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DATA LINK SHORT-MESSAGE COCKPIT DISPLAY TEST

Donald Larson

DECEMBER 1974

FINAL REPORT

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16. Abstract

Evaluation was made of four pilot/cockpit displays for air traffic control messages. The four displays were: (1) gas discharge, (2) light-emitting diodes, (3) fiber optics, and (4) cathode-ray tube displays. Data obtained were in the form of questionnaires and measured controller response time to the messages. The results will be used to determine the optimum display for crew environment tests. It was found that, through training and practice, pilot crews can readily set up cockpit procedures and operate in an ATC data link display communications environment.

This report documents a series of tests on cockpit input/output devices performed in a GAT-II cockpit simulator at the National Aviation Facilities Experimental Center during November 1973. These tests were in support of the Systems Research and Development Service Air-Ground Data Link Development Subprogram. Additional human factors analysis performed by the Transportation System Center based on these tests is documented in the following report: Hilborn, Edwin H., "Human Factors Experiments for Data Link: Interim Report No. 4", Report No. FAA-RD-74-81.

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TABLE OF CONTENTS

	Page
INTRODUCTION	1
Purpose	1
Background	1
Description of Equipment	1
DISCUSSION	7
Experimental Design	7
Test Results	10
Results from the Questionnaire	24
ANALYSIS	27
Pilot Opinion	27
Factor Ranking	27
CONCLUSIONS	28
REFERENCES	28

APPENDIXES

A Scenario Descriptions
B Data Link Cockpit Display Test Briefing Material
C GAT-II Data Sheets
D Summary of NAFEC Crew and Volunteer Crew Response to Data Link Cockpit Display Questionnaires
E NAFEC Crew Data Link Cockpit Display Questionnaire Comments
F Pilot Questionnaire Air-Ground Data Link Development Summary for the ATA, ALPA, and AOPA Pilot Crew Cockpit Display Test

LIST OF ILLUSTRATIONS

Figure		Page
1	32-Window Display	2
2	3X7-Window Display	4
3	7-Window Display	4
4	NIMO Display	5
5	NIMO Display Shadow Mask	6
6	GAT-II Test Control Setup	8
7	GAT-II Cockpit	9
8	Response Time as a Function of Mean Age of Each Pilot/Copilot Crew	13
9	Response Time as a Function of Crew Mean Hours of Flying Experience	14
10	Response Time as a Function of Information Units in ATC Message	17
11	Response Time as a Function of Message Length with Radiofrequency/Transponder Code Messages Omitted	18

LIST OF TABLES

Table		Page
1	Mean Response Time in Seconds for Combinations of Scenarios, Day vs. Night Conditions for Each Display for Each NAFEC Pilot/Copilot Crew	11
2	Mean Response Time in Seconds for Combinations of Scenarios, Day vs. Night Conditions for Each Display for Each Volunteer Pilot/Copilot Crew	11
3	Mean Response Times in Seconds to Acknowledge ATC Message	12
4	Mean Response Time in Seconds to Acknowledge ATC Message as a Function of Day/Night Conditions	15
5	Mean Response Time in Seconds to Acknowledge ATC Message for Each of the Four Data Link Cockpit Displays	16
6	WILCO/UNABLE Switch Response Times in Seconds by the Volunteer Pilot/Copilot Crews	20
7	WILCO/UNABLE Switch Response Times in Seconds by the Volunteer Pilot/Copolit Crews	21
8	Mean Response Time of the WILCO/UNABLE Response Options by NAFEC Pilot/Copilot Crews	22
9	Mean Response Time of the WILCO/UNABLE Response Options by the Volunteer Pilot/Copilot Crews	23
10	Number of Display Message Recalls/Rescrolling Under Day/Night Conditions	24
11	3X7-Window Display Control Settings	24
12	7-Window Display Control Settings	25
13	Summary of Individual NAFEC Test Crew Pilots on Data Display Preferences	25
14	Weighted Scores of Display Preference by the NAFEC Test Crew Pilots	26
15	Summary of Individual Volunteer Crew Pilots on Data Display Preferences	26
16	Weighted Scores of Display Preference by the Volunteer Crew Pilots	26

INTRODUCTION

PURPOSE.

The purpose of this activity was to evaluate four short-message data-link cockpit displays in order to reduce the number of displays for subsequent flight tests by having National Aviation Facilities Experimental Center (NAFEC) pilots and then volunteer commercial and private pilots fly a general aviation trainer as experimental crew subjects using the display to present air traffic control (ATC) messages for the conduct of the flight.

BACKGROUND.

This work was the next level of effort which was previously conducted and reported on by the Transportation Systems Center (TSC) of the Department of Transportation. Briefly, the first of the two reports (reference 1) describes a series of studies to determine the relative effectiveness of various sizes of visual cockpit displays in terms of the potential repertoire of ATC up-link messages which could be displayed on each. The second report (reference 2) covers the evaluation of four displays, all having the capability of a wide variety of ATC command presentations which were evaluated in the TSC GAT-I simulator using eight NAFEC test pilots as experimental subjects. This report covers experimentation with these four types of displays using two-man pilot crews in the NAFEC GAT-II cockpit simulator.

DESCRIPTION OF EQUIPMENT.

The four displays used in this experiment were called the 32-window (32W), the 3X7-window (3X7W), the 7-window (7W), and the NIMO (all commercial displays). Certain display characteristics were common to all displays.

The common display characteristics were:

1. The message flashed momentarily when first presented, and then it would remain ON steadily without flashing.

2. The WILCO light on the display flashed continuously until the WILCO or UNABLE button was pushed.

3. The MESSAGE-PENDING light flashed when there was an additional message to be displayed, and the currently displayed message had not been WILCO'd or UNABLED. When the WILCO or UNABLE button was pushed, the displayed message was replaced by the pending message.

THE 32-WINDOW DISPLAY. The 32W display (figure 1) displayed all characters on one line, using a gas discharge 5X7 dot matrix. Character color was red-orange, and character size was 0.20 inch high and 0.14 inch wide. Light output per dot was 25 footlamberts nominal. As a result of prior pilot recommendations (reference 2), the last heading, altitude, and speed message was always presented in the last 11 character spaces under the appropriate callout which was permanently affixed on the display.

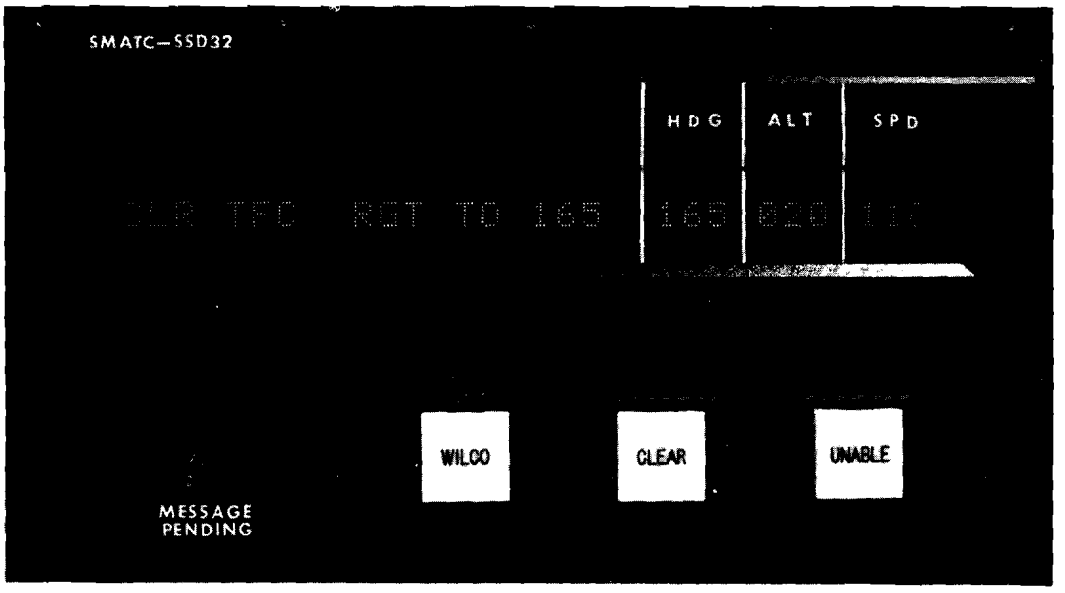

FIGURE 1. 32-WINDOW DISPLAY

Operationally, the WILCO, CLEAR, and UNABLE button use was as follows:

1. WILCO was used to acknowledge the message in the first 21 character spaces and to allow a pending message to be displayed, and caused the previous message to be removed.

2. CLEAR was used to remove a displayed message. A second push of the button would cause the message to be redisplayed.

3. UNABLE was used to indicate the noncompliance or rejection of the message. Operationally, the voice channel would be used to resolve the issue.

An additional display characteristic of the 32W display was the fact that heading, speed, and altitude were continuously displayed in the last eleven character spaces and were automatically and concurrently updated by any message.

THE 3X7-WINDOW DISPLAY. The 3X7W display (figure 2) displayed the message(s) in three lines of seven characters, using light-emitting diodes (LED) which were red in color and were based on a 5X7 dot matrix. Character height was 0.35 inch and width, 0.25 inch, with the brightness typically 300 footlamberts. As a result of pilot recommendations made during earlier tests (reference 2), an intensity control was added, and the heading, altitude, and speed information was always presented on a scratch pad basis regardless of the contents of the last message. This was an additional display characteristic besides those indicated earlier. The scratch pad capability was provided by having the last heading, speed, and altitude command in storage for recall.

Operationally, the WILCO, MESSAGE PENDING, UNABLE, and RECALL button use was as follows:

1. WILCO was used to acknowledge a message. The message stayed until a new message was received.

2. MESSAGE PENDING was used to remove the message from the display, and a second depression of it caused the message to reappear, and this process could be repeated. This indicator button was used as a CLEAR button. This button also flashed to indicate that another message was ready for display when the preceding message had not been WILCO'd.

3. UNABLE was used to indicate the noncompliance or rejection of the message. Operationally, the voice channel would be used to resolve the issue.

4. RECALL was used to display heading, speed, and altitude on request. When pushed again, the last message was redisplayed, and this process could be repeated.

THE 7-WINDOW DISPLAY. The 7W display (figure 3) had seven characters on one line, using incandescent lamps and fiber optics which were white in color. The character height was 0.42 inch high and up to 0.42 inch wide, with brightness typically 400 footlamberts. As a result of pilot recommendations in earlier tests (reference 2), a brightness control and a scroll-rate control were added. Scroll or scrolling is defined as the ability of the display to recall messages in storage; typically, heading, speed, and altitude messages. Depending upon the display, this function is manual and/or automatic. All messages longer than seven character and up to 21 characters were scrolled automatically and continuously until the WILCO button was pushed.

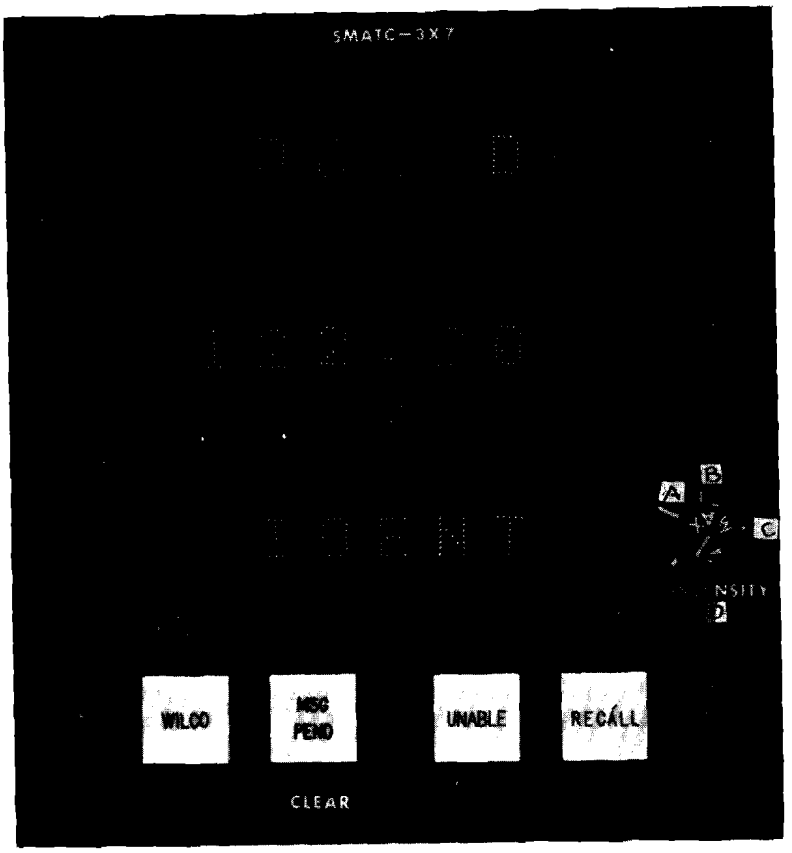

FIGURE 2. 3X7-WINDOW DISPLAY

FIGURE 3. 7-WINDOW DISPLAY

Operationally, the button use was as follows:

1. WILCO was used to acknowledge a message and also stop scrolling.

2. MESSAGE PENDING was used, when this button was not flashing, to indicate a new message. It could also be depressed to scroll manually; that is, for each depression of the button another part of the message was displayed.

3. CLEAR was used to remove the message from the display. A second depression of the button would return the message. This was independent of the manual scrolling function.

4. UNABLE was used to indicate the noncompliance or rejection of the message. Operationally, voice channel would be used to resolve the issue.

THE NIMO DISPLAY. The NIMO display (figure 4) was a miniature charactron cathode-ray tube (CRT) with three lines of six characters available in the color green. The tube contained an array of 64 cathodes and 64 discrete mask areas, so arranged that any cathode and its associated mask section could produce a character or a message on the 3/4-inch-square viewing area (figure 5). No deflection circuitry was used; the position at which information appears on the tube face was entirely a function of the geometry of the cathodes and their associated mask areas. Certain mask positions were reserved for individual digits as specific locations, so that by time-sharing cathodes and mask positions at a flicker-free rate, it was possible to display messages along with required numerical values. The NIMO display had just the basic display characteristics previously described for all of the displays.

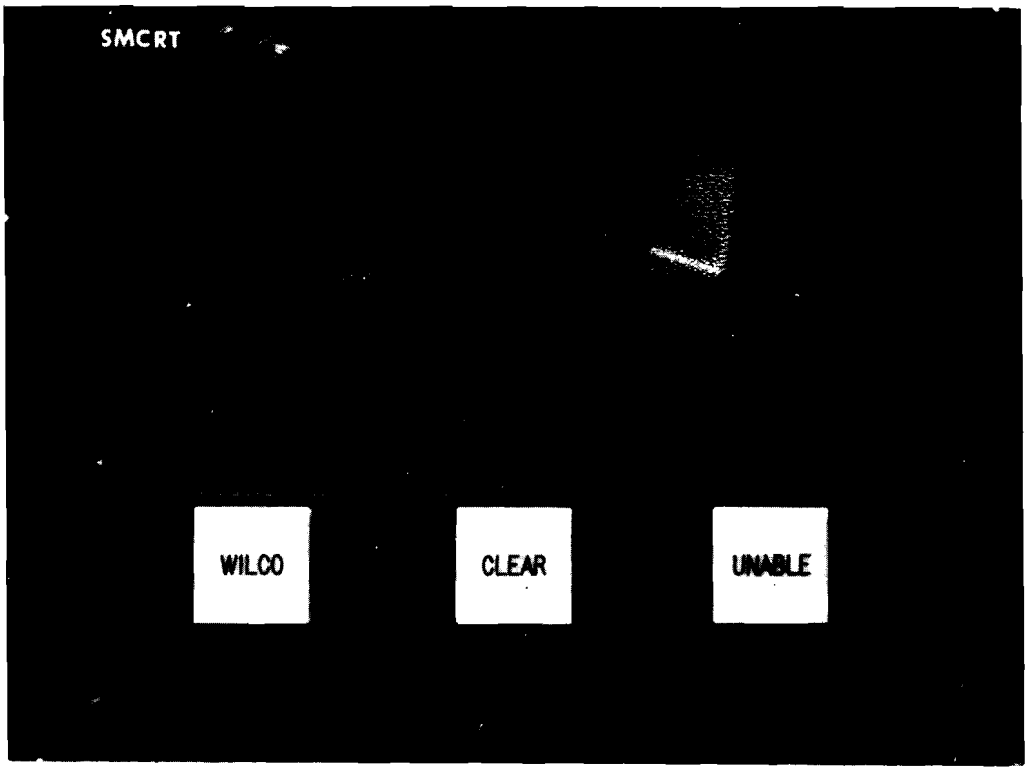

FIGURE 4. NIMO DISPLAY

SEE PRINTR	EST DELAY MIN	DEPART STACK MIN*	NO RADAR CONTCT	NEG ON REQST	REQST OK'D	RADAR CONTCT	TRAFIC ML
CONTCT TOWER	CONTCT GROUND	CONTCT DEPRTR	CONTCT CENTER	CONTCT APPRCH	DATA LINK	CLEARD TO TAXI	SQUAWK
TURN → →	TURN ← ←	MAINTN HEADNG	CLIMB ↑ ↑	DESCND ↓ ↓	MAINTN ALTUDE	MAINTN SPEED	CLEARD TAKOFF RY
ALTMTR	CLEARD TOLAND RY	0	1	2	3	0	1
2	3	4	5	6	7	8	9
0	1	2	3	4	5	6	7
8	9	0	1	2	3	4	5
6	7	8	9	5	R	L	*

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FIGURE 5. NIMO DISPLAY SHADOW MASK

Operationally, the button use was as follows:

1. WILCO was used to acknowledge a message, which also allowed the second message to appear.

2. CLEAR was used to remove a message from the display; a second depression of the button would cause the message to return.

3. UNABLE was used to indicate the noncompliance of the message. Operationally, voice channel would be used to resolve the issue.

TEST CONFIGURATION. For the tests, the displays were connected to a standard teletype through an interface box which provided the required decoding, storage, and control functions. The interface box further provided control of the duration of flashing of new messages when they appeared on the display and of flashing of the WILCO button to alert pilots when they did not respond to a new message within a predetermined time from its appearance. New messages were typically flashed three times at a rate of twice per second and with a 50-percent duty cycle. If there was no response within 2 seconds, the WILCO button was flashed at the same rate and duty cycle. The flashing of the display of a new message was accompanied by an audio alert in the cockpit

which "beeped" at the same rate. Indicator lights on the interface box informed the test controller of a WILCO response by the display pilot or copilot and of an UNABLE response of MESSAGE PENDING when a pilot had not yet responded to an earlier message. The WILCO response initiator (pilot or copilot) was recorded. An outlet on the interface box connected to an interval timer so that response times could be measured.

Figure 6 shows the test control setup, and figure 7 shows an interior view of the GAT-II trainer cockpit.

DISCUSSION

EXPERIMENTAL DESIGN.

A group of nine crews of NAFEC pilots were the first test subjects, and then a group of nine crews of participating volunteers representing commercial (ATA, and ALPA) and private pilots (AOPA) were test subjects.

The sequence of tests and test subjects was determined by use of the Greco-Latin Square design to counterbalance any practice effects. The variables were (1) four displays, (2) pilot/copilot rotation position of each crew, (3) day or night simulated condition, and (4) scenario A or B.

The test matrix was as follows:

Crew	Flight 1	Flight 2	Flight 3	Flight 4
1	32W DAY Scenario A	7W DAY Scenario B	NIMO NIGHT Scenario B	3X7W NIGHT Scenario A
2	7W NIGHT Scenario B	32W NIGHT Scenario A	3X7W DAY Scenario A	NIMO DAY Scenario B
3	NIMO NIGHT Scenario A	3X7W NIGHT Scenario B	32W DAY Scenario B	7W DAY Scenario A
4	3X7W DAY Scenario B	NIMO DAY Scenario A	7W NIGHT Scenario A	32W NIGHT Scenario B

The matrix was repeated for each set of four crews.

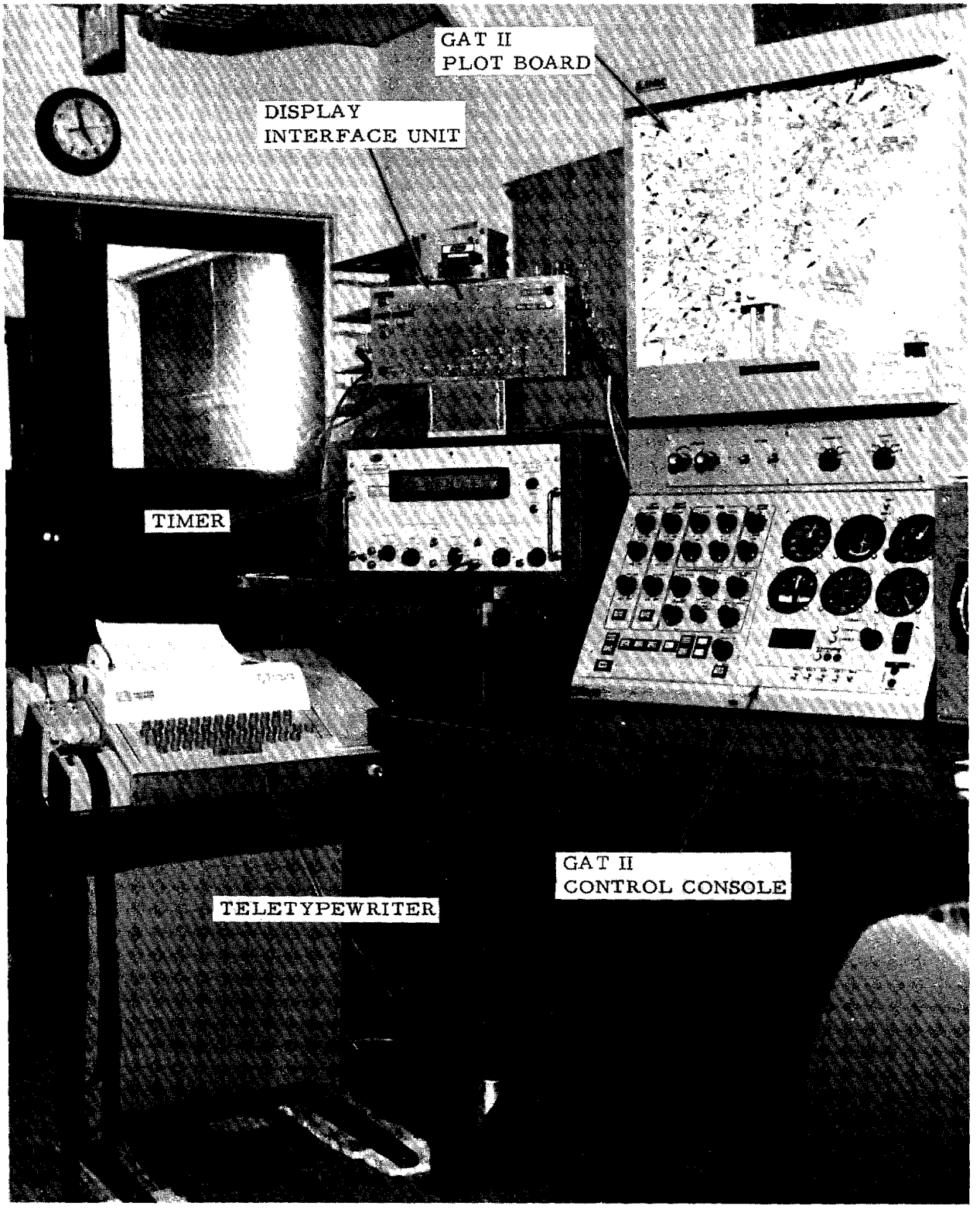


FIGURE 6. GAT-II TEST CONTROL SETUP

FIGURE 7. GAT-II COCKPIT

Scenarios A and B consisted of typical ATC messages and pilot responses for a flight. Scenario descriptions are given in appendix A. Occasionally, impossible messages were given so that the UNABLE button would be used. The pilots were advised of this possibility in the prebriefing.

These procedures were the same for both pilot groups (NAFEC and volunteer); that is, each pilot crew was given a briefing on the purpose of the tests, instructions on what was expected, and a copy of the questionnaire. A set of the briefing material is given in appendix B. The crew was than allowed time for familiarization with the GAT-II before a data run was made.

Each data run (flight) lasted about 1 hour, and the four data runs were completed in 1 day. For all flights, a tape recorder was operating in the cockpit to allow pilots to make comments about the displays. Subsequent review of the tapes indicated that the number of comments was very low. However, the pilot questionnaires were found to be most adequate for comments.

Data sheets (appendix C) were used by the GAT-II test controller for recording the elapsed time from the time that a message appeared on the display until either member of the crew responded by depressing the WILCO or UNABLE button. The test controller also noted whether the pilot or the copilot initiated the response by observing the appropriate light on the interface box. The data sheets were also used by a cockpit observer when the 3X7W or 7W display was being flown. The observer noted the setting of the control for brightness and scroll rate and which member of the crew used the recall function.

TEST RESULTS.

RESPONSE TIME DATA. Pilot crew response times to acknowledge the presentation of new ATC short messages were made with four data link cockpit displays. These response times assisted in judging the adequacy of a display along with compiling the subjective opinions of display quality.

Crew response times to the nearest tenth of a second were recorded for each message on each test run. The test matrix design (Greco-Latin Square) cancelled out the effects of practice for the following variables: (A) display type, (B) scenario, and (C) day versus night operations when data from each of the two sets of nine pilot crews were combined. Tables 1 and 2 give the mean response time for each crew for the test conditions under which they performed. No crew performed under all possible conditions. If a complete block design had been used, the number of test runs would have been increased by a factor of four. Then, part of the data could be questionable because, on the eighth run on a scenario, the crew would be expected to anticipate many of the ATC messages.

Differences in crew mean response time were as much as 3.4 seconds (8.4 seconds, highest, and 5.0 seconds, lowest) for the NAFEC pilot crews and 5.1 seconds (9.5 seconds, highest, and 4.4 seconds, lowest) for the volunteer crews. These data are shown in table 3.

TABLE 1. MEAN RESPONSE TIME IN SECONDS FOR COMBINATIONS OF SCENARIOS, DAY VS. NIGHT CONDITIONS FOR EACH DISPLAY FOR EACH NAFEC TEST PILOT CREW

			CREW									
Scenario	Day/Night	Display	A	B	C	D	E	F	G	H	I	MEAN
A	D	NIMO				6.0				6.7		6.3
A	N	NIMO			5.8				8.6			7.2
A	D	7W			10.7				7.1			8.9
A	N	7W				5.9				10.0		7.9
A	D	3X7W		5.1				4.1				4.0
A	N	3X7W	6.3				4.5					5.4
A	D	32W	6.0				6.7				7.2	6.6
A	N	32W		8.8				6.1				7.4
									Mean Average			6.7
B	D	NIMO		6.4				4.8				5.6
B	N	NIMO	4.3				4.3					4.3
B	D	7W	8.3				8.0					8.1
B	N	7W		13.3				7.0			5.7	8.7
B	D	3X7W				3.7				6.6		5.1
B	N	3X7W			6.9				5.9		5.6	6.1
B	D	32W			5.6				9.3			7.4
B	N	32W				4.7				5.7		5.2
									Mean Average			6.3
Mean			6.2	8.4	7.2	5.0	5.9	5.5	7.7	7.3	6.1	6.6

TABLE 2. MEAN RESPONSE TIME IN SECONDS FOR COMBINATIONS OF SCENARIOS, DAY VS. NIGHT CONDITIONS FOR EACH DISPLAY FOR EACH (VOLUNTEER) CREW

Scenario	Day/Night	Display	A	B	C	D	E	F	G	H	A[1]	MEAN
A	D	NIMO				5.3				4.8		5.1
A	N	NIMO			4.8				5.2			5.0
A	D	7W			5.6	5.3			5.2			5.4
A	N	7W				4.7				4.9		4.8
A	D	3X7W		5.4				4.7				5.1
A	N	3X7W	4.6				6.2			5.9		5.6
A	D	32W	6.4				13.6					8.7
A	N	32W		8.3				8.2				8.3
B	D	NIMO		5.8				5.7				5.8
B	N	NIMO	5.8				6.5				5.8	5.4
B	D	7W	7.9				11.6				9.0	9.5
B	N	7W		7.9				8.1				8.0
B	D	3X7W				4.1				4.9		4.5
B	N	3X7W			5.9				5.9			5.9
B	D	32W			7.0				4.1			5.6
B	N	32W				3.4				4.5		5.0
Mean			6.2	6.9	5.8	4.4	9.5	6.7	5.1	4.8	6.2	6.0

TABLE 3. MEAN RESPONSE TIME TO ACKNOWLEDGE ATC MESSAGE

Crew*	Mean Reaction Time in Seconds
A	6.2
B	8.4
C	7.2
D	5.0
E	6.0
F	5.5
G	7.7
H	7.3
I	6.1

*NAFEC pilots

Crew**	Mean Reaction Time in Seconds
A	6.2
B	6.8
C	5.8
D	4.4
E	9.5
F	6.7
G	5.1
H	4.8
A^1	6.2

**A to D = ATA pilots
E to H = ALPA pilots
A^1 = AOPA pilots

There appears to be no general correlation between mean crew response time and mean crew age for either the NAFEC pilots or the volunteer crews, except for only one data point. Crew "E" showed considerably longer response times and a higher mean age. These data are shown in figure 8.

There does not appear to be any correlation between response time and flying experience for either the NAFEC or volunteer crews. These data are presented in figure 9.

No significant difference was found in comparing the two scenarios for difficulty. Mean response time for scenarios A and B was 6.7 and 6.3 seconds, respectively, for the NAFEC test pilot crews and 6.1 and 6.2 seconds, respectively, for the volunteer crews.

Two of the displays showed no apparent differences in mean response time as a function of the differences between simulated day and night illumination levels for the NAFEC test pilot crews. Response time was appreciably greater for the 32W display under simulated daylight conditions. This same greater response time was experienced at the previous GAT-I tests at the TSC. Again, this may reflect the noticeable washout of this display under high ambient illumination levels and should be examined closely when the displays are used under natural daylight conditions. Response time was greater for the 3X7W display under simulated night conditions. No reason for this is apparent since this was the brightest display and had a brightness setting control. Mean response time data for these four displays are presented in table 4.

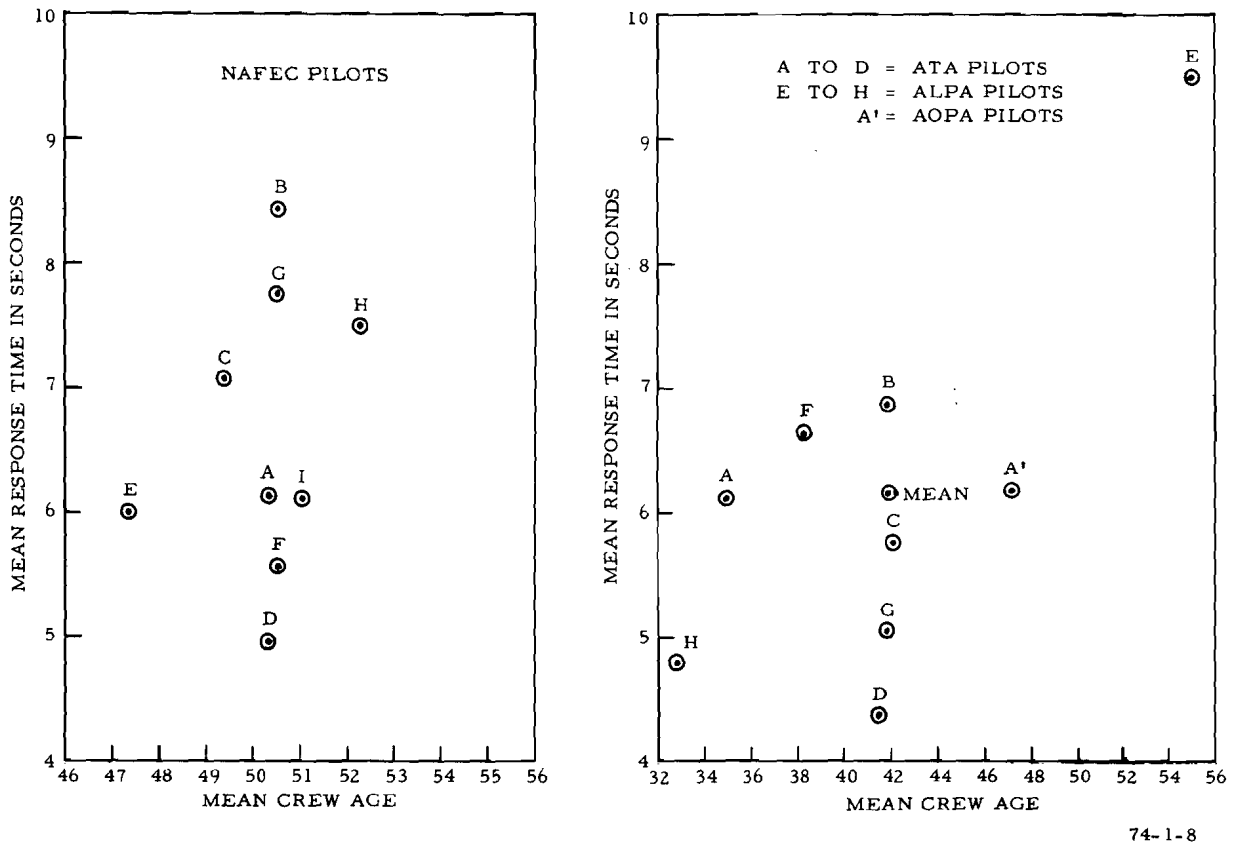


FIGURE 8. RESPONSE TIME AS A FUNCTION OF MEAN AGE OF EACH PILOT/COPILOT CREW

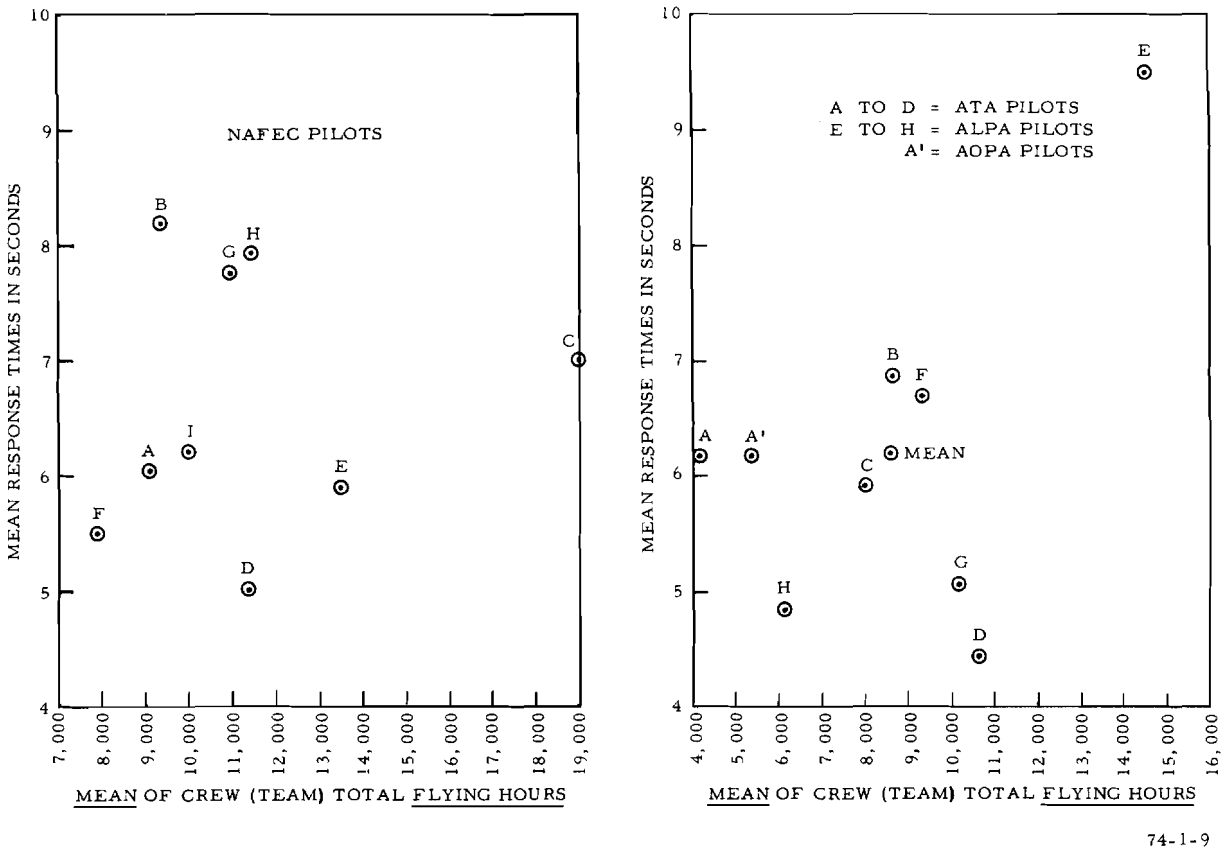


FIGURE 9. RESPONSE TIME AS A FUNCTION OF CREW MEAN HOURS OF FLYING EXPERIENCE

TABLE 4. MEAN RESPONSE TIMES TO ACKNOWLEDGE ATC MESSAGE AS AS A FUNCTION OF DAY/NIGHT CONDITIONS

	NAFEC PILOTS			ATA, ALPA, AND AOPA PILOTS		
Display	Day	Night	Mean	Day	Night	Mean
NIMO	6.0	5.8	5.9	5.4	5.2	5.3
7W	8.5	8.4	8.5	7.9	6.4	7.1
3X7W	4.9	5.9	5.4	4.8	5.7	5.2
32W	6.9	6.3	6.6	7.4	6.1	6.8
	6.6	6.6	6.6	6.4	5.9	6.1

Only the NIMO display showed no apparent difference between simulated day and night illumination levels for the volunteer crews. Response time was greater for both the 7W and the 32W displays under simulated daylight conditions. The increased response time for the 32W display may be for the same reason (washout due to illumination level) as mentioned about this display in the previous paragraph. No reason is apparent for the increased response time to the 7W display since, like the 3X7W display, there is a brightness-setting control. Also, the response time was appreciably greater for 3X7W display under night conditions for the volumteer crews than it was with the NAFEC crews, as discussed in the last paragraph. Day/night response-time data for these four displays are presented in table 4.

The differences in response time for different displays was not consistent with those obtained in prior reports (reference 2). This may be due to the fact that these were crew tests as compared to the individual pilot tests previously held at the TCS, and either the pilot or copilot could respond to the messages. Table 5 lists the mean response time for each display for each of the NAFEC crews. With these crews, the 3X7W display had the shortest response times of the four displays, the NIMO display had the next longest, the 32W display the third longest, and the 7W display, the longest.

Table 5 lists the mean response time for each display for each of the volunteer pilot crews. With these crews, the 3X7W and NIMO displays had the shortest and identical mean response time, with the 32W display the next longest, and the 7W display, the longest.

Differences in response times are influenced by differences in message length to some extent. With the NIMO display, it was possible to present only a single unit of information at a time. A unit of information in this case is defined as a single message. With the other displays, it was possible to present a new message while maintaining a "scratch pad" of previous values of other parameters or to provide a new radiofrequency setting and transponder code setting in a single message.

TABLE 5. MEAN RESPONSE TIMES TO ACKNOWLEDGE ATC MESSAGE FOR EACH OF THE DISPLAYS

	NAFEC Pilot/Copilot Crew									
Display	A	B	C	D	E	F	G	H	I	MEAN
NIMO	4.3	6.4	5.9	6.0	4.3	4.8	8.6	6.7	6.1	5.9
7W	8.3	13.3	10.7	5.9	8.0	7.0	7.1	10.0	5.7	8.4
3X7W	6.3	5.1	6.9	3.7	4.5	4.1	5.9	6.6	5.6	5.4
32W	6.0	8.8	5.6	4.7	6.7	6.1	9.3	5.7	7.2	6.7
Mean	6.2	8.0	7.3	5.0	5.9	5.5	7.7	7.3	6.1	6.6

	ATA Pilots				ALPA Pilots				AOPA Pilots	
	A	B	C	D	E	F	G	H	A[1]	MEAN
NIMO	5.8	5.8	4.8	5.3	6.5	5.7	5.2	4.8	3.8	5.3
7W	7.9	7.9	5.6	4.7	11.6	8.1	5.2	4.4	9.0	7.2
3X7W	4.6	5.4	5.9	4.1	6.2	4.7	5.9	4.9	5.9	5.3
32W	6.4	8.3	7.0	3.4	13.6	8.2	4.1	4.5	6.0	6.8
Mean	6.2	6.8	5.8	4.4	9.5	6.7	5.1	4.8	6.2	6.1

Figure 10 shows the mean response times of the two test groups, respectively, for the four displays as a function of number of units of information in the display. The mean response time decreased then remained at this level thereafter as the number of units of information in a message increased from two to three. This resulted from large response times for two-units-of-information messages which provided radiofrequency and transponder settings. When these messages are omitted from the calculations, as presented in figure 11, there is a gradual and slight increase in mean response time as the number of units of information messages is increased for both the 3X7W and the 32W displays. The mean response time for these multiple units-of-information messages on the 7W display increases to a level that would probably not be tolerable for ATC.

For purposes of clarification, it should be pointed out that the messages containing radiofrequency and transponder settings required the use of all three registers of the 7W display. They are considered as three-units-of-information messages even though they contain only two units of information.

The NAFEC and volunteer crews were informed before starting the test runs that occassionally impossible messages would be issued. This was done so the crews would not routinely push the WILCO button without first interpreting the meaning of the message. Typical impossible messages asked the pilots to "Descend to 120" instead of "Descend to 20" when they were at flight level "35," and to "Squawk 1092" instead of "Squawk 1042" when transponder code 1092 does not exist. A total of 34 such messages were introduced into

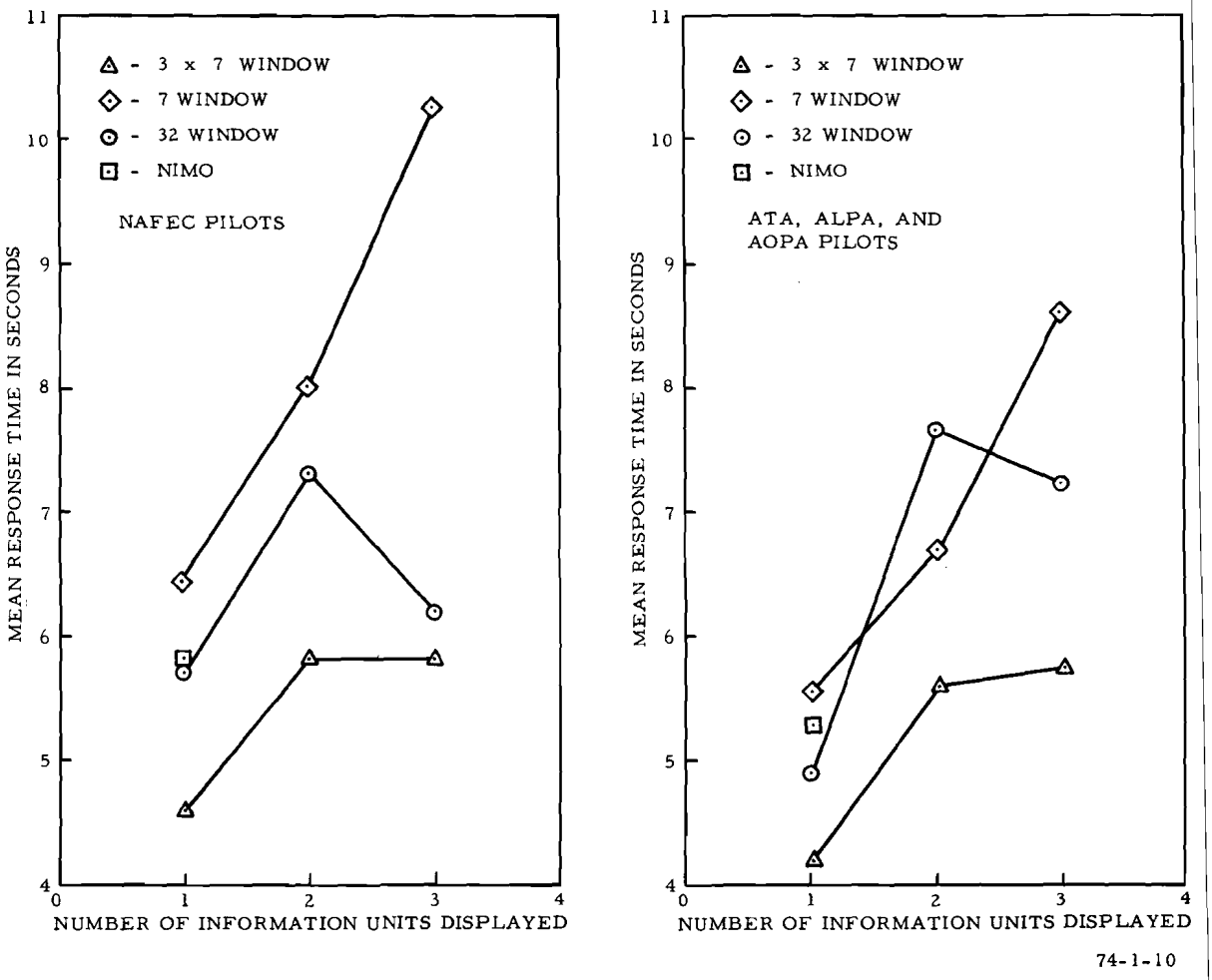


FIGURE 10. RESPONSE TIME AS A FUNCTION OF INFORMATION UNITS IN ATC MESSAGE

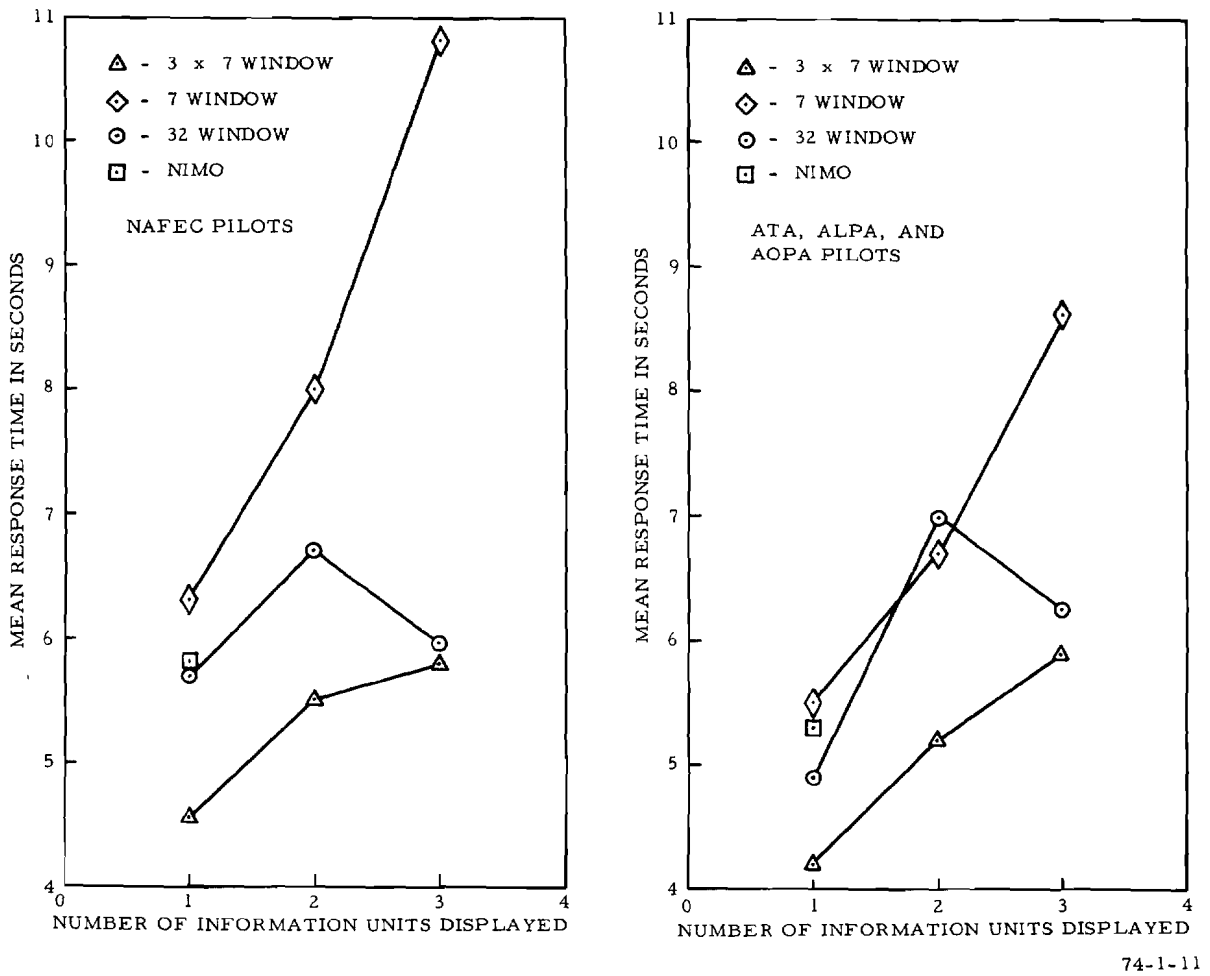


FIGURE 11. RESPONSE TIME AS A FUNCTION OF MESSAGE LENGTH WITH RADIOFREQUENCY/TRANSPONDER CODE MESSAGES OMITTED

the 36 test runs performed by the NAFEC crews. Sixteen of these produced an immediate UNABLE response; 13 produced a WILCO immediately followed by an UNABLE, and five of the impossible messages were WILCO'd and the error was not corrected. Mean response time for the messages immediately and correctly detected as erroneous was 7.75 seconds as compared with a mean value of 9.29 seconds for all these type messages. A total of 32 of these messages were introduced into the 36 test runs performed by the volunteer crews. Nineteen of these produced an immediate UNABLE response; 10 produced a WILCO immediately followed by an UNABLE, and three of the impossible messages were WILCO'd, and the error was not corrected. Mean response time for the messages immediately and correctly detected as erroneous was 8.19 seconds, as compared with a mean value of 9.02 seconds for all these type messages.

CONTROL BUTTON RESPONSE DATA. The crews had the option of (1) responding to the WILCO button in three ways on all four displays tested; (2) recalling the last message or scratch pad presentation and setting the intensity on the 3X7W display; (3) manually scrolling to recall the last complete message; (4) setting the scroll rate; or (5) setting the light intensity on the 7W display. Presentation of these data follows:

1. Tables 6 and 7 present the optional three ways of response to the WILCO/UNABLE buttons by the two groups of crews.

2. Tables 8 and 9 present the mean response times of the three optional ways of responding to the WILCO/UNABLE buttons of the displays by the two different groups of pilot crews.

These four tables show that all three options of response were used, and that the copilot attended more to "busy cockpit" duties, as would be expected in the flying situation.

3. Table 10 shows the number of last-message recalls for the 3X7W display and rescrolling of the last message on the 7W display by the two different groups of pilot crews. The recall feature was used extensively by the two groups.

4. Table 11 presents the brightness (light intensity) settings on the 3X7W display for the two crew groups. Settings were from A through D, where A was the minimum.

5. Table 12 shows the 7W display control settings of scroll rate and brightness by the two groups of crews. For both settings, selection A was the minimum.

RESULTS FROM AUDIO TAPES. An audio, cassette-type tape recorder was placed in the GAT-II cockpit for all test runs. The crews were instructed to "feel-free" to make any comments about the displays during the test runs.

A review of all tapes did not reveal any additional information for assessment of the displays. Rather, the questionnaires provided the information.

TABLE 6. DISPLAY WILCO/UNABLE SWITCH RESPONSE TIMES IN SECONDS BY THE NAFEC TEST PILOT CREWS

SCENARIO	DAY/NIGHT	DISPLAY	CREWS A			B			C			D			E			F			G			H			I		
			P	C	D	P	C	D	P	C	D	P	C	D	P	C	D	P	C	D	P	C	D	P	C	D	P	C	D
A	D	NIMO										0	31	6										0	9	27	1	0	20
A	N	NIMO							38	0	1										2	30	7						
A	D	7W							2	0	36										0	37	1						
A	N	7W										0	36	1										23	0	16			
A	D	3X7W				0	31	7										13	21	11									
A	N	3X7W	0	34	5										3	17	20												
A	D	32W	2	31	8										0	38	2										8	1	9
A	N	32W				1	0	37										0	29	10									
B	D	NIMO				0	38	4										3	35	5									
B	N	NIMO	2	0	40										0	40	2												
B	D	7W	5	13	25										5	18	14												
B	N	7W				10	0	30										0	0	40							13	8	1
B	D	3X7W										0	40	2										9	0	32			
B	N	3X7W							39	0	3										1	37	3				13	6	0
B	D	32W							32	7	4										2	39	0						
B	N	32W										0	37	6										0	3	40			
MEAN			2.3	19.5	19.5	2.8	17.3	19.5	27.8	1.8	12.5	0	36	3.8	2	28.3	9.5	4	21.3	16.5	1.3	35.8	2.8	4	3	28.8	8.8	3.8	7.5

CODES USED:
P = pilot yoke WILCO switch
C = copilot yoke WILCO switch
D = display WILCO switch or UNABLE switch

TABLE 7. DISPLAY WILCO/UNABLE SWITCH RESPONSE TIMES IN SECONDS BY THE ATA, ALPA, AND AOPA PILOT CREWS

SCENARIO	DAY/NIGHT	DISPLAY	CREW A			B			C			D			E			F			G			H			A[1]		
			P	C	D	P	C	D	P	C	D	P	C	D	P	C	D	P	C	D	P	C	D	P	C	D	P	C	D
A	D	NIMO										0	36	0										0	2	34			
A	N	NIMO							23	0	0										5	0	31						
A	D	7W							21	0	0										0	25	13						
A	N	7W										1	36	1										0	0	38			
A	D	3X7W				0	6	11										0	0	39									
A	N	3X7W	0	0	39										3	33	3										37	1	1
A	D	32W	1	4	33										9	0	29										35	0	3
A	N	32W				0	0	38										1	0	37									
B	D	NIMO				2	17	5										0	0	42									
B	N	NIMO	0	6	36										3	23	13										40	0	2
B	D	7W	1	0	39										1	31	8										38	0	2
B	N	7W				4	1	35										38	0	2									
B	D	3X7W										13	25	1										1	0	39			
B	N	3X7W							38	0	2										0	32	7						
B	D	32W							19	1	1										0	0	40						
B	N	32W										2	38	0										0	35	6			
MEAN			0.5	2.5	36.8	7.5	6.0	22.3	25.3	0.25	0.75	4.0	33.8	0.5	4.0	21.8	13.3	9.8	0	30.0	1.3	14.3	22.3	0.3	9.3	29.3	37.5	0.3	2.0

CODES USED:
P = pilot yoke WILCO switch
C = copilot yoke WILCO switch
D = display WILCO switch or UNABLE switch

TABLE 8. MEAN RESPONSE TIME OF WILCO/UNABLE RESPONSE OPTIONS BY THE NAFEC TEST PILOT CREWS

DISPLAY		NIMO			7W			3X7W			32W		
CREW		P	C	D	P	C	D	P	C	D	P	C	D
A	N	2.0	0	38.0	5.0	12.0	18.0	0	34.0	5.0	2.0	25.0	5.0
	Σ	14.0	0	159.0	23.6	81.7	118.3	0	180.5	65.5	16.3	151.8	24.6
	$\overline{X}$	7.0	0	4.18	4.72	6.8	10.4	0	5.3	13.1	8.15	6.07	4.92
B	N	0	38.0	4.0	10.0	0	30.0	0	32.0	6.0	1.0	0	37.0
	Σ	0	229.8	39.9	124.0	0	411.7	0	161.2	33.7	3.2	0	334.3
	$\overline{X}$	0	6.04	9.97	12.4	0	13.72	0	5.03	5.61	3.2	0	9.03
C	N	38	0	0	2.0	0	36.0	39.0	0	1.0	32.0	7.0	2.0
	Σ	223.0	0	0	8.6	0	399.6	273.3	0	3.4	190.5	32.5	9.2
	$\overline{X}$	5.88	0	0	4.3	0	11.1	7.0	0	3.4	5.95	4.64	4.6
D	N	0	30.0	6.0	0	36.0	1.0	0	40.0	0	0	36.0	5.0
	Σ	0	110.2	105.9	0	213.8	6.9	0	148.7	0	0	152.4	44.1
	$\overline{X}$	0	3.67	17.65	0	5.93	6.9	0	3.71	0	0	4.23	8.82
E	N	0	40.0	2.0	5.0	18.0	14.0	3.0	16.0	20.0	0	36.0	1.0
	Σ	0	167.3	13.2	40.2	146.4	110.0	13.8	66.8	93.5	0	243.7	7.8
	X	0	4.18	6.6	8.04	8.13	7.85	4.6	4.17	4.67	0	6.76	7.8
F	N	3	35.0	4.0	0	0	40.0	13.0	14.0	11.0	0	29.0	9.0
	Σ	18.9	151.7	31.7	0	0	283.9	47.4	52.5	58.8	0	175.9	57.3
	$\overline{X}$	6.3	4.33	7.92	0	0	7.09	3.64	3.75	5.34	0	6.06	6.36
G	N	2.0	30.0	6.0	1.0	37.0	2.0	2.0	39.0	0	0	37.0	1.0
	Σ	16.0	260.8	51.1	21.4	159.9	55.2	38.1	343.7	0	0	260.4	10.3
	$\overline{X}$	8.0	8.69	8.51	21.4	4.32	27.6	19.05	8.81	0	0	7.03	10.3
H	N	0	9.0	26.0	22.0	0	16.0	9.0	0	30.0	0	2.0	39.0
	Σ	0	59.4	173.4	230.3	0	149.9	77.9	0	182.7	0	11.6	225.2
	$\overline{X}$	0	6.60	6.66	10.46	0	9.36	8.65	0	6.09	0	5.80	5.77
I	N	1.0	0	19.0	13.0	8.0	0	13.0	6.0	0	8.0	1.0	8.0
	Σ	8.8	0	114.9	70.6	49.8	0	64.7	43.0	0	46.2	8.0	69.7
	$\overline{X}$	8.8	0	6.04	5.43	6.22	0	4.97	7.16	0	5.77	8.0	8.71

N = Number of Responses

Σ

$\overline{X}$ = Mean Response Time in Seconds

TABLE 9. MEAN RESPONSE TIME OF WILCO/UNABLE RESPONSE OPTIONS BY THE VOLUNTEER PILOT CREWS

DISPLAY		NIMO			7W			3X7W			32W		
CREW		P	C	D	P	C	D	P	C	D	P	C	D
A	N	0	6	36.0	1.0	0	39.0	0	0	39.0	1.0	4.0	33.0
	Σ	0	51.8	191.9	34.1	0	280.8	0	0	181.2	10.2	27.4	204.2
	$\bar{X}$	0	8.63	5.33	34.1	0	7.20	0	0	4.64	10.2	6.85	6.18
B	N	2.0	17.0	5.0	4.0	1.0	35.0	0	6.0	11.0	0	0	38.0
	Σ	7.9	98.2	32.5	31.4	11.6	271.8	0	261.1	66.3	0	0	313.7
	$\bar{X}$	3.95	5.77	6.5	7.85	11.6	7.76	0	4.35	6.02	0	0	8.25
C	N	23.0	0	0	21.0	0	0	38.0	0	2.0	19.0	1.0	1.0
	Σ	110.1	0	0	118.1	0	0	204.4	0	31.6	97.2	3.2	46.8
	$\bar{X}$	4.78	0	0	5.62	0	0	5.37	0	15.8	5.11	3.2	46.8
D	N	0	36.0	0	1.0	36.0	1.0	13.0	25.0	1.0	2.0	38.0	0
	Σ	0	192.1	0	6.5	163.1	7.7	44.9	110.8	5.8	9.6	126.8	0
	$\bar{X}$	0	5.33	0	6.5	4.53	7.7	3.45	4.43	5.8	4.8	3.33	0
E	N	3.0	23.0	13.0	1.0	31.0	8.0	3.0	33.0	3.0	9.0	0	29.0
	Σ	37.7	136.1	80.8	25.9	309.6	127.0	14.3	204.5	22.5	148.6	0	368.9
	$\bar{X}$	12.56	5.91	6.21	25.9	9.98	15.87	4.76	6.19	7.50	16.51	0	12.72
F	N	0	0	42.0	38.0	0	2.0	0	0	39.0	1.0	0	37.0
	Σ	0	0	240.6	292.2	0	33.6	0	0	181.1	8.4	0	302.4
	$\bar{X}$	0	0	5.72	7.68	0	16.80	0	0	4.74	8.4	0	8.17
G	N	5.0	0	31.0	0	25.0	13.0	0	32.0	7.0	0	0	40.0
	Σ	19.8	0	168.8	0	117.5	80.4	0	166.0	63.1	0	0	162.3
	$\bar{X}$	3.96	0	5.44	0	4.70	6.18	0	5.18	9.01	0	0	4.05
H	N	0	2.0	34.0	0	0	38.0	1.0	0	39.0	0	35.0	6.0
	Σ	0	10.7	161.1	0	0	186.3	11.4	0	184.1	0	150.5	35.2
	$\bar{X}$	0	5.35	4.73	0	0	4.90	11.4	0	4.72	0	4.3	5.86
A[1]	N	40.0	0	2.0	38.0	0	2.0	37.0	1.0	1.0	35.0	0	3.0
	Σ	148.7	0	9.3	333.6	0	24.7	212.9	12.5	6.6	208.1	0	18.9
	$\bar{X}$	3.71	0	4.65	8.77	0	12.35	5.75	12.5	6.6	5.94	0	6.3

N = Number of Responses

$\bar{X}$ = Mean Response Time in Seconds

RESULTS FROM THE QUESTIONNAIRE.

Two pilot questionnaires were used. The first one was used by the NAFEC crews, and the second one was used by the volunteer crews. Each questionnaire asked for similar information. The subjective opinions of display quality and preference were obtained. Table 13 summarizes the number of first, second, third, and fourth place rankings by the NAFEC crew pilots. The weighted scores shown in table 14 were obtained for these same pilots by assigning a weight of 4 for the first place ranking, 3 for second, 2 for third, and 1 for fourth. In this series of tests, the 32W display was first, the 3X7W display was second, the 7W display was third, and the NIMO display was fourth.

TABLE 10. DISPLAY MESSAGE RECALLS/RESCROLLING UNDER DAY/NIGHT CONDITIONS

NUMBER OF RECALLS/SCROLLING

NAFEC CREW	3X7W DAY	3X7W NIGHT	7W DAY	7W NIGHT	MEAN	ATA ALPA AOPA CREW	3X7W DAY	3X7W NIGHT	7W DAY	7W NIGHT	MEAN
A		26	22		24.0	A		41	158		99.5
B	54			37	45.5	B	10			1	5.5
C		24	102		63	C		18	48		33.0
D	8			83	45.5	D	22			1	11.5
E		60	140		100.0	E		47	52		49.5
F	51			54	52.5	F	22			31	26.5
G		0	46		23.0	G		36	33		34.5
H	2			22	12.0	H	37			51	44.0
		No Observations				A[1]		26	45		35.5
MEAN	28.8	27.5	77.5	49.0	45.7		22.8	33.6	67.2	21.0	37.7

TABLE 11. 3X7-WINDOW DISPLAY CONTROL SETTINGS BY THE TEST PILOT CREW

		NAFEC BRIGHTNESS					ATA, ALPA, AOPA BRIGHTNESS		
Crew	D/N	Initial	Intermediate	Final	Crew	D/N	Initial	Intermediate	Final
A	N	A-B	A, C	A	A	N	A	none	none
B	D	A	none	none	B	D	B	none	none
C	N	A	none	none	C	N	A	none	none
D	D	A B	none	none	D	D	A	E	B
E	N	A	C	A	E	N	C D	none	A
F	D	B	none	none	F	D	B	none	none
G	N	A B	A, E	A	G	N	A	none	none
H	D	A B	none	none	H	D	B	none	none
I	N	No observations			A[1]	N	D	none	A

TABLE 12. 7-WINDOW DISPLAY CONTROL SETTINGS BY TEST PILOT CREWS

NAFEC

Crew	D/N	SCROLL RATE Initial	SCROLL RATE Intermediate	SCROLL RATE Final	BRIGHTNESS Initial	BRIGHTNESS Intermediate	BRIGHTNESS Final
A	D	C-D	E	D	C	D-E	C
B	N	B	none	C	C	none	B
C	D	B	B C C D, E	D	B	none	B C
D	N	C	E	C D	A B	none	none
E	D	C	E	C	C	none	none
F	N	C	none	none	C	none	none
G	D	C D	none	none	C	none	none
H	N	C	none	none	C	none	none
I	No observations				No observations		

ATA, ALPA, AOPA CREWS

A	D	D	none	none	C	none	none
B	N	C	none	none	C	none	none
C	D	D	none	none	B	none	A B
D	N	C	none	none	B	none	none
E	D	C	none	none	C	none	none
F	N	C	none	none	B	none	none
G	D	C	E	C	E	none	none
H	N	C	none	D	C	none	A
A[1]	D	C	none	none	C	none	none

TABLE 13. SUMMARY OF INDIVIDUAL NAFEC TEST CREW PILOTS ON DATA DISPLAY PREFERENCES

Preference	7W	3X7W	32W	NIMO
1st	3	3	11	1
2nd	3	9	4	2
3rd	7	6	1	4
4th	5	0	2	11
Pilots Answering Questionnaire	18	18	18	18

TABLE 14. WEIGHTED SCORES OF DISPLAY PREFERENCE BY THE NAFEC TEST PILOTS

Preference	7W	3X7W	32W	NIMO
1st (4)	12	12	44	4
2nd (3)	9	27	12	6
3rd (2)	14	12	3	8
4th (1)	5	0	2	11
Weighted Score	40	51	61	29

Table 15 further summarizes the number of first-, second-, third-, and fourth-place rankings by the volunteer pilots. The weighted scores shown in table 16 were obtained for these pilots also by assigning a weight of 4 for the first place ranking, 3 for second, 2 for third, and 1 for fourth. In this series of tests, the scoring order was the same as with NAFEC crews; the 32W display was first, the 3X7W display was second, the 7W display was third, and the NIMO display was fourth.

TABLE 15. SUMMARY OF INDIVIDUAL VOLUNTEER CREW PILOTS ON DATA DISPLAY PREFERENCES

Preference	7W	3X7W	32W	NIMO
1st	0	7	11	0
2nd	3	8	7	0
3rd	12	3	0	3
4th	3	0	0	15
Pilots Answering Questionnaire	18	18	18	18

TABLE 16. WEIGHTED SCORES OF DISPLAY PREFERENCE BY THE VOLUNTEER CREW PILOTS

Preference	7W	3X7W	32W	NIMO
1st (4)	0	28	44	0
2nd (3)	9	24	21	0
3rd (2)	24	6	0	6
4th (1)	3	0	0	15
Weighted Score	36	58	65	21

A comparative summary of the questions and answers to the questionnaires is given in appendix D.

ANALYSIS

PILOT OPINION.

Based on discussions with the various crews and the remarks in the questionnaire, the crew pilots felt that a data link cockpit display provided a welcome relief from the constant chatter that constitutes present ATC communication. However, there were reservations about its operational use. Some of the pilots missed the "real world" information that is obtained in the present air/ground voice simplex ATC communications system. In the event of a delay holding ahead or an emergency in the approach of two or three aircraft ahead, the crew pilots would not be able to ready themselves for diverting actions as they had been able to do before. They felt that they would really be in the "cradle" of the air traffic controller. The volunteer pilots were violently against any possible automatic control by ATC of the "heading bugs" on their navigational aids. This was covered in the questionnaire responses. They felt that "pilot-in-command" is responsible for the flight of the aircraft.

FACTOR RANKING.

Based on the data, the crew pilot preferred a display with "scratch pad" capability. This was shown by the ranking derived from the questionnaire and summarized therein. The 32W and 3X7W were first and second in ranking, respectively by both groups of crew pilots. Some of the crew pilots disliked the LED red color of the 3X7W display because they did not like red for cockpit displays. The control of intensity was not a factor in disliking the red color. The control response data for various ambient light conditions showed that the crew pilots used different light-intensity settings for this and other displays: this was an improvement feature incorporated after the previous GAT-I display tests at TSC. Further, even though it received the fourth and last ranking, the NIMO could possibly be utilized for scratch pad use in conjunction with another digital display. The NIMO's small size and readibility probably ruled it out as a preferred display; however, it is possible to use it for a scratch pad.

The 7W received the third or next-to-last ranking of display preference by both groups of crew pilots. This is probably due to the difficulty in reading and understanding of the whole message, due to the scrolling feature, even though the scrolling rate could be varied. This was evidenced by the highest mean response time for this display in these tests. However, the character size and color were its desirable features. Since this was a two-man crew operational test, the busiest crew member, the copilot, made most of the responses and recalls of messages. Also, the tests showed that with a minumum of briefing and practice on the GAT-II trainer and the displays, the two groups of crew pilots readily adapted to the data link tests.

CONCLUSIONS

It is concluded that:

1. Data link cockpit displays can be used as a means of transferring ATC commands and advisory messages to aircraft crews.

2. A scratch pad type of display having a means to present the last heading, speed, and altitude command is the most desirable to reduce cockpit "busy work."

3. The desirable features of each of the displays are needed to arrive at an optimum display; features such as scratch pad, nonred color, clear and legible characters, accessibility of the response to control buttons, and light-intensity potentiometers were the most frequently selected.

4. Through minimal training and practice, pilot crews can readily set up cockpit procedures and operate in an ATC data link display communication environment.

5. Pilot age, pilot flying hours, or day/night conditions were not a factor in the results.

REFERENCES

1. Mpontsikaris, P., Correlation of Short Message Display Capabilities with ATC Message Length: Preliminary Report, KHL-TSC-73-1037, January 12, 1973.

2. Hilborn, Edwin H. and Wisleder, Robert W., Human Factors Experiments For Data Link, Interim Report No. 3, FAA-RD-73-69, August 1973.

APPENDIX A

SCENARIO DESCRIPTIONS

	Page
Description of Scenario A	A-1
Scenario A - Typical Data Link Messages	A-4
Scenario A - Map with Message Numbers Shown	A-6
Description of Scenario B	A-7
Scenario B - Typical Data Link Messages	A-11
Scenario B - Map with Message Numbers Shown	A-13

SCENARIO A

JFK to ACY

Message Number	Message Type	Elapsed Time Min	Elapsed Time Sec	Message
1	VOSYN (Atis)	00	00	This is JFK International Airport ceiling measured 1000 overcase visibility 4, haze wind 330 degrees at 8. temperature 62. Altimeter two niner niner six. ILS runway 13L approach in use, landing 13L. departures on runway 13R. In form the controller on initial contact you have information charlie.
2	VOSYN	00	23	ATC clears GAT II to Atlantic City Airport maintain 5000 via radar vectors V-16, V-16 Coyle. Sgk 1100 JFK ground 121.9 when ready to taxi.
3	D/L	1	20	GAT II taxi into position. Takeoff Runway 13R. JFK tower 119.1 when ready to take off.
4	D/L	1	40	Position and Hold.
5	D/L	2	25	GAT II cleared to Runway 13R.
6	D/L	2	40	Maintain Runway heading 1,500.
7	D/L	3	10	Contact JFK departure control 121.1 when airborne.
8	D/L	3	40	GAT II Sqk ident*
	D/L	3	55	Radar contact climb* and maintain 3000.
9	D/L	4	50	GAT II turn right heading 150 radar vectors V-16.
10	D/L	5	40	GAT II turn right heading 230.
11	D/L	6	50	GAT II turn right heading 260.

Scenario A
JFK to ACY

Message Number	Message Type	Elapsed Time Min	Elapsed Time Sec	Message
12	D/L	7	40	GAT II position 4 miles* southeast V-16.
13	D/L	7	45	GAT II climb and maintain 5000 resume normal navigation.
14	D/L	8	45	GAT II contact McGuire Approach control 124.8 now.
15	D/L	9	05	GAT II Sqk ident 1120.
16	D/L	9	20	GAT II radar contact.
17	D/L	9	45	GAT II traffic 1 o'clock your position 4 miles slow moving.
18	D/L	10	35	GAT II clear of traffic.
19	D/L	12	10	Maintain air speed 120.
20	D/L	14	35	GAT II traffic 2 o'clock your position 5 miles northeast bound fast moving.
21	D/L	15	05	GAT II turn left heading 195 to avoid traffic.
22	D/L	17	00	GAT II turn right heading 260 clear of traffic.
23	D/L	17	45	GAT II position 3 miles V-16*
24	D/L	17	50	Resume normal navigation.
25	D/L	22	45	GAT II descend and maintain 3,500.
26	VOCYN	24	25	This is Atlantic City Airport, ceiling measured 500 overcast, visability 1/4 mile. wind calm. temperature 60. dew point 63. Altimeter two niner niner two. VOR runway 31 approach in use landing runway 31. departures on runway 4. inform the controller on initial contact that you have information Bravo.

Scenario A
JFK to ACY

Message Number	Message Type	Elapsed Time Min	Elapsed Time Sec	Message
27	D/L	26	35	GAT II contact Atlantic City approach control 124.6 now.
28	D/L	26	55	GAT II Sqk ident 1015.
29	D/L	27	10	GAT II radar contact altimeter 2994.
30	D/L	28	55	GAT II cleared Gretna int via 039 degree radial of ACY VOR.
31	D/L	30	10	GAT II hold Gretna left turns.
32	D/L	37	15	Expect further clearance in 6 min.
33	D/L	37	25	GAT II airspeed 110 altitude 3,500.
34	D/L	42	45	GAT II descend and maintain 2,000.
35	D/L	45	55	GAT II cleared to Atlantic City VOR via 039 degree radial of ACY.
36	D/L	48	40	GAT II vectors VOR runway 31 approach.
37	D/L	48	50	GAT II turn left heading 095.
38	D/L	52	45	GAT II traffic 11 o'clock your position 3 miles westbound.
39	D/L	53	15	GAT II clear of traffic turn right heading 165.
40	D/L	54	10	GAT II turn right heading 235.
41	D/L	54	40	GAT II turn right heading 280.
42	D/L	54	55	GAT II cleared VOR rnway 31 approach.
43	D/L	55	40	Contact Atlantic City tower 118.9.
44	D/L	56	00	GAT II cleared to land.

*Indicates an incremental part of the total message & an additional message will follow.

SCENARIO A

JFK to ACY

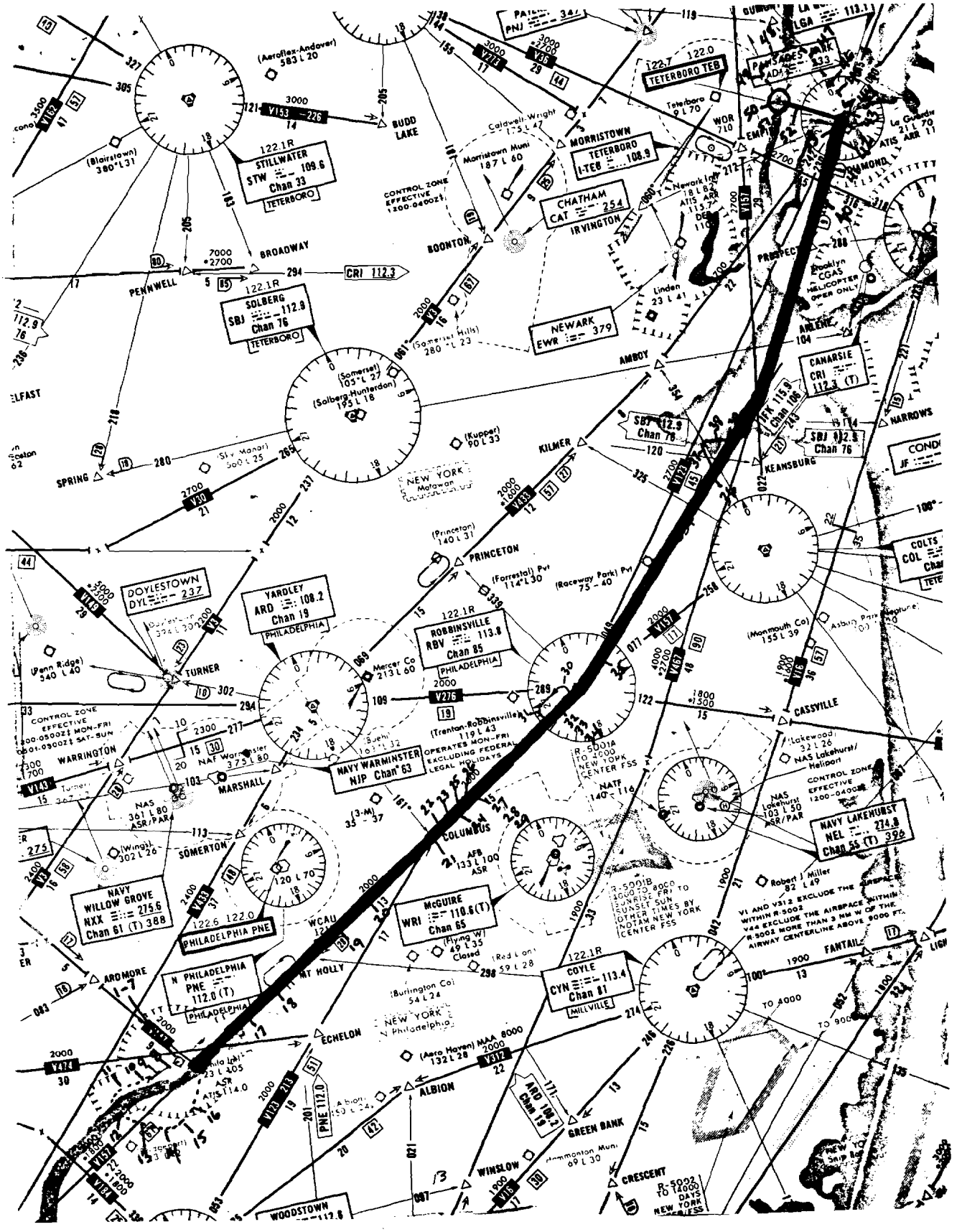
D/L Msg#	Time Min	Sec		Hdg	Alt	Spd
1		35	JFK G 121.90			
2	1	20	Txi Rwy 13R*			
3	1	30	JFK T 119.10*			
4	1	40	PSN Hld			
5	2	25	CLR TKOF*			
6	2	40	CLB to 015 Hdg 130*	130	015	
7	3	10	JFK D 121.10 Ident*	130	015	
8	3	55	RDR Ctc Clb to 030	130	030	
9	4	50	Rgt to 150 Vctr V-16	150	030	
10	5	40	Rgt to 230	230	030	
11	6	50	Rgt to 260	260	030	
12	7	40	PSN 4 NM SE V-16*	260	030	
13	7	45	Clb to 050 Resm Nav*		050	
14	8	45	Wri A 124.80		050	
15	9	05	Sqk 1120 Ident		050	
16	9	20	Rdr Ctc		050	
17	9	45	Tfc 01 4 nm Slo		050	
18	10	35	Clr Tfc		050	
19	12	10	Spd 120		050	120
20	14	35	Tfc 02 5 nm Neb Fst		050	120
21	15	05	Lft to 195 - Tfc	195	050	120
22	17	00	Rgt to 260 Clr Tfc	260	050	120
23	17	45	Psn 3 SE V-16*		050	
24	17	50	Resm Nav Spd Norm*		050	
25	22	45	Dsnd to 035		035	
27	26	35	ACY A 124.60		035	
28	26	55	Sqk 1015 ident		035	
29	27	10	Rdr Ctc ACY Altm 994		035	
30	28	55	*Clr Gretna Via*		035	
			ACY R-039		035	
31	30	10	Hld Gretna Lft Turns		035	
32	37	15	Efc in 6 min		035	
33	37	25	Spd 110 Alt 035		035	110
34	42	45	Dsnd to 020		020	110
35	45	55	Clr ACY via R-039		020	110
36	48	40	Vctr VOR Rwy 31		020	110
37	48	50	Lft to 095	095	020	110
38	52	45	Tfc 11 3 nm WB	095	020	110

2

Scenario A
JFK to ACY

D/L Msg#	Time Min	Sec		Hdg	Alt	Spd
39	53	15	Clr Tfc Rgt to 165	165	020	110
40	54	10	Rgt to 235	235	020	110
41	54	50	Rgt to 280	280	020	110
42	54	55	Cfap VOR Rwy 31			
43	55	40	ACY T 118.90			
44	56	00	Clr Lnd Wnd 290/6			

*Indicates an incremental part of the message and an additional message will follow.


TETERBORO TEB
STILLWATER
STW 109.6
Chan 33
TETERBORO
MORRISTOWN
TETERBORO
I-TEB 108.9
CHATHAM
CAT 254
IRVINGTON
BUDD LAKE
BROADWAY
PENNWELL
CRI 112.3
SOLBERG
SBJ 112.9
Chan 76
TETERBORO
NEWARK
EWR 379
AMBOY
CANARSIE
CRI 112.3 (T)
KEANSBURG
NARROWS
KILMER
SPRING
PRINCETON
DOYLESTOWN
DYL 237
YARDLEY
ARD 108.2
Chan 19
PHILADELPHIA
ROBBINSVILLE
RBV 113.8
Chan 85
PHILADELPHIA
TURNER
WARRINGTON
MARSHALL
NAVY WARMINSTER
NJP Chan 63
OPERATES MON-FRI
EXCLUDING FEDERAL
LEGAL HOLIDAYS
CASSVILLE
NAVY LAKEHURST
NEL 274.8
Chan 55 (T) 396
NAS Lakehurst/
Heliport
SOMERTON
COLUMBUS
NAVY
WILLOW GROVE
NXX 275.6
Chan 61 (T) 388
PHILADELPHIA PNE
McGUIRE
WRI 110.6 (T)
Chan 65
ARDMORE
N PHILADELPHIA
PNE 112.0 (T)
PHILADELPHIA
MT HOLLY
COYLE
CYN 113.4
Chan 81
MILLVILLE
FANTAIL
ECHELON
ALBION
GREEN BANK
WINSLOW
CRESCENT
WOODSTOWN
NEW YORK
Philadelphia
NEW YORK
Metowan
CONTROL ZONE
EFFECTIVE
1200-0400Z‡
CONTROL ZONE
EFFECTIVE
1200-0400Z‡
CONTROL ZONE
EFFECTIVE
0800-0500Z‡ MON-FRI
0801-0900Z‡ SAT-SUN
R-5001A
TO 4000
NEW YORK
CENTER FSS
R-5001B
1000 TO 8000
MON-FRI TO
SUNRISE SUN
SUNSET SUN
OTHER TIMES BY
NOTAM NEW YORK
CENTER FSS
V1 AND V312 EXCLUDE THE AIRSPACE WITHIN
WITHIN R-5002
V44 EXCLUDE THE AIRSPACE WITHIN
R-5002 MORE THAN 3 NM W OF THE
AIRWAY CENTERLINE ABOVE 8000 FT.
R-5002
TO 12000
DAYS
NEW YORK
CENTER FSS

SCENARIO B

PHILA AIRPORT to LA GUARDIA AIRPORT
(Data Link Messages Only)

Message Number	Elapsed Time Min	Elapsed Time Sec	Message	Hdg	Alt	Spd
3	01	10	PHL G 121 - 90			
4	02	15	CLR TX1 RWY 27R			
5	02	35	PHL T 118 - 50			
6	02	50	PSN HLD			
7	03	05	CLR TKOF			
8	03	15	CLB to 020 HDG 270	270	020	150
9	03	45	PHL D 119.00 IDENT	270	020	
10	04	00	RDR CTC VCTR V157	270	020	
11	05	10	LFT TO 200	200	020	
12	06	00	LFT TO 140 THRU V157	140	020	
13	06	20	CLB TO 040	140	040	
14	07	30	LFT TO 040	040	040	
15	07	45	PSN 2NM SE V157	040	040	
16	07	55	RES M NAV		040	
17	10	15	TFC 02 5NM NWB FST		040	
18	11	45	CLR TFC		040	
19	13	10	TFC 10 4 NM SWB SLO		040	
20	14	50	CLF TFC		040	
21	16	10	LGA A 127.30		040	
22	16	20	SQK 1042 IDENT		040	
23	16	45	RDR CTC CLB TO 050		050	
25	17	50	LGA A 118.00 IDENT		050	
26	18	10	RDR CTC		050	
27	18	20	*HLD W RBV V157*		050	
28	18	30	1 MIN LEG LFT TURNS		050	
29	24	30	EFC IN 15 MIN		050	
30	24	30	TFC 12 5NM WB FST		050	
31	26	10	CLR TFC		050	
32	33	00	*CLR LGA VIA RBV*		050	
33	33	10	R-054 AND LGA R-220		050	
34	33	20	ALT 050		050	
35	33	50	DSND TO 040		040	
36	38	05	LFT TO 350 - TFC	350	040	
37	39	30	RGT TO 115	115	040	
38	40	05	TFC 03 2NM SB SLO	115	040	
39	42	30	CLR TFC RESM NAV		040	
40	47	10	DSND TO 030		030	

2

Scenario B
Phila Airport to LaGuardia Airport
(Data Link Messages Only)

Message Number	Elapsed Time Min	Sec	Message	Hdg	Alt	Spd
41	51	40	LGA A 127.30 IDENT		030	
42	52	10	RDR CTC LGA ALTM 988		030	
43	53	00	VCTR ILS RWY 13		030	
44	53	40	LFT TO 350 SPD 130	350	030	130
45	54	00	DSND TO 018	350	018	130
46	54	30	SPD 110	350	018	110
47	55	45	LFT TO 260	260	018	110
48	56	40	LFT TO 180	180	018	110
49	57	00	LOM 2NM	180	018	110
50	57	15	CFAP ILS RWY 13			
51	57	30	LGA T 118.70			
52	58	10	CLR LND WND 125/08			
53	60	00	LGA G 121.70			

NOTE: Messages 1, 2, and 24 are VOSYN type and are not a part of this scenario.

SCENARIO B

PHILA AIRPORT to LA GUARDIA AIRPORT

Message Number	Message Type	Elapsed Time Min	Elapsed Time Sec	Message
1	VOSYN (Atis)	00	00	This is Phila. Intnl. Airport. Ceiling measured 2000 feet, overcast, visibility 6, smoke. wind 280°/8, temperature 61°, altimeter setting 29.96. Landing runway 27 left, departures on 27 right. Inform controller on initial contact that you have received information Bravo.
2	VOSYN	00	30	GAT-2 cleared to Robbinsville VORTAC via V-157, cross Columbus intersection at 4,000 feet, cruise 4,000'. Maintain runway heading to 2,000 feet. Contact departure control on 119.0 after take-off for radar vectors.
3	D/L	01	10	Contact Phila. ground control - 121.9 for taxi clearance.
4	D/L	02	15	Cleared to taxi, runway 27 right.
5	D/L	02	35	Contact Phila. tower on 118.5 for take-off.
6	D/L	02	50	Cleared into position and hold.
7	D/L	03	05	Cleared for take-off.
8	D/L	03	15	Climb to 2,000 feet, maintain 270°.
9	D/L	03	45	Contact Phila. departure control on 119.0, ident.
10	D/L	04	00	Radar contact - vectors to V-157.
11	D/L	05	10	Turn left to 200°.

Scenario B
Phila. Airport to LaGuardia Airport

Message Number	Message Type	Elapsed Time Min	Elapsed Time Sec	Message
12	D/L	06	00	Turn left to 140° thru V-157.
13	D/L	06	20	Climb to 4,000 feet.
14	D/L	07	30	Turn left to 040°.
15	D/L	07	45	Position 2 nmi southeast of V-157.
16	D/L	07	55	Radar vectors terminated, resume normal navigation.
17	D/L	10	15	Traffic at 2 o'clock, 5 nmi, northwest bound, fast moving.
18	D/L	11	45	Clear of traffic.
19	D/L	13	10	Traffic 10 o'clock, 4 nmi, southwest bound, slow moving.
20	D/L	14	50	Clear of traffic.
21	D/L	16	10	Contact LaGuardia approach control on 127.30.
22	D/L	16	20	Squawk 1042 and ident.
23	D/L	16	45	Radar contact, climb to 5,000 feet.
24	VOSYN (Atis)	17	00	This is LaGuardia Airport, ceiling is 900 feet, visibility 3, haze. Wind 120°/5, temperature 59°. Altimeter setting 29.90. Expect ILS approach to runway 13. Palisade Park radio beacon for ILS runway 13 out of commission until further notice. All ILS approaches will be radar vectored. Inform controller on initial contact that you have received information FOXTROT.

Scenario B
Phila. Airport to LaGuardia Airport

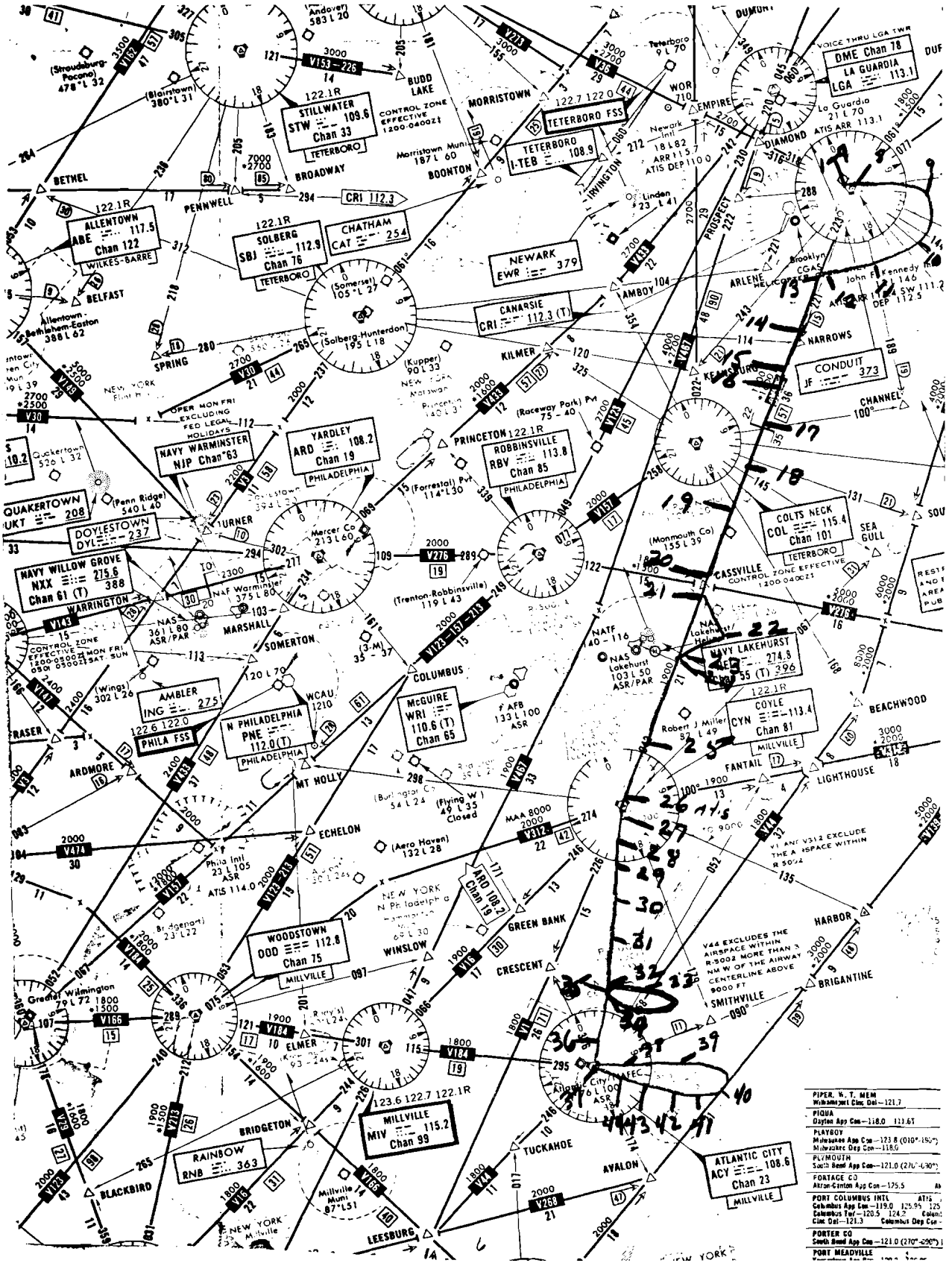
Message Number	Message Type	Elapsed Time Min	Elapsed Time Sec	Message
25	D/L	17	50	Contact LaGuardia approach control on 118.0 and ident.
26	D/L	18	10	Radar contact.
27	D/L	18	20	Hold west of Robbinsville VORTAC on V-157*
28	D/L	18	30	Left turns, one minute*
29	D/L	24	30	Expect further clearance in 15 minutes.
30	D/L	24	30	Traffic 12 o'clock, 5 nmi, west bound, fast.
31	D/L	26	10	Clear of traffic.
32	D/L	33	00	Cleared to LaGuardia VOR*
33	D/L	33	10	Via 054° radial of Robbinsville and the 220° radial of LaGuardia*
34	D/L	33	20	Maintain 5,000 feet.
35	D/L	33	50	Descend to 4,000 feet.
36	D/L	38	05	Turn left to 350° - unidentified traffic.
37	D/L	39	30	Turn right to 115°.
38	D/L	40	05	Traffic at 3 o'clock, southbound, slow.
39	D/L	42	30	Clear of traffic, resume normal navigation.
40	D/L	47	10	Descend to 3,000 feet.
41	D/L	51	40	Contact LaGuardia approach control on 127.30 and ident.
42	D/L	52	10	Radar contact - LaGuardia Altimeter 29.88.

4

Scenario B
Phila. Airport to LaGuardia Airport

Message Number	Message Type	Elapsed Time Min	Elapsed Time Sec	Message
43	D/L	53	00	This will be radar vectors for runway 13 ILS.
44	D/L	53	40	Turn left to 350° - Reduce speed to 130 kts.
45	D/L	54	00	Descend to 1,800 feet
46	D/L	54	30	Reduce speed to 110 kts.
47	D/L	55	45	Turn left to 260°.
48	D/L	56	40	Turn left to 180°.
49	D/L	57	00	You are now 2 nmi north of the outer marker*
50	D/L	57	15	Cleared for ILS approach to runway 13.
51	D/L	57	30	Contact LaGuardia tower on 118.70.
52	D/L	58	10	Cleared to land - wind 125°/8.
53	D/L	60	00	Contact LaGuardia ground control on 121.7

*Indicates an incremental part of the total message and an additional message will follow.


STILLWATER
STW 109.6
Chan 33
TETERBORO
TETERBORO FSS
TETERBORO
I-TEB 108.9
DME Chan 78
LA GUARDIA
LGA 113.1
ALLENTOWN
ABE 117.5
Chan 122
WILKES-BARRE
SOLBERG
SBJ 112.9
Chan 76
TETERBORO
CHATHAM
CAT 254
NEWARK
EWR 379
CANARSIE
CRI 112.3 (T)
CONDUIT
JF 373
NAVY WARMINSTER
NJP Chan 63
YARDLEY
ARD 108.2
Chan 19
PHILADELPHIA
ROBBINSVILLE
RBV 113.8
Chan 85
PHILADELPHIA
COLTS NECK
COL 115.4
Chan 101
TETERBORO
DOYLESTOWN
DYL 237
NAVY WILLOW GROVE
NXX 275.6
Chan 61 (T) 388
WARRINGTON
NAVY LAKEHURST
Chan 95 (T) 396
AMBLER
ING 275
PHILA FSS
N PHILADELPHIA
PNE 112.0 (T)
PHILADELPHIA
McGUIRE
WRI 110.6 (T)
Chan 65
COYLE
CYN 113.4
Chan 81
MILLVILLE
WOODSTOWN
OOD 112.8
Chan 75
MILLVILLE
MILLVILLE
MIV 115.2
Chan 99
RAINBOW
RNB 363
ATLANTIC CITY
ACY 108.6
Chan 23
MILLVILLE
PIPER, W. T. MEM
PIQUA
PLAYBOY
PLYMOUTH
PORTAGE CO
PORT COLUMBUS INTL
PORTER CO
PORT MEADVILLE

APPENDIX B

DATA LINK COCKPIT DISPLAY TEST BRIEFING MATERIAL

	Page
General Description	B-1
Instructions for Experimental Subjects	B-3

GENERAL DESCRIPTION

You are about to participate in a series of simulated flights to evaluate four prototype in-cockpit data link displays. The displays differ as to the number of characters which may be displayed at one time, the size and color of the characters, and the ways in which the characters are formed. A prime object of this experiment is to determine how much verbal communications between the pilot and ATC can be eliminated by use of data link, and how rapidly you comprehend the messages.

You will be flying two different scenarios or flight plans, and each flight will start "at the ramp" at the beginning of a typical IFR flight. You will fly four sessions (flights), one for each display, and will be instructed in the use of each display prior to the simulated flights.

During the course of each flight, you will receive a variety of messages. You will be required to interpret the message and acknowledge by pushing the WILCO button on the display panel or the button on the pilot's or copilot's control column - each serves the same purpose.

Each message will be preceeded by an audio alert signal. As each message is displayed, it will flash momentarily and if the message is to be acknowledged, the WILCO button will also flash momentarily. If the message does not require acknowledgement, the WILCO button will not flash. Occasionally, we will present an impossible message, such as "climb to 90,000 feet" or "turn right to 540°." Your response, of course, will be to press the UNABLE button. Such messages are introduced to force you to interpret the message correctly and not to press the WILCO button routinely without thinking. The controller, in such case, will then give you a proper command.

On messages that require you to make an adjustment such as a radiofrequency setting, please press the WILCO button first, then make your setting. The radiofrequency settings which will be given to you represent the channel on which you would obtain voice contact if it were required. Even though a message might say "Contact Tower on 119.1," a voice response is not required. Please use voice only if you require clarification of a message, or an emergency situation arises.

To summarize, you should acknowledge all command-type messages such as - turn left, contact tower, change frequency, and all traffic advisories. No acknowledgement is required for informational type messages such as - "position 2 miles," "radar contact," etc.

A tape recorder will be in the cockpit to record any comments you might have throughout the flight. It is an "open" microphone, so talk as freely as you wish.

Occasionally a message will appear as *(message)*. The asterisks indicate the first portion of a message that is too long for a single line. The other portion of the message will appear immediately after WILCO is pushed.

Two displays have "scratch pad" capability; that means that heading, altitude, and speed will always be available to you on the display. One display will show these items continuously (32W) and the other will display the items "on call" (3X7W).

At the conclusion of the series of flights, you will be asked to fill in a questionnaire concerning your evaluation of the displays. Please remember that the displays which you will have flown represent only four out of many possibilities and that within certain limitations, the size, color, shape, and orientation of the characters in the messages could be varied independently to yield a better combination for the next generation prototypes.

The following abbreviations will be used in the messages:

Abbreviation	Message Meaning	Abbreviation	Message Meaning
ALT 030	Maintain Altitude 3000	NML	Normal
ALTM 992	Altimeter 2992	PSN	Position
CLB (DSND):	Climb (Descend)	R-039	Radial - 39°
CFAP	Cleared for Approach	RDR CTC	Radar Contact
CLR	Clear(ed)	RESM NAV	Resume Normal Navigation
DSND (CLB)	Descent (Climb)	RGT (LFT):	Right. (Left)
EFC	Expect Further Clearance	SPD	Maintain Speed
HDG 130	Maintain Heading 130°	SQK	Squawk
HLD	Hold	TFC 01 4 NM	Traffic 1 o'clock 4 miles
LFT (RGT):	Left (Right)	NEB FST (SLO)	Northeast bound fast (slow)
LND	Land	TKOF	Takeoff
LOM	Outer Marker	WND 115/12	Wind 115° @ 12 knots
NM	Nautical Miles	VCTR	Radar Vectors
A	Approach Control - ex. (DCA A 127.3)		
G	Ground Control - ex. (LGA G 121.9)		
T	Tower - ex. (PHL T 118.5)		
D	Departure control - ex. (ACY D 123.5)		

The purpose of the data link cockpit display tests is to evaluate four candidate short ATC message displays.

The subject crews will fly each of the four displays for a one-hour flight. Two scenarios are used. One is a flight from Philadelphia to LaGuardia and the other is from J. F. Kennedy to Atlantic City. Each crew will fly two other displays under night time conditions. In addition, the crew will alternate seats in the cockpit.

The crew will be briefed on each display before each flight and a questionnaire will be completed at the end of the series of four flights.

The Data Link Pilot Briefing Sheet and Questionnaire for GAT-II Tests are attached as are copies of photographs of each display.

INSTRUCTIONS FOR EXPERIMENTAL SUBJECTS

You are about to participate in a series of simulated flights to evaluate four prototype displays which will present typical ATC messages. The displays differ as to the number of characters which may be displayed at one time, the size and color of the characters and the ways in which the characters are formed. Some of the displays also have recall capability. You will be instructed as to the use of each display just prior to the simulated flight which you will make with it.

At the conclusion of the series of simulated flights, you will be asked to fill in a questionnaire concerning your evaluation of the several displays. Please remember that displays which you will have flown represent only four out of many possibilities and that within certain limitations, the size, color, shape, and orientation of the characters in the messages could be varied independently to yield a better combination for the next generation prototypes.

Also, please note that while the display packaging is the same for the present four prototypes in order to facilitate their installation in the GAT-II, some of the display packages could physically be made much smaller. Remembering that the smaller the display can be made, the greater is its chance of competing for prime panel space, you will also be asked for your opinion concerning the tradeoffs between a small display in prime panel space and a larger display which might require installation in a less prime location.

The scenarios which you will be flying must, of necessity, represent a compromise between the flying characteristics of the GAT-II simulator and the message types which might be more applicable to a commercial jet. This is an experimetal limitation over which we have no control. Please try to imagine that you are a commercial pilot.

We are interested in how rapidly you comprehend messages and will be measuring your response time. On messages which require you to make an adjustment, such as a radiofrequency setting, please press the WILCO button first, then make you setting.

Occasionally, we will give you an impossible message such as "Climb to 90,000 feet" or "Turn right to a heading of 540°." Your response to such messages, of course, is to press the the UNABLE button. Such messages are introduced to force you to interpret the messages correctly and not to press the WILCO button routinely and without thinking. The controller, in such cases, will then give you a reasonable and proper command.

Each member of the pilot team will alternate in the Pilot-In-Command and Co-Pilot positions for each of the four sessions. Both pilots will discuss and come to full agreement as to individual in-cockpit duties during each flight.

Always "Wilco" a traffic advisory. In the absence of an out-the-window display, we must assume that you can always locate such imaginary traffic. The small CRT (the NIMO) presently does not have a means for indicating that the traffic is no longer a threat. Please assume that when the next message is presented, you should no longer be concerned with the traffic advisory.

The radio frequency settings which will be given to you represent the channel on which you would obtain voice contact if it were required. Even though a message might say "Contact Tower on 119.1," a voice response is not required. Please use voice only if you require clarification of a message, saving other comments for later. A tape recorder is provided in the cockpit to permit you to make notes concerning such comments. A prime objective of this experiment is to determine how much verbal communication can be eliminated by the use of Data Link.

"Scratchpad" capability will be provided in different ways and amounts on some of the displays. You will be instructed on this as you are briefed on the different displays.

Please do not discuss the details of the scenarios with the other pilots until after they have completed all of their simulated flights.

The following abbreviations will be used in the messages:

Abbreviation	Message Meaning	Abbreviation	Message Meaning
ALT 030	Maintain Altitude 3000	NML	Normal
ALTM 992	Altimeter 2992	PSN	Position
CLB (DSND):	Climb (Descend)	R-039	Radial - 39°
CFAP	Cleared for Approach	RDR CTC	Radar Contact
CLR	Clear(ed)	RESM NAV	Resume Normal Navigation
DSND (CLB)	Descent (Climb)	RGT (LFT):	Right, (Left)
EFC	Expect Further Clearance	SPD	Maintain Speed
HDG 130	Maintain Heading 130°	SQK	Squawk
HLD	Hold	TFC 01 4 NM	Traffic 1 o'clock 4 miles
LFT (RGT):	Left (Right)	NEB FST (SLO)	Northeast bound fast (slow)
LND	Land	TKOF	Takeoff
LOM	Outer Marker	WND 115/12	Wind 115° @ 12 knots
NM	Nautical Miles	VCTR	Radar Vectors

ZZZ A XXX.XX	ZZZ Approach Frequency XXX.XX
ZZZ G XXX.XX	ZZZ Ground Frequency XXX.XX
ZZZ T XXX.XX	ZZZ Tower Frequency XXX.XX
ZZZ D XXX.XX	XXX Departure Frequency XXX.XX

---------- This indicates the first portion of a message that is too long for a single line. Last part of the message will appear immediately after WILCO is pushed.

Your copy of the questionnaire is attached so that while you are flying the displays you will know the type of information that we are looking for.

APPENDIX C

GAT II DATA SHEETS

	Page
32-Window Scenario A	C-1
32-Window Scenario B	C-2
3X7-Window Scenario A	C-3
3X7-Window Scenario B	C-4
7-Window Scenairo A	C-5
7-Window Scenario B	C-6
NIMO Scenario A	C-7
NIMO Scenario B	C-8

32-Window Scenario A

	RESPONSE TIME	RESPONSE SOURCE	COMMENTS
JFK G 121.90			
CLR TXI RWY 13R			
JFK T 119.10			
PSN HLD			
CLR TKOF			
CLB TO 015 HDG 130 130 015			
JFK D 121.10 IDENT 130 015			
RDR CTC CLB TO 030 130 030			
RGT TO 150 VCTR V16 150 030			
RGT TO 230 230 030			
RGT TO 260 260 030			
PSN 4NM SE V16 260 030	X	X	
CLB TO 050 RESM NAV 050			
WRI A 124.80 050			
SWK1120 IDENT 050			
RDR CTC 050	X	X	
TFC 01 4NM SLO 050			
CLR TFC 050	X	X	
SPD 120 050 120			
TFC 02 5NM NEB FST 050 120			
LFT TO 195 - TFC 195 050 120			
RGT TO 260 CLR TFC 260 050 120			
PSN 3NM SE V16 260 050 120	X	X	
RESM NAV SPD NML 050			
DSND TO 035 035			
ACY A 124.60 035			
AWK1015 IDENT 035			
RDR CTC ACY ALTM 994 035			
CLR GRETNA VIA 035			
ACY R-039 035			
HLD GRETNA LFT TURNS 035			
EFC IN 6MIN 035	X	X	
SPD 110 ALT 035 035 110			
DSND TO 120 120 110			
DSND TO 020 020 110			
CLR ACY VIA R-039 020 110			
VCTR VOR RWY 31 020 110			
LFT TO 095 095 020 110			
TFC 11 3NM WB 095 020 110			
CLR TFC RGT TO 165 165 020 110			
RGT TO 235 235 020 110			
RGT TO 280 280 020 110			
CFAP VOR RWY 31			
ACY T 118.90			
CLR LND WND 290/6			
		P-	Pilot
		C-	Co-pilot
		D-	Display

32-Window Scenario B

	RESPONSE		
	TIME	SOURCE	COMMENTS
PHL G 121.90			
CLR TXI RWY 27R			
PHL T 118.50			
PSN HLD			
CLR TKOF			
CLB TO 020 HDG 270 270 020			
PHL D 119.00 IDENT 270 020			
RDR CTC VCTR V157 270 020			
LFT 10 200 200 020			
LFT TO 140 THRU V157 140 020			
CLB TO 040 140 040			
LFT TO 040 040 040			
PSN 2NM SE V157 040 040			
RESM NAV 040			
TFC 02 5NM NWB FST 040			
CLR TFC 040			
TFC 10 4NM SWB SLO 040			
CLR TFC 040			
LGA A 127.30 040			
SQK1092 IDENT 040			
SQK1042 IDENT 040			
RDR CTC CLB TO 050 050			
LGA A 118.00 IDENT 050			
RDR CTC 050			
HLD W RBV V157 050			
1MIN LEG LFT TURNS 050			
EFC IN 15MIN 050			
TFC 12 5NM WB FST 050			
CLR TFC 050			
CLR LGA VIA RBV 050			
R-054 AND LGA R-220 050			
ALT 050 050			
DSND TO 040 040			
LFT TO 350 - TFC 350 040			
RGT TO 115 115 040			
TFC 03 2NM SB SLO 115 040			
CLR TFC RESM NAV 040			
DSND TO 030 030			
LGA A 127.30 IDENT 030			
RDR CTC LGA ALTM 988 030			
VCTR ILS RWY 13 030			
LFT TO 350 SPD 130 350 030 130			
DSND TO 018 350 018 130			
SPD 110 350 018 110			
LFT TO 260 260 018 110			
LFT TO 180 180 018 110			
LOM 2NM 180 018 110			
CFAP ILS RWY 13			
LGA T 118.70			
CLR LND WND 125/8			
LGA G 121.70			
		P-	Pilot
		C-	Co-pilot
		D-	Display

3 x 7-Window Scenario A

	RESPONSE		COMMENTS		
	TIME	SOURCE	BRIGHTNESS	RECALL	
JFK G 121.90					
HDG --- ALT --- SPD ---					
CLR TXI RWY 13R					
JFK T 119.10					
PSN HLD					
CLR TKOF					
*015 HDG 130					
HDG 130 ALT 015 SPD ---					
JFK D 121.10 IDENT					
RDR CTC *030					
HDG 130 ALT 030 SPD ---					
\150 VCTR V16					
HDG 150 ALT 030 SPD ---					
\230					
HDG 230 ALT 030 SPD ---					
\\260					
HDG 260 ALT 030 SPD ---					
PSN 4NM SE V16					
*050 RESM NAV					
HDG --- ALT 050 SPD ---					
WRI A 124.80					
SQK1120 IDENT					
RDR CTC					
TFC 01 4NM SLO					
CLR TFC					
SPD 120					
HDG --- ALT 050 SPD 120					
TFC 02 5NM NEB FST					
*195 TFC					
HDG 195 ALT 050 SPD 120					
\260 CLR TFC					
HDG 260 ALT 050 SPD 120					
PSN 3NM SE V16					
RESM NAV SPD NML					
HDG --- ALT 050 SPD ---					
$035					
HDG --- ALT 035 SPD ---					
ACY A 124.60					
SQK1015 IDENT					
RDR CTC					
ACY ALTM 994					
CLR GRETNA VIA					
ACY R-039					
HLD GRETNA *TURNS					
EFC IN 6MIN					
SPD 110 ALT 035					
HDG --- ALT 035 SPD 110					
$120					
HDG --- ALT 120 SPD 110					
$020					
HDG --- ALT 020 SPD 110					
CLR ACY VIA R-039					
VCTR VOR RWY 31					
*095					
HDG 095 ALT 020 SPD 110					
TFC 11 3NM WB					
CLR TFC \165					
HDG 165 ALT 020 SPD 110					
\235					
HDG 235 ALT 020 SPD 110					
\280					
HDG 280 ALT 020 SPD 110					
CFAP VOR RWY 31					
HDG --- ALT --- SPD ---					

3 x 7-Window Scenario B

	LEFT/RIGHT RESPONSE		COMMENTS		
	TIME	SOURCE	BRIGHTNESS	RECALL	
PHL G 121.90					
HDG --- ALT --- SPD ---					
CLR TXI RWY 27R					
PHL T 118.50					
PSN HLD					
CLR TKOF					
*020 HDG 270					
HDG 270 ALT 020 SPD ---					
PHL D 119.00 IDENT					
RDR CTC VCTR V157					
*200					
HDG 200 ALT 020 SPD ---					
*140 THRU V157					
HDG 140 ALT 020 SPD ---					
*040					
HDG 140 ALT 040 SPD ---					
*040					
HDG 040 ALT 040 SPD ---					
PSN 2NM SE V157					
RESM NAV					
HDG --- ALT 040 SPD ---					
TFC 02 5NM NWB FST					
CLR TFC					
TFC 10 4NM SWB SLO					
CLR TFC					
LGA A 127.30					
SQK1092 IDENT					
SQK1042 IDENT					
RDR CTC *050					
HDG --- ALT 050 SPD ---					
LGA A 118.00 IDENT					
RDR CTC					
HLD W RBV V157					
1MIN LEG *TURNS					
EFC IN 15MIN					
TFC 12 5NM WB FST					
CLR TFC					
CLR LGA VIA RBV					
R-054 AND LGA R-220					
ALT 050					
$040					
HDG --- ALT 040 SPD ---					
*350 TFC					
HDG 350 ALT 040 SPD ---					
\115					
HDG 115 ALT 040 SPD ---					
TFC 03 2NM SB SLO					
CLR TFC RESM NAV					
HDG --- ALT 040 SPD ---					
$030					
HDG --- ALT 030 SPD ---					
LGA A 127.30 IDENT					
RDR CTC					
LGA ALTM 988					
VCTR ILS RWY 13					
*350 SPD 130					
HDG 350 ALT 030 SPD 130					
$$018					
HDG 350 ALT 018 SPD 130					
SPD 110					
HDG 350 ALT 018 SPD 110					
*260					
HDG 260 ALT 018 SPD 110					
**180					
HDG 180 ALT 018 SPD 110					
LOM 2NM					
CFAP ILS RWY 13					
HDG --- ALT --- SPD ---					
LGA T 118.70					
CLR LND WND 125/8					

7-Window Scenario A

	RESPONSE		COMMENTS		
	TIME	SOURCE	SCROLL RATE	BRIGHTNESS	MESSAGE PENDING
JFK G 121.90 --------					
CLR TXI RWY 13R --------					
JFK T 119.10 --------					
PSN HLD ----------					
CLR TKOF --------					
"015 HDG 130 --------					
JFK D 121.10 IDENT					
RDR CTC "030 --------					
\150 VCTR V16					
\230 ----------					
\260 ----------					
PSN 4NM SE V16 --------					
""050 RESM NAV					
WRI A 124.80 --------					
SQK1120 IDENT --------					
RDR CTC ----------					
TFC 01 4NM SLO --------					
CLR TFC ----------					
SPD 120 ----------					
TFC 02 5NM NEB EST					
'195 TFC --------					
\\260 CLR TFC --------					
PSN 3NM SE V16 --------					
RESM NAV SPD NML					
$035 ----------					
ACY A 124.60 --------					
SQK1015 IDENT --------					
RDR CTC ----------					
ACY ALTM 994					
CLR GRETNA VIA					
ACY R-039 --------					
HLD GRETNA 'TURNS					
EFC IN -6MIN --------					
SPD 110 ALT 035 --------					
$120 ----------					
$020 ----------					
CLR ACY VIA R-039					
VCTR VOR RWY 31					
'095 ----------					
TFC 11 3NM WB --------					
CLR TFC \165 --------					
\235 ----------					
\280 ----------					
CFAP VOR RWY 31					
ACY T 118.90 --------					
CLR LND WND 290/6					

DIM SETTING

SCROLL RATE

P- Pilot

C- Co-pilot

D- Display

7-Window Scenario B

	RESPONSE		COMMENTS		
	TIME	SOURCE	SCROLL RATE	BRIGHTNESS	MESSAGE PENDING
PHL G 121.90 --------					
CLR TXI RWY 27R --------					
PHL T 118.50 --------					
PSN HLD ----------					
CLR TKOF --------					
*020 HDG 270 --------					
PHL D 119.00 IDENT					
RDR CTC VCTR V157					
*200 ----------					
*140 THRU V157					
*040 ----------					
*040 ----------					
PSN 2NM SE V157 --------					
RESM NAV --------					
TFC 02 5NM NWB EST					
CLR TFC ----------					
TFC 10 4NM SWB SLO					
CLR TFC ----------					
LGA A 127.30 --------					
SQK1092 IDENT --------					
SQK1042 IDENT --------					
RDR CTC *050 --------					
LGA A 118.00 IDENT					
RDR CTC ----------					
HLD W RBV V157					
1MIN LEG *TURNS					
EFC IN 15MIN --------					
TFC 12 5NM WB EST					
CLR TFC ----------					
CLR LGA VIA RBV					
R-054 AND LGA R-220					
ALT 050 ----------					
$040 ----------					
*350 TFC --------					
\\115 ----------					
TFC 03 2NM SB SLO					
CLR TFC RESM NAV					
$030 ----------					
LGA A 127.30 IDENT					
RDR CTC ----------					
LGA ALTM 988					
VCTR ILS RWY 13					
*350 SPD 130 --------					
$018 ----------					
SPD 110 ----------					
*260 ----------					
*180 ----------					
LOM 2NM ----------					
CFAP ILS RWY 13					
LGA T 118.70 --------					
CLR LND WIND 125/8					
LGA G 121.70 --------					
		P-	Pilot	DIM SETTING	
		C-	Co-pilot		
		D-	Display	SCROLL RATE	

NIMO Scenario A

		RESPONSE TIME	RESPONSE SOURCE	COMMENTS
3	G1219			
4	X			
5	W1185			
6	"POSITION & HKD, RWY 27R."			
7	K 27R			
8	B 020			
8	H 270			
9	D1190			
9	Q			
10	Z			
	NML DEP "EXPECT VECTRS TO V157"			
11	L 200			
12	L 140			
13	B 040			
14	L 040			
15-16	NML DEP "YOUR POSN IS 2 MILES SE V157, RESM NML NAV."			
17	F02 5			
18	T 040			
19	F10 4			
20	T 040			
21	A1273			
21-A	Q1092			
22	Q1042			
23*	Z			
23	B 050			
25	A1180			
26	Q			
26	Z			
27	LGA APP "HLD W OF ROBBINSVILLE ON V157, 1 MIN LEG, LFT TURNS."			
29	Y15			
30	F12 5			
31	T 050			
32	LGA APP "CLR TO LA GUARDIA VIA ROBBINSVILLE VOR 054 DEG RADIAL & LA GUARDIA VOR 220 DEG RADIAL."			
35	E 040			
36	L 350			
37	R 115			
38	F03 2			
34	LGA APP "CLR TRAFFIC, RESM NML NAV."			
39	T 040			
40	E 030			
41	A1273			
42	Q			
42	Z			
42	M2988			
43	LGA APP "EXPECT VECTRS FOR ILS RWY 13 APPR."			
44	L 350			
44	S 130			
45	E 018			
46	S 110			
47	L 260			
48	L 180			
49	LGA APP "POSITION IS 2 MILES FROM THE LOM, CLR ILS APPR RWY 13."			
51	W1187			
52	N 13			
53	G1217			

F- Pilot
C- Co-pilot
D- Display

NIMO Scenario B

	RESPONSE TIME	RESPONSE SOURCE	COMMENTS
G1219			
X			
W1191			
"POSITION & HLD, RWY 13R"			
K 13R			
B 015			
H 130			
D1211			
Q			
Z			
B 030			
R 150			
"EXPECT VECTRS TO V16"			
R 230			
R 260			
"YOUR POSN IS 4 MILES SE V16, RESM NML NAV"			
B 050			
A1248			
Q1120			
Z			
F01 4			
T 050			
S 120			
F02 5			
L 195			
R 260			
"CLR OF TRAFFIC. RESM NML NAV & NML CRUISE SPEED."			
E 035			
A1246			
Q1015			
Z			
M2994			
"CLR TO GRETNA VIA ATLANTIC CITY VOR 039 DEG. RADIAL."			
"HLD @ GRETNA, LFT TURNS."			
Y 6			
S 110			
T 035			
E 120			
E 020			
"CLR TO ATLANTIC CITY VIA 039 DEG RADIAL."			
"EXPECT VECTRS FOR VOR RWY 31 APPR."			
L 095			
F11 3			
R 165			
R 235			
R 280			
"CLR FOR VOR RWY 31 APPR."			
W1189			
N 31			

P- Pilot
C- Co-pilot
D- Display

APPENDIX D

SUMMARY OF NAFEC CREW AND VOLUNTEER CREW RESPONSE TO DATA LINK COCKPIT DISPLAY QUESTIONNAIRES

NAFEC CREW RESULTS (QUESTIONNAIRE SUMMARY).

1. Displays in order of preference

	32W	3X7W	7W	NIMO
First preference	11 1/2	3	3	1 1/2
Second preference	4	9	3	2
Third preference	2	6	6	3
Fourth preference	2	0	4	11

2. Did displays provide too much information?

No 18 Yes 0

3. Were any display abbreviation confusing?

No 17 Yes 1

4. Preference between small display in prime area versus larger display in a less desirable location.

Smaller 7 Larger 7 Other 4

5. Were any displays difficult to read in simulated daylight?

Yes 5 - NIMO No 13

6. Was the dimming control adequate for the 3X7W and 7W for the simulated night conditons?

Yes 12 Other 6

7. Is automatic or manual scrolling preferred on the 7W?

Automatic 12 Manual 2 Other 4

8. Character size preference versus display.

3X7W 6 32W 7 7W 6 NIMO 2

9. Color preference for message display.

White 8 Red 3 Amber 3 Green 3

10. Did flashing of the displays provide sufficient alerting?

Yes 15 No 3

11. Is longer or shorter flashing desired?

Longer 1 Shorter 1 As is 16

12. Was audio alert helpful?

Yes 18 No 0

13. Was the synthetic speech intelligible?

No 11 Yes 3 Borderline 3 Not observed 1

14. Would understanding of synthetic speech improve with practice?

No 7 Yes 6 Possibly 2

15. No response.

16. Should some messages not require a WILCO?

Yes 14 No 2

17. Character preference.

Dot Matrix 6 Stencil 1 Segments 5

18. Use of synthetic speech instead of visual display.

No 16 Possible 2

19. WILCO button preferred location - on display or on control column.

Display 4 Control column 7 Both 6

20. Location of other controls.

Display 4 Both 7

21. Case where too much information was presented.

No 15 Yes 4

22. Better to present one piece of information at a time.

No 13 Yes 1

23(a). Did you ever clear the display?

Yes 16 No 5

b. If so was it regularly or infrequently?

Regularly 4 Infrequently 9

c. Which display?

32W 2 3X7W 1 7W 2 NIMO 2

24. Would new NIMO change your opinion?

Yes 11 No 5 Don't know 2

25. Was lack of decimal point troublesome?

Yes 1 No 15

26. What kind of a display would you design (answers were complex)?

32W 7, White 4, 3X7W 1, 7W 1, NIMO 1, Stencil 1

27. Would additional experience change your opinion of data link.

Yes (to better) 8 No 6 Great 3

28. Want separate displays for pilot and copilot.

Yes 4 No 12

29. Impact of data link on work load.

More 1 Less 17

30. Keep scratch pad ability for 32W or have it all message.

As is 13 All message 4

31. Like recall of 3X7W, how often used, prefer this to 32W.

Recall - like 10, dislike 5; use - frequent 4, infrequent 3;
Prefer - 3X7W = 2, 32W = 6

32. Have data link set the heading bugs automatically after pushing WILCO/

Yes 9 No 1

Would you prefer this to scratch pad or both?

Scratch pad - Yes 1, No 1; both - Yes 6, No 0

33. Additional Comments.

VOLUNTEER CREW (QUESTIONNAIRE SUMMARY).

	32W	3X7W		7W	NIMO	
1. Rate character size.						
Too large	0	8		8	0	
Too small	1	0		0	15	
Satisfactory	17	10		10	3	
2. Red-orange color-ease of reading.		Day	Night		Day	Night
Yes	18	9	13	16	2	5
No	0	7	3	2	6	6
3. Loss of first part of message when WILCO is pushed.						
Yes	12					8
No	5					10
4. Did you use "clear" button?						
Yes	2					
No	5			1	3	
Occasionally	11			11	6	
Rarely				1	7	
Considerable				1	2	
5. Does "clear" serve a useful function?						
Yes	12			14	12	
No	5			4	5	
6. Understandable abbreviations.						
Yes	17			14	11	
No	1			4	6	
7. Is continuous display or recall of heading, speed, altitude desirable?						
Yes	17	17				
No	1	1				
8. Would you prefer all message instead?						
Yes	9					
No	6					

9. Rate pushbutton brightness.

Too bright	4	4	0
Satisfactory	13	15	13
Too dim	0	0	0

10. Relabel pushbuttons or have new pilot response function.

Yes	6
No	10

SPECIFIC QUESTIONS VERSUS DISPLAY

4. 3X7W. Did you feel this provided too much information?

Yes	0	0	-
No	18	18	-

6. 3X7W. This increase cockpit work load.

Yes	2	13	13
No	15	5	6

2. 7W. Is automatic scrolling desirable?

Yes	-	9	-
No	-	8	-

3. 7W. Prefer manual scroll of one.

Yes	-	8	-
No	-	10	-

8. 3X7W. Scroll rate desirable.

Yes	-	5	-
No	-	11	-

9. 3X7W. Brightness control a benefit.

		Day	Night	
Yes	-	10	6	-
No	-	2	2	-

APPENDIX E

NAFEC CREW DATA LINK COCKPIT DISPLAY QUESTIONNAIRE COMMENTS

The answers to these questionnaires are summarized for the nine two-man crews at the maximum extent possible, however, individual verbatum comments or paraphrased comments are listed for pilot as crew No. (A through I), and pilot No. (1 or 2) following the introduction and each question No. 1, 2, 3, etc. up to and including 33. A table follows the questionnaire and lists the pilot crews and gives their ages, mean ages, total flying time, and mean flying time.

QUESTIONNAIRE FOR GAT-II TESTS

Hours of flying experience _____ Hours in light aircraft last year _____.

Crew/Pilot	Age	Total Hrs.	Last Year	Crew/Pilot	Age	Total Hrs	Last Year
B/1	50	10,500	50	F/1	48	11,000	40
B/2	47	8,300	61	F/2	45	4,242	12
C/1	51	20,000	--	G/1	51	5,000	120
C/2	51	18,000	400	G/2	51	15,300	10
D/1	49	9,500	25	H/1	50	13,650	0
D/2	48	13,000	200	H/2	54	9,000	--
E/1	51	19,000	--	I/1	51	10,000	25
E/2	51	8,000	75	I/2	50	12,000	25

You have just participated in the evaluation of four prototype displays for Data Link:

1. 7W: A display limited to 7 windows (characters) using incandescent lamps and fiber optics.

2. 3X7W: Three lines of seven characters using light emitting diodes in a 5X7 dot matrix for character generation.

3. 32W: A display presenting 32 characters on one line, using plasma.

4. NIMO: A miniature Charactron Cathode Ray Tube.

Thirty-three questions followed to be answered, and they are tabularized on the following pages of this appendix.)

1. Please rate the displays in the order of your preference, and briefly state why.

<u>1st Preference</u> - (11 1/2) 32W, (3) 7W, (3) 3X7W, (1 1/2) NIMO

A/1 32W, because it is the most concise, easy to read, no scrolling needed, and continuous scratch pad information which is most desirable.
A/2 32W. Most needed information displayed all the time.
B/1 32W. Adequate information with least effort.
B/2 32W. Day only. Good readability, and speed, altitude, and heading good retain.
C/1 32W. Most versatile display of all from block-to-block. It provided and retained the most information at the lowest workload without the problems of scrolling.
C/2 32W. Most information available on one line, prefer white color.
D/1 7W. I like the ability to dim lites; the amber color and scrolling to leave the desired part of message displayed.
D/2 NIMO. For general aviation, small size, good color, potential.
32W. For transport A/C
E/1 32W.
E/2 32W. Adequate info. Ease of operation. Displays prime info (A/S - altitude - heading).
F/1 32W. Best mainly because of the continuous readout at heading, altitude, and speed.
F/2 32W. Separate block for message; heading, altitude, and speed.
G/1 7W. Easy to read. Could stop message and use as reminder and use recall if necessary.
G/2 7W. Nice size letters. Like recall feature of messages.
H/1 3X7W. All four displays were excellent.
H/2 3X7W. Seemed the best.
I/1 3X7W. Because of the scratch pad.
I/2 32W.

<u>2nd Preference</u> - (9) 3X7W, (4) 32W, (3) 7W, (2) NIMO

A/1 3X7W. For similar reasons (as first choice, 32W, however, scratch pad requires button pushing.
A/2 3X7W. Most needed info can be recalled.
B/1 3X7W. Most information, but requires continuous operator attention.
B/2 NIMO. Day only. Readability and compactness, good.
C/1 3X7W. Most versatile, retain the most information. Scrolling is a problem.
C/2 3X7W. Easy to read, however, info broken up different lines. Like recall feature.
D/1 3X7W. Very close betweeen this and 7W (best) but do strongly object to red characters.
D/2 32W. For general aviation. Good readability, auto and scratch pad.
E/1 3X7W.
E/2 7W. Same as 32W (best) only info not as complete.

F/1 3X7W. Same as 32W (best) except readout has to be called-up.
F/2 3X7W. Liked size of display and recall.
G/1 32W. Liked the info that remained on right side of display.
G/2 32W. Would like to see these numerics and letters, color, etc., used on the 7W (best).
H/1 7W.
H/2 7W.
I/1 32W. Message retention and recall.
I/2 NIMO.

3rd Preference - (6) 3X7W, (6) 7W, (3) NIMO, (2) 32W, (1) None

A/1 NIMO. Do not like green phosphor - too bright at night.
A/2 7W. Auto scrolling and manual capability.
B/1 7W. Not enough information and requires heavy workload for operator.
B/2 3X7W. Night only. Readability good.
C/1 None. NIMO and 7W are both inadequate. Cause more workload. They were very susceptable to loosing information, which is dangerous.
C/2 7W. Message is presented in bits so that information is broken. Light and brightness, least of all.
D/1 NIMO. Small size.
D/2 3X7W.
E/1 7W.
E/2 3X7W. Not as complete on info.
F/1 7W. There is no way to call information back. To fly this unit, you would have to write down the important information like altitude, heading, and airspeed.
F/2 7W. Like character size.
G/1 3X7W. Easy to read but I do not care for red letters.
G/2 3X7W.
H/1 32W. My objection to 32W was its inability to repeat the different segments of longer messages.
H/2 NIMO. Harder to see.
I/1 3X7W. Character style and size.
I/2 3X7W.

4th Preference - (11) NIMO, (4) 7W, (2) 32W, (1) None

A/1 7W. Confusing because of limited characters requiring maximum use of abbreviations. Auto scrolling can give ambigious info.
A/2 NIMO. Not sufficient information. Must be augmented with voice.
B/1 NIMO. Very poor display, not enough information and requires heavy workload for operator.
B/2 7W. Night only. Readability misleading. Intensity control bad. Note, order of preference is misleading. The units were tested under different conditions and all have faults.
C/1 None. Both the NIMO and 7W are inadequate. Cause more workload. They were very susceptable to loosing information, which is dangerous.
C/2 NIMO. Info capability is limited. Numbers difficult to read, hard to read in bright light. Like green color.

D/1 3X7W. Least desirable.
D/2 7W. Time consuming.
E/1 NIMO.
E/2 NIMO. Inadequate display and info.
F/1 NIMO.
F/2 NIMO.
G/1 NIMO. Not as easy to read as others.
G/2 NIMO. Too small and characters jumbled at times. Don't care for green tube.
H/1 NIMO.
H/2 32W.
I/1 NIMO.
I/2 7W.

2. Did you feel that any of the displays provided too much information?
18 No 0 Yes

3. Were any of the displays confusing because of the need for abbreviations? If so, do you remember any confusing messages?
14 Yes 4 No

A/1 7W. TFC ← 350. At first we thought this was a traffic advisory. Then realized we were supposed to turn left to 350 to avoid traffic conflict.
A/2 7W. TFC ← 350.
B/1 All displays had some unusual abbreviations. No time allowed to record everything. CEAP-PSN. NIMO because of poor characters.
B/2 Yes. VECTOR versus VICTOR. Frequently there was delay while crew pondered for interpretation of various messages.
C/1 Because of character makeup, the NIMO Nos. are easily read wrong, B-9-6. Also reading altitude is hard.
C/2 Yes. However, any standard system would be learned and accepted. The symbol VCTR bothers me.
D/1 I imagine most pilots would be suckered into reading 120 as 1200 feet but practice would eliminate.
D/2 No.
E/1 NIMO - CONTCT TOWER etc. CONTCT APPROACH CNTL etc.
E/2 Yes. Radar vector should always be emphasized.
F/1 Yes. I was not familiar with them. They could be changed to those a pilot is more familiar with.
F/2 Mistook A (approach) for R (radar) sometimes. Altitude for heading, except on 32W display no problem.
G/1 Not confusing.
G/2 Not confusing after adapting for an hour per system - appears that all abbreviations same for all displays.
H/1 No.
H/2 Using U for a V takes time to get used to.
I/1 The arrows indicating direction of turn and climb and descent were slow to register as information, tend to be interputed as spacers.
I/2 No.

4. If you were faced with a tradeoff between a small display in prime location and a larger display in a less desirable location, which would you prefer?
(7) small, (7) large, (4) other

A/1 32W. Display somewhere in front of the pilots.
A/2 Larger in less desirable location.
B/1 No answer would be reasonable or logically correct until actually evaluated.
B/2 Depends on how much less desirable the location is, and whether a second pilot is available. Small/prime is better for solo pilot.
C/1 Larger display in less desirable location.
C/2 Larger display visible to all crew members with adequate alerting.
D/1 Larger display in less desirable location.
D/2 Small display with a repeater for first officer.
E/1 NIMO would be acceptable for lite A/C.
E/2 Large display. I think!
F/1 Split. The heading, altitude, and speeding in a prime location and the other messages in a less desirable location.
F/2 Small display prime location.
G/1 Larger display in less desirable location.
G/2 How about a medium size display in a prime location. Location is important or else copilot has to read and verify the message continually.
H/1 Small display in prime location.
H/2 Large display in two-pilot aircraft.
I/1 Small display.
I/2 Small display.

5. Were any of the displays difficult to read under simulated daylight?
(13) No, (5) yes - NIMO

A/1 No.
A/2 No. The two we saw at daylight were OK. The other two were under night conditions.
B/1 NIMO because of very poor display.
B/2 No, for 3X7W and NIMO. Not tested in daylight for 7W and 32W.
C/1 No.
C/2 NIMO required some effort in bright light.
D/1 No.
D/2 No difficulty. I imagine that under direct sunlight (very rare condition in cockpit) the NIMO might be hard to read.
E/1 No.
E/2 Yes, NIMO.
F/1 Yes, NIMO was difficult under all conditions.
F/2 No.
G/1 No.
G/2 The 7W and 32W were only flown in simulated daylite, although NIMO was flown under simulated darkness.

H/1 No.
H/2 No.
I/1 No.
I/2 No.

6. Was sufficient dimming capability provided for simulated night conditions? on the 3X7W and 7W display?
(12) yes, (6) other

A/1 Yes.
A/2 Yes on the 3X7W. 7W not observed. The WILCO lights, however, had no dimming and they were needed.
B/1 Display OK, however, control button lights very bright and distracting.
B/2 7W, no. Buttons are much too bright and undimmable, 3X7W, unknown.
C/1 Yes.
C/2 Yes.
D/1 Only flew 7W and 32W in night conditions, but both were good.
D/2 Yes, the control was set initially about two-thirds the way from A to B.
E/1 Prefer white lighting as opposed to red or green, however, green better than red.
E/2 Yes.
F/1 Did not see the 3X7W unit under night conditions.
F/2 Did not use.
G/1 Yes.
G/2 Only 3X7 looked at at simulated night. Dimming seemed OK on all features. Don't belive NIMO had dimming control.
H/1 Yes.
H/2 More than what was needed.
I/1 3X7W was a little bright at lowest intensity.
I/2 Yes.

7. Did you like the automatic scrolling feature on the 7W display, or would you prefer manual scrolling?
(12) automatic, (2) manual, (4) other.

A/1 Don't like auto scroll, and don't care for any type of scrolling for new message acquisition.
A/2 Like the capability of both. If only one allowed, prefer auto.
B/1 Automatic good when manual scrolling available.
B/2 No. Requires memorizing and preoccupies pilot to avoid missing details. Incompatible with instrument flying.
C/1 Prefer automatic because the message could be reviewed while occupied elsewhere.
C/2 Manual.
D/1 Like automatic very much, particularly speed selection.
D/2 Object to manual scrolling as being time consuming and distracting.

E/1 OK, but not important.
E/2 As is, good.
F/1 (No comment.)
F/2 Automatic.
G/1 Automatic.
G/2 I liked automatic scrolling with manual playback control combined.
H/1 Automatic.
H/2 Automatic was good.
I/1 Automatic.
I/2 Automatic.

8. Neglecting other considerations, did you have a preference for the character size used on some particular display?
(4) 3X7W, (4) 32W, (3) 7W, (1) NIMO, (6) other

A/1 32W was fine. Only complaint is the shape of the "V" character, but it is acceptable.
A/2 3X7W.
B/1 32W and 7W are perfect for me.
B/2 The bigger the better if you neglect all other considerations.
C/1 Any were suitable.
C/2 32W.
D/1 Hard choice, but I will pick 3X7W.
D/2 I found the characters on the 32W to read rapidly.
E/1 3X7W.
E/2 All good except NIMO.
F/1 Size and definition are extremely important but this depends on location of the unit as to distance.
F/2 7W.
G/1 3X7W. Red letters were the size I liked.
G/2 32W and 7W preferred.
H/1 No.
H/2 Larger the better.
I/1 7W. Best size characters.
I/2 NIMO.

9. Did you have any color preference for message display?
(8) white, (3) red, (3) amber, (3) green.

A/1 White, or some pale cool color.
A/2 White.
B/1 3X7W or 32W orange/red. Perfect for me.
B/2 White first, then green. Red is least desirable.
C/1 No. However white is the present theme.
C/2 White.

D/1 Amber or green.
D/2 Green on the NIMO.
E/1 White. All instrument panels are being displayed white.
E/2 White.
F/1 No.
F/2 No.
G/1 White.
G/2 Amber color on the 32W.
H/1 No preference, except the message display should not be red.
H/2 No.
I/1 Prefer red.
I/2 Red.

10. Did the flashing of the display provide sufficient alerting?
(15) yes, (3) other

A/1 No. As a matter of fact, the WILCO light was much too bright. Needs a dimming feature.
A/2 Yes, under night conditions; although under daylight audio is highly desirable.
B/1 Yes, but much too bright. Copilot dozed off for a few seconds and was not alerted by either avoid or flashing WILCO button.
B/2 Not immediately, if both pilots happened to be looking away from the flasher.
C/1 Yes, but audio was the real key.
C/2 Not always. This was affected by lighting and location of display. An audio alert is necessary.
D/1 Yes, along with audio alert as well.
D/2 Yes, but after a while (when I was pilot) I found that I was not looking at the display, but after audio alert was relying on the copilot reading it out loud!
E/1 Yes.
E/2 Yes, prefer audio and visual.
F/1 Yes, with oral signal.
F/2 Yes.
G/1 Yes.
G/2 I like beeping also in case both pilots are engaged in other activities, i.e., looking outside window for aircraft.
H/1 Yes.
H/2 OK, audio alert should follow-up WILCO if message not WILCO'd for.
I/1 Yes.
I/2 Yes.

11. Would you prefer longer or shorter flashing?
(16) OK as is, (1) longer, (1) shorter

A/1 OK as is.
A/2 Neither.

B/1 OK as is, however color and dimming capability should be incorporated and evaluated.
B/2 Neither, but flashing should not commence till message is complete.
C/1 No. Appeared about right.
C/2 OK as is.
D/1 Fine as is.
D/2 OK as is.
E/1 Midway.
E/2 As is.
F/1 I might prefer the short flash.
F/2 As is.
G/1 Neither.
G/2 OK the way it is.
H/1 Longer.
H/2 OK as is.
I/1 No opinion.
I/2 (No comment)

12. Did you find the audio alert helpful?
(18) yes, (0) no

A/1 Definitely.
A/2 Yes.
B/1 Could occassionally hear the audio alert in GAT II. In GAT I audio very noticeable and helpful.
B/2 Yes.
C/1 Very.
C/2 Yes.
D/1 Yes.
D/2 Very much so, especially in the afternoon.
E/1 Yes.
E/2 Yes.
F/1 Yes with the oral signal.
F/2 Yes, very.
G/1 Yes.
G/2 Very, I think it is a must.
H/1 Yes.
H/2 Definitely.
I/1 Yes, definitely.
I/2 Yes.

13. Was the synthetic speech on the test tape sufficiently intelligible?
(11) no, (3) yes, (3) borderline, (1) not observed.

A/1 No.
A/2 No.
B/1 No. Pilots generally lose high frequency. Try increasing treble instead of bass.
B/2 No. Interpretation required intense concentration.

C/1 Not observed.
C/2 (Done at TSC). Would require practice.
D/1 Yes.
D/2 I'm afraid I would have missed a lot of it.
E/1 No. Unintelligible.
E/2 No!
F/1 No. Has room for improvement.
F/2 Very poor.
G/1 No.
G/2 No!!
H/1 Intelligible, but not good.
H/2 Borderline.
I/1 Slightly slurred but OK.
I/2 Yes.

14. Do you think your understanding would improve with practice?
(7) no, (6) yes, (2) possibly, (2) other, (1) not observed.

A/1 No.
A/2 No. Not unless there was improvement of quality.
B/1 Tape with increased bass not intelligible to anyone I observed in evaluation.
B/2 Yes. However, to be practical audio should be more easily interpreted without such gross preoccupation.
C/1 Not observed.
C/2 Possibly.
D/1 By all means.
D/2 Yes.
E/1 Have heard much better synthetic speech in conjunction with ARTS III IFR advisories in Knoxville, Tenn.
E/2 No.
F/1 Yes. I base this and a similar project with VOLSCAN back in the early 1960's.
F/2 No.
G/1 No.
G/2 No - No!
H/1 Probably.
H/2 Yes.
I/1 No.
I/2 Yes.

15. (No question. Questions were misnumbered, skipping 15).

16. Do you feel that some messages should not require a WILCO? Did you agree with the choices made for this type of message in the experiment?

A/1 Generally OK.
A/2 Yes. Not all.
B/1 (No comment)
B/2 If a message is not important enough to warrant.

C/1 (No comment)
C/2 No. All messages should be responded to.
D/1 Yes. Good idea to eliminate the continual WILCO of all messages.
D/2 Yes.
E/1 Yes. Same as should be using with voice communication presently.
E/2 WILCO not always required, like procedures used.
F/1 Yes.
F/2 Yes. Copilot input could improve or shorten some of messages, in general.
G/1 Yes.
G/2 Yes. Very well applied.
H/1 I feel all messages should be WILCO'd. Choice of messages in the experiment was excellent.
H/2 Yes. So we did not WILCO for them.
I/1 Some messages require acknowledgement. Messages were OK.
I/2 Yes.

17. Did you have any preference for the method in which characters were generated: Dot Matrix versus Stencil (the NIMO CRT) versus Segments (7-W)?
(3) no, (3) no comment, (5) dot matrix, (4) segments, (1) stencil, (2) other

A/1 Segments were the most concise in most cases. Particularly "V" in 32W is marginal. Rest of 32W is good.
A/2 3X7W.
B/1 Dot matrix and segments, OK - stencil very poor.
B/2 Stencil is best, dot matrix next, and segment least desirable. Fidelity of reproduction is the object.
C/1 7W much cleaner.
C/2 Dot Matrix.
D/1 I am hard-pressed to choose, but will take the incandescent lamps and fiber optics as my preference.
D/2 (No comment)
E/1 Preferred 32W.
E/2 (No comment)
F/1 I think the question was answered in question 1.
F/2 Dot matrix.
G/1 Yes. Segments.
G/2 Prefer the type segments in the 7W or 32 W.
H/1 No preference. However the NIMO CRT was the poorest.
H/2 No preference. The larger the better.
I/1 (No comment)
I/2 No.

18. Do you think that synthetic speech might be preferable to the use of visual display?
(16) no, (2) possibly

A/1 No.
A/2 No.
B/1 No. Might be helpful. Should be evaluated.
B/2 Possibly. Development hasn't progressed to that point yet.

C/1 No.
C/2 No.
D/1 The two together would be useful, but I'd like to try before deciding.
D/2 No. There is a need to retain certain messages longer than verbally, and preferably keep a printed record.
E/1 No. Keep voice out of cockpit. Conflicts with crew conversation, check lists, etc.
E/2 No.
F/1 No.
F/2 No.
G/1 No.
G/2 No!!!
H/1 Definitely no.
H/2 No.
I/1 No.
I/2 No.

19. What is your preference for location of the WILCO button; on the display or on the control column?

(7) control column, (6) both, (4) display

A/1 Depends on distance from operator. Either one was OK for GAT II. Used control stick mostly.
A/2 Control column in aircraft because the display may be too far away.
B/1 For this test, on the display. In larger cockpit this will be a problem. Believe center of wheel is best. "Horn" position caused several accidental WILCO responses.
B/2 Depends on the proximity of the panel - in this case either is OK, but pilot/copilot coordination is a problem.
C/1 On display, because it made me more aware of message, especially when scrolling was required.
C/2 Control column.
D/1 Both.
D/2 The control column location is more convenient, however, by forcing the pilot to use a button on the display, he will not be able to WILCO it superficially without looking for it.
E/1 Both.
E/2 Both.
F/1 On the control column.
F/2 Display.
G/1 On the display.
G/2 Both - the way it has been presented. However, the present control column position in simulation should be put in another position on the wheel.
H/1 On the display. This position gives both pilots adequate time for the readout. On the control column, one of the pilots could possibly press the button before the other digested the message.
H/2 OK as is.
I/1 On control column would be best.
I/2 Control column.

20. What about location of the other controls?
(7) both, (4) display

A/1 (No comment)
A/2 Somewhere accessible to pilot or copilot as necessary.
B/1 Same as question 19.
B/2 No difficulty as is.
C/1 Adequate for display.
C/2 Should be on display.
D/1 GAT II locations seem just fine.
D/2 OK where they are.
E/1 On panel is OK.
E/2 Within easy reach of both pilots.
F/1 This depends on the environment of the cockpit, therefore, is difficult to answer.
F/2 Display.
G/1 Good where located.
G/2 OK.
H/1 No.
H/2 OK.
I/1 OK.
I/2 (No comments)

21. Were there case where too much information was present at one time?
(15) no, (4) yes

A/1 Yes, on the auto scroll 7W. Some abbreviations were excessive or unclear, like NEB when NE is best, or running works together on NIMO, i.e., TOLAND.
A/2 Not that I recall.
B/1 Yes. Memory displays became inadequate and display operator has to maintain scratch pad information.
B/2 No, but some kind of retainer display for critical parameters is needed.
C/1 No.
C/2 No.
D/1 No.
D/2 Not any more than is given verbally.
E/1 No.
E/2 No.
F/1 No.
F/2 Yes, where two-part message and you could only recall second part.
G/1 No.
G/2 Two-line messages broken up in two segments might be too much if you could not manually rescroll the first segment.
H/1 No.
H/2 No.
I/1 No.
I/2 No.

22. Would it be better to present only one piece of information at a time, even though this increased the requirements for WILCO button pushing?
(13) No, (1) yes (4) other

A/1 No. Not a factor for 32W, which I much prefer over all others.
A/2 No.
B/1 Yes, unless memory displays can be increased or automatic tape information provided.
B/2 No, present all at once, if applicable, but allow pilot to digest it on his schedule.
C/1 This would be completely unacceptable because it breaks the message up too much.
C/2 If individual messages are identified or spaced, multiple information OK.
D/1 No.
D/2 Not necessary if there is means to retain a message longer.
E/1 As presented in 32W.
E/2 Pushing WILCO button prefered.
F/1 No. Bits and pieces can be confusing. The whole message is the most desirable.
F/2 32W. This would be no problem since it has separate space block. Other displays may be bothersome.
G/1 No.
G/2 No. Not as long as you were able to automatically rescroll or manually rescroll first piece of information.
H/1 Either way OK.
H/2 No.
I/2 Perhaps, in some instances, but not as shown in GAT II.
I/2 No.

23. Did you ever clear the display? If, regularly or infrequently? Which displays?
(13) yes, (4) no, (9) infrequently, (4) regularly, (2) NIMO, (1) All, (1) 7W, (1) 32W

A/1 At times, NIMO. Too bright at night.
A/2 Yes. Infrequently.
B/1 No. Believe this function can be eliminated.
B/2 Yes, Infrequently, and unnecessarily.
C/1 Infrequently. Did not seem too necessary.
C/2 Yes, infrequently. During night operations.
D/1 I don't believe so.
D/2 No. Liked to see that last command, especially to remind altitude, speed, and heading.
E/1 Yes, particularly the NIMO presentation.
E/2 Frequently for practice and to get familiar.
F/1 Infrequently, all displays.
F/2 Regular → traffic, altitude ↓, altitude change, heading change, and when on speeds.
G/1 Did not clear display.
G/2 Infrequently. I believe only two times.

H/1 Yes, about half the time - on all displays.
H/2 Regularly.
I/1 Infrequently. 32W and 7W.
I/2 Infrequently.

24. A new NIMO mask is on order which will have a better character alignment and can display a larger percentage of the required messages. Might this change your opinion of the NIMO?
(11) Yes, (5) no, (2) don't know or possibly

A/1 Perhaps to a small degree.
A/2 No.
B/1 This question is not pertinent.
B/2 No. I like NIMO. I assume alignment will be fixed and duplication of tubes can solve the required message problem.
C/1 It undoubtebly will improve the display, however, its limit and difficulty is in its readability.
C/2 Yes.
D/1 Possibly.
D/2 I like the NIMO. It has a great potential. It is as good as it is for general aviation.
E/1 Presentation too small for large cockpit aircraft.
E/2 Don't know. Looks sloppy.
F/1 A little, but not much better than I have already stated.
F/2 Yes.
G/1 Yes.
G/2 Should still be larger tube. Possibly change my opinion. Would have to see it operate.
H/1 Yes it would.
H/2 Yes.
I/1 It might.
I/2 Improvement.

25. Was the lack of decimal point in certain displays troublesome?
(16) no, (1) yes

A/1 No.
A/2 No.
B/1 NIMO - very poor display.
B/2 No.
C/1 No.
C/2 No.
D/1 No.
D/2 No.
E/1 No. Poorly displayed numbers.
F/1 Yes.
F/2 No problem, once you were
G/1 No.
G/2 No. Apparently not.

H/1 No really. Being familiar with the characters does help, however.
H/2 No.
I/1 No.
I/2 No.

26. If you were designing a display for Data Link, how many lines of how many characters would you like, what type character style, color, and character size.

A/1 32W with segment characters.
A/2 Something similar to 3X7 in white.
B/1 32W best for further development. Possibly two lines or vertical presentation. Increase memory display.
B/2 Two or three lines of 15 to 20 characters each, stencil style, white color with intensity control, sized like NIMO. However, numerous other acceptable combinations exist, I'm sure.
C/1 It appears from most messages that a display of 24 active message units further amplified by scrolling, if needed, would handle the most complex of messages.
C/2 As many characters as possible on one line. Character style and size used in the 32W. White color.
D/1 I think I have already answered this in questions 1, 4, 8, 9.
D/2 A slightly enlarged version of the NIMO with three lines. I feel the CRT has a great potential and versatility to display a number of other symbols not presently used.
E/1 32W characters are fine, clear, readable, concise.
E/2 Same as 32W.
F/1 This is too small a space to answer this question. It would also take a lot of thinking.
F/2 One line; character style of 32W or try to use symbols; character size between 32W and 7W; as to color, further evaluation needed.
G/1 Two lines, two window style, white (yellow), of the size of the 3X7W display.
G/2 Would like a combo as indicated in question 1. Two lines and 7 to 32 characters. Style and color as in 32W (amber).
H/1 I'd like to see the 3X7W improved with the addition of a continued readout of altitude and airspeed. I feel the amber color would be ideal. One-half character size. All-in-all, the displays presented were excellent.
H/2 Two lines only. Character style, color and size were OK as demonstrated.
I/1 32W or 7W are good. Character style, color, and size of 7W is preferred.
I/2 (No comment)

27. Do you feel that additional experience working as a two or three man crew might change your opinion of Data Link.
(8) no, (3) yes, (7) other

A/1 For the better.
A/2 No.

B/1 Certainly, for a two-man active crew. Three-man not pertinent. ATC function on other end of the data link absolutly essential.
B/2 Yes. Experience always provides new information, and we haven't more than just begun to start.
C/1 Either (1) man or (2) data link does reduce voice requirement necessary in todays system.
C/2 Data link, properly presented, is preferable to voice for any crew size, and especially for single pilot operation.
D/1 No. I think its great!
D/2 No. I always liked data link as early as AGACS days!
E/1 Have a high regard for data link. A much needed system. Too much conversation and sorting of conversation is confusing.
E/2 No.
F/1 It might, but I doubt it.
F/2 No.
G/1 No.
G/2 I like it very much. I think that additional crew training experience would make me certain that I want the radio noise out of the cockpit.
H/1 I feel that the data link setup is excellent for one, OK for more crew.
H/2 I approve of data link and additional experience will improve the operation.
I/1 No.
I/2 No.

28. Would you like separate displays in prime location for pilot and copilot.
(12) no, (4) yes, (2) other

A/1 Not necessarily, but it would provide the increased reliability of redundancy.
A/2 One should be sufficient.
B/1 Might be necessary, should be evaluated in large cockpit.
B/2 Yes, if necessary. Both should have visual access. In GAT II, one display is OK.
C/1 Not required unless you infer a second backup system.
C/2 Not if display is located within view of both.
D/1 No. One display in central location is answer.
D/2 See question 4.
E/1 Yes.
E/2 No.
F/1 Yes. The biggest reason being you would have a backup in case of a failure of one unit.
F/2 No. One in a prime location.
G/1 No.
G/2 (No comment.)
H/1 This would be OK, however a center-mounted display is adequate.
H/2 No.
I/1 One display in center would be sufficient.
I/2 No.

29. What are you feelings concerning the impact on pilot workload if data link becomes available.
(14) reduce workload, (1) too much workload, (3) other.

A/1 Can be of considerable value enroute, some problems in the terminal area.
A/2 Reduced with data link. Voice communication is more of a load.
B/1 Too much workload on all of these displays. Large memory display essential.
B/2 It will reduce workload if its done right. Thats a fundamental objective.
C/1 With a display equal to 32W, a definite lowering if ATC will not mix voice and data link.
C/2 Properly displayed and presented, it will reduce workload.
D/1 Will certainly decrease the pilot workload.
D/2 Will lessen the workload.
E/1 Reduced drastically. Only problem could be too relaxing.
E/2 Would reduce workload.
F/1 Less the workload if properly designed and addressed.
F/2 Great help to crew where message is displayed for either.
G/1 Reduce pilot load.
G/2 The type of aircraft makes a difference. The GAT II instability would make a copilot support operation mandatory.
H/1 Ease the pilot workload. More relaxing, more efficient.
H/2 Lessen the workload.
I/1 Should lessen the workload.
I/2 Reduce workload.

30. Did you like the automatic scratch pad capability of the 32W display, or would you prefer to have all of the windows available for messages?
(13) as is, (4) all windows

A/1 Fine as is.
A/2 Yes, more windows are not necessary.
B/1 A giant step forward. Needs additional windows for increased memory or possible scroll type memory.
B/2 Auto retention/display is good for critical parameters. Scratch pad is a misnomer unless retention is permanent. This 32W isn't.
C/1 Prefer all the windows available with ability to call up scratch pad if desired.
C/2 Prefer to use all windows with manual recall.
D/1 I like it.
D/2 Yes. Nice to have. The last data inspected, especially in the fluid environment of radar vectors with frequently changing headings, altitudes, and speeds. Sometimes messages get confused and forgotten.
E/1 Preferred it.
E/2 Like 32W as is.
F/1 The more you can see of the whole message the better it is.
F/2 Prefer 32W.
G/1 Yes.
G/2 (No comment)
H/1 Automatic scratch pad capability is most satisfactory.
H/2 Windows available for messages.
I/1 Scratch pad is good.
I/2 Yes.

31. Did you like the scratch pad recall capability of the 3X7W display? How often did you use it? Did you prefer this to the 32W display?
Recall - like (10), no (5); Use - frequent (4), Prefer - 3X7W (2), 32W (6)

A/1 Yes. Requently. No.
A/2 Yes. Often. No.
B/1 Used it constantly. Prefer 32W memory.
B/2 The question is loaded. The retention is good but need to recall isn't, and the pilot should be able to retain as long as he likes.
C/1 No, but it was adequate, and like what I would want on a 32W.
C/2 This is an excellent feature. Prefer manual recall to automatic.
D/1 I also like this and yes I do prefer this method over the 32W.
D/2 No. I feel this is too distracting and creates excessive workload, especially in single pilot operation.
E/1 Yes.
E/2 Preferred 32W. 3X7W OK.
F/1 Yes, quite a bit. See question 30.
F/2 Used 3X7W recall very little. I prefer 32W scratch pad.
G/1 Did not use it. No.
G/2 Yes. Would like to see these combined.
H/1 Scratch pad recall on the 3X7W display is excellent.
H/2 No. Tried it. No.
I/1 Good.
I/2 No.

32. What is your opinion of having data link set the heading bugs and altitude alert automatically after pushing WILCO? Would you prefer this to the scratch pad capability? Both?

A/1 Would be nice. No. Would like both.
A/2 No. I think that the pilots should always have liberal control of bugs, etc.
B/1 Both would no doubt reduce workload. Would cost.
B/2 (No comment.)
C/1 (No comment.)
C/2 Having the above information automatically set in would be great. Would reduce.
D/1 Like to try it first.
D/2 And speed when applicable. Progress!
E/1 Both.
E/2 (No comment.)
F/1 Yes. This system is in the Air National Guards' F-106 and it worked beautifully. This system has been used by the USAF for the past 15 years.
F/2 Both.
G/1 Would like to try it out.
G/2 (No comment.)
H/1 I would prefer both capabilities.
H/2 Good. Yes.
I/1 Prefer scratchpad.
I/2 Both.

33. Any additional comments would be appreciated.

A/1 The peace and quiet of visual data link is magnificent. Visual presentation of numbers, e.g., heading, altitude, and frequencies is far superior to spoken command information. Far less chance for error. Biggest problem for data link is in the terminal area, because much helpful oral info is not available, i.e., command or advisory info between controllers and other aircraft.

A/2 None.

B/1 (1) Dislike scratch pad terminology for display. An actual scratch pad is now necessary for operator. Believe memory display is more descriptive term. (2) Am disappointed that NIMO was not updated as promised. Does the possibility exist that NIMO might prove to be an expensive or unreliable display? (3) At least 1 hour should be spaced between flights for recording experience of previous run. (4) Two-man crew in GAT II much less fatiguing than one-man crew in GAT I. Have some doubt in value of reducing flt. crews alertness by workload at this stage. (5) Copilot position will probably be operator of display and controls, especially memory, should be oriented to that position. (6) Evaluation should be primarily directed toward a standard display, low cost or suitable displays for light aircraft are an additional problem and cannot, in my opinion, be evaluated simultaneously with more sophisticated but necessary displays.

B/2 (1) This questionnaire should be rearranged to provide for the fact that different subjects tested the various units under different conditions, making comparison of all units by one subject impossible in many respects. (2) The avionics equipment discrepencies in GAT II should not be tolerated. They unnecessarily preoccupy the pilot and disrupt the tests. Aircraft faults of this sort are not acceptable, and there's no reason that these should be. (3) Messages should never be subject to inadvertent severance by the pilot. As it stands now, the pilot can prevent reception merely by a premature "WILCO" in many instances. This is an unacceptable design fault. (4) All lighted controls and functions should have intensity controls. (5) WILCO flash should be delayed until message reception is complete. (6) Automatic scrolling is undesirable because it requires continuous visual monitoring and memorizing by somebody. The workload thus goes up rather than down, defeating the purpose. (7) The control-wheel-mounted WILCO buttons are subject to inadvertent actuation. (8) Retention/display after WILCO is essential to any practical application of this data link concept, if workload increase is to be avoided. (9) There is applicability for both temporary and permanent message retention/display. The pilot has frequent need to refer back to previous advisories, including in some cases data that has been superceded. He needs a means of retaining some info at his option. (10) Red display characters demand much higher visual quality than white or green. White should be used if at all possible, with intensity control. (11) Some markings were not illuminated except by the aft overhead light. This is generally not acceptable for cockpit nite lighting. (12) Interpretation of numbers would be much enhanced by including dimensions (Ft, kts, deg, etc.) on display. It is very easy to confuse the meanings of a group of

3-digit numbers when they all fall, within each other's ranges and are dimensionless. (13) The pilot needs a means to indicate whether he had made visual contact with traffic called out by Radar Advisory, such as a special form of the WILCO function indicating "contact" or "no contact." It's equivalent to current audio communication procedure for collision avoidance.

C/1 (No comment.)

C/2 Data link reduces workload of crew, and reduces chance of misinterpretation or "missed" instruction.

D/1 I am most anxious to see data link operational in our aircraft.

D/2 (1) Abbreviation NM should be changed to MI (controllers don't say nautical miles but just miles). This means nautical automation. (2) The buttons on the display (WILCO, CLEAR etc.) should have some nominal lighting, so as to be readable in the dark. Now, only the lit button is readable. (3) I would very much like to see a running printout (tape printer would be fine) so one can go back and reread past clearance or whatever else. To confirm a clearance after it has been erased by a new message.

E/1 Highly in favor of data link and hope someday it can be tied to auto pilot T/O CLB ENRTE ARRVL and LAND.

E/2 Since having been exposed to radio info and using it to comprehend terminal traffic situations I don't know how the lack of it would effect.

F/1 The biggest deficiency I saw in all the units was; there was no way of positively in determining the "clearance limit."

F/2 (1) Would like to have printed rip off copy as backup references. (2) I don't think this questionnaire should have been ask for this soon since I flew 32W and 7W nite conditions only and 3X7 and NIMO day only. (3) Also, I didn't like recall of only last part of two part message. (4) In reporting direction of turn such as Rt 090° display shows arrow 090°. I prefer arrow 090° . (5) I think maybe symbols such as arrows versus wording stand out more and are shorter. (6) I liked 32W most of all because in message chg you still had your separate blocks showing your last altitude - HDG- SPD or cross check of chg.

G/1 Very impressed with the whole program and think it has great possibilities.

G/2 Would like to see the ALT-HDG-SPD in all displays to indicate latest instruction. This is a great step forward in ground-to-air communication.

H/1 I feel the data link displays are a tremendous improvement in ground-to-air communications and should be implemented as soon as possible. The one big disadvantage of the system is that in the future the pilots will have to learn to read!

H/2 We copied all important messages such as altitudes, heading, clearances. If a copy of readout could be incorporated the copilot would have more time for other duties.

I/1 (No comment.)

I/2 (No comment.)

Questioning of the FAA NAFEC test pilots concerning their experience was limited to determination of their age, total flying hours in all types of aircraft and hours flown in a light single-engine aircraft during the previous year. These data are tabulated below:

Crew Team	Pilot No.	Age	Total Flying Hours	Lt Aircraft Hrs. Last Year	Mean Age of Crew	Mean Flying Hrs.
A	1	45	8,000	10		9,000
	2	53	10,000	10	49	
B	1	53	10,500	50	50	9,400
	2	47	8,300	61		
C	1	51	20,000	--	51	19,000
	2	51	18,000	400		
D	1	49	9,500	25	48.5	11,250
	2	48	13,000	200		
E	1	51	19,000	--	51	13,500
	2	51	8,000	75		
F	1	48	11,000	40	46.5	7,621
	2	45	4,242	12		
G	1	51	5,000	120	51	10,150
	2	51	15,300	10		
H	1	50	13,650	--	52	11,325
	2	54	9,000	--		
I	1	51	10,000	25	50.5	11,000
	2	50	12,000	25		
	MEAN:	49.9	11,360.0	59.0	49.0	11,360.0

APPENDIX F

PILOT QUESTIONNAIRE AIR-GROUND DATA LINK DEVELOPMENT SUMMARY FOR THE ATA, ALPA, AND AOPA PILOT CREW COCKPIT DISPLAY TEST

The answers to these questionnaires are summarized for the nine two-man crews to the maximum extent possible; however, individual verbatum comments or paraphrased comments are listed for each pilot as crew No. (A through H, and A^1) and pilot No. (1 or 2) following the introduction to each section (a total of five) and each question (1, 2, 3, etc.) A table follows the questionnaire which lists the pilot crews and gives their ages, mean ages, total flying time and mean flying time.

32-WINDOW DISPLAY

A display presenting 32 characters on one line, using a dot matrix (LED).

Character color: Red-Orange.

Display characteristics:

1. Message flashes momentarily when presented - then steady.
2. WILCO button flashes continuously until pushed.
3. HDG-ALT-SPD presented continuously (scratch pad) - updates.
4. Message Pending light: When flashing, indicates additonal message to follow.

Response Buttons: WILCO CLEAR UNABLE

Operational Procedure:

1. Push WILCO: to acknowledge message allows second message to come up - lose first message.
2. Push CLEAR: to wipe out message - push again to return message.
3. Push UNABLE: to acknowledge receipt of an impossible message.

Please answer the following questions relating to the 32-Window display.

1. How would you rate the character size of this display?

	No. of Pilots
Too large:	0
Too small:	1
Satisfactory:	17

No unsolicited comments by any of the pilots were given.

2. Was the Red-Orange color of the characters easily readable?
(6) yes (3) no (9) no comment

A/1 (No comment.)
A/2 (No comment.)
B/1 (No comment.)
B/2 Would prefer white to standardize with other cockpit lighting.
C/1 (No comment.)
C/2 This appeared to be most satisfactory color and format for readability.
D/1 The best.
D/2 The best of the four displays tested.
E/1 But white would be better.
E/2 (No comment.)
F/1 This (display color) may not have been so good under intense sunlight. Our test was under simulated nighttime conditions.
F/2 Under lighting conditions (night) existing during test.
G/1 (No comment.)
G/2 (No comment.)
H/1 If the display were located directly in front of each pilot, the letters would not be too small.
H/2 Better than the red and green, not as good as the white.
A^1/1 (No comment.)
A^1/2 (No comment.)

3. When presenting a long message, this display loses the first portion of the message when WILCO is pushed. Is this a tolerable feature?
(10) yes, (5) no, (3) no response

A/1 Yes. More tolerable than 7W scrolling. However, this type of message should kept to a minimum.
A/2 Yes. It isn't desirable but may be tolerable after one gets used to it.
B/1 No response. Believe some capability of recall is necessary.
B/2 No. Don't recall any messages that long. Prefer to have "recall" capability of entire message or else have hard copy retention on a printer.
C/1 Yes.
C/2 Yes. Tolerable, but not desirable, pilots must record data.
D/1 Yes.
D/2 Yes.
E/1 No. Must be able to retrieve an entire message as important as these.
E/2 No. Recall of whole message could be imperative for clarity.
F/1 No. Prefer to have the whole message available by scrolling - in case of forgetting or showing other crew member, who may have been busy when WILCO was first pushed.
F/2 No. Believe full recall is necessary. Double character capacity would solve this, and also, could probably handle original airways (ATC) clearance.
G/1 (No comment.)
G/2 (No comment.)
H/1 Yes. If a cockpit printer is used.
H/2 Yes. More desirable to have entire message.

$A^1/1$ Yes. Pilot education should solve any problems with this.
$A^1/2$ Yes. But would prefer the ability to call back the first part of message in some manner.
4. Did you use the
4. Did you use the CLEAR button at any time?
(2) yes, (5) no, (11) ocassionally

Only pilot No. 2 from crew C added the unsolicited comment of "not required." There were no other comments.

5. Do you feel that the CLEAR button served any useful purpose?
(12) yes, (5) no, (1) no response

A/1 Yes. Nice to have a completely clear display. However, recall would be nice.
A/2 Yes. Under night conditions it would reduce cockpit glare (our's was day simulation).
B/1 Yes. It is at times desirable to remove "stale" information, as it is somewhat distracting.
B/2 Yes. Was able to live with continuous display, but found some advisory display (i.e., TFC) distracting when not cleared.
C/1 Yes. Removes information no longer needed.
C/2 No. Not required.
D/1 (No comment.)
D/2 Yes.
E/1 Yes. You don't have to stare at used data.
E/2 No. The change of message and flashing WILCO are good attention getters. The residual message is desirable.
F/1 Yes. Didn't use on this display, but did on others where it was used and liked, since I like all advisory and warning lights out during normal conditions.
F/2 No response. Limited.
G/1 No.
G/2 Yes.
H/1 Yes.
H/2 Yes. To remove message which after received serve no useful purpose.
$A^1/1$ No. None.
$A^1/2$ Yes. Comments given were not applicable to this display.

6. Were the abbreviations used in this display easily understandable?
(17) yes (1) no

A/1 Yes. Prefer abbreviations to arrows use. Entire message more often presented making abbreviation easier to understand in context.
A/2 Yes. However, use of unfamiliar three-letter NAVAID or station identification can cause confusion and need a way to query for clarification.
B/1 Yes.
B/2 Yes. There has been little need to standardize may of these abbreviations in the past. Although some pilots disagree. I see no problem with abbreviations as long as standards are adopted and abbreviations are spaced apart so they can be distinguished quickly.

C/1 Yes. Except through V-157.
C/2 Yes. Had some trouble but this would disappear with experience.
D/1 Yes. Wind direction velocity not standard.
D/2 Yes.
E/1 Yes. With practice.
E/2 Yes. Any problem would disappear with use.
F/1 Yes. Abbreviation of place names would have been difficult in unfamiliar area.
F/2 Yes.
G/1 Yes.
G/2 Yes.
H/1 Yes.
H/2 Yes. None.
A^1/1 Yes. Pilot education will be required.
A^1/1 No.

7. This display presents HDG-ALT-SPD <u>continuously</u> (scratch pad). Is this a desirable feature?
(17) yes (1) no

A/1 No. It is desirable to recall these items - and without destroying current message. However, a clear display is sometimes nice.
A/2 Yes. If pilot tires of looking at this display they can clear it.
B/1 Yes. Very useful.
B/2 Yes. Especially in G/A aircraft where no hdg, alt, or A/S bugs are available. Be of less use in airline type aircraft where BUGS must be set for flight guidance system input as well as for a memory jogger.
C/1 Yes.
C/2 Yes. Eliminates hand recording of data or necessity of pushing "recall."
D/1 Yes.
D/2 Yes.
E/1 Yes. Would also be satisfactory if it were always available but not necessarily always on display.
E/2 Yes. These are valuable references that would reduce note taking. No notes were taken at any time.
F/1 Yes. In this simulator, no other memory crutches were available (heading, airspeed, bugs, altitude, alert). In a jet cockpit with these devices, it might be desirable to erase them.
F/2 Yes.
G/1 Yes. Most desirable feature.
G/2 Yes.
H/1 Yes. The panel lettering should be backlighted or have flood lighting from the front, at night the heading, altitude, and speed were not visible.
H/2 Yes. For the absence of a heading bug and altitude reminder, or alert system.
A^1/1 Yes.
A^1/2 Yes.

8. Given the option, would you rather utilize the entire window for message display and have HDG-ALT-SPD available on call?
(11) yes, (6) no

A/1 Yes. Seeing entire message is (available with more windows) much easier and less attention-diverting. But recall of important items is very important.
A/2 Yes. This would allow longer messages to be presented which might help resolve the problem mentioned in No. 3.
B/1 No strong preference either way.
B/2 Yes. As long as it is available that is adequate. Possibly longer messages could wipe HDG-ALT-SPD out only if necessary with recall available for this case.
C/1 Yes.
C/2 No.
D/1 No.
D/2 No.
E/1 Yes. Definitely a better utilization of space.
E/2 Yes. If this would reduce or eliminate broken messages without recall.
F/1 Yes. Especially during terminal radar vectoring, I found the 3X7 with this feature annoying in that I continually had to recall the HDG-ALT-SPD.
F/2 Yes.
G/1 No. HDG-ALT-SPD remover is necessary.
G/2 Yes. H/1
H/1 Yes.
H/2 Yes.
A^1/1 No. Continuous presentation is desirable but not essential.

9. Rate the brightness of the pushbuttons when lit.
(4) too bright, (13) satisfactory, (0) too dim

A/1 Too bright. At night the lights are definitely too bright. However, some dim light continuously would help identify buttons at night.
A/2 Satisfactory. Probably too bright for night, although we didn't see it.
B/1 Satisfactory.
B/2 Satisfactory.
C/1 Satisfactory. Needs dimming feature for night.
C/2 Satisfactory.
D/1 Satisfactory.
D/2 Satisfactory.
E/1 Satisfactory.
E/2 Satisfactory.
F/1 Too bright. For night conditions.
F/2 Satisfactory.
G/1 Satisfactory.
G/2 Satisfactory.
H/1 Too bright. Dimming feature needed for night.
H/2 Too bright. Should have brightness control switch.
A^1/1 Satisfactory.

10. Would you prefer relabeling any of the pushbuttons and/or establishing a different pilot response function on the display?
(6) yes, (10) no, (2) no response

A/1 No.

A/2 Yes. Consideration should be given to designing so that both pilots have to push a WILCO button to insure that they both understand the message. For instance, present equipment could be wired so that first response through pushing either control wheel button or instrument panel button would change the WILCO light from flashing to steady and provide an acknowledgment signal to ATC. The the second pilot (who normally would be the one flying) would have to extinguish the WILCO light by pressing his own control column button, thereby, signalling acknowledgment of the message without requiring a vertical communication between the pilots. This arrangement may become even more essential in military aircraft with tandem seating, or in any situation where an interphone system must be used for crew communications.

B/1 No. Not based on this initial evaluation. Further work may indicate some changes to be desirable.

B/2 No response. Believe UNABLE is unnecessary since the reason for the UNABLE must be resolved with ATC anyway. Why not just have the pilot call on voice if unable. Every time I pushed UNABLE ATC asked "Whats your problem. Voice discussion followed. Does a WILCO for a traffic advisory mean "I'll watch for the traffic" or "I have the traffic in sight?"

C/1 No.

C/2 Yes. Remove CLEAR button. Allow manual scrolling of long messages through repeated pressing of WILCO button. The entire message should be available to the crew until replaced by another message. Even then, a hard copy printout should be available for later retrieval, if necessary.

D/1 No.

D/2 No.

E/1 Yes. Add button to call up HDG-ALT-SPD on demand. Have message and avoid flash <u>continuously</u> when prescribed, until WILCO or UNABLE buttons are pressed. Momentary alert is not enough and could be missed if attention is diverted.

E/2 Yes. Make CLEAR into RECALL and use it for HDG-ALT-SPD on call.

F/1 Yes. WILCO does not allow the "pilots' discression" option. There should be an 'acknowledge' (ack) and a start action (STRT ACT) button. Also, the UNABLE apparantly construes an "impossible" meaning to the designers. Many messages received today, receive an "unwilling" response meaning 'give me another option.'

F/2 Yes. Relabel CLEAR to read recall so first message can be returned.

G/1 No.

G/2 No.

H/1 No response. The WILCO button should have a dimming feature for night.

H/2 No. For night operation this display needs background lighting to label HDG-ALT-SPD with brightness control capability.

A^1/1 No.

A^1/2 No.

3X7-WINDOW DISPLAY

A display presenting three lines of 7 characters using light-emitting diodes in a 5X7 dot matrix.

Character color: Red

Display Characteristics:

1. Message flashes momentarily when presented - then steady.
2. WILCO flashes continuously until pushed.
3. Message Pending: When lit, indicates additional message to follow.
4. RECALL: Push to display HDG-ALT-SPD (scratch pad) on request.

Response buttons:	WILCO	MESSAGE PENDING	UNABLE	RECALL

Operational Procedure:

1. Push WILCO: to acknowledge message. Message stays until a new message comes up.
2. Push Message Pending: Wipes out message - push again to return message.
3. Push UNABLE: to acknowledge receipt of an impossible message.
4. Push RECALL: to display HDG-ALT-SPD on request.

Plesse answer the following questions relating to the 3X7-window display.

1. How would you rate the character size of this display?
   (8) too large, (0) too small, (10) satisfactory

A/1 Satisfactory.
A/2 Too large.
B/1 Satisfactory. Although could be smaller.
B/2 Satisfactory. Device too large to get into most cockpits. RNAV and other new systems will also be competing for prime space.
C/1 Too large.
C/2 Too large.
D/1 Too large.
D/2 Satisfactory.
E/1 Satisfactory. Could be smaller if space is a factor.
E/2 Too large.
F/1 Satisfactory. Maybe a little large.
F/2 Too large.
G/1 Satisfactory.
G/2 Satisfactory.
H/1 Satisfactory.
H/2 Satisfactory.
A^1/1 Too large.
A^1/2 Too large.

2. Was the red color of the characters easily readable during the following conditions?

Day - (9) yes, (2) no, (7) no response
Night - (13) yes, (3) no, (2) no response

A/1 Yes day and night.
A/2 Day unknown, and night no. Brightness capability such that readability should be good.
B/1 No, day and night. I do not care for red light for instrument lighting or any purpose such as this.
B/2 Yes, day and night. Prefer white lighting though, for cockpit standardization red is normally reserved for critical warning, engine fire, power failure, etc.
C/1 Yes, day and night.
C/2 No, night.
D/1 Yes, day and night.
D/2 Yes, day and night.
E/1 Yes, day and night. But white is better.
E/2 Yes, night.
F/1 Yes, night. Day not evaluated because did not test in bright sunlight.
F/2 Yes, night.
G/1 Yes, night. Did not evaluate during day.
G/2 Yes, night. Did not evaluate during day.
H/1 Yes, day.
H/2 No, day. Readable, but had a fuzzy double image appearance.
A^1/1 Yes, night.
A^1/2 Yes, day and night.

3. Rate the brightness of the pushbuttons when lit.
(4) too bright, (0) too dim, (15) satisfactory, (0) no response

A/1 Too bright and satisfactory. Both displays used at night needed some dim light in the control buttons so they could be properly identified in the dark; the 3X7W particularly because of the recall feature. In the dark it would be possible to push the "unable" button while trying for the "RECALL."
A/2 Satisfactory.
B/1 Satisfactory.
B/2 Satisfactory.
C/1 Satisfactory.
C/2 Satisfactory.
D/1 Satisfactory.
D/2 Satisfactory.
E/1 Satisfactory.
E/2 Satisfactory.
F/1 Satisfactory.
F/2 Satisfactory.
G/1 Satisfactory.
G/2 Satisfactory.

H/1 Satisfactory.
H/2 Satisfactory. Didn't notice the brightness during daytime operation.
A^1/1 Satisfactory.
A^1/2 Too bright.

4. Did you feel that this display provided too much information?
(0) yes (18) no

A/1 No. I prefer being able to have the entire message available at one time as was most often the case with this display.
A/2 No.
B/1 No.
B/2 No.
C/1 No. Color should be other than red.
C/2 No. Allows the use of fewer abbreviations.
D/1 No.
D/2 No.
E/1 No.
E/2 No.
F/1 No. I didn't feel that any of the displays gave as much useful information as we now receive by voice.
F/2 No.
G/1 No.
G/2 No. This unit seemed to be the easiest to work with.
H/1 No.
H/2 No.
A^1/1 No.
A^1/2 No.

5. This display presents HDG-ALT-SPD (scratch pad) when desired by pushing RECALL button. Is this information desirable? b. In this fashion? Comment.__

A/1 Yes. Being able to completely blank out the display with the recall is useful.
A/2 Yes. I think so. It's better than the 32W display.
B/1 Yes. Satisfactory this way although it is also satisfactory as is done on the 32 window display.
B/2 Yes. But redundant if HDG, ALT, and SPD BUGS must be set (see comments elsewhere).
C/1 No.
C/2 Yes. Prefers continuous display.
D/1 Yes.
D/2 Yes.
E/1 Yes. Excellent feature. Best way is on demand.
E/2 Yes. It was all right.
F/1 Yes. I liked it better when it stayed there till I erased it - not until some income message did.
F/2 Yes. Do not remember Recall button.
G/1 Yes. Excellent reference to assigned HDG-ALT-SPD.
G/2 Yes.

H/1 Yes. The scratch pad display was the most expressive part of this display. It could be very useful in almost operation. The letters could be smaller if the display were located directly in front of each pilot. However, with the center panel location the present size is very readable.

H/2 Yes. Same comment as 32 window. I liked this better than the display of of the 32 window.

A^1/1 Yes. Scratch pad capability very desirable.

A^1/2 Yes.

6. Did this display have any tendency to increase cockpit workload?
(2) yes (16) no

A/1 No. However, overall cockpit workload is increased by all displays.

A/2 No.

B/1 No.

B/2 No.

C/1 No.

C/2 Yes. Requires attention to be shifted from instruments to display.

D/1 No.

D/2 No.

E/1 No.

E/2 No.

F/1 Yes. Constant pushing of the recall button (in addition to being a visual distraction).

F/2 The vertical separation between message lines was too great. Like reading down a billboard from a close distance.

G/1 No. Reduced workload.

G/2 No.

H/1 No.

H/2 No.

A^1/1 No.

A^1/2 No.

7. Did the display provide too much information?
(0) yes (18) no

A/1 No. I found this display to be the most desirable of the 4.

A/2 No. Overall, I'd have to rate the 3X7 display as best of the four. Characters were larger than necessary, but information was adequate. This was the last of the four displays we tested, so by the time we'd worked out a cross-cockpit procedure whereby the C.P. did not push the WILCO button until after the P had verbally read the message. We'd been hand-flying the trainer long enough so that there was a fatigue factor involved which to me became noticable in my heading and altitude control, and on two occasions a failure to understand a clearance involving a heading or an altitude correctly. As the P during this test I found that I was taxed somewhat to remember that a verbal response was required of me whenever a message arrived whenever I was involved in an

instrument maneuver other than straight-and-level. When my response was not quick enough the C.P. would verbally repeat the message and I would nod, which worked out okay because I has usually already read the message mentally. This, I think is an additional argument to support the installation of wiring so both pilots can manually acknowledge receipt of the message without verbal cross-cockpit communication.

B/1 No. Same as question 4.

B/2 No.

C/1 No.

C/2 Yes. The more the better. The red LED's had a disconcerting effect - appeared to be blurred or flickering at a rate above the visual threshold. Scratch pad actually decreases workload by eliminating the need to record data.

D/1 No.

D/2 No.

E/1 No. Additional comments: (1) Same as for 32 window - present new message flashing until acknowledge button is pressed. (2) You should be able to recall all portions of message. (3) This applies to 32 window also: Have HDG-ALT-SPD numbers flash any time aircraft is outside certain parameters. Suggest limits of HDG $\pm 5°$, ALT $\pm 200'$, SPD ± 10 kts. This when pilot is complying with requested HDG-ALT-SPD the numbers are steady when he is outside predetermined limits they flash to alert him and keep flashing until correct values are achieved.

E/2 No. For the space it took up it did not have the desired message capacity.

F/1 No. Answered in No. 4.

F/2 No.

G/1 No.

G/2 No.

H/1 No.

H/2 No.

A^1/1 No.

A^1/2 No.

NIMO DISPLAY

A miniature Charactron cathode ray tube with three lines of seven characters available.

Character color: Green

Display characteristics:

1. Message flashes momentarily - then steady.
2. WILCO button flashes continuously until pushed.
3. Message Pending Light: when flashing, indicates additional message to follow.

Response buttons: WILCO CLEAR UNABLE

Operational Procedure:

1. Push WILCO: to acknowledge message - allows second message to come up - lose first message.
2. Push CLEAR: Wipes out message - push again to return message.
3. Push UNABLE: To acknowledge receipt of an impossible message.

Please answer the following questions relating to the NIMO display.

1. How would you rate the character size of this display?
   (0) too large, (15) too small, (3) satisfactory

A/1 Too small.
A/2 Too small.
B/1 Too small. Am not certain that it was the size or the shape that made them difficult to read.
B/2 Too small.
C/1 Satisfactory.
C/2 Too small.
D/1 Too small.
D/2 Too small.
E/1 Too small.
E/2 Too small. Unclear, not well formed.
F/1 Too small.
F/2 Too small.
G/1 Too small.
G/2 Too small.
H/1 Too small.
H/2 Too small.
A^1/1 Satisfactory.
A^1/2 Satisfactory.

2. Was the green color of the characters easily readable during the following conditions?
Day (2) yes, (6) no Night (5) yes, (6) no

A/1 No, day and yes, night.
A/2 Day, unknown but would guess more difficult to read in day. Yes, night.
B/1 No, day and night.
B/2 Yes, day, but not standard with cockpit color standards. Evaluations with sunlight directly on the display were not conducted. Some displays completely "wash-out" under this condition, others show glare. Night not evaluated.
C/1 No, day and night.
C/2 Yes, night.
D/1 No, day and night.
D/2 No, day and night.
E/1 No, day and night.
E/2 Day, no comments. No, night.
F/1 Day, no.
F/2 No, day.
G/1 Day, not used. Yes, night.
G/2 Day, no comment. No, night.
H/1 Day, no comment. Yes, night.
H/2 No, day.
A^1/1 Day, no comment. No, night.
A^1/2 Yes, day and night.

3. Did you use the CLEAR button at any time?
(2) considerably, (6) occasionally, (7) rarely, (3) not at all

A/1 Rarely.
A/2 Occasionally.
B/1 Rarely.
B/2 Not at all. I was flying, other pilot communicating, but he used it seldom also.
C/1 Rarely.
C/2 Rarely.
D/1 Rarely.
D/2 Rarely.
E/1 Occasionally.
E/2 Not at all.
F/1 Considerably.
F/2 Rarely.
G/1 Occasionally.
G/2 Occasionally.
H/1 Considerably.
H/2 Occasionally.
A^1/1 Not at all.
A^1/2 Occasionally.

4. Do you feel that the CLEAR button serves any useful purpose on this display?

(12) yes (5) no

A/1 No. The small size does not present a visual distraction and did not need clearing.
A/2 Yes. At nite it reduces the light in cockpit.
B/1 Yes. Again, it may at times be desirable to wipe out "stale" info.
B/2 Yes. See previous 3X7 and 32W comments. How about WILCO clearing display with recall.
C/1 Yes. No comment.
C/2 No. Not too much to be gained by erasing message.
D/1 No.
D/2 Yes.
E/1 Yes.
E/2 No. Not needed, old message not objectionable.
F/1 Yes. This was the last one tested, we were used to the displays and did not like the lights being constantly on. It gives the feeling of something being incomplete.
F/2 (Limited comment.)
G/1 Yes. Eliminating the display.
G/2 Yes.
H/1 Yes.
H/2 Yes. To remove messages which after received serve no useful purpose.
A^1/1 No.
A^1/2 Yes. I guess so, recall feature desired.

5. When presenting a long message, this display loses the first part of the message when WILCO is pushed. Is this a tolerable feature?

(8) yes (10) no

A/1 No. In all of the displays this loss was annoying more than a problem. I found a reluctance to push WILCO until I had fully understood first part of message, but light keeps flashing, urging action.
A/2 Yes. See No. 3 on 32 window display.
B/1 No. Some recall needed.
B/2 No. Didn't like NIMO at all. Difficult to read characters (even if lozy alignment of last line was overlooked) due to poor contrast, broken segments of letters, small size recessed presentation and fuzzy letters. Need recall - see question No. 3, for 32W.
C/1 No. Would prefer some retrieval capability.
C/2 Yes. Tolerable, but not desirable, pilots must record data.
D/1 No.
D/2 Yes.
E/1 No. Should have complete message retrieval.
E/2 No. On complicated clearances, note taking could be required.
F/1 No. This will lead to misunderstanding and errors.
F/2 No. Should have recall.
G/1 Yes.
G/2 Yes.

H/1 Yes. If a cockpit printer is used.
H/2 No. Should be able to recall first part of message.
A^1/1 Yes. Needs pilot education.
A^1/2 Yes. If No. 4 is complied with.

6. Did this display have any tendency to increase cockpit workload?
(13) yes, (6) no

A/1 No. Again - no more than others.
A/2 Yes. Due to smallness sometimes one has to lean toward display to read digits when eyeballs should be looking outside cockpit.
B/1 Yes. Difficult to read.
B/2 Yes and no. Overall workload, no if we didn't have to study display to read it. Yes, as it was during the tests....very hard to read.
C/1 Yes. Hard to see some numerals - I'm sure this is correctable.
C/2 Yes. Requires attention to be shifted from instruments to display.
D/1 No.
D/2 Yes. Because it was difficult to read.
E/1 No.
E/2 Yes. Needed verification of letters. The "8" way looked more like 11 until carefully examined.
F/1 Yes. All the displays did this by denying the use of the auditory sense.
F/2 No.
G/1 Yes. Radio transmission.
G/2 Yes. Unable to recall previously assigned HDG, ALT, and SPEED which is most desirable.
H/1 Yes. Display was hard to read - especially numbers.
H/2 No.
A^1/1 Yes. Small characters and distortion required more concentration on display.
A^1/2 Yes.

7. Were any of the messages on this display confusing due to the need for abbreviations? If yes, do you recall the message?
(6) yes (11) no

A/1 No.
A/2 Yes. The left or right turn arrows were too hard for someone with glasses to see. They appeared almost diamond shaped. One large arrow or words "left" or "right" would be preferable.
B/1 No.
B/2 Yes. No, but character shape and presentation difficult to read.
C/1 No.
C/2 Yes. Traffic messages.
D/1 No.
D/2 Yes. Not as easy as the other messages.
E/1 Yes. Hard to read due to size.
E/2 No. Do not remember any.
F/1 No. All potentially confusing message were transmitted by voice.
F/2 No.

G/1 No.
G/2 No. No comment.
H/1 No.
H/2 No.
A^1/1 No.
A^1/2 Yes. Abbreviation because of tiny window.

8. Rate the brightness of the pushbuttons when lit:
(2) too bright (0) too dim (13) satisfactory

A/1 Too bright at night. Satisfactory during daylight.
A/2 Too bright at night particularly - this was true with all four displays. Sound level of alerting beep-tone was good. Lack of decimal points in numbers was no problem. It took too much time to decipher traffic advisory messages partly because of size of digits.
B/1 No comment.
B/2 Don't recall - I was flying leg and other pilot was communicating.
C/1 No comment.
C/2 Satisfactory. We discussed the inadequate display readability. It appears to use too much prime space.
D/1 No comment.
D/2 No comment.
E/1 Satisfactory. Too small and there was distortion of bottom line. Far inferior to all others has this fault.
E/2 Satisfactory. We were super aware of the panel. I did not especially notice the brightness.
F/1 Satisfactory daytime test. Because of masking problems, the lower part of the display was at times totally unreadable. I would not have accepted this aircraft for flight.
F/2 Satisfactory. This display was very unsatisfactory. Believe it would be very difficult to read in most daylight conditions.
G/1 Satisfactory.
G/2 Satisfactory.
H/1 Too bright. Should be dimmable. I would hate to see a CRT display ruled out on the results of this small NIMO display.
H/2 Satisfactory. Didn't notice the brightness during daytime operation.
A^1/1 Satisfactory.
A^1/2 No comment.

7-WINDOW DISPLAY

A display limited to 7 characters on one line, using incancdescent lamps and fiber optics.

Character color: White.

Display characteristics:

1. Message flashes momentarily when presented - then steady.
2. WILCO button flashes continuously until pushed.
3. Message Pending button: Flashes to indicate additional message to follow.
4. All long messages scroll automatically/continuously until WILCO is pushed.

Response Buttons:	MESSAGE PENDING	WILCO	CLEAR	UNABLE

Operational Procedure:

1. Push WILCO: To acknowledge message - also stops scrolling.
2. Push Message Pending: (after WILCO) to scroll manually.
3. Push CLEAR: To wipe out message - push again to return message - does not destroy manual scrolling function.

External Controls:

1. Scroll rate: Adjusts rate of scrolling, fast or slow.
2. Brightness: Adjusts character brightness.

Please answer the following questions relating to the 7 Window display.

1. How would you rate the character size of this display?
   (9) too large, (0) too small, (9) satisfactory.

A/1 Too large.
A/2 Too large.
B/1 Satisfactory.
B/2 Satisfactory.
C/1 Too large.
C/2 Satisfactory.
D/1 Too large.
D/2 Satisfactory.
E/1 Satisfactory.
E/2 Too large.
F/1 Satisfactory.
F/2 Too large.

G/1 Satisfactory.
G/2 Too large.
H/1 Satisfactory.
H/2 Satisfactory.
A^1/1 Too large.
A^1/2 Too large.

2. Do you think the automatic scrolling feature of this display is a desirable feature.
(9) yes (8) no

A/1 No. Even with the speed control the message changing annoyed me - prefer to control it manually.
A/2 No. Scrolling stops when WILCO is pushed and this may inadvertently stop the presentation of the complete message.
B/1 Yes. Very useful.
B/2 Undecided. Preconceived opinion scrolling not desirable. Experience today - indicates may be acceptable although blinking of stale info somewhat annoying.
C/1 Yes. No
C/2 Yes. I wouldn't pay a lot of money for it. Manual scrolling adequate.
D/1 No.
D/2 No.
E/1 Yes. Excellent.
E/2 Yes. Absolutely necessary on this one - desirable to eliminate pending messages that disappear the first half on the and other displays.
F/1 Yes. Not only desirable, but necessary if any message is too long to print all at once.
F/2 Yes.
G/1 No.
G/2 No.
H/1 No. The scrolling feature took too much time to read.
H/2 Yes.
A^1/1 No. Tendency to stop scrolling after first part of compound message!
A^1/2 Yes. All features being equal.

3. Would you prefer strictly manual scrolling for one message at a time?
(8) yes (10) no

A/1 Yes.
A/2 No. Unit should be wired so WILCO lite doesn't illuminate until message and scrolling is complete.
B/1 No.
B/2 No. "Medium" changing rate would be adequate - no need for very slow rate or fast rate. Found distracting continuing to change after msg comprehended.
C/1 No.
C/2 No. Lukewarm about this.
D/1 Yes.
D/2 Yes.

E/1 No. As long as manual is available.
E/2 No.
F/1 No. The automatic scrolling leaves you hands free for other tasks.
F/2 No.
G/1 Yes.
G/2 Yes.
H/1 Yes.
H/2 No. But the option to scroll manually is preferable.
A^1/1 Yes. This would increase workload, but would help avoid missing part of message.
A^1/2 Yes.

4. Did this display have any tendency to increase cockpit workload?
(13) yes, (5) no

A/1 No. Again - no more than the others.
A/2 Yes. At times it made us concerned whether we were complying properly with ATC instructions.
B/1 No.
B/2 No. Overall, no. Not having to pick out msg addressed to me from other chatter was helpful.
C/1 Yes. Requirement for scrolling after WILCO pressed.
C/2 Yes. Requires attention to be shifted from instruments to display.
D/1 Yes. Had to be monitored to get complete message.
D/2 Yes.
E/1 Yes.
E/2 Yes. Takes longer to interpret - no hold of ALT-HDG-SPD involved.
F/1 Yes. Extra buttons to push, but most important is the need to look away from flight instruments and traffic watch. This is common to all the displays.
F/2 No.
G/1 Yes.
G/2 Yes. It is necessary monitor longer for complete message which slows instrument crosscheck.
H/1 Yes.
H/2 No.
A^1/1 Yes. Increased attention to display necessary while scrolling. Scrolling feature undesirable.
A^1/2 Yes. Little more than others in decode.

5. Was the color (white) of the characters easily readable?
(16) yes (2) no

A/1 Yes.
A/2 Yes.
B/1 Yes.
B/2 Yes.
C/1 Yes.
C/2 Yes.
D/1 Yes.
D/2 Yes.

E/1 Yes. Excellent.
E/2 Yes.
F/1 Yes. I like it better than red. It is not so hard on the eyes.
F/2 Yes.
G/1 Yes.
G/2 No.
H/1 No.
H/2 Yes. The best of 4 displays. Refer to #6.
A^1/1 Yes.
A^1/2 Yes.

6. How often did you use the CLEAR button?
(1) considerable, (11) occasionally, (5) rarely, (1) not at all

A/1 Occasionally.
A/2 Occasionally.
B/1 Occasionally.
B/2 Considerable.
C/1 Rarely.
C/2 Rarely.
D/1 Rarely.
D/2 Occasionally.
E/1 Occasionally.
E/2 Not at all.
F/1 Rarely. This was the first test and we were getting used to the equip.
F/2 Rarely.
G/1 Occasionally.
G/2 Occasionally.
H/1 Occasionally.
H/2 Occasionally. Regards to Questions 5 and 6. I think synthetic speech is preferable to visual displays because the visual requires too much attention to be devoted within the cockpit. The visual display might be satisfactory at altitudes above ten thousand feet in a ARTC radar environment because most other traffic at these altitudes would be ARTC controlled. In the approach and departure segments of flight at lower altitudes in high traffic areas a visual data display along with all the required checklist items to be performed prior to landing and after takeoff requires too much attention to be focused within the cockpit. This greatly increases the potential of midair collision. I don't feel there is any significant change in pilot workload with data link. No more action is required to acknowledge a data link message than to acknowledge a radio transmission.
A^1/1 Occasionally.
A^1/2 Occasionally.

7. Do you feel that the CLEAR button serves any useful purpose on this display?
(14) yes (4) no

A/1 Yes. A partial message remaining on display was distracting; clearing was useful.

A/2 Yes. Display would cause too much cockpit glare at nite (even if dimmed) which makes CLEAR button important.
B/1 Yes.
B/2 Yes. See previous comment.
C/1 Yes.
C/2 No.
D/1 No.
D/2 Yes.
E/1 Yes. Same as others.
E/2 No.
F/1 Yes. Same as before - like to get rid of unnecessary lights so when one comes on, it means something.
F/2 Yes. Would be desirable under some conditons.
G/1 Yes. To eliminate display.
G/2 Yes.
H/1 No.
H/2 Yes.
A^1/1 Yes.
A^1/2 Yes.

8. Is the scroll rate adjust capability a desirable feature?
(5) yes (11) no

A/1 No. I didn't like the automatic scrolling, so adjusting the speed would not be necessary.
A/2 No. A fixed rate, slightly faster than the midpoint on the adjustment we used, would be acceptable.
B/1 No. Difficult to assess but don't think it necessary.
B/2 No. Need not apparent because we left display at 'medium' rate.
C/1 Yes.
C/2 Yes. For auto scrolling it will be required.
D/1 No.
D/2 No.
E/1 Not necessary - one rate as long as manual available.
E/2 Yes.
F/1 No. Didn't even use it. You picked a good rate when you left us with it.
F/2 No. No. One setting should be satisfactory.
G/1 No.
G/2 Yes.
H/1 No. A manual scroll might be better than an automatic. The automatic scroll was not at the right rate.
H/2 Yes. A must with automatic scrolling.
A^1/1 No.
A^1/2 No comment.

9. Was the brightness control feature of any benefit during the simulated day and/or night condition?
Day - (10) yes, (2) no Night - (6), (2) no

A/1 Yes, day and night.
A/2 Yes, day. Though we didn't use it at night, this feature would be very important during night flight.
B/1 No, day and night.
B/2 Day, not evaluated. Prior experience showed a brightness control necessary for varying lighting conditions. No, night.
C/1 Yes, day and night.
C/2 Yes, day.
D/1 Yes, day and night.
D/2 Yes, day and night.
E/1 Yes, day and night. Excellent.
E/2 Yes, day.
F/1 Yes, night.
F/2 No comment.
G/1 Yes, day.
G/2 No, day.
H/1 Yes, day.
H/2 Yes, night. The push buttons were too bright, they also should have a brightness control capability.
A^1/1 No, day.
A^1/2 No comment.

10. Do you feel that this display provided too much information?
(0) yes (18) no

A/1 No. In fact, I dislike not seeing more of the message at one time.
A/2 No.
B/1 No.
B/2 No.
C/1 No.
C/2 No.
D/1 No.
D/2 No.
E/1 No.
E/2 No.
F/1 No. This, like all the displays provides far too little information.
F/2 No.
G/1 No.
G/2 No.
H/1 No.
H/2 No.
A^1/1 No.
A^1/2 No.

11. Were any of the messages on this display confusing due to the need for abbreviations?
(4) yes (14) no

A/1 No. Often the message was not completed prior to the WILCO flight flashing, and by pushing the button, the scrolling would stop. Only by manually scrolling did we discover that there was an additonal instruction - for example, an "ident" instruction at the end of another message.

A/2 Yes. Clearances were confusing when we were cleared to do something like "ALT 050" when wer had been maintaining that altitude for some time. Caused pilots to wonder whether either the altimeters or the transponder was malfunctioning.

B/1 No.

B/2 No. Many were clear - liked use of arrows, otherwise 7W would be confusing.

C/1 No.

C/2 Yes. This may disappear with experience.

D/1 No.

D/2 No.

E/1 No. (1) should have HDG-ALT-SPD info. (2) why should this not have endless scroll capability for messages? Why have message broken after 3 lines presented?

E/2 No. It could be confusing with long messages and lack of recall.

F/1 No. The abrv. wr. fn.

F/2 Yes. The letter "C" appeared as the letter "V".

G/1 No.

G/2 No.

H/1 No. The automatic scroll feature took too long to read - on occassion three times through the message if a word were missed the first time through. The rate control really didn't help since different words or commands are read at different rates.

H/2 No.

A^1/1 No.

A^1/2 Yes.

GENERAL

The following questions are of a general nature and apply to all four displays.

1. Did you find the audio alert signal preceeding each message to be helpful?
   (17) yes, (0) no, (1) no response

A/1 Yes. Necessary in an actual airborne environment to alert pilots.
A/2 Yes. Volume was very good. But frequency or tone was too nearly identical to that used by altitude alerting devices now in use on air carrier aircraft.
B/1 Yes. This appeared to be useful however with the multiplicity of audio alert functions in today's aircraft, more thought needs to be given to ways of attractng the pilots attention.
B/2 Yes. Necessary especially if display not balnked before new message.
C/1 Yes. Definitely needed, but sounds similar to altitude alert tone.
C/2 Yes. This will be a requirement, but must be effective while not annoying.
D/1 Yes.
D/2 Yes.
E/1. Yes. Absolutely necessary.
E/2 Yes.
F/1 Yes. It is necessary to draw attention to that part of the instrument panel
F/2 Yes. Essential.
G/1 Yes.
G/2 I found it to be annoying at night (flashing WILCO lite sufficient), but helpful in daylight.
H/1 Yes. This is a good signal, both sound and duration.
H/2 Yes.
A^1/1 Yes. Essential function.
A^1/2 Yes.

2. Did the momentary flashing of the message provide any meaningful alert function.
   (12) yes (5) no (1) no response

A/1 No. Once audible signal heard, no other alert is necessary, especially with lited "WILCO."
A/2 It gave a visual cue that catches pilots' eye when other cockpit workload is heavy, i.e., when scanning for traffic; when troubleshooting malfunctions; when using RADAR while operating thru areas of weather activity.
B/1 Yes. Depending on location of unit in cockpit, it may obliviate need for audio alert.
B/2 Yes.
C/1 Yes.
C/2 No. This could be removed if aural warning is used.
D/1 Yes.
D/2 Yes.
E/1 Yes. Should be continuous until acknowledgment.
E/2 Yes. It is hard to be sure how much.

F/1 No. It just made the message hard to read.
F/2 Limited.
G/1 No. Audio is sufficient.
G/2 Yes.
H/1 No.
H/2 Yes.
A^1/1 Yes.
A^1/2 Yes. You soon become accustomed to some message being in the window most of the time and the flashing feature should indicate that there is something new.

3. Would you prefer a longer or shorter flashing duration of the message?
(3) longer, (2) shorter, (12) as is, (1) no response

A/1 Shorter.
A/2 As is.
B/1 Longer.
B/2 As is.
C/1 Longer.
C/2 Prefer none. You must wait until flashing stops to read message.
D/1 As is.
D/2 As is.
E/1 Longer. Continuous.
E/2 As is.
F/1 Shorter.
F/2 As is.
G/1 As is.
G/2 As is.
H/1 As is.
H/2 As is.
A^1/1 As is.
A^1/2 As is.

4. What is you preference for location of the WILCO button?
(6) on the display, (2) on control column, (10) both

A/1 Both. We used the one on display more, but with use the pilots would develop procedures, and I believe the control column button would be used more.
A/2 Both. See comment after #10 on 32 window display regarding the necessity to have a non-verbal way for both pilots to acknowledge receipt of message. In addition, several times the WILCO lite malfunctioned and we were able to extinguish it only with control column buttons.
B/1 Both.
B/2 Both. Used button on display more than I anticipated I would.
C/1 Both.
C/2 On control column.
D/1 On the display.
D/2 On the display.

E/1 Both.
E/2 Both. The visual button on display is very good.
F/1 The display. The control column button was too handy. I was WILCOing messages I later had second thoughts about, just to put out the flashing light.
F/2 On the display. ONLY!
G/1 Both.
G/2 Both.
H/1 On the display.
H/2 Both
A^1/1 On control column.
A^1/2 On the display. I'd be inclined to warn against the control column because so many airplanes these days have emergency cut-off buttons for the autopilots on the control column.

5. Do you think improved synthetic speed might be preferable to the use of visual character displays?
(5) yes (8) no (5) no response

A/1 No.
A/2 No. One of the very nice features of the visual displays were the "SCRATCH PAD" and "RECALL" features. Even good voice might lose this. In addition it seems the length of time for receiving voice msgs. would be greater.
B/1 Have not had an opportunity to evaluate synthetic speech.
B/2 Yes. When I was flying and other pilot radioing, found myself looking at display unnecessarily for many msgs. such as frequency changes and transponder squawks which diverted unnecessarily my attention from flt. instruments.
C/1 I think it should be evaluated - I think I prefer the visual display.
C/2 Yes. Pilot visual channels are already overloaded.
D/1 No.
D/2 No.
E/1 Let me hear it - then I'll tell you. Unfair question - loaded.
E/2 No. There would be more confusion in retention and interpretation.
F/1 Yes. I can't evaluate synthetic speech having neverheard it; but many times, the visual display was distracting at a critical time.
F/2 Might be. Would like to try it.
G/1 No.
G/2 No.
H/1 Yes.
H/2 Yes. I think synthetic speech is preferable to visual displays because the visual requires too much attention to be devoted within the cockpit. The visual display might be satisfactory at altitudes above 10,000 feet in a ARTC radar environment because most other traffic at these altitudes would be ARTC controlled. In the approach and departure segments of flight at lower altitudes in high traffic areas a visual data display along with all the required checklist items to be performed prior to landing and after takeoff requires too much attention to be focused within the cockpit. This greatly increases the potential of midair collision.

$A^1/1$ No. Might be as good, but certainly not better.
$A^1/2$ Possibly, although I think the scratcpad capability of seeing characters displayed continuously or repeated are of considerable value to a pilot who is flying a complete procedure all alone.

6. What are your feelings concerning the impact on pilot workload if data link becomes available?
(13) benefit/improve/reduce/lessen, (2) increase/greater, (3) same

A/1 Workload will be reduced, especially in terminal areas where much time is consumed receiving and repeating routine instructions.
A/2 Workload will definitely be reduced.
B/1 Difficult to say based on this evaluation. Overall workload would appear to be about the same, however, something may be gained by not having to monitor radiofrequencies.
B/2 Hopefully overall will be reduced. It will take some time to learn usage and abbreviations but this should present no significant problem. Major workload reduction seems to be for the controller with the pilot receiving the same messages as today.
C/1 I don't think it would be significant.
C/2 Properly handled, data link can improve cockpit conditions. The method of data presentation is the key, and deserves careful attention.
D/1 Would lessen workload in terminal areas.
D/2 Data link should lessen the pilot workload.
E/1 OK if you don't foul it up with a lot of "garbage." Keep it strictly operational and practical.
E/2 There is a definite safety factor and workload benefit to data link.
F/1 There will be some increase in cockpit workload but this problem in insignificant compared to the loss of pilot awareness of his situation in the air traffic system. The latter presents grave economic safety considerations.
F/2 Could be a useful tool if properly and workably organized.
G/1 It will definitely reduce the workload in the cockpit.
G/2 I don't believe it will change pilot workload very much. Freq and transponder codes will have to be changed (as always). The only thing eliminated is the time lag of establishing voice communications.
H/1 Workload should be decreased since the only messages received of for that aircraft. It should make things a lot quieter and more orderly.
H/2 I don't feel there is any significant change in pilot workload with data link. No more action is required to acknowledge a data link message than to acknowledge a radio transmission.
$A^1/1$ Would ease workload slightly.
$A^1/2$ It should help and will certainly cut down on the verbage on the present communications frequencies but there is one aspect to this that kept occurring to me as I participated in thes tests: I wonder how many other pilots will react somewhat unfavorably to the almost total silence? I've become so accustomed to the casual, friendly conversation back and forth with controllers that I wonder about the psychological effect of all this computerized precision. I wonder how many people would prefer a printout of some kind to a telephone where they talk with the people they're

calling? And somewhere in all of this there absolutely must be some practical recognition of the fact that data link may not ever serve the total purpose to which you tried to apply it in these tests. I can't imagine how you can automate or standardize the kind of information you were purporting to give in such simple routine things as taxiing instructions, take-off clearance and so on. I don't know of a pilot anywhere who doesn't have numerous questions that pertained to the circumstances at hand at any given moment and you just can't ask a computer to answer them. Of course you can pump all the pertinent data into an ATIS presentation - but then how do you warn a pilot that he should look out for wing tip vortices? How does a pilot find out where to taxi on a strange airport? How does a pilot find out if he can take off from an intersection? These are typical of dozens of questions that take place all the time in a person's ordinary flying.

7. Would you like separate displays in prime locations for pilot and copilot?
(8) yes (8) no (2) no response

A/1 No. One display sufficient, needed procedures to insure both pilots got message. Would recommend two WILCO lites - one for each pilot, that would flash until pushed. Pushing either would send acknowledgement to ground. But by having two lights, each pilot could determine at a glance that the other had received the message.
A/2 Yes. Desirable but by no means essential unless we reach a stage where redundancy is required.
B/1 Yes.
B/2 Yes. Pilot actuated functions should be interconnected so when non-flying pilot pushes WILCO - it acknowledges and puts out WILCO lights on both pilot and copilot panels.
C/1 No. One is sufficient.
C/2 No. Central display seems adequate.
D/1 No.
D/2 Yes. In the DC-9 I feel this would be preferable.
E/1 Not necessary if one convenient to both.
E/2 No. Not if visibility is satisfactory to both.
F/1 Yes. They should be in the center of the control wheels (smaller).
F/2 Yes. Install in center of control yokes. Would not lose prime panel space. Would be in normal reading position.
G/1 No. Not enough cockpit panel space available.
G/2 Yes.
H/1 Yes.
H/2 No.
A^1/1 No.
A^1/2 Not applicable.

8. If you were faced with a trade-off between a small display in a prime location or a larger display in a less desirable location, which would you prefer?
(14) small/prime, (1) large/less desirable, (3) no response

A/1 Small/prime. Depending on meaning of less desirable.
A/2 Small/prime. Prime location is very important - to attract pilot's attention.
B/1 Small/prime.
B/2 Small/prime. Especially true to terminal area and approach phases of flight.
C/1 Small/prime. Prime location is important.
C/2 Small/prime. Must have access to information with minimum of effort.
D/1 (No comment.)
D/2 Small/prime. This display must still be large enough to read even in turbulence.
E/1 I won't accept a trade-off on location - it must be both of adequate size and must be an acceptable location OR FORGET IT!! Anything else and we better keep what we have.
E/2 Small/prime. This would need evaluation of a proposal before final decision.
F/1 Small/prime. Provided there was one available to each pilot.
F/2 Large/less desirable.
G/1 Small/prime.
G/2 Small/prime.
H/1 Small/prime.
H/2 Small/prime.
A^1/1 Small/prime. Characters could be smaller without loss of readability.
A^1/2 It all depends on what you mean by a small display. The only actual small display I saw was NIMO which is almost inexcusable. I could only make such a judgment on the basis of some logical modern display.

9. Do you have any color preference for message display?
(15) yes (3)no (5 1/2) red (5 1/2) white (2 1/2) orange (1 1/2) green

no
A/1 Yes. Red.
A/2 Yes. Red. Having worked in cockpits with all red, all white, and comb. red and white instrument lighting. I have a definite preference for RED lighting with good bright/dim controls.
B/1 Yes. Prefer white.
B/2 Yes. White - to standardize with other panel and cockpit lighting.
C/1 Yes. Green - not red.
C/2 Yes. Amber/orange part of the spectrum.
D/1 Yes. Red/orange.
D/2 Yes. Red/orange.
E/1 Yes. White.
E/2 Yes. Red-orange is quite adequate; white was OK as presented. Cathode Ray colors may not be adequate under all conditions.
F/1 Yes. White.
F/2 Yes. Red/night -- White/day.
G/1 No.
G/2 Yes. Light Red, Blue, or Green.
H/1 No. I thought that white would be best, but after observing the four displays I believe any color contrasting with white cockpit would be acceptable.

H/2 Yes. White, with brightness control capability.
A^1/1 Yes. Red.
A^1/2 No.

10. Would you prefer an improved CRT display or the use of line/s for message display?

(0) CRT, (15) lines, (3) no response

A/1 Line/s. CRT of larger size displaying lines, OK. Similar to Computer Terminal displays.
A/2 Line/s. Question hard to judge because CRT display was so tiny, although not too difficult to read.
B/1 Line/s.
B/2 Further development, evaluation, and discussion needed.
C/1 Line/s.
C/2 Line/s. May change my mind after seeing improved CRT.
D/1 Line/s.
D/2 Line/s.
E/1 Line/s.
E/2 Line/s. Visibility seemed better.
F/1 The CRT would have to be improved to be useable - the lines were OK.
F/2 Line/s.
G/1 Line/s.
G/2 Line/s.
H/1 No preference - A good CRT such as used on RNAV displays.
H/2 Line/s.
A^1/1 Brite display would be OK.
A^1/2 Line/s. CRT NIMO stated as almost inexcusable in comments to question 8.

11. If you were designing a display for Data Link using a line/s display, how many lines of how many characters would you prefer?

(4) 32W (3) 3X7W (10) other

A/1 3 lines, 7 characters. This is difficult to answer. I prefer the 3X7.
A/2 3 lines, 30 characters.
B/1 1 line, 32 characters. Based on what we observed here the 1 line 32 characters presentation seemed very desireable however would like to give more thought to subject.
B/2 Make characters as large as possible within available space (space available probably no larger than standard instrument use).
C/1 1 line, and as many characters as possible in the space available.
C/2 1 line, 25 - 30 characters.
D/1 (No comment.)
D/2 (No comment.)
E/1 1 line, maximum characters.
E/2 2-3 lines, 64-96 characters. Depending on length of longest message expected. There should not be a requirement to lose half of message.
F/1 1 or 2 lines, at least 32 characters per line.
F/2 2 lines, 64 characters.
G/1 1 line. The single line presentation and 32 characters presented the best display; additional characters could possibly be utilized.

G/2 3 lines, 7 characters.
H/1 3 lines minimum, 7 characters. The 3X7 was the easiest to read at a glance - requiring the least amount of time devoted to reading messages.
H/2 (No comment.)
A^1/1 3 or less lines, as many characters as possible.
A^1/2 I don't think it matters once you get the characters down to a usable size.

12. What is you opinion of having Data Link set the heading bug and altitude alert automatically after pushing WILCO?
(7) yes (10) no (1) no response

A/1 No. Experience has been that automatic systems are abrupt and mechanical with no concern for the overall aircraft position and configuration - let pilots do it.
A/2 No. This gets into the argument of who is flying the airplane and when if or whether these tasks are accomplished is none of the controller's business so long as control instructions are complied with. As an ALPA safety and engineering representative I am appalled at even the suggestion that a controller should have the electronic capability of repositioning any devices of any nature associated with flight instruments or cockpit controls!!! To me, even such a suggestion indicates a lack of knowledge on the part of someone about the mental and physical actions required of pilots in the performance of cockpit duties under instrument flight conditions in jet aircraft. Most jets have a heading bug mode on autopilot. If engaged data link could turn aircraft. This is not an acceptable arrangement.
B/1 No. This type of function must remain a cockpit crew responsibility.
B/2 Yes. Concept needs evaluation but sounds useful. Would need annunciation to differentiate when controlling and when pilot is setting bugs .
C/1 Yes, It should be <u>optional</u>.
C/2 Pilot should have the <u>option</u>. Perhaps one push to acknowledge, second push to allow automatic insertion of data.
D/1 No. May be unable to comply or wish to delay to - frequently.
D/2 No.
E/1 No. One more mechanical link which can go wrong and obviously must be X-checked anyhow.
E/2 Yes. Desirable but not mandatory.
F/1 No. I wouldn't even ride as a passenger in an airplane where the pilot didn't have to think about what heading and altitude he would fly.
F/2 No. Requiring pilots to set heading bug and altitude alert would provide a double check on pilot <u>comprehension</u> of message. Want <u>NO AUTOMATIC MANIPULATION OF OTHER FLT/NAV COMPONENTS IN COCKPIT</u>.
G/1 Yes. Decrease workload.
G/2 No.
H/1 Yes.
H/2 Yes. Another step toward reducing cockpit workload.
A^1/1 No. Malfunction would be chaotic.
A^1/2 Leave all the exotic development to the manufacturers.

b. Would you prefer this to scratch pad capability?
(3) yes, (14) no, (1) no response

A/1 No.
A/2 No. Comment to #12 applicable - there are too many valid and important safety reasons for heading bugs and altitude alert devices to be manually set by pilots instead of electronically by contractors.
B/1 No.
B/2 Yes.
C/1 No.
C/2 No.
D/1 No.
D/2 No.
E/1 No.
E/2 No. The pilot should be able to set his own bugs and alerts and not have some fault in system miss set something.
F/1 No. The pilot still has to take the information from the scratch pad and apply it to his flight. He must do this if he is to remain in control and effectively monitor for dangerous errors.
F/2 No.
G/1 Yes. Decrease workload.
G/2 No.
H/1 No.
H/2 Yes.
A^1/1 No. Scratch pad one of best features.
A^1/2 (No comment.)

13. Please rate the four displays you have just flown in the order of your preference (1-2-3-4).

Crew/Pilot	32W	3X7W	7W	NIMO
A/1	2	1	4	3
A/2	2	1	3	4
B/1	1	2	3	4
B/2	1	2	3	4
C/1	1	2	3	4
C/2	1	2	3	4
D/1	1	2	3	4
D/2	1	3	2	4
E/1	1	2	3	4
E/2	1	2	3	4
F/1	1	3	2	4
F/2	1	3	2	4 (99th)
G/1	1	2	4	3
G/2	2	1	3	4
H/1	2	1	3	4
H/2	2	1	3	4
A^1/1	1	2	4	3
A^1/1	2	1	3	4

Additional comments:

A/2 It hasn't been mentioned elsewhere, but is important to note that the cockpit reactions to responding to the WILCO lite was exactly opposite in day and nite simulation. Daytime we automatically felt it more important to accomplish the instruction before punching out the lite, whereas at nite we automatically felt it more important to shield the pilots eyes from the pulsing glare of the lite before accomplishing the instructions. This we felt, is something that can be corrected by having a capability to make the response lites very dim. There also needs to be a background liting capability for the response buttons because under certain lighting conditions, it was impossible to see which button to punch. When given an instruction to both descend and slow down, on the 3X7 display, there was no capability to indicate which the controller wanted first. This is always a problem whenever flying an aircraft that can not do both at the same time. Controllers never seem to learn that when they slow an aircraft then that aircraft's descent rate must be reduced, often substantially, if they are to comply with the restricted speed. Other points to be made are as follows: There will be difficulty convincing pilots that data link communications won't deprive them of that very necessary sense of what is going on with respect to other airplanes around them. For instance, it's damned important to one's mental preparation to know that the two airplanes ahead of you both missed their approach. Inmumerable other such situations can be cited. How, too, does one communicate with the computer to get clarification of instructions or advisories about traffic? How does one get an immediate avoidance vector for traffic? How does one get a deviation around ? How does one indicate an inability to climb or descend to resolve traffic conflicts? (descending into severe WX or climbing on occount of weight.) On balance it would seem that far more research is necessary before data link communications can be accepted by pilots as a safe and useful tool for ATC communcations purposes. Also this pilot thought the 32W and 3X7W displays "were both of nearly equal preference."

E/1 Combine good features on one set for ideal: (1) 32 window or more with scroll to give unlimited capability. (2) Scratch pad capability on request. (3) White figures the size of those on 3X7. (4) Complete message retrievability. (5) Better alerting system.

F/2 Believe there were too many displays to evaluate during one occasion. Recollections tend to overlap. A single light intensity with a day/night filter might prove workable. Clearances should contain trip identification for confirmation. Data Link communications concepts have interesting potential applications but, at this time, I think there are limitations we should not try to exceed without very cautious and thorough consideration of the "real-world" operational, rather than just technical problems.

$A^1/1$ 32-window (preference 1) and 3X7 window (preference 2) "almost tied."

Questioning of the ATA, ALPA, and AOPA pilots, concerning their experience was limited to determination of their age and total flying hours in all types of aircraft. These data are tabulated below:

Crew Team	Pilot No.	Age	Total Flying Hours	Mean Age of Crew	Mean Flying Hours
A	1	30	2,700	35	4,375
	2	40	6,050		
B	1	54	17,000	42	8,900
	2	30	800		
C	1	39	5,000	42.5	8,000
	2	46	11,000		
D	1	46	16,000	41.5	10,750
	2	37	5,500		
E	1	55	25,000	55.5	14,250
	2	56	3,500		
F	1	32	3,900	38.5	9,450
	2	45	15,000		
G	1	42	7,000	42	10,250
	2	42	13,500		
H	1	37	7,000	33	6,250
	2	29	5,500		
A[1]	1	35	3,400	47.5	5,500
	2	60	7,600		
	MEAN:	41.9	8,636.1	41.9	8,636