Figure 1 - ATCSIM FUNCTIONALITIES



2.2 Alerting in Automated and Datalink Capable Cockpits

Over the past few years, a variety of experiments have been performed in the MIT Advanced Cockpit Simulator in the area of weather hazard and terrain alerting. As a result of these experiments, it was noticed that there is a common generic thread in implementing advanced alerting systems. The focus of this research is to explore the idea of a general theory for Advanced Hazard Alerting in future situations where there may be a mix of airborne and ground sensors, and a reliable datalink to exchange information quickly. It is assumed both that pilots and controllers will be involved in detecting and resolving any deviation required by an unexpected hazard, and that their respective roles will be well defined.

While the different types of hazards (precipitation, wind shear, terrain, traffic) present different inputs, there are always five sequential processes in a Hazard Avoidance process:

1. Hazard Detection and Alerting
2. Communication / Display of Hazard Information
3. Generation and Decision on Hazard Resolution
4. Communication of Planned Resolution Path
5. Execution and Monitoring of the Resolution Path

The decision on the resolution path is assumed to be the responsibility of the captain of the aircraft. There will be "reaction" times necessary for the execution of each process, and the need to establish detection, intervention, and resolution criteria which are a function of hazard detection sensor performance, display capabilities, and aircraft state and performance capabilities. It is clear that the uncertainties in hazard detection vary with the "probe" or "lookahead" time. Various strategies for minimizing risk must be developed which are acceptable to both pilots and controllers. It is intended that pilot acceptance will be explored using the MIT Advanced Cockpit.

3. ANNOTATED REFERENCES OF 1992 - 93 PUBLICATIONS

- 3.1 Liu, Manly, Tracking Aircraft around a Turn with Wind Effects, SM Thesis, Department of Aeronautics and Astronautics, MIT, Cambridge, MA, 02139, June 1993

Currently, it is possible for ATC to use radar tracking to estimate an aircraft's current groundspeed and direction if it is flying a straight path, but large transient errors occur when the aircraft begins and ends a turn. The introduction of SSR Mode S datalink will make aircraft state information (heading, turn rate, groundspeed and direction, etc.) available for ground-based radar trackers, but it is desirable to minimize such transmissions. The minimal state information would be the declaration that the aircraft is no longer in a state of straight-line flight, but is currently turning. A "Turn Signal" indicating a left or right turn can be sent whenever the aircraft maintains a minimum bank angle for some period (e.g., 10° for more than 3 seconds).

In this research, two new "Turn Tracker" algorithms are devised to use the few radar position reports during a Turn Signal episode to estimate the initial position, groundspeed, and direction for the new straight line segment when normal radar tracking is resumed. The algorithms were implemented in a last-time simulation called TASIM, and compared with performance of an existing ATC tracker. The results show a significant reduction in average and maximum deviations of estimated values for groundspeed and direction during the turn, and a faster convergence on good estimates of the new groundspeed and direction along the new straight-line path after the turn.

4. REFERENCES TO PUBLICATIONS, 1992 - 1993

- 4.1 Liu, Manly, Tracking Aircraft around a Turn with Wind Effects, SM Thesis, and Flight Transportation Laboratory Report 93-4, Flight Transportation Laboratory, MIT, Cambridge, MA June 1993,
- 4.2 Hansman, R. John; Wanke, Craig; Kuchar, James; Mykitishyn, Mark; Hahn, Edward; Midkiff, Alan, Hazard Alerting and Situational Awareness in Advanced Air Transport Cockpits, Paper at 18th ICAS Congress, Beijing, China, September, 1992
- 4.3 Wanke, Craig; Hansman, R. John, A Data Fusion Algorithm for Multi-sensor Microburst Hazard Assessment, Preprint, AIAA Atmospheric Flight Mechanics Conference, Hilton Head, SC, August, 1992
- 4.4 Wanke, Craig; Hansman, R. John, Hazard Evaluation and Operational Cockpit Display of Grand Measured Windshear Data, AIAA Journal of Aircraft, Vol 29, No. 3, May-June, 1992
- 4.5 Wanke, Craig; Kuchar, Jim; Hahn, Edward; Pritchett, Amy; Hansman, R. John, A Graphical Workstation Based Part-Task Flight Simulator for Preliminary Rapid Evaluation of Advanced Displays, Preprint, SAE AEROTECH Conference and Exposition, Anaheim, CA, October, 1992