Investigation of Alert Zone and Display Concepts for Free Flight
(End of Year Summary, 1997)

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December 8, 1997

The following is a summary of work performed between 1/1/97-12/31/97 at MIT under NASA Research Grant NAG2-1111.

Research continued in the development of a probability-based method for conflict detection and alerting. A paper entitled "Prototype Conflict Alerting System for Free Flight" was presented at the 35th AIAA Aerospace Sciences Meeting and Exhibit in January, 1997 with a follow-up of the same title published in the July-August 1997 edition of the Journal of Guidance, Control, and Dynamics. The paper summarizes the design and development of an alerting logic that was based on probabilistic trajectory estimation between pairs of aircraft. Several versions of the logic code have been delivered to NASA Ames for use in their simulator experiments. Work is currently on-going to support a new version of the alert logic to handle multi-aircraft conflicts concurrently. A preliminary version should be available to NASA simulator personnel at the latter part of December 1997.

To better understand the potential benefits and drawbacks of utilizing a probability-based method, a number of alternative approaches to the collision avoidance problem were examined and summarized in the paper "Survey of Conflict Detection and Resolution Modeling Methods" which was presented in August 1997 at the AIAA Guidance, Navigation, and Control Conference. The paper provides a summary and comparative evaluation of the many different approaches that have been used in the past to perform conflict analysis. Each method is categorized in its dynamic modeling approach and method of handling conflict detection and conflict resolution. For example, one category included the extrapolation method used to predict future trajectories of which 3 were defined: nominal, probabilistic, and worst-case. Another category listed the metrics and parameters used by each method to make conflict decisions (i.e. estimated time to closest point of approach, miss distance, current separation, expected maneuvering cost, probability of conflict). Other useful information such as the ability to handle multi-aircraft conflicts and cooperative and non-cooperative maneuvering is also included.

In analyzing conflicts using probabilities, it is apparent that alerting thresholds could be designed based on values of probabilities (i.e. probability of conflict, probability of false alarm, probability of safe avoidance). This was the tactic utilized in the alerting logic currently being provided to NASA Ames. However, during our study of the various alternative approaches, a question arose as to the ability of human operators, in our case pilots, to understand alerts based on probabilistic interpretations. Misunderstandings and disputed alerts (or non-alerts) could lead to pilot mistrust, confusion, and non-compliance. To better understand how probability of conflict, P(C), relates to other metrics such as time, miss distance, and range, current work has begun to look into mapping the probabilistically designed alerting thresholds into these different dimensions. Available methods include the use of neural networks or neural-fuzzy logic computations to achieve the functional relationships.

Recently, research emphasis at MIT has been toward examining the potential benefits of including intent type information into the alerting design, mainly by incorporating probabilistic

intent into the trajectory model. Since the ability to predict the future position of an aircraft is necessary to determine a conflict, the accuracy of the trajectory model essentially affects the performance of any alerting system. Knowing that an approaching aircraft will, or may possibility turn sometime within 2 minutes can be a crucial element in deciding the proper course of action: alert or not alert. Intent information, even if probabilistic, can be beneficial by providing better knowledge of future aircraft positions. A preliminary analysis is documented in the paper, "Incorporation of Uncertain Intent Information in Conflict Detection and Resolution," to be presented at the 36th IEEE Conference on Decision and Control in December 1997 in San Diego.