En route Air Traffic Controller Commands: Frequency of Use During Routine Operations

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May 2006

DOT/FAA/TC-TN06/04

U.S. Department of Transportation
Federal Aviation Administration

Technical Report Documentation Page

1. Report No.
DOT/FAA/TC-TN06/04

2. Government Accession No.

3. Recipient's Catalog No.

4. Title and Subtitle
En route Air Traffic Controller Commands: Frequency of Use During Routine Operations

5. Report Date
May 2006

6. Performing Organization Code
NAS Human Factors Group

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8. Performing Organization Report No.
DOT/FAA/TC-TN06/04

9. Performing Organization Name and Address
NAS Human Factors Group
Federal Aviation Administration
William J. Hughes Technical Center, Bldg. 28
Atlantic City International Airport, NJ 08405

10. Work Unit No. (TRAIS)

11. Contract or Grant No.

12. Sponsoring Agency Name and Address
Federal Aviation Administration
Human Factors Research and Engineering Division
800 Independence Ave., S.W.
Washington, DC 20591

13. Type of Report and Period Covered
Technical Note

14. Sponsoring Agency Code
Human Factors Research and Engineering Division, ATO-P

15. Supplementary Notes

16. Abstract

The Federal Aviation Administration has started development of the En route Automation Modernization (ERAM) system to replace the current en route system consisting of the Host Computer System, Display System Replacement (DSR), and the User Request Evaluation Tool . ERAM will provide a variety of new user interface (UI) capabilities for accessing and executing controller commands. An appropriate evaluation of the new UI capabilities will determine how effectively controllers are able to work with the new system. This technical note documents the frequency of use of controller commands using the legacy system. We calculated the number of each entry type made per hour in an 11-hour period at a field site and found that the most frequently used commands were: 1) Offset Datablock, 2) Implied Aircraft Selection (i.e., Accept Handoff/Force Datablock), 3) Initiate Handoff, and 4) Assign Interim Altitude. The 30 most frequently used commands made up approximately 95% of the total number of controller entries. We recommend that future test activities target these most frequent commands. We discuss future phases of the project and ways that these data can be used to compare ERAM to the legacy system.

17. Key Word
Air Traffic Control
En route
Human Factors

18. Distribution Statement
This document is available to the public through the National Technical Information Service, Springfield, Virginia, 22161.

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price
Unclassified	Unclassified	34	

Form DOT F 1700.7 (8-72) **Reproduction of completed page authorized**

Acknowledgements

We would like to thank Drs. Pamela Della Rocco and D. Michael McAnulty of the Federal Aviation Administration (FAA) National Airspace System Human Factors Group who helped develop the technical approach followed in this report. We would also like to thank Fatiha (Fa) Jackson of L-3 Communications Titan Corporation for her assistance in conducting the data reductions reported here.

We would like to acknowledge the assistance of Sheila Mathis and J. D. Hunt of the FAA En route Operational Systems Division and Randy Rupp from Lockheed Martin Corporation who provided us with crucial information on the reduction and analysis of Display System Replacement (DSR) System Analysis Recording (SAR) data. Steve Souder and other technical experts from the FAA Integration and Interoperability Facility (I^2F) also provided guidance and information.

Finally, we would like to thank the FAA Human Factors Research and Engineering Division and En route Automation Modernization (ERAM) Program Office for funding this project through the ERAM Test Group at the William J. Hughes Technical Center.

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Executive Summary

The Federal Aviation Administration (FAA) has started developing the En route Automation Modernization (ERAM) system to replace the current en route system consisting of the Host Computer System (HCS), Display System Replacement (DSR), and the User Request Evaluation Tool (URET). ERAM will provide a variety of new user interface (UI) capabilities for accessing and executing controller commands. An appropriate evaluation of the new UI capabilities will determine how effectively controllers are able to work with the new system. The *Test and Evaluation Master Plan* for ERAM requires that the ERAM Test Program validate critical operational issues, such as verifying that ERAM supports en route operations with at least the same effectiveness as the current system (FAA, 2003). The FAA ERAM Automation Metrics Test Working Group is developing metrics that quantify the effectiveness of key system functions to provide methods for comparing the legacy system and ERAM. The system functions include Surveillance Data Processing, Flight Data Processing, Conflict Probe Tool, and the Display System. This technical note documents the frequency of use of controller commands using the legacy system.

The HCS, DSR and URET data summarized in this report were recorded at the Air Route Traffic Control Center in Washington, DC over an 11-hour period in March 2005. The focus of the current analysis was on controller use of system commands and the means by which the interaction with the system occurred (e.g., keyboard). We used a number of processing steps and a combination of existing and custom-developed tools to extract these data from the available recordings. The controller entry data were sorted into more than 20 fields including the entry type, a description of the entry type (e.g., Assign Interim Altitude), the sector and position associated with the entry, the modality used to initiate and complete the entry, whether or not the entry was implied (i.e., did or did not begin with a specific command key), and whether or not the entry was accepted by the system. We calculated the number of each entry type made per hour and found that the most frequently used commands were: Offset Datablock, Implied Aircraft Selection (i.e., Accept Handoff/Force Datablock), Initiate Handoff, and Assign Interim Altitude. The 30 most common commands made up approximately 95% of the total number of controller entries, and we recommend that future test activities target these most frequent commands.

We found that the Computer Identifier (CID) was the most frequent way in which controllers specified tracks. This has implications for ERAM, because changes to the length of the CID may lead to changes in the time and effort required to make routine entries. We also found preferences for the way in which controllers adjusted range and vector line length. Controllers performed both of these commands most frequently using the Keypad Selection Device rather than the views and toolbars provided for these purposes. This information is useful because ERAM will provide similar new toolbars and capabilities.

In the next phase of this process, we propose evaluating the criticality of controller commands to determine which may be operationally critical, for example during emergencies, but are otherwise used infrequently. We discuss possible future phases of the project, including an analysis of aspects of ERAM that do not target the UI but that may affect how controllers use the system, an analysis of the usage characteristics of frequent and critical commands, and the creation of a test plan for a baseline simulation comparing the legacy system and ERAM.

1. Introduction

The Federal Aviation Administration (FAA) is developing the En route Automation Modernization (ERAM) system to replace the legacy en route Air Traffic Control (ATC) automation system that consists of the Host Computer System (HCS), the Display System Replacement (DSR), and the User Request Evaluation Tool (URET). En route controllers use the legacy system to control thousands of flights each day at 20 Air Route Traffic Control Centers (ARTCCs) in the conterminous United States. Lockheed Martin Corporation is the primary ERAM contractor.

The *Test and Evaluation Master Plan* for ERAM requires that the ERAM Test Program verify critical operational issues (COIs) (FAA, 2003). The first COI requires that ERAM support en route ATC operations with at least the same effectiveness as the legacy system. Therefore, ERAM must allow controllers to accomplish their tasks as well or better than HCS, DSR, and URET. To determine this, the baseline performance of the legacy system must be measured to provide standards for later comparisons to ERAM.

1.1 Purpose

This technical note provides the frequency of use of controller commands using the legacy en route ATC system from one typical en route facility. This study is one of several conducted by the Automation Metrics Test Working Group (AMTWG) described in the *ERAM Automation Metrics and Preliminary Test Implementation Plan* (FAA, 2005).

1.2 Background

The FAA ERAM Test Group formed the AMTWG in 2004. The team supports ERAM developmental and operational testing by developing metrics that quantify the effectiveness of key system capabilities in ERAM. The targeted capabilities are the Surveillance Data Processing (SDP), Flight Data Processing (FDP), Conflict Probe Tool (CPT), and the Display System (DS) modules. The metrics are designed to measure the performance of the legacy system and to allow valid comparisons to ERAM.

The metrics development project will occur in several phases. First, during 2004, the AMTWG generated a list of approximately 100 metrics and mapped them to the services and capabilities found in the *Blueprint for the National Airspace System Modernization 2002 Update* (FAA, 2002). The initial metrics were published in a progress report (FAA, 2004b). Second, during 2005, the team prioritized the metrics for more refinement and created an implementation plan (FAA, 2005). The implementation plan lists the selected metrics, gives rationales for their selection, and describes how they identified high priority metrics. The implementation plan allows each metric to be traced to basic controller decisions and tasks, COIs, and the ERAM contractor's technical performance measurements. The categories of high priority metrics are

- SDP radar tracking,
- SDP tactical alert processing,
- FDP flight plan route expansion,
- FDP aircraft trajectory generation,
- CPT strategic aircraft-to-aircraft conflict prediction,
- CPT aircraft-to-airspace conflict prediction,

- additional system level metrics, and
- DS human factors and performance metrics.

In the final project phase, the AMTWG will further refine and apply the metrics to the legacy en route automation system. The team is planning to deliver four reports for fiscal year 2005 with one covering each of the ERAM components discussed previously: SDP, FDP, CPT, and DS. These reports will be published in several deliveries to the ERAM Test Group. This technical note documents the second of these reports examining the ERAM DS. It documents the frequency of use for current en route control automation commands and allows testers to target those aspects of ERAM that controllers use most. Later reports will provide equivalent measures for the operational criticality of commands and examine commands for detailed usage characteristics.

1.3 User Interface Changes in En route Automation Modernization

ERAM provides a variety of new user interface (UI) capabilities over the legacy automation system. These include

- toolbars and buttons that can be "torn off" of the main toolbars and placed in different locations,
- expansion of the capability to issue multiple commands to a track using a single entry,
- a capability to issue the same command to multiple tracks using a single entry,
- a capability to preprogram macros containing multiple commands and associate these macros with toolbar buttons,
- tabular lists that become interactive views where controllers can click on items, and
- flight plan readouts that automatically update instead of requiring the controller to manually update them.

Many of these new UI capabilities are intended to reduce routine data entry tasks by allowing controllers to accomplish several tasks at once. For example, for each aircraft arriving at a particular fix, a controller may need to enter a new interim altitude, hand the aircraft off to the next sector, and offset the datablock. A properly constructed macro would allow the controller to complete these three commands with a single entry.

An appropriate evaluation of these new capabilities would examine their effects on controller interactions. If the new capabilities are indeed beneficial to controllers, or at least do no harm, an equal number of or fewer interactions should be evident in ERAM. For example, if the tear-off toolbars are indeed beneficial, a reduction in time spent manipulating the overall toolbars might be evident. If data entry workload is reduced, controllers may be able to allocate the corresponding time and effort to other tasks such as planning, communicating, and separating aircraft. Accompanying increases in operational efficiency and possibly safety could result. This report provides the frequency with which controllers make different entry types using the legacy automation system. These data can be used to guide future ERAM testing and to ensure that testing targets the most frequent and important controller commands.

1.4 Previous Research

During the development process for DSR, the National Airspace System (NAS) Human Factors Group conducted baseline simulations of the original HCS with the Plan View Display (PVD)

(Galushka, Frederick, Mogford, & Krois, 1995) and the HCS with the DSR (Allendoerfer, Galushka, & Mogford, 2000). In these studies, we measured controller interactions and compared them at the level of HCS data entry types, such as None (QN) and Amendment (AM). At the time, we did not examine the subtypes of HCS data entries. For example, the QN entry type contains Offset Datablock, Accept Handoff, and Assign Altitude commands. We did not evaluate these commands separately though they are conceptually very different.

We also did not consider the various ways that a data entry can be made. For example, an Assigned Altitude command can be entered by typing the desired altitude on the keyboard followed by the three-character Computer Identification (CID) for the aircraft. Assigned Altitude can also be entered by typing the altitude followed by the beacon code or callsign. Finally, Assigned Altitude can be entered by typing the altitude on the keyboard and clicking on the aircraft with the trackball cursor. The multiple methods for entering an Assigned Altitude command differ in their information requirements, the amount of time and effort they require, and their appropriateness for a given situation.

In the earlier baseline studies, we did not measure the display control commands that are not processed by the HCS. These commands include adjusting the range, vector line length, and brightness. The primary reason for not including these commands was a lack of automated data collection capabilities on the PVD (these commands were provided with mechanical knobs at the time) and a lack of familiarity with the DSR data recording methods.

Finally, since we conducted our original studies, many changes have occurred in the legacy system. Most important, URET has been introduced and deployed to the field. It provides many new commands and changes the way that controllers accomplish original HCS commands like amending flight plans. In addition, new DSR capabilities have been introduced such as flyout menus that allow changes to altitude, speed, and heading and new toolbars that allow controllers to adjust range and add annotations.

The current project seeks to improve on all these limitations. We examine controller interactions at a much more detailed level than the earlier baselines, and we include all types of interactions, including display controls and URET commands. Finally, we use a much larger and richer data set that contains tens of thousands of interactions.

1.5 Functions and Interactions

Controller usage of a system can be analyzed at different levels of abstraction (see Figure 1). At the highest level of abstraction, controllers' overall goals can be examined, such as how successfully they maintain an efficient flow of traffic. It can be very difficult to formally evaluate complex systems at the goal level because so many other systems and factors, such as training and procedures, affect how well the system supports the achievement of the goals. In any case, the overall goals of the legacy system and ERAM do not change. Controllers are still expected to maintain a safe and efficient flow of traffic following the established procedures of the FAA and their local facility.

To achieve goals, a controller must engage in one or more tasks, such as maintaining an accurate flight database. Evaluating a complex system at the task level is feasible, and the tasks that ERAM is intended to support are discussed in the implementation plan (FAA, 2005). In most cases, the tasks associated with the legacy system do not change in ERAM.

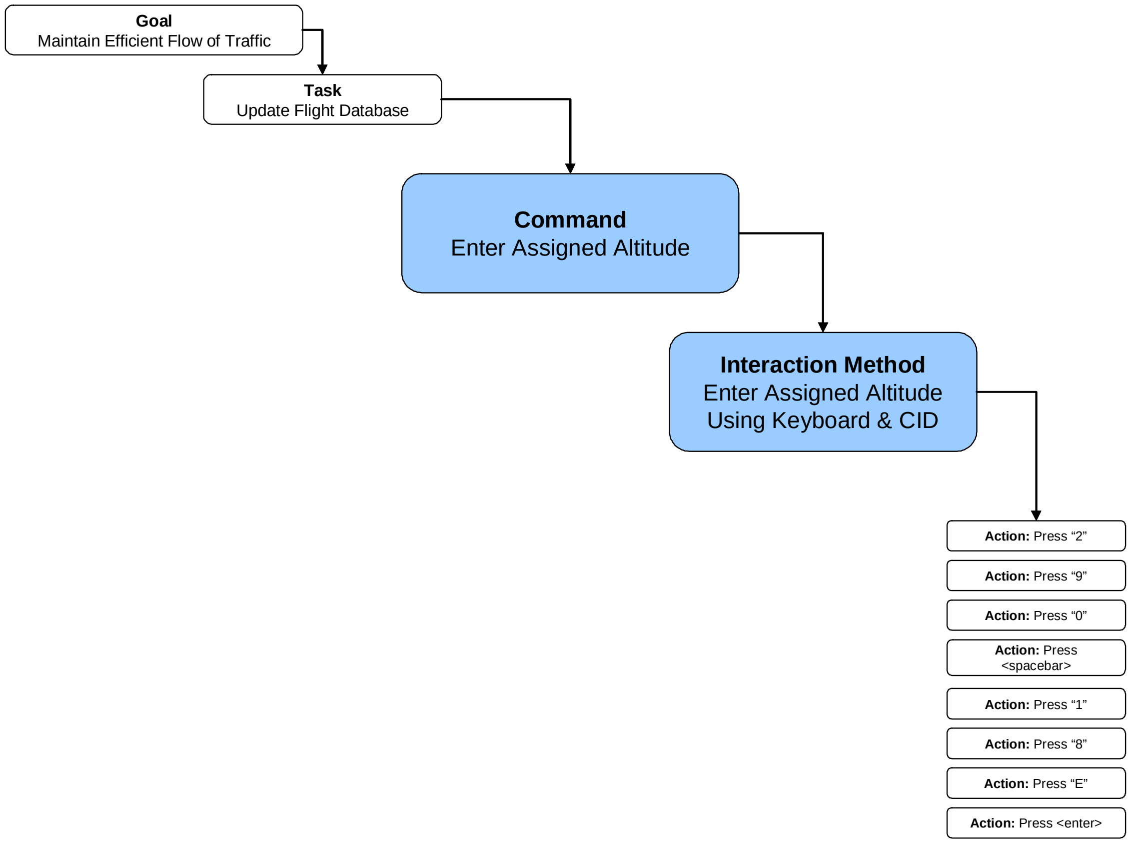

Figure 1. Levels of analysis of controller usage of a system.

Accomplishing a task using the legacy system or ERAM requires that a controller use one or more system commands. A command is a system-oriented term relating to one thing the system can do, such as display a piece of information or accept a type of input data. Examples of commands include Assigned Altitude, Offset Datablock, and Amend Flight Plan. Analysis of the most commonly used commands is one focus of the current report.

In the legacy system and ERAM, many commands can be accomplished through one or more interaction methods**.** An interaction method is a group of individual actions that accomplish a command. For example, if a controller wishes to complete the Adjust Range command to change the zoom of his or her radar display, the controller can choose among the following interaction methods.

- On the Situation Display (SD) Range Toolbar, click on the current range value and type the desired value with the keyboard.
- On the SD Range Toolbar, move the cursor over the "-/+" pick area. Click with the trackball pick or enter key to decrease or increase the value.
- On the SD Range Toolbar, click and drag the range slider bar to the desired value. Alternately, click the trough areas of the slider to decrease or increase the value.
- On the SD Range Toolbar, click on one of two preset range settings to change the current setting to the preset value.

- On the Keypad Selection Device (KSD), press one of the RNG range arrow keys (marked “RNG”) to increase or decrease the setting.
- Activate a preference set with a different range setting.

The second focus of the current report is to examine the specific interaction methods that controllers use to accomplish commands. An interaction method is made up of individual user actions. An action is a keystroke or a trackball button click. Some interaction methods require many actions, others require very few. In the current report, we do not analyze the data at the action level. That is, we are not concerned here with individual keystrokes or clicks. The data reduction methods described here, however, do allow for analysis at the action level if needed in the future.

2. Data Collection

To provide the most comprehensive data set possible, we based the analysis on System Analysis Recording (SAR) data recorded by the FAA Integration and Interoperability Facility (I^2F) at Washington ARTCC (ZDC) on March 17-18, 2005. These recordings were made to assist the AMTWG in a number of its activities. The data set includes 11 hours 25 minutes of controller interactions recorded across the entire facility, including more than 110 operational positions and more than 50 sectors. This represents 663 controller shifts and 168 individual controllers. The dataset includes over 200,000 controller interactions and responses. To our knowledge, this is the largest in-depth analysis of en route controller interactions ever conducted by the FAA.

3. Data Reduction

Several steps were necessary to prepare the data for the analysis. Existing software tools did not provide the level of analysis required for this project. As a result, we used a combination of existing and custom-developed tools.

3.1 Database Fields

The primary levels of analysis in this report are commands and interaction methods. We created a database containing fields that describe interaction methods according to the fields provided in Table 1.

Table 1. Data Fields for Functions

Field	Description
Index	Line number of the data from the HCS or DSR SAR file (e.g., 10004942)
Source	HCS or DSR recording (e.g., Host)
Date	Date when entry was recorded (e.g., 2005-03-17)
InitTime	Time an entry was recognized as initiated by the system (e.g., 22:30:02.013)
CompTime	Time an entry was recognized as completed by the system (e.g., 23:32:01.453)
Sector	Sector associated with the entry (e.g., 25)

Table 1. Data Fields for Functions (continued)

Field	Description
Position	Controller position associated with the entry (e.g., R)
View	System view or window where the entry occurred (e.g., Display Controls)
TwoLetter	Two letter identifier of HCS entries (e.g., QQ)
Type Description	Explanation of entry type (formal command names can be abstracted from this field) (e.g., Assign Interim Altitude)
SeqNo	Sequence number of entry used by HCS SAR file (e.g., 6c2c)
CID	Aircraft CID obtained from HCS SAR file (e.g., 730)
Flight Identifier (FLID) Method	Describes how the controller indicated which aircraft to act upon in the entry, if needed (e.g., <callsign>)
Other Parameter	Additional parameters used in the entry beside CID, FLID method, SeqNo (e.g., 290 for Assigned Altitude)
InitModality	Method used to initiate the entry (e.g., KYBD)
CompModality	Method used to complete the entry (e.g., FLYOUT)
Implied	Identifies whether or not the entry began with a specific command key (e.g., TRUE)
Accepted	Identifies whether or not the HCS accepted or rejected the entry (e.g., FALSE)
Text	Contains the complete text of the entry or the text description from the SAR file (e.g., QQ 310 30F)
Response	Contains the text of any messages returned by the HCS to indicate to controllers whether the entry was successful or not (e.g., ROUTE NOT DISPLAYABLE)
Response Type	Categorizes the type of response into an acceptance or one of several rejection types (e.g., Invalid Data Error)
Response Time	Time at which the system generated the response message (e.g., 23:34:02.166)

3.2 HCS Data Reduction

We had experience working with HCS SAR tapes during earlier baseline studies, such as the DSR Baseline (Allendoerfer et al., 2000). However, no suitable tools existed for reducing or analyzing the tapes at the level of detail required for this project. Using Microsoft Excel and Visual Basic for Applications (VBA), we created a data reduction tool called Entry Counter. Entry Counter analyzes HCS SAR data files and outputs a table consisting of each controller entry with data parsed into the fields described in Table 1.

3.2.1 Assumptions

The following section describes assumptions we made while conducting the data analysis of the HCS data.

3.2.1.1 Matching Entry and Response Messages

When a controller makes an incorrect HCS entry, the HCS provides a response message. In some cases, the HCS also provides response messages for accepted entries, as in flight plan readout entries. Unfortunately, there is no simple way to use the HCS data to match a response message to the entry that generated it, especially when the response is a general error message such as MESSAGE TOO SHORT.

Because we are interested in error rates for different commands, we have implemented a matching algorithm in Entry Counter. The algorithm appears to provide accurate matching of responses to the entries that generated them. To qualify as a match,

- the response must be listed later in the data file than the entry,
- the response and entry must have occurred in the same sector and position,
- the response and entry must occur within 2.5[1] seconds of each other, and
- the entry cannot already have a response assigned to it.

3.2.2 Issues

The following subsections describe issues we encountered while reducing and analyzing the HCS SAR data. In future projects, fixes or workarounds for these problems may be necessary.

3.2.2.1 Implied Aircraft Selections

Implied entries are HCS entries where the controller does not press a command key at the beginning of the entry. In these cases, the HCS determines the meaning of the entry from other data in the entry and, in some cases, the context in which the entry occurs. For example, clicking on a track with no accompanying data in the Message Composition area or entering a CID with no accompanying data (e.g., 56E <enter>) yields different outcomes depending on the status of the track. If the aircraft is in handoff status, the HCS interprets the entry as Accept Handoff. If the aircraft is not in handoff status and being shown as a limited datablock, the HCS interprets the entry as Force Datablock (i.e., the datablock is displayed as a full even though the controller does not own the target).

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[1] This and other similar criteria are based on careful inspection of the data by the psychologists. In this case, using 2.5 seconds resolves the overwhelming majority of response messages with a minimum of false resolutions.

The HCS SAR recordings do not contain a simple manner to determine the context of implied aircraft selections. They list that the controller clicked on a target and that no error was generated. However, the recordings do not indicate directly whether the click resulted in an Accept Handoff or Force Datablock command. To determine this, a much more detailed analysis of the track data would be necessary. The level of ambiguity in this algorithm is not desirable. These are reported as "Implied Aircraft Selection" as a separate entry type even though it is truly composed of Accept Handoff and Force Datablock. Future analyses should explore mechanisms for determining the status of aircraft to establish the context and nature of implied aircraft selections.

3.2.2.2 Unreliable Timestamps

A response message occurs after the entry that generated it. However, in the HCS data, the timestamps for response messages sometimes showed that the response occurred at the same time or occasionally several milliseconds *before* the entry that generated it. We suspect this issue is caused by the recording priorities and techniques of the HCS. To account for these discrepancies, calculations in Entry Counter involving time are programmed to consider a window of time rather than a value in a specific direction. For example, Entry Counter requires a response message to occur *within* 2.5 seconds of an originating entry to qualify as a match rather than requiring the response to occur *after* the entry.

The sequence of lines in the HCS data appears to reliably reflect the order of events. That is, a response message is always listed after its originating entry regardless of their timestamps. This allows Entry Counter to consider the line number in addition to timestamps in some of its calculations. For example, in addition to requiring a window of time, Entry Counter requires that a response message occur later in the data file than the entry to qualify as a match.

3.2.2.3 Undetermined Frequent Blank Entries

The HCS data included a number of blank entries that had no obvious equivalents in the DSR or URET data. These entries appear as if the controller pressed the Enter key with no data in the Message Composition area. Typically, blank entries receive a MESSAGE TOO SHORT response. We have seen controllers habitually press the Clear key, but we currently have no explanation for why they would press the Enter key so frequently with no data in the composition area. The frequency of these entries leads us to suspect that they result from interactions with DSR or URET that we do not currently understand. We suspect that if controllers were actually seeing so many MESSAGE TOO SHORT response messages, they would have complained. These are reported as "Undetermined" in subsequent analyses.

3.2.2.4 Unmatched Responses

The HCS SAR includes responses to all types of entries, even if those commands were entered through a mechanism other than the HCS. This leads to response messages that seemingly do not have an originating entry. For example, if a controller enters a flight plan amendment through URET, the HCS still processes the amendment and provides a response. There is no record in the HCS SAR of the entry itself because it was made through URET. However, the response message does appear in the controller's readout area and is recorded in the HCS SAR data. This leads to "orphaned" response messages that can only be resolved by manually considering the DSR and URET data in parallel, which is beyond the scope of this analysis.

3.2.2.5 No Quicklook Entries

For reasons we have not been able to identify, no Quicklook (QL) commands appear in the HCS SAR data. We see no reason why these commands should not appear when all other HCS commands do, including many obscure ones. QL commands do appear in the corresponding DSR files, and we have used these in the counts reported in this document.

3.3 DSR and URET Data Reduction

Unlike the HCS data, we had no previous experience working with DSR SAR files, which contain data about controller interactions made through DSR and URET. An additional level of reduction was necessary for these data. First, we used the System Wide Analysis Capability (SWAC) tool to pull gates (i.e., units of recording) that apply to controller interactions. The gates we selected are listed in Table 2. Second, we brought the reduced files into Entry Counter.

Table 2. DSR SAR Gates Analyzed

Gate	Description
AG_12006	Interactions with the Display Controls (DC) View
AG_12015 AG 12016	Interactions with the Computer Readout Display (CRD)
AG_12017	Interactions with the Keypad Selection Device (KSD)
AG_12019	Interactions with the Flight Plan Readout View
AG_12020	Interactions with the Continuous Range Readout View
AG_12021, AG_12022, AG_12023	Interactions with the Annotation Toolbars
AG_12026	Interactions with the Flyout Menus
AG_12027, AG_12028	Interactions with Situation Display (SD) Toolbars
R_CMD, D_CMD, A_CMD,	Interactions with the DSR keyboard and trackball
HOST_CMD	HCS commands composed by DSR or URET
R_CMDKEY, D_CMDKEY, A_CMDKEY	Interactions with DSR keyboard by pressing a command key
R_CMDRS, D_CMDRS, A_CMDRS, R_CMDFB, D_CMDFB, A_CMDFB	Response and feedback messages
AG_11806	Every pick with the trackball and corresponding affected views
AG_13110	Interactions with URET

3.3.1 Assumptions

The following section describes assumptions we made while conducting the data analysis of the DSR and URET data.

3.3.1.1 Edges of Interactions

Many entries in DSR involve rapid repetition of the same action. For example, to increase the vector line length, a controller may click on the VECTOR pick area in the with the center trackball button. One click increases the vector line length by one available value (i.e., 0, 1, 2, 4, or 8 minutes of flying time). If the controller wishes to increase the length by multiple units, multiple clicks are necessary.

In our analysis, we treat rapid repetition of the same DSR action by the same controller as multiple clicks serving to create a single entry. This is to ensure comparability with the HCS entries in which many keystrokes are necessary to compose a single entry. To determine what qualifies as rapid repetition, we examined DSR entries of various types and determined that a window of 1 second provided reasonable, interpretable sequences. For example, in Figure 2, the controller makes eight keystrokes in a row on the KSD. The first four keystrokes, each occurring within 1 second of its predecessor, all were on the VECT ↑ key. The second four keystrokes, each occurring with 1 second of its predecessor, all were on the VECT ↓ key. The gap of about 10 seconds between the fourth and fifth keystroke and that the controller pressed different keys forms the break between one Adjust Vector Line entry and another.

Time	DSR Command
22:16:22.149	VEC_UP
22:16:22.291	VEC_UP
22:16:22.421	VEC_UP
22:16:22.565	VEC_UP
22:16:32.169	VEC_DN
22:16:32.390	VEC_DN
22:16:32.551	VEC_DN
22:16:32.711	VEC_DN

1st Adjust Vector Line

2nd Adjust Vector Line

Figure 2. Example of rapid repetition of actions.

3.3.1.2 Preference Set Clusters

Similar to rapid repetition, the application of a preference set in DSR results in a rapid sequence of display setting adjustments. Because these were generated by the preference set and not individual controller actions, they should be counted as part of the preference set, not separately. However, the DSR gates do not indicate whether a display setting adjustment was accomplished through a preference set. In our analysis, to count as a display setting adjustment resulting from a preference set, an adjustment must occur within 250 ms following a Sign In, Invoke Preference Set entry or within 250 ms following a display setting adjustment from a preference set. For example, in Figure 3, a controller signs in and immediately 15 changes are made to the display by the controller's preference set. Two seconds later, the controller adjusts the range manually and makes another entry, which are separate from the preference set actions.

Time	DSR Command
22:14:52.674	QP SI RU 1
22:14:52.828	MAKE_VIEW_SEMI_TRANSPARENT
22:14:52.838	SET_BCG_FROM_DISPLAY_CONSTANTS
22:14:52.847	TOGGLE_SEMI_TRANSPARENT
22:14:52.848	DECREMENT_FONT_SIZE
22:14:52.849	INCREMENT_FR_NUM
22:14:52.849	INCREMENT_FR_NUM
22:14:52.850	INCREMENT_FR_NUM
22:14:52.850	INCREMENT_FR_NUM
22:14:52.851	TOGGLE_LBL
22:14:52.851	TOGGLE_SPD
22:14:52.851	TOGGLE_FIX
22:14:52.851	TOGGLE_TIM
22:14:52.876	SET_BCG_FROM_DISPLAY_CONSTANTS
22:14:52.917	SHOW_ALTITUDE_LIMITS_TOOLBAR
22:14:52.930	HIDE_CRR_VIEW
22:14:54.004	RNG_UP
22:14:55.249	OVM

Sign In entry (22:14:52.674)

Display Adjustments Made by Preference Set (22:14:52.828 – 22:14:52.930)

Subsequent Display Adjustments Made by Controller (22:14:54.004 – 22:14:55.249)

Figure 3. Example of a preference set cluster.

3.3.2 Issues

In the reduction and analysis of the DSR SAR files, we encountered several problems. The following sections discuss these problems and the methods we used to address or work around them.

3.3.2.1 Flyout Menus Not Recorded

AG_12026, the gate associated with the DSR flyout menus, was mistakenly not recorded in the data set from ZDC. This prevented us from examining controllers' use of these menus in detail. However, because these are an important capability of DSR and have many analogs in new ERAM capabilities, we concluded that it was worthwhile to identify these commands as best we could from the AG_11806 gate, which records each trackball click and the views it affects. In this way, even though we could not identify which pieces of the flyout menus were being clicked, we could at least determine the number of times controllers used the flyout menus. In addition, we adopted a criterion by which if the HCS received a Interim Altitude (QQ), Assigned Altitude (QZ), or Speed/Heading/Free Form Text (QS) entry that immediately followed clicks in a flyout menu (i.e., no other commands issued in between), the entry was counted as having been entered through the flyout menu. For example, in Figure 4, a controller makes two picks in a flyout menu immediately followed by a change speed command. By our criteria, this entry was counted as having been made through the flyout menu and not by the keyboard.

Time	DSR Command
00:16:03.612	MENU
00:16:05.191	MENU
00:16:05.464	QS /290- 573

Picks in Flyout Menu

Enter Speed from Flyout Menu

Figure 4. Example of identifying flyout menu usage from clicks.

3.3.2.2 Unmatched Responses

Like the HCS data, there are some response messages recorded in the DSR data that seem to have no originating event. The orphaned response messages typically are recorded as MESSAGE TOO SHORT. As noted in Section 3.2.2.3, they are typically associated with blank HCS entries and do not appear in the DSR SAR. As a result, there are many MESSAGE TOO SHORT orphaned responses in the DSR data that cannot be tracked to an entry that generated them. By examining the HCS and DSR data in parallel, the orphaned messages can be resolved, though why so many blank HCS entries appear in the data set is not currently known.

3.3.2.3 Unidentified Commands

In the URET data, a message called DISPLAY_LOCATION occurred very frequently, often associated with other commands occurring within a few milliseconds. We believe that this message relates to updating the URET windows and lists, but we have not been able to identify its full purpose. Based on the frequency of the message, we believe that it is not a controller entry but rather a system message.

3.3.2.4 Filesize Issues

DSR SAR files contain enormous amounts of information, approximately 650 MB per hour in binary form. Reducing the data using SWAC for the selected gates produced files of approximately 50 MB per 40 minutes. The number of lines and entries tests the limits of Entry Counter in the Microsoft Excel VBA environment, which was selected for its simplicity and rapid development time. Future analyses of these data may require a more robust data reduction and database management system.

4. Results

The following sections contain tables showing the frequency of use of various controller commands. Later sections provide examples of detailed analysis of specific commands.

4.1 Sample Table

Table 3 shows a sample of the frequency data for the 10 most frequent entry types across the ARTCC during the 11.4-hour recording period. Table A-1 in Appendix A shows the table for all entry types. The table shows the overall and cumulative percentages for each entry type.

Table 3. Frequency of Use for 10 Most Frequent HCS/DSR/URET Functions

	Type	Entries	Overall %	Cumulative %
1.	Offset Datablock	39355	19.8%	19.8%
2.	Implied Aircraft Selection (Accept Handoff/Force Datablock)	32642	16.4%	36.3%
3.	Initiate Handoff	15017	7.6%	43.8%
4.	Assign Interim Altitude	10871	5.5%	49.3%
5.	Adjust Vector Line	9491	4.8%	54.1%
6.	Route Display	7279	3.7%	57.8%
7.	Delete Aircraft	6965	3.5%	61.3%
8.	Toggle Bookkeeping Checkmark	6700	3.4%	64.7%
9.	Quicklook	5673	2.9%	67.5%
10.	Flight Plan Readout Request	5637	2.8%	70.3%

4.2 Details on Host Computer System Entries

The frequency of use data can be examined at many levels of detail using the other data fields. Table 4 contains sample details for three common HCS entry types. The syntax for these entries requires the controller to specify a flight identifier (FLID) in addition to other parameters. The controller can do this using the beacon code (e.g., 32 6271 <enter>, which initiates a handoff of the aircraft with beacon code 6271 to Sector 32), the callsign (e.g., 50 USA176 <enter>), the CID (e.g., 38 88G <enter>), or by clicking on the target with the trackball (e.g., 12 <trackball>).

Table 4. HCS Entry Type by FLID Method

	FLID Method			
Entry Type	Beacon Code	Callsign	CID	Trackball
Offset Datablock	0.2%	0.1%	60.8%	38.9%
Implied Aircraft Selection	0.9%	0.1%	54.8%	44.2%
Initiate Handoff	0.1%	0.3%	70.0%	29.6%

This type of analysis may be useful in ERAM testing because changes to the UI may affect which FLID method controllers select. For example, using the CID, a three-digit code (e.g., 128) is the most common FLID method for these entry types. Beacon code is four octal digits (e.g., 2477) and callsign can range from one to seven alphanumeric characters (e.g., AAL1234). However, if the length of the CID is increased in ERAM from three to four characters, controllers may shift their preference toward the other methods. Because entry methods differ with respect to the amount of time or effort required, such a shift may result in changes in data entry workload.

Another type of analysis that may be useful in ERAM testing is to examine the mistakes controllers make for certain important commands. For example, Initiate Handoff is an extremely common command on which controllers frequently make mistakes. In the ZDC data, controllers received an error nearly 9% of the time they attempted to initiate a handoff. This error rate creates workload and frustration for the controllers and increases the chances that erroneous data will be entered into the NAS or that handoffs will not be made in a timely manner. Using Entry Counter, controller data entry errors can be analyzed in detail, as shown in Table 5.

Table 5. Sample Errors for Initiate Handoff

Controller Entry	Error Message	Error Description
54 <trackball>	SECTOR 19 HAS CONTROL INITIATE HANDOFF AAL2031 54 <trackball>	The controller tried to initiate a handoff on AAL2031 to Sector 54. However, the aircraft is being controlled by Sector 19 and the handoff is disallowed.
34 <trackball>	NO TB FLIGHT ID CAPTURE UNIDENTIFD ACTN 34 <trackball>	The controller tried to handoff an unknown aircraft to Sector 34 but did not click on a track with the cursor.
V 160	NO ARTS FP INITIATE HANDOFF GLB39 V 160	The controller attempted to handoff an aircraft to an ARTS facility but it did not have the aircraft flight plan.
N 325	AC IN HANDOFF INITIATE HANDOFF COA1055 N 325	The controller tried to handoff COA1055 to the N sector but the aircraft was already in handoff status.
QZ 40 61C	SECTOR NOT ACTIVE INITIATE HANDOFF N41PC 40 61C	The controller tried to handoff N41PC to Sector 40 but that sector was not currently active according to the sector configuration.
33 6811	FLID FORMAT UNIDENTIFD ACTN 33 6811	The controller entered an invalid flight identifier. In this case, it is difficult to tell if the controller meant to enter a beacon code but pressed the 8 key by mistake (beacon codes cannot have 8s) or if the controller was trying to enter a CID and hit the 1 key twice (CIDs have only 3 digits).
83 <trackball>	NON-ADAPTED SECTOR INITIATE HANDOFF JIA2330 83 <trackball>	The controller tried to handoff JIA2330 to Sector 83 but no such sector exists in the ZDC adaptation.

4.3 Details on DSR and URET Entries

Many entry types in the legacy system can be accomplished in several ways. Table 6 contains sample data for each of the ways that controllers can adjust the range discussed in Section 1.5. By a large margin, the most common method was using the KSD. The individual methods provided by the SD Range Toolbar, a fairly recent addition to the DSR UI, were used considerably less often, although cumulatively they represent 20.2% of controller entries.

Table 6. Interaction Methods for Adjusting Range

Interaction Method	Toolbar (if applicable)	Percentage
Keypad Selection Device (KSD)		72.3%
Inc/Dec Button	SD Range Toolbar	9.8%
Display Constants		7.5%
Slider	SD Range Toolbar	6.5%
Toggle Button	SD Range Toolbar	1.6%
Type Slider Value	SD Range Toolbar	1.4%
Slider Trough	SD Range Toolbar	0.5%
Restore Previous Setting	SD Range Toolbar	0.4%

Table 7 contains sample data for each of the ways that controllers can adjust the vector line length. Similar to adjusting range, controllers choose to adjust the vector line using the KSD by a wide margin over the DC View. This type of analysis may be useful for ERAM testing because ERAM may provide new toolbar capabilities and methods for entering commands, similar to the SD Range Toolbar.

Table 7. Interaction Methods for Adjusting Vector Line Length

Interaction Method	Percentage
Keypad Selection Device (KSD)	80.1%
Display Control and Status View	19.9%

Table 8 contains sample data for each of the ways that controllers can make flight plan amendments and related commands. For these commands, in addition to the traditional methods for making entries using the keyboard and trackball, controllers can use flyout menus on the main radar display and the Aircraft List in URET. The data show that controllers vary their entry method on an entry-by-entry basis. This analysis may be important for ERAM testing because the ERAM UI is increasingly oriented toward entering information in windows and fields rather than using the command syntax of the HCS. This may change the speed and accuracy with which controllers can make these entries.

Table 8. Methods for Making Selected Entries

	Flyout Menu	Keyboard Only	Keyboard & Trackball	URET
Amendment (AM)	n/a	7.4%	0.0%	92.6%
Speed, heading, free form text (QS)	68.2%	31.4%	0.3%	1.8%
Flight Plan (FP)	n/a	44.4%	2.8%	52.8%

5. Discussion and Next Steps

5.1 Frequency Analysis

Table 3 shows a sample of the frequency data for the 10 most frequently used entry types during regular operations at ZDC. The main data table show which commands are used most frequently and the detailed analyses show how some common commands are used. For future ERAM testing, we recommend focusing on the top 30 commands because these will encompass about 95% of controller entries. Detailed analyses, such as those reported here, should be conducted for each selected entry type.

5.2 Critical Situation Analysis

Frequency of use is not the only factor affecting the operational significance of a command. Some commands are operationally important but used infrequently, especially those related to emergencies and other critical events. Because the analysis reported here is based on routine operations at ZDC, the frequency of use for rare but important commands may be underrepresented in Table 3. Additional analysis is required to identify commands that are operationally important in certain uncommon situations but infrequent during regular operations.

We will conduct this analysis in 2005 by interviewing and surveying subject matter experts from ARTCCs. We will identify uncommon situations, such as emergencies and equipment outages, and identify the HCS/DSR/URET commands controllers use to respond. These commands may appear only rarely (or not at all) during the day-in-the-life analysis. These rare but important commands will be added to the list of commands for detailed analysis in later phases of the project.

5.3 Mapping of ERAM Changes

ERAM makes a number of changes to the legacy system. As discussed in Section 1.3, some of these changes are directly related to the controller UI and have a clear potential to affect how controllers use the system. These effects can be beneficial or detrimental and will be examined in later phases of the ERAM testing.

However, other ERAM changes are not specifically targeted at the UI but may have latent effects on how controllers use the system. In later phases of the project, we will conduct an analysis to identify areas where other changes in ERAM may affect how controllers use and interact with the system. We will include these areas in our subsequent test plans and activities.

There are other ERAM changes that we anticipate may have some effect on controllers:

- ERAM will use a single flight database across multiple ARTCCs. This may require modification to the number of characters in the CID to accommodate a larger number of simultaneous tracks. Given the number of times controllers enter the CID (over 7000 times per hour across the ZDC dataset), this change could have a substantial effect on how controllers make entries and use ERAM.
- ERAM will incorporate new tracker algorithms. Other members of the AMTWG are examining the ERAM tracker from the accuracy and performance standpoints. However, as occurred on the Standard Terminal Automation Replacement System (STARS) deployment, changes in tracker algorithms, if obvious to controllers, can affect controllers' acceptance of and trust in the new system. Identification of situations where

controllers might notice differences in ERAM due to its tracker algorithm should be identified early and included in ERAM testing and training.

- ERAM will contain a new approach toward system redundancy and backup. This change is not targeted at the UI but may affect how controllers respond to equipment outages.

5.4 Usage Characteristics

Once a suitable list of frequent and critical commands has been compiled, we may conduct detailed analyses to determine usage characteristics for each. Usage characteristics include some of the sample analyses reported here but also examine each command at a very detailed level. The usage characteristics assessment for each command will include the following details:

a. Proportion of Data Entry Method (keyboard, trackball, flyout menu, URET, etc.);
b. Time to complete the command;
c. Number of keystrokes or mouse clicks required;
d. Error rate and common categories of data entry errors for the command and
e. Time spent looking at the keyboard, trackball, keypad, or screen while entering the command.

We will base the usage characteristic assessment on data already collected from ZDC and other ARTCCs. The analysis will also include observations and measurements made in the I^2F for critical commands that are not found in the day-in-the-life recordings.

5.5 Additional Facilities

All the analyses reported here are based on data recorded at ZDC. Though these data represent the largest analysis of this type ever attempted, ZDC is not representative of all ARTCCs in terms of its traffic, procedures, equipment, or work practices. In particular, other ARTCCs have received significant new equipment such as Traffic Management Advisor (TMA). A more definitive analysis of usage of the legacy system should account for some observed interfacility differences.

Data for seven adjacent ARTCCs were collected at the same time as the ZDC data and could be used for validation or to further generalize the results reported here. Examination of ARTCCs where TMA or other tools have been deployed may be informative regarding the effects on controller interactions. Possible explanations of observed interfacility differences could be differences in traffic pattern, traffic volume, unusual events such as emergencies or equipment outages, airspace size and design, and local procedures and practices.

5.6 Baseline Simulation Test Plan

The best method for directly comparing controller usage of the legacy system and ERAM is to conduct a baseline simulation on both platforms. In the baseline simulations, controllers will be presented with selected traffic situations and asked to respond. Controllers will respond to the same situations using both systems. The same metrics will be calculated for both systems and direct comparisons can be made with a minimum of confounding variables. Discussion of the baseline methodology can be found in the *Air Traffic Control Baseline Methodology Guide* (Allendoerfer & Galushka, 1999) and the reports of baseline simulations conducted for the PVD (Galushka et al., 1995) and the DSR (Allendoerfer, Galushka, & Mogford, 2000).

If the changes in ERAM result in changes in how controllers interact with the system, these differences should appear in the baseline metrics. For example, if the ERAM macro capability is beneficial to controllers' data entry workload, the benefits should appear as reductions in the number of entries, error rate, or time to complete. Alternately, the ERAM capabilities could shift controllers' preferred method for completing certain entries from the keyboard to the trackball, which would appear as differences in interaction method.

If changes in ERAM result in changes in other aspects of controllers' tasks, such as operational efficiency, these differences should appear in other baseline metrics. These metrics include measures of air traffic safety, efficiency, and workload (Allendoerfer & Galushka, 1999). For example, if an ERAM change reduces controller data entry workload which, in turn, results in controllers being able to handle more traffic, baseline metrics such as the number of aircraft handled per hour or the average time in the airspace may show improvements.

In preparation for the baseline simulations, we could write a test plan that outlines the situations to be simulated, metrics that will be captured, and other methodological details. The descriptions of the simulated situations will outline requirements for traffic volume and characteristics (e.g., number of aircraft, number of intersecting trajectories) and events (e.g., emergencies, outages) that will occur in several scenarios. The simulated situations will allow controllers to exercise all selected commands and will be designed to elicit latent effects of other ERAM changes, if any. We will develop and shakedown the scenarios as part of preparations for the simulations.

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Acronyms

Note: The two-letter identifiers for Host Computer System commands (e.g., QQ) are not included in this list and can be found in the NAS-MD-311 (FAA, 2004a).

AMTWG	Automation Metrics Test Working Group
ARTCC	Air Route Traffic Control Center
ATC	Air Traffic Control
CID	Computer Identifier
COI	Critical Operational Issues
CPT	Conflict Probe Tool
DC	Display Controls
DS	Display System
DSR	Display System Replacement
ERAM	En route Automation Modernization
FAA	Federal Aviation Administration
FDP	Flight Data Processing
FLID	Flight Identifier
FP	Flight Plan
HCS	Host Computer System
I^2F	Integration and Interoperability Facility
KSD	Keypad Selection Device
NAS	National Airspace System
PVD	Plan View Display
SAR	System Analysis Recording
SD	Situation Display
SDP	Surveillance Data Processing
SWAC	System Wide Analysis Capability
TMA	Traffic Manager Advisor
UI	User Interface
URET	User Request Evaluation Tool
VBA	Visual Basic for Applications
ZDC	Washington ARTCC

Appendix A

Frequency of Use of HCS/DSR/URET Functions

Table A-1. Frequency of Use of HCS/DSR/URET Functions

	Type	Entries	Overall %	Cumulative %
1.	Offset Datablock	39355	19.8%	19.8%
2.	Implied Aircraft Selection (Accept Handoff/Force Datablock)	32642	16.4%	36.3%
3.	Initiate Handoff	15017	7.6%	43.8%
4.	Assign Interim Altitude	10871	5.5%	49.3%
5.	Adjust Vector Line	9491	4.8%	54.1%
6.	Route Display	7279	3.7%	57.8%
7.	Delete Aircraft	6965	3.5%	61.3%
8.	Toggle Bookkeeping Checkmark	6700	3.4%	64.7%
9.	Quicklook	5673	2.9%	67.5%
10.	Flight Plan Readout Request	5637	2.8%	70.3%
11.	Cleanup Display or List	4530	2.3%	72.6%
12.	Show or Hide View/Window/Toolbar/Area	4479	2.3%	74.9%
13.	Display/Inhibit Halo	3857	1.9%	76.8%
14.	Adjust Range	3490	1.8%	78.6%
15.	Request/Suppress Datablock	3283	1.7%	80.2%
16.	Remove Interim Altitude	2927	1.5%	81.7%
17.	Assigned Altitude	2843	1.4%	83.2%
18.	Full Datablock speed, heading, or free form text amendment	2793	1.4%	84.6%
19.	Point Out	2781	1.4%	86.0%
20.	Undetermined (typically errors)[2]	2624	1.3%	87.3%
21.	Cursor Home	2430	1.2%	88.5%
22.	AM Amendment	2195	1.1%	89.6%
23.	Combined Toggle Filter	1880	0.9%	90.6%
24.	Adjust Console Attribute	1644	0.8%	91.4%
25.	Toggle Aircraft from Special Attention Area	1369	0.7%	92.1%
26.	Toggle Special Coding	1310	0.7%	92.7%
27.	Continuous Range Readout	1226	0.6%	93.4%
28.	Adjust Background Color	1153	0.6%	93.9%
29.	Set Background Color	1061	0.5%	94.5%
30.	Track Reroute	985	0.5%	95.0%

[2] Undetermined entries are those that did not correspond cleanly to an entry type. In almost all cases, undetermined entries are syntax errors rejected by the HCS as "UNIDENTIFD ACTN."

Table A-1. Frequency of Use of HCS/DSR/URET Functions (continued)

	Type	Entries	Overall %	Cumulative %
31.	Suppress/Request Conflict Alert Pair	780	0.4%	95.4%
32.	Sign In	706	0.4%	95.7%
33.	Range Bearing Readout (Two points)	568	0.3%	96.0%
34.	Toggle Opaque/Transparent	489	0.2%	96.2%
35.	Show Flight Data Readout	391	0.2%	96.4%
36.	Adjust Number of Flight Plans	334	0.2%	96.6%
37.	Acknowledge Point Out	324	0.2%	96.8%
38.	Adjust Font Size	317	0.2%	96.9%
39.	Sort List	308	0.2%	97.1%
40.	Toggle Posting Mode	299	0.2%	97.2%
41.	Adjust Altitude Setting	281	0.1%	97.4%
42.	Toggle Color	266	0.1%	97.5%
43.	Initiate Track	260	0.1%	97.6%
44.	Range/Bearing/Fix Readout (fix & point)	226	0.1%	97.8%
45.	Show All Alerts	226	0.1%	97.9%
46.	Delete Annotation	167	0.1%	98.0%
47.	Save Preference Set	167	0.1%	98.0%
48.	Delete All Flight Plans	165	0.1%	98.1%
49.	Reposition List	155	0.1%	98.2%
50.	Adjust View Frame	153	0.1%	98.3%
51.	Adjust Annotation	142	0.1%	98.4%
52.	Edit Flight Data	127	0.1%	98.4%
53.	Suppress View	119	0.1%	98.5%
54.	Show Alert Type	118	0.1%	98.5%
55.	Altimeter Request	112	0.1%	98.6%
56.	Drop Track Only	111	0.1%	98.6%
57.	Create Trial Plan	109	0.1%	98.7%
58.	Weather Request	104	0.1%	98.8%
59.	Delete Flight Plan	102	0.1%	98.8%
60.	Toggle Multi/single Line	102	0.1%	98.9%
61.	Remove Point Out	91	< 0.1%	98.9%
62.	Request Flight Plan Transfer	91	< 0.1%	99.0%
63.	Display Aircraft Entry	90	< 0.1%	99.0%
64.	Create Annotation	85	< 0.1%	99.0%
65.	Map Request	79	< 0.1%	99.1%
66.	Add Annotation	76	< 0.1%	99.1%
67.	Display Sign In Data	76	< 0.1%	99.2%
68.	Adjust Group Color	73	< 0.1%	99.2%
69.	Remove Strip	69	< 0.1%	99.2%

Table A-1. Frequency of Use of HCS/DSR/URET Functions (continued)

	Type	Entries	Overall %	Cumulative %
70.	Show Sector Alerts	69	< 0.1%	99.3%
71.	Reported Altitude	63	< 0.1%	99.3%
72.	Show FreeForm Text Area	63	< 0.1%	99.3%
73.	Delete Flight or Group	62	< 0.1%	99.4%
74.	Adjust Time Delta	61	< 0.1%	99.4%
75.	Confirmation of QX/RS	57	< 0.1%	99.4%
76.	Modify Altitude Limits	57	< 0.1%	99.4%
77.	Emergency Airport Display	54	< 0.1%	99.5%
78.	Adjust Map Center	52	< 0.1%	99.5%
79.	Suppress FreeForm Text	48	< 0.1%	99.5%
80.	Add FreeForm Text	46	< 0.1%	99.5%
81.	Toggle Datablock Field	46	< 0.1%	99.6%
82.	Departure Message (activate departure flight plan)	45	< 0.1%	99.6%
83.	Show Trial Plan	45	< 0.1%	99.6%
84.	Invoke Preference Set	44	< 0.1%	99.6%
85.	Resector	42	< 0.1%	99.7%
86.	Click on Delete Annotation	40	< 0.1%	99.7%
87.	Send Trial Plan Amendment	40	< 0.1%	99.7%
88.	Show Previous Route	40	< 0.1%	99.7%
89.	Initiate Heading or Speed Amendment	39	< 0.1%	99.7%
90.	Code Insert/Delete	37	< 0.1%	99.8%
91.	Sign Out[3]	37	< 0.1%	99.8%
92.	Combined FP Flight Plan	36	< 0.1%	99.8%
93.	Move View or Window	29	< 0.1%	99.8%
94.	Code Modification	24	< 0.1%	99.8%
95.	Move Annotation	24	< 0.1%	99.8%
96.	Delete Trial Plan	21	< 0.1%	99.8%
97.	Delete FreeForm Text	18	< 0.1%	99.9%
98.	Edit Range Toggle Value	18	< 0.1%	99.9%
99.	VFR Abbreviated Flight Plan	16	< 0.1%	99.9%
100.	Adjust Airspace Status	15	< 0.1%	99.9%
101.	Strip Request	15	< 0.1%	99.9%
102.	Discrete Code Request	14	< 0.1%	99.9%

[3] When a controller relieves another controller, the second controller signs on to the position. This automatically signs the first controller out. The manual sign out command normally is only used when the position is being shut down for the day and its airspace has been consolidated with another sector.

Table A-1. Frequency of Use of HCS/DSR/URET Functions (continued)

	Type	Entries	Overall %	Cumulative %
103.	Qualifier Modification	14	< 0.1%	99.9%
104.	Show Unsuccessful Transmission Message	14	< 0.1%	99.9%
105.	Toggle Remarks	14	< 0.1%	99.9%
106.	Adjust History	13	< 0.1%	99.9%
107.	Combo DB Offset & Initiate Handoff	12	< 0.1%	99.9%
108.	Display/Delete TMU FDBs	12	< 0.1%	99.9%
109.	Hold	12	< 0.1%	99.9%
110.	Toggle Route	12	< 0.1%	99.9%
111.	Automatic Handoff	11	< 0.1%	99.9%
112.	Cancel Slider Mode	10	< 0.1%	> 99.9%
113.	Suppress Data Blocks	10	< 0.1%	> 99.9%
114.	Update Range Toggle Value	10	< 0.1%	> 99.9%
115.	Find Flight	9	< 0.1%	> 99.9%
116.	Traffic Count Adjustment	9	< 0.1%	> 99.9%
117.	Compose Adjust Target Limits	6	< 0.1%	> 99.9%
118.	Keep Aircraft in List	6	< 0.1%	> 99.9%
119.	Request Route Conversion	6	< 0.1%	> 99.9%
120.	Show FreeForm Text	6	< 0.1%	> 99.9%
121.	Group Suppression	5	< 0.1%	> 99.9%
122.	Adjust Leader Line	4	< 0.1%	> 99.9%
123.	Coast Track	4	< 0.1%	> 99.9%
124.	Compose Adjust LDB Limits	3	< 0.1%	> 99.9%
125.	Radar Sort Box Readout	3	< 0.1%	> 99.9%
126.	Adjust WX Setting	2	< 0.1%	> 99.9%
127.	Delete Preference Set	2	< 0.1%	> 99.9%
128.	Departure Message	2	< 0.1%	> 99.9%
129.	Test Device	2	< 0.1%	> 99.9%
130.	Instrument Approach Count	1	< 0.1%	> 99.9%
131.	Resequence Request	1	< 0.1%	> 99.9%
132.	Stereo Flight Plan	1	< 0.1%	> 99.9%
133.	Toggle Filtering	1	< 0.1%	> 99.9%
134.	Weather Input	1	< 0.1%	> 99.9%
	Total	198483		**100%**