A PILOT EVALUATION OF TEXT DISPLAY FORMATS FOR WEATHER INFORMATION IN THE COCKPIT

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October 1995

DOT/FAA/CT-TN95/42

U.S. Department of Transportation
Federal Aviation Administration
Technical Center
Atlantic City Airport, N.J. 08405

Technical Report Documentation Page

1. Report No. DOT/FAA/CT-TN95/42	2. Government Accession No.	3. Recipient's Catalog No.
4. Title and Subtitle A PILOT EVALUATION OF TEXT DISPLAY FORMATS FOR WEATHER INFORMATION IN THE COCKPIT		5. Report Date October 1995
		6. Performing Organization Code CSERIAC Task #93956-24
7. Author(s) Albert J. Rehmann; Michael C. Reynolds, Mark E. Neumeier, Midwest Systems Research, Inc.		8. Performing Organization Report No. DOT/FAA/CT-TN95/42
9. Performing Organization Name and Address U.S. Department of Transportation Federal Aviation Administration Technical Center Atlantic City International Airport, NJ 08405		10. Work Unit No. (TRAIS)
		11. Contract or Grant No.
12. Sponsoring Agency Name and Address U.S. Department of Transportation Federal Aviation Administration Technical Center Atlantic City International Airport, NJ 08405		13. Type of Report and Period Covered Technical Report
		14. Sponsoring Agency Code
15. Supplementary Notes		

16. Abstract

This study examined four alternative means to present weather information to flight crews in the cockpit. The four means were abbreviated, plain english, chunked, and structured into vertical columns. In addition, four alternative means were also examined for pilots to enter requests for weather products. These were soft key select, numberical, keyboard entry of character identifiers, and a pseudo mouse function using arrow keys to select groups of responses.
The data were gathered in a part-task study environment.

17. Key Words Data Link Human Factors Man Machine Interface		18. Distribution Statement This document is available to the public through the National Technical Information Service, Springfield, VA 22161	
19. Security Classif.(of this report) Unclassified	20. Security Classif.(of this page) Unclassified	21. No. of Pages 100	22. Price

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

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EXECUTIVE SUMMARY

This report documents a part-task study performed by Midwest Systems Research, Inc., (MSRI) Dayton, Ohio, in support of the Federal Aviation Administration (FAA) Technical Center Data Link Program. The focus was on the weather (WX) services portion of Data Link. A two-phase evaluation was conducted with 16 air transport (ATP) and general aviation (GA) pilots. The pilots evaluated four data formatting options and four data entry methods. Measures of performance included times, errors, and subjective ratings.

The four formatting options included teletype (RTTY) horizontal and vertical, and English (ENG) horizontal and vertical. The four data entry methods included line select keys (bezel), cursor select, number select, and typing.

The analysis shows that the ENG vertical format was the best in terms of information retrieval time and error reduction. The ENG vertical format was subjectively preferred by the GA pilots. The RTTY horizontal format was preferred by the ATPs for two of the five weather product types. The analysis indicates that the bezel key data entry was best in terms of time. Both pilot qroups (ATP and GA) subjectively preferred the bezel method.

The study was, again, part-task in nature. The pilots were not under the stresses of time and flight. The results are nonetheless valuable and should be validated in a more sophisticated evaluation environment.

INTRODUCTION

This report will outline the results of a study initiated by the Federal Aviation Administration (FAA) to begin investigating selected human factors issues surrounding the design of a Mode Select (Mode S) Data Link pilot-vehicle interface (PVI). The motivation for this research was the head-down time issue identified in the Society of Automotive Engineers (SAE) G-10 Flight Deck Information Management Subcommittee's paper titled Human Enqineering Issues For Data Link Systems. The goal of this project was to initiate investigations of control and display issues which may contribute to a pilot's head-down time while operating a Data Link system.

One FAA Technical Center objective is to develop a Data Link display system which reduces head-down time. The factors selected for this phase of research were information format characteristics and data entry methods which directly impact the time a pilot must be head-down. The Technical Center plan for this research is to generate knowledge for use by the certification personnel within the FAA for establishing interface standards.

BACKGROUND.

Data Link, a feature of the Mode S radar system, is a digital communications system proposed by the FAA. The system is intended to alleviate the congestion on the voice radio frequencies by providing for a two-way exchange of routine air traffic control (ATC) and weather (WX) messages between the ground and the aircraft. An airborne Data Link control and display device may be the main interface between the pilot and the Mode S Data Link, although printers are being considered as an alternative to displays.

An input device will provide the pilot the capability to transmit data (requests, position reports, etc.) to the ground via the Mode S Data Link. A further added benefit of Data Link may be the on-board electronic storage of messages received, which will allow the pilot to “recall" stored WX and ATC messages for review.

It is expected that the result of implementing the Data Link system will be an increase in the effectiveness and safety of aircraft operations. With the current voice communications system errors are frequent, e.g., miscommunications, misunderstandings, and stuck microphones. The growth in air traffic has been accompanied by an increase in voice communications; during peak periods, obtaining a voice link with a controller can be very difficult. Coupling errors with peak demands has decreased the effectiveness of the national airspace system. The presentation of WX and ATC information on a display dictates the need for a detailed examination of the ramifications of such a change.

DATA LINK IMPLICATIONS.

The use of the visual modality for WX and ATC information will place an additional burden on the resources of the pilot's visual system. Pilots of modern aircraft have been expressing concern for some time about the amount of head-down time required to input data and interpret information presented on computer-based systems (Aviation Week & Space Technology [AW&ST], August 7, 1989). Data Link systems, whether display or printer based, must be carefully designed and implemented to guard against overly distracting pilots from their primary task of flying.

The display of text information such as WX and ATC instructions in the cockpit will be a novel concept for some pilots. Many airline organizations are, however, using the Aeronautical Radio, Inc., (ARINC) Aircraft Communications

Addressing and Reporting System (ACARS) for company communications, and predeparture clearances (PDC), at selected airports.

The visual presentation of WX information may require pilots to decipher information which may be highly coded (teletype) and difficult to understand. While instrument rated pilots must learn how to interpret aviation WX reports and forecasts, it is difficult to imagine that pilots can maintain the high level of skill with teletype that meteorologists do as trained experts. A pilot's primary responsibility is to maintain control of the aircraft, not the translation of potentially complex WX codes.

Typically, a pilot will receive a WX report prior to departure by either speaking with a meteorologist or reading teletype reports and graphic charts. In both cases, the pilot has the luxury of time and is in a nonthreatening environment and thus, the teletype language does not cause a major concern. While flying, a pilot currently receives WX via the voice radio; the acronyms and contractions inherent to the meteorologist's teletype language are transparent since the WX person speaks in translated terminology not "acronymese.”

If teletype language is used on a Data Link display, problems may arise out of unfamiliarity or time required to decipher the message. Several articles have appeared in the literature concerning teletype WX information. From a discussion on the FAA's Direct User Access Terminal (DUAT), a ground-based system, (George, 1990), writes: "It's [DUAT] a double-edged sword if you're not a skilled decoder.”

Jones (1990), asks "Why should anyone be forced to translate a long string of archaic FAA teletype codes to get a briefing? Isn't that what the computer is for?" Teletype messages from DUAT are causing some concern with pilots during preflight. Using teletype on the Data Link system may overburden the pilot durinq fliqht when communications is secondary task to maintaining control of the airplane. A final quote concerning teletype messages and the DUAT from Silitch 1990, states:

> You might think that pilots who have been actively flying for many years wouldn't have any trouble with the encoded weather reports, but that's not always the case. Once we memorized all that weather stuff to pass the exam, we promptly forgot it, because it wasn't used in the real world. In the real world, flight service specialists have long been doing most of the encoding for us, and the sudden sight of all the encoded information [in DUAT] has been more than a little shock to our systems.

This research attempts to address issues raised by the SAE Flight Deck Committee (SAE G-10 Flight Deck Information Management Subcommittee, 1990) and the reactions of pilots as reported in the literature.

OBJECTIVE.

The purpose of this study was to gather both objective and subjective data from operational pilots about: (1) the text oriented display of WX information on simulated cockpit display in part-task evaluations, and (2) various data entry techniques. Data were gathered from both professional air transport pilots (ATP) and private, general aviation (GA) pilots.

APPROACH

This research was composed of two independent phases. The first phase assessed the differences in WX information presentation methodologies;

language and structure variations were examined. For language, teletype (meteorological) and English (natural) presentations were compared. The WX message formats used as stimuli for this research are shown in appendix A. For structure, vertical (chunked), and horizontal (embedded) structures were compared.

The second phase assessed the differences in four data entry methods. The methods examined were manual typing, line select (bezel switches), cursor select, and number select. The display screens for each of these input methods are shown in figure l. The main menu and keyboard configuration are also shown in this figure. The following discussion will provide the theoretical basis for the work and state the hypotheses being tested in this research.

PHASE 1.

The basis for the language research in this first phase was based on the theories of behavior by Spence (Hill, 1964). A model of human-computer interaction, designated the Model Human Processor (MHP) (Card, Moran, and Newell, 1983), was also employed. A description of the theories and the hypotheses for this research follow.

BEHAVIOR THEORY. Spence's behavioral theory (Hill, 1964), contains a number of intervening variables that link independent and dependent variables. One variable is excitatory potential (E) which represents the strength of the tendency to give a certain response to a particular stimulus; E is not directly measurable and must be inferred from some observable characteristic of the response. E is predicted from values of the independent variables, and in turn, the dependent variables.

The other variables are habit strength (H), drive (D), and incentive motivation (K). Habit strength, H, reflects permanent learning and depends on practice; i.e., the number of prior occurrences of the response to the stimulus. The sum of D and K equals effective motivation. The symbolic statement relating these variables is $E = H^*(D+K)$. Reinforcement is a result of motivation, (K), not habit strength and is a variable in performance rather than learning.

This theory can be applied to this research by accepting the fact that the pilots were heavily practiced in reading English text and as such have a high habit strength, H. Thus, it is hypothesized that, in general, the English WX messages will result in shorter response times (RTs) and fewer errors than the meteorologist's (teletype) dictionary.

The ATP pilots who have experience with the meteorologist's dictionary would be expected to have a high habit strength (H) value which would be reflected in their RT. The teletype RTs from the ATP group should not differ significantly from the times from English conditions. In addition, the English should result in shorter RTs and fewer errors than the teletype for GA pilots. The RTs and errors on the teletype dictionary will compare closely with the English dictionary for ATP pilots.

MODEL HUMAN PROCESSOR. The process of a pilot interacting with Data Link is classic case of human-computer interaction. The pilot processes information presented by the computer (Data Link). The MHP provides an approximate description of gross human behavior as an information processing system. MHP is composed of a set of memories, processors, and is governed by a set of principles.

The interacting subsystems within the MHP are the perceptual, motor, and cognitive systems. The perceptual and cognitive subsystems are of most interest in this research. Two important principles of the MHP, the Encoding Specificity Principle and the Discrimination Principle, apply in this research. From Card, Moran, and Newell (1983):

> Encoding Specificity Principle. Specific encoding operations performed on what is perceived determine what is stored, and what is stored determines what retrieval cues are effective in providing access to what is stored.

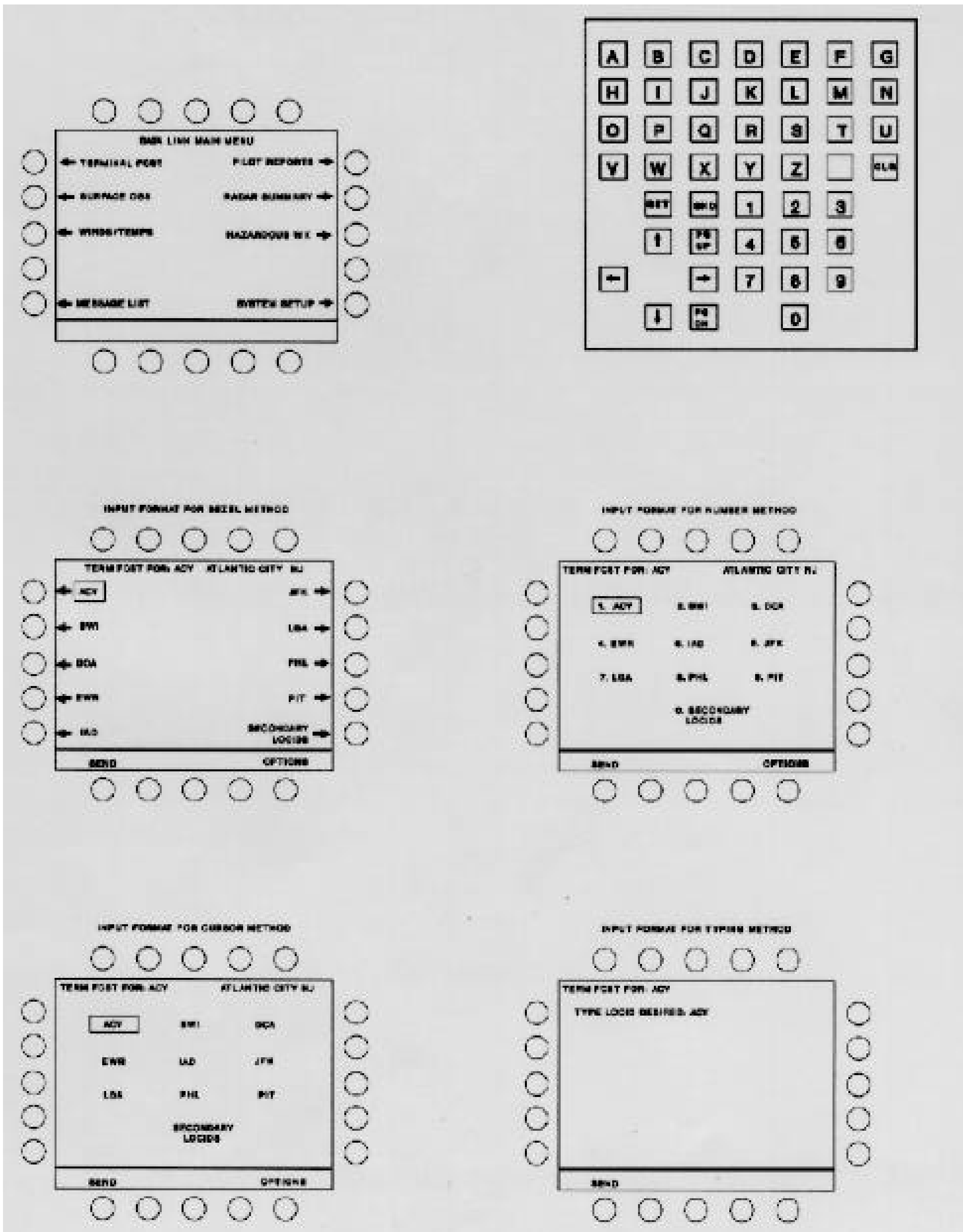

FIGURE 1. MAIN MENU, KEYBOARD, AND INPUT SCREENS

> *Discrimination Principle*. The difficulty of memory retrieval is determined by the candidates that exist in the memory, relative to the retrieval cues.

Card, Moran, and Newell (1983) provide an example (readinq rate, pages 50-51) which is similar to the present research; it was stated that reading rate is a function of the skill of the reader and the difficulty of the material.

Considering the MHP, it is expected that, in general, teletype will result in larger RTs and more errors than English; i.e., the difficulty of teletype is higher than English. However, it is expected that ATP pilots, because of higher <u>skill</u> levels (a result of experience) will perform better on teletype than GA pilots who do not have as much experience and hence, skill.

<u>PHASE 2</u>.

In addition to the Model Human Processor model described above, Card, Moran, and Newell (1983), described a model of human data entry performance called the Keystroke Level Model (KLM). The KLM model is an extension of the keystroke level analysis of the GOMS model of behavior (Card et. al., 1983). Both models describe human behavior as a sequence of information processing operators and the time required for the user to complete a defined unit task is the sum of the times of the individual operators. Furthermore, GOMS model tries to predict through a set of selection rules what a users method of choice may be for a given task. By definition, the KLM model is more conducive to this phase of study because the interests lie only in the time to execute each data entry method and not of predicting the method of choice.

The operators describe basic physical and mental actions of the user. The KLM model is comprised of four physical-motor operators (Keystroking, K; Pointing, P; Homing, H; and Drawing, D), one mental operator, M, and a System Response, R, operator. The time to execute a given task can then be equated as:

$$T_{execute}=T_K+T_p+T_H+T_D+T_M+T_R.$$

To determine how well predicted execution times compared with observed execution times, an empirical validation (Card et. al., 1983) of the model was employed. The model was accurate to a standard error of 21 percent for some 1280 user-system-tasks.

If desired, each data entry method can be encoded in terms of the operators by applying a set of heuristic rules. However, our interests are not in comparing predicted times against observed times, thus validating the model, but to use the model as a guide to indicate the relative differences in each data entry method. Therefore, considering the KLM model, one hypothesis would be based on the number of keystrokes (K) alone; i.e, the KLM model would predict that the manual typing method (four keystrokes) would require more time than any of the other three methods (two keystrokes). In addition, the number and cursor select methods would require more time than the line (bezel) select method because there are additional mental (M) operators required in selecting the station identifier. This is so, because the pilots need to associate an identifier with a number or series of cursor movements to be mapped to a different physical location of the input device, whereas in the line select and typing modes the identifier is chosen directly with no extra mental operations required.

HYPOTHESES.

PHASE 1 INFORMATION RETRIEVAL. Several hypotheses were made concerning the information retrieval phase. It was hypothesized that, in general:

1. The vertically structured English language messages would result in shortest RT and fewest errors.

2. The horizontally structured teletype language messages would result in the largest RTs and most errors.

3. That a positive correlation would exist between high pretest familiarity scores and smaller RTs (and accuracy).

4. Highly experienced ATP pilots will prefer, subjectively, the traditional unstructured teletype message and conversely, GA pilots with fewer flight hours will prefer, subjectively, the structured text format.

PHASE 2 DATA ENTRY. The research hypotheses for the data entry phase were the following: (1) the typing method would require more time and result in more errors than any of the other three methods, and (2) the number and cursor methods would require more time than the line select method.

METHOD

EXPERIMENTAL DESIGN.

PHASE 1 INFORMATION RETRIEVAL. A four-factor mixed-model, repeated measures design was used in this experiment. The independent variables were information language, information structure, WX message, and pilot experience type. A separate two factor analysis was performed on the data from winds/temperatures aloft (FD) forecast trials because its characteristics were not amenable to the same language and structure manipulations as the other services; the factors investigated were style, and pilot type. Each pilot completed 38 randomly presented trials.

The dependent variables for this phase were response time (RT) and errors. The RT was defined as the total time the information was visible to the pilot. An error was tabulated if a response was incomplete or incorrect. A detailed discussion of each independent variable is presented next.

Lanquage. The language of information was in either the meteorologist's teletype method or the standard English style.

Structure. The structure of the information was in either a horizontal (embedded) style or vertical (or chunked) style.

Weather. The WX messages utilized in this study were the FAA's package one services (see appendix B), i.e., terminal forecast (FT), surface observation (SA), pilot report (PIREP or UA), wind/temperatures aloft, and hazardous WX (WST). The package one services also included radar summaries (SD), however, these were not directly evaluated in this study. The four services chosen were amenable to language and structure variations since they are alphanumerically based formats. Radar summaries, by definition, are pseudo-graphic maps showing precipitation information; the design variations of this service were constrained by this definition.

No specific hypotheses were made concerning the WX message variable. It is recognized that inherent complexity and quantity differences exist between the services and as such, were not of direct research interest. In addition, for each WX service type, two repetitions were presented. Within a given service, the information of research interest was slightly modified in each of the four language/structure conditions, e.g., 3 miles blowing snow(BS) was changed to 2 miles BS. These slight changes were introduced to prevent programmed responses due to learning. Actual National Weather Service messages were selected from the FAA's Aviation Weather Services handbook for this research.

Style. The style variable within the winds and temperatures aloft portion of the study had three levels. The primary difference in the three was in the structure of the information (see appendix A).

PHASE 2 DATA ENTRY. A two-factor, mixed-model, repeated measures design was used in this experiment. The independent variables were data entry method and pilot experience. Four levels of the data entry variable were examined, i.e., manual typing, line select (bezel), cursor select, and number select. Two levels of experience type were used, i.e., ATP and GA.

The dependent variables were total entry time and errors. Entry time was measured as the time from selecting a service type through selecting a location identifier (LOCID) of interest to "sending" the request. The system computer automatically recorded each keystroke label and associated time for each trial. This was accomplished to allow for error tabulation and analysis.

PILOTS.

A total of 16 pilots participated in this study. Half were GA-type instrument rated pilots. The remaining half were commercial ATP. A wide cross-section of experience (flight hours) levels in each group was obtained; a summary of experience is provided in table 1. Pilots were provided a test information package prior to participating in the evaluation. The package contained a cover letter, an overview of the Data Link concept, and a pilot information questionnaire (see appendix C).

TABLE 1. PILOT EXPERIENCE SUMMARY

	General Aviation		Air Transport	
	Mean Age	Mean Flight Hours	Mean Age	Mean Flight Hours
	38	1380	40	9800
Pilot Ratings	Commercial, Instrument, Flight Instructor Instrument, Advanced Ground Instructor, CFII		ATP,Command, CFII-AMEl, Glider	
Typical Flight Lenqth	1.5 hours		4 hours	
Aircraft	PA-23, PA-24, PA-28, C-150, C-152, C-172, M20J		B-767, MD-80, DC-10 DC-8, C-310, CV-640	
Source of Weather Information	FSS, DUAT, Base OPS		Company, JEPPS, DATACOMP, Other computer, FSS	
Equipment Experience	Stormscope, LORAN WX Radar		ACARS, Omega, INS, Radar, LORAN	

APPARATUS.

A Hitachi Corporation color liquid crystal display (LCD) was utilized for this study. This display is capable of displayinq eight colors on display surface of 3.78” (H) by 5.04" (W). Color was not manipulated as an independent variable in this study. In the information retrieval phase, WX messages were presented as white on a black background.

The input devices to this display were 20 bezel mounted switches (five per side) and a separate alphanumeric keyboard. The control display system is shown in figure 2. The top row of switches were not required for this testing; the remaining keys were used in some manner, as explained in later sections. A separate hand-held switch box was used to control various aspects of the system. It must be emphasized that this system, while potentially "usable,” did not represent an optimal cockpit device. It was adapted for the sole purpose of inquiry into concepts such as information structure, language, and data entry methods.

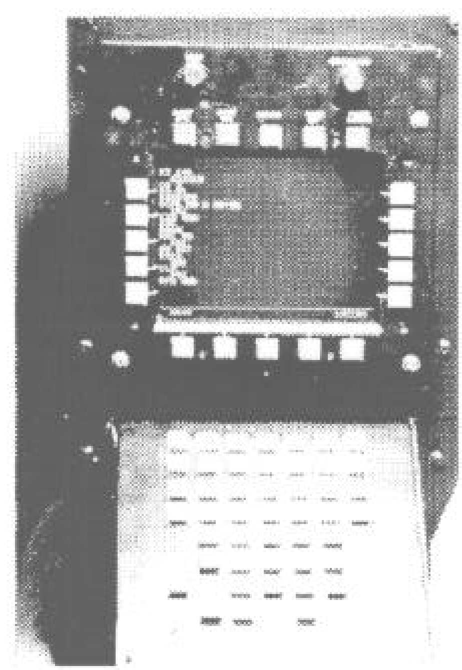

FIGURE 2. CONTROL DISPLAY SYSTEM

PROCEDURE.

GENERAL. A test session began with a brief introduction, review of the test package material, and a general question and answer period. The experimenters briefed the pilot on the control display system, demonstrated each of the data entry methods, and displayed sample WX message formats. The pilot was given the opportunity to interact with the display and ask questions.

Prior to beginning the evaluation process the pilots completed a pretest to determine familiarity with the acronyms and contractions used in WX reports. The pretest was followed by the information retrieval phase, the data entry phase, and finally the questionnaire completion period. Details are provided next on the procedures in each phase.

PRETEST. In an attempt to establish a separate measure of each pilot's familiarity with the acronyms and contractions used in WX messages, a stand-alone acronym familiarity test (AFT) was developed. Although not exhaustive, a sample of ten common acronyms and contractions was selected for each of the four services to be a part of this research (see appendix D). A series of three or four "words" was selected for each acronym to provide a context during testing. The test strings were presented on the study's display. To facilitate recognition, colors were used in the AFT to highlight the acronym of interest within the context string; additionally, the test “word" was shown with a bracket just below it, e.g.:

TSTMS EXPCTD TO CONT

The color and bracket cues were presented to clearly distinguish the test "word" from the context words.

In a self-paced and totally random manner, the acronyms were displayed to the pilots. The pilot's task was to verbalize the acronym's meaning as rapidly as possible. Prior to an acronym being displayed, an indication was provided (on the display) as to what type of WX service the acronym was extracted from; this service cue was provided because the acronym for a given term is not always consistent across services. For example, thunderstorms have been shown as T in some WX products and as TSTMS in other products.

After the service cue was recognized, the pilot depressed the handheld switch to bring the test string onto the screen and start the automatic timing device. After verbalizing the meaning, the pilot depressed the switch again to remove the test string and stop the timer. The experimenter used the display device's keyboard to input the result of the trial (correct, incorrect, or unknown) after which the next service cue was displayed to start the next trial. The pilot was given no indication of performance during the data collection phase. However, a copy of the AFT test strings and answers was given to the pilot after completion of the AFT.

PHASE 1 INFORMATION RETRIEVAL. Pilot questions were answered prior to the beginning of the testing phase. The pilot was shown sample WX messages (on the display) representative of the type to be seen during the data collection trials, and again allowed to ask questions. The test procedure was explained and demonstrated to the pilot to ensure understanding. An experimental trial consisted of the following:

1. Informing the pilot of the type of service to be displayed.

2. Asking the pilot a two-part question (see appendix E) and having him/her restate the question to ensure understanding.

3. The pilot depressing the switch box button (to start an automatic timer and simultaneously present the WX information).

4. The pilot retrieving the information and answering the question as accurately as possible.

5. The pilot depressing the button to stop the timer and remove the information from the display.

6. The experimenter comparing the response to the actual answer and making any relevant notes. The pilot was not given any feedback concerning their responses. If, after completing all trials, the pilot inquired about performance, a verbal summary was given by the experimenter.

PHASE 2 DATA ENTRY. The pilot was instructed on all input aspects of the system, given the opportunity to again practice on each input method, and ask questions. When the pilot was comfortable with the procedures, the trials began. The pilot was told the service and LOCID of interest for each trial (the LOCID was specified by its three letter code, as on the display, to control for unfamiliarity).

The pilot was instructed to read back the service and LOCID to ensure understanding, then depressed a handheld button which put the main system menu

on screen to begin the request. After the request was SENT, the trial was finished as no WX messages were delivered during experiment trials. The pace of subsequent trials was selected at the pilot's discretion.
The order of WX services and LOCIDs was completely randomized for each pilot. The nine LOCIDs available were selected once in each of the four input methods for a total of 36 trials. Having each LOCID selected once ensured that there was no bias in determining overall time for each method.

POST-TEST. After completing all testing, the pilots were asked to complete two questionnaires (see appendixes F and G) on the information retrieval and data entry phases. A post-test interview period was conducted for addressing any pilot questions and to allow the experimenters to clarify responses made in either of the questionnaires. The comments received from the pilots during pre- and post-test interviews are contained in appendix H.

DATA ANALYSIS

PRETEST.

Descriptive statistics were generated on the data from the AFT. A correlation analysis was performed between the AFT and informational retrieval (phase 2) time data.

PHASE l INFORMATION RETRIEVAL.

A four-way analysis of variance (ANOVA) (language, structure, WX, and pilot type) was performed on the data. A two-way ANOVA (style and pilot type) was performed on the data from the winds/temperature aloft trials. In addition, appropriate post-hoc analyses were performed. Descriptive statistics on the data are presented. Error data were compiled, analyzed, and presented. The Kendall's Coefficient of Concordance Test was employed to evaluate the ranking type data from the questionnaire.

PHASE 2 DATA ENTRY.

A two-way ANOVA (method and pilot type) was performed on the data. In addition, appropriate post-hoc analyses were performed. Descriptive statistics on the data are presented. Error data were compiled, analyzed, and presented. As in Phase l, Kendall's Coefficient of Concordance Test was employed to evaluate the ranking type data from the questionnaire.

RESULTS

PRETEST.

The frequency data from the AFT are shown below in table 2. The percentages of correct, incorrect, and unknown responses are listed; the frequency count is listed in parentheses. The mean time data from the AFT are shown below in table 3 and figure 3.

TABLE 2. AFT FREQUENCY DATA

	Terminal Forecast	Surface Observations	Pilot Reports	Hazardous Weather
ATP				
Correct	92.5 (74)	96.3 (77)	47.5 (38)	90.0 (72)
Incorrect	5.0 (4)	2.5 (2)	15.0 (12)	3.8 (3)
Unknown	2.5 (2)	1.2 (1)	37.5 (30)	6.2 (5)
GA				
Correct	81.2 (65)	93.8 (75)	71.3 (57)	92.5 (74)

Incorrect	8.8 (7)	2.5 (2)	7.5 (6)	3.8 (3)
Unknown	10.0 (8)	3.7 (3)	21.2 (17)	3.7 (3)

Frequency Count in parentheses

TABLE 3. AFT MEAN RESPONSE TIME DATA (SECONDS)

	Terminal Forecast	Surface Observations	Pilot Reports	Hazardous Weather
Correct				
GA	3.0	2.9	3.5	2.2
ATP	2.8	2.9	3.7	2.7
Incorrect				
GA	3.8	4.2	3.0	4.4
ATP	6.7	3.3	6.0	5.7
Unknown				
GA	10.6	9.1	8.9	7.1
ATP	9.7	10.2	6.7	9.9

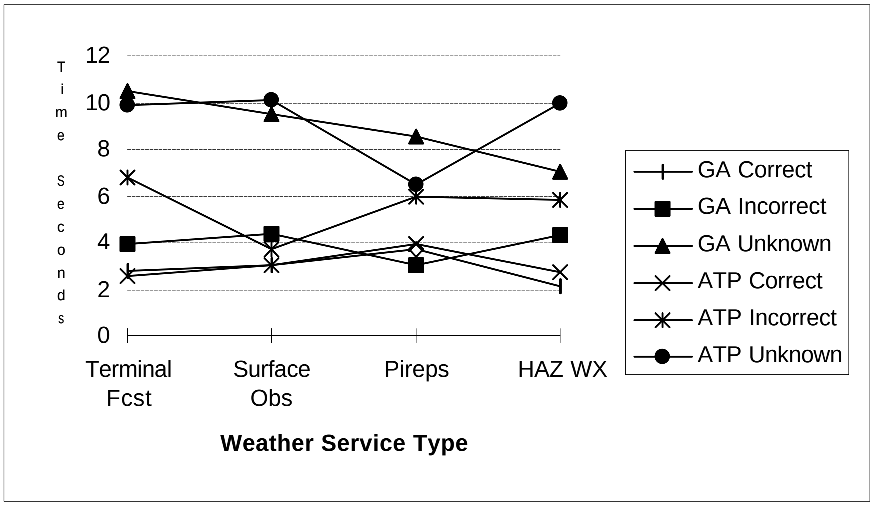

FIGURE 3. AFT MEAN RESPONSE TIME DATA

A correlation analysis was performed on the pretest AFT time data (correct responses only) and the RT data (teletype/horizontal only) obtained in the information retrieval test. An analysis was performed on each of the four WX service types by pilot type. It was expected that low pretest RTs would correspond to low test RTs, and vice versa. The sample correlation coefficients (r) from this analysis are in table 4.

TABLE 4. CORRELATION ANALYSIS RESULTS

	General Aviation	Air Transport
Terminal Forecast	0.32 (.4)	-0.14 (.7)
Surface Observations	0.16 (.7)	0.35 (.4)
Pilot Reports	0.44 (.3)	0.45 (.3)
Hazardous Weather	-0.11 (.8)	0.11 (.8)

p Values in parentheses

PHASE l INFORMATION RETRIEVAL.

OBJECTIVE. The ANOVA table for the RT data is shown in table 5; for the winds/temperatures aloft data, see table 6. The descriptive time data are shown in table 7 and fiqure 4.

TABLE 5. RESPONSE TIME ANOVA TABLE FOR PHASE 1

Source of Variation	SS	DF	MS	F	Sig of F
Pilot	21.5	1	21.5	.10	.762
Structure	1164.6	1	1164.6	27.61	.000*
Pilot*Structure	63.4	1	63.4	1.50	.240
Language	820.2	1	820.2	21.60	.000*
Pilot*Language	1.4	1	1.4	.04	.849
WX	2058.3	3	686.1	19.49	.000*
Pilot*WX	23.4	3	7.8	.22	.881
Struc*Language	.1	1	.1	.00	.945
Pilot*Structure*Language	18.1	1	18.1	.61	.447
Structure*WX	34.5	3	11.5	.46	.714
Pilot*Structure*WX	6.4	3	2.2	.09	.968
Language*WX	431.5	3	143.8	7.82	.000*
Pilot*Language*WX	49.2	3	16.4	.89	.453
Structure*Language*WX	108.0	3	36.0	1.28	.293
Pilot*Structure*Language*WX	135.6	3	45.2	1.61	.201

* significant at .05 level

TABLE 6. RESPONSE TIME ANOVA TABLE FOR WINDS/ALOFT DATA

Source of Variation	SS	DF	MS	F	Sig of F

Pilot	6.3	1	6.3	.36	.559
S/Pilot	244.5	14	17.5	---	---
Style	118.0	2	59.0	12.30	.000*
Pilot*Style	8.0	2	4.0	.83	.445
Style*S/Pilot	134.2	28	4.8	--	---

significant at .05 level

TABLE 7. MEAN RESPONSE TIMES BY WEATHER SERVICE (SECONDS)

	Terminal Forecast	Surface Observations	Pilot Reports	Hazardous Weather	Winds/Temp Aloft
T/H	18.2 (11.2)	12.3 (9.0)	12.1 (7.5)	23.3 (18.4)	9.1 (5.0)
T/V	15.3 (7.4)	9.1 (5.5)	8.6 (3.6)	15.7 (9.3)	5.4 (2.0)
E/H	16.5 (9.2)	10.6 (6.4)	11.1 (6.0)	13.1 (8.5)	--- ---
E/V	11.0 (8.1)	7.1 (2.5)	6.6 (3.3)	9.9 (7.6)	6.5 (3.5)

T = Teletype E = English H = Horizontal V = Vertical

Standard Deviation in Parentheses

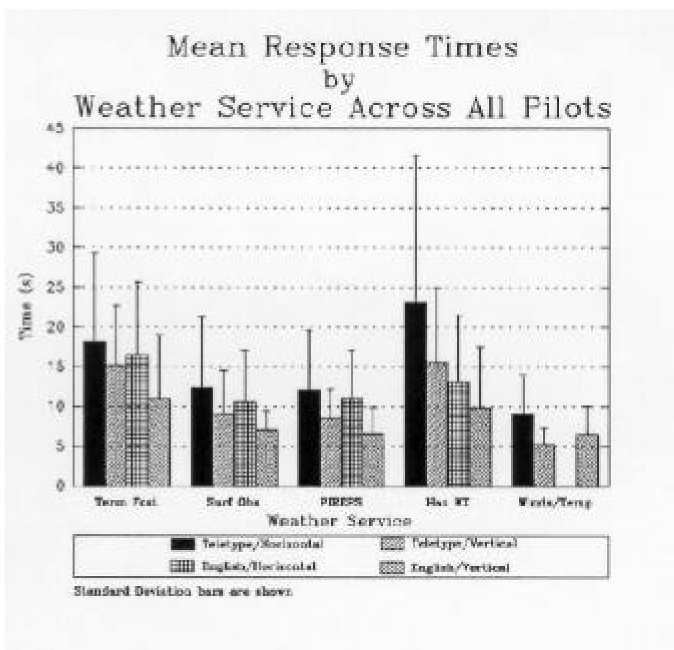

FIGURE 4. MEAN RESPONSE TIME DATA BY WEATHER (SECONDS)

The error count data for GA, ATP, and overall are shown below in tables 8, 9, and 10, respectively; figure 5 presents the data graphically. An error was tabulated if a response was incomplete or incorrect. An ANOVA was performed on the error data excluding winds/temperatures aloft data. The ANOVA table for the error data is shown in table 11.

TABLE 8. GENERAL AVIATION ERROR DATA

	Terminal Forecast	Surface Observations	Pilot Reports	Hazardous Weather	Winds/Temp Aloft
T/H	2	6	2	1	2
T/V	5	8	1	0	0
E/H	8	4	1	0	N/A
E/V	2	1	0	0	1

T = Teletype E = English H = Horizontal V = Vertical

TABLE 9. AIR TRANSPORT ERROR DATA

	Terminal Forecast	Surface Observation	Pilot Reports	Hazardous Weather	Winds/Temp Aloft
T/H	8	4	1	5	3
T/V	4	5	0	3	1
E/H	8	2	0	0	N/A
E/V	8	2	0	0	4

T = Teletype E = English H = Horizontal V = Vertical

TABLE 10. OVERALL ERROR DATA

	Terminal Forecast	Surface Observation	Pilot Reports	Hazardous Weather	Total	Winds/Temp Aloft
T/H	10	10	3	6	29	5
T/V	9	13	1	3	26	1
E/H	16	6	1	0	23	N/A
E/V	10	3	0	0	13	5
Totals	45	32	5	9	91	

T = Teletype E = English H = Horizontal V = Vertical

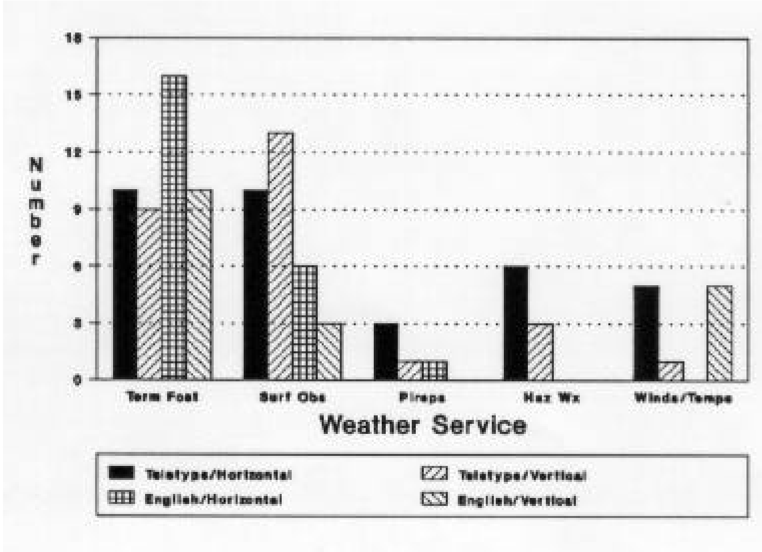

FIGURE 5. ERROR COUNT DATA BY WEATHER

TABLE 11. ERRORS ANOVA TABLE FOR PHASE 1

Source of Variation	SS	DF	MS	F	Sig of F
Pilot	.08	1	.08	.65	.432
Structure	.17	1	.17	6.07	.027
Pilot*Structure	.00	1	.00	.04	.852
Language	.35	1	.35	7.82	.014
Pilot*Language	.00	1	.00	.02	.885
WX	4.24	3	1.41	16.57	.000
Pilot*WX	.76	3	.25	2.97	.042
Structure*Language	.05	1	.05	1.28	.276
Pilot*Structure*Language	.35	1	.35	9.46	.008
Structure*WX	.10	3	.03	.77	.520
Pilot*Structure*WX	.03	3	.01	.21	.890
Language*Weather	.96	3	.32	5.99	.002
Pilot*Language*WX	.26	3	.09	1.63	.196
Structure*Language*WX	.23	3	.08	1.33	.276
Pilot*Structure*Language*WX	.38	3	.13	2.20	.103

* significant at .05 level

SUBJECTIVE. The complete set of comments received from the pilots can be found in appendix I; the questions are presented along with ranking and preference type data. The Kendall's Coefficient of Concordance Test results are shown for question 1.

QUESTION 1. Four different ways of presenting information have been shown. Overall and for each specific service type, please rank order the four methods in terms of preference. Examples will be provided for your reference.
l = Most preferred 4 = Least preferred

Note:
METHOD A = Teletype/Horizontal METHOD B = Teletype/Vertical
METHOD C = English/Horizontal METHOD D = English/Vertical

SURFACE OBSERVATION

	ATP Rank				GA Rank			
	1	2	3	4	1	2	3	4
METHOD A	6	1	0	1	0	1	5	2
METHOD B	1	3	4	0	2	4	1	1
METHOD C	0	2	0	6	0	1	2	5
METHOD D	1	2	4	1	6	2	0	0

Kendall's
ATP W=.41 p<.03
GA W=.62 p<.002

TERMINAL FORECAST

	ATP Rank				GA Rank			
	1	2	3	4	1	2	3	4
METHOD A	4	2	1	1	1	1	3	3
METHOD B	1	2	5	0	1	3	1	3
METHOD C	1	2	0	5	1	3	2	2
METHOD D	2	2	2	2	5	1	2	0

Kendall's
ATP W=.16 p<.3
GA W=.22 p<.16

PILOT REPORTS

	ATP Rank				GA Rank			
	1	2	3	4	1	2	3	4
METHOD A	1	1	3	3	0	0	3	5
METHOD B	3	1	3	1	3	3	2	0
METHOD C	0	4	0	4	0	2	3	3
METHOD D	4	2	2	0	5	3	0	0

Kendall's

ATP	GA
W=.23	W=.66
p>.1	p<.002

HAZARDOUS WEATHER

	ATP Rank				GA Rank			
	1	2	3	4	1	2	3	4
METHOD A	1	2	2	3	0	0	2	6
METHOD B	3	0	3	2	2	3	3	0
METHOD C	0	3	2	3	0	3	3	2
METHOD D	4	3	1	0	6	2	0	0

Kendall's

ATP	GA
W=.23	W=.68
p>.1	p<.002

WINDS TEMPERATURE ALOFT

	ATP Rank			GA Rank		
	1	2	3	1	2	3
METHOD A	0	2	6	0	0	8
METHOD B	3	5	0	4	4	0
METHOD C	5	1	2	4	4	0

Kendall's

ATP	GA
W=.42	W=.75
p<.05	p<.003

QUESTION 2. Are there any other methods that you can suggest that would make the information clearer and easier to read?

No responses received.

QUESTION 3. Would you prefer a graphics presentation of weather where at all feasible?

ATP	GA
YES: 7	YES: 7
NO: 1	NO: 1

QUESTION 4. Do you prefer the spelling out of the information or the use of acronyms in weather messages?

	Acronyms	Spelled out	Mixed
ATP	5	1	2
GA	1	5	2

QUESTION 5. Were the character sizes: (check one)

	ATP	GA
Just right	5	4
Too small	3	4
Too large	0	0

PHASE 2 DATA ENTRY.

OBJECTIVE. The ANOVA table for the RT data is shown in table 12. The descriptive data are shown in table 13 and figure 6. The listing of errors by input method are listed in table 14.

TABLE 12. ANOVA TABLE FOR THE PHASE 2 RESPONSE TIME DATA

Source of Variation	SS	DF	MS	F	Siq of F
Pilot	.2	1	.2	.09	.768
S/Pilot	37.6	14	2.7	--	---
Method	34.9	3	11.6	60.93	.000
Pilot*Method	.4	3	.1	.68	.571
Method*S/Pilot	8.0	42	.2	--	---

** Average data for each method were used in the analysis
* Significant at .05 level

TABLE 13. MEAN RESPONSE TIMES BY INPUT METHOD (SECONDS)

CURSOR	NUMBER	TYPING	BEZEL
3.9 (1.6)	3.4 (1.3)	4.9 (1.5)	2.9 (1.0)

Standard Deviation in parentheses

TABLE 14. ERROR CLASSIFICATION BY INPUT METHOD

Cursor	2 errors 1) Hit page up key instead of Send key (twice)
Number	0 errors
Typing	2 errors 1) Entered ACI instead of ACY 2) Entered ACW instead of ACY

Bezel	1 error 1) Hit bezel button to right of Send key

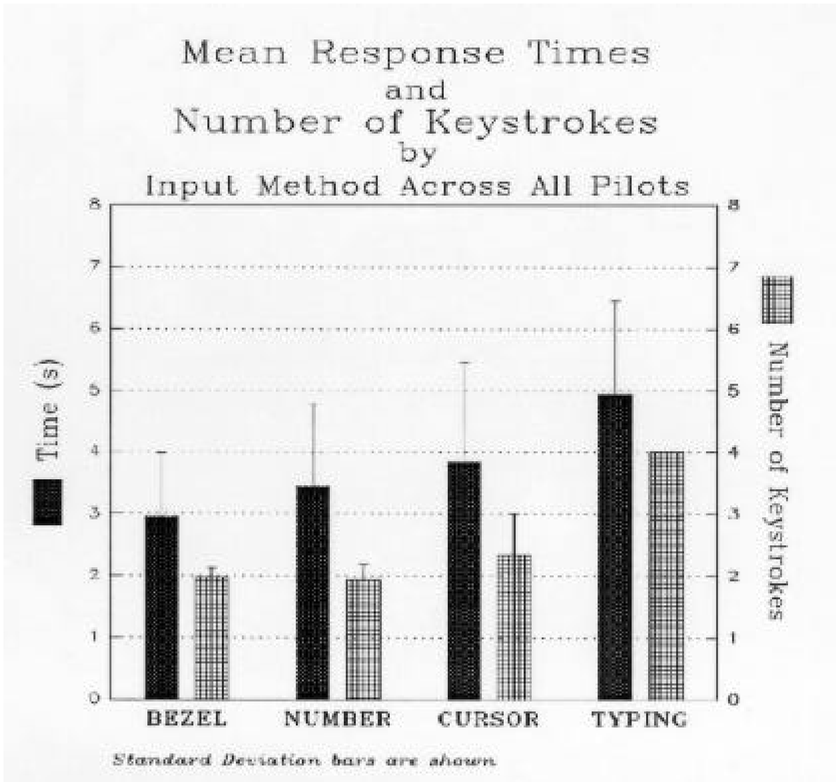

FIGURE 6. DATA ENTRY DATA

An analysis was performed on the data representing time per keystroke. Note: Keystroke count does not include selection of WX service. The ANOVA results are shown in table 15. The mean data by method is shown in table 16.

TABLE 15. TIME/KEYSTROKE ANOVA

Source of Variation	SS	DF	MS	F	Sig of F
Pilot	.09	1	.09	.19	.669
Method	3.48	3	1.16	28.20	.000
Pilot*Method	.06	3	.02	.52	.671

* significant at .05 level

TABLE 16. TIME PER KEYSTROKE BY METHOD (SECONDS)

Method	Mean	Standard Deviation
Cursor	1.7389	0.7284
Number	1.8387	0.8700
Typing	1.2370	0.3777
Bezel	1.4921	0.5136

SUBJECTIVE. The complete set of comments received from the pilots can be found in appendix I; the questions are presented along with ranking and preference type data. The Kendall's Coefficient of Concordance Test results are shown for question 1.

QUESTION 1. Input methods ranked by preference

l=MOST PREFERRED 4=LEAST PREFERRED

	ATP Rank				GA Rank			
	1	2	3	4	1	2	3	4
Cursor	1	0	4	3	2	1	5	0
Number	1	6	1	0	1	3	3	1
Typing	0	2	1	5	0	1	0	7
Bezel	6	0	2	0	5	3	0	0

Kendall's	
ATP	GA
W=.34	W=.57
p<.05	p<.004

QUESTION 2. Please specify any characteristics about your most preferred method that would make it even better?

No responses received.

QUESTION 3. If you had encountered these input methods "cold," would it have been obvious how to enter a location identifier? The number of responses is listed.

ATP	CURSOR	NUMBER	TYPING	BEZEL
YES	2	6	8	7
NO	6	2	0	1

GA_	CURSOR	NUMBER	TYPING	BEZEL
YES	4	7	7	7
NO	4	.1	1	1

QUESTION 4. For each method please describe briefly its major advantages and disadvantages.

No responses received.

QUESTION 5. Do you have any preference on how the location identifier should be ordered on the display (e.g., alphabetically, by route, random, or other)? Please specify or draw.

No responses received.

QUESTION 6. Should one of the LOCIDs be designated as appears?

ATP		GA *	
YES	NO	YES	NO
6	2	4	1

Missing question's data from three GA pilots.

QUESTION 7. If you have made a weather request for, say LAX, should LAX become the default LOCID whenever you make another request (regardless of type)?

	YES	No
ATP	5	3
GA	3	5

QUESTION 8. Was the additional information provided by the translation of the three-letter station identifier useful? (e.g., LAX Los Angeles International, CA).

ATP	GA
YES: 6	YES: 7
NO: 1	NO: 1

* Yes for new guys, no otherwise.

QUESTION 9. During the typing mode, the LOCID was entered; if additional characters were entered, the left most letter dropped out and the last two shifted left. The entered letter is placed in the right most position. Is this acceptable? If no, explain.

ATP	GA
YES: 6	YES: 4
NO: 2	NO: 4

QUESTION 10. Was the terminology used (e.g., Send, clear, etc.) Acceptable?

	ATP				GA			
	SEND	CLEAR	MAIN	LOCID	SEND	CLEAR	MAIN	LOCID
YES	8	8	7	6	8	8	8	6
NO	0	0	1	2	0	0	0	2

QUESTION 11. The message status indicators: sent, processing, and available appeared after making a weather request.

Was this terminology acceptable?			Was the location acceptable?		
ATP	Yes: 8	No: 0	ATP	Yes: 7	No: 1
GA	Yes: 8	No: 0	GA	Yes: 7	No: 1

QUESTION 12. What type of annunciation (e.g., flashing light, tone, etc.) of incoming messages would you desire in an operational system?

No responses received.

QUESTION 13. Do you think the use of color on a display of weather and ATC information is....

ATP	GA	
7	5	-VERY HELPFUL
0	2	-SOMEWHAT HELPFUL
1	1	-NO PREFERENCE EITHER WAY
0	0	-SOMEWHAT DETRIMENTAL
0	0	-VERY DETRIMENTAL

QUESTION 14. Were you satisfied with the appearance and operational characteristics of the main menu?

ATP	GA
Yes: 8	Yes: 8
No: 0	No: 0

QUESTION 15. Were the character sizes: (check one)

	ATP	GA
-TOO SMALL	3	4
-JUST RIGHT	5	4
-TOO LARGE	0	0

DISCUSSION

PHASE 1 INFORMATION RETRIEVAL.

OBJECTIVE.

Response Time. The significant factors from the four-way RT ANOVA were: (1) structure, (2) language, (3) weather, and (4) the language by weather interaction. The structure mean RTs were, 10.4 and 14.7, for vertical and horizontal, respectively, a 41 percent difference. The language mean RTs were, 10.7 and 14.3, for English and teletype, respectively, a 34 percent difference. The WX mean RTs were, 15.3, 9.8, 9.6, and 15.5, for terminal forecasts, surface observations, pilot reports and hazardous WX advisories, respectively.

No in-depth analyses were performed on the WX variable since observed differences could be inherent to the complexity of the message and not to the design of Data Link. The significant language by WX interaction was caused by the hazardous WX data; the English-teletype difference was greater for hazardous advisories than with the other services. It appears that English facilitated information retrieval more so with hazardous weather than with other services. It appears to have been much clearer as to what the response was to the question posed since many pilots provided more information than requested with the teletype, thus inflating RTs. The English version made differentiation of the information qroups (i.e., current activity versus forecast) much easier.

Errors. The occurrence of errors was lowest with the English vertical messages and highest with the teletype horizontal messages. The significant design related factors from the four-way errors ANOVA were structure and language. For the structure variable, the errors were 39 and 52, for vertical and horizontal, respectively, a 33 percent difference. For the language variable, the errors were 36 and 55, for English and teletype, respectively, a 53 percent difference. The errors by service were 45, 32, 5, and 9 for, respectively, terminal forecast, surface observations, pilot reports, and hazardous WX advisories.

Summary. The hypothesis that vertically structured English messages would result in the fastest RT and fewest errors is supported by this data. Across the four message types, the mean time for the English vertical messages was 8.7 seconds compared to 16.5 seconds for the horizontal teletype messages; the errors were 13 and 29, respectively. The RTs and errors for horizontal teletype messages were the largest of the four conditions, as hypothesized.

Winds Data. The style factor from the winds aloft analysis was significant. A Tukey test was performed on the data and the results indicate that the only significant difference was between methods A and B, that is, the teletype vertical and horizontal methods. The teletype horizontal structure required 69 percent more time than the vertical style. The teletype horizontal and English vertical resulted in five errors each; the teletype vertical resulted in one error.

Pretest. The hypothesis concerning pretest scores and phase 1 scores is not supported by this data. The correlation analysis resulted in small correlation coefficients (r) between the pretest times and test RTs. Possible explanations for this result may be the study's sample size, and/or the small number of trials in the pretest, or simply, no relationship.

In general, the pilots performed well on the AFT; above 90 percent correct in 5 of 8 categories. The ATP group did poorly on the pilot reports portion. Many commented that they rarely, if at all, use pilot reports - which explains their performance. The GA group performed better than the air transport pilots on the pilot reports portion, which may suggest that GA pilots use pilot reports more often.

The time data from the AFT appears reasonable. The ATP and GA pilots performed similarly on correct responses. For both groups, times went up on the incorrect responses, indicating an additional (unsuccessful) search time. As expected, times increased considerably when the subjects did not know the acronym's meaning; this was more apparent with ATP than GA.

SUBJECTIVE. The hypothesis that ATP pilots would prefer the horizontal teletype messages is generally supported by this data. The GA pilots preferred the vertical English messages as hypothesized. The Kendall’s Coefficient of Concordance Test results for question l indicate that the GA pilot's rankings of preferred presentation format generally agree with each other on all services except the terminal forecast. For the ATP pilots, the test indicates an agreement for winds/temp aloft and Hurface observation only; there was no significant agreement on presentation preference for the remaining services.

PHASE 2 DATA ENTRY.

OBJECTIVE.

Time. The mean RT for the typing method was the largest of the three methods as hypothesized. The order, best to worst, of the remaining three was: (1) bezel, (2) number select, and (3) cursor select. A Tukey test was performed on the RT data and the results indicate that: (l) typing is significantly different from all other methods, (2) bezel is significantly different from all methods except the number method, and (3) the cursor and number methods are not significantly different.

As hypothesized, the RT for bezel select was quicker than the number or cursor select methods, though the RT for number was not significantly different than bezel. The mean time per keystroke for the number method was 1.8 seconds. The order best to worst, of the remaining three was: (l) typing (1.2), (2)bezel (1.5), and (3) cursor select (1.7). A Tukey test was performed on the time per keystroke data and the results indicate that: (1) the typing method is significantly different from both the cursor and number methods, (2) the number and bezel method are significantly different from one another, (3) the bezel method is not significantly different from the typing method, and (4) the cursor method is not significantly different from either the number or bezel method.

Errors. There were not many input errors made by the pilots. This was probably a function of the part-task evaluation. Two errors were made in the cursor and the typing method; one error was made in the bezel method and no errors were made in the number method.

SUBJECTIVE. The bezel and number methods were preferred by the ATP group; the bezel method was the preference of the GA group. Typing was, generally, the least preferred by both groups. The Kendall's Coefficient of Concordance Test results for question 1 indicate that the GA and ATP pilot's rankings of the input methods were concordant among themselves. The reader is referred to table l for a listing of equipment experience. The preference may be related to the equipment the pilots have in their cockpit.

CONCLUSION/RECOMMENDATIONS

PHASE 1 INFORMATION RETRIEVAL.

Overall, the teletype language messages required 33 percent more time than English to gather the requested data. The unstructured messages required 41 percent more time than the structured to gather the requested data. Overall, the teletype language resulted in 61 errors (320 trials) and the English language resulted in 41 errors (288 trials). The error rates for teletype and English, were 19 and 14 percent, respectively.

The language hypothesis developed from the theory within the Model Human Processor (MHP) discussion is supported with the data from this group of pilots. The language hypothesis developed from behavior theory, concerning the habit strength of the English language over the teletype language, is supported with the data from this group of pilots.

These findings concerning significant part-task performance differences suggest the need for further research in a more realistic setting. A mockup level evaluation is recommended to investigate how information retrieval performance is affected by the addition of routine (and extreme) workload within a cockpit environment. A verification of this data with an independent sample of pilots is recommended.

The pilots have suggested, through pre- and post-test interviews and questionnaires, methods of further optimizing the display of weather (WX) information. It is suggested that efforts be made to incorporate these suggestions into a design iteration, where feasible.

The display of information in the English language may not be realistic, when considering display constraints, etc. However, this research indicates a possible need for redefinition of the WX data dictionary. As one pilot put it, "I would hate to misinterpret a sigmet because I couldn't decipher the acronyms.”

PHASE 2 DATA ENTRY.

The optimal data input method, in terms of time, was the bezel method. Bezel entry was, subjectively, the preferred method with both the general aviation (GA) and air transport pilot (ATP) groups. The typing method required the most time. Typing was, subjectively, the least preferred method with both types of pilots. This data supports the expectations of the Keystroke Level Model.

Similar to the comments in the phase l effort, these findings should be verified in a more realistic setting. Technology constraints may become a consideration in selection of an input methodology. The design should however, allow maximum flexibility in terms of choice, e.g., if bezels are used primarily, then typing into a scratchpad should be an option if the desired station is not listed.

This research should be conducted in an operational setting for the purposes of determining the interaction characteristics of each method.

SUMMARY.

English vertical weather formats and the bezel select data entry method appear to minimize head-down time. While ATP pilots preferred the teletype horizontal weather formats, one must remember that this is what they see on a regular basis.

Data Link will be a major change in communications technology. The issue of head-down time is but one of many issues that must be examined. Other factors may contribute to head down time, e.g., display vibration, ambient lighting affects on the display, dual system operations (voice and Data Link), etc. These factors could not be addressed in this part-task test. These factors and many other will require attention in the future. A human factors evaluations plan is being developed to guide the necessary research in a logical manner.

The pilots that participated in this study provided numerous comments about the design of a Data Link system. Many of these comments should be incorporated in design and evaluated. The pilots stressed their desires for an integrated system, e.g., frequency management, etc. Data Link can become an extremely valuable tool for the pilot/crew if a systems integration approach is taken in its implementation. Data Link as a stand-alone system could possibly increase workload levels

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LIST OF ABBREVIATIONS, ACRONYMS, AND SYMBOLS

ACARS	Aircraft Communications Addressing and Reporting System
ADF	Automatic Direction Finder
AFT	Acronym Familiarity Test
AIRMET	Airman's Meteorological Information
ANOVA	Analysis of Variance
ARINC	Aeronautical Radio, Inc.
ATC	Air Traffic Control
ATIS	Automatic Terminal Information Service
ATP	Air Transport Pilot
AW&ST	Aviation Week and Space Technology
CNI	Communications, Navigation, Identification
DF	Degrees of Freedom
DME	Distance Measuring Equipment
DUAT	Direct User Access Terminal
FAA	Federal Aviation Administration
FD	Winds/Temperatures Aloft Forecast
FE	Flight Engineer
FSS	Flight Service Station
FT	Terminal Forecast
GA	General Aviation
KLM	Keystroke Level Model
LOCID	Location Identifier
MHP	Model Human Processor
MSRI	Midwest Systems Research, Inc.
NAV	Navigation
PDC	Pre-Departure Clearance
PIREP	Pilot Report (UA)
PVI	Pilot-Vehicle Interface
RDU	Remote Display Unit
RTs	Response Times
SA	Surface Observation
SAE	Society of Automotive Engineers
SD	Radar Summary
SIGMET	Significant Meteorological condition
UA	PIREP (pilot report)
VOR	VHF Omnidirectional Range
WCP	Weather Communications Processor
WILCO	Will Comply
WST	Hazardous Weather
WX	Weather

APPENDIX A

DATA LINK WEATHER FORMATS

APPENDIX A. Data Link Weather Formats

Repetition 1

WINDS/TEMPERATURES ALOFT (FD) FORECAST

```
FD XWBC
BASED ON 151200Z
VALID 151800Z FOR USE 1700Z - 2100Z
TEMPS NEG ABV 24000
FT  3000   6000   9000   12000   18000
DCA 2113 2325+07 2332+02 2339-04 2356-
16
   24000   30000 34000   39000
 2373-27  239440  730649  731960
```

<u>METHOD A</u>

```
FD KWBC
BASED ON 151200Z DATA
VALID 151800Z FOR USE 1700Z - 2100Z
TEMPS NEG ABV 24000
DCA
FT
3000   2113
6000   2320+06
9000   2332+02
12000  2339-04
18000  2356-16
24000  2373-27
30000  239440
34000  730649
39000  731960
```

<u>METHOD B</u>

```
WINDS/TEMPERATURES FORECAST FOR
WASHINGTON D.C.

VALID: 15TH 1800Z FOR USE 1700Z -2100Z
BASED ON 15TH 1200Z DATA

ALTITUDE DIRECTION VELOCITY TEMP.(C)
3000        210   13      --
6000        230   27      05
9000        230   32      02
12000       230   39     -04
18000       230   56     -16
24000       230   73     -27
30000       230   94     -40
34000       230  106     -49
39000       230  119     -60
```

<u>METHOD C</u>

A-1

TERMINAL FORECAST

FT LGA 251010 C5 X 1/2S-BS 3325G35 OCNL
C0 X OS+BS. 16Z C30 BKN 3BS 3320 CHC
SW. 22Z 30 SCT 3315. 00Z CLR. 04Z
VFR
WND..

METHOD A

FT LGA
251010
C5 X
lS-BS
3325G35
OCNL C0 X OS+BS
  16Z
C30 BKN
2BS
3320
CHC SW
  22Z
30 SCT
3315
OOZ CLR
  04Z
VFR WND

METHOD B

TERMINAL FORECAST FOR LA GUARDIA INT'L

TIME VALID: 25TH 1000Z - 26TH 1000Z
1000Z - 1600Z
SKY: CEILING 500 OBSCURED
VISIBILITY: 1/2 LIGHT SNOW BLOWING SNOW
WIND: 330/25 GUSTS: 35
REMARKS: OCCASIONAL CEILING 0
SKY OBSCURED VISIBILITY 0
HEAVY SNOW BLOWING SNOW
1600Z - 2200Z
SKY: 3000 BROKEN
VISIBILITY: 2 BLOWING SNOW
WIND: 330/20
30% - 50% CHANCE LIGHT SNOW SHOWERS
2200Z - 0000Z
SKY: 3000 SCATTERED
WIND: 330/15
0000Z - 0400Z
SKY: CLEAR
0400Z - 1000Z
VFR WIND > 25

METHOD D

TERMINAL FORECAST FOR LA GUARDIA
INT'L

TIME VALID: 25TH 1000Z - 26TH 1000Z
1000Z- 1600Z SKY: CEILING 500
OBSCURED
VISIBILITY: 3/4 LIGHT SNOW BLOWING
SNOW
WIND: 330/25 GUSTS: 35 REMARKS:
OCCASIONAL CEILING 0 SKY OBSCURED
VISIBILITY 0 HEAVY SNOW BLOWING SNOW
1600Z - 2200Z SKY: 3000 BROKEN
VISIBILITY: 1 BLOWING SNOW WIND:
330/20
30% - 50% CHANCE LIGHT SNOW SHOWERS
2200Z - 0000Z SKY: 3000 SCATTERED
WIND:
330/15 0000Z - 0400Z SKY: CLEAR
0400Z - 1000Z VFR WIND > 25

METHOD C

A-2
SURFACE OBSERVATIONS

SA PHL 1852 7 SCT 250 SCT 6HK
129/60/59/ 2504/991

SA PHL 1852
7 SCT
230 SCT
6HK
129
60/59
2405
991

METHOD A

METHOD B

SURFACE OBSERVATION FOR PHILADELPHIA

TIME: 1852Z
SKY: 800 SCATTERED 22000 SCATTERED
VISIBILITY: 6
OBSTRUCTION: HAZE SMOKE
SEA LEVEL PRESSURE: 1012.9
TEMPERATURE/DEW POINT: 60/59
WIND: 230/4
ALTIMETER: 29.91

METHOD D

SURFACE OBSERVATION FOR PHILADELPHIA

TIME: 1852Z SKY: 900 SCATTERED 21000 SCATTERED VISIBILITY: 6 OBSTRUCTION: HAZE SMOKE SEA LEVEL PRESSURE: 1012.9 TEMPERATURE/DEW POINT: 60/59 WIND: 260/3
ALTIMETER: 29.91

METHOD C

A-3

PILOT REPORTS

```
UA /OV MRB-PIT/TM 1600/FL 100/TP BE55
/SK 024 BKN 032/042 BKN-OVC/TA -12/IC
LGT RIME 060/RM WND COMP HEAD 020
MH310
TAS 1 80
```

METHOD A

```
UA /OV MRB-PIT
   /TM 1600
   /FL 100
   /TP BE55
   /SK 024 BKN 032
       042 BKN-OVC
   /TA -12
   /IC LGT RIME 050
   /RM WND COMP HEAD 020
       MH310
       TAS 180
```

METHOD B

PILOT REPORT FOR PITTSBURGH

```
LOCATION: MARTINSBURG-PITTSBURGH
TIME: 1600Z
ALTITUDE: 10000
AIRCRAFT TYPE: BE55
SKY: 2400 - 3200 BROKEN
4200 BROKEN-OVERCAST
TEMPERATURE: -12
ICING: LIGHT RIME 5400
REMARKS: HEAD WIND COMPONENT 20
       MAGNETIC HEADING 310
       TRUE AIR SPEED 180
```

METHOD D

PILOT REPORT FOR PITTSBURGH

LOCATION: MARTINSBURG-PITTSBURGH TIME: 1600Z ALTITUDE: 10000 AIRCRAFT TYPE: BE55 SKY: 2400 - 3200 BROKEN 4200 BROKEN-OVERCAST TEMPERATURE: -12 ICING:
LIGHT RIME 4000 REMARKS: HEAD WIND COMPONENT 20 MAGNETIC HEADING 310 TRUE AIR SPEED 180

METHOD C

HAZARDOUS WEATHER ADVISORIES

MKCC WST 221655 CONVECTIVE SIGMET 17E PA
MD VA VCNTY RIC-HAR LINE NO SGFNT TSTMS
RPRTD FCST TO 1855Z LINE TSTMS DVLPG BY
1755Z WILL MOV EWD 30 - 35 KTS THRU
1855Z HAIL TO 1 1/2 IN PSBL

<u>METHOD A</u>

MKCC WST 221650
CONVECTIVE SIGMET 17E
  PA MD VA
  VCNTY RIC-HAR LINE
  NO SGFNT TSTMS RPRTD
FCST TO 1855Z
  LINE TSTMS DVLPG BY 1755Z WILL MOV
  EWD 30 - 35 KTS THRU 1855Z
  HAIL TO 1 1/2 IN PSBL

<u>METHOD B</u>

CONVECTIVE SIGMET FOR EASTERN U.S.

DATE: 22ND OF MONTH
TIME VALID: 1630Z
OBSERVATIONS
STATES: PA MD VA
AREA: RICHMOND-HARRISBURG LINE
ACTIVITY: NO SIGNIFICANT THUNDERSTORMS
REPORTED
FORECAST TO 1855Z
LINE THUNDERSTORMS DEVELOPING BY 1755Z
WILL MOVE EASTWARD 30 - 35 KNOTS THRU
1855Z HAIL TO 1 1/2 IN POSSIBLE

<u>METHOD D</u>

CONVECTIVE SIGMET FOR EASTERN U.S.

DATE: 22ND OF MONTH TIME VALID: 1635Z
OBSERVATIONS STATES: PA MD VA AREA:
RICHMOND-HARRISBURG LINE ACTIVITY: NO
SIGNIFICANT THUNDERSTORMS REPORTED
FORECAST TO 1855Z LINE THUNDERSTORMS
DEVELOPING BY 1755Z WILL MOVE
EASTWARD
30 - 35 KNOTS THRU 1855Z HAIL TO 1
1/2
IN POSSIBLE

<u>METHOD C</u>

Repetition 2

WINDS/TEMPERATURES ALOFT FORECAST

```
FD KWBC
BASED ON 151200Z DATA
VALID 151800Z FOR USE 1700Z - 2100Z
TEMPS NEG ABOVE 24000
FT 3000 6000 9000 12000 18000
ACY 2107 2006+03 2215-01 2322-06 2338-
17
   24000  30000     34000     39000
2348-29        236143    237252    238160
```

<u>METHOD A</u>

```
FD KWBC
BASED ON 151200Z DATA
VALID 151800Z FOR USE 1700Z - 2100Z
TEMPS NEG ABV 24000
ACY
 FT
     3000      107
     6000      006+03
     9000      215-01
     12000          320-05
     18000          338-17
     24000          348-29
     30000          36143
     34000          37252
     39000          38160
```

<u>METHOD B</u>

WINDS/TEMPERATURES FORECAST FOR
ATLANTIC CITY NJ

VALID: 15TH 1800Z FOR USE 1700Z - 2100Z
BASED ON 15TH 1200Z DATA

ALTITUDE	DIRECTION	VELOCITY	TEMP.(C)
3000	210	07	--
6000	200	06	03
9000	220	15	-01
12000	230	25	-07
18000	230	38	-17
24000	230	48	-29
30000	230	61	-43
34000	230	72	-52
39000	230	81	-60

<u>METHOD C</u>

TERMINAL FORECAST

```
FT IAD 151010 C10 OVC 2H OCNL C5 X 1/2F.
16Z 60 SCT 6 OCNL F 3305 22Z CLR 3315.
00Z CLR 33/15.  04Z VFR..
```

METHOD A

```
FT IAD
  151010
Cll OVC
2H
OCNL C5 X 1/2F
  16Z
70 SCT
6 OCNL F
3305
  22Z
CLR
3315
  OOZ
CLR
3315
  04Z
VFR
```

METHOD B

```
TERMINAL FORECAST FOR DULLES INT'L

TIME VALID: 15TH 1000Z - 16TH 1000Z
           1000Z - 1600Z
SKY: CEILING 900 OVERCAST
VISIBILITY: 2 HAZE
WIND: CALM
REMARKS: OCCASIONAL CEILING 500
         SKY OBSCURED VISIBILITY 1/2 FOG
             1600Z - 2200Z
SKY: 5000 SCATTERED
VISIBILITY: 6 OCCASIONAL FOG
WIND: 330/05
             2200Z - 0000Z
SKY: CLEAR
WIND: 330/15
              000Z - 0400Z
SKY: CLEAR
WIND: 330/15
              0400Z - 1000Z
VFR
```

METHOD D

```
TERMINAL FORECAST FOR DULLES INT'L

TIME VALID: 15TH 1000Z - 16TH 1000Z
1000Z - 1600Z SKY: CEILING 800
OVERCAST
VISIBILITY: 2 HAZE WIND: CALM
REMARKS:
OCCASIONAL CEILING 500 SKY OBSCURED
VISIBILITY 1/2 FOG 1600Z - 2200Z SKY:
9000 SCATTERED VISIBILITY: 6
OCCASIONAL
FOG WIND: 330/05 2200Z - 0000Z SKY:
CLEAR WIND: 330/15 0000Z - 0400Z SKY:
CLEAR WIND: 330/15 0400Z - 1000Z VFR
```

METHOD C

SURFACE OBSERVATIONS

METHOD A	METHOD B
SA BWI 1854 150 SCT 8K 181/62/58/1310 /015	SA BWI 1854 150 SCT 7K 181 62/58 1310 014

METHOD D	METHOD C
SURFACE OBSERVATION FOR BALTIMORE WASHINGTON INT'L TIME: 1854Z SKY: 15000 SCATTERED VISIBILITY: 6 SMOKE SEA LEVEL PRESSURE: 1018.1 TEMPERATURE/DEW POINT: 62/58 WIND: 130/10 ALTIMETER: 30.13	SURFACE OBSERVATION FOR BALTIMORE WASHINGTON INT'L TIME: 1854Z SKY: 15000 SCATTERED VISIBILITY: 9 SMOKE SEA LEVEL PRESSURE: 1018.1 TEMPERATURE/DEW POINT: 62/58 WIND: 130/10 ALTIMETER: 30.16

A-8

PILOT REPORTS

```
UA /OV EWR 270050/TM 1522/FL 080/TP C172
/SK 018 SCT 030/TA -04/IC LGT RIME 060
/RM WND COMP HEAD 010 MH300 TAS 115
```

METHOD A

```
UA /OV EWR 270050
   /TM 1522
   /FL 090
   /TP C172
   /SK 018 SCT 030
   /TA -05
   /IC LGT RIME 060
   /RM WND COMP HEAD 010
       MH300
       TAS 115
```

METHOD B

PILOT REPORT FOR NEWARK

LOCATION: 270 DEGREES 50 MILES FROM NEWARK TIME: 1522Z ALTITUDE: 7000 AIRCRAFT TYPE: C172 SKY: 1800 - 3000 SCATTERED TEMPERATURE: -07 ICING: LIGHT RIME 6000 REMARKS: HEAD WIND COMPONENT 10 MAGNETIC HEADING 300 TRUE AIR SPEED 115

METHOD D

PILOT REPORT FOR NEWARK

LOCATION: 270 DEGREES 50 MILES FROM NEWARK TIME: 1522Z ALTITUDE: 10000 AIRCRAFT TYPE: C172 SKY: 1800 -
3000
SCATTERED TEMPERATURE: -06 ICING:
LIGHT
RIME 6000 REMARKS: HEAD WIND COMPONENT 10 MAGNETIC HEADING 300 TRUE AIR SPEED
115

METHOD C

HAZARDOUS WEATHER ADVISORIES

```
MKCC WST 201345 CONVECTIVE SIGMET 18E
NJ DE MD PA NY FROM ACY TO BWI TO BGM
TO BDR TO ACY AREA TSTMS WITH FEW
EMBDD CELLS FCST TO 1900Z DSPTG AREA
WILL MOV EWD 25 KNTS
```

METHOD A

```
MKCC WST 201350
CONVECTIVE SIGMET 18E
  NJ DE MD PA NY
  FROM ACY TO BWI TO BGM TO BDR TO ACY
  AREA TSTMS WITH FEW EMBDD CELLS
FCST TO 1900Z
  DSPTG AREA WILL MOV EWD 25 KNTS
```

METHOD B

```
CONVECTIVE SIGMET FOR EASTERN U.S.

DATE: 20TH OF MONTH
TIME VALID: 1355Z
OBSERVATIONS
  STATES: NJ DE MD PA NY
AREA: FROM ATLANTIC CITY TO BALTIMORE
TO BINGHAMTON TO BRIDGEPORT TO
ATLANTIC CITY
ACTIVITY: AREA THUNDERSTORMS WITH FEW
EMBEDDED CELLS FORECAST TO 1900Z
  DISSIPATING AREA WILL MOVE EASTWARD
AT 25 KNOTS
```

METHOD D

```
CONVECTIVE SIGMET FOR EASTERN U.S.

DATE: 20TH OF MONTH TIME VALID: 1340Z
OBSERVATIONS STATES: NJ DE MD PA NY
AREA: FROM ATLANTIC CITY TO BALTIMORE
TO BINGHAMTON TO BRIDGEPORT TO
ATLANTIC CITY ACTIVITY: AREA
THUNDERSTORMS WITH FEW EMBEDDED CELLS
FORECAST TO 1900Z DISSIPATING AREA
WILL MOVE EASTWARD 25 KNOTS
```

METHOD C

A-10

APPENDIX B

DATA LINK SERVICES

APPENDIX B. Data Link Services

The following are the initial data link weather (WX) and air traffic control (ATC) services.

ATC SERVICES

Altitude Assignment: This service provides an assigned altitude, and altimeter setting, if required.

Sector Hand-off or Frequency Change: This service provides the radio frequency of a sector to whom control is being transferred. It will contain other data such as altimeter setting or interim altitude.

WX SERVICES

Terminal Forecast (FT): This is a 24 hour prognosis of surface WX conditions within the immediate vicinity of an airport. A domestic terminal forecast includes some or all of the following elements: 1) Station identifier, 2) Date-time, 3) sky and ceiling, 4) visibility, 5) WX and obstructions to vision, 6) wind, 7) remarks, 8) expected changes and, 9) six-hour categorical outlook. The pilot may optionally specify a time of day when making a request for terminal forecasts.

Winds/Temperatures Aloft (FD): This service provides projected winds and temperatures for a range of altitudes for a specific location identifier for a specific forecast time period. For each altitude, the report provides wind speed, wind direction, and temperature. Reports are given for 3000, 6000, 9000, 12000, 18000, 24000, 30000, 34000, 39000 and, (high altitude) 45000 and 54000 (feet). The pilot may optionally specify a time of day when making a request for terminal forecasts.

Surface Observations (SA): This service provides current meteorological WX at a selected location. It includes some or all of the following elements: 1) station designator, 2) type and time of report, 3) sky condition and ceiling, 4) visibility, 5) WX and obstructions to vision, 6) sea level pressure, 7) temperature and dew point, 8) wind direction, speed and character, 9) altimeter setting, and 10) additional remarks.

Pilot reports (UA or PIREPS): This service contains reports of in flight WX conditions made by pilots. It includes some or all of the following elements: 1) location of reported phenomena, 2) time, 3) altitude/flight level, 4) aircraft type, 5) sky cover, 6) flight visibility and WX, 7) temperature, 8) wind, 9) turbulence, 10) icing and, 11) remarks. The pilot may optionally specify any one of the following parameters: 1) Altitude, 2) "C" for information on cloud bases and tops, 3) "I" for information on icing, 4) "T" for information on turbulence. If no parameters are contained in the request, then all Pireps associated with locations within a specific radius of the requested location are delivered.

Radar Sunmaries (SD): This service is a low-resolution graphic representation of precipitation intensities using ASCII characters. The Weather Communications Processor (WCP) shall return a portion of the radar summary which is centered about a specified location.

Hazardous Weather Advisories (WST): Four types are provided, i.e., Convective Sigmets (significant meteorological information), Urgent Sigmets, Sigmets and, Airmets (airman's meteoroloqical information) in order of increasing severity.

APPENDIX C

PILOT INFORMATION SHEET

APPENDIX C. Pilot Information Sheet

Name

Age

May we contact you for further assistance and/or clarification of responses, and to provide you a report of results?

YES___________ NO___________

If YES, please tell us how to reach you.

Address:

Telephone: ( ) Best time to call

FAX:

Pilot Ratings:

How many years have you been flying?

Please list all types of experience you have.

____ Commercial airline ____Corporate

____ General aviation ____Military

Please list the primary aircraft, your position and, hours in the next question.

Aircraft Position (e.g. PIC) Approximate flight hours IFR time

Total hours = Total IFR =

How frequently do you fly?

___Daily

___1-2 times per week

___1-2 times per month

___(Specify)______________

When was your last flight?

How long (time) is a typical flight for you?

C-1

What is your source of weather information?

____ FSS

____ DUAT

____ Other computer sources

____ (Specify)

What types of specialized communication/navigation equipment do you have experience with? (e.g., Loran, ACARS)

How familiar are you with the data link system being proposed by the FAA?

C-2

APPENDIX D

ACRONYM/CONTRACTION FAMILIARITY TEST

APPENDIX D. Acronym/Contraction Familiarity Test

SURF OBS

Acronym	Context
1. CLR	BOS SA 1854 CLR
2. SCT	CVG SA 1630 150 SCT
3. -BKN	DAY SA 1300 -BKN
4. OVC	SAT SA OVC
5. VSBY	SFC VSBY 1/2
6. M	MDW RS 1856 -X M7
7. T	T W MOVG E
8. F	OVC 1 1/2 R+F
9. 1522G35	53/49/1522G35
10. 991	1522G35/991

TERM FCST

1. S-BS	C5 X 1/2S-BS
2. OCNL	OCNL C0
3. X	C5 X
4. VCNTY	TRW VCNTY
5. SW	3BS 3320 CHC SW
6. AMDTS	NO AMDTS AFT 03Z
7. MVFR	04Z MVFR
8. C	C5 X
9. CHC	CHC SW
10. -x	C5 -X

PIREP

1. BL	INTMTLY BL
2. CAT	MDT CAT
3. /TM	/TM 2200
4. /SK	/SK 024 BKN
5. UNKN	/FL UNKN
6. LGT-MDT	/IC LGT-MDT RIME
7. RNWY	RNWY 22 JFK
8. /TA	/TA -08
9. MH310	/RM MH310 TAS 180
10. /TP	/TP BE55

WST

1. PSBL	HAIL TO 1/2 IN PSBL
2. TSTMS	LINE TSTMS
3. DVLPG	TSTMS DVLPG
4. SGFNT	NO SGFNT TSTMS
5. MOVG	MOVG FROM 2315
6. CONT	LINE WILL CONT
7. SVR	SVR ICING
8. EMBDD	EMBDD CELLS
9. INTSFYG	WILL CONT INTSFYG
10. SPRDG	SPRDG OVR

APPENDIX E

QUESTIONS FOR PHASE ONE

APPENDIX E. Questions for Phase One

Each task/question was designed specific to the information available in particular WX service. The first question was asked for the first repetition; the second question was asked for the second repetition. Questions that were asked under each service follow:

<u>Pirep</u>

What kind of aircraft created the report and what icing conditions are reported?

At what altitude was the report made and what is the temperature reported?

<u>Surface Observation</u>

What are the sky conditions and the wind?

What is the visibility and altimeter setting?

<u>Terminal Forecast</u>

What are the visibility conditions for the first and second time periods?

What are the sky conditions for the first and second time periods?

<u>Convective Siqmet</u>

What is the time valid of this report and the current activity?

<u>Wind/Temp Aloft</u>

What conditions are forecasted at 6000 feet.

What conditions are forecasted at 12000 feet.

APPENDIX F

PHASE 1 POST-TEST QUESTIONNAIRE

APPENDIX F. Phase 1 Post-Test Questionnaire

1. Four different ways of presenting information have been shown. Overall and for each specific service type, please rank order the four methods in terms of preference. Examples will be provided for your reference.

1 = MOST Preferred 4 = LEAST Preferred

SURFACE OBSERVATION Why?

Method A______

Method B______

Method C______

Method D______

TERMINAL FORECAST Why?

Method A______

Method B______

Method C______

Method D______

PILOT REPORTS Why?

Method A______

Method B______

Method C______

Method D______

HAZARDOUS WEATHER Why?

Method A______

Method B______

Method C______

Method D______

WINDS/TEMP ALOFT   Why?

Method A______

Method B______

Method C______

2. Are there any other methods that you can suggest that would make the information clearer and easier to read?

3. Would you prefer a graphics presentation of weather where at all feasible?

4. Do you prefere the spelling out of the information or the use of acronyms in weather messages.

Acronyms______   Spelled out______

Explain:

5. Were the character sizes: (check one)

Too small______

Just right______

Too large______

APPENDIX G

PHASE 2 POST-TEST QUESTIONNAIRE

APPENDIX G. Phase 2 Post-Test Questionnaire

1. Please rank order the four input methods in terms of preference.

1 = MOST Preferred   4 = LEAST Preferred

Direct typing___________

Bezel select___________

Number select___________

Cursor select___________

For example, appearance, intuitiveness, susceptibility to errors, speed or operation, etc.

2. Please specify any characteristics about your MOST Preferred method that would make it even better.

3. If you would have encountered these input methods "cold", would it have been obvious how to enter a location identifier?

Direct typing___________YES   ___________NO, it was not obvious

Bezel select___________ YES   ___________NO, it was not obvious

Number select___________YES   ___________NO, it was not obvious

Cursor select___________YES   ___________NO, it was not obvious

4. For each method please describe briefly its major advantages and disadvantages.

Direct typing

Bezel select

Number select

Cursor select

5. Do you have any preference on how the location identifier should be ordered on the display (e.g., alphabetically, by route, random or other). Please specify or draw.

6. Should one of the LOCIDs be designated as default when the menu appears?

___________Yes   ___________No

If Yes, which one (e.g. first, last, center, other)?

7. If you have made a weather request for, say LAX, should LAX become the default LOCID whenever you make another request (regardless of type)? Please explain.

___________YES ___________NO

8. Was the additional information provided by the translation of the three letter station identifier useful? (e.g., LAX Los Angeles Int'l Ca).

YES___________ NO___________ Explain

9. During the typing mode the LOCID was entered; if additional characters were entered, the left most letter dropped out and the last two shifted left. The entered letter is placed in the right most position. Is this acceptable? Select one and if no, explain. YES ___________ NO ___________

10. Was the terminology used (e.g., SEND, CLEAR, etc) acceptable?

	YES	NO
SEND	___________	___________
CLEAR	___________	___________
MAIN	___________	___________
LOCID	___________	___________

Changes suggested:

11. The message status indicators: SENT, PROCESSING and, AVAILABLE appeared after making a weather request.

Was this terminology acceptable? YES___________ NO___________

Was the location acceptable? YES___________ NO___________

Explain.

12. What type of annunciation (e.g., flashing light, tone, etc.) of incoming messages would you desire in an operational system?

ATC messages Weather messages

G-2

13. Do you think the use of color on a display of weather and ATC information is:

____________ Very helpful

____________ Somewhat helpful

____________ No preference either way

___________ Somewhat detrimental

___________ Very detrimental

Why?

14. Were you satisfied with the appearance and operational characteristics of the main menu? YES ___________ NO ___________ If no, please explain.

15. Were the character sizes: (check one)

Too small___________

Just right___________

Too large___________

G-3

APPENDIX H

PRE- AND POST-TEST PILOT COMMENTS

APPENDIX H. Pre- and Post-test Pilot Comments

The subsequent paragraphs describe the comments/suggestions made by the pilots during the Mini Studies evaluation of input methodologies and screen/format presentations for the initial package one WX Services.

Air Transport Pilot # 1

"We can get WX anytime through ACARS (ARINC) on a printer, in fact, its already done quite eaeily."

He described the keystrokes for requesting WX using the ACARS equipment : MISC (miscellaneous button) -7-Enter(or slew to the desired station first-the default is his destination airport)-SEND. In practice, he requests surface observations and terminal forecasts. He wasn't very familiar with Pilot Reports, in fact, he said the "little guys" down below are concerned with PIREPS, he's more concerned with Ride Reports. He also said that nobody cares about FD's (Winds/Temps Aloft).

His dispatcher sends SIGMETS automatically over ACARS.

"If you go to airline people make sure you make people aware that you already know what is out there."

"Airline community would be underwhelmed--Why are you doing this, we already have a better system."

"Why would I waste my time with FAA WX generated ground precipitation intensities when my WX radar displays precipitation at my altitude."

"Where this (data link) can help is with radios."

He would still like a warm fuzzy coming up through DL conveying somehow that ATC has him on the new frequency.

He described how an altitude assignment may be handled with the use of a NEW TARGET and CURRENT TARGET bugs. A simple switch hit would set the NEW TARGET bug to the altitude of the data linked AA, and a subsequent switch hit would put it in the TARGET (current) bug.

Some responses to the loss of the "Party Line": "The thought of losing it (party line) never bothers me"; "If WX goes to pot and the plane ahead of you is holding then you have a feeling that you're going to hold too--but I don't really need it"; "You'd have to be paying a lot of attention to know if someone has been cleared into your airspace."

He expressed thoughts about an optimized ATC system, a so called "conveyer system" that would manage more effectively traffic into "slots.

He would "love" ATIS through DL.

He prefers a printer to a display; "It's a logistics problem..this display is prime piece of real estate that I may use only one time" [the above comment was ma~ with regard to an earlier comment that he may only request WX once in a normal/routine flight].

On viewing the communications, navigation, identification (CNI) page demo the following suggestions were made: "It is cluttered (he saw the cluttered version of the CNI page, the uncluttered version wasn't available yet)"; "I think it's GREAT"; "Do this also for altitudes, headings and airspeeds"; "Put USE in a brighter color, different from STDBY- deemphasize COMM 2, we (at American Airlines) primarily use COMM 1 in the air and COMM 2 on the ground for ATIS, etc.

He prefers the Terminal Forecast in English and the Surface Obs in the "cryptic" style. "At the very least, separate the answers from the field descriptors and adding color may help"

About FT's: "FT's - I'm up at cruise, I've got the time - easiest way to understand it is in WORDS - Format D (English and structured)."

Additional comments about the WX formats:

"Reading WX formats is not a dynamic, real time, high workload event.

The following comments were made with regards to the Input Methodologies experiment: "99 out of 100 (pilots) wouldn't load LOCIDs in (prior to departure) - cities that you fly over aren't important."

"...by default I should be able to type in a LOCID and a scratchpad could come up.

"I can go a whole month without calling up any WX other then my destination, unless my WX at destination is getting worse and I want to look at an alternate airport." "I only care about two cities at most; it's a moot point that I would have 9 LOCIDs available"; "I can't see that in a typical situation you would have more than 2 to 3 LOCIDs."

"NOT VALID testing, because you're not going to enter it in that way anyway"; ...doesn't matter what the best way is"; "WX Input: - minor thing as far as taking your attention away."

With regards to the typing method: "I don~t like it already"; "Obviously, there is a big learning curve on the Reypad."

He talked about a situation where a crew was flying, on approach, perpendicular to the two parallel runways 27L and 27R at ORD and the pilot was cleared visual to 27R. In a nutshell, the pilot missed the approach because he had "become a slave to the FMC", "When it's new (such as the computer) they (the pilots) make it tunnel vision for themselves.

Air Transport Pilot # 2

"At night time....how do we get WX at night time?...FSS (Flight Service Station) is asleep....this would be a big help."

"We fly the little dinosaurs, there's nothing like an auto throttle." With regards to an automatic uplinked speed change: "I don't think people would want to do that."

"I generally don~t use Pilot Reports at all - doesn't affect me at all"; "Almost never see a Pilot Report at the altitudes (flown) for a big airplane"; "Pirep is usually reported by the guys down below (GA)."

With regards to the English style presentation for the WX formats: "It would prevent you from screwing up"; "I've never seen anything in long hand before." "I'm back 100 yrs., I'm still using the old symbols (the circular style symbols for cloud cover), I'm happy with the old symbols myself."
"He's going to get his WX way before he actually gets there."
He talked about the current way they broadcast convective sigmets, and how they'll describe a line of thunderstorms in relation to some seldom heard station identifier, how a series of these can be difficult in picturing the actual WX phenomena.
With regards to crew alerting: "ATC is more important, use yellow or a caution color, for WX, use some other color like a blue or magenta.....yellow is for an alert light...yellow on our INS and inertial NAV flashes and catches your eye real quick"; "I prefer flashing the light because there's so much noise anyway." "Some planes need to TOD (Top of Descent) earlier more so than others, therefore its often that one would request to descend so they can get to their destination.

Air Transport Pilot # 4 and 5 (Joint Pre-test Interview)

LOCID menu: "Would this be on your route of flight?. How would they get in there?”; "Put major cities that you're going to hit into the LOCID menu, you may have to type in the alternate because the alternate changes everyday"; "I like the idea of inputting a letter which would bring up the page of station identifiers corresponding to the letter chosen."
Winds/Temp Aloft: "They could be real helpful, we currently get winds data on the airplane; the data linked FD would give us an idea how accurate that is.
WX formats in general: "Might be hard to read that close together anD that small...add a spacer between the lines of text"; "Everybody is so used to looking at the formats that the FAA puts out~'; "We don't have dispatchers, we have to do this all on our own"; "...suggest integration into WX radar."

Message List: "I'd be able to get trend information rather easily, now its so much of a hassle"; "For WX, this would be fantastic."

H-4

ATC Services: ~'It would almost have to be enroute, in the terminal area, no.

Crew Alerting: "A tone, or something, to let you know that something is there. You need a light and tone."

Air Transport Pilot # 5, 6, and 7 (Joint Pre-test Interview)

Crew Alerting: "Does it have an audible, a way of alerting you that something has come up....probably both an audible and a light would suffice."

ATC Frequency Change: "...something that tells you that he has checked in; currently, there is no way of checking in until you have a voice call. Maybe, an asterisk or some indication that the ground has you on frequency."

"Looks like ACARS here, looks exactly like ACARS...It's like ACARS-you touch it on the screen--I like line select the best." (Note: they've seen ACARS through jump seat rides).

"The trend is going to manual typing and computer programming; instead of reducing pilot workload they're rechanneling it to a different area.

"I like the vertical setup (teletype version)."; "Add color on the time periods in the vertical structure FT."

"For example, clearances would be better in hard copy form rather than having to write everything down."

Radar Summaries: "I don't like those l's, 2's and 3's they have on those Radar Summaries."

Pilot comments (No objective data collected)

"Need redundancy of the alerting system, if something goes out something else goes on." "In the approach/departure environment below 20,000 ft, ATC does a lot of things that you see now and act on later." "Any piece of equipment in the airplane should be useful from block to block." "WX reporting stations, are not collocated or coordinated with the actual VOR itself. "FD's are forecasted, not actually going on right now - that's not goo~ ror me. "You don't actually get PIREPS from airlines-we don't volunteer anything." "A lot of people don't know what the cryptic abbreviations for type of aircraft are.

H-5

We don’t use ARINC very often unless were over the Pacific or something - we don’t use it very often."

"What's it going to do for me that I don't already have now?"

"When at TOD 130 miles out, you want to plan on a particular runway, you want to listen to ATIS." "I don't see anything here that ACARS can't give me."; "Don't reinvent the wheel. "I thing this is a waste of money."; "If ACARS didn't exist this would be wor investing the money to do this. "You don't need NOTAMS in the a Clearance delivery, enroute information over the ocean, and an integrated altitude alert were recommended in response to what a DATA LINK system could do for them.

General Aviation Pilot # 1 "If you're going to talk in terms of how to decrease my workload than this is great."

CNI demo: “When I’m flying it would take me longer to look down and type 117 than to turn a knob."

"Some LORAN receivers have the ability to select a station identifier by their literal translation, a convenient look-up function."

"Put sea level pressure next to altimeter."

In response to having a keyboard: "Leaning over can easily induce vertigo if you are in hard IFR, maybe there should be controls on the yoke, or down to your side." "Typing in information may be O.K. in a preflight mode."

"I've seen LORANS where you can scroll thru LOCIDs or thru cities and using a radio like switch, when turned, scrolls thru the alphabet..... and so on.

In response to WILCO: “What controller really wants to hear is --affirmative.

"Is there any recourse for stopping the transmission of an incorrect response to an ATC message?”

"Learning ATC phraseology is one of the most difficult tasks in becoming a pilot.

H-6

General Aviation Pilot # 2

In response to the CNI demo and a data linked frequency change: "At the top level it~s a neat idea, but it seems like there~s a lot of gadgets to just say-N...turn to 108.50."

"I don't think I like that (cursor key method)."

"The concept is neat, especially getting WX information and looking at it at your own leisure. It gets kind of squeamish getting ATC stuff over data link; it doesn't seem to be reinforced enough as it is verbally, you don't get the positive acknowledgement - maybe it's just that I don't feel comfortable. I get a warm fuzzy by reading clearance information back correctly, both ATC and you have heard it twice; with data link, the controller may have had a typo and you may have not read it right.”

"When ATC gives you an amended heading or an amended clearance you hear it over the headset. Especially if you are VFR looking outside, trying to figure out checkpoints. (With data link) I don't know how you're going to see it - it may be as simple as a beeper going off in your headset."

Alerting: "Problem with a light is you have to see it; you may not get back (in your scan) to the visual indicator, your ear will always hear that, like a tone in your headset."

"If you had the letters in the form as a typewriter it would be better for me.

"I didn't like the 3x3 cursor key arrangement; if I want to get Chicago (ORD) I nave to cursor over twice. The more keystrokes I make the better chance for me to make an error.

“This is kind of bizarre......in the F-16 you can call up a zillion things on the HUD by not taking your hands off the throttle & yoke. This would be great here too.”

"For a GA guy, I think the WX stuff is more useful.”

"If you can replace the transponder, NAV/COM, ADF and DME then something that size is not bad (referencing the display); You can get by with 2 or three lines with the coded format of surface observation that you get now, but with radar summaries you need something bigger."

H-7

"Typing was the most versatile one, even though the data may show that it took the longest."

General Aviation Pilot # 3

"I use DUAT all the time, I don't have too much problem with it, but I know a lot of people that are up in arms with it."

"I like the idea that I can make multiple requests and be able to retrieve the one that I want.

"I think Surface Obs is better than SA."

"We're used to seeing sea level pressure as pressure altitude."

"Can you make the information a different color, maybe even spaces,so when you are at the point when you're used to it you can just pick out the information you want a lot easier.

"Maybe you can put the cursor keys on the yoke.”

"Skip a line, alternating colors or perhaps connect a thin line that brings the information together." [1,1 version of FD]

"What I think would be nice to have is a RDU (Remote Display Unit) tied with a master caution light, that would be all head up so I can act now with the information and deal with the display later."

You have to be familiar with giving them to understand what's out there." [Pireps] "I prefer to continue using line select/bezel keys instead of first using bezel (for selecting service) then going to either the number pad or cursor keys below (to select the station identifier).

General Aviation Pilot # 4

“Not enough time to type; not all pilots type.

General Aviation Pilot # 5

"Put number pad to the right or left, not melted with other keys.

"If you can get it on the window (line select functions) why have the alternate method of punching keys?"

H-8

"Minimize keyboard as much as possible! (bumpy air)"

"We, GA, never see Pireps.”

"In some WX reports the minus (s-bs, x-, etc.) is not consistent, sometimes it appears before and sometimes after.”

"Put more English in Pireps, "we" (pilots) never see them printed out.”

"We only hear WX advisories over the radio and only hear them once, once you start to listen you have already missed the first part. Need to repeat the entire advisory." With regards to WX formats in general: "Ones that you see more often are OK in line (horizontal structure~, the ones you don't see spell it out and arrange it vertically.”

H-9

APPENDIX I

QUESTIONNAIRE COMMENTS

APPENDIX I. Questionnaire Comments

PHASE 1 Information Retrieval

QUESTION 1. Four different ways of presenting information have been shown. Overall and for each specific service type, please rank order the four methods in terms of preference. Examples will be provided for your reference.

1= MOST Preferred   4 = LEAST Preferred

SURFACE OBSERVATIONS

ATP

Method A is the normal fashion to most pilots. Method B is too hodge-podge and it non-standard manner. Method C has the question and answers on is presented in different lines. Method D is readable.

Method A is about equal to B. Method B, the info popped out at me, easy to read. I would rather rear D over C.

Method A I am used to using.

Method A is the most comfortable for me.

Method A is the easiest to see and to read.

Methods A and D not written in English, Methods C and D: can find what I want quickly.

GA

Method C is too cluttered to scan. Method D is easy to read with no interpretation required. This is an important feature for GA pilots that don't fly often.

Method C requires you to search for information and is too run together.

Method D is easy to find what I want.

Combine method B and method D (see question 2).

For me method B and method D are excellent ways of presenting data. It is easy to read in the line by line fashion. Method B is merely a less decoded version of method D.   Method D is better for that reason.   Improve on method D by abbreviating categories and making them a different color from the data. Separate the two with more spaces.

I-1

Method D iB easy to decipher and visually pleasing.

Method D is the most complete and specific. With speed and amount of information available with data link, information should be CLEAR.

Method D is easier to read and requires no interpretation. I'm not sure which is better "B" or "C"

TERMINAL FORECAST

ATP

Method A is normal fashion to most pilots. Method 8 is too hodge-podge and it is presented in non-standard manner. Method C contains questions and answers on different lines. Method D is readable.

Method B is a little bit more difficult than D. Method C is the hardest to read on the computer screen. Method D is first because it is easiest for me to find info quickly.

Method A is the method I am used to using.

Method C runs together. Method D takes longer to read but the information is spelled out.

Method A is the easiest to see and read.

Methods A and D not written in English, Methods C and D: can find what I want quickly.

GA

Same as SA.

Method B, I don't know where to look for time increments. Method C is okay, but words seem too tightly packed. Method D is broken into logical groups, i.e., time.

I-2

Combine method B and method D. (See question 2)

Again, better organization and greater use of abbreviations (not obscure ones like the current group). The use of color will further aid the pilot to find the data he needs.

I'm used to method A, so therefore its quicker, but at the same time it's hard to remember all the abbreviations. Method C is nice to read and comprehend.

Method C is clear. Method D is clear, complete, and informative.

Method B is easier to read than method C however, it requires more thinking.

PILOT REPORTS

<u>ATP</u>

Method C is a bad format, but the “words” are good. I am not used to reading pilot reports, all the TM/FL/TP stuff is too cryptic.

Method A has all those slashes to pick between, which I don't like. Method B is the easiest to extract information quickly. Method C is harder to pick information out of the block format. Method D has more words to read and understand, but the indentations are good.

Unfamiliarity with some abbreviations; prefer spelled out without running info together.

Method B is the easiest to understand.

Methods A and D not written in English, Methods C and D: can find what I want quickly.

<u>GA</u>

Same as SA.

Method A is what I'm used to. Method B is better than method A because it lists categories. Method C is okay, but words seem too tightly packed.

Method D is broken into logical groups.

Combine method B and method D. (see question 2)

Method B is concise and orderly. The abbreviations can make it tedious but its a better tradeoff. Method D, the verbiage on this form is less attractive.

Method A is standard. Method B is easy and quick. Method C is wordy. Method D is more definitive.

Method A is too cryptic and it does not reduce pilot workload as the use of data link should. Method D uses advanced technology to inform and advise the pilot.

Method C has information all running together and not broken out into groups.

HAZARDOUS WEATHER

ATP

Method B: indenting helps readability. Method C and D: readability words are better than acronyms.

Method A is a mixture of acronyms that I have to translate while searching for data; makes it cluttered and busy. Method B is the easiest to extract info quickly. Method C is getting more cluttered and wordy. Method D has more words to deal with and the symbology of unabbreviated words is harder to get, but the intentions are good.

Unfamiliarity with some abbreviations, prefer spelled out, without running information together.

Methods A and D not written in English, Methods C and D: can find what I want quickly.

GA

Same as SA.

Same as above.

I-4

Concise and clear.

A fine line exiets between B and D for me. D has crossed the verbosity line again. B still has some bad abbreviations, but it is clearer. I can find the information I need quickly without having to stare at the display.

Need for data link to help pilot is more with hazardous WX since such advisories are not as frequently used as surface observation and terminal forecast. These are hard to read, need good readability to understand exactly.

Group broken out into segments for ease of reading and understanding.

WINDS/TEMPERATURES ALOFT

ATP

Method C was very graphic. Method A was a mumbo-jumbo mix. Method B is the easiest to read and fastest to comprehend. Method C, looking across columns is not quite as easy Method C, no conversion of wind temp required for higher altitude readings. Method C is very easy to see and understand.

Methods A and D not written in English, Methods C and D: can find what I want quickly.

GA

Same as SA.

Method A is okay, but only because I know what to look for. Method B is easier to read. Method C is very clear and descriptive.

Concise and clear.

Effective use of space to maximize spelling out of data. No guessing on where zeros and minus signs go.   Could be simplified by screening unwanted data i.e., in Cessna 172, I'm not too concerned about winds above 12000 ft.

I-5

Method B is very easy to read quickly and understand. Method C is too wordy and
spread out.

Method A is too strung out and unorganized. Method B is too cryptic. Method C is
straight forward, organized, clear, informative, and shows trend of direction,
velocity, and temp.

Method A requires figuring out the reporting method and it's too confusing.

Method B is broken out into groups. Method C has too many columns.

QUESTION 2. _Are there any other methods that you can suggest that would make the information clearer and easier to read?

ATP

Color code questions from answers. Add paragraphs or indents for different valid times. Keep questions and answers on same line.

Valid times different colors.

Make the information in different colors: i.e. (SKY: 2400-3000 BROKEN). Here sky could be blue and the information could be white.

GA

Modify method D to look like:

TIME: 18752Z
SKY: 8 SCT 220 SCT
VISIBILITY: 6

OBSTRUCTION: HZ SMK

TEMP/DEW PT: ...

WIND: ...

ALT: ...

This would require less reading by giving more separation between description and data.

I-6

SA PHL 1852

SKY: 7SCT

230SCT

VSBY: 6 HK

PRES: 129

etc.

Arrange concise abbreviations in one column (in subdued color) and then place information (not necessarily translated into full English) in brighter color opposite.

My big items are color and spaces. Maybe a blank line between data lines if able. Maybe make some sort of line to connect the category with data if the space is large. Use obvious abbreviations.

If space is available on formats, separate lines of information with wider spaces to provide reading ease.

QUESTION 3. Would you prefer a graphics presentation of weather where at all feasible?

ATP

Especially radar summery charts, "sigmets".

Radar summarv and prog charts

GA

For hazardous WX it would be great to superimpose it on map.

A map of the states near your route with the dominant pressure systems would be nice.

A picture tells a thousand words.

I-7

Toss in a stormscope and a couple of radar WX maps and you've got a deal.

A moving map that automatically shows where you are and where you are headed.

With option to call up matrix of information for detail or a location.

If there would be some continuity and not a lot of obscurity.

Maybe, I'm not sure how you would do it. I would have to see it first.

<u>QUESTION 4</u> Do you prefer the spelling out of the information or the use of acronyms in weather messages.

Acronyms ___________ Spelled out__________

<u>ATP</u>

Acronyms for current observations. Spelling out for forecasts and hazardous WX.

few items so standard acronyms are

For current observation I am only interested in quick & familiar. To read a forecast it is easier to rea~ wor~s slnce 1 am typically not in a hurry or only looking for one or two items.

Acronyms are better but only if the information is arranged neatly and not cluttered.

Acronyms are preferred because there is less chance of a mistake and it is faster. Saves space, reduces clutter.

Acronyms are preferred.

Acronyms are ok for SA and FT because of familiarity. However, other reports contain acronyms which are not as recognizable, e.g. Haz Wx, Pireps.

Acronyms are preferred as long as they are understandable.

Spelled out, I'm lazy

GA

Spelling out where acronyms are not obvious. Contractions are also acceptable.

I-8

Spelled out is better, but only if it doesn't crowd the screen.

Combination of the two is acceptable. However, change some of those bogus acronymq. TSTRM is pretty good but why iB SMK spelled K?

Both are acceptable. Some acronyms are perfect e.g., KTS, FCST, SGFNT. Some stink, e.g., EWD, PSBL. A better choice would help. Spelling out will only crowd the screen and make it difficult to read/find information. Remember, I have to fly too. Spelled out if the information is life threatening. I would hate to misinterpret a sigmet because I couldn't decipher the acronyms. Some are okay though like winds and winds aloft.

Data link is fast and broad band (plenty of information). Use the technology to reduce work load.

All professions use acronyms. The problem with aviation is that too often there is no continuity to the acronyms.

I prefer words spelled out: but I prefer grouping of items over using either acronyms or spelling out.

QUESTION 5 Were the character sizes: (check one)

Too small ____

Just right ____

Too large ____

ATP

No comments received.

GA

The space between major categories was too small for easy reading.

The character sizes were just a little too small. Also reduce your number buttons, if possible.

I -9

A bit small, in bumpy air they would be hard to read.

A COMMENT....

In general, pilots complain about the present system of information and abbreviations primarily because they didn't get to use it enough. They are not familiar with the formats or abbreviations. The only times they use it is when they are studying for their licenses. After that, they get the info from the FSS or the weatherman and he deciphers the code into English. As DUAT use becomes more widespread, more and more pilots will become familiar with the formats and abbreviations. Your system will also help keep pilots proficient in this area.

PHASE 2 DATA ENTRY.

QUESTION 1 Please rank order the four input methods in terms of preference.

1 = MOST Preferred 4 = LEAST Preferred

ATP

Typing requires too much head-down; unfamiliar keyboard. Using the bezel, one cannot see all cities at one glance because they are too far apart.

Probably the easiest and quickest to understand is the bezel method. Direct typing is harder and it takes more attention. Also, with typing, one is more likely to make errors. Reading the number pads is a bit harder than the bezel, but the data are compressed so reading it from the screen is easier. I think I liked the short hand and finger movements of the number select a lot.

Direct typing, bezel, and number selects were acceptable, but the cursor select method was not. The cursor method did not allow for easy operation. They were ranked according to ease of operation.

Typing is cumbersome, but largest selection of LOCIDs. Bezel is easiest - 2 hits and you have it. Number - ? Cursor - have to stare at CRT until selection is made.

GA

Bezel would be easier to execute in bumpy air.

Bezel select allows me to focus attention on screen and one doesn't have to shift between screen and keyboard. Direct typing is too slow, but it is flexible. Cursor select is too indirect and requires too many keystrokes.

"Visual" or "object oriented" selection (where you don't need to think about what number you want or how to "spell" on the keypad) is direct from thought action..less chance of error, more comfortable". (Bezel)

With bezel I could select my desired service, choose my LOCID, and send all within the same general area. Number select I had to first locate my LOCID, read the number, then find the key pad. Then I had to find the number, then send. A lot of eye movement = bad in IFR.

Faster, easier, and appearance. (Cursor)

The cursor select method - speed of operation, reduced work load, and one may correct mistakes made.

Past experience with diagnostic equipment that utilized this format (number select). Easier and faster. (Bezel)

QUESTION 2 Please specify any characteristics about your MOST Preferred method that would make it even better.

ATP

No ideas which could improve method.

GA

A better keyboard "feel"; i.e. feedback from tactile sense when you depressed the function key (similar to an HP-41 calculator feel).

Send key seems a bit redundant. Why not send as a result of the selection of an identifier?

The only problem I had with Bezel select was when the selection button I wanted was on the right hand side of the screen... it took and extra eecond to find it over there.

If I pushed my LOCID button a second time that would equal a [SENT] saved keystroke. This would reduce the amount of head-down time and only require me to find one button.

It is easy to visualize where your 3 letter identifier is in relation to the cursor. Then just feel for the arrows and check once again before sending.

Need for cockpit workload to be reduced or mistakes to be corrected.

Making the numerical pad sufficiently separate, and apart from the alpha keys. Also, make the "5" key similar to a calculator so that the pilot might be able to use his sense of feel.

They are fine the way they are. Maybe use green for the lettering since pink may be difficult to see with the sun on the screen.

<u>QUESTION 3</u> If you would have encountered these input methods "cold", would it have been obvious how to enter a location identifier?

NO COMMENTS RECEIVED

<u>QUESTION 4</u>   For each method please describe briefly its major advantages and disadvantages.

<u>DIRECT TYPING</u>

<u>ATP</u>

Typing in mistakes is possible. It takes too long to type in data. Direct typing takes too long.

The pilot may not know the identifier.

Familiarity in working with a 3 letter identifier; poor speed.

You can type in designator that is not shown on the screen.

Will access unknown identifiers (advantage), typing skills (disadvantage).

Min effort to qet any location in the system, if I knew the identifier.

GA

Advantage-you can enter any location you desire. Disadvantage-you must remember LOCIDs and there are too many keys to press while still flying an airplane (SA degradation).

Advantage-very flexible and can use any identifier. Disadvantage-takes to long to use every time.

Advantage-Allow more choices (reports not on menu). Disadvantage-too much head-down time; keyboard not user friendly; too many keystrokes and I don't like typing.

Advantage-maximum flexibility enroute. Will be especially useful if diverting or changing plan. Disadvantage-Requires pilot knowledge of wx reporting LOCID which sometimes is different from airport identifier.

Disadvantage-very slow, hard to find letters and it takes too much time.

BEZEL SELECT

ATP

Eye has to move around perimeter of video and hands move around more than on other methods.

You only have to touch one button.

Easy and obvious.

Choices are too far apart.

Easy to use.

Speed (advantage).

Look, find, hit, but what if your LOCID isn’t listed.

GA

Advantage-easy to execute (even in turbulence). There is no memory of LOCIDs required. Disadvantage-LOCIDs limited by screen space and bezel keys available. Advantage-minimizes the number of keystrokes. Disadvantage-limited to pre-defined identifiers.

Advantage-quick, obvious and could do it in a tstorm. Disadvantagenot enough room for a whole lot of choices on menu.

Advantages-excellent method, especially if I pre-flighted it. I should know where the info is, I find it, put my finger to it and send. Disadvantage-could be bad if desired LOCID is not on page, but if you combine with direct entry, you get the best of both worlds.

Advantage-obvious, intuitive and easy to understand.

NUMBER SELECT

ATP

Once you choose your desired station number-it happens quickly. Then you have to search and choose the right number key.

Is intuitive once the system is learned.

You only have to touch one button.

Is obvious.

Good speed and reliability.

Takes time to read station than find number to push.

Allows for remote operation.

Look, find, hit, but what if your LOCID isn't listed.

GA

Advantage-easy to execute (even in turbulence) and no memory of LOcIDs are required. Disadvantage-more steps to execute than the bezel.

Advantage-minimizes the number of keystrokes. Disadvantage-must shift focus from screen to keypad and back.

Advantage-better than direct typing. Disadvantage-Have to think to much and don't like typing.

Disadvantage-too much busy work. First I have to read the li~t to find the LOCID, then I have to find it~s number. Then I have to find the number on the keyboard, Then send it. This is too DIFFICULT.

Advantage-obvious, intuitive, and easy to understand. Disadvantage prone to greater error.

CURSOR SELECT

ATP

To move the cursor around requires extra hand movements, but it is accurate and is used in many software programs.

Is intuitive.

Takes to much time to move around screen.

Extra moves are required to call up diagonally.

Somewhat time consuming.

Speed.

What if your LOCID isn~t listed.

GA

Advantages-easy to execute even in turbulence and there is no memory of LOCIDs required. Probably not as difficult to execute in turbulence as the number select.

Disadvantages-moving cursor in matrix is too indirect. Takes too many strokes. Advantage-would allow a alot of choices like number and direct (fill the screen and use page up and page down). Disadvantage-may have to "type around"; a lot to land on choice.

Advantage-good because I know exactly what I'm getting: no typos or miss-entered numbers. Disadvantage-too much head-down time making sure cursor is in correct spot.

Disadvantage-slower and requires eye and finger coordination. Do not like as well as bezel or number selection.

QUESTION 5 Do you have any preference on how the location identifier should be ordered on the display (e.g., alphabetically, by route, random or other). Please specify or draw.

ATP

Route is definitely the best; sequentially would be good. For example, suppose the flight was from LAX to ORD than the order should be (LAX-PHX-DEN-DSM/MSP-ORD).

By route with alternate and destination always in some preselected location.

Alphabetically or by route.

Alphabetically

By route

Alphabetically.

Bezel-order of flight plan.

Number-order of flight plan.

Cursor- rder of flight plan. Cursor follows flight plan with only one advance button needed. On recall cursor is located at enroute point of flight.

Route.

<u>GA</u>

By route. Future capability to couple with a moving map would be nice.

Alphabetically makes the most sense to me.

2 modes: (1) user selected (let me format my own menu before/during flight), (2) alphabetically within region (i.e., select IAP region or state you~re in, then list alphabetically). LOCIDs should be user identified during pre-flight. If they are, then it is up to each user to order them. If the LOCIDs are not identified, machine defaults to direct typing mode, there also should be a memory. The last LOCIDs entered should stay unless cleared out. One of the options on any select should be blank: i.e. left for direct entry. see opposite.

Have mixed thoughts on alphabetically vs route of flight, but think alphabetically is best.

<u>QUESTION 6</u>   Should one of the LOCIDs be designated as a default when the menu appears? _______Yes _____ No   If Yes, which one (e.g. first, last, center, other)?

<u>ATP</u>

First one, so that the screen can be ~moved up~ to current one if necessary as the flight rolls along.

Destination.

Recall to page, LOCIDs should designate station along flight plan to reflect current position.

Destination.

GA

Point of destination, home base

User defined, i.e., home base, destination, etc.

How about closest LOCID to acft position.

Those from the last flight.

Except for cursor, that should be the center LOCID as you have.

QUESTION 7 If you have made a weather request for, say LAX, should LAX become the default LOCID whenever you make another request (regardless of type)? Please explain. _____YES   _____ NO

ATP

Destination should be default so as to provide continuous update of dest WX.

Destination should be default.

Default = destination.

As a jet crew member, all I'm really worried about is destination WX (mostly). I'll watch that as the flight continues. If it looks bad then I'll look at others. As a rule, I always get my alternate wx with destination, so maybe the display should be set up to acquire multiple WX report at once, then I have all I'm interested in right in front of me and I don't have to "flip pages" back and forth. Enroute WX is checked several times for any changes at arrival airport.

Yes, that way you can get FT, SA, etc.

GA

I would prefer that the system default back to the destination.

Your typically concerned with WX at one given location. Hence you may want several products at the same location.

When I'm looking at WX, I will usually pull up a set of FT's (FT LAX, FT BKR, FT

etc) then a set of SA's (SA LAX, SA BKR, SA etc) instead of pulling up a series of WX on a specific location.

Sure, chances are if I checked the wx there, I would like to update it. I really have no preference here.

You might be checking your destinations, or your home, but actually you are still enroute.

No, may need WX for alternate or in event of emergency another location.

Flying is dynamic. I appreciate software programming is still a huge workload. But flexibility, info and trends are larger workload for pilot in much shorter time.

Would maintain continuity and alleviate another cognizant thought process.

As one flies further on down the route toward destination I suspect the next enroute WX request will be a different location. I have no thoughts on what should be your default LOCID.

QUESTION 8 Was the additional information provided by the translation of the three letter station identifier useful? (e.g., LAX   Los Angeles Int'l Ca).

YES_____ NO_____

ATP

Yes for new guys, No for experienced guys.

I knew that I had the exact airport (although in the test I didn't pay too much attention).

For pilots who don't know ID.

If working with unfamiliar flight plan.

If working with an unfamiliar airport.

For airports one is not familiar with.

I-19

GA

On an unfamiliar route, you may not be familiar with a particular LOCID.

Some cities have many airports. You would have to spell out abbreviation fully, just list the city.

It would be helpful only to verify that I was looking at the right one. How about giving me the hint before I made a selection.

Acts as backup particularly in direct entry mode if by mistake I type LBX instead of LAX, and the decode is "Lebanon county KS" instead of "Los Angeles CA", that help.

I don't remember seeing the translation. But, it would be helpful to be able to decipher these quickly.

LAX and DCA are well known, however how about MQJ or C62? Lets get realistic.

Might help alleviate an error, especially with an identifier like 4I9 (GREEN CTY), might be construed as 419.

Not sure how useful the information was but it serves as a reminder just in case the pilot forgets.

QUESTION 9 During the typing mode the LOCID was entered; if additional characters were entered, the left most letter dropped out and the last two shifted left. The entered letter is placed in the right most position. Is this acceptable? Select one and if no, explain. Yes _____ NO _____

ATP

Some airports (overseas especially) have weird identifiers. KDAY is really the same as DAY.

I would like to see a one letter clear button also.

It is better to have whole words.

I-20

GA

In turbulence, you may accidently strike an extra letter causing the left most letter to drop off. Then, you would have to retype the LOCID.

The last three entered letters are used as LOCID, that way I don't have to find/use clear button. I like it.

Well I didn’t notice this, but I suppose mistakes would be compounded. I don't think this is a good practice. You would need a clear button or an erase back arrow.

Too complicated in stressful high workload situation.

Take into consideration turbulence and bouncing in the cockpit.

QUESTION 10 Was the terminology used (e.g., SEND, CLEAR, etc) acceptable?

SUGGESTED CHANGES:

ATP

Could use STATION (instead of LOCID)

GA

"Enter" might make more sense than "send", especially for those used to computers.

I prefer "station identifier" over LOCID, this is preference only.

QUESTION 11 The message status indicators: SENT, PROCESSING and, AVAILABLE appeared after making a weather request.

Was this terminology acceptable? YES _____ NO _______

Was the location acceptable? YES _____ NO_________

ATP

Maybe moving to center of screen so that it is in easier "eyes grasp" of the fovea.

GA

TERMINOLOGY Yes, concise indication of system status.

Yes, good idea, one can see the system is processing the request-feedback!

LOCATION

No, when in the "processing" or "wait" mode, a reverse background/color message should appear in center of screen. When data is available, have the LOCID flash or have flashing background. Selected data not yet sent or available would have continuous background highlight.

Yes, might improve. Using the number pad, I learned that "send" was next to number one.

QUESTION 12 What type of annunciation (e.g., flashing light, tone, etc.) of incoming messages would you desire in an operational system?

ATC messages Weather messages

ATC MESSAGES:

ATP

Flashing and tone.

Tone, flashing light and voice would get my attention.

Flashing light and tone.

Both flashing light and tone.

Flash and tone.

Tone and flashing light on screen.

Light and tone.

Fast flashing light (med bright)

I-22

<u>GA</u>

Tone or voice. Pilots are familiar with listening for instructions. In IFR conditions with lightening, etc. a light may be missed.

Tone

Flashing light and tone.

A separate remote display unit (RDU) on glare shield in front of pilot should display current non changing information, like ATC frequency, ALT cleared to, and heading required, etc. A flashing light would be part of this RDU to alert the pilot of ATC message (a sort of "Master Caution").

Usual microphone voice-more reliable immediate feedback and reassurance.

Flashing light.

Perhaps a screen flash or a tone that oscillated.

These are fine. The flashing words are not alarming.

WEATHER MESSAGES:

<u>ATP</u>

Flashing light and tone.

Message light on screen.

Flash.

Both flashing light and tone.

Flashing light only.

Light only.

Slow flashing light (dimmed)

GA

Tone or voice. Pilots are familiar with listening for instructions. In IFR conditions with lighting etc. a light may be missed.

Highliqhted message on screen stating wx info is available.

Light only or nothing, If I request WX I'll get to it when I have a chance.

Underline or a different color.

Aural tone to signify intensity of WX message being relayed.

They're fine, the flashing words are not alarming.

QUESTION 13 Do you think the use of color on a display of weather and ATC information is:

___ Very helpful ____Somewhat helpful

____ No preference either way ____Somewhat detrimental

____ Very detrimental

ATP

With readability on busy screen.

Helps my mind pick information easier. The Tracor 7900 Omega has a very good color display.

Emphasis.

On WX, if valid time is different color it helps isolate data.

Less work to assimilate into useful information.

Easier to read.

No preference, color expensive

GA

Somewhat helpful because it would allow you to locate the important information more quickly in a time crunch.

Somewhat helpful. It helps highlight the important information.

Very helpful. Pilots = children; we need color coding.

Very helpful. For wx, the categories could be of one color while the data could be

of another. For that matter, any data needed to be given to pilot could be of a bright color, meant to highlight it from other information on the screen.

Very helpful. To make it easier to read in a cluttered environment.

Very helpful. We distinguish color information best (almost intuitively). Red means warning and green means safe.

Very helpful. Having used a pc recently with color, I've found info that is presently in intense shades is easily seen and noticed.

No preference either way except I prefer another color other than pink.

QUESTION 14 Were you satisfied with the appearance and operational characteristics of the main menu? YES ____ NO ____

ATP

None

GA

Yes, maybe you could reduce the quantity of buttons.

Yes, seems clear and not too busy.

Yes, I have nothing to compare it to.

QUESTION 15 Were the character sizes: (check one)

Too small ____ Just right ____ Too large ____

ATP

Too small, if the flight engineer (FE) becomes involved he/she will have trouble reading letter size. In some cases the format for wx will be too cluttered for the FE to pick out important information.

I-25

Would like to see a smaller display unit.

GA

Just right, the spaces between lines was too small.

Too small, in turbulence reading will be difficult plus this takes time away from flying the plane and clearing the area.

Too small, the size of the letters were a bit too small.

I-26