technical note techn

Electronic Tabular Display Subsystem (ETABS) Study: A Controller Evaluation of An En Route Flight Data Entry and Display System

Bruce L. Rosenberg
Thomas E. Zurinskas

October 1983

DOT/FAA/CT-TN83/09

U.S. Department of Transportation
Federal Aviation Administration

Technical Center
Atlantic City Airport N.J. 08405

NOTICE

This document is disseminated under the sponsorship of the Department of Transportation in the interest of information exchange. The United States Government assumes no liability for the contents or use thereof.

The United States Government does not endorse products or manufacturers. Trade or manufacturer's names appear herein solely because they are considered essential to the object of this report.

Technical Report Documentation Page

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
DOT/FAA/CT-TN83/09		

4. Title and Subtitle	5. Report Date
ELECTRONIC TABULAR DISPLAY SUBSYSTEM (ETABS) STUDY: A CONTROLLER EVALUATION OF AN EN ROUTE FLIGHT DATA ENTRY AND DISPLAY SYSTEM	October 1983
	6. Performing Organization Code: ACT-100
	8. Performing Organization Report No.: DOT/FAA/CT-TN83/09
7. Author(s): Bruce L. Rosenberg and Thomas E. Zurinskas	
9. Performing Organization Name and Address: Federal Aviation Administration, Technical Center, Atlantic City Airport, New Jersey 08405	10. Work Unit No. (TRAIS)
	11. Contract or Grant No.: 122-113-600
	13. Type of Report and Period Covered: Technical Note, March 1982 - January 1983
12. Sponsoring Agency Name and Address: U.S. Department of Transportation, Federal Aviation Administration, Program Engineering and Maintenance Service, Washington, D.C. 20590	14. Sponsoring Agency Code
15. Supplementary Notes	

16. Abstract

This report describes a subjective evaluation of an automated en route air traffic control (ATC) flight data handling system known as the Electronic Tabular Display Subsystem (ETABS) engineering model. This engineering model was installed at the Federal Aviation Administration (FAA) Technical Center's En Route ATC Laboratory for operational simulation tests. The main objective of these tests was to determine the potential value of specific ETABS features for use in the future En Route Sector Suite. The features evaluated were primarily the replacement of paper flight strips and printers by a cathode-ray tube (CRT) electronic flight strip display and a separate menu-prompted CRT touch screen data entry device. Ten volunteer, active, en route ATC specialists served as test subjects, each alternating as a radar (R)-controller, data (D)-controller, or observer at their assigned sectors. Data were collected in the form of eight questionnaires administered at various training and test intervals. Results showed that the feature most highly rated was the CRT display of flight strips on the near tabular display. Most said that this was the one ETABS feature ready for operational implementation. They preferred a two-line flight strip format with local ability to modify strip data format and contents. Controllers reported problems with interactive display touch-entry errors and with complexity of menu structure. ETABS was judged fairly easy to learn and operate. The subject controllers made many written comments for improving ETABS. The controllers judged that implementation of this modified ETABS concept and its operational use could result in a substantial improvement to the present ATC system.

17. Key Words	18. Distribution Statement
Air Traffic Control, ATC Displays, Flight Data Handling, ETABS, Subjective Evaluation, Controller/Computer Interface, Sector Suite, Flight Progress Strips	Document is on file at the Technical Center Library, Atlantic City Airport, New Jersey 08405

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price
Unclassified	Unclassified	258	

TABLE OF CONTENTS

	Page
EXECUTIVE SUMMARY	vii
INTRODUCTION	1
Purpose	1
Background	1
EQUIPMENT DESCRIPTION	1
Controller ETABS Equipment	1
Computer Complement	3
Typical Input Operation	3
TEST DESIGN	8
Experimental Approach	8
Simulation Facility	8
Subjects	8
Subject Training	8
Questionnaires	10
Design Matrix	11
ANALYTICAL METHOD	12
RESULTS	12
Form A - Preliminary Survey Results	12
Form B - Daily Training Survey Results (Last Day)	14
Form C - Post Training Survey Results	15
Form D - Post Familiarization Survey Results	15
Form E - Post Run Survey Results	15
Form F - Wrap-Up Survey Results	16
Form G - Observer Results	19
Form H - Follow-Up Survey Results	23
Comparison Between Forms	24
OVERALL INTERPRETATION OF RESULTS	45
Preliminary Attitudes	45
Learning ETABS	45
After Testing	45
Follow-Up Testing	47
CONCLUSIONS	48
RECOMMENDATIONS	48

TABLE OF CONTENTS (CONTINUED)

Page

BIBLIOGRAPHY 49

APPENDIXES

A — Form A - ETABS Preliminary Survey
B — Form B - ETABS Daily Training Survey
C — Form C - Post Training Survey
D — Form D - Post Familiarization Survey
E — Form E - Post Run Survey
F — Form F - Wrap-Up Survey
G — Form G - Observer's Reporting Form
H — Form H - ETABS Follow-Up Questionnaire
I — Statistical Data Analysis Tables
J — Narrative Answers to Form A - Preliminary Survey
K — Narrative Answers to Form B - Daily Training Survey (10/7/83)
L — Narrative Answers to Form C - Post Training Questionnaire
M — Narrative Answers to Form D - Post Familiarization
N — Narrative Answers to Form E - Post Run Questionnaire
O — Narrative Answers to Form F - Wrap-Up Questionnaire
P — Narrative Answers to Form G - Observer's Questionnaire
Q — Narrative Answers to Form H - Follow Up Questionnaire
R — Categorized Form F Narrative Comments
S — Questionnaire Design Considerations

LIST OF ILLUSTRATIONS

Figure		Page
1	ETABS R-Controller and D-Controller Sector Equipment	2
2	ETABS Keyboard	4
3	Multiple Formats for En Route and Departure FDE's	5
4	ETABS Interactive Display Fields	6
5	Schedule of ETABS Training and Test Runs	9
6	Test Run Matrix Design Showing Controller Assignments (Controllers 1 Through 10)	11
7	Relocation of Flight Data Fields from Paper Strip to FDE	22

LIST OF TABLES

Table		Page
1	En Route FDE, Proposed Changes (F22.3)	20
2	Departure FDE, Proposed Changes (F22.3)	21
3	General Aspect Results - Form A, Controller Preliminary Expectations of ETABS	26
4	General Aspect Results - Form F (Wrap-Up), Controller Evaluation at the End of Testing (Obtained)	26
5	General Aspect Results - Form H (Follow-Up), Controller Evaluation Leaving Out Projected-if-Refined Concepts (Obtained)	27
6	General Aspect Results - Form H (Follow-Up), Controller Expectations for a Conceptually Refined ETABS (Expected)	28
7	Problems-Versus-Benefits Results for the Four Answer Sets (Forms D, F, HE, and HO)	33

EXECUTIVE SUMMARY

This report describes the evaluation of an automated en route air traffic control (ATC) flight data entry and display system called the Electronic Tabular Display Subsystem (ETABS) engineering model. The purpose of the evaluation was to study equipment concepts relevant to future sector suite design involving cathode-ray tube (CRT) displayed flight strips, electronic touch-entry input, automatic posting and updating, and computerized recordkeeping.

Ten controllers from various facilities were used as subjects. Three controllers manned the radar (R)-positions, three manned the data (D)-positions, and three controllers observed each test run. The other controller was rotated through the three sector positions. Half of the 12 test runs used manual posting and half used automated posting of flight data entries (FDE's). The New York Air Route Traffic Control Center (ARTCC) sectors were selected for the test runs using the National Airspace System (NAS) A3d2.7 system. Data were collected in the form of questionnaire rating values and narrative comments. Statistical tests were used to determine the rating scale responses to ETABS concepts.

The results showed that using simulated ETABS, as tested, would lead to a degradation of NAS effectiveness. However, the controllers rated the concept of ETABS as a potential improvement over the present ATC system.

Data manipulation using the interactive device was perceived to be the biggest problem with the ETABS model. The sensitivity of the touch-entry system, menu sequencing, viewing angle, and fingerprint smudging contributed to this problem. Characters often required retouching, sometimes several times, before entry. Six of the ten controller subjects indicated that the safety of the ATC system could be adversely affected by the attention intensiveness required of the interactive device. Because the quick-action keyboard (QAK) and the interactive device consumed most of the console shelf space, controllers had insufficient area for writing. The overall console configuration was considered poor due mainly to the problems with the interactive device and tabular display farthest from the R-controller position. That far tabular display location created poor ratings for viewing angle, legibility, and eyestrain, especially as viewed from the R-controller position.

The controllers gave the tabular display closest to the R-controller position good ratings for CRT aspects. The sharpness, visibility, brightness/contrast controls, absence of reflections, and the green color were rated good. Eight of the ten controllers said that the best ETABS features were the near tabular display and elimination of flight data printers (FDP's), strip stuffing, and marking. Six of the ten controllers recommended that the near tabular display be implemented for depicting flight strip data.

Controllers favored using a larger tabular display to display controller-selectable strip information and fix headers along with an expanded general information and status message space. This display should be movable and rotatable to improve R-controller viewing. Favored input concepts were voice entry, touch sensitive tabular display, interactive display located vertically under the tabular display, and quick action keyboard only input. Favored features were automatic recordkeeping, overhead map or rapid access paging for map displays, and stabilized

movement of FDE's on both the interactive display and tabular displays. Automatic indication of remote updates, oversize aircraft identification, and altitude characters were also rated as good ideas. The controllers agreed that ETABS was fairly easy to learn and operate.

Based on controller opinion of ETABS in an ATC simulation, it is concluded that:

1. The controllers considered a properly adapted CRT-displayed automated flight data handling system, such as ETABS, as a probable future improvement to ATC.

2. The highest rated feature was the tabular display nearest the R-controller and it was considered to be ready for operational implementation.

3. The ETABS input procedure using the interactive device was too attention intensive for timely operation for two main reasons. First, controllers frequently had to make several "touches" to successfully activate a menu function or select a character. Second, the menu method of data input and function selection required a greater number of keystrokes than currently used in the NAS.

4. Automatic posting and updating needs some form of manual controller acknowledgement for flight data changes in a sector.

5. Flight data fields and format should be adaptable for various sector and facility requirements.

From the conclusions, it is recommended that:

1. Alternative data entry and update approaches be developed to reduce errors, increase speed, and improve accuracy.

2. ATC procedures be adapted (i.e., strip marking, handoff, displayed strip data, and posting requirements) to streamline ATC data manipulation to more effectively use automation capabilities.

3. Further work be accomplished in developing an automated flight data handling system utilizing the controller recommendations from this study.

4. The presently developed subjective survey technique and data reduction and analysis capability be used for evaluation of future flight data handling and display systems.

5. ATC specialists continue to be involved in development of flight data handling and display systems.

INTRODUCTION

PURPOSE.

This report describes an evaluation of an automated en route air traffic control (ATC) flight data entry and display system called the Electronic Tabular Display Subsystem (ETABS). The purpose of the evaluation is to study equipment features relevant to future sector suite design involving cathode-ray tube (CRT) displayed flight strips, touch-entry input, automatic posting, and computerized recordkeeping.

BACKGROUND.

ETABS was developed to replace the data (D) sector-controller's present National Air Space (NAS) equipment. The equipment replaced includes the flight strip printer (FSP), paper flight strips, holders, bays, and associated Computer Update Equipment (CUE), including the present Quick-Action Keyboard (QAK) and the Computer Readout Display (CRD) which allows preview of keyboard messages before entry. The impetus to replace this partly manual (FSP-side) and partly automated (CUE-side) system began in the early 1970's and has been consistently pursued, as indicated by the Bibliography. A major milestone in this effort has been the development of this first comprehensive ATC flight data handling system engineering model called ETABS.

The philosophy of ETABS is to duplicate all present functions of ATC according to present operational procedures, realizing that, once accomplished, future adaptation and tailoring could ensue to meld procedures with new equipment capabilities. The new system is expected to reduce time-consuming manual activities in the following ways:

1. Through the electronic display of data, ETABS can automatically transfer data that are updated elsewhere and eliminate the requirement for using duplicate controller data entries (flight strips and NAS computer) to keep flight data current.

2. Through a touch entry input device and menu-driven operation, ETABS can assist the controller in message composition, speed up data input, and reduce message entry errors.

3. Through automatic recording of all flight plan data and controller flight data notations, ETABS can eliminate the need to accumulate large volumes of paper strips for recordkeeping purposes.

EQUIPMENT DESCRIPTION

CONTROLLER ETABS EQUIPMENT.

The controller interface ETABS equipment (figure 1) consists of two touch-entry interactive displays (ID's) located one each at the radar (R)-controller and D-controller console writing surfaces. These are used for data input, while two

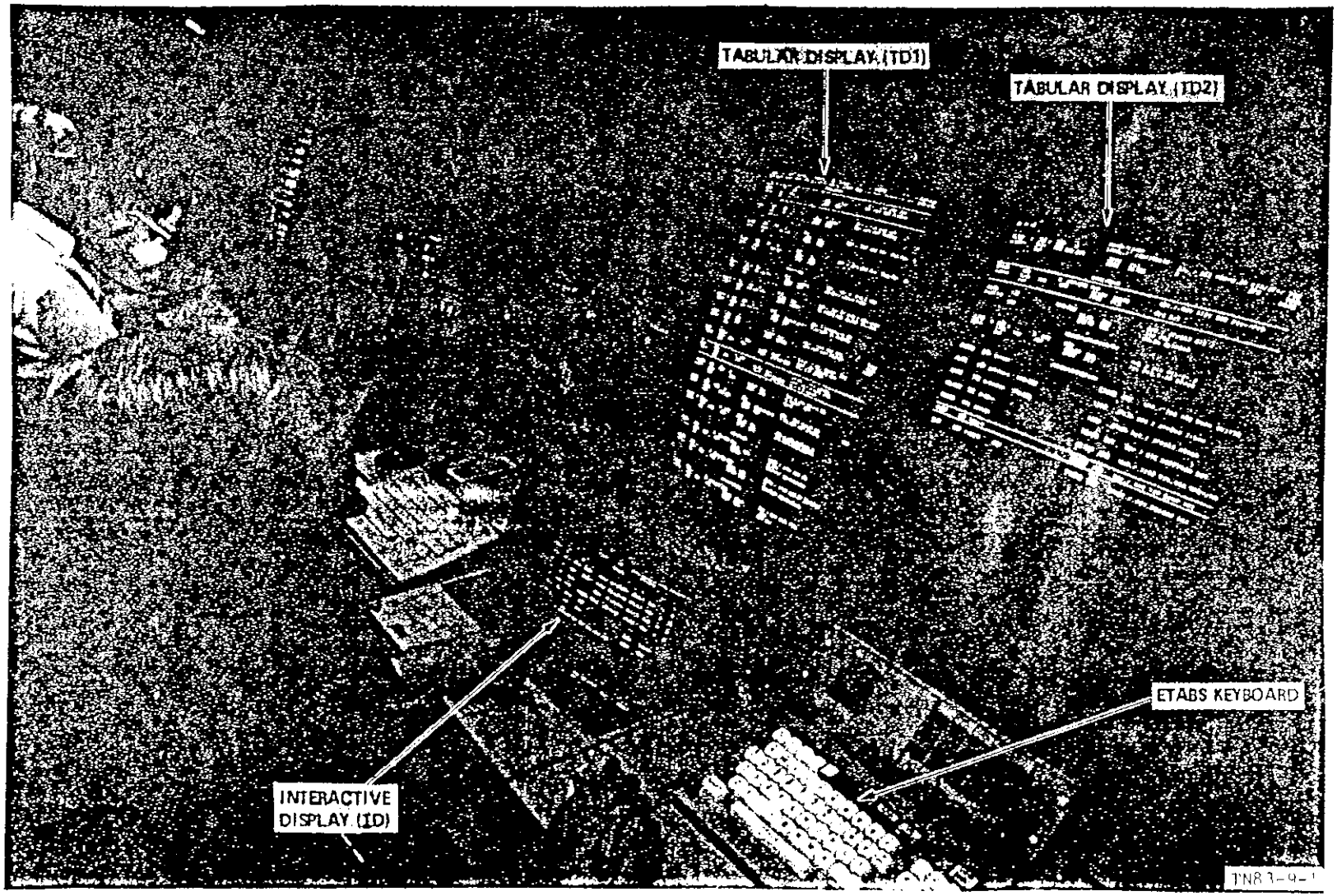


FIGURE 1. ETABS R-CONTROLLER AND D-CONTROLLER SECTOR EQUIPMENT

tabular displays (TD's) located on the D-controller console turret are used for data display. In addition, an ETABS keyboard is located on the D-controller console writing surface as a backup input device for the ID (figure 2).

The ID is a 14-inch CRT, mounted at an approximate 60° angle on the writing surfaces of both the R and D sides (figure 1). Inputs from the ID update the TD and also updates the NAS Central Computer Complex (CCC) which transmits the inputs to all appropriate sectors. The CRT surface of the ID is spanned by infrared light beams in grid fashion emitted on one side and received on the other to form an XY matrix. Redundant beams are used to eliminate parallax caused by tube curvature. Breaking the beams with a finger touch or with any other implement above the CRT surface causes that point to be selected for input into the system. This display was developed especially for ETABS data entry.

The two TD's are off-the-shelf, 25-inch CRT's mounted in the vertical orientation on the console turret. The near tabular display (TD1) only displays flight data entries (FDE's), which are electronic versions of strips and contain all present strip information as well as information derived from the plan view display (PVD) (figure 3). The far tabular display (TD2) displays FDE spillover from TD1 as well as weather, restricted area information, general information (GI) messages, and Greenwich Mean Time.

Organization of the FDE's on the TD's is similar to present arrangements with strips. Bay headers are controller selectable, and FDE's can be sequenced by time, altitude, or identity under them. The amount of information per FDE is selectable from one to four lines. Postings of FDE's can be selected as either manual or automatic; i.e., controller acknowledged (manual) or nonacknowledged (automatic). Highlighting of FDE's is accomplished by boxing, underlining, double brightening, or flashing so that all strip bay operations can be performed in some way on the TD's.

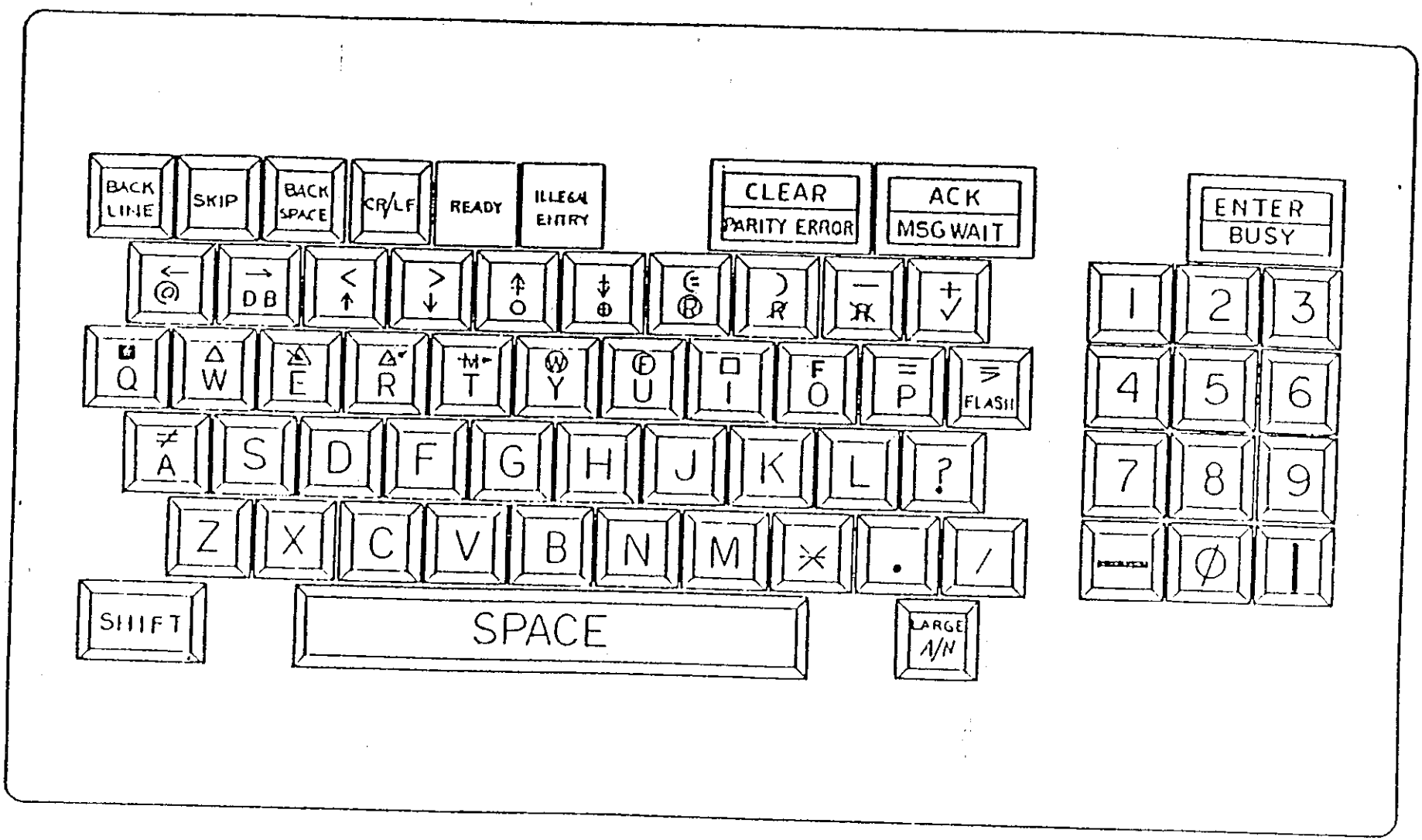
Both the TD's and the ID are slow-decay P39 phospher CRT's refreshed at a 40-hertz (Hz) rate for flicker-free operation using the stroke-writing technique. Layout of the ETABS displays on the consoles was first prototyped before final compromises were made for optimum location according to Military Standard (MIL-STD)-1472.

COMPUTER COMPLEMENT.

Briefly, the heart of the ETABS sector is a Graphic 7 display processor manufactured by Sanders Associates Inc. It generates the symbols and positioning and provides nonvolatile data storage for the ETABS equipment. The Graphic 7 is serially linked to two Perkin Elmer Model 3220 interface processors which act as switches for data between the ETABS sector equipment and the NAS computer in both directions. The interface processors also provide nonvolatile data storage. Each processor has 1 megabyte of memory with peripherals accessible via switched buses. Additional information is available on the computer complement from documents listed in the Bibliography.

TYPICAL INPUT OPERATION.

Operation of the ID by the controller is primarily accomplished through a menu-prompted data selection technique. The following are the seven functional areas of the ID (figure 4) as they would be used during typical data entry.



S-80-0153-032

FIGURE 2. ETABS KEYBOARD

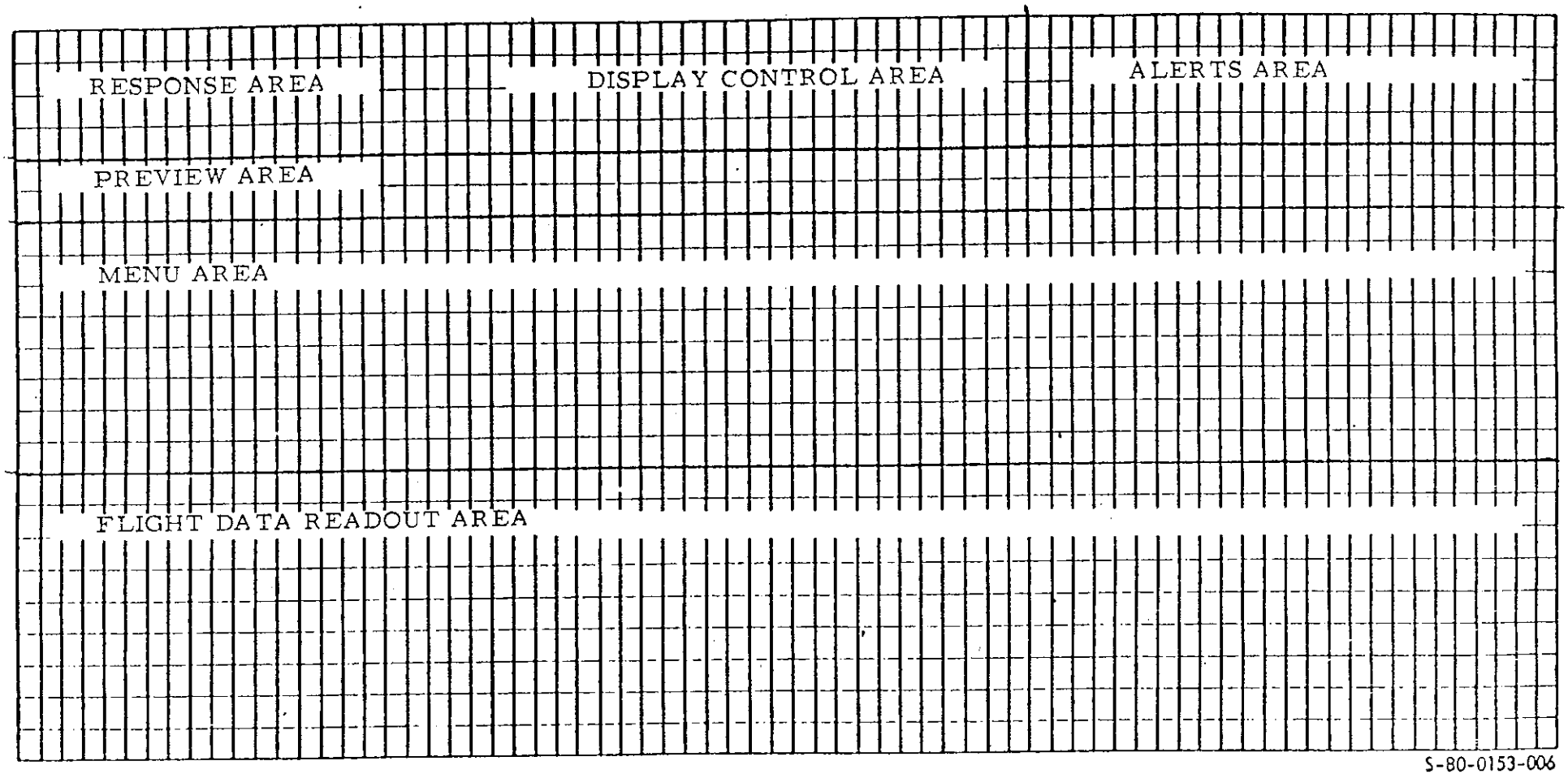


FIGURE 4. ETABS INTERACTIVE DISPLAY FIELDS

1. Aircraft Identity List Area. This is the primary or rest state configuration of the ID. The aircraft identities (AID's) of all the aircraft currently displayed on the TD are listed on the ID in the order that they appear on the TD. To enter a message concerning a particular aircraft, the controller must first touch select that aircraft by touching its AID on the ID. This repages the ID screen and brings up the flight plan information for that AID in the flight data readout area of the ID.

2. Flight Data Readout Area. The FDE for the selected AID is displayed for modification. Touching any data field of the FDE repages the screen and brings forth a menu of replacement alternatives for that data field in the menu area of the ID.

3. Menu Area. The tailored alternatives for a selected FDE data field are displayed in the menu area. For instance, a menu of all relevant altitudes would be displayed for the altitude data field. Touch selection of any one menu item causes the ID screen to repage, enter the selected data item in the preview area where the message is being composed, and then display the next relevant menu for the controller's next data selection.

4. Preview Area. This area, like the present NAS CRT, displays a message as it is being composed for preview before entry. Touching the preview area enters the message for processing by the computer. The ID then clears and returns to rest state (AID list).

5. Display Control Area. This area contains six functions pertinent to display management.

a. CLEAR - returns ID to rest state (AID list).

b. K/BD - clears screen and brings up the ID keyboard to build a message not covered by menus.

c. /OK - overrides eligibility restriction to allow changing flight data of a particular flight.

d. NO-AID - indicates message is not for a particular aircraft.

e. PREV - scrolls display up and down.

f. NEXT - displays next menu when not automatic.

6. Response Area. In this area, the computer responds to controller inputs. Responses include message rejection, acceptance, and error.

7. Alerts Area. Here the computer generates alerts to advise the controller about system conditions. The Message Waiting Indicator (MWI) blinks for acknowledgment until touched. If not touched within a prescribed time, a general information (GI) message is generated.

These seven function areas allow the controller to input any messages presently necessary for ATC. Several special symbols are also provided to replicate strip marking symbols.

TEST DESIGN

EXPERIMENTAL APPROACH.

The approach taken for the ETABS study was to perform a subjective questionnaire evaluation by current, experienced, impartial en route ATC specialists (field controllers) using ETABS with simulated traffic in the New York operational Air Route Traffic Control Center (ARTCC) environment.

SIMULATION FACILITY.

Facilities at the Federal Aviation Administration (FAA) Technical Center En Route ATC Laboratory were utilized to simulate the ARTCC environment. Six ETABS sectors were delivered by the manufacturer for testing, but, due to the unavailability of controller subjects during the controller strike aftermath, the functions of the six sectors were combined into three sectors. This resulted in some inadvertent menu crowding and multiple fix postings on single aircraft. The three ETABS sectors were configured in the following manner: one high-altitude sector, Coyle (02), and two low-altitude sectors, Atlantic City (18) and Woodstown (19). The New York area was simulated using the NAS 3d2.7 computer version for operations.

Five "ghost" sectors manned by FAA Technical Center staff controllers supported the three ETABS sectors by giving and receiving handoffs. These personnel were located in the ARTCC along with training and equipment specialists who could quickly answer any questions.

Simulator pilots (SIMOP's) interfaced with the test and ghost controllers replicating a real life pilot-controller interface. Each SIMOP could pilot up to 10 aircraft according to the prearranged scenarios of the traffic sample.

A light-density traffic sample of about 56 typical instrument flight rule (IFR) aircraft per 90-minute run was utilized. This included high- and low-altitude, commercial, military, and general aviation aircraft.

SUBJECTS.

Ten experienced controllers from nine en route facilities were used as subjects. Data on their background and experience were obtained from the questionnaire responses. Their identities were encoded as numbers 1 to 10 to retain anonymity for testing purposes.

SUBJECT TRAINING.

The subject controllers were each mailed introductory literature about ETABS for familiarization prior to arriving at the FAA Technical Center for the 3-week evaluation period. Upon arrival at the FAA Technical Center, the subjects were given the form A (appendix A) questionnaire to determine prior knowledge about ETABS as well as background and other information.

The schedule for training and test runs is given in figure 5. The first day of training was an overview in which controllers toured the facility and were given a

DATE	DAY	EVENT	SURVEY FORM
October 4	Mon	Familiarization, Lectures, Tours	A
October 5	Tues	Training	B
October 6	Wed	Training	B
October 7	Thurs	Training	B,C
October 8	Fri	Test Run	E,G
October 9	Sat	--	--
October 10	Sun	--	
October 11	Mon	Holiday	--
October 12	Tues	Test Run	E,G
October 13	Wed	Test Run (System Malfunction)	No Data
October 14	Thurs	Test Run	E,G,D
October 15	Fri	Test Run	E,G
October 16	Sat	--	--
October 17	Sun	--	--
October 18	Mon	Test Run	E,G
October 19	Tues	Test Run	E,G,F,D
October 20	Wed	Demo Run	E,G
January 19	Wed	Follow-up	H

FIGURE 5. SCHEDULE OF ETABS TRAINING AND TEST RUNS

demonstration of the ETABS equipment. The next 3 days were routine training days which consisted of textbook and hands-on training. The remainder of the time was dedicated to testing.

QUESTIONNAIRES.

Eight questionnaires were administered to the controller subjects. These are shown in appendices A through H. Each questionnaire had a separate function as described below.

FORM A - PRELIMINARY SURVEY. This questionnaire was administered before the first day of training to obtain information about the past experience of the controller, preliminary knowledge of ETABS, and any prior opinions as to how ETABS would affect the controller or system.

FORM B - DAILY TRAINING SURVEY. This questionnaire was administered at the end of each day of training. It covered general and specific areas of difficulty and requested recommendations for improving training aids and content. It also gave the controller the opportunity to comment on each of the total set of ETABS messages.

FORM C - POST TRAINING SURVEY. This questionnaire was given after the last day of training. It was designed to evaluate ergonomic aspects of ETABS. These same questions were repeated in the "Wrap-Up" survey after the evaluation runs were completed to detect any change in opinion.

FORM D - POST FAMILIARIZATION SURVEY. This questionnaire was given after the first set of test runs. The questions were in the form of rating scales to determine simulation realism and problems versus benefits.

FORM E - POST RUN SURVEY. This questionnaire was given after each run. Progress in knowledge and skill was queried, and influencing aspects were evaluated. Rating scales on the traffic sample, ability of each controller to keep up, and helpfulness of ETABS were provided.

FORM F - WRAP-UP SURVEY. This questionnaire was given once at the end of the evaluation. Questions were replicated from forms A, C, and D to see if and how controller's opinions changed. General questions asked controller's to sum up their observations and recommendations. Narrative comments as well as rating scales were utilized.

FORM G - OBSERVERS REPORTING FORM. This form was completed by the observer during and after the completion of each simulation run. The form was in two parts. The first part was an observer record of comments made by the controller regarding ETABS or other notable events experienced by the observer during the run. The second part consisted of six items to be completed by the observer at the end of the run. These six items were rated on 10-point rating scales for both the R- and D-controllers.

FORM H - FOLLOW-UP QUESTIONNAIRE. This follow-up questionnaire, form H, was given for the following reasons:

1. To clarify some questions in previous questionnaires which arose between the "concept" and "as tested" points of view.

2. To clarify some questions in previous questionnaires which arose between the R- and D-side points of view.

3. To add some general questions on overall ETABS as-tested applicability.

4. To add a rating scale for evaluating various concepts and ideas mentioned as having ATC improvement potential. Some of these were options being considered for the sector suite.

DESIGN MATRIX.

The design matrix for the first 3 days of testing can be seen in figure 6. This design was repeated in the 3 ensuing days to fill-in any data collection gaps. Questions were asked to determine which equipment were operationally adequate enough to recommend further adaptation and which procedures and concepts were acceptable.

It can be seen from figure 6 that each controller was assigned to only one sector and was shifted between three sector positions per test. This eliminated the necessity of the controller learning more than one sector geometry.

It can also be seen that two successive data runs were made per day; the first using automatic posting and the second using the manual posting mode. The presentation order maintained a constant change of one mode to the other.

		Day 1 Position			Day 2 Position			Day 3 Position		
Run	Sector	R	D	O	R	D	O	R	D	O
1 Auto	18	1/10	2	3	3	1	2	2	3	1
	02	4	5	6	6/10	4	5	5	6	4
	19	7	8	9	9	7	8	8/10	9	7
2 Manual	18	2	3/10	1	1	2	3	3	1	2
	02	5	6	4	4	5/10	6	6	4	5
	19	8	9	7	7	8	9	9	7/10	8

FIGURE 6. TEST RUN MATRIX DESIGN SHOWING CONTROLLER ASSIGNMENTS (CONTROLLERS 1 THROUGH 10)

ANALYTICAL METHOD

The questionnaires were composed of rating scales and narrative questions. Most of the rating scales were seven-category scales with the fourth (or center) category being neutral and the other three categories on either side of a dichotomy. Significant (alpha = 0.05) clustering of responses toward either side of the dichotomous scale was measured using t tests for each rating scale question. Repeated questions from different forms were compared for significance (alpha = 0.05) using the Kruskal-Wallis test. Appendix I shows computer printouts of the statistical data and results for the tabular questions.

Narrative responses were collected from the various forms and depicted in appendixes J through O. Narrative responses from the Wrap-Up Survey (appendix M) were especially important since these responses summed up final opinions. These responses were categorized into six main categories in appendix P. These categories are (1) ID, (2) TD, (3) General Concepts, (4) ATC Procedures, (5) Workload and Procedures, and (6) Functional Requirements. Repeated comments in each category were tallied. The frequency of response for any comment showed the degree of controller consensus about that comment.

RESULTS

FORM A - PRELIMINARY SURVEY RESULTS.

PARTICIPANT BACKGROUND. The form A survey as given to the subjects is presented in appendix A; the results are discussed in the same order as the questions. All narrative answers to form A are presented in appendix J.

AGE. The average age of the controllers in the subject sample was 38.3 years, with a standard deviation of 3.7 years. The range of ages in the sample was 34 to 45 years.

ATC CURRENCY (A1.1). All subjects except one were currently controlling traffic. The one exception last controlled traffic 1 year prior.

EN ROUTE ATC EXPERIENCE (A1.2). The average en route experience for the subject controllers was 11.6 years, with a standard deviation of 4.8 years. The range was 2 to 20 years.

TERMINAL ATC EXPERIENCE (A1.3). The average terminal experience for the subject controller was 1.1 years. This figure was misleading since eight controllers had no experience, one had 1 year, and one controller had 10 years terminal experience.

PRESTRIP ATC EXPERIENCE (A1.4). Two controllers had controlled traffic prior to introduction of flight strip printers into the ATC system in the late 1960's and early 1970's. Eight controllers did not have previous experience.

PRE-NAS ATC EXPERIENCE (A1.5). Only one controller had controlled traffic prior to the introduction of NAS data blocks using shrimp boats.

TECHNICAL CENTER PERSONNEL (A2.1). None of the controllers were FAA Technical Center personnel.

PRE-HANDS-ON (A2.2). One controller had prior hands-on experience with ETABS.

PRELITERATURE (A2.3). Half of the controllers had not seen literature or photos of ETABS prior to the evaluation.

PREFAMILIARIZATION (A2.4). Only 2 of the 10 controllers were familiar with the basic objectives of ETABS before the evaluation.

TOUCH TYPING (A3.1). Half of the controllers were touch typists while the other half were "hunt and peck" typists. Eight said they occasionally looked at the typewriter keys, one said almost always, and one said seldom. Self-rated typing speed indicated eight moderate and two slow typists.

TYPE FACILITY (A3.2). Eight controllers represented level IV facilities, while the remaining two controllers represented level III and V facilities.

FACILITY OPERATION (A4.2). Controllers were asked the percentage of time that the R-, D-, and assistant (A)-controllers handled various tasks at their facilities. The results were depicted as the averages of responses. When primary responsibilities at the facilities varied, that task was judged inconsistent between facilities; i.e., at some facilities posting strips was primarily a D task, at other an A task.

Task	Controller R (%)	D (%)	A (%)	Comparison
Ripping and stuffing strips	6	23	71	Consistent
Requesting strips	6	65	29	D-A inconsistent
Posting strips	10	50	40	D-A inconsistent
Manipulating strips in bay	17	77	6	Consistent
Marking (notating) strips	45	54	1	R-D inconsistent
Entering flight plan data	16	73	11	Consistent
Talking to pilots	90	10	0	Consistent

The comparison showed that for some tasks, there were reversals of responsibility. For "requesting strips," three controllers indicated that this was primarily an A-side task, the seven other controllers called it a D-side task. For "posting strips," four controllers stated that this was predominantly an A-side function, five said it was a D-side function, and one divided it equally between D and A. Finally, for "marking strips," three controllers split the responsibility equally between R and D, four favored D and three favored the R-side. All the other tasks showed consistent patterns of responsibility with the possible exception of "ripping and stuffing strips"; two controllers called it primarily a D function, while the other eight called it a primary A function.

SECOND CONTROLLER (A4.3). Eight out of ten controllers indicated that the "second" controller at their facility was a manual controller. The other two controllers indicated that the second controller at their respective facilities was a handoff/tracker controller.

PRESENT DATA PROBLEMS (A4.4). There were three main areas portrayed as problems in the present NAS: (1) four controllers said that too many strips are generated (i.e., there should only be one strip per aircraft); (2) four controllers stated that the present printers are too slow and break down too often causing a bottleneck; and (3) three controllers indicated that computer inputs are too restrictive (D-side only input for some functions). (See appendix J for additional comments.)

FIXES FOR PROBLEMS (A4.5). There were two major solutions offered for present problems in en route ATC. Three controllers indicated that the FSP's need to be replaced by a faster, more efficient device. Two controller's stated that R-side inputs should be allowed for more functions. Other various comments are listed in appendix J.

GENERAL ASPECTS (A5.1 to A5.22). This multiple-aspect question asked for the controller's expectations of the effect of ETABS on ATC in relation to present NAS. They were instructed to rate each aspect using a seven-category scale ranging from GREATLY DECREASE (1) through NO CHANGE (4), to GREATLY INCREASE (7). As described in detail in the Method section, t scores for the deviation of the mean ratings from midscale were computed. Those scores exceeding the critical t score indicated a significant agreement among the controllers toward one side of the scale.

The eight significant results (the most significant listed first) for this question are listed below for ETABS expectations:

Rank	Aspect
1	Work required for flight data handling will decrease (A5.1).
2	Overall system effectiveness of NAS with ETABS will increase (A5.21).
3	Job satisfaction will increase (A5.3).
4	Amount of weather/status information available will increase (A5.14).
5	Number of aircraft delays will decrease (A5.12).
6	Capacity to handle simultaneous flights will increase (A5.18).
7	Confidence in the system will increase (A5.19).
8	Complexity of flight data handling procedures will decrease (A5.2).

As can be seen, all of the expected changes were favorable to ETABS. The ratings on the remaining 13 general aspects did not differ significantly from the midscale category NOT CHANGE. It was evident that the significant aspects represented high expectations for ETABS, or contrarily, perhaps these eight significant positive aspects were areas envisioned for the most relief in the present system. At any rate, this same multiaspect question was repeated two more times: once at the conclusion of the simulation tests (form F) and once 3 months later in a follow-up questionnaire (form H). Results are depicted in the Comparison Between Forms section for the General Aspects question.

COMMENTS ON EXPECTATIONS (A5.23). Nine of the ten controller subjects had no comments. The various comments by the other controller are listed in appendix J.

FORM B - DAILY TRAINING SURVEY RESULTS (LAST DAY).

This questionnaire was administered after the last day of training, October 7, 1983. The following is a summary of the question responses.

AIDS FOR LEARNING (B1.0). Five of the subject controllers did not report the need for other aids for learning ETABS, while two reported that visual aids would help. Various other comments are listed in appendix K.

MESSAGE ENTERING PROBLEMS (B2.0). Four of the ten controllers had problems involving "interim altitude" and "remove interim altitude" messages. Two controllers also indicated problems with handoffs. These items were checked on the problem list. In the Comments section, three controllers indicated that the FDB was not being updated at times by the ETABS interim altitude updates. Also, handoffs at times were difficult. The other various comments are listed in appendix K.

LEARNING ETABS (B3.1 to B3.12). This question consisted of 12 aspects rated on the ease or difficulty of learning ETABS. Results are discussed in the Comparison Between Forms section.

COMMENTS ON DIFFICULTY (B3.13). Five controllers had no comments. The other controllers had various comments, with only one comment given twice — that touch entry can be frustrating. The various comments are listed in appendix K.

ETABS KNOWLEDGE LEVEL (B4.1). The rating of present knowledge of ETABS is given in summary form in the Comparison Between Forms section in which progress in attaining ETABS knowledge is depicted. No comments (B4.1) were made to this question.

ETABS SKILL LEVEL (B5.1). This rating of present skill using ETABS is given in summary form in the forthcoming Comparison Between Forms section in which progress in attaining ETABS knowledge is depicted. No appreciable comments (B4.1) were made to this question.

FORM C - POST TRAINING SURVEY RESULTS.

Form C consisted of two multiple-aspect rating scale questions, which were also presented in forms F and H. Therefore, discussion of results is contained in the Comparison Between Forms section presented later in the report. The two questions involved human factors aspects and CRT display aspects. There were eight various narrative comments rendered. These are listed in appendix L.

FORM D - POST FAMILIARIZATION SURVEY RESULTS.

Form D consisted of two multiple-aspect rating scale questions which were also presented in forms F and H. Therefore, discussion of the results is contained in the Comparison Between Forms section.

FORM E - POST RUN SURVEY RESULTS.

Most of these results were not analyzed per se since they were duplicated, for the most part, in the form F questionnaire. This survey served two main purposes:

1. To prime the subjects as to what type of questions were forthcoming in the final evaluation questionnaire and keep them vigilant toward these aspects during the conduct of the runs.

2. To document system problems or personnel problems during each run so as to take remedial steps and for consideration when the final questionnaire Wrap-Up is evaluated.

Analysis of questions E1.1 and E1.3 (ETABS level of knowledge and skill, respectively) is contained in the Comparison Between Forms section.

Comments to the Post Run questionnaires are given in appendix N.

FORM F - WRAP-UP SURVEY RESULTS.

HUMAN FACTORS ASPECTS (F1.1 to F1.13). This question consists of a set of multiple rating scale aspects which were administered also in other forms for comparison. The Comparison Between Forms section shows the response comparison between forms C, F, and H. Narrative comments to this question indicated 12 responses. Of these, three controllers said that the ID touch points caused errors. Two controllers made the following comments: (1) the overall concept is good, (2) the ID should be tiltable, and (3) the system configuration is poor. There were 12 other various comments which are contained in appendix O.

CRT DISPLAY ASPECTS (F2.1 to 2.12). These rating scale responses are evaluated in the Comparison Between Forms section between forms C, F, and H. Various other comments can be seen in appendix O.

GENERAL ASPECTS (F3.1 to 3.22). These rating scale responses are evaluated in the Comparison Between Forms section for forms A, F, and H. Comments to this question elicited responses on 24 aspects. Three controllers commented that ETABS required too many entries; three said that the response time is too slow; and two felt that ETABS required excessive searching for entries. Two also stated that it required too much attention. There were 14 other various responses (see appendix O).

CONTROLLER JOB SECURITY (F4.1). On a seven-category scale, controller responses indicated that they felt that increased use of automation would neither increase nor decrease controller job security significantly.

ATC SAFETY USING ETABS (F5.1). There were 24 ETABS aspects mentioned as affecting ATC safety. Six controllers indicated that for safety's sake the ID is too attention intensive. Each of the following replies were given by two controllers: (1) response times are too long, (2) touch entry points have problems, and (3) ETABS is too unreliable. There were 11 other various replies (see appendix O).

ATC EFFICIENCY USING ETABS (F6.1). There were 17 ETABS aspects mentioned as affecting ATC efficiency. Four controllers projected ATC improvements using a refined ETABS, three projected relief from non-ATC duties, and two said that the TD was more efficient than paper strips. There were eight other various comments (see appendix O).

TRAFFIC MOVEMENT USING ETABS (F7.1). There were 12 ETABS aspects mentioned as affecting the expeditious movement of air traffic using ETABS. Three controllers indicated that projected reduced workload of the D-controller would be a positive effect. Two others said that the ID should be eliminated from the R-side. There were seven other various comments (see appendix O).

ATC FUNCTIONS NOT IN ETABS (F8.1). There were 10 comments regarding ATC functions not having a counterpart in ETABS. The comments all varied. These can be seen in appendix O.

ATC PROCEDURES AFFECTED BY ETABS (F9.1). There were 12 comments regarding ATC aspects which could be simplified or eliminated by use of ETABS. Seven controllers indicated that strip marking procedures would be affected by ETABS. There were five other various comments (see appendix O).

MOST FAVORED ETABS FEATURES (F10.1). There were 36 comments regarding what was liked most about ETABS. Eight controllers indicated that they liked the tabular CRT display of flight data; eight controllers mentioned that they liked the elimination of printers, strip stuffing, and marking; five liked the projected faster flight data handling; three said that the CRT is more readable than strips; two said that the menu concept was good; and two others said that touch entry was good. There were six other various comments (see appendix O).

LEAST FAVORED ETABS FEATURES (F11.1). There were 33 comments regarding what was liked least about ETABS. Four controllers stated that the ID takes too much time; four said that there was too much information in the menus; four said that ETABS was too attention demanding; three mentioned the unreliability of the system; and two others did not like the light beam breaker touch-input system on the ID. There were 16 other various comments (see appendix O).

ETABS ASPECTS FOR IMPLEMENTATION (F12.1). There were 11 comments as to which aspects of ETABS were of such obvious benefit to present NAS that they deserved immediate implementation. Six controllers said that the TD strip display was good enough for implementation. Two controllers felt there were no aspects ready for implementation. There were five other various comments (see appendix O).

PRESENT NAS EFFECTIVENESS (F13.1). The mean response of the 10 controllers rating the effectiveness of present NAS (with printed strips) on a scale of 1 to 10 was 7.1, with a standard deviation of 1.2. This means that the present ATC system effectiveness was rated on the high side. It is significantly higher (alpha = 0.05) than midscale with a t score of 4.23.

ETABS EFFECTIVENESS (F14.1). The mean response of the 10 controllers on a scale from 1 to 10 rating the effectiveness of using ETABS with NAS was 3.4, with a standard deviation of 1.7 and t score of -3.7. This means that the controllers rated the effectiveness of NAS with ETABS significantly lower (alpha = 0.05) than midscale. Comparing F13.1 to F14.1, the effectiveness of NAS with ETABS was judged significantly lower (alpha = 0.05) than present NAS.

ETABS FIELD IMPLEMENTATION (F15.1). The mean response of the ID controllers on this seven-point scale was 2.2, indicating that implementation of ETABS in the field environment would lead to a degradation of NAS effectiveness. With a standard deviation of 1.8 and a t score of 3.14, the rating response was significantly different (alpha = 0.05) from NO CHANGE (4) in the direction of DEGRADATION.

ETABS IMPLEMENTATION COMMENTS (F15.2). There were 10 comments as to the operational effect of ETABS if implemented in field facilities. Two controllers said that ETABS needed further adaptation. The eight other various opinions are listed in appendix O.

WHAT SHOULD BE ADDED TO ETABS (F16.1). There were 23 comments as to what features should be added to ETABS to make it more effective. Four controllers mentioned

easier or automatic strip marking; two mentioned using a TD touch interactive or cursor interactive display; two recommended adding more space for FDE's on the TD; and two controllers wanted the addition of rotatability of the TD for better viewing by the R-side. The 13 other various comments are listed in appendix O.

WHAT SHOULD BE DELETED FROM ETABS (F17.1). There were 14 comments as to what should be deleted from ETABS as extraneous features. Three controllers said that the ID was unnecessary at the R-side; three said that some items in the menus should be deleted; two controllers recommended that D functions should be deleted from the R-side; and two said that the menus were too complicated. Four other various comments are listed in appendix O.

WHAT SHOULD BE CHANGED ABOUT ETABS (F18.1). There were 33 comments as to changes recommended for ETABS. Five controllers said that the TD should be made interactive; three desired a better ID touch method; three wanted reduced menu steps; two controllers suggested the use of a rectangular PVD with touch-sensitive corners; two desired stabilization of fix headers on the TD; and two suggested locating the ID vertically below the TD. The 16 other various comments are listed in appendix O.

POSSIBLE EFFECTIVENESS OF A MODIFIED ETABS (F19.1). The mean response of the 10 controllers on a seven-point scale rating the possible effect of implementing ETABS with the addition of controller-recommended modifications was 6.2, with a standard deviation of 0.8. This indicated that the controllers felt that using ETABS modified as they suggested would result in an IMPROVEMENT of NAS effectiveness if implemented in the field. With a t score of 8.82, results differed significantly (alpha = 0.05) from NO CHANGE in the direction of IMPROVEMENT.

COMMENTS AS TO A MODIFIED ETABS (F19.2). There were four various comments regarding implementing a modified ETABS according to controller recommendations. These are listed in appendix O.

ALTERNATIVE FLIGHT DATA HANDLING CONCEPTS (F20.1). There were 10 comments as to alternative flight data handling concepts besides ETABS or strips for use in en route ATC. Six controllers said that they could not think of any alternatives. Four other various comments were expressed and are listed in appendix O.

CONTROLLER SELF-RATING OF ETABS SKILL AND KNOWLEDGE (F21.1). The mean response of the 10 controllers on a seven-point scale evaluating whether they had enough knowledge and skill in ETABS to give it a fair evaluation was 5.9, with a standard deviation of 0.88. A significant t score of 6.86 indicated that the controllers thought they had more than enough knowledge and skill necessary for a fair evaluation of ETABS. Nine responses were on the MORE THAN ENOUGH side of midscale, with one response at JUST ENOUGH (center scale), and no responses on the LESS THAN ENOUGH side of midscale.

COMMENTS ON KNOWLEDGE AND SKILL EVALUATION (F21.2). There were seven comments as to the self-evaluation of controllers regarding whether their knowledge and skill was adequate to give ETABS a fair evaluaton. Two controllers said that it was a good team and should be reassembled for the next evaluation. Five other various comments were given as listed in appendix O.

PREFERRED EN ROUTE FDE FORMAT (F22.1). The controllers were asked to rank the four en route FDE formats in order of preference. The resultant ranking is shown below

with the most preferred listed first. The numbers in parenthesis equal the sum of the rankings.

1.	Two-line format	(17)
2.	Three-line format	(21)
3.	One-line format	(25)
4.	Four-line format	(35)

The Friedman two-way analysis of variance of ranks resulted in a chi-square of 10.08 for 3 degrees of freedom (Siegel, 1956). This chi-square was significant beyond the alpha = 0.02 level, indicating that there was at least one significant difference among the four formats. A subsequent Nemenyi pair comparison test (Linton and Gallo, 1980) showed that the two-line format was ranked significantly better than the four-line format. None of the other differences were found significant.

PREFERRED DEPARTURE FDE FORMAT (F22.2). The controllers were asked to rank the two departure FDE formats in order of preference. Although there were seven controllers who preferred the two-line format and three who preferred the one-line format, this preference was not significant at the alpha = 0.05 level.

PROPOSED CHANGES FOR FDE'S (F22.3). The controller subjects were asked to mark up a copy of the en route and departure FDE layouts indicating which data fields either posed problems, could be deleted, or should be moved. Tables 1 and 2 show the frequency of markup. These tables are composites of data for all four formats for en route and both departure FDE's.

In general, the results corroborated question F22.1, which found that the two-line format was significantly better than the four-line format. In other words, controllers desired fewer data fields for the FDE, as was indicated in F22.3 by the number of marked deletions of data fields. The data fields deleted were primarily: groundspeed, sector identity, next fix, and redundant altitude fields for the en route FDE. For the departure FDE, sector identity and notes were the primary candidates for deletion. It should be noted that the layout of an FDE was changed from that normally depicted by a flight strip. Figure 7 indicates the relocation of data fields from strip to FDE. These changes required some getting used to by the subject controller. In general, the ETABS philosophy was to retain maximum flight data for the four-line FDE format, with the option of selecting three-, two-, and one-line FDE formats when less information was desired. As we have seen, the two-line format was considered significantly better than the four-line, indicating that controllers desired less information than was capable of being displayed.

FDE FORMAT COMMENTS (F22.4). After the controllers were asked to examine and mark up a diagram of the FDE formats, comments were solicited on each change. Eighteen comments were made. Three controllers gave detailed examples of new strip formats; two controllers said that the data fields of the FDE should be controller-selectable; and two others said that the best choice for en route FDE was the one-line format. Eleven other various comments were made (see appendix O).

FORM G - OBSERVER RESULTS.

These results were not analyzed per se, since they served mainly as a backup chronolog to the form E Post Run results given by the R- and D-controllers. Form G

TABLE 1. EN ROUTE FDE, PROPOSED CHANGES (F22.3)

Columns	Data Field	Controllers									
	Fields	1	2	3	4	5	6	7	8	9	10
5-10	AID										
	A/C Data										
	U										
	A										
	HHIN						X	X	X		
11-19	CID (2)								X		P
	BCN							X			P
	IAS				X			X	X		P
	GSPD			X	X	X	X	X	X		P
20	ASN ALT										P
	CC							X			
	INT				P		X	X			P
	RPT				P		X		M		P
	FIX ASN ALT						X	X	X		
30	Mode C							X	X	X	
	REQ ALT								X	X	P
	PI TM							X	X		
	VEC (L)						X	X			
40	SEC							X	X	X	X
	PVTM				X		X	X			
	PSTM (L)										
	NXTM					X		X	X		
50	NOTES (L)								X	X	
	PREV FIX						X		X	X	
	POST FIX										
	NEXT FIX						X		X	X	X
60 & 70	ROUTE										
	REMARKS										
80	CIN CIN								X	X	
	CIN CIN								X	X	
	CIN CIN								X	X	
90	HOTM								X	X	
	HOLD FIX								X	X	

X = Delete
P = Problems
M = Move

TABLE 2. DEPARTURE FDE, PROPOSED CHANGES (F22.3)

Data Field	Controllers									
	1	2	3	4	5	6	7	8	9	10
AID (L)										
A/C Data							X			
U							X	X		
A							X	X		
CID (L)								X		
BCN							X			
							X			
REQ ALT (L)							X			
T							X			
TAS							X	X		
SEC							X	X		X
NOTES (L)						X		X	X	
EDCT (L)							X			
Time (L)							M			
D FIX (L)							M			
ROUTE							X			
REMARKS							X			
CIN CIN								X	X	
CIN CIN								X	X	
CIN CIN								X	X	

X = Delete
M = Move

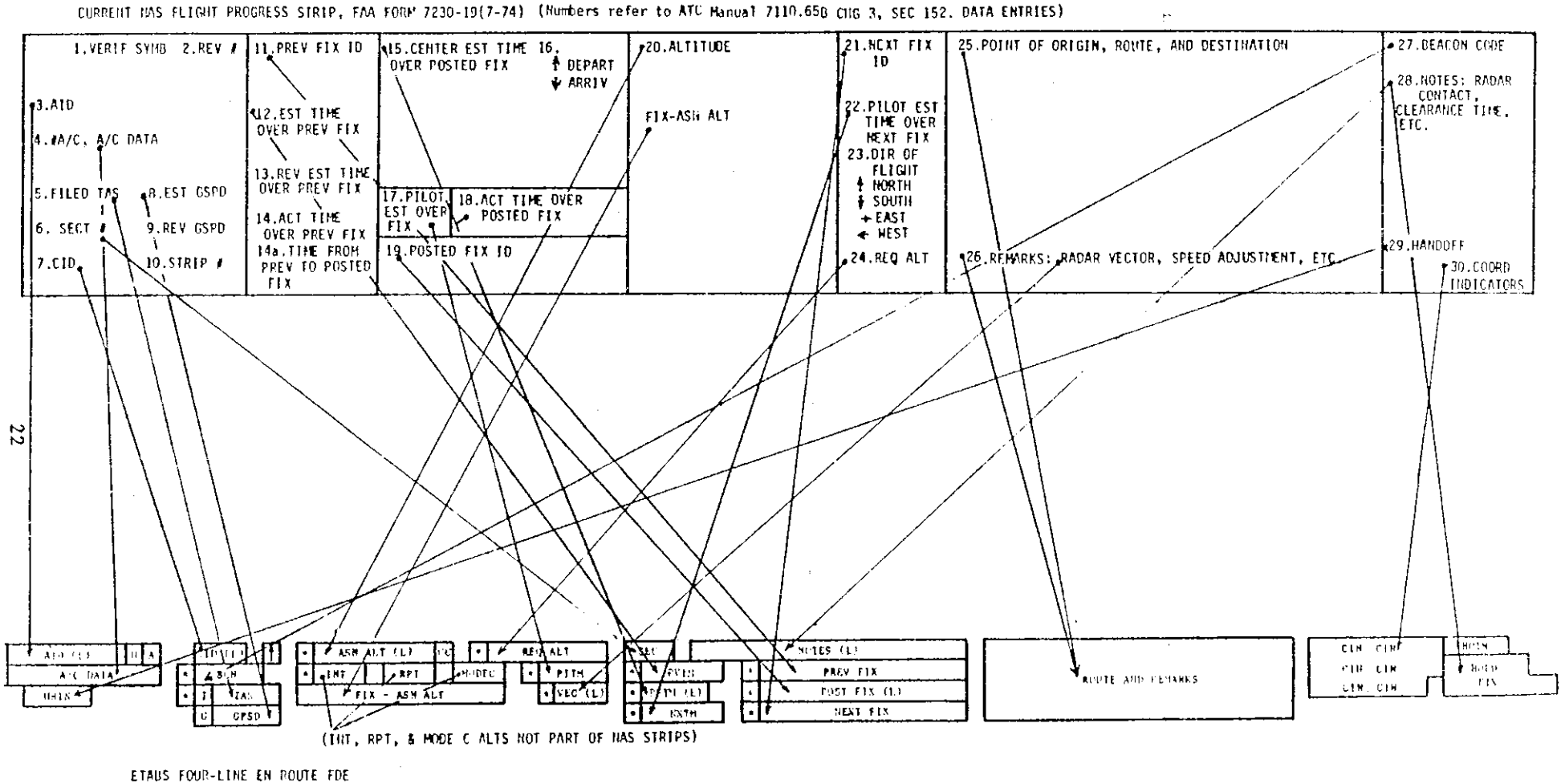


FIGURE 7. RELOCATION OF FLIGHT DATA FIELDS FROM PAPER STRIP TO FDE

was filled out during the data runs by the nonactive member of the three-man team. It served two functions:

1. To keep the nonactive controller occupied in the team process.

2. To record system problems and controller observations spontaneously so that they were not lost to recollection.

All observer comments on form G were retained and listed in appendix P.

FORM H - FOLLOW-UP SURVEY "BOTTOM-LINE" RESULTS (H5.1, H5.2, H6.1 AND H7.1).

This form was administered 3 months after the completion of testing. Most questions in form H were repeated multiaspect questions from other forms and, thus, are discussed in the Comparison Between Forms section. However, four of the remaining form H questions along with comparisons to the same questions in form F (Wrap-Up) are discussed below. The differences of each controller's rating between forms (each controller his own control) were used as the data for computation of the comparisons.

EFFECTIVENESS OF PRESENT NAS (PAPER STRIPS) (H5.1). The effectiveness of present NAS was rated on a ten-category scale as in form F (F13.1). The results showed no significant change from the form F ratings. As in form F, the form H mean of 7.0 and a t score of 5.03 showed that the effectiveness of present NAS was rated significantly better than the center scale value of 5.5. This shows consistency between forms.

EFFECTIVENESS OF NAS WITH ETABS (H5.2 ACTUAL AND CONCEPT). The effectiveness of NAS using ETABS was rated two ways on a ten-category scale as in form F (14.1). First it was rated according to the actual, as-tested ETABS and then for the potential of the ETABS concept. The mean rating for "actual" ETABS was 3.35 with a t score of -4.35. This differed significantly from midscale in the direction of low system effectiveness. The mean rating for "conceptual" ETABS was 8.4 with a t score of 8.53, differing significantly from midscale in the direction of high system effectiveness.

There was no significant difference between the mean rating of the effectiveness of NAS with ETABS on form F (F14.1) and the actual ETABS rating on form H (H5.2). However, the mean rating for conceptual ETABS was significantly better than both actual ETABS ratings for forms F and H.

How do these results compare to those for the effectiveness of the present NAS (H5.1 above)? The effectiveness of NAS with actual ETABS was rated significantly lower than that of the present system, while the effectiveness of NAS with a conceptual ETABS was rated significantly higher. These statements are also true for similar comparisons with the present NAS effectiveness rating from the Wrap-Up survey (F13.1), i.e., conceptual was higher and actual was lower than present NAS effectiveness.

CHANGE IN OPERATIONAL NAS EFFECTIVENESS WITH USE OF ETABS (H6.1 ACTUAL AND CONCEPT). The change in operational effectiveness with ETABS was rated two ways on a seven-category scale with 4.00 as midscale. The actual ETABS mean rating was 2.00 with a t score of -4.24. This is a significant deviation in the direction of

actual ETABS producing "a degradation of" NAS effectiveness. The mean rating for conceptual ETABS was 6.30 with a t score of 7.67. This is a significant deviation in the direction of conceptual ETABS producing "an improvement of" NAS effectiveness.

In form F, two nearly identical questions (F15.1 and F19.1) were asked. These questions are comparable to H6.1, actual, and H6.1, conceptual. F15.1 asks for the rating of operational NAS effectiveness with the use of ETABS as it was tested. This is comparable to actual ETABS in question H6.1. The second question (F19.1) was preceded by three questions (16.1, 17.1, and 18.1) which solicited suggestions for improvements to ETABS. F19.1 then asked, assuming that the preceding improvements were made, how would you rate operational NAS effectiveness with use of ETABS? This question is comparable to H6.1 on the effect of using conceptual ETABS.

The mean ratings for questions F15.1 (before improvements) and F19.1 (after improvements) did not differ from those for H6.1, actual ETABS, and H6.1, conceptual ETABS, respectively. In both cases, actual ETABS was seen as degrading NAS effectiveness and conceptual ETABS as improving it.

SUMMARY OF FINDINGS ON NAS EFFECTIVENESS AND ETABS. Although five of the above questions used a ten-category scale and four of them used a seven-category scale, they were very similar and could be compared. In every case, conceptual ETABS was seen as increasing and actual ETABS as decreasing NAS effectiveness. Compared to present NAS, conceptual ETABS was seen as better and actual ETABS as worse.

SUITABILITY OF ETABS FOR OPERATIONAL USE (H7.1). This question was rated on a five-category scale with 3.00 as midscale. Three controllers chose category 3, Marginally Suitable, Major Modifications Necessary, and seven controllers chose category 2, Unsuitable, Concept is OK; but Complete Redesign is Essential. The mean rating was 2.3 with a t score of -4.58 for the deviation from midscale. Thus, the rating is significantly better than Unsuitable, Entire Concept is Inappropriate (t score of 8.67) and significantly worse than Marginally Suitable, Major Modifications Necessary (t score of -4.58).

This rating of ETABS as category 2 was consonant with the results on effectiveness of NAS with ETABS. The controllers were telling us that the ETABS they used was not ready for field use, but that the concept was a workable one.

COMPARISON BETWEEN FORMS.

GENERAL ASPECTS. The general aspects multiple-item question contained 21 aspects for controller evaluation pertaining to automated flight data handling in general. This multi-item question was administered three times: first in form A (page A-4), to elicit controller expectations prior to learning ETABS; second in form F (page F-3), after the test runs, to evaluate how ETABS actually performed; and third in form H (page H-3), for dual answers to separate the "as-tested" (obtained) point of view from the "concept" (expected) point of view. Thus, this question was answered four times, encoded as follows in appendix I.

Form A = A4 1EXPECTED CHANGE
Form F = F3 1OBTAINED CHANGE
Form H = HE 2EXPECTED CHANGE
Form H = HO 2OBTAINED CHANGE

Controller responses (raw scores) are listed on page I-4 for the four administrations of this question.

The wording of this general aspects question was presented to the controllers in the following form (numbers in parenthesis are assigned values for the rating): "Compared to present NAS, when using ETABS this aspect will... (check one)."

- Greatly Decrease (1)
- Moderately Decrease (2)
- Slightly Decrease (3)
- Not Change (4)
- Slightly Increase (5)
- Moderately Increase (6)
- Greatly Increase (7)

Each of the 21 aspects received 10 responses, one from each of the 10 controllers. The mean and standard deviation of these responses were calculated and t scores determined. The t score per aspect represented a comparison between the mean of the 10 responses per aspect and center scale (4) to see if the ratings were significantly clustered to either side of midscale.

Table 3 shows the results of form A, the first administration of the general aspects question, with results listed in descending t score order. Only the aspects with responses significantly different from midscale (alpha = 0.05) are listed. As can be seen, all significant t scores were favorable toward ETABS, indicating high expectations for the system. The complete list of ranked t scores is given on page I-6 under the heading "FORM A4 1EXPECTED CHANGE."

Table 4 shows the results of the form F (Wrap-Up) administration of the general aspects question listed with significant t scores in descending order. These results reflect controller opinion after experiencing the total regime of training and test runs. The total t score data are listed on page I-6, "FORM F3 1OBTAINED CHANGE." As can be seen, all significant t scores were unfavorable toward ETABS. It showed a lack of controller confidence and increased frustration with the system after having been trained and having used it. The main reasons for this, as indicated from these data, were misreading, miskeying, and input-error propensity.

Three months after completion of testing, the Follow-Up (form H) questionnaire was administered to the 10 controller subjects to explicitly separate the controllers' projected-if-refined (expected) opinions from their as-tested (obtained) opinions. The general aspects question was one of the questions readministered. The t scores are given on page I-6 under the headings "FORM HE 2EXPECTED CHANGE" and "FORM HO 2OBTAINED CHANGE."

Table 5 shows the results of the as-tested (obtained) form H significant t scores. These are comparable to the form F (obtained) results (table 4) with the understanding that form H "obtained" results eliminated any projected-if-refined (expected) considerations. It can be seen that all significant form H (obtained) t scores were unfavorable to ETABS. The asterisks indicate repeated significant aspects from table 4 (Wrap-Up). The other aspects became significant due to the fact that controllers were told to eliminate all thoughts of conceptualized refinements. The controllers probably foresaw in form F that refinements would enhance these aspects and, thus, indicated less negative aspects for form F than form H (obtained).

TABLE 3. GENERAL ASPECTS RESULTS - FORM A, CONTROLLER PRELIMINARY EXPECTATIONS OF ETABS

t Score Rank	Aspect	Change	Interpretation Regarding ETABS
1	Work required for flight strip data handling will:	Decrease	Favorable
2	Overall system effectiveness of NAS with ETABS will:	Increase	Favorable
3	Job satisfaction will:	Increase	Favorable
4	Amount of weather/status information available will:	Increase	Favorable
5	Number of aircraft delays will:	Increase	Favorable
6	Capacity to handle simultaneous flights will:	Increase	Favorable
7	Confidence in the system will:	Increase	Favorable
8	Complexities of flight data handling procedures will:	Decrease	Favorable

TABLE 4. GENERAL ASPECTS RESULTS - FORM F (WRAP-UP), CONTROLLER EVALUATION AT THE END OF TESTING (OBTAINED)

t Score Rank	Aspect	Change	Interpretation Regarding ETABS
1	Number of message input errors or rejects	Increase	Unfavorable
2	Amount of frustration	Increase	Unfavorable
3	Likelihood of miskeying data	Increase	Unfavorable
4	Confidence in the system	Decrease	Unfavorable
5	Likelihood of misreading	Increase	Unfavorable

TABLE 5. GENERAL ASPECTS RESULTS - FORM H (FOLLOW-UP), CONTROLLER EVALUATION LEAVING OUT PROJECTED-IF-REFINED CONCEPTS (OBTAINED)

t Score Rank	Aspect	Change	Interpretation Regarding ETABS
1*	Confidence in the system	Decrease	Unfavorable
2*	Likelihood of miskeying data	Increase	Unfavorable
3*	Number of message input errors or rejects	Increase	Unfavorable
4	Capacity to handle simultaneous flights	Decrease	Unfavorable
5*	Amount of frustration	Increase	Unfavorable
6	Number of aircraft delays	Increase	Unfavorable
7	Complexity of flight data handling procedures	Increase	Unfavorable
8	Work required for non-flight strip data handling	Increase	Unfavorable
9*	Likelihood of misreading	Increase	Unfavorable
10	Amount of weather/status information available	Decrease	Unfavorable
11	Likelihood of A/C-to-A/C conflicts	Increase	Unfavorable
12	Amount of eyestrain	Increase	Unfavorable
13	Overall system effectiveness of NAS with ETABS	Decrease	Unfavorable

*Also significantly unfavorable in form F.

The complete listing of t scores can be seen on page I-6 under the heading "FORM HO 2OBTAINED CHANGE."

On the other hand, table 6 shows the results of the form H projected-if-refined (expected) judgments on the general aspects question. Only the aspects having significant (alpha = 0.05) t scores are listed. The other aspects and their t scores can be found on page I-6 under the heading "FORM HE 2EXPECTED CHANGE."

As can be seen from table 6, there were nine aspects, all favorable to ETABS, which significantly differed from midscale. This indicates that after experiencing ETABS, controllers still held high expectations for the concept of a refined automated flight handling system. In fact, these expectations were akin to those expectations for ETABS in the form A Preliminary Questionnaire results (table 3). The asterisked items of table 6 show that six out of the nine aspects that were significant for form H (expected) were also significant for form A (table 3). This shows that the controllers still felt as optimistic toward the potential of the concept of ETABS after the evaluation as before the evaluation.

TABLE 6. GENERAL ASPECTS RESULTS - FORM H (FOLLOW-UP), CONTROLLER EXPECTATIONS FOR A CONCEPTUALLY REFINED ETABS (EXPECTED)

t Score Rank	Aspect	Change	Interpretation Regarding ETABS
*1	Work required for flight strip data handling	Decrease	Favorable
*2	Complexity of flight data handling	Decrease	Favorable
*3	Confidence in the system	Increase	Favorable
4	Amount of frustration	Decrease	Favorable
*5	Number of aircraft delays	Decrease	Favorable
6	Number of sector-sector interphone calls	Decrease	Favorable
*7	Job satisfaction	Increase	Favorable
*8	Overall system effectiveness of NAS with ETABS	Increase	Favorable
9	Likelihood of A/C to A/C conflicts	Decrease	Favorable

*Also significantly favorable in form A.

Another indication of this was a comparison of the differences in ratings between form A (1 expected) and form H (2 expected) which was accomplished on page I-11. The results under heading, "FORM 13 1EXPECTED - 2EXPECTED" showed no significant differences. Controller's high expectations at the outset were not significantly diminished (alpha = 0.05) at test end.

Comparisons of how the individual controller changed his ratings between forms were accomplished for all four administrations of the general aspects questions. Pages I-11 and I-12 show the six total comparisons. The most interesting was the form H as-tested (obtained) versus the form H projected-if-refined (expected) comparison under the heading "FORM 34 2EXPECTED - 2OBTAINED." This gave the greatest number of significantly different t scores (16 of 21 aspects) than any other comparison. All significant differences showed better ratings for the projected-if-refined (expected) point of view than from the point of view for the as-tested (obtained) system.

The other comparison of note was between forms F and H (both obtained) for which no differences were expected. The results listed on page I-12 under heading "FORM 24 1OBTAINED - 2OBTAINED" showed only three significant aspects: "aircraft delays, complexity of flight data handling, and capacity to handle traffic" — all more negative in form H.

When asked to rate the aspects from both "as tested" and "potential of the concepts" points of view, the ratings became more divergent, i.e., potential became

more favorable and as tested became more unfavorable. This showed that the as-tested answers to form F included some projected concept-type thinking and tended, therefore, to be more favorable toward ETABS than if considered strictly as tested; however, only the 3 general aspects listed previously (out of 21) were significantly affected.

To summarize the results for General Aspects, the following inferences are drawn:

1. Prior to experiencing ETABS, the controllers' attitudes were favorable to ETABS or, in general, to some form of automatic flight data handling. This was indicated by the fact that all eight significant aspects for the form A General Aspects question were favorable toward ETABS with none unfavorable out of the 21 general aspects evaluated.

2. Controller evaluation of the ETABS system as tested fell far short of their initial (form A) expectations. The form H (obtained) results showed that all of the 16 significant aspect t scores were unfavorable to ETABS, with none favorable, out of the 21 general aspects evaluated.

3. Controllers had a tendency to project conceptualized refinements into the system which tempered their form F results. This form had only five significant t scores, all negative to the as tested ETABS; whereas form H, with instructions to eliminate conceptualized improvements, had 16 significant t scores, all negative to ETABS, out of the total 21 aspects evaluated.

4. After experiencing ETABS, controllers still had the same high expectations for a refined automatic flight data handling system that they indicated before testing; there were no significant differences comparing form A (1 expected) to form H (2 expected). Form A had 8 of 21 significant aspects favoring ETABS (with none unfavorable), while form H (2 expected) had 9 of 21 aspects favoring ETABS (with none unfavorable). Both forms A and H (expected) received significantly favorable ratings for important aspects such as increases in job satisfaction, confidence in the system, and overall system effectiveness aspects.

LEVEL OF ETABS KNOWLEDGE AND SKILL (B4.1, E1.1; AND B5.1, E1.3). Both similarly phrased questions were rated on a seven-category scale. The questions in form E were repeated five times during the course of the simulation. Form B was administered prior to the form E administrations. The results for these six administrations (numbered 1 through 6, form B being first) then constitute a time series which should reflect self-perceived learning by the controller participants. An increase in self-rated knowledge and skill was expected over the course of the evaluation.

The mean ratings and their standard errors were computed. Following this, t scores for the deviation of the mean ratings from midscale were determined. Finally, all possible differences between the six mean ratings and the t scores for the deviation of the differences from zero were computed. These latter t scores test the null hypothesis that there is no difference between the ratings over the course of the evaluation.

RESULTS OF LEVEL OF ETABS KNOWLEDGE.

Administration	1	2	5	6	3	4
Mean Rating	3.9	4.0	4.3	4.5	4.5	4.5

None of the above mean ratings differed significantly from a "moderate" level of ETABS knowledge. Administration numbers covered by the same line do not differ significantly from each other. Thus, in the above results, the only significant differences are administrations 3 and 4 showing significantly higher knowledge ratings than administration 1. Administrations 1, 2, 5, and 6 do not differ significantly from each other; nor do administrations 2, 5, 6, 3, and 4.

RESULTS FOR LEVEL OF ETABS SKILL.

Administration	1	2	3	4	5	6*
Mean Rating	3.7	3.9	4.3	4.4	4.4	4.6

(*Administration 6 skill self-rating was significantly higher than moderate with a t score of 2.71. None of the other ratings differed significantly from midscale.)

As for ETABS knowledge above, numbers covered by the same line do not differ from each other. Administration 6 was significantly higher than 1 and 2; administrations 4 and 5 were significantly higher than 1. Administrations 1, 2, and 3 do not differ significantly from each other; nor do 2, 3, 4, and 5; nor 3, 4, 5, and 6. These results show the expected progressive increase in level of ETABS skill with experience.

Although both ETABS knowledge and skill show a significant increase with experience, the results of ETABS skill are more consistent with the expectation of a progressive increase with administration order. Only one of the means was moderately high. Although this indicates that the amount of training and exposure to ETABS was insufficient to achieve a "high" level of ETABS knowledge or skill, the controllers reported in form F (F21.1) that their operating skill and knowledge was enough for a fair evaluation.

SIMULATION REALISM. The simulation realism multiple-item question contained eight aspects for controller evaluations pertaining to how realistic the simulation appeared to them. This multi-item question was administered two times: once during Post Familiarization (form D, page D-1) after the first set of 3-day test runs, and once for the Wrap-Up (form F, page D-1) administered after the final 3 days of test runs.

The wording for this question was: "Please place a check mark in the column which best reflects your opinion of the realism of the following aspects." The following seven rating categories were provided (numbers in parenthesis are assigned values for the ratings).

Realism was (check one)	Very Low	(1)
	Low	(2)
	Moderately Low	(3)
	Moderate	(4)
	Moderately High	(5)
	High	(6)
	Very High	(7)

Each of the eight aspects listed received 10 responses from the 10 controller subjects per administration. The mean and standard deviation of these responses were calculated and t scores determined. The t scores per aspect represented a comparison between the mean of the 10 responses per aspect and center scale (4) to see if the ratings were significantly clustered to either side.

Results from the first administration of the simulation realism question for form D (after the first three test runs) showed only one significant aspect: realism of "the simulation as a whole" was judged significantly lower than midscale. However, since no other particular aspect was judged significant, no single aspect could be singled out as being the primary causal element. These t scores can be seen on page I-16 under the heading "Form D1 1SIM REALISM." The raw ratings are also available on the same page under the heading "Form 1 D1 1SIM REALISM."

Results from the second administration of the simulation realism question in form F (after the second 3 days of test runs) indicated one positive and one negative significant aspect. The positive aspect was "communications," for which realism was judged significantly higher than midscale. The negative aspect was "traffic samples" for which realism was judged signficantly lower than midscale. These t scores can be seen on page I-16 under the heading "Form D2 2SIM REALISM." The raw scores are available on the same page under the heading "Form 2 D2 2SIM REALISM."

t tests comparing how each individual controller's ratings changed between forms, depicted on page I-18, showed that the aspects, traffic samples, communications, and simulation as a whole, were the only aspects for which responses significantly changed between administrations. The communications and simulation as whole aspects were judged significantly more realistic for form F as opposed to form D. The other five aspects on realism showed no controller opinion change between administrations.

In summary, the results indicate that the realism of the simulation as whole was judged significantly below moderate during the first three test runs, and was judged to significantly improve to moderate for the second three test runs. A corresponding significant increase in communications realism may have helped account for this. At the same time, the traffic sample aspect was judged to have become less realistic for the second administration (form F) than for the first (form D).

It should be noted that during the second half of the simulation, the participant controllers were aware of unsuccessful attempts by the experimenters to increase traffic density, which could account for the lower traffic sample realism ratings. Also, adaptation to the simulation environment might have accounted for the positive change in simulation as a whole judgments.

PROBLEMS VERSUS BENEFITS (D2 FIRST, D2 SECOND, H4 CONCEPTUAL, H4 ACTUAL). The participants were asked whether 13 key ETABS features created more problems or benefits for the controllers. This problems/benefits question was administered three times: first in form D (page D-3) after the first three test runs, second along with form F (page D-3) after the second three test runs, and third in form H (page H-4) 3 months after testing. The form H administration required dual answers: one for conceptualized operation and another for as-tested operation. Thus, this question was answered four times as encoded in appendix I:

1. Form D = D1 1PROB VS BENE
2. Form F = D2 2PROB VS BENE
3. Form H = HE EPROB VS BENE
4. Form H = HO OPROB VS BENE

Controller responses (raw data) are listed on page I-20 for the four administrations of this question.

The wording of this problems/benefits multiple-item question was presented to the controllers as follows: "Comparing ETABS to the present NAS system, determine whether or not any problems in using these features outweigh the benefits, visa versa, or no change." Again, a seven-category scale was used for rating each feature. (The numbers in parenthesis beside each category are the numerical values assigned to the response.)

"Using this ETABS feature creates:

Many More Problems	(1)
More Problems	(2)
Slightly More Problems	(3)
Problems = Benefits	(4)
Slightly More Benefits	(5)
More Benefits	(6)
Many More Benefits"	(7)

Each of the 13 features received 10 responses, 1 from each of the controllers. The mean and standard deviation of these responses were calculated, and t scores determined. These t scores per feature represented a comparison between the mean of the 10 responses to center scale (4) to test for significant clustering to either side of midscale.

The t scores are given on page I-22 for the four administrations. Inspection of the results indicated few significant results for the first two administrations of the question; i.e., forms D and F. Therefore, it appeared that controller subjects may have projected ETABS improvements into the evaluation instead of evaluating the system as tested.

The form H results bore this out. The results under the heading "FORM HO OPROB VS BENE" showed that controller opinion, when instructed not to consider foreseen refinements, resulted in 8 significantly unfavorable evaluations out of the 13 features, with none favorable. However, under the heading "FORM HE EPROB VS BENE," controller opinion of a conceptually refined ETABS operation gave 10 significantly favorable evaluations out of the 13 features, with none unfavorable. This is illustrated in table 7.

TABLE 7. PROBLEMS-VERSUS-BENEFITS RESULTS FOR THE FOUR ANSWER SETS (FORMS D, F, HE, AND HO)

Using This ETABS Feature Creates (More or Fewer Problems Than Benefits)	Form* D1	Form* D2	Form* H	Form** H
1. Reading electronic strips instead of paper strips	-	-	-	F
2. Touch data entry instead of keyboard entry	U	-	U	F
3. Touch data updating instead of pencil	-	-	U	F
4. Second tabular display for overflow or status	-	-	U	-
5. Automatic posting	-	-	U	-
6. Manual posting	-	-	-	F
7. Automatic updates	-	-	U	-
8. Manual updates	-	-	-	F
9. Handoffs	-	-	U	F
10. Computerized recordkeeping instead of strips	F	F	-	F
11. Highlighting techniques	-	F	-	F
12. Speed of ETABS data handling as a whole	U	-	U	F
13. Reliability of ETABS data handling as a whole	U	-	U	F

F = Favorable (more benefits)
U = Unfavorable (more problems)
- = Not signficantly different from neutral

*(actual)
**(conceptual)

Table 7 illustrates the difference between the controllers' actual (obtained) versus conceptual (expected) viewpoints. The form H (actual) ratings showed that, as tested, there were eight features of ETABS operation that were significantly more problematical than beneficial. However, form H (conceptual) ratings showed that the controllers envisioned significant improvements for all features to the extent that five areas judged problematical "as tested" were judged capable of being beneficial if improved. Interestingly, ID data entry and updating were two of these five features. The other three were handoffs, speed of data handling, and reliability of ETABS as a whole.

Another interesting result showed that computerized recordkeeping received the most consistent positive judgments, although never really utilized during the simulation. Finally, a most interesting result showed that manual posting and updating were favored as opposed to automatic posting and updating. This indicated that controllers wanted to control the insertion of all updates and postings in their sector.

A comparison of how each individual controller's ratings changed between the four sets of answers to the problem/benefit question was accomplished to ascertain what changes of opinion were significant between administrations. This can be seen on page I-26, with the raw scores listed on page I-24. The most interesting result was obtained under the heading "FORM EO E-O PROB/BENE" on page I-26. This was the comparison of the form H expected (projected-if-refined) ratings versus the form H obtained (as tested) ratings. It showed that 13 out of 13 features were significantly different, favoring the form H "expected" side versus the "obtained" side. This showed that controllers envisioned improvement for all these ETABS features, or conversely, that actual ETABS performance did not measure up to what the controllers expected it could if refined.

Out of the four sets of responses, three were "obtained-type" responses (i.e., forms D, F, and H obtained), while one was "expected-type" judgments (form H expected). When the three sets pertaining to obtained judgment were compared together, the greatest disparity was found between the form F and HO results, with 9 of 13 features rated significantly more favorable to ETABS for form F than HO. This showed that controllers for the Wrap-Up questionnaire (form F) did "read-in" some projected refinements when they gave their judgments of these features.

In summary, the between forms comparison of the Problems/Benefits question showed the following results:

1. Of the features rated, computerized recordkeeping obtained the most consistent significantly (alpha = 0.05) favorable rating.

2. The manual posting and updating features were consistently rated more favorably than the automatic posting and updating features.

3. The operation of "actual" ETABS, when evaluated without considering projected refinements, received controller ratings indicating that 8 of the 13 features had more problems then benefits, with none having more benefits than problems.

4. The operation of "conceptual" ETABS received controller ratings indicating that 9 of the 13 features had more possible benefits than problems.

5. Comparing actual to conceptual ratings, all features were rated significantly better for conceptual than actual ETABS operation.

EASE OF LEARNING (B3). The Ease of Learning multiple-item question contained 11 aspects for controller evaluation regarding the ease or difficulty of learning ETABS. This question was administered during training. The results from the last training day are presented here. The raw scores and significance listings can be found on page I-14.

The wording of the Ease of Learning question was presented in the following format (numbers in parentheses are assigned values to the ratings): "Please evaluate the ease or difficulty you experienced today in learning or using the following aspects of the ETABS Simulation."

(Learning this) Aspect (was)	Very Hard	(1)
	Hard	(2)
	Moderately Hard	(3)
	Moderate	(4)
	Moderately Easy	(5)
	Easy	(6)
	Very Easy	(7)

Each aspect received 10 responses, one from each of the controller subjects. The mean and standard deviations of these responses were calculated and the t scores determined. The t score per aspect represented a comparison between the mean of the 10 responses per aspect and center scale (4) to see if the ratings were significantly grouped to either side of midscale.

The results on page I-14 showed that there were 3 out of 11 aspects which received significant responses, all on the "easy" side of midscale, with no significant aspects on the "hard" side of midscale. The three easy-to-learn aspects were: "Tabular Strip FDE Format - 1 Line, Tabular Strip FDE Format - 2 Line, and Keyboard Message Entry Sequence."

It was very interesting to note that the responses for learning the ID touch sequences or ID touch entry techniques were not judged significantly harder to learn than center scale. These aspects received critical review elsewhere in the evaluation. However, form B was prior to the actual operational simulation testing, the problems later reported for ID touch entry may not have as yet been fully perceived by the controllers.

HUMAN FACTORS (C1, F1, H1 R-SIDE, H1 D-SIDE). The Human Factors multiple-item question contained 12 aspects for controller evaluation pertaining to the "hands-on" man/machine interface. This question was administered three times: first in form C (page C-1) which was after training but before test runs, second in form F (page F-1) which was immediately after testing, and third in the followup form H (page H-1) which was given 3 months after testing. Dual answers were required for form H regarding the as tested R-side and D-side points of view. Thus, the question reviewed four sets of responses. Raw scores can be found in appendix I page I-28.

The wording of this Human Factors Aspects question was presented as follows (numbers in parentheses are assigned values to the ratings): "Please rate the various human factors aspects by marking the appropriate columns."

Aspect to be evaluated was (check one)		
	Very Poor	(1)
	Poor	(2)
	Moderately Poor	(3)
	Fair	(4)
	Moderately Good	(5)
	Good	(6)
	Very Good	(7)

Each aspect received 10 responses, one from each of the 10 controllers. The mean and standard deviation of these responses were calculated and the t scores determined.

The t score per aspect represented a comparison between the mean of the 10 responses and center scale (4) to see if the ratings were significantly grouped to either side of midscale.

Page I-30 shows the results of the four administrations of the Human Factors question. All the response means significantly different (alpha = 0.05) from center scale are indicated by a plus (+) or minus (-) sign. Page I-30 indicates that all significant ratings were negative; they all were unfavorable to ETABS. All 25 significant aspects of the 48 evaluated, deviated significantly from FAIR toward the POOR side, with none to the GOOD side.

Results showed that two aspects were judged poor for every administration of the Human Factors question. These were Error Free Selection of Characters on the Interactive Display and Overall Effectiveness of Console Configuration. Other aspects receiving POOR ratings in three of the four test administrations were: Convenience of Location and Angle of Interactive Display for Touch Entry, Format of Interactive Display Menus, and Overall Effectiveness of Touch-Screen Data Entry Technique.

Also of note for the form H administrations was that the R-side received eight negative ratings, while the D-side received only three negative ratings.

The differences showing how each individual controller changed his ratings between the four administrations of the Human Factors question were compared to ascertain what differences were significant. The raw score comparisons are depicted on page I-32, with the significance listings on page I-34. Of interest were the results under heading "FORM 12 1-2 HUMAN FACTORS." This showed that no ratings changed significantly between the form C (after training) and form F (immediately after testing) administrations. This showed consistency of controller opinions on forms C and F which did not separate the R- and D-side points of view. However, the comparison for form H under the heading "FORM RD R-D HUMAN FACTORS" indicates five aspects which were all rated significantly poorer for the R-side than the D-side. As might be expected, four of these five involved using the ETABS keyboard, which was not available at the R-side. The other was Overall Effectiveness of the Console Configuration. This probably also reflected the lack of an ETABS keyboard on the R-side.

In summary, the comparison of the human factors question between forms showed the following results:

1. No aspects were rated as GOOD for ETABS human factors. Twenty-five significant aspects out of 48 were rated POOR.

2. For all four administrations, Error-Free Selection of Characters on the Interactive Display was judged POOR.

3. For all four administrations, the Overall Effectiveness of Console Configuration was judged POOR.

4. No significant differences were found between form A (after training) versus form F (after testing) results. This indicates survey-to-survey reliability. These two forms evaluated the ETABS sector without discriminating between positions.

5. Form H compared the R-side versus D-side responses. There were five significant differences, all negative to the R-side. However, four reflected the absence of an ETABS keyboard, which was not available at the R-side. The other negative aspect was Overall Effectiveness of Console Configuration for R-side ETABS use.

CRT DISPLAY ASPECTS (C2, F2, H2 R-SIDE, H2 D-SIDE). The CRT Display Aspects multiple-item question contained 12 aspects for controller evaluation pertaining to the three ETABS displays: the ID, TD1 (near TD), and TD2 (far TD). This question was administered three times: first in form C (page C-2) after training, second in form F (page F-2) for Wrap-Up, and third in form H (page H-2) for Follow-Up, 3 months after testing. The form H administration required dual answers separating responses for the R-controller and D-controller point of view. Thus, each display (ID, TD1, and TD2) received four evaluations over the administration of the three forms (C, F, HR, and HD).

The wording of this CRT display aspects question was presented as follows (numbers in parentheses are assigned values to the ratings): "Please rate the various CRT display aspects by checking the appropriate column for each of the displays."

Aspect of the CRT Display to be Evaluated (was)		
	Very Poor	(1)
	Poor	(2)
	Moderately Poor	(3)
	Fair	(4)
	Moderately Good	(5)
	Good	(6)
	Very Good	(7)

Each aspect received 10 responses, one from each of the controllers. The mean and standard deviation of the responses were calculated and the t scores determined. The t score per aspect represented a comparison between the mean of the responses and center scale (4) to see if the ratings were significantly grouped to either side of midscale. The three ETABS displays, ID, TDI, and TD2, are discussed separately.

Interactive Display. The raw scores of the responses for the ID CRT display aspects are listed on page I-36 along with the ranked listing of all t score

differences from center scale. It can be seen that 21 of the 48 aspects received significant (alpha = 0.05) t scores. Of these, 13 were significant to the good (+) side, and 8 were significant on the poor (-) side of midscale.

Page I-37 shows the t scores and significances for the four administrations. Form C had the least number of significant scores (4) and form F the most (8). Results indicated that one aspect was rated significantly poorer than midscale for all four forms. This was the Absence of Fingerprint Smudges from ID Screen aspect. There were four other negative significant aspects, two regarding ID Viewing Angle (forms F and HR), plus Overall Display Effectiveness (form F), and Absence of Eyestrain (form C). On the positive side, the Phosphor Color (green) was rated significantly (alpha = 0.05) GOOD for three forms: F, HR, and HD. Highlighting Conspicuity also received three GOOD ratings (forms F, HR, and HD). Other aspects received two GOOD ratings each: Absence of Reflections (forms C and F), Stability of Image (forms HR and DR), and Adequacy of Adjustment Range (forms C and F).

Page I-39 depicts the raw scores for the comparison of how the individual controller changed his ratings on the same questions between forms. The four forms resulted in the six comparisons depicted on page I-41. Note that for the six comparisons, only two significantly different aspects were found. These were under heading "FORM 12 1-2 ID," comparing forms C and F. Responses for both significant aspects, Highlighting Conspicuity and Absence of Eyestrain, changed in the negative (-) direction between administrations, indicating that these aspects were judged significantly better for form C than F. No other aspects showed significant changes.

In summary, the comparison of the ID CRT Display Aspects question between forms (forms C, F, HR, and HD) showed the following results:

1. For the four administrations, there were 48 (4x12) aspects, for which 21 t scores were significantly different (alpha = 0.05) from center scale. Of the 21, 13 were on the GOOD (+) side while 8 were on the POOR (-) side.

2. Only one aspect, Absence of Fingerprint Smudges on Screen, was rated POOR for all four administrations.

3. Two aspects, Phosphor Color (green) and Highlighting Conspicuity, received three GOOD ratings out of the four administrations.

4. There were no significant differences between R-controller and D-controller responses regarding the ID CRT display aspects.

Near Tabular Display (TDl). The raw scores of the responses for TDl CRT display aspects are listed on page I-43. On the same page is the ranked listing of all t score differences from center scale. It shows that 22 of 48 aspects received significant t scores (alpha = 0.05). All of these significant t scores were on the GOOD (+) side of scale, favoring ETABS. No individual aspect was rated significant on all four forms, but five aspects were rated significant on three out of four forms. Those rated GOOD were:

1. Highlighting Conspicuity (forms C, F, and HD)
2. Absence of Geometric Distortion (forms C, F, and HD)
3. Uniformity of Resolution (forms C, F, and HD)

4. Phosphor Color (green) (forms F, HD, and HR)
5. Stability of Image (forms F, HD, and HR)

Page I-44 shows the t scores for each form. The most interesting result was the difference between the form HR R-controller ratings (form HR RNEAR TAB DISPLAY), which had only two significant aspects, and the other three forms which had six or seven significant aspects apiece. Thus, fewer positive ratings were given for the R-controller side.

A comparison of individual controller rating differences between forms was performed to determine change of opinion between administrations. The raw scores are given on page I-47. There were six total comparisons for the four forms. The results of the comparisons are given on page I-48 in the form of ranked t scores with significance indicated by + or -. Results indicated that there were no significant differences between forms C and F. Of the 13 significant changes found, 12 involved the R-controller aspects.

The most interesting result for the individual TDI aspects involved the aspect Uniformity of Resolution or Sharpness of Image Across Screen. This was the only aspect that was significantly different on one of the three forms. In this case, the form HR (R-controller) rating was less favorable toward the TDI display than the ratings for forms C, F, and HD. This difference was probably due to the greater viewing distance and more oblique viewing angle from the R-side.

Another interesting result for the TDI comparison of individual controller rating differences between forms was obtained for the R-controller versus D-controller comparison. Seven aspects were significant, all rated higher for the D-position.

In summary, the comparison of the TDI CRT Display Aspects question between forms C, F, HR, and HD showed the following results:

1. For the four administrations, 48 (4x12) aspects were evaluated, of which 22 t scores were significant, all on the GOOD (+) side favoring the TDI display.

2. Responses significantly better than center scale were given for five aspects on three of the four forms. These TDI aspects were:

   a. Highlighting Conspicuity
   b. Absence of Geometric Distortion
   c. Uniformity of Resolution
   e. Phosphor Color (green)
   f. Stability of Image

3. The aspect, Uniformity of Resolution or Sharpness of Image Across Screen, was rated lower for the R-controller side (form HR) than the D-controller side (form HD) or sector-as-a-whole (forms C and F).

4. The R-side ratings for 7 of the 12 TDI aspects were significantly less favorable than those for the D-side; however, no ratings were significantly below midscale or poor.

Far Tabular Display (TD2). The raw scores of the responses for TD2 CRT display aspects are listed on page I-50. On the same page is the ranked listing of all t score differences from center scale. It shows that 20 of the 48 aspects received significant (alpha = 0.05) t scores. Of these, 10 were significant toward the GOOD (+) side, and 10 were significant toward the POOR (-) side of midscale.

Page I-51 shows the t scores and significances (+ or -, alpha = 0.05) per aspect for the individual forms. An interesting distribution of +'s and -'s was present. Forms C and HD (D-controller side) showed no significant ratings toward the POOR side of scale. Form HR (R-controller side) received only POOR significant ratings, while form F (sector-as-a-whole) received an equal mix of four significant aspects for each side of center scale.

Considering individual aspects, six aspects were consistently rated lower for the R-position (form HR) point of view using TD2 than for forms C, F, and HD. Four of these six aspects, Overall Effectiveness, Uniformity of Resolution, Eyestrain, and Adjustment Range were also rated significantly poorer than center scale. Two other aspects, Viewing Angle and Legibility, would have joined the list, but they rated POOR for form F, and the difference between forms F and HR ratings was not significant. These results are probably due to the viewing distance and acute viewing angle of TD2 as viewed from the R-position.

A comparison of individual controller rating differences between forms was done to determine change of opinion about TD2 between administrations. The raw scores are given on pages I-53. There were six comparisons for four forms. The results of the comparison are given on page I-55 and show that the R-controller ratings (form HR), when compared to the other three forms (C, D, and HD), resulted in the most TD2 significant differences. Comparing the point of view of the R-position to the D-position showed that 9 of the 12 aspects were rated significantly lower for the R side (form HR) than the D-side (form HD), with none being significantly favored in HR. This same result was indicated for form C (sector-as-a-whole), with 8 of 12 aspects significantly lower for form HR compared to form C ratings. Compared to form F (sector-as-a-whole), HR also had 6 of the 12 aspects receiving significantly poorer ratings, with none significantly favoring form HR (R-controller side).

In summary, the comparison of the TD2 CRT Display Aspects question between administrations showed the following results:

1. For the four forms evaluating TD2, 48 (4x12) aspects were evaluated, of which 20 t scores were significantly different (alpha = 0.05) from center scale. Of these, 10 aspects were rated GOOD (+) and 10 were rated POOR (-).

2. No single aspect for TD2 was given a significant rating for all four or even three out of four forms.

3. No significant t scores on the POOR side of midscale where found for forms C and HD (D-controller side) for TD2. None were found on the GOOD side for form HR (R-controller side). An equal mix of four GOOD and POOR aspects was found for form F (sector-as-a-whole).

4. Results from the R-controller point of view showed that six TD2 aspects were rated significantly poorer for form HR than for the other three forms,

including Overall Effectiveness of TD2. The distance of TD2 from the R-side probably accounts for these results.

5. Nine of 12 aspects were rated significantly poorer for R-side (form HR) than for the D-side (form HD), including Overall Effectiveness of TD2.

Comparing ID, TD1, and TD2 Results, Forms C and F. A comparison of the ID, TD1, and TD2 results for the CRT Display Aspects question for forms C and D was done to see if ratings differed between displays for these two sector-as-a-whole forms. Page I-58 shows the raw scores. Page I-59 shows the ranked t scores, with the significant t scores on the GOOD side of center scale indicated by a +, and the significant t scores on the poor side of scale indicated by a -. Page I-60 shows the same t scores ranked under the pertinent display heading.

Form C. These results show that for the mean ratings for ID, TD1, and TD2 displays for form C (after training), there were 14 significant aspects out of a total of 36. Of these, 12 were significant on the GOOD side of center scale, with 2 significant on the POOR side. Both poor aspects involved the ID display. These aspects were Absence of Eyestrain and Absence of Fingerprint Smudges on the Screen. Page I-64 depicts the comparison of the individual controller rating differences between displays, and also indicates that the poor ID Eyestrain and Fingerprints aspects were the only significant differences between the ID and the other two displays.

Form F. For form F, which was administered right after testing, results for the ID, TD1, and TD2 comparison show that there were 23 significant CRT display aspects out of a total of 36. Of these, 16 were significant on the GOOD side of center scale and 7 were significant on the POOR side of scale.

1. TD1 received seven significant aspect ratings, all on the good side. The Overall Effectiveness aspect for TD1 was rated GOOD, while the same aspects for both the ID and TD2 were rated POOR.

2. For the ID, two poor aspects, Viewing Angle and Fingerprints, led to its poor Overall Effectiveness evaluation.

3. For TD2, poor ratings for three aspects: Viewing Angle, Eyestrain, and Legibility, led to its POOR Overall Effectiveness rating, even though more significant good ratings than poor were given for both displays.

The comparison of the individual controller rating differences between displays is given on page I-64.

1. TD1 received better ratings for Legibility and Viewing Angle than both ID or TD2, which led to a significantly more favorable Overall Effectiveness rating for TD1.

2. The ID was shown to differ from TD1 and TD2 regarding significantly poorer ratings on two aspects, Fingerprints and Stability of Image.

3. TD2 had only one aspect, Highlighting Conspicuity, that significantly differed from the other two displays and was rated poorer.

In summary, comparing the ID, TD1, and TD2 ratings for the CRT Display Aspects question showed the following results for the sector-as-a-whole forms C and F ratings only:

1. For form C, there were 12 aspects rated GOOD (+) and 2 rated POOR (-) out of the 36 aspects evaluated. Comparing the individual controller rating difference between displays showed that two aspects, Fingerprints and Eyestrain, were rated poorer for the ID than for TD1 or TD2.

2. For form F, 16 aspects were rated good and 7 rated POOR of the 36 aspects evaluated.

a. The Overall Effectiveness aspect was rated GOOD for TD1, while it was rated POOR for both the ID and TD2. Also, TD1 received better ratings regarding Legibility and Viewing Angle than ID or TD2.

b. The ID differed from TD1 and TD2 regarding poorer ratings for two aspects, Fingerprints and Stability of Image.

c. TD2 differed from both TD1 and ID in receiving a poorer rating for Highlighting Conspicuity.

Comparing ID, TD1, and TD2 Results, Forms HR and HD. A comparison of the ID, TD1, and TD2 results for the CRT Display Aspects question for forms HR and HD was done to see if the ratings differed between displays. Page I-67 contains the raw scores. Page I-68 shows the ranked t scores, with the significant t scores indicated by + for GOOD and - for POOR. Page I-69 shows the same t scores ranked under the pertinent display heading.

Form H R-Side. For form HR, which depicted the R-controller point of view, results show that there were 14 significant aspects out of a total of 39 (3x13). Of these, five were on the GOOD side of midscale, and nine were on the POOR side for judgments regarding all three displays. Of the nine POOR t scores, seven pertained to TD2, which received no significantly GOOD t scores. The two other POOR aspects pertained to the ID, with TD1 receiving two GOOD ratings and no POOR ratings of its 13 aspects evaluated.

Form H D-Side. For form HD, which depicted the D-controller point of view, there were 13 significant aspects out of a total of 39. Of these, 12 were significant to the GOOD (+) side of center scale with only 1 aspect, Fingerprints for the ID, rated on the POOR (-) side of center scale. Besides the one POOR aspect, the ID had three GOOD aspects. TD1 received seven GOOD ratings and TD2 received two GOOD ratings, with neither TD1 or TD2 having any ratings on the POOR side of center scale.

The raw scores for the comparison of how each controller rating changed between displays are given on page I-71 for forms HR and HD. The combined ranked t scores are given on page I-72. This is broken down by display on page I-73.

1. The primary results for the R-controller (form HR) ratings showed that the controllers rated eight TD2 aspects significantly poorer than ratings for both the ID and TD1, including the Overall Effectiveness aspect.

2. For the D-controller position ratings:

a. TD1 received significantly better ratings than ID and TD2 for three aspects: Absence of Eyestrain, Viewing Angle, and Legibility.

b. TD2 differed from both the ID and TD1 regarding a significantly poorer rating on the Highlighting Conspicuity aspect.

c. The ID was rated significantly poorer than TD1 and TD2 on the Fingerprints aspect.

In summary, comparing the ID, TD1, and TD2 controller ratings for the CRT Display Aspects question showed the following results for forms HR and HD:

1. For the 39 aspects on form HR R-side for the three displays, 9 were rated POOR and 5 were rated GOOD. TD2 accounted for seven of the nine POOR ratings, and the ID the other two. The TD2 Overall Effectiveness aspect was rated POOR. Comparing the differences of ratings between displays showed that TD2 had eight aspects rated poorer than the ID or TD1, including Overall Effectiveness. The only significant difference between ID and TD1 was the Fingerprints Aspect, which was poorer for the ID.

2. For the 39 form HD D-side aspects for all three displays, 12 were rated GOOD and only 1 (Fingerprints for the ID) was rated POOR. For all three displays, the aspects Phosphor Color and Stability of Image were rated GOOD. In comparing the differences of ratings between the displays:

a. The ID differed from both TD1 and TD2 on only one aspect, Fingerprints, which was rated poorer for the ID.

b. TD1 had better ratings than both the ID and TD2 for three aspects: Eyestrain, Viewing Angle, and Legibility.

c. TD2 had one aspect, Highlighting Conspicuity, rated poorer than ID or TD1.

CONCEPTS AND IDEAS FOR ETABS. The Concepts and Ideas multiple-item question contained 43 concepts evaluated for potential application toward en route automatic flight data handling. These concepts were derived from controller comments and suggestions obtained from the various questionnaire responses. Putting these concepts in a rating scale format allowed some quantification as to their adequacy or popularity for automated en route ATC. In effect, the subject controllers were rating many of their own ideas and suggestions relating to ETABS.

The question was administered in form H requiring dual answers, one from the R-controller point of view and another from the D-controller point of view. The question was presented to the controllers as follows (numbers in parentheses are assigned values for the ratings): "Based on your experience with and without ETABS, what concepts and ideas involving flight data handling show the best potential for development in ATC?"

Concepts to be evaluated		
	Very Poor	(1)
	Poor	(2)
	Moderately Poor	(3)
	Fair	(4)
	Moderately Good	(5)
	Good	(6)
	Very Good	(7)

Controller responses (raw scores) are listed on page I-75 for both forms HR (R-side) and HD (D-side). A t score ranking is given on page I-76 with + indicating significance to the GOOD side of center scale and - indicating significance to the POOR side of center scale. It can be seen that 40 of the 86 total concepts were significant, all to the GOOD side of scale, 19 for R-controller and 21 for D-controller sides.

A comparison of the shifts in individual controller ratings between HR and HD was done to determine any significant changes between R- and D-side opinions. The raw scores are presented on pages I-79 along with the ranked differences. This shows that only one significant difference was found. The Use of an Interactive Display with Menus to Build Messages (make updates) was rated significantly better for the D-controller than R-controller. However, use of this aspect was not rated significantly better than midscale for the D-side.

Considering all the significantly GOOD aspects rated by the controller, it was possible to build the following scenario for an improved automated flight data handling system.

For automated flight data display, this system would utilize a tabular display, accommodating more strips than TDl, which would be movable (swivel, tilt, roll-out) for R-controller viewing. Flight strips (FDE's) would be depicted on the TD with larger AID and altitude characters than ETABS. FDE data would be controller selectable, and outdated, rare strip marking symbology would be deleted. The FDE's would not "move around" on the TD unless the controller moved them under controller-selectable fix posting headers. A larger note pad and GI message area would be available. An overhead display area would be available for maps; however, a TD quick-look (fast-paging) feature for maps could be used instead. Handoffs or updates made elsewhere would be indicated. Automatic recordkeeping would replace manual.

Suggested input techniques were various. A touch-sensitive TD, a touch-sensitive ID located vertically under a no-touch TD, or a QAK with preview display were all judged significantly GOOD as D-side input devices. These were not significantly favored for the R-side. However, voice updating was favored for both D- and R-controllers. If a touch ID were to be used, it should be eliminated or modified for the R-side. Both R- and D-controllers stated that the FDE's should not move around on the ID. Interestingly, using a trackball, a joystick, or a light pen for making entries were not rated significantly to the GOOD side of center scale.

As a final note, "improving the present strips system, i.e., better procedure, better equipment" was also rated as having significantly positive potential.

OVERALL INTERPRETATION OF RESULTS

All underlined question numbers (shown in parenthesis) indicate controller preference based on significant (alpha = 0.05) t scores.

PRELIMINARY ATTITUDES.

From form A, it was seen that the subjects were experienced (A1.0) controllers, ranging in age from 34 to 45, from different facilities which employed different procedures (A4.2) of ATC operation. Even though they were, for the most part, unfamiliar (A2.4) with ETABS, they indicated high hopes for ATC system improvement (A5.21) through ETABS utilization. They also indicated that there were some faults with the present system (A4.4); mainly excessive strips generated, faulty printers, and input procedures being too restrictive for the R-controller among other things (A4.4). Various fixes were recommended (A4.5).

LEARNING ETABS.

From form B, it was found that none of the ETABS features were rated HARD to learn (B3.0), and 3 out of 11 items were rated MODERATELY EASY to learn: 1- and 2-Line FDE Formats and Keyboard Message Entry Sequence. Problems were found with the operation of the interim altitude (B2.3.4) and remove interim altitude (B2.3.6) messages. It was mentioned that the FDE was not being updated by the ETABS interim altitude updates at times. On the last day of training the subject team, as a whole, indicated that they had achieved a moderate level of skill (B4.2) and knowledge (B4.1) using ETABS.

AFTER TESTING.

Judgments for this Wrap-Up questionnaire (form F) were given from the sector-as-a-whole point of view. The important questions from forms C, D, and E were all contained in the Wrap-Up questionnaire, form F. Results show that the controllers' self-rated skill and knowledge (B4.1, B5.1, E1.1, and E1.3) increased slightly, but significantly, over the course of the ETABS evaluation; never exceeding moderately high. However, controllers agreed that they had achieved enough knowledge and skill to give ETABS a fair evaluation (F19.1). They indicated that automation, in general, would not change controller's job security (F4.1); thus, ETABS probably was not viewed as a job threat by the participant controllers.

The controllers judged that, in an operational field environment, using ETABS would lead to a degradation of NAS effectiveness (F15.1). NAS effectiveness using the ETABS Engineering Model (F13.1) was rated less than the effectiveness of the present NAS (F14.1).

The one area that contributed most to the POOR rating for implementing ETABS was data manipulation using the ID.

1. Error-free selection of characters (F1.4) was judged POOR. The characters often required retouching, sometimes several times before entry.

2. The ID menu sequences (F1.7), formats (F1.6), and the overall ID touch screen technique (F1.12) were judged POOR.

3. Six of the ten controller subjects indicated that the safety of the ATC system could be adversely affected by the attention intensiveness of the ID (F5.1).

4. Poor ratings for Viewing Angle (F2.5) and Fingerprint Smudges (F2.10) led to a poor rating for the Overall Effectiveness of the ID (F2.12), even though the Reflections (F2.1), Adjustment Range (F2.8), Highlighting Visibility (F2.7), Green Color (F2.9), and Uniform Sharpness (F2.2) of the display were rated GOOD.

Other negative ratings were as follows:

1. The ETABS console Writing Shelf Depth (F1.1) was considered POOR because the QAK and ID locations preempted most of the space.

2. The Overall Console Configuration (F1.10) was judged POOR due mainly to the above problems with the ID, as well as problems with TD2, since TD2 location created a Viewing Angle (F2.5) that was rated POOR, especially for the more distant R-controller position.

3. TD2 received poor ratings for other aspects such as Legibility (F2.6) and Eyestrain (F2.11) which led to a POOR TD2 Overall Effectiveness rating (F2.12).

On the other hand, evaluation of TD1 showed controller acceptance:

1. TD1 had only GOOD ratings for CRT aspects.

2. Eight of the ten controller subjects mentioned TD1 as the feature they liked best (F10.1) about ETABS, as well as the possibility of eliminating FDP's and strip stuffing and marking.

3. Six of the ten controller subjects recommended TD1 for immediate implementation (F12.1) for depicting flight strip data.

The favored strip (FDE) formats were two-line, three-line, one-line, and four-line, in that order, for en route (F22.1), with the two-line significantly better than the four-line. Although seven controllers preferred the two-line and three preferred the one-line format for departure strips, the preference was not statistically significant (F22.2).

Consonant with the controllers favoring the two-line en route FDE format over the four-line format, a few of the controllers felt that the following data fields in the FDE were not needed: ground speed, sector identity, next fix, and redundent altitude fields (e.g., interim, reports, and mode C altitudes). Some of the data fields were relocated in transferring from the present NAS flight strips to the ETABS FDE. This relocation required some getting used to by the participant controllers.

Although this simulation was less realistic than the present ATC environment, due mainly to the light traffic sample (FD1.1) used, controllers conceptualized that ETABS properly reconfigured would be a significant improvement (F19.1) over present NAS. Various additions (F16.1), deletions (F17.1), and changes (F18.1) were suggested to improve the ETABS system. Narrative comments (appendix R) show that all controllers mentioned that the ETABS concept and TD1 were good, with 9 of 10 controllers mentioning that ETABS needed proper adaptation.

FOLLOW-UP TESTING.

One reason for giving form H was to find any differences between R-side and D-side considerations upon readministration of the form F multiple-item questions. Results showed that the R-side responses for form H had fewer good ratings and a greater number of poor ratings than D-side for human factors and CRT aspects for each of the three ETABS displays. TD2 was the main culprit. Being located the farthest distance of any of the displays from the R-position and at the most acute viewing angle, it received only POOR R-side ratings, while, at the same time, receiving only GOOD D-side ratings. This disparity came from the D-side tailoring of the equipment, since ETABS was designed with the D-controller as the primary user. Controllers indicated the desirability of a movable TD1 or TD2 display (H8.17) for better R-side viewing, and the need for better tailoring of the ID input function for effective R-side use (H8.19) (i.e., minimum number of input steps).

Another reason for giving form H was the separation of points of view between the conceptualized (or expected) ETABS versus the actual (or obtained) ETABS through readministration of form F multiaspect questions. The results showed that the Actual Versus Conceptualized evaluations of the system were polar extremes and that form F results fell in between them. Interpretation of this considered that the form H Actual evaluations were worst-case, and unforgiving of the fact that the equipment was prototype in nature and unrefined; form F (Wrap-Up) results probably included some foreseen basic improvements, while form H (expected) results portrayed controller evaluation of an idealized ETABS system including conceptualized refinements.

Form H (expected) results corroborated form F opinion that refining the ETABS concept could result in a flight data handling system superior to present NAS (F19.1, H5.1, and H6.1). Form H results also corroborated that, although the ETABS concept was rated good, ETABS was unsuitable for present operational implementation as configured (F15.1 and H7.1). Concepts rated beneficial were Electronic Strip Display (H14.1), Touch Entry and Updating (H4.2 and H4.3), Manual (not automatic) Updating/Posting (H4.8 and H4.6), and Automated Recordkeeping (H4.10). It was also envisioned that ETABS speed (H4.12) and reliability (H4.13), though unfavorable, were conceptually favorable upon refinement.

Form H also evaluated the many alternative concepts proposed for ETABS by the subject controllers and others during the test period. The following scenario was developed of the concepts rated significantly on the GOOD side of midscale.

1. It indicated that controllers favored using a larger (H8.34) tabular display which would display controller-selectable strip information (H8.36) and fix headers (H8.37), along with expanded GI and status message space (H8.41). This display should be movable and rotatable for improved R-side viewing (H8.17).

2. Favored input concepts were voice entry (H8.43), touch sensitive TD (H8.6), ID located vertically under the TD (H8.21), and QAK (H8.5) only input.

3. Favored features were Automatic Recordkeeping, (H8.33) Overhead Map (H8.26) or Quick TD Paging for Map Displays (H8.27), and Stabilized Movement of FDE on both the ID and TD displays (H8.39 and H8.40).

4. Automatic indication of remotely made updates (H8.30) and oversize AID and altitude characters (H8.25) were also rated as good ideas.

CONCLUSIONS

Based on controller opinion of the Electronic Tabular Display Subsystem (ETABS) in an air traffic control (ATC) simulation it is concluded that:

1. A properly adapted cathode-ray tube (CRT)-displayed automated flight data handling system such as ETABS is foreseen by the controller subjects as a probable future improvement to ATC.

2. The feature most highly rated was the near tabular display (TDl). Most said that this was the one ETABS feature ready for operational implementation.

3. The ETABS input procedures and input device, namely the ID, are too attention intensive for timely operation. There were two main reasons for this. First, controllers frequently had to make several "touches" to successfully activate a menu function or select a character. Second, the menu method of data input and function selection required a greater number of keystrokes than currently used in the NAS.

4. Automatic posting and updating needs some form of manual controller acknowledgement for any change of flight data in sector.

5. Flight data fields and format should be adaptable for various sector and facility requirements.

RECOMMENDATIONS

From the conclusions, it is recommended that:

1. Alternative data entry and update approaches be developed to reduce errors, increase speed, and improve accuracy.

2. ATC procedures be adapted (i.e., strip marking, handoff, displayed strip data, and posting requirements) to streamline ATC data manipulation to more effectively use automation capabilities.

3. Further work be accomplished in developing an automated flight data handling system utilizing the controller recommendations from this study.

4. The presently developed subjective survey technique and data reduction and analysis capability be used for evaluation of future flight data handling and display systems.

5. ATC specialists continue to be involved in development of flight data handling and display systems.

BIBLIOGRAPHY

Bonello, A. H. and Crimbring, W. R., Project Plan for Electronic Tabular Display Subsystem (ETABS) Test and Evaluation, FAA-CT-80-182, May 1981.

CCC/ETABS Interface, OAO, DOT-FA79WA-039.

Celio, J. C. and Ditmore, M. A., Electronic Tabular Display Subsystem (ETABS) Engineering Model: Test Adaptation, Mitre Working Paper, December 1981.

Control Sector Redesign - Electronic Tabular Display Input Devices, FAA Technical Center, NA-77-32-LR, 1977.

Cost Analysis of Electronic Tabular Display Subsystem En Route ATC Operational Impact, FAA-AVP-77-31, 1977.

Electronic Tabular Display Subsystem, Proposal, Sanders Assoc., Inc., Volumes 1-6, prepared by Information Product Div., Federal Systems Group, in response to FAA RFP LGR-8-5106, May 1978.

Electronic Tabular Display Subsystem (ETABS), Sanders Associates, Contractt DOT-FA79WA-4270.

Electronic Tabular Display Subsystem (ETABS) Engineering Model, FAA, Systems Research and Development Service, Project Management Plan, March 1980.

En Route National Airspace System Operational Equipment, FAA/DOT, National Air Traffic Training Program, FAA Academy, N-10, September 1977.

Engineering and Development Program Plan En Route Control, FAA-ED-12-2A.

ETABS ATC Users Manual, DOT, Transportation Systems Center, August 1982.

ETABS Cost Benefit Validation, SRI International, Contract DOT-FA79WA-4311.

ETABS Factory Acceptance Test Procedures, Software, Rev. C, Sanders Associates, January 1982.

ETABS Qualification and Acceptance Test Plan, Rev. E, Sanders Associates, December 1981.

Expanded Quality Assurance Test Procedures 9020/ETABS Interface, OAO, September 1981.

Facility Operations Manual, FAA, 7210.3F, May 1983.

Fend, A. V., and Couluris, G. J., Analysis and Report of Improved Controller Performance Due to Electronic Tabular Display Subsystem (ETABS), Pilot Test Plan, SRI Working Paper, Contract DOT-FA79WA-4311, September 1980.

Grossberg, M., Analysis of Six New York ARTCC Sectors in Preparation for the NAFEC Simulation Study of ETABS, Working Memorandum to A. Chantker, January 21, 1980.

Grossberg, M., Future Workload Saving for En Route Air Traffic Controllers Due to the Electronic Tabular Display Subsystem (ETABS), FAA-968-WP-79-1, Working Paper, June 1979.

Grossberg, M., Plan for ETABS Readiness Tests, Memorandum to B. Andrews, March 1982.

Kelly, J. P. and Lawrence, M. J. Electronic Tabular Display Subsystem (ETABS) Engineering Model, FAA-ER-110-208, Engineering Requirement, January 1978.

Linton, M. and Gallo, P. S. Jr., The Practical Statistician Simplified Handbook of Statistics, Brooks/Cole Publishing, Monterey, California, 73-91423, 1980.

Lucas, Robert J., Evaluation of a TV Data Transfer System, FAA-RD-64-146, October 1974.

Manison, W. A., et al., Electronic Tabular Display Subsystem (ETABS), Engineering Model Specifications, Vol. 1-7, MTR-7620, MTR-7621.

Poulton, E. C., Biases in Quantitative Judgements, Applied Ergonomics, 13.1, 31-42, March 1982.

Sager, D. W., En Route Sector Position Development; Preliminary Tabular Display Applications, Mitre, MTR-6932, June 1975.

Siegel, S., Nonparametric Statistics for the Behavioral Sciences, McGraw-Hill, New York, N.Y., 56-8185, 1956.

Sulzer, R. S. and Lucas, R. J., En Route Sector Redesign (Field Survey of Flight Strip Data), FAA-RD-75-138, 1975.

Tuan, P., Proctor, H. S., and Courulis, G. L., Advanced Productivity Analysis Methods for Air Traffic Control Operations, DOT/TSC, FAA-RD-76-164, October 1976.

Winer, B. J., Statistical Principles in Experimental Design, McGraw-Hill, New York, N.Y., 79-133392, 1971.

Woolley, David, Successful First Year for New Netherlands Control System, Airports International Magazine, May 1982.

Wright, P. and Barnard, P., Asking Multiple Questions About Several Items: The Design of Matrix Structures on Application Forms, Applied Ergonomics, 9.1, 7-14, March 1978.

APPENDIX A

FORM A

ETABS PRELIMINARY SURVEY

This survey determines the past experience of the controller, present pretraining knowledge of ETABS, and any prior opinions as to how ETABS will affect the controller or system.

CONTROLLER ID NO. _____
DATE _____
AGE _____

ETABS Evaluation
Proj. No. 122-113-600
Questionnaire FORM A

ETABS PRELIMINARY SURVEY

This questionnaire is designed to be given before ETABS training to determine past ATC experience and prior opinion toward ETABS. Please feel free to make comments after any questions.

1.1 How many years ago was it that you last controlled traffic in ATC (0 if presently)? _____

How many years experience have you had as an Air Traffic Control Specialist with the FAA? (Enter the appropriate numbers below.)

1.2 ____years in En Route Air Traffic Control
1.3 ____years in Terminal Air Traffic Control

1.4 Have you ever controlled traffic prior to use of flight strip printers?

____yes
____no

1.5 Have you ever controlled traffic prior to installation of NAS (digitized flight tracking)?

____yes
____no

2.0 The next questions can be answered by circling yes or no.

2.1 Are you Tech Center personnel assigned to ETABS? yes no

2.2 Have you had hands-on experience with ETABS before? yes no

2.3 Have you seen literature or photos on ETABS before? yes no

2.4 Are you familiar with the basic objectives of ETABS? yes no

CONTROLLER ID NO. _____

DATE _____

ETABS Evaluation
Proj. No. 122-113-600
Questionnaire FORM A

3.0 Please complete the following statements.

3.1 When I use typewriter (QWERTY) keyboards I usually: (Check one.)

____touch type ____hunt and peck

3.2 When I type I: (Check one.)

____hardly ever look at the keys.
____seldom look at the keys.
____occasionally look at the keys.
____frequently look at the keys.
____almost always look at the keys.

3.3 I would rate my typing speed as: (Check one.)

____very fast.
____fast.
____moderate.
____slow.
____very slow.

4.0 This section is for presently active field controllers.

4.1 What is the level of your present facility?_____

4.2 During normal operation at your present facility, please estimate the percentage of time each of the controllers spends on the following tasks.

TASKS	CONTROLLER R	D	A	TOTAL
4.2.1 Ripping and stuffing strips	____% +	____% +	____%	= 100%
4.2.2 Requesting strips	____% +	____% +	____%	= 100%
4.2.3 Posting strips	____% +	____% +	____%	= 100%
4.2.4 Manipulating strips in bay	____% +	____% +	____%	= 100%
4.2.5 Marking (notating) strips	____% +	____% +	____%	= 100%
4.2.6 Entering flight plan data	____% +	____% +	____%	= 100%
4.2.7 Talking to pilots	____% +	____% +	____%	= 100%

CONTROLLER ID NO. _____

DATE _____

4.3 At my present facility the second (D) controller is primarily: (Check one.)

____a manual controller.
____a handoff/tracker controller.

4.4 Please list below any problems which you feel may exist in flight data handling in your present NAS facility.

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

4.5 Have you any suggestions as to how the above problems might be resolved?

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

CONTROLLER ID NO. _____

DATE _____

ETABS Evaluation
Proj. No. 122-113-600
Questionnaire FORM A

The purpose of the following questions is to elicit your opinion on how ETABS will affect you and your ability to do your job. Even though you now may not know much about ETABS, please indicate your expectations on the following general aspects. Check one column for each row.

COMPARED TO THE PRESENT NAS, WHEN USING ETABS---	Greatly Decrease	Moderately Decrease	Slightly Decrease	Not Change	Slightly Increase	Moderately Increase	Greatly Increase
5.1 Work required for flight strip data handling will							
5.2 Complexity of flight data handling procedures will							
5.3 Job satisfaction will							
5.4 Work required for non-flight strip data handling will							
5.5 Amount of eyestrain will							
5.6 Speed of inputting messages to the computer will							
5.7 Speed of system response will							
5.8 Likelihood of miskeying data will							
5.9 Likelihood of misreading will							
5.10 Number of message input errors or rejects will							
5.11 Ease of correcting message input errors or rejects will							
5.12 Number of aircraft delays will							
5.13 Amount of R-D controller coordination will							
5.14 Amount of weather/status info. available will							
5.15 Amount of frustration will							
5.16 Number of sector-sector interphone contacts will							
5.17 Likelihood of A/C to A/C conflicts will							
5.18 Capacity to handle simultaneous flights will							
5.19 Confidence in the system will							
5.20 Ease of R-D controller coordination will							
5.21 Overall system effectiveness of NAS with ETABS will							
5.22 Other (list)							

5.23 Please use the space below for any comments you may wish to make regarding your answers to the above items.

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

6.1 How would you complete the following statement? "I feel that, in general, increasing use of automation in the ATC system will _____ the average controller's job security." (Check one.)

____greatly increase
____moderately increase
____slightly increase
____not change
____slightly decrease
____moderately decrease
____greatly decrease

APPENDIX B

FORM B

ETABS DAILY TRAINING SURVEY

This survey is administered at the end of each day of training. It attempts to bring out general and specific areas of difficulty and solicit recommendations as to training aids and emphasis. It also familiarizes the controller with the total set of messages.

CONTROLLER ID NO. _____

DATE _____

ETABS Evaluation
Proj. No. 122-113-600
Questionnaire FORM B

DAILY TRAINING SURVEY

This survey is given at the end of each training day to obtain feedback on the progress of ETABS familiarization.

1.0 After today's training sessions, can you think of any aids or procedures that could be utilized to help you learn ETABS?

CONTROLLER ID NO. _____

DATE _____

ETABS Evaluation
Proj. No. 122-113-600
Questionnaire FORM B

CONTROLLER MESSAGES

2.0 Below is the complete list of ETABS messages and data fields needed to input them. Please check any that give you special problems. A comment section is provided beside and after the list. Please explain all checks.

COMMENTS

2.1.0 ENTER NEW FLIGHT PLAN AND AMEND
(Data fields needed)
2.1.1 ____Aircraft ID
2.1.2 ____Aircraft data
2.1.3 ____Beacon code
2.1.4 ____True airspeed
2.1.5 ____Coordination fix
2.1.6 ____Coordination time
2.1.7 ____Altitude
2.1.8 ____Route
2.1.9 ____Remarks

2.2.0 AMEND FLIGHT PLAN
2.2.1 ____Equipment qualifier message
2.2.2 ____Interim altitude message
2.2.3 ____Beacon code request message
2.2.4 ____Reported altitude message

2.3.0 ALTERNATIVE BEACON AND ALTITUDE AMENDMENTS
2.3.1 ____Beacon code entry
2.3.2 ____Beacon code request
2.3.3 ____Reported altitude
2.3.4 ____Interim altitude
2.3.5 ____Interim altitude used a reporting altitude
2.3.6 ____Interim altitude deletion
2.3.7 ____Assigned altitude

2.4.0 AMEND FLIGHT STATUS DATA
These are also modifiable by CCC
2.4.1 ____Ground speed
2.4.2 ____Previous fix and time
2.4.3 ____Posting fix and time
2.4.4 ____Coordination indication

2.5.0 ENTER CONTROLLER NOTATIONS
2.5.1 ____Pilot time message
2.5.2 ____Radar vector message
2.5.3 ____Text note message

2.6.0 HIGHLIGHT FLIGHT DATA Four mark menu modes
2.6.1 ____Double character brightness
2.6.2 ____Flashing characters
2.6.3 ____Large characters
2.6.4 ____Underline

COMMENTS

(Three keyboard and keyboard menu modes)

2.6.5 ____Double character brightness
2.6.6 ____Flashing characters
2.6.7 ____Large characters
(Also)
2.6.8 ____Boxing an FDE (cocking)
2.6.9 ____Highlighting an FDE data field with a mark

2.7.0 MANAGE TABULAR NON-FLIGHT DATA*
2.7.1 ____Set weather message*
2.7.2 ____Weather request message*
2.7.3 ____Set altimeter message*
2.7.4 ____Altimeter request message*
2.7.5 ____Upper winds request message*
2.7.6 ____Restricted area request message*
2.7.7 ____General information message*

2.8.0 CHANGE STATUS OF A FLIGHT
2.8.1 ____Departure message
2.8.2 ____Progress report message
2.8.3 ____Hold message
2.8.4 ____Accept handoff message
2.8.5 ____Retract handoff message
2.8.6 ____Initiate handoff message
2.8.7 ____Drop flight plan and track message
2.8.8 ____Cancel NAS not ARTS message
2.8.9 ____ARTS flight plan transfer message

2.9.0 MODIFY FLIGHT TRACK*
2.9.1 ____Automatic handoff message*
2.9.2 ____Re-establish track message*
2.9.3 ____Coast track message*
2.9.4 ____Drop track message*

2.10.0 MANAGE PVD FULL DATA BLOCKS
2.10.1 ____Offset direction/leader length message
2.10.2 ____Force FDB message
2.10.3 ____Request/suppress FDB message
2.10.4 ____Point out FDB message
2.10.5 ____Route display message
2.10.6 ____Conflict alert

2.11.0 MANAGE CONTROLLER'S PVD
2.11.1 ____Sector/facility auto handoff message
2.11.2 ____Suppress conflict alert group message*
2.11.3 ____Altimeter request message*
2.11.4 ____Altitude limits message*
2.11.5 ____Beacon code insert/delete message*
2.11.6 ____Flight plan readout message

*These items are not being taught due to time restrictions

12.12 COMMENTS: _____

CONTROLLER ID NO. _____

DATE _____

ETABS Evaluation
Proj. No. 122-113-600
Questionnaire FORM B

3.0 Please evaluate the ease or difficulty you experienced today in learning or using the following aspects of the ETABS Simulation. Check one box for each aspect. Use NA if not covered in today's training.

ASPECTS	Very Hard	Hard	Moderately Hard	Moderate	Moderately Easy	Easy	Very Easy
3.1 Interactive display message entry sequences							
3.2 Keyboard message entry sequences							
3.3 Tabular display FDE (strip) format - 1 line							
3.4 Tabular display FDE (strip) format - 2 line							
3.5 Tabular display FDE (strip) format - 3 line							
3.6 Tabular display FDE (strip) format - 4 line							
3.7 Tabular display non-FDE information formats							
3.8 Simulation environment							
3.9 New sector geometry							
3.10 Interactive display touch entry technique							
3.11 ETABS control of PVD functions							
3.12 Other aspects affecting you (please list)							

3.13 COMMENTS: _____

CONTROLLER ID NO. _____

DATE _____

4.1 Please estimate your present level of knowledge of ETABS. (Check One.)

____ very high
____ high
____ moderately high
____ moderate
____ moderately low
____ low
____ very low

4.2 Comments (if any): _____

_____

_____

_____

_____

_____

_____

5.1 Please estimate your present skill level in using ETABS. (Check One.)

____ very high
____ high
____ moderately high
____ moderate
____ moderately low
____ low
____ very low

5.2 Comments (if any): _____

_____

_____

_____

_____

_____

_____

APPENDIX C

FORM C

POST TRAINING SURVEY

This survey is given after the last day of training. It is designed to evaluate ergonomic aspects of ETABS. These same questions are repeated in the "Wrap-Up" survey after the evaluation runs are completed to detect any change in opinion.

CONTROLLER ID NO. _____

DATE _____

ETABS Evaluation
Proj. No. 122-113-600
Questionnaire FORM C

1.0 Please rate the various human factors aspects by checking the appropriate column.

	ASPECTS TO BE EVALUATED	Very Poor	Poor	Moderately Poor	Fair	Moderately Good	Good	Very Good
1.1	Depth of console shelf (adequacy of space for reference material)							
1.2	Accessibility of ETABS keyboard (location and orientation)							
1.3	Visibility of ETABS keyboard (labels and backlighting)							
1.4	Error-free selection of characters on interactive display							
1.5	Convenience of location and angle of interactive display for touch entry							
1.6	Format of interactive display menus							
1.7	Naturalness of menu touch sequences							
1.8	Adequacy of special strip marking symbols on mark menu							
1.9	Ease of coordinating ETABS keyboard and interactive display							
1.10	Overall effectiveness of console configuration							
1.11	Overall effectiveness of ETABS keyboard							
1.12	Overall effectiveness of touch-screen data entry technique							
1.13	Other							
1.14	Comments							

CONTROLLER ID NO. _____

DATE _____

ETABS Evaluation
Proj. No. 122-113-600
Questionnaire FORM C

2.0 Please rate the various CRT display aspects by checking the appropriate column for each of the displays.

Column Heading Abbreviations:
VP = very poor, P = poor, MP = moderately poor, F = fair, MG = moderately good, G = good, VG = very good

ASPECT OF THE CRT DISPLAY TO BE EVALUATED	CRT Displays																						
	Interactive							Near Tabular							Far Tabular								
	VP	P	MP	F	MG	G	VG	VP	P	MP	F	MG	G	VG	VP	P	MP	F	MG	G	VG		
2.1 Absence of reflections on tube face																							
2.2 Uniformity of resolution or sharpness of image across screen																							
2.3 Stability of image (absence of jitter, swim, or flicker)																							
2.4 Absence of geometric distortion across screen																							
2.5 Acceptability of viewing angle (height, location, mount. angle)																							
2.6 Legibility of characters (size, shape, readability)																							
2.7 Highlighting conspicuity (2X bright, box, underline, flash)																							
2.8 Adequacy of adjustment range (focus, brightness, etc.)																							
2.9 Phosphor color (green)																							
2.10 Absence of fingerprint smudges on screen																							
2.11 Absence of eyestrain																							
2.12 Overall display effectiveness																							
2.13 Other (please list)																							

APPENDIX D

FORM D

POST FAMILIARIZATION SURVEY

This survey is given after the final familiarization run. The questions are in the form of rating scales and will be evaluated to determine simulation realism and problems versus benefits.

CONTROLLER ID NO. _____

DATE _____

ETABS Evaluation
Proj. No. 122-113-600
Questionnaire FORM D

SECTOR WORKED _____ POSITION WORKED (Check One) R _____ D _____

POST FAMILIARIZATION

This survey is given once after the familiarization runs. Please be candid. Feel free to comment. All replies will be confidential. No names will be used during data analysis and reporting.

CONTROLLER ID NO. _____

DATE _____

ETABS Evaluation
Proj. No. 122-113-600
Questionnaire FORM D

The purpose of the following questions is to determine opinions on the realism of the operational simulation of the ETABS.

1.0 Please place a check mark in the column which best reflects your opinion of the realism of the following aspects.

ATC SIMULATION ASPECTS	REALISM WAS						
	Very Low	Low	Moderately Low	Moderate	Moderately High	High	Very High
1.1 Traffic samples							
2.2 Sector geometry							
1.3 Communications							
1.4 Pilot responses, verbal							
1.5 Aircraft dynamic response							
1.6 Physical layout of consoles, etc.							
1.7 General environment (lighting, noise, etc.)							
1.8 The simulation as a whole							
1.9 Other (please list)							

1.10 COMMENTS: _____

_____

_____

1.11 What would you change to improve the realism of the simulation?

_____

_____

_____

CONTROLLER ID NO. _____

DATE _____

ETABS Evaluation
Proj. No. 122-113-600
Questionnaire FORM D

2.0 Comparing ETABS to the present NAS system, determine whether or not any problems in using ETABS features outweigh the benefits, vice versa, or no change. (Check One)

USING THIS ETABS FEATURE CREATES	Many more Problems	More Problems	Slightly More Problems	Problems = Benefits	Slightly More Benefits	More Benefits	Many More Benefits	ANY COMMENTS?
2.1 Reading electronic strips instead of paper strips								
2.2 Touch data entry instead of keyboard entry								
2.3 Touch data updating instead of grease pencil								
2.4 Second tabular display for overflow or status								
2.5 Automatic posting								
2.6 Manual posting								
2.7 Automatic updates								
2.8 Manual updates								
2.9 Handoffs								
2.10 Computerized recordkeeping instead of strips								
2.11 Highlighting techniques								
2.12 Speed of ETABS data handling as a whole								
2.13 Reliability of ETABS data handling as a whole								

APPENDIX E

FORM E

POST RUN SURVEY

This survey is given after each run. Developmental progress in knowledge and skill is queried the same as during training. ETABS aspects regarding workload are evaluated and comments solicited. Rating scales on the traffic sample, ability of controller to keep up, and helpfulness of ETABS are provided.

CONTROLLER ID NO. _____

DATE _____

ETABS Evaluation
Proj. No. 122-113-600
Questionnaire FORM E

POST RUN SURVEY

SECTOR NO. _____ POSITION WORKED (Check one.) R _____ D _____ TIME OF DAY _____

1.0 Please answer the following questions from the point of view of the position (R or D) which you worked on the run just completed. Please give your honest, independent opinions, not necessarily those which you may have heard expressed by associate controllers or the Technical Center staff.

1.1 Please estimate your present level of knowledge of ETABS. (Check one.)

____ very high
____ high
____ moderately high
____ moderate
____ moderately low
____ low
____ very low

1.2 COMMENTS (if any)_____

_____

_____

1.3 Please estimate you present skill level in using ETABS. (Check one.)

____ very high
____ high
____ moderately high
____ moderate
____ moderately low
____ low
____ very low

1.4 COMMENTS (if any):_____

_____

_____

CONTROLLER ID NO. _____

DATE _____

ETABS Evaluation
Proj. No. 122-113-600
Questionnaire FORM E

2.0 A large number of things contribute to air traffic control workload. Please rate the following aspects with respect ot the amount of workload or difficulty each presented during the run just completed. (Please check one column in each row. If you did not perform any of the aspects, mark them with NA.)

ASPECTS CONTRIBUTING TO WORKLOAD ON THIS RUN	LEVEL OF WORKLOAD						
	Very Low	Low	Moderately Low	Moderate	Moderately High	High	Very High
2.1 Dealing with nearly simultaneous traffic entering or exiting sector (bunching)							
2.2 Maintaining a mental picture of the location and movement of the A/C in your sector							
2.3 Issuing control instructions to pilots							
2.4 Getting used to the simulation environment							
2.5 Learning new sector geometry							
2.6 Getting used to communicating with "sim op" pilots instead of real pilots							
2.7 Getting used to reading strips on a CRT (tabular display)							
2.8 Getting used to ETABS message entry formats							
2.9 Getting used to touch entry on the interactive display							
2.10 Getting used to ETABS menu operation sequences (logical order of performing actions)							
2.11 Getting used to posting flight strips via ETABS							
2.12 Getting used to entering new flight plans into ETABS							
2.13 Getting used to updating or modifying flight strip information via ETABS							
2.14 Getting used to ETABS strip marking symbols and controller notation techniques							
2.15 Getting used to making or accepting handoffs via ETABS							
2.16 Getting used to ETABS considered in its entirety							
2.17 Other (please list)							

CONTROLLER ID NO. _____

DATE _____

POSITION _____

2.18 In the above question on aspects contributing to workload, if you rated the contribution to workload of any aspect "MODERATELY HIGH" or higher, please briefly state why below.

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

3.1 For this run, how would you rate typical system response delays? (Check one.)

____ acceptable, very short.
____ acceptable, short.
____ acceptable, moderately short.
____ marginal, moderate.
____ unacceptable, moderately long.
____ unacceptable, long.
____ unacceptable, very long.

CONTROLLER ID NO. _____

DATE _____

POSITION _____

ETABS Evaluation
Proj. No. 122-113-600
Questionnaire FORM E

4.1 Please list below any other problems (not mentioned elsewhere) which you may have had with anything involving ETABS.

_____

_____

_____

_____

_____

_____

_____

_____

5.1 Please list below any problems which you may have had with the ATC simulation.

_____

_____

_____

_____

_____

_____

_____

_____

6.1 Please rate your workload in the run just completed. Use the scale of one to ten below. Circle the number most closely matching your overall workload.

WORKLOAD

1	2	3	4	5	6	7	8	9	10
LOWEST									HIGHEST

CONTROLLER ID NO. _____
DATE _____
POSITION _____

ETABS Evaluation
Proj. No. 122-113-600
Questionnaire FORM E

7.1 In the run just completed, how would you rate the amount of traffic handled in comparison to average traffic at your own facility position. Nonactive controllers mark N/A. (Check one.)

____ much greater than average
____ greater than average
____ slightly greater than average
____ the same
____ slightly less than average
____ less than average
____ much less than average

7.2 COMMENTS (if any): _____

_____

_____

_____

_____

8.1 Please complete the following statement. "On the run just completed I feel that I was _____ the ATC task demand." (Check one)

____ way ahead of
____ ahead of
____ slightly ahead of
____ just keeping up with
____ slightly behind
____ behind
____ way behind

8.2 COMMENTS (if any): _____

_____

_____

_____

_____

CONTROLLER ID NO. _____

DATE _____

POSITION _____

ETABS Evaluation
Proj. No. 122-113-600
Questionnaire FORM E

9.1 On the run just completed, how would you rate the contribution of ETABS to the performance of your ATC job? (Check one)

____ a great help
____ a help
____ a slight help
____ neutral
____ a slight hindrance
____ a hindrance
____ a great hindrance

9.2 COMMENTS (if any): _____

APPENDIX F

FORM F

WRAP-UP SURVEY

This survey is given once at the end of the evaluation. The first three questions are the same as those from the Preliminary and Post Training Surveys to see how or if these opinions change. The other questions are general in nature asking controllers to sum up their feelings. Narrative comments are solicited as well as rating scales. Comparison to the present system is made. Aspects for an ideal system are requested. Hypotheses on the worthwhileness of the ETABS "concept" are solicited.

CONTROLLER ID NO. _____

DATE _____

ETABS Evaluation
Proj. No. 122-113-600
Questionnaire FORM F

1.0 Please rate the various human factors aspects by checking the appropriate column.

	ASPECTS TO BE EVALUATED	Very Poor	Poor	Moderately Poor	Fair	Moderately Good	Good	Very Good
1.1	Depth of console shelf (adequacy of space for reference material)							
1.2	Accessibility of ETABS keyboard (location and orientation)							
1.3	Visibility of ETABS keyboard (labels and backlighting)							
1.4	Error-free selection of characters on interactive display							
1.5	Convenience of location and angle of interactive display for touch entry							
1.6	Format of interactive display menus							
1.7	Naturalness of menu touch sequences							
1.8	Adequacy of special strip marking symbols on mark menu							
1.9	Ease of coordinating ETABS keyboard and interactive display							
1.10	Overall effectiveness of console configuration							
1.11	Overall effectiveness of ETABS keyboard							
1.12	Overall effectiveness of touch-screen data entry technique							
1.13	Other							
1.14	Comments							

CONTROLLER ID NO. _____

DATE _____

ETABS Evaluation
Proj. No. 122-113-600
Questionnaire FORM F

2.0 Please rate the various CRT display aspects by checking the appropriate column for each of the displays.

Column Heading Abbreviations:
VP = very poor, P = poor, MP = moderately poor, F = fair, MG = moderately good, G = good, VG = very good

ASPECT OF THE CRT DISPLAY TO BE EVALUATED	CRT Displays																						
	Interactive							Near Tabular							Far Tabular								
	VP	P	MP	F	MG	G	VG	VP	P	MP	F	MG	G	VG	VP	P	MP	F	MG	G	VG		
2.1 Absence of reflections on tube face																							
2.2 Uniformity of resolution or sharpness of image across screen																							
2.3 Stability of image (absence of jitter, swim, or flicker)																							
2.4 Absence of geometric distortion across screen																							
2.5 Acceptability of viewing angle (height, location, mount. angle)																							
2.6 Legibility of characters (size, shape, readability)																							
2.7 Highlighting conspicuity (2X bright, box, underline, flash)																							
2.8 Adequacy of adjustment range (focus, brightness, etc.)																							
2.9 Phosphor color (green)																							
2.10 Absence of fingerprint smudges on screen																							
2.11 Absence of eyestrain																							
2.12 Overall display effectiveness																							
2.13 Other (please list)																							

CONTROLLER ID NO. _____

DATE _____

ETABS Evaluation
Proj. No. 122-113-600
Questionnaire FORM F

3.0 Based on your own experience with present NAS and ETABS simulation, please indicate your thoughts on the following general aspects. (Check one.)

COMPARED TO THE PRESENT NAS, WHEN USING ETABS---	Greatly Decreased	Moderately Decreased	Slightly Decreased	Did Not Change	Slightly Increased	Moderately Increased	Greatly Increased
3.1 Work required for flight strip data handling							
3.2 Complexity of flight data handling procedures							
3.3 Job satisfaction							
3.4 Work required for non-flight strip data handling							
3.5 Amount of eyestrain							
3.6 Speed of inputting messages to the computer ~~with~~							
3.7 Speed of system response							
3.8 Likelihood of miskeying data							
3.9 Likelihood of misreading							
3.10 Number of message input errors or rejects							
3.11 Ease of correcting message input errors or rejects							
3.12 Number of aircraft delays							
3.13 Amount of R-D controller coordination							
3.14 Amount of weather/status info. available							
3.15 Amount of frustration							
3.16 Number of sector-sector interphone contacts							
3.17 Likelihood of A/C to A/C conflicts							
3.18 Capacity to handle simultaneous flights							
3.19 Confidence in the system							
3.20 Ease of R-D controller coordination							
3.21 Overall system effectiveness of NAS with ETABS							
3.22 Other (list)							

3.23 Please use the space below for any comments you may wish to make regarding your answers to the above items.

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

4.1 How would you complete the following statement? (Check one.)

"I feel that, in general, increasing use of automation in the ATC system will _____ the average controller's job security."

____ greatly increase
____ moderately increase
____ slightly increase
____ not change
____ slightly decrease
____ moderately decrease
____ greatly decrease

5.1 Is there anything about ETABS which you feel might affect ATC safety?

6.1 Is there anything about ETABS which you feel might affect ATC efficiency?

7.1 Is there anything about ETABS which you feel might affect expeditious movement of traffic?

8.1 If there are any normal ATC tasks or functions which do not have their counterparts in ETABS, please list them below.

_____

_____

_____

_____

_____

_____

9.1 If there are any ATC procedures (as in the ATP manual) which can be simplified or eliminated by the use of ETABS, please list them below.

_____

_____

_____

_____

_____

_____

10.1 What do you like most about ETABS, and why?

_____

_____

_____

_____

_____

_____

10.1 Continued _____

11.1 What do you like least about ETABS, and why?

12.1 Are there any aspects of ETABS which are of such obvious benefit to present NAS that you would recommend immediate implementation?

_____

_____

_____

_____

_____

_____

13.1 How would you rate the effectiveness of the present NAS (with printed strips)? (Circle one.)

SYSTEM EFFECTIVENESS

1	2	3	4	5	6	7	8	9	10
LOWEST									HIGHEST

14.1 How would you rate the effectiveness of the simulated NAS using ETABS? (Circle one.)

SYSTEM EFFECTIVENESS

1	2	3	4	5	6	7	8	9	10
LOWEST									HIGHEST

15.1 How would you complete the following statement? (Check one.)

"As presently configured, I feel that use of ETABS in an operational field environment would lead to _____ NAS effectiveness."

____ a great improvement of
____ an improvement of
____ a slight improvement of
____ no change to
____ a slight degradation of
____ a degradation of
____ a great degradation of

15.2 COMMENTS: _____

16.1 What would you like to see added to ETABS? Is any needed feature missing?

17.1 What would you like to see deleted from ETABS? Are there superfluous or undesirable features?

18.1 What about ETABS would you like to see changed? What would you want done differently?

19.1 Assuming that the above additions, deletions, and changes were made to the ETABS, please complete the following statement. (Check one.)

"Given the above modifications, I feel that use of ETABS in an operational field environment would lead to _____ NAS effectiveness."

____ a great improvement of
____ an improvement of
____ a slight improvement of
____ no change to
____ a slight degradation of
____ a degradation of
____ a great degradation of

19.2 COMMENTS (IF ANY): _____

20.1 Can you think of any other type of flight data handling concept which might be used in enroute ATC in the place of strips or ETABS?

CONTROLLER ID NO. _____

DATE _____

ETABS Evaluation
Proj. No. 122-113-600
Questionnaire FORM F

21.1 Please complete the following statement. (Check One.)

"My operating skill in the use of ETABS and my knowledge of ETABS are _____ to give it a fair evaluation."

____ much more than enough
____ more than enough
____ slightly more than enough
____ just enough
____ slightly less than enough
____ less than enough
____ much less than enough

21.2 COMMENTS: _____

_____

_____

_____

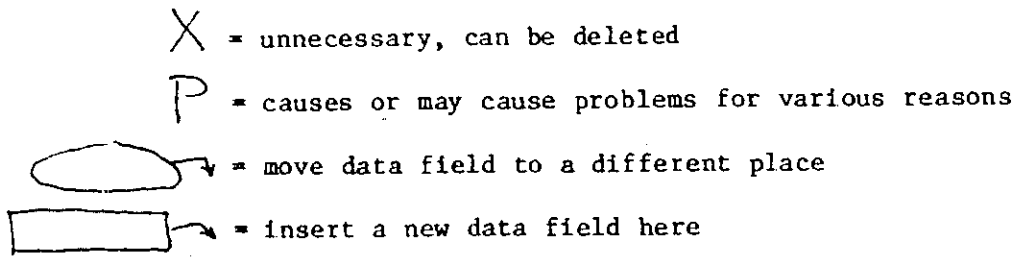
22.1 The following fold-out shows the four en route FDE formats (one-line to four-line) and the two departure FDE formats (one- and two-line) for your review. Please rank (best to worst) each of the four en route FDE formats indicating how well you feel the FDE would meet the ATC needs of your present position at your facility. (One is best and four is worst.)

____ one-line format
____ two-line format
____ three-line format
____ four-line format

22.2 Please put a check next to the departure FDE format which you would favor as best meeting the needs of your position at your facility.

____ one-line format
____ two-line format

22.3 On the fold-out sheet depicting the FDE formats, please boldly mark over any data field that, in your opinion, needs changes. Use the following symbology:



22.4 Please comment on each change: _____

APPENDIX G

FORM G

OBSERVER'S REPORTING FORM

This form is completed by the observer during and after the completion of each simulation run. The form is in two parts. The first part is an observer record of comments made by the controller regarding ETABS or other notable events seen by the observer during the run. The second part consists of six items to be completed by the observer at the end of the run. These six items are rated on 10-point rating scales, both for R and D controllers. The responses to these items will be correlated to subjects' responses to evaluate the degree of correlation between the two.

CONTROLLER ID NO. _____

DATE _____

ETABS Evaluation
Proj. No. 122-113-600
Questionnaire FORM G

1.1 This form is completed by the observer during runs. The object is to record observations made by the controller or unreported significant events noticed by the observer.

CONTROLLER ID NO. _____

DATE _____

Controller observations continued.

CONTROLLER ID NO. _____

DATE _____

ETABS Evaluation
Proj. No. 122-113-600
Questionnaire FORM G

The observer is to complete the following questions at the conclusion of each run.

2.0 How would you rate the interest of the controller in the simulation?

2.1 R Controller

1	2	3	4	5	6	7	8	9	10
NOT INTERESTED									VERY INTERESTED

2.2 D Controller

1	2	3	4	5	6	7	8	9	10
NOT INTERESTED									VERY INTERESTED

3.0 How would you rate the rapport between the controllers?

1	2	3	4	5	6	7	8	9	10
VERY LOW									VERY HIGH

4.0 How would you rate the controller's typing speed?

4.1 R Controller

1	2	3	4	5	6	7	8	9	10
VERY SLOW									VERY FAST

4.2 D Controller

1	2	3	4	5	6	7	8	9	10
VERY SLOW									VERY FAST

5.0 How was the controller workload during this run?

5.1 R Controller

1	2	3	4	5	6	7	8	9	10
VERY LIGHT									VERY HEAVY

5.2 D Controller

1	2	3	4	5	6	7	8	9	10
VERY LIGHT									VERY HEAVY

APPENDIX H

FORM H

ETABS FOLLOW-UP QUESTIONNAIRE

This follow-up questionnaire, Form H, is given for the four following reasons:

1. To clarify some questions in the ETABS questionnaire confounded between the "concept" and "as tested" points of view.

2. To clarify some questions in the ETABS questionnaire confounded between the R-side and D-side points of view.

3. To add some general questions on overall ETABS as-tested applicability.

4. To add a rating scale for evaluating various concepts and ideas mentioned as having ATC advancement potential.

CONTROLLER ID NO. _____

DATE _____

ETABS Evaluation
Proj. No. 122-113-600
Questionnaire FORM H

1.0 Please rate the various human factors by marking the appropriate columns. Mark each with an "R" (for R-side) and "D" (for D-side). Put "R" and "D" in the same box if appropriate.

ASPECTS TO BE EVALUATED	Very Poor	Poor	Moderately Poor	Fair	Moderately Good	Good	Very Good
1.1 Depth of console shelf (adequacy of space for reference material)							
1.2 Accessibility of ETABS keyboard (location and orientation)							
1.3 Visibility of ETABS keyboard (labels and backlighting)							
1.4 Error-free selection of characters on interactive display							
1.5 Convenience of location and angle of interactive display for touch entry							
1.6 Format of interactive display menus							
1.7 Naturalness of menu touch sequences							
1.8 Adequacy of special strip marking symbols on mark menu							
1.9 Ease of coordinating ETABS keyboard and interactive display							
1.10 Overall effectiveness of console configuration							
1.11 Overall effectiveness of ETABS keyboard							
1.12 Overall effectiveness of touch-screen data entry technique							
1.13 Other							
1.14 Comments							

CONTROLLER ID NO. _____

DATE _____

ETABS Evaluation
Proj. No. 122-113-600
Questionnaire FORM R

2.0 Please rate the various CRT aspects by marking the appropriate column for each of the displays (AS TESTED). Mark each with a "R" (for R-side) and "D" (for D-side). Put "R" and "D" in the same box if appropriate.

Column Heading Abbreviations:
VP = very poor, P = poor, MP = moderately poor, F = fair, MG = moderately good, G = good, VG = very good

ASPECT OF THE CRT DISPLAY TO BE EVALUATED	CRT Displays: Interactive							Near Tabular							Far Tabular						
	VP	P	MP	F	MG	G	VG	VP	P	MP	F	MG	G	VG	VP	P	MP	F	MG	G	VG
2.1 Absence of reflections on tube face																					
2.2 Uniformity of resolution or sharpness of image across screen																					
2.3 Stability of image (absence of jitter, swim, or flicker)																					
2.4 Absence of geometric distortion across screen																					
2.5 Acceptability of viewing angle (height, location, mount. angle)																					
2.6 Legibility of characters (size, shape, clarity)																					
2.7 Highlighting conspicuity (2X bright, box, underline, flash)																					
2.8 Adequacy of adjustment range (focus, brightness, etc.)																					
2.9 Phosphor color (green)																					
2.10 Absence of fingerprint smudges on screen																					
2.11 Absence of eyestrain																					
2.12 Overall display effectiveness																					
2.13 Size of the characters																					

CONTROLLER ID NO. _____

DATE _____

3.0 Based on your own experience with present NAS and ETABS simulation, please indicate your thoughts on the following general aspects. Mark each with an "A" (for As tested) and "C" (for Concept). Put "A" and "C" in the same box if appropriate.

COMPARED TO THE PRESENT NAS, WHEN USING ETABS---	Greatly Decreased	Moderately Decreased	Slightly Decreased	Did Not Change	Slightly Increased	Moderately Increased	Greatly Increased
3.1 Work required for flight strip data handling							
3.2 Complexity of flight data handling procedures							
3.3 Job satisfaction							
3.4 Work required for non-flight strip data handling							
3.5 Amount of eyestrain							
3.6 Speed of inputting messages to the computer							
3.7 Speed of system response							
3.8 Likelihood of miskeying data							
3.9 Likelihood of misreading							
3.10 Number of message input errors or rejects							
3.11 Ease of correcting message input errors or rejects							
3.12 Number of aircraft delays							
3.13 Amount of R-D controller coordination							
3.14 Amount of weather/status info. available							
3.15 Amount of frustration							
3.16 Number of sector-sector interphone contacts							
3.17 Likelihood of A/C to A/C conflicts							
3.18 Capacity to handle simultaneous flights							
3.19 Confidence in the system							
3.20 Ease of R-D controller coordination							
3.21 Overall system effectiveness of NAS with ETABS							
3.22 Other (list)							

CONTROLLER ID NO. _____

DATE _____

ETABS Evaluation
Proj. No. 122-113-600
Questionnaire FORM H

4.0 Comparing ETABS to the present NAS system, determine whether or not any problems in using ETABS features outweigh the benefits, vice versa, or equality. Mark each with an "A" (for As tested) and "C" (for Concept). Put "A" and "C" in the same box if appropriate.

USING THIS ETABS FEATURE CREATES	Many more Problems	More Problems	Slightly More Problems	Problems = Benefits	Slightly More Benefits	More Benefits	Many More Benefits	ANY COMMENTS?
4.1 Reading electronic strips instead of paper strips								
4.2 Touch data entry instead of keyboard entry								
4.3 Touch data updating instead of grease pencil								
4.4 Second tabular display for overflow or status								
4.5 Automatic posting								
4.6 Manual posting								
4.7 Automatic updates								
4.8 Manual updates								
4.9 Handoffs								
4.10 Computerized recordkeeping instead of strips								
4.11 Highlighting techniques								
4.12 Speed of ETABS data handling as a whole								
4.13 Reliability of ETABS data handling as a whole								

CONTROLLER ID NO. _____

DATE _____

ETABS Evaluation
Project No. 122-113-600
Questionnaire Form H

5.1 (F13.1) How would you rate the effectiveness of the present NAS (with printed strips)? (Circle one.)

SYSTEM EFFECTIVENESS

1 2 3 4 5 6 7 8 9 10
LOWEST HIGHEST

5.2 (F14.1) How would you rate the effectiveness of NAS using ETABS? (Circle two. Indicate "A" for actual and "C" for concept.)

SYSTEM EFFECTIVENESS

1 2 3 4 5 6 7 8 9 10
LOWEST HIGHEST

6.1 (F15.1) How would you complete the following statement?

"I feel that use of ETABS in an operational field environment would lead to _____ NAS effectiveness." (Indicate "A" for actual and "C" for concept.)

____ a great improvement of

____ an improvement of

____ a slight improvement of

____ no change to

____ a slight degradation of

____ a degradation of

____ a great degradation of

7.1 On the basis of the equipment and procedures used in ETABS, indicate your opinion of its suitability for operational use in ARTCC's. Please check one of the five statements below. (Actual only.)

____ Suitable, fine as is

____ Suitable, but minor modification desirable

____ Marginally suitable, major modifications necessary

____ Unsuitable, concept is OK; but complete redesign is essential

____ Unsuitable, entire concept is inappropriate

CONTROLLER ID NO. _____

DATE _____

ETABS Evaluation
Proj. No. 122-113-600
Questionnaire FORM H

H-8. Based on your experience with and without ETABS, what concepts or ideas involving flight data handling show the best potential for development in ATC. Please mark the appropriate box with an "R" (for R-side) and "D" (for D-side) if necessary.

CONCEPTS TO BE EVALUATED	POTENTIAL FOR ATC IS						
	Very Poor	Poor	Moderately Poor	Fair	Moderately Good	Good	Very Good
8.1 Improving the present strip system - i.e., better procedures, better equipment							
8.2 Switching to a tabular display (TD) electronic displayed strips (FDE's)							
8.3 Use an interactive display (ID) with menus to build messages (make updates)							
8.4 Use an ID without menus to build messages (make updates)							
8.5 Use QAK with a preview display (like a CRD) to build messages for the TD							
8.6 Use a touch-sensitive TD to build messages							
8.7 Use a trackball-cursor to build messages on the TD							
8.8 Use a joystick-cursor to build messages on the TD							
8.9 Use a light pen to build messages on the TD							
8.10 Use a touch-sensitive PVD to build messages on the TD							
8.11 Use a TD touch-sensitive perimeter and grid coordinates to build messages from QAK							
8.12 Use a TD perimeter grid and input coordinates to build messages via QAK							
8.13 Use an audible beep for all ID touches							
8.14 Use an audible beep for auto posting or updating							
8.15 Operating perfectly - retain ID light break touch method							
8.16 Operating perfectly - use a wire touch overlay system							
8.17 Make flight data displays movable - tilt, pull out, and rotate							
8.18 Give R-side PVD quick-look capability of the TD							
8.19 Tailor the ID for the R-side (less info)							
8.20 Remove the ID from the R-side							
8.21 Position the ID vertically below the TD							

CONTROLLER ID NO. _____

DATE _____

ETABS Evaluation
Proj. No. 122-113-600
Questionnaire FORM H

H-8. Based on your experience with and without ETABS, what concepts or ideas involving flight data handling show the best potential for development in ATC. Please mark the appropriate box with an "R" (for R-side) and "D" (for D-side) if necessary.

CONCEPTS TO BE EVALUATED	POTENTIAL FOR ATC IS						
	Very Poor	Poor	Moderately Poor	Fair	Moderately Good	Good	Very Good
8.22 Use a color TD							
8.23 Use a color ID							
8,24 Put field delimit lines (borders) around FDE's (strips)							
8.25 Eliminate the A-side through automating flight data handling							
8.26 Give overhead display of charts, maps, and weather radar							
8.27 Make charts, maps, weather radar available for TD quick-look							
8.28 Give quick-look capability for other sectors							
8.29 Use large AID and ALT lettering							
8.30 Give automatic indication of remotely made updates - i.e., handoffs							
8.31 Put automatic "R" on strips							
8.32 Delete "R" and let absence of NR stand for R							
8.33 Make recordkeeping automatic							
8.34 Give more room for strips on TD							
8.35 Make FDE format exactly like strips							
8.36 Give controller selection of displayed FDE data fields							
8.37 Give controller ability to post fix sublist on TD							
8.38 Use a smaller strip size so more strips can be displayed on the TD							
8.39 Keep the FDE from moving around on the TD							
8.40 Keep the FDE from moving around on the ID							
8.41 Give more area for note pad and GI messages							
8.42 Delete seldom used strip marking symbols							
8.43 Voice Entry							

APPENDIX I

STATISTICAL DATA ANALYSIS TABLES

This appendix contains listings of the original controller ratings and results of the statistical data analysis of the multi-item, seven-category, tabular format question sets. For example, the general aspect question on page A-4 of form A is a set containing 21 items. This set of questions was repeated in form F and twice in form H, once from the point of view of evaluating the system "as tested" and once from the point of view of the "potential of the concept." A computer program was developed to efficiently analyze these data to compare the results for the different forms and to printout easily interpretable results which appear in this appendix.

This appendix is divided into sections for presenting the results of the analysis of the different multiple-item questions. The results are organized within each section as follows (see page I-4): the first page of computer printout typically contains a listing of the original controller ratings grouped by forms and aspects within the forms. The 10 numbers per aspect are the original ratings from the 10 participants (controllers 1 through 10 are listed as the left-most through the right-most colums, respectively). The second page (I-5) typically shows the results for each of the questions ranked by the absolute values of their t scores. The t scores were computed to determine the significance of the deviation of the mean rating from the value of center scale (in this case, NOT CHANGE). The t scores and signs are presented in the right-most column. Nonsignificant t scores do not have + or - signs. To the left of the t scores are abbreviated versions of the text of the questions. Immediately to the left of the text is the number of the aspect as it appeared in the form. To the left of the decimal point is the code for the form (A4, F3, HO, and HE). Finally, the left-most column shows the rank number of the aspect, with 1 having the highest + or - t score.

Following the ranked listing of aspects, the sum and mean rank are printed. Following this, the number of significant results above, below, and not different from midscale are printed.

The next page presents the same information but in a different format. Each of the aspects is listed under the form in which it was given. This permits a comparison of the relative aspect rank and t score magnitude from form to form. Finally, at the end of the printout by form, results of a Kruskal-Wallis analysis of variance of ranks appears. Significance at or beyond alpha = 0.05 is indicated by an asterisk following the value of H. A finding of significance indicates that the mean ranks within each of the forms differed by more than would be expected by chance variation alone. That is, some of the forms had more significant results in them than others because the controllers responded differently to the different administrations of the same questions.

The second part of the analysis for the data on the general aspects question is the difference analysis. With four forms there are six possible differences: form 1 versus (vs) form 2, 1 vs 3, 1 vs 4, 2 vs 3, 2 vs 4, and finally, form 3 vs form 4. With the exception of the fact that these are rating differences, the layout of the results is the same as discussed in the above paragraphs. One can discriminate between ratings and differences by the presence of minus signs in the

original rating difference tables. The t scores for the differences indicated whether the controllers answered the questions differently on the different forms.

The following multiple aspect questions are addressed in this appendix in 13 analyses:

Analysis No.	Question Name	No. of Items	Form Page No.	Page No.
1	General Aspects	21	A-4, F-3, H-3	I-3
2	Ease of Learning	11	B-5	I-13
3	Simulation Realism	8	D-2, F(D-2)	I-15
4	Problems vs Benefits	13	D-3, F(D-3), H-4	I-19
5	Human Factors	12	C-1, F-1, H-1	I-27
6	ID Aspects	12	C-2, F-2, H-2	I-35
7	TDl Aspects	12	C-2, F-2, H-2	I-42
8	TD2 Aspects	12	C-2, F-2, H-2	I-49
9	CRT Display Aspects (Post Training)	12	C-2	I-56
10	CRT Display Aspects (Wrap-Up)	12	F-2	I-56
11	CRT Display Aspects (R-Side)	13	H-2R	I-65
12	CRT Display Aspects (D-Side)	13	H-2D	I-65
13	ATC Improvement Concepts	43	H-6 & 7, H-6 & 7	I-74

ANALYSIS 1: RESULTS FOR TABULAR, MULTI-ITEM RATINGS

These items concern General Aspects

and involve comparisons between expected and obtained changes.

Data are presented on 21 items repeated in 4 forms:

1. Preliminary Survey, Form A, page 4, "Prior expectations"
   called "A4 1 Expected Change" herein.

2. Wrap-Up Survey, Form F, page 3, "After experience with ETABS in simulation"
   called "F3 1 Obtained Change" herein.

3. Follow Up Survey, Form H, page 3, "Conceptualized"
   called "HE 2 Expected Change" herein.

4. Follow Up Survey, Form H, page 3, "As tested"
   called "HO 2 Obtained Change" herein.

The items were rated on the following scale: Compared to present NAS, when using ETABS (the stated aspect will change/changed as indicated.

	7.	Greatly Increase
	6.	Moderately Increase
	5.	Slightly Increase
(midscale)	4.	Not Change
	3.	Slightly Decrease
	2.	Moderately Decrease
	1.	Greatly Decrease

Positive and negative t scores indicate significant deviation from "Not Change" in the directions of "Greatly Increase" and "Greatly Decrease," respectively.

FORM 1) A4 1EXPECTED CHANGE

F1,Q1)	1	1	1	1	1	2	1	2	1	2
F1,Q2)	2	2	1	4	2	3	5	5	3	2
F1,Q3)	4	5	6	5	4	4	5	6	6	5
F1,Q4)	3	3	1	5	4	4	6	5	2	2
F1,Q5)	3	4	2	4	5	3	6	2	5	5
F1,Q6)	4	6	1	6	3	3	3	4	5	4
F1,Q7)	6	7	1	7	3	6	2	6	6	4
F1,Q8)	4	6	1	4	3	7	4	5	1	5
F1,Q9)	4	4	1	4	3	5	4	4	4	5
F1,Q10)	4	5	2	4	3	6	6	5	1	5
F1,Q11)	4	5	1	4	5	5	3	4	6	4
F1,Q12)	3	3	1	3	4	4	4	3	3	4
F1,Q13)	4	2	1	4	4	5	7	3	4	4
F1,Q14)	4	5	7	4	5	6	4	4	7	5
F1,Q15)	3	3	1	5	4	5	6	3	1	3
F1,Q16)	4	3	1	4	4	6	6	2	2	4
F1,Q17)	4	4	1	4	4	4	4	4	2	4
F1,Q18)	4	5	7	4	4	5	4	6	6	4
F1,Q19)	6	5	7	2	5	5	5	6	7	4
F1,Q20)	5	5	1	4	5	5	2	6	6	4
F1,Q21)	6	6	7	6	5	6	7	6	6	5

FORM 2) F3 1OBTAINED CHANGE

F2,Q1)	6	4	4	2	5	2	3	6	7	7
F2,Q2)	6	4	4	3	5	3	2	6	6	7
F2,Q3)	4	5	4	4	4	4	5	4	2	1
F2,Q4)	5	3	5	5	4	5	4	3	7	7
F2,Q5)	3	5	5	4	3	4	5	5	5	7
F2,Q6)	6	5	1	5	3	5	5	7	1	1
F2,Q7)	2	6	1	4	3	5	3	2	1	6
F2,Q8)	6	3	4	6	6	6	6	6	7	6
F2,Q9)	5	3	5	4	5	4	5	4	6	6
F2,Q10)	6	4	6	5	6	6	5	6	7	6
F2,Q11)	5	3	1	6	5	7	2	6	5	2
F2,Q12)	4	3	4	4	4	4	4	4	7	4
F2,Q13)	4	5	4	5	4	6	5	6	4	1
F2,Q14)	4	5	1	4	4	4	6	4	1	5
F2,Q15)	5	4	4	5	6	6	6	5	7	6
F2,Q16)	4	3	4	4	4	4	3	4	7	4
F2,Q17)	4	3	4	4	4	4	6	5	5	5
F2,Q18)	3	5	4	4	4	4	1	5	1	1
F2,Q19)	2	5	4	2	2	3	3	2	1	1
F2,Q20)	4	4	4	4	4	2	4	4	1	1
F2,Q21)	2	5	3	5	5	2	6	3	1	1

FORM 3) HE 2EXPECTED CHANGE

F3,Q1)	2	2	1	1	2	4	1	2	1	2
F3,Q2)	2	3	4	2	2	4	2	2	1	2
F3,Q3)	6	5	7	4	4	4	6	4	6	5
F3,Q4)	4	3	4	6	2	4	2	4	2	4
F3,Q5)	2	3	4	4	2	5	5	4	3	6
F3,Q6)	6	6	2	2	2	4	5	3	6	5
F3,Q7)	7	6	1	4	2	4	4	4	6	5
F3,Q8)	2	3	4	6	2	6	5	4	2	4
F3,Q9)	2	3	4	4	2	5	5	4	3	5
F3,Q10)	2	2	3	6	2	5	4	5	3	4
F3,Q11)	5	2	4	6	2	4	4	5	7	3
F3,Q12)	2	3	2	4	4	4	3	4	2	3
F3,Q13)	3	3	1	4	2	4	2	4	4	6
F3,Q14)	6	6	6	4	4	4	1	4	5	5
F3,Q15)	1	3	2	4	2	4	3	4	2	3
F3,Q16)	4	3	2	3	4	4	3	4	2	3
F3,Q17)	4	3	4	4	4	4	4	3	3	3
F3,Q18)	6	5	5	4	4	5	1	5	6	5
F3,Q19)	6	6	4	4	6	5	5	5	6	5
F3,Q20)	2	5	7	4	2	4	4	4	7	6
F3,Q21)	7	6	6	6	2	3	6	5	6	6

FORM 4) HO 2OBTAINED CHANGE

F4,Q1)	6	5	3	1	5	6	1	5	2	7
F4,Q2)	6	5	7	3	5	5	3	6	6	7
F4,Q3)	3	3	1	4	2	4	6	2	4	1
F4,Q4)	4	5	6	6	7	6	3	5	6	4
F4,Q5)	3	6	6	3	5	5	5	5	5	6
F4,Q6)	1	2	7	2	7	2	2	6	1	1
F4,Q7)	2	2	7	4	1	3	2	5	2	2
F4,Q8)	5	6	6	6	7	6	6	6	7	6
F4,Q9)	3	6	7	4	7	5	5	4	5	5
F4,Q10)	6	6	7	6	7	5	5	7	7	6
F4,Q11)	2	6	7	6	7	4	2	7	2	6
F4,Q12)	6	5	7	4	4	4	5	5	7	6
F4,Q13)	5	5	7	4	7	4	6	5	1	1
F4,Q14)	3	2	1	4	4	4	1	4	2	4
F4,Q15)	6	6	7	5	7	4	6	7	7	6
F4,Q16)	4	5	7	4	4	4	4	4	4	5
F4,Q17)	4	6	7	4	4	4	4	6	7	5
F4,Q18)	3	2	1	2	4	2	1	2	1	2
F4,Q19)	2	2	1	1	1	2	2	2	2	2
F4,Q20)	5	3	1	4	6	3	4	4	1	2
F4,Q21)	2	2	1	3	7	3	3	2	2	2

ALL 84 RATINGS FROM—— FORMS ARE
21 ITEMS IN 4 RATING FORMS ARE
RANKED BY THEIR T SCORES FROM
HIGH TO LOW (TOP TO BOT).

1	A4.1	WORK F DAT HNDLNG	-17.6
2	HO.19	CONF IN SYSTEM	-15.0
3	HO.8	PROB MISKEYING DA	+11.6
4	A4.21	OVRALL SYS EFFECT	+9.48
5	HO.10	N MSG INPUT ERROR	+8.81
6	HE.1	WORK F DAT HNDLNG	-7.57
7	HO.18	CAPAC HNDL TRAFFI	-6.70
8	HO.15	AMOUNT FRUSTRATIO	+6.67
9	F3.10	N MSG INPUT ERROR	+6.52
10	HE.2	COMPLX F DAT HNDL	-5.23
11	HE.19	CONF IN SYSTEM	+4.81
12	F3.15	AMOUNT FRUSTRATIO	+4.58
13	F3.8	PROB MISKEYING DA	+4.31
14	A4.3	JOB SATISFACTION	+3.87
15	F3.19	CONF IN SYSTEM	-3.73
16	HE.15	AMOUNT FRUSTRATIO	-3.67
17	HO.12	N A/C DELAYS	+3.54
18	HO.2	COMPLX F DAT HNDL	+3.30
19	HE.12	N A/C DELAYS	-3.25
20	HE.16	N INTRFONE CALLS	-3.20
21	HE.3	JOB SATISFACTION	+3.16
22	HO.4	WORK NON-F DAT HN	+3.08
23	A4.14	AMOUNT WX/STAT IN	+2.90
24	A4.12	N A/C DELAYS	-2.75
25	HO.9	PROB MISREADING D	+2.70
26	HO.14	AMOUNT WX/STAT IN	-2.70
27	HO.17	PROB CONFLICTS	+2.70
28	HE.21	OVRALL SYS EFFECT	+2.62
29	A4.18	CAPAC HNDL TRAFFI	+2.58
30	HO.5	AMOUNT EYESTRAIN	+2.58
31	A4.19	CONF IN SYSTEM	+2.57
32	A4.2	COMPLX F DAT HNDL	-2.53
33	HO.21	OVRALL SYS EFFECT	-2.51
34	HE.17	PROB CONFLICTS	-2.44
35	F3.9	PROB MISREADING D	+2.33
36	HO.3	JOB SATISFACTION	2.02
37	F3.20	EASE R-D COORDINA	1.92
38	F3.4	WORK NON-F DAT HN	1.80
39	HO.7	SPEED SYS RESPONS	1.73
40	HO.16	N INTRFONE CALLS	1.62
41	F3.5	AMOUNT EYESTRAIN	1.61
42	F3.18	CAPAC HNDL TRAFFI	1.56
43	HE.13	AMOUNT R-D COORDI	1.56
44	F3.17	PROB CONFLICTS	1.5
45	A4.17	PROB CONFLICTS	1.46
46	HO.20	EASE R-D COORDINA	1.35
47	HE.18	CAPAC HNDL TRAFFI	1.32
48	HO.11	EASE CORRECT ERRO	1.30
49	HE.4	WORK NON-F DAT HN	1.24
50	F3.21	OVRALL SYS EFFECT	1.21
51	A4.7	SPEED SYS RESPONS	1.17
52	F3.7	SPEED SYS RESPONS	1.17
53	A4.15	AMOUNT FRUSTRATIO	1.15
54	F3.2	COMPLX F DAT HNDL	1.15
55	HO.6	SPEED MSG INPUT	1.13
56	HE.14	AMOUNT WX/STAT IN	1.04
57	A4.4	WORK NON-F DAT HN	1
58	F3.1	WORK F DAT HNDLNG	1
59	HE.20	EASE R-D COORDINA	0.88
60	F3.13	AMOUNT R-D COORDI	0.88
61	HE.10	N MSG INPUT ERROR	0.88
62	HE.9	PROB MISREADING D	0.81
63	A4.16	N INTRFONE CALLS	0.76
64	F3.3	JOB SATISFACTION	0.75
65	HO.13	AMOUNT R-D COORDI	0.74
66	F3.12	N A/C DELAYS	0.61
67	A4.20	EASE R-D COORDINA	0.57
68	A4.9	PROB MISREADING D	0.55
69	HE.7	SPEED SYS RESPONS	0.51
70	HE.5	AMOUNT EYESTRAIN	0.48
71	HO.1	WORK F DAT HNDLNG	0.41
72	HE.8	PROB MISKEYING DA	0.40
73	F3.14	AMOUNT WX/STAT IN	0.39
74	A4.13	AMOUNT R-D COORDI	0.39
75	HE.11	EASE CORRECT ERRO	0.39
76	F3.11	EASE CORRECT ERRO	0.30
77	F3.16	N INTRFONE CALLS	0.26
78	A4.11	EASE CORRECT ERRO	0.23
79	A4.5	AMOUNT EYESTRAIN	0.23
80	A4.6	SPEED MSG INPUT	0.20
81	A4.10	N MSG INPUT ERROR	0.19
82	HE.6	SPEED MSG INPUT	0.18
83	F3.6	SPEED MSG INPUT	0.14
84	A4.8	PROB MISKEYING DA	0

RANKS: SUM=3570 MEAN=42.5
RESULTS ARE 21 ABOVE, 14 BELOW
AND 49 NOT DIFFERENT (P<=.05)
FROM MIDSCALE.

```
FORM A4  1EXPECTED CHANGE
1    A4.1   WORK F DAT HNDLNG-17.6
2    A4.21  OVRALL SYS EFFECT+9.48
3    A4.3   JOB SATISFACTION +3.87
4    A4.14  AMOUNT WX/STAT IN+2.90
5    A4.12  N A/C DELAYS      -2.75
6    A4.18  CAPAC HNDL TRAFFI+2.58
7    A4.19  CONF IN SYSTEM    +2.57
8    A4.2   COMPLX F DAT HNDL-2.53
9    A4.17  PROB CONFLICTS     1.46
10   A4.7   SPEED SYS RESPONS  1.17
11   A4.15  AMOUNT FRUSTRATIO  1.15
12   A4.4   WORK NON-F DAT HN  1
13   A4.16  N INTRFONE CALLS   0.76
14   A4.20  EASE R-D COORDINA  0.57
15   A4.9   PROB MISREADING D  0.55
16   A4.13  AMOUNT R-D COORDI  0.39
17   A4.11  EASE CORRECT ERRO  0.23
18   A4.5   AMOUNT EYESTRAIN   0.23
19   A4.6   SPEED MSG INPUT    0.20
20   A4.10  N MSG INPUT ERROR  0.19
21   A4.8   PROB MISKEYING DA  0
RANKS.  SUM=1038  MEAN=49.428571
RESULTS ARE 5 ABOVE, 3 BELOW
AND 13 NOT DIFFERENT (P<=.05)
FROM MIDSCALE.

FORM F3  1OBTAINED CHANGE
1    F3.10  N MSG INPUT ERROR+6.52
2    F3.15  AMOUNT FRUSTRATIO+4.56
3    F3.8   PROB MISKEYING DA+4.31
4    F3.19  CONF IN SYSTEM    -3.73
5    F3.9   PROB MISREADING D+2.33
6    F3.20  EASE R-D COORDINA  1.92
7    F3.4   WORK NON-F DAT HN  1.80
8    F3.5   AMOUNT EYESTRAIN   1.61
9    F3.18  CAPAC HNDL TRAFFI  1.56
10   F3.17  PROB CONFLICTS     1.5
11   F3.21  OVRALL SYS EFFECT  1.21
12   F3.7   SPEED SYS RESPONS  1.17
13   F3.2   COMPLX F DAT HNDL  1.15
14   F3.1   WORK F DAT HNDLNG  1
15   F3.13  AMOUNT R-D COORDI  0.88
16   F3.3   JOB SATISFACTION   0.75
17   F3.12  N A/C DELAYS       0.61
18   F3.14  AMOUNT WX/STAT IN  0.39
19   F3.11  EASE CORRECT ERRO  0.30
20   F3.16  N INTRFONE CALLS   0.28
21   F3.6   SPEED MSG INPUT    0.14
RANKS.  SUM=999  MEAN=47.571429
RESULTS ARE 4 ABOVE, 1 BELOW
AND 16 NOT DIFFERENT (P<=.05)
FROM MIDSCALE.
```

```
FORM HE  2EXPECTED CHANGE
1    HE.1   WORK F DAT HNDLNG-7.57
2    HE.2   COMPLX F DAT HNDL-5.23
3    HE.19  CONF IN SYSTEM    +4.81
4    HE.15  AMOUNT FRUSTRATIO-3.67
5    HE.12  N A/C DELAYS      -3.25
6    HE.16  N INTRFONE CALLS  -3.20
7    HE.3   JOB SATISFACTION  +3.16
8    HE.21  OVRALL SYS EFFECT+2.62
9    HE.17  PROB CONFLICTS    -2.44
10   HE.13  AMOUNT R-D COORDI  1.56
11   HE.18  CAPAC HNDL TRAFFI  1.32
12   HE.4   WORK NON-F DAT HN  1.24
13   HE.14  AMOUNT WX/STAT IN  1.04
14   HE.20  EASE R-D COORDINA  0.88
15   HE.10  N MSG INPUT ERROR  0.86
16   HE.9   PROB MISREADING D  0.81
17   HE.7   SPEED SYS RESPONS  0.51
18   HE.5   AMOUNT EYESTRAIN   0.46
19   HE.8   PROB MISKEYING DA  0.40
20   HE.11  EASE CORRECT ERRO  0.39
21   HE.6   SPEED MSG INPUT    0.16
RANKS.  SUM=910  MEAN=43.333333
RESULTS ARE 3 ABOVE, 6 BELOW
AND 12 NOT DIFFERENT (P<=.05)
FROM MIDSCALE.

FORM HO  2OBTAINED CHANGE
1    HO.19  CONF IN SYSTEM    -15.0
2    HO.8   PROB MISKEYING DA+11.6
3    HO.10  N MSG INPUT ERROR+8.84
4    HO.18  CAPAC HNDL TRAFFI-6.70
5    HO.15  AMOUNT FRUSTRATIO+6.67
6    HO.12  N A/C DELAYS      +3.54
7    HO.2   COMPLX F DAT HNDL+3.30
8    HO.4   WORK NON-F DAT HN+3.06
9    HO.9   PROB MISREADING D+2.70
10   HO.14  AMOUNT WX/STAT IN-2.70
11   HO.17  PROB CONFLICTS    +2.70
12   HO.5   AMOUNT EYESTRAIN  +2.58
13   HO.21  OVRALL SYS EFFECT-2.54
14   HO.3   JOB SATISFACTION   2.06
15   HO.7   SPEED SYS RESPONS  1.78
16   HO.16  N INTRFONE CALLS   1.62
17   HO.20  EASE R-D COORDINA  1.38
18   HO.11  EASE CORRECT ERRO  1.30
19   HO.6   SPEED MSG INPUT    1.13
20   HO.13  AMOUNT R-D COORDI  0.74
21   HO.1   WORK F DAT HNDLNG  0.41
RANKS.  SUM=623  MEAN=29.666667
RESULTS ARE 9 ABOVE, 4 BELOW
AND 8 NOT DIFFERENT (P<=.05)
FROM MIDSCALE.

KRUSKAL-WALLIS ANOV,H=8.4392958
CHI SQ, 3 DF.
```

ANALYSIS 1: DIFFERENCES

GENERAL ASPECTS

FORM 3)
1EXPECTED-2OBTAINED
FORM 4)
2OBTAINED-1EXPECTED
FORM 3)
1EXPECTED-2OBTAINED
FORM 4)
2OBTAINED-1EXPECTED

FORM 51
24 OBTAINED-20BTAINED
FORM 51
EXPECTED OBTAINED

ALL 126 DFRNCES FROM
21 ITEMS IN 6 DFRNCE FORMS ARE
RANKED BY THEIR T SCORES FROM
HIGH TO LOW (TOP TO BOT).

1	34.19	CONF IN SYSTEM	+15.6
2	14.19	CONF IN SYSTEM	+7.71
3	34.2	COMPLX F DAT HNDL	-6.14
4	34.15	AMOUNT FRUSTRATIO	-5.90
5	23.15	AMOUNT FRUSTRATIO	+5.75
6	12.1	WORK F DAT HNDLNG	-5.52
7	23.19	CONF IN SYSTEM	-5.44
8	34.18	CAPAC HNDL TRAFFI	+5.21
9	14.18	CAPAC HNDL TRAFFI	+5.11
10	14.21	OVRALL SYS EFFECT	+5.07
11	12.21	OVRALL SYS EFFECT	+4.83
12	12.19	CONF IN SYSTEM	+4.66
13	14.1	WORK F DAT HNDLNG	-4.5
14	34.10	N MSG INPUT ERROR	-4.47
15	34.1	WORK F DAT HNDLNG	-4.44
16	34.8	PROB MISKEYING DA	-4.11
17	23.10	N MSG INPUT ERROR	+3.99
18	23.1	WORK F DAT HNDLNG	+3.93
19	12.15	AMOUNT FRUSTRATIO	-3.58
20	14.12	N A/C DELAYS	-3.58
21	14.15	AMOUNT FRUSTRATIO	-3.54
22	34.12	N A/C DELAYS	-3.49
23	34.3	JOB SATISFACTION	+3.47
24	14.14	AMOUNT WX/STAT IN	+3.40
25	14.3	JOB SATISFACTION	+3.35
26	14.2	COMPLX F DAT HNDL	-3.17
27	24.12	N A/C DELAYS	-3.16
28	34.4	WORK NON-F DAT HN	-3.15
29	12.18	CAPAC HNDL TRAFFI	+3.15
30	23.2	COMPLX F DAT HNDL	+3.09
31	14.8	PROB MISKEYING DA	-2.97
32	23.8	PROB MISKEYING DA	+2.94
33	34.17	PROB CONFLICTS	-2.87
34	14.10	N MSG INPUT ERROR	-2.84
35	23.5	AMOUNT EYESTRAIN	+2.75
36	34.21	OVRALL SYS EFFECT	+2.71
37	34.16	N INTRFONE CALLS	-2.62
38	34.14	AMOUNT WX/STAT IN	+2.58
39	24.2	COMPLX F DAT HNDL	-2.58
40	23.3	JOB SATISFACTION	-2.58
41	34.5	AMOUNT EYESTRAIN	-2.53
42	12.3	JOB SATISFACTION	+2.51
43	34.9	PROB MISREADING D	-2.49
44	24.18	CAPAC HNDL TRAFFI	+2.44
45	23.21	OVRALL SYS EFFECT	-2.44
46	23.17	PROB CONFLICTS	+2.44
47	14.4	WORK NON-F DAT HN	-2.42
48	23.18	CAPAC HNDL TRAFFI	-2.33
49	14.17	PROB CONFLICTS	-2.27
50	12.10	N MSG INPUT ERROR	-2.27
51	23.4	WORK NON-F DAT HN	2.24
52	13.1	WORK F DAT HNDLNG	2.23
53	12.12	N A/C DELAYS	2.23
54	12.2	COMPLX F DAT HNDL	2.19
55	23.12	N A/C DELAYS	2.18
56	23.9	PROB MISREADING D	2.12
57	12.8	PROB MISKEYING DA	2.09
58	12.17	PROB CONFLICTS	2.07
59	12.7	SPEED SYS RESPONS	2.00
60	14.9	PROB MISREADING D	1.90
61	12.9	PROB MISREADING D	1.86
62	24.10	N MSG INPUT ERROR	1.86
63	14.5	AMOUNT EYESTRAIN	1.86
64	14.7	SPEED SYS RESPONS	1.82
65	24.19	CONF IN SYSTEM	1.80
66	23.16	N INTRFONE CALLS	1.78
67	24.14	AMOUNT WX/STAT IN	1.58
68	14.20	EASE R-D COORDINA	1.58
69	12.4	WORK NON-F DAT HN	1.56
70	24.15	AMOUNT FRUSTRATIO	1.56
71	13.21	OVRALL SYS EFFECT	1.56
72	12.14	AMOUNT WX/STAT IN	1.54
73	23.20	EASE R-D COORDINA	1.51
74	23.13	AMOUNT R-D COORDI	1.49
75	12.20	EASE R-D COORDINA	1.46
76	24.17	PROB CONFLICTS	1.41
77	24.3	JOB SATISFACTION	1.41
78	23.7	SPEED SYS RESPONS	1.36
79	12.5	AMOUNT EYESTRAIN	1.35
80	24.8	PROB MISKEYING DA	1.34
81	13.15	AMOUNT FRUSTRATIO	1.32
82	34.7	SPEED SYS RESPONS	1.28
83	13.14	AMOUNT WX/STAT IN	1.26
84	14.16	N INTRFONE CALLS	1.22
85	34.20	EASE R-D COORDINA	1.11
86	34.13	AMOUNT R-D COORDI	1.10
87	24.21	OVRALL SYS EFFECT	1.03
88	24.5	AMOUNT EYESTRAIN	1
89	13.7	SPEED SYS RESPONS	1
90	13.10	N MSG INPUT ERROR	0.92

```
91  12.13  AMOUNT R-D COORDI  0.91
92  14.11  EASE CORRECT ERRO  0.88
93  13.15  N INTRFONE CALLS   0.88
94  23.14  AMOUNT WX/STAT IN  0.81
95  13.2   COMPLX F DAT HNDL  0.80
96  13.13  AMOUNT R-D COORDI  0.80
97  24.16  N INTRFONE CALLS   0.80
98  24.9   PROB MISREADING D  0.80
99  34.6   SPEED MSG INPUT    0.79
100 14.13  AMOUNT R-D COORDI  0.77
101 24.6   SPEED MSG INPUT    0.73
102 24.11  EASE CORRECT ERRO  0.70
103 14.6   SPEED MSG INPUT    0.69
104 24.4   WORK NON-F DAT HN  0.68
105 12.16  N INTRFONE CALLS   0.68
106 34.11  EASE CORRECT ERRO  0.67
107 13.18  CAPAC HNDL TRAFFI  0.66
108 24.1   WORK F DAT HNDLNG  0.39
109 13.12  N A/C DELAYS       0.36
110 13.6   SPEED MSG INPUT    0.34
111 13.8   PROB MISKEYING DA  0.33
112 24.7   SPEED SYS RESPONS  0.30
113 13.3   JOB SATISFACTION   0.28
114 13.17  PROB CONFLICTS     0.26
115 13.20  EASE R-D COORDINA  0.23
116 24.20  EASE R-D COORDINA  0.23
117 13.9   PROB MISREADING D  0.23
118 23.6   SPEED MSG INPUT    0.22
119 12.11  EASE CORRECT ERRO  0.19
120 13.5   AMOUNT EYESTRAIN   0.17
121 24.13  AMOUNT R-D COORDI  0.16
122 13.11  EASE CORRECT ERRO  0.15
123 13.4   WORK NON-F DAT HN  0
124 23.11  EASE CORRECT ERRO  0
125 13.19  CONF IN SYSTEM     0
126 12.6   SPEED MSG INPUT    0
RANKS.  SUM=6001 MEAN=63.5
RESULTS ARE 22 ABOVE, 28 BELOW
AND 76 NOT DIFFERENT (P<=.05)
FROM MIDSCALE.
```

```
FORM 12 1EXPECTED-10BTAINED
1   12.1   WORK F DAT HNDLNG-5.52
2   12.21  OVRALL SYS EFFECT+4.83
3   12.19  CONF IN SYSTEM    +4.66
4   12.15  AMOUNT FRUSTRATIO-3.58
5   12.18  CAPAC HNDL TRAFFI+3.15
6   12.3   JOB SATISFACTION  +2.51
7   12.10  N MSG INPUT ERROR-2.27
8   12.12  N A/C DELAYS       2.23
9   12.2   COMPLX F DAT HNDL  2.19
10  12.8   PROB MISKEYING DA  2.09
11  12.17  PROB CONFLICTS     2.07
12  12.7   SPEED SYS RESPONS  2.00
13  12.9   PROB MISREADING D  1.86
14  12.4   WORK NON-F DAT HN  1.56
15  12.14  AMOUNT WX/STAT IN  1.54
16  12.20  EASE R-D COORDINA  1.46
17  12.5   AMOUNT EYESTRAIN   1.35
18  12.13  AMOUNT R-D COORDI  0.91
19  12.16  N INTRFONE CALLS   0.68
20  12.11  EASE CORRECT ERRO  0.19
21  12.6   SPEED MSG INPUT    0
RANKS.  SUM=1247 MEAN=59.380952
RESULTS ARE 4 ABOVE, 3 BELOW
AND 14 NOT DIFFERENT (P<=.05)
FROM MIDSCALE.
```

```
FORM 13 1EXPECTED-2EXPECTED
1   13.1   WORK F DAT HNDLNG  2.23
2   13.21  OVRALL SYS EFFECT  1.56
3   13.15  AMOUNT FRUSTRATIO  1.32
4   13.14  AMOUNT WX/STAT IN  1.26
5   13.7   SPEED SYS RESPONS  1
6   13.10  N MSG INPUT ERROR  0.92
7   13.16  N INTRFONE CALLS   0.88
8   13.2   COMPLX F DAT HNDL  0.80
9   13.13  AMOUNT R-D COORDI  0.80
10  13.18  CAPAC HNDL TRAFFI  0.66
11  13.12  N A/C DELAYS       0.65
12  13.6   SPEED MSG INPUT    0.34
13  13.8   PROB MISKEYING DA  0.33
14  13.3   JOB SATISFACTION   0.28
15  13.17  PROB CONFLICTS     0.26
16  13.20  EASE R-D COORDINA  0.23
17  13.9   PROB MISREADING D  0.23
18  13.5   AMOUNT EYESTRAIN   0.17
19  13.11  EASE CORRECT ERRO  0.15
20  13.4   WORK NON-F DAT HN  0
21  13.19  CONF IN SYSTEM     0
RANKS.  SUM=2136 MEAN=101.71429
RESULTS ARE 0 ABOVE, 0 BELOW
AND 21 NOT DIFFERENT (P<=.05)
FROM MIDSCALE.
```

```
FORM 14 1EXPECTED-2OBTAINED
1    14.19 CONF IN SYSTEM    +7.71
2    14.18 CAPAC HNDL TRAFFI+5.11
3    14.21 OVRALL SYS EFFECT+5.07
4    14.1  WORK F DAT HNDLNG-4.5
5    14.12 N A/C DELAYS      -3.58
6    14.15 AMOUNT FRUSTRATIO-3.54
7    14.14 AMOUNT WX/STAT IN+3.40
8    14.3  JOB SATISFACTION +3.35
9    14.2  COMPLX F DAT HNDL-3.17
10   14.8  PROB MISKEYING DA-2.97
11   14.10 N MSG INPUT ERROR-2.84
12   14.4  WORK NON-F DAT HN-2.42
13   14.17 PROB CONFLICTS  -2.27
14   14.9  PROB MISREADING D 1.90
15   14.5  AMOUNT EYESTRAIN  1.86
16   14.7  SPEED SYS RESPONS 1.82
17   14.20 EASE R-D COORDINA 1.58
18   14.16 N INTRFONE CALLS  1.22
19   14.11 EASE CORRECT ERRO 0.88
20   14.13 AMOUNT R-D COORDI 0.77
21   14.6  SPEED MSG INPUT   0.69
RANKS:  SUM=945   MEAN=45
RESULTS ARE 5 ABOVE, 8 BELOW
AND 8 NOT DIFFERENT (P<=.05)
FROM MIDSCALE.

FORM 23 1OBTAINED-2EXPECTED
1    23.15 AMOUNT FRUSTRATIO+5.75
2    23.19 CONF IN SYSTEM    -5.44
3    23.10 N MSG INPUT ERROR+3.99
4    23.1  WORK F DAT HNDLNG+3.93
5    23.2  COMPLX F DAT HNDL+3.09
6    23.8  PROB MISKEYING DA+2.94
7    23.5  AMOUNT EYESTRAIN  +2.75
8    23.3  JOB SATISFACTION  -2.58
9    23.21 OVRALL SYS EFFECT-2.44
10   23.17 PROB CONFLICTS    +2.44
11   23.18 CAPAC HNDL TRAFFI-2.33
12   23.4  WORK NON-F DAT HN  2.24
13   23.12 N A/C DELAYS       2.16
14   23.9  PROB MISREADING D  2.12
15   23.16 N INTRFONE CALLS   1.76
16   23.20 EASE R-D COORDINA  1.51
17   23.13 AMOUNT R-D COORDI  1.49
18   23.7  SPEED SYS RESPONS  1.36
19   23.14 AMOUNT WX/STAT IN  0.81
20   23.6  SPEED MSG INPUT    0.22
21   23.11 EASE CORRECT ERRO  0
RANKS:  SUM=1112 MEAN=52.952381
RESULTS ARE 7 ABOVE, 4 BELOW
AND 10 NOT DIFFERENT (P<=.05)
FROM MIDSCALE.

FORM 24 1OBTAINED-2OBTAINED
1    24.12 N A/C DELAYS      -3.16
2    24.2  COMPLX F DAT HNDL-2.58
3    24.18 CAPAC HNDL TRAFFI+2.44
4    24.10 N MSG INPUT ERROR  1.86
5    24.19 CONF IN SYSTEM     1.80
6    24.14 AMOUNT WX/STAT IN  1.58
7    24.15 AMOUNT FRUSTRATIO  1.56
8    24.17 PROB CONFLICTS     1.41
9    24.3  JOB SATISFACTION   1.41
10   24.8  PROB MISKEYING DA  1.34
11   24.21 OVRALL SYS EFFECT  1.03
12   24.5  AMOUNT EYESTRAIN   1
13   24.16 N INTRFONE CALLS   0.80
14   24.9  PROB MISREADING D  0.80
15   24.6  SPEED MSG INPUT    0.73
16   24.11 EASE CORRECT ERRO  0.70
17   24.4  WORK NON-F DAT HN  0.68
18   24.1  WORK F DAT HNDLNG  0.39
19   24.7  SPEED SYS RESPONS  0.30
20   24.20 EASE R-D COORDINA  0.23
21   24.13 AMOUNT R-D COORDI  0.16
RANKS:  SUM=1741 MEAN=82.904762
RESULTS ARE 1 ABOVE, 2 BELOW
AND 18 NOT DIFFERENT (P<=.05)
FROM MIDSCALE.

FORM 34 2EXPECTED-2OBTAINED
1    34.19 CONF IN SYSTEM    +15.6
2    34.2  COMPLX F DAT HNDL-6.14
3    34.15 AMOUNT FRUSTRATIO-5.90
4    34.18 CAPAC HNDL TRAFFI+5.21
5    34.10 N MSG INPUT ERROR-4.47
6    34.1  WORK F DAT HNDLNG-4.44
7    34.8  PROB MISKEYING DA-4.11
8    34.12 N A/C DELAYS      -3.49
9    34.3  JOB SATISFACTION +3.47
10   34.4  WORK NON-F DAT HN-3.15
11   34.17 PROB CONFLICTS    -2.87
12   34.21 OVRALL SYS EFFECT+2.71
13   34.16 N INTRFONE CALLS  -2.62
14   34.14 AMOUNT WX/STAT IN+2.56
15   34.5  AMOUNT EYESTRAIN  -2.53
16   34.9  PROB MISREADING D-2.49
17   34.7  SPEED SYS RESPONS 1.28
18   34.20 EASE R-D COORDINA 1.11
19   34.13 AMOUNT R-D COORDI 1.10
20   34.6  SPEED MSG INPUT   0.79
21   34.11 EASE CORRECT ERRO 0.67
RANKS:  SUM=820  MEAN=39.047619
RESULTS ARE 5 ABOVE, 11 BELOW
AND 5 NOT DIFFERENT (P<=.05)
FROM MIDSCALE.

KRUSKAL-WALLIS ANOV,H=45.752192
CHI SQ, 5 DF.
```

ANALYSIS 2: RESULTS FOR TABULAR, MULTI-ITEM RATINGS

These items concern Ease of Learning

Data are presented on 11 items in 1 form:

1. Daily Training Survey, Form B, page 5, called "B5 Ease of Learning" herein.

The items were rated on the following scale: Evaluate the ease or difficulty you experienced today in learning or using the specific ETABS or simulation aspect.

7. Very Easy
6. Easy
5. Moderately Easy
(midscale) 4. Moderate
3. Moderately Hard
2. Hard
1. Very Hard

Positive and negative t scores indicate significant deviation from "Moderate" in the directions of "Very Easy" and "Very Hard," respectively. Since there is only one set of questions, no difference analysis was possible.

```
ALL 11 RATINGS FROM FORMS ARE
11 ITEMS IN 1 RATING FORMS FROM
RANKED BY THEIR SCORES FROM
HIGH TO LOW (TOP TO BOT).

FORM BS EASE OF LEARNING
BS.....11
BS.....10
BS.....9
BS.....8
BS.....7
BS.....6
BS.....5
BS.....4
BS.....3
BS.....2
BS.....1

RANK SUM=66 MEAN=6 BELOW
RESULT SUMS ARE ABOVE, (P<=.05)
AND ARE NOT DIFFERENT
FROM MIDSCALE.

KRUSKAL-WALLIS ANOV,H=0
CHI SQ, 0 DF.
```

```
FORM 11 BS EASE OF LEARNING
```

ANALYSIS 3: RESULTS FOR TABULAR, MULTI-ITEM RATINGS

These items concern realism of the operational simulation of the ETABS and involve comparisons between mid- and post-experiment opinions.

Data are presented on 8 items repeated in 2 forms:

1. Post Familiarization Survey, Form D, page 2, "Mid-experiment" called "D1 1SIM Realism" herein.

2. Post Familiarization Survey, Form D, page 2, "Post-experiment (wrap-up) administration" called "D2 2SIM Realism" herein.

The items were rated on the following scale: For the stated ATC simulation aspect, realism was

	7.	Very High
	6.	High
	5.	Moderately High
(midscale)	4.	Moderate
	3.	Moderately Low
	2.	Low
	1.	Very Low

Positive and negative t scores indicate significant deviation from "Moderate" in the directions of "Very High" and "Very Low," respectively.

```
FORM 1)  D1 1SIM REALISM
F1,01)   4314241453
F1,02)   4574444445
F1,03)   5445463324
F1,04)   5645463325
F1,05)   4417463455
F1,06)   3564244475
F1,07)   4474444554
F1,08)   4314342253

FORM 2)  D2 2SIM REALISM
F2,01)   2213241422
F2,02)   6654444534
F2,03)   6555463445
F2,04)   5654453446
F2,05)   5423253554
F2,06)   5644434576
F2,07)   6674445436
F2,08)   5554443445
```



```
ALL 16 RATINGS FROM
8 ITEMS IN 2 RATING FORMS ARE
RANKED BY THEIR T SCORES FROM
HIGH TO LOW (TOP  TO BOT).

1   D2.1   TRAFFIC SAMPLES   -5.07
2   D1.8   SIMUL AS A WHOLE  -2.37
3   D2.3   COMMUNICATIONS    +2.33
4   D2.7   GENL ENVIRONMENT   2.21
5   D1.1   TRAFFIC SAMPLES    2.07
6   D2.6   CONSOLE LAYOUT     2.05
7   D2.4   SIMOP VRBL RESPS   1.96
8   D1.2   SECTOR GEOMETRY    1.62
9   D2.2   SECTOR GEOMETRY    1.62
10  D1.7   GENL ENVIRONMENT   1.62
11  D2.8   SIMUL AS A WHOLE   1.40
12  D1.6   CONSOLE LAYOUT     0.88
13  D1.4   SIMOP VRBL RESPS   0.70
14  D1.5   A/C DYNAM RESP     0.57
15  D2.5   A/C DYNAM RESP     0.51
16  D1.3   COMMUNICATIONS     0
RANKS:  SUM=136   MEAN=8.5
RESULTS ARE 1 ABOVE, 2 BELOW
AND 13 NOT DIFFERENT (P<=.05)
FROM MIDSCALE.

FORM D1 1SIM REALISM
1   D1.8   SIMUL AS A WHOLE  -2.37
2   D1.1   TRAFFIC SAMPLES    2.07
3   D1.2   SECTOR GEOMETRY    1.62
4   D1.7   GENL ENVIRONMENT   1.62
5   D1.6   CONSOLE LAYOUT     0.88
6   D1.4   SIMOP VRBL RESPS   0.70
7   D1.5   A/C DYNAM RESP     0.57
8   D1.3   COMMUNICATIONS     0
RANKS:  SUM=80    MEAN=10
RESULTS ARE 0 ABOVE, 1 BELOW
AND 7 NOT DIFFERENT (P<=.05)
FROM MIDSCALE.

FORM D2 2SIM REALISM
1   D2.1   TRAFFIC SAMPLES   -5.07
2   D2.3   COMMUNICATIONS    +2.33
3   D2.7   GENL ENVIRONMENT   2.21
4   D2.6   CONSOLE LAYOUT     2.05
5   D2.4   SIMOP VRBL RESPS   1.96
6   D2.2   SECTOR GEOMETRY    1.62
7   D2.8   SIMUL AS A WHOLE   1.40
8   D2.5   A/C DYNAM RESP     0.51
RANKS:  SUM=56    MEAN=7
RESULTS ARE 1 ABOVE, 1 BELOW
AND 6 NOT DIFFERENT (P<=.05)
FROM MIDSCALE.

KRUSKAL-WALLIS ANOV,H=1.5882353
CHI SQ, 1 DF.
```