Air Ground Integration Study

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A simulation was conducted to examine the effect of shared air/ground authority when each is equipped with enhanced traffic- and conflict-alerting systems. The potential benefits of an advanced air traffic management (ATM) concept referred to as "free flight" include improved safety through enhanced conflict detection and resolution capabilities, increased flight-operations management, and better decision-making tools for air traffic controllers and flight crews. One element of the free-flight concept suggests shifting aircraft separation responsibility from air traffic controllers to flight crews, thereby creating an environment with "shared-separation" authority.

During FY00, NASA, the Federal Aviation Administration (FAA), and the Volpe National Transportation Systems Center completed the first integrated, high-fidelity, real-time, human-in-the-loop simulation. A number of related accomplishments contributed to the successful completion of this effort: (1) linking Ames simulation facilities on the West Coast with those of the FAA William J. Hughes Technical Center (WJHTC) on the East Coast; (2) developing a prototype cockpit display of traffic information with alerting logic (CDTI-AL) which served as a flight crew decision support tool (figs. 1, 2); and (3) incorporating the User Request Evaluation Tool (URET) developed by MITRE Corporation for the air traffic controllers.

The simulation, conducted over a 4-week period, involved 6 line pilots; 12 certified

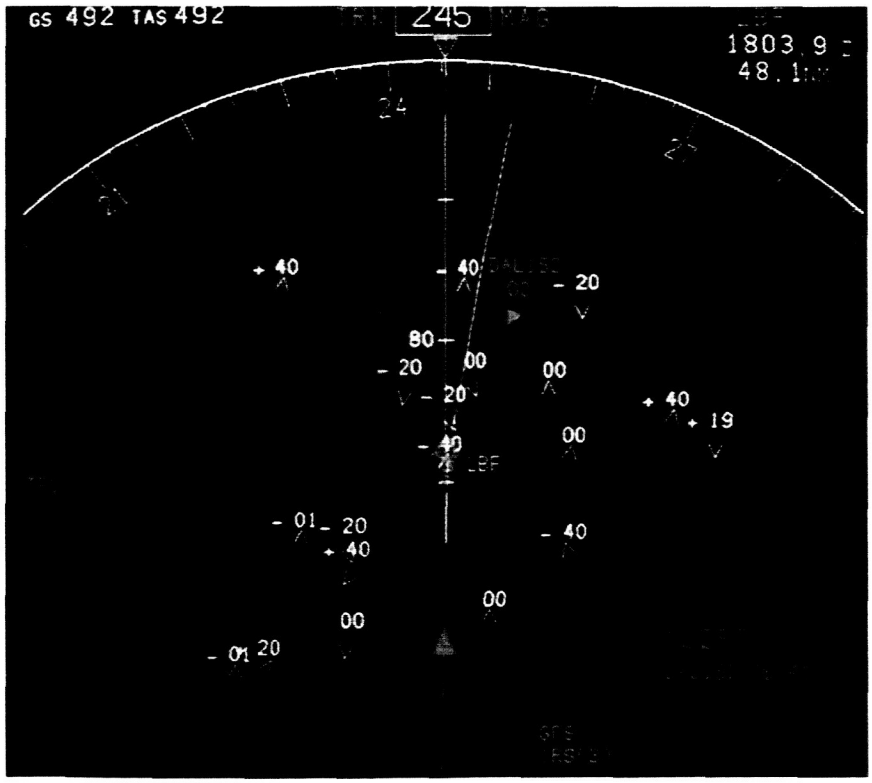

Fig. 1. Flight deck cockpit display of traffic (CDTI) showing an impending conflict with DAL152.

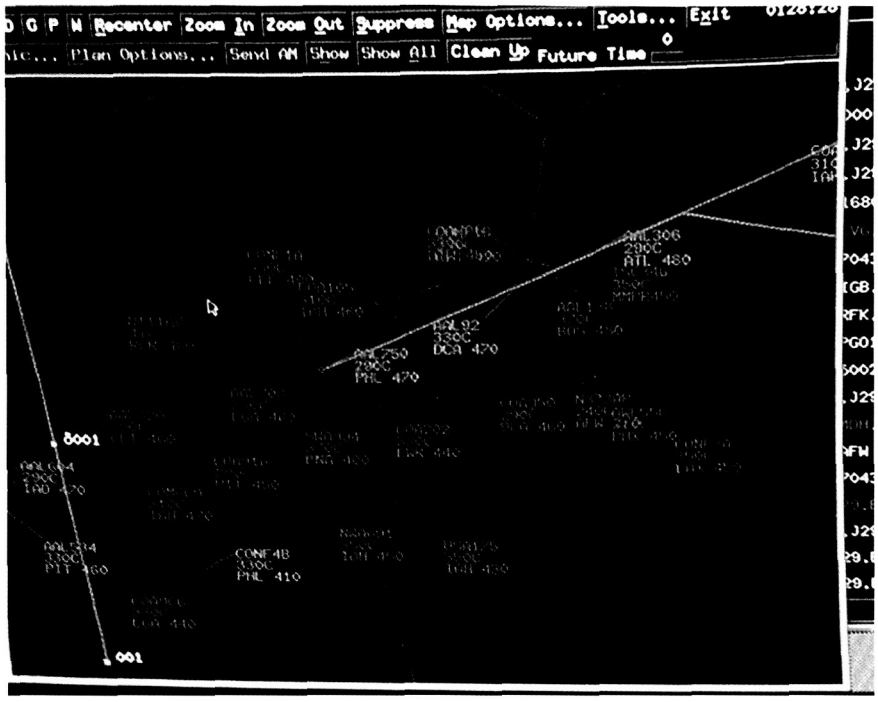

Fig. 2. Flight deck cockpit display of traffic (CDTI) depicting predictor tools to enable conflict detection awareness.

professional controllers, who served as participants; and 4 operations supervisors, who served as subject matter experts and observers. Two Memphis Air Route Traffic Control Centers (ARTCC) were emulated in the experiment. Four test conditions were defined by level of controller and flight crew shared-separation responsibilities and associated procedures. Standard separation rules of 5 nautical miles horizontal or 1,000/2,000 feet vertical (as appropriate) were observed throughout. All flight crews and controllers experienced all four conditions. Objective ground-side data included communications, separation errors, URET alerts and trial plans, closest point of approach, traffic density, and number of free-flight cancellations. Objective air-side data consisted of communications, separation errors, CDTI-AL alerts, closest point of approach, and number of free-flight cancellations. Subjective ground-side and air-side data consisted of workload and situation awareness ratings and comments about shared-separation experiences, traffic realism, and other details. Expert observers recorded critical observations.

The controllers expressed concern about the feasibility of shared-separation as simulated in this study and its potential effect on flight safety. They reported higher workload, they preferred to resolve conflicts earlier than pilots did, and they tended to cancel free-flight when they perceived that pilots were delaying resolution of the conflict. However, their level of situation awareness was high across all conditions. Pilots preferred shared-separation conditions, particularly the one affording them the highest level of separation responsibility (SS:L2). They rated both shared-separation conditions as being relatively safer than current operations and as providing more situation awareness.

This research helped to facilitate the technical connection and collaboration between multiple organizations. It also demonstrated some of

the advantages of exploring free flight and shared-separation authority in a full-mission study environment.

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Enabling Cockpit-Based Self-Separation

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Data from capacity studies suggest that the National Airspace System (NAS) will reach its capacity limits with the current centralized Air Traffic Control (ATC) system within the next 2 decades. The goals of this effort were to design and develop prototypes of flight deck tools to support airborne management of separation and to evaluate the feasibility of shifting flight deck and ATC roles and responsibilities relating to the management of separation. The concept of Free Flight introduces many challenges for aviation operations in the air and on the ground. Of considerable concern is the plan to move from centralized control and responsibility for aircraft separation to decentralized control and distributed responsibility.

Because of the impending NAS overload, research on distributed air-ground concepts has been undertaken to identify and develop air-ground concepts to ensure that free-flight operations are implemented successfully. The underlying concept evaluated in this effort was based on three principles: (1) aircraft pilots should always broadcast intent information in the form of current flight plans; (2) all flight plans should be deconflicted to the maximum extent possible (in this case out to a range of 120 nautical miles); and (3) the interface for flightpath replanning tools should be graphical and impose low workload.

A full-mission air-ground simulation was conducted in the Ames' Crew Vehicle Systems Research Facility in support of this effort. Its goal was to evaluate the effect of advanced displays with intent information (for example, four-dimensional (4-D) flight plans) on flight crew and ATC performance during limited free-flight operations. To assess the value of 4-D intent information, flight crews performed real-time, strategic flightpath replanning with and without access to graphically presented 3-D flight plan information about surrounding traffic during en route operations. To support the replanning task, flight crews used an enhanced cockpit situation display (CSD) that depicted surrounding traffic, a dynamic 4-D predictor symbology, and tools that alerted the crew to impending losses of separation (fig. 1). The conflict-alert tool was color-coded (blue, white, and green) to reflect aircraft and portions of flight plans that were above, at, or below own-ship altitude. The CSD also contained a graphical route assessment and replanning tool used to develop alternative (deconflicted) flight plans (fig. 2). Once developed, modified flight plans were submitted electronically for approval and, upon approval, automatically loaded into the autopilot and data linked to all surrounding traffic. The study also examined two levels of ATC authority: (1) Limited Authority, at which level ATC intervened only when a loss of separation was imminent; and (2) Full Authority, at which level ATC ran the sector as they would normally.

The results suggest that flight crews with advanced 4-D flight plan information can perform strategic self-separation during operations in densely populated traffic environments. And, when ATC remains in the information