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Accounting and Information
Management Division

B-278055

February 23, 1998

The Honorable James L. Oberstar
Ranking Minority Member
Committee on Transportation
and Infrastructure
House of Representatives

Subject: Air Traffic Control: FAA Has Not Fully Assessed Its User Request Evaluation Tool

Dear Mr. Oberstar:

We briefed your office on October 17, 1997, on our review of the Federal Aviation Administration's (FAA) efforts to assess its User Request Evaluation Tool (URET), a prototype for detecting potential conflicts between aircraft paths. Enclosed is a copy of the materials presented during that briefing, amended to provide additional information requested by your office. Our review objective was to assess the adequacy of FAA's actions to evaluate URET.

To address this objective, we analyzed URET assessments by FAA and MITRE Corporation, the developer of the URET prototype. These assessments included evaluations of air traffic controllers' experiences using URET and quantitative analyses of URET performance–assessments of conflict likelihood, conflict warning time, and trajectory accuracy and stability.[1] We also analyzed documentation supporting URET's false and missed alert rates.[2] In addition, we interviewed staff from FAA and MITRE. We did not independently verify the performance data provided by FAA or MITRE. We conducted our work from

[1]Conflict likelihood is the probability that a URET alert corresponds to a "true" conflict. Conflict warning time is the time interval between a URET alert and a potential conflict. Trajectory accuracy and stability assessments measure the quality of URET's projected aircraft trajectories.

[2]False alerts, also called false alarms, are URET-issued alerts that do not correspond to a potential conflict. Missed alerts are potential conflicts that URET fails to detect.

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August 1997 through January 1998, in accordance with generally accepted government auditing standards.

OVERVIEW OF FAA's DEVELOPMENT OF A CONFLICT PROBE CAPABILITY FOR ITS EN ROUTE ENVIRONMENT

Air traffic controllers in FAA's 20 en route centers control aircraft over the continental United States in transit and during approaches to some airports. There are two key types of controllers--radar controllers and data controllers. The radar controllers are responsible for tactical aircraft control; data controllers assist radar controllers by providing strategic aircraft monitoring. The radar controllers currently receive warnings--or conflict alerts--from the Host Computer System that aircraft trajectories may intersect. These warnings come about 2 minutes in advance of a projected intersection.

In the mid-1970s, FAA determined that a conflict probe capability that would allow its controllers to look further ahead could provide more efficient aircraft routing. After a false start associated with the now-restructured Advanced Automation System, MITRE embarked on the development of a prototype called URET--a decision-support tool for the data controllers in the en route sector. URET is designed to not only identify potential conflicts with more advance warning time than current systems provide, but also to aid controllers in resolving these potential conflicts. URET does this by obtaining aircraft flight plans and radar data on actual aircraft paths from the Host computer system and obtaining upper air wind data from the National Weather Service. It then plots aircraft trajectories, identifies potential conflicts, and alerts air traffic controllers of these potential conflicts. URET also allows controllers to "try out" potential solutions to see if other conflicts would result.

In January 1996, FAA first deployed URET at its Indianapolis en route center, to gain operational experience with its new capabilities, determine operational and technical requirements for a full-scale production system, and demonstrate potential benefits. In the ensuing months, Indianapolis air traffic controllers evaluated the system and provided feedback for refining it to better meet their needs. MITRE has continued to refine URET; its most recent enhancement--interfacility automation--was installed at the Indianapolis and Memphis en route centers in October 1997. Interfacility automation allows URET conflict prediction and resolution to cross en route center boundaries. That is, controllers in one center can identify potential conflicts in an adjacent center and resolve them before handing off the planes to that center.

Because of its experience with URET, in April 1997 senior FAA managers decided to acquire a deployable tool for detecting and resolving potential

conflicts, called the Initial Conflict Probe (ICP). This tool is to be based on the URET prototype and FAA plans to deploy ICP to all 20 en route centers. FAA plans to award the ICP contract in March 1998, with first-site delivery scheduled for mid-2000.

FAA AND MITRE HAVE NOT FULLY ASSESSED URET PERFORMANCE

While no clear industry or government standards exist for evaluating prototypes, experts in conflict probe technology agree that a comprehensive evaluation of a conflict probe capability should include both qualitative and quantitative analyses. Qualitative analyses should entail assessments of the system's utility and benefits based on users' views. Quantitative analyses, on the other hand, should entail analytical assessments of the tool's performance, including conflict likelihood, conflict warning time, trajectory accuracy and stability, and other performance measures–such as missed alerts.

Qualitative analyses have been conducted over the almost 2 years that URET has been installed at Indianapolis. MITRE conducted monthly evaluations of controllers' views, requesting feedback on URET's suitability at Indianapolis. From this qualitative analysis, MITRE reported that controllers stated that URET is suitable for supporting strategic problem detection and resolution planning, has operationally accurate trajectory models and problem-detection capabilities, and has operationally suitable data display, availability, and manipulation capabilities. These results were independently validated by Crown Communications, Inc.

Fewer data are available on a quantitative level. MITRE's quantitative studies were limited to a sample of data from only two centers and were not independently validated. MITRE's analyses showed that URET's conflict warning time was most often 15 minutes in advance of conflicts. MITRE also identified deviations between URET-predicted trajectories and actual paths flown, and significant reasons for these deviations. Using MITRE's trajectory accuracy data, FAA calculated URET's false and missed alert rates and confirmed an inverse relationship between the two that is adjustable. That is, URET can be adjusted to issue a low rate of missed alerts, but will at the same time issue a higher rate of false alerts (low false negatives but higher false positives).

In October 1997, FAA's William J. Hughes Technical Center began independently validating URET performance using a simulator. This effort, however, had not been completed by the time we completed our audit work in January 1998.

FAA's Technical Center also evaluated URET algorithms and concluded that the assumptions and approximations used in URET were reasonable for prototype software. They also recommended that these assumptions and approximations be independently verified and validated. This was not done due to other work priorities.

FAA's and MITRE's quantitative assessments of URET are limited in two ways–they are based on traffic data in only two centers and they were not independently validated. Without validated performance results based on a variety of test scenarios, FAA risks misrepresenting URET's performance capabilities. For example, FAA could overstate URET's accuracy in projecting aircraft trajectories. Because the Initial Conflict Probe will be based on URET's performance, this makes it difficult for FAA to clearly define performance requirements as it drafts the Initial Conflict Probe's specification.

DELAYS IN FAA PLANS FOR BETTER QUANTIFYING URET PERFORMANCE MAY INCREASE ICP RISK

FAA's en route product team, responsible for developing and implementing ICP, acknowledges that the limited amount of information on URET performance constitutes a technical risk to developing ICP. According to an FAA official, little time remains for further assessing URET accuracy or comprehensively simulating its performance before the planned March 1998 ICP contract award. This official also stated that any delay in awarding the ICP contract would likely cause FAA to miss its planned mid-2000 ICP implementation date–a high priority for the en route product team because ICP is the first application planned for its Display System Replacement.

To mitigate the risk of developing ICP with limited URET performance information, FAA is drafting ICP performance requirements based on existing URET performance data, with the understanding that these requirements may be modified in the future. Also, FAA has drafted a conflict probe requirements verification plan, which officials expect to finalize in late February 1998. This plan calls for more detailed analysis of URET performance through independent simulations at FAA's Integration and Interoperability Facility by the end of May 1998. Depending on the results of this evaluation, FAA may modify the performance requirements within the scope of the ICP contract.

Awarding the ICP contract before independently validating URET performance and developing firm requirements for ICP is unwise. We have previously reported that emphasizing concern for schedule at the expense of disciplined systems development and careful, thorough testing has proven to be imprudent

and unproductive in many software development efforts.[3] The results are typically systems that cost more than expected, are of low quality, and are late as well.

In Air Traffic Control: Immature Software Acquisition Processes Increase FAA System Acquisition Risks (GAO/AIMD-97-47, March 21, 1997), we made recommendations to address weaknesses in FAA's software acquisition processes that have contributed to FAA's past failures to deliver promised system capabilities on time and within budget. Specifically, we recommended that FAA institutionalize mature software acquisition processes. Such processes include (1) ensuring that reasonable planning for a software acquisition is conducted, and that all elements of the project are included, (2) establishing a common and unambiguous definition of software acquisition requirements understood by the acquisition team, system user, and the contractor, and (3) identifying risks as early as possible, and adjusting the acquisition strategy to mitigate those risks. FAA concurred with our recommendation and has since initiated efforts to improve its software acquisition processes. These efforts, however, have not yet been finalized or implemented throughout FAA. Without strong software acquisition processes in place on its ICP procurement, FAA risks making the same mistakes it did on its past failed system acquisition efforts.

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On February 5, 1998, we obtained oral agency comments on a draft of this letter from officials at the Department of Transportation and FAA. These officials generally agreed with the facts presented. At that meeting, FAA officials responsible for URET evaluations released preliminary results of the Technical Center's independent analysis of URET performance. This effort, however, is still preliminary. Specifically, the results are based on one simulation run and did not include an evaluation conflict warning time. Officials hope to complete 10 additional simulations and an analysis of conflict warning time by mid-March. The en route product team representatives also received these results for the first time and had not yet had time to review them to determine their effect on the ICP specification. One en route product team representative commented that FAA may delay the ICP contract award date to later in spring

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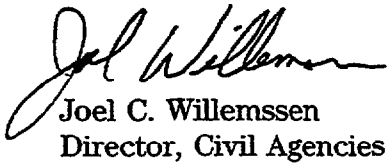
[3]High-Risk Series: An Overview (GAO/HR-95-1, Feb. 1995); High-Risk Series: Information Management and Technology (GAO/HR-97-9, Feb. 1997); DOT's Budget: Safety, Management, and Other Issues Facing the Department in Fiscal Year 1998 and Beyond (GAO/T-RCED/AIMD-97-86); and Federal Management: Addressing Management Issues at the Department of Transportation (GAO/T-RCED/AIMD-97-172, May 21, 1997).

1998 (although this decision is not yet final), allowing more time for the results of the independent studies to be incorporated in the specification.

FAA officials also commented specifically on particular language in the draft letter. These comments have been incorporated into the letter where appropriate.

We are sending copies of this letter to the Chairman of the House Committee on Transportation and Infrastructure; the Chairman and Ranking Minority Member of the Subcommittee on Aviation, House Committee on Transportation and Infrastructure; the Chairman and Ranking Minority Member of the Senate Committee on Commerce, Science, and Transportation; the Chairman and Ranking Minority Member of the Subcommittee on Aviation, Senate Committee on Commerce, Science, and Transportation; the Secretary of Transportation; the Administrator of the Federal Aviation Administration; the Department of Transportation Inspector General; the Director of the Office of Management and Budget; and other interested parties. Copies will also be made available to others upon request. If you have any questions on the material in this letter, please contact me at (202) 512-6253, or Colleen Phillips, Assistant Director, at (202) 512-6326. We can also be reached by e-mail at *willemssenj.aimd@gao.gov* and *phillipsc.aimd@gao.gov*, respectively.

Sincerely yours,



Joel C. Willemssen
Director, Civil Agencies Information Systems

Enclosure

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FAA's User Request Evaluation Tool (URET) Demonstration Activities

Briefing to the Ranking Democratic Member, House Committee on Transportation and Infrastructure

October 17, 1997

As amended, January 1998

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Objective

Assess the adequacy of FAA's actions to evaluate its User Request Evaluation Tool (URET)

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Background

FAA is acquiring a conflict probe capability for its en route environment

- FAA is enhancing and evaluating URET, a prototype conflict probe
- FAA plans to begin full-scale development of its Initial Conflict Probe (ICP) system, based on URET capabilities, in early 1998

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Background (cont'd.)

User Request Evaluation Tool (URET)

- Prototype decision support tool for en route sector controllers
- To identify potential conflicts and aid controllers in resolving them
- Developed and evaluated by MITRE
- Undergoing enhancements
  - Interfacility automation
  - 2-way Host interface

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Background (cont'd.)

Initial Conflict Probe (ICP)

- Based on URET prototype
- A decision support tool for en route sector controllers
- To identify potential conflicts and aid controllers in resolving them
- To be developed by Lockheed Martin as part of Display System Replacement (DSR) contract

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Chronology of Events

• 1974-1995	MITRE developed a conflict probe capability, now called URET
• January 1996	FAA deployed URET at Indianapolis for evaluation
• February 1997	FAA selected URET as the basis for ICP development
• April 1997	FAA approved continued URET enhancements and initiated ICP investment analysis

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Chronology of Events (cont'd.)

• October 1997	URET interfacility automation introduced and evaluated

Planned

• Early 1998	ICP full-scale development approval
• March 1998	ICP contract award
• Mid-2000	ICP first site delivery

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Prototyping: Why do it? How do you measure it?

- Prototyping can be an effective method of reducing systems acquisition/development risks
- Prototyping improves the requirements analysis and definition process by soliciting user input
- Evaluation criteria vary, depending on intended use; no clear industry or government standards

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Why did FAA choose to prototype?

URET installed at Indianapolis to

- gain operational experience with new capabilities
- gain insight into URET's suitability and acceptability for use in strategic flight planning and flight monitoring
- determine operational and technical requirements needed for full-scale development of a production system (such as ICP)
- demonstrate potential benefits

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Prerequisites for a Comprehensive Conflict Probe Evaluation

A comprehensive evaluation of conflict probe capabilities should include both qualitative and quantitative analyses

- Qualitative Analysis
  Assessments of system's utility and benefits, based on users' views

- Quantitative Analysis
  Analytical assessments of performance
  - conflict prediction accuracy--missed and false alerts
  - conflict warning time
  - trajectory accuracy

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MITRE and FAA Performed Both Qualitative and Quantitative Analyses

MITRE performed

- operational evaluations
- conflict likelihood analysis (false alerts)
- conflict warning time analysis
- trajectory accuracy and stability analysis

Using MITRE data, FAA calculated

- missed and false alert rates

FAA Technical Center performed

- independent algorithm assessment

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MITRE Assessment Results: Operational Evaluations

According to controllers' opinions, URET

- is suitable for supporting strategic problem detection and resolution planning
- has operationally accurate trajectory models and problem detection capabilities
- has operationally suitable data display, availability, and manipulation capabilities

Independent assessment by Crown Communications yielded similar results

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MITRE Assessment Results: Conflict Likelihood

URET Statistical Model of Conflict Probe Performance Horizontal Likelihood for Conflicts with Predicted Loss of Separation Ideal and Typical Operations			
Miss Criteria	Ideal - Calm Winds	Ideal - Turbulent	Typical
9 nautical mile	0.997	0.96	0.78
7 nautical mile	0.990	0.88	0.68
5 nautical mile	0.900	0.72	0.53

- Shows a wide variance in the likelihood that a URET alert corresponds to a potential conflict
- Means that under typical conditions, URET alerts may result in unnecessary controller actions

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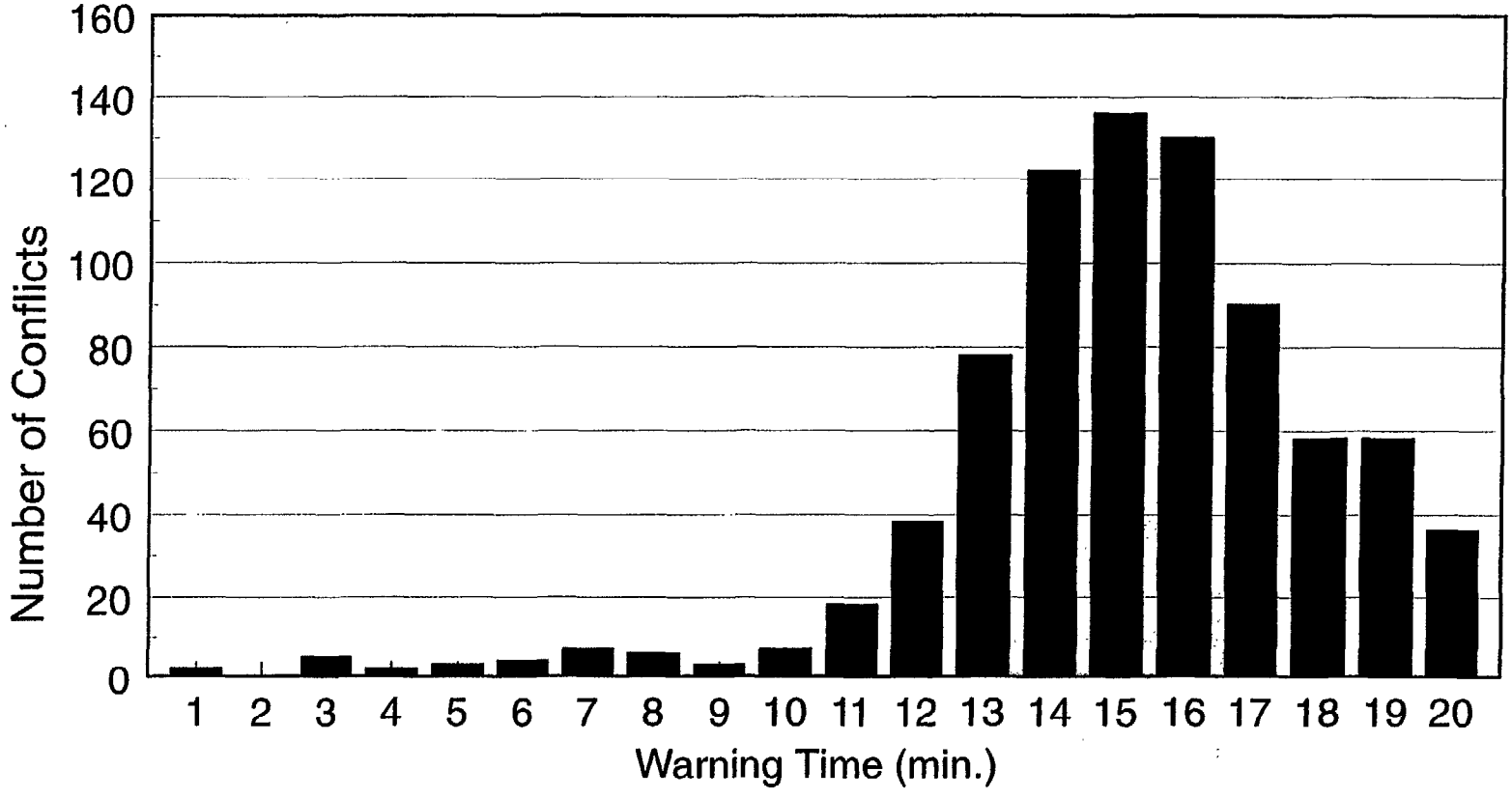
MITRE Assessment Results: Conflict Warning Time



- URET's conflict warning time was most often 15 minutes

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MITRE Assessment Results: Trajectory Accuracy and Stability

- Deviations between predicted trajectories and actual paths flown were determined
- Most significant sources of errors were uncertainties and constraints in the ATC environment
  - unpredicted controller actions
  - wind and temperature errors
- Trajectories require reestimation about once every 5 minutes

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FAA Analyses: Missed and False Alert Rates

	Minimum Separation Distance (nmi)	Upper Limits of Rates
False-Alarm		
	5.01	0.94
	10	0.50
	15	0.062
	20 or more	0.001
Missed - Alert Rates		
	0	0.001
	5	0.06

- Shows an adjustable, inverse relationship between false and missed alerts
- Means that even with a small probability of a conflict, URET will identify a potential conflict

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FAA Assessment Results: Algorithm Analysis

- URET assumptions and approximations reasonable for prototype software
- Recommended independent verification and validation of URET software based on simulations and live data tests
  - None planned

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Quantitative Performance Evaluations Were Limited

MITRE performance results were based on a sample of data from two locations; may not be generalizable to other locations

Results were not independently assessed

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FAA Initiating Efforts to Independently Evaluate URET Performance

- FAA's Technical Center is simulating URET performance based on 4 hours of flight data from Indianapolis
  - will independently estimate URET missed and false alert rates and conflict warning times
  - concern exists that time frames do not allow thorough analysis

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FAA Acknowledges Limitations in URET Evaluations

- ICP product team acknowledges that the lack of information on URET performance is a major acquisition risk
  - Time constraints limit options for further assessing URET accuracy
    - Full simulations not possible by March ICP contract award date
    - Mathematical analysis provides no basis for determining a good alert rate

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FAA Plans to Further Assess URET Performance

- FAA is drafting the ICP specification based on URET performance, and plans to finalize the ICP contract in March 1998
- FAA plans to further validate URET performance capabilities through simulations that will last through May 1998
- FAA may modify the ICP contract based on simulation results

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Summary

- MITRE has evaluated controllers' opinions of URET and has performed quantitative assessments
- MITRE's quantitative analyses have not been independently verified
- FAA has not fully assessed URET's performance to date
- FAA plans to further assess URET's performance through simulations and to modify the ICP contract accordingly

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