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MITRE TECHNICAL REPORT

Laboratory Validation Results of Proposed En Route NAS Midterm Responsibilities and Capabilities

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Abstract

In fiscal year (FY) 1998 MITRE's Center for Advanced Aviation System Development (CAASD) developed a *Proposed En Route National Airspace System (NAS) Midterm Operational Concepts, Revision 2* [1]. That document proposed a possible way in which the FAA's 2005 operational concept could be implemented in terms of roles, responsibilities and capabilities. However, defined with that operational concept were a number of issues associated with the details of the proposed concepts and capabilities that required validation. This document presents results of initial exercises for validating a selected set of proposed midterm en route responsibilities and capabilities. The validation consisted of a series of three initial exercises performed in the CAASD laboratories using human-in-the-loop (HITL) simulation capabilities.

KEYWORDS: Air Traffic Control, En Route, Midterm, Operational Concepts, Strategic Service Provider, Tactical Service Provider

Executive Summary

Background

To accommodate the predicted growth in air traffic, the Federal Aviation Administration (FAA) in concert with the aviation community developed a concept called Free Flight. Free Flight provides users with as much flexibility of flight as possible, while maintaining or even increasing National Airspace System (NAS) safety. To describe Free Flight, the FAA and industry have developed a number of operational concept documents. All identify the requirement for enhanced capabilities, such as problem prediction, problem resolution, and improved information sharing between NAS users and the FAA. These documents also identify emerging technologies such as datalink, improvements for hazardous weather forecast and display, and advanced aircraft flight management systems (FMSs).

The Free Flight related documents describe operational concepts and capabilities at a high level. Recognizing the need for a lower level of detail that explores roles and responsibilities as well as specific capabilities, The MITRE Corporation's Center for Advanced Aviation System Development (CAASD) developed a *Proposed En Route National Airspace System (NAS) Midterm Operational Concepts, Revision 2* document[1]. That document described changing service provider roles, responsibilities, and supporting capabilities for the midterm. That document also described a number of issues associated with the proposed concepts and capabilities that required validation. This document describes findings from initial Human In The Loop (HITL) exercises that address several of those issues.

Fiscal Year 1999 Validation Efforts

The concepts in the *Proposed En Route National Airspace System (NAS) Midterm Operational Concepts, Revision 2* [1] focus on moving toward a more strategic and less tactical concept of operation, and will require new decision support capabilities to achieve that objective. The document introduces the concept of tactical and strategic service providers who work independently, with a division of responsibility, to manage traffic within a center. The future traffic occurring in a free flight environment is projected to be less structured and thought to require strategic planning capabilities to support monitoring and control. This concept will entail changes in roles and responsibilities for which there are many issues. Laboratory analysis and initial validation exercises were planned to investigate several issues to assess the impact and potential benefits of the proposed concepts. The

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1 Hollenberg, J., et. al., *Proposed En Route National Airspace System (NAS) Midterm Operational Concepts, Revision 2*, September 1998, The MITRE Corporation, McLean, VA., MTR98W00000102.

validation exercises performed were described in *Laboratory Validation Plan for Proposed En Route NAS Midterm Responsibilities and Capabilities*[2]. That document included: the exercises to be performed; operational concept, roles, responsibilities, and capabilities; laboratory setup; and metrics.

During fiscal year (FY) 1999, two capabilities believed necessary to support strategic sector operations were addressed: (1) automated coordination between the strategic and tactical service provider, and (2) the time-based allocation of responsibility for predicted problem resolutions to service provider positions. The validation methodology included a phased approach that facilitates the comparison of addition capabilities to a measured baseline capability consisting of FFP1 capabilities, without duplicating previous efforts. This approach will help to effect the evolution from en route FFP1 operations to the FAA's vision of midterm en route operations. This validation effort consists of three (3) exercises to examine these issues.

The initial exercise established a baseline of capabilities, available under FFP1, as a benchmark against which the effectiveness of the proposed en route midterm responsibilities and capabilities can be compared. The exercise set-up included two sectors of en route airspace with a pair of service providers assigned to each sector. The baseline capabilities include the following for the strategic service provider: (1) problem prediction and notification, (2) manual trial planning, (3) automated replan, and (4) strategic-to-strategic service provider automated coordination. Baseline validation measurements for this exercise include (1) the number of aircraft the service providers can handle with problem notification and trial planning only available at the strategic service provider's position, (2) the number of problems the tactical and strategic service providers can handle while still maintaining other duties, and (3) the workload associated with strategic-to-tactical service provider verbal coordination for problem resolution implementation.

The second exercise studied the operation of several advanced capabilities. This exercise set-up was the same as for the first exercise. Available capabilities at each position include (1) conflict probe, (2) problems assigned based on predicted "time-to-problem," (3) graphic and list presentation of predicted problems, (4) manual trial planning, (5) automated replan, and (6) automated coordination of trial plans from strategic service providers to tactical service providers. This exercise studied the associated (or saved) workload by allowing the automation to perform problem assignment to specific service providers, and providing an electronic capability for the strategic service provider to coordinate problem resolution maneuvers with any tactical service provider. Validation measures included (1) improved

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2 Thompson, K., et. al., *Laboratory Validation Plan for Proposed En Route NAS Midterm Responsibilities and Capabilities,* August 1999, The MITRE Corporation, McLean, VA., MTR99W0000024.

coordination and communication, (2) efficiency, (3) number of aircraft handled, and (4) number of problems resolved while still conducting other duties.

The third exercise studied the concept of the strategic service provider operating more independently from the tactical service provider. The evaluation included two sectors of en route airspace each with a tactical service provider, but the two sectors supported by only a single strategic service provider. The available capabilities at each position and the validation measures are the same as for the second exercise.

Metrics and Data Collection

The metrics used to validate the concepts were analyzed to answered questions relating to the validation criteria. Some of the questions to be validated included, for example, how do the concepts affect the manner and efficiency of (1) how service providers respond to increasing sector workload, (2) coordination between service providers—both within and between sectors, (3) how service providers resolve problems, and (4) how service providers handle pilot requests? Planned metrics included traffic counts, automated coordination counts, problems resolved, and trial plans checked, as well as workload feedback indicators obtained through questionnaires administrated following the exercises.

The data required to analyze the measurements were defined to be the same for each exercise. Also, the results must be considered preliminary based on the nature of these initial exercises. Required data items were not limited to but included (1) predicted problem information (identifier, description, time of problem, and time of display); (2) trial plan information (time requested, contents, and resulting action); (3) pilot request information (time initiated, time to respond, number of trial plans to resolve, and final action); and (4) coordination information (initiator, time of initiation, which sector currently controls the aircraft).

The data was collected electronically by logging capabilities (URET D-Log and a tactical position database). Standard reports were used to extract data for populating a spreadsheet from which graphs of results were generated.

Results and Conclusions

Three exercises were completed. The results of these initial exercises and the data analysis are more qualitative than quantitative. Detailed measured values collected during the exercises were plotted and reviewed for trends between the various data sets for the exercises.

The results of the analysis showed that the additional capabilities—namely, time-based problem notification to tactical and strategic service providers, automated coordination from strategic to tactical service providers, and different service provider configuration (i.e., multi-sector planner) were feasible.

Since only limited data sets are available, they at best might suggest ranges, magnitudes, or interdependencies between different data items. Any insight into event relationships obtained must be considered preliminary since the number of exercises was limited, the traffic scenarios did not adequately represent expected 2005 traffic volume or routings, and the participating service providers had limited time for training with the new capabilities.

Post-exercise debriefings were performed and much feedback concerning strategic-to-tactical automated coordination was obtained. All of the participants considered automated coordination from strategic service provider to tactical service provider to be potentially useful and there was agreement that automated coordination from the strategic to the tactical service provider should be recommended as a mid-term capability. In addition:

- Most participants thought the information provided in the automated coordination request to be adequate; suggestions were made regarding how to better describe clearances for lateral maneuvers.
- There was agreement that the use of automated coordination would change the way the tactical and strategic service providers interact and might compromise the ability of the tactical and strategic service providers to work as a team to manage the sector's traffic.
- Most participants thought that automated coordination would have little impact on service provider workload, with the decrease in verbal communication offsetting the additional work in entering and responding to requests.

Next Steps

The FY 1999 exercises accomplished the first steps towards validating the proposed midterm en route responsibilities and capabilities. The capabilities chosen for validation are considered essential building blocks for future concept validation exercises. CAASD planned follow-on exercises for FY 2000 through FY 2002, many of which were planned to include participation by FAA field personnel. The exercises chosen were based on the perceived priority to create the necessary building blocks for future exercises. As our operational concept validation work continues, further details for each of these planned exercises will be developed in a manner similar to that used for these initial exercises as provided in *Laboratory Validation Plan for Proposed En Route NAS Midterm Responsibilities and Capabilities* document (ibid).

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Jack Brennan trained the tactical service providers and helped test the software. David J. Winokur trained the strategic service providers in their position’s capabilities. Celesta Ball and Gretchen Jacobs trained the sim-pilots, as well as helping test the software.

Ellen F. Friedman and Michelle C. Bradshaw carefully reviewed the report for compliance with MITRE and CAASD documentation standards, as well as facilitating the publishing process.

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Section 1

Introduction

In fiscal year (FY) 1998 MITRE's Center for Advanced Aviation System Development (CAASD) developed *Proposed En Route National Airspace System (NAS) Midterm Operational Concepts, Revision 2* [1]. That document proposed a possible way to evolve en route center roles, responsibilities and capabilities towards the FAA's 2005 operational concept. However, there are a number of issues associated with the proposed concepts and capabilities requiring validation. This document presents results from conducting initial exercises completed in FY1999 aimed toward validation of several issues. These initial exercises and follow-on exercises consist of a series of laboratory exercises to be conducted in the CAASD laboratories using human-in-the-loop (HITL) simulation capabilities. The validation of the operational concepts is expected to be a multi-year effort. Some next steps are outlined as logical next exercises and issues to be addressed in future validation activities and have been documented in *Laboratory Validation Plan for Proposed En Route NAS Midterm Responsibilities and Capabilities* [2].

1.1 Background

To help the Federal Aviation Administration (FAA) meet its goals of increased safety, capacity, and efficiency, while at the same time responding to pressure from users to better accommodate user preferences, a number of efforts are underway. The *ATS Concept of Operations for the National Airspace System in 2005* [3], and the related document *ATS Concept of Operations for the National Airspace System in 2005, Addendum 1, Operational Tasks and Scenarios* [4], describe the FAA's vision of the NAS at a high level. The *Final Report of RTCA Task Force 3 Free Flight Implementation* [5], expressed the need for increased user flexibility, increased operating efficiencies, and increased levels of capacity and safety to meet the growing demand for air transportation. In response to that report, the *Government/Industry Operational Concept for the Evolution of Free Flight* [6], and the *Government/Industry Operational Concept for the Evolution of Free Flight Addendum 1: Free Flight Phase 1 Limited Deployment of Select Capabilities* [7] were prepared. CAASD's *Proposed En Route National Airspace System (NAS) Midterm Operational Concepts, Revision 2* [1] uses the aforementioned concepts but takes them to an increased level of detail.

The concepts build upon the capabilities of Free Flight Phase 1 (FFP1) and, in particular, on the problem prediction and notification capability provided by the User Request Evaluation Tool (URET) [8, 9]. The concept also addresses the role of other Communications, Navigation, and Surveillance (CNS) and Air Traffic Management (ATM) capabilities, such as data link, advanced weather dissemination, and more effective coordination between the en route sector team and the Traffic Management Unit (TMU).

1.2 Purpose and Scope

This document describes the results of three initial exercises for validating a proposed en route operational concept. Included is a description the exercises, the metrics that were used with the exercises, the data collected as part of each exercise, a description of the required laboratory architecture and infrastructure, and results and findings from the exercises.

The scope of this document is limited to initial validation exercise results.

1.3 Document Organization

An overview of the major themes in the proposed midterm en route responsibilities and capabilities is presented in Section 2. Section 3 describes the overall approach and methodology used to conduct the validation exercises, and identifies the subset of concepts and issues that were addressed during FY 1999 validation exercises. Section 4 contains descriptions of the validation exercises. Section 5 provides an overview of the CAASD laboratory that was used for conducting the validation exercises. The data collected, analyzed, and results are summarized in Section 6. Section 7 briefly describes suggested next steps for beyond FY 1999. The appendix contains the collected responses to the post-exercise questionnaire.

Section 2

En Route Operational Concept Overview

The FAA's future en route concepts have been developed with the goals of accommodating user preferences, handling increased traffic, and maintaining or improving aviation safety. The concepts incorporate emerging technological advances and identify capabilities that will be used by Air Traffic Control (ATC) service providers to better manage their workload.

It is envisioned that most of the tasks performed by the en route sector controllers today will also be performed in the midterm; however, as a result of new technologies to assist in en route workload management, the nature and allocation of the tasks may differ. The nature of tasks may become more strategic, and with the aid of decision support capabilities, tasks may be allocated differently between tactical and strategic service providers.

Today, an en route sector is staffed by either a Radar (R) controller working alone or by an R controller supported by a collocated Radar Associate Flight Data or "D" controller. The R and D controllers typically share the load of separating aircraft and planning aircraft flows through the assigned airspace. The R controller generally monitors the radar display and handles control actions of a more immediate (tactical) nature, while the D controller monitors flight progress strips to perform flow planning and helps the R controller as necessary. In addition, there are Traffic Management Unit (TMU) positions that are responsible for flow planning on a Center-wide basis and for collaborating with Aeronautical Operational Controls (AOCs).

In the future, new decision support capabilities will improve the ATC service provider's ability to identify and resolve potential problems. A problem is defined to be the predicted loss of separation between aircraft and other aircraft, Special Use Airspace (SUA), complex traffic airspace, terrain and obstructions, hazardous weather, or compliance with traffic planning constraints.

New decision support capabilities will also help service providers determine whether user requests for flight plan changes will be problem-free. If a user request is predicted to have a problem, service providers can use decision support capabilities to automatically check that request periodically and notify the service provider as soon as the request is problem-free. Decision support capabilities will include intra-sector, inter-sector, and inter-facility automated coordination capabilities that will reduce the service provider workload associated with verbal communication. It is hypothesized that the accumulated benefits of automated capabilities will allow service providers to provide ATC services to more aircraft.

As service providers become accustomed to using automated decision support capabilities, it is anticipated that their tasks will evolve from those with a tactical emphasis to

more strategic operations. This evolution from a tactical to a strategic control environment is a major thrust of the proposed midterm concept. As a result, there could be changes in roles and responsibilities. Rather than having both an R controller and a D controller, there would be Tactical Service Providers (TSP) and Strategic Service Providers (SSP). The tactical service provider would have primary responsibility for communicating with pilots, resolving tactical problems, and responding to pilot requests. The strategic service provider would have primary responsibility for resolving problems before they become tactical, thereby decreasing the tactical service provider workload.

The separation of responsibilities between the tactical and the strategic service providers should ensure that there is no interference by one service provider's actions on others. For this reason, one of the proposed concepts is the time-based allocation of responsibility for predicted problem notification to the appropriate service provider. Since traffic volume and complexity varies by time of day, by season, and by location, the time horizons that define whether a task is tactical or strategic must be able to be adjusted accordingly.

Although the proposed midterm operational concepts define an evolution from controllers working in teams to the assignment of individual responsibilities for specific airspace for service providers, there is a continuing need for service provider coordination. This leads to a need for capabilities that facilitate coordination among service providers. In particular, an automated coordination capability between service providers is a major theme. Automated coordination is an electronic means for communicating information, such as a trial plan that defines a flight plan amendment to resolve a problem, between service providers for either information or implementation. It enables service providers to exchange trial planning information in both textual and graphical formats, thus facilitating inter- and intra-sector communications. This could potentially enhance sector team efficiency and provide a means of easily entering flight plan amendments.

The concept of automated coordination among service providers can be broadened to include electronic coordination between traffic management coordinators (TMCs) and strategic service providers. This concept enables the communication of TMC reroutes to en route strategic service providers.

The concepts described above lead to new options for configuring sector positions. In a medium density traffic situation, a strategic service provider could support multiple sectors. This is a new theme that needs to be fully validated in terms of operational feasibility and acceptability. The strategic service provider could be either collocated with the tactical service providers or non-collocated. For example, when the strategic service provider supports two tactical service providers in adjacent sectors, the strategic service provider's workstation could be placed between the two tactical service providers' workstations, and thus be collocated with them. When the strategic service provider supports more than two tactical service providers, the strategic service provider may not be collocated with any of the tactical service providers due to physical arrangement problems.

When sector workload is predicted to increase, minimizing the impact on the users also is desirable. One way to accomplish this is to adjust the sector-staffing configuration, such as the service provider workforce assignments and service provider to sector assignments, to accommodate changing traffic complexities and loads.

In summary, the proposed midterm operational concepts document [1] describes concepts and capabilities needed to support tactical and strategic service providers and identifies issues that require validation to determine whether the concepts and capabilities provide a viable approach to achieve the FAA concept of operations for 2005. The laboratory validation plan document [2] describes exercises to validate proposed en route midterm concepts. Although the overview presented here does not cover every concept, it highlights some of the major themes and provides some background to understand the focus of the validation exercise results reported herein.

Section 3

Concept Validation Methodology

Validation of the proposed midterm operational concept will be performed in phases, where each phase represents a building block subset of the concept. The intent of this approach is to add more Decision Support System capabilities over time. This approach will support the evolution from en route FFP1 operations to the FAA's vision of midterm en route operations.

The subset of capabilities chosen for initial validation exercises supports a possible transition from FFP1 to midterm operations, and also lays the foundation for evaluating key elements of the proposed midterm en route responsibilities and capabilities. In defining a possible evolution sequence of increasing capabilities, thought has been given to minimizing the impact on NAS infrastructure. An important issue needing evaluation is the separation of responsibilities between the tactical and strategic service providers so that there is no interference between their actions, such as creating and implementing flight plan amendments. To address this issue, two components were selected from the concept, chosen because they form a foundation on which many other components of the concept are based.

- **Automated coordination**, but in particular, automated coordination from a strategic service provider to a tactical service provider (having current control of the aircraft to be maneuvered). This is an extension of the URET-CCLD automated coordination capability that exists in the FFP1 timeframe.
- **Time-based allocation of responsibility for predicted problem notification** (called time-based problem notification) to the appropriate tactical or strategic service provider, with the tactical service provider receiving problems predicted to occur in a shorter timeframe.

The overall approach to validating automated coordination and the time-based problem allocation was to:

- Establish a baseline that consisted of the capabilities available in the FFP1 timeframe.
- Compare the baseline to exercises using time-based problem notification and inter/intra sector automated coordination.

These exercises enabled a first estimate of the effectiveness of the proposed capabilities, and assessed their combined advantages. Associated with each of the capabilities are various issues that also must be addressed. The following set of validation increments have been completed:

- Strategic service providers perform trial planning, initiate automated replans, receive problem prediction notification, and initiate automated coordination between strategic service providers. The tactical service provider can view the strategic service provider's display to review predicted problems.
- Strategic service providers and tactical service providers perform trial planning, initiate automated replans, and are allocated problems based on time-based problem notification. Strategic-to-tactical service provider automated coordination includes automated coordination from a strategic to tactical service provider in another sector, as well as automated coordination from a strategic service provider to the collocated tactical service provider.
- Same as above but the strategic service provider has responsibility for more than one sector.

The specific validation exercises are described in detail in Section 4.

Section 4

Operational Concept Validation Exercises

The operational concept validation exercise descriptions include the following general information for each validation exercise: 1) the applicable portion of the midterm concept, 2) validation exercise and capability definition, and 3) data requirements. Other sections and documents provide traffic scenario information [10, Appendix 4.1]; laboratory information, including provider positions required to support each exercise (Section 5); and analysis and results (Section 6).

4.1 Portion of the Proposed Midterm Responsibilities and Capabilities to be Validated

The portion of the proposed midterm responsibilities and capabilities addressed by the initial validation exercises uses the following four basic capabilities:

- Problem notification and resolution capabilities added to tactical position
- Predicted problems allocated to tactical or strategic service providers based on initial predicted time remaining until the start of the problem
- Automated coordination of a problem resolution from a strategic service provider to the tactical service provider controlling the aircraft
- Independent operation for tactical and strategic service providers supported by different service provider configurations

The midterm concept [1] identifies five possible service provider configurations. Of the five, those used in the initial validation exercises are in bold type. The service provider configurations are:

- Configuration 1: Tactical service provider only
- **Configuration 2: Tactical service provider and collocated strategic service provider**
- Configuration 3: Two tactical service providers with a collocated strategic service provider
- **Configuration 4: Tactical service provider with a non-collocated strategic service provider**
- **Configuration 5: Multiple tactical service providers with a single non-collocated strategic service provider**

4.2 Definition of the Validation Exercises and their Capabilities

Table 4-1 summarizes the initial validation exercises. For each exercise, the table identifies which sector configuration was used, the number of sectors used, and the number of tactical and strategic service providers required. The table also identifies the specific issues to be addressed by each exercise.

Table 4-1. Initial Exercises

Exercise Number	Capability Description	Configuration	Issue Reference
1	FFP1 baseline using problem prediction, notification, and resolution to support the strategic service provider	Configuration 2 2 Sectors 2 TSP and 2 SSP	Evaluate a configuration in which the tactical service provider operates the sector with the support from a collocated strategic service provider.
2	Problem prediction, notification, and resolution supporting the tactical and strategic service provider, automated coordination from a strategic service provider to any tactical service provider, and time-based problem allocation to the appropriate tactical or strategic service provider	Configuration 4 2 Sectors 2 TSP and 2 SSP	Display conflicts in a conflict/flight data list to tactical service provider through a URET display viewable by the tactical service provider. Graphically depict conflicts to tactical service provider through a URET display viewable by the tactical service provider Display conflicts in a list to tactical service provider on DSR Graphically depict conflicts to tactical service provider on DSR Develop strategic-to-tactical and tactical-to-strategic automation coordination allowing for the display of trial plans on tactical side list with appropriate clearance language Graphically depict strategic service provider developed trial plans on tactical service provider display Demonstrate and evaluate the utility of manual tactical service provider trial planning and replanning Display trial plans and replans on tactical service provider list Activate trial plans and replans from tactical service provider side Perform evaluations to understand tactical and strategic service provider workload issues associated with resolving problems based on the problem notification time parameter assignments.
3	Same as 2	Configuration 5 2 Sectors 2 TSP and 1 SSP	Perform evaluations to understand tactical and strategic service provider workload issues associated with resolving problems based on the problem notification time parameter assignments. Evaluate workload, including service provider coordination, to understand the utility of the various proposed service provider configurations as a function of sector workload and traffic conditions.

Note: TSP = Tactical service provider; SSP = Strategic service provider

4.3 Data Collected for the Initial Validation Exercises

The goal of the initial validation exercises was to gain insight into the usefulness of proposed capabilities in supporting the changing roles and responsibilities of en route service providers. The data collection and analysis was not intended to be exhaustive, or be sufficient to define quantitative service provider workload benefits attributable to specific capabilities. However, it provided some insight into the usefulness of each capability for enhanced en route operations.

Exercise data collected was in the following forms:

- Recorded quantitative data, such as the time that each aircraft entered and exited the sector, using automated tools.
- During each exercise an observer assigned to each sector documented service provider actions that cannot be collected electronically.
- Upon completion of the exercise, an observer interviewed the service providers to gather further subjective data on the merits of concepts as well as service provider recommendations. A survey (included in the appendix) was used to query the service providers on their appraisal of the concepts, covering all aspects of the validation exercises. The survey included exercise-specific questions targeted to the goal(s) of that exercise, and allowed service providers to provide both specific responses and general comments.

4.4 Description of the Traffic Scenarios

Traffic volumes in the scenarios for these exercises were desired to be typical of the 2005 time frame, with moderate to moderately heavy traffic—enough to keep both service providers busy, but not to the point that the workload became unmanageable. Traffic was desired to be mostly off airways and jet routes, so that intersections of flight plans would tend not to be at ATC fixes and intersections. However, development of representative 2005 traffic scenarios was not completed in time for the initial exercises. Instead, lighter traffic loads were used and traffic consisted of a mix of on-route and off-route traffic. This will necessitate rerunning the exercises with the 2005 traffic loads at a later time. Details of the traffic scenarios used for these initial exercises can be found in [10, Appendix A 4.1].

4.5 Validation Exercise 1: FFP1 Baseline

The purpose of this exercise was to gain operational experience with a baseline using FFP1 capabilities to use as a benchmark for measurement. The FFP1 en route capabilities were available at the strategic service provider's position and included the following:

- Problem prediction and notification (shown both textually and graphically)
- Trial planning
- Automated replan
- Strategic-to-strategic service provider automated coordination

4.5.1 Description

In the baseline exercise, tactical and strategic service providers staffed two sectors with adjacent airspace. Each strategic service provider received notification of all problems predicted to occur in their sector. Trial planning and automated replan were available to assist the strategic service provider in the resolution of the problem. When the resolution required maneuvering an aircraft in another sector, automated coordination was available to transmit the trial plan to the strategic service provider in the sector controlling the flight for coordination with that sector's tactical service provider. Coordination between the tactical and strategic service providers was verbal; situations requiring verbal coordination included the following:

1. The strategic service provider received automated notification of a predicted problem and developed a problem-free trial plan necessitating a maneuver to an aircraft in the sector. The strategic service provider verbally conveyed this plan to the collocated tactical service provider for implementation.
2. The strategic service provider received an automated coordination request from another sector to maneuver an aircraft in the sector. The strategic service provider verbally conveyed this plan to the collocated tactical service provider for implementation.
3. The strategic service provider received notification of a tactical problem that the tactical service provider may already be resolving; the strategic service provider verbally checked with the tactical service provider before attempting to develop a resolution.
4. The tactical service provider verbally requested that the strategic service provider perform a trial plan to check for problems with a pilot request for a flight plan change.

4.5.2 Validation Analysis

In the course of the exercise, the items listed below were used to establish the baseline against which the midterm capabilities were compared:

- Develop an understanding of the relationship of workload to traffic count.
- Develop an understanding of the relationship of workload to aircraft-to-aircraft/airspace predicted problems.
- Develop an understanding of the relationship of the coordination and problem resolution implementation workload to traffic and predicted problem counts.

4.6 Validation Exercise 2: Problem Prediction, Notification, and Resolution Supporting the Tactical and Strategic Service Provider, Time-Based Problem Notification, and Enhanced Automated Coordination

This exercise examined the merits of migrating FFP1 en route capabilities to the tactical service provider's position as well as the addition of some new capabilities including:

- Predicted problem list (automatically displayed on tactical and strategic service provider displays)
- Graphic depiction of problem (displayed upon service provider request)
- Trial planning, including graphical depiction of problems
- Automated replan, including graphical depiction of problems
- Time-based problem notification to tactical and strategic service providers
- Strategic-to-tactical service provider automated coordination

4.6.1 Description

In this exercise, tactical and strategic service providers staffed two sectors of adjacent airspace. Single-service provider operation, where the tactical service provider operates the sector alone, is described in [10]. Both the tactical and strategic service providers received notification of problems predicted to occur in the sector based on time frames of notification (set to 0-5 minutes for the tactical; greater than 5 minutes for the strategic), with each service provider having a list containing predicted problems. Also, both the TSP and SSP have the capability to generate trial plans and perform replans for resolving predicted problems, and for the TSP to check that pilot requests are problem free before they are implemented. The expected benefit of this arrangement over the baseline was that the service providers would not have to procedurally coordinate which problems to resolve. With enhanced automated coordination, SSPs coordinated resolution trial plans with their collocated TSP as well as TSPs for other sectors.

These capabilities were used by the service providers at each sector, allowing more independent operation and separation of duties between the tactical and strategic service providers. The exercise provided some insight to advantages derived from operating in this manner.

4.6.2 Validation Analysis

The following areas were used to assess the effectiveness of the concept:

- Understand the relationship between workload and traffic count, and between predicted problem count and resolutions when the tactical service provider and strategic service provider shared the predicted problem resolution responsibility and used automated coordination to support problem resolution implementation.
- Develop an understanding of the workload associated with implementing resolutions developed by collocated SSPs and by SSPs from other sectors.

4.7 Validation Exercise 3: One SSP and 2 TSPs Resolving Problems

This exercise examined the feasibility of having one strategic service provider and two tactical service providers resolving problems predicted to occur in two sectors.

4.7.1 Description

This exercise examined the operation of two sectors, with a strategic service provider resolving strategic problems predicted to occur in both sectors, and with each sector operated by a tactical service provider. The tactical and strategic service providers had the same capabilities as in Exercise 2. To implement problem resolution maneuvers, the strategic service provider used strategic-to-tactical service provider automated coordination.

4.7.2 Validation Analysis

The following topics were addressed during this exercise:

- Develop an understanding of the relationship of workload and traffic count, predicted problem count, and problem resolution implementation for tactical and strategic service providers operating and sharing sector responsibilities.
- Develop an understanding of the relationship between predicted problem level of occurrence and time to develop and implement problem resolutions. Also, develop an understanding of the relationship between problem resolution implementation time and traffic count.
- Describe the observations concerning the working relationship between the tactical and strategic service providers when sharing separate tasks related to situations for the same sector, but working more independently.

Section 5

Laboratory Information

This section provides an overview of the laboratory service provider positions, hardware, software, and personnel that supported initial validation exercises of the proposed en route responsibilities and capabilities.

The service provider positions used for each exercise are shown in Table 5-1. In the table, sectors A and B refer to sectors that were staffed for the exercises, and "other" sectors refers to all other sectors that were represented by a single position to interact with the A and B sectors.

The midterm validation laboratory supports testing using up to two sectors. Figure 5-1 depicts the laboratory configuration. The sectors can be staffed with a tactical and strategic service provider for each sector, or the strategic service provider positions can be combined into a single position to validate initial aspects of the multi-sector strategic service provider concept. The laboratory included a tactical service provider position that is used to function as "all other tactical positions" to support proper operation of sector handoff and coordination actions. Also included were pseudo-pilot positions and system control positions.

Table 5-1. Service Provider Position Requirements

Available Positions*	Exercise 1	Exercise 2	Exercise 3
Sector A			
73	TSP	TSP	TSP
	SSP	SSP	Multi-sector planner***
Sector B			
74	TSP	TSP	TSP
	SSP	SSP	Multi-sector planner***
Other Sectors			
75	TSP	TSP	TSP
Pseudo Pilot**	Staffed	Staffed	Staffed

* Sector 73, 74, and 75 are Dynamic Simulation sector airspaces.

** Staffed support positions that are not evaluated as part of the validation activity.

*** Requires one strategic service provider for both sectors.

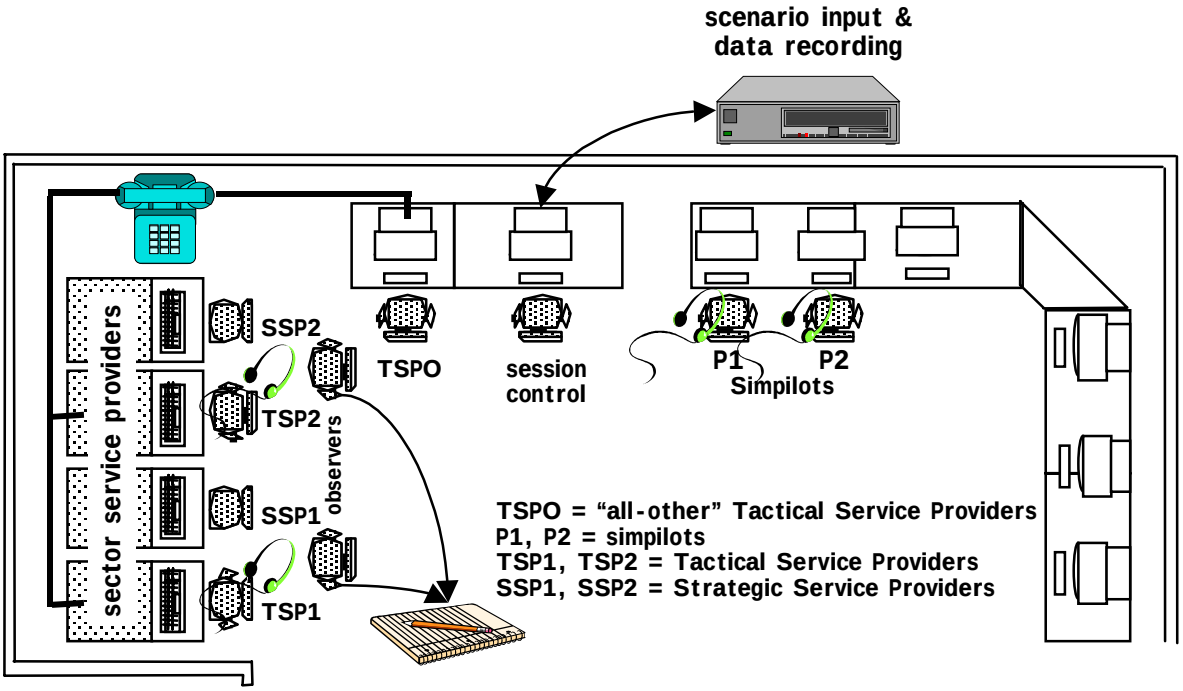

Figure 5-1. Lab Configuration Used for Exercises

The application software packages used to support the exercises are the following:

Host System:	Host A4E version 2.1
URET system:	URET version 3.1
HDM:	HDM (Host Data Multiplexor) version 3.3
Data Recording:	DLOG; HDM Log

Section 6

Summary Results of Initial Midterm Validation Exercises

The three initial validation exercises identified in Section 4 explored the impact of specific concepts and capabilities on service provider workload. Section 6.1 describes data collection for the exercises. Metrics to provide insight into that impact are defined in Section 6.2. Section 6.3 provides summary descriptions of subjective information obtained from subject service providers immediately following each exercise.

The results of these initial exercises and the data analysis are more qualitative than quantitative. Detailed measured values collected during the exercises are graphed and reviewed for trends between the various data sets for the exercises. Since only limited data sets were available, they at best suggest ranges, magnitudes, or interdependencies between different data items. Any insight into event relationships obtained must be considered preliminary since the number of exercises was limited, the traffic scenarios did not adequately represent expected 2005 traffic volume and routings, and the participating service providers had limited training using the new capabilities.

6.1 Data Collection

The data needed to analyze the exercises is the same for each exercise. Data items were recorded in electronic log files. The reports defined in [11] provided the required information for the strategic positions. Other reports (undocumented) were used to provide the tactical position information. The supplemental data (shown in bold) were planned to be manually recorded by exercise observers to capture items such as verbal coordination actions between tactical and strategic service providers.

The data items include:

- For each aircraft traversing a staffed sector:
  - When the aircraft entered and left the sector; times of inbound and outbound handoff initiation; times of inbound and outbound handoff acceptance; whether the flight was climbing, level, or descending at inbound handoff acceptance; the flight plan; simulation start time; and location
  - Account for the special cases: flights already in the sector at simulation start, flights that never leave the sector during the run, flights that take off within or land within the sector, handoffs that are taken back (identified by accepting sector being the same as the initiating sector)

- For each problem displayed to the tactical service provider:
  - Complete information such as conflict identifier, conflict description, predicted time of conflict, initial time of display, any updates, when it was removed and why, whether and when the tactical service provider suppressed the display, how long the conflict took to resolve
  - Observe whether and when the tactical service provider built one or more trial plans to test a resolution (link to appropriate trial plans by aircraft identifier and sequence of events), or **whether the tactical service provider re-allocated the problem to the strategic service provider verbally**
- For each conflict displayed to the strategic service provider:
  - Complete information such as: conflict identifier, conflict description, predicted time of conflict, initial time of display, any updates, when it was removed and why, type of alert, lists in which displayed, how long it took to resolve
  - Observe whether and when the strategic service provider built one or more trial plans to test a resolution (link to appropriate trial plans by aircraft identifier and sequence of events), whether the strategic service provider re-allocated the problem to the tactical service provider verbally
- For each trial plan generated by the tactical and strategic service provider:
  - Complete information such as time requested, contents, problems detected, new predicted arrival time, "fate" (made current, timed out, deleted, etc.) and time of occurrence, and time clearance was issued if made current
- For each automated replan submitted by the tactical and strategic service provider:
  - Complete information such as time requested, trial plan on which it was based, problems detected, "fate" (made current, cancelled, etc.) and time of occurrence
- For each flight plan amendment (route or altitude change) made by the tactical service provider:
  - Complete information and whether it was made without first building a trial plan; whether the clearance resulted in a conflict
  - Change in arrival time resulting from the amendment
- For each flight plan amendment (speed, route, or altitude change) made by the strategic service provider:
  - Complete information and whether the clearance resulted in a conflict
  - Change in arrival time resulting from the amendment

- For each automated coordination request:
  - Complete information such as initiator, time of initiation, which sector currently controls the flight, recipient, time of response, response given, "fate" (timed out, requested change made current, etc.) and time of occurrence
- For each Conflict Alert:
  - Complete information such as flights involved, time of display, time display removed
- Chain of actions:
  - **Workload: responses to questionnaires on perceived workload**

6.2 Metrics Summary

The validation exercises for the proposed concepts were designed to examine:

- The way service providers respond to increasing sector workload
- The manner and efficiency of coordination between service providers, both within and between sectors
- The manner and efficiency of how service providers resolve problems

6.2.1 Sector Workload Metrics Summary

6.2.1.1 Exercise Traffic Data

Figures 6-1 through 6-3 suggest the workload presented to each of the sectors in each of the exercises, measured here by the instantaneous count of aircraft under track control. The horizontal axis in these figures represents elapsed time, with zero being the time the scenario began.

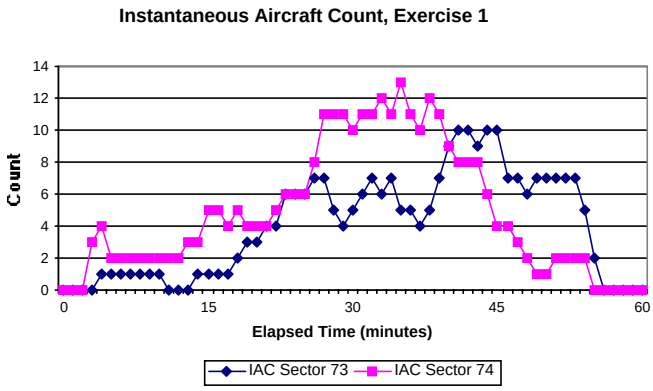

Figure 6-1. Instantaneous Aircraft Count, Exercise 1, Scenario 1

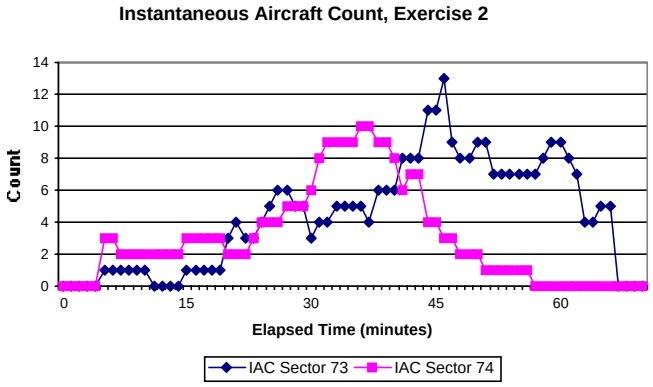

Figure 6-2. Instantaneous Aircraft Count, Exercise 2, Scenario 1

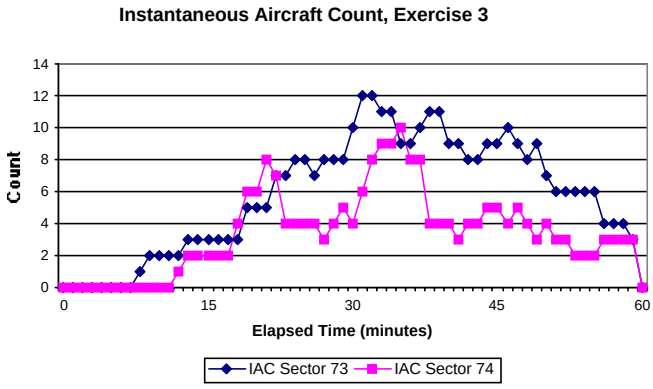

Figure 6-3. Instantaneous Aircraft Count, Exercise 3, Scenario 2

6.2.1.2 Tactical Position Data

Each exercise also presented conflict situations to be solved; the service provider reaction to each conflict, of course, altered the remainder of the scenario so that each exercise resulted in different circumstances that were handled. In addition, many of the aircraft entered the sector with a user request, causing additional service provider workload.

In Exercises 2 and 3, the tactical service providers had trial planning and automated replanning capabilities, received automated coordination requests from strategic service providers, and were notified of problems with 5 or fewer minutes to go before loss of separation (see Section 4.6 and 4.7). Figures 6-4 and 6-5 compare the instantaneous count of aircraft under track control with the number of conflicts, trial plans, and automated coordination requests under consideration. This data is shown for Exercises 2 and 3, for each staffed tactical position, to allow comparison across exercises; the data are not intended to depict a definitive measure of workload. The data are graphed as the sum of the instantaneous aircraft count (IAC), the number of conflicts in the Conflict Probe List, the number of trial plans in the Plans List, the number of automated replan trial plans in the Plans List, and the number of automated coordination requests in the Coordination List.[3] The horizontal axis in each figure represents elapsed time, with zero being the time the scenario began. Since each scenario was stopped at a predetermined time, the data are truncated, even though flights might still have been active in a sector.

While there are clearly differences between sectors and across exercises, the causes of these differences are less clear. During Exercises 2 and 3, from 1 to 4 problems were assigned to tactical positions. Trial plans and automated replans were performed in response to pilot requests and observed potential problems, and tactical service providers responded to automated coordinations from strategic service providers. As noted in [10], service providers react differently to the same traffic and capabilities. Consequently, differences between sectors and across exercises need further exploration to determine to what degree those differences resulted from the concepts the exercises examined.

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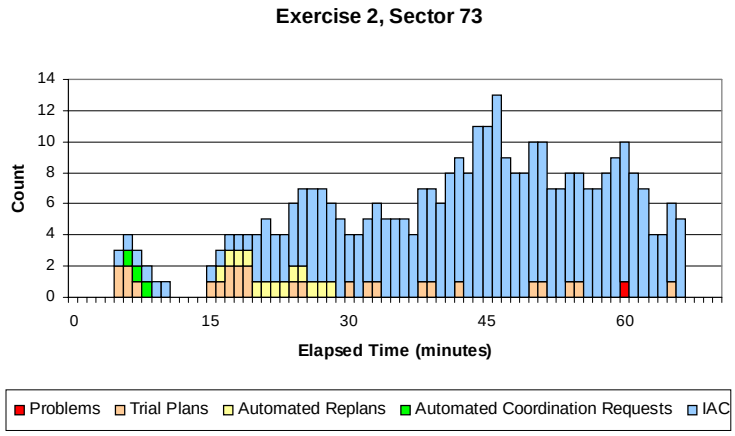
[3] For example, the Count value of 14 at minute 35 in Exercise 2 in Figure 6-5 represents one displayed conflict, three displayed trial plans, one displayed automated replan, and nine aircraft under the track control of sector 74.



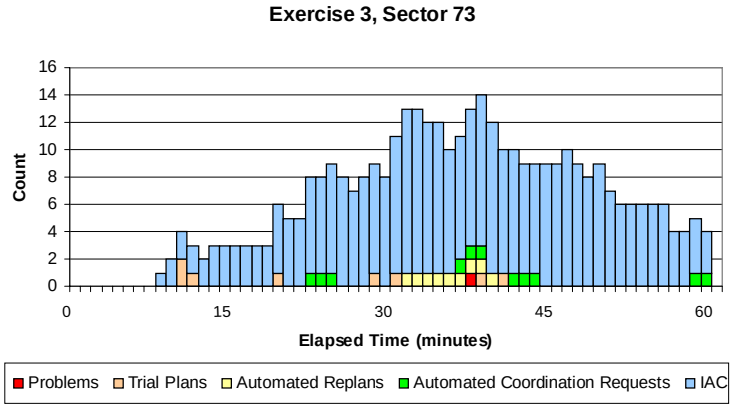
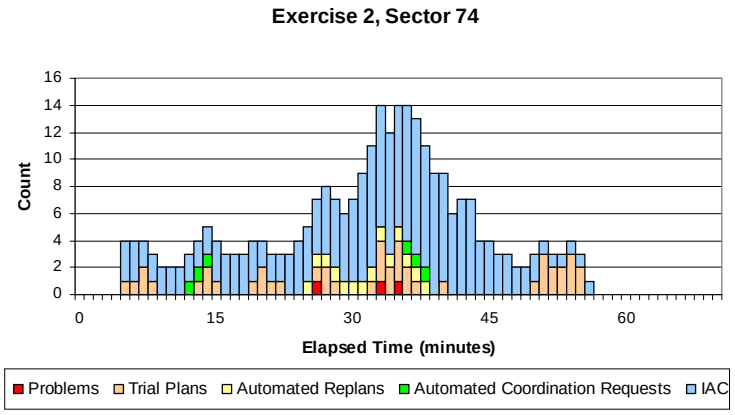


Figure 6-4. Tactical Position, Sector 73



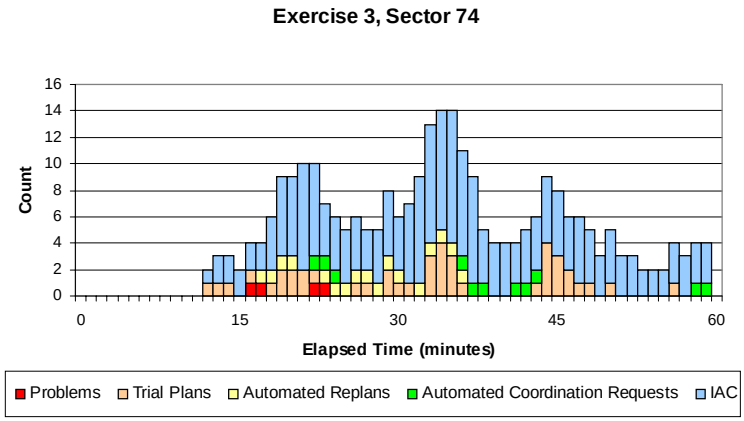


Figure 6-5. Tactical Position, Sector 74

6.2.1.3 Strategic Position Data

Figures 6-6 and 6-7 show information for the strategic service provider for Exercises 1 and 2 for sectors 73 and 74, respectively. Figure 6-8 shows information for Exercise 3 where both sector 73 and 74 were assigned to a single strategic service provider. As for the tactical position, differences and similarities across the exercises can be seen. The data are graphed similarly. The graphs show the sum of the IAC, the number of conflicts in the Aircraft List, the number of trial plans generated by the strategic service provider, and the number of automated coordination messages sent, all plotted against elapsed time for the exercise.

For Exercise 1, all problems were assigned to the strategic position, and for Exercises 2 and 3, problems with a lead time of greater than 5 minutes were assigned to the strategic position. The graphs provide an indication of the strategic service provider workload for each exercise and sector.

Also, as for the tactical positions, specific causes for the differences between the exercises cannot be confirmed without additional exercises. However, it can be observed from the graphs that trial planning and automated coordination were used in response to problems. Problems, trial planning, and automated coordination appear to be correlated (as expected), but do not seem related to periods of greater traffic. This confirms the expectation that problems were resolved prior to the traffic entering the sector.

6.2.2 Automated Coordination Results

Each of the participants staffing the evaluation positions[4] was interviewed individually at the completion of each exercise. They responded to questions about the exercise and the concepts being examined, as summarized below. They also provided feedback on the laboratory capabilities, procedures, and training for the exercises. These responses to the questionnaire and comments were noted for anyone planning future laboratory concept validation exercises and the details are included in the Appendix.

All of the participants considered automated coordination from the strategic service provider to the tactical service provider to be potentially useful. Most found that they responded differently to requests from other service providers when automated coordination was available. Most participants thought the information provided in the automated coordination request was adequate; suggestions were made regarding how to better describe clearances for lateral maneuvers. There was agreement that the use of automated

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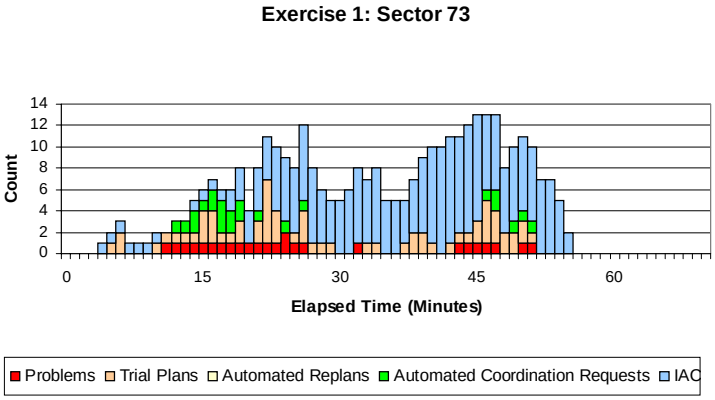
[4] For these exercises, the evaluation positions were staffed by MITRE CAASD personnel, each of whom has at least three years experience as a full performance level (FPL) controller at one or more facilities.

coordination would change the way the tactical and strategic service providers interact. Some comments indicated concern that reduced verbal coordination would compromise the ability of the tactical and strategic service providers to work as a team to manage the sector's traffic. Most participants thought that automated coordination would have little impact on service provider workload, with the decrease in verbal communication offsetting the additional work in entering and responding to requests. One comment was that making requests with automated coordination is less susceptible to misunderstandings between the service providers, so it's less "workload" even though it may not be quicker. There was agreement among all participants that automated coordination from the strategic to the tactical service provider should be recommended as a midterm capability.

6.2.3 Sector Problem Resolution Time Metrics Summary

Figure 6-9 shows the problem resolution times for the two strategic positions (sectors 73 and 74) in the three exercises. The problem resolution time includes time to view the problem, time to develop trial plan(s), and time to automatically coordinate the trial plan resolution to the tactical service provider (Exercises 2 and 3; vertical coordination for Exercise 1). Most problems assigned to the strategic service provider were resolved within 4 minutes. The problem resolution times appear to be consistent across the three exercises except for problems that occurred at the initiation of Exercise 1. With the limited quantitative data available it is not possible to state conclusions relating to the relative efficiency of problem resolution by strategic service providers with the additional capabilities and/or the impact of the different configurations used in the exercises.



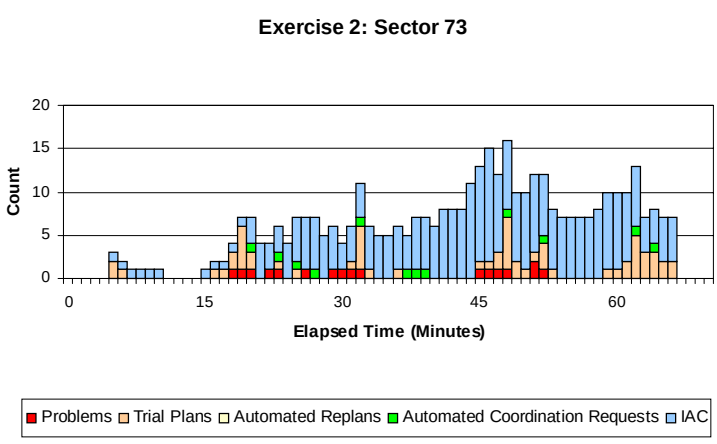


Figure 6-6. Strategic Position, Sector 73

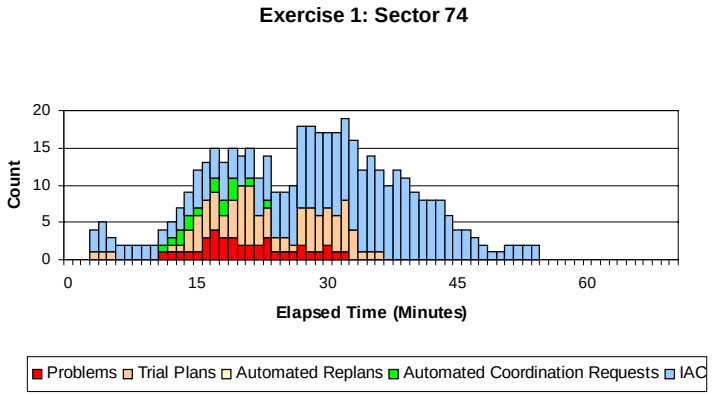


Figure 6-7. Strategic Position, Sector 74

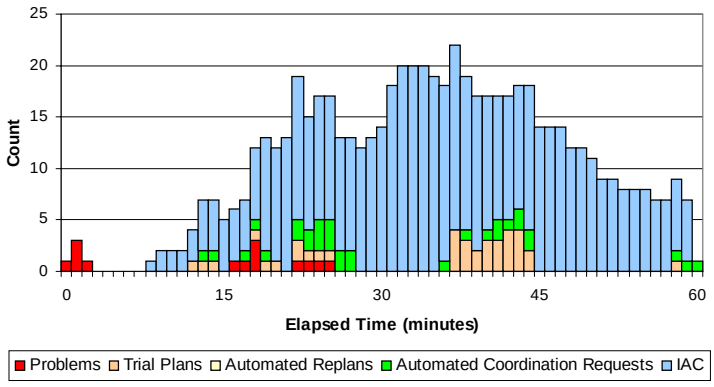


Figure 6-8. Strategic Position, Sectors 73 and 74

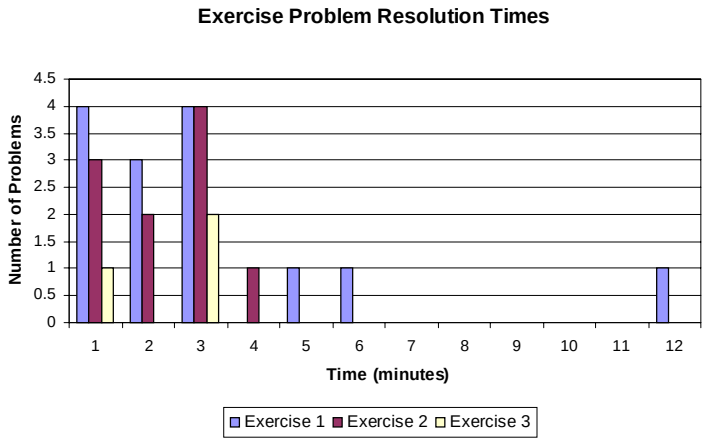


Figure 6-9. Problem Resolution Time: Strategic Positions

Section 7

Next Steps

As described in this document, the initial concept validation exercises focused on the following:

- Problem prediction and notification supporting the tactical service providers, in addition to the strategic service providers.
- Automated coordination from a strategic service provider to any tactical service provider.
- Time-based problem allocation to the appropriate tactical or strategic service provider.

As noted, the specific laboratory exercises shown in Table 4-1 were performed by CAASD personnel having ATC experience. These exercises were a first step towards validating the proposed midterm en route responsibilities and capabilities, and were chosen as essential building blocks for future concept validation exercises. However, the exercises were inconclusive. The traffic scenarios did not contain sufficient flights to generate a high workload to stress the tactical and strategic service providers to a level that would show differences in operation that might result from providing different capabilities and/or configurations of service providers.

It is recommended that the exercises be rerun using scenarios more representative of expected 2005 traffic. If differences in workload result, then the exercises should be performed using FAA service providers familiar with the scenario airspace and with adequate training in the use of the new capabilities. Following the rerun of the initial exercises, it is recommended to continue with follow on exercises as defined in Table 8-1 of [2], which lists candidate exercises planned for FY 2000 through FY 2002. The exercises shown in that table were chosen based on the perceived priority to create the necessary building blocks for future exercises, and are expected to be feasible provided that the necessary operational personnel and CAASD staffing and funding resources are available.

Further details for each of these planned exercises should be developed in a manner similar to that provided by this document for the FY 1999 validation exercises.

List of References

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10. Ball, C., G. J. Jacobs, *Recommendations for R-Side Evolution: Initial Candidated for Evaluation,* August 1999, The MITRE Corporation, McLean, VA, MP99W00000018.
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Appendix

Collected Responses to Post-Run Questions

Initial Midterm Concept Validation Exercises

Enhanced R & D Side Midterm Capabilities and Procedures

Post-Run Questions

Summary of answers and comments

Responses are keyed by exercises, position, and participant. For example, "1a-2" is session #1, position a, participant 2.

Key to exercises

Exercise 1: Baseline FFP1, no TSP capabilities except Flight Data list; SSP URET capabilities with only SSP-to-SSP Automated Coordination; SSP gets all problem notifications; two sector teams, each with a TSP and a SSP.

Exercise 2: Enhanced TSP capabilities including Conflict Probe results and Trial Planning, SSP URET capabilities plus SSP-to-TSP Automated Coordination; TSP gets problems with 5 minutes or less to go, SSP gets all problems plus list of those displayed to TSP; two sector teams, each with a TSP and a SSP.

Exercise 3: Multi-sector planning position with separate displays for each sector's URET capabilities plus SSP-to-TSP Automated Coordination; Enhanced TSP capabilities including Conflict Probe results and Trial Planning; TSP gets problems with 5 minutes or less to go, multi-sector planner gets all problems plus list of those displayed to TSP; one multi-sector planner and two sectors with only a TSP.

Key to positions

a. Sector 73, R-side
b. Sector 74, R-side
c. Sector 73, D-side
d. Sector 74, D-side
e. Sectors 73 & 74, multi-sector planner

R-Side Flight Data List:

1. Rate the potential usefulness of the Flight Data List to help you evaluate the impact of new aircraft on sector operations (i.e., planning).

Very Useful				Not Useful
2a-2: if no strips	3a-2	1b-2 3b-1	1a-1 (->) 2b-1	2a-2: if have strips

1b-2: if comparing to strips

2a-2: link to replace of strips

3a-2: assuming no strips, OK for tactical planning

2. Was the information provided in the Flight Data List adequate?

Yes	No
1a-1 1b-2 2b-1 3a-2: for tactical planning 3b-1	2a-2

If No, What information would make this capability more useful?

2a-2: URET may need to keep last 2 or 3 route(s) and support retrieval

3. Was the information provided in the Flight Data List displayed and removed at the correct time (e.g., displayed at handoff)?

Yes	No
1a-1	2b-1
1b-2	3a-2
3b-1	

If No, What timing would be more useful?

2b-1: display *before* handoff (parameter time)

3a-2: Prior to handoff and forced if it is a conflict case

4. Did the lack of opportunity to view, mark and handle flight progress strips reduce your ability to handle traffic?

Yes	No
2a-2	1a-1
	1b-2
	2b-1
	3a-2
	3b-1

If Yes, Explain

1b-2: Can mark strips but can't mark flight data list; Because didn't have strip – lose track of where guy is going [after amending original route]

5. In what conditions or circumstances would the Flight Data List be most useful as an R-Side capability?

1a-1: Don't know

2b-1: ?

3a-2: see above (tactical)/ if no strips, need aircraft data; strip remarks section info

3b-1: all

6. Were the procedures you used regarding flight data information appropriate?

Yes	No
1a-1 2b-1 3b-1	

7. Would the use of the Flight Data List change the way the R-controller might interact with the D-controller?

Yes	No
2a-2	1a-1 2b-1 3a-2 3b-1

Explain

3a-2: Does not affect D interaction

3b-1: no interaction with mult-sector planner

8. Rate the likely workload impact of including the Flight Data List on R-Side.

Greatly Increase		No Change	Greatly Decrease
	3a-2	1a-1 2b-1 3b-1	

2a-2: function of whether or not one has strips

9. Would you recommend including the Flight Data List as an R-side capability?

Yes	No
1a-1 2b-1 3a-2 3b-1	

Other comments about the Flight Data List:

3a-2: Need complete info from strip; Need electronic strip bucket to retrieve “previous route of flight”

R-Side Conflict Probe

1. Rate the potential usefulness of Conflict Probe to help identify potential conflicts.

Very Useful						Not Useful
2a-2 2b-1 3a-2 3b-1						

2. Were you aware of problems earlier than you would be with current capabilities as a result of the information provided by Conflict Probe?

Yes	No
2a-2 3a-2	3b-1

Explain

2b-1: Don't know – would have to compare to run without it (5 min param)

3b-1: Was not able to identify them as early, because they weren't displayed until 5 minutes to go

3. Did you take action to resolve problems earlier as a result of the information provided by the Conflict Probe List?

Yes	No
2a-2 3a-2	2b-1 3b-1

Explain

2b-1: Could have acted sooner if notified sooner

3b-1: later (see above)

4. Was the information provided in the Probe List adequate?

Yes	No
2a-2	
2b-1	
3a-2	
3b-1	

5. Was the separation distance (i.e., 5 miles) used to predict conflicts optimal?

Yes	No
	2a-2
	3a-2

2b-1: Don't know

3b-1: Don't know – some seemed a bit too close for comfort

If No, What distance would be more useful?

2a-2: 6.5 miles

3a-2: 6.5 – see previous notes

6. Were the procedures you used regarding conflict probe information appropriate?

Yes	No
2b-1	
3a-2	
3b-1	

7. Would the use of Conflict Probe on the R-Side change the way the R-controller might interact with the D-controller?

Yes	No
2a-2	3b-1
2b-1	
3a-2	

Explain

2a-2: Would not request D to do TP for in-sector aircraft

2b-1: Change in emphasis of R side tasks

3a-2: Would also not impact D side workload

3b-1: no interaction when multi-sector planner has this capability

8. Would you recommend including Conflict Probe/Conflict Probe List as an R-side capability?

Yes	No
2b-1	
3a-2	

Other comments about Conflict Probe on the R-Side:

2a-2: When an aircraft is moved vertically for traffic, a TP and Auto Replan should be done to allow controller to offer old altitude

2b-1: Would have found it more useful if all conflicts are shown on R-side – time horizons not relevant to problem resolution – need to have D working under direction of R side, not working independently – R side responsible for integrating everything that happens in the sector

R-Side Trial Planning:

1. Rate the potential usefulness of Trial Planning to help you evaluate and resolve conflicts.

Very Useful			Not Useful
2a-2 2b-1 3a-2 3b-1			

2. Rate the potential usefulness of Trial Planning to help you evaluate user requests.

Very Useful			Not Useful
2a-2 2b-1 3a-2 3b-1			

3. Rate the likely workload impact of including Trial Planning on R-Side.

Greatly Increase	No Change		Greatly Decrease
	3b-1	2a-2 3a-2	2b-1: saves future workload

2a-2: less verbal coordination

4. Did you handle user requests differently (i.e., earlier) as a result of the Trial Planning capability on the R-Side?

Yes	No
2a-2	2b-1
3a-2	3b-1

If Yes, How?

2a-2: Eliminated need for verbal coordination with next sector

3a-2: Do on R side rather than with for D side support

3b-1: respond the best one can, even though using new tool

5. Was the information provided in the Trial Plan List adequate?

Yes	No
2a-2	
2b-1	
3a-2	
3b-1	

6. In what conditions or circumstances would Trial Planning be most useful as an R-Side capability?

2a-2: For user requests and resolve problems

2b-1: all

3a-2: for user requests earlier and more efficiently

3b-1: all

7. Would the use of Trial Planning on the R-Side change the way the R-controller might interact with the D-controller?

Yes	No
2a-2 2b-1 3a-2	

Explain

2a-2: Replaced verbal requests for D side TPs. – Being collocated allowed R to check workload with D and decide if R wanted to have D do the TP for the R.

2b-1: Wouldn't have to talk as much

3a-2: Sharing workload

3b-1: don't know

8. Were the procedures you used regarding Trial Planning appropriate?

Yes	No
2a-2 2b-1 3a-2 3b-1	

9. Rate the likely workload impact of including the Trial Planning on R-Side.

Greatly Increase		No Change		Greatly Decrease
			2a-2 3a-2	

2a-2: Reduces "analysis" workload at expense of an increase of input action workload

2b-1: see # 20

3a-2: Supports analysis of planning

3b-1: see # 20

10. Would you recommend including Trial Planning as an R-side capability?

Yes	No
2a-2	
2b-1	
3a-2	
3b-1	

Other comments about Trial Planning on the R-Side:

2a-2: Highly!

2b-1: Essential

3a-2: Highly; R&D collocation would have allowed for better overall workload sharing/balancing; R/D could check either position and "help" if not busy!

3b-1: He likes it

R-Side Auto Replan:

1. Rate the potential usefulness of the Auto Replan to help you handle user requests.

Very Useful		Not Useful
	3b-1	

2b-1: Don't know – not enough experience

3b-1: less than expected – couldn't easily see why conflict was found

2. Rate the likely workload impact of including the Auto Replan on R-Side.

Greatly Increase	No Change	Greatly Decrease
	2b-1 3b-1	

3b-1: Don't know, but not likely to take much

3. Did you handle user requests differently as a result of the Auto Replan capability on the R-Side?

Yes	No
	2b-1 3b-1

4. Did you handle requests from other controller differently as a result of the Auto Replan capability on the R-Side?

Yes	No
	2b-1 3b-1

5. Was the Auto Replan information provided in the Trial Plan List adequate?

Yes	No
2b-1 3b-1	

6. Was the Auto Replan indicator provided in the data block useful?

Yes	No
3b-1: with more training	

2b-1: Never saw it

7. In what conditions or circumstances would Auto Replan be most useful as an R-Side capability?

2b-1: Don't know – to record flight requests when not too busy

8. Were the procedures you used regarding auto replan appropriate?

Yes	No
2b-1 3b-1	

9. Would the use of the Auto Replan on the R-Side change the way the R-controller might interact with the D-controller?

Yes	No
	2b-1

Explain

3b-1: Don't know

10. Rate the likely workload impact of including the Auto Replan on R-Side.

Greatly Increase		No Change		Greatly Decrease
		2b-1 3b-1		

11. Would you recommend including Auto Replan as an R-side capability?

Yes	No
2b-1 3b-1	

Other comments about Auto Replan on the R-Side:

2a-2: Did not use. Could not do – needed more training.

2b-1: Usefulness depends on how well CHI is designed

3a-2: Did not have to use – all TP for user requests were green

3b-1: need more experience to understand how it fits into sector operations

12. Was the scenario realism (i.e., traffic, events, etc.) adequate for the purpose of the exercise? – see # 67 on sheets

13. Was the level of fidelity (e.g., display, command entry, response time, etc.) adequate for the purpose of the exercise? – see # 68 on sheets

14. Was the training you received adequate to allow you to participate in the exercise? – see # 69 on sheets

D-Side Conflict Probe

1. Rate the potential usefulness of Conflict Probe to help identify potential conflicts.

Very Useful						Not Useful
1c-3						
1d-4						
2c-4						
2d-3						
3e-4						

2. Were you aware of problems earlier than you would be with current capabilities as a result of the information provided by Conflict Probe?

Yes	No
1c-3	
1d-4	
2c-4	
2d-3	
3e-4	

1d-4: Wouldn't have been looking for them so soon; looking at more airspace than would have otherwise

2d-3: Further out – wouldn't usually see them so far out

3e-4: Looking sooner

3. Did you take action to resolve problems earlier as a result of the information provided by the Aircraft List?

Yes	No
1d-4	2c-4
2d-3	
3e-4	

1d-4: Immediately looked to GPD and initiated TPs

2c-4: Used GPD as focus; 2nd level effort to update aircraft

2d-3: Used GPD – could see what was happening

3e-4: As soon as notified

4. Was the information provided in the Aircraft List adequate?

Yes	No
1c-3	1d-4
2c-4	
2d-3	
3e-4	

If No, What information would make this capability more useful?

1d-4: Correlate aircraft between displays – clicking on ID in GPD should highlight corresponding entry in aircraft list

2c-4: Would like selection on GPD to highlight item on aircraft list

2d-3: Used the GPD – adequate for conflicts

5. Was the separation distance (i.e., 5 miles) used to predict conflicts optimal?

Yes	No
2d-3	1d-4 2c-4

If No, What distance would be more useful?

1d-4: Uncomfortable for R side; 7 miles

2c-4: Should be longer – 6 or 7

3e-4: Made no difference

6. Were the procedures you used regarding conflict probe information appropriate?

Yes	No
2c-4 2d-3 3e-4: see Auto Coordination	1d-4

If No, Explain

1d-4: Unrealistic to verbally communicate graphic reroute to R side/pilot because he knew the pilot would not "know" how to fly it

7. Would the use of Conflict Probe on the D-Side change the way the D-controller might interact with the R-controller?

Yes	No
1c-3 1d-4 2c-4 2d-3 3e-4	

1c-3: Verbal coordination would change, +/- depending on situation

1d-4: Multiple conflicts drew attention away from other tasks supporting R side and situation awareness – didn't feel like "D side" position any longer

2c-4: Lots, changes D activities (more detached) workload higher for D; probably less for sector team

2d-3: Eventually, as these functions evolve to planning position; but still need controller assistance for R side

3e-4: No verbal interaction, so not really functioning as D controller, just as strategic problem solver

8. Would you recommend including Conflict Probe/Aircraft List as a D-side capability?

Yes	No
1c-3: optional 1d-4 2c-4 2d-3 3e-4	

Other comments about Conflict Probe on the D-Side:

1d-4: Misleading at times: worked resolution, sent Auto Coordination, went green before Auto Coordination response received

- Also, some problems went away while he was working them => wondered whether it was worth working on them early

- Right click on flight with multiple conflicts showed all routes in conflict, not just ones he wanted to work – so where routes overlapped, it wasn't clear which flight he could send direct – unfamiliar with how to remove displayed routes selectively [later experiment showed one can't de-select highlighting of the route of an individual flight in conflict – all routes in a conflict are either highlighted or not]

2d-3: Stuff that pops up doesn't really draw your attention

3e-4: Conflicting feelings:

- Felt responsible to resolve problems because of early information

- None actually his responsibility

- Completely focused on conflict resolution, no other D side tasks done and no situation awareness maintained

D-Side Trial Planning:

1. Rate the potential usefulness of Trial Planning to help you evaluate and resolve conflicts.

Very Useful			Not Useful
1c-3 2d-3 3e-4: essential	1d-4 2c-4		

2c-4: Could be better – very time consuming; need quicker way to delete red TP and do new one

2. Rate the potential usefulness of Trial Planning to help you evaluate user requests.

Very Useful			Not Useful
1c-3 1d-4 2c-4 2d-3			

3e-4: Not applicable

3. Rate the likely workload impact of including Trial Planning on D-Side.

Greatly Increase		No Change		Greatly Decrease
1d-4	1b-2 2c-4	2d-3	1c-3	

2d-3: Balances out – more work to do but less likely to get "unable" on coordination

3e-4: Hard to compare because it's such a different position – much less workload than doing D side task

4. Was the information provided in the Aircraft List adequate?

Yes	No
1c-3 1d-4: didn't use for TPs 2c-4 2d-3: about TPs 3e-4	

5. Would the use of Trial Planning on the D-Side change the way the D-controller might interact with the R-controller?

Yes	No
1c-3 1d-4 2c-4 2d-3	

1b-2: Asking D to do added stuff - increases workload -> D has to respond back

1d-4: R side asking for D to check pilot request; automatically checked overheard requests; kept prompting for clearance of TP, because TP about to time out

2d-3: Still need to coordination with R, but gives D's suggestion more weight – need to work out roles each time a team sits down

3e-4: No interaction

6. Were the procedures you used regarding Trial Planning appropriate?

Yes	No
1c-3: not sure of question 1d-4 2c-4 2d-3 3e-4	

1d-4: Pilot request near boundary after handoff and before physical control: want to check with previous controller – had to do it manually

2c-4: could help more if could listen to aircraft with R

7. Rate the likely workload impact of including the Trial Planning on D-Side.

Greatly Increase		No Change		Greatly Decrease
2c-4	1d-4	1c-3		

2d-3: see # 52

3e-4: see # 52

8. Would you recommend including Trial Planning as an D-side capability?

Yes	No
1b-2	
1c-3	
1d-4	
2c-4	
2d-3	
3e-4	

Other comments about Trial Planning on the D-Side:

1c-3: Time for D responding to D-D auto coordination causes degree of uncertainty.

- May need to have tool make TP being Auto-Coordination alerted to other D to cause response

- Change A/C time parameters

- Need to know "how clean" a clean TP is! Show yellow status for TPs.

1d-4: Route TP: Dialog box for directs goes away and shows results graphically – when red, have to iterate – would like to know while dialog box is open (turn letters green or red in dialog?)

- Didn't know fixes well enough to propose non-direct route amendments

- Didn't try speed TPs

- Automated Replan: Did not use: didn't know how and no desire to use

    - Assumed something else would work or request denied

    - But didn't track pilot requests, especially when already involved in a conflict

2c-4: Graphic TP hard for R to implement – Need new way to give reroutes

- Our configuration 5 – had a problem; D could not listen on 2 frequencies to support 2 Rs

2d-3: Good feature

3e-4: Same comments as session 1

- Concern about R side seeing graphic reroute – R side couldn't see problem it resolved

- Altitude TP dialog didn't show altitudes above current altitude – not sure why

R & D-Side Automated Coordination of Trial Plans

1. Rate the potential usefulness of the Automated Coordination D to R to help you handle predicted conflicts.

Very Useful			Not Useful
3b-1 3e-4	1d-4 (D-D only) 2a-2 2c-4 2d-3	3a-2	

2a-2: Reduce verbal coordination; but not sufficient for laterals.

2b-1: Don't know – not enough exposure to it – never saw a textual route change – would need to see route change graphically as well

2c-4: If D at sector, Auto Coordination should go through Ds

2d-3: If R busy all the time, no need to interrupt him verbally

2. Did you handle requests from other controller differently as a result of the Automated Coordination capability on the D-Side?

Yes	No
1d-4 2d-3	3b-1

1c-3: No incoming D-D A/C; so no answer!

1d-4: Less priority than if they called, kept focus on conflicts

2d-3: When R requests something – coordination better (less last moment)

3e-4: Not applicable

3. Was the Automated Coordination information provided in the Trial Plan adequate?

Yes	No
1d-4	2a-2
2c-4	3a-2
2d-3	
3b-1	
3e-4	

If No, What information would make this capability more useful?

1d-4: For receiving, want to see it graphically

2a-2: See question 58

3a-2: Need additional info for laterals

3e-4: Except not sure default coordination sector was the best choice

4. In what conditions or circumstances would Automated Coordination be most useful as an R-Side capability?

1c-3: Not appropriate For R side in present form; too time intensive.

2a-2: Not useful as R tactical (unless there is lots of time)

2c-4: Maybe R could use with default to 1st upstream sector

2d-3: Busiest times

3a-2: Not useful for tactical time frame

3b-1: All

5. Were the procedures you used regarding Automated Coordination appropriate?

Yes	No
1c-3	
1d-4	
2a-2	
2c-4	
2d-3	
3e-4	

If No, Explain

2a-2: For receiving from D and implementing

3b-1: Didn't have a clear procedure for R side

3e-4: Except countdown sometimes ended before response returned – concerned about need to take additional action, can't tell whether R side is working it

- Need a procedure about what R should do if it times out before clearance given

- Needed phone to follow up on timeouts

6. Would the use of the Automated Coordination between the D-side and R-Side change the way the both the D and R-controllers might interact?

Yes	No
1c-3	
2a-2	
2c-4	
2d-3	
3a-2	
3e-4	

1c-3: Less verbal

2a-2: Productivity lower unless collocated

2c-4: Reduce verbal coordination, especially if not collocated

2d-3: See note above

3a-2: Less verbal comm.

3e-4: Defines how they interact (no verbal)

7. Rate the likely workload impact of including the Automated Coordination D-side to D-Side.

Greatly Increase		No Change		Greatly Decrease
		2d-3		

2d-3: Balance out

1c-3: Not clear of impact based on 1 exercise

8. Rate the likely workload impact of including the Automated Coordination D-side to R-Side.

Greatly Increase		No Change		Greatly Decrease
		2a-2: about same as verbal 3a-2: but like 'non-interruptive nature 3b-1	2c-4	3e-4

2c-4: Hard to tell based on 1 run

9. Would you recommend including Automated Coordination as a midterm capability?

Yes	No
1c-3: D-D min. 2a-2 2c-4 2d-3 3a-2 3b-1 3e-4	

Other comments about Automated Coordination:

1a-1: Aircraft should have 'clickable' field to see it now! [show trial plan to R side graphically]; Possibly need way to do 'back to route' clearance as R aid – list of 'upcoming clearances', time ordered & 'alert' for R action

1c-3: Need method to "notify" incoming A/C requests

1d-4: (see previous comment about back coordinating)

- Auto Coordination with "all other" unrealistically quick and easy for graphic reroute
- Indicator on aircraft list was most visible one

Verbal coordination with R side:

- Did coordination verbally: red conflicts with no resolution and short time => pointed out to R side on R-side display (because R & D displays don't always correlate)
- Verbal coordination: other sector to back-coordination after handoff and before physical control
- Unrealistic verbal coordination of graphic TP reroute with R-side
- Many requests from R about whether proposed change was green (pilot requests and conflict resolutions), even though R side did "send AM"

2a-2: If above condition resolved!

- Could use (or test) a count down timer for R side to give indication of how urgent R needs to respond

2d-3: Controller procedures are critical, need individual negotiation on how R side wants to work

- Comment on split in conflict responsibility – critical to resolve problems strategically

3a-2: Auto coordination needs count down indicator on R side

3b-1: Need good CHI

- Not necessarily quicker, but less susceptible to misunderstandings than verbal coordination and is less “workload”
- Sector team does *not* act as separate individuals, so shift of workload from one to the other is not a net savings
- Separate position doesn’t know sector plan for managing traffic – could end up getting in each other’s way
- Needs to handle “back coordinating” when have track control but don’t have physical control

3e-4: Automatically selected sector may not always be best

General Questions:

1. Was the scenario realism (i.e., traffic, events, etc.) adequate for the purpose of the exercise?

Yes	No
1b-2	1d-4
1c-3	
2a-2	
2b-1	
2c-4	
2d-3	
3a-2	
3b-1	
3e-4	

1a-1: ?

2b-1: But irritating stuff like 2 flights in handoff already in conflict; MEM arrivals @ FL240 didn't add anything to scenario

2d-3: Except a few wrong altitude for direction

3b-1: More realistic for 2005 if more directs

3e-4: A bit light on conflicts

If No, Explain

1d-4: Auto flying vectors/graphic TPs – would need more simpilots [to do it any other way]; simpilot entered heading change, but flight didn't fly it – had to re-resolve conflict

2. Was the level of fidelity (e.g., display, command entry, response time, etc.) adequate for the purpose of the exercise?

Yes	No
1a-1	
1b-2	
1c-3	
1d-4	
2a-2	
2b-1	
2c-4	
2d-3	
3a-2	
3b-1	
3e-4	

1d-4: Auto coordination response too quick from "all other" – no suspense

2c-4: Except for auto replan for TPs to 75

3a-2: Except for pilot requests do not match aircraft navigation capability [direct requested by '/A' equipped flight]

3e-4: Multi-sector planner needs integrated displays and list, as well as phone to R positions

3. Was the training you received adequate to allow you to participate in the exercise?

Yes	No
1a-1	
1b-2	
1c-3	
1d-4	
2a-2	
2b-1	
2c-4	
2d-3	
3b-1	
3e-4	

If No, Explain

1b-2: R side asking D to TP pilot requests

1d-4: But need some improvement in training scenario to exercise all capabilities

2d-3: Needed more practice with multiple conflicts (use of “show all”)

3b-1: Needs procedural guidelines as to what to do when simple fix would let user have request

- OK to offset from route?

- OK to clear part of way to new altitude?

3e-4: This session’s training needed more conflicts to practice with

Glossary

AOC	Aeronautical Operational Control
ATC	Air Traffic Control
ATM	Air Traffic Management
ATS	FAA Air Traffic Services
CAASD	Center for Advanced Aviation System Development
CNS	Communications, Navigation, and Surveillance
D	Radar Associate (Flight Data) Controller
DSR	Display System Replacement
FAA	Federal Aviation Administration
FFP1	Free Flight Phase 1
FMS	Flight Management System
FY	Fiscal Year
GPD	Graphic Plan Display
HDM	Host Data Multiplexor
HITL	Human-in-the-Loop
HOST	ATC Host Computer
IAC	Instantaneous Aircraft Count
NAS	National Airspace System
R	Radar Controller
SSP	Strategic Service Provider
SUA	Special Use Airspace
TFM	Traffic Flow Management
TMC	Traffic Management Coordinator
TMU	Traffic Management Unit
TSP	Tactical Service Provider
TSPO	Tactical Service Provider “all-other”
URET	User Request Evaluation Tool

List of Terms

Automated Coordination	A capability that supports non-voice (electronic) coordination among service providers within a Center as well as across Center boundaries
Automated Replan of Trial Plans	A capability that periodically evaluates trial plans for predicted problems, notifying the appropriate service provider when a trial plan has become problem-free.
Complex Traffic Airspace	Airspace expected to increase predicted sector workload due to factors such as aircraft counts, aircraft interaction, aircraft maneuverability, airspace availability, and aircraft profile mix. A complex traffic airspace is defined by lateral, vertical, and time limits (e.g., between 1200Z and 1300Z).
Current Plan	The flight plan that the controller has specified as the plan the aircraft is currently expected to fly.
Flight Plan	The original filed flight plan for a flight, with all later flight plan changes incorporated.
Hazardous Weather	Conditions, based on aircraft type, that present a potential danger to a flight and the occupants of an aircraft.
Midterm	The nominal time period, centering around the year 2005, when new operational concepts and capabilities are planned for the en route environment
Plan	Information about a flight as well as pilot and controller intentions regarding that flight.
Problem	A predicted loss of separation between an aircraft and the following: other aircraft, Special Use Airspace (SUA), complex traffic airspace, terrain and obstructions, hazardous weather, or compliance with a traffic planning constraint.
Sector Configuration	The specific definition of the sectors and their airspace boundaries for a Center.
Service Provider	FAA personnel in the centers performing en route control, traffic planning, and workload management tasks.

Service Provider Configuration	A combination of tactical and strategic service providers.
Strategic Service Provider	The en route service provider responsible for resolving problems and responding to electronic requests in the strategic time interval. This service provider is also responsible for implementing traffic planning constraints.
Tactical Service Provider	The en route service provider responsible for ensuring aircraft separation and responding to pilot requests in the tactical time interval. This service provider may also be responsible for implementing traffic planning constraints.
Traffic Management Coordinator	The en route service provider performing Traffic Flow Management (TFM) tasks and collaborating with Aeronautical Operational Controls (AOCs).
Trial Plan	Any proposed plan created by a service provider or action by the automation.

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