A Benefits Assessment of the User Request Evaluation Tool (URET)

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ABSTRACT

In 1998 the Federal Aviation Administration (FAA) established the Free Flight Phase 1 program to provide new decision-support systems to a limited number of facilities in a relatively short time (by the end of 2002), with the goal to providing increased user benefits and maintaining current levels of safety. The FAA selected systems that were anticipated to meet those goals and had demonstrated support within the Air Traffic community.

The User Request Evaluation Tool (URET) is one of the systems selected for inclusion in the program. URET was an operational prototype that had been deployed at two of the twenty Air Route Traffic Control Centers within the continental United States, Indianapolis and Memphis, in the 1996-97 timeframe. It is a decision-support tool used by the sector team in an Air Route Traffic Control Center. It is implemented at the Radar Associate Position to support the strategic operations of the team in an integrated fashion.

With URET, controllers can provide better service by detecting and resolving problems earlier, maneuvering aircraft less off their filed route, and reducing some airspace constraints (such as static altitude restrictions). URET provides an automated conflict probe and trial-planning capability that informs the controller of projected conflicts and assists the controller in evaluating resolutions to determine if they are conflict free before the issuance of a new clearance and amendment. URET also provides flight data management capabilities that reduce controller dependence on paper flight strips.

This paper describes the benefits to users of the National Airspace System attributable to URET. The metrics and measurements described are based on the experience with URET at the Indianapolis and Memphis en route centers. From early May 1999 until the deployment of the production system in January 2002, data was collected on a daily basis in order to assess the operational impact of the system. Analysis of the metrics has demonstrated that savings to airlines and general aviation (GA) attributable to URET derive most directly from savings in nautical miles flown from the issuance of lateral amendments by controllers and reduction in fuel burn from the lifting of static altitude restrictions. The savings in distance flown measured approximately 7,000 nautical miles daily for the two Centers. Reduction in fuel burn from the lifting of static altitude restrictions totaled approximately 950,000 gallons annually. The demonstrated benefits

of URET resulted in the recent decision by the FAA to deploy URET at all twenty Air Route Traffic Control Centers within the continental United States.

Introduction

In 1998 the Federal Aviation Administration (FAA) established the Free Flight Phase 1 program to provide new decision-support systems to a limited number of facilities in a relatively short time (by the end of 2002), with the goal to providing increased user benefits and maintaining current levels of safety. The FAA selected systems that were anticipated to meet those goals and had demonstrated support within the Air Traffic community (see Reference 1). The follow-on program for further development and deployment of decision-support capabilities to additional sites in the 2003-2005 timeframe, is known as Free Flight Phase 2 (FFP2).

The User Request Evaluation Tool (URET) is one of the systems selected for inclusion in the Free Flight program. The MITRE Corporation's Center for Advanced Aviation System Development (CAASD) in conjunction with the FAA developed URET as an operational prototype, and deployed the system at two of the twenty Air Route Traffic Control Centers (ARTCC) within the continental United States, Indianapolis and Memphis, in the 1996-97 timeframe. Under the FFP1 program initiative, URET was implemented as a production system and deployed to seven en route centers. It will be deployed to the other thirteen centers within the continental United States under the FFP2 program (see Figure 1).

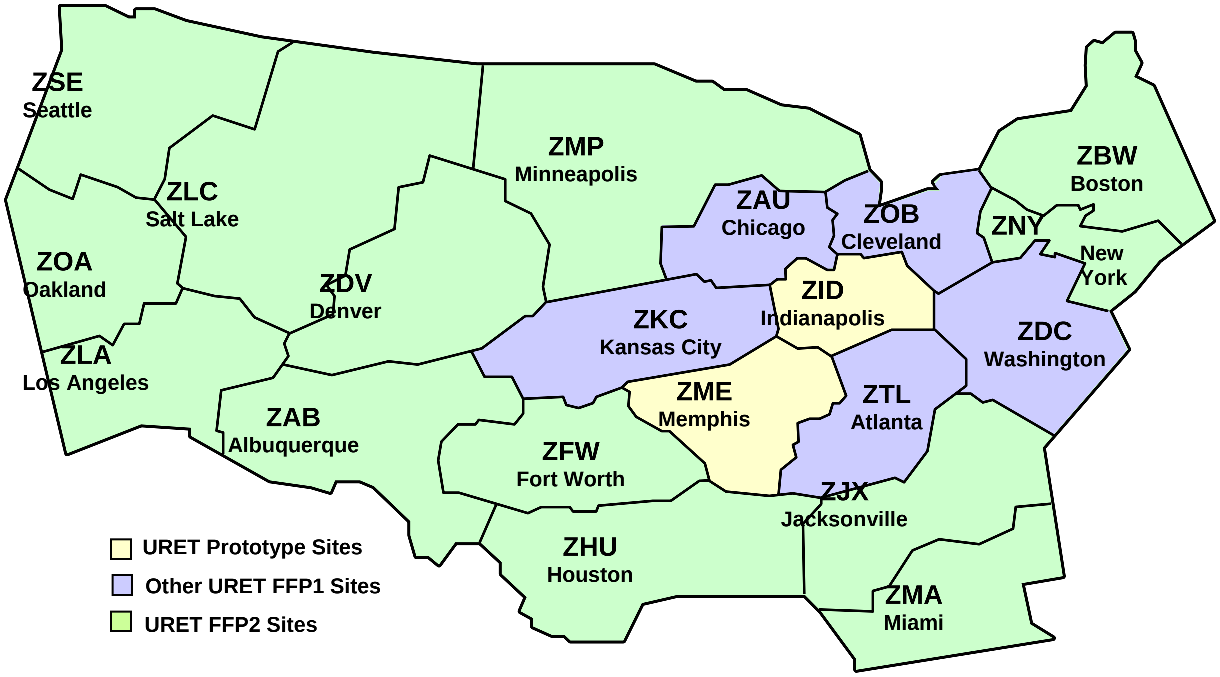

Figure 1. URET Prototype, FFP1 and FFP2 sites

URET is a decision-support tool used by the sector team in an ARTCC. It is implemented at the Radar Associate Position to support the strategic operations of the team in an integrated fashion. The tool provides an automated conflict probe and trial planning capability that informs the controller of projected conflicts and, upon controller request evaluates resolutions to determine if they are conflict free before the controller issues a new clearance and amendment. URET also reduces controller dependence on paper flight strips, replacing them in most instances with electronic flight data. For more details about URET capabilities, benefits, and operational concept, refer to Reference 2.

This paper describes the benefits to users of the National Airspace System attributable to URET. The metrics and measurements described are based on the experience with URET at the Indianapolis and Memphis en route centers. From early May 1999 until the deployment of the production system in January 2002, data was collected on a daily basis in order to assess the operational effectiveness of the system.

URET System Description

URET Functionality

URET assists air traffic controllers with the detection and resolution of aircraft-to-aircraft and aircraft-to-airspace separation problems. The key URET capabilities include:

- Trajectory modeling

- Aircraft and airspace conflict detection
- Trial planning to support conflict resolution of user or controller requests
- Electronic flight data management

URET processes real-time flight plan and track data from the ARTCC's Host Computer System (or Host). These data are combined with site adaptation, aircraft performance characteristics, and winds and temperatures in order to build four-dimensional flight profiles, or trajectories, for all flights within and inbound to the center. For each flight, incoming track data are continually monitored and compared to the trajectory in order to keep it within acceptable tolerances. In the event that the observed position or altitude is not within these tolerances, URET invokes a "reconformance" function that remodels the trajectory and adapts it to the observed speed and/or altitude transition rate. URET systems in neighboring facilities exchange flight data and trajectories for all incoming flights across facility boundaries a parameter time in the future (usually set to 20 minutes).

URET maintains "current plan" trajectories (i.e., those that represent the current set of flight plans in the system) and uses them to continuously check for aircraft and airspace conflicts. URET provides three classes of alerts; "red,“ yellow," and "blue," where "red" indicates a predicted aircraft encounter distance of 5 miles or less, "yellow" indicates an aircraft encounter within specified system parameters (usually 10-12 miles), and "blue" indicates a predicted airspace encounter. When a conflict is detected, URET notifies the appropriate sector controller up to 20 minutes prior to the start of that conflict. The more likely it is that the predicted conflict will occur, the closer to 20 minutes the controller is notified. However, notification of a predicted conflict is never delayed longer than 10 minutes before the predicted conflict start time. Trial planning allows a controller to check a desired flight plan amendment for potential conflicts before a clearance is issued. The controller can then send the flight plan amendment message to the Host knowing the conflict status of the trial plan.

URET is the sector team's main source of flight data. The Aircraft List is the primary textual display, listing the flights currently controlled by the sector and those flights that will be controlled by the sector in the next 20 minutes. The Aircraft List provides controllers with many options. Controllers can sort the Aircraft List entries by various criteria; they can record speed and heading; they have the capability to enter clearances as reminders; they can add free-text to any entry; they can control the scrolling of the list, etc.

Analysis of URET's impact on operational performance is based on the 4-year experience with the URET prototype at Indianapolis and Memphis centers. Initial operations, in 1996 at Indianapolis, had a one-way Host connection to URET. Inter-facility communications between the two centers began in 1997. When the two-way Host connection was implemented in 1999, usage increased to the point that it was used all the available time at both centers. (See Figure 2, which shows the amount of URET scheduled availability and the utilization of URET as a percentage of availability over the period 1998 – 2001.) The prototype was replaced at both centers by the FFP1 implementation of URET at the end of January 2002.

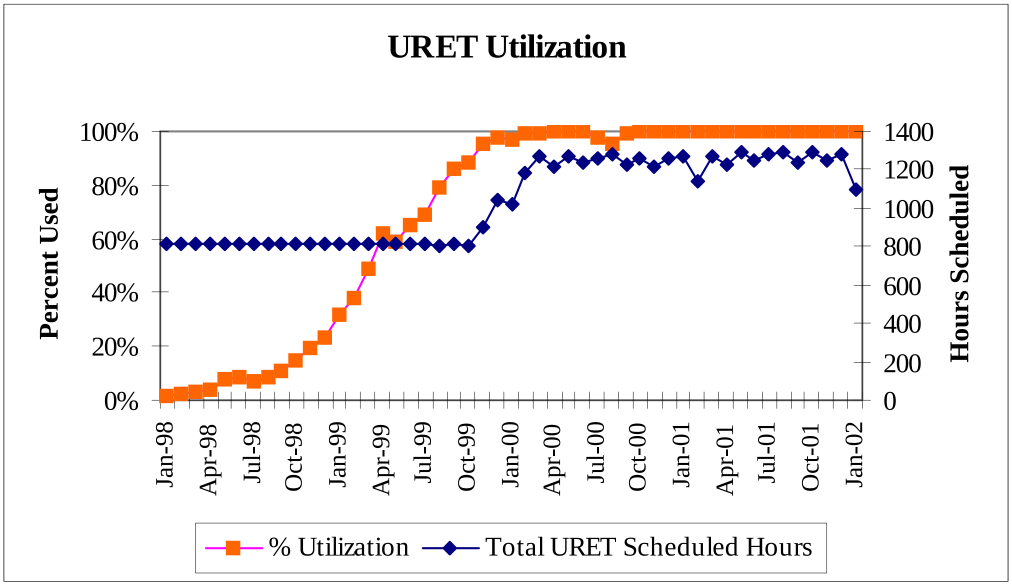

Figure 2. URET Utilization: ZID and ZME

URET Benefits

Benefit Areas

URET savings derive most directly from savings in nautical miles flown from issuance of lateral amendments by controllers and reduction in fuel burn from the lifting of static altitude restrictions. Lateral amendments consist of route changes with no altitude changes. They include amendments that increase flying distance; e.g., when aircraft are vectored off course to avoid traffic conflicts or severe weather conditions, as well as those that decrease total distance. Controllers issue lateral amendments for various reasons:

- To resolve a conflict or avoid a convective weather area
- To respond to a user request
- To modify an aircraft's flight path in order to send the aircraft on a more direct route to destination
- To modify an aircraft's flight path to intercept a Host-based specified route (e.g., Preferential Arrival Route).

Savings from lateral amendments derive from various aspects of URET. URET provides controllers with increased situational awareness, through the 20-minute look-ahead of incoming traffic and potential conflicts. Controllers can resolve these conflicts earlier, resulting in less aggregate maneuvering overall. URET increases controller efficiency, derived from:

- Reduction in voice coordination with downstream controllers;
- Trial planning, which helps controllers determine if a route modification will cause problems downstream, supporting both conflict resolution and pilot requests for new clearances; and
- Electronic display of flight data, which reduces the manual, repetitive, time-consuming task of strip manipulation.

Static altitude restrictions are instituted at en route centers to help controllers manage incoming traffic in a predictable manner and to minimize voice coordination with the upstream controller. Controllers separate incoming aircraft from surrounding airspace to better manage the traffic flows. The static altitude restrictions are both between sectors, Standard Operating Procedures, and between centers, Letters of Agreement. They specify that aircraft arriving at or departing from a specified airport shall cross between sectors or centers at or below the specified altitude, e.g., Indianapolis arrivals shall cross from sector 87 to 88 at FL310 or below (see Figure 3). Static altitude restrictions generally constrain aircraft to lower than their most fuel-efficient altitudes. With URET, controllers rely on the advance information provided by the system to separate incoming aircraft from each other, rather than separating the aircraft from airspace reserved for a separate traffic flow. Operational personnel are, therefore, willing to review altitude restrictions to determine if they can be safely removed or modified, thereby allowing aircraft to stay at their preferred altitude longer and resulting in reduced fuel burn.

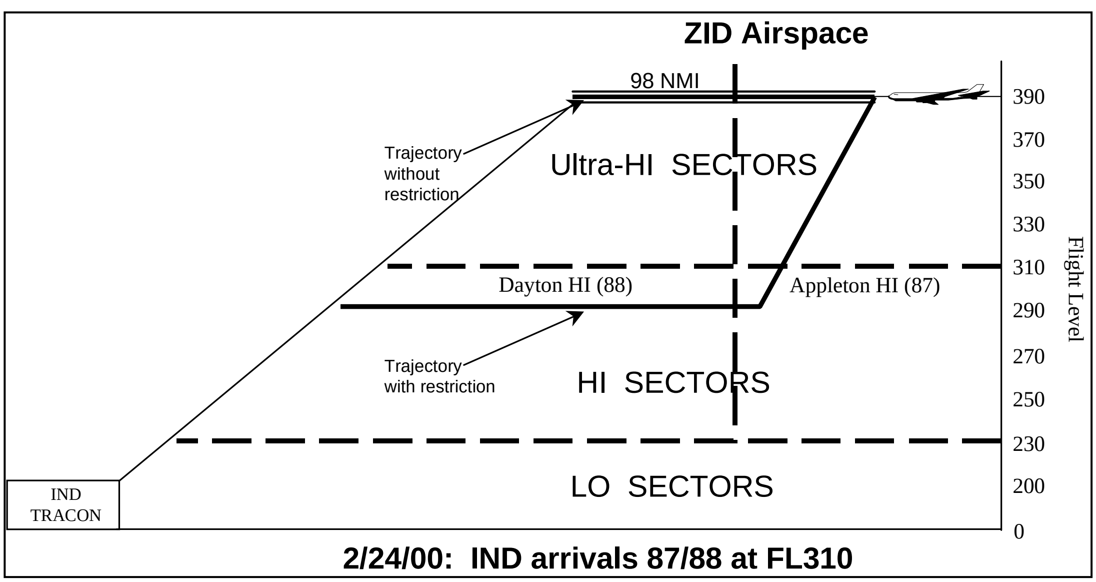

Figure 3. Removal of Static Altitude Restriction

Process to Achieve Benefits

During the development and use of the prototype, operational personnel at Indianapolis and Memphis, working with FAA Headquarters and the National Air Traffic Conflict Probe (ATCP) Team representatives, developed a process to effectively use

URET to provide benefits to users of the National Airspace System and to operational personnel. This process includes:

- Modification to procedures, particularly in the area of the reduction in the requirements for the use of paper flight strips
- Determination of recommended techniques or “good practices” in the use of URET, for operational personnel to become effective users of URET as rapidly as possible
- Training in the functional capabilities and operational usage of URET, as well as training in how to use URET strategically to provide benefits to NAS users
- Establishment of Procedures and Benefits Teams to review and evaluate restrictions, with the goal of lifting or modifying restrictions for user benefits
- Working with the airlines to formally involve them in the decision-making process of restriction evaluation.

Data Sources for Measuring URET Benefits

Two primary sources of data were used to measure the benefits from issuance of lateral amendments and removal of altitude restrictions: Host Interface Device (HID) files and Enhanced Traffic Management System (ETMS) files, both of which contain flight and track data. URET receives flight plans from the HID for aircraft departing within the center approximately thirty minutes before planned departure time. The HID also provides URET with amendments and flight plans transmitted from upstream centers when they are received by the Host. Track data are collected at 12-second intervals in the HID files and at 1-minute intervals in the ETMS files. HID data is used by URET to provide current information to the sector team. ETMS data is nationwide and is used by URET in the analysis of user benefits. The URET prototype also produces a data log (DLOG) file used for problem and benefits analysis. The DLOG file, based on the input from the HID data and derived URET data, contains center traversal information (time and actual distance from center entry point to exit point) for each flight. Great circle distance for each flight from center entry to center exit point is captured in a subset of the ETMS file, the Boundary Crossing Table, which is maintained in the Air Traffic Control System Command Center in Herndon, Virginia.

There are many factors that can affect the performance of individual flights and of the system as a whole. Traffic patterns are substantially affected by weather, and in particular convective activity. Benefits analysis shows substantial variability on days with heavy convective weather. For comparability, therefore, many of the metrics are calculated only on what have been called “good weather days,” i.e., days that experience little or no precipitation throughout the day at or near the center of interest. A national weather radar mosaic was used to identify good weather days. The data are collected in five minute increments in three different altitude layers: 0-FL240, FL240-FL330, and FL330-FL600. Days were selected with minimum precipitation in the subject en route centers or in first-tier centers (those bordering the subject en route center).

Traffic patterns vary by day of the week, the heaviest traffic days being Wednesdays and Thursdays. To account for daily variations of traffic volume, some metrics were collected for the same weekdays over time. While wind variability is not accounted for directly, differing wind patterns can be partially accommodated by including comparison of metrics by season (since prevailing wind patterns tend to be seasonal). Table 1 sets forth the timeframe, days of the week, and weather factors for the metrics described in this paper.

Table 1. URET Metrics

Metric	Description	Airspace	Timeframe	Data Selection Criteria
Distance Saved by Lateral Amendments:	Comparison over time of distance saved by all lateral flight plan amendments from point of amendment to destination airport	Indianapolis (ZID) and Memphis (ZME)	May '99 – Jan. 02	2 days/week; good weather days; typically Wednesday and Thursday
Excess Distance over the Great Circle Route	Comparison over time of great circle distance and actual distance flown from center entry to exit point	ZID, ZME and Washington Centers (ZDC)	Sep. 98 – Apr 01	All days
Fuel Burn Savings from Lifting of Altitude Restrictions	Savings derived from the lifting of static altitude restrictions within the URET center, allowing aircraft to stay at higher altitudes longer	ZID	May 2000- Aug. '01	Static altitude restrictions removed from adaptation data

Distance Saved by Lateral Amendments

The metric determines the average of the daily sum of distance changed for all lateral amendments from the point of the amendment to the destination airport. The before- and after-amendment trajectories for the remainder of the flight are compared. The data source, from the HID, is all lateral flight plan amendments sent to URET by the Indianapolis and Memphis Hosts.

Indianapolis consistently exhibits more distance savings than does Memphis. The different airspace characteristics and operational practices at the two sites affect this metric. Indianapolis has about thirty-five percent less airspace and five to ten percent more traffic during peak hours than Memphis. In January 2002 URET predicted more than twice as many potential conflicts in Indianapolis airspace as in Memphis - over 7000 alerts average weekday count for Indianapolis vs. approximately 3330 for Memphis (see Reference 3). Controllers at Indianapolis issue more amendments, both vectoring aircraft more and giving more direct routings than do Memphis controllers. Generally, traffic through Memphis airspace is on more direct routes than in Indianapolis. Memphis controllers, therefore, have less opportunity to reroute aircraft to reduce distance.

As is apparent from Figure 4, the distance saved from May 1999 (before the two-way Host interface was implemented) through May 2001 increased substantially at both centers. The comparison is made for the same month of the year, as there are seasonal variations in distance saved from lateral amendments. The data includes all Host lateral amendments during the ten busiest hours at Indianapolis and the eight busiest hours at Memphis on the two most heavily trafficked days of the week, Wednesday and Thursday. (See Reference 3.)

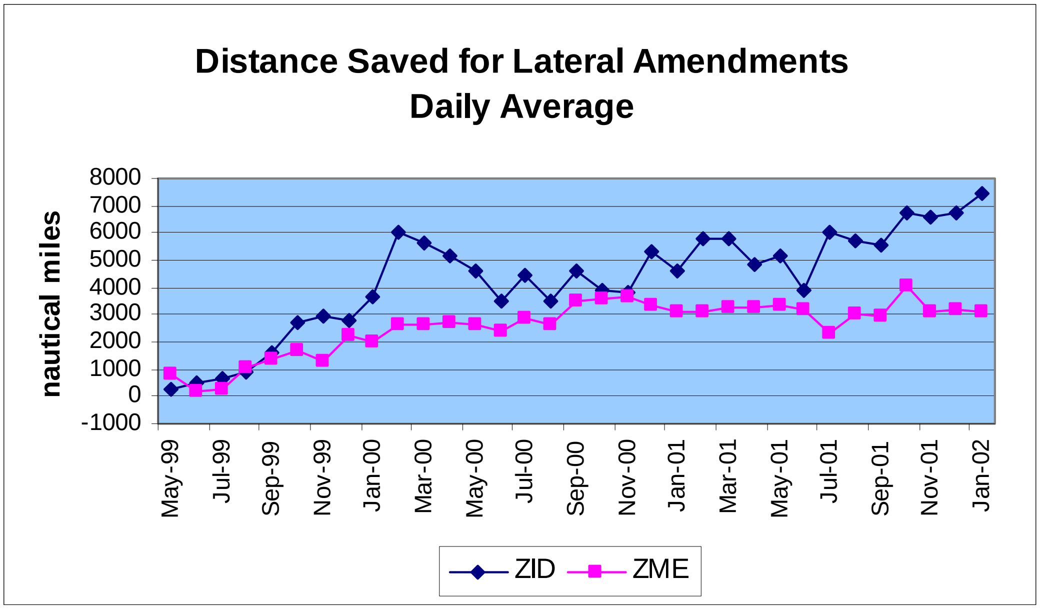

Figure 4. Indianapolis (ZID) and Memphis (ZME): Distance Saved from Lateral Amendments

Data provided by the Air Transport Association was used to estimate the economic benefit to airlines and GA pilots from the increase in distance saved over time. The assumed ground speed for all flights was 7 miles/minute. The Air Traffic Association delay cost data for the year 2000 is $ 52.52 per airborne minute (see Reference 4). When Indianapolis and Memphis are averaged together, distance saved in May 2001 is approximately 3500 nautical miles per day per center over the savings in May 1999 (before the controller could send amendments directly to the Host via URET). At $52.52 per minute, the saving per month is $787,500 per Center, or $1,575,000 total monthly savings from the two URET centers. This savings estimate is very conservative, as distance saved is calculated for only the ten busiest hours, and the extrapolation does not include the other hours of the day.

Excess Distance over the Great Circle Route

The excess distance flown metric measures how close aircraft come to flying great circle routes within a center. Excess distance flown is calculated on a per flight basis by taking the difference between the actual distance flown and the great circle distance between center entry and exit points. The data are derived from ETMS data. Excess distance was calculated for the two URET prototype Centers, Indianapolis and Memphis, and for a single new URET FFP1 Center, Washington Center. Washington Center data was collected to provide a baseline of excess distance before the deployment of URET. The metric is the monthly average of excess distance for all flights through a center. (Metrics on excess distance are being collected at all new FFP1 centers to determine the impact of URET over time on the excess distance flown for all flights through a center).

Each flight was examined to ensure that it was reasonable and a possible candidate for URET benefits. Only civilian flights that were in the Center for a minimum of 15 minutes and for more than 50 nautical miles were included. The metric was computed for all days in the sample period.

Figure 5 shows the excess distance flown from September 1998 through April 2001. There is a substantial difference between the distance flown at URET prototype centers and that flown at Washington center. The trend line also is significant. There is a slight positive slope over the period for Memphis (approximately 0.5 nautical miles), a slightly shallower slope for Indianapolis (0.3 nautical miles), and a substantially greater increase in excess distance over the period for Washington (about 1.8 nautical miles). Thus, over this period, excess distance increased in Washington over three times as much as it did in Memphis, and roughly six times as much as in Indianapolis.

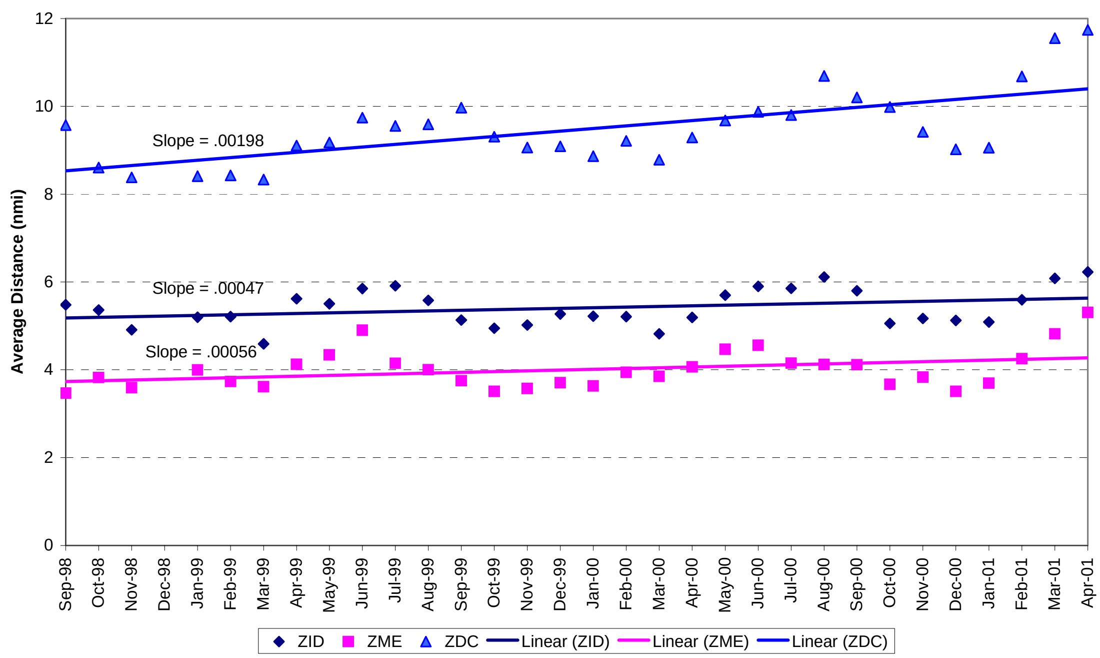

Figure 5. Excess Distance Over the Great Circle Route

As expected, the excess distance is greatest at all three centers in the summer months, when traffic is heaviest and convective weather most interferes with planned routes.

Fuel Burn Savings from Lifting of Altitude Restrictions

With the support of URET, operational personnel at Indianapolis and Memphis reviewed the altitude restrictions in their centers to identify those that were no longer operationally required. In the fall of 1999, the two centers established Procedures and Benefits teams for this purpose (see Reference 5 for a description of this work).

Indianapolis evaluated intra-facility static altitude restrictions for possible removal throughout 2000 and much of 2001. The Procedures and Benefits team met regularly in-house and quarterly with airline representatives, FAA headquarters representatives, and CAASD. The team identified candidate restrictions based on the potential savings to users as well as feasibility; they evaluated the restrictions by temporarily removing them (usually for about a two week period) to determine if permanent removal or modification were feasible; and then they decided how to proceed (i.e., remove, modify, re-evaluate, leave in place). The results to date are shown in Table 2. The fields are described below.

Table 2. Specific Restrictions and Savings in Fuel Burn, ZID 2000-2001

Restriction (Description, To-From Sectors, Altitude)	No. of A/C Daily	Average Distance at Restricted Altitude (Nautical Miles)	Annual Projected Savings in Gallons of Fuel
PIT arrivals, 83/85 FL290	9	88.5	168,840
CLE arrivals, 83/87 FL290	2	82.0	16,725
BNA arrivals from DET DTW and CLE, 88/82, FL310	5	99.6	33747
SDF arrivals, 35/17, 150	11	19.2	15,038
SDF arrivals via Darby, 85/83, FL280	16	40.7	23,716*
CMH, 86/85, FL290	23	35.9	84,206
PIT Arrivals, 86/85, FL290	8	90.1	73,508
CVG arrivals, 80/35, FL240	62	46.3	424,893
IND arrivals, 88/33, FL240	34	20.9	105,179
SDF arrivals, 83/26, FL240	15	5.9	13,099
Estimated Annual Savings in Gallons			**935,235**

*Evaluated, not removed

- Restriction: Lists the arrival airport, the sectors to which the restriction applies, and the altitude at which the aircraft is required to cross between sectors; e.g., the first restriction: 'PIT arrivals, 83/85 FL290,' indicates that arrivals to Pittsburgh airport, passing from sector 83 to sector 85 (in ZID airspace) shall be at FL290 or below.

- No. of A/C Daily: Lists the number of aircraft that were subject to the restriction on the day that the analysis was done; e.g., 9 aircraft were above FL290 going from sector 83 to 85 for arrivals into Pittsburgh. They were required to descend to FL290 or below.

- Average Distance at Restricted Altitude: Lists the average distance in nautical miles that the aircraft were in level flight at the restricted altitude; e.g., the 9 aircraft en route to Pittsburgh were constrained to FL 290 or below for an average distance of 88.5 nautical miles each.

- Annual Projected Fuel Burn Savings: Lists the projected annual savings in gallons if the aircraft had been permitted to stay at their preferred, higher altitude rather than meet the altitude crossing restriction. The savings is based on fuel burn by altitude by aircraft type (see Reference 6).

In the fall of 2001, Indianapolis temporarily disbanded the Procedures and Benefits team to prepare for the deployment of the FFP1 version of URET. After deployment, Indianapolis intends to continue to evaluate altitude restrictions with the goal of lifting a much larger number, including many inter-facility restrictions that may no longer be required. The other FFP1 centers plan to establish comparable Procedures and Benefits teams to evaluate restrictions, with the goal of increasing user benefits through their removal.

Projected Benefits of URET at All Centers

The measured benefit of URET from usage in Indianapolis and Memphis is only a part of the future benefits URET will deliver when implemented on a national scale. Much of URET's value in enabling more direct routing and reducing altitude restrictions will not be realized until all contiguous centers have the same URET capability. Coordination with adjacent centers will be improved allowing aircraft to exit center airspace at more optimal altitudes and on more efficient trajectories when URET is in use in contiguous centers.

The FAA investment analysis document for FFP2 (see Reference 7) provides estimates of the benefits that will accrue to airlines and GA when URET is available at the thirteen FFP2 en route Centers. URET Centers were compared to non-URET Centers to estimate distance savings from lateral amendments. ETMS data was collected and the distance saved from lateral amendments was calculated for each trajectory. Additional factors for each center were collected; and a linear regression technique was used to identify the characteristics that affect the total distance saved in an Air Route Traffic Control Center. The investment analysis for FFP2 considered a number of variables, including percentage of military flights, number of high and super high sectors, number of low sectors, average monitor alert value and average time in sector. The results predict that, when URET is deployed and used, annual savings from reduction in distance will be approximately 14,000,000 nautical miles annually for the 13 FFP2 sites (see Reference 7). The analysis was based on projected fiscal year 2003 traffic levels and assumed that operational personnel were trained in the use of URET and were using it effectively. The estimated savings from reduction in distance flown for all twenty en route centers was approximately 24,000,000 nautical miles annually.

The projection of savings for the FFP2 sites from the removal of altitude restrictions was substantially less (see Reference 7). The investment analysis document for FFP2 assumes that URET availability at contiguous centers will provide the opportunity to remove some inter-facility restrictions that operational personnel at Indianapolis and Memphis will not consider removing without the advance notification of incoming traffic and projected conflicts that URET provides. According to this analysis, fuel savings from removal of altitude restrictions at the FFP2 sites total approximately 8,000,000 gallons annually. The projected savings for all twenty en route centers from reduction in fuel burn resulting from aircraft staying at their preferred altitude longer is approximately 24,000,000 gallons annually.

Acronyms

CAASD	Center for Advanced Aviation System Development
DLOG	Data Log
ETMS	Enhanced Traffic Management System

FAA	Federal Aviation Administration
FFP1	Free Flight Phase 1
FFP2	Free Flight Phase 2
FL	Flight Level
GA	General Aviation
HID	HOST Interface Device
URET	User Request Evaluation Tool
ZDC	Washington Center
ZID	Indianapolis Center
ZME	Memphis Center

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Biography

Marilyn Walker joined the Center for Advanced Aviation System Development of the MITRE Corporation in 1987. Since then she has been working with the FAA on modernization of Air Traffic Control systems, in particular on several programs that further the FAA goal of evolution to a Free Flight environment. Most recently, she has worked on the establishment of metrics and analysis for benefits of the User Request Evaluation Tool (URET).