Full AERA Services Operational Description

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Dr. Bruce C. Wetherby
Joseph C. Celio
Sonya M. Kidman
Margaret A. Stanley

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MITRE Department
and Project Approval:

E. P. Carrigan
Department Head
System Planning and Design
ABSTRACT

The operational characteristics of Full AERA Services (FAS) are described. This includes a background description of the program and its Air Traffic Control (ATC) system benefits, a discussion of the environment for FAS and its key automation features, and a description of FAS capabilities. Major FAS capabilities include automated problem detection and resolution, including automation processing support and planning and replanning aids, and enhanced operational capabilities in the controller-to-controller coordination and controller-to-pilot communication areas. To facilitate an understanding of the application of FAS, military and air carrier scenarios incorporating the use of this system are illustrated. Finally, an appendix is provided which delineates the differences between FAS and Introductory AERA Services (IAS), an interim step in the transition to FAS.

KEYWORDS: Automated En Route Air Traffic Control (AERA) Services, Air Traffic Control (ATC), Full AERA Services (FAS), Introductory AERA Services (IAS), Operational Description (OD), Automated Problem Detection (APD), Automated Problem Resolution (APR)
FOREWORD

This Full AERA Services Operational Description (OD) differs from the previous version of this document (i.e., AERA 2 Operational Description, Revision 2) in three major ways:

- The introductory material concerning how AERA Services are incorporated into the Area Control Computer Complex (ACCC) has been updated based on the latest discussions at the Federal Aviation Administration (FAA).

- The entire document has been revised to make it consistent with the latest recommendations of the Air Traffic AERA Team that will be embodied in the Specification for Full AERA Services (to be published) and the Introductory AERA Services (IAS) NAS Change Proposal (FAA, 1992).

- An Appendix has been added to describe IAS operations.

The previous version of the OD was published by Brad Fordham (1990).
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Steve Baird  Nashville TRACON
Richard DeCramer  Minneapolis Center
Mark De Plasco  Air Force, National Airspace Systems Office
James Ekins  Boston Center
Ian Graves  Las Vegas Tower
Philip Kain  Washington Center
Douglas Kelley  Indianapolis Center
Dennis Poore  Atlanta Center
John Potter  FAA Technical Center
Richard Ridgway  Philadelphia Tower
Bruce Schwindt  Portland TRACON
Bradley Seitz  Kansas City Center
Thomas St. Clair  Los Angeles Center
John Warner  Seattle Center

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Lowell Rhodes  FAA, retired
John Ryan  Air Force Communications Center

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EXECUTIVE SUMMARY

INTRODUCTION

The Federal Aviation Administration (FAA) has published its Capital Investment Plan (CIP) for modernizing the nation's ATC system. The plan responds to the demands being placed on the current system by a rapidly growing aviation community with ever-increasing needs for more convenience in flights, independent routing, point-to-point navigation, and departure and arrival times which accommodate key business hours. The CIP identifies an evolutionary upgrade of the current system which includes new computer hardware and software, surveillance radars, and navigation aids. This upgrade will accommodate the increasing number of aircraft and the changing needs of the aviation community, while keeping system safety foremost. Safety is the key constraint in determining how technology can be applied effectively to the orderly modernization and enhancement of individual ATC system components.

One of the key elements of the CIP is the Advanced Automation System (AAS), which provides new hardware and software to be used in ATC. Scheduled to be implemented in the 1990s, the AAS includes a new controller display system—the Initial Sector Suite System (ISSS)—which provides for electronic versions of today’s paper flight strips, as well as high-resolution, large-screen color graphic displays. The ISSS is followed by the Area Control Computer Complex (ACCC), which includes a complete replacement of the en route ATC computer hardware and a software upgrade.

In addition to incorporating functions of, and enhancements to, the currently fielded ATC system, the AAS will incorporate a collection of new automation capabilities for air traffic controllers known as AERA Services. AERA Services is composed of two major functional capabilities, called Introductory AERA Services (IAS) and Full AERA Services (FAS), with the capabilities of the former fully integrated into the capabilities of the latter. As a consequence, when reference is made to AERA Services, FAS capabilities are implied. AERA 2 is the former name of FAS, and previous operational descriptions of FAS (e.g., Fordham, 1990) have been published using the name AERA 2.

FAS includes the following capabilities:

- Automated Problem Detection (APD), which detects ATC problems associated with a current or proposed route of flight. Problems can be with other aircraft, airspaces, or flow instructions.
• Automated Problem Resolution (APR), which generates resolutions to these problems and displays resolution alternatives at the appropriate positions.

• Supplemental automation features to assist controllers with ATC separation, coordination, and handoff tasks. These features include graphic display capabilities, automated planning aids, and clearance generation aids.

AERA Services will be implemented following a phased development approach in order to avoid disruptive changes in ATC tasks and operational procedures. Extensive testing and evaluation will be conducted to minimize risks associated with introduction of new capabilities and procedures. IAS is a subset of FAS which will be developed and deployed (1) to facilitate controller transition to FAS and (2) to bring some of the benefits of AERA to the aviation community as early as possible. IAS will include APD and supplemental automation features, but only limited problem resolution aids. Table ES-1 provides a summary of the capabilities of IAS and FAS.

Table ES-1. Capabilities of IAS and FAS

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<tr>
<th>Capability</th>
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<td>Automated Problem Detection (APD)</td>
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Following the implementation of ISSS, various functional enhancements will be fielded as the capabilities mature and complete development, including data link, the Center Terminal Automation System (CTAS), and IAS. IAS will relieve the controller of some of the workload associated with situation monitoring and will provide automated assistance in strategic planning of aircraft maneuvers. Controller tasks at first will remain similar to those that characterize today's ATC system, but will evolve as controllers and ATC system personnel gain experience and expertise in using AERA capabilities. It will provide controllers a learning period during which separation tasks will be accomplished primarily as in today's environment, but with added support provided by the strategic lookahead of APD, which extends the controller's planning horizon. For example, with automation providing reliable early warning of emerging separation or flow instruction problems, controllers will be able to grant user-preferred routes and schedules more readily when these preferences are conflict-free.

The extension from IAS to FAS is primarily accomplished with the addition of APR's automatic generation of resolutions to aircraft-to-aircraft and aircraft-to-airspace problems and noncompliances with flow instructions. Alternative resolutions in all three dimensions of flight will be evaluated and the highest ranked resolution will be displayed to the controller for consideration. Resolutions in other dimensions and for other aircraft are available upon controller request. With the capability to "see" (i.e., extrapolate) further into the future than the controller, APR will be able to generate resolutions more attuned to the needs of airspace users. Along with the FAS implementation, the complete replacement of the ATC computer hardware and software will be accomplished.

**ATC SYSTEM BENEFITS FROM FAS**

FAS makes significant contributions to the attainment of the key ATC system goals: safe, orderly, expeditious air traffic flow, and increased controller productivity. FAS's contributions to the ATC system are summarized below:

- **Enhanced Safety** - The expected increase in the use of airspace creates the potential for a higher number of conflict situations. FAS detects problems (aircraft/aircraft/ flow instruction) for aircraft known to the system, and offers system solutions to resolve the problems.

  Loss of Instrument Flight Rules (IFR) separation occurs when problems are not recognized and, more frequently, when a resolution to a recognized problem is given too late, given with an insufficient maneuver, or not given at all. FAS reduces
operational errors because it provides resolutions to IFR problems early, resolutions that work, and resolutions that completely specify the required maneuvers.

Additionally, FAS functions enable the controller to check a plan for problems prior to issuing the clearance, and to continue checking for problems until the plan is implemented. This planning capability significantly reduces the number of problems that controllers unwittingly create for downstream controllers.

The ACCC provides the capability for identifying areas of known hazardous weather to the automation. FAS generates routes for avoiding these areas much the same as it would for restricted or prohibited airspace.

- **Increased System Capacity** - With today's increased traffic volume, the number of flow instructions and the routing of air traffic along specific routes have increased markedly. With FAS, many of these instructions and ATC-preferred routings are not necessary because FAS problem detection and resolution capabilities will allow a less structured utilization of airspace, with no derogation of safety and a significant increase in system capacity.

- **Improved Service to Users** - The increased system capacity provided by FAS allows aircraft to fly their User Preferences (UPs). This capability will better enable system users to meet their operational demands. In addition to allowing aircraft to fly UPs, FAS also remembers when a UP was denied because a restricted airspace was active, or a flow instruction was in effect. When the restricted airspace or flow instruction is deactivated early, the availability of the UP is displayed to the controller for clearing the aircraft on its UP.

FAS allows a dynamic and flexible response by controllers to en route aircraft requests. When a pilot request for a change in clearance cannot be issued at the time the original request is made, FAS allows the controller to enter the request into the automation, and the system notifies the controller when the request can be granted.

- **Increased Controller Productivity** - FAS provides aids to the controller to permit efficient and effective identification and resolution of problems. Problems are identified in a strategic time frame, and multiple resolutions are available, allowing the controller to select and implement the resolution that best serves the individual aircraft and system operations.
FAS provides continual and automatic problem detection and resolution for all IFR aircraft. Since it uses all data available and makes precise calculations, FAS is much more effective and accurate than the controller scanning and interpreting flight data. This is particularly true for random route postings, which are more difficult for the controller to analyze than postings for airway routes. FAS treats each with the same accuracy. This allows more aircraft to be handled because the controller only deals with those aircraft identified by FAS for attention.

The need for coordination between controllers is reduced because the highest ranked resolution is problem-free in almost all cases and therefore can be implemented without coordination.

Data link is expected to be the primary communication medium between controller and pilot. When used in the strategic environment, data link reduces the amount of voice communications required with the aircrew and, in addition, reduces communication errors.

THE ENVIRONMENT FOR FAS

FAS is an automated capability which primarily provides support to controllers in the prediction and resolution of problems along an aircraft's flight path. The central idea behind FAS is to detect ATC problems far enough ahead so that they can be resolved using relatively smooth maneuvers that minimally disturb the user-requested path for the aircraft. For this to occur, the future flight path of the aircraft must be stable and predictable. Such an environment is afforded in today's system by aircraft operating under IFR. Pilots of IFR aircraft file a flight plan with the ATC system stating their intended flight path. They may not alter this flight path unless the changes have been approved by ATC. This provides the system with a degree of predictability. This IFR-based system predictability will continue into the future and provide the basis for FAS.

The ability of FAS automation to predict problems well into the future and generate conflict-free resolutions permits the controller's thinking to become more strategic. The strategic control environment of FAS allows most aircraft to fly extended direct routes. Less dependence on airspace and route structure in FAS results in the ATC system becoming more capable of satisfying pilot requests. Users file flight plans that more precisely correspond to their actual intent (for example, direct from departure point to destination), rather than flight plans that anticipate probable ATC constraints. FAS then attempts to keep the aircraft as close to the filed user preferences as feasible, consistent with safety.

Aircraft position data will be available as in today's system, i.e., through altitude-encoding transponders and ATC surveillance radars. However, FAS will be available in areas of interrupted or no radar coverage and in case altitude-encoding transponders malfunction.
While FAS does not require advanced aircraft equipage, it capitalizes on such equipage, when available. Flight management systems can provide more accurate flight intent data. Data link, if available, will be used as the primary form of communication between the aircraft and the ground for aircraft so equipped.

FAS has interfaces with many systems. The relationship with the Traffic Management System (TMS), illustrated in Figure ES-1, is one of the most crucial. The TMS provides the goals necessary to organize traffic nationally and locally in the aggregate. The purpose is to achieve maximum safe utilization of saturable entities, such as airports. FAS then responds on an aircraft-specific basis to carry out the flow instructions of TMS while maintaining safe aircraft separation.

As a result of FAS, a new relationship between controllers and automation will exist. This necessitates the development and use of new ATC procedures. Training is also required to help controllers effectively utilize the new capabilities.

Figure ES-1. Overview of the FAS Relationship to TMS
KEY FEATURES OF FAS AUTOMATION

FAS provides the sector controller with Automated Problem Detection (APD) capabilities. APD detects problems predicted to occur within a certain time interval in the future and provides an AERA Alert to the controller which details the nature of the problem. These types of problems are: aircraft-to-aircraft, aircraft-to-airspace, and flow instruction. As a consequence, APD allows FAS to detect and resolve problems in a more strategic time frame than today’s radar-based control, achieving a lookahead time of up to 20 minutes for aircraft-aircraft problems, and to destination for aircraft-airspace and flow instruction problems. The computer is well suited to this task of detection, and can quickly and accurately compare all three-dimensional flight paths projected into the future. A controller attempting to do this today is faced with the difficult task of mentally projecting and comparing the aircraft flight paths based on paper flight strips. As more and more aircraft fly direct (off standard route) paths, this mental job becomes increasingly difficult.

FAS also provides the controller with Automated Problem Resolution (APR). APR generates resolutions (i.e., potential solutions) for APD-detected problems and prepares them for use by the appropriate controller. These resolutions correspond to the basic dimensions in which the controller can move an individual aircraft (left/right, speed up/slow down, climb/descend, hold). Rather than present to the controller all the resolutions that have been evaluated by APR for a particular problem however, FAS automation will present a Highest Ranked Resolution (HRR) that best meets the operational needs of the controller. If this HRR is deemed not to be operationally suitable, the FAS controller may then request that more resolutions be presented and these will be calculated and displayed within a few seconds. Further, in conditions where the Point of Violation (POV) is short, FAS will generate additional resolutions with the HRR in order to provide the controller a faster response to a request for more resolutions when it is time-critical to resolve a conflict.

In generating the resolutions, the automation considers the characteristics of each aircraft and the effects of the particular problem geometry and airspace characteristics. It orders the resolution dimensions into an operationally weighted list. Then the FAS automation generates the best resolution that solves the original problem, does not create another problem, and gives the aircraft a revised path that is as close as possible to the originally stated user preferences. This HRR is presented to the selected controller along with the AERA Alert that describes the problem. The controller may choose the HRR, request additional resolutions, or may create a resolution using Trial Planning (described later) or Controller Assisted Resolution (CAR). CAR is simply the manual mode of APR. Regardless of how an AERA Alert is solved, the lookahead time for resolutions is sufficient so that the controller has time to consider alternatives and transmit the clearance to the aircraft, and the pilot to maneuver accordingly. If enough time passes before the controller takes action so that the HRR becomes inappropriate, the automation generates a new HRR.

For aircraft-aircraft problems, up to 12 resolutions may be generated, six (i.e., left/right, speed up/slow down, climb/descend) for each aircraft involved in the problem. Hold is available as a
substitute for slow down when a speed decrease cannot solve the problem. After the HRR is generated, the AERA Alert and HRR are displayed to the controller who is controlling the aircraft that is maneuvered in that resolution. Note that when the two aircraft involved in a problem are controlled by different controllers, FAS does not notify both controllers, but rather only the one who controls the selected aircraft. Figure ES-2 illustrates this concept; only the controller of Sector 13 receives any notification of the potential conflict between UAL302 and AAL123.

Aircraft-airspace problems include predicted entry into a Restricted Area, a Military Operations Area (MOA), a severe weather area, or any other special-purpose ATC Defined Airspace. Each airspace is defined to the automation as a three-dimensional volume, with times of activation and deactivation. The automation detects when an aircraft might violate separation minima with an airspace. The lookahead time for these problems can be significantly extended to the end of flight for many airspaces, since an airspace is less dynamic than an aircraft. An HRR is generated as in the aircraft case with the AERA Alert and HRR presented to the position controlling the aircraft. More resolutions are available to the controller upon request.

Flow instructions are developed by the TMS to solve capacity-demand imbalance problems, and generally affect all aircraft that meet certain criteria. The flow instruction contains elements that identify applicable aircraft (for example, all aircraft destined for a certain airport), and the action to be taken for any aircraft in that group. The automation detects when an aircraft meets the criteria in a flow instruction and then generates a resolution which either makes the aircraft compliant with the flow instruction constraint or causes it to be exempt from the criteria. The lookahead time for these types of problems can generally be to the end of the flight.

In generating alternative resolutions for any of the above problems, APR tries to avoid creating other problems. In the unusual case, APR may find that a particular type of maneuver (e.g., turn left) cannot yield a problem-free resolution. A resolution that has problems is generally not presented to the controller unless it is specifically requested.

The APR capability also constructs composite and multiple maneuvers when single-dimension maneuvers do not suffice. Composite maneuvers are those which maneuver a single aircraft in two dimensions (for example, turn left and climb). Multiple maneuvers are those which maneuver two aircraft (either the two involved aircraft, or one of the involved aircraft, and a secondary uninvolved aircraft).

The controller and automation influence the APR process by "preferring" and "nonpreferring" certain maneuvers for certain aircraft. For instance, the controller can prefer to climb aircraft in resolving problems. APR automatically does its part by identifying specific aircraft callsigns, beacon codes, and route strings that suggest special handling. For example, an aircraft squawking an emergency beacon code, or a military aircraft during refueling, would not normally be the HRR aircraft.
Figure ES-2. Alert and Resolution Notification
The strategic control afforded by the longer lookahead times of FAS does not apply to all airspace. Around busy airports, in particular, there may be areas where control remains quite short-term or tactical, and FAS would not be operationally beneficial. Adapted areas, known as APD Inhibited Areas (APDIA), are developed to identify where APD and APR should not operate. These areas are defined by supervisory personnel and can differ by time of day, configuration of runways, and other factors.

ADDITIONAL AUTOMATION FEATURES SUPPORTING FAS

The Plan Processing capability supports the maintenance of the seven (7) AERA Plan types: Current Plans, Trial Plans, Pending Plans, Machine Plans, Protected HRRs, Dormant Current Plans, and Dormant Trial Plans. A Current Plan is that which the pilot has been cleared and which ATC expects the pilot to fly. A Trial Plan is any plan created by the controller to test whether a proposed change in the Current Plan will be problem-free. A Pending Plan is one which the controller expects to name as the Current Plan for an aircraft after coordination with other controllers or the pilot. An APR-generated resolution is made into a Machine Plan. The HRR is made a Protected HRR when APR is automatically initiated and the HRR is problem-free. Finally, Dormant Current and Dormant Trial Plans are former plans in these categories which may serve as the basis for building a new plan at a later point in time.

Flight plan data are used to construct a four-dimensional trajectory of an aircraft's intended route of flight projected into the future. This Trajectory Estimation process can use the same information contained in today's Flight Plans, or can use additional elements, such as a desired climb or descent profile. If these additional elements are not part of the individual Flight Plan filing, the automation uses nominal values, according to aircraft type and/or equipage, in generating the trajectory.

While traversing a trajectory, the aircraft is enclosed in a region of conformance. This region is derived from conformance bounds that reflect the aircraft's ability to fly the nominal path (and thus reflect aircraft equipage and wind prediction accuracies), as well as the characteristics of the route (for example, the ground Navigational Aids [NAVAIDs] used to guide turns). Conformance Monitoring will detect when an aircraft is outside the conformance region whether it is because of pilotage, instrument failure, unexpected winds, or a control action not yet entered into the automation. Figure ES-3 depicts lateral conformance bounds for an aircraft trajectory; there are also vertical bounds that take into account climb and descent rate variances and overshoots, and longitudinal conformance bounds that take into account speed fluctuations.

The flight plan data, the trajectory, and the conformance region form the automation's knowledge of aircraft intent. Based on these data, problems are detected and APR generates resolutions to problems. Thus, it is critical that the automation contain the latest and most accurate data. If the aircraft's intended route of flight changes (because of controller instructions), the data in the automation must be updated in a timely manner.
When an aircraft is found to be out of conformance, Reconformance immediately constructs a new internal plan for the aircraft, attempting to make the automation's knowledge agree with the actual aircraft flight. One exception to this is for "vertical drift" out-of-conformances, in which the aircraft is nominally in level flight, but "drifts" higher or lower. In this case, the controller will coordinate with the pilot of the aircraft to determine what action is necessary. For lateral and vertical nonconformance, and longitudinal resynchronization due to a missed or unplanned maneuver, the automation notifies the controller that the aircraft has passed outside of its conformance bounds. The controller then takes any action necessary to ensure that computer, controller, and aircraft are operating on the same basis of aircraft intent.

The Future Situation Display (FSD) assists the controller in evaluating ATC situations and in choosing or creating resolutions. This display shows the predicted position of each aircraft at a selected time in the future. This time may be selected to relate to a particular problem, or to be some number of minutes in advance of the current time. The controller may display selected resolutions as well. The controller can move the display forward or backward in time. The capabilities of the FSD greatly reduce the utility of electronic flight strips to the extent that the strips need not be routinely displayed to obtain flight information. Selected ones are displayed when they relate to a problem, or upon controller request.

Trial Planning is available to assist the controller in evaluating possible changes to an aircraft's path. These changes can be the result of an in-flight request from an aircraft's pilot or the need for the controller to respond to a new ATC situation. The controller can create a Trial Plan...
reflecting the proposed change. The automation checks for problems associated with a proposed plan change before a revised clearance is issued to the aircraft. The controller can delete the Trial Plan, modify it, or issue it as a clearance to the aircraft. There is also an analogous capability to test the consequences of implementing a new controlled airspace. To use this capability, the controller specifies a "trial" airspace and asks the automation to list all aircraft that would be in predicted or actual conflict with that airspace were it implemented. This information aids in deciding whether to implement the trial airspace, with or without changes; the automation supports both modification and implementation.

Using a variation of Trial Planning called Quick Trial Planning, the controller can request a set of Trial Plans that vary in a specific dimension. For example, if the specified dimension is "vertical," the automation produces Trial Plans for several altitude transitions and informs the controller whether any are problem-free.

The controller can invoke Automated Replan on a Trial Plan that contains an APD-detected problem. The Trial Plan is then checked periodically, and when it becomes problem-free, the controller is notified automatically. This capability helps the controller respond to user requests in a timely manner with minimal impact on controller workload.

Since the APD and APR capabilities have a long lookahead time, detection (and resolution where necessary) can extend into adjacent sectors. As a result, a controller usually can issue problem-free clearances without coordination with other controllers because the automation works across sectors. When coordination is required (for example, when requesting another controller to move an aircraft), the controller's job is simplified by Automated Coordination, a non-verbal exchange via the automation. A controller is able to use this capability to ask the current controller of an aircraft to maneuver it to solve a presented problem; this capability can also be used to inform other controllers of a planned action.

FAS's problem detection and resolution capabilities also allow Automatic Acceptance of Handoffs when the handoff was automatically initiated. This feature will relieve the controller of having to project the trajectories of aircraft before accepting handoff.

The controller's task of issuing clearances to aircraft, and also that of updating the automation's database, is simplified in two ways. First, if the new clearance is one generated by the automation, the associated Clearance Language is provided, and only controller approval and delivery is needed. Second, when the aircraft is data link equipped, the entire clearance can be delivered to the aircraft by the same simple controller approval process. In this event, the new clearance is automatically protected (as is the current clearance) during the time it takes to complete the full data link cycle. If there are any problems or data link failure conditions, the controller is notified. Data link capabilities can also be used by the pilot to downlink flight plan amendment requests, if available.

Reminders are provided to controllers for certain control actions. These reminders include notifications that a previously planned altitude maneuver, or Top of Descent Point, is a
parameter time away for the aircraft; that an aircraft has not provided a position report at a mandatory reporting point; and that a flight will change from IFR to Visual Flight Rules (VFR) before reaching its destination. If data link is available and an aircraft is so equipped, the Top of Descent Point reminder will be provided to the aircraft; otherwise, the controller will receive this notification.

Also available to help the controller evaluate the future movement of aircraft in the sector are Sector Activity Measures. They indicate how sector activity will evolve over the next 30-60 minutes in terms of traffic count and complexity.

Finally, capabilities are provided for aircraft that have not departed. For instance, a proposed flight plan can be checked against flow instructions and certain airspaces. This Predeparture Check provides an initial clearance for an aircraft that avoids known ATC constraints applicable at the time of departure.

A SAMPLE FLIGHT

To illustrate the features of FAS and how they affect both controllers and pilots, a sample IFR flight is described. The flight departs from a high-density airport, transits en route airspace on a route containing off-airway segments, and lands at a high-density airport. Most of the features and FAS capabilities discussed in this example are applicable to all air carrier, commercial, military, or general aviation aircraft flying between any two airports. Significant uses of FAS capabilities for this flight are summarized in Figure ES-4.

When the pilot calls in for initial clearance, a predeparture check is initiated by the controller. At this time, the automation generates amendments to the requested plan to resolve problems with current flow instructions and certain airspaces. An IFR clearance is issued to the flight by the controller.

After the aircraft takes off and is established on its Flight Plan some distance from the airport, FAS begins continually checking its trajectory for problems with other aircraft, terrain, special-use airspace areas, and flow instructions. After the aircraft reaches its cruise altitude, FAS detects a potential separation problem with another aircraft. APR constructs the HRR and presents it to the controller. The controller evaluates the computer-suggested resolution and decides to accept it. The controller then transmits the clearance to the aircraft (by voice or data link). Upon pilot acknowledgment, the clearance becomes part of the new flight plan, and the automation monitors the aircraft for conformance to the new clearance.

The flight continues in accordance with the revised flight plan. Later, the pilot requests a change in route to avoid severe weather. The controller enters the request into the system; the FAS automation then constructs a trial trajectory incorporating the request and checks it for problems. No problems are detected and the controller approves the pilot request.
When the flight begins its arrival phase to the high-density terminal area, the ATC system helps the controller plan the arrival sequencing and spacing for the flight. FAS, as part of an integrated ATC system, assists the controller by generating problem-free flight paths necessary to achieve the desired arrival sequencing and timing. APD is terminated some distance from the arrival airport where tactical maneuvering by the terminal controller makes the Flight Plan-based trajectory unsuitable for strategic problem detection.
SECTION 1
INTRODUCTION

This section provides the purpose, background, scope and organization of this Operational Description (OD) of Full AERA Services (FAS). Air Traffic Control (ATC) system benefits derived from FAS are also described, as are documents related to this OD.

1.1 PURPOSE

This OD describes FAS functional capabilities as they will be used by controllers. The text provides a description of the general operational "concepts," or functions, that the controller is expected to make use of in an FAS operational environment, but does not describe the specifics of how FAS may actually be implemented as an automation system (i.e., it does not describe the operation of a completed system). Nonetheless, the text does attempt to describe information displayed to operational personnel during the use of FAS and of their potential interactions with the automation. The functional capabilities of Introductory AERA Services (IAS), a subset of FAS, and their use by controllers is described in Appendix A.

1.2 BACKGROUND

The Federal Aviation Administration (FAA) has published its Capital Investment Plan (CIP) for modernizing the nation's ATC system. The plan responds to the demands being placed on the current system by a rapidly growing aviation community with ever-increasing needs for more convenience in flights, independent routing, point-to-point navigation, and departure and arrival times which accommodate key business hours. The CIP identifies an evolutionary upgrade of the current system which includes new computer hardware and software, surveillance radars, and navigation aids. This upgrade will accommodate the increasing number of aircraft and the changing needs of the aviation community, while keeping system safety foremost. Safety is the key constraint in determining how technology can be applied effectively to the orderly modernization and enhancement of individual ATC system components.

One of the key elements of the CIP is the Advanced Automation System (AAS), which provides new hardware and software to be used in ATC. Scheduled to be implemented in the 1990s, the AAS includes a new controller display system—the Initial Sector Suite System (ISSS)—which provides for electronic versions of today's paper flight strips, as well as high-resolution, large-screen color graphic displays. The ISSS is followed by the Area Control Computer Complex (ACCC), which includes a complete replacement of the en route ATC computer hardware and a software upgrade.

In addition to incorporating functions of, and enhancements to, the currently fielded ATC system, the AAS will incorporate a collection of new automation capabilities for air traffic controllers known as Automated En Route ATC (AERA) Services. AERA Services is
composed of two major functional capabilities, called Introductory AERA Services (IAS) and Full AERA Services (FAS), with the capabilities of the former fully integrated into the capabilities of the latter. As a consequence, when reference is made to AERA Services, FAS capabilities are implied. AERA 2 is the former name of FAS, and previous operational descriptions of FAS (e.g., Fordham, 1990) have been published using the name, AERA 2.

FAS includes the following capabilities:

- Automated Problem Detection (APD), which detects ATC problems associated with a current or proposed route of flight. Problems can be with other aircraft, airspaces, or flow instructions.

- Automated Problem Resolution (APR), which generates resolutions to these problems and displays resolution alternatives at the appropriate positions.

- Supplemental automation features to assist controllers with ATC separation, coordination, and handoff tasks. These features include graphic display capabilities, automated planning aids, and clearance generation aids.

AERA Services will be implemented following a phased development approach in order to avoid disruptive changes in ATC tasks and operational procedures. Extensive testing and evaluation will be conducted to minimize risks associated with introduction of new capabilities and procedures. IAS will be developed and deployed (1) to facilitate controller transition to FAS and (2) to bring some of the benefits of AERA to the aviation community as early as possible. IAS will include APD and supplemental automation features, but only limited problem resolution aids. Table 1-1 provides a summary of the capabilities of IAS and FAS.

Following the implementation of ISSS, various functional enhancements will be fielded as the capabilities mature and complete development, including data link, the Center Terminal Automation System (CTAS) and IAS. IAS will relieve the controller of some of the workload associated with situation monitoring and will provide automated assistance in strategic planning of aircraft maneuvers. Controller tasks at first will remain similar to those that characterize today’s ATC system, but will evolve as controllers and ATC system personnel gain experience and expertise in using AERA capabilities. It will provide controllers a learning period during which separation tasks will be accomplished primarily as in today’s environment, but with added support provided by the strategic lookahead of APD, which extends the controller’s planning horizon. For example, with automation providing reliable early warning of emerging separation or flow instruction problems, controllers will be able to grant user-preferred routes and schedules more readily when these preferences are conflict-free.
Table 1-1. Capabilities of IAS and FAS

<table>
<thead>
<tr>
<th>Capability</th>
<th>IAS</th>
<th>FAS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Automated Problem Detection (APD)</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Reconformance</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Automated Coordination</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Automated Planning Aids: Trial Planning, Quick Trial Planning,</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Automated Replan, Predeparture Check</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Future Situation Display</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Sector Activity Measures</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Aircraft-Specific and Flight-Specific Characteristics Data</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Reminders: Start Maneuver, Monitor Report, Top of Descent, and Planned</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Change to Visual Flight Rules (VFR)</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Data Link Communication</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Automated Problem Resolution (APR)</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Automatic Acceptance of Handoff</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Reminder: Transfer of Communications</td>
<td></td>
<td>X</td>
</tr>
</tbody>
</table>

The extension from IAS to FAS is primarily accomplished with the addition of APR's automatic generation of resolutions to aircraft-to-aircraft and aircraft-to-airspace problems and noncompliances with flow instructions. Alternative resolutions in all three dimensions of flight will be evaluated and the highest ranked resolution will be displayed to the controller for consideration. Resolutions in other dimensions and for other aircraft are available upon controller request. With the capability to "see" (i.e., extrapolate) further into the future than the controller, APR will be able to generate resolutions more attuned to the needs of airspace users. Along with the FAS implementation, the complete replacement of the ATC computer hardware and software will be accomplished.

1.3 ATC SYSTEM BENEFITS FROM FAS

FAS makes significant contributions to the attainment of the key ATC system goals: safe, orderly, expeditious air traffic flow, and increased controller productivity. FAS's contributions to the ATC system are summarized below:

- Enhanced Safety - The expected increase in the use of airspace creates the potential for a higher number of conflict situations. FAS detects problems (aircraft/aircraft/flow instruction) for aircraft known to the system, and offers system solutions to resolve the problems.
Loss of Instrument Flight Rules (IFR) separation occurs when problems are not recognized and, more frequently, when a resolution to a recognized problem is given too late, given with an insufficient maneuver, or not given at all. FAS reduces operational errors because it provides resolutions to IFR problems early, resolutions that work, and resolutions that completely specify the required maneuvers.

Additionally, FAS functions enable the controller to check a plan for problems prior to issuing the clearance, and to continue checking for problems until the plan is implemented. This planning capability significantly reduces the number of problems that controllers unwittingly create for downstream controllers.

The ACCC provides the capability for identifying areas of known hazardous weather to the automation. FAS generates routes for avoiding these areas much the same as it would for restricted or prohibited airspace.

- **Increased System Capacity** - With today's increased traffic volume, the number of flow instructions and the routing of air traffic along specific routes have increased markedly. With FAS, many of these instructions and ATC-preferred routings are not necessary because FAS problem detection and resolution capabilities will allow a less structured utilization of airspace, with no derogation of safety and a significant increase in system capacity.

- **Improved Service to Users** - The increased system capacity provided by FAS allows aircraft to fly their User Preferences (UPs). This capability will better enable system users to meet their operational demands. In addition to allowing aircraft to fly UPs, FAS also remembers when a UP was denied because a restricted airspace was active, or a flow instruction was in effect. When the restricted airspace or flow instruction is deactivated early, the availability of the UP is displayed to the controller for clearing the aircraft on its UP.

FAS allows a dynamic and flexible response by controllers to en route aircraft requests. When a pilot request for a change in clearance cannot be issued at the time the original request is made, FAS allows the controller to enter the request into the automation, and the system notifies the controller when the request can be granted.

- **Increased Controller Productivity** - FAS provides aids to the controller to permit efficient and effective identification and resolution of problems. Problems are identified in a strategic time frame, and multiple resolutions are available, allowing the controller to select and implement the resolution that best serves the individual aircraft and system operations.

FAS provides continual and automatic problem detection and resolution for all IFR aircraft. Since it uses all data available and makes precise calculations, FAS is much more effective and accurate than the controller scanning and interpreting flight data.
This is particularly true for random route postings, which are more difficult for the controller to analyze than postings for airway routes. FAS treats each with the same accuracy. This allows more aircraft to be handled because the controller only deals with those aircraft identified by FAS for attention.

The need for coordination between controllers is reduced because the highest ranked resolution is problem-free in almost all cases and therefore can be implemented without coordination.

Data link is expected to be the primary communication medium between controller and pilot. When used in the strategic environment, data link reduces the amount of voice communications required with the aircrew and, in addition, reduces communication errors.

1.4 SCOPE

This document covers the operational aspects of FAS, the AERA Services "end state," with emphasis on how, when, and why these capabilities are used. The operational aspects of IAS are included in an appendix. ATC events that involve the use of AERA Services capabilities are presented in an operational context by identifying the conditions under which the capabilities are used, the operational intent, the information controllers receive from the automation, and how the features are managed by controllers to accomplish the ATC mission.

Key assumptions and theory used to develop FAS capabilities, displays, and controller interactions are included. One of these assumptions is that ATC data link services will be available during the FAS time frame. While this document includes descriptions of the use of FAS in conjunction with data link, FAS is not dependent upon data link for implementation.

1.5 RELATED DOCUMENTS

This FAS OD is one of a set of operationally oriented documents describing how AERA Services capabilities are used by controllers to provide ATC. Also included in this set is the Controller Perspective of AERA 2, (Celio, 1990), which focuses on the controller’s role, tasks, and priorities. The AERA 2 Controller Activity Sequences (Celio, et al., 1989), includes a number of ATC event scenarios that illustrate how controllers use the automation to solve problems and manage routine situations anticipated with AERA 2. The event scenarios are intended as specific examples of the operating principles found in the Controller Perspective of AERA 2 and this OD.

This OD excludes many details such as display formats and the identifications of most of the displays upon which specific FAS information is found. These details and others such as algorithmic design and response times for automated functions are found in the appropriate companion documents. The AAS System Level Specification, (Federal Aviation Administration, 1987), the IAS NAS Change Proposal (FAA, 1992), and the Specification for
FAS, (to be published), include the functional and performance requirements that the AAS and AERA must meet, the allocation of requirements to functional areas, and the interfaces among the functional areas. At a more detailed level are the AERA 2 Algorithmic Specification, (Kirk, et al., 1991), AERA 2 APR Knowledge Base (Davis, 1992) and the AERA 2 Computer Human Interface Specification, (Kulik, et al., 1991).

1.6 ORGANIZATION

This document is organized in the following sections. Section 2 provides a brief overview of the key FAS concepts and capabilities and highlights the major assumptions of FAS's operational environment. This is followed, in Section 3, by a description of the central concepts and functionality behind automated problem detection and resolution, while Section 4 provides a description of the enhanced ATC operational capabilities that are provided by FAS. In both Sections 3 and 4, functions are described with an overview of how controllers will interact with the automation through FAS displays. Finally, Section 5 illustrates the use of FAS capabilities by describing how a typical flight would progress through the ATC system with FAS and data link operational. In this section, commonplace operational circumstances for a typical flight are traced from beginning to end through FAS automation processing. Appendix A describes how IAS will be used operationally by the controllers. This is done by illustrating the differences between FAS and IAS.
SECTION 2
FAS SUMMARY

This section describes the anticipated operational environment for FAS and the key features of FAS automation that support this environment. Some additional automation features that support FAS are also described.

2.1 THE ENVIRONMENT FOR FAS

FAS is an automated capability which primarily provides support to controllers in the prediction and resolution of problems along an aircraft's flight path. The central idea behind FAS is to detect ATC problems far enough ahead so that they can be resolved using relatively smooth maneuvers that minimally disturb the user-requested path for the aircraft. For this to occur, the future flight path of the aircraft must be stable and predictable. Such an environment is afforded in today's system by aircraft operating under Instrument Flight Rules (IFR). Pilots of IFR aircraft file a flight plan with the ATC system stating their intended flight path. They may not alter this flight path unless the changes have been approved by ATC. This provides the system with a degree of predictability. This IFR-based system predictability will continue into the future and provide the basis for FAS.

The ability of FAS automation to predict problems well into the future and generate conflict-free resolutions permits the controller's thinking to become more strategic. The strategic control environment of FAS allows most aircraft to fly extended direct routes. Less dependence on airspace and route structure in FAS results in the ATC system becoming more capable of satisfying pilot requests. Users file flight plans that more precisely correspond to their actual intent (for example, direct from departure point to destination), rather than flight plans that anticipate probable ATC constraints. FAS then attempts to keep the aircraft as close to the filed user preferences as feasible, consistent with safety.

Aircraft position data will be available as in today's system, i.e., through altitude-encoding transponders and ATC surveillance radars. However, FAS will be available in areas of interrupted or no radar coverage and in case altitude-encoding transponders malfunction.

While FAS does not require advanced aircraft equipage, it capitalizes on such equipage, when available. Flight management systems can provide more accurate flight intent data. Data link, if available, will be used as the primary form of communication between the aircraft and the ground for aircraft so equipped.

FAS has interfaces with many systems. The relationship with the Traffic Management System (TMS), illustrated in Figure 2-1, is one of the most crucial. The TMS provides the goals necessary to organize traffic nationally and locally in the aggregate. The purpose is to achieve
maximum safe utilization of saturable entities, such as airports. FAS then responds on an aircraft-specific basis to carry out the flow instructions of TMS while maintaining safe aircraft separation.

As a result of FAS, a new relationship between controllers and automation will exist. This necessitates the development and use of new ATC procedures. Training is also required to help controllers effectively utilize the new capabilities.

![Overview of the FAS Relationship to TMS](image)

Figure 2-1. Overview of the FAS Relationship to TMS

### 2.2 KEY FEATURES OF FAS AUTOMATION

FAS provides the sector controller with Automated Problem Detection (APD) capabilities. APD detects problems predicted to occur within a certain time interval in the future and provides an AERA Alert to the controller which details the nature of the problem. These types
of problems are: aircraft-to-aircraft, aircraft-to-airspace, and flow instruction. As a consequence, APD allows FAS to detect and resolve problems in a more strategic time frame than today’s radar-based control, achieving a lookahead time of up to 20 minutes for aircraft-aircraft problems, and to destination for aircraft-airspace and flow instruction problems. The computer is well suited to this task of detection, and can quickly and accurately compare all three-dimensional flight paths projected into the future. A controller attempting to do this today is faced with the difficult task of mentally projecting and comparing the aircraft flight paths based on paper flight strips. As more and more aircraft fly direct (off standard route) paths, this mental job becomes increasingly difficult.

FAS also provides the controller with Automated Problem Resolution (APR). APR generates resolutions (i.e., potential solutions) for APD-detected problems and prepares them for use by the appropriate controller. These resolutions correspond to the basic dimensions in which the controller can move an individual aircraft (left/right, speed up/slow down, climb/descend, hold). Rather than present to the controller all the resolutions that have been evaluated by APR for a particular problem however, FAS automation will present a Highest Ranked Resolution (HRR) that best meets the operational needs of the controller. If this HRR is deemed not to be operationally suitable, the FAS controller may then request that more resolutions be presented and these will be calculated and displayed within a few seconds. Further, in conditions where the Point of Violation (POV) is short, FAS will generate additional resolutions with the HRR in order to provide the controller a faster response to a request for more resolutions when it is time-critical to resolve a conflict.

In generating the resolutions, the automation considers the characteristics of each aircraft and the effects of the particular problem geometry and airspace characteristics. It orders the resolution dimensions into an operationally weighted list. Then the FAS automation generates the best resolution that solves the original problem, does not create another problem, and gives the aircraft a revised path that is as close as possible to the originally stated user preferences. This HRR is presented to the selected controller along with the AERA Alert that describes the problem. The controller may choose the HRR, request additional resolutions, or may create a resolution using Trial Planning (described later) or Controller Assisted Resolution (CAR). CAR is simply the manual mode of APR. Regardless of how an AERA Alert is solved, the lookahead time for resolutions is sufficient so that the controller has time to consider alternatives and transmit the clearance to the aircraft, and the pilot to maneuver accordingly. If enough time passes before the controller takes action so that the HRR becomes inappropriate, the automation generates a new HRR.

For aircraft-aircraft problems, up to 12 resolutions may be generated, six (i.e., left/right, speed up/slow down, climb/descend) for each aircraft involved in the problem. Hold is available as a substitute for slow down when a speed decrease cannot solve the problem. After the HRR is generated, the AERA Alert and HRR are displayed to the controller who is controlling the aircraft that is maneuvered in that resolution. Note that when the two aircraft involved in a problem are controlled by different controllers, FAS does not notify both controllers, but rather only the one who controls the selected aircraft. Figure 2-2 illustrates this concept; only the
Figure 2-2. Alert and Resolution Notification
controller of Sector 13 receives any notification of the potential conflict between UAL302 and AAL123.

Aircraft-airspace problems include predicted entry into a Restricted Area, a Military Operations Area (MOA), a severe weather area, or any other special-purpose ATC Defined Airspace. Each airspace is defined to the automation as a three-dimensional volume, with times of activation and deactivation. The automation detects when an aircraft might violate separation minima with an airspace. The lookahead time for these problems can be significantly extended to the end of flight for many airspaces, since an airspace is less dynamic than an aircraft. An HRR is generated as in the aircraft case with the AERA Alert and HRR presented to the position controlling the aircraft. More resolutions are available to the controller upon request.

Flow instructions are developed by the TMS to solve capacity-demand imbalance problems, and generally affect all aircraft that meet certain criteria. The flow instruction contains elements that identify applicable aircraft (for example, all aircraft destined for a certain airport), and the action to be taken for any aircraft in that group. The automation detects when an aircraft meets the criteria in a flow instruction and then generates a resolution which either makes the aircraft compliant with the flow instruction constraint or causes it to be exempt from the criteria. The lookahead time for these types of problems can generally be to the end of the flight.

In generating alternative resolutions for any of the above problems, APR tries to avoid creating other problems. In the unusual case, APR may find that a particular type of maneuver (e.g., turn left) cannot yield a problem-free resolution. A resolution that has problems is generally not presented to the controller unless it is specifically requested.

The APR capability also constructs composite and multiple maneuvers when single-dimension maneuvers do not suffice. Composite maneuvers are those which maneuver a single aircraft in two dimensions (for example, turn left and climb). Multiple maneuvers are those which maneuver two aircraft (either the two involved aircraft, or one of the involved aircraft, and a secondary uninvolved aircraft).

The controller and automation influence the APR process by "preferring" and "nonpreferring" certain maneuvers for certain aircraft. For instance, the controller can prefer to climb aircraft in resolving problems. APR automatically does its part by identifying specific aircraft callsigns, beacon codes, and route strings that suggest special handling. For example, an aircraft squawking an emergency beacon code, or a military aircraft during refueling, would not normally be the HRR aircraft.

The strategic control afforded by the longer lookahead times of FAS does not apply to all airspace. Around busy airports, in particular, there may be areas where control remains quite short-term or tactical, and FAS would not be operationally beneficial. Adapted areas, known as APD Inhibited Areas (APDIA), are developed to identify where APD and APR should not operate. These areas are defined by supervisory personnel and can differ by time of day, configuration of runways, and other factors.
2.3 ADDITIONAL AUTOMATION FEATURES SUPPORTING FAS

The Plan Processing capability supports the maintenance of the seven (7) AERA Plan types: Current Plans, Trial Plans, Pending Plans, Machine Plans, Protected HRRs, Dormant Current Plans, and Dormant Trial Plans. A Current Plan is that in which the pilot has been cleared and which ATC expects the pilot to fly. A Trial Plan is any plan created by the controller to test whether a proposed change in the Current Plan will be problem-free. A Pending Plan is one which the controller expects to name as the Current Plan for an aircraft after coordination with other controllers or the pilot. An APR-generated resolution is made into a Machine Plan. The HRR is made a Protected HRR when APR is automatically initiated and the HRR is problem-free. Finally, Dormant Current and Dormant Trial Plans are former plans in these categories which may serve as the basis for building a new plan at a later point in time.

Flight plan data are used to construct a four-dimensional trajectory of an aircraft's intended route of flight projected into the future. This Trajectory Estimation process can use the same information contained in today's Flight Plans, or can use additional elements, such as a desired climb or descent profile. If these additional elements are not part of the individual Flight Plan filing, the automation uses nominal values, according to aircraft type and/or equipage, in generating the trajectory.

While traversing a trajectory, the aircraft is enclosed in a region of conformance. This region is derived from conformance bounds that reflect the aircraft's ability to fly the nominal path (and thus reflect aircraft equipage and wind prediction accuracy), as well as the characteristics of the route (for example, the ground Navigational Aids [NAVAIDs] used to guide turns). Conformance Monitoring will detect when an aircraft is outside the conformance region whether it is because of pilotage, instrument failure, unexpected winds, or a control action not yet entered into the automation. Figure 2-3 depicts lateral conformance bounds for an aircraft trajectory; there are also vertical bounds that take into account climb and descent rate variances and overshoots, and longitudinal conformance bounds that take into account speed fluctuations.

The flight plan data, the trajectory, and the conformance region form the automation's knowledge of aircraft intent. Based on these data, problems are detected and APR generates resolutions to problems. Thus, it is critical that the automation contain the latest and most accurate data. If the aircraft's intended route of flight changes (because of controller instructions), the data in the automation must be updated in a timely manner.

When an aircraft is found to be out of conformance, Reconformance immediately constructs a new internal plan for the aircraft, attempting to make the automation's knowledge agree with the actual aircraft flight. One exception to this is for "vertical drift" out-of-conformances, in which the aircraft is nominally in level flight, but "drifts" higher or lower. In this case, the controller will coordinate with the pilot of the aircraft to determine what action is necessary. For lateral and vertical nonconformance, and longitudinal resynchronization due to a missed or unplanned maneuver, the automation notifies the controller that the aircraft has passed outside
of its conformance bounds. The controller then takes any action necessary to ensure that computer, controller, and aircraft are operating on the same basis of aircraft intent.

The Future Situation Display (FSD) assists the controller in evaluating ATC situations and in choosing or creating resolutions. This display shows the predicted position of each aircraft at a selected time in the future. This time may be selected to relate to a particular problem, or to be some number of minutes in advance of the current time. The controller may display selected resolutions as well. The controller can move the display forward or backward in time. The capabilities of the FSD greatly reduce the utility of electronic flight strips to the extent that the strips need not be routinely displayed to obtain flight information. Selected ones are displayed when they relate to a problem, or upon controller request.

Trial Planning is available to assist the controller in evaluating possible changes to an aircraft's path. These changes can be the result of an in-flight request from an aircraft's pilot or the need for the controller to respond to a new ATC situation. The controller can create a Trial Plan reflecting the proposed change. The automation checks for problems associated with a proposed plan change before a revised clearance is issued to the aircraft. The controller can delete the Trial Plan, modify it, or issue it as a clearance to the aircraft. There is also an analogous capability to test the consequences of implementing a new controlled airspace. To use this capability, the controller specifies a "trial" airspace and asks the automation to list all

Figure 2-3. Lateral Conformance Bounds for an Aircraft Trajectory
aircraft that would be in predicted or actual conflict with that airspace were it implemented. This information aids in deciding whether to implement the trial airspace, with or without changes; the automation supports both modification and implementation.

Using a variation of Trial Planning called Quick Trial Planning, the controller can request a set of Trial Plans that vary in a specific dimension. For example, if the specified dimension is "vertical," the automation produces Trial Plans for several altitude transitions and informs the controller whether any are problem-free.

The controller can invoke Automated Replan on a Trial Plan that contains an APD-detected problem. The Trial Plan is then checked periodically, and when it becomes problem-free, the controller is notified automatically. This capability helps the controller respond to user requests in a timely manner with minimal impact on controller workload.

Since the APD and APR capabilities have a long lookahead time, detection (and resolution where necessary) can extend into adjacent sectors. As a result, a controller usually can issue problem-free clearances without coordination with other controllers because the automation works across sectors. When coordination is required (for example, when requesting another controller to move an aircraft), the controller's job is simplified by Automated Coordination, a non-verbal exchange via the automation. A controller is able to use this capability to ask the current controller of an aircraft to maneuver it to solve a presented problem; this capability can also be used to inform other controllers of a planned action.

FAS's problem detection and resolution capabilities also allow Automatic Acceptance of Handoffs when the handoff was automatically initiated. This feature will relieve the controller of having to project the trajectories of aircraft before accepting handoff.

The controller's task of issuing clearances to aircraft, and also that of updating the automation's database, is simplified in two ways. First, if the new clearance is one generated by the automation, the associated Clearance Language is provided, and only controller approval and delivery is needed. Second, when the aircraft is data link equipped, the entire clearance can be delivered to the aircraft by the same simple controller approval process. In this event, the new clearance is automatically protected (as is the current clearance) during the time it takes to complete the full data link cycle. If there are any problems or data link failure conditions, the controller is notified. Data link capabilities can also be used by the pilot to downlink flight plan amendment requests, if available.

Reminders are provided to controllers for certain control actions. These reminders include notifications that a previously planned altitude maneuver, or Top of Descent (TOD) Point, is a parameter time away for the aircraft; that an aircraft has not provided a position report at a mandatory reporting point; and that a flight will change from IFR to Visual Flight Rules (VFR) before reaching its destination. If data link is available and an aircraft is so equipped, the TOD Point reminder will be provided to the aircraft; otherwise, the controller will receive this notification.
Also available to help the controller evaluate the future movement of aircraft in the sector are Sector Activity Measures. They indicate how sector activity will evolve over the next 30-60 minutes in terms of traffic count and complexity.

Finally, capabilities are provided for aircraft that have not departed. For instance, a proposed flight plan can be checked against flow instructions and certain airspaces. This Predeparture Check provides an initial clearance for an aircraft that avoids known ATC constraints applicable at the time of departure.
SECTION 3

AUTOMATED PROBLEM DETECTION AND RESOLUTION

This section describes the key FAS operational components of Automated Problem Detection (APD) and Automated Problem Resolution (APR). APD provides improved conflict-detection capabilities to controllers, while APR assists controllers in resolving problems automatically detected in aircraft Plans. An understanding of how APD and APR works may be obtained through an overview of the automation processing support, automated conflict support, alerts and notices, controller actions, and planning and replanning aids provided by this functionality.

3.1 AUTOMATION PROCESSING SUPPORT

APD and APR are dependent upon a number of automation support capabilities. To assist the controller with advanced ATC planning, the activities performed by the automation assist with the determination of predicted position, data management, and the conformance between predicted position and track data. The specific capabilities include:

- Trajectory Estimation
- AERA Plan Processing
- Flight Data Base Processing
- Conformance Monitoring
- Reconformance

A major portion of this foundation relates to the categorization, manipulation and maintenance of the large volume of data used by the automation. Sections 3.1.1 through 3.1.5 discuss the organization and maintenance of this data to prepare the reader for the later discussions (beginning with Section 3.2) of the FAS capabilities that depend on the data.

3.1.1 Trajectory Estimation

A fundamental AERA concept involves the representation of aircraft intent to the automation functions. The basic construct for communicating aircraft intent is trajectory, which is a mathematical model of an aircraft's current and future position in four-dimensional (x = latitude, y = longitude, z = altitude, t = time) space. Thus, an aircraft's trajectory conveys to the automation a precise prediction of an aircraft's position at any point in time for the duration of the flight. This information is used extensively by the automation and is updated as necessary to maintain accuracy as aircraft intent changes.
Trajectory Estimation is the function which calculates aircraft trajectories for FAS. Trajectory Estimation uses the following data to construct aircraft trajectories:

- Flight Plan and other AERA Plan Data
- Fix and Airway Data
- Environmental Data (such as winds and temperatures aloft)
- Aircraft Characteristics Data (such as climb and descent rates, weight)
- Track Data

In order to build the most accurate trajectory possible, AERA will process aircraft characteristic data on a flight-specific basis. If aircraft operators do not supply flight-specific data, AERA will use generic data based on aircraft type that will not be as accurate. Track data are used to keep the trajectory data in close conformance to the aircraft’s actual position.

A trajectory is built by starting at an initial position. Future positions are constructed as a series of straight-line segments joined by their end-points, called cusps. Trajectory Estimation constructs a trajectory in an iterative fashion, one segment at a time. Figure 3-1 illustrates a complete trajectory with cusps and segments.

Figure 3-1. Trajectory Estimation
3.1.2 AERA Plan Processing

The primary data used to derive a trajectory are referred to as Plans. FAS supports a number of Plan types, as described below.

The Flight Plan is defined as the data submitted to the ATC system about the course of a flight and is an electronic representation of those data. The Flight Plan contains a record of those data for use by the automation; there is no trajectory associated with it. Specifically, the FAS Flight Plan includes the following data fields:

- **Required**
  - Altitude
  - Callsign
  - Coordination Fix
  - Coordination Time/Elapsed Time to Coordinate Fix
  - Departure Point
  - Departure Time
  - Equipment
  - Route
  - Type of Aircraft
  - True Air Speed

- **Optional**
  - Alternate Destination
  - Average Descent Rate
  - Average Fuel Burn Rate
  - Average Takeoff Climb Rate
  - Beacon Code
  - Cruise Speed Schedule
  - Destination
  - Estimated Elapsed Time to Destination
  - Flight Rules
  - Heavy Jet Indicator
  - Maximum Altitude Capability
  - Model Number
  - Mode S Code
  - NOPAR Indicator
  - Number of Aircraft
  - Remarks
  - Tail Number
  - Type of Flight
  - Weight
FAS also supports seven (7) additional types of Plans, collectively referred to as AERA Plans, that are the primary tools for conveying and manipulating actual and proposed aircraft intent. These AERA Plan types are:

- **Current Plan** - The Plan which the pilot is cleared to fly—i.e., the Plan which the controller and the pilot have agreed that the aircraft will follow.
- **Dormant Current Plan** - A former Current Plan stored for possible reexamination by a controller.
- **Pending Plan** - A Plan which the controller expects to clear a pilot to fly—i.e., the Plan the controller expects will be the aircraft's next Current Plan.
- **Trial Plan** - A Plan that is a proposed change to the Current Plan that needs to be evaluated for problems.
- **Dormant Trial Plan** - A former Trial Plan stored for possible reexamination by a controller.
- **Machine Plan** - A Plan created by APR to resolve a problem.
- **Protected Highest Ranked Resolution (HRR)** - The best Machine Plan available to resolve a problem. If a Current Plan problem is addressed, no Pending Plan exists for the involved aircraft, and the created HRR is problem-free, then the created Machine Plan is called a Protected HRR.

The characteristics of each type of Plan are described further in the following subsections.

AERA Plans can be introduced into the system (i.e., initiated) and deleted automatically or by controller action. Depending upon Plan type, initiation can be accomplished by manual creation from scratch, by copying and/or modifying an existing Plan, or by changing the status of an existing Plan. Figure 3-2 illustrates the primary Plan status transitions.

There are specific rules applied to each Plan to render it obsolete after a certain time, and the automation deletes it or reduces its status accordingly. This feature helps maintain and limit the size of the Flight Data Base Processing (Section 3.1.3) and prevents the use of Plans with outdated information. All Plans for a flight are automatically deleted a parameter time after the flight terminates.

The expanded set of Plans in FAS provides ATC system benefits that include improved methods for planning and coordinating aircraft movement, automatic establishment of complete descriptions of a planned maneuver so that implementation as the Current Plan will require only a single action, easy access to Plan data in and out of active use, improved communications between controllers, and better management of data storage. AERA Plans have distinct
operational roles in assuring that an expected variety of operational needs are met. Each type of AERA Plan is described below.

Figure 3-2. Progression of Plans
3.1.2.1 Current Plan Characteristics

The purpose of the Current Plan for a flight is to represent the agreement between the pilot and ATC for what the aircraft is expected to do. The Current Plan includes all data applicable to the flight including the trajectory and associated conformance bounds, a speed schedule, an altitude profile and all information essential for delivery of the clearance by voice or data link.

There is exactly one Current Plan for a flight. The Current Plan is automatically initiated for a flight upon successful completion of processing for a filed Flight Plan. The owner of the Current Plan is always the position currently controlling the associated flight and ownership transfers are performed automatically upon handoff. Only the owner of the Current Plan for a flight (termed the "current position") is allowed to manually amend, replace or delete it. The current position can implement any Protected HRR, Pending Plan, Machine Plan or Trial Plan as the Current Plan with a single action. Such a status change may be implemented even when the Trial Plan, Machine Plan, Pending Plan or Protected HRR has been identified as having problems detected by APD. The current position can manually amend the Current Plan to initiate a new Current Plan. A new Current Plan can also be initiated automatically by the Reconformance function (Section 3.1.5). The current position for an aircraft is the only position allowed to issue a clearance for that aircraft, initiate Automated Replan for that aircraft, or initiate a Control Transfer for that aircraft.

3.1.2.2 Dormant Current Plan Characteristics

The purpose of Dormant Current Plans is to provide a mechanism for the retrieval of data associated with former Current Plans. A Dormant Current Plan includes all the data from the associated Current Plan except the trajectory. Each Dormant Current Plan contains enough information for generation of (and editing of, if necessary) a Trial Plan, and can be made a Trial Plan by controller action.

A Dormant Current Plan is automatically created when a Current Plan is replaced or when a Current Plan's route, altitude profile or speed schedule is amended. Resynchronizations do not cause creation of a Dormant Current Plan. Dormant Current Plans may be retrieved by a controller. This capability is similar in function to the "strip bucket" used in today's system as a repository for (paper) flight progress strips discarded from the position's strip bay.

A Dormant Current Plan for a flight is initially owned by the position that owned the Current Plan that was replaced or amended (the current position). When an aircraft handoff occurs, the ownership of Dormant Current Plans for that aircraft is automatically transferred to the receiving position. At flight termination, the Dormant Current Plans for that aircraft are deleted. At any given time, up to two Dormant Current Plans may exist for each aircraft. Whenever a Dormant Current Plan is created for an aircraft for which two already exist, the oldest Dormant Current Plan for that aircraft is deleted.
3.1.2.3 Pending Plan Characteristics

The purpose of the Pending Plan is to ensure that a Plan receives continual problem detection in preparation for being implemented as the Current Plan. Like the Current Plan, the Pending Plan includes all the data applicable to the flight including the Pending Plan trajectory, the associated conformance bounds and all information essential for clearance delivery by voice or data link. The automation will support at most one Pending Plan or Protected HRR per aircraft at any given time. A controller at the current position can manually create a Pending Plan. The Pending Plan for an aircraft can be initiated by changing the status of a Trial Plan or Machine Plan for that aircraft. This status change can be manually performed by a controller at the current position, by Automated Replan (Section 3.5.2.3), through Automated Coordination (Section 4.1.1), or by the automation upon clearance delivery via data link (Section 4.2.2).

In general, the Pending Plan has a limited lifetime since it is expected to become the Current Plan a short time after its initiation. When the Pending Plan is not made the Current Plan within a specified time, it is demoted automatically to Trial Plan status because the purpose of the Pending Plan is a short-term method of receiving continual APD protection.

The Pending Plan for an aircraft is owned by the position currently controlling the associated aircraft. Unlike the Current Plan, there is some flexibility in the transfer of ownership upon handoff. Normally, Pending Plan ownership is transferred to the receiving position upon handoff. The Pending Plan's owner can direct automation not to transfer ownership of the Pending Plan at handoff. This direction is followed, and the Pending Plan is deleted at handoff, unless the Pending Plan is subject to Automated Coordination.

3.1.2.4 Trial Plan Characteristics

The purpose of a Trial Plan is to assist controllers in the evaluation of proposed changes to another Plan, particularly with respect to the existence of problems. A Trial Plan for an aircraft includes all the data applicable to the flight as described for the Current Plan, plus additional data to describe the amendment or proposed change. The Trial Plan trajectory is calculated based on the amendment and the trajectory of the Plan to which the amendment is applied. Also included are the associated conformance bounds and information essential for clearance delivery by voice or data link.

Trial Plans can be initiated manually or automatically. Any controller can create a Trial Plan from scratch or by copying (and possibly modifying) any other Plan, whether it is a Current Plan, a Pending Plan, a Protected HRR, another Trial Plan, or a Machine Plan. The controller can also initiate a Trial Plan by retrieving a Dormant Trial Plan or a Dormant Current Plan and modifying it. A Trial Plan may be created from the pilot's originally filed Flight Plan. A controller at any position can initiate a Trial Plan for any flight from any other Plan regardless of which position owns the Plan or whether the aircraft is under their control. A Trial Plan can also be initiated manually by demoting a Pending Plan. Trial Plans can be initiated
automatically by Quick Trial Planning, Automated Replan and upon receipt of certain data link messages from an aircraft.

Since they are used in so many ways, a limit for the number of Trial Plans allowed per aircraft does not exist, but each Trial Plan has a limited lifetime. Trial Plans are deleted automatically when the time limit is reached because APD is invoked automatically only upon their creation; the problem information is not updated automatically and therefore may be obsolete. When the Current Plan for a flight changes, any Trial Plan (except those created by Automated Replan) based upon that Current Plan is deleted because the Trial Plan may no longer correspond to the Current Plan. There is a facility-wide limit on the total number of Trial Plans for which storage is available. The oldest Trial Plan in the facility is deleted automatically when the limit is reached. Deletion rules for Trial Plans created by Automated Replan are found in Section 3.5.2.3.

When a Trial Plan is initiated manually, the owning position is the position from which the Trial Plan was initiated. When a Trial Plan is initiated automatically (upon receipt of a Flight Plan Amendment, Top of Descent Preference, or IFR Clearance Activation Request data link message; by Automated Replan; by specification of an HRR or Machine Plan for simultaneous checking), ownership is assigned to the current position. A Trial Plan created due to a cancellation of, or subtraction of, an individual aircraft or a group from a group, or an Altitude Reservation (ALTRV), is owned by the position controlling the group or ALTRV. A Trial Plan manually initiated by a status change to a Pending Plan is owned by the position that owned the demoted Pending Plan. Ownership of Trial Plans can be transferred both manually and automatically. The owner of a Trial Plan can manually transfer ownership to another position. The owning position can request ownership transfer for a Trial Plan and designate the transfer be performed at handoff to the position receiving handoff. Trial Plans created automatically by Automated Replan or upon receipt of a data link message have ownership transferred automatically to the receiving position upon handoff. Ownership transfer for Trial Plans upon handoff helps the new controller deal with pilot requests or existing problems for which the Trial Plan may provide a resolution.

### 3.1.2.5 Dormant Trial Plan Characteristics

The purpose of a Dormant Trial Plan is to provide a method of storing and retrieving Trial Plan data for a Trial Plan that has been deleted. Dormant Trial Plans contain all the Trial Plan data except the trajectory. This provides a method for the controller to retrieve old Trial Plan data that could be used to construct other Trial Plans without the controller reentering the data. It also allows the controller to easily remember the "what-if" cases that were tried previously.

A Dormant Trial Plan is generally initiated when a Trial Plan is deleted. When an aircraft is handed off, all Dormant Trial Plans owned by the position initiating handoff are deleted.
3.1.2.6 Machine Plan Characteristics

The purpose of a Machine Plan is to provide a formal representation of the maneuver(s) for an aircraft included in a resolution generated by APR. A Machine Plan includes all the data applicable to a Current Plan, including:

- The Plan constructed by APR
- The trajectory corresponding to the resolution's change to the Plan with the problem and the associated conformance bounds
- A description of the resolution maneuver (e.g., maneuver start time, turn angle)
- The expiration time for the resolution (the time by which the clearance must be issued)
- Any objections or undesirable characteristic of a resolution (e.g., the failure to provide a conflict-free resolution)
- All preferences and nonpreferences that apply
- All essential information for clearance delivery by voice or data link

The initial owner of all Machine Plans produced for a problem is the position to which the AERA Alert is displayed or the position that initiated APR processing. The owner of a Machine Plan can transfer its ownership to a designated position. When ownership of any Plan is transferred upon aircraft handoff, ownership of any Machine Plans in existence for a problem in that Plan is automatically transferred.

A Machine Plan is initiated to represent the maneuver(s) for one aircraft moved by a resolution. When a resolution moves two aircraft, two Machine Plans are initiated. A Machine Plan has a limited lifetime since the resolution is based on the operational environment at the time the problem is detected and is not automatically updated. After a specified amount of time these data can no longer be considered valid. A Machine Plan is deleted automatically under conditions dictated by APR, or after flight termination.

3.1.2.7 Protected HRR Characteristics

The HRR is the resolution which is ranked highest among those Machine Plans generated by APR in response to a particular problem. HRRs are provided for all of the operational modes of APR except for additional resolutions that may be requested. The HRR is operationally significant because it is considered by the automation to be the best solution for a problem. It is provided to the position which controls the aircraft to be moved in the HRR, with the expectation that the controller will likely use a HRR to solve the problem. As a result, a
Protected HRR is created and processed like a Pending Plan (i.e., provided continual checking by APD), when the following conditions occur:

- The HRR is for a Current Plan problem
- No Pending Plan exists for the involved aircraft
- APD finds the HRR to be problem-free

Protected HRRs have a lifetime equal to the expiration time of their resolutions. Protected HRRs are deleted at their expiration time when resolutions are regenerated. A Protected HRR is demoted to a Machine Plan when the controller creates a Pending Plan for the aircraft or when the controller manually changes the status of the Protected HRR.

3.1.3 Flight Data Base Processing

FAS software includes data storage and retrieval capabilities to efficiently store, modify, retrieve, and delete data used by controllers and automation. Flight-related data necessary to support automated planning, problem detection, and problem resolution functions are said to be contained in the Flight Data Base. The Flight Data Base includes the following data for each controlled aircraft:

- The filed Flight Plan (i.e., an electronic representation of the Flight Plan filed with ATC as received by the ACCC)
- The Flight Plan as processed by the ACCC, including Flight Plan amendments
- The Current Plan for the flight, including the trajectory for the aircraft
- The current set of User Preferences (UPs) for the aircraft, including UP-Route, UP-Altitude profile, and UP-Speed schedule. The UPs indicate the pilot's preferred path to destination. User Preferences are initialized based on the pilot's filed Flight Plan, and can be updated when the pilot's preferred path changes. The automation considers a resolution's deviation from the UPs, assigning higher rank to resolutions with smaller deviations from the UPs.
- The current set of System Preferences (SPs) for the aircraft. SPs include specialized constraints applied to the aircraft's route during Route Processing (e.g., a named route must be flown between two points or a specific fix or altitude must be in the route). SPs also include time-based flow instruction constraints and maneuvers generated by APR to comply with a flow instruction. When generating resolutions to a problem (Section 3.2.2.3), the automation nonprefers resolutions that do not conform to SPs.
The Metering Decision Points (MDPs) for the flight. Each MDP is a point where the trajectory is checked to determine whether the aircraft will reach a meter fix or boundary crossing within the time range associated with that point.

All other Plans associated with the flight (Trial Plans, Machine Plans, Dormant Current Plans, Dormant Trial Plans, and not more than one Protected HRR or Pending Plan), plus their calculated trajectories where applicable.

Aircraft- and flight-specific data required for Automation Processing. For example, "engine type" is aircraft-specific; it may not be constant for all aircraft of a particular model. "Fuel load" is flight-specific; it differs from flight to flight for the same aircraft. Nominal data for the class of aircraft of which this aircraft is a member will be used where aircraft- and flight-specific values are not provided.

FAS uses these data to improve significantly the ability to detect problems and support development of efficient resolutions that comply with system constraints and satisfy users' needs.

3.1.4 Conformance Monitoring

Associated with Trajectory Estimation is the notion of conformance, a measure of accuracy for the trajectory. At any given time, an aircraft is in conformance when its track position (at that time) is within a specified distance of its trajectory-predicted position (at that time) vertically, laterally and longitudinally. An aircraft is in conformance laterally when its track position is within a tolerance distance right or left of the centerline of the flight path represented by its trajectory. An aircraft is in conformance vertically when its track position is within a tolerance distance above or below the altitude or the expected climb or descent path according to its trajectory. An aircraft is in conformance longitudinally when its track position is within a tolerance distance ahead or behind of its longitudinal position according to its trajectory. The tolerances allowed in each dimension define the conformance bounds in that dimension. The union of all the conformance bounds at a given time define a volume of airspace called the conformance region. When an aircraft's track position is within the conformance region associated with its trajectory at that time, it is said to be in conformance.

Conformance between an aircraft's track position and its position as predicted in the Current Plan trajectory must be maintained to assure the validity of the trajectory-based data provided by the automation. The controller's role in maintaining conformance is to assure that the data base used by the automation accurately reflects what the aircraft is doing. Conformance Monitoring automatically and periodically monitors conformance between the trajectory-predicted position for an aircraft and the position of the aircraft according to the radar-based track or pilot reports. When radar coverage is not available or the aircraft has been designated for nonradar separation, Conformance Monitoring is based on controller-entered pilot position and altitude reports in lieu of surveillance reports.
The size of a conformance region is based on factors in the operational environment that affect the anticipated accuracy of aircraft navigation. Factors affecting the conformance bounds include aircraft equipage (e.g., electronics to use Very High Frequency Omnidirectional Range [VOR], and Distance Measuring Equipment [DME]), location and status of Navigational Aids (NAVAIDs), maneuvers in the route, availability of radar coverage, military considerations such as formations, the assigned altitude, altitude transitions and the availability of valid altitude reports from aircraft equipment.

An example of how lateral conformance bounds are adjusted to reflect the potential for imperfect navigation, particularly when maneuvering, is illustrated in Figure 3-3. The lateral conformance bounds also reflect the fact that navigation depending on NAVAIDs is more uncertain as the distance from the NAVAID increases.

![Figure 3-3. Lateral Conformance Bounds](image)

The size of the conformance region is adjusted when radar coverage is unavailable, such as during an equipment failure or in adapted nonradar areas. A controller also has the option to declare an aircraft as subject to either radar or nonradar separation standards. For aircraft under nonradar standards, the conformance bounds associated with that part of the trajectory in the nonradar area may be enlarged. Pilot altitude reports are also used when the aircraft equipment is not providing valid altitude data (e.g., when the altitude-encoding transponder fails). Conformance bounds are expanded to reflect the additional uncertainty in this case.
Lateral nonconformances include when the route is straight and the aircraft drifts outside a lateral conformance bound or when a planned maneuver incorporated in the trajectory is performed so late or so early that the lateral conformance bounds are crossed. Vertical nonconformance occurs under three conditions:

1. The aircraft is in level flight and drifts vertically, or

2. A planned vertical transition is performed early or late and thus a vertical conformance bound is crossed, or

3. An altitude transition is imprecisely executed and the aircraft drifts outside the vertical conformance bounds.

Vertical nonconformance occurs under three conditions:

1. The aircraft is in level flight and drifts vertically, or

2. A planned vertical transition is performed early or late and thus a vertical conformance bound is crossed, or

3. An altitude transition is imprecisely executed and the aircraft drifts outside the vertical conformance bounds.

Longitudinal nonconformance occurs due to the speed of the aircraft not matching the trajectory's speed. This can occur because of inaccurate wind data or an unexpected speed change by the aircraft.

3.1.5 Reconformance

The Current Plan trajectory is adjusted automatically (i.e., reconformed) when the associated aircraft is found to be out of conformance vertically, laterally, or longitudinally, except when an aircraft in level flight drifts vertically out of conformance. In this situation, the controller must confer with the pilot of the aircraft to determine his intention and what action is necessary. Reconformance is performed using the radar-reported or pilot-reported position and the assumption that the aircraft intends to comply with its clearance. The reconformance will adjust the trajectory so that it agrees with the surveillance-reported or pilot-reported position and the current performance characteristics of the aircraft, such as the climb rate.

The controller is notified of all out of conformance detections and reconformances except longitudinal nonconformances (called resynchronizations) other than missed or unplanned speed maneuvers. The position controlling the aircraft gets the notification with the dimension of nonconformance, description of the updated route of flight, and the number of reconformances that have occurred within a short time. When APD detects a problem involving a recently reconformed aircraft, the controller is notified of the recent reconformance.

Reminders and data link applications discussed in Sections 4.2.1 and 4.2.2, respectively, highlight the automation features provided to help controllers actively manage and maintain aircraft conformance.
3.2 AUTOMATED CONFLICT SUPPORT

APD uses trajectories and other data characterizing the operational environment to check for, and to provide early warnings of, situations in which applicable separation standards potentially will not be assured. APR assists controllers in the resolution of problems detected by APD. APR generates resolutions to problems detected between two aircraft trajectories (aircraft-to-aircraft problems), between an aircraft trajectory and an airspace volume (aircraft-to-airspace problems) and between an aircraft trajectory and a flow instruction (predicted or actual noncompliance with flow instructions). This allows controllers to plan aircraft movements strategically and minimizes the need for tactical maneuvers.

Before focusing attention on the interactional aspects of the automated detection and resolution of problems in Sections 3.3 and 3.4, it is useful to examine the concepts and operational principles that motivate how problems are detected and resolutions are generated by FAS automation. While most of these aspects of APD and APR will be transparent to the controller, effective usage of the automation depends on an appreciation of these behind-the-panel characteristics.

3.2.1 Automated Problem Detection

APD strategically detects problems with Current Plans, Pending Plans, Protected HRRs, Trial Plans, and Machine Plans. The type of problems detected by APD include aircraft-to-aircraft conflicts, aircraft-to-airspace conflicts, and flow instruction noncompliances. Controllers use APD problem information as the basis for decisions regarding when and how to maneuver aircraft. The APD problems can be solved by the APR capability, either automatically or upon request by position, depending on the Plan type.

Three functional components describe APD processing: Conflict Probe, Separation Criteria, and Operational Constraints. These are discussed below.

3.2.1.1 Conflict Probe

APD’s conflict probe capability relies on the accuracy of projected trajectories of controlled aircraft and their allowable conformance regions. Using these trajectories, APD checks all non-dormant Plan types for potential problems between aircraft, violations of adapted strategic airspaces, adapted and temporary Planning Region Airspaces and Minimum Safe Altitude Warning (MSAW) areas, and violations of metering and flow instructions. APD detects problems predicted to occur within a certain time interval in the future—the lookahead time—using airspace and flight specific separation criteria. APD checking can be disabled at anytime for specified airspaces or aircraft.

As previously indicated (Section 3.1.1), an aircraft trajectory is a representation in x, y, z, and t coordinates of the path an aircraft is expected to take from the current time until destination. It is based on the flight intent recorded in the Plan, aircraft characteristics adapted
for the aircraft type or input for the specific flight, and environmental data such as winds and temperatures aloft. Conflict probe is based on the assumption that aircraft may be physically located anywhere within a three-dimensional conformance region representing the allowable deviation of actual aircraft position from the trajectory estimate. The size and location of the conformance region around an aircraft’s position on its trajectory is defined by conformance bounds. These conformance bounds represent possible uncertainty, in the three dimensions, between the actual position of the aircraft and the trajectory estimate. Uncertainty in projecting aircraft position occurs because of winds, equipment variations, pilot handling of the aircraft, aircraft performance rates, and inexact data measurements.

### 3.2.1.2 Separation Criteria

APD’s separation criteria reflect operational concerns and physical realities. Expanded vertical protection is provided to an aircraft during an altitude transition to account for the additional positional uncertainty. Similarly, at higher altitudes, vertical separation criteria reflect the limitations of the pressure sensing equipment.

Since system uncertainty contributes to a very dynamic air traffic system, problem detection, particularly long term detection, is based on probabilistic predictions. These predictions must balance probabilistic uncertainty with operational utility. If alerts are declared too far in advance, there would be an operationally unacceptable number of alerts generated for aircraft that would eventually miss by a distance substantially greater than separation standards. This would increase workload, reduce system capacity by protecting large volumes of airspace for individual aircraft, and reduce controller confidence in the system. On the other hand, if alerts are delayed to ensure the probabilistic certainty of calling the alert correctly, the advantages of strategic problem detection could be lost. Thus, the APD performance requirements for aircraft-to-aircraft problems are somewhat complex. The average warning time for alerts, for example, is 15 minutes with 97.5 percent of the alerts with at least eight minutes warning. All alerts must be declared with more than three minutes prior to the violation of separation standards. Since safety is of utmost importance, the requirements for problem detection are skewed to minimize the number of missed alerts and be tolerant of alerts where the missed distance is greater than, but near, the separation standards. Figure 3-4 provides a graphic representation of this relationship.

APD checks plans for problems by basing separation criteria on standards defined in FAA Order 7110.65, both radar and nonradar, and conformance bounds calculated for the flight. Problem detection is done repeatedly for Current Plans, Pending Plans, and Protected HRRs, but on a one-time (snapshot) basis for Trial and Machine Plans. APD checks separation in both vertical and horizontal (lateral/longitudinal) dimensions.
To check for vertical separation, APD makes a straightforward application of current, manual separation procedures, using trajectory data without explicit consideration of vertical conformance bounds. APD considers level aircraft to be separated vertically when the trajectory altitudes differ by the required vertical separation standards, assuming there is little downstream uncertainty associated with vertical position of level aircraft. For transitioning aircraft, APD uses conformance-based separation checking. Conformance regions account for vertical deviations that allow for late or early start time, and a range about the nominal rate of climb/descent. Vertical conformance regions and their impact on APD vertical separation checking are illustrated in Figure 3-5.

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APD’s horizontal separation check accounts for both lateral and longitudinal deviations from the trajectory. Nominal conformance bounds are associated with trajectory segments having no turns or speed changes. For trajectory segments within a parameter distance of a turn or speed change, nominal conformance bounds are adjusted to allow for early or late start of the maneuver. APD determines the minimum distance between each pair of trajectory segments. The encounter geometry of the two trajectories (e.g., merging, in-trail, or crossing) determines the amount of airspace protected by the conformance amount. Aircraft are in conflict when the minimum distance between trajectories is less than the separation standard plus the conformance amount.

Figure 3-5. Vertical Separation Checking
3.2.1.3 Operational Constraints

Alert determination in APD considers time to minimum separation and problem-specific characteristics. The APD lookahead time depends on several factors including the type of problem for which APD is checking and the type of Plan being checked. In checking Current Plans, Pending Plans, and Protected HRRs for aircraft-to-aircraft problems, the lookahead time is the same (nominally, up to twenty minutes) and is defined by a system parameter. When APD checks a trajectory associated with any Plan for aircraft-to-airspace problems or flow instruction violations, the lookahead time is the entire flight duration, reflecting the less dynamic nature of airspaces and flow instructions. The lookahead time for Trial Plans is also defined by a system parameter that is distinct from the lookahead parameter for Current Plans, Pending Plans, and Protected HRRs. This is so that the two parameters can be set to different values if desired. Machine Plans are checked for problems the same parameter time into the future as Trial Plans, but are also checked for a parameter lookahead time farther into the future for purposes of ordering resolutions.

APD is applied to all airspaces for which there is an operational advantage. To accommodate operational needs, each facility can define volumes of airspace within which APD will be inhibited. An APD Inhibited Area (APDIA) can be defined during adaptation. The APDIA can be an airspace surrounding an airport within which APD is inhibited due to the tactical nature of the environment. A facility supervisor or Traffic Management Coordinator (TMC) will be able to define additional APDIAs and activate or deactivate APDIAs. Every airport will include APDIAs as part of their configuration. The size and shape of the APDIA can be adjusted as required, based on operational needs.

Another method of controlling APD's scope is through exemptions. Exemptions to problem detection can be applied to individual aircraft. An aircraft identified as a member of a group can be exempt from detection of aircraft-to-aircraft problems with other aircraft in that group. Aircraft identified to the automation as operating with an Altitude Reservation (ALTRV) are exempt from aircraft-to-aircraft problems with each other. Aircraft operating as a group or ALTRV will have a designated aircraft identified as the leader, around which formation limits are defined for use by APD in detection of problems as though the group or ALTRV is a single aircraft. While an aircraft is exempt from detection of aircraft-to-aircraft problems, no notification of the existence of such a problem is generated for any of the aircraft's Plans.

Individual aircraft also can be exempted from detection of aircraft-to-airspace and flow instruction problems. Activation and deactivation of an exemption is possible from the TMC position and the position controlling the aircraft. An aircraft is automatically exempted from detection of an aircraft-to-airspace problem when the airspace identifier appears in the Flight Plan for the aircraft. The exemption applies to all Plans for the aircraft. No notification of the existence of a problem is generated for any of the aircraft's Plans while the exemption is active.
3.2.2 Automated Problem Resolution

APR assists the controller in resolving problems detected by APD. A resolution for a problem is composed of one or more maneuvers, called resolution maneuvers, which are different from maneuvers in the original Plan with the problem. A resolution refers to any Plan generated by APR for controller consideration.

APR can operate in five modes:

1. **Automatic Mode.** APR is automatically initiated for all problems detected in Current Plans, except for encounters with Notify-only airspaces and conflicts with short-term predicted track positions. In this mode, APR may generate only a Protected HRR. If the time to violation is short, APR generates some additional resolutions so that, if the controller requests additional resolutions, the automation can respond in the shortest time possible. The Protected HRR is determined using the process outlined below of Problem Analysis (Section 3.2.2.1), Resolution Ordering (Section 3.2.2.2), and Resolution Generation (Section 3.2.2.3).

2. **Trial Plan Mode.** APR can be automatically initiated for problems in Trial Plans (except for Trial Plans generated by Automated Replan and Quick Trial Planning). The controller has the option of enabling this feature to operate automatically. APR treats the resolution process as if it was a new problem, going through all of the processing steps except that problem set formation needs to be tailored to the problems identified with the Trial Plan rather than the Current Plan for that aircraft. An HRR is produced as a result, not a Protected HRR.

3. **Controller-Assisted Mode.** The controller can manually initiate APR at any time for problems detected by APD in any specific plan; Current, Pending, Protected HRR, Machine, or Trial. This can be any problem including a Notify-only airspace encounter, but not a conflict with a short-term predicted track position. APR treats the resolution process the same as if it was a new problem, going through all of the processing steps, except that problem set formation is tailored to the problem or plan specified.

4. **Regeneration Mode.** APR is automatically invoked when certain conditions cause a regeneration of resolutions. Some possible conditions are when the Protected HRR expires, the problem information changes (reconformance occurs), or external factors involved in resolution generation change (NAVAID fails or APDIA changes). APR treats the resolution process the same as if it was a new problem, going through all of the processing steps.

5. **Additional Resolutions Mode.** For any of the problems that have been initially resolved by APR, the controller can request additional resolutions. This request can take several forms, including:
a. For a request for the "Next Best" resolutions, APR will use the problem analysis and resolution ordering results already completed for the problem and continue the resolution generation process used to build the HRR to build 3 more resolutions that are the next best.

b. For a request for all of the resolutions in a specific dimension (e.g., laterals for both aircraft), APR will provide those specific resolutions that can be built without objections and are single dimension maneuvers (no composite or multiple maneuvers). Resolution ordering data is not used to determine which resolution alternative to construct.

c. For a request for a resolution in a specific dimension, direction, and aircraft, APR will build a resolution that includes that maneuver. Even a resolution with an objection may be returned.

APR processing goes through several logical steps to select and generate an HRR/Protected HRR and possibly additional resolutions. First, upon initiation, APR performs Problem Analysis to form a problem set for resolution and determine which resolution alternatives are applicable for the problem set. Second, APR prioritizes the resolution alternatives as candidates for maneuver generation through an evaluation process called Resolution Ordering. Finally, Resolution Generation constructs a maneuver for the resolution alternatives until a resolution is generated that stays close enough to the current plan of the flight. The following sections describe the details associated with these steps.

3.2.2.1 Problem Analysis

The type of problems detected by APD include aircraft-to-aircraft conflicts, aircraft-to-airspace conflicts, and flow instruction noncompliances. All of these types of problems can be solved by APR. When APR is initiated, APR forms and maintains problem sets. The problem set is the basic unit for which APR generates resolutions. A problem set contains one or more problems, one of which is designated the primary problem. A multiple problem occurs when an aircraft is simultaneously involved in more than one problem. In this case, APR selects a primary problem from the set, treating the remaining problems as situations to be avoided by the resolution.

For aircraft-to-aircraft conflicts and aircraft-to-airspace conflicts, APR examines a set of resolution maneuvers in the lateral, vertical, and longitudinal dimension for each aircraft involved in the conflict. Each resolution alternative can be uniquely identified by a resolution type and direction. The dimension of a resolution type refers to the dimension of an aircraft flight that would be altered. Several maneuver types are defined for each dimension and provide a general direction or intent for a resolution. For example, the lateral maneuver type "Change Path - Left Side" indicates a change in route to the left side of the original route. The vertical maneuver type "Alter Altitude - Above" indicates a change in an original vertical
transition and an intent for the resolution to stay at or above the originally planned altitude profile.

APR examines either Initiate Altitude or Alter Altitude vertical maneuver types depending on whether an altitude transition is planned. If an aircraft does not have a planned altitude transition within a parameter lookahead, APR considers Initiate Altitude - Climb and Initiate Altitude - Descend maneuvers. If an aircraft does have a planned altitude transition within a parameter lookahead, APR looks at Alter Altitude - Above and Alter Altitude - Below maneuvers. When a speed decrease maneuver cannot solve the conflict, a hold may be built.

APR examines single dimension maneuvers, composite maneuvers, and multiple maneuvers to solve the problem. Composite maneuvers move one aircraft in two dimensions, while multiple maneuvers move two aircraft, each in one dimension. The set of resolution alternatives is depicted in Figure 3-6.

The single dimension resolution alternatives for solving flow instruction noncompliances are shown in Figure 3-7. APR always attempts to resolve a problem by compliance with the constraint embedded in the flow instruction. In addition, for selected applicability criteria, APR attempts to alter the aircraft's path such that the applicability criteria no longer apply. A flow instruction constraint is often associated with a single dimension (e.g., altitude), so the problem may be solvable in only one dimension (e.g., vertical). Conversely, a resolution to a Flow-Restricted Area problem is attempted in each of the three dimensions. Composite maneuvers can be used whenever single dimension maneuvers are not sufficient to solve the problem. Resolutions to a time-based flow instruction can be generated in each dimension as well as composite maneuvers that include a speed change.

3.2.2.2 Resolution Ordering

Resolution ordering is the process that prioritizes the resolution alternatives that are applicable for a given problem set and identifies when composite and multiple maneuver resolutions should be attempted. Several operational considerations are used in the ordering. Some of these considerations do not depend on the specific properties of the resolution; these are called a priori factors. Other considerations depend on the specific resolution maneuvers; these are called resolution-specific factors. In order to determine an initial ordering for the resolution alternatives, the resolution-specific factors are estimated using an approximation of the possible final maneuver. This approximation can be very crude, using only problem data and not actually building a maneuver, or it can be very detailed by building the maneuver to at least solve the primary problem, or possibly a hybrid approach. When the full trajectory construction indicates a significant error was made in the estimation process, a revised ordering will be made based on the results of the construction. The software design will make the tradeoff in what approach will provide the smallest computer load on the system while still providing operationally acceptable maneuvers.
Figure 3-6. Resolution Alternatives
Each resolution ordering factor will move a resolution alternative higher or lower in the priority ordering. There will be a weight assigned to each factor that determines how much that factor will affect the alternative ordering.

The a priori factors include the following:

1. Preferences applied to one of the aircraft. Preferences can be system-wide, applied to all APR modes, or can be entered by the controller and be specific to the particular mode of APR. Preferences can apply to any of the resolution alternatives and will make that alternative move higher in the priority ordering. System-wide preferences include maneuvering the aircraft with a trajectory that was just reconformed and,
before the reconformance, was problem-free. The controller can prefer any resolution alternative or set of alternatives for a specific aircraft.

2. **Nonpreferences applied to one of the aircraft.** Nonpreferences can be system-wide, applied to all APR modes, or can be entered by the controller and be specific to the particular mode of APR. Nonpreferences can apply to any of the resolution alternatives and will make that alternative move lower in the priority ordering. System-wide nonpreferences include aircraft using a special beacon code, aircraft with certain adapted callsigns such as "A1" or "EVAC," and special military routes. The controller can nonprefer any resolution alternative or set of alternatives for a specific aircraft.

3. **Multiple aircraft maneuvers.** In general, maneuvers involving two aircraft will be lower in the resolution ordering. This reflects the fact that these maneuvers require additional coordination with pilots and possibly controllers when the two aircraft are controlled at different positions. Also, multiple aircraft maneuvers may require much more computer capacity to generate because of the many degrees of freedom allowed in the maneuvers.

4. **Flight phase of the aircraft involved in the problem.** The list of resolution alternatives can be ordered by the flight phase of the involved aircraft. There are three flight phases defined:

   a. **Arrival phase:** that part of an aircraft's flight between a parameter time before the Top of Descent point prior to arrival at its destination airport and the destination airport

   b. **Departure phase:** that part of an aircraft's flight between its departure airport and the point at which it achieves cruise altitude

   c. **En route phase:** that phase of an aircraft's flight which is neither departure or arrival

For aircraft-to-aircraft conflicts, a particular order is given to the resolution alternatives of the two aircraft based on the flight phase of each. For aircraft in the same flight phase, e.g., both en route, no distinction is made in the ordering. For an en route and departure, favor maneuvering the departure. For en route and arrival, favor maneuvering the arrival. For arrival and departure, favor maneuvering the departure.

When ordering alternatives for each aircraft, each flight phase has its particular order. For example, en route aircraft maneuvers might be ordered:
Lateral > Climb > Speed Increase > Speed Decrease > Descent > Composite

Composite maneuvers would reflect the priority of its constituent single maneuvers.

Using the above set of a priori factors, many of the resolution alternatives will order themselves for resolution generation. However, there will still be many cases when there are ties in the ordering. As an example, for a conflict with two en route aircraft, neither aircraft is favored over the other and the first maneuvers to try would be lateral. Since there are four possible lateral maneuvers, these must be estimated or built to determine the final ordering.

The resolution-specific factors include:

1. **Resolution objections.** Objections are one of the following:
   a. An aircraft-to-aircraft conflict between any flights
   b. An aircraft-to-airspace conflict (except for entry into Notify-only airspaces)
   c. A predicted or actual Flow Instruction (FI) noncompliance
   d. A conflict with the short-term track of an IFR aircraft

Ordering is affected by the existence of one of these objections as well as the type of objection and the time to the objection. Resolutions with aircraft and airspace conflicts will generally be ordered lower than those with flow instruction noncompliances. For aircraft and airspace conflicts, the resolution with the earliest time to objection will generally be ordered lower.

As described in resolution generation (Section 3.2.2.3), objections are to be avoided in generating resolutions. Therefore, there should be few resolutions that have objections when APR is finished.

2. **Deviations from the Current Plan trajectory.** The ordering of resolutions are lowered the farther away they are from the Current Plan of the aircraft. This deviation is measured separately for each maneuver dimension:

   a. For lateral maneuvers: the change in the flight time caused by the maneuver and the sum of the maneuver turn angles
   b. For vertical maneuvers which may assign a new cruise altitude: the number of Assignable Altitude (AA) changes caused by the maneuver. For other vertical maneuvers: the number of AA changes a parameter time from the original top of climb or descent point which was modified
c. For speed maneuvers: the product of the magnitude of the speed change and duration of the speed change

3. **Problem Recurrence.** The primary problem in the problem set may be resolved for the normal lookahead time of APD (about 20 minutes) but reoccur a short time after that. This may happen in certain overtake situations. The ordering of these particular alternatives will be lowered.

4. **Meter Fix Time.** For time-based FI constraints, the resolution must stay close to the meter fix time assigned. The farther away the resolution keeps the aircraft from the meter fix time, the more its order will be lowered.

5. **Notify-only Airspace and Uncontrolled Airspace.** Resolutions can be built to go through Notify-only or Uncontrolled airspace. Although these resolutions can be given to a flight, it would require some additional coordination on the part of the controller. Therefore, the ordering of these resolutions should be lowered.

Resolution-specific factors are also objectives for APR to use in generating resolutions. The ability of the generation process to handle these factors will determine, to a large extent, what order they will have.

### 3.2.2.3 Resolution Generation

Once the Resolution Ordering process has initially ordered all of the resolution alternatives, Resolution Generation constructs resolution maneuvers. For each selected single dimension resolution alternative, there are one or more maneuver shapes which are acceptable. The following figures are provided to illustrate all of the different maneuver shapes:

- Figure 3-8 provides illustrations of right turn lateral maneuvers "Change Path - Right Side" for VOR-navigating aircraft.
- Figure 3-9 provides illustrations of left turn lateral maneuvers "Change Path - Left Side" for self-navigating (Point-to-Point) aircraft.
- Figure 3-10 provides illustrations of vertical maneuvers "Initiate Altitude - Climb" and "Initiate Altitude - Descend."
- Figure 3-11 provides illustrations of vertical maneuvers "Alter Altitude - Above" and "Alter Altitude - Below."
- Figure 3-12 provides illustrations of longitudinal maneuvers "Speed Change - Increase," "Speed Change - Decrease," and "Hold."
Figure 3-8. Maneuver Shapes for "Change Path - Right Side" for VOR-Navigating Aircraft
Figure 3-9. Maneuver Shapes for "Change Path - Left Side" for Self-Navigating Aircraft
Figure 3-10. Maneuver Shapes for "Initiate Altitude - Climb" and "Initiate Altitude - Descend"
Figure 3-11. Maneuver Shapes for "Alter Altitude - Above" and "Alter Altitude - Below"
Resolution generation starts building resolutions using the maneuver shapes associated with the highest ordered resolution alternative. This construction attempts to build a maneuver that meets a set of constraints and objectives.

Constraints are applied by APR in generating resolutions to ensure that the resolutions include only maneuvers the aircraft can actually perform. APR considers physical realities such as aircraft performance limitations, radar coverage, altitude restrictions, and equipment status such as NAVAID failures. Resolutions must return the aircraft to its route and destination and provide exact values for all maneuver parameters. Maneuvers are generated according to rules regarding minimum and maximum heading changes, speed changes, and lengths for vectors.

A resolution maneuver must be completed at or before the AERA Arrival Fix (AAF), a location along the aircraft trajectory after which an aircraft will be dealt with in a tactical manner. The AAF can be defined in adaptation as a fix along a standard arrival route, as the destination airport, or can be the point on the trajectory intersecting the boundary of an APDIA. Within the

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APDIA, no automatic detection of problems is performed so there are no automatically generated resolutions, and all resolution maneuvers must therefore begin and end outside the APDIA. Essentially, this APR constraint is intended to ensure that APR-generated maneuvers are wholly contained in airspace that can be controlled strategically, taking advantage of the longer lookahead times associated with APD and APR.

Figure 3-13 presents a conceptual view of the AAF and APDIA under arrival conditions at a terminal. It is not intended to suggest an actual definition for an airport. DEF is the AAF and the metering fix for southwest arrivals to XYZ airport. The route to XYZ airport after fix ABC is defined as a standard arrival route.

The principle objectives for APR are the same as the resolution ordering factors:

1. Solve the primary problem and avoid recurrences of the problem
2. Avoid objections
3. Reduce maneuver parameters such as turn angles
4. Stay close to the Current Plan

The criteria used to measure how close the resolution maneuver must be to the Current Plan are set in adaptation for each resolution dimension. A set of superior criteria has been defined as
one assignable altitude level up or down, within 20 knots or .02 Mach in speed, and less than 30 seconds added flight time for lateral maneuvers. As APR builds maneuvers using the priority order of alternatives, the first one that meets the resolution constraints, objectives, and is within the superior criteria, is the HRR. It may not be possible to build any resolutions that meet all of the constraints and objectives while still being superior. APR will then continue to search for resolutions by relaxing the objective criteria. The entire process is governed by a set of adaptable weights associated with the various resolution ordering criteria.

APR will also generate specific maneuver alternatives based on the controller request for additional resolutions. In these cases, APR will try to meet all of the objectives for that maneuver type and will try composite or multiple maneuvers if necessary.

Although resolution generation has a set of objectives to meet as stated above, it is not the intent that these objectives be completely minimized during the construction process. Reasonable approximations can be and should be used to guide the process so excessive computer power is not used to squeeze the last bit of goodness out of the resolutions. This is especially true with respect to lateral maneuvers where there can be several degrees of freedom. The concept of superior criteria for maneuvers should allow for a degree of flexibility.

Each resolution created by APR will be embodied in a Protected HRR or Machine Plan. A Protected HRR is created for Automatic Mode and Controller-Assisted Mode invocations if no Pending Plan for the aircraft already exists. In this way, future invocations of APR and manually created Trial Plans will not conflict with the HRR while the controller is analyzing the resolution and clearing the new plan. Constructing a Machine Plan enables the controller to easily manipulate the Plan when necessary. Each resolution is complete and will have clearance language created for display to the controller.

APR also determines the time interval during which initiation of the resolution maneuver is feasible and presents this timing information to the controller. This is called the resolution expiration time and is based on aircraft equipage, type of problem resolved, the operational environment, and assumptions on the time it will take for a controller to respond to the resolution. The expiration time ensures that the resolutions displayed to a controller can be implemented and will work as intended. When a HRR expires, APR regenerates the HRR for that problem based on the current operational data.

When APR generates a resolution that maneuvers two aircraft, two Protected HRRs or Machine Plans are created and the controller must implement both of them for the problem to be solved. AERA will provide some special processing that links the implementation of these two plans together so that they can be made current simultaneously. This feature will overcome many operational difficulties when making one current before the other.
3.2.3 Dependence on Plan Type

This section describes the aspects of problem detection and resolution dependent on Plan type. The operational roles of each Plan type dictate variations when checks for problems are made, the nature of the checks, the applicable separation criteria, whether resolutions are generated and the position to which the problem and/or resolution information is displayed.

Table 3-1 summarizes how Plan type affects the automatic detection and resolution of problems. Current Plans, Protected HRRs, and Pending Plans receive continual problem detection, i.e., APD checks these Plans for problems whenever there is a change in the operational environment that could affect their problem status. Automation recognizes when a check for problems is necessary for each Current Plan, Protected HRR, and Pending Plan and APD is invoked automatically. When a problem is detected, the appropriate controller is notified and, for problems in a Current Plan, resolutions are provided by APR. Continual checking assures that problems are detected at the earliest possible time and that problem and resolution information is kept up-to-date. Trial Plans and Machine Plans receive snapshot problem detection, i.e., APD checks these Plans for problems when they are initiated (introduced into the system) and does not recheck them automatically as it does Current Plans, Protected HRRs, and Pending Plans. Controllers have the option to automatically receive resolutions for problems detected in a Trial Plan, and can manually invoke APR for any problem detected in any Plan. The Controller-Assisted Mode gives controllers numerous additional options to augment the automatic detection and resolution of problems (Section 3.5.1).

The separation criteria used for Current Plans, Protected HRRs, and Pending Plans are the same, reflecting their close linkage to a clearance. The same separation criteria are used for Trial Plans as for Machine Plans, but these criteria are not necessarily the same as those used for Current Plans, Pending Plans, and Protected HRRs. In fact, Trial and Machine Plan separation often will be larger, reflecting the primary use of these Plan types as planning tools, and the fact that they receive only snapshot (not continual) problem detection.

When a Current Plan is checked for aircraft-to-aircraft problems, the Current Plan trajectory is checked for violations of separation criteria with respect to the Current, Pending Plan, and Protected HRR trajectory of every other aircraft for which a Flight Plan has been activated. Those same checks are made to detect aircraft-to-aircraft problems in Trial Plans and Machine Plans and an additional check is made against the short-term predicted track position of each IFR aircraft and each altitude-encoding-transponder-equipped VFR aircraft. The checks against track position are made to detect a situation in which the trajectory representing the Trial Plan, Pending Plan, Protected HRR or Machine Plan, if implemented as the Current Plan, would cause a Conflict Alert with an IFR or VFR aircraft.
Table 3-1. FAS Handling of Plans

<table>
<thead>
<tr>
<th>Plan Type</th>
<th>Number</th>
<th>AERA Problem Detection and Resolution</th>
<th>Recipient of Problem and Resolution Information</th>
</tr>
</thead>
<tbody>
<tr>
<td>Current Plan</td>
<td>1 per Aircraft</td>
<td>Continual Detection &amp; Resolution Against Other Current Plans</td>
<td>AERA Selected</td>
</tr>
<tr>
<td>Pending Plan</td>
<td>1 per Aircraft**</td>
<td>Continual Detection Against Other Current Plans, Pending Plans, Protected HRRs and Against IFR &amp; VFR Tracks*</td>
<td>Owner of Pending Plan</td>
</tr>
<tr>
<td>Protected HRR</td>
<td>1 per Aircraft**</td>
<td>Continual Detection Against Other Current Plans, Pending Plans, Protected HRRs and Against IFR &amp; VFR Tracks*</td>
<td>AERA Selected (Same as Current Plan)</td>
</tr>
<tr>
<td>Machine Plan</td>
<td>Available upon Request</td>
<td>Snapshot Detection Against Current Plans, Pending Plans, Protected HRRs and Against IFR &amp; VFR Tracks*</td>
<td>Requesting Position</td>
</tr>
<tr>
<td>Trial Plan</td>
<td>No Limit per Aircraft***</td>
<td>Snapshot Detection &amp; Resolution Against Current Plans, Pending Plans, Protected HRRs and Against IFR &amp; VFR Tracks*</td>
<td>Owner of Trial Plan</td>
</tr>
<tr>
<td>Dormant Current Plan</td>
<td>2 per Aircraft</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Dormant Trial Plan</td>
<td>No Limit per Aircraft***</td>
<td>None</td>
<td>None</td>
</tr>
</tbody>
</table>

* Short-term predicted track positions of altitude-encoding-transponder-equipped VFR aircraft and the short-term predicted track positions of IFR aircraft.
** One Pending Plan or Protected HRR per aircraft.
*** Facility-wide limit applies.
Checks for aircraft-to-airspace problems in any Plan identify violations of separation criteria between a trajectory and Special-Use Airspaces (including Strategic Airspaces, Planning Region Airspaces, and Notify-only Airspaces), and Minimum Safe Altitude Warning (MSAW) Airspace Regions. Predicted violations of separation criteria involving airspaces other than Notify-only Airspaces are termed airspace conflicts, while predicted violations of separation criteria involving aircraft and Notify-only Airspaces are termed encounters. Strategic Airspaces are recognized nationally in all facilities. Planning Region Airspaces are recognized only in the facilities in which they exist. MSAW Airspace Regions are defined in adaptation as altitudes below which safe separation from terrain or obstacles will be lost. Notify-only Airspaces include uncontrolled airspaces, adapted nonradar areas, alert areas and controlled firing areas. Notify-only Airspaces are defined as airspace volumes for which a controller is advised of violations of separation criteria but these violations are not considered safety-critical and may not warrant controller action. APD detects Notify-only Airspace encounters but APR is not automatically invoked to generate resolutions. If action is necessary, the controller will resolve these encounters by coordinating with the agency controlling the airspace.

The ACCC allows an aircraft to be exempted from detection of airspace conflicts and encounters if:

- A controller at the aircraft's current position or at the local Traffic Management Coordinator position has activated an exemption for the aircraft.

- The conflicts and encounters involve airspaces whose identifiers appear in the aircraft's Flight Plan.

Checks for flow instruction problems in any Plan identify predicted or actual noncompliance of a trajectory with flow instructions that are characterized by applicability criteria and constraints. Applicability criteria identify the aircraft to which the instruction applies. The identification can be a specific aircraft, a performance class, a group identified by arrival or departure airport, or a location such as a fix, route, sector or line crossed. A flow instruction can be assigned a time interval of applicability. The constraints are classified as local or route-specific. Local constraints include miles-in-trail or minutes-in-trail at a fix or boundary, Meter Fix Times (MFTs), Boundary Crossing Times (BCTs), altitude constraints and aircraft speed. Route-specific constraints include no directs, Flow Restricted Areas (FRAs) or specified sequences of route segments and fixes. For example, a flow instruction can designate a sequence of fixes into an airport for all aircraft inbound from a designated facility.

FAS maintains an extensive data base of information relevant to the detection of problems including aircraft intent, separation standards, equipment status, and activation periods for flow instructions and protected airspaces. In general, whenever a change occurs in a data base entry relevant to the detection of problems, APD is invoked automatically for the appropriate trajectories. The conditions under which APD and APR are initiated for each type of Plan and the position receiving any resulting problem notification or HRR are delineated in the following subsections.
3.2.3.1 Current Plans

APD automatically checks the appropriate Current Plan trajectory for problems when any of the following events occur:

- A Current Plan trajectory is created or amended (e.g., the Current Plan is replaced or resynchronized).
- The Flight Plan associated with the Current Plan is activated.
- An active Flight Plan is received from another facility.
- Conformance bounds for the aircraft are changed.
- The aircraft is added to or subtracted from an ALTRV or a group subject to group suppression.
- There is a change in an APDIA and the Current Plan is affected by the change.
- Flight Plan data (e.g., equipment) is changed for the subject aircraft.
- An airspace or flow instruction is defined, modified, activated or deactivated any time other than the scheduled time.
- An exemption from detection of aircraft-to-airspace conflicts or flow instruction problems is entered or removed for the aircraft.
- The Current Plan for the aircraft is submitted for predeparture checks.
- The constraint is an MFT or BCT and the flight reaches a Metering Decision Point for that flight.

When APD checks for, but detects no problems in a Current Plan, no notification is generated. When APD detects a problem in a Current Plan (except a problem involving a Notify-only Airspace), APR is invoked automatically.

3.2.3.2 Pending Plans

APD automatically checks the appropriate Pending Plan trajectory for problems when any of the following events occur:

- A Pending Plan trajectory is created or amended.
• Conformance bounds for the aircraft are changed.
• A Pending Plan is received from another facility.
• The aircraft is added to or subtracted from an ALTRV or a group subject to group suppression.
• An airspace or flow instruction is defined, modified, activated or deactivated at any time other than the scheduled time.
• An exemption from detection of aircraft-to-airspace conflicts or flow instruction problems is entered or removed for the aircraft.

When no problems are detected, no notification is generated. When problems are detected in a Pending Plan, APR is not invoked but a notification is displayed to the position that owns the Pending Plan. This reflects the role of the Pending Plan as one that may be in coordination between controllers, in transmission via data link or otherwise represents a new clearance not yet issued and acknowledged. When the Pending Plan has a problem involving a Current Plan, it is the owner of the Pending Plan that needs to know since the problem can be avoided by not issuing the clearance associated with the Pending Plan. A problem detected between two Pending Plans owned by different positions results in notification to both positions.

The notified position can initiate APR manually in the Controller-Assisted Mode to obtain resolutions to problems in a Pending Plan. When APR is initiated manually for a problem in a Pending Plan, the APR-designated position is always the initiating position.

3.2.3.3 Trial Plans

APD automatically checks the appropriate Trial Plan trajectory for problems when the corresponding Plan is generated. A Trial Plan's trajectory is checked for aircraft-to-aircraft conflicts with:

• The trajectories of Current Plans and Pending Plans of other aircraft
• The short-term predicted track positions of altitude-encoding-transponder-equipped VFR aircraft
• The short-term predicted track positions of IFR aircraft

When a Trial Plan is checked for problems and no problems are detected, a message indicating no problems is displayed. Upon detection of a problem in a Trial Plan, a notification is automatically displayed to the position owning the Trial Plan unless the Trial Plan was generated by Automated Replan. Notification of a problem detected in a Trial Plan generated
by Automated Replan occurs only when a controller at the owning position has specifically requested to be notified.

Controllers can enter a message requesting automatic invocation of APR for Trial Plans owned by that position (excluding Trial Plans generated by Quick Trial Planning and Automated Replan). When APR is invoked automatically for a Trial Plan, the position to receive the resolutions is the position owning the Trial Plan. Controllers can also manually initiate APR for problems in Trial Plans. When APR is invoked manually through Controller-Assisted Mode for a Trial Plan, the position initiating the request always receives the resolutions. These rules ensure that the recipient of resolutions is the position requesting the service.

### 3.2.3.4 Machine Plans

APD automatically checks the appropriate Machine Plan trajectory for problems when the corresponding Plan is generated. A Machine Plan's trajectory is checked for aircraft-to-aircraft conflicts as follows:

- When the Machine Plan is generated in a Controller-Assisted Mode request, the Machine Plan's trajectory is checked against the trajectories of Trial and Machine Plans specified, for checking, in that same request.
- When the Machine Plan is generated as part of a primary or secondary multiple maneuver resolution, the Machine Plan's trajectory is checked against the trajectories of the other Machine Plan in the same primary or secondary multiple maneuver resolution.
- In all cases, the Machine Plan's trajectory is checked against the trajectories of Current Plans, Pending Plans, and Protected HRRs of aircraft which do not have one or more associated Machine Plan or Trial Plan trajectories checked in accordance with the above two checks.
- In all cases, the Machine Plan's trajectory is checked against the short-term predicted track positions of IFR aircraft and the short-term predicted track positions of altitude-encoding-transponder-equipped VFR aircraft.

When a problem is detected in a Machine Plan, it is displayed to the owning position as an objection to the Machine Plan. APR is not invoked automatically for Machine Plans but can be invoked through Controller-Assisted Mode, in which case the APR-designated position is the position owning the Machine Plan.
3.2.3.5 Protected Highest Ranked Resolutions

APD automatically checks the Protected HRR's trajectory for problems in a manner similar to Pending Plans. When a problem is detected in a Protected HRR, it is displayed to the owning position as an objection.

3.2.4 Pre-Set Controller Influences over APD and APR

Controllers can exercise considerable advance influence over the way problems are detected and how resolutions are generated. For example, controllers can use input commands, or messages, to communicate with APD. This includes requests for APD services, identification of aircraft for special treatment, and definition of conditions APD must acknowledge in the checks for problems. With these messages, controllers can shape what APD considers a problem and the type of problem for which APD checks.

APD does not automatically check a Trial Plan or Machine Plan trajectory against the trajectory of other Trial Plans or Machine Plans. This check, however, can be requested manually. The controller can designate up to three Trial Plans or Machine Plans (one Plan per aircraft) for simultaneous checking against each other for aircraft-to-aircraft problems. This planning tool is useful to controllers considering promoting Machine Plans and/or Trial Plans to Current Plans since the controller will be informed of whether aircraft-to-aircraft problems will result if the Trial Plans and/or Machine Plans are implemented as the Current Plan.

Controllers can also inform the automation system of circumstances affecting the amount of airspace to protect for an aircraft by identifying aircraft for which to initiate or terminate special consideration. Circumstances requiring special consideration include a malfunctioning altitude-encoding transponder, lack of radar coverage or a controller's request to apply radar or nonradar separation rules for an aircraft, and the use of celestial navigation by an aircraft.

APD alters its detection and notification of problems based on controller entered messages informing automation of group formations, Military Authority Assumes Responsibility for Separation of Aircraft (MARSA), exemptions to problem detection, and inhibitions of displays. For example, a controller can designate any adapted or ATC-defined airspace (including a Trial Airspace) as a Notify-only Airspace. When any airspace is defined in adaptation or by controller action, the creator is required to specify the position to which notification of predicted penetrations of the Notify-only Airspace will be posted. The automatic display of Notify-only Airspace penetration notifications is an option that a controller may enable or inhibit (except when detected during a predeparture check). When inhibited, no notification is displayed. When enabled, the designated position receives notification of predicted penetrations of Notify-only Airspaces by a Current Plan trajectory. The receiving position can invoke APR manually to obtain assistance in resolving the problem.

Controllers can activate or deactivate a flow instruction defined in adaptation or created by Traffic Management, and activate or deactivate an airspace. Controllers are informed of special
options in effect that influence the detection of problems or presentation of data to the position. These options give controllers the ability to designate airspaces or flow instructions for desired handling by APD.

Another APD feature assists controllers in assessing the effects of activating an airspace. Controllers can manually define a Trial Airspace or activate an adapted airspace as a Trial Airspace. When a Trial Airspace is created or changed, APD is invoked to determine the identity of any aircraft with a Current Plan trajectory that penetrates the Trial Airspace. Results of the checks including the identity of any affected aircraft is presented to the controller who created the Trial Airspace. The information can be used for planning purposes. The controller can then decide whether to activate the Trial Airspace.

Controllers can exercise significant influence over certain aspects of APR including the process of ranking resolutions. When a controller is operating in an environment in which the application of certain rules would enhance the controller's ability to ensure safe and expeditious traffic flow, it is possible to guide the resolution process by invoking these rules. One option available is defining types of resolutions which the controller prefers or does not prefer. The ability to apply preferences and nonpreferences facilitates a controller's search for the "best" resolution when circumstances in the operational environment cause a controller to want resolution ranking to reflect these circumstances. The preferred resolutions are biased toward the top while nonpreferred resolutions are biased lower. The Automatic Mode and Controller-Assisted Mode (Section 3.5.1) of APR have separate sets of options available with which the controller can influence APR.

In the Automatic Mode of APR, a controller can specify for a specific aircraft under control of that position that the following maneuver types be classified as preferred or nonpreferred:

- Any designated maneuver types
- All maneuver types
- All maneuver types in a specified dimension

For example, if an aircraft requests not to go higher in altitude for special circumstances (other than aircraft performance, which is already considered by APR), the controller can instruct APR that all climb maneuvers must be nonpreferred. If a controller wants to ensure the HRR for a problem does not maneuver a given aircraft, the controller can request that APR nonprefer all resolution types for that aircraft. On the other hand, if a maneuver of a certain type or in a certain dimension would be favorable for an aircraft, the controller can instruct APR to prefer resolutions of that type or dimension. These options apply to all resolution maneuvers generated for the designated aircraft that begin within a period of applicability that the controller can specify. The default period of applicability is from the current time until arrival at an AAF. Automatic Mode options can be entered by a controller at any time. Controller-Assisted Mode options are described in Section 3.5.1.
3.2.5 Conditions that Cause the Automatic Invocation of APR and the Deletion of Machine Plans

APR is invoked automatically to produce resolutions when:

- A Current Plan problem is detected.
- A Trial Plan problem is detected and the controller has invoked automatic resolution to Trial Plans.
- The expiration time of the HRR is reached.
- The occurrence of other events which indicate that previously generated resolutions need replacement due to a change in the operational environment upon which the previous resolutions were based.

Some examples of other events include flight data changes that make an existing resolution for a problem in that aircraft's Current Plan inconsistent with the new data, a NAVAID outage when an existing resolution depends on that NAVAID, and absence of a data link accept response (Section 4.2.2).

Due to the importance of the AAF and APDIA to the resolution generation process, changes in the AAF and APDIA may necessitate the reinvocation of APR. When the AAF for an aircraft changes while it is involved in a problem, APR generates a new set of resolutions to replace the previously generated resolutions. When an APDIA changes in a way which affects an aircraft with a problem, APR regenerates all resolutions for the problem.

Whenever an APR Automatic Mode option is entered, some resolutions already in existence may need replacing (since the new rules could contradict the old rules). Therefore, upon such an entry, any aircraft to which the entry applies that is involved in a problem will have all new resolutions generated by APR to replace the ones generated prior to the entry. This replacement process ensures that the controller always has a set of resolutions generated and ranked under the desired set of rules.

A Machine Plan is deleted at its expiration time or when the problem for which the Machine Plan was created is resolved, changes or disappears. When APR generates a new HRR for a problem (e.g., upon automatic or manual refresh), all previously generated Machine Plans for that problem are deleted. Machine Plans generated to resolve a problem in a Pending Plan, Protected HRR, or Trial Plan are deleted when the Pending Plan, Protected HRR, or Trial Plan is deleted or changes status.

Displayed information is always kept up-to-date. For example, when a Machine Plan is deleted by automation or reaches its expiration time it is marked and then removed shortly thereafter.
When a displayed resolution is replaced, the replacing resolution is displayed and the replaced resolution is marked and later removed from the display. When the APR-designated position owns a problem-free Pending Plan that subsequently is deleted, demoted or develops a problem before a resolution is implemented, the entry indicates the change in the Pending Plan until APR produces a replacement set of resolutions. To reduce visual clutter and keep attention focused on items needing attention, alerts are removed whenever the alert conditions no longer exist, the APR-designated position changes, or control of the aircraft to be maneuvered is transferred. When a controller takes an action that makes displayed data no longer germane, those data are removed immediately. For example, when a Machine Plan is implemented as the Current Plan, all the displayed problem and resolution data are removed immediately. This feature ensures that the display always contains only information needed by the controller and extraneous data is removed to keep controller attention focused on items for which action may be required.

3.2.6 Rules for Position Notification

The APR-designated position to receive the problem notification and resolutions is chosen based on operational considerations. The rules used by APR to select the appropriate position are described below. Usually, the key factor is the position controlling the aircraft that must be moved to resolve the problem. When a resolution maneuvers an aircraft not under the control of the position receiving the resolution (e.g., a multiple maneuver resolution), coordination with the position controlling that aircraft is necessary to implement the resolution. APR attempts to minimize the need for coordination between controllers, subject to other operational concerns, by judicious selection of the position to receive resolutions.

Figure 3-14 illustrates the case in which a Current Plan is found to be in violation of APD's separation criteria with another Current Plan and no Protected HRR or problem-free Pending Plan exists for either aircraft. The HRR is presented to the position (Sector 25) controlling the aircraft maneuvered by the HRR (Aircraft A). Note that the choice of receiving position is independent of the location of the area of violation. Controllers for sectors 23 and 24 do not receive any notification in this scenario.

In the most common case, when APR is automatically initiated for an aircraft-to-aircraft problem in a Current Plan, the APR-designated position is determined by considering the following rules in the given order:

- When a clearance associated with a resolution is uplinked via data link and a data link accept (Section 4.2.2) to the clearance is not received from the aircraft, APR is automatically reinvoked to refresh the resolutions for that problem. To maintain operational continuity, the position that originally delivered the clearance gets the new HRR and must coordinate with the aircraft and other positions as necessary to resolve the problem.
- When the HRR in a multiple aircraft resolution moves an aircraft involved in the original problem and a secondary aircraft not part of the original problem, the position controlling the primary aircraft receives the HRR moving that aircraft and movement of the secondary aircraft must be coordinated with the owner of the secondary aircraft's Current Plan, if required.

- When exactly one involved aircraft has a problem-free Pending Plan, the problem notification and resolution is displayed to the owner of that Pending Plan regardless of the aircraft moved by the HRR. Thus, the automation notifies the Pending Plan owner that the most efficient way to resolve the problem is to make the Pending Plan the Current Plan. If that position does not promote the Pending Plan, the problem could be resolved by choosing the HRR or another resolution and coordinating with
other positions as necessary. The Pending Plan owner is thereby informed that the Pending Plan resolves the problem and can either make the Pending Plan the Current Plan or coordinate the HRR as necessary.

- When there is no problem-free Pending Plan (the usual case) or when two positions have a problem-free Pending Plan, the position owning the Current Plan changed by the HRR receives the HRR.

- When the HRR moves two primary aircraft controlled by different positions, APR randomly selects one of those positions to receive the HRR.

When APR is unable to generate a resolution for an aircraft-to-aircraft problem involving only Current Plans, the designated position is chosen arbitrarily from the positions controlling the involved aircraft. The designated position receives notification of the problem and an indication that no resolutions were generated.

When APR is automatically initiated for an aircraft-to-airspace or flow instruction problem in a Current Plan, the current position receives the problem notification and resolutions.

Problems detected in a Current Plan can also be resolved in the Controller-Assisted Mode of APR. In this mode, the controller initiating the request receives the resolutions unless that controller requests APR to determine the recipient as for the Automatic Mode.

When an airspace or flow instruction is changed or deactivated at other than the scheduled time, APD determines the identity of every aircraft that was maneuvered to avoid the airspace or comply with the flow instruction. If the aircraft has not passed the airspace or the flow instruction's area of applicability, the position controlling the aircraft is notified of the aircraft's identification and the airspace or flow instruction that was changed or deactivated. This feature helps controllers give pilots a more desirable routing when it becomes available. The controller can plan and issue a new clearance more closely aligned with the pilot's originally-stated preference.

APD detects when an aircraft's Current Plan indicates that it is operating in a Strategic or Planning Region Airspace but the aircraft is actually outside of that airspace. This type of occurrence is know as a spillout. The position monitoring that airspace receives the spillout notification.
3.3 ALERTS AND NOTICES

Since FAS operates in a strategic rather than tactical environment, the controller's role changes to use the new automated capabilities. Figure 3-15 presents an overview of the FAS process for detecting and resolving problems as compared to today's process. FAS controllers will rely on automation to detect and resolve problems and monitor for, and respond to, automatically generated notifications posted to their position. In particular, the controller observes the data presented, evaluates the problems and resolutions, and takes actions as appropriate to resolve the problem.

When problems are detected and resolutions are generated, information is automatically presented to the appropriate controller(s). Additional data is optionally available for display to assist the controller in the analysis of the problem and the selection of a resolution. The data displayed automatically and the data optionally available are delineated in the following paragraphs.

To assist controllers in maintaining separation in a strategic control environment, FAS includes new display capabilities corresponding to the new automation features. The Alert and Resolution Display (ARD) provides a vehicle for the unified display of high priority problem information and resolutions. This display provides controllers with alert notifications of aircraft emergencies, Conflict Alerts, aircraft detected out of an assigned airspace or formation, and problems detected between two Current Plans or between a Current Plan and an airspace or flow instruction.

When the ARD includes information and/or resolutions regarding several problems, the controller can request the alerts to be sorted to assist in planning the priority for acting on the problems. Sorting can be requested based on any of the following criteria:

- Expiration time of the HRR
- Occurrence time of predicted problem
- Alert category
- Occurrence time of predicted problem within category

When the HRR expiration time is chosen, the alerts are presented in order of increasing expiration time. When the time the problem is predicted to occur is chosen, the ordering is by increasing time until the problem occurs. When the alert category is chosen, the alerts are listed by category in the following order:

- Conflict Alerts
- MSAW
Figure 3-15. Controller Activities for Detecting and Resolving Aircraft Problems Today and Using FAS (From Rhodes and Carlson, 1989)
• Aircraft-to-aircraft problems
• Aircraft-to-airspace problems
• Aircraft detected outside assigned airspace (spillouts)
• Aircraft emergencies
• Flow instruction noncompliances

For a problem involving only Current Plans, the notification automatically presented to the APR-designated position includes the HRR and associated clearance information, e.g., the specific maneuver parameters, a countdown clock for the HRR expiration time, any objections, an identifier for the problem, callsigns and data link equipage of involved aircraft, and time of predicted violation of separation standards.

Controllers also receive data to indicate special conditions that they must consider such as a notice when the problem is in a Current Plan recently initiated due to a reconformance and a notice indicating the existence and problem status of a Pending Plan for involved aircraft under control of the APR-designated position. These data along with other available data help the alerted controller understand the basics of the problem and resolutions to facilitate controller analysis of the situation and associated coordination.

Other types of displayed information assist the controller in identifying, analyzing and resolving problems. For example, the data block includes an indicator while the alert is posted and a Full Data Block appears at the APR-designated position for all aircraft for which the Current Plan is involved in the problem.

While the HRR is posted, Flight Data Entries are automatically posted for the Current Plan aircraft involved in the problem and any other involved aircraft predicted to enter the sector so the controller does not have to request this data manually. The Flight Data Entry includes data essential to the analysis of the problem and resolutions such as the preferences and nonpreferences used by APR, route information, callsign, exemptions and indicators of the User Preferences.

Other displays will be available for controller inspection that present data for the problem. Trajectories associated with Plans can be displayed that indicate all problems, plus the routes, the predicted violation area, the direction of flight, the airspaces involved and/or conformance information. The scale and center of geographical displays can be adjusted as necessary to view the area of concern. There is an indication of the portions of the routes for which radar separation and nonradar separation standards apply.

The FSD (Section 3.5.3) gives controllers a way to perform advanced planning by displaying the relative position of all aircraft predicted to be within a selected geographical area at a
designated future time. The controller can examine the positions of aircraft as predicted from the trajectory for any one of their associated Plans (i.e., Current Plans, Pending Plans, Protected HRRs, Trial Plans, Machine Plans) and the data is dynamically updated to reflect trajectory changes and the detection of problems. The controller can request the FSD for a specific designated time in the future, resulting in a static display; or request the display to be dynamically updated to continually reflect the predicted positions of the aircraft at a designated number of minutes in the future. The FSD can also be used to show the predicted positions of aircraft at a specified number of minutes prior to the time a problem is predicted to occur.

The position receiving the HRR also receives ownership of any other Machine Plans representing resolutions to that problem. For assistance in choosing a resolution, a controller can display resolutions in addition to the HRR, three at a time in rank order, or request seeing all resolutions in a given dimension. Displayed resolutions are accompanied by the same type of data presented with the HRR (e.g., a description of any objections and clearance information). When a resolution is presented that maneuvers an aircraft controlled at another position, the identification of the controlling facility and position is displayed. Additional data the controller can display include preferences and nonpreferences. These optional data give a controller all the information necessary to evaluate and implement a resolution and coordinate with other controllers.

3.4 CONTROLLER ACTIONS

A controller's response to the presentation of problem information varies depending on the type of problem, the type of Plan to which it applies and whether the information was presented automatically or upon request. Figure 3-16 provides an overview of the problem detection and resolution process including a controller's options upon receipt of an automatically generated HRR for a problem in a Current Plan. Receiving the HRR means receiving responsibility for resolving the problem. The controller can examine the data described in Section 3.3 to determine the appropriate action. Most problems are expected to be resolved by controller implementation of the HRR. When the HRR has no objections and the controller knows of no operational or safety reasons for rejecting the HRR, the HRR should be accepted and the associated clearance delivered. However, a controller need not accept the HRR and may exercise other options such as requesting other resolutions and choosing one of them for implementation. This option can be exercised when the HRR does not suit the controller's needs or when another resolution is considered more operationally appropriate.

A controller can also reject all APR generated resolutions and devise a maneuver manually through Quick Trial Planning (Section 3.5.2.1) or by using Trial Planning (Section 3.5.2.2). Trial Plans can be created to test the effect on the problem of changes in the aircraft's Current Plan. Whenever the aircraft cannot execute the resolution maneuver for any reason (not known to automation) this option can be exercised to determine an appropriate resolution.
A controller may also choose to use CAR to guide APR to generate another set of resolutions as described in Section 3.5.1. Unless there is an operational reason for implementing a resolution with an objection, an objection-free resolution should be implemented. A situation in which implementing a resolution with an objection might occur is when a resolution solves a near-term problem and the objection is predicted to occur significantly in the future. In this situation, one option is to try to resolve the problem using CAR. Using CAR, a controller can have APR reconsider a problem using different preferences or nonpreferences. In that way, APR assists the controller in developing a resolution that resolves the problem and does not create another.

When a controller uses CAR to resolve an objection in a Machine Plan, a set of resolutions is presented along with additional data with which the controller assesses the resolutions. Each resolution includes an indication that it was produced as a result of a CAR request. The controller evaluates the results and can choose one of the CAR generated resolutions, choose a resolution in the original set, or continue the effort to produce a resolution.
Since a resolution generated by APR is based on a snapshot of the operational environment at the time of resolution, a controller could feel that the operational environment has changed in the time between generation and the choice of a resolution, and initiate Regeneration Mode to refresh the resolutions. APR then produces new resolutions based on the latest data available. In some cases, a controller may choose to take no action, resulting in the resolutions being refreshed automatically upon expiration of the HRR.

When a problem in a Pending Plan is presented, a controller responds according to the operational situation in which the alert occurs. Factors involved include the use of Automated Coordination and data link that is underway. Details are found in Sections 4.1.1 and 4.2.2, respectively. Problems in Trial Plans are also dealt with in a situation-dependent manner. Factors include the use of Automated Replan and Quick Trial Planning described in Section 3.5.2.

Whenever controllers at other positions should be involved (such as when an aircraft under another position's control must be moved), coordination can be accomplished using Automated Coordination or by phone. Once any coordination has been completed and a resolution has been chosen, the controller delivers the associated clearance by voice or data link. Data link is the preferred option since it minimizes controller workload and avoids the communications weaknesses of radio. A FAS controller uses radio when data link is unavailable or whenever there is an operational advantage to radio.

When voicing clearances, a controller can take steps to obtain maximum benefit from the automation. A Machine Plan that represents the clearance can be promoted to Pending Plan status thereby receiving continual checks for problems from APD. When a Machine Plan is promoted to Pending Plan, the controller still owns a Machine Plan representing the clearance and any problems detected are presented with the Machine Plan as objections. This technique ensures that no changes in the operational environment have occurred since the Machine Plan was initiated that make the resolution operationally inadvisable. While waiting for a response from the aircraft, the existing Current Plan and the Pending Plan associated with the new clearance are protected by automation by continual problem detection. After an acknowledgment of a voiced clearance is received from the aircraft, the controller updates the Current Plan to inform the automation of the new clearance the aircraft is following.

### 3.5 PLANNING AIDS

FAS provides the controller with the capability to tailor APR resolutions with the Controller-Assisted Mode of APR (i.e., CAR); capabilities to assist with the checking, preplanning and modification of Plans; and the capability to view the predicted future positions of aircraft. Each of these capabilities is discussed below.
3.5.1 Controller-Assisted Resolution

The Controller-Assisted Mode of APR, or Controller-Assisted Resolution (CAR), provides options to the initiating position that a controller can use to influence APR for that particular invocation of APR. These options are entered by the controller when initiating the CAR request, apply in addition to those which apply to the aircraft when APR is automatic and can be used to customize one invocation of APR without changing the automatic options. When a CAR option contradicts an automatic option, the CAR option is applied. The available options are described in the following paragraphs.

CAR provides the ability to designate specific maneuver types for an aircraft be included in the preferred or nonpreferred class of resolutions for the CAR request only, not affecting the Automatic Mode options. These options can be for:

- Any designated maneuver types
- All maneuver types
- All maneuver types in a particular dimension

Through CAR, a controller can specify the problem to solve in a designated Plan from among those problems detected in that Plan by APD. Using this capability, a controller can get resolutions for problems involving Notify-only Airspaces or override APR's rules for choosing the problem to resolve in a Plan when more than one have been detected.

CAR gives controllers a way to check the Machine Plan trajectory associated with each CAR-generated resolution against the trajectory of other Machine Plans and/or Trial Plans. Aircraft-to-aircraft problems detected involving these specified Plans are identified as objections. These checks are in addition to the automatic checks made for objections to Machine Plans giving controllers a way to augment the automatic checks for aircraft-to-aircraft problems in Machine Plans. This feature can be used to do advanced planning in a way similar to the manual invocation of APD to check for aircraft-to-aircraft problems between Trial Plans and/or Machine Plans to see the impact of changing several Plans.

CAR also allows the controller to direct APR to choose the position to receive the HRR resulting from the CAR request, overriding the default mode in which the position initiating CAR receives the results. This option allows the HRR to go to another position when the HRR moves that position's aircraft, thereby streamlining the resolution process. A controller may allow APR to choose the receiving position when the operational environment makes it likely that the new HRR would maneuver an aircraft not under the control of the position initiating CAR. An example situation is when the position receiving the automatically generated HRR initiates CAR and nonprefers resolutions for the involved aircraft controlled by that position.
3.5.2 Automated Planning Aids

The capabilities already discussed give controllers advance warning of potential problems and produce alternative resolutions. To complement these capabilities, the ACCC also includes functions that allow controllers to quickly create Trial Plans based on a preferred maneuver type (Quick Trial Planning), create completely new Trial Plans based upon controller input or derived with the assistance of APR (Trial Planning), to periodically check a designated Trial Plan for problems and notify the controller when the Trial Plan is problem-free (Automated Replan), or check, upon request, a Current Plan for problems (Predeparture Check). These functions improve a controller's ability to respond to pilot requests, provide UPs, and plan for future maneuvers.

3.5.2.1 Quick Trial Planning

Quick Trial Planning (QTP) is an ACCC capability unchanged by FAS. Upon request, the automation constructs up to four Trial Plans using a controller-selected maneuver type and checks the Trial Plans for problems detected by APD. The controller can select one of the following four maneuver types:

1. Altitude maneuvers to move the aircraft up and down one or more usable flight levels
2. Lateral route offset maneuvers moving the aircraft left and right, but parallel, to the aircraft’s current route
3. Changes to the aircraft’s air speed
4. Vectors to move the aircraft left or right, which include a depart-from-route vector and a return-to-route vector

The controller can specify the maneuver start point or the start point is determined automatically. The intent of QTP is to quickly construct Trial Plans to investigate pilot-requested changes to the Current Plan. QTP is also useful to explore simple maneuvers for problem resolution purposes. For example, when a controller rejects all the resolutions to a problem produced by APR, the QTP function can assist in exploring other alternatives. The QTP function is much more important in Introductory AERA Services where no resolutions are generated.

The results of APD checking of Trial Plans created by QTP are displayed to the controller. The controller may select a problem free Trial Plan, if one exists, or may select one that has a problem if he/she believes it to be minor, or solvable at a later point in time. The controller would then provide the appropriate clearance to initiate the desired control action.
### 3.5.2.2 Trial Planning

Trial Planning provides the controller with the capability to investigate a proposed action, such as an alternative route for a problem or a pilot request, before implementation in order to determine if the new Plan would create any problems. The difference between this and QTP is that Trial Planning provides the controller with the capability to construct a unique, or tailored, Trial Plan from scratch for use in solving a problem. If desired, the controller performing Trial Planning may also request that APR check and modify his/her Trial Plans so that they become problem free.

The Trial Plan created by the controller must include only eligible amendments to the Current Plan. Eligible amendments include any combination of the following:

- A reroute, starting at a specified time in the future (e.g., direct to a specified fix from wherever the aircraft is at the time of the re-evaluation)
- A reroute, starting at a specified time or at a specified fix in the Current Plan
- An altitude change starting at a specified time in the future
- An altitude change at a specified time or at a specified fix in the Current Plan
- A speed change starting at a specified time in the future
- A speed change at a specified time or at a specified fix in the Current Plan

Trial Plans created from pilot requests may be entered into the automation directly by the controller who has received the request via radio, or automatically by FAS when the request has been received via data link. The controller may also specify that a Trial Plan be created from a Current or previously existing Plan, such as a Dormant Current Plan or Dormant Trial Plan. Either way, as was the case for QTP, the created Trial Plan is automatically checked upon creation by APD for problems against Current Plans, airspaces, and flow instructions and the results are presented to the controller.

In the case where the controller also wishes for APR to assist with the construction of problem-free Trial Plans, the controller simply needs to turn on this function. APR will then automatically check the Trial Plans as soon as they are created by the controller, modify them where necessary, and return them problem-free to the initiating position.

### 3.5.2.3 Automated Replan

Automated Replan presents the capability to have Trial Plan problems periodically checked, or reevaluated, by APD in order to determine when this amendment will become problem free. This capability assists controllers in satisfying user requests, particularly when the request is
initially denied because it would cause a problem. The controller can submit a Trial Plan with a problem, and with proper eligible amendments, to Automated Replan so that later, if the user’s request can be granted, the controller is notified automatically. At most, one Automated Replan can be in effect for an aircraft.

Initially, the controller's choice of amendment is conveyed to the automation for Automated Replan by designation of an existing Trial Plan owned by the Current Position. Thereafter, a new Trial Plan (to replace the previous Trial Plan) is built automatically and submitted to APD at each recurrent Automated Replan cycle. The replaced Trial Plan is automatically deleted. The Trial Plan built automatically is owned by the current position and is based on the specified amendment applied to the Current Plan position at the time of the recurrent Automated Replan cycle.

Once the Automated Replan process has begun, the current position is notified when the Trial Plan is problem-free or when Automated Replan automatically terminates. When requested by the current position, Automated Replan provides a status report for an aircraft in Automated Replan by initiating a new cycle and displaying the results from APD. Finally, when Automated Replan terminates and the Trial Plan has not been promoted to Pending Plan or Current Plan status, the Trial Plan is deleted.

For a Trial Plan found to be problem-free, a Pending Plan is created from the problem-free Trial Plan and displayed with all the clearance delivery information so the current position can issue the associated clearance by voice or data link. When the amendment is for a change in altitude of more than one assignable altitude level and the target altitude is not available, Automated Replan will search for the closest altitude to the target to find one that is problem-free. If a problem-free altitude is found, a Pending Plan is created for that altitude and displayed to the current position. The Automated Replan remains in effect for the target altitude. If a later cycle discovers a problem, a notification will be displayed to indicate the Pending Plan is no longer problem-free and Automated Replan continues.

The Automated Replan process for an aircraft continues to cycle as described above until one of the following conditions is met:

- The flight terminates.
- The current position manually terminates the process.
- The Trial Plan in use by Automated Replan is deleted by the current position.
- The Trial Plan or Pending Plan implementing the amendment is made the Current Plan.
The Current Plan has changed such that the amendment makes no sense (e.g., for a request for a direct route to a fix, that fix has been passed or is no longer part of the Current Plan).

3.5.2.4 Predeparture Check

Predeparture Check (PDC) provides the controller with the capability to apply, upon controller request, an APD check to a Flight Plan prior to departure. This check, usually in response to a pilot's indication that his/her aircraft is ready to depart, will provide the controller with advance information (i.e., before the aircraft leaves the airport) about the adequacy of a Flight Plan.

PDCs include detection of aircraft-to-airspace problems and flow instruction violations. Checks for aircraft-to-aircraft problems are excluded since the uncertainty associated with aircraft departure times would minimize the usefulness of the results.

When a controller requests a PDC for an aircraft's Flight Plan, a Current Plan is constructed by the automation so that APD can check for problems. If APD detects a problem with a Current Plan, APR is invoked automatically and the problem data and resolutions are displayed to the initiating controller. In this way, problems with the Flight Plan are resolved while the aircraft is on the ground and the aircrew has time to update their flight data. In general, it is easier to amend a Flight Plan while an aircraft is on the ground rather than flying through the initial control sectors.

3.5.3 Future Situation Display

The Future Situation Display (FSD) provides the controller with the capability to graphically view the predicted future positions of aircraft rather than mentally project these positions from flight data. This capability is important because it enables the controller to view a particular problem in more detail and/or to explore the adequacy of proposed control alternatives such as a reroute, change in altitude, etc. It is also expected to reduce the controller's reliance on tabular flight data and to assist the controller in anticipating operational events and conditions that may impact alternative route planning.

The FSD provides an advanced planning capability by allowing the controller to view a geographic area of concern at a specified future time. This geographic area of concern is the same area that is presented on the Situation Display, and contains much of the same data such as map data, aircraft symbology, route data, graphic weather, display of time, moving data blocks, and problem notification. The FSD, however, is coded in such a fashion to ensure that the user is aware that he/she is looking at projected aircraft positions, routes, etc. in future time, and not current time. This characteristic provides the controller with a useful display of contextual information that lends itself to the strategic analysis of aircraft problems.
Three modes of FSD operation are provided:

1. **Static** - Provides a frozen view of a situation at a specified future time. Time may be adjusted forward or backward dynamically or by designating a new future time.

2. **Problem** - Provides a frozen view of a situation a parameter time before a specified problem (except for Trial Plan Alerts and Flow Instruction noncompliances) is to occur. May be adjusted forward or backward dynamically or by designating a new future time.

3. **Continuous** - Provides a continuously updated view of a situation at a fixed future time. The time can be adjusted by designating a new future time.

Controllers at a given position can specify that a Current Plan be graphically presented in the FSD in any mode, and can also specify that a Trial Plan, Pending Plan or Protected HRR be presented as replacements for a Current Plan or with the Current Plan. Other resolutions (or Machine Plans) can also be presented upon controller request in this display. Data block information is also updated to show that a Machine Plan has been changed to a Pending Plan.

The future time presented in the FSD may be adjusted by the controller in any mode. For the Static and Problem modes, the controller may adjust the future time dynamically, meaning that the time can be adjusted with the assistance of a time scale, or slider, to see map updates on the FSD within a matter of seconds. Such dynamic control over future time projections will assist the controller to make strategic and evaluative judgments about the nature of a problem and/or the alternative plan(s) designed to remediate the problem. For Continuous Mode, the controller is expected to take advantage of the constantly updated projection of aircraft positions at a set future time by using this information to assess the nature of future traffic flows.

Figure 3-17 shows the components of the FSD when it is in problem mode. This means that the controller is able to view a static representation of a problem a parameter time before projected problem is set to occur. The insight provided from this view of a problem should better enable the controller to devise a proper control maneuver.
Figure 3-17. Components of the Future Situation Display in Problem Mode
SECTION 4
ENHANCED OPERATIONAL CAPABILITIES

This section describes the controller-to-controller coordination, controller-to-pilot communication, interaction with terminal operations, and measurement of sector activity capabilities provided by FAS. These features have been enhanced by FAS in order to improve the speed with which many routine controller activities may be performed.

4.1 CONTROLLER-TO-CONTROLLER COORDINATION

Improved coordination, handoff, and airspace interaction capabilities are provided to the controller by FAS. This functionality is described below.

4.1.1 Automated Coordination

Automated Coordination provides controllers with a nonverbal means of communicating ATC data to other controllers. Proposed aircraft actions may be forwarded to other controllers for information purposes through the automation system.

Any position can initiate Automated Coordination for any Trial Plan, Protected HRR, Pending Plan or Machine Plan owned by that position. When the Plan is designated for Automated Coordination, the Plan automatically becomes the Pending Plan for the aircraft (if not the Pending Plan already). Pending Plans are the central communications vehicle during Automated Coordination since the coordination is used prior to promoting a Plan to Current Plan. Thus, continual problem detection for the Plan being coordinated is necessary. The lifetime of a Pending Plan used by Automated Coordination is extended when necessary and lasts until Automated Coordination is completed or terminated. The Pending Plan either becomes the Current Plan or a Trial Plan (with ownership assigned to the initiating position) depending on the current position's actions with respect to the coordination.

The position initiating Automated Coordination is termed the initiating position and positions receiving the data through Automated Coordination are termed receiving positions. The actions of a controller depend primarily on whether the initiating position is the current position. When the initiating position is not the current position, the primary operational intent is to request that the current position make the designated Plan the Current Plan. When the initiating position is the current position, the primary operational intent is to communicate the current position's intentions to other positions. The discussion below is divided into these two cases.

4.1.1.1 Automated Coordination Initiated by a Noncurrent Position

When a controller owns a Trial Plan or Machine Plan for an aircraft controlled by another position, Automated Coordination may be used to show the Plan to the current position and request the current position to make the Pending Plan used by Automated Coordination (and owned by the current position) the new Current Plan. The only receiving position is the
current position since only the current position can implement a Plan as the Current Plan. The current position can respond by designating the Pending Plan as the Current Plan either manually or by transmitting the clearance and receiving the pilot's acknowledgment via data link. The current position can instead respond with "Unable" thereby denying the Automated Coordination request. When the current position fails to respond within a specified time, the "Unable" response will be generated automatically.

After the response is generated, a final message is displayed at the initiating position indicating the response. When the response is "Unable," the Pending Plan automatically becomes a Trial Plan owned by the initiating position, and Automated Coordination terminates. This process is illustrated by Figure 4-1.

Before responding to the request, the current position has the option to extend the Automated Coordination to other positions of choice. This second component of the Automated Coordination is subject to the rules discussed below.

4.1.1.2 Automated Coordination Initiated by the Current Position

When a controller at the current position is considering making a Trial Plan, Pending Plan or Machine Plan the Current Plan, Automated Coordination may be initiated to advise other controllers of impending actions. The positions to receive Automated Coordination data are determined automatically based on local adaptation. The default list of receiving positions is displayed at the current position and the controller may modify the list as desired or accept the default list.
As in the case described in the previous section, a Pending Plan is used by Automated Coordination for communicating intentions to other positions. All the receiving positions receive the Automated Coordination data and can respond. When a response has been generated for each receiving position, a single consolidated response is displayed at the current position. The current position can then make the Pending Plan the Current Plan or demote it to a Trial Plan and Automated Coordination terminates. Any receiving position whose response is contrary to the final action of the current position is notified. Otherwise, the receiving position receives nothing more from Automated Coordination and knows the recommended action was taken by the current position.

4.1.1.3 Aspects of Automated Coordination Common to Both Types of Initiation

Certain aspects of Automated Coordination do not depend upon which position initiated it. The receiving position always receives pertinent data for the Pending Plan and the identification of the initiating position. All positions involved in the coordination receive the same information. Along with the Plan data, all positions receive any problem information associated with the Pending Plan. The problem data is updated when it changes, to assist the involved controllers in deciding whether the Pending Plan should be promoted to Current Plan status.

A request for Automated Coordination can be canceled at any time by the initiating position. When the current position is involved in a two-component Automated Coordination for which it is both a receiving position and an initiating position, a request for cancellation of Automated Coordination by either initiating position cancels only the component initiated by that position, to prevent cancellation of the other component that is still being pursued by its own initiator.

Since Pending Plans must be short-lived in the automation system, Automated Coordination cannot be allowed to continue indefinitely and a time limit is applied. When the Pending Plan is neither made the Current Plan nor demoted to a Trial Plan before the time limit is exceeded, Automated Coordination automatically demotes the Pending Plan to Trial Plan and terminates. Controllers are notified when Automated Coordination terminates automatically.

4.1.2 Handoff of Controlled Aircraft

FAS adds a new capability to the transfer of operational responsibility between controllers: automatic acceptance of handoff. This capability allows the system to automatically provide Control Transfer as long as the handoff was automatically initiated and the current controller has not inhibited this function. Sector boundary crossings by controlled aircraft are anticipated automatically using trajectories.

FAS handoff is accomplished in two steps: Control Transfer and Transfer of Communications (TOC). Typically, Control Transfer for an aircraft is automatic when it reaches a point in the trajectory shortly before the sector boundary. In Figure 4-2, automatic initiation and acceptance of Control Transfer by Sector 2 would normally occur at Point B. Between Point A and Point B, Control Transfer is initiated and accepted automatically regardless of the existence of Current Plan problems. If a new Current Plan problem is detected or if the HRR for an
existing Current Plan Problem expires, the alert and resolution would be displayed at Sector 2 and not at Sector 1. In order to retain the aircraft and problem for continued analysis, however, the Sector 1 controller must inhibit automatic initiation of Control Transfer prior to resolution expiration or the aircraft reaching Point B. When the analysis is finished, automatic control transfer is reenabled and the normal handoff process occurs. There are no points in the example where a manual acceptance by the receiving position is required.

![Diagram of Control Transfer]

Figure 4-2. Control Transfer

Controllers can also initiate Control Transfer manually. When this happens, or when the receiving position is not FAS-supported, manual acceptance is required. Manual acceptance of Control Transfer requires the receiving position to accept control through a message input. The position initiating the transfer can retract that transfer any time before acceptance or rejection by the receiving position. When the receiving position is not FAS supported, the initiating position is shown an indication that Control Transfer will need to be accepted manually.

A short time after manual or automatic acceptance of Control Transfer, TOC is initiated. For data link equipped aircraft, TOC is automatic unless automatic transfer has been inhibited. When automatic transfer is inhibited or the aircraft is not data link equipped, the initiating position receives a reminder to initiate TOC and the TOC is done via radio. At radio frequency change boundaries where no Control Transfer takes place, TOC is handled as above except the initiating event is the aircraft's arrival at a point on its trajectory that is a parameter distance from the radio frequency change boundary.
4.1.3 Interaction With Non-FAS Airspaces

The ACCC will provide FAS services to facilities that border airspace controlled by non-FAS facilities. FAS design is in no way predicated on pilot knowledge of facility support levels. The following discussion indicates the requirements needed to accommodate conditions that will exist when FAS airspace borders non-FAS airspace.

In determining when to forward flight data, the ACCC uses the following rules:

- When a flight's trajectory exits FAS airspace and is planned to reenter FAS airspace, flight data regarding the flight is forwarded to both the non-FAS facility which the flight is entering and the FAS facility controlling the first FAS airspace the flight will reenter.

- When a flight's trajectory exits FAS airspace and is not planned to reenter FAS airspace, flight data regarding the flight is forwarded only to the non-FAS facility controlling the non-FAS airspace which the flight is entering.

The ACCC detects problems of all kinds (aircraft-to-aircraft, aircraft-to-airspace, flow instruction noncompliance) in non-FAS airspace when trajectory, conformance, and flight data are available to support problem detection, irrespective of whether the aircraft are operating in, or are predicted to enter, non-FAS airspace. The ACCC also resolves problems of all kinds (aircraft-to-aircraft, aircraft-to-airspace, flow instruction noncompliance) when trajectory, conformance and flight data are available to support problem resolution, irrespective of whether the aircraft are operating in, or are predicted to enter, non-FAS airspace. Finally, in ordering resolutions, the ACCC places in the nonpreferred class all resolutions that would cause the subject aircraft to enter non-FAS airspace, if the originally-filed Flight Plan for that aircraft did not call for the aircraft to enter non-FAS airspace.

In determining the APR-designated position, the ACCC uses the following rules:

- When at least one aircraft involved in a problem is currently controlled by a position in an FAS facility, the APR-designated position is determined as stated in Section 3.2.6, except that positions not supported by FAS facilities shall be excluded from the selection process.

- When all aircraft involved in a problem are currently controlled by non-FAS facilities, the APR-designated position is the position controlling the FAS airspace that will be entered first by the aircraft maneuvered in the HRR.

When a receiving position in Automated Coordination is not supported by FAS, the initiating position is notified that coordination with the receiving position must be conducted via voice communications. After the initiating position controller has completed coordination with the receiving position, the initiating position controller must enter the receiving position's
response, to complete that part of the coordination. Overall, the ACCC conducts Automated Coordination as though all receiving positions were supported by FAS.

Automated Replan functions as described in Section 3.5.2.3, except that the ACCC (1) inhibits Automated Replan when the subject flight is within a parameter time of entering a non-FAS airspace and (2) automatically terminates any ongoing Automated Replan services for a flight a parameter time before that flight enters non-FAS airspace.

The parameter specifying the amount of time prior to boundary crossing between two sectors that the ACCC must use in calculating when to initiate handoff is replaced by two separate parameters. One of these applies to situations where handoff will be from one FAS facility to another FAS facility; the other applies where handoff will be from a FAS facility to a non-FAS facility.

The ACCC furnishes AERA reminders as follows:

- FAS controller reminders are furnished to controllers only when the reminders concern events that occur in FAS airspace.
- FAS pilot reminders are furnished to pilots only when the subject aircraft are operating in FAS airspace.

When a flight is planned partly in FAS airspace and partly in non-FAS airspace, the ACCC generates all FAS reminders applicable to the part(s) of the flight in FAS airspace, just as though the flight were being conducted entirely in FAS airspace.

The ACCC generates Future Situation Displays irrespective of whether adjacent facilities are supported by FAS. All FSDs will reflect information on all aircraft for which sufficient trajectory, conformance, and flight data are available, irrespective of whether the aircraft are operating in, or are predicted to enter, non-FAS airspace.

4.2 CONTROLLER-TO-PILOT COMMUNICATION

Communications between controller and pilot are improved with the provision of reminders for control actions to controllers and data link support. This functionality is described below.

4.2.1 Reminders

In the current system (NAS/Host), when the controller enters a Flight Plan amendment message into the system, the clearance and the data base are changed immediately. Any action planned for the future must be remembered by the controller and/or written down for later implementation.
With automated aids detecting problems earlier, there is a need for a mechanism to enter expected future actions into the system and to remind the controller or pilot of the actions before they are supposed to be implemented. This helps the controller enjoy the benefits of early planning.

Reminders inform controllers and pilots to take certain actions. Controllers are reminded that a previously planned action (such as a maneuver requiring issuance of a clearance) is scheduled to occur in the near future and has not been taken. This is necessary especially when the action is to occur in a sector other than the one in which the clearance was issued. Another benefit is in helping controllers keep aircraft from going out of conformance with their Current Plan. Pilots are reminded of the control actions they are scheduled to take by data, if available, or by the controller. This is important for helping pilots meet their Flight Plans. Table 4-1 lists all the FAS Reminders and indicates the purpose and recipients of each. Each Reminder is discussed in the following subsections.

### Table 4-1. FAS Reminders

<table>
<thead>
<tr>
<th>Reminders</th>
<th>Recipient</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td>Start-Maneuver</td>
<td>C*, P**</td>
<td>Prompt start of previously cleared maneuver</td>
</tr>
<tr>
<td>Top-of-Descent</td>
<td>C*, [C, P] +</td>
<td>Prompt start of descent to destination</td>
</tr>
<tr>
<td>Mandatory Reporting Point (Monitor Report)</td>
<td>C</td>
<td>Indicates position report is overdue</td>
</tr>
<tr>
<td>Planned Change to VFR</td>
<td>C</td>
<td>Indicates planned change from IFR to VFR</td>
</tr>
</tbody>
</table>

C = Current Position  
P = Pilot  
+ = When data link is available, exactly one as adapted  
* = When data link is not available  
** = When data link is available


4.2.1.1 Start-Maneuver

When an aircraft's Current Plan includes a previously cleared altitude, speed, or hold maneuver, the Start Maneuver reminder is generated prior to the time at which the maneuver is to begin. When the aircraft is able to receive data link messages, the reminder is transmitted via data link to the aircraft and the controller is uninvolved. For aircraft unable to receive a data link transmission, the reminder goes to the controller and the controller monitors the aircraft to ascertain that the maneuver begins as planned and may remind the aircraft by voice.

4.2.1.2 Top of Descent

A reminder to begin the aircraft's descent to its destination is generated prior to the time at which the descent is to begin. When the aircraft is unable to receive data link transmissions, the reminder is displayed to the controlling position and voice transmittal to the aircraft can be initiated. Facility adaptation controls the Top of Descent (TOD) reminder process for data link equipped aircraft. One option is for the reminder to be sent to the aircraft automatically via data link without controller intervention. The other option has the reminder displayed to the controller. Upon receipt of the reminder the controller can manually transmit the reminder via data link or use radio.

Figure 4-3 illustrates the relationship of this reminder to the TOD and the automatic reconformance of the aircraft trajectory (Section 3.1.5).

4.2.1.3 Mandatory Reporting Point (Monitor Report)

When an aircraft reaches a mandatory reporting point, it must contact ATC. The ACCC expects the controller to indicate receipt of the position report when received. When the indication from the controller is not entered within a certain amount of time after it is expected, this reminder is displayed. The reminder notifies controllers that an aircraft missed a mandatory reporting point and the controller responds by acquiring and entering the required position report.

4.2.1.4 Planned Change to VFR Reminder

When a flight is going to change status from IFR to Visual Flight Rules (VFR) before reaching its destination, the Planned Change to VFR Reminder is generated a parameter time before the IFR-to-VFR transition is to occur.
4.2.2 Data Link Support

FAS will use a two-way digital data link for nonvoice communication between aircraft and ATC automation. Data link will be the primary communication medium between controllers and the aircraft for aircraft suitably equipped. Data link communication will be based on the RTCA Minimum Operational Performance Standards for ATC Data Link Communications. The MOPS defines the up-link and down-link messages that will be supported.

The system maintains a record of the controlled aircraft capable of data link communications at any time and maintains an open session with those aircraft. For each of these aircraft, there is only one position in the facility that has the authority to send data link messages to the aircraft. Each controller's display will show which aircraft are eligible for data link messages and whether that position has authority to send data link messages. Controllers will be told when an attempt is made to communicate via data link but the aircraft cannot receive messages.

Several types of down-linked messages trigger automatic actions and responses that are processed by FAS and presented to the controller. Certain types of messages are uplinked to aircraft, either automatically or through controller action. Data link communication will primarily be used in FAS to:

- Maintain a radio frequency for voice communication between ATC and the pilot
• Deliver routine clearances from ATC to the aircraft
• Receive requests from the aircraft for clearance changes
• Maintain synchronization between aircraft intent with the ATC automation trajectory
• Advise aircraft of ATC intent, e.g., metering delay in the future

For most messages there is a set of responses that can be given by the receiver. For uplink messages, the aircraft can respond WILCO, ROGER, STANDBY, UNABLE, AFFIRM or NEGATIVE. A response of WILCO or ROGER is considered a standard response, and the automation will assume that the aircraft will comply with the clearance or instruction. Any other response is considered nonstandard and the automation will display an alert to the controller that further action is required.

For downlink messages, specifically clearance change requests, the controller can respond UNABLE, STANDBY, REQUEST DEFERRED, ROGER, AFFIRM, or NEGATIVE. The controller will use the first four responses as is described below. AFFIRM or NEGATIVE will not be used because they are not appropriate responses to aircraft clearance requests.

4.2.2.1 Transfer of Communications

Data link will be used to inform aircraft when a radio frequency change needs to occur. This can happen after handoff of track control to another position, or when an aircraft crosses a boundary between areas of different radio frequency coverage. There is an automatic mode and a manual mode for transmitting this message. In automatic mode, the message is sent without controller action; a parameter time after the transfer of control is complete or a parameter time before crossing the radio frequency boundary, a CONTACT message is sent via data link. In manual mode, the controller acknowledges a transfer of communication reminder to generate and transmit the CONTACT message. When the data link fails to deliver the message, no response is received within a parameter time, or the response from the aircraft is anything but WILCO or ROGER, a nonstandard condition exists for data link message. For a nonstandard condition to a CONTACT message, both the initiating and receiving positions in the handoff are notified. Procedures will be defined for the initiating position to make voice contact with the aircraft.

The receipt of the WILCO or ROGER response from the aircraft is an indication that the aircraft radio frequency is now tuned to the new frequency. No additional pilot or controller communication, either by voice or data link, is necessary to verify that the frequency is correct.

When the controller attempts to contact an aircraft via radio and the pilot does not respond, the controller will try to reestablish radio communication. The system will keep track of which frequency was the last one sent to the aircraft via data link. The controller can request a display of this frequency. The controller can also manually send a CONTACT message via data link to have the aircraft change to a particular frequency. In this way, the controller can try to contact the aircraft on the last known frequency or get the aircraft on the correct frequency for the sector.
4.2.2.2 Clearance Delivery

Data link can be used for transmission to an aircraft of any clearance consisting of an altitude assignment (with or without restrictions), a future altitude assignment, a route change (with or without embedded altitude and speed changes), vectors, or a clearance limit/holding instruction. When the controller designates that a clearance be sent via data link as represented by an AERA Plan for an aircraft, the system will make that Plan a Pending Plan so it is continually checked for problems while the clearance is in coordination. If no problems are detected when the Plan is first made Pending, the clearance is transmitted via data link immediately. If the Plan has a problem, the controller receives the problem information and then must enter a confirmation for the clearance to be sent. If a confirmation is entered, the clearance is sent via data link. If no confirmation is entered, no message is sent. When the data link message is transmitted, display of alert information and other Plans associated with the aircraft will be suppressed as if the Plan was made Current.

When a standard response is received from the aircraft, the system promotes the Pending Plan to Current Plan and no additional controller display is generated. For any nonstandard response, the Pending Plan is retained since the controller does not know the aircraft's intentions; the position controlling the aircraft gets the information on the clearance. The pilot is expected to make voice contact with the controller. Other displayed information that was suppressed when the clearance was data linked will be redisplayed. If the data linked clearance came from a Plan that solved an APD detected problem, APR will regenerate resolutions for the problem and the resolution information is displayed to the position controlling the aircraft. The controller can cancel the data link message if no response was received and must also delete the Pending Plan once the aircraft intentions are known.

4.2.2.3 Flight Plan Amendment Request

This message is initiated by the aircraft to request a clearance change. When the system receives the message, it is checked for format and logic errors. When an error is found, an error message is sent to the aircraft via data link and an entry is displayed to the controller that includes the request and the error.

When the request is free of logic and syntax errors, the system automatically initiates a Trial Plan by incorporating the request into the Current Plan. The Trial Plan is then processed through problem detection. The Trial Plan with any applicable problem information is displayed at the position controlling the aircraft, with an indication that the Trial Plan resulted from receipt of a data link message.

The controller can respond to the Trial Plan in several ways. A clearance implementing the request can be transmitted to the aircraft. This would be the usual response for conflict-free requests. The controller could respond STANDBY or ROGER which indicates that more time is needed to analyze the request. Subsequently, the clearance may be sent when the analysis is complete. The controller could UNABLE the request which would also delete the Trial Plan. The Trial Plan can be put into Automated Replan when it has a conflict. This will also initiate transmission of a REQUEST DEFERRED response via data link. When the Automated Replan is available, a clearance can be transmitted.
4.2.2.4 Synchronization of Maneuver Start Points (MSPs)

It is important that the system, the controller, and the pilot use the same start point for maneuvers planned for the aircraft. Data link has a role in the coordination needed to ensure the synchrony, when the latter is not established by the flight's initial clearance.

The point at which synchrony is established or validated varies according to how the MSP is defined.

- The MSP is well-defined when it is a fixed geographic point, for example, a NAVAID or an intersection of air routes.

- The MSP is less precisely defined when the maneuver is planned to begin a specified time or distance after departure. The departure time is not a precise value, as recorded in the system, nor is the pilot required to fly a specific speed schedule associated with the flight plan. Therefore, the departure time estimates can be several minutes off.

Most maneuvers having well-defined start points are considered "cleared" when they are included in a flight's initial clearance. Most maneuvers based on time or distance from departure require coordination between pilot and controller, and a clearance, before execution. A special altitude case that requires clearance is a flight's TOD point.

Figure 4-4 illustrates the possible problem. A flight has an altitude climb to FL370 in its initial Flight Plan and clearance based on time from departure. The system also calculates a TOD point for the flight. At some point a conflict is encountered and the aircraft is rerouted. Both the climb point and TOD are recalculated for the new routing. These new MSPs must be coordinated with the aircraft.

To get the MSP accurately established for aircraft conflict detection, an entry will be displayed to the controller a parameter time prior to the start of the maneuver. The controller can then clear the MSP via voice or data link. For voice only aircraft, the controller issues the MSP via radio. The pilot could then synchronize the maneuver with the ground either by accepting the start time or requesting a different time.

For data link equipped aircraft, a manual or automatic mode for MSP coordination can be used. In manual mode, the entry is displayed to the controller and the controller enters a command to data link the clearance. If the aircraft wants a different maneuver start point, the pilot can make a flight plan amendment request. In the automatic mode, instead of the controller receiving a displayed entry, a CLEARANCE message is sent at the time the entry would have been displayed. The controller only sees an entry if the aircraft returns a nonstandard response.

The manual or automatic mode can be set differently for maneuvers entered in the Flight Plan versus maneuvers generated by the system. It is envisioned that maneuvers already coordinated with the aircraft in the Flight Plan will not need controller acknowledgment but system maneuvers such as TOD may require controller action to send.
4.2.2.5 ATC Intent Data

Data such as meter fix or boundary crossing times that ATC intends to issue clearances for the aircraft to meet will be sent to the aircraft prior to clearances being issued. This allows the pilot time to analyze how best to absorb the delay and request efficient maneuvers rather than accepting controller or system generated maneuvers. This intent data will be sent to the aircraft as free text messages and no response will be required by the aircraft.

4.3 CENTER TERMINAL AUTOMATION SYSTEM INTEGRATION

The Center Terminal Automation System (CTAS) schedules and sequences flights into terminal areas for arrival to the airport. CTAS will be implemented for a limited number of airports; the metering function will provide schedules and sequences for other airports. Part of CTAS called Descent Advisor also calculates fuel efficient descent profiles and advisories to meet the meter fix time. Descent Advisor information includes a TOD point, speeds to be flown in the descent, and routes and vectors to lengthen the path of the flight.
FAS will use CTAS information to build arrival trajectories and maneuvers to meet the meter fix time. FAS will incorporate the TOD point and speeds into the Current Plan trajectory. Other CTAS data will be used by APR as the highest ordered resolution dimension for resolving the metering noncompliance. If APR finds the CTAS advisory is conflict-free, it builds a Protected HRR with the data and displays it to the controller. If the CTAS advisory has a conflict, APR proceeds through its logic to find a conflict-free maneuver as it would for other airports with meter fix times but no CTAS advisory.

### 4.4 SECTOR ACTIVITY MEASURES

Sector Activity Measures quantify the activity level in a sector during successive five minute periods into the future as determined from trajectory data. The data for a sector can be observed by controllers of that sector. Supervisory positions have access to the data for all positions they supervise. A monitoring feature enables automation to alert a position when a selected measure is predicted to fall outside a predetermined range. The types of measures predicted are those requiring the most activity from a controller such as situations requiring voiced clearances, potential problem situations, metering or high traffic density. The information is useful in judging the impact of a resectorization or in identifying sectors expected to be heavily loaded. The FAS Sector Activity Measures include:

- The maximum numbers of controlled data-link-equipped aircraft, and controlled non-data-link-equipped aircraft (separate totals)
- The number of planned actions for aircraft requiring voiced clearances (aircraft that are not data-link-equipped and aircraft in nonradar areas)
- The number of aircraft subject to metering
- The number of aircraft, anywhere, that have not yet departed and that would be in the sector of interest during the five-minute interval of interest if they departed as scheduled and followed their Current Plans
This section describes FAS automation processing from departure to destination for two types of flights. A military aircraft scenario typifies military operations including airborne refueling and maneuvers inside a Military Operations Area (MOA). An air carrier scenario typifies flights by a scheduled airline between large airports. This discussion brings together many of the major concepts described in the previous sections and each scenario places FAS in the context of the aircraft's flight from origin to destination.

### 5.1 MILITARY AIRCRAFT SCENARIO

A group of military fighter aircraft departs a military Base of Operations (BASOPS) for exercises within a MOA. Part of the route includes an IFR Route (IR)—a Military Training Route (MTR) in which the aircraft fly IFR. Following the IR and prior to entering the MOA, the fighters rendezvous with a tanker for refueling. The rendezvous occurs at a specified fix within a specified block altitude. The "track" is accomplished by having the tanker fly a predetermined path in the block altitude while the receivers sequentially refuel. After refueling, all aircraft continue on their filed Flight Plans. The fighters enter the MOA. One of the fighter must depart the MOA earlier than expected and return to the military base due to mechanical difficulties. The fighters are not equipped with data link. Figure 5-1 provides an overview of the scenario.

#### 5.1.1 Flight Plan

Each fighter files a Flight Plan that includes the IR, the route to the rendezvous fix, the refueling route, the route to the MOA, the MOA, and the return route from the MOA to the military base. The data included in the Flight Plan for one fighter, "GUNDOG1" is shown in Table 5-1. The other fighters have the same Flight Plan with different Aircraft Identifications (ACIDs). The route explicitly states the altitudes, entry and exit fixes for the refueling track and MOA, and the approach fix for landing. The Remarks include four items: the identification of the IR with the entry and exit times and altitude, the refueling track with the tanker identification and block altitude, the activities in the MOA, and the approach for landing.
Figure 5-1. Military Aircraft Scenario Overview
5.1.2 Departure and Handoff to Center

Departure clearances are issued by military control. The military monitors the flights and provides separation services while in military airspace. A Group Suppression message is entered identifying the group as GUNDOG so APD will not detect aircraft-to-aircraft problems between group members. The automation also recognizes the MOA name in the route of flight and the intent of the aircraft to enter the MOA, so no problem with the airspace is detected.

After the aircraft depart, the radar detects the aircraft and tracks are started. The routine handoff to the Area Control Facility (ACF) (Sector 1) includes automatic initiation and acceptance of Control Transfer. The military controller receives confirmation of the acceptance and the Center controller receives the Full Data Block (FDB). Since the fighters are not data link equipped, the Transfer of Communications is voiced by the military controller. Voice communication with the controller of Sector 1 is established.

Table 5-1. Flight Plan Data

<table>
<thead>
<tr>
<th>Data Field</th>
<th>Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aircraft ID</td>
<td>GUNDOG1</td>
</tr>
<tr>
<td>Aircraft Data</td>
<td>F16/Pv</td>
</tr>
<tr>
<td>Beacon Code</td>
<td>4712</td>
</tr>
<tr>
<td>True Air Speed</td>
<td>500</td>
</tr>
<tr>
<td>Departure Point</td>
<td>LMT</td>
</tr>
<tr>
<td>Departure Time</td>
<td>P1600</td>
</tr>
<tr>
<td>Altitude</td>
<td>270</td>
</tr>
<tr>
<td>Route</td>
<td>LMT . . LKV . IR300/190 . BOI350049 . . RBL351079/270 . AR7BA/260B280 . RBL349079 . BAM . JUNI . BAM . . PEREZ/1400 . . LMT</td>
</tr>
<tr>
<td>Remarks</td>
<td>IR300 E 1615 X1710 RAL270 . AR W/TANK 1 260B280 . JUNIPER W/GUNCAT . REQ HI TACAN 32</td>
</tr>
</tbody>
</table>
5.1.3 Military Training Route

In today's system, each aircraft is cleared into, and reports leaving, the IR. With FAS, unless there is a change to the Flight Plan such as an early IR exit, MTR entry and exit require no communication between the controller and the aircraft, since the entry and exit have already been cleared as filed. While the aircraft are on the MTR, APD still predicts problems for them. If a problem was detected involving a fighter and another aircraft not on the MTR, APR would automatically nonprefer any resolutions produced that move a fighter on the MTR. Upon the exit from the MTR, the previously cleared altitude maneuver (climb to FL 270) is performed. If the pilot wants an early exit from the IR, communication with ATC can establish the necessary Flight Plan Amendment. The fighters continue on the filed route for tanker rendezvous.

5.1.4 Rendezvous and Refueling

When the tanker and fighters converge near the designated rendezvous fix, the controller asks the tanker to advise ATC when ready to declare Military Assumes Responsibility for Separation of Aircraft (MARSA). When the tanker declares MARSA identifying the involved aircraft, the controller enters the aircraft identifications with a Group Suppression message. No entry is made for the group name so it defaults to the name of the group leader (TANK1). The identifications of all the fighters are entered with the single entry, "GUNDOG," which automation recognizes as the group name defined previously in the Group Suppression message.

Formation limits around the lead aircraft (the tanker) are used by APD in problem detection. Standard (default) formation limits around the lead aircraft are used in this case, since no entry was made in the Group Suppression message. The location of a group for APD processing is the location of the lead aircraft which must have its transponder on. All communication with the group is conducted through the lead aircraft's callsign (or data link address). Acceptance of the Group Suppression message by the automation sets up special rules for APD to use for the involved aircraft. APD generates no alerts between the group aircraft and protects the group by identifying any aircraft whose Trajectory violates separation standards with the formation. APR automatically nonprefers maneuvers that move a group. The fighters move around within the block altitude to refuel sequentially and remain with the group led by the tanker.

When the refueling is ten to twenty minutes from completion, the tanker advises the controller that the refueling will end. The tanker requests clearance for continuing on its course at present altitude. The fighters request (through the tanker) a direct route to the MOA entry fix at present altitude for the group (GUNDOG). The previously recorded group leader (GUNDOG1) turns on its transponder. Since the tanker has been receiving APD services for its Current Plan, the controller clears the tanker as requested. The controller verifies that vertical separation exists between the tanker and the fighters and cancels the TANK1 group. Automation produces a Trial Plan for GUNDOG when the group is canceled and presents it to the controller. APD detects no problems with the Trial Plan so it is made the Current Plan by the controller.
5.1.5 Exercises within the MOA

Based on the previously entered MOA activation time, automation activates the MOA airspace. While the MOA is activated, APD detects aircraft-to-airspace problems for aircraft (other than the fighters) with a Trajectory violating separation standards for the airspace during its activation period. While the MOA is activated, the MOA boundary, label, activation period, altitude limits and agency controlling the MOA, are displayed and emphasized.

Figure 5-2 illustrates what a display might look like indicating the MOA and the four fighter aircraft after they have begun operations within the MOA. (The illustration is not intended to show a recommended or planned display format.) The aircraft are detected by radar and the radar returns are represented by asterisks but the full data blocks are suppressed. Once the fighters enter the MOA, the military is responsible for separation of the military aircraft within the MOA. ATC separates other aircraft from the MOA. If a fighter is detected outside the MOA, the controller is notified.

5.1.6 Early Exit from the MOA

Prior to the scheduled MOA exit time, one fighter (GUNDOG2) radios ATC to request an early exit from the MOA and a direct return route to the military base due to mechanical difficulties. The remaining fighters continue their exercises. The controller deletes GUNDOG2 from the Group and a Trial Plan for GUNDOG2 is created automatically. No problems are detected. Because the fighter is experiencing mechanical difficulties, the controller creates a Trial Plan that is a direct to base. This plan is shown in Table 5-2 including those fields changed by the controller; it is not intended to suggest a format for, or represent, a display. An entry is also made for GUNDOG2 so that all maneuvers for that aircraft are nonpreferred by APR in the event a problem is detected. When the Trial Plan is created, it is analyzed by APD and no problems are detected. The Trial Plan and the indication of no problems are displayed. The controller voices the associated clearance (which is also displayed) and performs a status change, making the Trial Plan the Current Plan.

When GUNDOG2 nears the military airspace around the base, automatic handoff is initiated and accepted. The controller of Sector 1 receives a reminder to transfer communications by voice. The new radio frequency is voiced to the pilot and handoff is complete.

The military assumes control and brings GUNDOG2 in for landing. After flight termination, all Plan data for the flight is deleted from the Flight Data Base.
Figure 5-2. MOA Activated
<table>
<thead>
<tr>
<th>Data Field</th>
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</tr>
</thead>
<tbody>
<tr>
<td>Aircraft ID</td>
<td>GUNDOG2</td>
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<tr>
<td>Aircraft Data</td>
<td>F16/Pv</td>
</tr>
<tr>
<td>Beacon Code</td>
<td></td>
</tr>
<tr>
<td>True Air Speed</td>
<td>500</td>
</tr>
<tr>
<td>Departure Point</td>
<td>BAM/230</td>
</tr>
<tr>
<td>Departure Time</td>
<td>1820</td>
</tr>
<tr>
<td>Altitude</td>
<td>230</td>
</tr>
<tr>
<td>Route</td>
<td>BAM . . LMT</td>
</tr>
<tr>
<td>Remarks</td>
<td></td>
</tr>
</tbody>
</table>
5.2 AIR CARRIER SCENARIO

This scenario follows the flight of a major air carrier flying between two large airports. The scenario provides an example of how FAS operates for a typical IFR flight. The AERA Services described in this scenario are, in general, applicable to any air carrier, commercial or general aviation aircraft, flying between any two airports. The scenario spans the entire flight from predeparture to arrival at the destination. Table 5-3 presents the predeparture data filed by the Airline Dispatch Office (ADO). The filed Flight Plan specifies a direct route between Miami and Los Angeles with en route altitude transitions.

5.2.1 Predeparture

In this example, an hour prior to AAL11’s proposed departure time, a flight plan is filed for the aircraft. The Flight Plan specifies the route, altitude transitions, and cruise speed planned for the flight. Table 5-3 contains the filed Flight Plan information. The User Preference file records the route, speed, and altitude information from the filed Flight Plan. The controller may use the information in the User Preference File during future flight planning to consider the aircraft's preferred routing.

At a time prior to the proposed departure time, the pilot requests an initial clearance. This request can be made via automation, similar to the Predeparture Check (PDC) that has recently been implemented at several major airports, or through the Clearance Delivery controller. In either case, an AERA PDC is done. APD checks the Current Plan for airspace and flow instruction problems. Two airspace problems are found with the plan, a warning area off the Florida coast and White Sands Missile Range. Both airspaces have TMS reroutes defined so AERA provides a route change to avoid both airspaces. Also, a standard departure route out of Miami is also in effect. This has the designation MIA5. The AERA-provided route is depicted in Figure 5-3.

APR generates resolutions to resolve any flow instructions and airspace problems that are known to the automation. The HRR is provided to the Clearance Delivery controller. A departure time is determined based on the latest information including probable departure runway, taxi time, departure activity, refined TMS estimates, etc. This initial clearance contains the following:

a. Route of flight

b. Assigned Altitude and altitude transitions filed in the Flight Plan, modified as necessary to resolve Airspace and Flow Instruction problems detected during the PDC
Table 5-3. Filed Flight Plan Data

<table>
<thead>
<tr>
<th>Data Field</th>
<th>Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>Callsign:</td>
<td>AAL11</td>
</tr>
<tr>
<td>Aircraft Type:</td>
<td>B757</td>
</tr>
<tr>
<td>Equipment:</td>
<td>Rd</td>
</tr>
<tr>
<td>Departure Point:</td>
<td>MIA</td>
</tr>
<tr>
<td>Departure Time:</td>
<td>1502</td>
</tr>
<tr>
<td>True Air Speed:</td>
<td>460</td>
</tr>
<tr>
<td>Altitude:</td>
<td>330/+60^350/+60^370/+90^390</td>
</tr>
<tr>
<td>Route:</td>
<td>MIA.LAX</td>
</tr>
<tr>
<td>Weight:</td>
<td>240</td>
</tr>
<tr>
<td>Cruise Speed:</td>
<td>M80</td>
</tr>
</tbody>
</table>
Figure 5-3. AERA-Provided Route
c. Departure instructions including estimated departure time and an initial assigned altitude, if applicable

d. Beacon code, if needed

Items a. and b. may be given "Cleared as Filed" if no changes are made to the filed Flight Plan. The clearance for AAL11 is:

Route: MIA5.SRQ.LEV.EWM.LAX
Altitude Transitions: Cleared as filed
Estimated Departure Time: 1510Z
Departure Frequency: 125.5
Squawk: 3245

This clearance is issued to the pilot via PDC or voice and, once accepted by the pilot, is made the Current Plan.

Prior to the aircraft departing, while at the gate or taxiing, another AERA PDC can be done to determine if other flow instructions were implemented since the initial check. This might occur if there had been a prolonged ground hold.

The key point in predeparture processing is to have the best trajectory possible in the automation prior to the aircraft being airborne. In general, it is easier to amend a Flight Plan while the aircraft is on the ground rather than flying through the initial control sectors.

5.2.2 Aircraft-to-Aircraft Conflict

Once the aircraft has taken off, a radar track is established. When the aircraft exits an adapted area where tactical maneuvering by the terminal controller ends, its trajectory is considered to be stable and APD starts continual checking against other Current Plan and Pending Plan trajectories.

While the aircraft is climbing, a problem is detected with UAL321, which is at FL250. The conflict is predicted to occur in another en route sector in 13 minutes. The best resolution moves AAL11 so the position currently controlling AAL11 is the position that receives the HRR. The clearance associated with the HRR for AAL11 is to deviate from the initially cleared route to a latitude and longitude that is southwest of Sarasota (SRQ) and then proceed direct to Grant Isle, Louisiana (LEV—Leeville VORTAC). Since the changed part of the route includes the climb to the initial cruise altitude, this information is also included in the clearance. The HRR is now protected so resolutions to other problems will avoid this Plan. The ARD shows:

AAL11.HP DRCT 2730N/8300W LEV ./. ↑ FL330 2:40
If the controller did not want to issue the lateral resolution, the next three best resolutions could be requested. The next best resolution calls for AAL11 to climb to and maintain FL240 until 1521Z, then continue the climb to the initial cruise altitude of FL330. That resolution is good for three minutes and 10 seconds

\[
\text{AAL11 ↑ FL240 at 1521Z ↑ FL330 [3:10]}
\]

The HRR is accepted by the controller. The clearance is issued via data link. A Pending Plan is created upon clearance delivery via data link and becomes the Current Plan when the accept is received from the aircraft.

With no problems indicated on the Alert and Resolution Display (ARD), the aircraft approaches the border of the first sector it will enter in the local ACF. Handoff is initiated and accepted automatically with TOC completed automatically using data link. No controller involvement is necessary. Ownership of the Current Plan is transferred automatically to the receiving position.

### 5.2.3 Reroute for Weather

The pilot is advised by American Airlines that a jet stream will adversely affect AAL11’s schedule and fuel consumption. Data link is used to request a reroute from ATC. A Trial Plan is constructed by the automation and a problem with another aircraft is detected. The current controller receives the Trial Plan and the problem data, and manually constructs alternate Trial Plans until one is found that is acceptable to the flight crew and is problem-free.

Figure 5-4 illustrates the Trial Plan produced by the controller, which takes AAL11 north of the jet stream.

The clearance associated with the Trial Plan is transmitted via data link to the aircraft and accepted. The Trial Plan becomes the Pending Plan when uplinked and becomes the Current Plan when the WILCO is received. The controller manually deletes the unused Trial Plan and it is immediately removed from the display. The controller may also elect to leave the Trial Plan displayed, but it will be removed automatically after a specified time.

### 5.2.4 Planned Altitude Transition

A climb from FL350 to FL370, that is included in the Flight Plan and was cleared as filed, is scheduled to occur in twenty minutes. The aircraft is automatically sent a reminder of the altitude transition via data link. The pilot accepts via data link. No notification to, or action by, the controller is required since an accept was received and no changes were requested. When
the aircraft enters the sector in which the altitude transition will occur, the FDB indicates the planned maneuver. When the maneuver is planned to start, the FDB shows that the aircraft should be climbing. The FDB for these two conditions are illustrated below:

AAL11
350F370
LAX 460

AAL11
370↑350
LAX 460

5.2.5 Flow Instruction Noncompliance

While the flight is in the Albuquerque ACF, a flow instruction is entered into the system. The flow instruction specifies a Standard Arrival Route (STAR) for aircraft landing at LAX. The flow instruction specifies the sequence of fixes: TNP.CIVET.ARNES.LAX. The automation responds by detecting a flow instruction noncompliance and generating a HRR that complies with the STAR. The HRR appears to the controller as:
Figure 5-5 depicts the new routing. The controller data links the clearance and the flight crew accepts it. The Current Plan is updated to reflect the new route.

5.2.6 Arrival Metering

A parameter number of minutes before the estimated arrival time at LAX, Traffic Management issues a MFT for AAL11 at the ARNES meter fix. APD checks to see if the estimated time at ARNES is within a parameter sized window about the MFT value. The estimated time at ARNES is within the parameter sized window so no control action is required at this time. The automation calculates a MDP for AAL11 that determines where APD will recheck the time-based flow instruction compliance if no other system changes activate APD before then.

APD is activated at the MDP and, in this example, determines that AAL11 is no longer within the required time window about the assigned MFT. APR is activated to determine a schedule adherence maneuver to meet the MFT. The generated HRR is a composite speed/lateral maneuver that adjusts the calculated trajectory times at ARNES to agree with the assigned MFT. The HRR appears to the controller as:

AAL11.HP DRCT 3315N/11320W TNP /. -.04M 1[50]

The controller uses data link to send the HRR to AAL11. The HRR becomes a Pending Plan when uplinked and becomes the Current Plan upon flight crew acceptance. Figure 5-6 depicts this maneuver.

Twenty minutes before the TOD point in the Current Plan, a Reminder with the TOD clearance is automatically displayed. The clearance is issued and accepted using data link and the Current Plan is updated.
Figure 5-5. Arrival Route
Control is transferred to the sector in which TOD will take place. The FDB in the sector containing the TOD reflects the new clearance as shown below:

```
AAL11
370F110
LAX 410
```

Prior to reaching TNP, TMS assigns a revised MFT for AAL11 at ARNES. APD determines that an FI noncompliance exists. APR produces an HRR that delays the aircraft by introducing a right turn and a return to the STAR as follows:

```
AAL11.HP DRCT TNP090070 TNP ./.. at 1939 ↓ 110 LAX altimeter 29.98
```
Figure 5-7 depicts the final metering maneuver. The controller sends the clearance and receives the accept via data link. The aircraft performs the maneuver, continues along the STAR, meets the MFT, and lands at LAX.
APPENDIX A

INTRODUCTORY AERA SERVICES

A.1 INTRODUCTION

This appendix describes the capabilities of IAS, focusing on how the controller will use these capabilities to resolve automation-detected problems. The first section of this appendix states the purpose of IAS, and which AERA capabilities are included in IAS. The second section describes IAS functionality associated with strategic problem detection. The third section gives an operational overview of the capabilities available to the controller for the analysis and resolution of problems. The final section provides a scenario of an air carrier flight, describing in more detail how IAS capabilities are used to perform ATC tasks. The reader may refer to the previous sections of this document for more complete descriptions of AERA terms and functionality.

A.1.1 IAS Purpose and Capabilities

The AERA capabilities described in this document allow a more strategic approach to ATC, and will therefore have a great effect on controller tasks. To achieve the timely realization of AERA benefits and to facilitate the controller's transition to the AERA environment, AERA will be implemented with IAS as an introductory step to FAS. The transition from the ACCC environment to IAS and then to FAS will facilitate controller training of AERA concepts and skills and allow for system stability during AERA implementation.

IAS will include all FAS functions except APR and those capabilities directly associated with APR. IAS will relieve the controller of some of the workload associated with situation monitoring and will provide automated assistance in strategic planning of aircraft maneuvers. Controller tasks at first will remain similar to those that characterize today's ATC system, but will evolve as controllers and ATC system personnel gain experience and expertise in using AERA capabilities. IAS will provide controllers a learning period during which separation tasks will be accomplished primarily as in today's environment, but with added support provided by the strategic lookahead of APD, which extends the controller's planning horizon. For example, with automation providing reliable early warning of emerging separation or flow instruction problems, controllers will be able to grant user-preferred routes and schedules more readily when these preferences are conflict-free. Table A-1 compares the AERA capabilities included in IAS and in FAS. The most significant difference between IAS and FAS is that IAS does not have APR. Also note that in IAS, handoffs are automatically initiated but are not automatically accepted.
Table A-1. Capabilities of IAS and of Full AERA Services

<table>
<thead>
<tr>
<th>Capability</th>
<th>IAS</th>
<th>Full AERA Services</th>
</tr>
</thead>
<tbody>
<tr>
<td>Automated Problem Detection (APD)</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Reconformance</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Automated Coordination</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Automated Planning Aids: Trial Planning, Quick Trial Planning, Automated Replan, Predeparture Check</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Future Situation Display</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Sector Activity Measures</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Aircraft-Specific and Flight-Specific Characteristics Data</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Data Link Communication</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Automated Problem Resolution (APR)</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Automatic Acceptance of Handoff</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Reminder: Transfer of Communication</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

A.2 PROBLEM DETECTION CAPABILITIES

ATC has evolved over the past 20 years from using flight progress strips for problem detection to relying more on tactical radar separation. This evolution has occurred for various reasons including:

- increased traffic volume
- increased speeds of aircraft
- improved radar coverage
- use of narrow band radar
- team approach to sector operations

The controller primarily uses the display of radar positions and information in FDBs to estimate future aircraft positions, predict possible conflicts, and plan appropriate actions. Flight Progress Strips are still used for many purposes in low altitude sectors and to anticipate future sector and controller workload, but infrequently for strategic problem detection and resolution. This is because the data printed on the flight strips is not accurate enough. ATC will become more strategic beginning with IAS, as APD accurately identifies problems that are predicted to occur up to 20 minutes in the future for loss of separation between aircraft, and even longer for loss of separation with airspaces or noncompliances with flow instructions. APD provides notification of problems and problem characteristics. The ARD is a unified display of problem
information, including Conflict Alerts and MSAW's, as well as alerts for APD-detected problems. The ARD entry is presented automatically to the controller when problems are detected.

In IAS as in FAS, the position that is notified of the alert has the responsibility for solving the problem. Information that is pertinent to the problem is automatically presented and additional data is available upon request. For example, the controller can request a graphic representation of the aircraft's trajectory to see where the problem is predicted to occur. Trial Planning and the Future Situation Display are available to help the controller evaluate and resolve the problem.

The following paragraphs of this section describe the rules used to assign alerts to sectors, and what information is included in the alert, for aircraft-to-aircraft, aircraft-to-airspace, and flow instruction noncompliance problems detected in Current Plans.

A.2.1 Aircraft-to-Aircraft Problems

The rules listed below determine which position is notified of an aircraft-to-aircraft Current Plan problem, and is therefore responsible for its resolution. The position designation for the conflict is different from FAS since APR is not providing a highest ranked resolution. In IAS, the position receiving the AERA Alert contains the initial point of conflict between the two aircraft's trajectories. In some boundary cases, there are two sectors that contain the initial points of conflict. The shaded area in figures A-1 through A-5 illustrate the position that receives the alert (the designated position), as determined by traversing the following rules from top to bottom until an item is found to be true for the problem situation:

1. Both initial Points Of Conflict (POC) lie within one sector: the designated position is the one controlling that sector (Figure A-1).

2. The initial POCs lie in different sectors, and only one of these sectors controls an involved aircraft: the designated position is the sector containing the crossing of the trajectories and an initial POC (Figure A-2).

3. The initial POCs lie in different sectors and one of those sectors contains the crossing of the trajectories: the designated position is the sector containing the crossing of the trajectories and an initial POC (Figure A-3).

4. The initial POCs lie in different sectors, and one of those sectors will have control of an involved aircraft soonest: the designated position is the one that contains an initial POC and will have the earliest control of an involved aircraft (Figure A-4).

5. The designated position is chosen arbitrarily from the two sectors containing an initial POC (Figure A-5).
Figure A-1. Initial Points of Conflict
Designated Position is Sector

Figure A-2. One Initial Point of Conflict and Control of an Involved Aircraft
Designated Position is Sector C
Figure A-3. One Initial Point of Conflict and Intersection of Trajectories
Designated Position is Sector C

Figure A-4. One Initial Point of Conflict and Earliest Control of Involved Aircraft
Designated Position is Sector C
Once a problem is detected, alert information is displayed to help the controller analyze the problem situation. The following information is automatically displayed to the designated controller:

- Situation Display - FDBs with alert indicators for the involved aircraft
- Flight Data Display - Flight Data Entries of the involved aircraft
- Alert and Resolution Display - A problem notification entry

The information included in the problem notification entries on the ARD is different for IAS than for FAS. Since IAS does not generate resolutions to the problems, the ARD entries include more information about the problem and no resolution information. Specifically, in IAS the ARD entries for aircraft-to-aircraft problems include: the callsigns of all involved aircraft and their controlling position, and a countdown clock until time of violation.

Figure A-6 illustrates an example of alert information that is automatically displayed on the Situation Display, Flight Data Display, and the ARD.
A.2.2 Aircraft-to-Airspace Problems

When an airspace problem is detected for an aircraft, the sector controlling that aircraft receives the alert. This is the same rule used for FAS. The alert includes the same problem information as defined for aircraft-to-aircraft problems, as well as Trial Plans or Pending Plans that are automatically generated to resolve certain types of problems. Trial Plans are automatically generated for resolving conflicts with Strategic Airspaces when TMS-preferred Routes around the airspace have been activated.
These Trial Plans are checked for problems upon creation. If a problem is detected in a Trial Plan, the problem information is displayed with the Trial Plan along with a countdown clock to show how long the Trial Plan is valid. If no conflicts are detected in the Trial Plan, a Pending Plan is automatically created from the Trial Plan. The Pending Plan is continually checked for problems. If a problem is detected while the Pending Plan is displayed, the entry is updated with the problem information. A Pending Plan has a "lifetime" which allows the controller adequate time to implement the Pending Plan. Automatically creating these Trial and Pending Plans is intended to facilitate controller entry of the plan amendments and delivery of clearances.

A.2.3 Flow Instruction Violations

IAS treats metering violations and nonmetering violations differently. For non-metering violations, the sector controlling the aircraft receives the alert. The alert contains problem information about the aircraft and the flow instruction being violated. In addition, for violations of flow instructions that specify a sequence of route segments and fixes, Trial Plans or Pending Plans are automatically generated to facilitate controller resolution of the violation. Processing all of these Plans is the same as for TMS-preferred Routes around airspaces described in the previous section.

For metering violations, the sector containing the meter fix or boundary receives the alert. The alert contains information about the delay necessary for the aircraft to meet its meter fix time. No maneuvers are generated automatically to absorb the delay. Trial Planning can be used to assist the controller in building plans to meet the meter fix time.

CTAS will be implemented for a limited number of airports. Along with metering data, CTAS provides a TOD point, speeds to be flown in the descent for fuel efficiency, and route and vector advisories to meet the meter fix time. IAS will use the TOD information and speeds to build a Current Plan trajectory. IAS will also conflict-check the advisories to meet the meter fix time. The controller can implement the advisory or perform Trial Planning to have the aircraft meet the meter fix time.

A.3 PROBLEM HANDLING TOOLS

The most significant difference between operations during IAS and FAS is in problem resolution, especially for aircraft-to-aircraft problems. IAS provides the strategic problem detection look-ahead time of APD, but does not provide resolutions. However, other IAS capabilities are available to help the controller analyze and resolve the problem. These capabilities, described in Sections 3.5.2 and 3.5.3, are summarized here.

To analyze the predicted problem, the controller receiving the alert can view the trajectories of the involved aircraft and the conflict region on the Situation Display or the FSD. The FSD, in particular, provides the controller with additional capabilities for analysis by graphically depicting the traffic situation at a time up to 20 minutes in the future. This assists the controller in assessing the impact of different resolution maneuvers on surrounding traffic.
To create resolutions and check them for problems, the controller may create one Trial Plan or use Quick Trial Planning. The controller can create one Trial Plan by specifying the exact altitude, speed, or route amendment to be made. The controller can create multiple plans by invoking Quick Trial Planning which generates several Trial Plans in a controller specified maneuver category, such as altitude. Default parameters are used to build these Trial Plans. Where there is a conflict in a plan, Quick Trial Planning will try to avoid the conflict by basing the maneuvers on avoiding the conflict region. In this way, the Trial Plans will likely resolve the original problem. In creating Trial Plans, UPs can be consulted to determine if one maneuver is closer to the pilot's preferred flight path. Whenever a Trial Plan is created, the system automatically checks the plan for conflicts and displays the plan and the conflicts to the controller. Conflict-free plans will generally be made Pending Plans to protect them while the controller is coordinating the clearance.

For pilot requests, the controller can create a Trial Plan that satisfies the request. When the plan is problem-free, the request can be granted. When the plan has a problem, the controller has options to satisfy the request. One of the options is to submit the Trial Plan to Automated Replan. When Automated Replan finds the request to be problem-free, it will notify the current controller of the aircraft even when the aircraft was handed off in the meantime.

Once a controller decides to implement a plan, it can be transmitted to the pilot or coordinated with the sector controlling the aircraft. A Trial Plan can be made a Pending Plan in order to protect that flight path while coordination is accomplished. When coordination with another sector is required, Automated Coordination is used to accomplish the coordination automatically.

In summary, IAS transitions the controller from today's environment to the strategic environment of FAS by providing automation to detect problems well into the future. Once notified of the problem, the controller can use information that is automatically displayed and the FSD to analyze the problem. Trial Planning and Automated Coordination can be used to resolve the problem. The concepts and skills the controller learns in using these AERA tools are built upon in the transition to FAS.

A.4 SINGLE AIRCRAFT OPERATIONAL THREAD: AIR CARRIER SCENARIO

This scenario of an IFR flight provides a more detailed, operational example of how a controller can use IAS capabilities. This scenario depicts for IAS the same flight and events as the scenario of Section 5.2. The flight is that of an air carrier, AAL11, departing from Miami (MIA) and arriving at Los Angeles (LAX). The 6 events are: departure, aircraft-to-aircraft conflict, reroute for weather, planned altitude transition, flow instruction noncompliance, and arrival metering.

A.4.1 Departure

In this example, an hour prior to AAL11's proposed departure time, a flight plan is filed for the aircraft. The Flight Plan specifies the route, altitude transitions, and cruise speed planned for
the flight. Table A-2 contains the filed Flight Plan information. The UP file records the route, speed and altitude information from the filed Flight Plan. The controller may use the information in the UP file during future flight planning to consider the aircraft’s preferred routing.

At a time prior to the proposed departure time, the pilot requests an initial clearance. This request can be made via automation, similar to the PDC that has recently been implemented at several major airports, or through the Clearance Delivery controller. In either case, an AERA predeparture check is done. APD checks the Current Plan for airspace and flow instruction problems. Two airspace problems are found with the plan, a warning area off the Florida coast and White Sands Missile Range. Both airspaces have TMS reroutes defined so AERA provides a route change to avoid both airspaces. Also, a standard departure route out of Miami is also in effect. This has the designation MIA5.

Table A-2. Filed Flight Plan Data

<table>
<thead>
<tr>
<th>Data Field</th>
<th>Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>Callsign:</td>
<td>AAL11</td>
</tr>
<tr>
<td>Aircraft:</td>
<td>B757</td>
</tr>
<tr>
<td>Equipment:</td>
<td>R</td>
</tr>
<tr>
<td>Departure Point:</td>
<td>MIA</td>
</tr>
<tr>
<td>True Air Speed:</td>
<td>1502</td>
</tr>
<tr>
<td>Altitude:</td>
<td>330/+60^350/+60^370/+90^390</td>
</tr>
<tr>
<td>Route:</td>
<td>MIA.LAX</td>
</tr>
<tr>
<td>Weight:</td>
<td>240</td>
</tr>
<tr>
<td>Cruise Speed:</td>
<td>M80</td>
</tr>
</tbody>
</table>
The clearance is provided to the Clearance Delivery controller as:

Route: MIA5.SRQ.LEV.EWM.LAX
Altitude Transitions: Cleared as filed
Climb and Maintain 70, expect requested altitudes 10 minutes after departure
Estimated Departure Time: 1510Z
Departure Frequency: 125.5
Squawk: 3245

Figure A-7 shows the cleared route for AAL11. This clearance is issued to the pilot via PDC or voice and, once accepted by the pilot, is made the Current Plan.

Prior to the aircraft departing, while at the gate or taxiing, another AERA PDC can be done to determine if other flow instructions were implemented since the initial check. This might occur if there had been a prolonged ground hold.

The key point in predeparture processing is to have the best trajectory possible in the automation prior to the aircraft being airborne. In general, it is easier to amend a Flight Plan while the aircraft is on the ground rather than flying through the initial control sectors.

Figure A-7. Cleared Route
A.4.2 Aircraft-to-Aircraft Conflict

AAL11 takes off and the radar track is established. When the aircraft exits an adapted area where tactical maneuvering by the terminal controller ends, its trajectory is considered to be stable and APD begins to continually check the Current Plan for conflicts. At this point, a problem is detected with UAL321, which is at FL250. This is depicted in Figure A-8. The conflict is predicted to occur in enroute sector #50 in 13 minutes. Because both initial points of conflict are in sector #50, the controller of sector #50 is responsible for resolving the conflict. The alert information that is forced on the display at sector #50 includes:

- FDBs with alert indicators for AAL11 and UAL321
- FDEs for AAL11 and UAL321
- ARD entry containing:
  - Problem number
  - Callsigns (AAL11 and UAL321)
  - Controlling positions (and facility if different) of AAL11 and UAL321
  - Countdown clock of time until predicted loss of separation

![Figure A-8. Aircraft Climb Trajectory and Conflict](image-url)
Figure A-9 illustrates the entry for this problem (the "2" indicates the problem number) on sector #50's ARD.

![ARD Entry](image)

Figure A-9. ARD Entry for an Aircraft-to-Aircraft Problem

The controller of sector #50 analyzes the problem by showing it graphically on the Situation Display. In considering maneuvers to resolve the problem, the controller may display the problem on the FSD and adjust the time moving the aircraft positions to understand the future traffic situation. The controller may choose from several planning options to resolve this problem. In this case, the controller is confident that a step climb will resolve the problem so the controller creates a Trial Plan. The Trial Plan is for AAL11 to level off at FL240 until after the conflict area is passed and then resume climbing. The Trial Plan is problem-free; Figure A-10 shows the Trial Plan as it is displayed on the Plans Display.

![Plans Display](image)

Figure A-10. Plans Display Entry for Problem-free Trial Plan

The controller of enroute sector #50 decides to coordinate the Trial Plan for AAL11 by using Automated Coordination, which automatically makes the Trial Plan a Pending Plan. The current controller of AAL11 receives the Pending Plan, issues the clearance, and makes the Pending Plan the Current Plan. When the Pending Plan is made the Current Plan, the alert information is removed from the display at sector #50.
A.4.3 Reroute for Weather

The pilot of AAL11 is advised by American Airlines that a high velocity jet stream has moved farther south than originally forecasted and will detrimentally affect AAL11's schedule and fuel consumption along the present route. The pilot requests a new routing that will take the flight north of the jet stream. The controller creates a Trial Plan that indicates that the requested route is problem-free, clears AAL11 as requested, and makes the Trial Plan the Current Plan. Figure A-11 shows the jetstream, and the routes of the filed flight plan and the problem-free Trial Plan.

Figure A-11. Reroute for Weather

A.4.4 Planned Altitude Transition

A climb from FL350 to FL370, that is included in the Flight Plan and was cleared as filed, is scheduled to occur in twenty minutes. A Start-Maneuver reminder is automatically displayed to the controller. The reminder is an entry on the Controller Reminder List, as illustrated in Figure A-12.
The controller delivers the reminder to begin the altitude transition in twenty minutes. The pilot acknowledges the reminder, and the controller deletes the reminder entry. Section 5.2 describes the FDB indicators before and after the maneuver begins.

A.4.5 Flow Instruction Noncompliance

A flow instruction is entered into the system while AAL11 is in Albuquerque ACF airspace. The flow instruction specifies a sequence of fixes for aircraft landing at LAX: TNP.CIVET.ARNES.LAX. When the system detects a noncompliance with the flow instruction, a Trial Plan is automatically created for AAL11, specifying a maneuver that will enable it to comply with the flow instruction. The Trial Plan is checked for conflicts. The Trial Plan is conflict-free, and is made a Pending Plan automatically. The detected flow instruction noncompliance and the Pending Plan are displayed on the ARD. The Pending Plan is displayed with a countdown clock indicating that the Plan is valid for 2 minutes and 34 seconds. Figure A-13 shows the ARD entry (the "4" indicates the problem number). The Pending Plan is made the Current Plan after the pilot accepts the clearance.

A.4.6 Arrival Metering

In the IAS timeframe, LAX is one of the airports supported by CTAS. Prior to reaching its TOD point, CTAS issues TOD point and descent profile information to IAS for AAL11. This
data is incorporated into the Current Plan trajectory of AAL 11 and displayed at the position controlling AAL 11 in the Full Data Block. This information is:

- TOD Point: 92 miles from LAX
- Speed to be Flown: .72 Mach until 285 IAS, continue at 285 IAS

The controller issues the clearance to AAL11 and acknowledges the advisory. The advisory is removed.

A parameter number of minutes from estimated arrival time, CTAS issues a MFT for AAL11 at the ARNES meter fix. The metering information is displayed on the Metering Advisory List and in the FDB. The Metering Advisory List includes an entry:

- Aircraft Callsign (AAL11)
- Meter fix (ARNES)
- Meter Fix Time (1955Z)
- Delay required (2 min.)

The FDB shows a delay of two (2) minutes and twenty (20) seconds necessary for AAL11. The controller uses QTP to build a vector maneuver to absorb the delay. The controller enters an initial maneuver of 30 degree right turn and QTP calculates the point to turn back. This Trial Plan is checked for conflicts. No conflicts are found, so it is made a Pending Plan and displayed on the Plans Display. Figure A-14 illustrates the Plans Display entry.

<table>
<thead>
<tr>
<th>10</th>
<th>AAL11.P</th>
<th>DRCT TNP090070 TNP RORU -.03M</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>FI-LAX-M65</td>
<td>at 1939Z ↓ 110 LAX altimeter 29.98</td>
</tr>
</tbody>
</table>

Figure A-14. Plans Display Entry for Problem-free Pending Plan

When the clearance is accepted by the pilot, the controller makes the Pending Plan a Current Plan. AAL11 performs the maneuver and meets the MFT. AAL11 subsequently reaches its TOD point and continues along its arrival route to LAX.
<table>
<thead>
<tr>
<th>ACRONYMS</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>AA</td>
<td>Assignable Altitude</td>
</tr>
<tr>
<td>AAF</td>
<td>AERA Arrival Fix</td>
</tr>
<tr>
<td>AAS</td>
<td>Advanced Automation System</td>
</tr>
<tr>
<td>ACCC</td>
<td>Area Control Computer Complex</td>
</tr>
<tr>
<td>ACF</td>
<td>Area Control Facility</td>
</tr>
<tr>
<td>ACID</td>
<td>Aircraft Identification</td>
</tr>
<tr>
<td>ADO</td>
<td>Airline Dispatch Office</td>
</tr>
<tr>
<td>AERA</td>
<td>Automated En Route Air Traffic Control</td>
</tr>
<tr>
<td>AERA 2</td>
<td>Automated En Route Air Traffic Control, Phase 2</td>
</tr>
<tr>
<td>ALTRV</td>
<td>Altitude Reservation</td>
</tr>
<tr>
<td>APD</td>
<td>Automated Problem Detection</td>
</tr>
<tr>
<td>APDIA</td>
<td>APD Inhibited Area</td>
</tr>
<tr>
<td>APR</td>
<td>Automated Problem Resolution</td>
</tr>
<tr>
<td>ARD</td>
<td>Alert and Resolution Display</td>
</tr>
<tr>
<td>ATAT</td>
<td>Air Traffic AERA Team</td>
</tr>
<tr>
<td>ATC</td>
<td>Air Traffic Control</td>
</tr>
<tr>
<td>BASOPS</td>
<td>Base Operations Office</td>
</tr>
<tr>
<td>BCT</td>
<td>Boundary Crossing Time</td>
</tr>
<tr>
<td>CAR</td>
<td>Controller-Assisted Resolution</td>
</tr>
<tr>
<td>CIP</td>
<td>Capital Improvement Plan</td>
</tr>
<tr>
<td>CTAS</td>
<td>Center Terminal Automation System</td>
</tr>
<tr>
<td>DME</td>
<td>Distance Measuring Equipment</td>
</tr>
<tr>
<td>FAA</td>
<td>Federal Aviation Administration</td>
</tr>
<tr>
<td>FAS</td>
<td>Full AERA Services</td>
</tr>
<tr>
<td>FDB</td>
<td>Full Data Block</td>
</tr>
<tr>
<td>FDE</td>
<td>Flight Data Entry</td>
</tr>
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<td>FI</td>
<td>Flow Instruction</td>
</tr>
<tr>
<td>FRA</td>
<td>Flow Restricted Area</td>
</tr>
<tr>
<td>FSD</td>
<td>Future Situation Display</td>
</tr>
<tr>
<td>HRR</td>
<td>Highest-Ranked Resolution</td>
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<tr>
<td>IAS</td>
<td>Introductory AERA Services</td>
</tr>
<tr>
<td>IFR</td>
<td>Instrument Flight Rules</td>
</tr>
<tr>
<td>IR</td>
<td>IFR Route</td>
</tr>
<tr>
<td>ISSS</td>
<td>Initial Sector Suite System</td>
</tr>
<tr>
<td>Abbreviation</td>
<td>Description</td>
</tr>
<tr>
<td>--------------</td>
<td>-------------</td>
</tr>
<tr>
<td>MARSA</td>
<td>Military Authority Assumes Responsibility for Separation of Aircraft</td>
</tr>
<tr>
<td>MDP</td>
<td>Metering Decision Point</td>
</tr>
<tr>
<td>MFT</td>
<td>Meter Fix Time</td>
</tr>
<tr>
<td>MINIT</td>
<td>Minutes in Trail</td>
</tr>
<tr>
<td>MIT</td>
<td>Miles in Trail</td>
</tr>
<tr>
<td>MOA</td>
<td>Military Operations Area</td>
</tr>
<tr>
<td>MOPS</td>
<td>Minimum Operational Performance Standards (Two-way data link)</td>
</tr>
<tr>
<td>MSAW</td>
<td>Minimum Safe Altitude Warning</td>
</tr>
<tr>
<td>MSP</td>
<td>Maneuver Start Point</td>
</tr>
<tr>
<td>MTR</td>
<td>Military Training Route</td>
</tr>
<tr>
<td>NAS</td>
<td>National Airspace System</td>
</tr>
<tr>
<td>NAVAID</td>
<td>Navigational Aid</td>
</tr>
<tr>
<td>OD</td>
<td>Operational Description</td>
</tr>
<tr>
<td>PDC</td>
<td>Predeparture Check</td>
</tr>
<tr>
<td>POV</td>
<td>Point of Violation</td>
</tr>
<tr>
<td>QTP</td>
<td>Quick Trial Planning</td>
</tr>
<tr>
<td>SP</td>
<td>System Preference</td>
</tr>
<tr>
<td>STAR</td>
<td>Standard Arrival Route</td>
</tr>
<tr>
<td>TMC</td>
<td>Traffic Management Coordinator</td>
</tr>
<tr>
<td>TMS</td>
<td>Traffic Management System</td>
</tr>
<tr>
<td>TOC</td>
<td>Transfer of Communications</td>
</tr>
<tr>
<td>TOD</td>
<td>Top of Descent</td>
</tr>
<tr>
<td>UP</td>
<td>User Preference</td>
</tr>
<tr>
<td>VFR</td>
<td>Visual Flight Rules</td>
</tr>
<tr>
<td>VOR</td>
<td>Very High Frequency Omni Directional Range</td>
</tr>
</tbody>
</table>
TERMS

Activate: vt.

a. Airspaces: Used in connection with airspaces (second meaning) that are not continuously active. To activate an airspace means to declare formally that the airspace is active. The restrictions on flying in an airspace apply only when the airspace has been activated and has not been subsequently deactivated. Cf. "Deactivate."

b. Flow Instructions: Used in connection with flow instructions that are not continuously active. To activate a flow instruction means to declare that the flow instruction is in effect. A given flow instruction is applied to aircraft only when the flow instruction has been activated and has not been subsequently deactivated. Cf. "Deactivate."

c. Flight Plans: Used in connection with Flight Plans that are filed while the subject aircraft are on the ground. The ACCC activates a Flight Plan when it receives a confirmed surveillance track on the subject aircraft or a controller at the position controlling the aircraft enters a Departure Message.

Adaptation: The process of entering adaptation data into an ATC automation system to tailor that system to the requirements of an individual ATC facility.

Adaptation Data: Data entered into an ATC automation system to assign specific values to system parameters. This data includes:

a. Display setup information.

b. Function optimization values.

c. Facility-specific data that describes the operational environment of an ATC facility's area of control, excluding aircraft. Included in facility-specific adaptation data are descriptions of airspaces, navigation beacons, radars, adapted nonradar areas, communications, fixes, routings, airfields, airways, IFR/VFR boundaries, weather reporting points, and all other features that must be defined for ATC purposes and that differ according to area of control responsibility.

Additional Resolutions Mode: The operating mode of APR which the system initiates when a position requests additional resolutions to a problem set. Up to a parameter number of new resolutions will be displayed when APR is able to generate them. Controllers at the position may specify that a parameter number of the “next best” resolutions be displayed regardless of factors such as dimension, maneuver type and/or maneuvered aircraft of the resolutions, or they may specify various combinations of these factors that the displayed resolutions must satisfy.
**Advanced Automation System (AAS):** See FAA-ER-130-005, Section 6. (AERA, the subject of this glossary, is to be implemented as an incremental enhancement to the AAS.)

**AERA Airspace:** Airspace controlled by an AERA facility.

**AERA Facility:** An FAA ATC facility supported by automation containing operational AERA software.

**AERA Alert:** A notification to a position that there is an aircraft-to-aircraft, aircraft-to-airspace or flow instruction problem in a Current Plan or Pending Plan owned by that position, as detected by APD.

**AERA Arrival Fix (AAF):** A fix, along an aircraft's Trajectory, used by APD to constrain resolution maneuvers so that they are completed before that location. Controllers will never see results of APR processing for problems detected beyond the AAF on the aircraft's Trajectory.

For a given flight, the AAF is found by traversing the following list, top to bottom, until an element in the list is found to be true; when no element is true, the flight's destination airport is selected as the AAF.

a. There is an AAF in the System Preferences for this flight. The automation will use that System Preference AAF.

b. The present configuration of the flight's destination airport includes an AAF for all aircraft arriving at that airport and meeting stated criteria, and the flight meets the criteria. The automation will use the airport's designated AAF.

c. There is an Automated Problem Detection Inhibited Area (APDIA) in effect for the destination airport. The automation will select the intersection of the aircraft's Trajectory with the APDIA boundary as the AAF.

**AERA Plan Processing:** A subcapability of Automation Processing that constructs and maintains a flight data base describing Flight Plans, other types of Plans built for flights known to Automation Processing, aircraft Trajectories, Metering Decision Points, and other flight-related data needed to support ATC.

**AERA Services:** A collective term for IAS and FAS. AERA Services are to be implemented as an enhancement to the AAS.

**Aircraft:** Craft that are used or intended to be used for flight in the air. In this document, the term "aircraft" includes the flight crew and all functioning on-board equipage, but does not include the cargo or passengers.

**Aircraft Conflict:** See "Aircraft-to-Aircraft Conflict."
**Aircraft-to-Aircraft Conflict:** A conflict involving exactly two aircraft.

**Aircraft-to-Airspace Conflict:** A conflict involving exactly one aircraft and one protected airspace (q.v.).

**Airspace:** This term has two different meanings in the ATC parlance:

a. **Broad:** The atmosphere, or some large category of it (e.g., "The National Airspace," "controlled airspace.")

b. **Narrow:** A volume, defined by a prism or a set of joined prisms described as a series of geographic locations on the Earth's surface and at most two altitudes above it, within which special restrictions on flight apply.

**Airspace Conflict:** See "Aircraft-to-Airspace Conflict."

**Airspace Exemption:** An exemption from the reporting of conflicts between a given aircraft and a given airspace. When an airspace exemption is recorded for a given aircraft-airspace pair, the aircraft is permitted to violate nominal separation standards with the airspace without APDs reporting any aircraft-to-airspace conflict between that airspace and that aircraft.

**Air Traffic AERA Team (ATAT):** A group of operationally-oriented ATC experts designated by the FAA to provide operational input during the development and testing of AERA. ATAT consists of FAA and U.S. Air Force air traffic controllers. (ATAT formerly was called the Air Traffic AERA Concepts Team—ATACT.)

**Air Traffic Control (ATC):** See FAA Handbook 7110.65.

**Alert:** Information which indicates that a problem has been detected in an aircraft's Trajectory.

**Alert and Resolution Display (ARD):** A logical display that contains detailed information on Conflict Alerts, Aircraft Emergencies, aircraft detected outside assigned airspace, and AERA Alerts involving Current Plans.

**Alter Altitude - Above:** A maneuver type for a problem in a Plan in which the aircraft is either (1) in transition or (2) will begin a transition within a time interval associated with the primary problem. An Alter Altitude - Above resolution is based on a vertical maneuver in which, for aircraft-to-aircraft and aircraft-to-airspace conflicts, the aircraft would be maneuvered to alter its transition to pass above the altitude(s) in the currently-planned Trajectory where a violation of separation is predicted to occur.

Notes: (1) The transition to be altered by an Alter Altitude - Above type of resolution can be either a climb or a descent. (2) APR will use the Alter Altitude - Above maneuver type in constructing resolutions to flow instruction noncompliances, but the application is different.
Alter Altitude - Below: A maneuver type for a problem in a Plan in which the aircraft is either (1) in transition or (2) will begin a transition within a time interval associated with the primary problem. An Alter Altitude - Below resolution is based on a vertical maneuver in which, for aircraft-to-aircraft and aircraft-to-airspace conflicts, the aircraft would be maneuvered to alter its transition to pass below the altitude(s) in the currently-planned Trajectory where a violation of separation is predicted to occur.

Notes: (1) The transition to be altered by an Alter Altitude - Below type of resolution can be either a climb or a descent. (2) APR will use the Alter Altitude - Below maneuver type in constructing resolutions to flow instruction noncompliances, but the application is different.

Altitude-encoding Transponder: A beacon radar transponder which, in interrogation mode, automatically reports altitude when correctly interrogated by a remote electronic device.

Altitude Profile: (Also, "Vertical Profile.") A description of the vertical component of an aircraft's flight. An altitude profile consists of an ordered set of pairs (a,t) in which a is an altitude and t is the time by which that aircraft is to have attained that altitude.

Altitude Reservation (ALTRV): See FAA-ER-130-005, Section 6.

Applicability Criteria: Criteria selected by Traffic Management as the basis for determining to which flights flow instructions should apply. Applicability criteria always consist of attributes of aircraft and individual flights; e.g., aircraft type, departure airport, destination, projected time of crossing a fix.

APR-Designated Position: The ATC position to which the results of Automated Problem Resolution are displayed automatically, for a particular problem.

A Priori Factor: A resolution ordering factor (q.v.), the value of which (for a given resolution) can be exactly determined before a complete trajectory model of that resolution is constructed.

Area Control Computer Complex (ACCC): The equipment and software which provide ATC automation support to en route controllers working within either (1) an Area Control Facility after consolidation of Air Route Traffic Control Centers (ARTCCs) or (2) an ARTCC prior to consolidation. The ACCC will include a replacement for today's Host computer, plus new software tools such as AERA. It is being developed as part of the Advanced Automation System.

Area Control Facility (ACF): See FAA-ER-130-005, Section 6.

Arrival: n. A facility-level Traffic Management term for a flight whose destination airport lies inside that facility's area of responsibility (regardless of what flight phase the aircraft is in, or of whether the aircraft currently is airborne).
**Arrival Phase:** That part of a flight which lies between (1) a parameter time before the top of descent point prior to arrival at the flight's destination airport and (2) the destination airport itself.

**ATC-assigned Airspace:** An airspace assigned by ATC to facilitate segregating, from other IFR traffic, aircraft engaged in specified activities.

**ATC-defined Airspace:** A temporary airspace for which dimensions and a schedule have been entered into the ACCC data base. ATC-defined airspaces can be used in handling emergencies (e.g., natural disasters, ATC facility outages), areas of extremely heavy traffic or severe weather, outdoor laser light demonstrations, and mission flights being conducted outside defined Special-Use and ATC-assigned Airspaces.

**Automated Coordination:** A capability that supports nonvoice coordination among ATC positions.

**Automated En Route Air Traffic Control (AERA):** A software upgrade to the Advanced Automation System. AERA includes aircraft problem detection and resolution capabilities, among others.

**Automated Problem Detection (APD):** An Automation Processing capability that checks Trajectories for problems (q.v.).

**Automated Problem Detection Inhibited Area (APDIA):** An airspace or set of adjoining airspaces within which APD can be inhibited. The boundaries of APDIAs reflect flying conditions such as airport configuration and traffic density. Each APDIA consists of from 1 to n adjoining convex polyhedrons (for example, an "inverted wedding cake" arrangement). The degenerate case, where an APDIA consists of a single point, is permitted. Each APDIA applies to a single set of configurations. APDIAs may overlap, so that, for example, a given airport may lie within several APDIAs. APDIAs can be established, and their boundaries redrawn, (1) during system adaptation; and (2) dynamically, by a facility supervisor or Traffic Management Coordinator.

**Automated Problem Resolution (APR):** An Automation Processing capability that produces computer-generated resolutions to problems detected by APD.

**Automated Replan:** A function which effectively creates and evaluates new Trial Plans for designated aircraft. For a given aircraft, each new Trial Plan generated by Automated Replan will be modeled 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 AR request for that aircraft. The input Trial Plan will define some maneuver that the controller wants the system to recheck periodically for problems.

**Automated Replan Amendment:** An amendment to an aircraft’s Current Plan, specified in a Trial Plan named in a Request Automated Replan message. The amendment and the Current Plan will be used by AR to build derivative Trial Plans. See "Automated Replan.”
**Automatic Mode:** An operating mode of APR. The system automatically initiates APR in automatic mode when and only when a problem involving only Current Plans has been newly detected, modified, or deleted.

**Automatic Mode Problem Set:** A problem set (q.v.) created in the Automatic Mode (q.v.) of APR. These problem sets contain only problems that involve Current Plans exclusively.

**Automation Processing:** One of the subareas formally described in FAA-ER-130-005.

**Base Plan:** The Plan on which a resolution maneuver is based. One or more resolution maneuvers are applied to the corresponding base Plan to produce a Machine Plan. (A Multiple Aircraft Resolution [q.v.] has two resolution maneuvers, two base Plans, and two Machine Plans embodying the resolution. A Composite Maneuver Resolution [q.v.] has two resolution maneuvers, one base Plan, and one Machine Plan embodying the resolution).

**Boundary Crossing Time (BCT):** A flow instruction constraint designating the time at which a specific flight should cross a designated line. This line may be a portion of a sector or facility area boundary or an arbitrary line described to the automation.

**Candidate Maneuver Type:** A maneuver type (q.v.) selected to resolve the primary problem. Generally, a given maneuver type will be selected at most once, for each initiation of APR and each involved primary aircraft.

**Capital Improvement Plan (CIP):** A Congressionally-mandated plan for long-range enhancement of the National Airspace System.

**Celestial Navigation:** The determination of geographical position by reference to the positions of celestial bodies; in aviation, normally used only as a secondary means of position determination.

**Change Path - Left Side:** A maneuver type based on a lateral maneuver in which the subject aircraft would be turned to the left (i.e., to a bearing $180 < d < 360$ degrees relative to its currently-planned route) at its first deviation from the currently-planned route.

**Change Path - Right Side:** A maneuver type based on a lateral maneuver in which the subject aircraft would be turned to the right (i.e., to a bearing $0 < d < 180$ degrees relative to its currently-planned route) at its first deviation from the currently-planned route.

**Clearance:** An authorization from ATC for an IFR aircraft to follow a specified route, altitude profile, and/or speed schedule. A clearance always applies to a particular set of traffic conditions within controlled airspace, and is designed to maintain separation minima between the cleared aircraft and other known aircraft. Cf. "ATC Instruction"
Clearance Delivery:

a. A position in an ATCT that reviews flight data and issues clearances to pilots with filed IFR Flight Plans. Provides clearances, as requested, for VFR, special VFR, and special radar service (e.g., Stage III and TCA). Files IFR Flight Plans when requested. Issues gate hold instructions to pilots.

b. The process of transmitting a clearance from a controller at an ATC position to a pilot in an aircraft.

Clearance Delivery Time: An estimate of the time required to transmit a clearance to an aircraft from its controlling position, by whatever means—voice or data link—is being used.

Clearance Language: Text fully describing a clearance, or a modification to a clearance, intended for eventual delivery to a pilot.

Climb:

a. n. A maneuver that increases the altitude of an aircraft.

b. vt. To transition to a higher altitude. In this meaning, "climb" is something that an aircraft does, under pilot control.

c. vt. To transmit a clearance directing that a pilot transition his aircraft to a higher altitude. In this meaning, "climb" is something that a controller does.

Common Console: See FAA-ER-130-005, Section 6.

Composite Maneuver Resolution: A resolution containing two resolution maneuvers, in different dimensions, for a single primary aircraft. The resolution maneuvers may be sequential or overlapping.

Conflict: An event detected by APD. One of the following:

a. Predicted violation of separation criteria (q.v.) between aircraft Trajectories

b. Predicted violation of separation criteria (q.v.) between an aircraft Trajectory and a protected airspace including a Notify-only Airspace

c. Predicted violation of separation criteria (q.v.) between an aircraft Trajectory and the short-term predicted track position of an IFR aircraft or an altitude-encoding-transponder-equipped VFR aircraft
Notice that "conflict" can (and is) used interchangeably with "problem" (q.v.) for events described in a.-c. above; however, "problem" also includes one further category of event, predicted or actual noncompliance of aircraft Trajectories with flow instructions.

**Conflict Alert:** See FAA-ER-130-005, Section 6.

**Conformance:** The condition established when an aircraft's actual position is within the conformance region constructed around that aircraft at its position, according to the Trajectory associated with the aircraft's Current Plan. The aircraft's actual position is established (estimated) from radar returns and/or pilot reports.

**Conformance Bounds:** Parameters used (1) by APD in determining when to declare conflicts, and (2) in Conformance Monitoring (q.v). Each conformance bound is based on a probabilistic estimate of the error in the position of an aircraft in some dimension (lateral, vertical, longitudinal) in relation to the aircraft's Trajectory. Conformance bounds depend on many factors such as availability and proximity of surveillance radar and turns in the aircraft's route.

**Conformance Monitoring:** An Automation Processing capability that detects when the actual position of an aircraft is not within the conformance region (q.v.) associated with the current time.

**Conformance Region:** A lozenge-shaped volume, bounded laterally, vertically, and longitudinally, within which an aircraft must be at a given time in order to be in conformance with the Current Plan Trajectory for that aircraft. At a given time, the conformance region is determined by the simultaneous application of the lateral, vertical, and longitudinal conformance bounds for the aircraft at the position defined by the time and aircraft's Trajectory.

**Constraint:** Has two meanings in this document:

a. As applied to flow instructions imposed on aircraft by Traffic Management: A restriction with which each flight that satisfies the applicability criteria of a flow instruction must comply. Boundary Crossing Times are examples of this type of constraint.

b. As imposed on the resolution generation process: Rules that bound APR's latitude in generating resolutions. For example, if a resolution is to be executable, it must be within the performance limits of the aircraft to which the resolution is to be applied.

**Constraint-based Resolution:** One of two kinds of resolution to flow instruction noncompliance problems, the other being the criteria-based resolution (q.v.). A constraint-based resolution maneuvers the aircraft so that it complies with the flow instruction constraint.
Continuous Mode: One of three modes in which information can be presented on the Future Situation Display (q.v.), at the controller's option. In continuous mode, the controller designates a lookahead time, and the ACCC treats it as a constant defining the distance into the future that the controller wants to monitor "continuously" (i.e., on a "continuously updated" basis). For example, suppose present time is represented by the variable "t" and the lookahead value is "k." Then in continuous mode the FSD will display the traffic situation at time t+k for any future t, maintaining the display dynamically.

Control Instruction: See "ATC Instruction."

Controlled Aircraft: An aircraft for which a paired track and Current Plan exist.

Controller-Assisted Mode: The operating mode of APR in which APR is initiated by a position request. The position may specify that resolutions be generated for a particular problem (except for one with a short-term predicted track), or all such problems in a Current Plan, Pending Plan, Protected HRR, Trial Plan, or Machine Plan. The position may also specify alternative Trial or Machine Plans against which to check the resolution (these Plans substitute for the corresponding Current Plans), and the position to receive the APR results.


Coordination: An attempt to negotiate agreement among all the positions having present and future responsibility for the consequences of some proposed change in an aircraft's clearance.

Criteria-based Resolution: One of two kinds of resolution to flow instruction noncompliance problems, the other being the constraint-based resolution (q.v.). A criteria-based resolution maneuvers the aircraft so that at least one of the flow instruction's applicability criteria no longer is satisfied.

Current Plan: The Plan for a flight that the controller has specified as the Plan that the aircraft currently is expected to fly. The automation constructs a flight's initial Current Plan from its filed Flight Plan. Later, controllers of the aircraft may substitute new Current Plans to resolve ATC problems. In addition, a Current Plan will be adjusted by Reconformance when the system detects certain types of out-of-conformance.

Current Plan Position: The expected position of the aircraft at this or some future time, as determined from the Current Plan Trajectory.
**Current Position:** This term has two different meanings in AERA:

a. In establishing ATC responsibility: The position (first meaning) that most recently was the receiving position (q.v.) in a Transfer of Control concerning an aircraft, as recorded in the ACCC.

b. In establishing location: The current placement of some object (e.g., an aircraft) on the earth's surface, or of some point on the earth's surface perpendicularly below the object.

Note: In most cases, context makes clear which of these meanings is intended. Where a specific distinction is needed, "current ATC position" is used to force meaning a. and "current geographic position," to force meaning b.

**Cusp:** The representation, in position coordinates, altitude, time, and velocity, of locations in the Trajectory model of a Plan. A cusp (possibly multiple cusps) will be generated whenever an aircraft will encounter one of the following in traversing its Trajectory:

a. Converted fixes.

b. Planned actions (points where changes in direction, gradient, or acceleration are planned).

c. Fix posting areas.

d. Crossings of facility boundaries; backup boundaries; atmospheric wind cell boundaries; strategic, planning region, and notify-only airspace boundaries; and oceanic, radar, and nonradar area boundaries.

e. Flow instruction-related fixes (for application of Meter Fix Times).

f. Points defined in preferential arrival and departure routes.

g. Points established by the ACCC where Conformance Bounds or separation criteria will change.

**Data Link:** A type of digital, non-voice communications that can be used to transmit messages between ATC personnel and the pilots of appropriately equipped aircraft. Data link can be used for the efficient transmission of clearances, acceptances, Flight Plan amendments, weather information, aircraft performance data, and other information.

**Data Link Clearance Language:** Clearance Language stated in a form acceptable to the Data Link Processing Subarea.
Deactivate: A term used herein in connection with airspaces (second meaning herein) and flow instructions that are not continuously active. "Deactivate" means to declare formally that such an airspace or flow instruction is inactive, implying that the restrictions on flying do not apply until and unless the airspace or flow instruction is activated once again. Cf. "Activate"

Departure: n. A facility-level Traffic Management term for a flight whose departure airport lies inside that facility's area of responsibility (regardless of what flight phase the aircraft is in, or of whether the aircraft currently is airborne).

Departure Phase: That part of an aircraft's flight which lies between its departure airport and whichever of the following lies closest to the departure airport: (1) The point at which the aircraft achieves cruise altitude (i.e., the first altitude of the user-preferred altitude profile recorded in the flight's User Preference File) or (2) The point at which the flight's Arrival Phase (q.v.) begins.

Deprecated: Obsolete; no longer used; no longer meaningful.

Descend:  
   a. vt. To transition to a lower altitude. In this meaning, "descend" is something that an aircraft does, under pilot control.  
   b. vt. To transmit a clearance directing that a pilot transition his aircraft to a lower altitude. In this meaning, "descend" is something that a controller does.

Descent: n. A maneuver in which an aircraft's altitude decreases with time.

Designated Position: The ATC position at which the ACCC will display a particular aircraft-to-aircraft, aircraft-to-airspace, or flow instruction problem, for controller resolution.

Dimension: One of three components into which flight is decomposed. The three are:
   a. Lateral Dimension. The horizontal component of flight; that is, the component of flight that can be modeled as taking place at a constant altitude. (Note: The lateral component of flight often is thought of as taking place on a plane surface. That is only a convenient approximation; actually, the surface is curvilinear.)
   b. Vertical Dimension. The component of flight that can be modeled as taking place along a line kept constantly perpendicular to the earth's surface as the aircraft flies above it.
   c. Longitudinal Dimension. The component of flight that can be modeled as velocity of travel along the aircraft's planned or actual path.
Display:

a. n. See "Logical Display."

b. vt. To negate any previous action to remove (q.v.) or inhibit (q.v.) information from a logical display, and simultaneously to direct the inclusion of that information in that logical display. (Note: As used in this document, the verb "display" does not mean "to make visible on the physical display at a position." Whether a given displayed piece of information is visible at a given instant depends on whether the corresponding part of the logical display is being presented on the physical display at that instant.)

Display Clearance Language: Clearance Language displayed in the form in which a controller would read it to a pilot.

Dormant Current Plan: A Plan created from an aircraft's Current Plan when that Current Plan is replaced by a new Current Plan that alters the aircraft's route, altitude profile, or speed schedule. All the data in the demoted Current Plan will be retained in the Dormant Current Plan, except the associated Trajectory.

Dormant Trial Plan: A Trial Plan which no longer is "valid" for some reason—for example, the Flight Plan on which the Trial Plan was based was amended after the Trial Plan was created, or the Trial Plan reached Trial Plan Deletion Time (q.v.). A Dormant Trial Plan contains the same information as a Trial Plan, except that it does not include a Trajectory.

Downstream: Adj.

a. A sector (or, in some usages, a facility area of control) which an aircraft will enter after it leaves the sector (or facility area of control) in which it currently is flying, according to the Trajectory associated with some Plan for that aircraft.

b. A position (or, in some usages, a facility) which will control an aircraft after it no longer is controlled by the current position (or facility in which the current position is located), if its flight continues according to the Trajectory associated with some plan for that aircraft.

Encounter: Any situation involving an aircraft and a Notify-only Airspace, in which the applicable separation minima are being violated or may be violated.

En Route Phase: That phase of a flight which is neither Departure Phase nor Arrival Phase. (Note: Some flights may not have an en route phase, because the time in level flight may be small or nonexistent.)
**Exempt:** Excluded from some category of which something otherwise would be a member. For example, military aircraft flying in Military Operations Areas are exempted from problem detection under certain circumstances.

**Expiration Time:** The time remaining during which a resolution or a resolution maneuver can be used. Expiration time of a resolution maneuver is the minimum of (1) Trial Plan Deletion Time (q.v.) and (2) the time remaining, from the current time, until the Latest Possible Clearance Delivery Time (q.v.). For a multiple maneuver resolution, the expiration time is the smallest of the expiration times of the resolution maneuvers that make up the multiple maneuver resolution.

**Expire:** A term applied to resolutions and resolution maneuvers. A resolution or resolution maneuver has expired when the current time exceeds the time of generation plus the expiration time of the resolution.

**Facility:** A short form of "ATC facility," which is a generic term for "Air Route Traffic Control Center" (ARTCC) and "Area Control Facility" (ACF). A facility is operated by the FAA and contains people, workspace, automation, and other support needed for air traffic control.

**Facility Area:** The airspace (second meaning herein) which is controlled by, and is the responsibility of, a given facility.

**FAS Airspace:** See "AERA Airspace."

**Filed Flight Plan:**

a. Information relating to the intended flight of an aircraft, filed orally or in writing with a flight service station, an ATC facility, or some other approved filing point.

b. Informally: The information in FAA Form 7233-1.

**Flight Data Base:** An ACCC-maintained repository of information about all flights known to Automation Processing. The Flight Data Base will include filed Flight Plans, updated Flight Plans, User Preferences, System Preferences, Metering Decision Points, and all AERA-generated Plans, including associated Trajectories and Conformance Bounds.

**Flight Data Entry (FDE):** See FAA-ER-130-005, Section 6.

**Flight Plan:** The original filed Flight Plan for a flight, with all later Flight Plan changes incorporated.

**Flight Termination:** See "Termination."
Flow Instruction (FI): A limitation on air traffic movement, defined in terms of applicability criteria and constraints (q.v.), issued to controllers by national- or center-level Traffic Management. The purpose of flow instructions is (1) to organize air traffic so that it can be managed by individual facilities and sectors with maximum safety and without undue stress on controllers, and (2) to ensure that ATC resources (runways, airspace) are used to the fullest extent possible to meet users' needs and avoid unnecessary delays. Typical FIs involve "miles (or minutes) in trail," "no directs," and other restrictions which the controller translates into specific pilot clearances.

Flow Instruction Noncompliance: One of the following situations:

a. The automation determines that an aircraft meets the applicability criteria of a flow instruction and does not obey the corresponding constraint in that flow instruction.

b. The automation predicts that an aircraft will meet the applicability criteria of a flow instruction if it continues to follow its Current Plan Trajectory, and will violate the corresponding constraint in that flow instruction at some time while it meets the applicability criteria.

Flow Instruction Violation: See "Flow Instruction Noncompliance."

Flow Restriction: Deprecated. See "Flow Instruction."

Flow Restricted Area (FRA): An airspace used as the constraint in a flow instruction. Flights that satisfy the accompanying applicability criteria are prohibited from entering the flow restricted area. Traffic Management uses flow restricted areas as a means of reducing the traffic volume through areas characterized by traffic saturation or hazardous weather.

Formation Flight: More than one aircraft which, by prior arrangement between their pilots, operate as a single aircraft with regard to navigation and position reporting. Separation between aircraft within the formation is the responsibility of the flight leader and the pilots of the other aircraft in the formation. This includes transition periods when aircraft within the formation are maneuvering to attain separation from each other to effect individual control and during join-up and breakaway. There are two kinds of formation flight:

a. Standard formations, in which a proximity of no more than one mile laterally or longitudinally and within 100 feet vertically from the flight leader is maintained by each wingman.

b. Non-standard formations, operating (1) when the flight leader has requested and ATC has approved other than standard formation dimensions, (2) when operating within an authorized altitude reservation or under the provisions of a Letter of Agreement, or (3) when the operations are conducted in airspace specifically designated for a special activity.
**Formation Limits:** Limits, in three dimensions, within which a set of aircraft in an ALTRV or group suppression are to operate. APD uses formation limits in detecting conflicts.

**Full AERA Services (FAS):** A set of AERA capabilities roughly equivalent to "AERA 2" as that term is defined in Appendix 70 of the AAS System Level Specification, FAA-ER-130-005H. (Further AERA guidance has been received from the Air Traffic AERA Team since Appendix 70 was approved, and other changes have been motivated by efficiency considerations and activity in other programs. An FAS specification reflecting the new realities was in preparation as this OD went to press.)

**Full Data Block (FDB):** See FAA-ER-130-005, Section 6.

**Future Situation Display (FSD):** A logical display that contains the plan view of a geographic area of concern at a specified future time. Controllers at a given position can specify that the Future Situation Display at that position be presented in any of three modes: Problem Mode, Static Mode, and Continuous Mode.

**Group Suppression:** A group of aircraft the members of which are exempt from AERA conflict detection with other members of that same group. (APD will detect conflicts between members and non-members, however.)

**Handoff:** An action taken to transfer ATC control of an aircraft from one position (the initiating position) to another (the receiving position) when the aircraft will enter the receiving position's airspace. Every handoff includes a transfer of control and a transfer of (radio) communications.

**Headlight:** See "Lookahead Time."

**Highest Ranked Resolution (HRR):** The resolution ordered highest among those generated by APR in response to a particular problem.

**Hold:** A maneuver type which keeps an aircraft within a specified airspace for a specified period of time.

**IFR Aircraft:** See FAA-ER-130-005, Section 6.

**Initial Sector Suite System (ISSS):** An early product of the ASS Program which is based on the availability of the Common Console/Sector Suite significantly earlier than the Area Control Computer Complex (ACCC). The ISSS is to use Host automation support to bring controllers the benefits of the Common Console/Sector Suite—particularly advanced Computer-Human Interface (CHI) capabilities—before the ACCC is available.

**Initial Point of Violation:** For an aircraft-to-aircraft conflict or aircraft-to-airspace conflict, the initial location where separation will be lost. For a flow instruction problem, the initial location of predicted noncompliance.
Initiate Altitude - Climb: A maneuver type based on a vertical maneuver in which an aircraft planned to be in level flight throughout a time interval associated with the primary problem would be maneuvered so as to climb to an altitude greater than its currently-planned altitude.

Initiate Altitude - Descend: A maneuver type based on a vertical maneuver in which an aircraft planned to be in level flight throughout a time interval associated with the primary problem would be maneuvered so as to descend to an altitude less than its currently-planned altitude.

Initiating Position:

a. In Automated Coordination: The position from which Automated Coordination is invoked.

b. In Handoff: The position currently controlling an aircraft.


Introductory AERA Services (IAS): A subset of Full AERA Services selected for early implementation in order to make advanced automation support available in the field as early as possible. The requirements for IAS are defined in an NAS Change Proposal approved by the AAS Configuration Control Board.

Lateral Maneuver: A maneuver (q.v.) that can be stated solely as a horizontal deviation (deviation in the x-y plane) from the clearance previously given the pilot of the aircraft.

Local Flow Instruction: A flow instruction whose constraint concerns one of the following: (1) Altitude, (2) Speed, (3) Miles in Trail or Minutes in Trail at a Fix or Boundary, (4) Meter Fix Time, or (5) Boundary Crossing Time.

Logical Display: A "conceptual" display containing prescribed types of information. When a given Logical Display is presented at an ATC position, all of the information in the display is available to controllers at that position, but not all that information necessarily will appear, together, on the display surface; scrolling or other actions may be necessary to view all the information.

Longitudinal Maneuver: A maneuver (q.v.) that can be stated solely as a longitudinal deviation (deviation in speed) from the clearance previously given the pilot of the aircraft.

Lookahead Time: A type of parameter representing an amount of time. Lookahead times are used in one of two ways:
a. **To define a time extent:** When used in this way, the lookahead time is added to the current time to define the upper bound of a time interval; the lower bound is the current time itself. For example, APD checks a Plan for aircraft-to-aircraft conflicts between (1) the current time (the time the check is made) and (2) a future time determined by adding a parameter lookahead time to the current time.

b. **To define a particular time in the future:** When used in this way, the lookahead time is added to the current time in order to define some future time. For example, see the use of "lookahead time" in the Continuous and Static Modes of the Future Situation Display.

Irrespective of use, lookahead time is a constant from AERA's perspective (unlike, for instance, "wall clock time," which continually advances).

**Machine Plan:** Any Plan generated by APR and not converted to some other Plan type by the automation. [Notes: (1) A Machine Plan can be "promoted" to Current Plan, Protected Plan, or Protected HRR, in which case it no longer is a Machine Plan. (2) Plans created by Quick Trial Planning are Trial Plans rather than Machine Plans.]

**Make Current:** Informal. An act, by the automation or by a controller at an aircraft's current position, that results in the designation of some Plan as the Current Plan for the current flight of that aircraft. (Note: The act of "making a Plan current" implies ATC procedures and ACCC processing, but these considerations are not part of the act itself.)

**Mandatory Reporting Point Reminder:** See "Monitor-Report Reminder."

**Maneuver:** This term has two entirely different meanings, usually distinguishable by context.

a. In common aviation parlance:

1. Any pilot action that causes the pilot's aircraft to fly differently than it is flying now. For example, turn, level off, slow down.

2. Any clearance from a controller that instructs a pilot to fly his aircraft in a manner different from what was previously agreed on or expected.

b. In AERA usage: An instruction given by a controller to a pilot as part of a clearance, in order to implement a new Current Plan. A maneuver always involves a change in heading, altitude, or speed. (Two examples: "Turn left to 170 degrees." "Climb and maintain FL 370.") One clearance implementing a new Current Plan can necessitate the pilot's performing more than one maneuver.

**Maneuver End Point (MEP):** The point at which the system considers a resolution maneuver to be completed. Determination of the MEP depends on the dimension of the resolution maneuver.
a. For vertical resolution maneuvers: The MEP is either (1) the point where the aircraft rejoins the altitude profile associated with the Plan from which the resolution maneuver digressed or (2) the point at which the aircraft reaches a new assigned altitude.

b. For lateral resolution maneuvers: The MEP is the point where the aircraft rejoins the route associated with the Plan from which the resolution maneuver digressed.

c. For longitudinal resolution maneuvers: The MEP is the point where the aircraft rejoins the speed schedule associated with the Plan from which the resolution maneuver digressed.

**Maneuver Shape:** The characteristic form associated with a given maneuver type, e.g., the number and kind of maneuver transition points (points at which the speed, altitude, and/or heading of the maneuvered aircraft is changed), the objectives and constraints for placement of these transition points, and the associated clearance language. Each resolution maneuver has exactly one maneuver shape.

**Maneuver Start Point (MSP):** The first point on a Plan Trajectory at which a resolution maneuver, if implemented, would cause the aircraft to digress from that Trajectory in any dimension (lateral, vertical, longitudinal).

**Maneuver Type:** One of the following categories of resolution maneuvers (q.v.):

**Message:**

a. A prescribed set of information that describes something. (Example: A clearance.)

b. The format in which a prescribed set of information must be stated, i.e., a required grammar and syntax. (Example: The format of Data Link Clearance Language.)

c. An instance of a message format, filled in. In this meaning, a message is a logical set of information in a particular format, transmitted by one entity (human or computer) to another such entity. (Example: A data link clearance message.)

**Meter Fix Time (MFT):** See FAA-ER-130-005, Section 6. Cf., "Boundary Crossing Time."

**Metering Advisory:** A schedule for use of an entity having a saturable capacity (e.g., airport, meter fix, sector boundary), in order to smooth the flow of traffic. Metering advisories are the basis for the development of metering plans by terminal or Traffic Management personnel.
Metering Decision Point (MDP): A position on the Trajectory of an aircraft where APD will examine that Trajectory to see whether it meets a MFT or BCT imposed by a FI constraint. With each MDP is associated a time range which depends on the estimated flight time between the MDP and the metering fix or boundary. The flight is determined to have met the FI constraint if the predicted arrival time error (difference between the MFT or BCT and the time the aircraft is predicted to arrive at the fix or boundary according to its Trajectory) is within the time range.

Metering Fix: A geographical position over which aircraft will be metered, i.e., constrained to cross at prescribed times.

Miles in Trail (MIT): A flow instruction constraint stating that aircraft satisfying the accompanying applicability criteria must be separated along a route by at least "x" nautical miles. The automation will detect and resolve MIT noncompliances only at fixes and boundaries.

Military Authority Assumes Responsibility for Separation of Aircraft (MARSA): A group of military aircraft which (1) are operating in close proximity on a military mission (e.g., an aerial refueling operation) and (2) for which a military agency assumes responsibility regarding separation among the members of the group. The FAA provides separation between the group, as a whole, and other air traffic, treating the group as though it were a single entity somewhat like an airspace. Under AERA, the automation will create an expanded conformance region about the group, reflecting the fact that the group has a much larger size than a single aircraft. Cf. "Formation Flight."


Minutes in Trail (MINIT): A flow instruction constraint requiring that aircraft satisfying the accompanying applicability criteria be separated along a route by at least "y" minutes flying time. The automation will detect and resolve MINIT noncompliances only at fixes and boundaries.

Mode C: See FAA-ER-130-005, Section 6.

Mode S: See FAA-ER-130-005, Section 6.

Monitor-Report Reminder: A reminder displayed at an aircraft's controlling position when the ACCC detects that the current time is a parameter time after that aircraft should have passed a mandatory reporting point and the controlling position has not indicated receipt of a position report from that aircraft.

Multiple-Dimension Resolution: A resolution which contains two resolution maneuvers. A multiple-dimension resolution may either be a Composite Maneuver Resolution, a Primary Multiple Aircraft Resolution, or a Secondary Multiple Aircraft Resolution (q.v.)

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Multiple Aircraft Resolution: A resolution containing two resolution maneuvers, each to be applied to a different aircraft. There are two kinds of multiple aircraft resolutions: Primary Multiple Aircraft Resolutions and Secondary Multiple Aircraft Resolutions (q.v.).


Non-AERA Airspace: Airspace controlled by a non-AERA facility.

Non-AERA Facility: An ATC facility not supported by automation containing operational AERA software. Three types of non-AERA facility are possible:

a. FAA ATC facilities not yet upgraded to use AERA software.


c. Foreign ATC facilities using foreign-developed ATC support configurations.

Non-FAS Airspace: See "Non-AERA Airspace."

Nonconformance: The state of (an aircraft's) being out of conformance. The condition for which Conformance Monitoring checks.

Nonpreference: See "Resolution Nonpreference."

Nonradar: Adj. Not requiring that reliable ATC radar coverage be regularly available. For example, "nonradar separation" is separation of aircraft based on position information from sources other than radar.

Nonradar Airspace: See "Nonradar Area."

Nonradar Area: An airspace defined, in facility adaptation, as lacking reliable ATC radar coverage.

Nonstandard Response: A type of response received by the ACCC after a data link message has been sent (uplinked) to an aircraft via the ATN Router (q.v.). Cf. "Standard Response."

Notify-Only Airspace: An airspace for which APD will detect planned aircraft entry, but APR will not be evoked automatically to generate resolutions. Controllers can resolve encounters involving Notify-only Airspaces by coordinating, with the agency controlling the airspace, to let aircraft fly through. Cf. "Strategic Airspace" and "Planning Region Airspace."
**Objection:** An undesirable characteristic of a resolution, detected by APD; that is, (1) an aircraft-to-aircraft conflict between aircraft trajectories, (2) an aircraft-to-airspace conflict (except for entry into Notify-only Airspaces), (3) a predicted or actual flow instruction noncompliance, or (4) an aircraft-to-aircraft conflict with the short-term predicted track positions of an IFR aircraft.

**Ordering Sum:** A figure of merit calculated for each resolution generated by APR. Ordering sums are used in determining the order in which resolutions will be generated and presented to the controller to resolve a problem set. Each resolution will have exactly one ordering sum, which consists of the sum of the pairwise products of the weights (q.v.) and values (q.v.) for all resolution ordering factors (q.v.) applicable to the problem set. The ordering sum associated with a resolution may change during the resolution evaluation process, as estimates of the values of resolution ordering factors become more accurate.

The resolutions generated for a given problem set will be ordered according to their ordering sums, with the resolution having the largest ordering sum being ranked highest (best), and so forth.

**Out of Conformance:** A term applied to an aircraft whose track is not in conformance, laterally, vertically, and/or longitudinally, with its Current Plan Trajectory.

**Overflight:** n. A facility-level Traffic Management term for a flight whose departure airport and arrival airport both lie outside that facility (regardless of what flight phase the aircraft is in, and even of whether the aircraft currently is airborne).

**Owning Position:** The ATC position at which controllers are permitted to terminate storage of the Plan. Every Plan, regardless of type, has exactly one Owning Position.

**Parameter:**

a. n. A variable affecting automation processing. The values of AERA parameters will be determined and set in one of two ways:

1. System-wide, based on testing at the FAA Technical Center prior to installation of the AERA automation in the field.

2. On a facility-by-facility basis, permitting the management of an individual facility to tailor the local automation to facility-specific requirements. This type of parameter can be set either explicitly, by specification, or implicitly, by default.

b. adj. "Parametrically-defined," where "parametrically" conveys both of the meanings of "parameter" in a.1 and a.2 immediately above. For example, "After a parameter time, the display will be removed," means "After a predetermined amount of time (which, in the operational environment, will be specified systemwide or set at the facility level), the display will be removed."
Pending Plan: A Pending Plan is a Plan that either (1) is in coordination prior to being made the new Current Plan for an aircraft or (2) has been specifically designated by a controller as the probable next Current Plan for the aircraft. The coordination can be between the current position and the aircraft's pilot (via data link or radio) or between the position initiating coordination and other positions. A Pending Plan receives continual checking for problems, just as a Current Plan does.

Period of Applicability: The time period or geographical extent of an aircraft’s flight during which a resolution preference or nonpreference may apply to resolutions which maneuver that aircraft. The preference or nonpreference applies only if the maneuver start point of every maneuver in a resolution lies within the period of applicability for the maneuvered aircraft. The controller can explicitly specify the period of applicability, or allow a default to be applied.

Plan:

a. Information about a flight, and pilot and controller intentions regarding that flight, needed for AERA to work with that flight. Such Plans include Flight Plans, Current Plans, Pending Plans, Trial Plans, Machine Plans, Dormant Current Plans, and Dormant Trial Plans. "Plan" also is used to refer generically to all of the preceding.

b. Miscellaneous other usages of the word (e.g, "site capacity plan"). When used this way, "plan" will be capitalized only if it begins a sentence or is part of a proper name (e.g., "The Capital Improvement Plan").

Planned Action: An action (e.g., change in route, altitude, speed, or hold) planned for an aircraft and reflected in the Trajectory of that aircraft for purposes of problem detection. The aggregate of Planned Actions for a flight represent both the pilot's intentions and the ATC's intentions for that flight.

Planned Change to VFR Reminder: A reminder displayed at an IFR flight's current position when the automation detects that the current time is a parameter time before that flight is to "go VFR," as determined from the pilot's filed Flight Plan and the Trajectory in the Current Plan for the flight.

Planning Region: The airspace volume controlled by a facility, plus a buffer volume around it to allow space for handoffs between ACFs, for problem detection, and for problem resolution.

Planning Region Airspace: An airspace whose location and activation schedule are known, at a given facility, only if the airspace is located in that facility's planning region. Cf. "Strategic Airspace" and "Notify-only Airspace." When APD detects planned entry into a planning region airspace, the system will invoke APR automatically to generate resolutions unless the controller has suppressed the display of alerts for this condition. (Note: "Planning Region Airspace" is equivalent to "Local Special Use Airspace.")
Plan Processing: An Automation Processing Subarea capability that accepts, processes, stores, maintains, and deletes Plans. Plan Processing is described in sections 3.7.1.1.3 and 3.7.1.1.4 of FAA-ER-130-005.

Plan Status: See "Plan Type."

Plan Type: There are seven Plan types: Current, Pending, Protected HRR, Trial, Machine, Dormant Current, and Dormant Trial. (Note: There are certain other terms used herein that contain the word "plan;" for example: base Plan, [stored] Flight Plan, Filed Flight Plan. These are not Plan types in the formal sense used here).

Point of Violation (POV): See "Initial Point of Violation."

Pointout: See FAA-ER-130-005, Section 6.

Position:

a. A Sector Suite designated to provide automation support to the controller(s) responsible for ATC in some sector.

b. The current geographic location of some object (e.g., an aircraft) on the earth's surface, or of some point on the earth's surface perpendicularly below the object.

Note: In most cases, context makes clear which of these meanings is intended. Where a specific distinction is needed, documentation uses "ATC position" to force meaning a. and "geographic position" to force meaning b.

Predeparture Check (PDC): A check by APD that is applied to a Current Plan, at controller request, usually in response to a pilot's indication that the aircraft is ready to depart.

Predicted or Actual Noncompliance: The situation which exists when (1) the flight which is the subject of a Plan meets a flow instruction's applicability criteria (q.v.) and (2) the Plan does not comply with a constraint (q.v.) in the flow instruction or is projected not to comply with that constraint in the future.

Preference:

a. In ranking resolutions: See "Resolution Preference."

b. In determining top of descent: A pilot's desired top of descent, provided, via data link, in response to a data-linked query.

Primary Aircraft: An aircraft involved in a primary problem.

Primary Multiple Aircraft Resolution: A resolution containing two resolution maneuvers, one for each of the primary aircraft involved in the problem being resolved.
Primary Problem: A problem, of those comprising a problem set (q.v.), that is used by APR to determine the selection of candidate maneuver types (q.v.).

Problem: One of the following:

a. Predicted violation of separation criteria between aircraft Trajectories
b. Predicted violation of separation criteria between an aircraft Trajectory and a protected airspace
c. Predicted violation of separation criteria between an aircraft Trajectory and the short-term predicted track position of an IFR aircraft or an altitude-encoding-transponder-equipped VFR aircraft
d. Predicted or actual noncompliance of an aircraft Trajectory with a flow instruction

Problem Mode: One of three modes in which information can be presented on the Future Situation Display (q.v.), at the controller's option. Problem mode provides a static display of traffic involved in some problem, based on Current Plan Trajectories. The display will be recalculated, rescaled, and recentered to:

a. Reflect the situation as it will appear a parameter time before the time when APD predicts that the violation will begin.
b. Place the predicted point of violation associated with the problem at the center of the display surface.
c. Include all the aircraft predicted to be involved in the problem, as well as other aircraft which might have an impact on the problem's resolution.

Problem Set: A collection of problems which APR attempts to solve with a single resolution, without the introduction of objections (q.v.). Problem sets are created in the Automatic, Trial Plan, and Controller Assisted Modes, and remain unmodified in the Additional Resolutions and Regeneration Modes.

Problem Type: One of the following categories of problems (q.v.):

a. Aircraft-to-aircraft conflicts, excluding conflicts with short-term predicted track positions
b. Predicted and actual noncompliances with flow instructions
c. Aircraft-to-airspace conflicts with other than Notify-Only airspaces
d. Aircraft-to-airspace conflicts with Notify-Only airspaces
e. Aircraft-to-aircraft conflicts with short-term predicted track positions of IFR aircraft

f. Aircraft-to-aircraft conflicts with short-term predicted track positions of altitude-encoding-transponder-equipped aircraft

**Protected Airspace:** For AERA purposes, one of the following:

a. A Strategic Airspace (q.v.)

b. A Planning Region Airspace (q.v.)

c. A Notify-only Airspace (q.v.)

d. An MSAW airspace

For other purposes, the strategic, planning region, and notify-only airspaces making up the set of protected airspaces also can be classified in other ways. For example, all of the following are protected airspaces:

aa. Special-use airspaces

ab. Airspaces designated as (severe) weather areas

ac. Warning areas

ad. ATC-assigned airspaces

**Protected Highest Ranked Resolution:** A former Machine Plan that the system has promoted to a special, higher status as a result of finding that (1) the Machine Plan is the Highest Ranked Resolution (q.v.) to a problem set constructed by APR in the Automatic Mode (q.v.), (2) no Pending Plan exists for the affected aircraft, and (3) the Machine Plan is problem-free. Protected HRRs are checked continually for problems, like Current and Pending Plans; however, they are deleted when their expiration times are reached, unlike Current Plans, which have no expiration time. (A Protected HRR's expiration time is the expiration time of the Machine Plan from which it was made.)

**Published Route:** An air route, officially delineated in published FAA charts and publications.

**Quick Trial Planning (QTP):** See FAA-ER-130-005, Section 6.

**Radar:**

a. n. An electronic means of tracking aircraft in flight.
b.  adj.  Implying a requirement that reliable ATC radar coverage be regularly available. For example, "radar separation" is separation of aircraft based on position information from radar returns, possibly augmented by other sources. A "radar area" is an airspace defined, in facility adaptation, as normally having reliable ATC radar coverage.

Receiving Position:

a.  In Automated Coordination: A position the approval of which is sought in the Automated Coordination process.

b.  In Handoff: The position to which the transfer of control of an aircraft is attempted.

Reconformance: For aircraft which are radar-identified: The process of bringing the aircraft's Current Plan Trajectory into conformance with its track. For aircraft which are not radar-identified: The process of bringing the aircraft's Current Plan Trajectory into conformance with its pilot-reported position.

Reconformance Aid: Deprecated.

Refresh: The regeneration of resolutions for a problem set, when requested by a position.

Regeneration Mode: The operating mode of APR in which APR is initiated to regenerate resolutions for a problem set. This mode may be initiated manually by a position to "refresh" (q.v.) a set of resolutions, and is initiated automatically to replace a set of resolutions that may have become invalid (e.g., due to HRR expiration, or a NAVAID outage).

Reminder: A message generated by the automation and automatically displayed at a position or transmitted to an aircraft at a time related to a particular event. AERA reminders are of five kinds: Start-maneuver, top of descent, monitor-report, transfer of communications, or planned change to VFR. (See separate definitions of these.)

Reroute: A change to a pilot's filed route; i.e., a new path of points, including NAVAIDs, latitude-longitude pairs, and/or DME distances from NAVAIDs on specified radials.

Resectorization: See FAA-ER-130-005, Section 6.

Resolution: A set of resolution maneuvers that are generated to resolve a problem identified in a Plan. Resolutions are implemented via Machine Plans, one Machine Plan for each maneuvered aircraft.

Resolution Maneuver: A maneuver which APR incorporates into a Plan when solving a problem. A given resolution maneuver applies to exactly one aircraft, and moves that aircraft in exactly one dimension.
**Resolution Nonpreference:** A resolution ordering factor which acts to “nonprefer” a resolution by lowering its resolution ordering sum (q.v.). Resolution nonpreferences are applied as per resolution preferences (q.v.).

**Resolution Ordering Factor:** When applied to a completed resolution: A property of a resolution (e.g., presence of objections) which affects its order relative to other resolutions. When applied in the course of determining a resolution: A property used to evaluate which of the candidate maneuver types (q.v.) to use in the completed resolution, along with the maneuver shape (q.v.) and specific maneuver parameters (e.g., location of turn points for a given lateral maneuver type) to use for a given maneuver type.

Application of a resolution ordering factor produces a value, which is weighted and summed together with the similar weighted values for other resolution ordering factors to form the resolution ordering sum (q.v.).

A resolution ordering factor is either “a priori” or “resolution specific,” depending on whether its value for a particular resolution can be exactly determined before a complete trajectory model of that resolution is constructed.

**Resolution Preference:** A resolution ordering factor which acts to “prefer” a resolution by raising its resolution ordering sum. Some resolution preferences are automatically applied system-wide, independent of the mode of APR in effect. Others may be position-applied, with a given period of applicability (q.v.). In the Automatic Mode, resolution preferences may be set for all resolutions for a specified aircraft, or all resolutions which maneuver a specified aircraft in a specified dimension or with a specified maneuver type. Resolution preferences may be further tailored on a problem-specific basis in the Controller Assisted Mode.

**Resolution Type:** Deprecated. See "Maneuver Type."

**Resynchronization:** Longitudinal Reconformance. (See "Reconformance," paragraph c.)

**Route:** A sequence of fixes and airways, where fixes may be in terms of NAVAIDs, named intersections, fix radial distances, or latitude-longitude pairs.

**Route Segment:** See FAA-ER-130-005, Section 6.

**Route-Specific Flow Instruction:** A flow instruction based on the aircraft's route of flight and not on the aircraft's relationship to other aircraft. One of the following: No Directs, Flow Restricted Area, or Specified Sequences of Route Segments and Fixes.

**Secondary Aircraft:** An aircraft which is not involved in the primary problem of a problem set, but which must be maneuvered in order to generate a problem-free resolution for a given maneuver type and primary aircraft.

**Secondary Multiple Aircraft Resolution:** A resolution that contains two resolution maneuvers, one of which affects a primary aircraft; and the other, a secondary aircraft.
Secondary Problem: A problem in a problem set (q.v.) that is not the primary problem (q.v.).

Sector: A unit of airspace within a facility area (q.v.). An airspace (second meaning) defined to represent exactly the volume within which control of air traffic is the responsibility of the controller(s) at a single position (first meaning).

Sector Activity: The workload—volume, complexity—of an ATC position, measured either instantaneously or over some interval.

Sector Activity Measure: An index of future activity at the position controlling some sector. For example: (1) The number of aircraft in the sector, (2) the number of aircraft in the sector having planned actions that require voiced clearances by controllers at the position, and (3) the number of aircraft in the sector that are subject to metering.

Sector Suite: See FAA-ER-130-005, Section 6.

Segment: A part of an aircraft's Trajectory, defined by two successive cusps (q.v.).

Separation: In ATC, the spacing of aircraft to achieve their safe and orderly movement, both in flight and while landing and taking off.

Separation Criteria: Separation criteria are values used in determining whether conflicts exist. They are calculated as functions of (1) the conformance bounds of the involved aircraft, (2) separation minima described in FAA Handbook 7110.65, and (3) the precision of APD algorithms. There are separate sets of separation criteria in the lateral, vertical, and longitudinal dimensions of flight. APD will detect a conflict between two aircraft or between an aircraft and an airspace when, and only when, separation criteria are violated in all dimensions.

Short-Term Predicted Track Position: The extrapolated position of a track at a time in the future that is not beyond the Conflict Alert lookahead time (a parameter).

Single Maneuver Resolution: A resolution containing exactly one resolution maneuver.

Special Automation Processing: An "exception" designation which controllers can apply, at their discretion, to individual aircraft. Special Automation Processing is intended as a means to obtain special ACCC treatment for aircraft because of circumstances not covered by adapted beacon codes applied to aircraft which have declared emergencies, been highjacked, lost communications, etc. In AERA, the "special treatment" consists primarily of using larger conformance bounds than otherwise would be applied to the same aircraft in the same airspace.

Special-Use Airspace: See 7110.65, Glossary.
Speed Change - Decrease: A maneuver type based on a longitudinal maneuver in which an aircraft would decrease its ground speed relative to its currently-planned ground speed at the point where the aircraft first would deviate from its currently-planned speed schedule. (Note: Resolutions containing vertical or lateral maneuvers having the incidental side-effect of decreasing speed are not Speed Change - Decrease resolutions.)

Speed Change - Increase: A maneuver type based on a longitudinal maneuver in which an aircraft would increase its ground speed relative to its currently-planned ground speed at the point where the aircraft first would deviate from its currently-planned speed schedule. (Note: Resolutions containing vertical or lateral maneuvers having the incidental side-effect of increasing speed are not Speed Change - Increase resolutions.)

Speed Schedule (also "Speed Profile"): A description of the speed (longitudinal) component of an aircraft's flight. A speed schedule is an ordered set of pairs (s,t) in which each t is the time at which the aircraft is expected to reach the corresponding speeds.

Spillout: The condition that exists when an aircraft's Current Plan indicates that the aircraft is operating in a given strategic or planning region airspace, and the aircraft is operating outside that airspace.

Start-Maneuver Reminder: A reminder either transmitted to an aircraft or displayed at the aircraft's controlling position a parameter time before the aircraft is to execute a previously cleared altitude, speed, or hold maneuver.

Static Mode: One of three modes in which information can be presented on the Future Situation Display (q.v.), at the controller's option. In static mode, the controller designates a lookahead time less than or equal to the problem detection lookahead time (a system parameter), and the automation treats that value as a constant which, when added to the current time, defines a point in the future at which the controller wants a "snapshot" of the traffic situation. For example, if t₀ is the time when a static mode FSD request is entered, and the lookahead value is "k," then the FSD will contain the traffic situation at time t₀+k, irrespective of wall clock time. The controller can scan forward and backward in time, by using an input device to change the value of "k."

Strategic Airspace: An airspace whose location and activation schedule are known to all facilities. Such airspaces, by virtue of their size, constancy, or ability to affect many aircraft, are judged significant enough that aircraft in other facility areas should be tested against them for problems. An airspace is strategic if it is so designated by the national component of the Traffic Management System. Cf. "Planning Region Airspace" and "Notify-only Airspace." When APD detects planned entry into a strategic airspace, the system will invoke APR automatically to generate resolutions unless the controller has suppressed the display of alerts for this condition. (Note: "Strategic Airspace" is equivalent to "Strategic Special Use Airspace").
System Preference (SP): Routes, altitudes, fixes, and published approaches represented in the trajectory of an aircraft, to which the system "prefers" that the aircraft conform. In addition, when APR solves an aircraft's FI noncompliance problem using a Constraint-based Resolution (q.v.), both the resolution maneuver in that Constraint-based Resolution and the FI that necessitated the resolution become System Preferences for that aircraft, for future planning purposes.

System Preferences take precedence over User Preferences (q.v.).

System Preference File: A file, within the Flight Data Base entry for a flight, that fully describes the automation's preferences for that flight, to the extent that these preferences have been computed and recorded.

Termination: The point in a flight at which ATC control of that flight ceases. Termination takes place when any of the following occurs:

a. The system determines, in accordance with 3.7.1.1.3.2.11b of FAA-ER-130-005, that the flight has landed.

b. The current controller designates that the flight has terminated.

c. The flight arrives at a point where it exits airspace for which the U.S. is responsible for providing ATC services, and the flight is not planned to re-enter airspace for which the U.S. is thus responsible. The subject aircraft's Trajectory, as calculated by Route Processing for the aircraft's Current Plan, will be used to establish the exit point and determine re-entry.

d. The pilot "goes VFR" before the flight ends. (Note: At the time of filing an IFR Flight Plan, the pilot may declare his intention of "going VFR" by including "VFR" as the last entry in the Plan's route string. The pilot also can "go VFR" without any prior announcement, by simply canceling any remaining part of the IFR Flight Plan.)

Time-Based Flow Instruction: A flow instruction that places a constraint on an aircraft's time of arrival at a point or boundary. This time constraint may either be stated directly, as in a Meter Fix Time, Boundary Crossing Time, or Minutes in Trail constraint, or indirectly, as in a Miles in Trail constraint.

Top of Descent (TOD): The location (expressed in geographic position or in time along Trajectory) at which an aircraft begins (or is to begin) its descent from cruising altitude to destination.

Top of Descent Reminder: A reminder either transmitted to an aircraft or displayed at the aircraft's controlling position a parameter time before the aircraft is predicted to reach its top of descent.
Track:

a. The projection on the earth’s surface of the path of an aircraft

b. The dynamic data, including position and velocity, stored for a flight and maintained by the Tracking Function

Traffic Flow Management (TFM): The process of (1) organizing air traffic nationally and locally so that it can be managed by individual facilities and sectors with maximum safety and without undue stress on controllers and (2) attempting to optimize the usage of ATC resources (e.g., runways, airspace) to the fullest possible extent to meet users' needs and avoid unnecessary ground and air delay.

Traffic Management: See "Traffic Flow Management."

Traffic Management Coordinator (TMC): An air traffic controller trained in Traffic Management and assigned to work in the Traffic Management Unit.

Traffic Management System (TMS): A system consisting of automation, communications, traffic management specialists in the national-level Air Traffic Control Command Center, and traffic management coordinators in the facility-level Traffic Management Units. The TMS is charged with optimizing traffic flow in the National Airspace. AERA is required to implement TMS directives (e.g., metering advisories).

Traffic Management Unit (TMU): One of the facility-level components of the Traffic Management System. Each ATC facility has a TMU, staffed by one or more air traffic controllers trained and assigned as traffic management coordinators. Where necessary, the TMU staff is augmented with military operations specialists.

Trajectory: A representation of the path an aircraft is expected to take all the way to its destination, based on a Plan. A ground-referenced representation, in x, y, z, and t, of the expected path, based on flight intent information recorded in the Plan.

Trajectory Estimation: The process of calculating the trajectory of an aircraft, based on a current or proposed plan, weather information, aircraft and flight characteristics data, and other variables.

Transfer: To convey ownership (e.g., of a Plan) or responsibility (e.g., of control, or communications) in such a way that, after the operation has been completed, the ownership or responsibility rests with the recipient of the transfer and no longer rests with the initiator.

Transfer of Communications (TOC): The process of transfer, from one position to another, of responsibility for radio communications with the pilot of an aircraft. Transfer of communications includes the designation of a new radio frequency for the pilot to use in communicating with ATC.
Transfer of Communications Reminder: A reminder either transmitted to an aircraft or displayed at the aircraft's controlling position after handoff has been accepted by the receiving position. The reminder includes the new frequency on which the pilot should communicate with ATC, and may include some other information.

Transfer of Control: The part of handoff that is concerned with designating a new current position for an aircraft.

Transition: v. or n. A change in altitude, speed, or route.

Transponder: The airborne radar beacon receiver/transmitter portion of a secondary radar system. The transponder automatically receives radio signals from an interrogator, and selectively replies with a pulse or pulse group containing information such as identification and altitude.

Trial Airspace: A volume described in the same way as an airspace (see "Airspace," second meaning) but not associated with any "real" restrictions on flight. A trial airspace can be defined by a controller as a "what-if," to see the operational effects of a "real" airspace of identical dimensions (for example, what aircraft-to-airspace conflicts APD detects between that trial airspace and the aircraft known to APD, during the airspace's "active" period). The results are reported to the controller who created the trial airspace.

Trial airspaces have no necessary consequences for ATC; no controller action is required when there is a "conflict" between an aircraft and a trial airspace, and no violation results if an aircraft loses separation with a trial airspace. Trial airspaces can be converted into "real" airspaces, after which they become indistinguishable from other airspaces according to the second meaning cited above.

Trial Plan: Any Plan created by Trial Plan Processing upon request of a controller or action by the automation.

Trial Plan Alert: A notification, to controllers at the position owning a Trial Plan, concerning a problem in that Trial Plan.

Trial Plan Mode: The operating mode of APR in which APR is automatically initiated to resolve problems between a Trial Plan (other than a Trial Plan generated by Automated Replan or Quick Trial Planning) and a Current Plan. This mode can be enabled or disabled at position option.

Trial Planning: Informal. A term used to refer, collectively, to all the means of Trial Plan creation.

Uncontrolled Airspace: See FAA-ER-130-005, Section 6.
**Upstream**: Adj.

a. The sector (or, in some usages, the facility area of control) from which an aircraft will enter some other sector (or facility area of control), according to the Trajectory associated with some Plan for that aircraft.

b. The position (or, in some usages, the facility) which will control an aircraft immediately before it is controlled by some other position (or facility in which the current position is located), if its flight continues according to the Trajectory associated with some Plan for that aircraft.

**User Preference File**: A file, within the Flight Data Base entry for a flight, that fully describes the pilot's User Preferences for that flight.

**User Preference (UP)**: A generic term used to describe "how the pilot wants to fly to the AERA Arrival Fix," i.e., the path the pilot would like to fly, described in x, y, z, and t. User preferences are described in terms of a route, altitude profile, and/or speed schedule. The preferences may apply only to one portion of aircraft flight, e.g., a preferred speed which applies only to the portion of flight at cruise altitude. The AERA automation stores user preferences in the Flight Data Base.

**Value**: The numeric "score" which the automation assigns to a specific resolution for a specific problem set, for a specific resolution ordering factor (q.v.). When a resolution's ordering sum is first calculated, some of the values associated with a resolution are estimated to avoid the need to generate the resolution itself. The automation will replace these estimated values if the resolution itself is generated subsequently. See "Ordering Sum."

**Vector**: 

a. A heading issued to the pilot of an aircraft, by a controller at the position controlling that aircraft, to provide navigational guidance supported by ATC radar.

b. A line, drawn on the display surface of a Sector Suite (or other controller workstation), connected to a position symbol for an aircraft. This type of vector indicates the corresponding aircraft's speed by the line's length, and that aircraft's direction of flight by the direction the line points (with "twelve o'clock" being north).

**Vertical Maneuver**: A maneuver for an aircraft that can be stated solely in terms of vertical deviations (deviations in the z-dimension) from the clearance previously given the pilot of that aircraft.

**Vertical Profile**: See "Altitude Profile."

**VFR Aircraft**: See FAA-ER-130-005, Section 6.
Violation: An actual loss of required separation between an aircraft and either another aircraft or an airspace.


VOR Aircraft: A generic term for aircraft that lack on-board computers or sufficiently sophisticated on-board navigation systems to enable their pilots to fly between geographic points, defined in latitude and longitude or in fix radial distance, without intervention by air traffic controllers.

Warning Time: The predicted time to violation of separation criteria (q.v.), measured at the time of the first appearance of an alert at the position whose controllers must take action.

Weight: A multiplier which is assigned to each resolution ordering factor to reflect the importance of that factor as a determinant of the resolution's merit. See "Ordering Sum."
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