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MITRE TECHNICAL REPORT

Integrated En Route Sector Concepts Status and Interim Findings

September 2000

Amy E. Gross

MITRE

Center for Advanced Aviation System Development
McLean, Virginia

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1. Introduction

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The Federal Aviation Administration (FAA) continues to evolve the computer-human interface (CHI) to enhance controller effectiveness in Air Traffic Control (ATC) operations. This activity builds upon the en route Display System Replacement (DSR) and enhances the functionality of the original DSR CHI. Simultaneously, other FAA groups are examining future concepts of operations where the roles and responsibilities of ATC service providers change to more efficiently deal with ever-increasing levels of traffic. These concepts take advantage of ongoing research in the area of conflict detection and resolution, data link, weather prediction, and traffic flow management. To date, these CHI enhancements and operational concept development activities have largely been performed independently from each other. This briefing describes the work performed by the Center for Advanced Aviation System Development (CAASD), at the request of the FAA, on the exploration of integrating these concepts and enhancing CHI principles for DSR to support these integrated concepts.

As future operational concepts evolve, the FAA is interested in assessing how these concepts could be represented in the en route environment using techniques found in the Operational Display and Input Development (ODID) user interface, developed by EUROCONTROL and used in their daily ATC operations. ODID changes the “look and feel” of the controller interface by eliminating paper flight strips and providing graphical and tabular displays of flight plan and other control-related information. The use of color is a significant component of ODID and EUROCONTROL has conducted much research into the human factors issues associated with color and other attributes of the ODID interface. The FAA has been working with EUROCONTROL to further develop and evaluate ODID for use in the National Airspace System (NAS). The FAA has requested that CAASD apply ODID principles while evaluating future operational concepts.

From the ATS Concept of Operations:

- In 2005, en route airspace structures and boundary restrictions are unconstrained by communications and computer systems, and aircraft are no longer required to fly directly between navaids along routes defined by the FAA. As a result, en route operations are characterized by the following:
  - Improved decision support tools for conflict detection, resolution, and flow management allow increased accommodation of user-preferred trajectories, schedules, and flight sequences
  - Automated, seamless coordination and communications within and between facilities enable airspace structure flexibility and reduced boundary restrictions
  - Demand and capacity imbalances are resolved, in collaboration with the users, via voluntary changes in trajectories or through the establishment of temporary routes and transition points in the affected area

FAA’s Air Traffic Services (ATS) has developed a significant vision for the future Air Traffic Management (ATM) system, a vision captured in their operational concepts for 2005. To assess the en route concepts using an ODID-like CHI, the CAASD team developed an operational concept “demonstrator” that illustrates, from a service provider’s perspective, the integration of many key operational concepts that will help shape future ATM systems. This capability consists of both a multimedia animation run on a personal computer and a laboratory demonstration environment to more fully investigate those concepts.

The concept demonstration, running Macromedia® Director® animations, is front-of-the-panel only. Consequently, it enables predefined scenarios to *demonstrate* key concepts using an ODID-like interface refined via laboratory demonstrations, without the need for implementing the operational algorithms. The purpose of this activity was to determine whether this type of animation could be used to help achieve ATC service provider consensus on both the concepts and interface and, also, to determine if these advanced concepts result in providing the right level of information content and presentation to the controller. After an initial assessment has been made, higher-fidelity HITL evaluations could then be planned and initiated leading to full-scale development of hardware and software modifications.

From the FY00 CAASD Work Program:

- In support of ATS's on-going DSR CHI upgrade activity, support the definition of the integration and evolution of operational concepts and evaluation of the operational suitability of alternative migration strategies for the en route domain. **This will include the development of a capability to provide rapid prototyping using ODID-like CHI principles to illustrate future en route ATC operational concepts.** Where necessary, appropriate laboratory infrastructure and scenarios will be developed to support the illustration of these concepts. The capability will help address sector team information access and display issues related to such en route operational concept elements as:

  - Conflict detection and resolution
  - En route flow management and spacing
  - Flight Object processing and display
  - Handoffs and other inter- and intra-facility communications
  - Integration of ATC weather information
  - Airspace management
  - Data link
  - Surveillance Data Fusion

The concept demonstration capability is not intended to evolve to a developmental prototype. However, information gained from its use could guide prototype development in the en route environment lab. For our en route CHI evolution work, we developed a portable version to interact with the Air Traffic DSR CHI Evolution Team (ATDET), which is responsible for all operational enhancements to DSR. The concept demonstration capability helps address issues such as sector team roles and responsibilities, information accessibility and display issues related to en route operational concepts such as:

- Conflict detection and resolution
- En route flow management and spacing
- Flight Object processing and display
- Handoffs and other inter- and intra-facility communications
- Integration of ATC weather information
- Airspace management
- Data link
- Surveillance Data Fusion

These concepts are being assessed in the context of the following en route ATM concepts:

- Traffic Management Advisor (TMA) – a controller planning tool to sequence and schedule aircraft to ensure proper spacing into the terminal area

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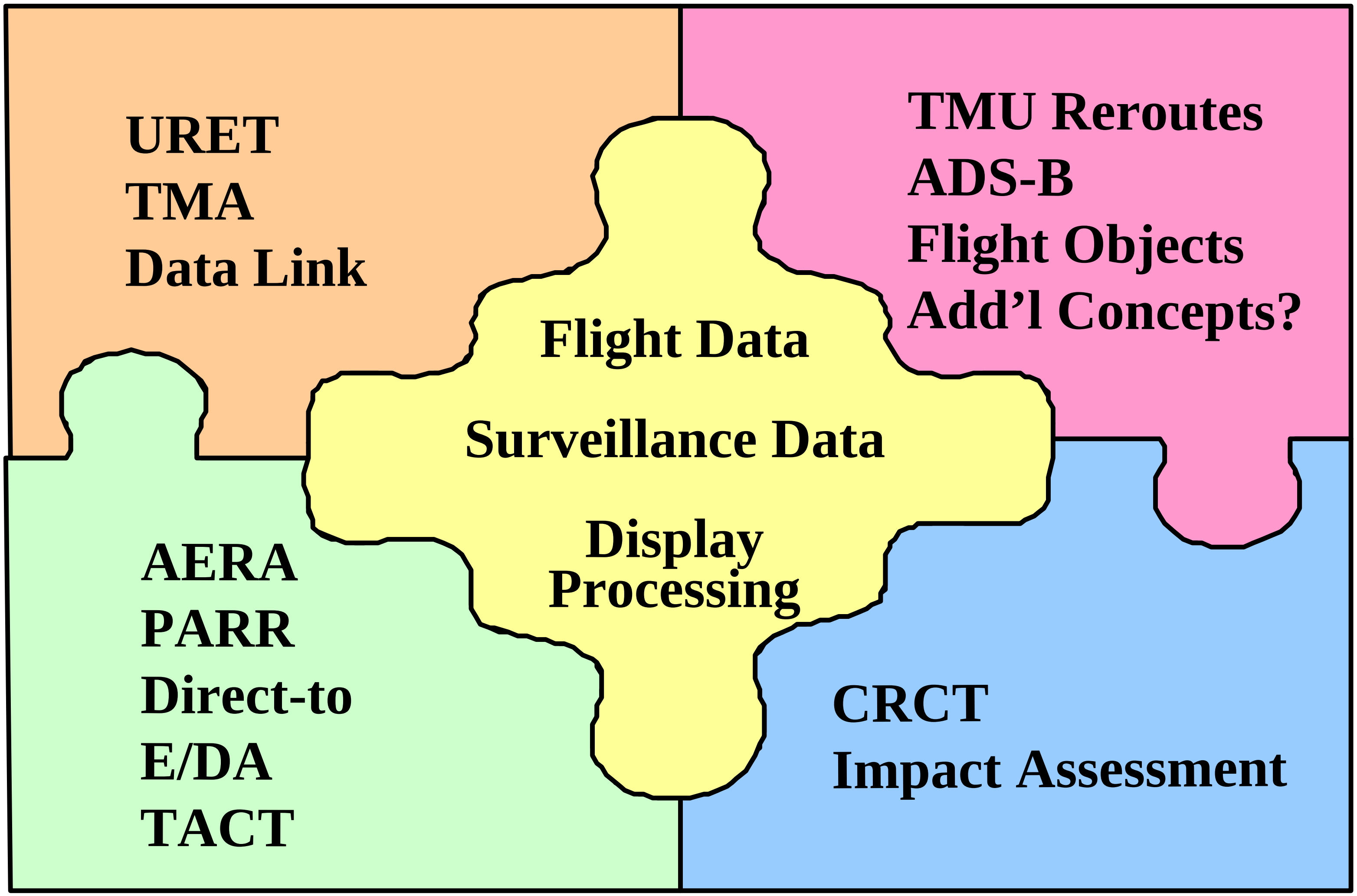
Integrating En Route ATM Concepts



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- User Request Evaluation Tool (URET) – a conflict probe capability to alert the controller to aircraft/aircraft and aircraft/airspace conflicts, conduct trial planning, and to respond to user requests for alternate routings

- Problem Analysis, Resolution and Ranking (PARR) – a resolution capability that assists the controller in deriving conflict-free resolutions to problems detected by URET

- Direct-To – a controller planning aid that notifies the controller to situations where a flight may safely be rerouted directly to downstream waypoints, thereby saving time and fuel.

- Descent Advisor – a controller planning tool to advise/remind the controller when an aircraft should begin its descent from the en route portion of its flight

- Collaborative Routing Coordination Tools (CRCT) – tools for the traffic management unit (TMU) to detect sector load situations and to assist in determining alternative routes to avoid weather and other hazardous or saturated airspace. CRCT will also provide a capability to assess the impact of various traffic flow restrictions.

- Data Link – air-ground communications that replace or supplement voice communications and provide additional information on aircraft state.

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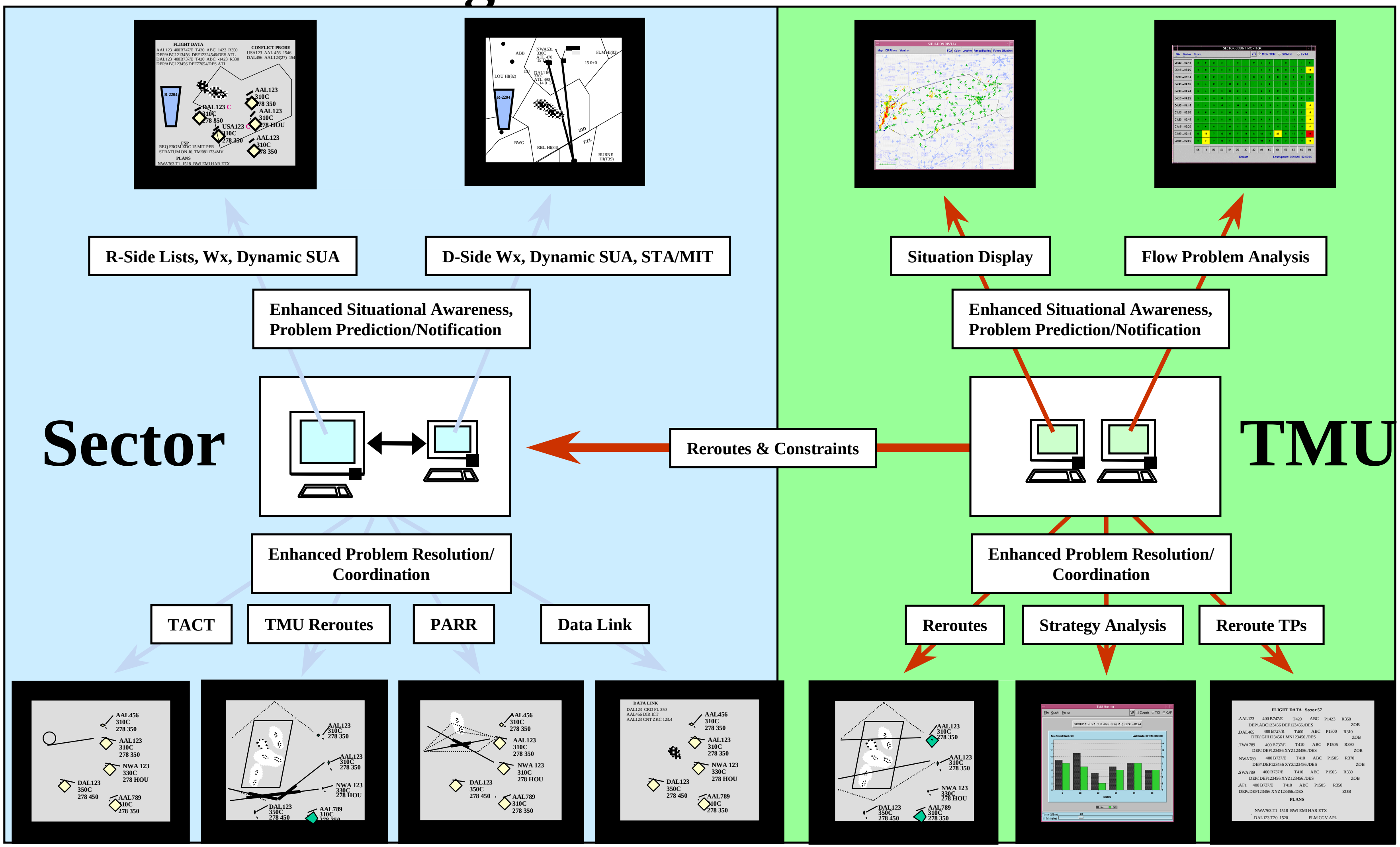
2. Approach

En Route Integration



This slide shows a vision of how the future en route ATM and TFM concepts could be integrated to result in an effective display of information for use by the Sector and TMU positions. This integration is essential for realizing the benefits (e.g., reduced workload, reduced frequency congestion, reduced flight delays, etc.) envisioned from the new capabilities.

Sector team functional capabilities would include:

- Enhanced Situational Awareness and Problem Prediction and Notification
  - R-Side Lists, D-Side Lists, Weather, Dynamic Special Use Airspace (SUA), Scheduled Times of Arrival/Miles-in-Trail Metering
- Enhanced Problem Resolution and Coordination
  - TACT Visualization Tool, PARR, TMU Reroutes, Datalink, Intra-sector Auto-coordination

Traffic Management Unit (TMU) functional capabilities would include:

- Enhanced Situational Awareness and Problem Prediction and Notification
  - Situation Display, Flow Problem Analysis
- Enhanced Problem Resolution and Coordination
  - Reroutes, Strategy Analysis, Reroute Trial Plans

Concept Integration - Evaluation Approach

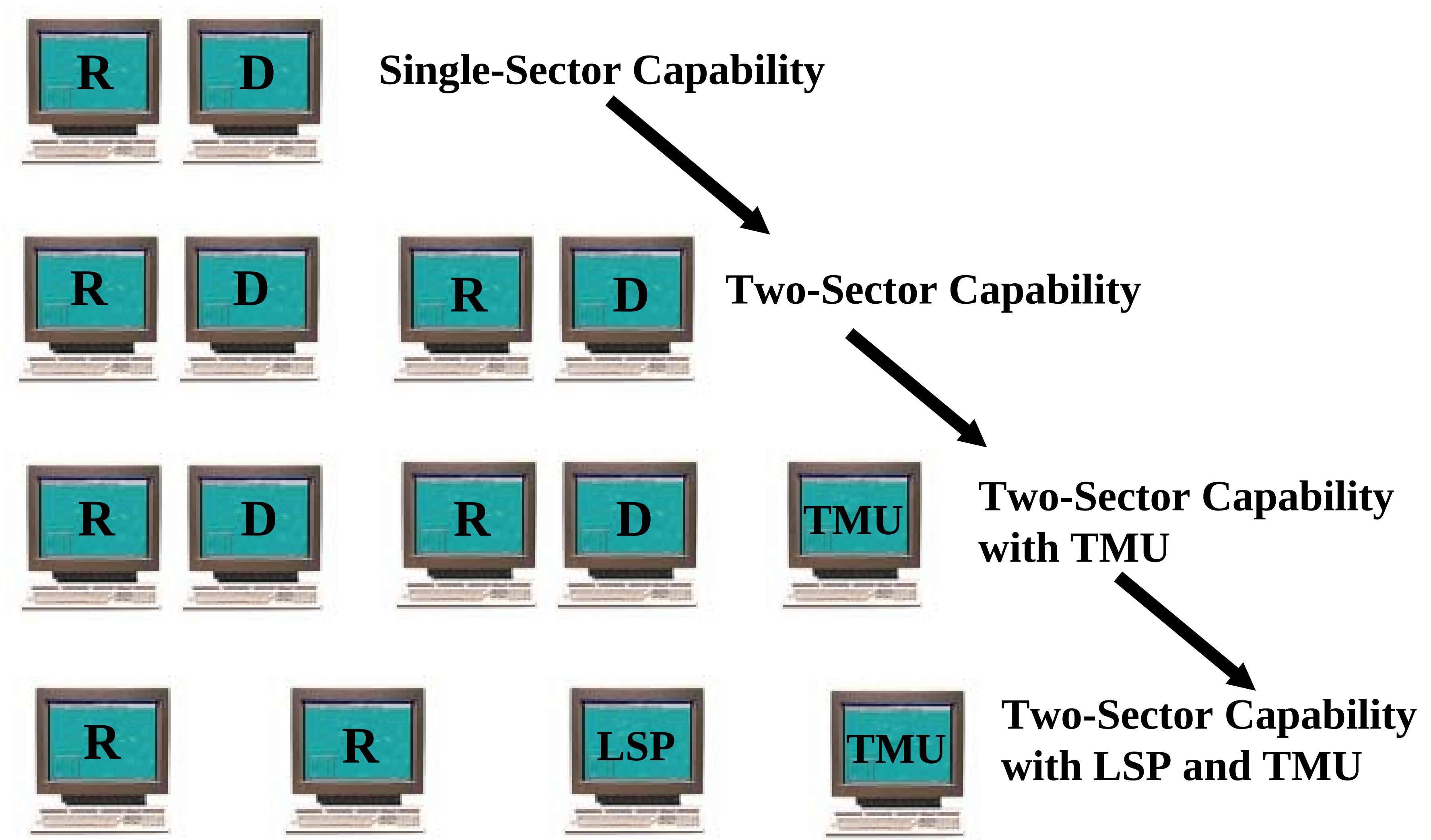
- Air Traffic DSR CHI Evolution Team (ATDET)
  - Periodic meetings to assess concepts and application of CHI principles
  - Provide feedback as to the operational suitability of alternative integration strategies
  - Key player in setting research agenda
- Capabilities and CHI that build upon each other
- Start with FFP1 capabilities; add RTCA '03-'05 recommended capabilities and future concepts

The effectiveness in demonstrating concepts depends on how successful we can begin clarifying CHI requirements and validating the “front end” of new operational concepts. Therefore, we have relied on the Air Traffic DSR CHI Evolution Team to evaluate the concepts and CHI, suggest modifications, and develop an agreed-upon approach to both concepts and CHI. The support of this team has been key to establishing a platform to evaluate future ATM concepts.

Regular meetings were held with the ATDET to establish the foundation for CHI and concept evaluation. ATDET feedback helps set the direction for future air traffic control CHI and concept development and validation. To that end, we developed scenarios where operational concepts were demonstrated using an ODID-like CHI. Those concepts were evolutionary, building upon existing Free Flight Phase 1 (FFP1) capabilities and adding some nearer-term future Free Flight Phase 2 (FFP2) capabilities. Further development of the concept demonstration capability would incorporate the remaining FFP2 capabilities and those capabilities needed to meet the Air Traffic Services Mid-term Concept of Operations.

As the progression of capabilities proceeds, the ATDET should continue to be involved. The team can help build upon the operational concept established with FFP1, which supports their charter to define the evolution of ATM operations and CHI.

Concept Integration - Progression of Capability



The initial progression of capabilities planned for inclusion into the concept demonstration are listed below. Capabilities and enhancements to FFP1 indicated with an asterisk in the list of capabilities below have not yet been incorporated into the initial concept demonstration capability. Currently scenarios exist for a Traffic Management Unit (TMU) position, a Layered Strategic Planner (LSP) position, an en route sector position, and a transition sector position.

The LSP position does not exist in today's operation; several options exist (e.g., assign to TMU) for how this new position or set of functions could be implemented in the NAS. In the concept for this future position, the LSP performs resource planning and flight planning in the short- to mid-range strategic time frame. Flight planning includes adjusting smaller traffic flows and handling strategic problems to maintain an operationally acceptable workload for the sector planning or tactical controllers. Details on this concept can be found in *Layered Strategic Planning in the En Route National Airspace System (NAS): Air Route Traffic Control Center (ARTCC) Perspective.*

FFP1 Capabilities:

Situation Display

- Flight Data Lists
- URET
- TMA
- ATC Weather*

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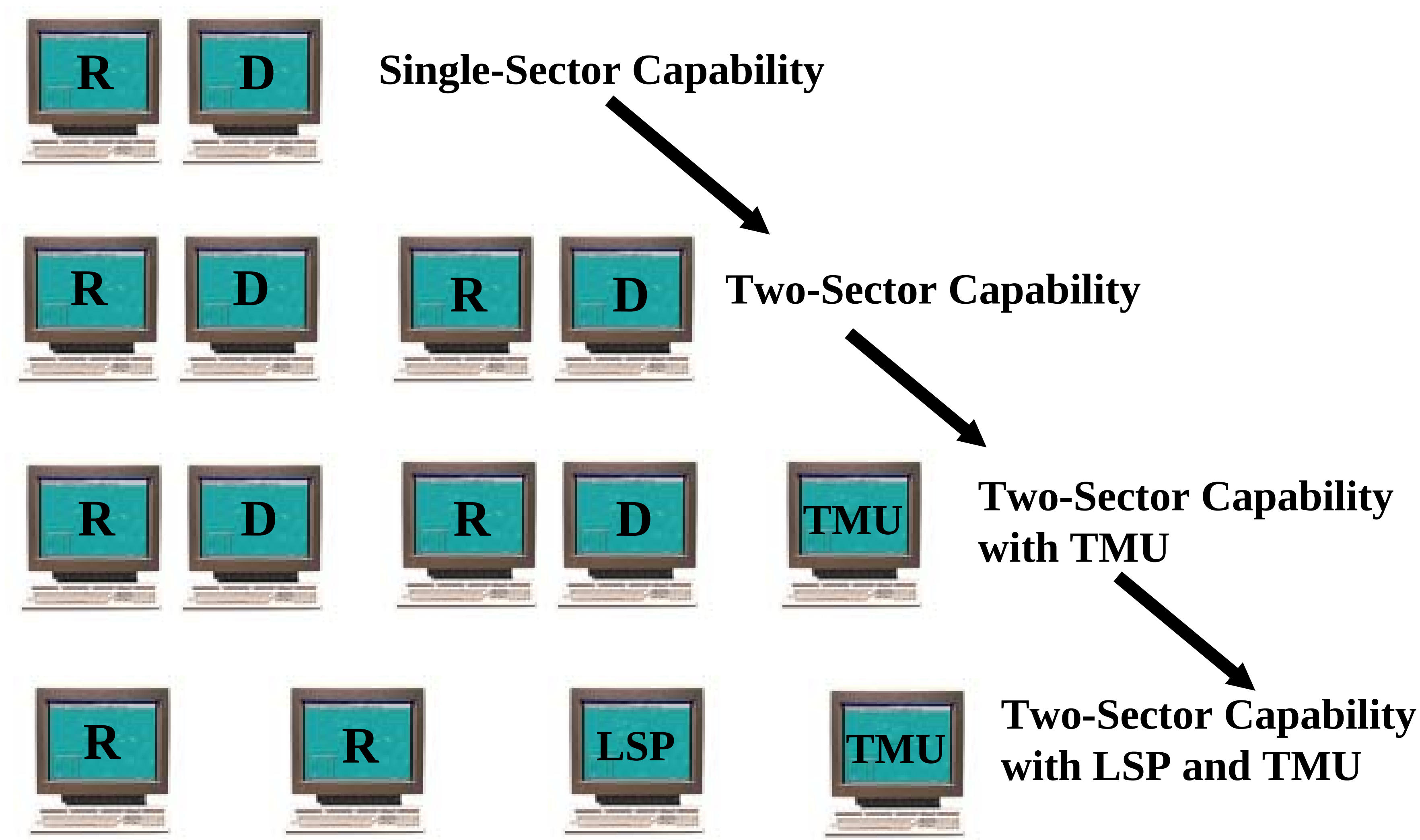
Concept Integration - Progression of Capability (continued)



Enhancements to FFP1:

- Visualization tools to support the implementation of time-based metering and/or miles-in-trail restrictions
- Conflict Resolution and Direct Route Planning
- Re-routes from TMU
- Controller Pilot Data Link Communications (CPDLC)
- Direct-To*
- Descent Advisor*
- Flight Object Display*
- Multi-Sector Planning

Concept Integration Process

- ATS 2005 Conops
- RTCA '03 - '05
- FFP1/FFP2
- NAS Architecture
- Prior research

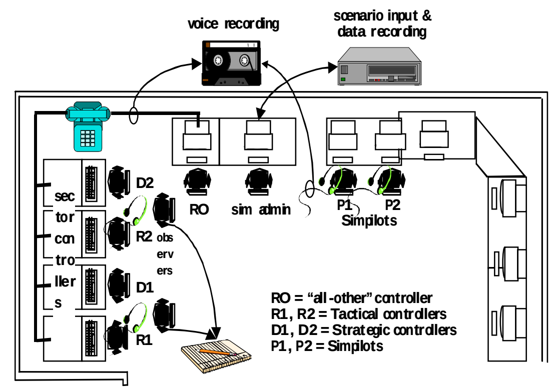
Integrated Concept Validation

PowerPoint Storyboard

- Descriptions of tools
- Roles and responsibilities
- Integrated Concepts
- Procedures, etc.

Controller Feedback on Integrated CHI

En Route Environment Lab



- Realistic DSR-like displays
- Realistic en route environment
- Driven by actual applications software
- Rapid Prototyping of CHI
- Human-in-the-loop demonstration

Macromedia® Director®

Integrated Concepts

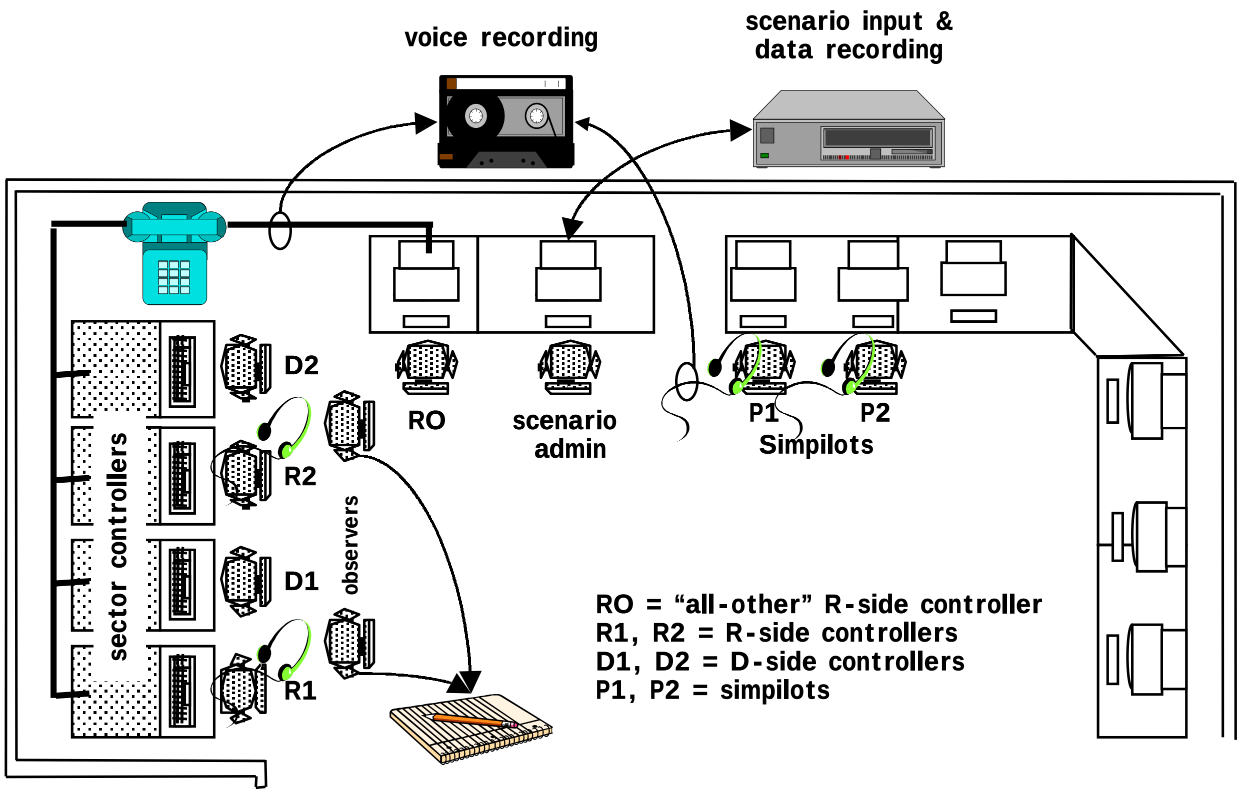
- Front-of-panel demonstration
- Rapid prototyping of concepts
- Vehicle for controller feedback
- Available to wide audience

Controller Feedback on Integrated Concepts

CAASD conducted a concept integration investigation using various media. PowerPoint storyboards were used to quickly obtain high-level conceptual feedback prior to developing more detailed scenarios. Animations demonstrating those concepts were then created using Macromedia® Director® and converted into Apple QuickTime™ movies (which can be run on multiple platforms including Macintosh, Windows, and Unix). Director® is the leading platform for developing interactive multimedia, combining text, graphics, animation, video, and sound to create interactive "movies" for presentations, CD-ROMs, or the Web. QuickTime™ movies are transportable to the internet and can be easily configured to demonstrate different concepts and CHI (i.e., rapid prototyping). When the concept demonstrations are sufficiently mature, sound can be added to provide narration for a wider audience. The application has been run on both a Macintosh, for the concept demonstration for the ATDET, and a Windows-based personal computer, for the En Route Area Work Team (ERAWT).

ODID-like CHI principles were developed in our en route laboratory using Operational Display Systems (ODS) Toolbox©, a commercial-off-the-shelf product by Orthogon GmbH (Corporation) designed to support software development and customization for operational display systems in the ATC domain. ODS Toolbox© was used in our lab to explore the ODID-like CHI. This saved time and effort since developers were able to adapt the display layout to changing and evolving requirements, without modifying existing applications software. The lab demonstration and evaluation were conducted using Sony 2K x 2K displays. The ODID-like CHI findings were factored into animations developed for the concept demonstrations. As the concept integration effort matures, it is expected that the animations would then be used to provide guidance for developing human-in-the-loop (HITL) simulations in the lab.

CAASD En Route Environment Laboratory - Physical Layout

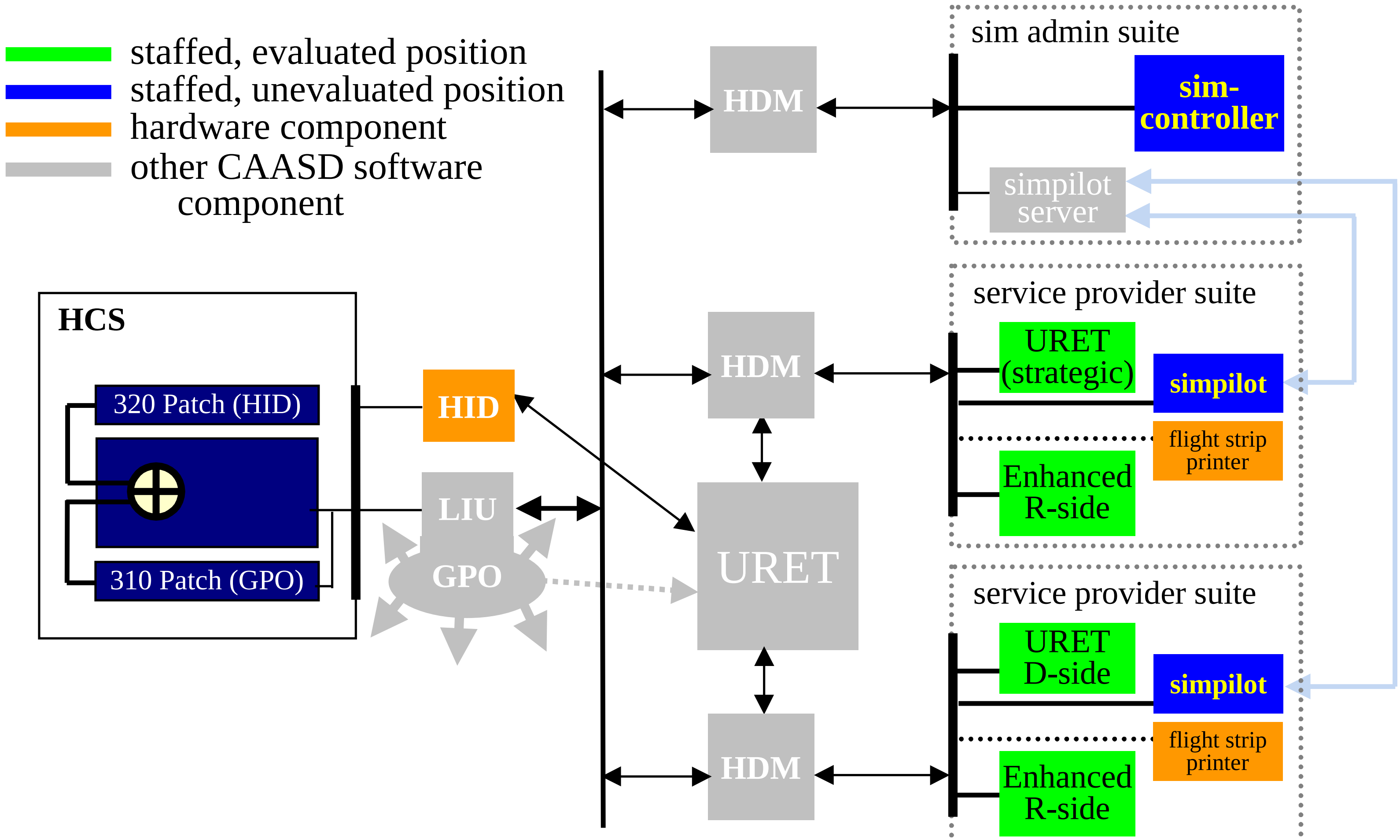


The focal points of the en route environment lab are the two “service provider” suites. A service provider suite consists of an enhanced DSR-like R-side control position as the tactical controller and a URET equipped D-side control position as the strategic controller.

The strategic D-side controller position is tasked with resolving problems that arise in the strategic time frame, and can use the “make current” (send a flight plan amendment to Host) and automated coordination (coordinate a flight plan change with another controller) capabilities of URET to resolve these problems. In the current configuration, all strategic positions use URET v3.2 on a 2K x 2K color display. No D-side Computer Readout Display (D-CRD) is provided since all D-side transactions with the Host are performed through the URET interface using a standard PC keyboard and mouse.

The tactical position is staffed by a trained R-side controller. Problem solving responsibilities are more focused in the “tactical” time frame. Tactical positions are modeled after early DSR with additional capabilities, and are displayed on a 2K x 2K color monitor. In addition to the capabilities traditionally found on DSR, the tactical controller can receive and display (graphically and textually) conflict probe alerts; change the notification threshold for conflict probe alerts; build, display, and “make current” trial plans and auto-replans; receive, display, and either “make current,” refuse, or ignore both intra- and inter-sector auto coordination plans; display and manipulate on-screen flight data and General Information (GI) messages; and display real time or stored weather in color. All DSR enhancements use the existing Host-like interface and paradigms wherever possible.

Lab Software/Hardware Architecture



The en route environment laboratory architecture is shown above. It includes:

Host Computer System (HCS) and Host Interface Device (HID)
The lab has an IBM s390 emulator which runs NAS A5f1.0 and serves as the HCS for the concept evaluations. All scenarios run under Dynamic Simulation (DYSIM). A HID can be used with a 3.20 patch for full bi-directional connectivity.

Lan Interface Unit (LIU)
The LIU is a (Transport Communications Protocol (TCP-based) interface to HCS and provides message service to controller positions while providing data for flight strip printers and simcontroller and simpilot positions.

Host Data Multiplexor (HDM)
The HDM is a flexible software component that allows TCP network interfaces between any laboratory software components.

Simcontroller and Simpilot
The simcontroller position is designed to oversee the realtime operation of the scenario from the ATC perspective of the unevaluated sectors, and manage the transition of the scenario into the evaluated sectors. The simcontroller display is a DSR-like interface built using Orthogon's ODS Toolbox© and runs on a Unix workstation under X-windows.

A simpilot station is staffed for each sector in the scenario. Generally, the simcontroller will act as his own simpilot. In any given sector, all aircraft are "flown" by one simpilot who has voice communication with the appropriate tactical controller. The sole responsibility of the simpilot is to follow ATC directives. The simpilot display is an X-windows based display that requires minimal training to operate.

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3. Status

Current Status of Director® Demonstration

- **Traffic Management Coordinator (TMC) tools**
  - **Situation Display**
  - **TMA**
  - **CRCT ***
  - **ETMS/CDM ***
  - **Automated Coordination/Pre-composed Messages**
- **Layered Strategic Planner (LSP) tools**
  - **Situation Display**
  - **Electronic Flight Data Display**
  - **Conflict Probe/Conflict Resolution**
  - **Automated Coordination/Pre-composed messages**

*** Use is described, but not illustrated, in current demonstration**

Appendix A provides a number of screen shots taken from the most recent Director® scenarios. In addition to a brief overview of capabilities described below, more detailed descriptions of scenarios are also presented in Appendix A. This deliverable also includes a CD-ROM that contains the QuickTime™ versions of this traffic scenario shown from the view of a TMC, an LSP, an en route sector radar controller, and an en route/transition sector radar controller.

The TMC scenario shows a situation display of traffic for an entire en route center based on Atlanta center airspace. It also shows two TMA time lines and TMA messages for arrival into Atlanta over the northwest and southwest corner posts. Although Enhanced Traffic Management System (ETMS) and CRCT are not part of the animation, (due to limitation of display space) the annotation provided in Appendix A describes how these tools would be incorporated into the TMC decision making process. The traffic situation examined in all the scenarios consists of rerouting traffic from the southwest to the northwest to balance the load and reduce delays.

Layered Strategic Planning is a future concept currently being considered to accommodate predicted growth in the NAS. It is included here in lieu of two D-controller scenarios to investigate some of the coordination issues concerning the concept, that were raised by the ATDET. The LSP animation demonstrates many of the same strategic activities that would be performed by a D-side position using similar electronic data and automation tools.

Current Status of Director® Demonstration (concluded)

- **Tactical Controller tools**
  - **Situation Display**
  - **Electronic Flight Data Display**
  - **Controller Pilot Data Link Communications**
  - **Meter List (arrival sector)**
  - **Transition Airspace Controller Tools (TACT)***
  - **Initial Conflict Resolution/Conflict Probe**
  - **Automated Coordination/Pre-composed messages**
  - **Automated Flight Plan amendments**

*** Use is described, but not illustrated, in current demonstration**

To effectively demonstrate the operational concept for use of automation tools and electronic data by the radar controller with a single traffic scenario, three animations were developed. The first animation demonstrates the sector responsible for effecting a reroute and shows integrated use of conflict probe, conflict resolution, data link, automated coordination, and automatic flight data updates. It shows the use of dialog boxes to transmit pre-composed data link messages and clearances. It also uses dialog boxes to receive down-linked pilot responses and requests.

Another animation was developed for the same sector and situation, but modified to show use of the data block (instead of dialog boxes) to receive a data link response and procedural coordination with the LSP, where reroutes were carried out exactly as specified. Once the initial traffic scenario had been developed, animation changes could be made quickly, enabling us to respond rapidly to ATDET feedback.

Finally, there is an animation for the transition sector, which is responsible for merging the rerouted aircraft into the rest of the arrival stream and meeting the associated scheduled times of arrival for the aircraft at the meter fix. Showing this sector position enabled use of the metering list, inbound list, and TACT tool to be integrated into the overall concept demonstration.

Current Status of Lab Demonstration

- Tactical/Strategic Controller Workstation
  - Integrated use of Metering and Conflict Probe
  - Initial DSR Enhancements
    - Multiple Flight Plan Readout
    - Dwell Lock
  - ODID-like CHI
    - Functionality through data block
    - Data access through data block
    - Use of Color
  - Transition Airspace Controller Tools (TACT) visualization aids

Appendix B provides a number of screen shots from the most recent ODID-like CHI scenario demonstration in our lab. The lab work focused on the R-side (Radar) controller workstation CHI and investigated how best to provide advanced tool capabilities of metering and conflict probe to this tactically-oriented position. In accordance with the ATS mid-term concept of operations, it was assumed that the system would be based on the use of electronic flight data, and not paper flight strips.

Potential ODID-like CHI approaches were demonstrated periodically to the ATDET co-leads, Dan Williams and Keven DeBoard and an MIT/Lincoln Laboratory aviation specialist, Maria Picardi, who has had significant experience in en route ATC human factors and CHI. Their feedback, summarized later in this briefing, was then addressed in subsequent scenarios and demonstrations.

For example, the ATDET was concerned that the radar controller needed a tool to help meet the metering list scheduled times of arrival (STAs). In response, we added the capabilities of the TACT to the scenario, and received very favorable feedback. TACT is a visualization tool that maximizes the benefits of time-based metering by helping controllers meet metering STAs. TACT provides enhanced decision support to increase effectiveness and address task complexity. The ATDET felt that TACT was beneficial because it enabled them to more intuitively visualize the time-based metering schedule. In addition, the Problem Analysis, Resolution and Ranking (PARR) was discussed as another possible tool to help meet STAs. Some of the PARR features could also be incorporated into a subsequent iteration of the lab scenario.

Future Concepts Not Yet Integrated into Demonstration

- **Automated Handoffs**
- **Integration of ATC Weather Information**
- **Flight Object Processing**
- **Airspace Management**
- **Surveillance Data Fusion**
- **Conflict Resolution**
- **Direct To tool**
- **Descent Advisor**

As previously described, the concept demonstration capability was intended to be a spiral development allowing for feedback and research findings to be factored into each subsequent version, along with the integration of additional capabilities. It is expected that full development of a concept demonstration capability would take place over several years. At the end of FY00, the Concept Demonstrator has not yet integrated the concepts listed above.

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4. Findings

Feedback received from ATDET ~ Operational Concept ~

- Concept Demonstration needs to be able to encompass the whole operation and not be limited to automation tools
  - Roles and responsibilities
    - Traffic Management Coordinator (TMC), Area Supervisor, Layered Strategic Planner (LSP), R-controller, D-controller, Airlines Operation Center (AOC), Pilot
  - Coordination requirements
  - Procedures requirements
  - Automation requirements
  - CHI requirements
- Need clearly defined roles and responsibilities
  - Will R-side take on a more strategic role?
  - Will there be Layered Strategic Planning?

The Director® animations, shown as QuickTime™ movies, proved an extremely effective media for eliciting feedback from operational personnel. The ability to visualize the concept enabled the ATDET participants to quickly articulate their concerns, identify what they liked, and prioritize what was important. The next series of slides identify specific feedback provided by the ATDET to the operational concepts demonstrated. A number of comments have already been accounted for in the current version of the Director® demonstration found on the enclosed CD-ROM. Other comments will need to be factored are integrated development of the concept demonstration capability progresses, additional capabilities are integrated, and more comprehensive scenarios are constructed.

The first animation shown to the ATDET demonstrated integrated use of metering and conflict probe only from the viewpoint of the two radar controller workstations: the sector executing the reroutes and the transition sector merging the rerouted aircraft into its metering stream. From the feedback received, it became clear that controllers couldn't adequately evaluate the validity of the concept without understanding how the role of the radar controller fits into the overall operation. As a result of that initial demonstration, a decision was made to implement an integrated metering and conflict probe concept for the two-sector capability with an LSP and a TMC, rather than continue to integrate new functionality into the existing two-sector scenario.

During each of the demonstrations, questions were raised regarding the future roles and responsibilities associated with each position. It became clear that in order to validate the integration concept and CHI requirements we will need to address unresolved issues, such as whether the radar controller will take on a more strategic role and whether there will be a multi-sector planning position.

Feedback received from ATDET ~ Operational Concept ~ (continued)

- Provide better coordination tools between TMC and Control positions
  - Provide general information, weather messages
  - May need tool to ensure maneuver is doable
  - Allow controllers to help identify needed reroutes to improve flow
- Provide procedural solutions for routine events
  - For example:
    - No response needed if reroute implemented as instructed
    - WILCOs do not need to be accepted
- Provide strategic tools to identify needed routing changes as early as possible
- Provide Controller visualization tools to meet Scheduled Time of Arrivals (STAs)

As the roles and responsibilities get better defined, improved coordination among the various position becomes critical for conducting an effective operation. Since personnel working on related traffic situations may no longer be located near each other, or even in the same facility, the current method of voice coordination becomes infeasible. Those routine situations that can be coordinated through predefined procedures to reduce unnecessary workload need to be clearly defined. Where coordination is required, the automation is needed to provide as much assistance as possible to help support the controller in decision making. For example, when the controller is directed to reroute traffic by the TMC, tools like TACT or PARR could help them first ensure that the reroute is feasible, subsequently helping the controller meet the scheduled TMA times.

The operational concepts for some of the desired future capabilities had not yet been developed in sufficient detail to demonstrate to the ATDET or make available to a wider controller community. Examples of such unresolved issues include defining the role of the layered strategic planner or automating the exchange and coordination of URET and CRCT information between the TMU, Area Supervisor, and Sector Team.

Feedback received from ATDET ~ Operational Concept ~ (concluded)

- **Identify aircraft and projected paths for conflict situations (even if target not yet displayed)**
- **Use display to provide operational information**
  - **Try to provide conflict-free routings to tactical controller**
  - **Provide pre-defined messages to accept and automatically update**
  - **Have TMC provide suggestions to strategic planner**
- **Tactical controller should not be focusing on "what if" situations**
  - **Do not change meter list based on trial plans**
- **Provide automatic transfer of control and communications through data link**
- **Provide integration of tools with data link**

Much of the feedback listed on this slide was received early on in the development of the concept demonstration and has already been factored in to the current scenario versions. For example, the tactical controller does not do trial planning to determine the revised route, that is done by the LSP, or other strategic position. However, the tactical controller does get graphic indication of predicted conflict status when a clearance is composed (both an altitude and route amendment are shown in the scenario). In response to prior ATDET feedback, when a conflict is displayed graphically, the aircraft ID and flight direction are clearly indicated for each flight path. Finally, the scenarios found in the enclosed CD-Rom show limited examples of data link and its integration with the other ATM tools, such as URET. Enhancements and additional integration of these capabilities could be incorporated in the next version.

As the remaining future concepts become better defined, it will be relatively easy to integrate them into the existing animations. However, without a clear definition of these future concepts and without a common understanding of roles and responsibilities, assumptions need be made regarding the usage, integration, and coordination of the information. The concept demonstration approach that we developed could help define such concepts, but nevertheless the validation of the ATS operational concept for 2005 needs to be an on-going activity.

Feedback received from ATDET
~ ODID-like CHI ~

- **Consider incorporating planned, near-term DSR enhancements**
  - Multiple flight plan readout
  - Multiple Dwell Lock
  - Continuous range readout
- **Unless pre-existing, do not use transparent lists (minimize lists on R-side)**
- **Avoid pop-up windows on R-side**
- **Maximize access to data, lists, and functionality through the data block**
  - Use of accessors (next to aircraft ID) has real potential
- **Use graphic representation rather than text**

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The ATS concept of operations for 2005 includes the elimination of flight strips; therefore the ability to quickly and accurately access, manipulate, and update data is a key requirement of the future system. This needs to be done in a way that minimizes the clutter of information on the screen and considers the roles and responsibilities of the users of the information. A major challenge for future concepts is the degree of the role of the radar controller to become more strategic and how best to provide strategic information and tools within the context of his primarily tactical job. Therefore, laboratory demonstrations focused on the future R-side CHI and the suitability of existing ODID features for FAA en route ATC automation. That early feedback included a direction to integrate those DSR enhancements scheduled to be implemented in the near-term (i.e., Multiple Flight Plan Readout, Multiple Dwell Lock, Continous Range Readout) into the laboratory demonstration. Other feedback included their desire to minimize the number and size of lists, to eliminate transparent lists and pop-up windows wherever possible, to maximize use of graphic rather than text data, and to maximize use of the datablock to access data lists and functionality.

The original demonstration to the ATDET surfaced much of the feedback shown on the above slide. The latest demonstration shown to the ATDET in June was based on a scenario that integrated the capability to maximize use of the datablock, maximize graphical and minimize list information, and demonstrate uses of graphical conflict probe, metering, and TACT tools. As detailed in Appendixt B, the Lab demonstration was revised to incorporate the feedback and direction provided by the ATDET at prior demonstrations. Planned enhancements to DSR that have not yet been implemented were also illustrated.

This demonstration, in August 2000, incorporated most of the prior ATDET concerns and was extremely well received. There was very little feedback or suggested changes to the ODID-like CHI made at that time. The ATDET especially liked the integration of the TACT tool into the overall scenario.

Feedback received from ATDET ~ ODID-like CHI ~ (concluded)

- **Improve readability of screen fonts**
- **Try to accommodate differences in controller and site preferences**
  - **Make displayed information adaptable, filterable, selectable**
  - **Easy access to most important information**
- **Core controller roles and responsibilities will remain similar to today**
- **Simple solutions are best**

At the August 2000 meeting, the ATDET responded positively to having accessors added to the right of the Aircraft ID (AID) in the datablock (Graphic examples of the accessors can be found in Appendix B). Additional research remains to be done to validate their operational suitability. The ATDET participants were especially pleased that the application avoided use of the fourth line of the datablock. As future iterations of the laboratory evaluations integrate additional capabilities, competing uses for the datablock, and display real estate will become key areas of further research.

As with the Director® demonstration, the roles and responsibilities of service provider personnel is an area that needs further definition. For purposes of the ODID-like CHI research done to date, the ATDET assumed that core controller roles and responsibilities in the future would remain similar to today. That direction played a key role in the CHI developed for the R-side, allowing the radar controller to remain focused on the datablocks and the real-time situation display using graphical information whenever possible. The objective was to minimize or eliminate any R-side activity that would move that focus elsewhere; such as needing to look at pop-up messages or lists, message composition windows, flight data lists, etc.

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5. Team

CAASD Team Members

- **Director® Demonstration**
  - **Amy Gross**
  - **Pauline Kapoor**
- **En Route Environment Lab Demonstration**
  - **Frank Sogandares**
  - **Gretchen Jacobs**
  - **Kyle Jaranson**
  - **Mike Tran**
  - **Urmila Hiremath**
  - **Jim Woodside and Dave Chaloux (PSI)**
  - **TACT - Chris DeSenti**
  - **CHI feedback - Maria Picardi (MIT/LL)**

This slide identifies the members of the team that put together the Director® and En Route Environment Lab demonstrations. If work were to continue on this activity, the next step for the en route environment lab would be to integrate the data link and PARR concepts via the latest Director® demonstration to evaluate the suitability of ODID-like CHI for those automation capabilities. The next step for the Director® concept demonstration would be to incorporate ODID-like CHI principles demonstrated in the lab and to integrate another future concept, such as weather information.

CAASD

Integrated En Route Sector Concepts Update Director® Scenarios

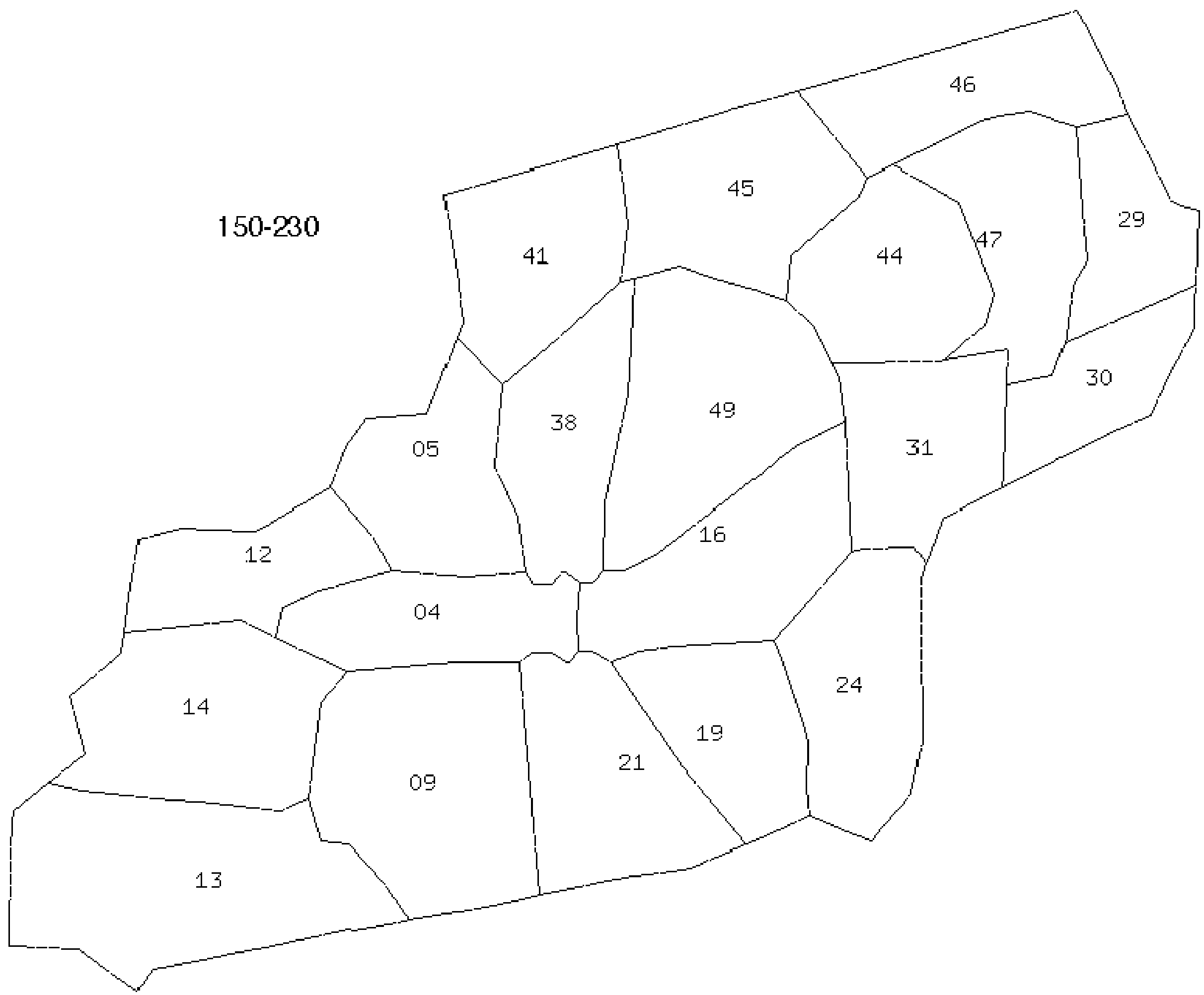
Appendix A

Appendix A provides a sequence of screen shots from the most recent Director® scenarios. These screen shots depict some of the scenarios' salient features that demonstrate an integrated concept for using the en route capabilities being developed to support the ATS vision for the future ATM system. This deliverable also includes a CD-ROM that contains the QuickTime™ versions of the five scenarios shown from the view of a TMC, an LSP, an en route sector radar controller, and an en route/transition sector radar controller. There are two scenarios for the en route sector contoller, one showing automated coordination, and the other showing procedural coordination. Instructions for running the animations are included on the CD-ROM.

The TMC is responsible for managing the arrival flows, balancing workload across the corner posts to minimize delays, and imposing restrictions if necessary. The LSP is responsible for developing an operationally suitable strategy for implementing the TMC's flow decisions. The sector controllers are then responsible for taking the tactical actions necessary (e.g. ensure separation, provide clearances, amend flight plans, etc.) to carry out that strategy.

The TMC scenario shows a situation display of traffic for an entire en route center based on Atlanta center airspace. It also shows two TMA time lines and TMA messages for the arrivals into Atlanta over the northwest and southwest corner posts. Although (ETMS and CRCT are not part of the animation, due to limitation of display space, the annotation provided here describes how these tools would be incorporated into the TMC decision making process. The traffic situation examined in all the scenarios consists of rerouting traffic from the southwest to the northwest to balance the load and reduce delays.

Atlanta ARTCC Low Altitude Sectors



This slide shows the sector configuration depicted in the Director® scenarios.

Background

- Traffic Management Coordinator tools
  - Situation Display, TMA, CRCT, ETMS, CDM, Automated Coordination
- Layered Strategic Planner tools
  - Situation Display, Electronic Flight Data Display, Conflict Probe, Conflict Resolution, Automated Coordination
- Tactical Controller tools
  - Situation Display, Electronic Flight Data Display, Controller Pilot Data Link, TMA Meter List, Transition Airspace Controller Tools (TACT), Conflict Resolution (PARR), Conflict Probe (URET), Automated Coordination, Automated FP amendments

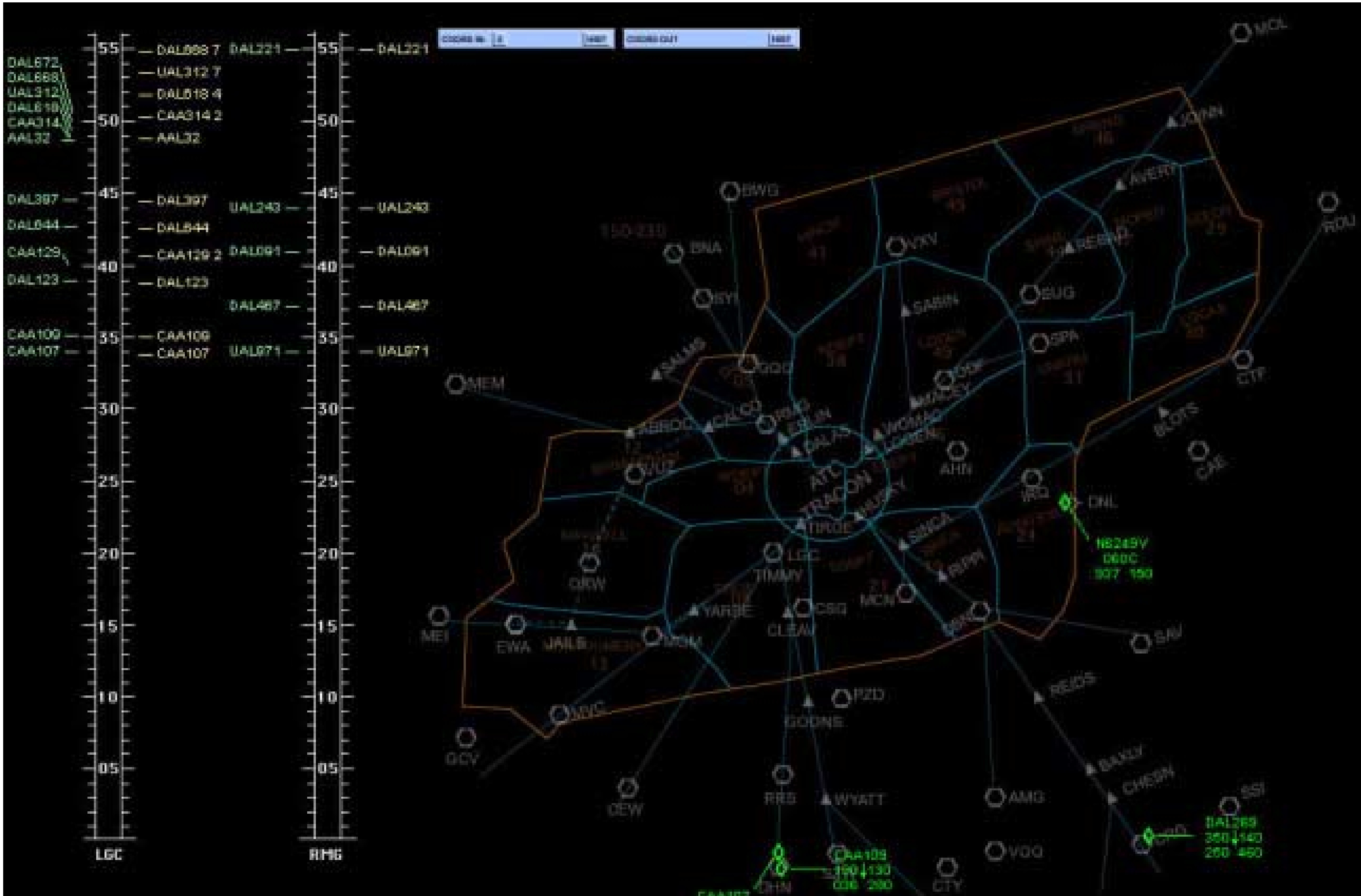
Layered Strategic Planning is a future concept currently being considered to accommodate predicted growth in the NAS. It is included here in lieu of two D-controller scenarios to investigate some of the coordination issues concerning the concept that were raised by the ATDET. The LSP animation demonstrates many of the same strategic activities that would be performed by a D-side position using similar electronic data and automation tools.

There are two scenarios shown for the radar controller responsible for Sector 13, the position responsible for implementing the reroute (i.e., send clearances, amend flight plans). The sector 13 scenario demonstrates controller use of Controller Pilot Data Link, Conflict Probe, Automated Coordination, Pre-composed messages, and Automated FP amendments. In one scenario, coordination is accomplished primarily through automation, while the other scenario shows procedural coordination.

The final scenario shows the traffic situation handled by the radar controller for the arrival sector. The Sector 5 scenario demonstrates the use of electronic flight data, and the TMA Meter List.

The airspace used as background in the demonstration is based on the low altitude sectors at the Atlanta Air Route Traffic Control Center (ARTCC). The traffic situation examined in all of the scenarios consists of a need to reroute traffic from the southwest to the northwest to balance the load and reduce delays.

TMC - Traffic Situation Display and TMA Timelines

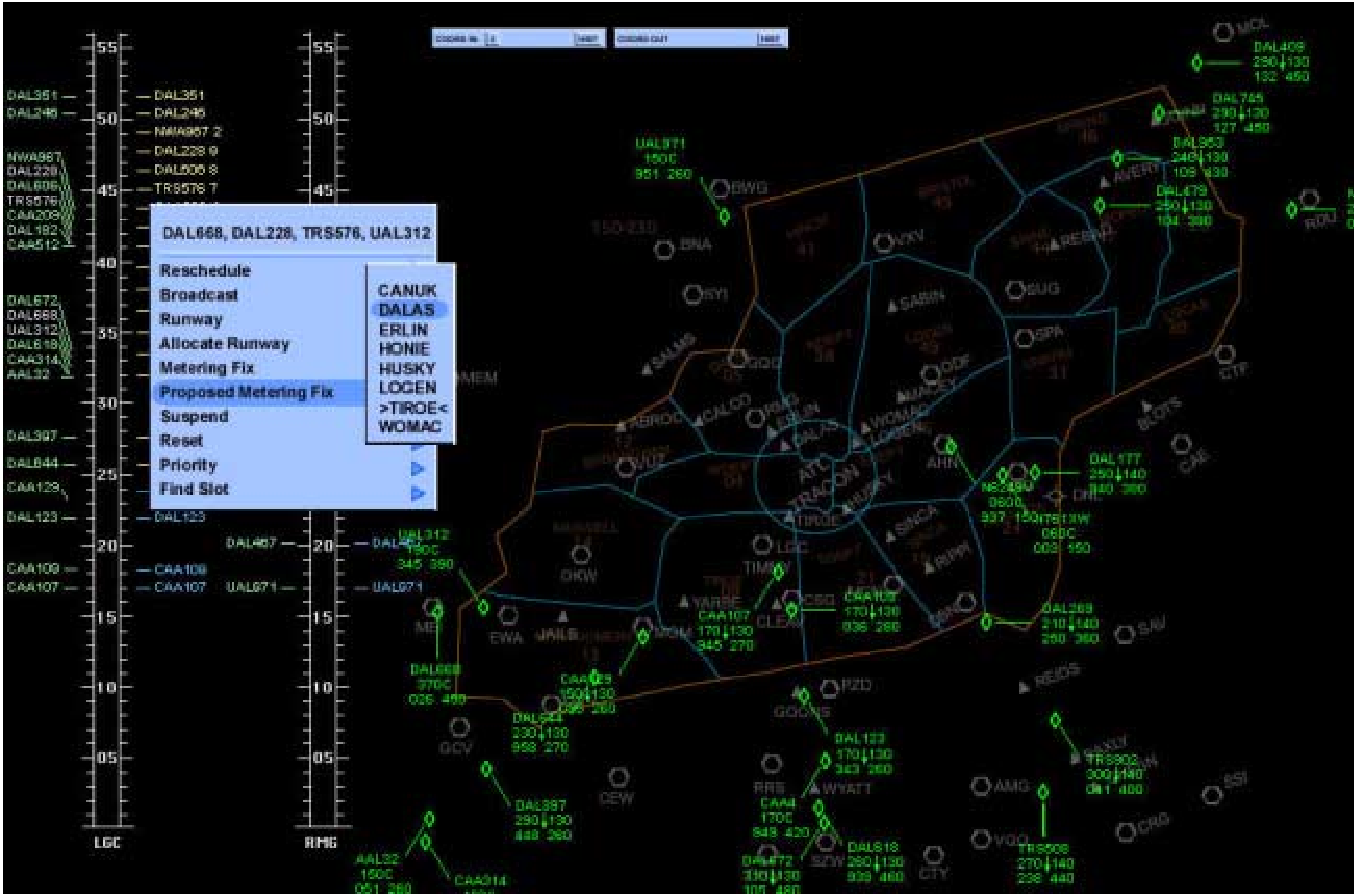


The TMC scenario depicts a situation display showing traffic for an entire en route center based on Atlanta center airspace. It also shows two TMA timelines and TMA messages for arrivals into Atlanta over the northwest and southwest corner posts. Due to the limited display size on which the animation is planned to be run, only the two timelines are shown even though there is traffic arriving over all four corner posts. Although ETMS and CRCT are not part of the animation, also due to the limitation of glass space, the annotation provided here describes how these tools would be incorporated into the TMC decision making process.

The above display shows the Atlanta ARTCC low altitude sectors and the main arrival traffic flows for scenario traffic. The example superimposes TMA timelines for the two western corner posts onto the TMC display. Lists are also available at the top of the screen to facilitate the exchange of coordination messages with other center personnel. When no messages are waiting to be received or sent, the list heading is miniaturized to reduce screen clutter.

The TMA timelines enable the TMC to see the estimated and scheduled times of arrival for aircraft crossing the TIROE (or LGC VOR) and DALAS (or RMG VOR) meter fixes. DALAS is a meter fix within Sector 5. The display contains information on flights that have not yet entered the center's airspace to provide the TMC greater time in the decision making process. In this example, the TMC currently sees that although traffic is relatively light, traffic is building coming in from the southwest. In about 50 minutes, without any action, there will be significant delays over TIROE.

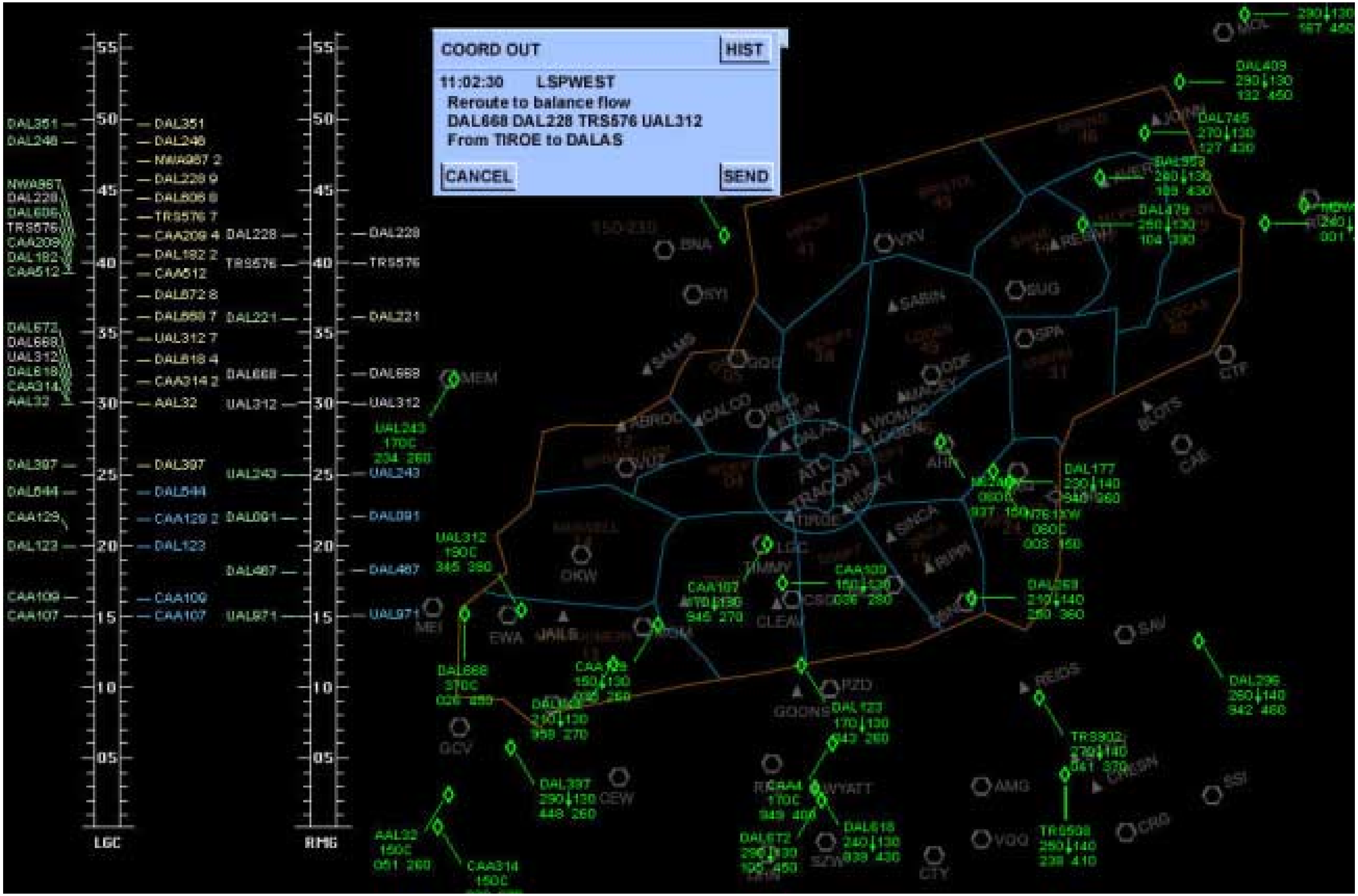
TMC - TMA Proposed Metering Fix Change



In this frame, the TMC has seen on the TMA time lines the delays continuing to build up over TIROE, while DALAS traffic remains relatively light. The number in the center of each time line indicates the minutes left until the aircraft will be crossing the meter fix. The TMC uses the ETMS traffic situation display to look at the traffic flows coming into the center. The TMC also uses the CRCT to examine sector workload over the time period in question. Using these tools, the TMC determines that several aircraft arriving on the northernmost route into TIROE are good candidates for a reroute to DALAS. The CRCT Sector Count Monitor assures the TMC that the reroute will not create an excessive workload situation for any of the sectors affected by the potential reroute.

To help balance gates, the TMC selects the TMA proposed metering fix feature to create clone aircraft tags for DAL668, DAL228, TRS576, and UAL312, tentatively assigned to an alternate metering fix. TMA calculates new flight paths and estimated times of arrival (ETAs) for the proposed rerouted aircraft. Until the reroute is accepted or cleared that aircraft tags for the affected aircraft are indicated in white on both timelines. This enables the TMC to see clearly the affect of the reroute on the arrival streams over each corner post. It also pre-composes a coordination message that can be sent to either a layered strategic planner, to an associate radar controller, or in some cases, to a radar controller, depending on the center’s current sector configuration. An example of the coordination message is discussed along with the next scenario frame shown.

TMC - Automated Coordination with LSP

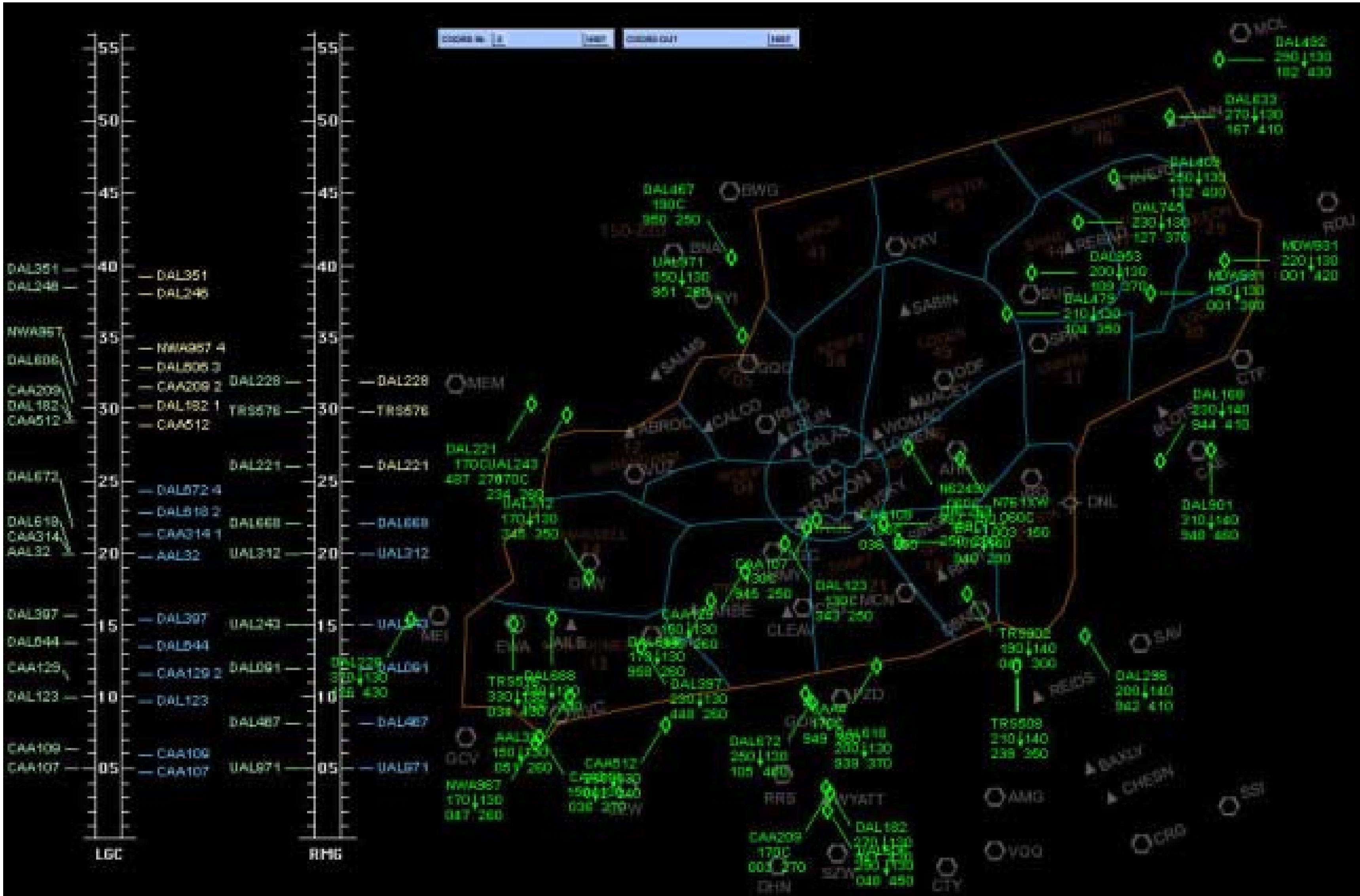


Upon receiving the proposed metering fix change, the system automatically pre-composes a coordination message for the TMC. The time-stamped message identifies the recipient (based on the center configuration), the action to be performed and why, and the aircraft involved. The TMC can decide to cancel the reroute and not send the message, modify any part of the message and send it, or send the message as is, by clicking on the CANCEL or SEND button in the message window. The TMC can also review any other coordination messages that have been sent within a preset time frame, but clicking on the HIST (History) button.

In this example, the TMC sends the coordination message to a multi-sector LSP. In the concept for this future position, the LSP performs resource planning and flight planning in the short- to mid-range strategic time frame. Flight planning includes adjusting smaller traffic flows and handling strategic problems to maintain an operationally acceptable workload for the sector planning or tactical controllers. Details on this concept can be found in the MITRE Technical Report MTR00W0000064, *Layered Strategic Planning in the En Route National Airspace System (NAS): Air Route Traffic Control Center (ARTCC) Perspective*, August 2000.

Until the reroutes have been carried out, the affected aircraft continue to be shown in white on both TMA time lines. The blue aircraft tags indicate that the STAs have been frozen for those aircraft and that they are now displayed at the sector position in the meter list. Rerouting aircraft after their STAs have been frozen is considered extremely undesirable.

TMC - Aircraft Rerouted, Timelines Updated



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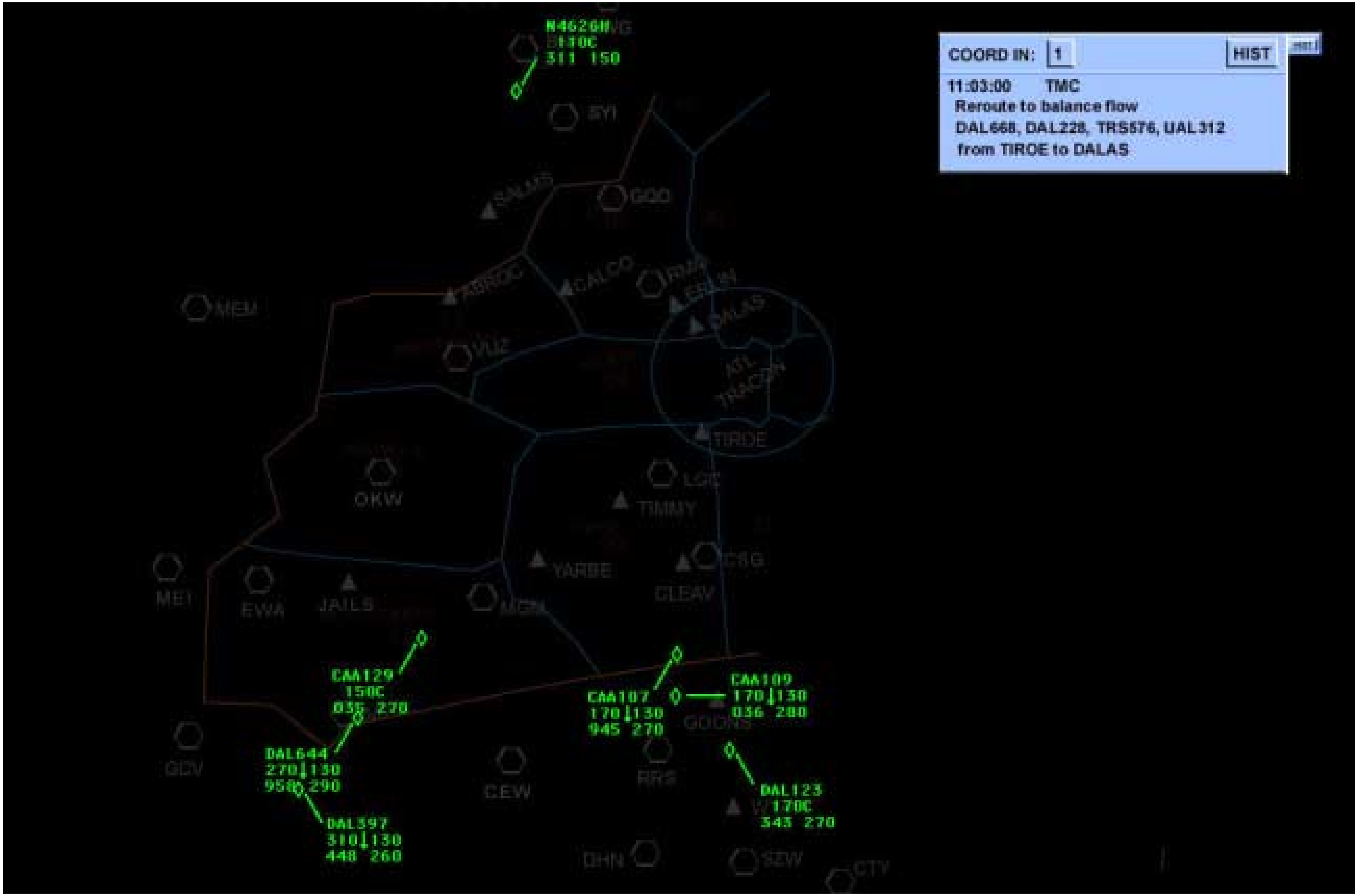
In this final frame shown from the TMC scenario, the TMC has been notified that the reroute has been executed by the Sector 13 radar controller, following instructions by the LSP. Subsequent scenarios further highlight the coordination and activities that have taken place at those positions, as well as show the effect of the reroutes on Sector 5, which is the arrival sector responsible for ensuring the STAs are met.

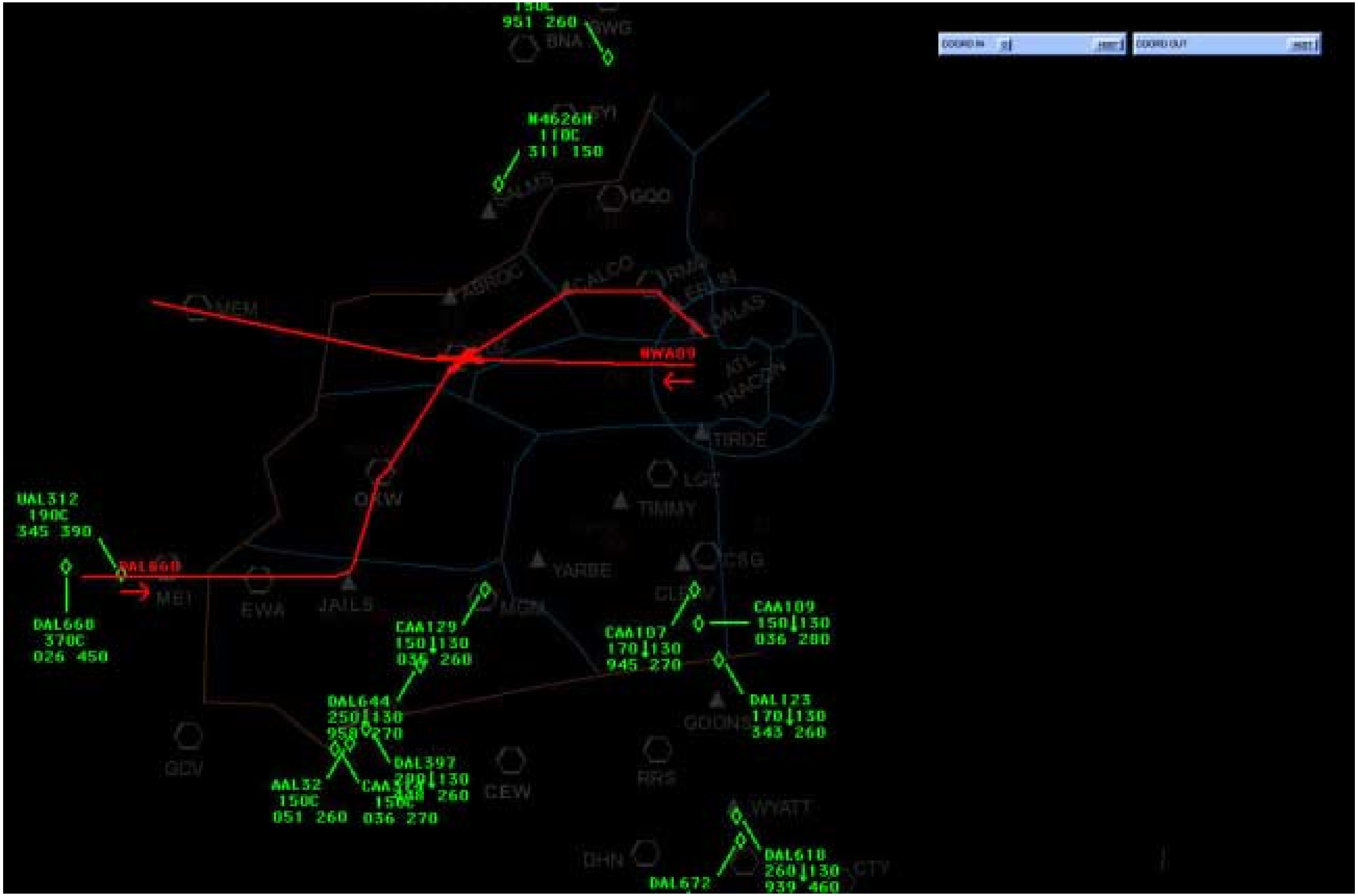
As can be seen on the display, UAL312 and DAL668 have begun to reroute to the north. The TMC has accepted the TMA proposed metering fix change and the time lines have been updated accordingly. The rerouted flights have been taken off the LGC timeline, and are no longer shown in white on the RMG time line. As a result, delays that need to be absorbed for LGC traffic have been reduced to no more than 4 minutes, an acceptable duration absorbable within Terminal Radar Approach Control Facility (TRACON) airspace. The other time line shows that the rerouted traffic can be merged into the RMG arrival stream with no additional delay needed to be absorbed to provide acceptable spacing at the DALAS meter fix. The animation continues until the last aircraft has been handed off to the Atlanta TRACON.

LSP - Coordination message received from TMC



This next scenario sequence shows the same traffic situation that was handled by the TMC, but from the viewpoint of the LSP position. Layered Strategic Planning is a future concept currently being considered to accommodate predicted growth in the NAS. It is included here in lieu of two D-controller scenarios, to investigate some coordination issues concerning the concept raised by the ATDET. The LSP animation demonstrates many of the same strategic activities that would be performed by a strategic-D position using similar electronic data and automation tools. In this example, the LSP has responsibility for strategic planning and problem resolution for the western sectors. The LSP has just displayed the coordination message received from the TMC requesting that the four aircraft be rerouted. The LSP displayed the message by clicking on the counter located in the header of the coordination message in the window.

LSP - URET shows Reroute has predicted Conflict



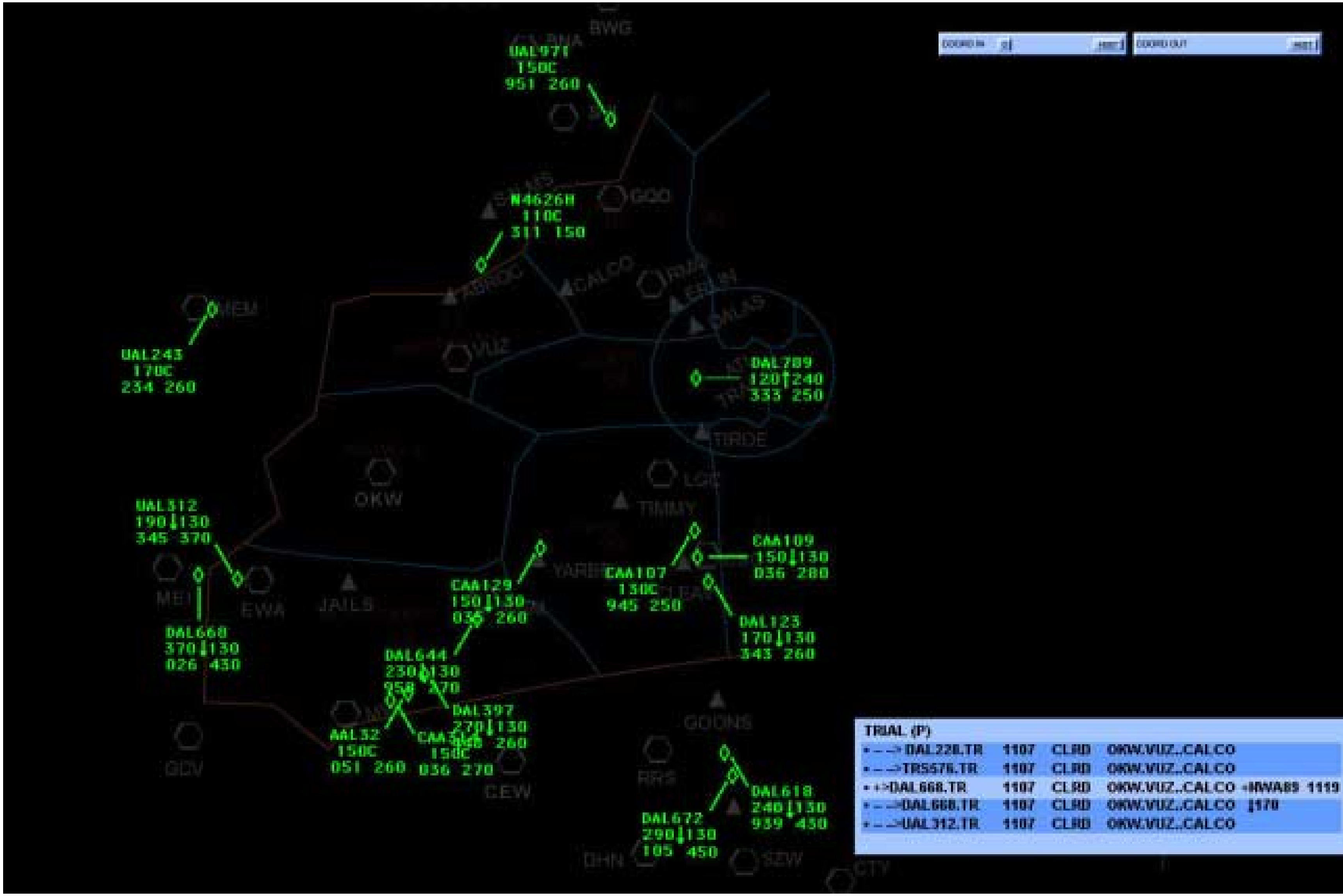
The LSP uses the conflict probe tool to draw out a reroute and determine whether that new route is conflict-free. The first reroute selected for DAL668 (by clicking on the desired points on the display) results in a potential conflict with NWA89, a flight scheduled to depart from Atlanta's Hartsfield airport in the near future. The LSP decides to examine alternate altitudes to seek a resolution. This is shown in the following screen shot.

LSP - URET shows Reroute is Conflict-free

Having seen the graphic display of the potential conflict between DAL668 and NWA89, the LSP decides to see whether alternate altitudes can resolve the conflict. Taking advantage of an ODID-like CHI feature, the LSP clicks on the altitude field in the DAL668 trial plan to bring up the altitude menu. (Note: this is just one example, the actual CHI for entering in composite maneuvers still needs to be defined.) The altitude menu provides further visual aid to the controller by indicating the conflict status of each altitude in the menu. The altitude menu shows that DAL668's assigned altitude of 13,000 feet at the point where it intersects NWA89's flight path has a potential conflict (i.e., colored red).

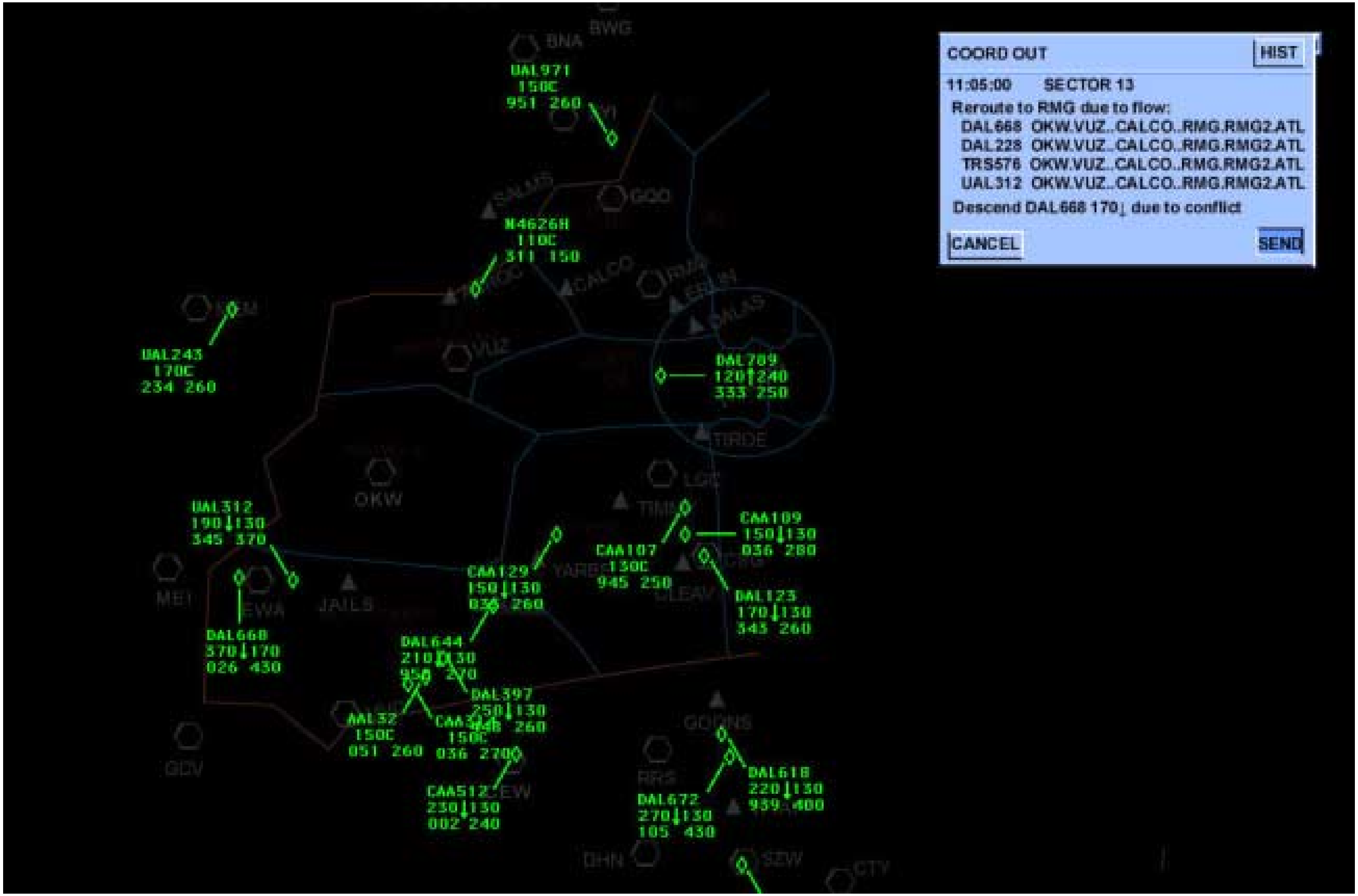
The LSP decides to instruct the Sector 13 radar controller to assign a conflict-free interim altitude of 17,000 feet and determine at a later time when to descend the aircraft to 13,000 feet prior to crossing DALAS. Although not shown in this frame, the LSP has checked the same route amendment for UAL312, TRS576, and DAL228 and determined those reroutes are conflict-free.

LSP - URET Trial Plans Selected from List



Each of the trial plans run by the LSP can be shown in a list, as well as graphically. This example shows the trial plans in a list at the bottom right corner of the situation display in accordance with chosen LSP preferences. It includes the trial plan that resulted in a conflict and the four conflict-free reroutes. Note that DAL668's plan will result in amendments to both route and altitudes. The LSP clicks on the trial plans for the radar controller to execute. This results in the pre-composition of coordination messages for the radar sector which has (or will have) control, based upon the trial plans selected, as shown in the next screen shot.

LSP - Pre-composed Reroute Message



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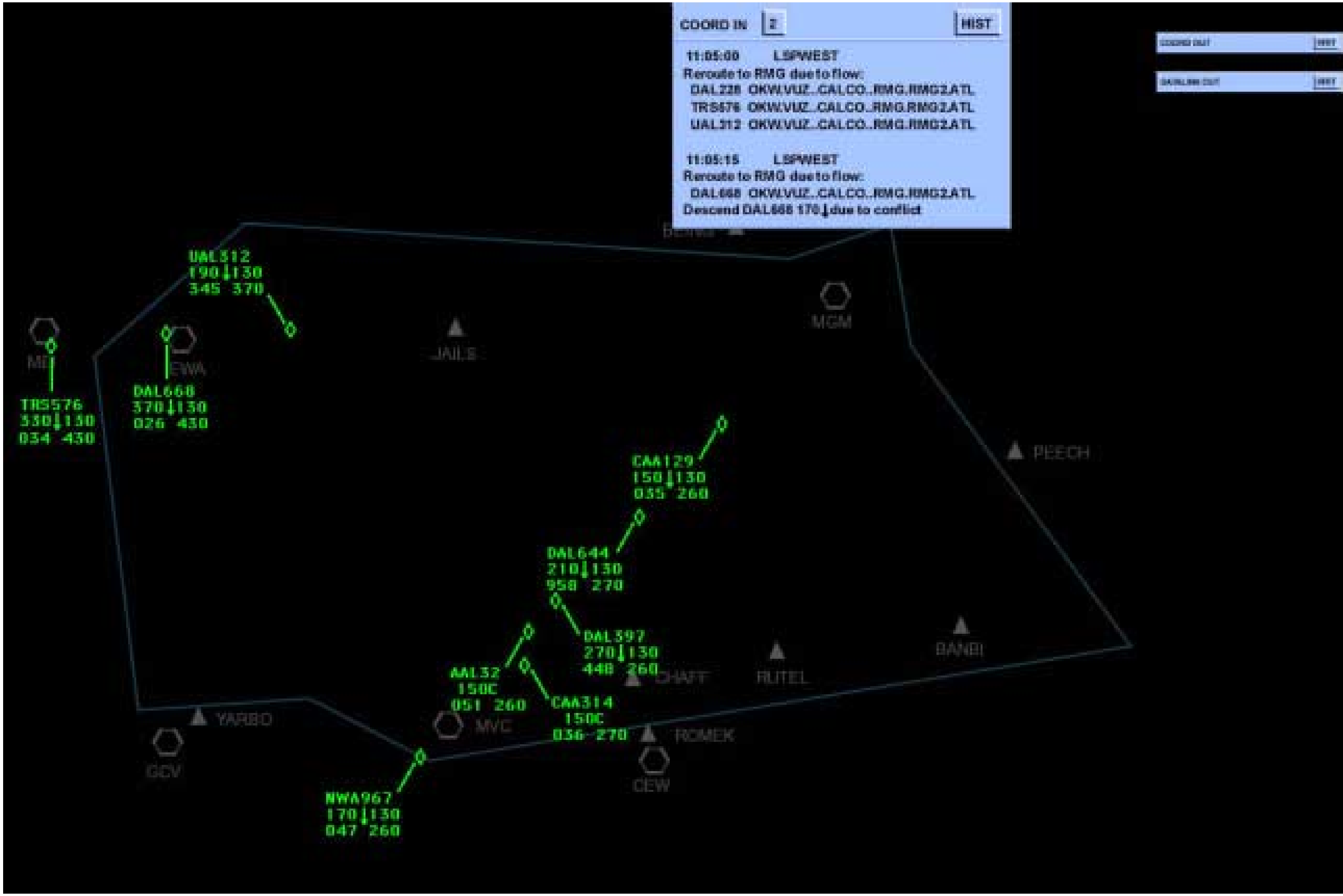
A list of pre-composed coordination messages is displayed to the LSP in accordance with chosen preferences, based on the selection of trial plans from the list. The LSP scans the messages to note if they accurately reflect the LSP's intent and chooses to send reroute messages to the sector radar controller for implementation, including sending the clearances and amending the flight plans. The coordination message includes the operational reason for the reroutes, the route change proposed, and any additional clearances needed to ensure the reroutes are predicted to be conflict-free. Subsequently, the LSP will receive an indication that the controller has issued the reroute and amended the aircraft's flight plan (this can be accomplished procedurally or through automatic generation of a message or indicator on the LSP workstation). Additional coordination is needed only in the event that the radar controller does not clear the aircraft as proposed by the LSP.

Sector 13 - Reroute Message Received from LSP

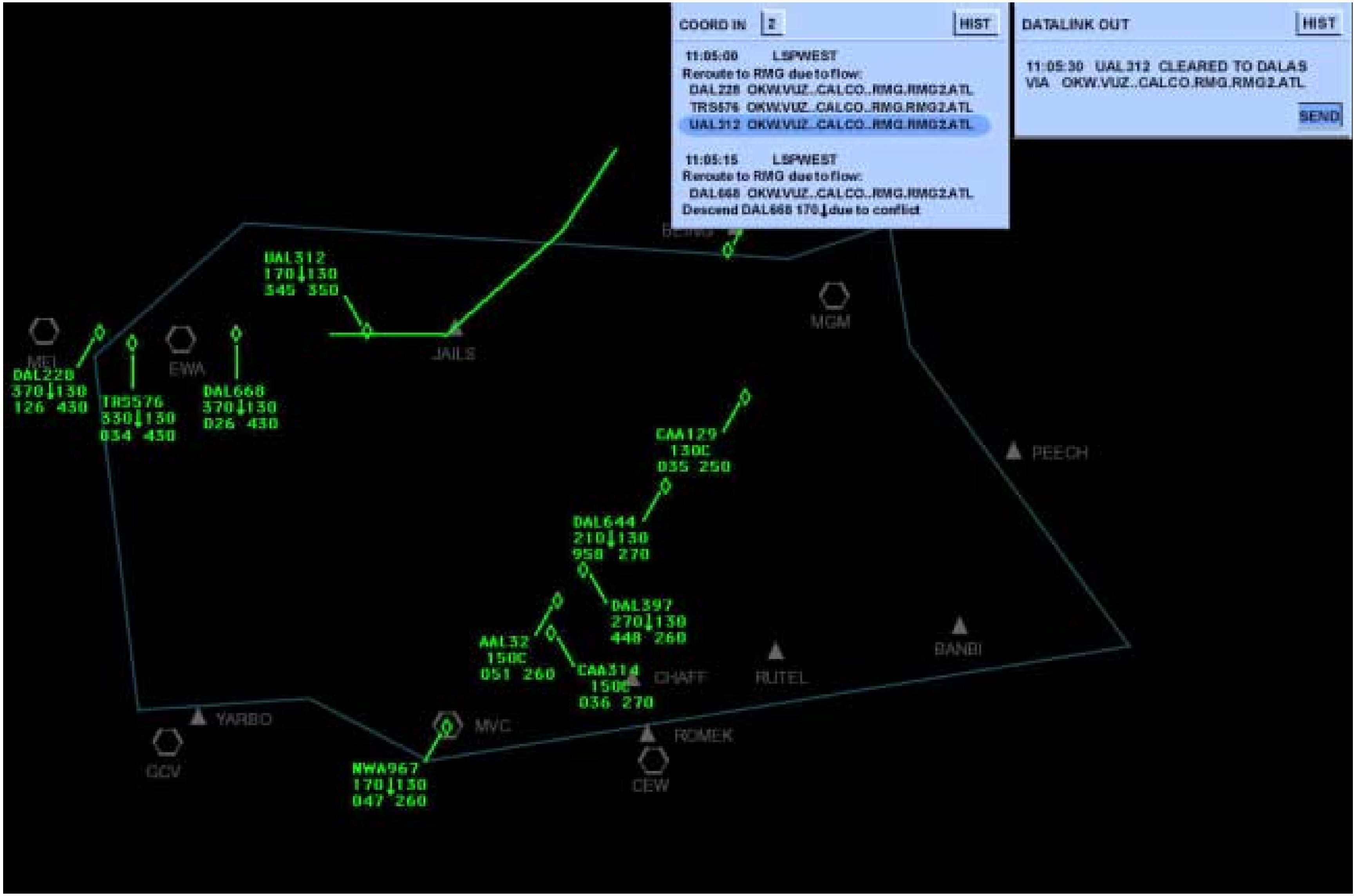


This next scenario sequence shows the same traffic situation that was handled by the TMC and LSP, but from the viewpoint of the Sector 13 radar controller. In this scenario, Sector 13, shown here, sends the reroute clearance to the aircraft. The animation for that sector shows integrated use of conflict probe, conflict resolution, data link, automated coordination, and automatic flight data updates.

Another animation was developed for the same sector and situation, but modified to show use of the data block to receive a data link response and procedural coordination with the LSP, where the reroutes were carried out exactly as specified. This illustrated how quickly animation changes could be made, enabling us to provide a rapid response to ATDET feedback on their preference for defining procedures, rather than use of automation, to handle routine situations.

In this frame, the Sector 13 radar controller has received and displayed the reroute messages from the Layered Strategic multi-sector Planner responsible for airspace west of the Atlanta TRACON. Based on procedures, the radar controller assumes that the LSP has checked for conflicts prior to sending reroute messages. If the radar controller gives the clearances specified, the result will be conflict-free routings.

Sector 13 - Route Clearance Uplinked to Aircraft



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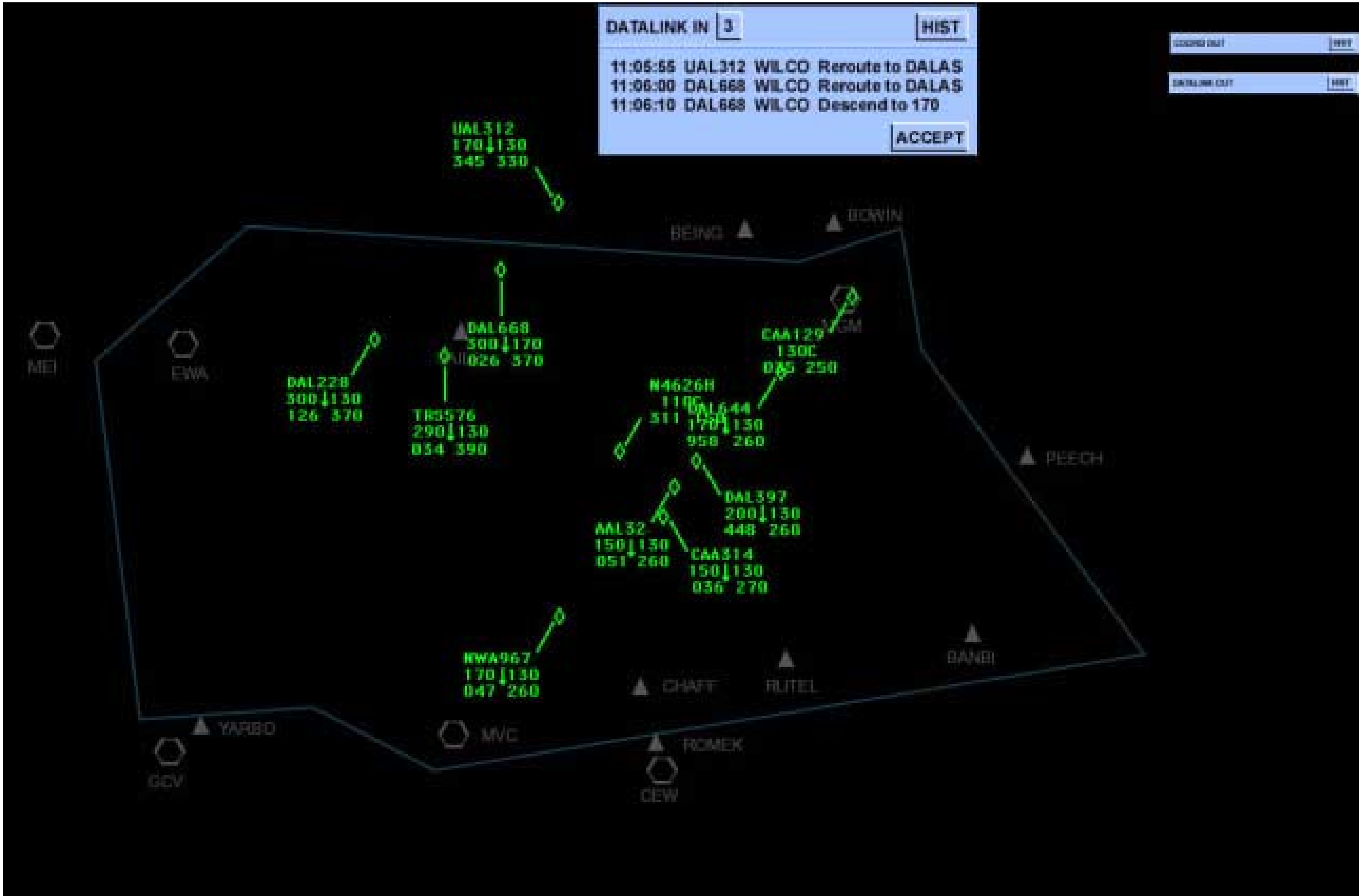
This display shows that by clicking on a reroute message sent by the LSP, the system automatically pre-composes a datalink message to be transmitted to the aircraft. In addition, the proposed reroute is displayed graphically on the radar controller's workstation, providing visual reassurance that the reroute is conflict-free, as indicated by its green color. The controller can choose to send the datalink message as composed, manually make changes, or cancel the message.

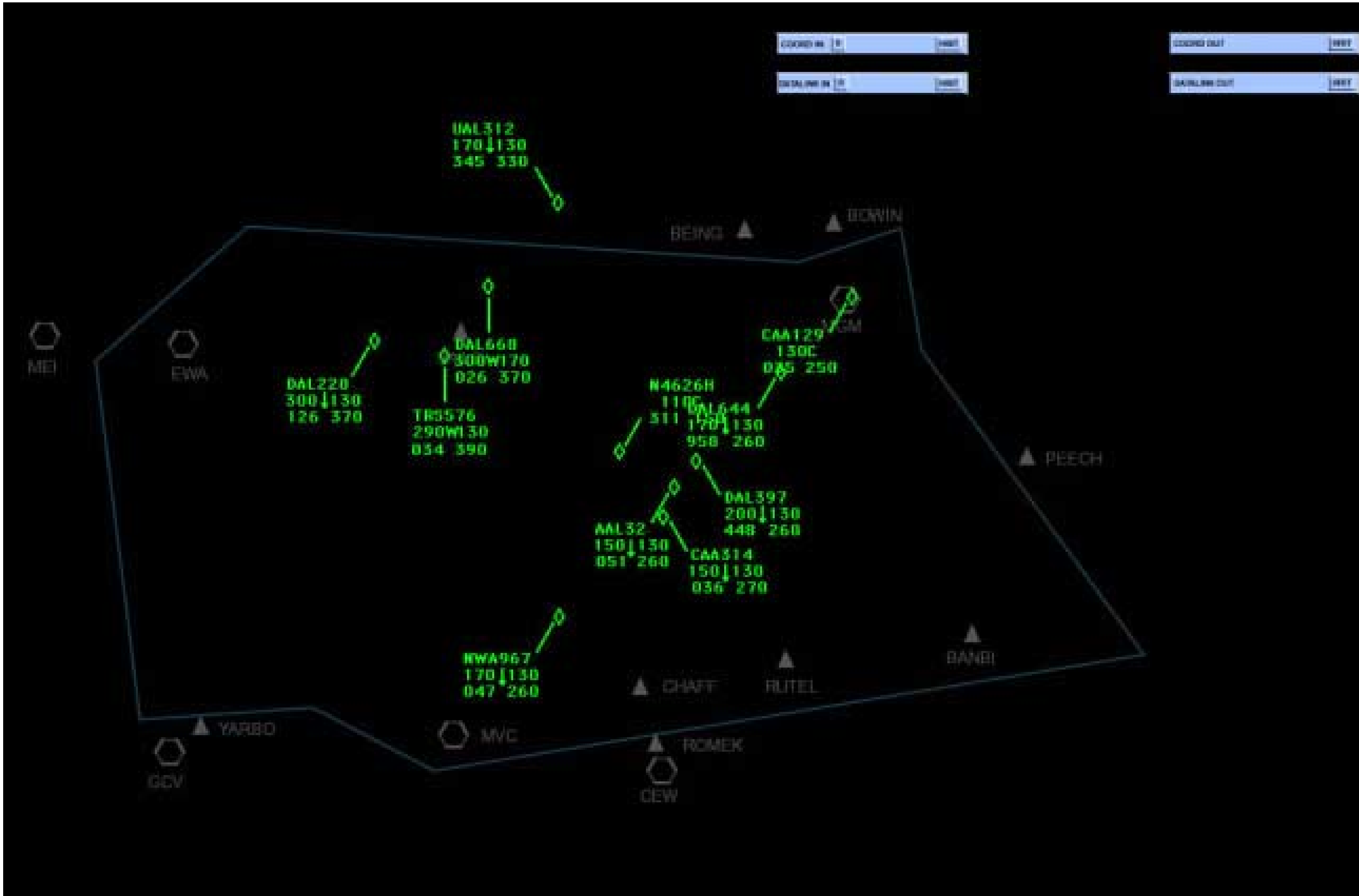
In this example, the controller sends the new route clearance to UAL312, as proposed by the LSP. When the controller issues reroute clearances to the involved aircraft, the aircraft's current flight plan is automatically updated to reflect the new route in the en route computer's flight plan database.

Sector 13 - Automated Coordination of WILCO



This screen shot shows an example of how the automation could be used to support coordination. The controller notes that there are data link messages and clicks on the title bar, which results in the display of those messages. In this case, the rerouted aircraft have responded with a “WILCO,” indicating that they will comply with the clearance given them by ATC. By selecting and accepting the data link messages, the system will automatically pre-compose coordination messages to send to the LSP, indicating that the reroutes have been made. The next slide demonstrates an alternative concept, whereby intrafacility coordination is handled through procedures for routine situations.

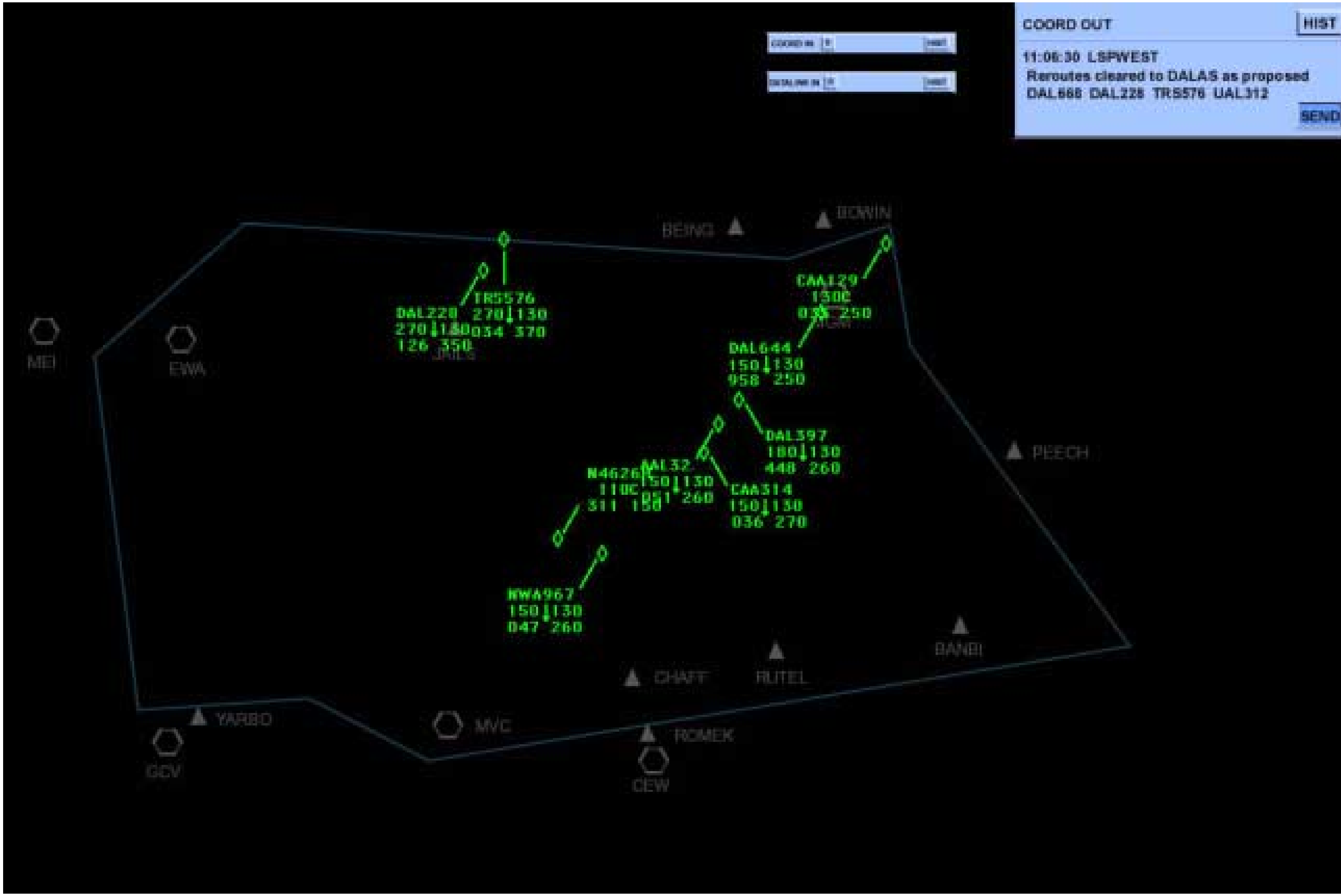
Sector 13 - Procedural Coordination of WILCO



This example shows the same traffic situation as the previous slide. In this case, instead of receiving a routine “WILCO” data link message, a “W” is inserted into the datablock for a short period of time. This enables the controller to acknowledge that the pilot is following the clearance without requiring additional manual response. This also enables the radar controller to maintain focus on the datablock and the traffic situation.

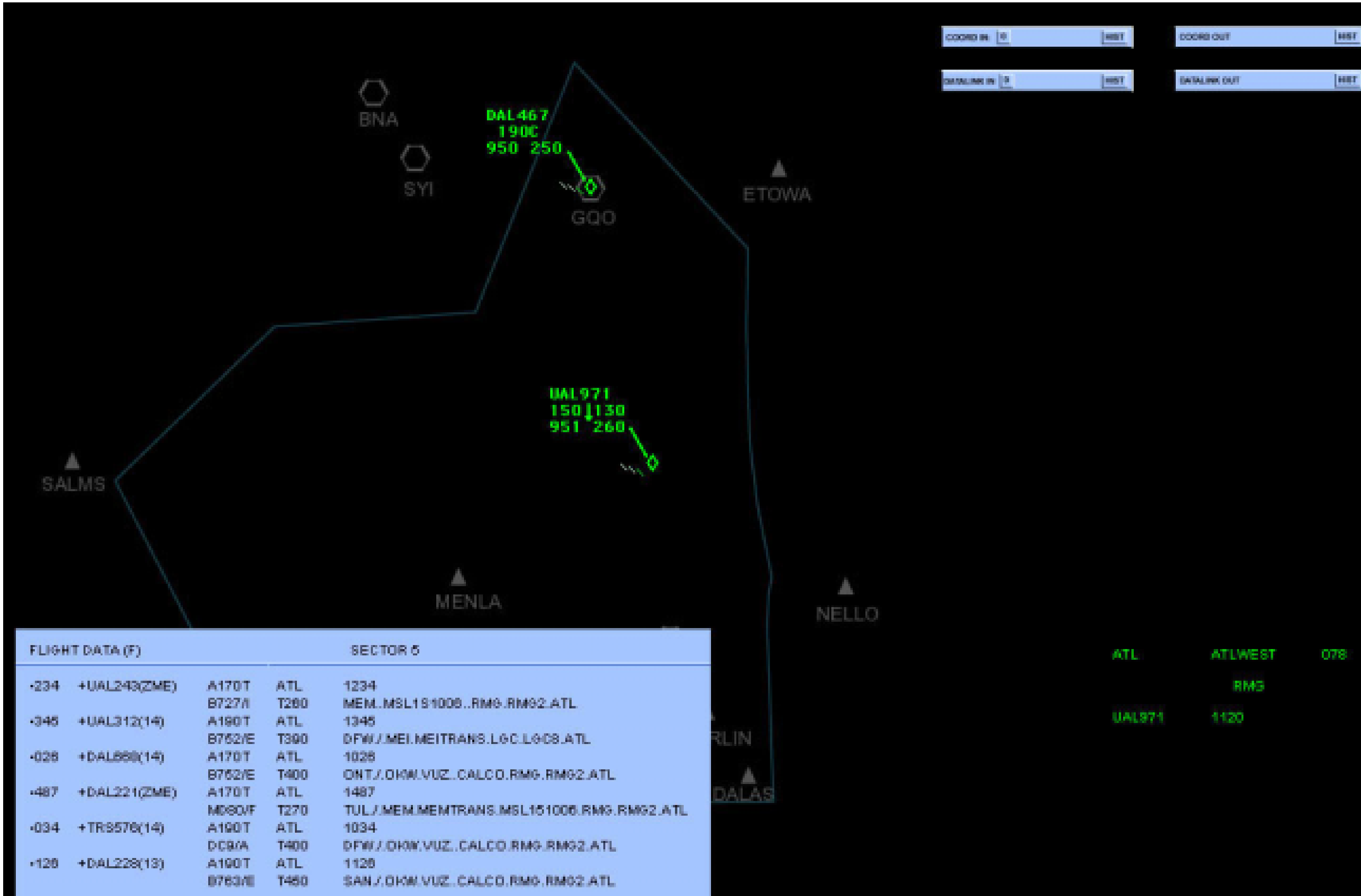
Another capability of this procedural solution is that the “W” would also be displayed on the LSP and TMC situation displays. Since the situation has been handled without exception to the instructions given by both positions, the procedures could also specify that this would meet the requirement for coordination. As a result, the workload for all positions would be reduced. This scenario was developed specifically to respond to ATDET feedback on the need to reduce workload, handle routine situations procedurally, and minimize the number of activities that could take the tactical controller’s focus away from the primary situation display.

Sector 13 - Automated Coordination with LSP



This example demonstrates a situation where coordination is still being handled through automation. The Sector 13 radar controller has accepted the downlinked “WILCO” messages shown previously and that has resulted in the automatic pre-composition of the coordination message. The controller can choose to send the message as composed, modify it, or cancel the coordination message to implement an alternative action.

Sector 5 - Inbound Traffic List is Displayed



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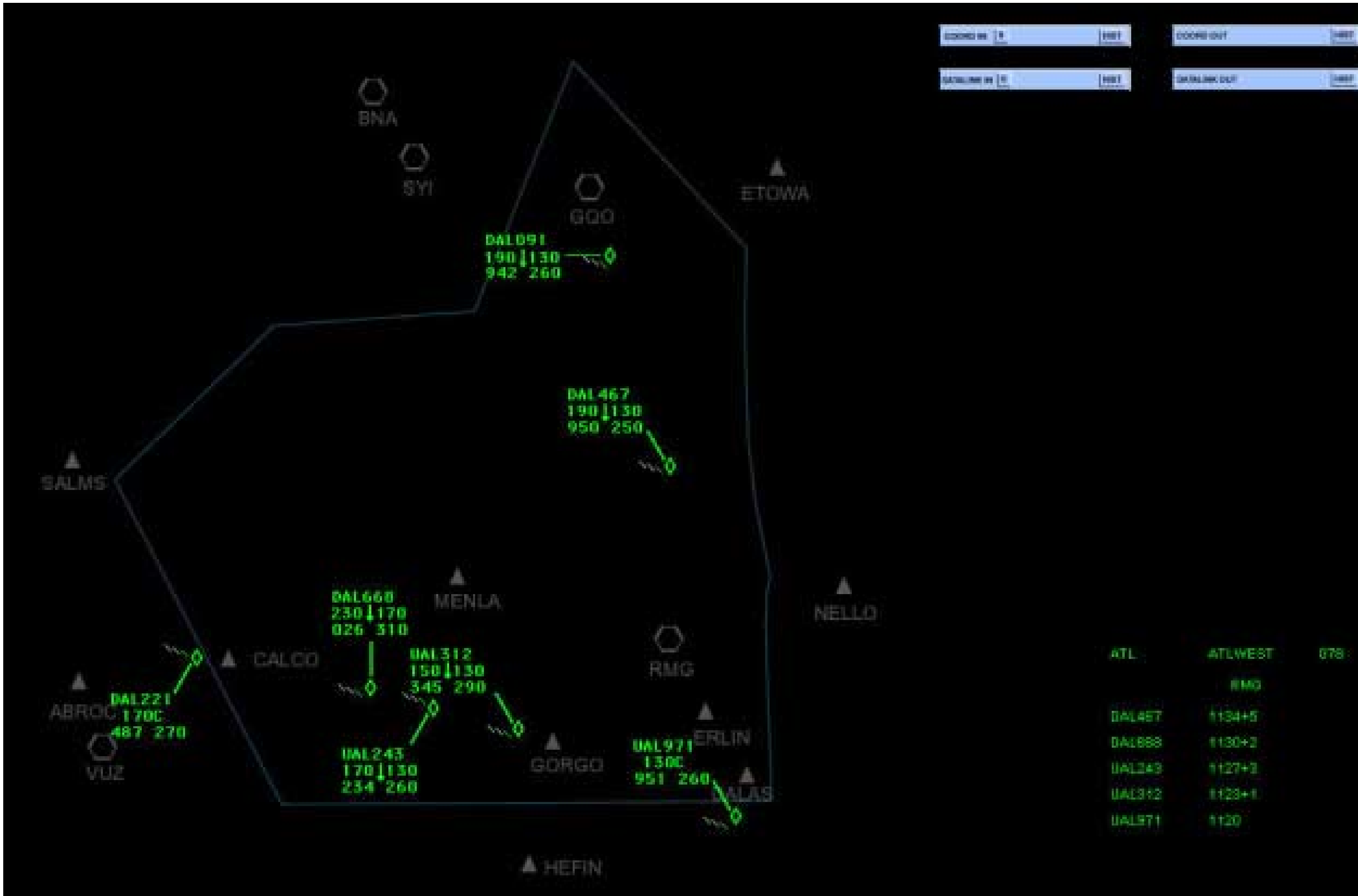
Sector 5 is the transition arrival sector responsible for merging rerouted aircraft into the arrival stream and meeting the associated scheduled times of arrival for the aircraft at the meter fix. Including this sector position in the overall concept enabled demonstration of the integration of the TMA metering list, inbound list, and discussion of the TACT tool.

This example from the Sector 5 animation shows the sector controller displaying the inbound list, which illustrates the use of electronic data, in place of paper flight strips. The inbound list provides the controller with information on flights under his control and those flights that will be entering his sector within some parameter of time. In this example, the inbound list has been updated to reflect flights that were rerouted by Sector 13.

The meter list is displayed in the lower right portion of the screen, as determined by controller preference. The meter list indicates that the runways are in a configuration designated Atlanta West, with the airport acceptance rate set at 78 aircraft an hour. UAL971 has a scheduled time of arrival at the meter fix of 11:20:00 and the radar controller does not need to have the aircraft absorb any delay. Because the Sector 5 radar controller has no active data link or coordination messages, the list headings have been miniaturized to reduce screen clutter.

Sector 5 - Meter List Times Displayed by TMA



Because of the previous strategic planning, the Sector 5 radar controller now has a relatively less complex workload. There should be fewer conflict situations that need to be resolved tactically. Instead, the focus is on ensuring that aircraft meet the scheduled times of arrival in the metering list, thereby maximizing available capacity, reducing delays, and improving fuel efficiency.

In this example, the TMA meter list indicates the schedule and sequences for aircraft arriving into Atlanta. Again, as a result of the strategic planning, the radar controller is able to have the aircraft meet the scheduled meter times without having to make additional tactical maneuvers to absorb delay. The rerouted aircraft have been merged effectively into the original arrival stream.

Note that history trails have been added to this scenario in order to demonstrate the flexibility of the animation to incorporate CHI features. The flexibility of the animation allows for a wide range of realism, incorporated as needed to convey a given concept.

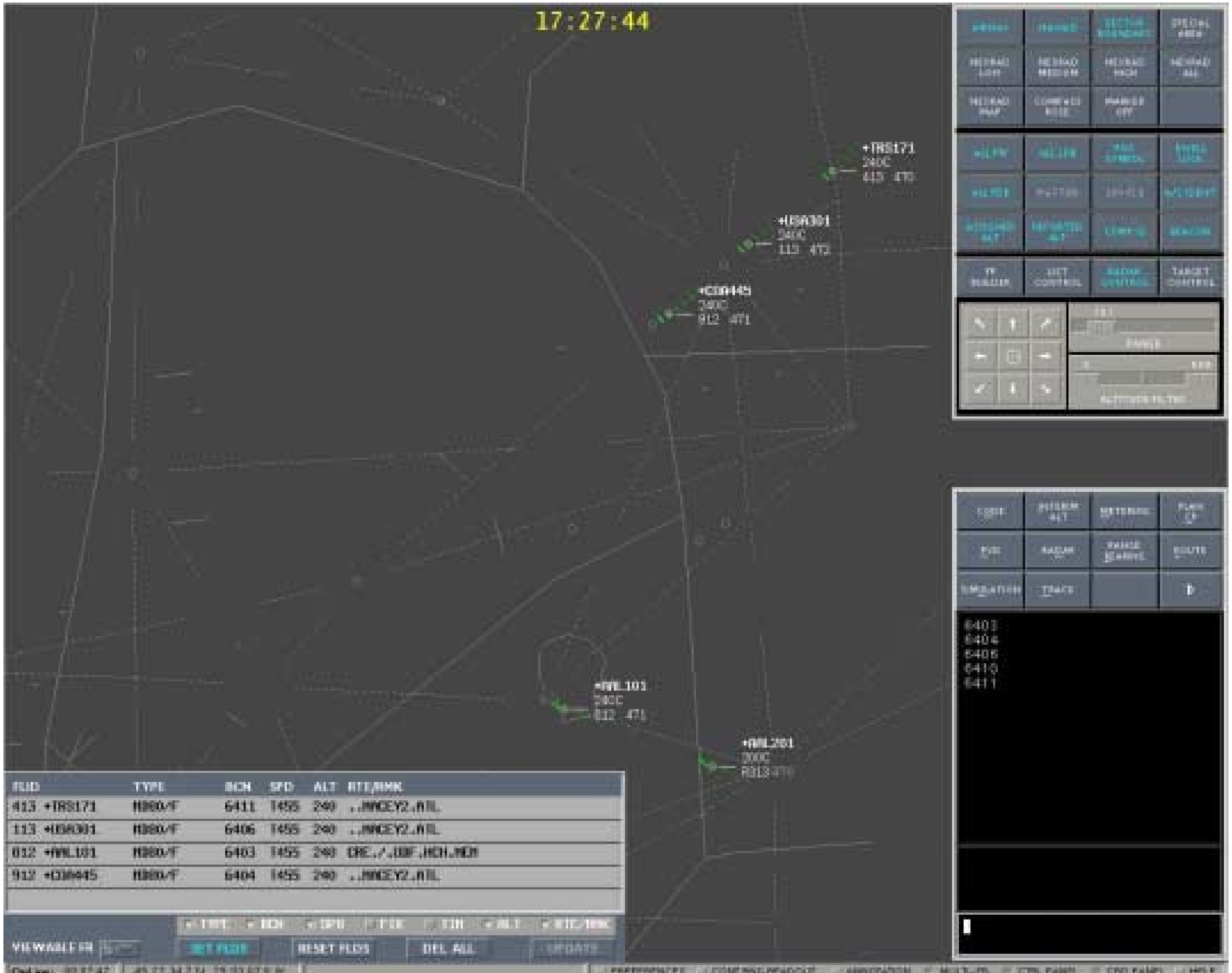
Integrated En Route Sector Concepts Update Laboratory Scenario

Appendix B

This appendix illustrates an ODID-like CHI, demonstrated in CAASD's laboratory environment, that supports an integrated concept for using various en route capabilities being developed to support the ATS vision for the future ATM system. The CHI builds upon prior research done by MITRE CAASD, EUROCONTROL, MIT/LL, and the Air Traffic DSR Evolution Team (ATDET). The CHI was developed consistent with guidance specified in the *En Route Oceanic CHI Upgrade Plan*. Appendix A of that document, ODID Design Principles and Associated Design Questions, addresses areas such as data block composition, flight plan information display, color, pop up windows, system assisted coordination, and three-button input devices.

For example, the uses of the three mouse buttons in the laboratory system were based on ODID design principles. The left (Action) button is used to initiate system dialogue and input new values into the system. It is used for all flight level modifications, route changes, and clearances. The middle (Information) button is used to graphically display additional flight plan information. The kind of information displayed is contextually implied by the field selected. The right (Window Management) button is used for window management applications such as resize, move, and close. A single click of the mouse button implies complete action, i.e. data input or information request.

Multiple Flight Plan Readout View

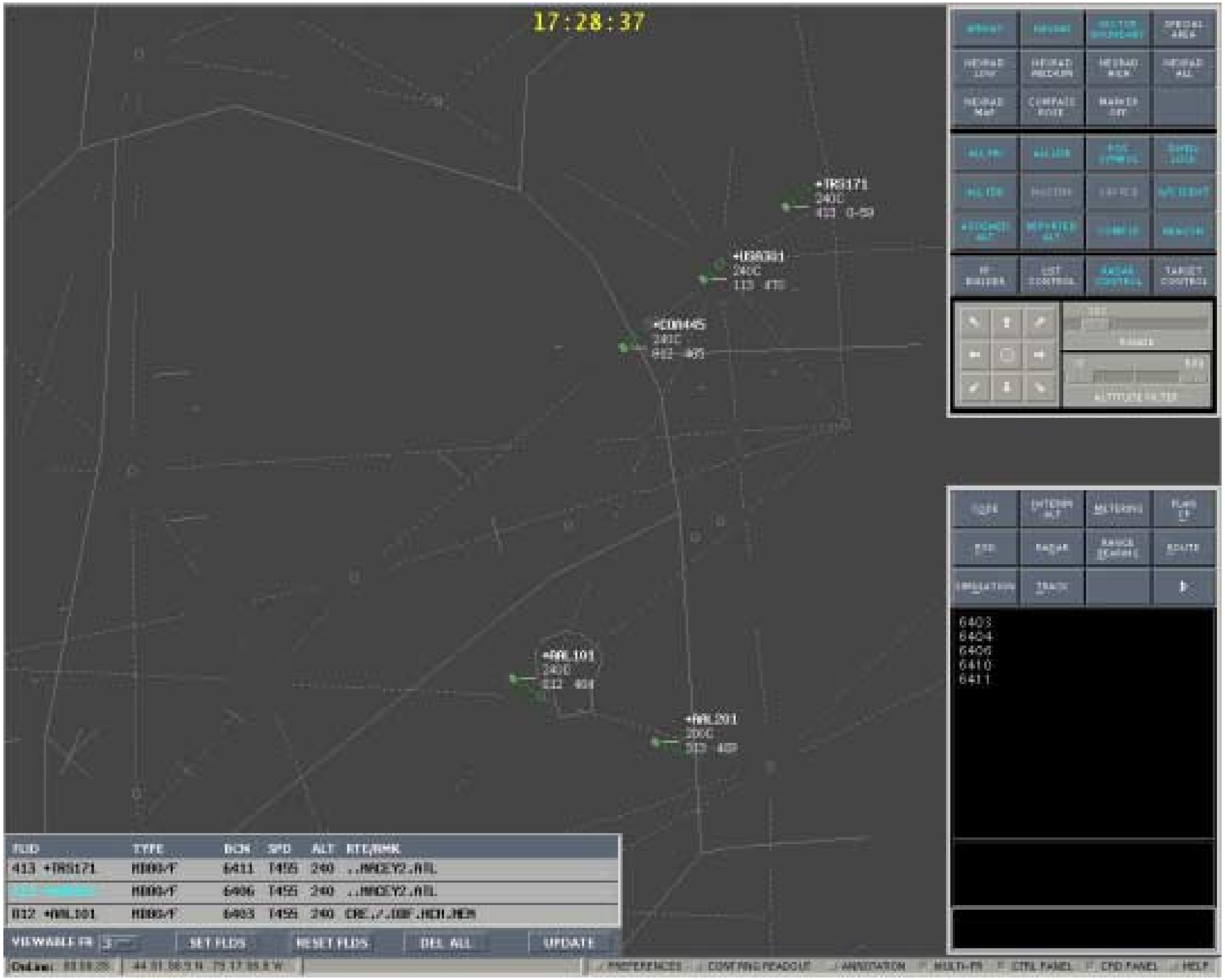


During the first lab demonstration, flight data information was displayed on the sector workstation based on prior research efforts. ATDET feedback indicated a preference for a DSR enhancement, being developed by Lockheed Martin, to enable flight information to be displayed at the radar controller position. Since this feature is being baselined into DSR, the decision was made to use ODS Toolbox© to quickly incorporate this planned enhancement into the lab capability.

This screen shows an example of the Multiple Flight Plan Readout (MFPR) view. DSR has the capability to display elements of flight plans in lists or associated with a designated datablock. The MFPR function ensures constantly available flight plan information to the radar controller in an environment without paper flight strips. A specific need is to be able to view up to five flight plans simultaneously for comparison purposes. This new functionality allows the D controller to concentrate on strategic planning duties, while allowing the R controller full access to flight plans in the new electronic flight data environment of the future.

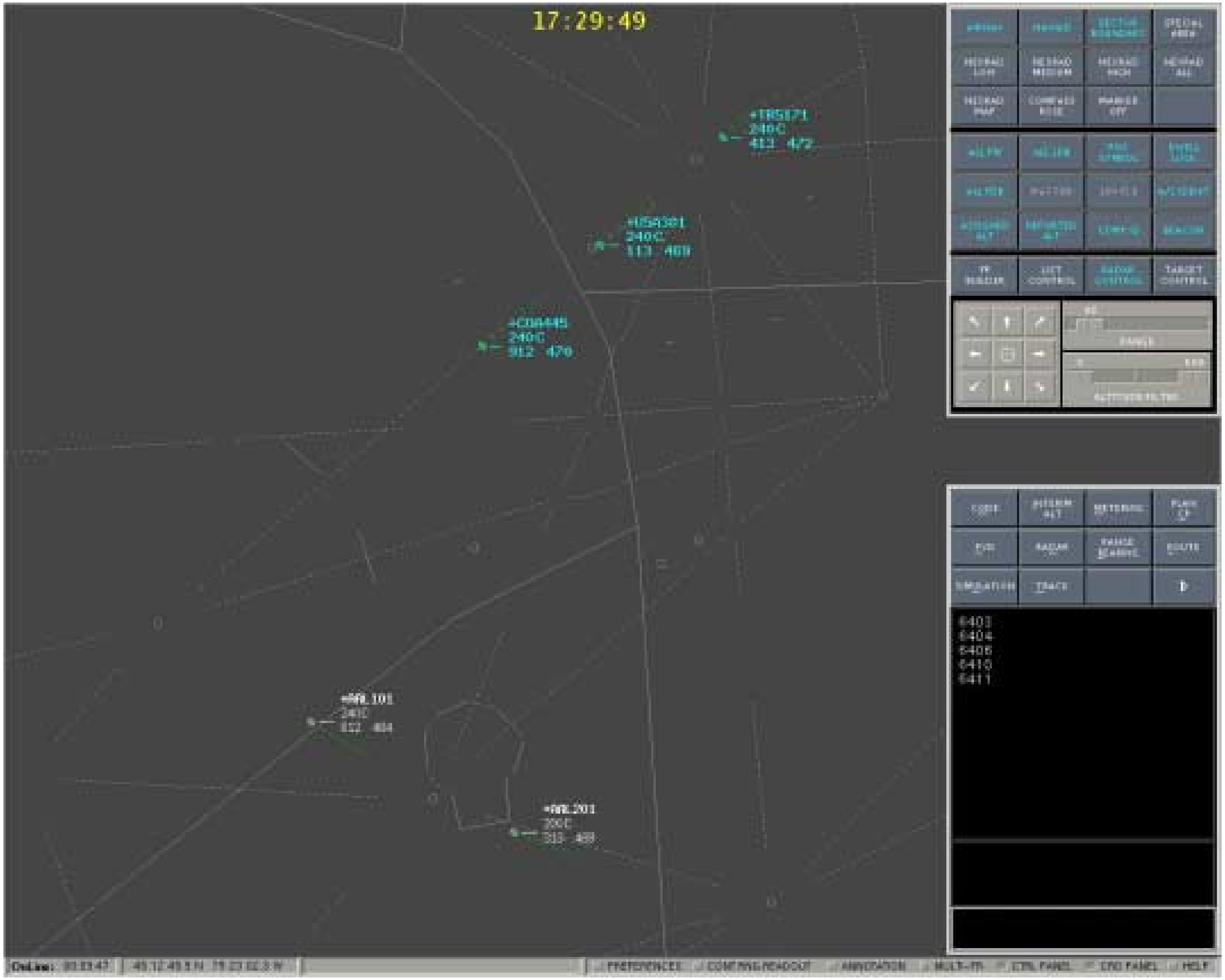
The laboratory implementation demonstrates most of the features of this DSR enhancement, including the ability to move the view, add/remove flight plans, and hide and show fields. In this example, an opaque MFPR view displays four flight plans. ODS Toolbox© does not support semi-transparent views, however, and this is one area of difference with the planned enhancement.

Multiple Flight Plan Readout with Highlight



The above view displays another feature provided by the MFPR function. This feature allows flight identification to be highlighted when changes have occurred to alert the controller to the change. In this example, the aircraft ID for USA301 has been highlighted. In order to manage screen clutter, the size of the MFPR view can be reduced or expanded by removing, collapsing, or redisplaying fields. This example also shows the ability to adjust the size of the view, to only reserve space for the actual number of flight plans selected.

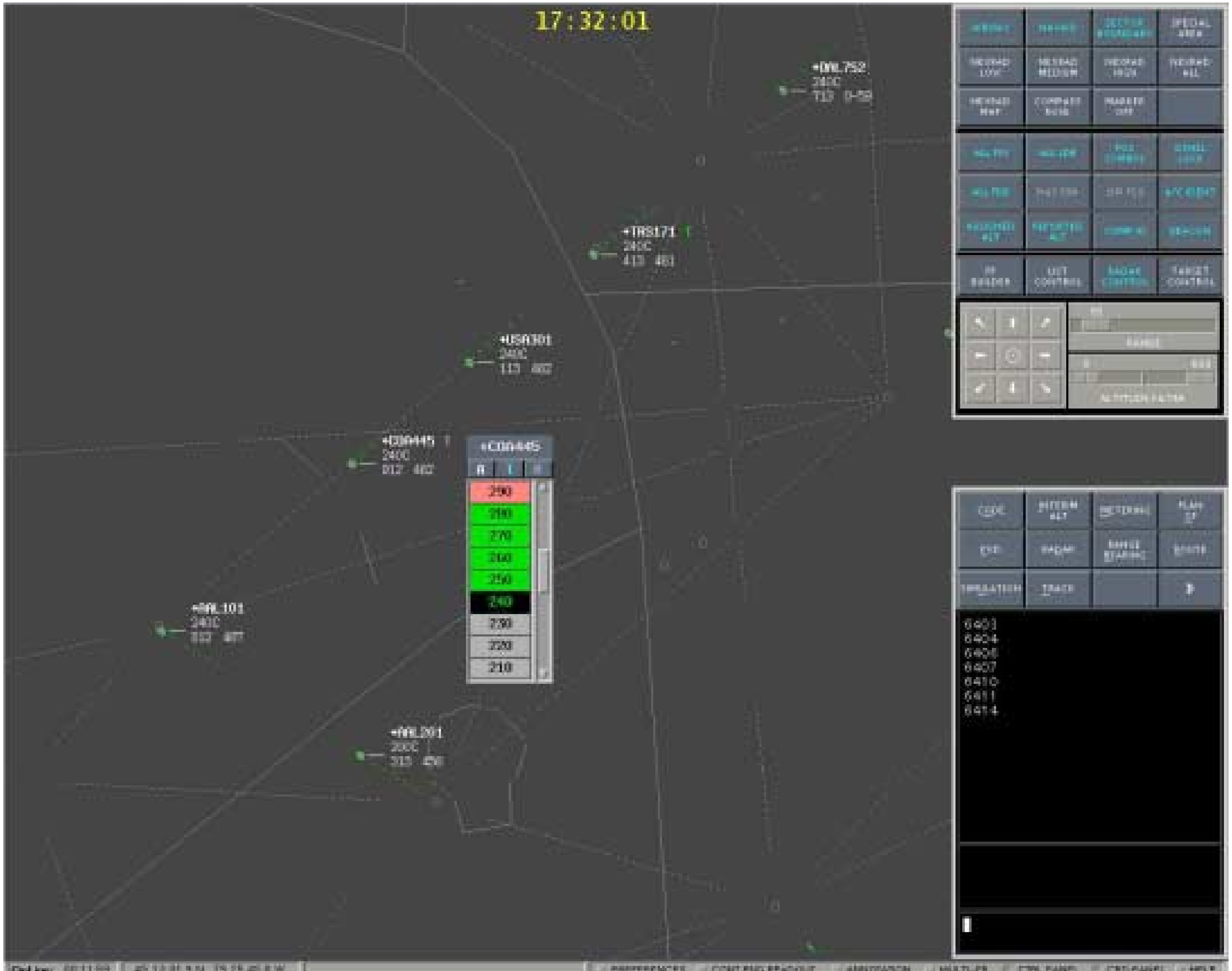
Dwell Lock


17:29:49
TRS171
240C
USA301
240C
113 469
CDA445
240C
912 470
AAL101
AAL201
6403
6404
6410
6411

Multiple Dwell Lock is another planned DSR enhancement incorporated into the laboratory demonstration. This enhancement provides a new feature, called Dwell, whereby a datablock (or an individual datablock field) can be emphasized by moving the cursor over it. This feature allows the controller to differentiate among overlapping datablocks and may serve as a visual reminder of some action to be taken at a later time. Dwell can be used to indicate to the associate radar controller that action is required or as a reminder to take some specific action. Multiple Dwell Lock allows for the locking of one or more datablocks in the dwell mode for a myriad of controller reminders and non-verbal communications.

In the above example, dwell locks have been initiated for the datablocks of COA445, USA301, and TRS171. These datablocks remain in the Dwell Lock mode until the controller clicks on the individual datablocks with the right mouse button. The Dwell Lock feature can be enabled/disabled with a single click on the “Dwell Lock” button on the control panel.

Altitude Pop Up View, Color Coded Trials and Trial Plan Indicator



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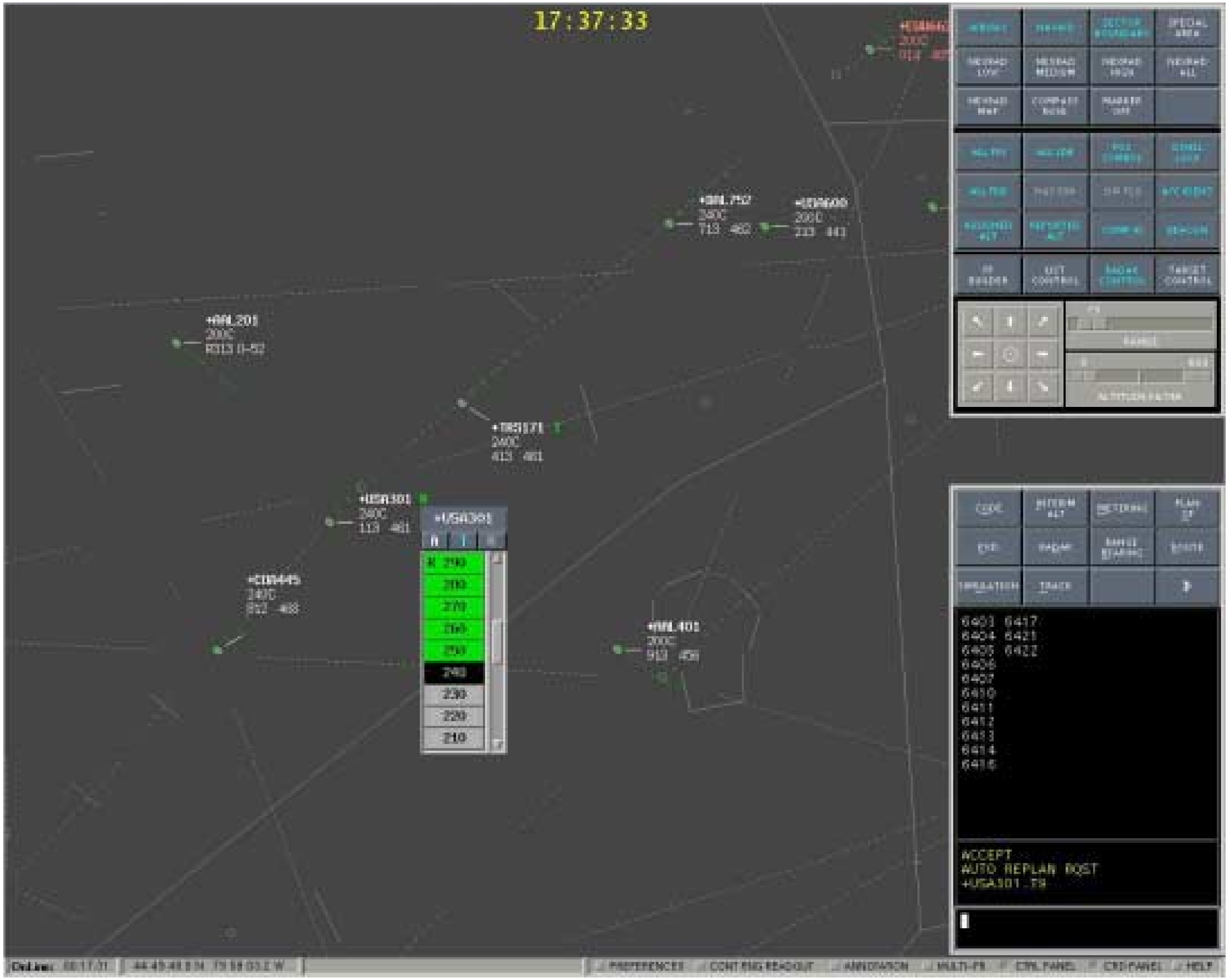
The above slide shows a Trial Plan feature. By clicking on the altitude field of the datablock, a menu will pop up allowing the controller to select an altitude that will be probed by URET for current and future conflicts. This feature provides a visual indication to the controller as to whether pilot requested or ATC-proposed altitude changes are conflict free. In this view, the controller can execute Trial Plans, initiate an Auto-Replan, or enter flight plan amendments into the system.

By clicking on the "A" button in the altitude menu and selecting an altitude, the flight plan can be automatically amended. Clicking on the "T" in the altitude menu enables one or more trial plans to be established. A "T" accessor is then added to the right of the datablock to indicate that trial plans have been established for that aircraft. Although not shown in this example, a Trial Plan list containing all Trial Plans for this aircraft can be displayed by clicking on that "T" accessor. The Auto-Replan "R" button capability is described as part of the next example.

When the cursor moves over an accessor, the character is highlighted to give clear visual confirmation to the controller for selection upon clicking the mouse button. In this example, one or more trial plans have been evaluated for TRS171 (the latest being conflict-free) and can be viewed by clicking on the "T" accessor. A trial plan for a COA445 altitude change to FL 290 has been evaluated and determined to contain a conflict, however, the altitude menu provides a visual indication (i.e., color-coding) of other altitudes that are conflict-free.

Altitude Pop Up View and Auto-Replan Indicator

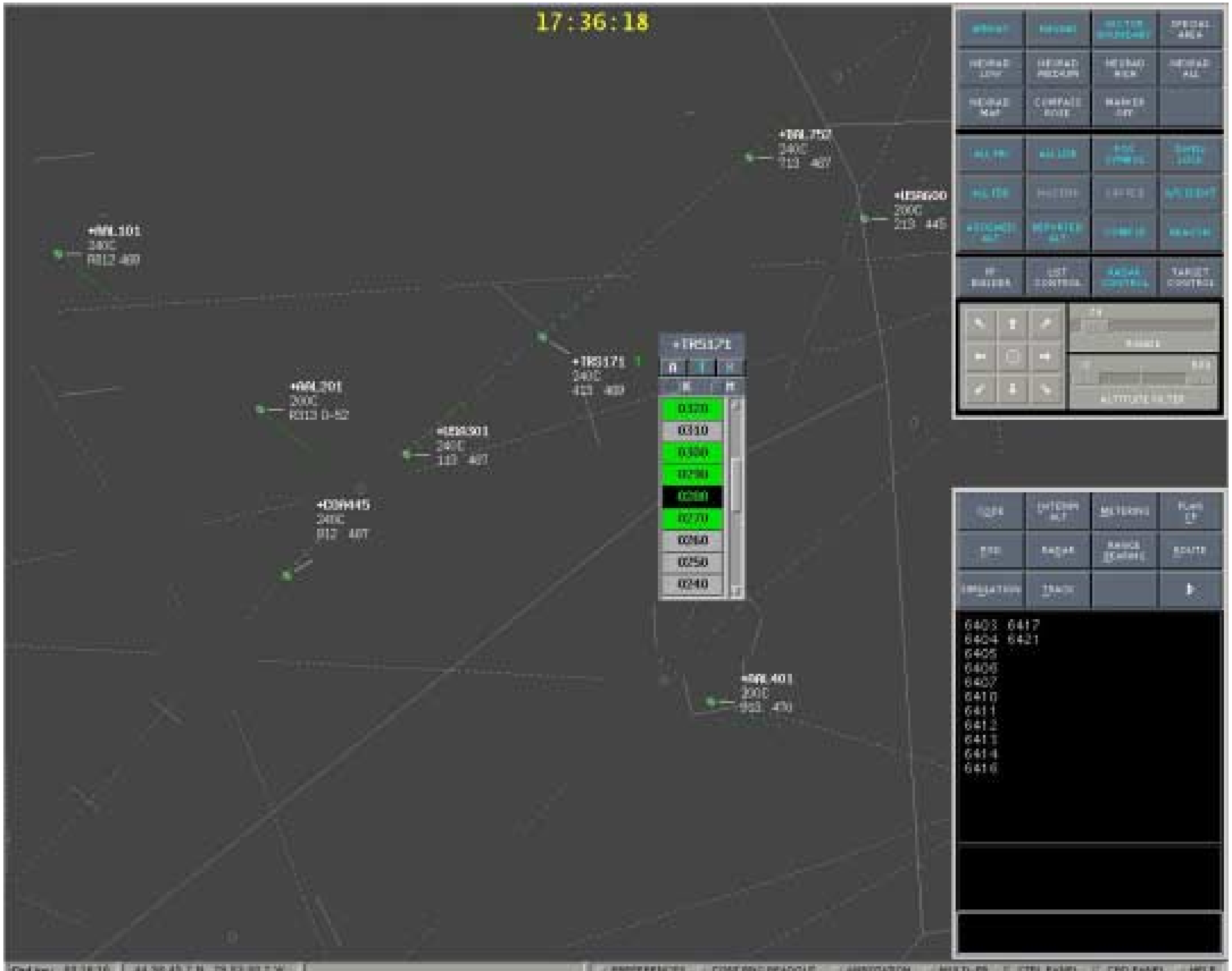


By clicking on the “R” button in the altitude menu, the controller can initiate an Auto-Replan which will be periodically rechecked by URET for the selected altitude. When Auto-Replan is initiated for a given aircraft, the trial plan is automatically evaluated as it is handed off from sector to sector. When Auto-Replan is initiated, an “R” accessor is added to the right of the datablock. If the Trial Plan becomes conflict-free at a later time, the “R” accessor will change from red to green. Note that because a specific Trial Plan is selected for Auto-Replan, the “R” supercedes “T” and therefore the “T” and “R” accessor would not be displayed simultaneously.

In this example, an Auto-Replan has been initiated for USA301 to climb from FL240 to FL290. The “R” indicator has turned green, indicating that the trial plan is now conflict-free.

Although not specifically part of the ODID-like CHI demonstration, note that the Host emulation software conflict alert algorithms have detected a conflict for EWW662 as indicated by the red datablock in the upper right corner of the situation display.

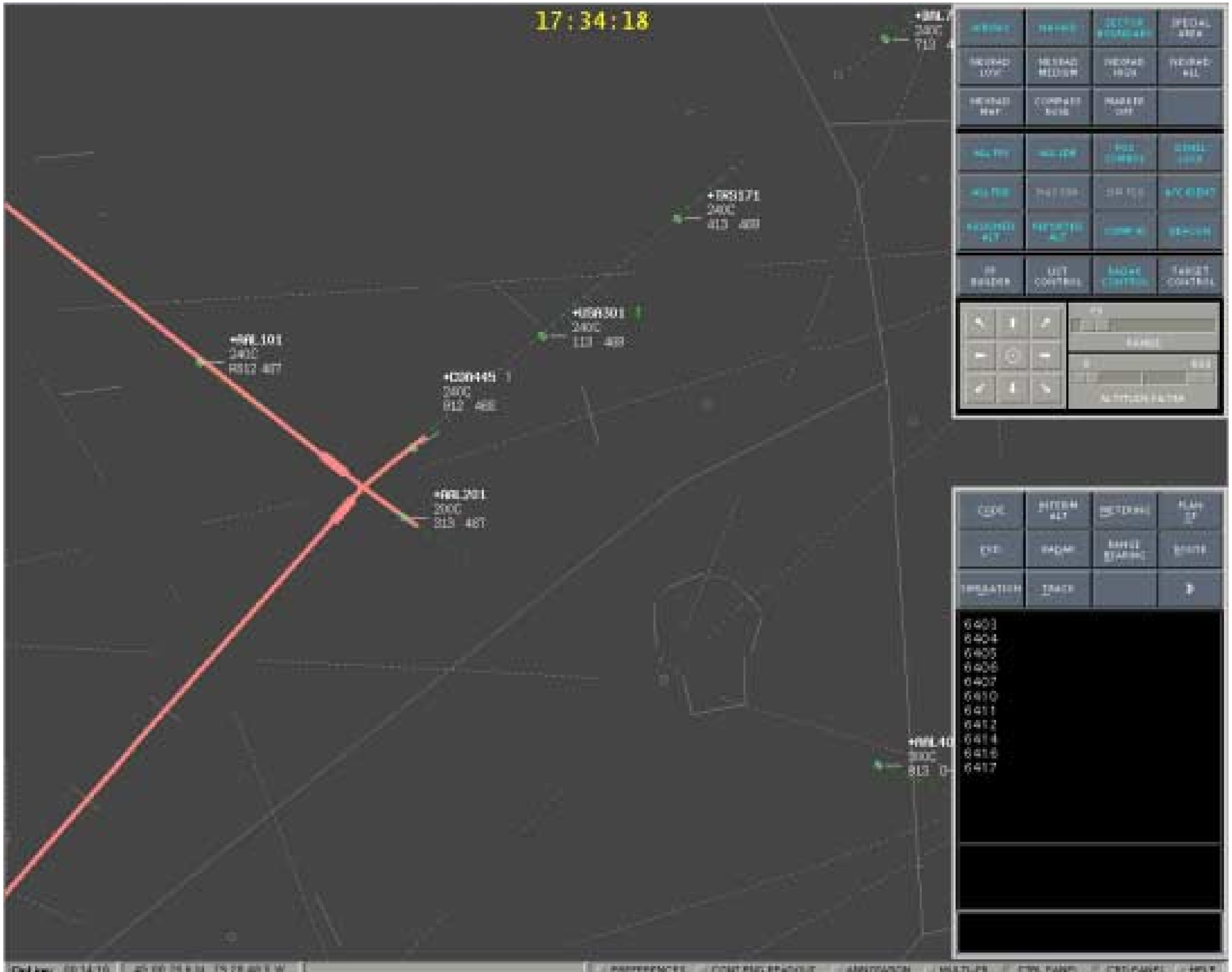
Speed Pop Up View and Color-Coded Trials



Similar to the Altitude Pop Up View, the above screen shows a Speed Trial Planning feature. By clicking on the speed field of the datablock, a menu will pop up allowing the controller to visualize easily whether pilot-requested or ATC-proposed speed changes are conflict-free. In this example, a trial plan to amend TRS171 from 240 to 280 knots is being evaluated for potential conflicts.

Although not included in these examples, a Route Pop Up View supporting route amendments and trial planning was also demonstrated.

Graphical Presentation of Altitude Trials

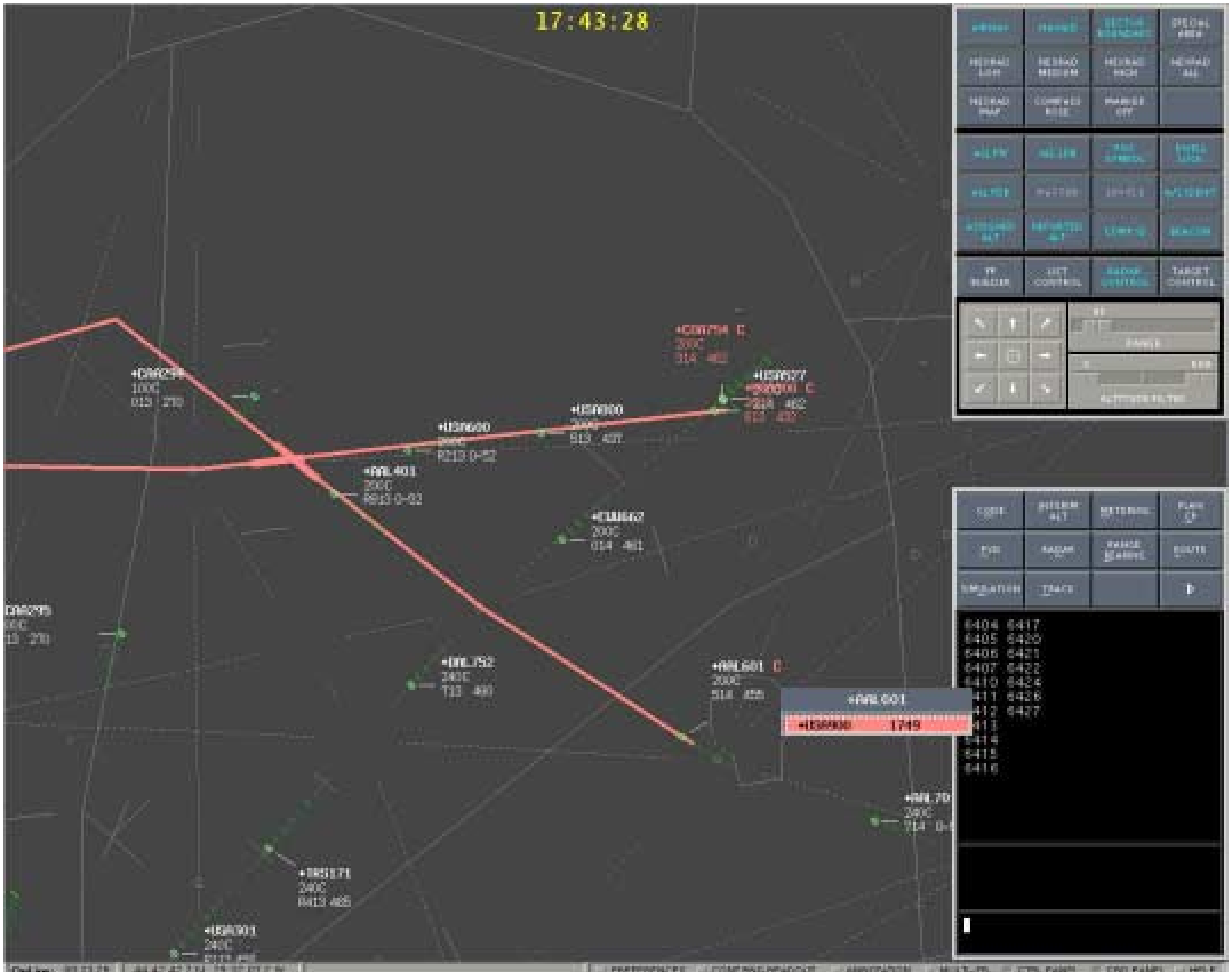


ATDET feedback has indicated that the radar controller will retain a primarily tactical function. This requires the controller to remain focused on the situation display and that there is a preference to see data displayed graphically, as opposed to in lists. The graphical presentation of the Trial Plan enables the controller to quickly visualize the status of proposed altitude changes, without having to refocus attention to the Trial Plan list.

If the Trial Plan is conflict-free, the proposed flight path is shown in green for a limited time on the display. It can be deleted if action is taken by the controller. If there is a predicted conflict, both the flight path of the selected aircraft and conflicting aircraft paths are shown in red, with the area of conflict emphasized. In this example, a Trial Plan is being evaluated for COA445 that would put it in conflict with AAL201.

Although not included in these examples, graphical presentations of speed and route trial plans were also demonstrated.

Conflict Pop Up View and Graphical Presentation



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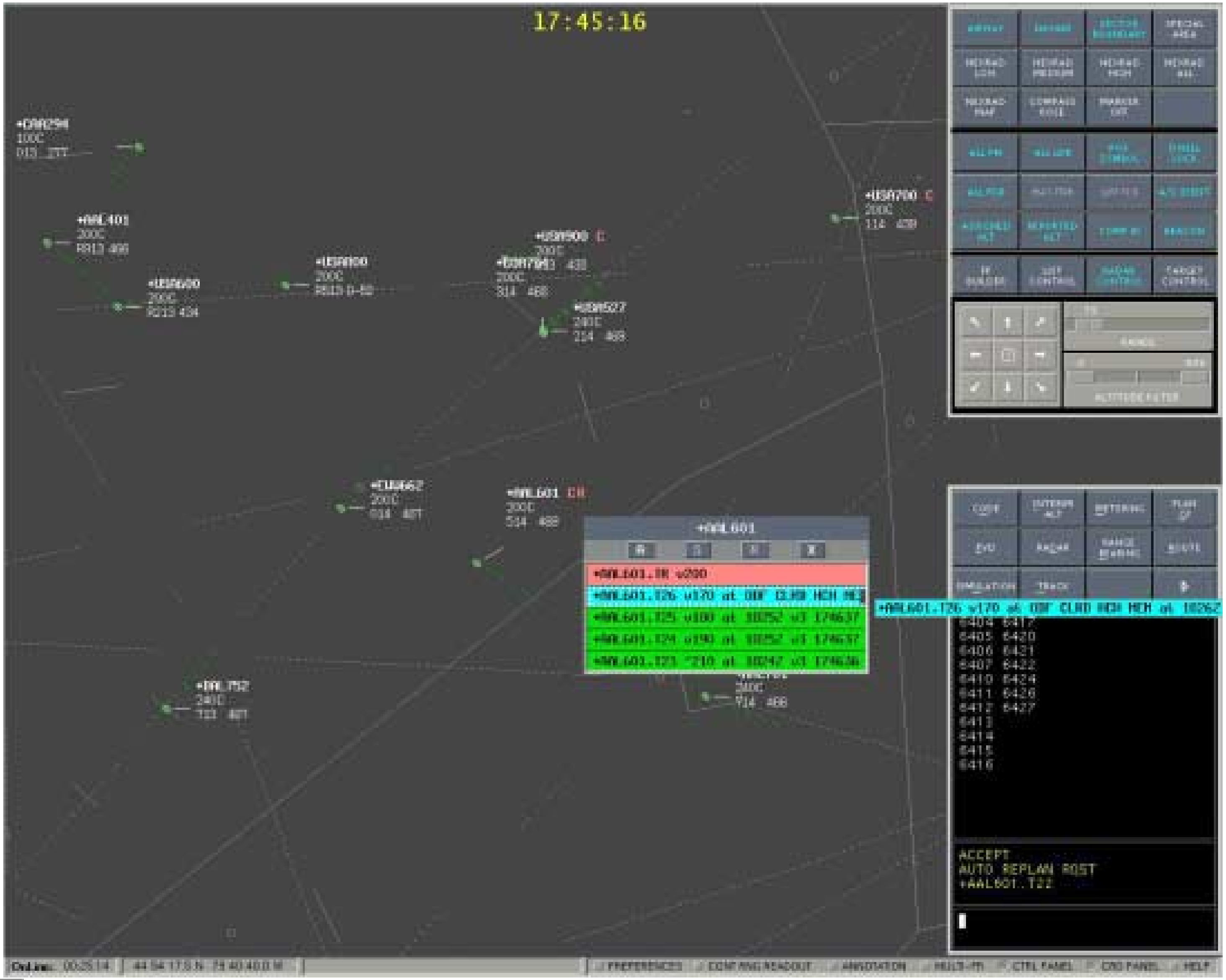
This example depicts the capability to graphically display predicted conflicts. When conflict probe automatically detects a potential conflict (either aircraft/aircraft or aircraft/airspace) in a future specified parameter time, a red “C” is added to the right of the datablock. By clicking on the “C” accessor to the right of the datablock, a pop up view lists all aircraft predicted to be in conflict with the selected aircraft. In this case, the conflict between AAL601 and USA900 can be shown graphically by clicking on the aircraft ID for USA900 shown in the conflict list for AAL601.

Auto-Extension Feature



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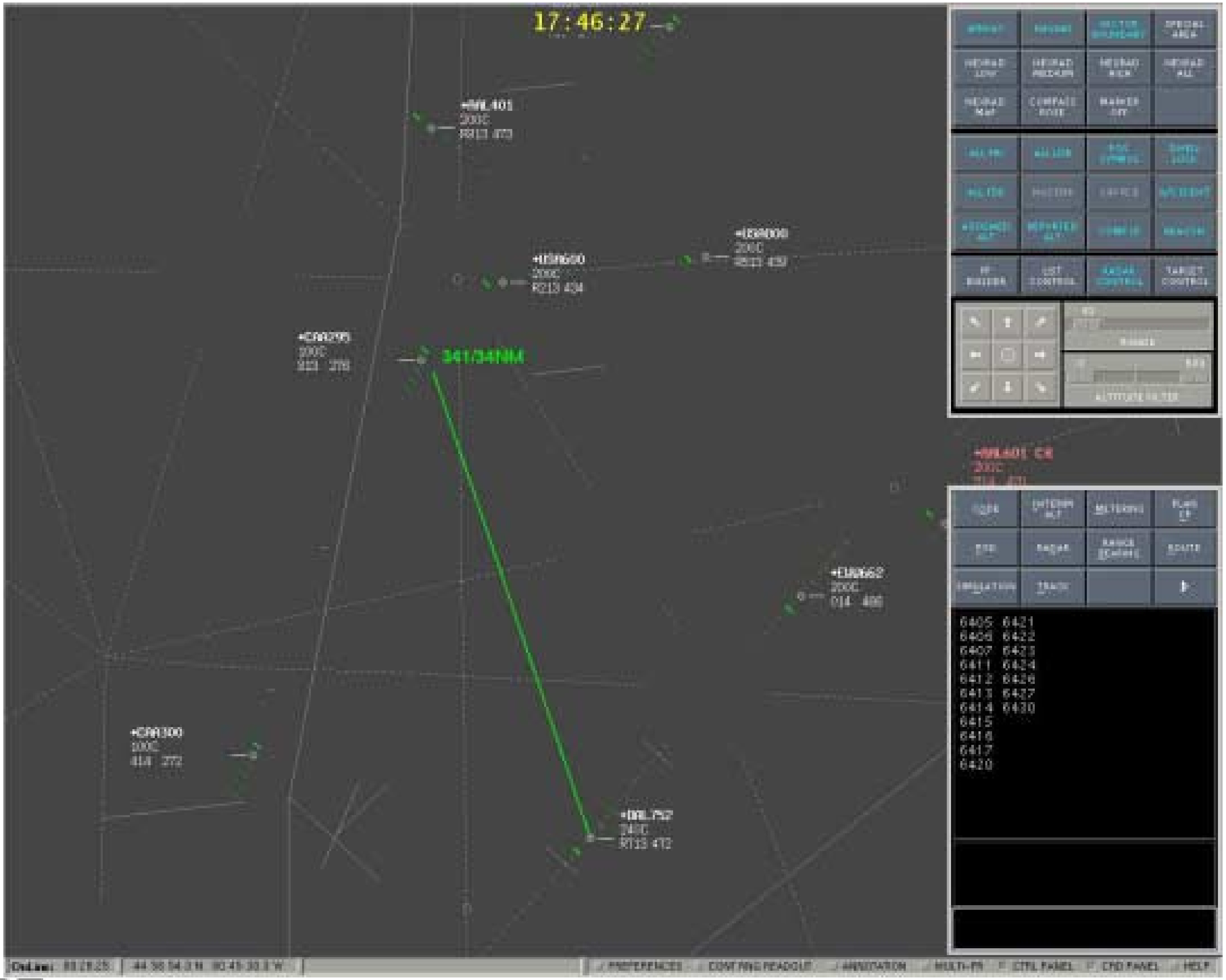
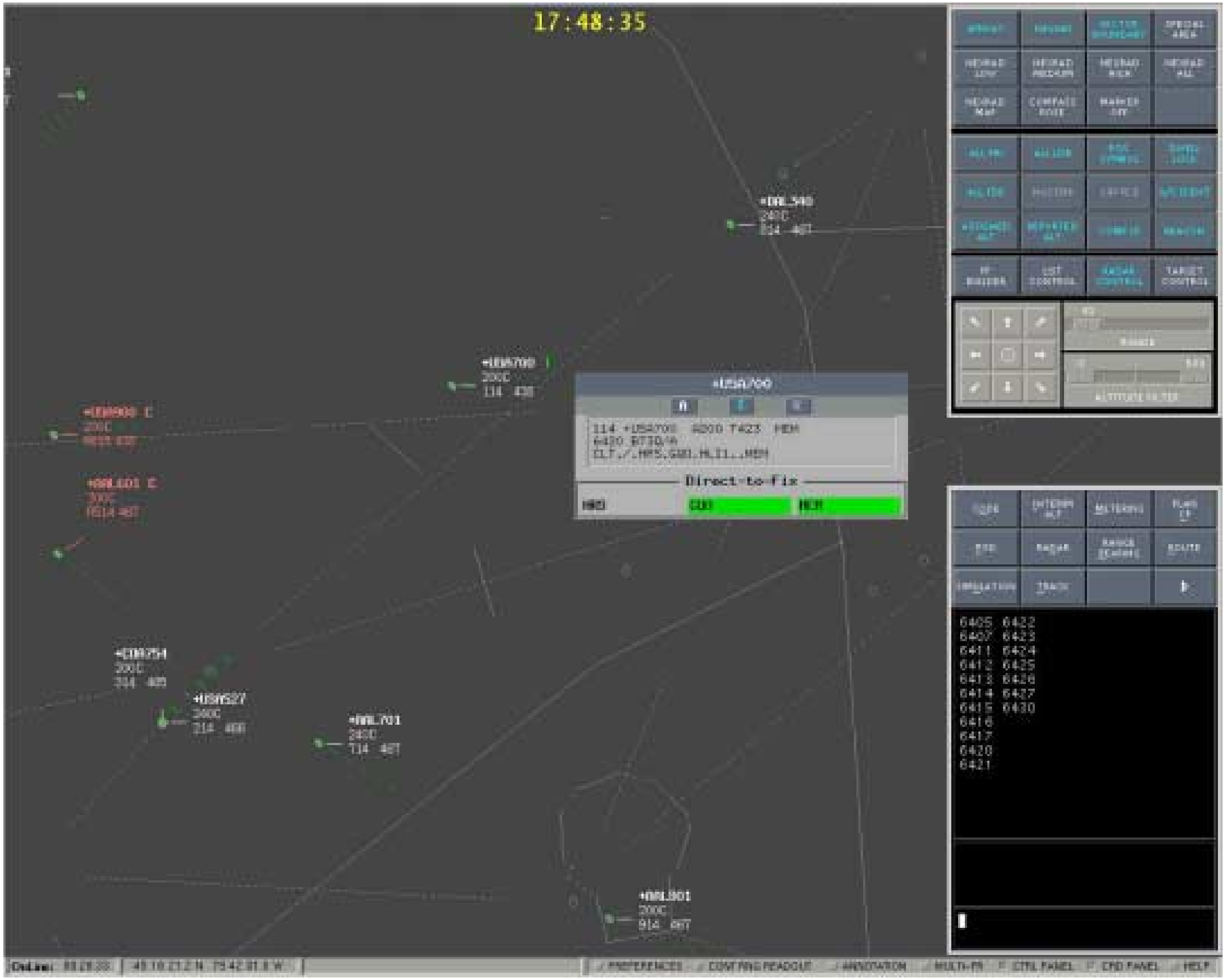
The Auto-Extension feature was proposed as a solution to the ATDET concern that list window sizes be kept to a minimum, in order to eliminate clutter or to prevent datablocks from being obscured. As shown in this example, window size is minimized. If there is essential data for a specific flight, that information can also be displayed without expanding the entire window. In this example, information has been appended to the 26th Trial Plan for AAL601.

Range/Bearing Feature



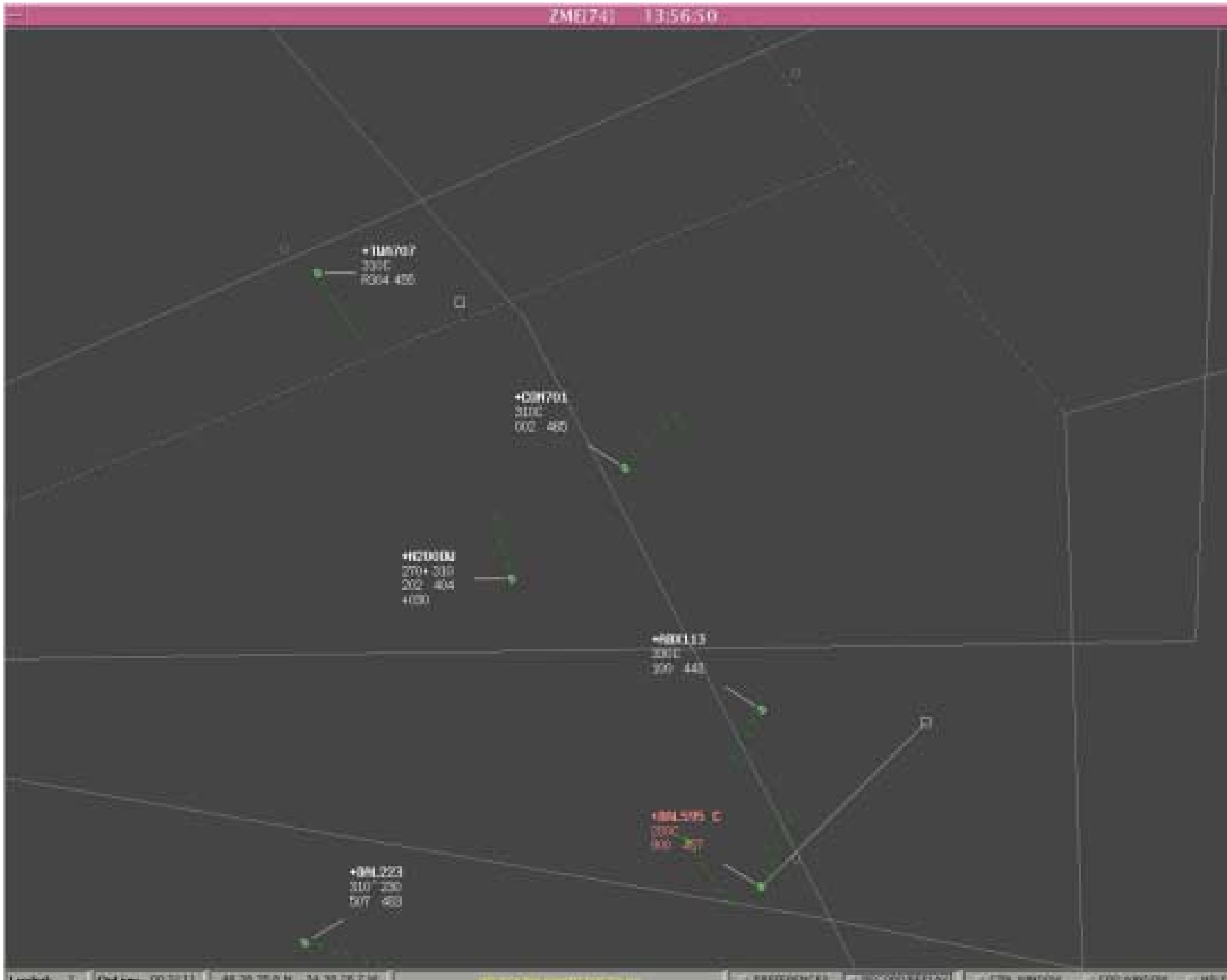
This example demonstrates the capability of the Range/Bearing function. Range/Bearing can be obtained between any two selected aircraft or between a selected aircraft and a map point. In this example, CAA295 and DAL752 were selected with the resulting Range/Bearing values of 341/34 nmi displayed.

Route Trial Plan: Direct-To-Fix Feature



The URET Direct-To-Fix feature was also demonstrated to the ATDET as a useful workload reducer. This enables the radar controller to evaluate, as part of route trial planning, whether a more fuel efficient and time efficient routing is possible for a particular flight. In this example, the Trial Plan view for USA700 indicates the downstream fixes on the aircraft's route of flight, color-coded to indicate whether direct routings to those fixes are conflict-free. In this case, conflict probe has determined that a direct routing to either GPO or MEM would be conflict-free.

Transition Airspace Controller Tools (TACT) View



TACT is being evaluated as a visualization tool intended to maximize the benefits of time-based metering in the NAS by assisting controllers to meet metering scheduled times of arrival. TACT addresses institutional barriers to time-based metering, while simultaneously providing enhanced decision support to increase effectiveness and address task complexity.

The Mileage Distance Marker (MDM) and Mileage in the Data Block (MDB), shown above, are TACT visualization aids to assist radar controllers with the complex task of managing streams of arrival traffic in transition airspace. The MDM does this by providing a highly intuitive, graphic means of displaying information to controllers. The MDM supports controllers in meeting required flow restrictions such as meter fix times or Miles-in-Trail. With MDM, the controller can display a marker that depicts the spatial magnitude of the adjustment needed for an aircraft to meet its time-based restriction. This display helps controllers intuitively understand temporal metering information within their spatial environment.

The MDB concept provides similar cognitive assistance by displaying a positive or negative number in the aircraft's datablock. This number represents a spatial increment (mileage adjustment) needed to meet the required restriction. TACT enhancess a controller's ability to accurately meet scheduled times, while mitigating the increased cognitive workload.

Glossary

AID	Aircraft Identification
AOC	Airlines Operation Center
ARTCC	Air Route Traffic Control Center
ATC	Air Traffic Control
ATDET	Air Traffic DSR CHI Evolution Team
ATM	Air Traffic Management
ATS	Air Traffic Services
CAASD	Center for Advanced Aviation System Development
CD-ROM	Compact Disk-Read Only Memory
CDM	Collaborative Decision Making
CHI	Computer-Human Interface
CPDLC	Controller Pilot Data Link Communications
CRCT	Collaborative Routing Coordination Tools
D-CRD	D position Computer Readout Display
D-side	D-side controller
DSR	Display System Replacement
DYSIM	Dynamic Simulation
ERAWT	En Route Area Work Team
ETA	Estimated Time of Arrival
ETMS	Enhanced Traffic Management System
FAA	Federal Aviation Administration
FFP1	Free Flight Phase 1
FFP2	Free Flight Phase 2
FP	Flight Plan
FY00	Fiscal Year 2000

Glossary (continued)

GI	General Information
GPO	General Purpose Output
HCS	Host Computer System
HDM	Host Data Multiplexor
HID	Host Interface Device
HIST	History
HITL	Human-in-the-Loop
LIU	LAN Interface Unit
LSP	Layered Strategic Planner
MDB	Mileage in the Data Block
MDM	Mileage Distance Marker
MEM	Memphis International Airport
MFPR	Multiple Flight Plan Readout
MIT	Miles-in-Trail
MIT/LL	Massachusetts Institute of Technology/Lincoln Labs
NAS	National Airspace System
ODID	Operational Display and Input Development
ODS	Operational Display Systems
PARR	Problem Analysis, Resolution and Ranking
QTP	Quick Trial Planning or Quick Trial Probe
R-side	Radar side controller
STA	Scheduled Time of Arrival
SUA	Special Use Airspace
TACT	Transition Airspace Controller Tools

Glossary (concluded)

TCP	Transmission Control Protocol
TMA	Traffic Management Advisor
TMC	Traffic Management Coordinator
TMU	Traffic Management Unit
TP	Trial Plan or Trial Planning
TRACON	Terminal Radar Approach Control Facility
URET	User Request Evaluation Tool
VOR	VHF Omnidirectional Radar
WILCO	Will Comply