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Free Flight Phase 1 Conflict Probe Operational Description

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Abstract

As part of the modernization of the National Airspace System (NAS) program, the Federal Aviation Administration (FAA) in collaboration with the aviation community, has developed a comprehensive plan, known as the NAS Architecture. The plan defines methods for modernizing the NAS well into the 21st Century through effective and efficient use of equipment, software, services, facilities, procedures, and resources. Included in the plan is the aviation concept called Free Flight.

Free Flight is a concept of air traffic management that permits pilots and controllers to share information and work together to manage air traffic from pre-flight through arrival without compromising safety. The first step in the evolution of capabilities is called Free Flight Phase 1 (FFP1).

This document describes the operational capabilities and concept of operations for the FFP1 Conflict Probe. Emphasis is placed on the functional capabilities and the operational context in which these capabilities are used. How the automation supports the use of these capabilities in accomplishing the tasks that provide the anticipated benefits to the user community is also described. Conflict Probe capabilities are discussed in sufficient detail to permit the reader to understand the automation concepts, to provide a framework for understanding the operational concept, and to enable the reader to understand how the benefits associated with Conflict Probe may be achieved.

KEYWORDS: Automated En Route ATC (AERA), Air Traffic Control (ATC), Conflict Probe (CP), Free Flight Phase 1 (FFP1), National Airspace System (NAS), User Request Evaluation Tool (URET)

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Executive Summary

Each year, user demand for the services provided by the National Airspace System (NAS) has increased and will continue to increase. To balance the demand with the available capacity, while maintaining safety, the current system has to rely on regulating measures which include using structured airways, imposing delays and flow restrictions, and increasing the denial of user requests for route and altitude changes.

As part of the modernization of the NAS program, the FAA in collaboration with the aviation community, has developed a comprehensive plan, known as the NAS Architecture. The goal of this plan is to modernize the NAS safely and systematically for all users while at the same time providing NAS users with economic benefits that are possible by reducing delays and increasing user preferred routing. The plan defines methods for modernizing the NAS well into the 21st Century through effective and efficient use of equipment, software, services, facilities, procedures, and resources. Included in the plan is the aviation concept called Free Flight.

In January 1995, the *Report of the RTCA Board of Director's Select Committee on Free Flight* was published as a result of the collaboration among government, industry, and the user community. This included defining the procedures, system architecture, and transition for Free Flight. Free Flight is a concept of air traffic management that permits pilots and controllers to share information and work together to manage air traffic from pre-flight through arrival without compromising safety. The use of on-board flight management systems, enhanced cockpit situation awareness, satellite-based navigation, and decision support systems coupled with procedures and systems will permit pilots to fly more cost effective flight paths between takeoff and landing. With Free Flight, pilots will not have to fly routes structured around ground-based navigation systems.

In order to achieve the benefits for Free Flight as early as possible, an evolutionary approach to developing and deploying several of the automation and decision making tools will lead to the final architecture. This incremental approach will bring user benefits to the system sooner, and it will allow the FAA to modernize the NAS gradually as a set of building blocks.

As part of the evolutionary approach to achieving Free Flight, the RTCA has made recommendations for the priority implementation of several decision support system capabilities. One of the capabilities is a Conflict Probe, specifically based on the User Request Evaluation Tool (URET) prototype, which provides a set of decision support capabilities including trajectory modeling and conflict detection to en route controllers.

Conflict Probe Functionality

The key capabilities of Conflict Probe are:

- Trajectory modeling
- Track Management
- Trial Planning
- Automated Problem Detection
- Automated Coordination
- The Computer Human Interface (CHI)

Conflict Probe processes real-time flight plan and track data from the Host computer system. These data are combined with site adaptation, aircraft performance characteristics, and winds and temperatures from the National Weather Service in order to build four-dimensional flight profiles, or trajectories, for all flights within or inbound to the facility. The "reconformance" function adapts each trajectory to the observed speed, climb rate, and descent rate of the modeled flight. For each flight, incoming track data are continually monitored and compared to the trajectory in order to keep it within acceptable tolerances. Neighboring Conflict Probe systems will exchange flight data, position and reconformance data, and status information in order to model accurate trajectories for all flights up to 20 minutes in the future.

Conflict Probe maintains "current plan" trajectories, i.e., those that represent the current set of flight plans in the system, and uses them to continuously check for aircraft and airspace conflicts. When a conflict is detected, Conflict Probe determines which sector to notify and displays an alert to that sector up to 20 minutes prior to the start of that conflict. Trial planning allows a controller to check a desired flight plan amendment for potential conflicts before a clearance is issued. The controller can then send the Trial Plan to the Host as a flight plan amendment. Coordination of Trial Plans between sectors, which might include those of neighboring centers, may be achieved non-verbally using Automated Coordination capabilities.

These capabilities are packaged within a Computer Human Interface (CHI) that includes text and graphic information. The text-based Aircraft List and Plans Display manage the presentation of current plans, trial plans, and conflict probe results for each sector. The Graphic Plan Display provides a graphical capability to view aircraft routes and altitudes, predicted conflicts, and trial plan results. In addition, the point-and-click interface enables quick entry and evaluation of trial plan route, altitude, or speed changes and sending the flight plan amendment to the Host.

URET Prototype

Conflict Probe capabilities are currently undergoing field trials at the Indianapolis and Memphis ARTCCs in the form of the User Request Evaluation Tool (URET) prototype.

These field trials are being carried out to evaluate the Conflict Probe capabilities for operational acceptability and suitability. Feedback from the evaluations will help to further shape the operational concept for the use of this functionality and to reduce risk in its production and implementation. The use of URET at the two facilities is also expected to achieve some near-term benefits.

Currently, there are approximately 750 operational personnel (controllers, supervisors, traffic management specialists, etc.) trained in the use of URET at the Indianapolis and Memphis ARTCCs. Both facilities extended their available hours of URET operation to 22 hours a day, 7 days a week early in 2000. The usage is slightly less than 24 hours a day because the prototype was never built to run continuously and requires several hours each day to reinitialize, run off-line analysis tools, and capture the previous day's data for off-line processing. On the weekends when the Host is off-line for preventative maintenance and software testing, URET is also unavailable.

Conflict Probe in Free Flight Phase 1

The NAS Modernization Task Force, at their January 1998 meeting, suggested a way to evolve the early Free Flight capabilities and called it Core Capability Limited Deployment (CCLD). The first step in the evolution of capabilities is called Free Flight Phase 1 (FFP1). Conflict Probe capabilities are currently planned to be deployed to seven sites by the end of 2002, with the initial operational site scheduled for late 2001.

The seven sites are shown in Figure ES-1. Table ES-1 defines the functionality for Build 1 scheduled for 2001 and Build 2 scheduled for 2002. Build 1 includes the basic functions in the URET prototype being used at Indianapolis and Memphis at the end of 1999. Build 2 contains the functions deemed necessary for operational acceptability at all seven FFP1 facilities.

In addition to the increased functionality defined in the builds, incremental software upgrades are to be scheduled every 6 months to address bug fixes and enhancements based on field input and software problem reports. Currently, field input from Indianapolis and Memphis are collected into discrepancy reports (DRs) which are the basis for developing requirements for enhancements. The DR process will be expanded to include all seven sites to define the incremental upgrades.

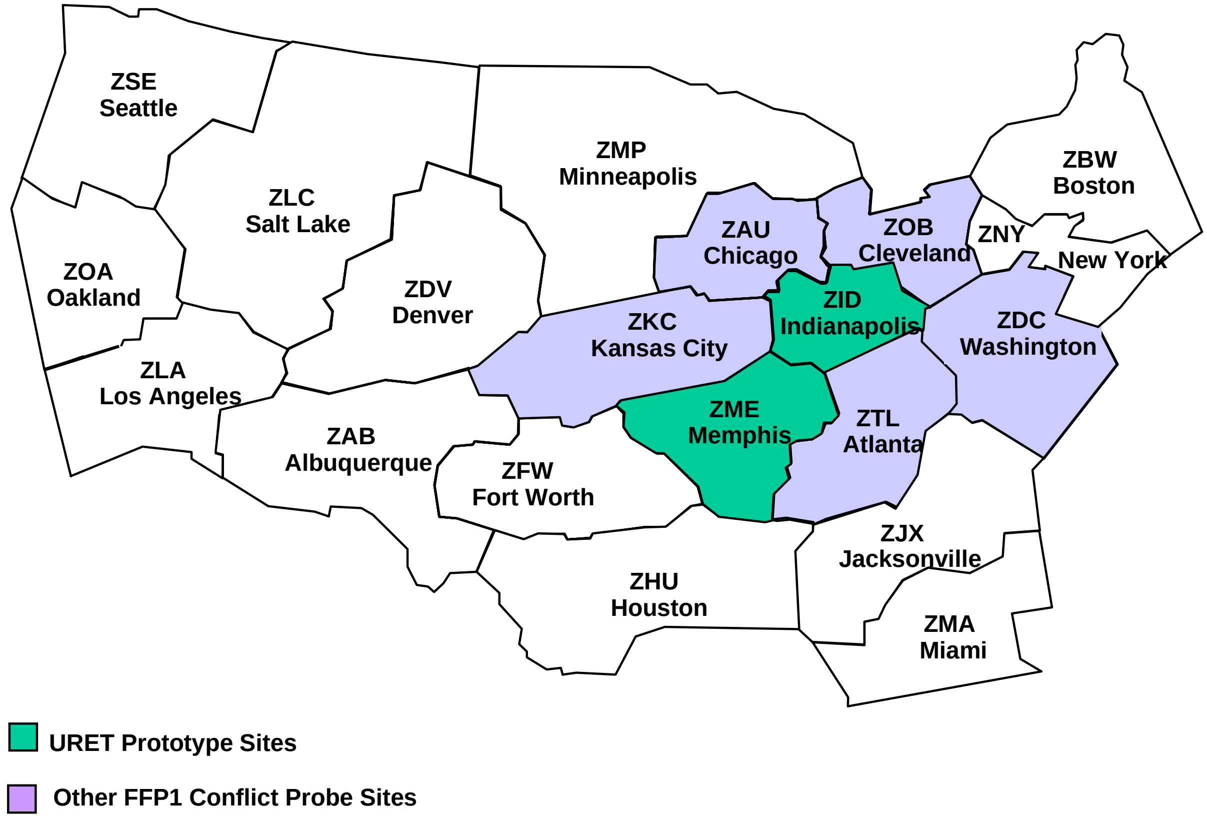

Figure ES-1. Seven FFP1 Conflict Probe Sites

Table ES-1. Conflict Probe Build Functional Capabilities

Build 1

- Basic Conflict Probe Functions
  - Trajectory Modeling
  - Automated Problem Detection
  - Trial Planning
- 2-way Host Interface
- Interfacility
- "Red Route" Processing
- Arrival Stream Filters
- Airspace Activation
- Automatic Resectorization
- Utilizes existing DSR M&C, SAR, DR&A

Build 2

- Military Operations
  - Single Aircraft Conflict Inhibit
  - Conflict Acknowledge
  - Group Suppression
  - Type 2&4 Coded Routes
- Automated Coordination
- Automated Replan
- Hold Processing
- ATC Preferred Route Processing

At the time of deployment of FFP1, en route ATC automation will consist of a centralized Host Computer System (HCS) that processes flight plan and radar data, and provides the backbone for automated en route operations. Networked to the HCS will be a set of display systems, (stationed at the sectors), known as the Display System Replacement (DSR) or simply the Display System (DS). Each DS sector contains three workstations. The Radar Controller (R-Controller) position contains a 20x20 inch display and associated display hardware, and communications hardware used to display radar and aircraft position information. The Radar Associate Controller (D-Controller) position will consist of a 20" flat panel on an articulating arm, flight strip bays, and communications support. This position will provide the D-Controller with the ability to display conflict probe data and interact with the system, to receive and send messages to the HCS, and to manually manipulate and mark paper flight strips. The A-Controller position will contain a flight strip printer and flight strip bays.

Operational Concept

The deployment of Conflict Probe capabilities at the sector will not change the fundamental responsibilities of the sector team. However, the automation tools provided will likely change the methods and processes by which the team carries out the tasks of conflict detection, resolution, and planning. Conflict detection capabilities, Trial Planning tools, and the graphic display of trajectories will provide the team with more accurate and timely information than is available in today's system. The new automation capabilities will complement their skills and will permit the sector team to shift task emphasis away from mental calculations required to ensure separation of aircraft. The sector team will be able to concentrate on more user-beneficial control actions that require their judgment and expertise to ensure separation. Use of these tools will also help smooth the sector team workload. The added coordination of problems and flight information between sectors and center facilities will further aid the separation process. The D-Controller will be a more active participant in early problem detection and resolution. Therefore, the D-Controller will be able to take or recommend actions before they reach the sector boundary, and therefore offload much of the separation task from the R-Controller. This will allow them to support a greater number of user preferred trajectories with more flexibility, thus providing enhanced benefits to the aviation community.

These capabilities are intended to augment, not replace, existing operational capabilities, procedures, and practices that ensure safety critical service. They are not intended to be used to maintain system safety nor to ensure aircraft separation. This responsibility continues to remain that of the sector team.

Benefits

The objectives of Free Flight are to provide greater flexibility and cost savings to the users without compromising safety. The evolution to Free Flight and the increased reliance on Conflict Probe and other capabilities are intended to provide tangible benefits early to users during the system’s life cycle. As new capabilities are added and the user community becomes more dependent on the flexibility afforded by user preferred routing, it is anticipated that increased benefits will be achieved. With an evolutionary approach it is possible to achieve a smooth operational transition of these capabilities to the sector controller. Conflict Probe will provide safety, FAA productivity, and user cost saving benefits.

Acknowledgments

Many people at MITRE/Center for Advanced Aviation System Development (CAASD) have helped to define and refine the Advanced En Route Air Traffic Control (ATC) (AERA) concepts and algorithms and have worked on the development of the User Request Evaluation Tool (URET) prototype. Their efforts are the building blocks for the definition of the FFP1 Conflict Probe capabilities. Over the years, their efforts have been documented in a series of MITRE reports. The authors have used these reports as the foundation of the current document and have extracted much of the description of the functional capabilities and operational concept for the FFP1 Conflict Probe from these documents. In a large part, the current document is a summary of all these references, updated to reflect the current FFP1 Conflict Probe concept. The individuals who have contributed to the evolution of conflict probe capabilities from its initial concept, as AERA, through its realization as a fielded URET prototype are too numerous to list. The technical information described in this document is the result of the work of all these individuals and the authors wish to thank them all for their efforts.

Special acknowledgement goes to Frank Leiber who published the first version of this description as WN98W000042 in August 1998.

Special thanks go to Patricia H. Palmer for helping to prepare this document for publication.

Section 1

Introduction

1.1 Purpose of the Document

This document provides an operational description of the Conflict Probe capabilities that will be available to en route air traffic controllers in the Free Flight Phase 1 (FFP1) time frame. The purpose of the document is to describe the operational capabilities that will be provided and how the user of the system may utilize these capabilities. The document includes an introduction to Conflict Probe concepts, functions, and the context in which they are employed. Intended primarily as a familiarization vehicle for all interested individuals including FAA personnel, contractors, and the user community, (i.e., airlines, military, the general aviation community), this document contains, at varying levels of detail, sufficient information on Conflict Probe to give the reader a general background in order to understand the system and the issues that will likely develop as the system progresses through its development life cycle.

1.2 Background

National Airspace System Architecture

Each year, user demand for the services provided by the National Airspace System (NAS) has increased and will continue to increase. To balance the demand with the available capacity, while maintaining safety, the current system has to rely on regulating measures which include using structured airways, imposing delays and flow restrictions, and increasing the denial of user requests for route and altitude changes.

As part of the modernization of the NAS program, the FAA in collaboration with the aviation community, has developed a comprehensive plan, known as the NAS Architecture. The goal of this plan is to safely and systematically modernize the NAS for all users while at the same time providing NAS users with economic benefits that are possible by reducing delays and increasing user preferred routing. The plan defines methods for modernizing the NAS well into the 21st Century through effective and efficient use of equipment, software, services, facilities, procedures, and resources. Included in the plan is the aviation concept called Free Flight.

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In order to achieve the benefits for Free Flight as early as possible, an evolutionary approach to developing and deploying several of the automation and decision making tools will lead to the final architecture. This incremental approach will bring user benefits to the system sooner, and it will allow the FAA to modernize the NAS gradually as a set of building blocks.

As part of the evolutionary approach to achieving Free Flight, the RTCA has made recommendations for the priority implementation of the following decision support system capabilities, which include:

- Conflict Probe, as represented by the User Request Evaluation Tool (URET) – which provides a set of decision support capabilities including trajectory modeling and conflict detection to en route controllers
- Collaborative Decision Making (CDM) – which involves users in the decision making process to ensure their needs and desires are incorporated into the actions taken, and provides capabilities for information exchange for all decision makers to have a shared view of the situation
- Traffic Management Advisor ((TMA) – an element of the Center/Terminal Radar Approach Control (TRACON) Automation System - CTAS) which allows more efficient sequencing and spacing of arrival traffic, and provides more accurate predictions of arrival times
- Passive Final Approach Spacing Tool (Passive FAST – an element of the Center/TRACON Automation System - CTAS) which allows more efficient spacing of arrivals on final approach to the runway to provide a greater arrival rate
- Surface Movement Advisor (SMA) – which facilitates the sharing of aircraft arrival information with airlines

Conflict Probe Functionality

Included in these tools are Conflict Probe decision aids which will provide the following operational capabilities:

- Timely identification of potential problems with traffic and airspaces
- Timely resolution of problems
- A Computer-Human Interface (CHI) that optimizes the effective exchange of information between the service providers and the decision support tools

Conflict Probe is a set of decision support capabilities that assist the en route controller team and will work in conjunction with the Host Computer System (HCS). The HCS provides Radar Data Processing (RDP) and Flight Data Processing (FDP) capabilities, while Conflict Probe provides improved problem detection capabilities, and a number of automation tools to assist with problem resolution and alternative route planning, utilizing an advanced CHI.

The basic Conflict Probe functionality, as defined in *Requirements Document for Initial Conflict Probe* [1] consists of:

- Trajectory Modeling
- Track Management
- Automated Problem Detection
- Trial Planning
- Automated Coordination
- The Computer Human Interface (CHI)

Conflict Probe processes real-time flight plan and track data from the Host computer system. These data are combined with site adaptation, aircraft performance characteristics, and winds and temperatures from the National Weather Service in order to build four-dimensional flight profiles, or trajectories, for all flights within or inbound to the facility. The “reconformance” function adapts each trajectory to the observed speed, climb rate, and descent rate of the modeled flight. For each flight, incoming track data are continually monitored and compared to the trajectory in order to keep it within acceptable tolerances. Neighboring Conflict Probe systems will exchange flight data, position and reconformance data, and status information in order to model accurate trajectories for all flights up to 20 minutes in the future.

Conflict Probe maintains “current plan” trajectories, i.e., those that represent the current set of flight plans in the system, and uses them to continuously check for aircraft and airspace conflicts. When a conflict is detected, Conflict Probe determines which sector to notify and displays an alert to that sector up to 20 minutes prior to the start of that conflict. Trial planning allows a controller to check a desired flight plan amendment for potential conflicts before a clearance is issued. The controller can then send the Trial Plan to the Host as a flight plan amendment. Coordination of Trial Plans between sectors, which might include those of neighboring centers, may be achieved non-verbally using Automated Coordination capabilities.

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Evolutionary Development and Deployment

Conflict Probe capabilities are currently undergoing field trials at the Indianapolis and Memphis Air Route Traffic Control Centers (ARTCCs) in the form of the User Request Evaluation Tool (URET) prototype. These field trials are being carried out to evaluate the Conflict Probe capabilities for operational acceptability and suitability. Feedback from the evaluations will help to further shape the operational concept for the use of this functionality and to reduce risk in its production and implementation.

Currently, there are approximately 750 operational personnel (controllers, supervisors, traffic management specialists, etc.) trained in the use of URET at the Indianapolis and Memphis ARTCCs. Both facilities extended their available hours of URET operation to 22 hours a day, 7 days a week early in 2000. The usage is slightly less than 24 hours a day because the prototype was never built to run continuously and requires several hours each day to reinitialize, run off-line analysis tools, and capture the previous day's data for off-line processing. On the weekends when the Host is off-line for preventative maintenance and software testing, URET is also unavailable.

The NAS Modernization Task Force, at their January 1998 meeting, suggested a way to evolve the early Free Flight capabilities and called it Core Capability Limited Deployment (CCLD). The first step in the evolution of capabilities is called Free Flight Phase 1 (FFP1). Conflict Probe capabilities are currently planned to be deployed to seven sites by the end of 2002, with the initial operational site scheduled for late 2001.

The seven sites are shown in Figure 1-1. Table 1-1 defines the functionality for Build 1 scheduled for 2001 and Build 2 scheduled for 2002. Build 1 includes the basic functions in the URET prototype being used at Indianapolis and Memphis at the end of 1999. Build 2 contains the functions deemed necessary for operational acceptability at all seven FFP1 facilities. This includes most of the functionality that is currently defined for Conflict Probe [1].

In addition to the increased functionality defined in the builds, incremental software upgrades are to be scheduled every 6 months to address bug fixes and enhancements based on field input and software problem reports. Currently, field input from Indianapolis and Memphis are collected into discrepancy reports (DRs) which are the basis for developing requirements for enhancements. The DR process will be expanded to include all seven sites to define the incremental upgrades.

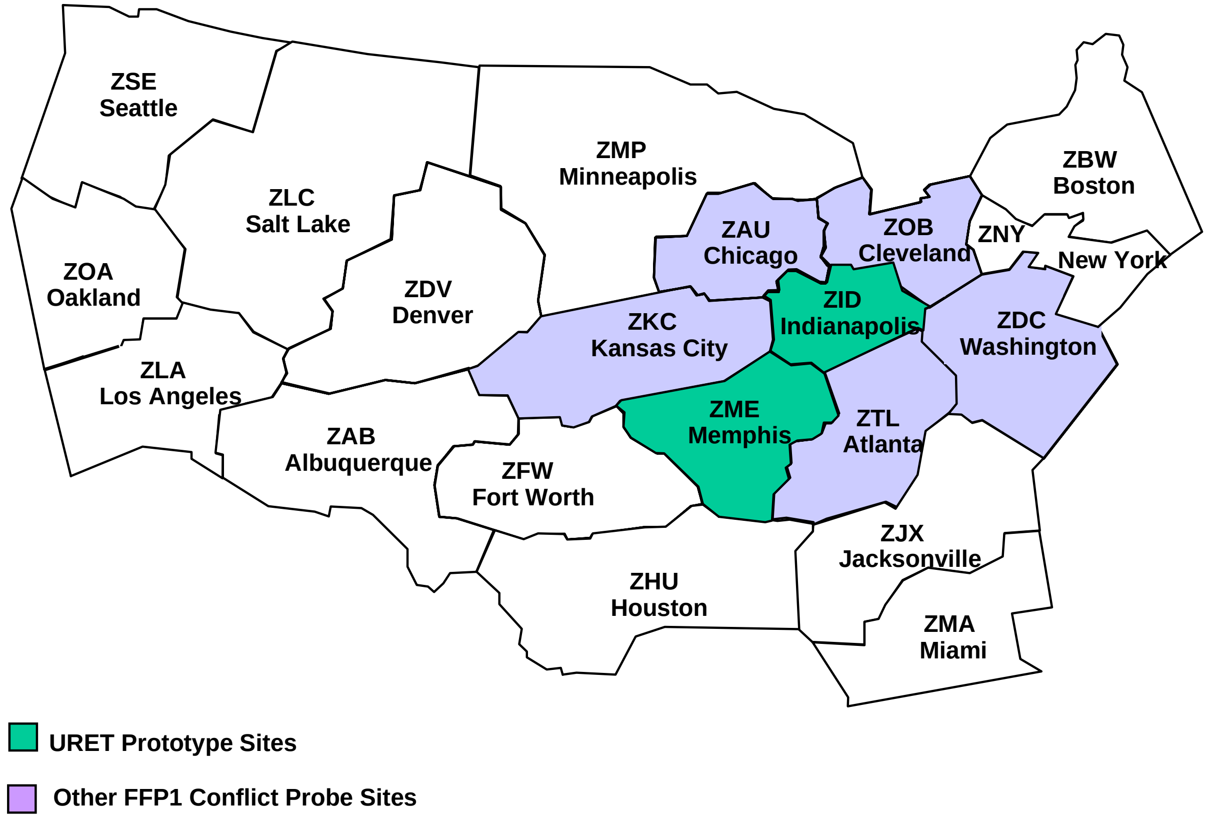

Figure 1-1. Seven FFP1 Conflict Probe Sites

Table 1-1. Conflict Probe Build Functional Capabilities

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- Interfacility
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- Airspace Activation
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- Utilizes existing DSR M&C, SAR, DR&A
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  - Single Aircraft Conflict Inhibit
  - Conflict Acknowledge
  - Group Suppression
  - Type 2&4 Coded Routes
- Automated Coordination
- Automated Replan
- Hold Processing
- ATC Preferred Route Processing

En Route Infrastructure and FFP1

At the time of deployment of FFP1, en route ATC automation will consist of a centralized Host Computer System (HCS) that processes flight plan and radar data, and provides the backbone for automated en route operations. Networked to the HCS will be a set of display systems, (stationed at the sectors), known as the Display System Replacement (DSR) or simply the Display System (DS). Each DS sector contains three workstations. The Radar Controller (R-Controller) position contains a 20x20 inch display and associated display hardware, and communications hardware used to display radar and aircraft position information. The Radar Associate Controller (D-Controller) position will consist of a 20" flat panel on an articulating arm, flight strip bays, and communications support. This position will provide the D-Controller with the ability to display conflict probe data and interact with the system, to receive and send messages to the HCS, and to manually manipulate and mark paper flight strips. The A-Controller position will contain a flight strip printer and flight strip bays.

As part of Conflict Probe deployment, a computer complex of processors will be networked to the HCS and to the DS D-Controller consoles. Figure 1-2 illustrates a high-level candidate network architecture for incorporating Conflict Probe into the en route automation system during FFP1. The Conflict Probe computer complex will also be networked to an external network router for communications with Conflict Probe systems at neighboring ARTCCs. The interface to the HCS, the Host Gateway (HGW), will permit Conflict Probe to receive flight plan and track information from the collocated HCS. The DS D-Controller console will be used by Conflict Probe as the output for its display information (flight data, problem detection, and planning information) and the input mechanism for interaction with the controller. The DS D-Controller console will be modified to support

Conflict Probe operations by replacing the existing display monitor with the 20" flat panel display.

In addition to the above components, the network will include interfaces to the Weather and Radar Processor (WARP) for weather data, to Monitor and Control (M&C) positions for system support, and to DS Dynamic Simulation (DYSIM) positions to be used for training and evaluation.

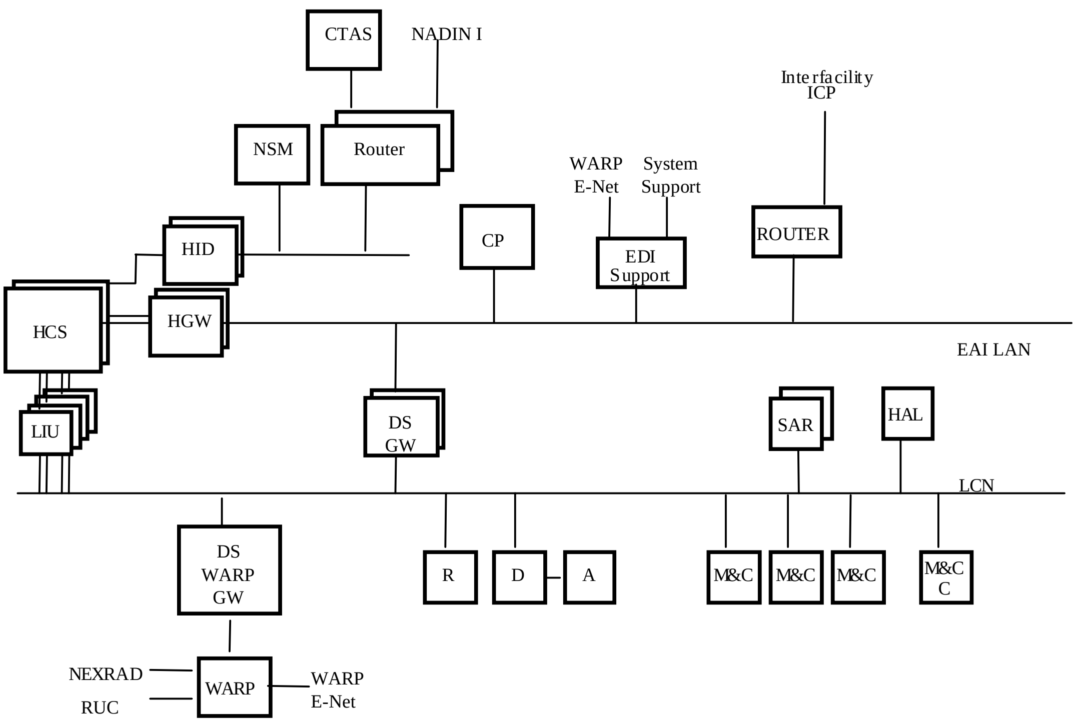


Figure 1-2. Candidate En Route Automation Infrastructure including CP

1.3 Assumptions/Dependencies

The following assumptions are made about the operational environment:

- The Display System Replacement (DSR) will support the R-Controller and D-Controller positions at the sector. Conflict Probe display/input functionality and D-Controller Computer Readout Device (D-CRD) display/input functionality will be integrated in the D-Controller Position console.

- The HCS will continue to provide Radar Data Processing and Flight Data Processing. Interfaces will exist with the HCS for receiving flight related messages from and sending amendments to the HCS.
- Conflict Probe functionality will not be critical to the safe operation of the ATC system and will not reduce current safe operations of ATC. The capabilities support efficiency of the sector operation and service to the user.
- The pilot in command remains responsible for safe operation of the aircraft, and can also expect discernible improvements in the flexibility of the Air Traffic Management (ATM) service provided.
- The controller team remains responsible for separation of controlled aircraft.
- Paper flight strips are still available to the sector team, although with the use of Conflict Probe reliance on them will likely diminish.
- Flow management operations will continue to define local and national flow management procedures and instructions and will continue to communicate and coordinate them with controllers, facilities, and airspace users as it does in current operations.
- Conflict Probe makes no assumptions on any change in the roles and responsibilities of participants of the ATM system, although it may coexist with other ATM automation tools and take advantage of these capabilities and the effects provided by these capabilities through increased collaboration. Dependencies of en route conflict probe capabilities with other ATM automation tools will evolve as the ATM system evolves toward Free Flight.
- Although many aircraft may be equipped with advanced avionics, such as satellite-based navigation, digital communications, and Flight Management Systems (FMS), Conflict Probe makes no assumptions on their availability but does take advantage of these capabilities in its operation if available. Ground-based navigation is still assumed in the timeframe associated with the initial Conflict Probe deployment.

Section 2

Scope

This document describes the operational capabilities and concept of operations for the FFP1 Conflict Probe. Emphasis is placed on the functional capabilities and the operational context in which these capabilities are used. How the automation supports the use of these capabilities in accomplishing the tasks that provide the anticipated benefits to the user community is also described. Conflict Probe capabilities are discussed in sufficient detail to permit the reader to understand the automation concepts, to provide a framework for understanding the operational concept, and to enable the reader to understand how the benefits associated with Conflict Probe may be achieved.

The discussion is presented in the context of en route NAS operations since the decision support capabilities proposed for Conflict Probe are to be used by en route sector controllers and are provided for within the supporting en route infrastructure provided by the NAS. In order to provide a contextual framework, a brief discussion describing the assumptions on the available components of the NAS and the environment in which Conflict Probe will initially be deployed is discussed in Section 1.2.

The benefits that are anticipated by early deployment of Conflict Probe capabilities and the long term benefits that will be realized as the NAS evolves towards Free Flight are described in Section 3.

The proposed functional capabilities of Conflict Probe are summarized in Section 4. A brief description of the major capabilities and the context within which these capabilities operate are discussed.

A brief discussion of the operational concept for Conflict Probe is provided in Section 5. The current ATC operations are described in order to provide a context for understanding the new capabilities. The operational concept is discussed in terms of the role of the controller when using the new automation tools. The discussion focuses on the role of the controller in detecting and resolving conflicts, responding to amendment requests, and coordinating with other controllers. A brief description of the proposed roles and responsibilities for Airways Facilities personnel, the system they support, and the modes of maintaining the system is also discussed in Section 5.

A collection of operational scenarios are included in Section 6. These scenarios will provide the reader with an understanding of the automation under various operating conditions. These scenarios reflect the use of Conflict Probe in the context of the NAS.

In addition, a summary of Conflict Probe performance characteristics is provided in Section 7.

This document is intended as a communication vehicle and educational tool that provides the reader with a unified discussion of the current operational assumptions of how Conflict Probe achieves its mission. The information in this document is likely to change and will be updated periodically to reflect the most current vision of Conflict Probe and its place in the evolutionary development process.

Section 3

Benefits

The objectives of Free Flight are to provide greater flexibility and cost savings to the users without compromising safety. The evolution to Free Flight and the increased reliance on Conflict Probe and other capabilities are intended to provide tangible benefits early to users during the system's life cycle. As new capabilities are added to the ATM and the user community becomes more dependent on the flexibility afforded by user preferred routing, it is anticipated that increased benefits will be achieved. With an evolutionary approach it is possible to achieve a smooth operational transition of these capabilities to the sector controller. Conflict Probe will provide safety, FAA productivity, and user cost savings benefits.

Safety

The safety benefit is achieved by reducing the risk of midair collision because of a controller error. This can also be translated into a reduction of operational errors and operational deviations. Conflict Probe increases safety by:

1. Increased situational awareness
2. Timely and continuous notice of emerging problems
3. Avoidance of time-critical, high stress traffic situations
4. Sector team collaboration
5. Consistently longer problem-identification lead times
6. Less uncertainty about potential conflict situations, and more confidence in long term effects of flight plan amendments

Several studies conducted for the FAA in recent years have identified the causes of most operational errors. These studies indicate that the controller was not aware of the operational error in a significant number of cases. Conflict Probe provides substantial warning time in these situations. With a consistent pattern of scanning for alerts by the controllers, these cases of not knowing that an operational error was imminent should not occur.

There were also operational errors when the controller gave an ill-advised clearance that put an aircraft into an immediate conflict. By using the trial planning function, the controller will be warned of this possibility.

In all cases, the quality of Conflict Probe results are not affected by aircraft density, the workload level of the controller, or whether the aircraft are flying on structured or unstructured routes. Conflict Probe will accurately and reliably detect that conflict situations exist. With training and consistent use of the conflict information, the potential for operational errors should be reduced even with the forecasted increase in traffic levels.

FAA Productivity

FAA productivity is accomplished by being able to safely handle increasing numbers of aircraft operations without a proportional increase in staffing or operating cost. Conflict Probe provides FAA productivity by:

1. Increased en route sector productivity
2. More effective utilization of sector team resources
3. Enhanced productivity from the D controller (with a potential for less workload given reduced requirements for flight strip manipulation and elimination of the need to scan strips for potential conflicts) with respect to planning, strategic problem detection, and problem resolution
4. Improved quality of flight plan and strategic problem information to the sector as a whole
5. Potential for reduced coordination between sectors when plans are known to be problem-free
6. Better team relationship between the D- and R-side
7. Capabilities that do not degrade as traffic complexity and volume increase

The productivity gains and reduction in sector workload are critical for the effective use of the tool. Relief from routine tasks and more efficient management of sector workload are essential aspects of Conflict Probe that create the opportunity to carry out the strategic planning tasks that will achieve user benefits.

Conflict Probe will be the primary source of flight data for the sector. The flight trajectory is a more accurate model of an aircraft's predicted flight path than what is presented on a paper strip. The trajectory is continually adjusted using Host track information, wind and temperature. These changes are automatically made to the displayed information. Conflict probe and trial plan results provide new, accurate, continuously updated future situation awareness data. This relieves the controller from performing routine, recurring and often time-consuming manual calculations to predict and compare future positions of aircraft.

User Cost Savings

User cost savings are increased by the accommodation of user preferences (route/altitude/speed profiles) and more flexible and deterministic schedules. Conflict Probe allows:

1. User-friendly maneuvers for conflict resolution
2. Potential for longer direct or wind-optimal routings
3. Reducing the restrictions to flight, both altitude and route restrictions
4. Use of more efficient cruise altitudes
5. Fewer dynamic restrictions based on miles-in-trail and ground delays

Several analyses have been performed to estimate the potential monetary benefits of relaxing route and altitude restrictions. These simulations have used different underlying assumptions and different base data to calculate their estimates. Three recent studies have all estimated the potential benefits at several hundred million dollars per year for air carrier operations.

The experience with the URET prototype at Indianapolis and Memphis, and opinions expressed by controllers participating in the enroute conflict probe program, have shown that about 30 to 50 percent of the maximum benefit can be obtained in practice using full conflict probe and resolution capability. During FFP1, with only seven of twenty centers implementing Conflict Probe, some smaller percentage of the benefits expect to be realized.

Section 4

Conflict Probe Functional Capabilities

4.1 General

Conflict Probe provides en route air traffic controllers with automated assistance in the strategic detection and resolution of predicted problems with traffic and adapted airspaces. Planning aids and tools are provided that will reduce the mental calculations that air traffic controllers currently perform to ensure separation of aircraft. These capabilities assist in strategic planning and will initially permit the Radar Associate Controller (D-Controller) a more proactive role in operations and ultimately provide the sector team with the ability to support a greater number of user preferred trajectories, more flexibility in flight routing, and increased capacity.

Figure 4-1 provides a block diagram of the major functional components of Conflict Probe.

Conflict Probe automation provides strategic planning capabilities to support controllers in the prediction and resolution of problems along an aircraft's flight path. The basis for providing these capabilities is accurate information on the aircraft's flight intent, including Flight Plan information, current position and track, forecasted winds and temperatures, aircraft performance characteristics, and facility adaptation. Using this information, the progress of an aircraft is continuously monitored, problems are detected, and controllers are notified of possible conflicts between the current flight and other aircraft and/or adapted airspaces. In addition, the controller is notified of possible conflicts between a controller-initiated proposed Flight Plan amendment and other aircraft or adapted airspaces.

In URET CCLD, Conflict Probe will be implemented in two builds, referred to as Build 1 and Build 2. Differences between Build 1 and 2 are indicated.

4.2 Processing of Flight Data (Plan and Track Processing)

Problem detection and planning information is developed by using flight plan information to predict the path of each controlled aircraft for which it receives flight information from the HCS or from a neighboring center's Conflict Probe. In addition, track data, received from the HCS, is used to insure that the predicted path conforms with the known current position of the aircraft. Processing components that compute the predicted path of the aircraft, monitor the aircraft's current position to insure that the predicted path is in conformance with this prediction, and adjust the path if it is not, are known as Trajectory Modeling, Conformance Monitoring, and Reconformance, respectively.

The projected path of a flight is modeled based on either (1) the system's knowledge of the current flight intent of the aircraft or (2) on controller specified proposed changes to the flight plan of an aircraft.

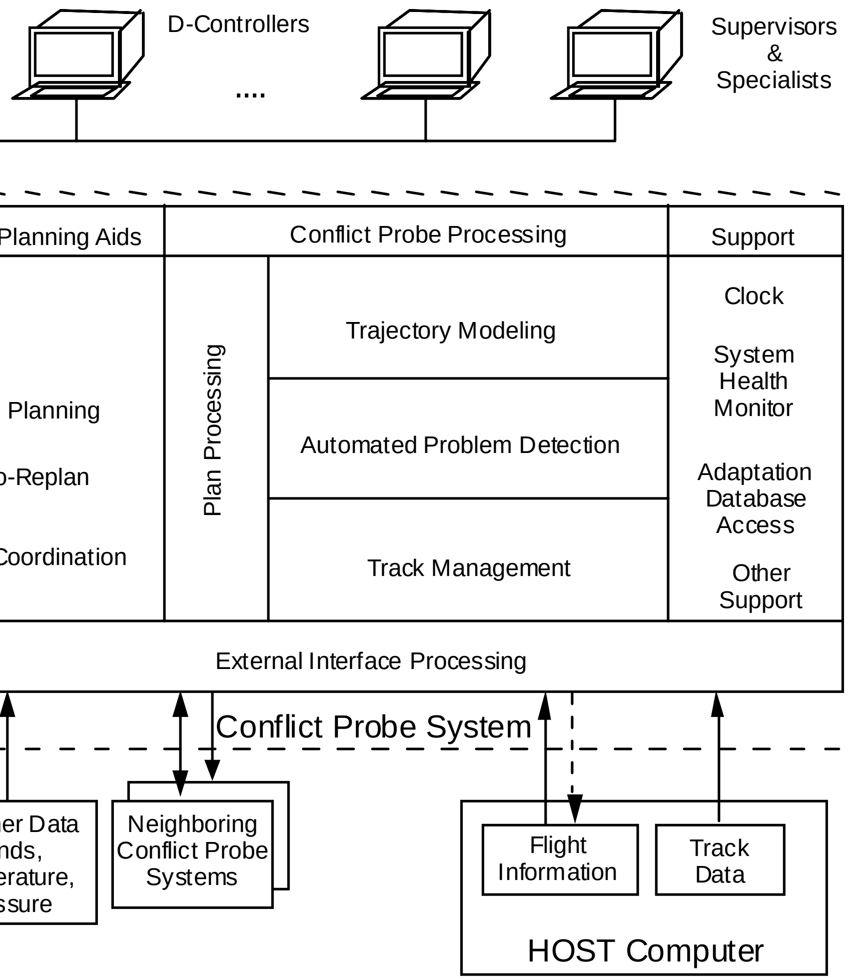


Figure 4-1. Conflict Probe System Block Diagram

When the projected path of a flight is based on the current flight intent of the aircraft, the system develops a Current Plan for the flight. The Current Plan includes flight plan data, track information, and the projected path of the aircraft known as a trajectory. Input into creating a Current Plan is the best current information on the path the aircraft is cleared to fly.

In addition to the Current Plan, the system may maintain a set of alternative plans that the controller wishes to evaluate. These alternative plans, known as Trial Plans, may be defined based on controller inputs of user requests for new routing or altitudes, or may be based on controller inputs to evaluate a resolution to a potential problem, or to coordinate proposed amendments with other controllers.

4.2.1 Trajectory Modeling

4.2.1.1 Introduction

A trajectory is a representation of an aircraft's predicted future position as it moves from an initial location and altitude (typically, either its departure airport or its actual airborne position) to a specified final location and altitude (typically a destination airport). Aircraft future positions are represented as a time-ordered sequence of points that describe the aircraft's planned route of flight in the horizontal, vertical, and time dimensions. The trajectory integrates flight plan data, active preferred routes, weather data, active altitude and speed restrictions, and aircraft characteristics data. Accurate trajectories are maintained within a boundary region around the facility to support accurate problem detection. Trajectories are created and maintained for both Current Plans and Trial Plans.

A trajectory is created or updated for each Current Plan whenever:

- A new Flight Plan, Flight Plan amendment message, or interim altitude message is received from the collocated HCS, or new or updated interfacility (IFA) Flight Plan information is received from a neighboring facility’s Conflict Probe system
- A hold message that indicates an aircraft is entering or leaving a holding pattern is received
- A reconformance occurs for the aircraft
- Control of the flight is determined to be within the center’s boundaries (i.e., airfiles, departures, arrivals from a non-Conflict Probe Center)
- A pre-filed flight plan has track data that indicates a new flight plan is the currently cleared flight plan for the aircraft

A trajectory is maintained for a Trial Plan whenever the controller creates a Trial Plan or has requested that a previous Trial Plan should be replanned as a result of the expiration of the plan or other change.

4.2.1.2 Route Conversion

The first step in creating a trajectory is Route Conversion. The route string contained in the Flight Plan is converted into a series of coordinates with adjustments made to the route so that it conforms with site specific adaptation data. Added to the converted route are any applicable preferred departure and arrival routes, (PARs and PDRs, see Section 4.9), that are contained within the adaptation data and not specified in the original route string. If the information available includes current aircraft position data (i.e., current track position or pilot position report), then the route is further adjusted to account for the aircraft's current position. Figure 4-2 illustrates a route which has preferential routes added as part of the Route Conversion process.

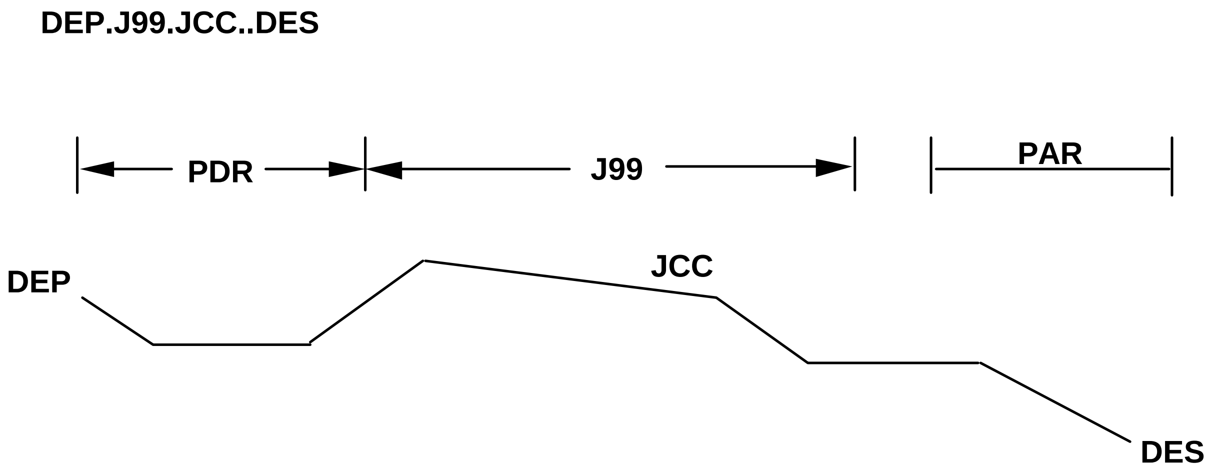


Figure 4-2. Route Conversion

4.2.1.3 Trajectory Generation

Once the route of flight is determined, the trajectory is updated to include any altitude transitions and estimated timing along the route based on planned actions (planned altitude changes, speed changes, and delays along the route), aircraft performance (including nominal climb and descent rates based on aircraft type and temperature, and speed and acceleration data based on aircraft type), and forecast weather data (including wind, temperature, and pressure).

Planned actions are determined: (1) from adapted altitude and speed restrictions, and delays, (2) from HCS messages (indicating delay and interim altitude information), and by controller action (proposed route, altitude, and speed changes included in a Trial Plan, see Section 4.4).

Altitude and speed restrictions or specified delays at route segment end-points are defined in adaptation for arrival routes (PARs or STARs), departure routes (PDRs, PDARs, or standard instrument departures (SIDs)), or coded routes (CRTEs). In addition, altitude and speed restrictions for arrivals into identified destination airports that are normally imposed at boundaries between control sectors, control facilities, and terminal areas are locally adapted from Letters of Agreement (LOAs) between facilities and from Standard Operation Procedures (SOPs). These proposed changes are incorporated into the trajectory and conflicts associated with these changes are coded when displayed to indicate that these restrictions where used to model the trajectory.

Altitude profiles are built based on requested or assigned altitudes, altitude restrictions, climb and descent gradients from adapted aircraft characteristics, and temperature and winds aloft data. During a descent phase, the trajectory is modeled to maintain the flight as high as possible while still meeting any applicable altitude restrictions and still land the aircraft at its designated airport.

Calculated times of arrival (CTAs) are computed for each fix in the converted route segment. The calculations incorporate planned speed, aircraft characteristics, weather, and any delays in the flight plan.

4.2.1.4 Calculating Conformance Bounds and Boundaries

Conformance Bounds

To insure that the trajectory remains consistent with current track updates, conformance bounds are assigned for each trajectory. Conformance bounds reflect the aircraft's ability to fly the nominal path and the characteristics of the route. Conformance bounds determine how far from the trajectory centerline, altitude or predicted along route distance, the aircraft can be before a new trajectory should be built. The system adjusts basic conformance bounds to account for an aircraft's navigational equipment and expanded protection around a turn in the aircraft's route or a vertical transition. When the track and altitude of an aircraft is within the conformance bounds associated with the trajectory of the Current Plan for an aircraft, the flight is said to be in conformance, otherwise it is said to be out of conformance. Figure 4-3 illustrates the trajectory and associated lateral and vertical conformance bounds for a flight.

Figure 4-4 shows nominal values for conformance bounds in the lateral, longitudinal, and vertical dimensions. These bounds may be expanded during climbs and descents (i.e., +/- 1000 ft.), during turns (i.e., +/- 1 NM longitudinally and laterally), and for non-RNAV equipped aircraft (i.e., +/- 1 NM laterally).

Boundaries

The times and positions where the aircraft trajectory enters and exits each control sector and APD boundary (adapted boundary larger than an ARTCC but containing it, see Section 4.7), are also computed and assigned to the trajectory. These values are used for assigning the Current Plan to the appropriate sector or transferring the information to other centers.

4.2.2 Track Management—Conformance Monitoring and Reconformance

Conformance Monitoring continually compares the trajectory-predicted position of the flight associated with the Current Plan with the reported position of the flight. Monitoring is be performed only for flights for which continuous, reasonable track data are received from the collocated HCS.

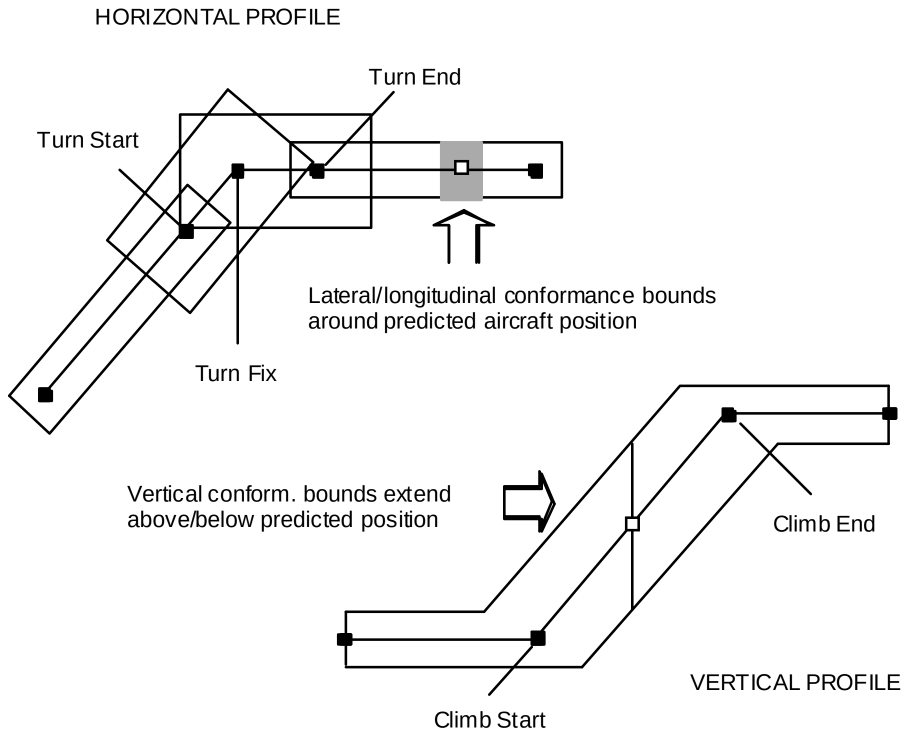


Figure 4-3. Horizontal and Vertical Profiles of a Trajectory with Conformance Bounds

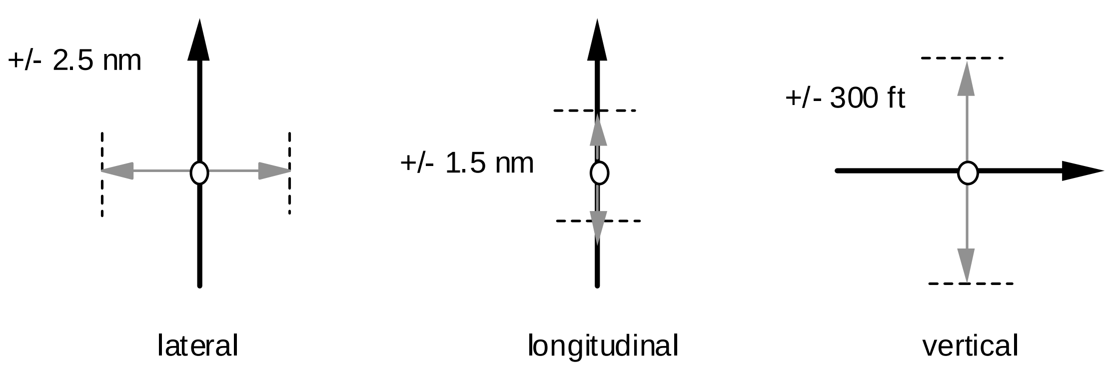


Figure 4-4. Nominal Conformance Bounds

When a nonconformance is detected, (i.e., when the reported positions are not contained within the lateral, longitudinal, and vertical conformance bounds of the associated trajectory position, as described in the previous section), the system recalculates the Current Plan's trajectory utilizing the track data position and velocity for that flight and ATC heuristics that represent intent for the aircraft. The process of remodeling the trajectory so that it again conforms to the current aircraft location, speed, and direction of motion is known as Reconformance. As a result of Reconformance, the trajectory associated with the Current Plan is updated and APD is invoked to check the new trajectory for problems.

Conformance Monitoring can be inhibited in airspaces surrounding airports. These areas are known as Tactical Airspaces. Section 4.3.3 discusses Tactical Airspaces in more detail.

Figure 4-5 illustrates how an out of conformance aircraft's trajectory would be modeled, (due to a vertical reconformance), when the track position shows (1) a descent earlier and (2) a descent later than the trajectory position indicates. The new trajectory is based on modeling the descent based on aircraft performance data.

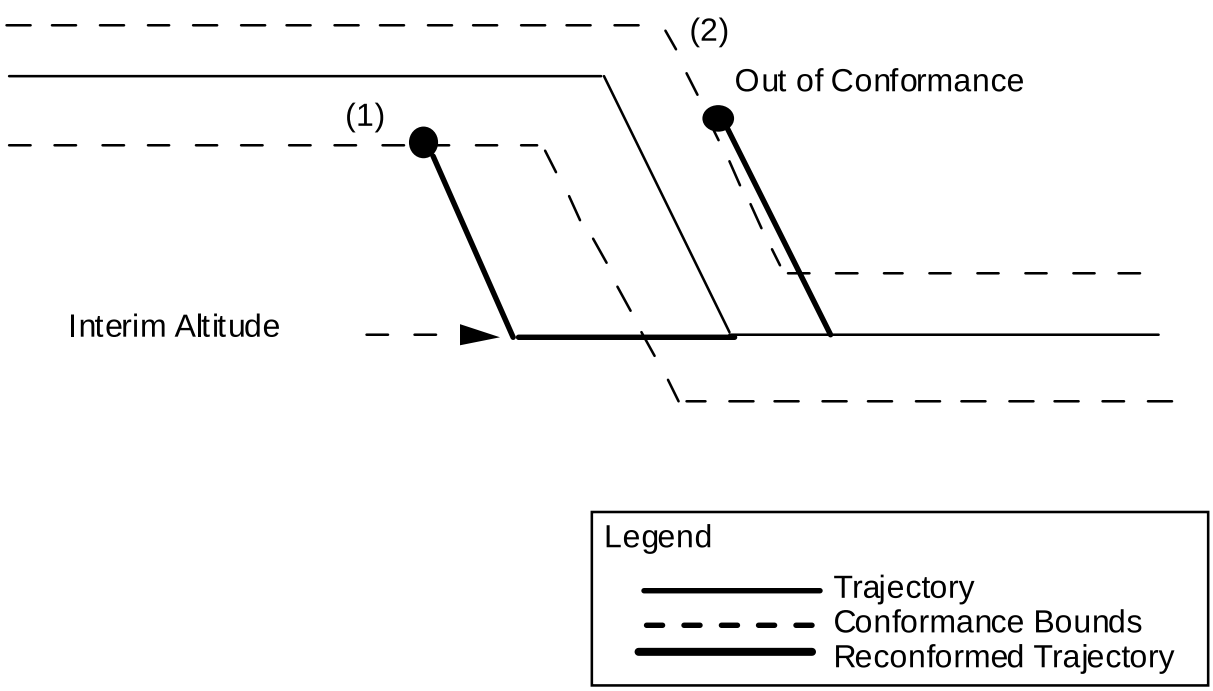


Figure 4-5. Vertical Reconformance

If a Current Plan trajectory is laterally out of conformance, then track history and the flight plan route information is used to determine the most likely location and path to model in order to rejoin the route. The method to be used depends on the type of out of conformance situation detected. The possible out of conformance situations include:

- Parallel offset
- Cut corner
- Direct to downstream point
- Converging towards route
- Diverging from route, stable track history
- Returning to route at downstream position (default if none of the previous cases apply)

Parallel Offset

If the track history indicates a parallel offset, the return to route is modeled using the default return to route at downstream position processing.

Cut Corner

If the track position history indicates the aircraft diverging from the route near a turn fix and the extrapolated intersection point with the route is beyond a turn fix, then the aircraft is assumed to be cutting a corner. The new trajectory is modeled to rejoin the route either at an intersection point downstream or at a nearby fix, as shown in Figure 4-6.

Direct to Downstream Point

If the track position history indicates that the aircraft is diverging from the route and its extrapolated position within a parameter distance from a downstream fix, then the new trajectory is modeled direct to that fix as shown in Figure 4-7.

Converging Towards Route

If the track position history indicates the aircraft is converging towards the route then the trajectory is modeled to converge to the route at an intersection point or, if the intersection point is near a fix, to that fix, as shown in figure 4-8.

Diverging from route, stable track history

In this case, an intermediate turn point from which the aircraft will be assumed to make a turn back to the flight plan converted route at a downstream location is modeled as shown in figure 4-9.

Returning to Route at Downstream Position

If none of the above cases apply, the default trajectory that is modeled is a return to route at a downstream position. The initial route segment modeled is a direct return to the flight plan route from the aircraft's current position. The possible paths that can be modeled are illustrated in figures 4-10 and 4-11.

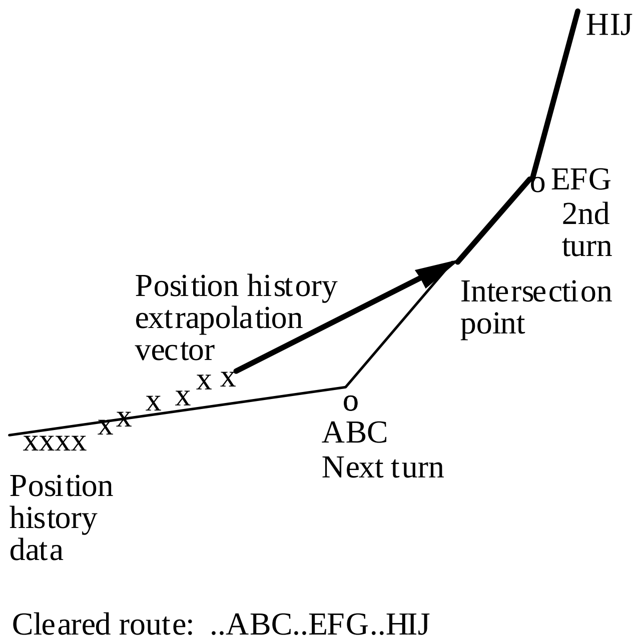
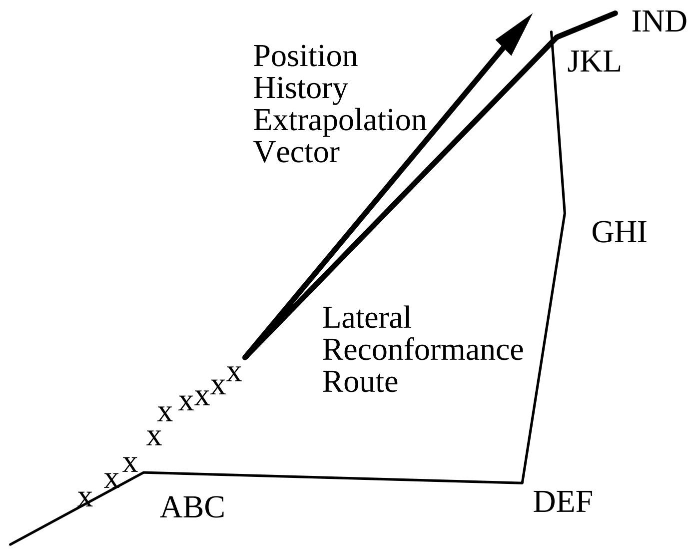
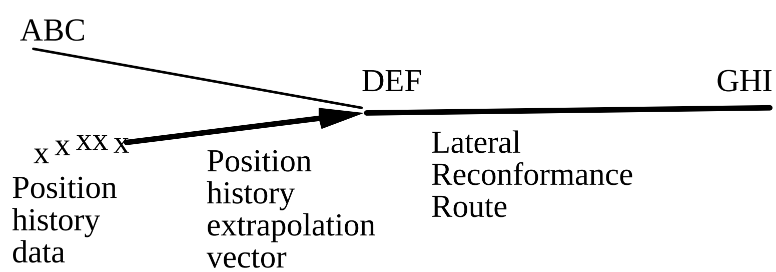


Figure 4-6. Reconformance when Aircraft is Cutting a Corner (Return to Route at Intersection Point of Track Extrapolation)



Cleared route string: ABC..DEF .. GHI .. JKL .. IND

Figure 4-7. Direct to Downstream Fix (Position History Vector Extrapolation Passes Close to Fix on the Route)



Cleared route string: ABC..DEF..GHI

Figure 4-8. Converging Towards Route

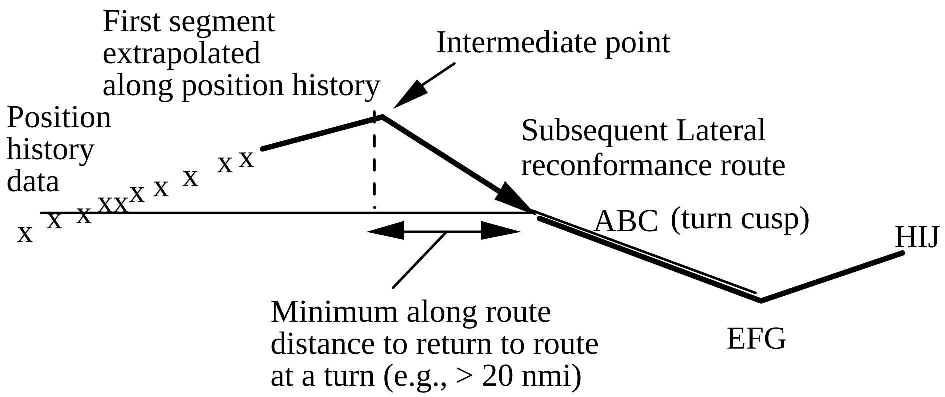


Figure 4-9. Position History Data Stable and Diverging from Route (return at Turn Fix)

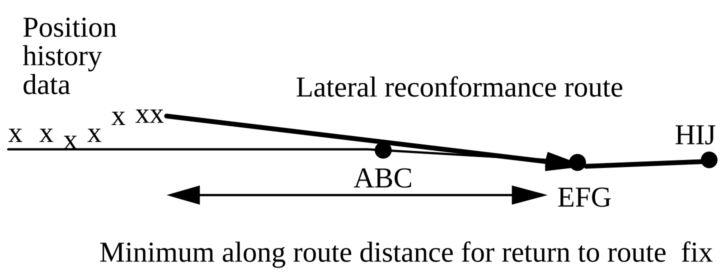


Figure 4-10. Position History Data Not Stable (No Significant Turn Before Return to Route Fix)

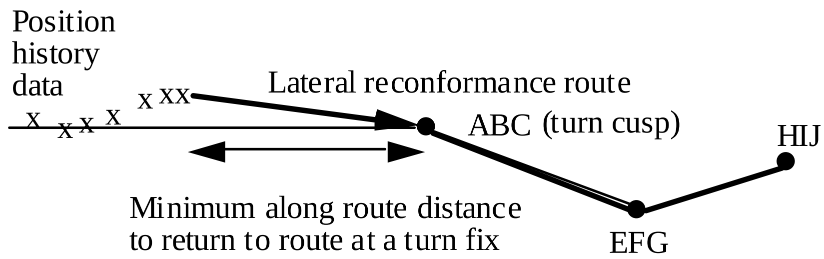


Figure 4-11. Position History Data Not Stable (Return to Route at Turn Fix)

4.3 Automated Problem Detection

4.3.1 Predicting Problems

Automated Problem Detection (APD) detects predicted aircraft-aircraft and aircraft-airspace problems by probing an aircraft's trajectory and then providing a notification for aircraft-aircraft problems for up to 20 minutes into the future, and further out for aircraft-airspace problems.

The system checks for conflicts in a Current Plan trajectory when either (1) a Current Plan trajectory is created or amended (e.g., the Current Plan is replaced or reconformed) or (2) the Flight Plan associated with the Current Plan is activated. It only checks those locally-owned Current Plans for which track data has been received from the HCS, (on either continuous or intermittent basis), or for flights inbound from another facility. The system checks for problems for a Trial Plan whenever it is created (see Section 4.4.1).

Current Plans are checked for conflicts against all other Current Plans in the region and against adapted airspaces in the region. Trial Plans are checked for conflicts against all other Current Plans in the region and against adapted airspaces in the region. Trial Plans are not checked against other Trial Plans.

In general, there are three cases when aircraft are maneuvered: (1) to avoid potential conflicts, (2) to avoid bad weather, and (3) to respond to a pilot or controller request for a change to a Current Plan. In the first two cases, the problem is either detected by APD or manually by the controller, and the controller may use a Trial Plan to resolve the problem. In the third case, an amendment under consideration, is entered as a Trial Plan and is submitted to the automation for probing.

When checking for problems with adapted airspaces, the system detects if a trajectory goes through a known military or special activity airspaces (SAAs), (Section 4.9). Associated with each airspace is an activation schedule. The system notifies the controller of a problem if the airspace scheduled to be active at the time of the predicted conflict or if the airspace has been manually activated. The trajectory from the aircraft's current position to the end of the trajectory or to the time the flight is terminated, is checked for violation of separation with all adapted airspaces in the region.

4.3.2 Separation Distances

Separation criteria are values used by APD in determining whether a conflict exists. The separation criteria are calculated as functions of (1) the conformance bounds associated with the trajectories of the aircraft, (2) separation standards (minima), as described in FAA Handbook 7110.65, and (3) the precision of the APD algorithms as determined by empirical observations. There are separate sets of separation criteria in the lateral, vertical, and longitudinal dimensions of flight. APD detects a conflict between two aircraft or between an aircraft and an adapted airspace when, and only when, separation criteria are violated in all dimensions.

In radar airspace, lateral separation standards are generally 5 nautical miles (nmi) depending on the aircraft proximity to a radar and whether radar returns are combined (mosaic mode) on the controller's display. (Generally, close to a terminal the separation standard is smaller; e.g., 3 nmi.) In addition to these standards, the conformance region is applied. Figure 4-12 shows the conformance region as a rectangle. APD determines whether the rectangles intersect in space and time. If they come closer than the lateral separation standards, then a problem is predicted in the horizontal dimension.

For radar airspace, the vertical transition is protected by the vertical separation standard and the vertical conformance bounds, as shown in Figure 4-13. Conformance regions account for vertical deviations that allow for a late or early start time to a vertical maneuver, and a range about the nominal rate of climb or descent. If both the horizontal and vertical loss of separation occurs, APD determines that a problem exists.

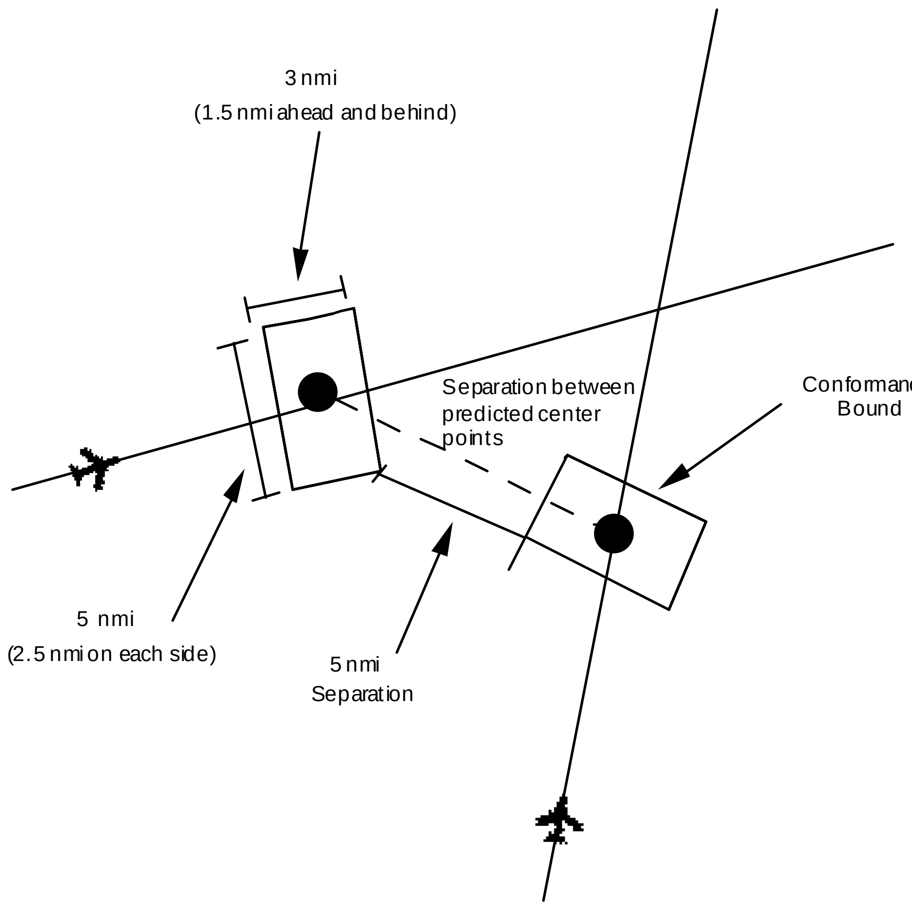


Figure 4-12. Lateral Separation and Conformance Region

The separation minima used in checking for airspace conflicts is adapted based on the type of activity expected to take place in the airspace (e.g., military maneuvers, severe weather, artillery fire). Typically, when airspace activity involves military flight operations, a separation buffer is superimposed on the airspace boundary, so that APD detects a conflict when this buffer is predicted to be penetrated as shown in Figure 4-14). Airspaces can also be defined without this buffer, in which case APD does not detect a conflict until the actual airspace boundary is predicted to be violated.

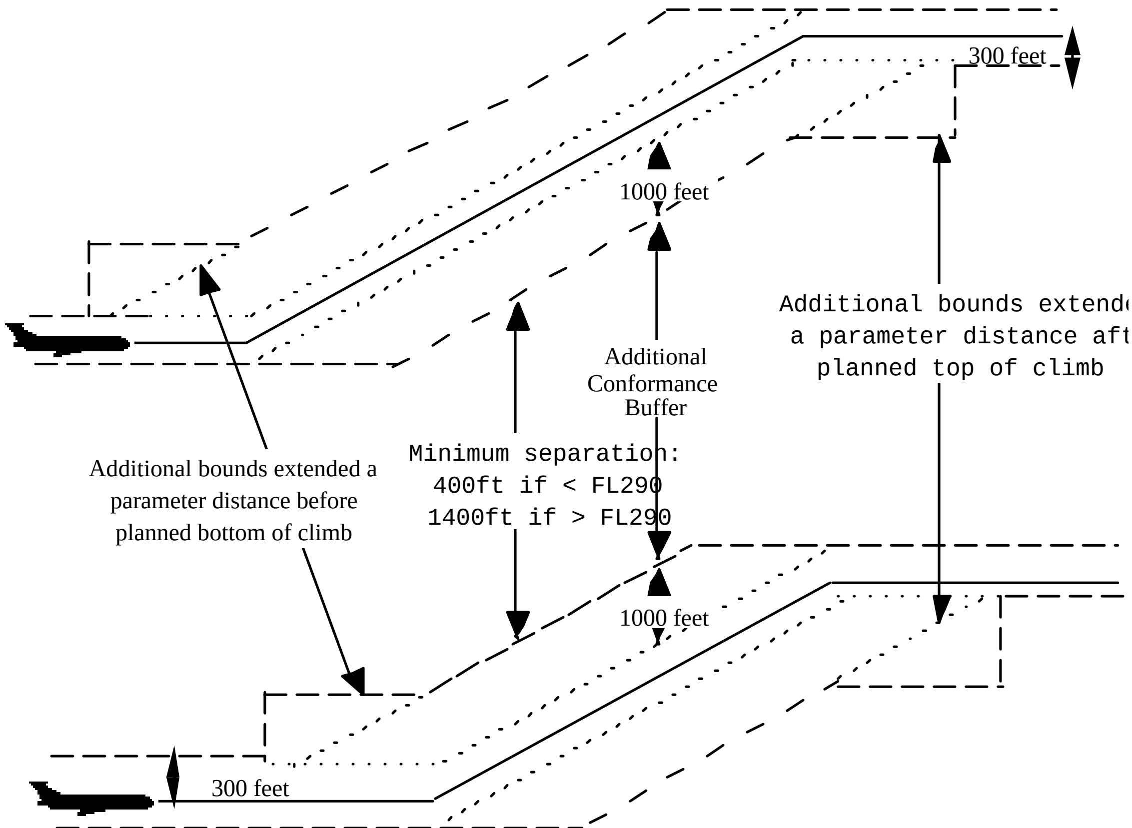


Figure 4-13. Vertical Separation and Conformance Buffer in Radar Airspace

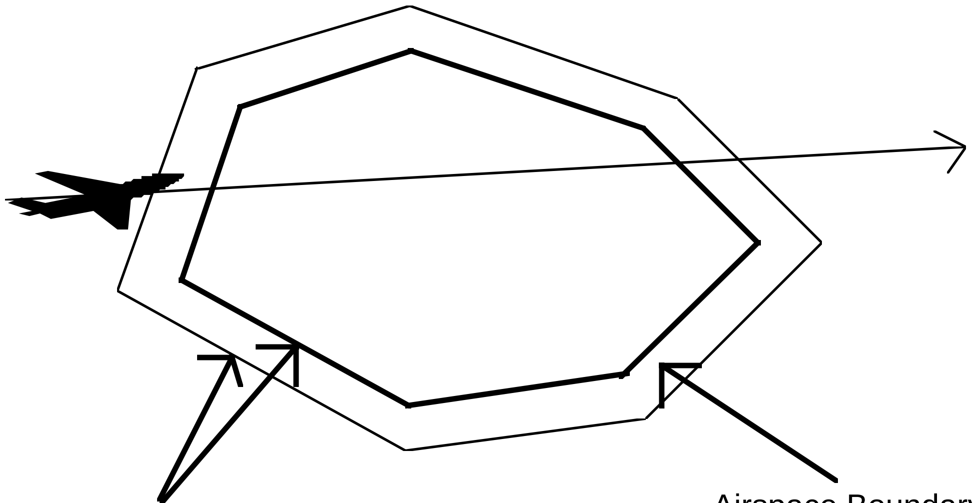


Figure 4-14. Aircraft-to-Airspace Conflict Detection

4.3.3 Inhibiting APD

The strategic control afforded by the longer look-ahead times is not always operationally beneficial. For example, around busy airports there may be areas where control remains short-term or tactical. The system provides several methods for determining when or where APD should not operate.

Aircraft-to-aircraft conflict detection is inhibited in the following cases:

1. For that portion of an aircraft's trajectory that is within volumes of airspace designated as active Automated Problem Detection Inhibited Areas (APDIAs)
2. When an aircraft's current position based on track data is within adapted volumes of airspace designated as a Tactical Airspace
3. Arrival Stream Filters for the aircraft arriving at an airport
4. Group suppression of military aircraft (Build 2)
5. Individual aircraft performing special maneuvers (Build 2)

APDIAs are volumes of airspace around airports where APD is inhibited. The boundaries of APDIAs will be the boundaries of approach control airspace.

Aircraft operating within a Tactical Airspace are inhibited from processing by APD and Conformance Monitoring. This reflects the conditions of a departing aircraft that can make dramatic turns within terminal airspaces before beginning on-course to the first filed fix in its Flight Plan. The boundaries of Tactical Airspaces, like APDIAs, reflect flying conditions such as airport configuration and traffic density. Each Tactical Airspace is contained in an APDIA having the same boundaries but a different altitude extent. A Tactical Airspace is activated if the paired APDIA is activated and deactivated if the paired APDIA is deactivated. Figure 4-15 illustrates the relationship between an APDIA and a Tactical Airspace for a departure.

An arrival stream filter is used to suppress notification of conflicts for aircraft pairs that are being sequenced for arrival to the same airport. In low altitude arrival sectors, aircraft arriving during a busy rush into a hub airport are sequenced much closer than the APD conflict detection separation criteria. The filter is adapted as a sector/airport pair. When a conflict is detected for two aircraft destined for the adapted airport and the conflict is designated to be notified to the adapted sector, then notification is suppressed. Conflicts between aircraft in the arrival stream and aircraft not in the stream are subject to notification.

Additional exemptions to APD are made possible by suppressing APD for selected groups of aircraft. Notification of conflicts between any aircraft within the group will be suppressed. Conflicts between any aircraft in the group and aircraft not in the group will still be subject to notification. Examples of group suppression are aircraft for which the Military Assumes Responsibility for Separation of Aircraft (MARSA) and aircraft identified as operating within an Altitude Reservation (ALTRV).

APD can be inhibited for a single aircraft that is performing special maneuvers. These include flight check aircraft, military aircraft in civilian airspace performing high speed maneuvers, and aircraft checking navigation aids. In these cases, the flight plan does not correspond to the actual aircraft's flight path during portions of the route.

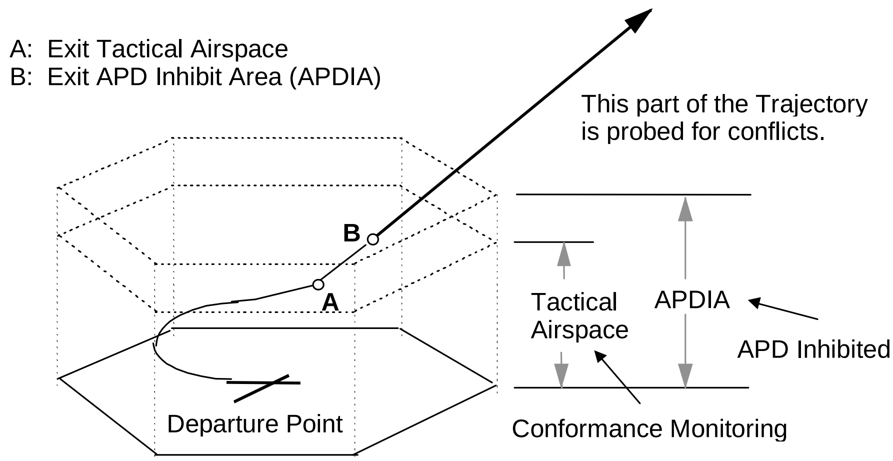


Figure 4-15. Example of Climb from Departure through an APDIA and Tactical Airspace

4.3.4 Notification of Conflicts

As stated earlier, a Current Plan is checked for problems automatically whenever there is a change, either because of a reconformance or a flight plan amendment. Although the system may detect a conflict, the controller may not immediately be notified. The time of notification is based on the type of conflict and other factors. A summary of the criteria for notification is contained in Table 4-1**.**

Table 4-1. Criteria for Conflict Notification

	Current Plan vs. Current Plan	Trial Plan vs. Current Plan
Aircraft - Aircraft	Notify when predicted start of conflict is within the warning time from current time. Warning time is variable and determined from likelihood of conflict.	Notify at time Trial Plan is entered. Check trajectory out to lookahead time (20 minutes) from time when Trial Plan is entered.
Aircraft - Airspace	Notify when predicted start of conflict is within the warning time from current time. Warning time is an adaptable parameter (40 minutes).	Notify at time Trial Plan is entered. Check trajectory out to exit of Planning Region.

For Current Plan aircraft-aircraft problems, the automation applies probabilistic reasoning to determine when to notify the controller of the problem. The probability of actual loss of separation for a detected conflict is based on empirical data derived from analysis of actual flight data and maintained in adaptation. An example warning time distribution is shown in Figure 4-16. The distribution shown is based on the URET prototype currently in use and the CP distribution may be different. Based on these measurements, the system may defer notification to obtain better knowledge of the problem depending on the time of violation and complexity in resolving the conflict.

When the decision to notify the controller is made, the notification is generally provided to the sector where the violation is predicted to occur for aircraft-to-aircraft problems. For aircraft-to-airspace problems, the sector controlling the aircraft receives the alert, and the notification is given at the time the problem is detected.

4.3.5 Determining Assignment of Conflict Notification

Determination of the designated position where Current Plan Alerts are assigned is made by applying the first applicable rule from the following list:

1. The location of both flights at the predicted start time of the conflict lie within a single FPA. The designated position is the position controlling that FPA.
2. The location of both flights at the predicted start time of the conflict lie in different FPAs, and exactly one of those FPAs is controlled by a position which is the owner of the Current Plan of one of the involved aircraft. The designated position is the

position which owns the Current Plan of the involved aircraft and which also controls the location of the flight at the predicted start time of the conflict.

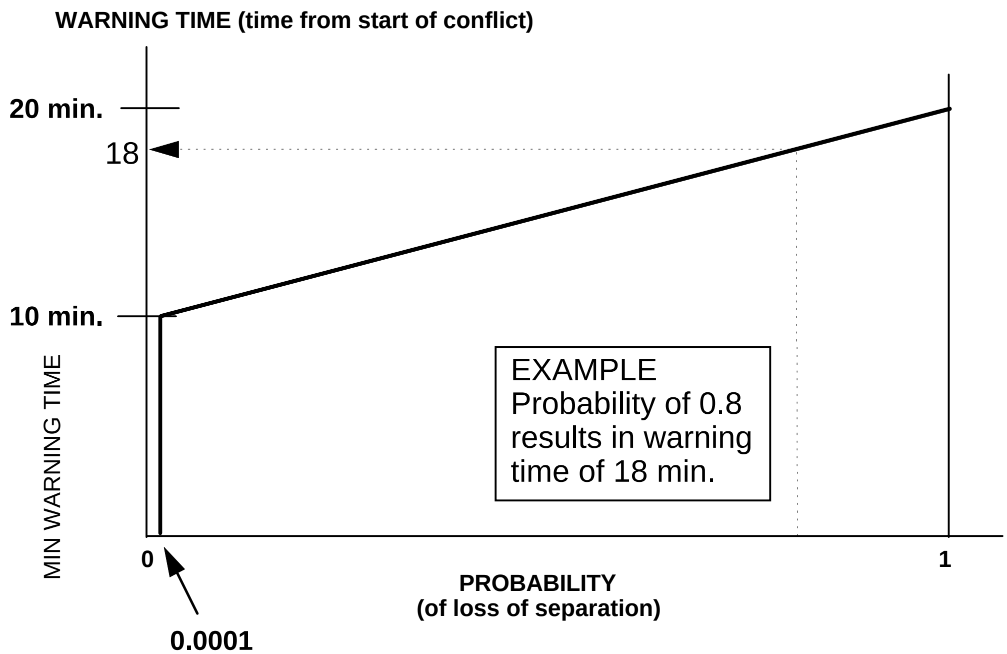


Figure 4-16. Warning Time as a Function of the Probability of Loss of Separation of a Conflict

3. The location of both flights at the predicted start time of the conflict lie in different FPAs and exactly one of those FPAs contains the intersection of the involved aircrafts' trajectories. The designated position is the position controlling the FPA containing the intersection.
4. The location of both flights at the predicted start time of the conflict lie in different FPAs, and the position controlling one of those FPAs will own the corresponding aircraft before the position controlling the other FPA will own the second aircraft. The designated position is the position that will own an aircraft earliest.
5. The designated position is a position controlling one of the FPAs where the flights are located at the predicted start time of the conflict.

Figures 4-17 through 4-21 illustrate these cases. For illustration purposes, FPA and sector boundaries have been made the same so that for example, the boundaries of FPA C are the same as sector C.

If two sectors are involved in a conflict, but only one is a sector with Conflict Probe operating, then the sector with Conflict Probe operating is notified of the conflict.

In addition, when aircraft are handed off from one sector to another, notification of the conflict is transferred at the time of handoff to the downstream sector (for interfacility this only applies to inbound handoff for the first aircraft handed off).

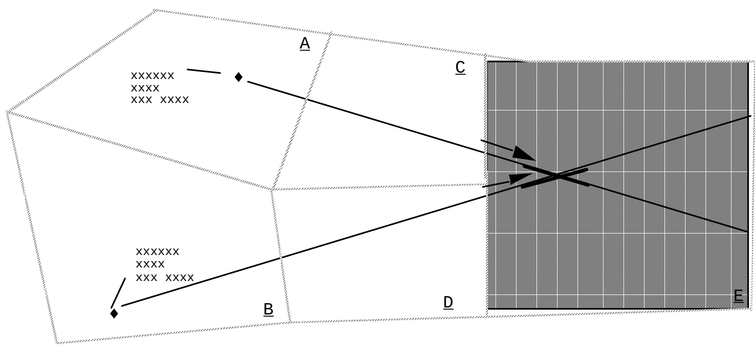


Figure 4-17. Initial Points of Conflict—Designated Position in Sector E

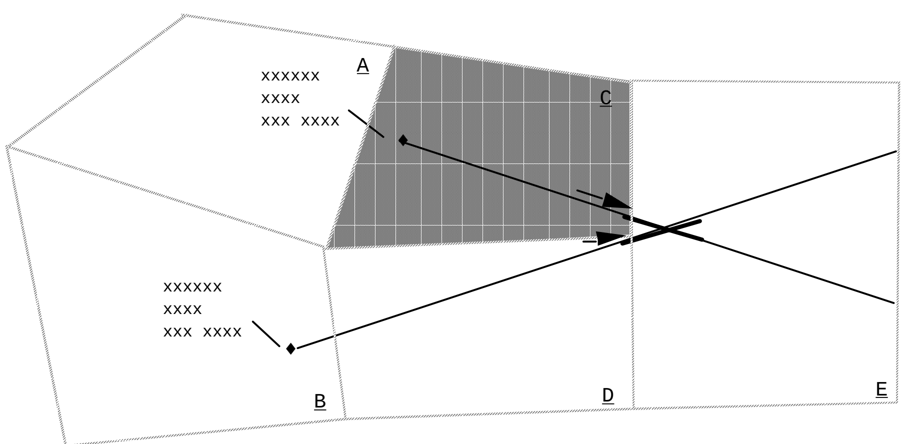


Figure 4-18. One Initial Point of Conflict and Control of an Involved Aircraft—Designated Position is Sector C

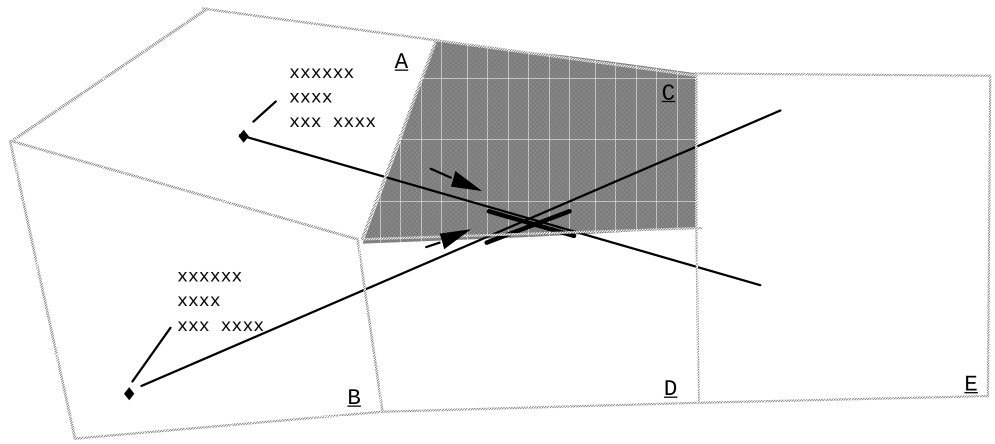


Figure 4-19. One Initial Point of Conflict and Intersection of Trajectories—Designated Position is Sector C

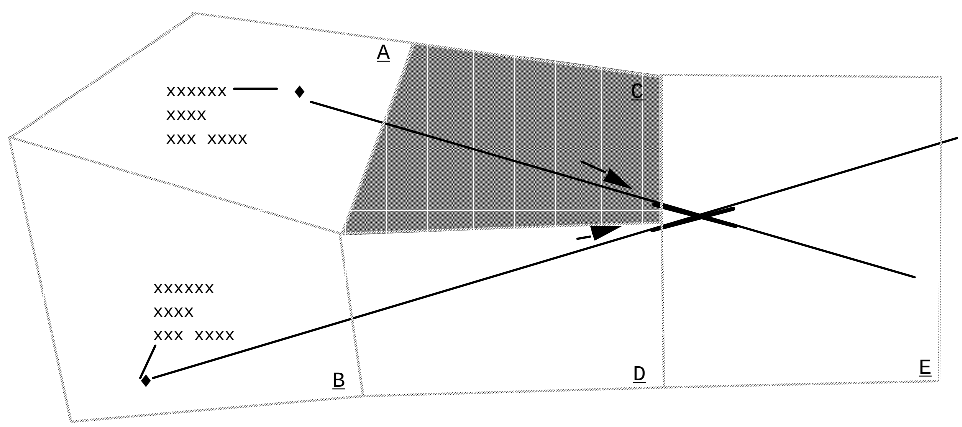


Figure 4-20. One Initial Point of Conflict and Earliest Control of an Involved Aircraft—Designated Position is Sector C

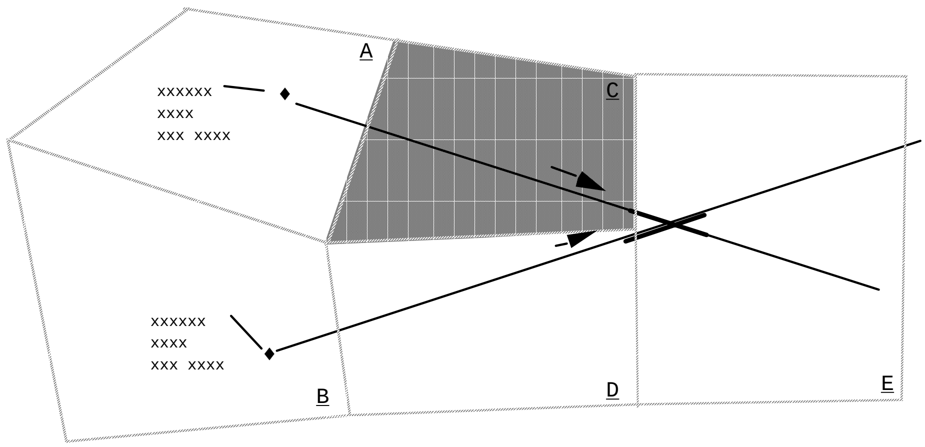


Figure 4-21. One Initial Point of Conflict with Sector Arbitrarily Chosen—Designated Position is Sector C

4.3.6 Coding of Alert Notifications

When the controller is notified of a conflict situation, the system codes the conflicts based on various criteria to aid the controller in distinguishing severity and determining the priority for handling the conflicts.

Based on the following criteria, an alert indicator is displayed for conflict notification:

a. If no alerts are assigned to the sector then no indicator is emphasized.

b. Alerts are designated as follows:

   1) Red Alerts

      a) Red - If the minimum miss distance for an aircraft alert is less than a procedural separation defined by a parameter (5 nautical miles).

      b) Muted Red - If the minimum miss distance for an aircraft alert is less than a procedural separation defined by a parameter (5 nautical miles) and loss of separation occurs on a portion of the route where an altitude transition is planned but not cleared.

   2) Yellow Alerts

      a) Yellow - If the minimum miss distance for an aircraft alert is greater than procedural separation and within the problem detection threshold defined by a parameter.

b) Muted Yellow - If the minimum miss distance for an aircraft alert is greater than procedural separation and within the problem detection thresholds and loss of separation occurs on a portion of the route where an altitude transition is planned but not cleared.

3) Blue - For Current Plans that lose separation with Special Use Airspace.

c. If an aircraft has at least one alert of any type (red, muted red, yellow, muted yellow or blue) assigned to the sector, then an indication of any alerts for that aircraft that are assigned to other sectors is displayed.

d. An aircraft entry that is not probed by APD has an indication of that fact displayed at the sector.

4.4 Planning and Coordination Aids

4.4.1 Trial Plan Definition

As previously discussed, a Trial Plan is a proposal for change to the current plan that is defined: (1) based on controller inputs of user requests for new routing or altitudes, (2) based on controller inputs to evaluate a resolution to a potential problem, or (3) to coordinate proposed amendments with other controllers. A Trial Plan for an aircraft includes all data applicable to a flight, including its trajectory, conformance bounds, and information essential for clearance delivery, plus amendment or other flight data constructed from controller input.

A Trial Plan is created when (1) a controller has used Single Trial Planning (Section 4.4.2) to select an existing plan (either a Current Plan or Trial Plan) and made proposed changes to the plan, (2) the controller has submitted a Trial Plan for Automated Replan (Section 4.4.3), initiating the automatic recreation of a new Trial Plan on a periodic basis, (3) the controller has resubmitted an existing Trial Plan, (4) an Automated Replan has been transferred from one facility to another, or (5) an interfacility coordination request has been received (Section 4.4.4).

A Trial Plan is deleted (1) when a controller at the position owning the Trial Plan has requested it, (2) when the system has deleted the corresponding flight plan (i.e., receives a deletion message from the HCS), (3) when it has timed out (based on an adapted parameter), or (4) when it is deleted by Automated Replan or Automated Coordination processing.

A Trial Plan remains valid until the trajectory for the Current Plan for that aircraft changes, a previous conflict for the aircraft is no longer valid, or a new conflict situation for the aircraft is predicted.

4.4.2 Single Trial Planning

The Single Trial Planning capability enables a controller to specify a Trial Plan as a proposed amendment or combination of proposed amendments to an aircraft's Flight Plan and have them checked for potential aircraft-aircraft problems and potential aircraft-airspace problems prior to amending the Flight Plan. A trial amendment includes altitude, speed, or route changes. Once created, the Trial Plan trajectory is checked once for problems with airspaces defined within the Planning Region boundary and with the trajectories of all other Current Plans.

The results for a single Trial Plan is displayed to the controller who created it. The results show either the system determination that the amendment is problem free, or an indication of problems encountered.

4.4.3 Automated Replan (Build 2)

Automated Replan is a capability which will permit a controller that has active control of an aircraft to create and evaluate new Trial Plans for designated aircraft on a periodic basis. When the plan is problem free the controller with active control of the aircraft will be notified thus being relieved of the burden of keeping track of and manually reassessing the plan. For a given aircraft, each new Trial Plan generated by Automated Replan is modeled based on (1) the aircraft's Current Plan and (2) amendments to the Current Plan specified in a Trial Plan named by a controller in an Automated Replan request for that aircraft. The controller with active control for the aircraft, (not necessarily the controller that created it), receives continuous feedback on the status of the Automated Replan. Only one Automated Replan may be active at a given time for any one aircraft. The controller with active control of the aircraft is the only one that can delete it.

The system automatically checks the validity of the replan and terminates it if (1) the Current Plan is deleted, (2) the controller deletes it, (3) the replan is not viable, (4) the Trial Plan associated with it is the same as the Current Plan, (5) the flight exits the facility, or (6) the user submits the Trial Plan for auto-coordination or sends it to the HCS.

4.4.4 Automated Coordination (Build 2)

Automated Coordination provides controllers with a means of non-voice coordination, between sectors that will be involved in the control of a particular aircraft. It provides a capability for a controller to send a Trial Plan to another sector in order to coordinate proposed flight plan amendments across sector and center boundaries. The Trial Plan that is sent to another sector for coordination is known as the Coordination Plan. Coordination Plans are valid until they are deleted or they time-out. To insure that coordination remains simple, only one coordination plan is permitted for an aircraft. The Coordination Plan is modeled and probed for problems at the time of creation. The receiving sector may reject the plan if one already exists for the aircraft or when Automated Coordination is disabled for the receiving sector. Automated Coordination also provides a capability to coordinate a Current Plan by sending the plan with reason text to another sector.

Trial Plan Coordination

Coordination may be initiated between any two sectors.

The receiving position may respond to the request with Approved/Wilco, Unable, or Send Amendment to send a flight plan amendment to the HCS. If no response to a request is provided, then the request times-out and a time-out message is forwarded to the initiating sector.

A Coordination Plan is updated when the trajectory for the Current Plan for that aircraft changes, a previous conflict for the aircraft is no longer valid, or a new conflict situation for the aircraft is predicted.

A Coordination Plan is deleted when the initiating controller requests it, when the system deletes the corresponding flight plan (i.e., receives a deletion message from the HCS), when the receiving position sends an amendment based on the Coordination Plan to the HCS, when the aircraft hands off to a sector other than the auto-coordination initiator/receiver, or when it expires.

Current Plan Coordination

For Current Plan Coordination, the initiating controller can optionally select one or more reasons for display to the receiving sector. The response to a Current Plan coordination can be Approve and Unable.

4.4.5 Hold Processing (Build 2)

The Hold capability includes functionality to apply, by manual action, a Planned Holding Area (PHA) to a Current Plan for a flight being put in a Hold. The PHA is a rectangular box with upper and lower altitude bounds against which Current Plan and Trial Plan trajectories for other flights are probed. The PHA can be thought of as an airspace, however, alerts are treated as an aircraft-aircraft alert. The trajectory for a flight with a PHA is also probed, but only up to the PHA. The PHA can be cancelled by manual entry or automatically. Reconformance will not occur while the flight is in the PHA. A PHA of one flight is not checked against the PHA of another flight. The altitude bounds of the PHA are adjusted as the aircraft's altitude changes.

Hold messages from the Host will not be processed in Build 2.

PHAs are adaptable to cover both published and unpublished holds. Only one size rectangle will be adaptable.

4.4.6 ATC Preferred Route Processing (Build 2)

Build 1 includes a capability to indicate when a flight is eligible for an ATC Preferred Route based only on destination airport. Build 2 adds functionality to determine when a flight is eligible for an ATC Preferred Route based on adapted ATC Preferred Routes and eligibility criteria. It also provides a capability to create a Trial Plan to insert the preferred route.

The preferred routes, with eligibility criteria, will be stored in adaptation.

4.5 Computer Human Interface

The effectiveness of Conflict Probe automation is dependent on an effective Computer Human Interface (CHI). The Conflict Probe CHI improves controller performance by presenting information in a readily usable format and permitting the efficient input and request of information through a graphical user interface.

The DSR D-Controller Console provides controllers with the capability to operate as they do today, using a logical display containing the equivalent of a D-Controller Computer Readout Device (D-CRD) and flight strips. Using this interface, the D-Controller will be able to receive and respond to messages from the HCS and will be able to review, maintain, and mark flight strips, as is done in today's system.

The D-CRD is augmented with Conflict Probe specific display windows and input areas on the DSR D-Controller Console display. The display consists of various windows that permits the D-Controller to operate a non-Conflict Probe sector, or to interact with and use Conflict Probe capabilities.

Display windows have standard manipulation features such as scrolling, sizing, moving windows and displayable objects, suppression of data and windows, and restoration of windows and data. The basic display windows on the D-Controller's monitor include:

- Message/Response Display
- Aircraft List
- Plans Display
- Graphic Plan Display
- Departure List
- Wind Grid Display

The following displays will have options available to display another window that may not be visible: Aircraft List, Departure List, Graphic Plan Display, Plans Display and Wind Grid Display.

The Aircraft List, Plans Display and Graphic Plan Display will have an indicator for an initiated or received coordination request. The indicator will be visible when there is at least one initiated or received coordination request and will display the number of Coordination Plans active for the sector. The indicator may be used to bring a hidden initiated or received coordination request into the viewing area.

To facilitate efficient interaction with the system, the D-Controller input includes an alphanumeric keyboard, an object oriented, and menu based message entry capability utilizing a trackball or similar device.

The D-Controller will be able to select sector specific parameters at the console. For example, menu set-ups, list ordering, alert priorities, and system overrides (e.g., for Airspace activation status, altitude restrictions).

The D-Controller will be able to enter NAS messages and receive display feedback through a Message/Response Display. The Message/Response Display includes a mechanism for notifying the controller when new information is displayed (e.g., color-coding) whether the window is active or inactive.

4.5.1 Aircraft List

The Aircraft List is the primary display for flight plan related data and alert status of aircraft. It also provides an interface for initiating planning activities. The display consists of aircraft identifiers and flight data for each aircraft under control of the sector and will be updated as new flight information is received. After a time-out period, the entry for a flight is removed from the display when an outbound handoff track message is received. Special coding is used to indicate new entries posted to the list, problems outside the sector, aircraft not being probed and aircraft with inadequate track data, initiation or receipt of a coordination request, overdue aircraft, ATC preferred route notification, route action notification, wrong altitude for direction and if any remarks are appended to route information.

The controller will have several tools available to perform bookkeeping tasks and to help manage information on the list, such as, manually post new entries, mark an entry for controller action, type notes in a free text area, bookkeeping box and area to record speed and heading information.

The controller will be able to add and delete aircraft, sort the list, search for aircraft on the list, convert the speed of aircraft (to/from true airspeed, indicated airspeed, or Mach speed), keep aircraft coded for removal, and designate a Current Plan to be added to the Plans Display. The controller also will be able to use the display to initiate Trial Planning, display flight plan data and previous route data, request the graphic display of a conflict on the Graphic Plan Display (GPD), enable/disable altitude restrictions, and initiate a Planned Holding Area. Figure 4-22 shows a sample of an Aircraft List. (The sample display shown illustrates the type of information that might appear on the Aircraft List. The actual display organization may be different than shown in this and subsequent examples.)

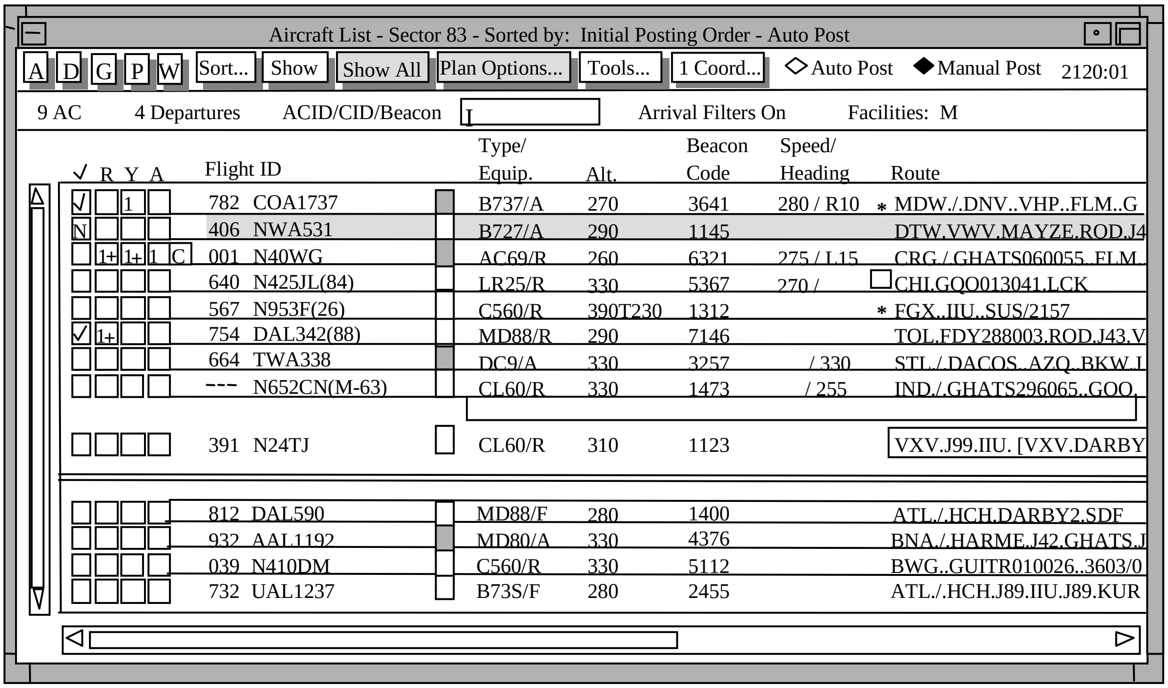


Figure 4-22. Aircraft List

The left-hand columns indicate various status information and the remaining columns show the flight data for each aircraft. Menu bar buttons at the top of display and the buttons located between the Flight identification (ID) column and the Type/Equip. column, permit the controller to initiate the various actions described above.

4.5.2 Plans Display

The Plans Display displays Trial Plans and detailed Current Plan conflict information. Trial Plans are displayed when they are created. Detailed Current Plan conflict information is displayed upon controller request (selected from the Aircraft List or Graphic Plan Display). The display includes coding to indicate Current Plans, Trial Plans, Trial Plan replans, amendment plans and initiated or received Coordination Plans.

The controller will have tools available to manage information on the list, such as being able to delete individual plans or to remove all applicable plans with one command.

The Plans Display is displayed when a Trial Plan is created or the controller requests the display of a Current Plan. If no entries remain on the Plans Display, the Plans Display will automatically be removed.

The controller will be able to use the display to initiate Trial Planning, display flight plan data and previous route data, initiate a Planned Holding Area and request the graphic display of a conflict on the Graphic Plan Display (GPD). When a Trial Plan is to be issued as a clearance, the controller will be able to enter it as an amendment to the collocated HCS from the same display/window.

Figure 4-23 shows a sample Plans Display.

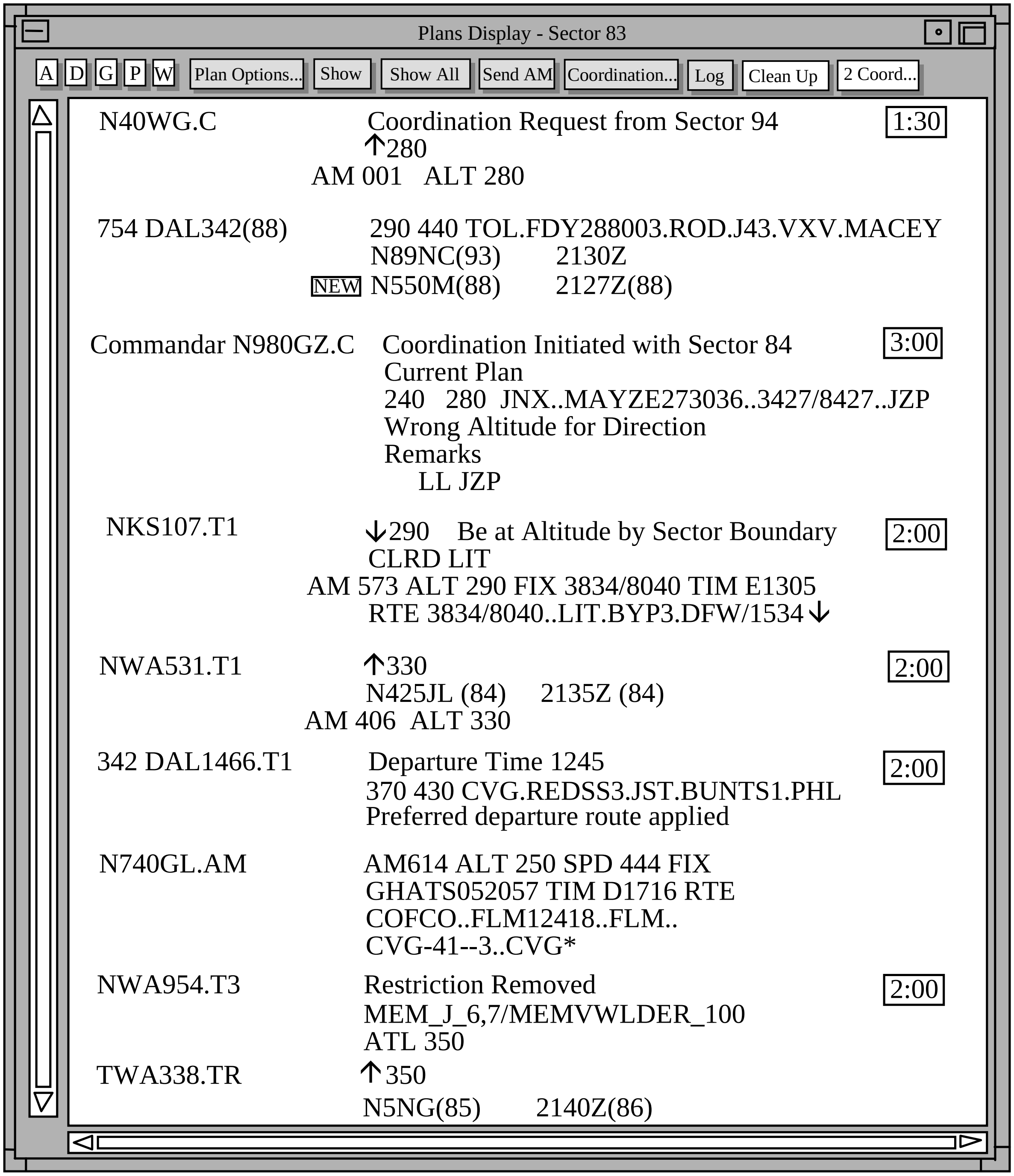


Figure 4-23. Plans Display

4.5.3 Graphic Plans Display

The Graphic Plan Display (GPD) enables the controller to see a graphic representation of aircraft trajectories and predicted Trial Plan and Current Plan problems. The display will be available at controller request. The GPD is a situation-type display that shows geographic data (sector boundaries, fixes, airports, airspace boundaries) and data blocks representing aircraft trajectory positions.

The controller will be able to display or remove the display of airways, sector boundaries, center boundaries, APD boundaries, Approach Control boundaries, special use airspace boundaries, scale indicator, airports, and labels on the map. In addition, the controller will be able to change the altitude filter range and turn the filter on and off, turn on/off an Aircraft List filter, data block offset, maneuver start points/end points and route preview indicators. The controller will be able to change the scale and center of the map, suppress all or individual data blocks not selected and not involved in specific route displays, reposition data blocks, remove all displayed routes, and exit the Graphic Plan Display. The controller will be able to designate a Current Plan to be added to the Plans Display.

The controller will be able to display Trial Plan and Current Plan route trajectories on the GPD and will be able to dynamically move time forward and backward to see the predicted future positions of aircraft.

The controller will be able to use the display to initiate Trial Planning, display flight plan data and previous route data, and initiate a Planned Holding Area.

The GPD displays all conflicts in an aircraft's route. This information could impact the controller's decision about which aircraft to move, or how to manipulate a trajectory (e.g., vector or climb. When a Trial Plan is to be issued as a clearance, the controller will be able to enter it as an amendment to the collocated HCS from the same display/window. The controller will also have the capability to "draw" a reroute on the GPD for an aircraft and have a Trial Plan of the reroute created. The controller will be able to see the impact of potential solutions in terms of creating other conflicts.

Figure 4-24 shows a predicted conflict on the GPD display.

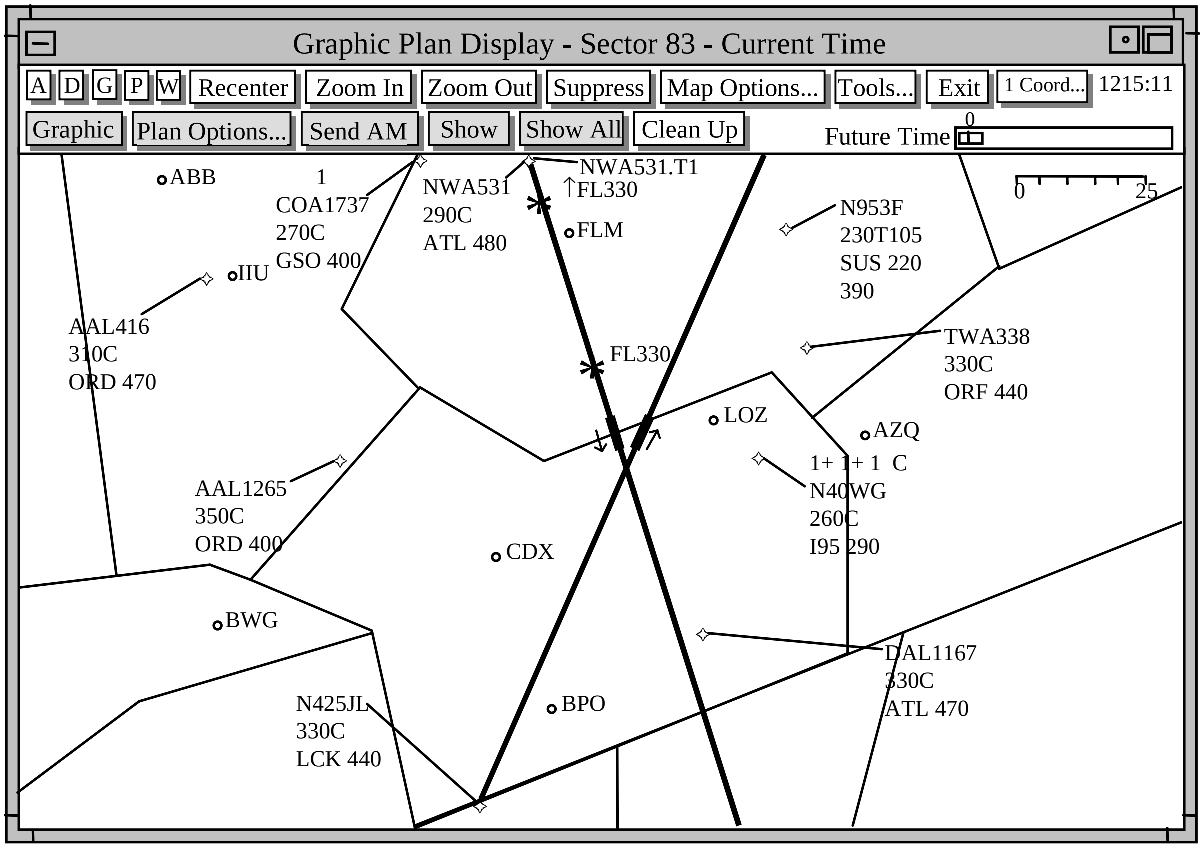


Figure 4-24. Graphic Plan Display

4.5.4 Departure List

The Departure List displays flight plan data for departure plans. It also provides an interface for initiating planning activities. The display consists of proposed departure time, aircraft identifiers and proposed flight data for each aircraft. After a time-out period, the entry for a flight is removed from the display when a Departure Message is received. Special coding is used to indicate a new entry on the list, ATC preferred route notification, route action notification, and if any remarks are appended to the route information.

The controller will have several tools available to perform bookkeeping tasks and to help manage information on the list, such as, mark an entry for controller action, type notes in a free text area, and bookkeeping box.

The controller will be able to add and delete aircraft, sort the list, search for aircraft on the list, and keep aircraft coded for removal. The controller will also be able to use the display to create a Trial Plan based on departure time and request the graphic display of a Trial Plan on the Graphic Plan Display. Figure 4-25 shows a sample of the Departure List.

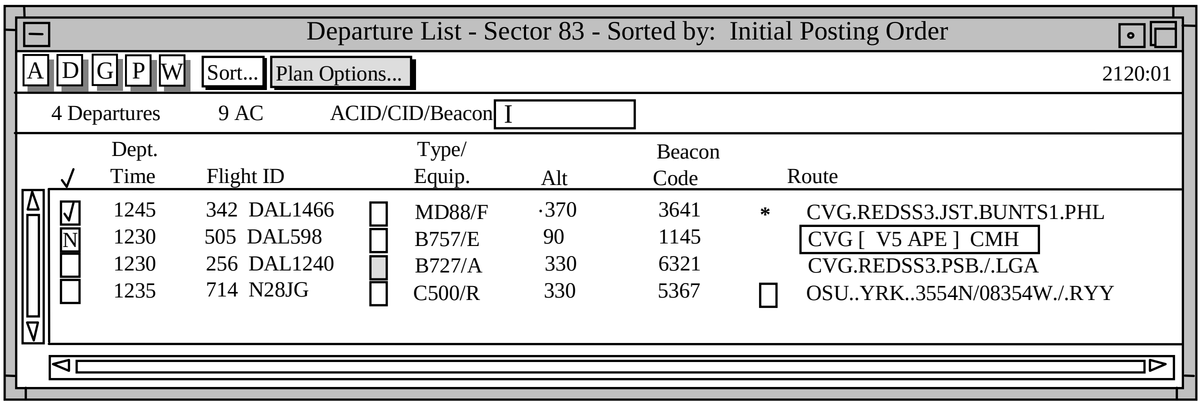


Figure 4-25. Departure List

4.5.5 Wind Grid Display

The Wind Grid Display displays the latest processed wind data overlaid on a map of the center sectors. The Wind Grid contains lateral sector boundaries, fixes, wind data represented by arrows of varying length to indicate direction and a numerical value in knots displayed with each arrow.

The Wind Grid also contains a linear scale and date and time National Weather Service data was loaded.

The display will only be displayed on request. If the Wind Grid is displayed when new wind data is received, the display will update.

The controller may adjust the scale for the display, change the focal center of the display select an altitude to display wind data and request the display of temperature and pressure.

The Wind Grid Display remains displayed until removed by the controller.

Figure 4-26 is an illustration of the Wind Grid Display.

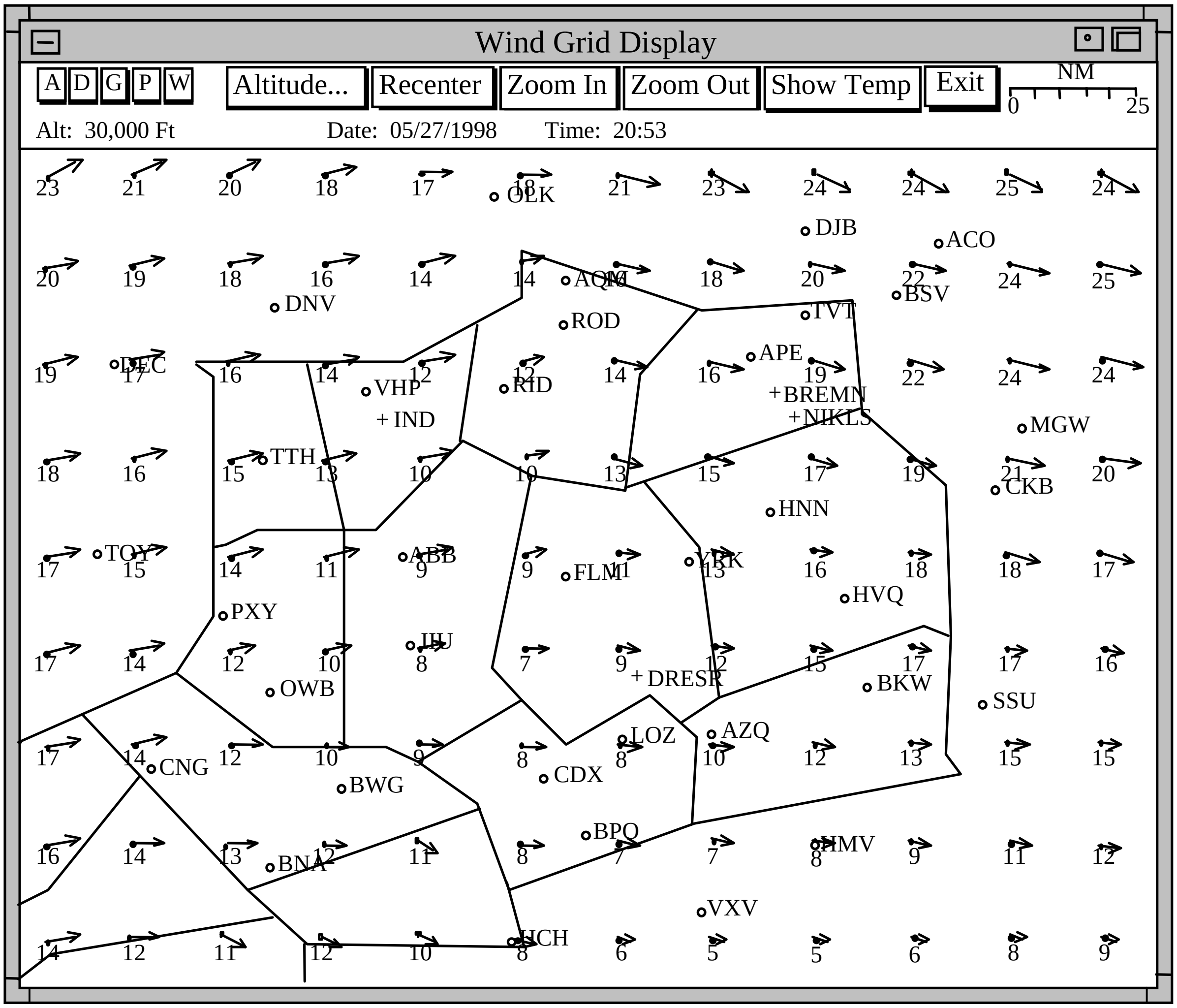


Figure 4-26. Wind Grid Display

4.5.6 Other Display Information

Conflict Probe also displays the HCS clock time and Conflict Probe Operational Status information.

The HCS clock time is displayed in Universal Coordinated Time (UCT).

The controller will be able to display the following Operational Status information (see also Section 4.10.1): status of neighboring facility Conflict Probe systems, Conflict Probe application active/inactive status for each sector, Automated Coordination active/inactive status for each sector, availability of wind and temperature data, active APDIAs, SUA activity and schedule, and active speed and altitude restrictions.

4.6 Host Computer System Data Processing

Conflict Probe receives flight data and track data from the collocated HCS and uses this data to generate trajectories and maintain its displays. It also receives other data from the HCS to keep the HCS and Conflict Probe in synchronization following ATC configuration changes and Conflict Probe startup/restart. Conflict Probe sends flight plan amendments generated from Trial Plans to the HCS.

The following messages are processed from the HCS: flight plans (active and proposed), supplemental flight plan data, flight plan amendments, interim altitude messages, aircraft identification amend messages, departure information, cancellation messages, hold messages (Build 1 only), track data (including track position, reported altitude, ground speed, controlling sector, receiving sector, HCS time), drop track messages, progress report, sector assignment status, adapted arrival/departure route status, interim altitude status, and hold status.)

4.7 Interfacility Processing

4.7.1 Facility Boundary Definition

There are 24 ARTCCs in the United States, (20 in the contiguous 48 states). Figure 4-27 shows the approximate geographic boundaries of the 20 centers. The volume of airspace over each center is called the facility airspace. Each facility airspace includes all airspace within the corresponding center boundary from the ground up in altitude.

Figure 4-27. ARTCC Facility Boundaries

To make Trajectory Modeling and Conflict Detection as accurate within a parameter distance outside of a facility's boundary as it is within the facility, each facility will require information from outside its boundaries. This distance is related to the conflict warning time and the distance most commercial aircraft fly at their nominal ground speed during that time. This interfacility area is called the Automated Problem Detection (APD) boundary. The facilities that overlap the APD boundary are referred to as neighboring facilities and may include facilities other than adjacent facilities. Conflict Probe, in each center, probes for conflicts within the APD boundary. Figure 4-28 shows the APD boundary for Indianapolis Center.

The planning region defines the basic geographic extent of the trajectory and Special Activity Airspace. The planning region is rectangular in shape; it is larger than and totally includes the APD Boundary (see Figure 4-28).

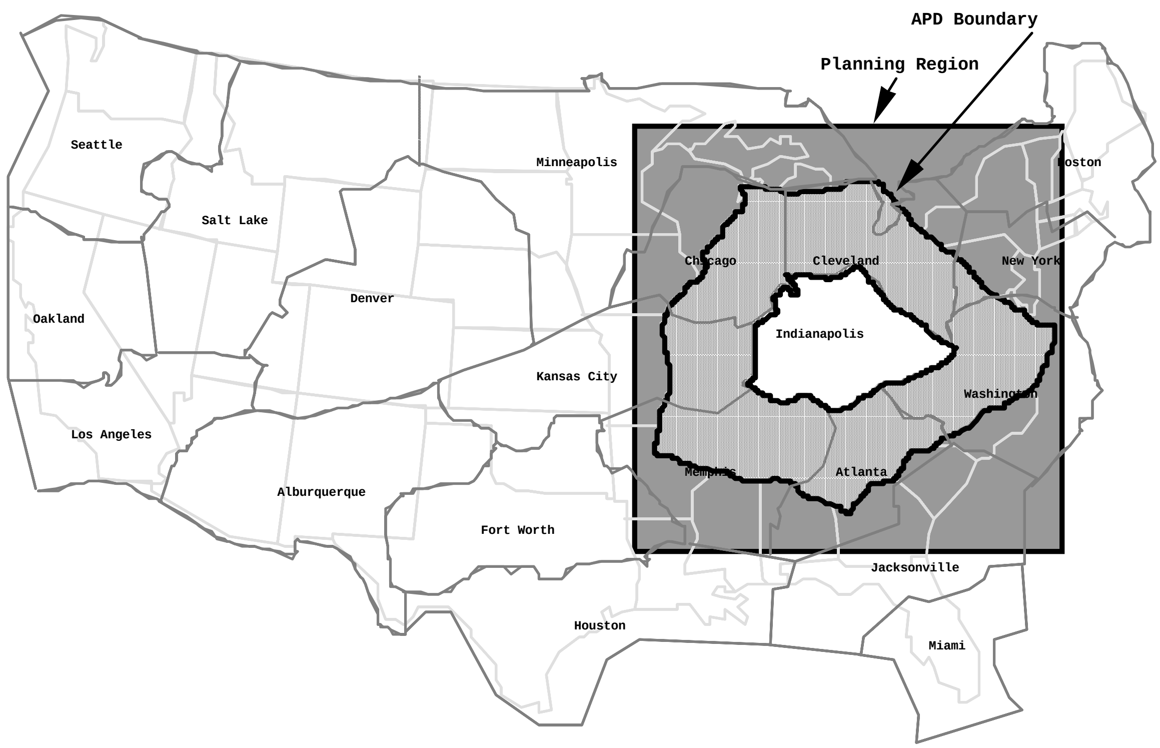


Figure 4-28. APD Boundary and Planning Region for Indianapolis Center

Each Conflict Probe in neighboring facilities exchanges flight data, position and reconformance data, preferential routes, and status information in order to model accurate trajectories for all flights within the APD boundary.

Conflict Probe adaptation data, which affects the creation of trajectories and determination of problems within the APD Boundary, is maintained at each facility. Where possible this data is based on nationally published sources and is consistent among all ARTCCs. Section 4.9 further discusses Conflict Probe adaptation.

4.7.2 Interfacility Exchange of Flight Data

Interfacility functionality permits the scope of Flight Plan information to be expanded beyond the current NAS environment. Controllers will see more accurate information for both inbound and outbound flights for a longer period of time. The range and accuracy of the strategic conflict probe extends across facility boundaries. To accomplish this, each Conflict Probe system is capable of communicating with neighboring Conflict Probe systems within that facility's APD boundary.

Each flight is owned by only one system at a time. This is the system whose collocated HCS controls the flight, if known. The system owning the flight is responsible for sending flight data, position and reconformance data, and flight status for the flight to all neighboring systems whose APD boundary contains the flight position.

For an example of how Conflict Probe handles the coordination of flight data across facility boundaries see Section 6.1.

4.8 Weather Data Processing

In order to maintain accurate trajectories, Conflict Probe uses winds and temperatures aloft data and barometric pressure data to adjust aircraft filed speeds, rate of ascent or descent, and other related information.

Conflict Probe obtains this data from WARP. It will receive five hours of the most recent Rapid Update Cycle (RUC) data. Each set of data is based on hourly updates made by the provider of the weather data and provided to the Conflict Probe system. This data is geographically filtered based on adaptation defined site boundary information and includes the wind vector components, temperature, and pressure.

If weather data is not received after some adaptable period of time, the system displays an indication that weather updates are not being received. When a weather update is not available for the current hour, forecast data for the current hour is used. If updated data is not available and the current hour is beyond the last forecast hour, then the latest forecast will be used.

4.9 Adaptation

Adaptation data refers to data used by Conflict Probe to customize the system to the unique operational environment of each en route facility and for fine tuning the performance of the supporting algorithms. Environmental data describes the operational environment of an ATC facility’s area of control. These data include facility airspace and FPAs, fixes, airways, preferred routes, airspace definitions unique to the Conflict Probe, and restriction data that reflect facility operating procedures. Algorithmic parameters that are common to all facilities include the definition of aircraft performance characteristics, prediction error distribution data for probability calculations, and system parameters that are common to all facilities, such as conformance criteria.

The adaptation process utilizes a combination of offline automated tools augmented by manual procedures for refining the adapted data.

4.9.1 Environmental Data

Environmental data adapted for each ARTCC includes:

- Airports
- FPA boundaries
- Fixes
- Routes (including airways, coded routes, SIDs, STARs, PARs, PDRs, and PDARs)
- Boundary restrictions
- APDIAs, Tactical Airspace (upper altitude), APD boundaries (discussed in Sections 4.3.2 and 4.7.1)
- Altitude and speed restrictions

Some of this data is nationally maintained and common across all facilities and some is facility-specific.

The primary nationally-maintained data sources are:

- Jeppesen library of worldwide navigational data
- National Oceanic and Atmospheric Administration (NOAA) Digital Aeronautical Chart Supplement (DACS) data files

Sources of facility-specific adaptation are:

- Host ACES (Adaptation Controlled Environment Subsystem)
- data derived from local procedures (Letters of Agreement (LOA), Standard Operating Procedures (SOP))

Jeppesen provides the primary source of data on airways, SIDs, STARs, fixes and Special Use Airspaces (SUAs) and published Holds.

The ACES provides a source for fix posting areas, aircraft type/class, Preferential Arrival Routes (PARs), Preferential Departure Routes (PDRs), Preferential Departure and Arrival Routes (PDARs), coded routes, transition lines, and nodes. ACES also provides data to supplement national sources of route, fix, airport data and Special Activity Airspaces.

DACS provides data on military training routes.

Airspace Definitions

The APD Boundary, and the Planning Region were discussed in Section 4.7.1. These boundaries are manually derived.

APDIAs and Tactical Airspaces were discussed in Sections 4.3.2. This data is derived from ACES terminal airspace.

Fixes and Airports

A fix is a geographic point that can be designated in one of three ways: by (1) its latitude and longitude, (2) its name and geographic location defined in the adaptation, or (3) as a fix radial distance (FRD) defined by a name, a radial from the fix and a distance from the fix.

Airports are defined in the same way as fixes. In addition, the airport definition also includes the elevation of the runway above mean sea level (MSL).

Adapted Routes

An adapted route consists of a series of fixes in geographical order; air traffic on an adapted route moves from one Navigational Aid (NAVAID) to the next. The NAS supports the following types of adapted routes, each with a different purpose.

An airway consists of a series of fixes. An airway can be filed by name as an element of the route field in a flight plan. A route element filed as an airway is subject to alteration in the vicinity of an airport by application of a preferential route.

A PAR is a specific arrival route from an appropriate en route transition point to an airport or terminal area. A Preferential Departure Route (PDR) is a specific departure route from an airport or terminal area to an en route transition point. A Preferential Departure and Arrival Route (PDAR) is a route between two terminals which are within or immediately adjacent to one ARTCC’s area.

A SID is a preplanned IFR ATC published procedure used by pilots in flight planning. SIDs provide transition from the terminal to the appropriate en route airspace. A STAR is a preplanned IFR ATC published procedure used by pilots in flight planning. STARs provide transition from the en route structure to an outer fix or an instrument approach fix/arrival waypoint in the terminal area.

A coded route consists of a series of fixes; it may contain an altitude, speed, or delay associated with each fix. Coded routes are not subject to modifications by the application of preferential routes. Generally, coded routes are used in association with military flights.

Figure 4-29 illustrates how an adapted route is defined. The PAR named “ASR21” is adapted in the Memphis center for turbojet aircraft with destination LIT (Little Rock). This route contains some fixes coded by name (i.e., JKS) and some coded as FRDs (i.e., LIT050050). There happen to be two transition fixes for this PAR. The route string is defined as:

JKS (transition fix)

MEM270013 (transition fix)

LIT050040 (FRD)

SR2

LIT050025 (FRD)

LIT

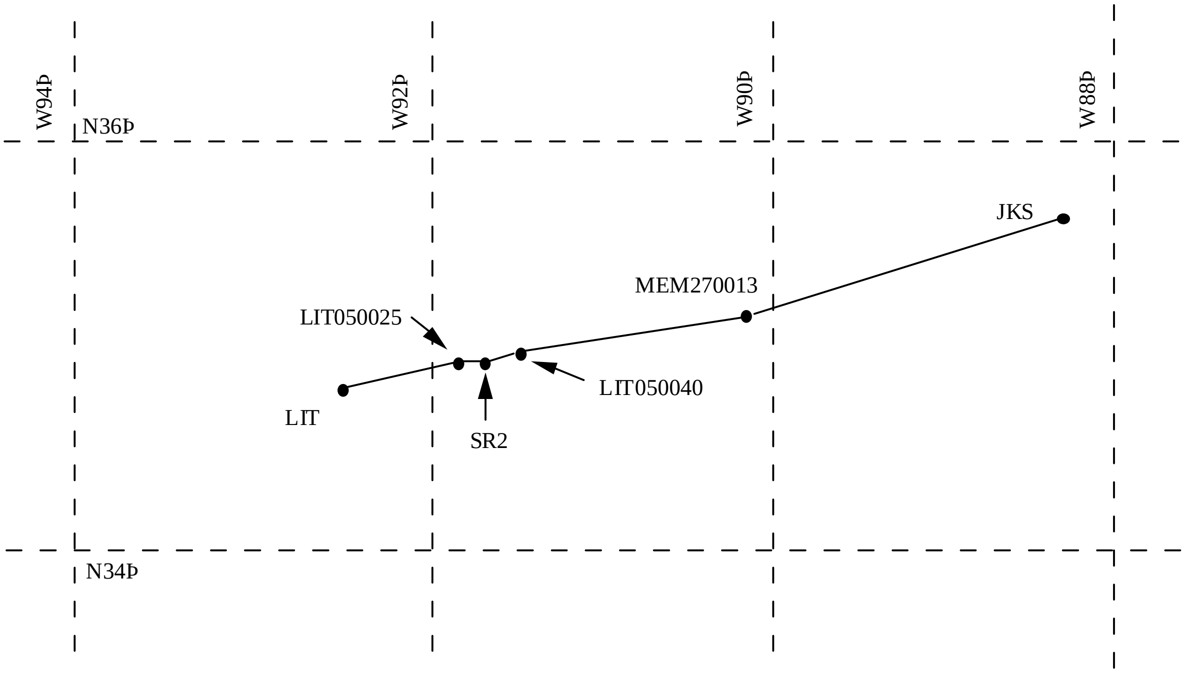


Figure 4-29. Preferential Arrival Route

Special Activity Airspaces

Special Activity Airspaces (SAAs) identify volumes of airspace where certain aircraft must be restricted from transitioning that airspace. SAAs may be defined for Alert Areas, Controlled Firing Areas, Military Operations Areas (MOAs), Prohibited Areas, Restricted Areas, or Warning Areas. SAAs may be available from national sources of published Special Use Airspaces (SUAs) or may be locally defined. SAA adaptation includes airspace designators, controlling agency, boundaries, altitude limits, separation distance, and activation schedule.

Altitude and Speed Restrictions

Altitude and speed restrictions are derived from facility Standard Operating Procedures and Letters of Agreement with other facilities. Restrictions are applied based upon departure and/or destination airport, altitude, aircraft class, flight path, and whether the restriction is currently active.

4.9.2 Algorithmic Data

Aircraft performance characteristics are used to model climb and descent profiles when modeling the trajectory. This data includes temperature and aircraft weight dependent climb profiles, weight dependent descent profiles, cruise speed envelope, maximum endurance speed, and acceleration and deceleration rates for different aircraft types. Initial values for this data are derived from aircraft manufacturer and aircraft operator documentation. Empirical data analysis of tracked aircraft also provides a method for refining this data to better reflect observed performance.

Conformance bounds and separation criteria are adapted as described in Section 4.3.1.4 and 4.3.2.

4.10 Supporting Capabilities

4.10.1 Status Information

In order to provide the controller and Area Manager with the flexibility to monitor the status and adjust the system to suit local operation both the controller and Area Manager are provided with displays of status information and the mechanism for updating various Conflict Probe specific parameters. Status information displayed to the controller and Area Manager include neighboring facility Conflict Probe status, weather data, activation status, Automated Coordination activation status, active APDIAs, SUA status and schedules, and active speed and altitude restrictions. The Area Manager and the controller at the sector, (if the center has adapted the sector for this operation), will be able to modify the following: enable/disable capability for Automated Coordination, APDIA active/inactive status, and speed/altitude restriction active/inactive status.

4.10.2 Monitor and Control

Conflict Probe Monitor and Control functions are integrated with the DSR Monitor and Control capabilities and include an integrated CHI interface for viewing system status and entering commands for be use by Airway Facilities personnel in maintaining systems operations.

Capabilities that are part of Monitor and Control support functions include:

- Startup capabilities—allowing for system initialization of Conflict Probe applications, interfaces and processors.
- Restart capabilities—allowing for the restart of Conflict Probe applications, interfaces and/or individual Conflict Probe processors including DSR D-Console interfaces for Conflict Probe.
- Shutdown capabilities—allowing for the shutdown of individual Conflict Probe processors or individual sector Conflict Probe interfaces.

- Reconfiguration of hardware, software, and interfaces.
- Monitoring the interface between neighboring Conflict Probe facilities, reporting status, and enabling and disabling interfaces.
- Terminate/activate Conflict Probe functionality/processing entirely, or at a D-position, or multiple D-positions.
- Software loading to control the loading of new software releases.
- The cutover of new software releases in system processors, including fallback to prior releases, if necessary.
- SAR recording—providing the capability to perform system analysis recording functions, including initiating and stopping recording, and controlling what data is recorded. System events that will be recorded include: initialization/startup, restarts due to failures or commanded action, database reconstitution, loss of processor to processor communications, processor termination activities, performance data, and system resource utilization.
- Startup/Restart—providing the capability to re-establish communications and reconstitute its databases as necessary following startup/startover of the network or its components, the HCS, or a neighboring facility.

Section 5

Conflict Probe Concept of Operations

The deployment of Conflict Probe capabilities at the sector will not change the fundamental responsibilities of the sector team. However, the automation tools provided will likely change the methods and processes by which the team carries out the tasks of conflict detection, resolution, and planning. Conflict detection capabilities, Trial Planning tools, and the graphic display of trajectories will provide the team with more accurate and timely information than is available in today's system. The new automation capabilities will complement their skills and will permit the sector team to shift task emphasis away from mental calculations required to ensure separation of aircraft. The sector team will be able to concentrate on more user-beneficial control actions that require their judgment and expertise to ensure separation. Use of these tools will also help smooth the sector team workload. The added coordination of problems and flight information between sectors and center facilities will further aid the separation process. The Radar Associate (D-Controller) will be a more active participant in early problem detection and resolution. Therefore, the D-Controller will be able to take or recommend actions before they reach the sector boundary, and therefore offload much of the separation task from the Radar Controller (R-Controller). This will allow them to support a greater number of user preferred trajectories with more flexibility, thus providing enhanced benefits to the aviation community.

These capabilities are intended to augment, not replace, existing operational capabilities, procedures, and practices that ensure safety critical service. They are not intended to be used to maintain system safety nor to ensure aircraft separation. This responsibility continues to remain that of the sector team.

The characteristic roles and responsibilities of the other participants in the system will also not change. The pilot in command of the aircraft will remain responsible for the safe operation of the aircraft. The responsibilities and tasks of traffic managers, military operators, and airline operators will be largely unaffected, as will the methods of communication and coordination between these participants.

5.1 Overview of Current ATC Operations

In today's ATC system the task of maintaining aircraft-aircraft and aircraft-airspace separation is performed by both R- Controller and D-Controller at the sector. The R-Controller monitors the Plan View Display (PVD) and relies on the data displayed as well as knowledge of traffic patterns, aircraft performance, airspace organization, and environmental factors, to detect problems. The R-Controller is primarily responsible for tactical resolution of problem situations. Because of the limitations of the information provided and the mental workload required to perform the monitoring and calculation tasks, the problem detection lookahead horizon for the R-Controller is usually within the confines of the sector controlled by that position.

The D-Controller is the member of the team that is responsible for strategic identification and resolution of separation problems. The D-Controller coordinates control instructions to other sectors to ensure separation prior to an aircraft entering the sector. In addition, the D-Controller supports the actions of the R-Controller and provides assistance when necessary to balance sector traffic capacity.

Under normal workload conditions, the D-Controller performs flight data analysis using the paper flight strips to compare aircraft flight paths and to detect potential conflicts that will occur in the sector among aircraft that may not yet be in the sector. The D-Controller identifies these potential situations and generally marks the flight strip in some manner to indicate the potential conflict. The D-Controller may also verbally inform the R-Controller of the possible conflict situation. In many cases, depending on the certainty of the conflict situation, the R-Controller may wait until the aircraft are closer to the sector before taking resolution action. A third controller may even be added to the sector team to assist in the critical task of tactical problem resolution.

When the workload of the sector increases, the R- and D-Controllers must divide their attention among growing numbers of possible conflict situations. Often, both controllers will monitor the PVD looking for problems among aircraft within the sector and the D-Controller will discontinue the task of strategic problem detection.

To prevent sector teams from becoming saturated with increasingly busier tactical situations, a number of restrictions and flow-instructions designed to separate potentially conflicting streams of aircraft are implemented. These constraints include standard departure and arrival routes and altitude restrictions for aircraft bound for certain destinations. The controller must issue instructions to aircraft to ensure compliance with these constraints. While these constraints are designed to assist the controller, they may in some cases increase controller workload because they are applied to all aircraft even when no separation problems exist. These constraints often prevent aircraft from flying on preferred routes and at preferred altitudes.

When problems between aircraft are detected in today’s system, the R-Controller takes action to resolve them. These actions are often tactical maneuvers such as clearances for aircraft to vector off course to avoid each other before returning to route. Depending on the conflict geometry and time of detection, the resolution maneuvers vary in terms of the disruption to the preferred routing or altitude of the flight. The controller may not always have the time or freedom in the traffic situation to accommodate user preferences when solving problems.

5.2 Role of the Controller Using Conflict Probe

With the addition of baseline Conflict Probe capabilities the role of the sector team will be largely unchanged. Controllers will still be responsible for providing separation services to controlled aircraft. The R-Controller will continue to monitor for tactical problems between aircraft in the sector and between aircraft and protected airspaces using the DSR Situation Display, (which will replace the PVD). The D-Controller will continue to strategically plan for conflicts that may occur in the future. However, instead of having only flight strips available as a means of predicting conflicts, the D-Controller will also have information available from the automation. The automation will perform the necessary calculations, will analyze traffic situations, and will display operationally significant information at the D-Controller console. This is information the D-Controller previously had to extrapolate mentally from the flight strips.

During operations when the sector is staffed by only the R-Controller, all the capabilities of Conflict Probe will still be available. The R-Controller, in addition to providing separation services to the controlled aircraft and monitoring the tactical situation, will be able to use Conflict Probe for strategic planning. The R-Controller will be able to use the Conflict Probe capabilities at the D-Controller console and will be able to perform the same services as the D-Controller, detecting and resolving conflicts, evaluating and responding to amendment requests, and coordinating with other sectors.

5.2.1 Detection of Conflicts

In today's system potential aircraft problems are determined by the sector team with the R-Controller concentrating on tactical situations, reviewing current traffic situations, while the D-Controller strategically analyzes flight strips and reviews current traffic patterns. With the addition of Conflict Probe capabilities, the system will provide strategic support by alerting the D-Controller of potential problems. The D-Controller will be able to analyze the situation by reviewing the Aircraft List (Section 4.5.1) and the Graphic Plan Display (Section 4.5.3) instead of or in addition to flight strips. The display of conflicts is coded to indicate the severity of loss of separation (greater or less than required procedural separation; see Section 4.3.6) and to aid the controller in prioritizing the handling of the resolution. The D-Controller will be able to use the GPD to see the routes of the involved aircraft, the geometry of the detected conflict, and the predicted loss of separation. Using these tools, as well as flight strip information, display information from the R-Controller display, and pilot communications, the D-Controller may decide to take action, notify the R-Controller, or continue to monitor the situation.

The D-Controller will coordinate movement of aircraft outside the sector with the controlling sector and will coordinate the movement of aircraft within the sector with the R-Controller. For very large sectors it is quite feasible that the D-Controller could strategically solve conflicts between aircraft already in the sector, because those aircraft will still be in the sector 20 minutes in the future. However, for small sectors, conflicts between aircraft within the sector would be solved by the R-Controller.

5.2.2 Resolution of Conflicts

With the aid of the automation, the D-Controller will be able to take a more active role in conflict resolution development. When a conflict situation is observed on the Aircraft List, the D-Controller will be able to create a Trial Plan, which can be reviewed on the Plans Display (Section 4.5.2). The Plans Display will present either a problem-free Trial Plan or a Trial Plan alert. When a Trial Plan has a potential problem, graphic representation of the Trial Plan trajectory and the trajectory(s) of the problem aircraft can be displayed on the GPD. The controller will be able to see the impact of potential solutions in terms of creating other conflicts. The controller may decide to wait and see how the situation progresses. The D-Controller would either communicate the developed strategic resolution to the sector working the aircraft either locally or in a neighboring facility (using Automated Coordination - Section 4.4.4), or communicate the solution to the R-Controller for implementation (tactical resolution). The D-Controller may also use Automated Replan to have the automation check a Trial Plan that currently shows problems until it is problem free. The automation would then be used to notify the controlling sector that the plan is available for resolution to a problem. The course of action will depend on sector workload and whether a reasonable strategic solution exists. Figure 5-1 provides an overview of the decision process.

5.2.3 Amendment Requests and Evaluating Proposed Amendments

Trial Planning may also be used to (1) check a pilot's request, (2) to check another controller's request (either from the R-Controller or a controller in an upstream sector), or (3) to evaluate a proposed amendment based on the controller's wish to adjust traffic in the sector.

Requests from an upstream controller may be due to a pilot's request or to coordinate the resolution of a conflict and may be received by the D-Controller verbally or non-verbally via an Automated Coordination request.

If the request was issued using Automated Coordination, the D-Controller , receiving the request, will be able to review the results of the proposed Coordination Plan and respond accordingly. If the sector receiving the request controls the aircraft, a clearance can be issued if the plan is acceptable, or reject the request. A notification of the disposition will be sent to the requesting sector using Automated Coordination. If the receiving sector does not control the aircraft, the D-Controller can use Automated Coordination to send a message to the requesting sector either accepting or rejecting the request. The sector controlling the aircraft would then issue the clearance with the new coordinated plan.

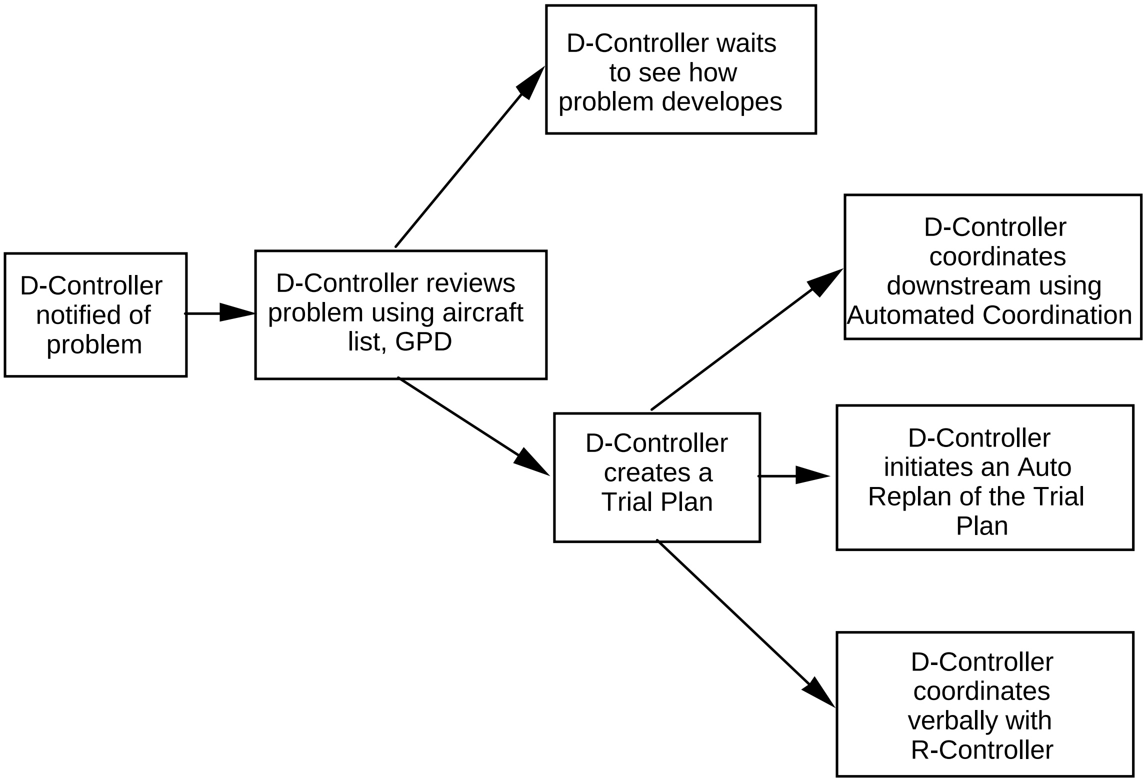


Figure 5-1. Overview of Resolution Decision Process

In response to a request issued verbally, the D-Controller will be able to create a Trial Plan by specifying the aircraft, a trial altitude, a trial speed or a route change using the Aircraft List. If the aircraft is not in the controller's Aircraft List, the aircraft can be added by entering the aircraft's ID.

The results of Trial Planning, including any problem information (Trial Plan alert), are displayed on the Plans Display. When a Trial Plan has a problem, a graphic representation of the Trial Plan trajectory and the trajectory(s) of the problem aircraft can be displayed on the GPD. The GPD will assist controllers in evaluating conflict geometry, eliminating the need to mentally project the positions and miss distance of the conflict pair. If the controller determines that a request should not be granted, the controller will be able to modify an existing trial plan, create a new one, or deny the request.

The D-Controller will be able to create a Trial Plan for any clearance that is being considered due to a pilot request. Using Trial Planning, the controller will be able to see the strategic effects of planned amendments and will be able to use this data in determining whether or not to issue clearances. The controller will be able to determine whether granting a request that may be problem free in the immediate future will result in downstream maneuvers for the pilot. This information can be used in several ways. A pilot request that has a problem or problems can be denied. When denying a request, the controller can advise the pilot about the problems detected and the need for maneuvering later to avoid them. The problem information and Trial Planning can also be used to develop a plan that avoids problems and accommodates the pilot's request. Figure 5-2 provides an overview of the process of responding to a request for an amendment.

Automated Replan (Section 4.4.3) may be used, by the D-Controller, when the need to issue a clearance is not immediate or a request cannot be accommodated. The automation continually processes a Trial Plan submitted by the controller. The D-Controller is notified when the plan is problem free, therefore being relieved of the burden of having to keep track of the plan and manually reassessing it. Since the future problem status of the amendment will be known, when the controller issues a problem free Trial Plan as a clearance, there may be no need to coordinate with other sectors. (In today's system coordination might be required).

The automation will have the most current and accurate information available on aircraft that are visible to the sector teams on their displays and on aircraft whose information is not yet available to the sector teams. It is, therefore, anticipated that the use of Trial Planning will become an integral part of the clearance delivery process.

Although the Trial Planning capability is not available directly to the R-Controller, the R-Controller will be able take advantage of this capability by coordinating a proposed amendment with the D-Controller. The D-Controller will the be able to evaluate the proposal using Trial Planning, (assuming sufficient time is available to evaluate a tactical situation) and will then be able to communicate the proposal to the R-Controller who will decide whether or not to issue a clearance.

5.2.4 Communication with Pilots

The R-Controller will remain primarily responsible for issuing clearances to pilots. However, at the discretion of the sector team, the D-Controller may also issue clearances especially in the case where the D-Controller has an acceptable Trial Plan available to resolve a detected problem. When a clearance is issued to a pilot, the D-Controller will enter that Plan as a flight plan amendment to the HCS. This will ensure that current and consistent information is maintained in both the HCS and Conflict Probe System.

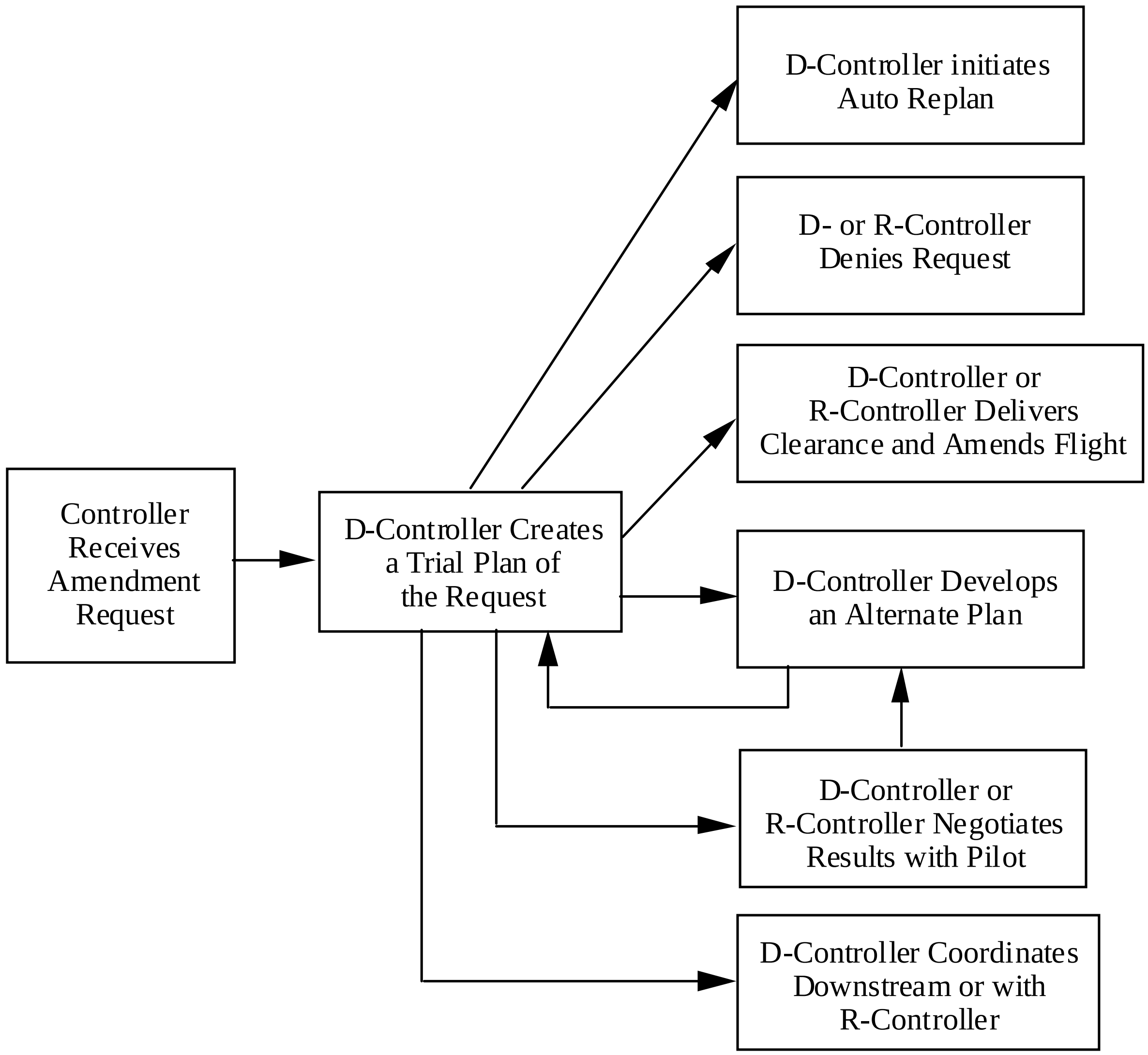


Figure 5-2. Overview of Amendment Request Process

It is not anticipated that data link will be initially available for communications between the pilot and the controller at the time of deployment of Conflict Probe capabilities. Conflict Probe, therefore, does not provide for the use of data link or depend on its use.

Future enhancements to Conflict Probe capabilities will take advantage of data link as the primary communication mechanism between the air and ground. The pilot may downlink specific requests and trajectory changes or the pilot may negotiate changes via data link.

5.2.5 Intrafacility/Interfacility Coordination

In many cases, problems may be detected between aircraft not under control of the sector where the problem is displayed. In these cases, the D-Controller may develop a solution to the problem and coordinate a strategic solution with the controlling sector using Automated Coordination. Included in this coordination will be communication of the problem status of the coordinated plan, the clearance language for the maneuver, and the text to send to the Host for the maneuver. Using this information, the controller receiving the request can see the plan and associated problems, if any, and can accept the plan as an amendment without having to recreate it. When the controlling sector receives a coordination request, the request should be given high priority with respect to other sector activities, since it can be assumed most of these requests are for problem resolution.

It is also possible for a sector that does not currently control the aircraft to enter a flight plan amendment. When aircraft coming into a sector from two different sectors would have a boundary conflict, it is typically too late to wait for the hand-off to resolve the conflict. Strategic planning by the D-Controller and coordination with one of the controlling sectors would move the aircraft's route prior to entry in the sector. Similarly, two aircraft under the control of one sector may be in conflict in the next sector. The D-Controller may coordinate with the next sector D-Controller to determine that controller's preference on how to alleviate the conflict.

The effect of taking action to resolve potential conflicts before aircraft reach the sector is expected to have the effect of smoothing workload at the sector. The D-Controller will have the capability to analyze and resolve situations before they become time critical and require action by the R-Controller. In many cases, this will prevent the sudden build-up of tactical alert situations that sometimes occurs in sectors today.

When coordination between sectors is required, Automated Coordination will facilitate a non-verbal exchange of information. One sector can use Automated Coordination to send plan information to other sectors and can receive notification about the disposition of information sent. Automated Coordination will support the controller in making control decisions that would impose unnecessary workload if verbal communication were required. For example, it could facilitate the imposition of altitude restrictions on a case by case basis instead of imposing the restriction for all aircraft in a given block of time.

5.2.6 Flight Data Management and Use of Flight Strips

Much of the information that the D-Controller uses today is derived from mental calculations associated with performing a traffic search on each flight strip, and mentally processing the information. The D-Controller may use Conflict Probe displays instead of or in conjunction with flight strips in support of strategic planning. The Aircraft List and the Graphic Plan Display will provide the information that is available on the flight strips. The

GPD may be used to view a graphic representation of the routes of the involved aircraft, the geometry of the detected conflict, and the predicted loss of separation.

With Conflict Probe available, it is anticipated that the need for flight strips will be reduced and the D-Controller will be able to spend time more accurately evaluating strategic situations. For example, in today's system the D-Controller may use the flight strips or radar display to calculate fixed radial distances, determine wrong altitude for direction traffic, project where aircraft may cross, and correlate time. With Conflict Probe available, these mental calculations are unnecessary, since the controller can easily see if there will be a conflict, based on the same information, using the supporting displayed information. Conflict Probe provides information on potential conflicts and predictions of future position of aircraft that the controller previously extrapolated from flight strips.

Conflict Probe also provides support tools for flight data management. The controller will be able to put a checkmark in front of the flight plan to indicate that something has been accomplished with that plan. The controller will be able to enter a speed and a heading for each aircraft to document information that cannot be sent to the Host. The controller will also have a text area in which to type instructions or notes for each aircraft. Each entry is annotated when added to the Aircraft List to indicate that it is new to the list. The controller will be able to select how new entries are added to the list: either sorted into the list according to the sort order (automatically) or segregated at the bottom so that they can be manually added to the main list by the controller.

5.2.7 Evaluating Accuracy and Suitability of Conflict Probe Data

While Conflict Probe is a valuable tool for strategic planning, the sector team will still be responsible for decision making associated with separating aircraft. For this reason, the D-Controller will need to continually evaluate the results of any Conflict Probe output against other system information. When evaluating these results, the controller must consider its accuracy with respect to information available on the R-Controller display, the flight strips, pilot information, sudden change in weather conditions, and their own knowledge of the environment.

Characteristics of sector airspace and sector procedures will influence, among other things, user requests and controller actions in response to those requests. These characteristics include relationships between controlled airspaces including adjacent sector or center airspace boundaries, traffic flow patterns across these boundaries, the existing agreements between controlled airspace sectors on handling traffic, the proximity of prohibited airspaces, existing route restrictions, and the relative proximity of major airports and/or air routes. Sectors may have unique requirements and standard procedures to be followed based on these characteristics, which must be considered by the controller when using the automation.

One limitation on the validity of the trajectory and conflict probe results is the data used to create the Current Plan, i.e., the Current Plan result can only be as good as the data that was used to create it. Conflict detection is based on aircraft trajectories. If the aircraft flight plan is not kept up to date to reflect the aircraft's clearance, then the accuracy of the trajectory as a model of the aircraft's path through space will begin to erode.

The controller must also consider that in the baseline Conflict Probe there will be no automation interface with traffic management tools used for metering and spacing, nor will there be the capability for the dynamic definition of restrictions which are used by the trajectory modeler. As stated earlier, the trajectory integrates adapted preferred routes and restrictions based on LOAs and SOPs. Individual restrictions can be dynamically turned on and off by the D-Controller or Area Manager independent of their scheduled times so that the accuracy of the modeler is maintained. The accuracy of Conflict Probe results are dependent on this information

The controller must also consider accuracy of the predicted trajectory for aircraft near the terminal area. The trajectory is not accurately modeled within terminal airspace. As stated in Section 4.3.2, this airspace around a terminal area is referred to as a Tactical Airspace. Trajectories inside the Tactical Airspace are not eligible for continual probing or conformance checking. The controller will not receive alerts for this portion of the route. The same limitations on the use of trajectories in APDIAs must be taken into account.

Additional situations where the reduced accuracy of the probe results must be accounted for by the sector team include the following:

(1) when an aircraft enters a holding pattern,

(2) when an aircraft enters a non radar area,

(3) when a center receives flight plan data from a neighboring facility and no track data is yet available,

(4) when aircraft are flying on parallel airways that are close (within separation thresholds) to each other,

(5) when HCS data or radar data is not available, and

(6) when data from neighboring facilities are not available for a flight.

The aircraft data displayed to the sector team is coded to indicate when track data is not available for the aircraft, when it is known by the system to be potentially inaccurate (i.e., insufficient track updates available), and when the system is operating in degraded mode (see Section 5.5).

5.3 Role of Airway Facilities

Airway Facilities (AF) personnel, at each ARTCC, along with contractor supplied system operators will be responsible for maintaining daily operations of the system. Using the Monitor and Control (M&C) position (Section 4.10.2), specialists will be able to monitor the status, integrity and performance of all Conflict Probe resources and display the results. The position is used to monitor and control start-up, restart, shutdown, reconfiguration, software downloads, software cutover, and certification of Conflict Probe. In addition, the specialist will be able to control the System Analysis Recording (SAR) of data and to store data for offline data reduction and analysis (DR&A). The Conflict Probe M&C functions will be an integral part of the DS M&C position. Simulation tools will be available for testing new Conflict Probe functionality.

5.4 Adaptation Process

Adaptation will be provided by facilities personnel responsible for site software maintenance in coordination with support staff at the William J. Hughes Technical Center. The Conflict Probe adaptation process will conform with the adaptation update process used for maintaining the HCS. Conflict Probe environmental adaptation data is typically updated in parallel with the 56-day update cycle that is used to update data on the center's HCS. The process will consist of both automated tools and manual processes. Section 4.9 describes the adaptation data in more detail.

Altitude restriction data will be updated on a similar cycle based on updates to the SOPs and LOAs for a facility. The update process is largely a manual one with support tools used to visualize the restrictions.

5.5 System Outages

A system outage or failure can occur in several ways: the Conflict Probe processor(s) may fail because of a software or hardware problem, data from the HCS may become unavailable because of a failure somewhere in the HCS, HGW, or Local Area Network (LAN) components, the interface to neighboring facilities may become unavailable, a neighboring facility may have failure in one of its components causing it to become unavailable or to be running its Conflict Probe in a degraded mode, the D-Controller console may fail, weather data becomes unavailable due to system outages or LAN failures, the entire facility fails due to power, or other global failure.

If Conflict Probe processing becomes unavailable, but the HCS and DS displays are still available, the controller will revert to manual strategic planning as is done in today's en route system. This is possible because the flight data continues to be available from the paper flight strips. In addition to flight strips, the functionality of the D-CRD for message receipt and response is still available.

During system recovery, the system reconstitutes data from the collocated HCS and data from neighboring facilities and restores data to all displays within minutes. Current Plan information is available, but Trial Plan information may be lost. Once recovery is complete the D-Controller may return to strategic planning using the automation.

If data from the HCS is not available, then Conflict Probe operates in a degraded mode. Conflict Probe is then coded to indicate no updates are being received from Host and neighboring facility Conflict Probe systems are notified of the failure. Eventually, Conflict Probe will become unusable because it is not receiving updated position information and new flight plans.

If a neighboring facility has a failure the local Conflict Probe uses local HCS data to model flights inbound and outbound to that neighbor when possible. Conflict Probe indicates to the controller that data is not available from the neighboring facility Conflict Probe.

When the D-Controller console fails, the D-Controller will revert to manual strategic planning using flight strips alone. All amendments and clearances will be handled by the R-Controller. The Conflict Probe continues to process data for that display and when the display processor is back on-line, the system immediately begins to generate data for the display and send it to the display processor. Since the system has continued processing all data, the status of Trial Plans are then updated. Auto Replans and Automated Coordination data should be available unless they have been deleted from the data base.

When weather data (winds, temperatures, and barometric pressure) is unavailable in any given hourly update, the previously stored data from the most recently obtained forecast for that hour is used.

In any failure situation, determining when to revert to manual strategic planning or revert back to Conflict Probe will be at the discretion of facility management and supervisors.

5.6 System Support Facility

The contractor will be responsible for the testing, implementation, maintenance, modification, and enhancement of Conflict Probe as well as the configuration management, quality assurance, and adaptation data management of all Conflict Probe sites. These activities will be accomplished at the contractor's development facility or the DSR System Support Facility (DSSF). Modifications to nationally deployed or mission-critical components must be tested and maintained at the DSSF. Conflict Probe unique components may be maintained at the contractor's facility.

Section 6

Operational Scenarios

This section contains several operational scenarios of Conflict Probe. They are intended to give the reader a better understanding of Conflict Probe capabilities and how the sector team might use these capabilities in specific situations or how the system handles specific situations. The controller actions taken, in each scenario, are not necessarily unique and different controllers might handle each scenario in a slightly different manner while still adhering to ATC procedures. The following scenarios are discussed:

- An aircraft-to-aircraft conflict
- A pilot request
- Severe weather avoidance

6.1 Aircraft-to-Aircraft Conflict

1. While scanning the Aircraft List for predicted conflicts, the D-controller at the Smyrna sector (MQY) observes a red "1" in the alert indicator box for MTE741 (e.g., indicating that this aircraft has a red conflict predicted to occur in the MQY sector at some point in the next 20 minutes). MTE741 is currently under the control of the Pocket City sector (PXV) in Indianapolis Center (ZID).
2. The D-controller takes an input action to show MTE741's predicted problem on the Graphic Plan Display. Viewing the problem graphically, the D-controller notes that the conflict is predicted to occur with AAL568, an aircraft currently under the control of the Memphis sector (MEM), in approximately 15 minutes.
3. Although neither aircraft is currently under Smyrna's control, the D-Controller decides to take action to develop a resolution for the predicted conflict. Using the Trial Planning capabilities, the D-controller creates a Trial Plan that routes the aircraft to a Fixed Radial Distance (FRD) and then direct to its destination (i.e., CLRD BNA073015 MCO). The Trial Plan shows no problems, and the D-Controller decides that this may be a suitable and desirable resolution. (Figure 6-1 depicts the predicted red conflict between the two aircraft as well as the proposed resolution.)
4. The D-Controller uses Automated Coordination to send the problem-free Trial Plan to the Pocket City sector. No voice communication is necessary.
5. The D-Controller at Pocket City receives the coordination request on the Plans Display. After reviewing the request and deciding it is acceptable, the Pocket City D-Controller coordinates with the R-Controller to clear the aircraft in accordance with the Trial Plan.

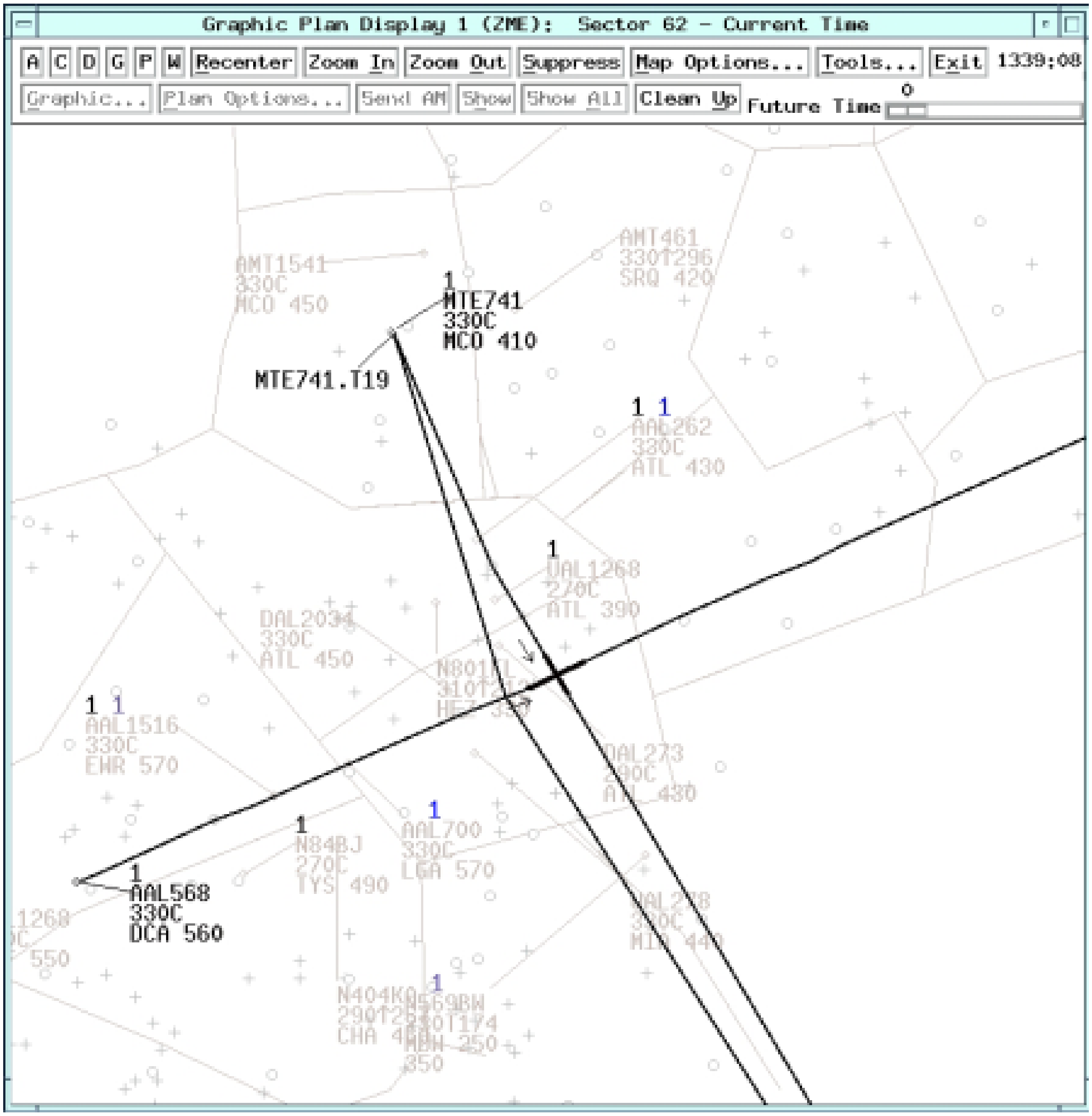


Figure 6-1. Interfacility Conflict Probe Plan Processing for Single Aircraft Scenario

6. The Pocket City R-Controller issues the clearance to MTE741. The D-controller sends the amendment (AM) message to the HCS from the Plans Display. (The AM message is accepted by the HCS.)

7. The D-controller at the Smyrna sector receives notification that the flight plan amendment has been sent to the HCS. The red alert indication for the two aircraft is removed.

Note that the amendment might change the sectors that the aircraft passes through and amendment flight strips will be posted by the HCS to those sectors affected. In addition, the Aircraft List at affected sectors will update to reflect the new amended flight plan, so that no communication is required with any intermediate sectors.

6.2 Pilot Request

1. The pilot for COA1230 contacts the Pocket City sector (PXV) to request a climb to Flight Level 330, the aircraft's preferred altitude. The request is not of a critical nature (e.g., it is not for weather or turbulence).
2. The R-Controller asks the pilot to "stand-by." From the Aircraft List, the D-Controller creates a Trial Plan for the requested altitude change.
3. The Trial Plan shows two red conflicts, both of which are predicted to occur downstream. The D-Controller verbally communicates this to the R-Controller.
4. The R-Controller informs the pilot that the desired altitude request would create several problems downstream and that, therefore, the clearance cannot be issued at the present time. The pilot is advised that he will be cleared to his requested altitude if and when it becomes available.
5. The D-Controller submits the request for continual automated checking using the Automated Reprobe capability (i.e., this is a capability that allows for a Trial Plan to be continuously probed, or re-evaluated, and updated as problem information changes.) Alternatively, the D-Controller could have continued to create Trial Plans in an attempt to develop a plan that was acceptable to the controller and pilot (e.g., a climb to a different altitude, a route change in addition to the requested altitude change).
6. The aircraft is handed off to the Louisville sector (LOU). As COA1230 hands off, the red Trial Plan (for the climb to Flight Level 330) is automatically posted on the Plans Display at the Louisville sector.
7. The Trial Plan for COA1230 continues to be probed and after a short while, the Louisville D-Controller notices that the Trial Plan becomes problem-free.
8. The LOU D-Controller informs the R-Controller that COA1230's preferred altitude is problem-free.
9. The R-Controller calls COA1230 to inform the pilot that the aircraft's requested altitude is now available.

10. The pilot accepts the clearance and the D-Controller sends the amendment (AM) message to the HCS from the Plans Display. (The AM message is accepted by the HCS.) The Aircraft List is updated at affected sectors to reflect the new Current Plan.

6.3 Severe Weather Avoidance

1. The pilot for USA922 contacts the Dayton sector (DAY) to request a reroute to avoid a thunderstorm that is observed by the pilot.
2. The R-Controller asks the pilot to “stand-by.” Based on the pilot’s observation regarding the location of the thunderstorm, the D-controller creates a graphic Trial Plan that reroutes USA922 around the reported storm area.
3. The Trial Plan shows a red conflict with another aircraft in the Dayton sector. Since the situation is rather critical, the D-Controller creates another Trial Plan attempting to reroute the aircraft in the other direction. This time the reroute is problem-free.
4. The D-Controller informs the R-Controller that a reroute to the west is possible and tells him the proposed clearance. The R-Controller checks the Plan View Display (PVD) and agrees with the D-Controller’s reroute.
5. The R-Controller issues the route clearance to the pilot.

The pilot accepts the clearance and the D-Controller sends the amendment (AM) message to the HCS from the Plans Display. (The AM message is accepted by the HCS.) The Aircraft List is updated at affected sectors to reflect the new Current Plan.

Section 7

Conflict Probe Algorithmic Performance and Accuracy Issues

Unless the sector team has confidence in the prediction accuracy of Conflict Probe, its use will be limited and the potential benefits of providing the user community with more beneficial routing will not be realized. In order to insure that problem prediction is acceptable to the controller, certain performance constraints are placed on the system and evaluations are continually performed to guarantee that these constraints are being met. Conflict Probe performance requirements are derived from technical performance metrics (TPMs) generated for actual air traffic scenarios. TPMs measure the accuracy and usability of Conflict Probe alerts. Complementing the TPMs are Operational utility metrics (OUMs), which compare Conflict Probe alerts to actions controllers actually take to separate air traffic. Like TPMs, OUMs are generated for actual air traffic scenarios.

The metrics presented in this section are based on actual air traffic scenarios collected from the Indianapolis and Memphis ARTCCs. As Conflict Probe matures, additional scenario data may be collected and used to generate new metrics which may be used to further refine the Conflict Probe performance requirements.

TPMs include false alert rates, missed alert rates, vertical prediction error, and conflict warning time. False and missed alert rates are expressed, respectively, as probabilities of detecting a conflict when one does not exist and of not detecting a conflict when one does, in fact, exist. Both are specified for a range of actual minimum separations. Missed alert rates also include a threshold; i.e., if a conflict is detected with less than a given warning time, it is considered missed. Vertical prediction error is expressed as the probability that the trajectory-predicted altitude of an aircraft will be within a given altitude tolerance from the actual altitude of the aircraft at specified lookahead times. Climb and descents are treated separately. Conflict warning time is the difference between the conflict notification time and the predicted conflict start time. Conflict warning time is presented as a mean and standard deviation for red and for all conflicts, for immediately notified conflicts and for conflicts with delayed notification.

7.1 False Alert Rate

For the purpose of Conflict Probe performance assessments, a false alert occurs when: (1) an aircraft is in adherence with its flight plan during the planning horizon and does not violate separation standards with an airspace or another aircraft that is also in adherence with its flight plan and (2) Conflict Probe displays an alert predicting a violation of separation standards involving the subject aircraft to at least one controller. A false alert also occurs when Conflict Probe displays an alert that is subsequently retracted without an amendment to the flight plan of at least one aircraft involved in the alerted conflict.

For the purpose of the TPM provided herein, a false alert is an aircraft to aircraft encounter with an actual minimum separation greater than 5 nm for which a conflict is predicted. Vertical prediction error is not considered by this metric. This definition differs from the above Conflict Probe definition and the differences could result in each methodology producing different false alert rates for the same scenario. Sample false alert rates are presented in Table 7-1 for a range of actual minimum separation distances of greater than 5 nm to 20 nm. Probabilities are given for all predicted conflicts and for the subset of those defined as red conflicts (i.e., predicted separation < 5 nm). Probabilities are based on actual air traffic scenarios.

7.2 Missed Alert Rate

A missed alert is an aircraft to aircraft encounter with a minimum separation less than or equal to 5 nm for which no conflict is predicted at a threshold time prior to the time of minimum separation. Sample missed alert rates are presented in Table 7-2 for a range of actual minimum separation values up to and including 5 nm. Probabilities are based on actual air traffic scenarios.

7.3 Vertical Prediction Error

Vertical deviation is the signed distance between a track report altitude and the trajectory-predicted altitude at the time of the report. Sample vertical prediction error probabilities, based on a real air traffic scenario, are presented in Table 7-3.

7.4 Conflict Warning Time

Conflict warning time is the difference between the time a conflict is notified to the controller and the time it is predicted to start. Minimum separation is the minimum horizontal separation between the trajectory centerlines in a predicted conflict. If this is less than or equal to 5 nm, the conflict is *red*. Otherwise, the conflict is *yellow*.

Conflict warning times are specified for unique problems that reach notification time. Values are provided for all unique conflicts and for the subset of those that are red conflicts. Each of these two categories is again divided and values are provided for all cases and for the subset of cases for which notification of the conflict is delayed. Four types of values are specified:

- Total number of conflicts
- Mean conflict warning time
- Warning time standard deviation
- Number of conflicts with less than 5 minutes of warning time

Table 7-1. False Alert Rate

Actual Minimum Separation Distance (nm)	All Conflicts	Red Conflicts
5.01	≥ 0.919	
6	≥ 0.882	≤ 0.384
7	≥ 0.830	≤ 0.286
8	≥ 0.762	≤ 0.207
9		≤ 0.147
10		≤ 0.101
11	≤ 0.464	≤ 0.069
12	≤ 0.358	≤ 0.046
13	≤ 0.268	≤ 0.030
14	≤ 0.196	≤ 0.019
15	≤ 0.140	≤ 0.012
16	≤ 0.098	≤ 0.008
17	≤ 0.067	≤ 0.005
18	≤ 0.045	≤ 0.003
19	≤ 0.030	≤ 0.002
20	≤ 0.019	≤ 0.001

Table 7-2. Missed Alert Rate

Actual Minimum Separation Distance	All Predicted Problems	Red Predicted Problems
0	0.005	0.162
1	0.006	0.177
2	0.011	0.233
3	0.020	0.298
4	0.035	0.393
5	0.060	0.499

Table 7-3. Vertical Prediction Error

	0-minute Lookahead	**5-minute Lookahead**	**10-minute Lookahead**	**15-minute Lookahead**	**20-minute Lookahead**
Climb	1.00	0.71	0.49	0.36	0.45
Descent	1.00	0.75	0.76	0.63	0.32

An actual air traffic scenario is assessed to determine Conflict Probe warning time requirements. Average conflict warning time is determined to be greater than or equal to the following:

- All Unique, Notified Conflicts
  - All Cases: 8.67 minutes
  - Delayed Notification Cases: 11.73 minutes
- Red Unique, Notified Conflicts
  - All Cases: 9.67 minutes
  - Delayed Notification Cases: 12.73 minutes

The percentage of all notified conflicts with a conflict warning time that is greater than five minutes will be greater than or equal to the following:

- All Unique, Notified Conflicts: 75%
- Red Unique, Notified Conflicts: 78%

The percentage of all delayed notification conflicts with a conflict warning time that is greater than five minutes will be greater than or equal to the following:

- All Unique, Notified Conflicts: 97%
- Red Unique, Notified Conflicts: 98%

7.5 Alert Validity

An actual air traffic scenario was assessed to determine Conflict Probe alert validity requirements. An aircraft-aircraft alert is considered to be valid if a controller moved one of the aircraft to resolve the conflict. The percentage of alerts that is valid will be greater than or equal to the following:

- All Alerts: 89%
- Red Alerts: 92%

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Glossary

ACES	Adaptation Controlled Environment System
AERA	Automated En Route ATC
ALTRV	Altitude Reservation
APD	Automated Problem Detection
APDIAs	Automated Problem Detection Inhibited Areas
ARTCC	Air Route Traffic Control Center
ATC	Air Traffic Control
ATM	Air Traffic Management
CAASD	Center for Advanced Aviation System Development
CCLD	Core Capability Limited Deployment
CDM	Collaborative Decision Making
CHI	Computer Human Interface
CRD	Computer Readout Device
CRTE	Coded Route
CP	Conflict Probe
CTA	Calculated Time of Arrival
CTAS	Center/TRACON Automation System
DACS	Digital Aeronautical Chart Supplement
D-CRD	D-Controller Position Computer Readout Device
DRs	Discrepancy Reports
DR&A	Data Reduction and Analysis
DS	Display System
DSR	Display System Replacement
DSSF	DSR System Support Facility

DYSIM	Dynamic Simulation
FAA	Federal Aviation Administration
FDP	Flight Data Processing
FFP1	Free Flight Phase 1
FMS	Flight Management Systems
GPD	Graphic Plan Display
HCS	Host Computer System
HGW	Host Gateway
ID	Identification
IFA	Interfacility
IFR	Instrument Flight Rules
LAN	Local Area Network
LOAs	Letter of Agreement
M&C	Monitor and Control
MARSA	Military Assumes Responsibility for Separation of Aircraft
MOAs	Military Operations Areas
MSL	Mean Sea Level
NAS	National Airspace System
NAVAID	Navigational Aid
NOAA	National Oceanic and Atmospheric Administration

PAR	Preferential Arrival Route
PDAR	Preferential Departure Arrival Route
PDR	Preferential Departure Route
PHA	Planned Holding Area
PVD	Plan View Display
RDP	Radar Data Processing
RUC	Rapid Update Cycle
SAA	Special Activity Airspaces
SID	Standard Instrument Departure
SOP	Standard Operating Procedure
STAR	Standard Terminal Arrival Route
SUA	Special Use Airspace
TMA	Traffic Management Adviser
TRACON	Terminal Radar Approach Control
URET	User Request Evaluation Tool
UCT	Universal Coordinated Time
WARP	Weather and Radar Processor