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AN EXPERT SYSTEM FOR AIR TRAFFIC CONTROL SYSTEM

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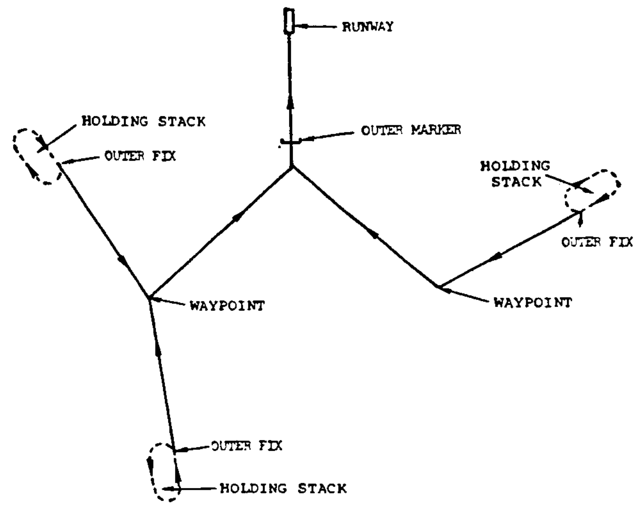
The objective of this project is to design a control logic which automates all or parts of the guidance function of air traffic control systems. A particular interest has been focused on automation of the terminal area control system, and preliminary study has been done on development of an expert system: a computer system that is capable of producing similar commands to those normally given by human controllers in various situations. The system may be used to assist controllers by providing them with feasible options in guiding each aircraft in the control area to its desired destination. It is assumed, however, that the final decision is still made by the controller and the computer system is used only as a supporting facility to increase efficiency and safety of the system.

AN EXPERT SYSTEM FOR AIR TRAFFIC CONTROL

* General Procedures for Terminal Area Control
* Previous Works on Automation of Terminal Area Control
* Expert Systems
* PROLOG; Artificial Intelligence Programming Language
* Conclusion and Plans for Further Study

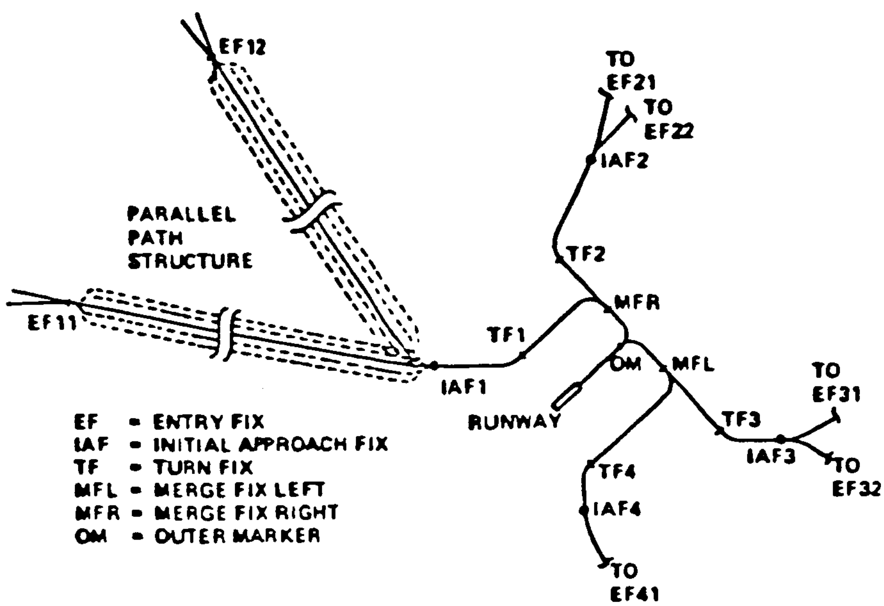
Generally, a terminal control area consists of a designated runway, an outer marker, outer fixes, and nominal paths connecting outer fixes with the outer marker. The primary function of a TCA controller is to safely direct each arriving aircraft from one of the outer fixes to the outer marker. Aircraft are then handed over to the tower controller for the final approach. If an aircraft is too close to another aircraft, i.e. a conflict is being predicted, the controller has to direct one of the aircraft into a delay maneuver or a holding pattern.



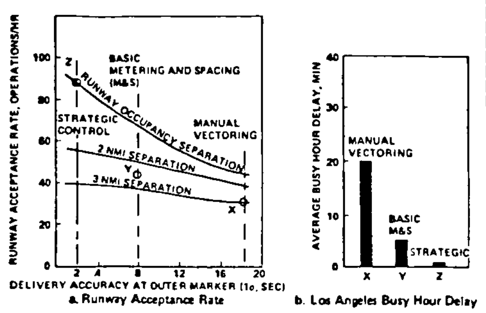
A TYPICAL TERMINAL CONTROL AREA

In an effort to automate the guidance process, Athans at MIT used a quadratic optimizing cost function to decide which aircraft is to leave the nominal path and go into a delay maneuver.[1] The algorithm assumes that desired separations are known and there is a unique desired speed. Penalty functions are included in the cost function so that any deviation from these desired values causes a higher cost. Aircraft with higher cost values are usually directed into delay maneuvers if conflicts are probable.

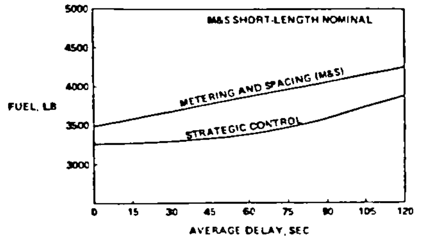
Erwin at Boeing Airplane Co. has proposed a new method called strategic control method which uses parallel paths to solve conflicts instead of delay maneuvers.[2] In this method, the terminal control area is extended from the usual 30 nautical-mile-radius to approximately 150 nautical-mile-radius, and the sequencing of arriving aircraft is done by the computer during the descent from cruise altitudes prior to the initial approach. He claims that the strategic control method will achieve an increased system capacity as well as a significant fuel savings.



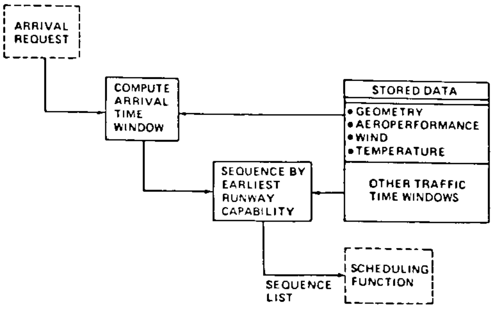
STRATEGIC CONTROL METHOD LAYOUT



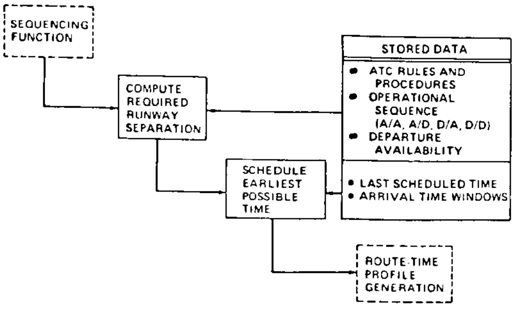
INCREASED CAPACITY WITH STRATEGIC CONTROL



FUEL SAVINGS WITH STRATEGIC CONTROL



SEQUENCE DETERMINATION



SCHEDULE DETERMINATION

The main problems in implementing these automatic systems are data management and the man-machine interface. First, the automated system has to consider various types of data, such as geometry of the controlled air space, aeroperformance of each aircraft, weather conditions, etc., in its calculations, so it must store enormous amounts of data. It must also be able to find any data in a relatively short period of time. Second, the automated system has to be able to "communicate" with controllers or pilots in order to make suggestions or to answer questions.

It is rather difficult to solve these problems with a conventional computer system, and application of artificial intelligence seems appropriate. Particularly, an expert system may be used as an interface between a human controller and a computer. An expert system is a software system which encapsulates specialist knowledge about a specific area of expertise and is capable of making intelligent decisions within that area. It can interpret the stream of numbers generated by the computer and present them in a more easily understood manner.

In continuing this project, the next step is to define a set of rules that constructs the knowledge base of the expert system. These rules will be encoded from manuals and from conversation with controllers, and they should cover all possible situations. Then the expert system, its control logic and knowledge base, will be programmed in PROLOG: an artificial intelligence programming language.

REFERENCES

1. Athans, M., "An Approach to Semiautomated Optimal Scheduling and Holding Strategies for Air Traffic Control," JACC Paper No. 6-D6, Washington University, St. Louis, MO, August 1971.

2. Erwin, Ralph L., Jr., "Strategic Control of Terminal Area Traffic", Plans and Developments for Air Traffic Systems, AGARD Conference Proceedings No.188, May 1975.