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HUMAN FACTORS EXPERIMENTS FOR DATA LINK
Interim Report No. 5

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16. Abstract

One and two-man crews of general aviation pilots and two-man crews of FAA/NAFEC test pilots made a series of simulated flights in a GAT-2 simulator to evaluate various complements of I/O equipment for Data Link. In the earlier experiments in this series, uplink messages have been limited to short ATC commands and advisories, and downlink capabilities limited to simple "Wilco" or "Unable" responses. In the present experiment, complete uplink capability was provided, including ATIS, clearances and weather reports, and downlink capability was extended to permit generation of requests for a variety of information.

Seven different combinations of devices were evaluated, the devices including a 16-character display for Short Message ATC (SMATC), a printer for longer ATC messages, a Voice Synthesizer (Vosyn), and two different Control and Downlink Units (CDU) varying in complexity and in capability for the repertoire of downlink messages which could be generated.

Pilot opinion was universally favorable. Uplink messages were interpreted rapidly and accurately, and despite limited training in its use, the more complex CDU presented no difficulties to the crews.

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PREFACE

The present report describes the first full-scale simulator evaluation of prototype equipment for Data Link. Complete downlink capability was provided, and uplink capability extended over that of previous tests, to permit the presentation of long messages such as clearances and weather information in addition to short time-critical ATC messages.

This program is sponsored by the Department of Transportation through the Federal Aviation Administration, Systems Research and Development Service.

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1. INTRODUCTION

This is the fifth in a series of Interim Reports, all titled "Human Factors Experiments for Data Link,"* which describe laboratory and simulator evaluations of concepts and prototype equipment for the digital transmission and presentation of air traffic control information. The overall objectives of the program have been two-fold: (1) to determine how best to present ATC information to facilitate its rapid and accurate comprehension, and (2) to explore the capabilities and limitations of a variety of I/O devices so as to reduce the number of possible candidates who would require eventual flight testing.

The present experiment, designated as Phase 1C of the Data Link Program, focussed on the needs of general aviation and small charter commuter operations, as reflected in the choice of flight scenarios, cockpit simulator and I/O device complements. Phase 1D will deal exclusively with commercial airline requirements.

The evaluations described in the previous reports of this series have been limited to presentations of short ATC messages, with down-link capability limited to simple "Wilco" or "Unable" responses. For the present experiment, capabilities were expanded to allow the presentation of longer uplink messages, such as ATIS, weather and clearances, while utilizing the previous experimental results for

*Hilborn, E. H., "Human Factors Experiments for Data Link: Interim Report #1." Report FAA-RD-72-150. November 1972.

Hilborn, E. H., and Devanna, L. R., "Human Factors Experiments for Data Link: Interim Report #2." Report FAA-RD-73-55 April 1973.

Hilborn, E. H., and Wisleder, R. W., "Human Factors Experiments for Data Link: Interim Report #3." Report FAA-RD-73-69. August 1973.

Hilborn, E. H., "Human Factors Experiments for Data Link: Interim Report #4." Report FAA-RD-74-81. April 1974.

An extended summary of the above is available as FAA-RD-74-82.

selection of the optimum short message display configurations. In addition, a more comprehensive evaluation of the possible role of synthetic speech for Data Link was made. Finally, complete downlink capability was provided through discrete function buttons to permit the flight crew to request a variety of types of information, and full alphanumeric capability was also provided to permit the generation of any desired message.

For the tests described in the present report, the I/O devices were installed in the cockpit of a GAT-2 simulator, which simulates the characteristics of a light twin piston-engine aircraft.

2. EXPERIMENTAL CONDITIONS

2.1 EXPERIMENTAL EQUIPMENT

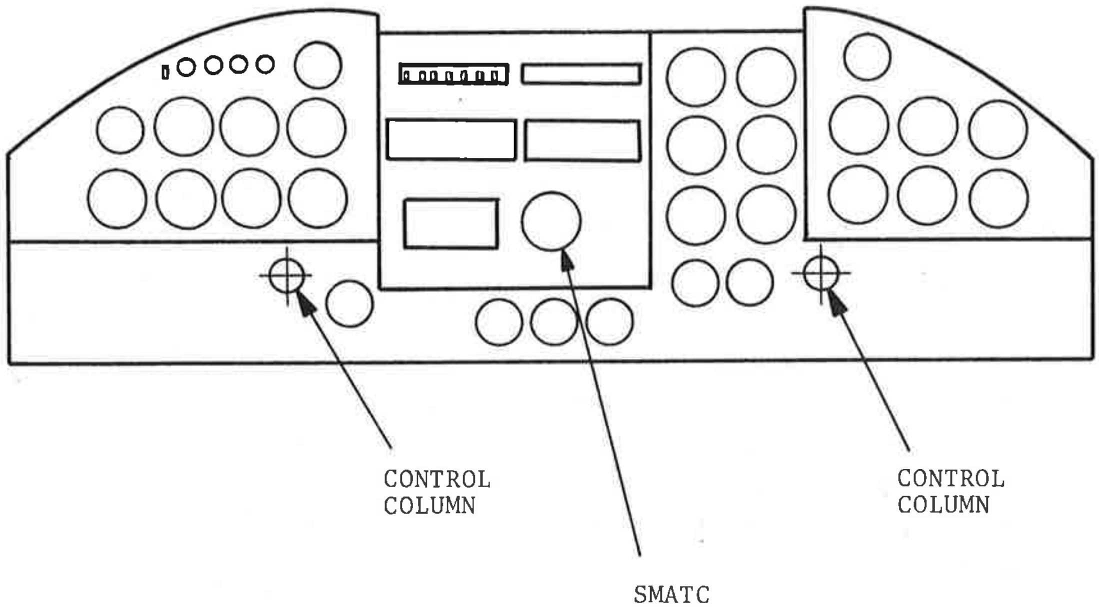
The cockpit I/O system consisted of three different displays for uplink messages: a 16-Window SMATC (Short Message ATC), a voice synthesizer and a printer. Two types of CDU's (Control and Downlink Units) were used, one providing full downlink capability and the other limited downlink capability. Programming and control of the experiment was accomplished through the use of a Texas Instrument 960A minicomputer and a printer/keyboard/cassette peripheral (TI Silent 700 ASR). A brief description of each item is contained below. A more detailed description may be found in Appendix A, reproduced verbatim from PSG-413-2.0, "Cockpit I/O System Specification." Figure 2-1 shows the location of the I/O devices within the cockpit.

2.1.1 <u>16-Window SMATC</u>

Figure 2-2 shows the 16-Window SMATC, which was configured as two lines of eight characters per line. Red dot-matrix LED (Light Emitting Diode) elements were used, and the unit was housed in an ATI-3 case. Capability was provided for the storage and recall of the latest heading, altitude and speed commands (with appropriate labels), as well as any other single message which the crew might wish to store temporarily for later recall. (Previous experiments had indicated that the character size (0.35" high) was easily readable by flight crews, and that 16 characters permitted the presentation of the majority of short ATC messages without requiring cryptic abbreviations.)

2.1.2 <u>Voice Synthesizer (VOSYN)</u>

The Vosyn, a Model 6 Votrax from the Vocal Interface Division of Federal Screw Works, generated synthetic speech by providing an audible output of its various stored phonemes upon command by the minicomputer. A vocabulary of 252 words was stored in the minicomputer to provide all of the required ATC messages for the Phase 1C experiment; this vocabulary is listed in Appendix "E".



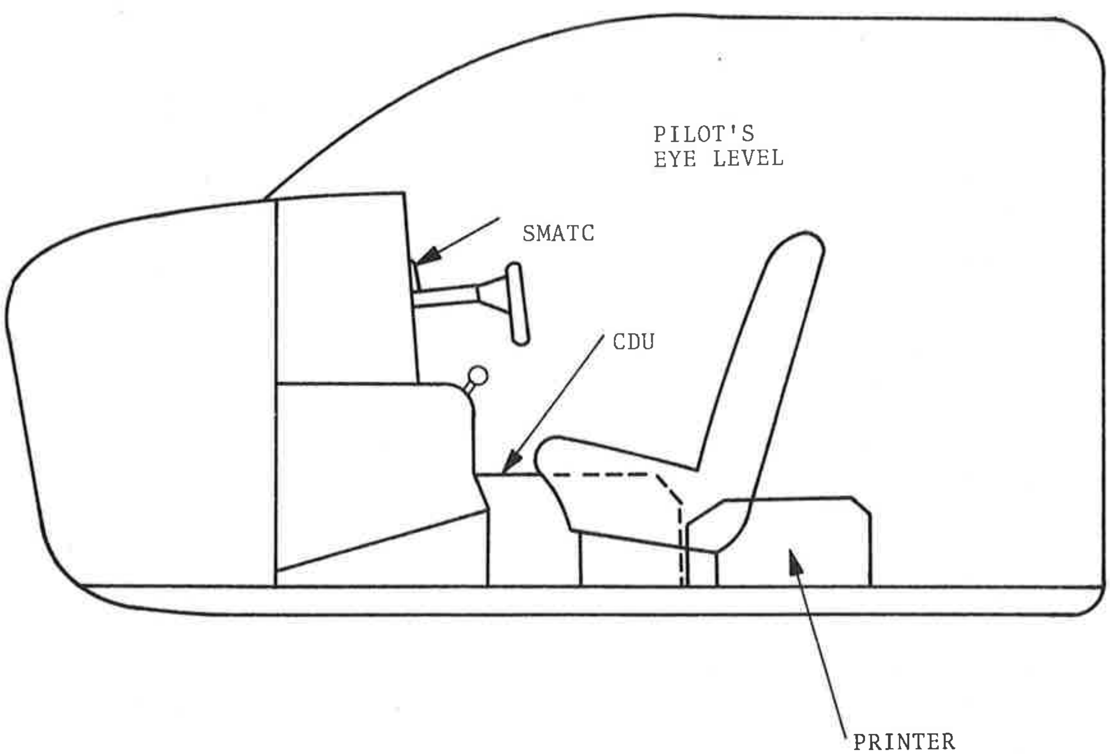


Figure 2-1. Equipment Locations in GAT-2

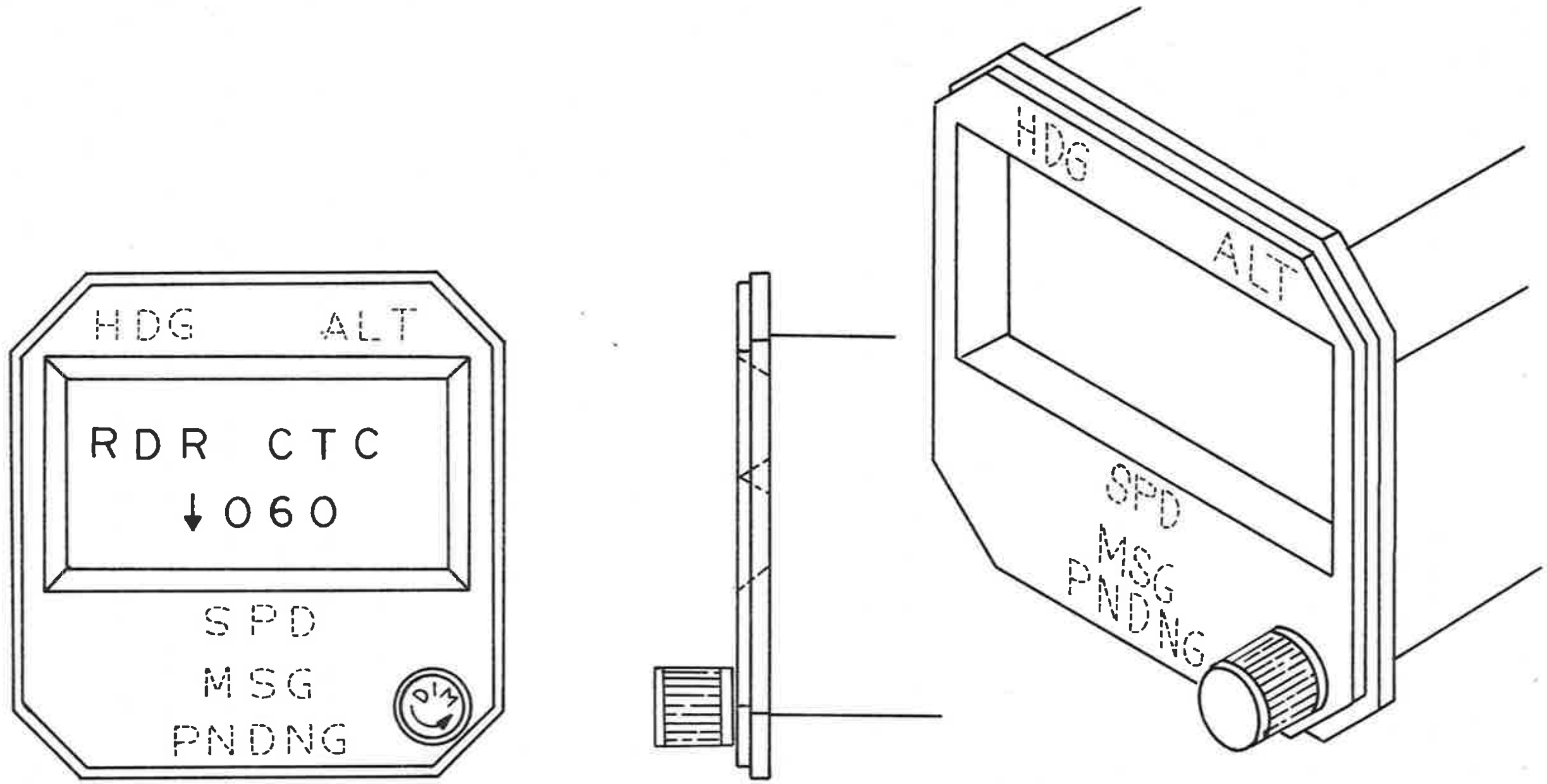


Figure 2-2. SMATC Display

A Vosyn volume control and a Vosyn repeat button were mounted on the CDU. The Vosyn was capable of repeating the current heading, altitude and/or speed commands when the proper request was made via the CDU, or any other single message which the crew might have stored temporarily. The Vosyn was mounted in an equipment rack with the minicomputer outside the simulator, and its output presented via a speaker mounted in the cockpit of the GAT-2.

2.1.3 Printer

A 21-column, two-color (red and black) Anadex impact printer was used as a hard copy display (Figure 2-3). Printing speed was 25 characters per second. The device was placed on the floor of the simulator cockpit, between the seats and behind the pedestal. All messages for Phase 1C were printed in black and were preceded by a time stamp. Red printing will be reserved for company business messages during the Phase 1D tests on airline simulators.

2.1.4 CDU (Control and Downlink Unit)

The CDU (Figure 2-4) contained all the buttons and controls required to allow the crew to operate the cockpit I/O system and generate downlink messages. Its functions included the following:

a. Function buttons for generating downlink messages.

b. An alphanumeric keyset for adding letters and/or numbers to downlink messages.

c. WILCO, UNABLE and STANDBY buttons to permit crew response to uplink messages.

d. "Heading, Altitude and Speed Recall" button for use with the SMATC and Vosyn.

e. A "Vosyn Repeat" button and "Vosyn Volume" control.

f. "Message Store" and "Message Recall" buttons for retaining and later recalling any single message via the SMATC or Vosyn.

g. "I/O Blank" button for blanking the SMATC.

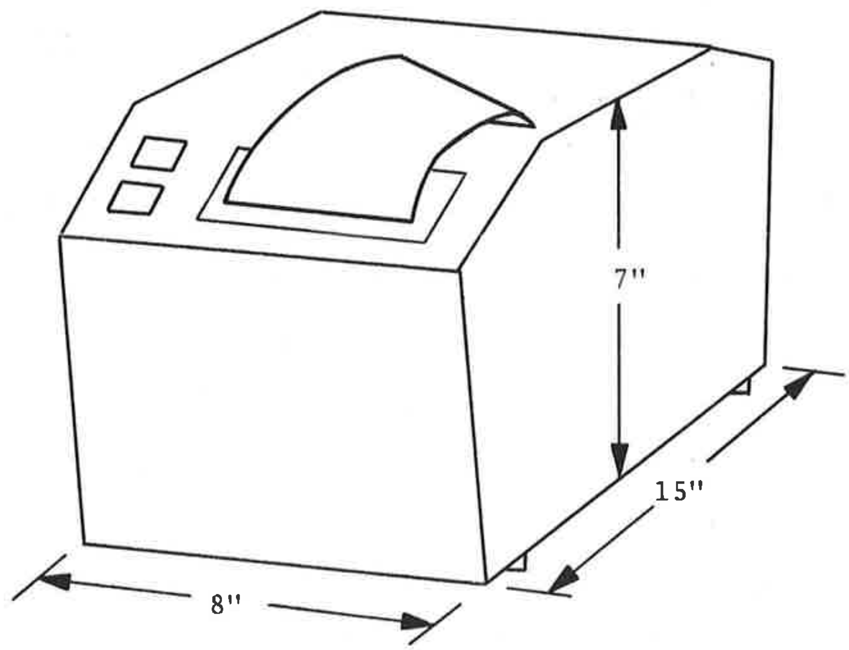


Figure 2-3. Anadex Printer, DP-751

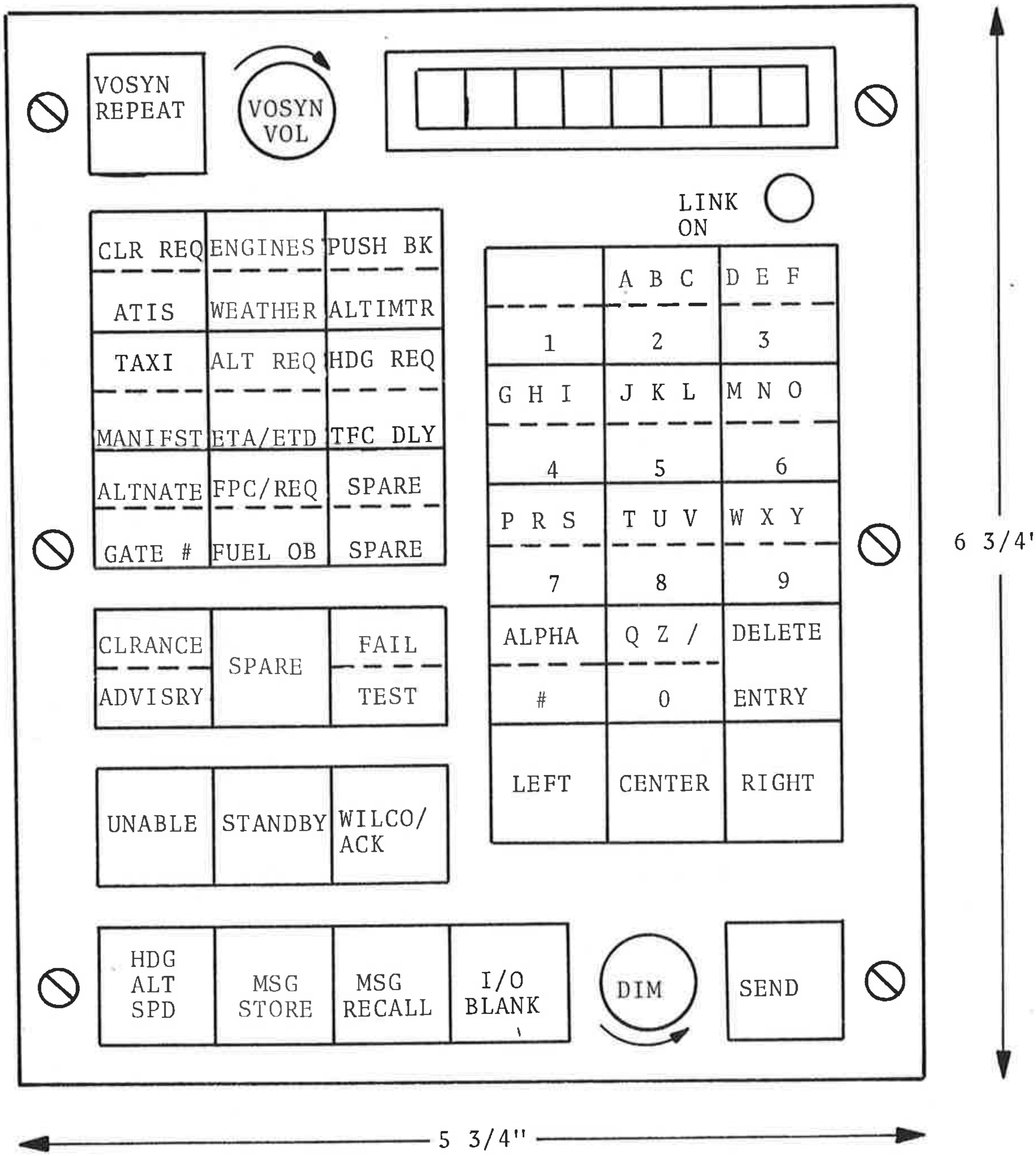


Figure 2-4 Full CDU Panel

h. "Send" button for dispatching a downlink message.

i. A "Link On" indicator to simulate active or inactive polling situations.

j. An eight-window scrtachpad display for reviewing downlink messages before depressing the "Send" button.

k. A "Fail/Test" button/indicator for simulating an I/O system self-test function.

Buttons were color coded to indicate functional groupings. Operation of the CDU is described in detail in Appendix B. In particular, it should be noted that many of the buttons provided two functions, and only the function that was enabled at a particular time was illuminated and readable.

The CDU was mounted in the center pedestal between the two seats. The WILCO button on the CDU was supplemented by additional WILCO buttons mounted on the control columns.

2.1.5 The SCDU (Simplified CDU)

For certain of the experimental runs, the CDU was replaced by an SCDU. The SCDU (Figure 2-5) contained only the buttons and controls necessary for operating the cockpit I/O system and for generating WILCO, UNABLE and STANDBY downlink responses. It did not provide the capability for generating other downlink messages. Specifically, it included functions c, d, e, f, g, i, and k described for the CDU. The SCDU was evaluated as a potential backup device in case the full CDU proved too difficult to use.

2.1.6 Minicomputer System

The minicomputer system consisted of a TI 960A minicomputer with 16K of memory, and a data terminal that included a standard teletype keyboard, 80 character-per-line silent printer, and a twin magnetic tape cassette read/write unit. Each scenario/device complement was programmed onto a single cassette; the other cassette position was used for data collection. The printer allowed the operator to observe the progress of the scenarios as each message

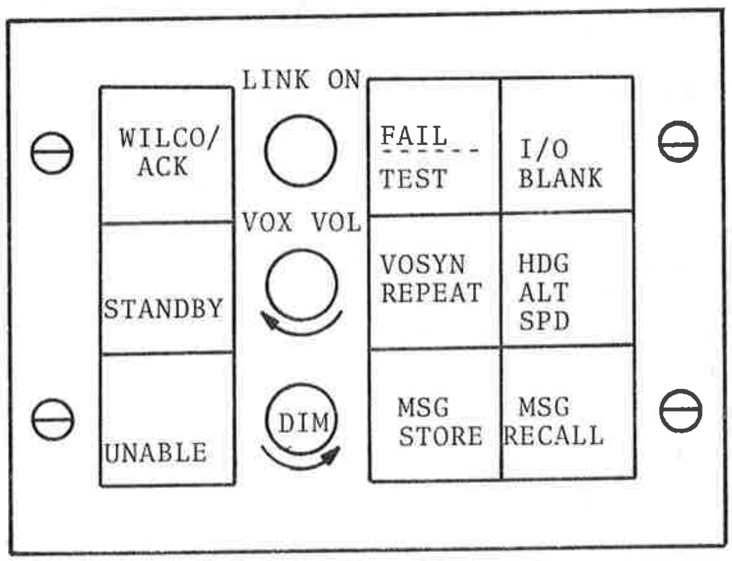


Figure 2-5 Simplified CDU Panel

was printed out. The keyboard gave the operator control over the system operation, enabling him to dispatch each message in sequence, skip or go back one or more messages, add messages, and initialize various parameters prior to a given experimental run. The computer was mounted in an equipment rack outside the simulator.

An off-line TA 960A minicomputer was also used for data reduction during and after completion of the experiment.

2.1.7 The Test Facility

The test facility used for the present experiment is located at FAA/NAFEC, Atlantic City, N.J. It consists of a Link GAT-2 cockpit simulator, an operator's station with control and display panel, strip chart recording equipment, and an X-Y plotter.

The GAT-2 is a two-man cockpit simulator which simulates a light twin piston-engine, retractable gear aircraft. It is fully instrumented, including dual nav/com, ADF, DME, glide slope and transponder. A third seat is provided for an observer (or instructor), and the communications channels provide a simulated radio link with an outside "controller/operator." The GAT-2 has limited pitch and roll motion, but is fixed with respect to the yaw axis. The simulator is set up to "fly" anywhere within a 12,500 square mile area in the vicinity of Atlantic City.

The outside operator's station is primarily a panel containing all the necessary controls and displays for simulating nearly any flight conditions. This includes controls for wind velocity and direction, turbulence, oil temperature and pressure, cylinder head temperature, barometric pressure, field elevation, and fuel remaining. Displays are provided for heading, altitude, air speed, turn coordinator, rate of climb, omni/loc/glide slope, nav/com frequencies, and gear position.

The strip chart recording equipment can be connected to various analog signals from the GAT-2 in order to record the relative performance of flight crews during an experimental run. Parameters which can be recorded in this manner include heading, altitude, air speed, course deviation, rate of climb, glide slope deviation, and localizer deviation.

An X-Y recorder with chart scaled to the area over which the simulator can "fly" permits a quick look at any major deviations from the planned flight path.

2.2 EXPERIMENTAL DESIGN

A number of different combinations were possible with the available I/O devices. From these possible combinations, seven were selected for the differences in capability which they provided to the flight crew, and which also might reflect complement selections by some future and cost-conscious user. To provide baseline data, it was also decided that one experimental run should use present-day voice-only procedures. The complements selected for study were identified by the letters "A" through "H" as follows:

- A: Voice only
- B: Vosyn (short messages), Printer (long messages), SCDU
- C: Vosyn (all messages), SMATC (Hdg, Alt. & Speed information only), SCDU
- D: Vosyn (long messages), SMATC, Full CDU
- E: SMATC, SCDU. (Voice for long messages).
- F: Vosyn (all messages), Full CDU
- G: SMATC, Vosyn (all messages), Printer (all messages), Full CDU
- H: SMATC, Printer (all messages), Full CDU.

With eight experimental variables to be evaluated, the ideal experimental design would involve the use of eight crews and eight different scenarios flown in a counterbalanced order. The impracticality of generating eight scenarios and of programming 64 different control tapes should be obvious to a reader who has had experience in either of these areas. Instead, it was decided to use only four different scenarios, to pair each scenario with two different device complements so that only eight program tapes were required, and to have different crews fly the complements and scenarios in different orders and with variations in day versus night conditions. The experimental design used is presented in Table 2-1, with "I", "J", "K" and "L" representing the four scenarios, and the final "D" or "N" indicating day versus night conditions.

TABLE 2-1. EXPERIMENTAL DESIGN

RUN	CREW 1	2	3	4	5	6	7	8
1	AID	BJN	CKD	DLN	ELN	FKD	GJN	HID
2	BJN	AID	DLN	CKD	GJD	HIN	ELD	FKN
3	CKN	DLD	AIN	BJD	HID	GJN	FKD	ELN
4	DLD	CKN	BJD	AIN	FKN	ELD	HIN	GJD
5	GJN	HID	ELN	FKD	BJD	AIN	DLD	CKN
6	HIN	GJD	FKN	ELD	CKD	DLN	AID	BJN
7	FKD	ELN	HID	GJN	DLN	CKD	BJN	AID
8	ELD	FKN	GJD	HIN	AIN	BJD	CKN	DLD

2.3 THE SCENARIOS

The four scenarios are described briefly below. The complete text of each scenario is presented in Appendix B. For the voice-only condition with scenario "I", the simulated responses from pilots of other aircraft were prerecorded on tape using a number of speakers so that the experimental subject heard not only the "controller" speak to himself and to other "aircraft", but also the replies from the "pilots" of these other "aircraft."

Scenario "I" presented the commands and advisories for a departure from Runway 1 at Greater WIlmington, Delaware airport via Newcastle to a landing on Runway 9 Right at Philadelphia International, followed by a departure on Runway 9 Left and via Pottstown 1 departure and East Texas to an eventual landing on Runway 6 at Allentown.

Scenario "J" presented the commands and advisories for a departure from Trenton-Robbinsville (an uncontrolled airport with simulated clearance via land line) to Philadelphia International via V157. After landing on Runway 27 Right and departure on Runway 27 Left, the flight continued, with a landing on Runway 32 at Greater Wilmington, Del.

Scenario "K" involved a simulated flight from Teterboro, N.J. to North Philadelphia. Simulated turbulence and thunderstorm activity in the vicinity of Trenton, N.J. required flight crews to request heading and altitude changes.

Scenario "L" provided the commands and advisories for a simulated flight from Cape May County Airport, N.J. (another uncontrolled airport) to Wings, Pa. Simulated bad weather conditions at Wings forced a change to an alternate destination, Mercer County Airport.

During all of the simulated flights on which a full CDU was available, flight crews had access to weather information from Philadelphia, Allentown, Wilmington, Teterboro, North Philadelphia, Trenton, Atlantic City, Millville, Newark, Reading and Cape May County. ATIS information was available only from Philadelphia International.

The nominal flight paths for the four scenarios are depicted in Figures 2-6/2-9.

2.4 EXPERIMENTAL SUBJECTS

Seventeen general aviation pilots and eight FAA/NAFEC professional test pilots participated in the experiments. Mean total flying hours for the general aviation pilots was 5300 hours (range 250 to 15,000 hours). For this group, the mean hours of instrument flying was 1020 (range 50 to 6000 hours), and mean multi-engine experience was 2965 hours (range 20 to 13,000 hours).

On the average, the test pilots were somewhat more experienced. Their mean flying experience was 9050 hours (range 3200 to 14,000 hours), their instrument flying experience had a mean of 1420 hours (range 187 to 3,000 hours), and their multi-engine experience had a mean of 4900 hours (range 1650 to 8000 hours).

While the general aviation pilots who participated in the experiment cannot be considered as representative of the total general aviation population, it must be recognized that Data Link

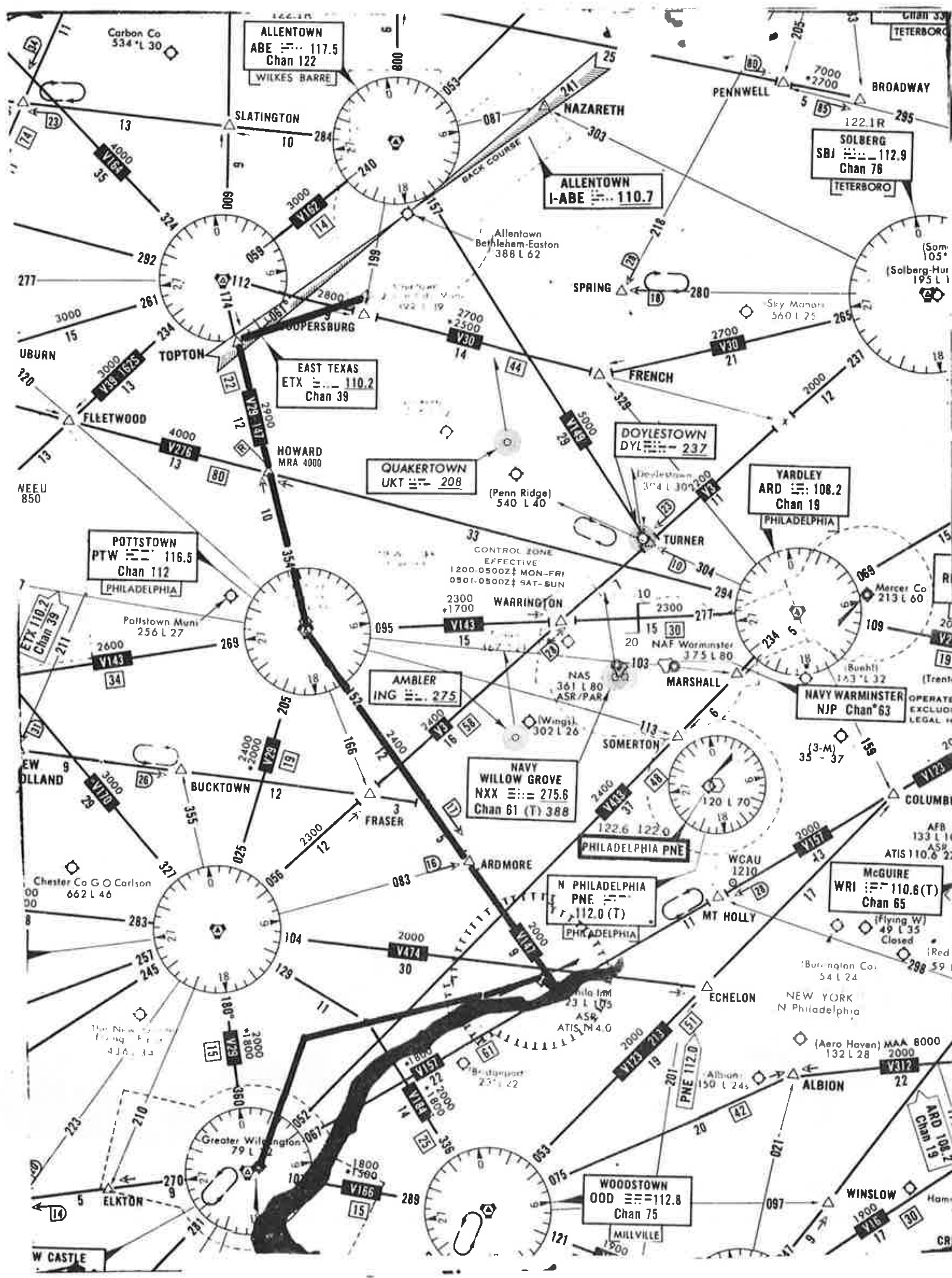


Figure 2-6. Nominal Flight Path for Scenario "I"

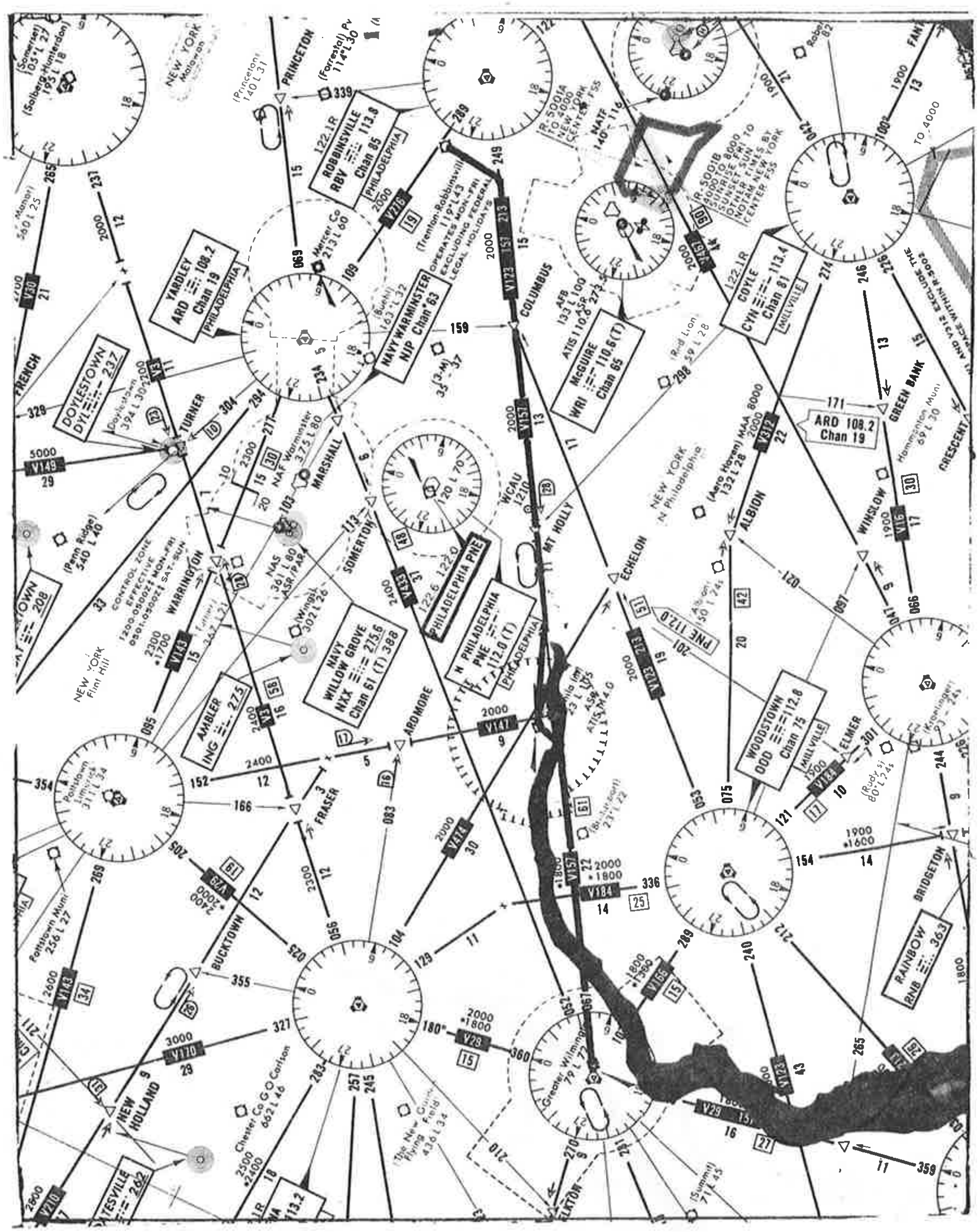


Figure 2-7. Nominal Flight Path for Scenario "J"

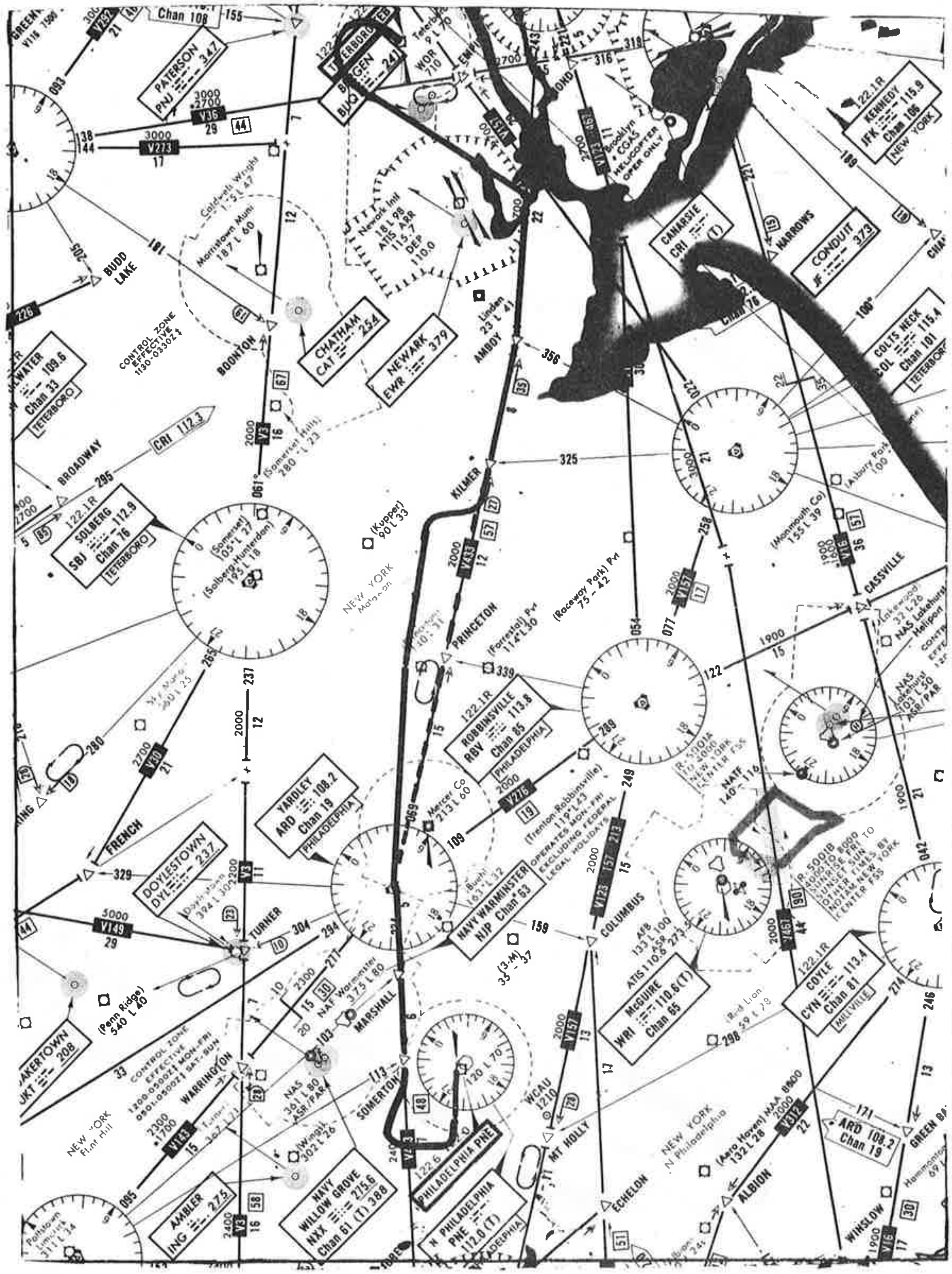


Figure 2-8. Nominal Flight Path for Scenario "K"

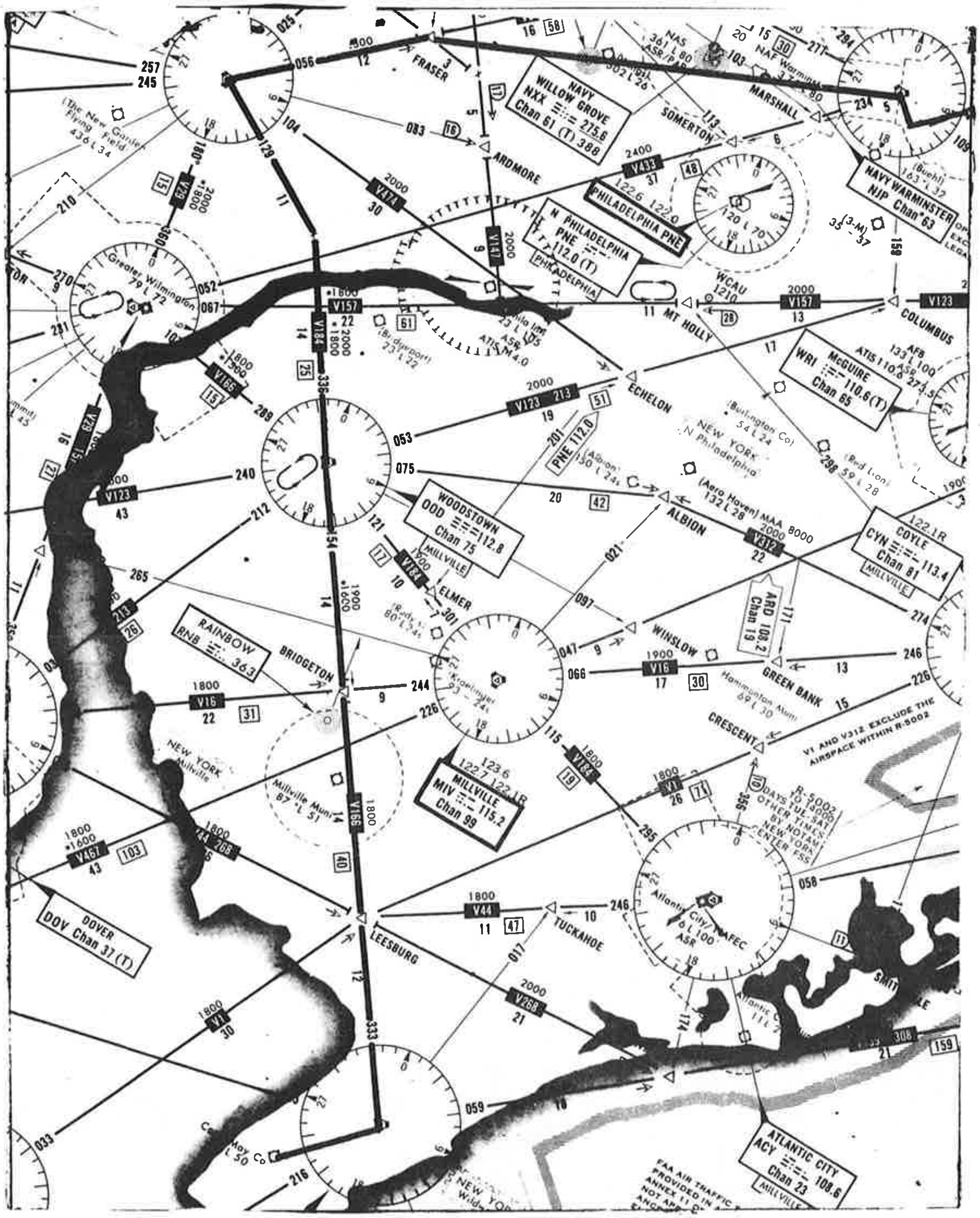


Figure 2-9. Nominal Flight Path for Scenario "L"

is designed primarily to meet the needs of IFR pilots, and that non-instrument-rated pilots would have had difficulty in flying the simulator using the procedures employed during the experiment.

2.5 EXPERIMENTAL PROCEDURES

The experiment as originally designed required that eight crews each fly eight times. During early planning, it was assumed that this eight-by-eight experimental design would be flown by four two-man crews and four one-man crews of general aviation pilots, and would be replicated by eight two-man test pilot crews. It was further assumed that a crew would fly four runs on one day and the remaining four runs on a second day.

Limitations of available simulator time forced a revision in these plans. Consequently, even though it was known that a training session and eight experimental runs with computer reprogramming between runs could not be accomplished in less than a ten hour day, it was found necessary for crews to fly all eight runs during a single day. It was also found necessary to limit the number of test pilot crews to four. With fourteen days of simulator time available, this left two extra days for contingencies.

Of the fifteen general aviation pilots who originally voluntеered to participate, seven failed to appear. Five of these sent replacements, and two cancelled with sufficient notice to allow a replacement crew to be scheduled; but it was found necessary to use one general aviation pilot and one test pilot for this crew. In addition, one general aviation crew, not realizing the importance to the experimental design of their making all eight runs, arrived late; another made only four runs due to mechanical problems in the simulator and difficulties in reprogramming the computer.

This confusion in turn led to errors on the part of the experimenters in the assignment of run sequences. As a result, for the general aviation pilots, no crew flew sequence six, two crews flew sequence seven and sequence eight is represented by a crew made up of one general aviation pilot and one test pilot. Test pilots flew only run sequences five, six and eight; and for sequence six, one crew member was forced to leave after the first three flights, and the remaining flights were made solo.

Several days prior to the experimental runs, the general aviation pilots were provided with the briefing sheet (reproduced as Appendix C) which described the equipment to be evaluated and explained its operation. Again through error due to the need for hasty rescheduling during the experiment, at least two of the test pilots failed to receive the briefing sheet and were not even aware of its existence until the debriefing session following the completion of the experiments.

When subjects reported for participation, they were first given an opportunity to check out the flying qualities of the simulator and to familiarize themselves with the layout of the flight instruments. They then practiced with the brief scenario (also reproduced in Appendix C) which demonstrated the capabilities of the several Data Link devices, with emphasis on the use of the CDU for the generation of downlink messages. During this practice scenario they were not required to fly the simulator.

Also prior to the beginning of the experimental runs, pilots were given a copy of the 83-item questionnaire (reproduced as Appendix D) so that by knowing what questions were to be asked, they would be in a better position to observe during their experimental flights. Most of the pilots completed the questionnaire within 24 hours of the completion of their experimental runs.

3. EXPERIMENTAL RESULTS

In previous reports in this series, emphasis has been placed upon response time data as indicative of the "goodness" of displays. Failure to maintain a rigorous experimental design during the present experiment, so as to cancel out any practice effects, reduces the value of response time data. Furthermore, the greatly increased I/O capabilities present in this experiment over those provided earlier permitted the generation of a greater number of pertinent questions for a questionnaire, and these results are accordingly reported first.

3.1 RESULTS FROM QUESTIONNAIRE

During the planning of the present experiment, TSC staff members had certain misgivings as to pilot acceptability of downlink keying requirements other than simple WILCO or UNABLE responses. The answer to the acceptability question is a resounding "Yes." Twenty-three participants found it reasonably easy to use with limited training, and one found it marginal. The lone dissenter may well have had his mind made up in advance, since his answer to the question "how much time did you spend on the briefing sheet prior to reporting?" was "2 minutes." One pilot, on the other hand stated, "If controllers can learn to use keyboards, so can pilots."

In general, pilots felt that two to three hours of training made them feel completely comfortable in the use of the CDU. Several listed the required time as 15 minutes, and only one pilot suggested "several days." The requirement for left handed keying by the copilot proved difficult to only one; however, it should be noted that seven of the 25 pilots who submitted questionnaires listed themselves as either left handed or ambidextrous, which is a somewhat higher percentage than occurs with a normal population.

On the question "Should downlink requirements other than WILCO and UNABLE be eliminated?", 15 replied "definitely not," four "probably not" and four were unsure. This again is evidence of the acceptability of downlink keying.

The pilots suggested the addition of six discrete function buttons, but none of these were suggested by more than one pilot. On the other hand, when EMERGENCY was suggested as an addition, 13 replied "yes," as did ten to a TRAFFIC LOCATED button; but here there were also 14 "no" responses.

The button pressure used (2.5 pounds with 0.187 inches of travel), although it had seemed somewhat stiff to TSC personnel when the CDU was being fabricated, was deemed acceptable under all conditions by 19 of the pilots; four found it too high even in turbulence. Daylight readability was found acceptable to 24 of the test subjects, with one "no, marginal." Sixteen would like to use the keyboard for other entries, such as transponder code settings or radio frequency settings, and one suggested that a calculator mode should be added. The use of the existing system of split function buttons was preferred over the addition of separate buttons (with a concurrent increase in CDU size) by 23 of the pilots. The present split between "Clearance" and "Advisory" modes was again approved by 23 of the pilots and with no suggestions of a better possible choice.

The yellow-white output of the lamps in the CDU buttons permitted only a limited choice of tints for color coding of functional areas. Thirteen pilots found that the tints aided them in recognizing functional groupings, while ten pilots found them of no value.

Only three of the pilots felt that downlink keying requirements should be limited to those available on the SCDU, and ten felt restricted when, after having used the CDU, only the small CDU was available. Ten responded "yes" to the question "should we consider something midway in capability between the CDU and the SCDU?", but no suggestions were made as to what should be deleted or added.

Although yellow and green single-element light-emitting diodes (LED) are presently available, the 5 x 7 dot matrices required for the generation of alphanumerics can be obtained only with red outputs, and these were used in the SMATC. Only three out of the 17 general aviation pilots surveyed found the red color unacceptable;

whereas five of the eight test pilots found this red unacceptable. Color preferences varied widely: green (9), white (5), yellow (4), red (3), amber (2), orange (2), and blue (1).

Aside from the color of the characters, the SMATC was generally acceptable. Twenty-three respondants replied "yes" on readability and on maintaining the existing character size, and 20 agreed that the number of characters (16) should remain as is. A suggestion that the SMATC might be installed on the control columns was voted down by 19 of the pilots.

The Vosyn was also generally acceptable. No pilot listed its intelligibility as "unacceptable", and 15 stated that the intelligibility improved with practice. No pilot listed the mechanical quality of the speech as "very annoying." Seventeen wished the Vosyn to be used at all times, and only three favored that its usage be limited to certain flight phases when the pilot's eyes are busiest. Nineteen voted for in-cockpit control of pitch and rate of speech; during the experiment these controls were not available, and instead were set from the experimenter's console at levels preferred by the individual pilots during the practice run.

The major objection to the printer was its poor location (behind the pedestal); 14 of the pilots listed this location as poor or marginal. Ten wanted the printer usage limited to long messages while 12 preferred it for all messages. Thirteen respondents approved of the lack of abbreviations or symbols, whereas several of the test pilots suggested the use of weather symbols. The time tag on the messages proved of value to only ten. Fifteen indicated the desirability of adding an "end of message" signal so that messages would not be torn off too soon. The question as to the need for an auditory signal to indicate the apperance of a new message on the printer could not be answered authoritatively, since noise levels in the simulator did not approximate those in actual aircraft; therefore, the attention value of the noise of the printer in operation could not be assessed. The use of two-color printing was found unnecessary by 23; two test pilots suggested the use of red for urgent messages.

The audio alert

approximated the inflection of a voice saying "Data Link" twice. Twenty-three of the respondents found this sufficiently distinctive; 21 preferred it over flashing of the SMATC or WILCO button as an alerting means. Nineteen pilots preferred the use of the audio alert over having the Vosyn speak the aircraft identification number.

A number of general questions were considered. A postulated deficiency of Data Link has been that pilots lose information when they cannot hear ATC transactions with other aircraft. During the present experiment, 14 pilots stated that no information was lost because of this absence, ten felt that a little information was lost, and only one felt that much information was lost.

During an earlier experiment, it was found that pilot responses were slower when information was provided both visually and via synthetic speech than when provided by either sensory modality alone. Pilots were questioned as to whether they felt any such tendency. Eleven responded "yes" and ten "no."

For recall of heading, altitude and speed (HAS) messages, 20 of the pilots preferred use of the SMATC, 5 advocated a dedicated HAS display, and only one preferred the use of the Vosyn. Fourteen felt that even with HAS information always available for recall, there was a need to store more than one other message. Autotune of radio frequency and transponder settings received 20 "yes" or "worth trying" responses, and the question concerning the advisability of setting heading, altitude and speed bugs automatically via Data Link similarly received 19 "yes" or "worth trying" responses.

To the question "Should a WILCO be required from both crew members?" 19 pilots responded "no." Seventeen felt that a WILCO response should not be required to the message "radar contact." Thirteen did not find the STANDBY useful while eight did.

Providing redundant information seemed generally acceptable. Only four pilots felt that too much information was provided when information was presented on the Vosyn, SMATC and printer simultaneously. Several suggested that the SMATC information might be presented via CRT, and that this might be used when an EADI CRT was present.

Pilots were asked to select what they considered an ideal device complement and a minimal device complement for various flight phases. The percentage of the time that various devices were selected for these several flight phases is presented in Tables 3-1 through 3-4. Here, it should be noted that for the ideal complements, the total suggested requirements for general aviation pilots were relatively constant across flight phases; whereas, test pilots wanted less Data Link equipment during takeoff and more en-route. General aviation pilots found some usage for all of the devices except the Vosyn when it was restricted to long messages only; test pilots, on the other hand, were more selective. Their typical device complement consisted of a SMATC for short messages, a Vosyn and printer for all messages, and a full CDU. The double means for the two groups are, on the other hand, quite comparable.

The comparable data for the two groups when asked to describe a minimal device complement (which are presented in Tables 3-3 and 3-4) are less meaningful. As might be anticipated, there was a shift from the use of the CDU to the SCDU. However, there is a question as to the significance of this query, since several pilots listed <u>only</u> a small CDU and made no provision for any uplink capability. Data link obviously can exist only when there is two-way communication.

Possible changes in crew workload are of major importance to the viability of Data Link. Only two pilots felt that Data Link would increase pilot workload, two felt that it would remain about the same, 16 felt that it would decrease workload, and two were unsure. Of equal importance is the confidence factor--the certainty of the pilot that he is receiving all messages intended for him and

TABLE 3-1. PERCENTAGE OF THE TIME VARIOUS DEVICES WERE SELECTED BY 16 GENERAL AVIATION PILOTS AS REPRESENTING PARTS OF THE IDEAL DEVICE COMPLEMENT FOR VARIOUS FLIGHT PHASES

DEVICE		FLIGHT PHASE					
	On Grnd	Tkof	Dep.	En-Route	App.	Lndg	Mean
SMATC (short messages)	53	71	59	59	59	71	62
SMATC (Hdg, Alt., Spd. only)	00	24	47	35	29	18	26
Vosyn, Short messages only	18	35	18	12	18	18	20
Vosyn, Long messages only	06	12	00	06	00	00	04
Vosyn, All messages	47	35	35	41	53	47	43
Printer, all messages	53	24	35	41	35	29	36
Printer, Long messages only	29	24	24	29	24	12	24
Full CDU	71	53	53	65	59	53	59
Small CDU	06	12	18	12	12	12	12
Total	283	290	289	300	289	265	
Mean	31	32	32	33	32	29	32

TABLE 3-2. PERCENTAGE OF THE TIME VARIOUS DEVICES WERE SELECTED BY 7 TEST PILOTS AS REPRESENTING PARTS OF THE IDEAL DEVICE COMPLEMENT FOR VARIOUS FLIGHT PHASES

DEVICE	FLIGHT PHASE						
	On Grnd.	Tkof	Dep.	En-Route	App.	Lndg	Mean
SMATC (short messages)	71	71	86	86	86	86	81
SMATC (Hdg, Alt., Spd. only)	00	14	00	00	00	00	02
Vosyn, Short messages only	00	14	00	00	14	00	05
Vosyn, Long messages only	00	00	00	00	00	00	00
Vosyn, All messages	57	57	71	57	57	71	62
Printer, All messages	86	29	57	86	57	29	57
Printer, Long messages only	14	00	14	14	00	14	09
Full CDU	86	71	71	86	71	71	76
Small CDU	00	00	00	00	00	00	00
Total	314	256	299	329	285	271	
Mean	35	29	33	37	32	30	33

TABLE 3-3. PERCENTAGE OF THE TIME VARIOUS DEVICES WERE SELECTED BY 16 GENERAL AVIATION PILOTS AS REPRESENTING PARTS OF THE MINIMAL DEVICE COMPLEMENT FOR VARIOUS FLIGHT PHASES

DEVICE	FLIGHT PHASE						
	On Grnd.	Tkof	Dep.	En-Route	App.	Lndg.	Mean
SMATC (short messages)	29	35	29	35	24	35	31
SMATC (Hdg, Alt., Spd. only)	24	47	47	47	47	35	41
Vosyn, Short messages only	24	24	12	12	24	18	19
Vosyn, Long messages only	00	00	06	00	00	00	01
Vosyn, All messages	18	06	12	12	18	18	14
Printer, All messages	00	06	12	06	06	12	07
Printer, Long messages only	41	29	35	41	24	24	32
Full CDU	06	00	00	12	12	00	05
Small CDU	41	41	41	24	29	35	35
Total	183	188	188	195	184	177	
Mean	20	21	21	22	20	20	21

TABLE 3-4. PERCENTAGE OF THE TIME VARIOUS DEVICES WERE SELECTED BY 6 TEST PILOTS AS REPRESENTING PARTS OF THE MINIMAL DEVICE COMPLEMENT FOR VARIOUS FLIGHT PHASES

DEVICE	FLIGHT PHASE						
	On Grnd	Tkof	Dep.	En-Route	App.	Lndg.	Mean
SMATC (short messages)	33	17	17	33	33	33	28
SMATC (Hdg, Alt. Spd. only)	17	50	50	33	33	17	33
Vosyn, Short messages only	17	17	00	00	17	17	11
Vosyn, Long messages only	00	00	00	00	00	00	00
Vosyn, All messages	17	17	17	17	17	17	17
Printer, All messages	00	00	00	00	00	00	00
Printer, Long messages only	50	00	33	33	33	33	28
Full CDU	17	17	17	17	33	33	22
Small CDU	83	67	83	83	67	67	75
Total	234	185	217	216	233	201	
Mean	26	21	24	24	26	22	24

is not reacting to messages intended for other aircraft. Sixteen pilots felt that their confidence would increase, one felt that there would be no effect, three indicated a decrease in confidence and five were unsure.

3.2 DEBRIEFING SESSION

One week after the completion of the experiment, eight of the pilots were interviewed in a debriefing session. A number of points were brought out. It should be emphasized that while these points represent the views of one or more of the pilot participants, they should not be construed as necessarily representing recommendations for future experiments.

1. Two of the test pilots stated that they had not seen the briefing sheet and were not aware of its existence until the debriefing session.
2. Several of the pilots stated that they were not aware that their responses were being timed, and thus felt no concern to make prompt responses.
3. Several of the pilots had heard the Univac voice response system and commented on the superiority of its output to that of the system used in the experiment. (The Univac system is not, however, airborne equipment.)
4. One test pilot stated that he had hearing deficiencies, and that regardless of the quality of the synthetic speech which might be presented, he would prefer a visual display.
5. Pilots felt that a single SMATC was sufficient for the GAT-2 simulator, but felt that two might be required in a commercial jet, particularly the jumbo jets.
6. It was suggested that for the next experiment, the questionnaire should not be limited to discrete responses such as "yes" and "no", but instead should provide a five-point scale between limits.

7. Red, to pilots, indicates "danger." All possible colors should be investigated for the SMATC before a final decision is made. (As pointed out earlier, red is the only color currently available for alphanumeric LED.)

8. Several of the pilots lost some confidence in Data Link because of an apparent software problem in message storage.

9. Pilots would like to be able to turn off the Vosyn during certain flight phases if the same information could be obtained visually.

10. An attempt should be made to integrate the CDU with RNAV input devices, since RNAV will be mandatory above 18,000 feet after 1977.

11. It would be desirable to have a 3-position switch, so that pilots could have Vosyn, SMATC or both.

12. Two pilots were unaware of the presence of the time stamp on the printer messages.

13. There was a question as to what a pilot should do when he has reached his clearance limit and no new Data Link message has appeared.

14. Test pilots would like weather symbology on the printer.

15. During experiments, certain impossible messages should be included to force an UNABLE response.

16. A RECONFIRM button should be added to the CDU.

17. Additions to the SCDU might include WEATHER and ATIS.

18. One pilot thought that the Data Link alert sounded somewhat like the 747 altitude alert.

19. One pilot thought that with a printer available, there was no requirement to store messages in the SMATC.

20. Adding autotune of VHF or transponder does not seem to infringe on the pilot's job, since in any event, this is for the benefit of ATC.

21. It was suggested that SMATC messages should be presented on the Electronic Attitude Director Indicator so as to avoid a requirement for an extra display.

3.3 QUANTITATIVE DATA

As indicated in Section 2.5 of this report, limitations on the availability of simulator time and crew rescheduling problems made adherence to the original experimental design virtually impossible. Furthermore, it was discovered in the debriefing session that some of the crews were not aware of the importance of making prompt responses. All of this reduces the value of response time data.

In order best to fulfill the design intentions, data from crews that made only a limited number of runs have been eliminated, and the remaining data forced into the best compromise. This is shown in Table 3-5, where crews "G" are general aviation pilots and "T" the test pilots, and the crew numbers following the "G" or "T" represent the sequence of trials listed in the original experimental design of Table 2-1.

TABLE 3-5. ACTUAL SEQUENCE OF RUNS FOR EACH CREW

Run	One Man Crews Gen. Aviation				Two Man Crews Gen. Aviation				Two Man Crews Test Pilots		
	G-1	G-2	G-4	G-5	G-3	G-7A	G-7B	G-8	T-5	T-6	T-8
1	AID	BJN	DLN	ELN	CKD	GJN	GJN	HID	ELN	FKD	HID
2	BJN	AID	CKD	GJD	DLN	ELD	ELD	FKN	GJD	HIN	FKN
3	CKN	DLD	BJD	HID	BJD	FKD	FKD	ELN	HID	GJN	ELN
4	DLD	CKN	FKD	FKN	AIN	HIN	HIN	GJD	FKN	ELD	CKN
5	GJN	HID		BJD	FKN	DLD	DLD	**	BJD	DLN	BJN
6	HIN	**		CKD	HID	AID	AID	BJN	CKD	CKD	
7	FKN	FKN		DLN	GJD	BJN	BJN	AID	AIN	BJD	
8	ELD					CKN	CKN	DLD	DLN		

** = Defective Data Recording. Crew G-8 contained one test pilot. The last five runs of crew T-5 were made with a single test pilot.

With such incomplete data, it would seem desirable to examine for internal consistency. Since a different device complement was used on each run, strong practice effects would not be anticipated; on the other hand, the results of previous experiments have indicated an improvement in performance on the second run with a given scenario resulting from some capability to anticipate certain commands. The mean reaction times of all crews to all short ATC messages as a function of run sequence are presented in Table 3-6. Here, it should be noted that there are no noticeable practice effects during runs one through four, or during runs five through eight, but that the means for runs five through eight are some 1.8 seconds shorter than for runs one through four, indicating the practice effects from second exposure to a scenario.

TABLE 3-6. MEAN RESPONSE TIME TO ALL SHORT ATC MESSAGES AS A FUNCTION OF RUN SEQUENCE

RUN	RESPONSE TIME	
1.	9.3"	10.3"
2.	10.5"	
3.	11.0"	
4.	10.3"	
5.	8.4"	8.6"
6.	8.4"	
7.	8.0"	
8.	9.5"	

As a second indicator of data consistency, the rank order of response times for each group of crews (one-man general aviation crews, two-man general aviation crews, and two-man test pilot crews) for each scenario/device complement combination are presented in Table 3-7, again for responses to all short ATC commands.

Here, the high degree of internal consistency should be noted. If one point is assigned to the scenario/device complement yielding the slowest response, increasing to seven points for that yielding for fastest, the rank order becomes that of Table 3-8.

TABLE 3-7. RANK ORDER OF RESPONSE TIMES OF GROUPS OF CREWS TO SCENARIO/DEVICE COMPLEMENT COMBINATIONS

	CREWS		
	G-1 G-2 G-4 G-5	G-2 G-7A G-7B G-8	T-5 T-6 T-8
Slowest	KC	KC	KF
	JB	LD	LD
	KF	KF	KC
	LD	JB	JG
	JG	JG	JB
	IH	LE	LE
Fastest	LE	IH	IH

TABLE 3-8. RANK ORDER OF RESPONSES BY THREE PILOT GROUPS TO THE SEVERAL SCENARIO/DEVICE COMPLEMENTS (HIGHER SCORES REPRESENT FASTER RESPONSES)

SCENARIO/DEVICE COMPLEMENT		SCORE
KC:	Vosyn (all messages), SMATC (HAS only) SCDU	5
KF:	Vosyn (all messages), Full CDU	7
LD:	Vosyn (long messages), SMATC, Full CDU	8
JB:	Vosyn (short messages), Printer (long messages), Small CDU	11
JG:	SMATC, Vosyn (all messages), Printer (all messages), Full CDU.	14
LE:	SMATC, Small CDU (voice for long messages)	19
IH:	SMATC, Printer (all messages), Full CDU	20

The data of the preceding three tables indicate that there is meaningful information in the overall data. At the same time, because of deficiencies in the implementation of the experimental design, and with the knowledge that at least some of the crews were not aware of the importance of making rapid responses, any apparent differences between experimental conditions must be viewed with caution.

3.3.1 Data on Responses to Uplink Messages

Even though the experimental procedures used were less than rigorous, the large number of responses obtained (3226 measured downlink responses to short uplink messages, for example) gives some assurance that major variables may be compared in a meaningful manner. Such variables include the Full CDU versus the small CDU, differences among crew types, differences between responses on the CDU and on the control column, differences between audio presentation on the Vosyn versus visual presentation on the SMATC versus a combination of the two, differences among message types, and differences between the use of the printer and the Vosyn for long messages.

Table 3-9 lists the mean response times to the various categories of short ATC messages and for all long messages (ATIS, clearance and weather reports) for each crew and crew type. Here, it should be noted:

1. That for many crews, traffic messages produced the shortest response, since crews flying a simulator are well aware that there can be no traffic hazard and thus reply automatically without attempting to establish the identity or location of the indicated traffic.
2. That for general aviation crews, short message responses were faster with two-man than with one-man crews, indicating the greater workload imposed on ome-man crews, and
3. That one test pilot crew was appreciably slower than the other two in their responses to both long and short messages.

TABLE 3-9. MEAN RESPONSE TIME IN SECONDS TO VARIOUS MESSAGE TYPES BY INDIVIDUAL CREWS AND CREW GROUPS

CREW	SHORT ATC MESSAGES				LONG MESSAGES
	HAS	Traffic	Other	All	
G-1	6.8"	5.1"	10.7"	9.3"	16.1
G-2	12.3	5.8	10.7	10.8	21.4
G-4	17.1	8.4	11.3	12.6	28.8
G-5	7.5	5.5	8.1	7.8	17.8
$\overline{X}$	10.9	6.2	10.2	10.1	21.0
G-3	7.2	9.0	7.6	7.6	23.8
G-7A	10.2	12.7	11.6	9.4	34.3
G-7B	7.6	10.0	7.5	7.5	19.6
G-8	8.7	8.8	9.4	9.2	28.9
$\overline{X}$	8.4	9.9	9.2	8.5	26.0
T-5	7.3	7.1	7.4	7.2	17.9
T-6	12.8	7.7	10.2	11.0	36.2
T-8	6.1	5.9	7.7	7.2	12.5
$\overline{X}$	7.9	7.0	9.0	8.3	23.3
$\overline{XX}$	9.4	8.5	9.3	9.1	23.4

Table 3-10 presents the mean response times to all short messages by pilot and co-pilot for the two-man crews, as well as a comparison of responses on the CDU and on the control column. Earlier data (Interim Report #4 in this series) have indicated that participants reacted faster when acting as co-pilot than as pilot. The requirement for left handed response by the co-pilot on the CDU may be responsible for the lack of differences found here. Of the responses, 80.1% were made by the co-pilot and only 19.9% by the pilot. Despite the apparent easier access to the WILCO button on the control column to that on the CDU or SCDU, 93.1% responses were made on the CDU (or SCDU). This was less true with the test pilots, who made only 84.3% of their responses on the CDU and 15.7% on the WILCO button of the control column; but this difference resulted entirely from the responses of one crew.

TABLE 3-10. MEAN RESPONSE TIME IN SECONDS FOR TWO-MAN CREWS, COMPARING PILOT VERSUS CO-PILOT AND RESPONSES ON CDU (OR SCDU) WITH THOSE ON CONTROL COLUMN: ALL SHORT MESSAGES

CREW	PILOT	CO-PILOT	ON CDU	ON COL.
G-3	12.0"	7.4"	7.6"	--
G-7A	5.6	11.6	9.4	--
G-7B	7.7	7.5	7.5	7.3"
G-8	13.6	9.2	9.2	10.0
$\bar{X}$	12.0	8.1	8.4	8.7
T-5	6.2	7.4	7.2	--
T-6	10.8	11.3	12.6	9.0
T-8	6.2	7.5	7.2	--
$\bar{X}$	9.4	8.0	9.0	9.0
$\overline{XX}$	8.8	8.8	8.7	8.7

While it might appear that the greater complexity of the CDU over that of the SCDU might lead to longer response times, this assumption is not borne out by the data. Table 3-11 lists the mean response times for the three pilot groups for the scenario/ device complements which employed the CDU and the SCDU. If we eliminate condition KF, which used the Vosyn only, where the listed time is from the start of the message, and where a response was not possible until the completion of the message (with an average speaking time of 5.3 seconds), the remaining responses were actually somewhat faster with the CDU.

In the first report in this series, it was noted that responses to a simultaneous visual/auditory display were slower than to either alone. At the same time the impossibility of direct comparison of timing was pointed out, since a short visual display can be comprehended almost instantaneously but auditory information is accumulated during the duration of the speaking. The data from the present experiment confirm that simultaneous visual/auditory presentation produces slower responses than visual alone, as indicated in Table 3-12 for short messages.

TABLE 3-11. MEAN RESPONSE TIMES IN SECONDS FOR THE THREE TEST GROUPS TO THE SCENARIO/DEVICE COMPLEMENTS EMPLOYING CDU AND SCDU RESPECTIVELY

	CDU		SCDU	
One-man Gen. Aviation Crews	IH	8.0"	KC	12.4"
	KF	10.5	JB	11.1
	LD	10.3	LE	6.8
	JG	9.1		
	$\bar{X}$	9.5		10.1
	$\bar{X}$ without KF	9.1		
Two-man Gen. Aviation Crews	IH	7.1	KC	10.4
	KF	11.5	JB	9.9
	LD	7.8	LE	5.2
	JG	8.1		
	$\bar{X}$	8.6		8.5
	$\bar{X}$ without KF	7.7		
Test Pilot Crews	IH	7.0	KC	8.5
	KF	11.2	JB	6.7
	LD	9.2	LE	8.2
	JG	7.9		
	$\bar{X}$	8.8		7.8
	$\bar{X}$ without KF	8.0		
	$\overline{XX}$	9.0		8.8
	$\overline{XX}$ without KF	8.3		

TABLE 3-12. MEAN RESPONSE TIMES IN SECONDS TO SHORT MESSAGES WITH VISUAL, AUDITORY AND SIMULTANEOUS PRESENTATION

SMATC Alone	7.0"
Vosyn Alone	10.6
Both	8.3

With the long ATC messages (clearances, ATIS and weather reports), a similar comparison is possible between the use of the Vosyn, printer and the simultaneous combination of the two. These data are presented in Table 3-13.

TABLE 3-13. MEAN RESPONSE TIMES IN SECONDS TO LONG MESSAGES ON VOSYN, PRINTER, AND SIMULTANEOUSLY ON BOTH

		N	Σ	
Vosyn	KC	26	638.6"	
		15	315.9	
	LD	26	676.6	
		28	760.1	
	KF	26	509.8	
		31	718.1	
	Σ	152	3619.1	$\overline{X}$ = 23.8"
Printer	JB	23	406.4	
		22	503.4	
	IH	18	442.6	
		20	439.8	
	Σ	83	1792.2	$\overline{X}$ = 21.6"
Printer + Vosyn	JG	11	456.2	
		21	478.4	
	Σ	32	934.6	$\overline{X}$ = 29.2"

No timing data are available to indicate the mean time required by the printer to complete a message at 25 characters per second, but in general the printer completed a long message in one-third to one-half the time required by the Vosyn for speaking the same message, and average Vosyn speaking time for the long messages was 33 seconds. We thus see in Table 3-13 that WILCO responses on the average were made before the Vosyn completed a message, and that response time for the Printer + Vosyn was slower than for the Printer alone.

With the long messages, responses by the pilot and co-pilot were nearly equal in number, but the predominant number of the responses were made on the CDU rather than the control column, as indicated in Table 3-14.

TABLE 3-14. RESPONSE DATA FOR LONG MESSAGES BY PILOT AND CO-PILOT, AND ON CDU VERSUS CONTROL COLUMN

	N	Σ	$\overline{X}$
Pilot	130	3130.2"	24.1"
Co-pilot	137	3215.7	23.5
On CDU	229	5593.5	24.4
Control Col.	38	752.4	19.8

3.3.2 Downlink Data and In-Cockpit Control Operations

Somewhat greater reliance may be placed upon the validity of the data concerning control operations using the CDU or SCDU, or for the generation of downlink messages other than WILCO, since these data resulted from volitional actions by the crews.

Table 3-15 presents data on seven such response categories. As might be anticipated, the one-man general aviation crews made fewer responses and control actions than the two-man general aviation crews; the greater workload imposed upon the single pilot prevented him from taking full advantage of the features inherent in data link. It should also be noted that, on the average, stored messages were recalled twice.

Comparison of the relative frequencies of the several responses and control operations cannot be made using the data of Table 3-15, since the Vosyn and SMATC were not both available on many of the runs. Data for the three runs in which both devices were present are presented in Table 3-16, and indicate that HAS recalls and I/O blanks accounted for more than two thirds of the actions, and that unable and standby responses were negligible.

Table 3-17 presents data concerning the usage of the alphanumeric keyboard. Mean keying time per keystroke was approximately two seconds, and the error rate was surprisingly high; this is difficult to reconcile with the degree of acceptability reported in the responses to the questionnaire, but the limited training given

TABLE 3-15. CREW RESPONSES TO SEVEN DIFFERENT CDU OPERATIONS

	G.A 1-MAN	G.A.-2-MAN CREWS			TEST PILOTS			OVERALL
		PILOT	CO-P.	TOTAL	PILOT	CO-P.	TOTAL	
HAS Recalls:								
# of Resp.	164	13	169	182	36	154	190	536
# of Runs	23	26	26	26	19	15	19	68
X̄ Resp/Run	7.1	0.5	6.5	7.0	1.9	10.3	10.0	7.9
Messages Stored								
# of Resp.	48	5	35	40	8	32	40	128
# of Runs	23	26	26	26	19	15	19	68
X̄ Resp/Run	2.1	0.2	1.3	1.5	0.4	1.9	2.1	1.9
Recalls								
# of Resp.	90	5	47	52	14	92	106	248
# of Runs	23	26	26	26	19	15	19	68
X̄ Resp/Run	3.9	0.2	1.8	2.0	0.7	6.1	5.0	3.6
I/O Blanks								
# of Resp.	79	23	180	203	36	108	144	426
# of Runs	15	19	19	19	13	10	13	47
X̄ Resp/Run	5.3	1.2	9.5	10.7	2.8	10.8	11.1	9.0
Vosyn Repeats								
# of Resp.	29	6	93	99	7	58	65	193
# of Runs	18	20	20	20	13	11	13	51
X̄ Resp/Run	1.6	0.3	4.7	5.0	0.5	5.3	5.1	3.8
Unables								
# of Resp.	22	6	16	22	8	4	12	56
# of Runs	23	26	26	26	19	15	19	68
X̄ Resp/Run	1.0	0.2	0.6	0.8	0.4	0.3	0.6	0.8
Standbys								
# of Resp.	10	1	1	2	1	1	2	14
# of Runs	23	26	26	26	19	15	19	68
X̄ Resp/Run	0.4	0.0	0.0	0.0	0.0	0.0	0.1	0.2
TOTALS								
# of Resp.	442	59	541	600	110	449	559	1601
X̄ # of Runs	22.2	25.1	25.3	25.3	18.1	14.4	18.1	65.6
X̄ Resp/Run	19.9	2.4	21.4	23.8	6.1	31.2	30.9	24.4

to crews and their anticipation of being able to do better with practice may account for this.

TABLE 3-16. NUMBER AND RELATIVE FREQUENCY OF SEVEN RESPONSES AND CONTROL ACTIONS

	SCENARIO				
	KC	JG	LD	TOTAL	%
HAS Recalls	70	94	76	240	31.5%
Stored	18	18	24	60	7.9%
Recalls	24	14	32	70	9.2%
I/O Blanks	63	120	93	276	36.2%
Vosyn Repeats	23	35	34	92	12.1%
Unables	6	10	4	20	2.6%
Standby	3	1	1	5	0.5%
					100.0%

TABLE 3-17. DATA ON USAGE OF ALPHANUMERIC KEYBOARD

	PILOT	CO-PILOT	TOTAL
# of Alpha Messages	48	78	126
# of Keys Depressed	346	476	822
Total Keying Time	894.9"	786.3"	1681.2"
# of Deletions	45	25	70
Mean Keys/Message	7.2	6.1	6.5
Mean Time/Key	2.6"	1.7"	2.0"
Error Rate %	13.0%	5.3%	8.5%

While the "standby" button was used only infrequently, crews invariably failed to follow this with a "WILCO" or "UNABLE" with any degree of promptness, as indicated in Table 3-18. In future experiments it is essential that a more positive alert be given to crews when they have failed to provide a follow-on response.

TABLE 3-18. TIME BETWEEN "STANDBY" AND "WILCO" OR "UNABLE" RESPONSES

	PILOT	CO-PILOT	TOTAL
"Standby" N	12	2	14
"Standby" Time	432.7"	289.9"	722.6"
Mean Time	36.5"	145.0"	51.6"

Depending on the device complement present in the cockpit, certain equipment or procedural variations might be required over those used in the present experiment. The high transmission efficiency of data link permits transmission of ATIS, weather and flight plan changes on the data link frequency. With a printer available, a second radio for tuning to the ATIS channel would not be required, and/or a second radio would be used only to provide redundancy. With only Vosyn and SMATC available as output devices, provision for storage of two messages besides the latest heading, altitude and speed information might be required, such that a pilot could use the Vosyn repeat to recall a flight plan change and ATIS while simultaneously monitoring his SMATC for new ATC commands and advisories.

Similarly, while the present experiment simulated a total data link environment, the unstructured nature of local controller communications may not make them suitable candidates for Data Link, and an alternate frequency might be used for such communications.

Except for its somewhat awkward location, the printer used during the experiment was found to be entirely adequate. No pilot objected to the 21-column format instead of a page printer. The speed of printing and print quality were exceptional for such a low cost unit, although it must be realized that repackaging would be required if this were to become an airborne unit.

Pilots found no difficulty in learning to use the CDU and SCDU with only brief training. Reaction times using the CDU were somewhat faster than for the SCDU, indicating that pilots found no difficulty in selecting the correct key even with the larger number of keys present on the CDU.

4. DISCUSSION

Previous experiments in this series have been limited to the presentation of short ATC messages and to downlink capability limited to "WILCO" or "UNABLE" responses. The present experiment for the first time provided full uplink capability, including long messages such as ATIS, clearances and weather information, and complete downlink capability, including means for generating full alphanumerics.

Except for the color of the characters, the SMATC display was found to be completely acceptable. With two lines of eight characters each, any short message required in any of the scenarios could be presented without awkward abbreviations, and the small size of the display permitted it to be installed in a prime location on the panel. Single element yellow and green LED elements as well as seven-segment characters for numerics are presently available; and there is no question but that five by seven dot matirx elements for alphanumerics will be available by the time that Data Link becomes operational, thereby overcoming pilot objections to the present red color.

Pilots found no difficulty in understanding the Vosyn except for the pronunciation of certain place names. In real life, however, it should be recognized that pilots would plan their own flights rather than flying a prewritten scenario, and thus would be familiar with the names of the navaids on their route of flight.

It is still impossible to make a realistic assessment of the relative merits of the SMATC and Vosyn for short ATC messages, since it has not yet been possible to present realistic out-the-window tasks to flight crews. In actual flight, it may well be that crews prefer the Vosyn when their eyes are busiest, such as at takeoff and landing, with the use of a visual display during the cruise phase of flight.

5. PLANS FOR FUTURE EXPERIMENTS

Work is currently underway on the Phase 1-D Data Link experiments on airline simulators. Under a contract with ARINC Research Corporation, time will be rented on a United Airlines B-727 simulator at Denver and a TWA DC-9 simulator at Kansas City. Airline crews will serve as experimental subjects. Typical company business messages will supplement the ATC messages previously used.

A second SMATC has been fabricated, so that the two SMATC displays may be installed in the prime viewing areas of the Captain and the First Officer. Based upon pilot acceptance of autotune, as indicated in their replies to the questionnaire, this feature will also be added.

6. SUMMARY

One and two man crews of general aviation pilots and two man crews of FAA/NAFEC test pilots made a series of simulated flights in a GAT-2 simulator to evaluate various complements of I/O equipment for Data Link. For the first time, complete uplink and downlink capability was provided.

The devices evaluated included a 16-character display for short ATC messages, a printer for longer ATC messages, a voice synthesizer (Vosyn), and two levels of complexity of a control and downlink unit (CDU) for the generation of downlink messages.

Pilot opinion was universally favorable. Uplink messages were interpreted rapidly and accurately, and despite limited training in its use, the CDU presented no difficulties to the crews.

APPENDIX A
SYSTEM SPECIFICATION

Appendix A is reproduced verbatim from PGS-413-2.0, "Data Link Phase 1C System Specification" except that paragraphs have been renumbered to conform with the format of this report, and figures previously presented in the body of this report have been omitted.

A.1 SYSTEM DESCRIPTION

A.1.1 Introduction

The Cockpit I/O System will consist of a set of cockpit I/O devices, a miniprocessor with associated terminal, and software. It will be designed initially to be used in simulating the cockpit environment of data link equipped aircraft of various classes from commercial jet to light general aviation. As a stand-alone system, it will perform the following functions:

1. Display prescripted and operator generated messages on the various cockpit displays one at a time, upon command of the operator.

2. Respond to pilot generated downlink requests for both ATC and company business by either retrieving the desired prescripted information (ATIS, clearance, etc.) from memory and presenting it on the proper display or by accepting responses from the operator via the terminal and presenting them on the proper display.

3. Simulate the link characteristics by providing suitable delays for polling cycles, BCS checks, and R/T turnaround times.

4. Collect and store on tape pilot performance and operational data, including message arrival and pilot response event times, use of recall and storage features by pilots, length of time for keying in downlink messages and any associated errors, and voice synthesizer repeats.

The system will be designed for installation in a variety of cockpit simulators, including initially a Link GAT-2. After a minimum amount of modification the system will be capable of being installed and operated within actual aircraft cockpits. It will also be able to accept messages from a ground system computer in lieu of or in addition to the prescripted messages used in a stand alone configuration. Some reformatting of these messages may be necessary, such as substituting arrows for letters representing vectors.

A.1.2 I/O Device Configuration

Each of the various I/O devices is described under A.2. A number of different configurations of I/O systems will be evaluated by selecting from among these I/O devices. The maximum configuration will include all of the devices tied in simultaneously with the exception of the simplified CDU. The minimum configuration will consist of the SMATC display and the simplified CDU. The system will be capable of operating with any combination of I/O devices between and including these two extremes.

A.1.3 Scenario Capabilities

The Cockpit I/O System, in the stand alone configuration, will utilize prescripted scenarios based upon particular I/O device configurations to simulate typical flights under data link operation. Each flight scenario will consist of a series of uplink messages to be individually dispatched by the operator at the proper time in the flight, and a set of stored ATIS, weather, and clearance messages to be dispatched when requested by the pilot. The miniprocessor will be capable of handling a scenario with the characteristics listed in Table A-1 without any additional reprogramming, memory loading, or cassette changes once the scenario has been started.

A.1.4 Experimental Procedures

The Cockpit I/O system will be designed for operation by one operator in addition to the pilot subjects (s). This operator's primary duties will be to dispatch each message, respond to downlink requests the replies for which are not contained in the miniprocessor storage, and to handle any required ATC verbal communication.

Prior to starting an experimental run, the operator will load the required scenario software into the miniprocessor via the cassette system. He will then review each input parameter and discrete and set only those which must be changed from the default value by appropriate keyboard entries. The experiment will then

TABLE A-1. SCENARIO CHARACTERISTCS

	Max Number of Messages	*Max Characters Per Message
Ground Initiated Messages:		
No. of messages	75 max	16 average
Pilot Requested Stored Messages:		
ATIS reports	4	220
Weather reports	4	220
Departure clearance	1	220
Manifest	1	220
Taxi Instructions	1	220
Altimeter	4	16
Gate #	2	8
Flight Plan Change	2	220
Heading & Altitude, Change Requests	4	5
Start Engines, Push Bk.	2	16
Alternate Airport	2	220
Traffic Delay	2	16
Total Characters (maximum)		4664

**Response time for ATIS, weather etc. — 30 seconds max.

Total time duration — 1 hour max.

*Based on printer or SMATC only.

**Time from when request is initiated by pilot to when message begins to appear on printer.

begin by either the operator dispatching the first uplink message, or the pilot requesting ATIS, departure clearance, etc., depending upon the particular scenario.

During the course of the experiment, the operator will dispatch each uplink message at the proper point in the flight by typing the "send" code on the operator keyboard. The message will be printed out for the operator as well as sent to the designated display. The pilot's response will be printed next to the message. When a downlink request is initiated by the pilot, it will be printed out for the operator and the miniprocessor will determine if the information is contained in storage. If so, it will automatically uplink it to the designated display and print it out for the operator next to the request. If the information is not stored, it will be the next message in the scenario. The miniprocessor will so designate to the operator on his printout and wait for the operator to dispatch the next scenario message. In all cases, the pilot's response to the requested information will be printed out for the operator. The operator will have the ability to skip and repeat messages by typing in the designated codes.

A.1.5 Data Acquisition

During the course of the experiments, the miniprocessor will automatically acquire, format, and store on a cassette the data listed in Table A-2. All data for a scenario, as defined in Table A-1, will fit on one cassette to preclude the need for changing cassettes during the experimental run.

A.2 COCKPIT I/O DEVICES

A total of seven different cockpit I/O devices will be utilized in various combinations within the I/O system. The following is a functional descrpition of each of these devices, including size and power requirements.

TABLE A-2. DATA REQUIREMENTS

EVENTS	DATA
1. Uplink messages	a. Message # or text b. Event time message arrived at display c. For printer, event time printing completed
2. Response to uplink messages	a. Type (WILCO, UNABLE, etc.) b. Source (CDU or control column) c. Event time button was pushed d. Event time button stopped flashing
3. Downlink request messages	a. Event time first button was pushed b. Exact text of message c. Event time if "Delete Entry" was pushed d. Event time "Send" was pushed e. Event time "Send" stops flashing
4. Onboard equipment use	a. Event time when any of the following buttons are pushed: "HDG, ALT, SPD", "MSG Store", "MSG RECALL", "I/O BLANK", "Vosyn Repeat", "Test," b. Message # or text when "Store" button is pressed.

A.2.1 SMATC Display

The SMATC display will consist of two lines of eight alphanumeric characters per line (Figure 2-3 in body of text). Five by seven dot matrix LED display elements will be used to form characters .27" high by .19" wide which will be red in color. Located above the two ends of the top line and below the center of the bottom line will be the lighted labels "HDG", "ALT", and "SPD" as shown in Figure 2-3. These abbreviations will be lighted independently from the display characters under software control and will indicate that the numbers within the main body of the display refer to the current heading and/or altitude and/or speed commands. Requests for this information to be displayed will be initiated by the pilot via buttons on the CDU. For normal ATC messages, these labels will be extinguished and not visible to the pilot. A dimming control will be included on the front panel of the SMATC display and will control the brightness of both the 16 alphanumeric characters and the three labels.

The alphanumeric characters displayed will consist of the standard 64 character USASCII code with the substitution of left, right, up, and down facing arrows, as defined in Table A-3.

A "Message Pending" indicator similar to the HDG, ALT, and SPD labels, will be included on the front panel of the display. This indicator will illuminate, under control of the miniprocessor, whenever a message is waiting to be sent to the display prior to the pilot's having responded to the previous message. The indicator will be extinguished and the new message displayed immediately after the pilot depresses either a WILCO or UNABLE button. The only exception to this operation will be if the new message mode is either 1 or 2, (see Table A-4) in which case it will immediately replace the previous message and no"Message Pending" indication will be given.

Upon receipt of a new message, the display will flash on and off at a rate controlled by software such that the on time and off time may be independently varied from 0.2 seconds to 5.0 seconds by setting the proper software input parameter. The length of time

TABLE A-3. SMATC CHARACTERS

b_7 b_6 b_5 / Bits					0 0 0	0 0 1	0 1 0	0 1 1	1 0 0	1 0 1	1 1 0	1 1 1
b_4	b_3	b_2	b_1	col / Row	0	1	2	3	4	5	6	7
0	0	0	0	0	NUL	DLE	SP	0	@	P	'	p
0	0	0	1	1	SOH	DC1	!	1	A	Q	o	q
0	0	1	0	2	STX	DC2	↑	2	B	R	b	r
0	0	1	1	3	ETX	DC3	#	3	C	S	c	s
0	1	0	0	4	EOT	DC4	↓	4	D	T	d	t
0	1	0	1	5	ENO	NAK	%	5	E	U	e	u
0	1	1	0	6	ACK	SYN	&	6	F	V	f	v
0	1	1	1	7	BEL	ETB	←	7	G	W	g	w
1	0	0	0	8	BS	CAN	(	8	H	X	h	x
1	0	0	1	9	HT	EM	)	9	I	Y	i	y
1	0	1	0	10	LF	SUB	*	:	J	Z	j	z
1	0	1	1	11	VT	ESC	+	;	K	[	k	{
1	1	0	0	12	FF	FS	,	<	L	→	l	|
1	1	0	1	13	CR	GS	-	=	M	]	m	}
1	1	1	0	14	SO	RS	.	>	N	^	n	~
1	1	1	1	15	SI	US	/	?	O	—	o	DEL

TABLE A-4. FUNCTION BUTTON DESCRIPTION

FUNCTION BUTTON LABEL	TYPE	2-LETTER CODE	OPERATOR CONSOLE PRINTOUT	#/α SELECT	FUNCTIONAL DESCRIPTION
WILCO/ ACK	3	WI	WILCO	-	Indicates concurrence with or receipt of previous uplink message. Also indicates traffic has been located.
UNABLE	3	UN	UNABLE	-	Indicates cannot comply with, or does not understand previous uplink message. Operator will establish voice contact to resolve the problem. Also indicates failure to locate traffic after receipt of advisory message.
STANDBY	3	WA	STANDBY	-	Indicates pilot is busy and will respond to uplink message later.
ATIS	1	AT	ATIS AAA	α	With attached 3-letter identifier, requests ATIS report for a particular airport. ATIS information is automatically retrieved from storage and sent to cockpit printer.
CL REQ	2	CL	CLEARANCE REQUEST	-	Requests that flight plan be retrieved from storage and displayed on cockpit printer.
MANIFEST	2	MA	MANIFEST	-	Requests that manifest be retrieved from storage and displayed on cockpit printer.
ENGINES	2	SE	START ENGINES	-	Requests permission from the controller to start engines.
PUSH BK	2	PB	PUSH BACK	#	Requests permission from the controller to push back. Must be followed by a 1 or 2 character gate number.

TABLE A-4. FUNCTION BUTTON DESCRIPTION (CONTINUED)

FUNCTION BUTTON LABEL	TYPE	2-LETTER CODE	OPERATOR CONSOLE PRINTOUT	#/α SELECT	FUNCTIONAL DESCRIPTION
WEATHER	1	WE	WEATHER AAA	α	Same as ATIS except requests the current weather report for a given location.
ALTIMTR	1	AM	ALTIMETER	-	Same as ATIS except limited to altimeter setting. Source is indicated on uplink reply.
GATE #	2	GA	GATE #	-	Request to the company for assignment of a gate upon arrival at an airport.
TAXI	2	TA	TAXI	-	Requests permission from the controller to taxi. Reply would indicate taxiway to use and limit of clearance.
ALT REQ	2	LT	ALTITUDE	#	Request from the pilot for a different altitude than currently assigned, must be followed by 3 digits indicating desired new altitude in hundreds of feet.
HDG REQ	2	HD	HEADING REQ A		Request from the pilot for a different heading for reasons such as the avoidance of a local storm. May be followed by either L or R indicating direction of desired new heading.
ETA/ETD	4	ET	ETA ETD NNNN	#	Informs the company of anticipated time of departure or arrival. The two terms are differentiated by context. Must be followed by 4 digit time (GMT).

TABLE A-4. FUNCTION BUTTON DESCRIPTION (CONTINUED)

FUNCTION BUTTON LABEL	TYPE	2-LETTER CODE	OPERATOR CONSOLE PRINTOUT	#/α SELECT	FUNCTIONAL DESCRIPTION
TFC DLY	1	TD	TRAFFIC DELAY	-	Requests information from the controller as possible delay time due to traffic.
ALTNATE	2	AR	ALTERNATE AIRPORT AAA	α	Requests permission from a controller to proceed to a new destination, or informs the company that this permission has been received. Must be followed by a 3-letter airport code.
FPC REQ	2	FP	FLIGHT PLAN CHANGE A..A	α	Requests change of flight plan, specified by following text of up to 14 characters.
FUEL OB	4	FO	FUEL ON BOARD NNNN #		Indicates to the company the remaining fuel on board. Must be followed by a four digit number indicating fuel in hundreds of pounds.

that the flashing continues will also be under software control and will be variable from 0 to at least 60 seconds. (This flashing applies only to uplinked messages and not to the display of HDG, ALT, and SPD requested by the pilot as described above.)

The SMATC display will interface with the miniprocessor via the CRU. The display will be packaged in a standard ARINC 3ATI case no greater than 8" deep including connectors. Power requirements for the display will be as follows:

$+5\pm0.1$ VDC, 2.0 amps
-12 ± 0.1 VDC, 0.25 amps
$+28\pm1.0$ VDC, 0.25 amps

A.2.2 Voice Synthesizer

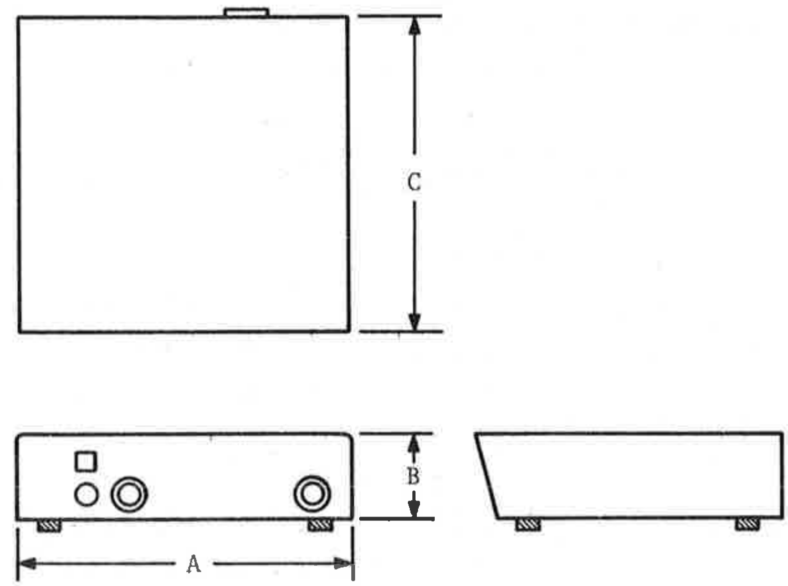
A Federal Screw Model 6 voice synthesizer (Vosyn) will be used for this I/O device. The unit will output its messages directly into the simulator or cockpit audio system. A volume control and a message repeat button will be contained on the CDU (see 2.5.4) for control of the Vosyn. Each time the message repeat button is depressed, the Vosyn (under control of the miniprocessor) will repeat the last message. The Vosyn vocabulary of 256 words is shown in Table A-4, which will be stored in the miniprocessor, with which the Vosyn will interface via the CRU.

The Vosyn mechanical configuration is shown in Figure A-1. Its power requirements are as follows:

115 VAC, 60 Hz, 22 watts max.

A.2.3 Printer

An Anadex Model DP-751 is to be used for the cockpit hard copy display. The unit will print 21 columns of characters on 3 1/2" paper in both red and black ink. The 42 different characters include the 26 letters, 10 numbers, and * $, -. / and are selected by the standard ASCII data codes. The characters are .102" high x .067" wide.



VOTRAX DIMENSIONAL CHARACTERISTICS

MODEL	A	B	C
STAND ALONE	11.87	3.06	11.25

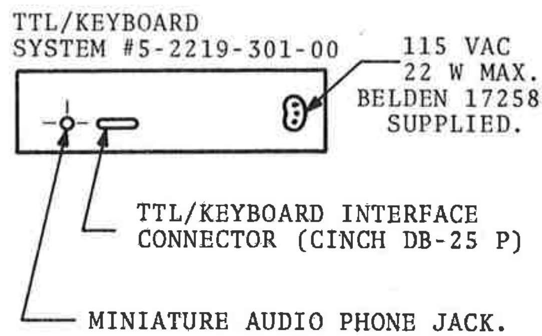


Figure A-1. Vosyn Dimensioning

The printer will be used in two basic configurations, determined entirely by the miniprocessor software. In the first configuration, it will function as an extended length message display, printing only those ATC messages sent to it by the particular scenario software due to their length. A message "See Printer" will be sent to the SMATC at the same time to direct the pilot's attention to the longer message. In the second configuration, the printer will record every message sent to the cockpit, whether it is displayed on any other I/O device or not. Again, the message "See Printer" on the SMATC will call attention to a message appearing only on the printer. In both configurations, typical company business type messages will be outputted by the printer to add a realistic workload to the experiments. All messages will be tagged on the printer with the time that the message arrived. The printer will interface with the miniprocessor via the CRU. The printers' mechanical configuration is shown in Figure 2-4 in the body of the text. Its power requirements are as follows:

Anadex: 115± 10 VAC, 50-400 Hz, 1/2 amp.

A.2.4 CDU

The CDU (Control and Display Unit) will have three functions:

1. Generation of messages of up to 16 characters by the pilot for downlink;
2. Control and status indication of the cockpit I/O system;
3. Provide certain control functions for some of the I/O devices (Vosyn repeat, message recall, etc).

The unit will be made up of 12 discrete function buttons and one clearance/advisory button for generating downlink messages; a 14 button keyboard for generating general alphanumeric messages and data; 12 buttons, knobs and indicators for control of the I/O system and status indications; and an eight window scratch pad display for message composition (Fig. 2.5 in the body of the text). The following is a functional description of each of these CDU elements.

A.2.4.1 Function Buttons - The function button portion of the CDU will have two modes of operation, "clearance" and "advisory", the mode being selected by the correspondingly labeled alternate action pushbutton. In the "clearance" mode, only the top half of each function button will be illuminated, and depressing a button will initiate the top, clearance type of downlink message. Similarly, when the "advisory" mode is selected, only the bottom half of the buttons will be illuminated and the corresponding messages are of the advisory type (see Fig. 2-5). The labeling on the switches will be such that the half not illuminated will be invisible. The function button messages are classified in four groups according to the type of function involved and the required response from the ground. Type 1 is a request for stored information (e.g., ATIS), which will result in the information being retrieved from storage and sent to the proper display by the miniprocessor. Both the request and response messages will also be printed out on the operator's console. A "?"will be printed on the console if no response is found in the miniprocessor. Type 2 is a request for a message that can only occur in sequence within the scenario, such as a request for a flight plan change. These result in the request being printed on the operator's console, after which the operator will dispatch the next message in the scenario, which will be the proper response message. Type 3 is a pilot response to an uplink message, such as "WILCO" or "UNABLE". These buttons will result in the indicated response being printed on the operator's console adjacent to the message for which the response was generated. Type 4 is a pilot initiated downlink message which requires no response from the ground, such as "ETA/ETD." It will simply be printed on the operator's console. Table A-4 contains an operational description of each function button.

Some of the downlink messages require identifiers or parameter values to be added to the basic message. Table A-4 indicates which messages have this requirement and whether the information is alphabetical or numerical in nature. When one of these messages is initiated by pushing the corresponding function button, the alphanumeric keyboard will automatically be placed in either the alpha or # mode, as appropriate.

Each half of a function button will be individually lighted with the brightness controlled by the CDU dimming control. Except in the case of Type 3 function buttons, the "Send" button must be pressed to initiate the message transmission to the ground. The "Send" button will flash off and on at a rate variable from .5 to 5 Hz via software during the simulated polling and transmission delays after it is pushed. The Type 3 function buttons will not require the "Send" button to be used, but will themselves initiate the simulated polling and transmission delays. Furthermore, messages requiring WILCO response will cause the WILCO light to flash off and on after the message has been displayed on the proper I/O device for a length of time adjustable from 0 to 30 seconds by setting the corresponding software input parameter. When "WILCO" is pushed (or one of the control column WILCO buttons) it will remain flashing until the simulated polling and transmission delays are complete. If "UNABLE" is pushed, it will begin to flash instead for the simulated delay period and the WILCO button will stop. If "STANDY" is pushed, it will flash for the simulated delay period but the WILCO button will remain flashing until it has been pressed. It will then stop flashing after the simulated delay period is complete. The function buttons will be square and mounted on 3/4" centers. Their operating force will be 16 ± 4 oz and circuitry will be designed to eliminate switch bounce caused by the inherent characteristics of the switch, as well as from typical in flight turbulence as it affects the pilot's ability to smoothly depress the buttons.

A.2.4.2 Alphanumeric Keyboard - The 14 button alphanumeric keyboard consists of 10 dual function alpha/number pushbuttons (the alpha half of the 1 button is not used), left, center, and right letter select buttons, and an alpha/# alternate action pushbutton. When the keyboard is in the alpha mode, only the top half of the 10 alpha/number keys will be illuminated, as will be the "alpha" half of the alpha/# select button. The numbers and the "#" legend on the alpha/# button will be invisible. By pressing the alpha/# button, the number mode will be selected, extinguishing the letters and "alpha" legend and illuminating the numbers on the lower half of each button as well as the "#" legend. Successive depressions of the alpha/# button will alternately select the alpha and # modes.

The primary use of the keyboard will be for generating alphanumeric identifiers of parameter values to be appended to downlink messages, such as "BOS" for a Boston ATIS request or "160" for a 16,000 foot altitude request. In order to generate numbers, the pilot will select the # mode with the alpha/# select button and then press the desired number key(s). The numbers selected in this way will automatically appear in the CDU eight window display as each key is pressed.

Letters are generated by first placing the keyboard in the alpha mode and then pressing first the button containing the desired letter, followed by the "left," "center," or "right" button depending upon the position of the letter within its own key. Thus, the letter J would be generated by pressing first the "JKL" key and then the "Left" key. After pushing the left, center, or right key, the selected letter will automatically appear in the CDU display.

As specified in A.2.4.1, the keyboard will be automatically placed in either the alpha or # mode when a function button is pressed which requires an identifier or parameter to be added. Thus under normal operation, the pilot will not have to manually select the desired mode.

The keyboard will also be used in a second application as an alternative to the function buttons. In this application, the keyboard must be placed in the alpha mode and then the unique two-letter code assigned to the desired function button message in Table A-4 is simply keyed in directly without use of the left, center, or right keys. The two letter codes have been assigned such that no two codes result in the same sequence of keys being pressed. Thus an ATIS request is generated by pressing the "ABC" and "TUV" keys in that order, while a gate assignment requires the "GHI" and "ABC" keys to be pressed. After the second key is pushed, the two letter code selected will automatically appear in the CDU display. If the pilot selects an unassigned two letter code a "?"

shall appear in the CDU display. This may be deleted by either pushing "Delete Entry," keying in a proper 2-letter code, or pushing a function button, the latter two cases will replace the "?" with the new 2-letter code. The 14 alphanumeric keys will be square and mounted on 3/4" centers. The selected half of each button will each be continuously illuminated with the brightness controlled by the CDU dimming control. The alphanumeric keys will not flash off and on when depressed.

A.2.4.3 CDU Display - The CDU will include an eight window alphanumeric scratch pad display to assist the pilot in generating messages with the keyboard. It will utilize red dot-matrix LED characters .27" high whose brightness will be controlled by the CDU dimming control.

Characters will appear on the display automatically, being added from left to right as they are generated with the function buttons and/or the alphanumeric keyboard in accordance with the procedures outlined under A.2.4.1 and A.2.4.2. For those messages requiring more than eight characters, the entire message will shift from right to left by one character as each character after the eighth is generated. The left most character will be simultaneously dropped from the display (but still remain in the message). After the "Send" button is pressed, the characters will remain on the display either until the "Send" button stops flashing or until the pilot pushes another function button or alphanumeric button to generate a new downlink message. This choice will be made by setting the corresponding software discrete.

A.2.4.4 Control Buttons and Status Indicators - The CDU will include 12 buttons, knobs, and indicators for various I/O system control and status indication functions. All pushbuttons are square and mounted on 3/4" centers. They are continuously illuminated and the brightness controlled by the CDU dimming control. The indicators are round and brightness also controlled by the CDU dimming control.

A.2.4.4.1 <u>Delete Entry</u> - This button is used to delete the last character or two letter code keyed into the CDU. If more than eight characters have been keyed into the message, pushing the "delete" button will result in the entire message shifting to the right one space (two spaces if the last key pressed was a two-letter coded function key) with the right most character(s) deleted and next one (or two) characters to the left reappearing on the display. In order to delete an entire message entered in the CDU the "Delete" button must be pushed once for each alpha, number, or two letter code in the message.

The button will be labeled "DELETE ENTRY".

A.2.4.4.2 <u>Send Button</u> - This button causes the message keyed into the CDU to be "sent" down the link. After the button is pressed, it flashes off and on until the time period simulating the link transmission and polling delays is over.

The button will be labeled "SEND".

A.2.4.4.3 <u>I/O Blank Button</u> - Pushing this button blanks all I/O displays (except the printer and Vosyn). A second push restores the messages to the displays. When the displays are blanked, a new message sent to a display will overwrite the blanking function.

The button will be labeled "I/O BLANK".

A.2.4.4.4 <u>HAS Recall Button</u> - Pushing this button with the SMATC display installed will cause the last value of heading, altitude, and/or speed sent to the cockpit, if any, to be displayed and the corresponding "HDG", "ALT," and "SPD" abbreivations on the display to illuminate. A second push will return the current message to the display. With the Vosyn installed, pushing the button will also cause it to output the last value of heading, altitude, and/or speed.

For the SMATC and Vosyn, when a message is sent to the device while it is outputting or displaying H.A.S. information, the new message will immediately replace the information.

The button will be labeled "HDG, ALT, SPD".

A.2.4.4.5 Message Storage Button - This button, when pushed, will store, for later recall, the current message appearing on either the SMATC display or the Vosyn. There will only be capability to store one such message at a time, so that any previous message stored in this manner will be lost when a new message is stored.

The button will be labeled "MSG STORE".

A.2.4.4.6 Message Recall Button - This button will be used to recall a message previously stored using the "MSG STORE" button. A second depression of the button will place the message back in storage and return the current message to the device. If a new message is sent to the device while it is displaying the stored message, the new message will immediately replace the stored message, which will be returned to storage.

The button will be labeled "MSG RECALL".

A.2.4.4.7 Vosyn Repeat Button - This button, when pushed, will cause the voice synthesizer to repeat the last message it received.

The button will be labeled "VOSYN REPEAT".

A.2.4.4.8 Vosyn Volume Control - This control knob will adjust the volume of the voice synthesizer.

The control will be labeled "VOSYN VOL".

A.2.4.4.9 Dimming Control - This control will adjust the brightness of all the the CDU indicators, lighted pushbuttons, and the eight window display.

The control will be labeled "DIM".

A.2.4.4.10 Poll Indicator -This indicator will be turned on at the end of each simulated link poll delay interval for a period of time variable from 1 to 60 seconds under software control. Thus, if the delay interval does not exceed the time period for which the indicator is turned on, the indicator will remain continuously illuminated. The indicator color will be green and it will be labeled "LINK ON".

A.2.4.4.11 Test Fail Button - When this button is pushed, the I/O system will go into a self-test routine, during which the "Test" half of the button will flash off and on. When the test is completed the "Test" legend will return to normal illumination. If the system passes the test, no other indications will be made. If it fails the test, the "FAIL" half of the button will be turned on and will remain on until the self-test operation is again initiated.

The self-test routine will cause the following to occur for a period of 15 seconds:

1. All indicators, buttons, and display elements on the CDU will be illuminated.
2. If installed, the SMATC display shall illuminate all 35 LED's for each character position.
3. If installed, the printer will print the message "TEST MESSAGE: SQUAWK 0123R".
4. If installed, the Vosyn will output the message "SQUAWK Zero One Two Three Romeo".

No hardware or software checks within the miniprocessor will be performed during self-test, so that no discrete to turn on the "FAIL" legend will be generated.

A.2.4.4.12 Spare Button - This button will be wired into the CDU electronics and will generate the appropriate signals so that only additions to the software are required to recognize and process a function assigned in the future.

A.2.4.5 CDU Design - The CDU will be designed for installation in the pedestal of a cockpit simulator or aircraft. Its dimensions will be 5 3/4" wide by 6 3/4" high by a maximum of 9" deep including connectors.

Power requirements for the CDU will be:

+5±0.1 VDC, 4.0 amps
+28±1.0 VDC, 3.5 amps
-12±0.1 VDC, 0.125 amps

A.2.5 Simplified CDU

The simplified CDU (SCDU) will include only a portion of the items of the full CDU (Fig.2-5 in body of the text). These items will function identically to those of the CDU, as described in Section A.2.4.4. The items included in the SCDU will be:

1. Function Buttons - WILCO, UNABLE, Standby
2. Controls - Blank, Dimming, Vosyn Volume, Vosyn Repeat, Test/Fail
3. Indicators - Link On

The SCDU will be designed for installation in the pedestal of an aircraft or cockpit simulator and its dimensions will be 3" high by 4" wide by 9" deep maximum including connectors.

The SCDU power requirements will be:

+5±0.1 VDC, 2.0 amps
+28±1.0 VDC, 2.0 amps
-12±0.1 VDC, 0.125 amps

A.2.6 Control Column WILCO Buttons

Buttons will be made available on each simulator or cockpit control column for the purpose of pilot WILCO response to an uplink message. These buttons will function independently of display configuration and will interface directly with the miniprocessor.

The software will be designed to accept either a normally open or a normally closed SPTS switch for this function.

A.2.7 Audible Alert

An audible alert will be incorporated into the cockpit I/O system for the purpose of indicating the receipt of a new message. This unit will be tied into the simulator or cockpit audio system and be activated under software control upon the receipt of every new uplink message (the same conditions under which message flashing is initiated). The characteristics of the alert, as described below, are different from those of any known audible alert used on the more common commercial aircraft.

The audible signal will be made up of the three tones generated by a solid state oscillator at 500 Hz, 400 Hz, and 450 Hz, with an accuracy of $\pm 1\%$. The tones will be sounded separately, in the above order, for a time variable under software control from .1 to 1 second each. The series will be repeated every .5 to 5 seconds for a total time of 1 to 60 seconds, both values being selected by software input parameters.

APPENDIX B

THE SCENARIOS AS PRESENTED

The exact messages, as they appered on each display for the various scenario/display complement combinations, are contained in this Appendix. The conventional voice scenario, with the messages to and from other aircraft, is also included.

The messages, along with the footnotes, should be self explanatory, with the exception of the various available weather reports. The following is a list of the reporting stations and the corresponding weather reports which were accessible to the crew upon request via the CDU. Unless a different weather report for a given location is included in the particular scenario, these are the weather messages that were available in all experimental runs.

Following the weather reports are the individual scenarios.

PHL - "Philadelphia, Pa. Weather: Ceiling measured 1000 overcast, visibility 2 in smoke, wind 060 at 17, altimeter 2988, temperature 41, dew point 35."

ABE - "Allentown, Pa. Weather: Ceiling measured 800 broken, visibility 1 in light rain, wind 050 at 12, altimeter 2984, temperature 44, dew point 38."

ILG - "Wilmington, Del. Weather: Ceiling measured 1100 overcast, visibility 2, wind 030 at 15, altimeter 2990, temperature 42, dew point 36."

TEB - "Teterboro, N.J. Weather: Ceiling estimated 2000 broken, visibility 3 in smoke and haze, wind 070 at 10, altimeter 3011, temperature 45, dew point 39."

PNE - "North Philadelphia Weather: Ceiling estimated 1200 broken, visibility 3, wind 050 at 5, altimeter 3010, temperature 42, dew point 37."

TTN - "Trenton, N.J. Weather: Ceiling measured 800 overcast, visibility 1 1/2 in light snow, wind 030 at 25, altimeter 2980, temperature 28."

ACY - "Atlantic City, N.J. Weather: Sky obscured, ceiling estimated 1000 broken, visibility 1/2 in fog, wind 010 at 10, altimeter 2978, temperature 35, dew point 34."

MIV - "Millville, N.J. Weather: 900 scattered, ceiling measured 1200 broken, visibility 1 in light fog, wind 040 at 8, altimeter 2979, temperature 34, dew point 33."

EWR - "Newark, N.J. Weather: Ceiling measured 1800 broken, visibility 2 1/2 in smoke and haze, wind 060 at 8, altimeter 3010, temperature 46, dew point 40."

RDG - "Reading, PA. Weather: 400 scattered, ceiling estimated 1000 broken visibility 1 in rain, wind 040 at 15, altimeter 2989, temperature 43, dew point 38."

WWD - "Cape May Co., Wildwood, N.J. Weather: Sky obscured, ceiling estimated 1200 broken, visibility 1 in fog, wind 020 at 5, altimeter 2979, temperature 37, dew point 36."

SCENARIO "I" DEVICE COMPLEMENT "H"

#	16-WINDOW	HAS (RECALL)	PRINTER	
1.	SEE PRINTER	(BLANK)	N12861 CLEARED TO CLAYMONT OUTER MARKER VIA 037 RADIAL OF EWT AND PHL RWY 9R LOCALIZER. MANTAIN 3000 FT. SQUAWK 1127 GROUND 121.7	(A)
2.	CLR TAXI RWY 1	(BLANK)	CLEARED TO TAXI TO RWY 1	(B)
3.	ILG TWR 126.0	(BLANK)	ILG TOWER 126.0	
4.	CLR TKOF RWY 1	(BLANK)	CLEARED FOR TAKEOFF RWY 1	
5.	↑↑030	H A 030 S	CLIMB AND MAINTAIN 3000 FEET	
6.	SEE PRINTER	H A 030 S	PHL INFO B: CEILING MEASURED 1000 OVERCAST. VISIBILITY 2. WIND 070 AT 15. ALTIMETER 2988. ILS RWY 9R APPROACH IN USE. DEPARTURES ON RWY 9L	(C)
7.	PHL APP 126.6	H A 030 S	PHL APPROACH 126.6	
8.	IDENT	H A 030 S	SQUAWK IDENT	
9.	RADAR CONTACT	H A 030 S	RADAR CONTACT	
10.	PHL ALTM 2989	H A 030 S	PHL ALTIMETER 2989	

(A) After pushing "Clearance Request" button
(B) After pushing "Taxi Request" button
(C) Philadelphia ATIS sent only if requested via CDU at a time in the scenario before message #24 has been sent.

SCENARIO "I" DEVICE COMPLEMENT "H"

#	16-WINDOW	HAS (RECALL)	PRINTER
11.	←←010	H 010 A 030 S	TURN LEFT HEADING 010
12.	VCTR ILS RWY 9R	H 010 A 030 S	VECTORS FOR ILS RWY 9R APPROACH
13.	↓↓020	H 010 A 020 S	DESCEND AND MAINTAIN 2000 FEET
14.	TFC 03 4 015 E H	H 010 A 020 S	TRAFFIC 3 O'CLOCK 4 MILES 1500 FEET EASTBOUND HEAVY
14a.	CLR OF TFC	H 010 A 020 S	CLEAR OF TRAFFIC
15.	SPEED 100	H 010 A 020 S 100	SPEED 100 KNOTS
16.	→→110	H 110 A 020 S 100	TURN RIGHT HEADING 110
17.	PSN 6 FROM LOM	H 110 A 020 S 100	POSITION 6 MILES FROM OUTER MARKER
18.	CFAP ILS RWY 9R	(BLANK)	CLEARED FOR ILS RWY 9R APPROACH
19.	PHL TWR 118.5	(BLANK)	PHL TOWER 118.5
20.	WIND 070 AT 12	(BLANK)	WIND 070 AT 12
21.	CLR LND RWY 9R	(BLANK)	CLEARED TO LAND RWY 9R
22.	HLD SHRT RWY 9L	(BLANK)	HOLD SHORT OF RWY 9L
23.	PHL GND 121.9	(BLANK)	PHL GROUND 121.9
24.	CLR TO GATE	(BLANK)	CLEARED TO GATE

SCENARIO "I" DEVICE COMPLEMENT "H"

#	16-WINDOW	HAS (RECALL)	PRINTER	
25.	USE GATE 23	(BLANK)	USE GATE 23	(D)
26.	SEE PRINTER	(BLANK)	PHL INFO C: CEILING MEASURED 1200 OVERCAST. VISIBILITY 3. SMOKE. WIND 080 AT 10. ALTIMETER 2989 ILS RWY 9R APPROACH IN USE. DEPARTURES ON RWY 9L	(E)
27.	SEE PRINTER	(BLANK)	N12861 CLEARED TO ETX VOR VIA POTTSTOWN ONE DEPARTURE. V147 TO ETX. EXPECT RADAR VECTORS TO ABE. MAINTAIN 3000. SQUAWK 1321. GROUND 121.9	(F)
28.	CLR TAXI RWY 9L	(BLANK)	CLEARED TO TAXI TO RWY 9L	(G)
29.	PHL TWR 118.5	(BLANK)	PHL TOWER 118.5	
30.	CLR TKOF RWY 9L	(BLANK)	CLEARED FOR TAKEOFF RWY 9L	
31.	PHL DEP 124.35	(BLANK)	PHL DEPARTURE 124.35	
32.	IDENT	(BLANK)	SQUAWK IDENT	
33.	RADAR CONTACT	(BLANK)	RADAR CONTACT	
34.	↑↑030	H A 030 S	CLIMB AND MAINTAIN 3000 FEET	
35.	←←270 TRAFFIC	H 270 A 030 S	TURN LEFT HEADING 270 DUE TO TRAFFIC	

(D) Sent only if gate request is made via CDU

(E) Philadelphia ATIS sent only if requested via CDU at a time in the scenario after message #24 has been sent.

(F) After pushing "Clearance Request" button

(G) After pushing "Taxi Request" button

SCENARIO "I" DEVICE COMPLEMENT "H"

#	16-WINDOW	HAS (RECALL)	PRINTER	
36.	TFC 02 3 ??? E ??	H 270 A 030 S	TRAFFIC 2 O'CLOCK 3 MILES ALTITUDE UNKNOWN EASTBOUND	
37.	CLR OF TFC	H 270 A 030 S	CLEAR OF TRAFFIC	
38.	CLR PTW DIRECT	H A 030 S	CLEARED TO PTW VOR DIRECT	
39.	NYC CTR 135.25	H A 030 S	NEW YORK CENTER 135.25	
40.	SQK 1327 IDENT	H A 030 S	SQUAWK 1327 IDENT	
41.	RADAR CONTACT	H A 030 S	RADAR CONTACT	
42.	↑↑060	H A 060 S	CLIMB AND MAINTAIN 6000 FEET	(H)
43.	TFC 11 4 050 N H	H A 060 S	TRAFFIC 11 O'CLOCK 4 MILES 5000 FEET NORTHBOUND HEAVY	
44.	CLR OF TFC	H A 060 S	CLEAR OF TRAFFIC	
45.	ABE APP 118.2	H A 060 S	ABE APPROACH 118.2	
46.	SQK 1025 IDENT	H A 060 S	SQUAWK 1025 IDENT	

(H) After pushing "Altitude Request" button due to turbulence

SCENARIO "I" DEVICE COMPLEMENT "H"

#	16-WINDOW	HAS (RECALL)	PRINTER
47.	RADAR CONTACT	H A 060 S	RADAR CONTACT
48.	ABE ALTM 2985	H A 060 S	ABE ALTIMETER 2985
49.	↓↓045	H A 045 S	DESCEND AND MAINTAIN 4500 FEET
50.	↓↓030	H A 030 S	DESCEND AND MAINTAIN 3000 FEET
51.	→→020	H 020 A 030 S	TURN RIGHT HEADING 020
52.	VCTR ILS RWY 6	H 020 A 030 S	VECTORS FOR ILS RWY 6 APPROACH
53.	↓↓025	H 020 A 025 S	DESCEND AND MAINTAIN 2500 FEET
54.	TFC 02 2 020 E H	H 020 A 025 S	TRAFFIC 2 O'CLOCK 2 MILES 2000 FEET EASTBOUND HEAVY
54(a)	CLR of TFC	H 020 A 025 S	CLEAR OF TRAFFIC
55.	SPEED 110	H 020 A 025 S 110	SPEED 110 KNOTS
56.	PSN 2 FROM LOM	H 020 A 025 S 110	POSITION 2 MILES FROM OUTER MARKER
57.	CFAP ILS RWY 6	(BLANK)	CLEARED ILS RWY 6 APPROACH
58.	ABE TWR 120.5	(BLANK)	ABE TOWER 120.5
59.	WIND 040 AT 10	(BLANK)	WIND 040 AT 10

SCENARIO "I" DEVICE COMPLEMENT "H"

#	16-WINDOW	HAS (RECALL)	PRINTER	
60.	CLR LAND RWY 6	(BLANK)	CLEARED TO LAND RWY 6	
61.	ABE GND 121.9	(BLANK)	ABE GROUND 121.9	
62.	CLEARED TO GATE	(BLANK)	CLEARED TO GATE	
63.	USE GATE 4	(BLANK)	USE GATE 4	(I)
64.	PHL ALTM 2989	(BLANK)	PHL ALTIMETER 2989	(J)
65.	ABE ALTM 2985	(BLANK)	ABE ALTIMETER 2985	(K)

(I) Sent only if gate request is made via CDU

(J) Sent only if "Altimeter" is requested via CDU at a time in the scenario before message #40 is sent.

(K) Sent only if "Altimeter" is requested via CDU at a time in the scenario after message #40 is sent.

SCENARIO "J". DEVICE COMPLEMENT "B"

(Clearance delivered via land line): N12861 cleared to Columbus intersection via V157. Maintain 2500. Request further clearance upon departure. Squawk 1031. McGuire Departure Control 124.15

	VOSYN HAS RECALL	PRINTER	VOSYN
1.	(BLANK)	N12861 CLEARED TO PHL RWY 27R OUTER MARKER VIA V157 AND RADAR VECTORS. MAINTAIN 4000. MCGUIRE DEPARTURE 124.15 SQUAWK 1031	
2.	H--- A040 S---		SQUAWK IDENT
3.	H--- A040 S---		RADAR CONTACT
4.	H--- A040 S---		MAINTAIN FOUR THOUSAND FEET
5.	H--- A040 S---		TRAFFIC ONE O'CLOCK TWO MILES. ALTITUDE UNKNOWN
6.	H--- A040 S---		CLEAR OF TRAFFIC

SCENARIO "J". . DEVICE COMPLEMENT "B"

	VOSYN HAS RECALL	PRINTER	VOSYN
7.	H--- A040 S---	PHL INFORMATION K. CEILING MEASURED 800 BROKEN. VISIBILITY 2 MILES IN HAZE. WIND 310 AT 15. ALTIMETER 2995. ILS RWY 27R APPROACH IN USE. DEPARTURES ON RWY 27L	
8.	H--- A040 S---		PHILADELPHIA APPROACH ONE TWO SIX POINT SIX
9.	H--- A040 S---		SQUAWK ONE ONE THREE FOUR. IDENT.
10.	H--- A040 S---		RADAR CONTACT
11.	H--- A040 S---		EXPECT ILS TWO SEVEN RIGHT APPROACH
12.	H--- A040 S---		PHILADELPHIA ALTIMETER TWO NINER NINER FIVE
13.	H--- A020 S---		DESCEND AND MAINTAIN TWO THOUSAND FEET

SCENARIO "J". DEVICE COMPLEMENT "B"

	VOSYN HAS RECALL	PRINTER	VOSYN
14.	H--- A020 S---		INTERCEPT RUNWAY TWO SEVEN RIGHT LOCALIZER
15.	H--- A--- S100		REDUCE SPEED TO ONE HUNDRED KNOTS
16.	H--- A020 S100		TRAFFIC TWELVE O'CLOCK, TWO MILES, TWO THOUSAND FEET, WESTBOUND, HEAVY
17.	H--- A--- S100		CLEARED FOR ILS RUNWAY TWO SEVEN RIGHT APPROACH
18.	H--- A--- S100		YOUR POSITION IS ONE MILE FROM THE OUTER MARKER
19.	(BLANK)		PHILADELPHIA TOWER ONE ONE EIGHT POINT FIVE
20.	(BLANK)		WIND THREE ZERO ZERO AT ONE SEVEN
21.	(BLANK)		RVR FIVE THOUSAND FEET
22.	(BLANK)		CLEARED TO LAND, RUNWAY TWO SEVEN RIGHT
23.	(BLANK)		PHILADELPHIA GROUND ONE TWO ONE POINT NINER
24.	(BLANK)		CLEARED TO GATE
25.	(BLANK)		USE GATE TWO FOUR

SCENARIO "J". DEVICE COMPLEMENT "B"

VOSYN HAS RECALL	PRINTER	VOSYN
26. (BLANK)	N12861 CLEARED TO EWT VOR VIA V157. MAINTAIN 2000. SQUAWK 1020. GROUND 121.9	
27. (BLANK)		CLEARED TO TAXI TO RUNWAY TWO SEVEN LEFT
28. (BLANK)		PHILADELPHIA TOWER ONE ONE EIGHT POINT FIVE
29. (BLANK)		POSITION AND HOLD
30. (BLANK)		CLEARED FOR TAKEOFF, RUNWAY TWO SEVEN LEFT
31. H270 A020 S---		CLIMB AND MAINTAIN TWO THOUSAND FEET. MAINTAIN RUNWAY HEADING
32. H270 A020 S---		PHILADELPHIA DEPARTURE ONE ONE NINER POINT ZERO
33. H270 A020 S---		SQUAWK IDENT
34. H270 A020 S---		RADAR CONTACT

SCENARIO "J". DEVICE COMPLEMENT "B"

	VOSYN HAS RECALL	PRINTER	VOSYN
35.	H190 A020 S---		TURN LEFT HEADING ONE NINER ZERO, VECTORS TO VICTOR ONE FIVE SEVEN
36.	H190 A020 S---		TRAFFIC TWELVE O'CLOCK, TWO MILES, TWO THOUSAND FEET, WESTBOUND, LIGHT
37.	H190 A020 S---		CLEAR OF TRAFFIC
38.	H190 A020 S---		YOUR POSITION IS THREE MILES NORTH OF VICTOR ONE FIVE SEVEN
39.	H--- A020 S---		RESUME NORMAL NAVIGATION
40.	H--- A020 S---		PHILADELPHIA APPROACH ONE TWO FIVE POINT ZERO
41.	H--- A020 S---		SQUAWK IDENT
42.	H--- A020 S---		RADAR CONTACT
43.	H170 A020 S---		TURN LEFT, HEADING ONE SEVEN ZERO

SCENARIO "J".   DEVICE COMPLEMENT "B"

	VOSYN HAS RECALL	PRINTER	VOSYN
44.	H170 A020 S---		VECTORS FOR VOR RUNWAY THREE TWO APPROACH
45.	H200 A020 S---		TURN RIGHT HEADING TWO ZERO ZERO
46.	H200 A020 S---	ILG WEATHER. CEILING MEASURED 1000 BROKEN. VISIBILITY 3 IN HAZE. WIND 310 AT 12. ALTIMETER 2996. TEMP 64. DEW POINT 51	
47.	H275 A020 S---		TURN RIGHT HEADING TWO SEVEN FIVE
48.	H275 A020 S---		YOUR POSITION IS TEN MILES FROM THE RUNWAY
49.	H--- A--- S---		CLEARED VOR RUNWAY THREE TWO APPROACH
50.	(BLANK)		WIND THREE ZERO ZERO AT TEN KNOTS
51.	(BLANK)		WILMINGTON TOWER ONE TWO SIX POINT ZERO
52.	(BLANK)		CLEARED TO LAND, RUNWAY THREE TWO
53.	(BLANK)		WILMINGTON GROUND CONTROL ONE TWO ONE POINT SEVEN
54.	(BLANK)		CLEARED TO THE GATE

SCENARIO "J". DEVICE COMPLEMENT "B"

	VOSYN HAS RECALL	PRINTER	VOSYN
54.	(BLANK)		CLEARED TO THE GATE
55.	(BLANK)		USE GATE TEN
56.	_______	PHL WEATHER. CEILING MEASURED 800 BROKEN. VISIBILITY 1.5 IN SMOKE AND HAZE. WIND 300 AT 10. ALTIMETER 2997. TEMP 62. DEWPOINT 50	
57.	_______	TTN WEATHER. 1000 SCATTERED. CEILING ESTIMATED 1200 BROKEN. VISIBILITY 4. ALTIMETER 2996. WIND 280 AT 8. ALTIMETER 2996. TEMP 60. DEW POINT 50	
58.	_______	ILG WEATHER. CEILING MEASURED 1000 BROKEN. VISIBILITY 3 IN HAZE. WIND 310 AT 12. ALTIMETER 2996. TEMP 64. DEW POINT 51	
59.	_______		TRENTON ALTIMETER TWO NINER NINER SIX
60.	_______		PHILADELPHIA ALTIMETER TWO NINER FIVE
61.	_______		WILMINGTON ALTIMETER TWO NINER FIVE

NOTE: ALL WEATHER MESSAGES WERE SENT TO THE PRINTER ONLY.

SCENARIO "J". DEVICE COMPLEMENT "G"

(Clearance delivered via land line): N12861 cleared to Columbus intersection via V157. Maintain 2500. Request further clearance via Data Link upon departure. Squawk 1031. McGuire Departure Control 124.15
NOTAM: Yardley VOR out of service.

#	16-WINDOW	HAS RECALL	PRINTER	VOSYN
1.	SEE PRINTER	(BLANK)	N12861 CLEARED TO PHL RWY 27R OUTER MARKER VIA V157 AND RADAR VECTORS. MAINTAIN 4000. MCQUIRE DEPARTURE 124.15 SQUAWK 1031	NOVEMBER ONE TWO EIGHT SIX ONE CLEARED TO PHILADELPHIA RUNWAY TWO SEVEN RIGHT OUTER MARKER VIA VICTOR ONE FIVE SEVEN AND RADAR VECTORS. MAINTAIN FOUR THOUSAND. MCGUIRE DEPARTURE ONE TWO FOUR POINT ONE FIVE. SQUAWK ONE ZERO THREE ONE (A)
2.	SQUAWK IDENT	H --- A 040 S ---	SQUAWK IDENT	SQUAWK IDENT
3.	RADAR CONTACT	H --- A 040 S ---	RADAR CONTACT	RADAR CONTACT
4.	ALT 040	H --- A 040 S ---	MAINTAIN 4000 FEET	MAINTAIN FOUR THOUSAND FEET
5.	TFC 01 2 ??? ?? ?	H --- A 040 S ---	TRAFFIC 1 O'CLOCK 2 MILES ALTITUDE UNKNOWN	TRAFFIC ONE O'CLOCK TWO MILES. ALTITUDE UNKNOWN
6.	CLR OF TRAFFIC	H --- A 040 S ---	CLEAR OF TRAFFIC	CLEAR OF TRAFFIC

(A) After airborne and pushing "Clearance Request" button.

SCENARIO "J". DEVICE COMPLEMENT "G"

#	16-WINDOW	HAS RECALL	PRINTER	VOSYN
7.	SEE PRINTER	H --- A 040 S ---	PHL INFORMATION K. CEILING MEASURED 800 BROKEN. VISIBILITY 2 MILES IN HAZE. WIND 310 AT 15. ALTIMETER 2995. ILS RWY 27R APPROACH IN USE. DEPARTURES ON RWY 27L	THIS IS PHILADELPHIA AIRPORT INFORMATION (B) KILO. CEILING MEASURED EIGHT HUNDRED BROKEN. VISIBILITY TWO MILES IN HAZE. WIND THREE ONE ZERO AT ONE FIVE. ALTIMETER TWO NINER NINER FIVE. ILS RUNWAY TWO SEVEN RIGHT APPROACH IN USE. DEPARTURES ON RUNWAY TWO SEVEN LEFT
8.	PHL APP 126.6	H --- A 040 S ---	PHL APPROACH 126.6	PHILADELPHIA APPROACH ONE TWO SIX POINT SIX
9.	SQK 1134 IDENT	H --- A 040 S ---	SQUAWK 1134 IDENT	SQUAWK ONE ONE THREE FOUR. IDENT
10.	RADAR CONTACT	H --- A 040 S ---	RADAR CONTACT	RADAR CONTACT
11.	EXPECT ILS 27R	H --- A 040 S ---	EXPECT ILS 27R APPROACH	EXPECT ILS TWO SEVEN RIGHT APPROACH
12.	PHL ALTM 2995	H --- A 040 S ---	PHL ALTIMETER 2995	PHILADELPHIA ALTIMETER TWO NINER NINER FIVE
13.	↓↓020	H --- A 020 S ---	DESCEND AND MAINTAIN 2000 FEET	DESCEND AND MAINTAIN TWO THOUSAND FEET
14.	INTERCPT 27R LOC	H --- A 020 S ---	INTERCEPT RWY 27R LOCALIZER	INTERCEPT RUNWAY TWO SEVEN RIGHT LOCALIZER

(B) Philadelphia ATIS sent only if requested via CDU.

SCENARIO "J". DEVICE COMPLEMENT "G"

#	16-WINDOW	HAS RECALL	PRINTER	VOSYN
15.	SPEED 100	H --- A --- S 100	SPEED 100	REDUCE SPEED TO ONE HUNDRED KNOTS
16.	TFC 12 2 020 W H	H --- A 020 S 100	TRAFFIC 12 O'CLOCK 2 MILES 2000 FEET WESTBOUND HEAVY	TRAFFIC TWELVE O'CLOCK, TWO MILES, TWO THOUSAND FEET, WESTBOUND, HEAVY
17.	CFAP ILS RWY 27R	H --- A --- S 100	CLEARED FOR ILS RWY 27R APPROACH	CLEARED FOR ILS RUNWAY TWO SEVEN RIGHT APPROACH
18.	PSN 1 FROM LOM	H --- A --- S 100	POSITION IS 1 MILE FROM OUTER MARKER	YOUR POSITION IS ONE MILE FROM THE OUTER MARKER
19.	PHL TWR 118.5	(BLANK)	PHL TOWER 118.5	PHILADELPHIA TOWER ONE ONE EIGHT POINT FIVE
20.	WIND 300 AT 17	(BLANK)	WIND 300 AT 17	WIND THREE ZERO ZERO AT ONE SEVEN
21.	RVR 5000	(BLANK)	RVR 5000 FEET	RVR FIVE THOUSAND FEET
22.	CLR LND RWY 27R	(BLANK)	CLEARED TO LAND RWY 27R	CLEARED TO LAND, RUNWAY TWO SEVEN RIGHT
23.	PHL GND 121.9	(BLANK)	PHL GROUND 121.9	PHILADELPHIA GROUND ONE TWO ONE POINT NINER
24.	CLR TO GATE	(BLANK)	CLEARED TO GATE	CLEARED TO GATE
25.	USE GATE 24	(BLANK)	USE GATE 24	USE GATE TWO FOUR (C)

(C) Sent only if gate request is made via CDU

SCENARIO "J". DEVICE COMPLEMENT "G"

#	16-WINDOW	HAS RECALL	PRINTER	VOSYN
26.	SEE PRINTER	(BLANK)	N12861 CLEARED TO EWT VOR VIA V157. MAINTAIN 2000. SQUAWK 1020. GROUND 121.9	NOVEMBER ONE TWO EIGHT SIX ONE (D) CLEARED TO NEW CASTLE VOR VIA VICTOR ONE FIVE SEVEN. MAINTAIN TWO THOUSAND. SQUAWK ONE ZERO TWO ZERO. GROUND ONE TWO ONE POINT NINER
27.	CLR TAXI RWY 27L	(BLANK)	CLEARED TO TAXI TO RWY 27L	CLEARED TO TAXI TO RUNWAY TWO SEVEN (E) LEFT
28.	PHL TWR 118.5	(BLANK)	PHL TOWER 118.5	PHILADELPHIA TOWER ONE ONE EIGHT POINT FIVE
29.	PSN HOLD	(BLANK)	POSITION AND HOLD	POSITION AND HOLD
30.	CLR TKOF RWY 27L	(BLANK)	CLEARED FOR TAKEOFF RWY 27L	CLEARED FOR TAKEOFF, RUNWAY TWO SEVEN LEFT
31.	↑↑020 HDG 270	H 270 A 020 S ---	CLIMB AND MAINTAIN 2000 FEET MAINTAIN RWY HEADING	CLIMB AND MAINTAIN TWO THOUSAND FEET. MAINTAIN RUNWAY HEADING
32.	PHL DEP 119.0	H 270 A 020 S ---	PHL DEPARTURE 119.0	PHILADELPHIA DEPARTURE ONE ONE NINER POINT ZERO
33.	IDENT	H 270 A 020 S ---	SQUAWK IDENT	SQUAWK IDENT
34.	RADAR CONTACT	H 270 A 020 S ---	RADAR CONTACT	RADAR CONTACT

(D) After pushing "Clearance Request" Button
(E) After pushing "Taxi Request" button

SCENARIO "J".   DEVICE COMPLEMENT "G"

#	16-WINDOW	HAS RECALL	PRINTER	VOSYN
35.	←←190 FOR V157	H 190 A 020 S ---	TURN LEFT HEADING 190 VECTORS TO V157	TURN LEFT HEADING ONE NINER ZERO, VECTORS TO VICTOR ONE FIVE SEVEN
36.	TFC 12 2 020 W L	H 190 A 020 S ---	TRAFFIC 12 O'CLOCK 2 MILES 2000 FEET WESTBOUND LIGHT	TRAFFIC TWELVE O'CLOCK, TWO MILES, TWO THOUSAND FEET, WESTBOUND, LIGHT
37.	CLR OF TFC	H 190 A 020 S ---	CLEAR OF TRAFFIC	CLEAR OF TRAFFIC
38.	PSN 3 N V157	H 190 A 020 S ---	POSITION 3 MILES NORTH OF V157	YOUR POSITION IS THREE MILES NORTH OF VICTOR ONE FIVE SEVEN
39.	RESUME NORM NAV	H --- A 020 S ---	RESUME NORMAL NAV	RESUME NORMAL NAVIGATION
40.	PHL APP 125.0	H --- A 020 S ---	PHL APPROACH 125.0	PHILADELPHIA APPROACH ONE TWO FIVE POINT ZERO
41.	IDENT	H --- A 020 S ---	SQUAWK IDENT	SQUAWK IDENT
42.	RADAR CONTACT	H --- A 020 S ---	RADAR CONTACT	RADAR CONTACT
43.	←←170	H 170 A 020 S ---	TURN LEFT HEADING 170	TURN LEFT, HEADING ONE SEVEN ZERO

SCENARIO "J". DEVICE COMPLEMENT "G"

#	16-WINDOW	HAS RECALL	PRINTER	VOSYN
44.	VCTR VOR RWY 32	H 170 A 020 S ---	VECTORS VOR RWY 32 APPROACH	VECTORS FOR VOR RUNWAY THREE TWO APPROACH
45.	→→200	H 200 A 020 S ---	TURN RIGHT HEADING 200	TURN RIGHT HEADING TWO ZERO ZERO
46.	ILG ALTM 2995	H 200 A 020 S ---	ILG ALTIMETER 2995	WILMINGTON ALTIMETER TWO NINER NINER FIVE
47.	→→275	H 275 A 020 S ---	TURN RIGHT HEADING 275	TURN RIGHT HEADING TWO SEVEN FIVE
48.	PSN 10 FROM RWY	H 275 A 020 S ---	POSITION 10 MILES FROM RWY	YOUR POSITION IS TEN MILES FROM THE RUNWAY
49.	CFAP VOR RWY 32	H --- A --- S ---	CLEARED VOR RWY 32 APPROACH	CLEARED VOR RUNWAY THREE TWO APPROACH
50.	WIND 300 AT 10	(BLANK)	WIND 300 AT 10	WIND THREE ZERO ZERO AT TEN KNOTS
51.	ILG TWR 126.0	(BLANK)	ILG TOWER 126.0	WILMINGTON TOWER ONE TWO SIX POINT ZERO
52.	CLR LND RWY 32	(BLANK)	CLEARED TO LAND RWY 32	CLEARED TO LAND, RUNWAY THREE TWO
53.	ILG GND 121.7	(BLANK)	ILG GROUND 121.7	WILMINGTON GROUND CONTROL ONE TWO ONE POINT SEVEN

SCENARIO "J".   DEVICE COMPLEMENT "G"

#	16-WINDOW	HAS RECALL	PRINTER	VOSYN	
54.	CLEARED TO GATE	(BLANK)	CLEARED TO GATE	CLEARED TO THE GATE	
55.	USE GATE 10	(BLANK)	USE GATE 10	USE GATE TEN	(F)
56.	SEE PRINTER	———	PHL WEATHER. CEILING MEASURED 800 BROKEN. VISIBILITY 1.5 IN SMOKE AND HAZE. WIND 300 AT 10. ALTIMETER 2997. TEMP 62. DEWPOINT 50	PHILADELPHIA WEATHER. CEILING MEASURED EIGHT HUNDRED, BROKEN. VISIBILITY ONE POINT FIVE IN SMOKE AND HAZE. WIND THREE ZERO ZERO AT ONE ZERO. ALTIMETER TWO NINER NINER SEVEN. TEMPERATURE SIX TWO. DEWPOINT FIVE ZERO	(G)
57.	SEE PRINTER	———	TTN WEATHER. 1000 SCATTERED. CEILING ESTIMATED 1200 BROKEN. VISIBILITY 4. ALTIMETER 2996. WIND 280 at 8. ALTIMETER 2996. TEMP 60. DEW POINT 50	TRENTON WEATHER. ONE THOUSAND SCATTERED. CEILING ESTIMATED ONE TWO HUNDRED, BROKEN. VISIBILITY FOUR. WIND TWO EIGHT ZERO AT EIGHT. ALTIMETER TWO NINER NINER SIX. TEMPERATURE SIX ZERO. DEW OINT FIVE ZERO	(H)
58.	SEE PRINTER	———	ILG WEATHER. CEILING MEASURED 1000 BROKEN. VISIBILITY 3 IN HAZE. WIND 310 AT 12. ALTIMETER 2996. TEMP 64. DEW POINT 51	WILMINGTON WEATHER. CEILING MEASURED ONE THOUSAND, BROKEN, VISIBILITY THREE IN HAZE. WIND THREE ONE ZERO AT ONE TWO. ALTIMETER TWO NINER NINER SIX. TEMPERATURE SIX FOUR. DEW POINT FIVE ONE	(I)
59.	TTN ALTM 2996	———	TTN ALTIMETER 2996	TRENTON ALTIMETER TWO NINER NINER SIX	(J)
60.	PHL ALTM 2995	———	PHL ALTIMETER 2995	PHILADELPHIA ALTIMETER TWO NINER NINER FIVE	(K)

(F) SENT ONLY IF GATE REQUEST IS MADE VIA CDU
(G) SENT ONLY IF "WEATHER PHL" IS REQUESTED VIA CDU
(H) SENT ONLY IF "WEATHER TTN" IS REQUESTED VID CDU
(I) SENT ONLY IF "WEATHER ILG" IS REQUESTED VIA CDU
(J) SENT ONLY IF "ALTIMETER" IS REQUESTED VIA CDU AT A TIME IN THE SCENARIO BEFORE MESSAGE #8 IS SENT
(K) SENT ONLY IF "ALTIMETER" IS REQUESTED VIA CDU AT A TIME IN THE SCENARIO AFTER MESSAGE #8 AND BEFORE MESSAGE #40 ARE SENT

SCENARIO "J". DEVICE COMPLEMENT "G"

#	16- WINDOW	HAS RECALL	PRINTER	VOSYN	
61.	ILG ALTM 2995	———	ILG ALTIMETER 2995	WILMINGTON ALTIMETER TWO NINER NINER FIVE	(L)

(L) SENT ONLY IF "ALTIMETER" IS REQUESTED VIA CDU AT A TIME IN THE SCENARIO AFTER MESSAGE #40 IS SENT.

SCENARIO "K". DEVICE COMPLEMENT "C" AND "F"

NOTE: DEVICE COMPLEMENT "F" USES THE FULL CDU BUT WITH THE "HAS" DISPLAY ELIMINATED. COMPLEMENT "C" USES THE SIMPLIFIED CDU.

#	HAS DISPLAY OR VOSYN RECALL	VOSYN	
1.	H --- A --- S ---	NOVEMBER ONE TWO EIGHT SIX ONE CLEARED TO SOMERTON INTERSECTION VIA DIX FIVE DEPARTURE AND VICTOR FOUR THREE THREE. MAINTAIN SIX THOUSAND. SQUAWK ONE ZERO TWO TWO. GROUND ONE TWO ONE POINT NINER	(A)
2.	H --- A --- S ---	CLEARED TO TAXI TO RUNWAY SIX	
3.	H --- A --- S ---	TETERBORO TOWER ONE ONE NINER POINT FIVE	
4.	H --- A 020 S ---	CLEARED FOR TAKEOFF RUNWAY SIX, MAINTAIN TWO THOUSAND FEET	
5.	H --- A 020 S ---	NEWARK DEPARTURE ONE ONE NINER POINT TWO	
6.	H --- A 020 S ---	SQUAWK IDENT	
7.	H --- A 020 S ---	RADAR CONTACT	
8.	H 240 A 020 S ---	TURN LEFT HEADING TWO FOUR ZERO. RADAR VECTORS TO VICTOR FOUR THREE THREE	(B)
9.	H 240 A 020 S ---	NEW YORK CENTER ONE THREE FIVE POINT ONE	

(A): AFTER PUSHING "CLEARANCE REQUEST" BUTTON, COMPLEMENT "F" ONLY
(B): AFTER TURN TO 300° CALLED OUT IN SID

SCENARIO "K" DEVICE COMPLEMENT "C" AND "F"

#	HAS	VOSYN	
10.	H 240 A 020 S ---	SQUAWK IDENT	
11.	H 240 A 020 S ---	RADAR CONTACT	
12.	H 180 A 020 S ---	TURN LEFT HEADING ONE EIGHT ZERO	
13.	H 180 A 060 S ---	CLIMB AND MAINTAIN SIX THOUSAND FEET	
14.	H 180 A 060 S --	YOUR POSITION IS THREE MILES FROM VICTOR FOUR THREE THREE. RESUME NORMAL NAVIGATION	
15.	H --- A 060 S ---	NEWARK ALTIMETER THREE ZERO ONE ZERO	
16.	H --- A 060 S ---	THUNDERSTORM AND SEVERE TURBULENCE AHEAD IN VICINITY OF PRINCETON	
17.	H 300 A 060 S ---	TURN RIGHT HEADING THREE ZERO ZERO. RADAR VECTORS AROUND THUNDERSTORM	(C)
18.	H 300 A 080 S ---	CLIMB AND MAINTAIN EIGHT THOUSAND FEET	(D)
19.	H 230 A 080 S ---	TURN LEFT HEADING TWO FIVE ZERO	
20.	H 230 A 080 S ---	CLEAR OF THUNDERSTORM	
21.	H --- A 080 S ---	CLEARED TO YARDLEY VOR DIRECT AND VICTOR FOUR THREE THREE TO SOMERTON	

(C) AFTER REQUEST FOR HEADING CHANGE VIA CDU (VIA VOICE FOR COMPLEMENT "C")
(D) AFTER REQUEST FOR ALTITUDE CHANGE VIA CDU (VIA VOICE FOR COMPLEMENT "C")

SCENARIO "K" DEVICE COMPLEMENT "C" AND "F"

#	HAS	VOSYN
22.	H --- A 080 S ---	NEW YORK CENTER ONE THREE FIVE POINT TWO FIVE
23.	H --- A 080 S ---	SQUAWK TWO ZERO THREE THREE. IDENT
24.	H --- A 080 S ---	RADAR CONTACT
25.	H --- A 060 S ---	DESCEND AND MAINTAIN SIX THOUSAND FEET
26.	H --- A 060 S ---	PHILADELPHIA APPROACH ONE TWO ZERO POINT ONE FIVE
27.	H --- A 060 S ---	SQUAWK ZERO FOUR ONE TWO, IDENT
28.	H --- A 060 S ---	RADAR CONTACT
29.	H --- A 060 S ---	NORTH PHILADELPHIA ALTIMETER THREE ZERO ZERO EIGHT *
30.	H --- A 030 S ---	DESCEND AND MAINTAIN THREE THOUSAND FEET
31.	H --- A 030 S ---	RADAR VECTORS FOR LOCALIZER BACKCOURSE RUNWAY SIX APPROACH AT NORTH PHILADELPHIA
32.	H 240 A 030 S ---	TURN RIGHT HEADING TWO FOUR ZERO
33.	H 240 A 030 S ---	YOUR TRAFFIC IS A LIGHT AIRCRAFT TWELVE O'CLOCK TWO MILES WESTBOUND, ALTITUDE UNKNOWN.

*Complement "F" only. For Complement "C", message is:
NORTH PHILADELPHIA WEATHER. CEILING ESTIMATED TWELVE HUNDRED BROKEN. VISIBILITY THREE. WIND ZERO FIVE ZERO AT FIVE. ALTIMETER THREE ZERO ONE ZERO. TEMPERATURE FOUR TWO. DEW POINT THREE SEVEN.

SCENARIO "K" DEVICE COMPLEMENT "C" AND "F"

#	HAS	VOSYN
34.	H 240 A 030 S ---	CLEAR OF TRAFFIC
35.	H 180 A 030 S ---	TURN LEFT HEADING ONE EIGHT ZERO
36.	H 180 A 020 S ---	DESCEND AND MAINTAIN TWO THOUSAND FEET
37.	H 090 A 020 S ---	TURN LEFT HEADING ZERO NINER ZERO
38.	H 090 A 020 S 100	SLOW TO ONE HUNDRED KNOTS
39.	H 090 A 020 S 100	YOUR POSITION IS FOUR MILES FROM JUNIATA INTERSECTION
40.	H --- A --- S 100	CLEARED LOCALIZER BACKCOURSE RUNWAY SIX APPROACH
41.	H --- A --- S ---	NORTH PHILADELPHIA TOWER ONE TWO ONE POINT THREE
42.	H --- A --- A ---	WIND ZERO FOUR ZERO AT FIVE KNOTS
43.	H --- A --- S ---	CLEARED TO LAND RUNWAY SIX
44.	H --- A --- S ---	GROUND CONTROL ONE TWO ONE POINT SEVEN
45.	H --- A --- S ---	CLEARED TO GATE
46.	H --- A --- S ---	USE GATE ONE (E)

(E) SENT ONLY IF GATE REQUEST IS MADE VIA CDU (FOR COMPLEMENT "F" ONLY)

SCENARIO "K". DEVICE COMPLEMENT "C" AND "F"

#	HAS	VOSYN	
47.	______	TRENTON WEATHER: CEILING MEASURED ONE THOUSAND OVERCAST, VISIBILITY TWO IN RAIN, WIND 050 AT SIX, ALTIMETER THREE ZERO ZERO EIGHT, TEMPERATURE FOUR FOUR DEGREES, DEW POINT FOUR ZERO DEGREES	(F)
48.	______	NEWARK ALTIMETER THREE ZERO ONE ZERO	(G)
49.	______	TRENTON ALTIMETER THREE ZERO ZERO NINE	(H)
50.	______	NORTH PHILADELPHIA ALTIMETER THREE ZERO ZERO EIGHT	(I)

(F) SENT ONLY IF "WEATHER TTN" IS REQUESTED VIA CDU , COMPLEMENT "F" ONLY.
(G) SENT ONLY IF "ALTIMETER" IS REQUESTED VIA CDU AT A TIME IN THE SCENARIO BEFORE MESSAGE #19 IS SENT , COMPLEMENT "F" ONLY.
(H) SENT ONLY IF "ALTIMETER" IS REQUESTED VIA CDU AT A TIME IN THE SCENARIO AFTER MESSAGE #19 AND BEFORE MESSAGE #26 ARE SENT , COMPLEMENT "F" ONLY.
(I) SENT ONLY IF "ALTIMETER" IS REQUESTED VIA CDU AT A TIME IN THE SCENARIO AFTER MESSAGE #26 IS SENT , COMPLEMENT "F" ONLY.

SCENARIO "L". DEVICE COMPLEMENTS "D" AND "E"

Note: Complement "D" uses full CDU and **VOSYN** Complement "E" uses simplified CDU and voice.
(Clearance Delivery via land line from Millville): N12861 is cleared direct SIE. Maintain 2000. Request further clearance via Data Link upon departure. Squawk 1322. ACY Departure 119.55

#	16-WINDOW	HAS RECALL	VOICE OR VOSYN	
1.	VOSYN	(BLANK)	NOVEMBER ONE TWO EIGHT SIX ONE CLEARED TO FRASER INTERSECTION VIA. DIRECT SEA ISLE VOR. VICTOR ONE SIX SIX TO WOODSTOWN VOR. VICTOR ONE EIGHT FOUR TO MODENA VOR. VICTOR THREE TO FRASER. MAINTAIN FIVE THOUSAND FEET. EXPECT FURTHER CLEARANCE TO EIGHT THOUSAND FEET. ATLANTIC CITY DEPARTURE ONE ONE NINER POINT FIVE FIVE. SQUAWK ONE THREE TWO TWO	(A)
2.	IDENT	(BLANK)		
3.	RADAR CONTACT	(BLANK)		
4.	↑↑050	H A 050 S		
5.	ACY ALTM 2978	H A 050 S		
6.	NY CTR 133.7	H A 050 S		
7.	SQK 1124 IDENT	H A 050 S		
8.	RADAR CONTACT	H A 050 S		
9.	TFC 01 5 045 W H	H A 050 S		

(A) After airborne and pushing "Clearance Request" button for Complement "D" or request via voice for complement "E".

SCENARIO "L". DEVICE COMPLEMENTS "D" AND "E"

#	16 WINDOW	HAS RECALL	VOICE OR VOSYN
10.	CLR OF TFC	H A 050 S	
11.	NY CTR 135.5	H A 050 S	
12.	IDENT	H A 050 S	
13.	RADAR CONTACT	H A 050 S	
14.	↑↑080	H A 080 S	
15.	NY CTR 134.8	H A 080 S	
16.	IDENT	H A 080 S	
17.	RADAR CONTACT	H A 080 S	
18.	NY CTR 135.25	H A 080 S	
19.	SQK 2200 IDENT	H A 080 S	
20.	RADAR CONTACT	H A 080 S	
21.	↓↓060	H A 060 S	

SCENARIO "L". DEVICE COMPLEMENTS "D" AND "E"

#	16-WINDOW	HAS RECALL	VOICE OR VOSYN
22.	PHL APP 120.15	H A 060 S	
23.	IDENT	H A 060 S	
24.	RADAR CONTACT	H A 060 S	
25.	PNE ALTM 2981	H A 060 S	NORTH PHILADELPHIA WEATHER. CEILING MEASURED 900. OVERCAST. VISIBILITY 1 IN HEAVY SNOW. WIND 030 AT 20. ALTIMETER 2979. TEMPERATURE 27. DEW POINT 24.
26.	↓↓040	H A 040 S	
27.	VOSYN	H A 040 S	WINGS REPORT ING VISIBILITY FIVE HUNDRED FEET IN HEAVY SNOW. TWO AIRCRAFT MISSED APPROACH IN PAST SIX ZERO MINUTES. SAY INTENTIONS
28.	VOSYN	H A 040 S	STANDBY FOR CLEARANCE TO MERCER COUNTY AIRPORT (B)
29.	CLR ARD DIRECT	H A 040 S	
30.	ALT 040	H A 040 S	
31.	VCTR ILS RWY 6	H A 040 S	
32.	→→110	H 110 A 040 S	

(B) After pushing "Alternate" button, Complement "D" only, or request via voice for Complement "E".

*Sent via voice for complement "E" only. Not sent for Complement "D" unless requested via CDU.

SCENARIO "L". DEVICE COMPLEMENTS "D" AND "E"

#	16- WINDOW	HAS RECALL	VOICE OR VOSYN
33.	TTN ALTM 2979	H 110 A 040 S	TRENTON, N.J. WEATHER: CEILING MEASURED 800 OVERCASE, VISIBILITY 1 1/2 IN LIGHT SNOW, WIND 030 AT 25, ALTIMETER 2980, TEMPERATURE 28. *
34.	↓↓020	H 110 A 020 S	
35.	TFC 01 4 020 E L	H 110 A 020 S	
36.	SPEED 100	H 110 A 020 S 100	
37.	CLR OF TFC	H 110 A 020 S 100	
38.	←←080	H 080 A 020 S 100	
39.	PSN 3 FROM LOM	H 080 A 020 S 100	
40.	CFAP ILS RWY 6	(BLANK)	
41.	TTN TWR 120.7	(BLANK)	
42.	WIND 030 AT 20-30	(BLANK)	
43.	CLR LND RWY 6	(BLANK)	
44.	TTN GND 121.9	(BLANK)	
45.	CLEARED TO GATE	(BLANK)	

* Sent via voice for Complement "E" only. Not sent for complement "D" unless requested via CDU.

SCENARIO "L". DEVICE COMPLEMENTS "D" AND "E"

#	16-WINDOW	HAS RECALL	VOICE OR VOSYN	
46.	USE GATE 5	(BLANK)		(C)
47.	VOSYN	-------	NORTH PHILADELPHIA WEATHER. CEILING MEASURED NINER HUNDRED, OVERCAST. VISIBILITY ONE MILE IN HEAVY SNOW. WIND ZERO THREE ZERO AT TWO ZERO. ALTIMETER TWO NINER SEVEN NINER. TEMPERATURE TWO SEVEN. DEW POINT TWO FOUR	(D)
48.	ACY ALTM 2979	-------		(E)
49.	PHL ALTM 2980	-------		(F)
50.	PNE ALTM 2979	-------		(G)
51.	TTN ALTM 2979	-------		(H)

(C) Sent only if gate request is made via CDU, Complement "D" only.
(D) Sent only if "Weather PNE" is requested via CDU, Complement "D" only.
(E) Sent only if "Altimeter" is requested via CDU at a time in the scenario before message #18 is sent, Complement "D" only.
(F) Sent only if "Altimeter" is requested via CDU at a time in the scenario after message #18 and before message #25 is sent, Complement "D" only.
(G) Sent only if "Altimeter" is requested via CDU at a time in the scenario after message #25 and before message #33 are sent, Complement "D" only.
(H) Sent only if "Altimeter" is requested via CDU at a time in the scenario after message #33 is sent, Complement "D" only.

SCENARIO I - VOICE BASELINE

CONTROLLER	TAPED REPLY
Eastern 385 cleared to Washington National as filed. Maintain 6000. Squawk 1121 on departure. Over	
	Roger, cleared as filed, maintain 6000, squawk 1121. Eastern 385
Readback correct - Ground 121.7	
	Roger Eastern 385
1. NOVEMBER 12861 READY TO COPY?	
2. NOVEMBER 12861 CLEARED TO CLAYMONT OUTER MARKER VIA 037 RADIAL OF NEWCASTLE AND PHILADELPHIA RWY 9R LOCALIZER. MAINTAIN 3000. SQUAWK 1127 ON DEPARTURE. OVER	
3. READBACK CORRECT. GROUND 121.7	
(After contacted by GAT pilot):	
4. NOVEMBER 12861 TAXI TO RWY 1	
Eastern 385 Tower now on 126.0	
	126.0 Eastern 385
5. NOVEMBER 861 CONTACT THE TOWER ON 126.0 WHEN READY	
(After contacted by GAT pilot): Standby. Eastern 385 contact Washington Center on 131.25, good day.	
	Washington Center on 131.25 Eastern 385 so long.
6. NOVEMBER 12861 CLEARED FOR TAKEOFF RUNWAY 1.	
November 22 Yankee position and hold	
	Roger 22 Yankee

7. NOVEMBER 861 CLIMB AND MAINTAIN 3000

November 22 Yankee cleared for takeoff

22 Yankee is rolling

November 81 Mike cleared to land, wind 030 at 12

Cleared to land, 81 Mike

8. NOVEMBER 861 CONTACT PHILADELPHIA APPROACH ON 126.6. GOOD DAY.

(After contacted by GAT pilot):

9. NOVEMBER 12861 SQUAWK IDENT

10. 861 RADAR CONTACT. PHILADELPHIA IS CURRENTLY CEILING MEASURED ONE THOUSAND, OVERCAST. VISIBILITY TWO. WIND ZERO SEVEN ZERO AT ONE FIVE KNOTS. ALTIMETER TWO NINER EIGHT NINER.

Allegheny 72 turn right heading 110

Right to 110. Allegheny 72

11. NOVEMBER 861 TURN LEFT TO A HEADING OF 010. VECTORS FOR AN ILS RWY 9 RIGHT APPROACH

Delta 10 descend to 7000

Down to seven. Delta 10.

12. NOVEMBER 861 DESCEND AND MAINTAIN 2000.

Philadelphia approach this is Allegheny 94 with you at 8000. And we can't seem to get ATIS

Standby Allegheny 94

13. NOVEMBER 861 YOU HAVE TRAFFIC 3 O'CLOCK, FOUR MILES, 1500 FEET, AN EASTERN 727.

Allegheny 94 Ident, Maintain 8000 Fly a heading of 030, vectors for an ILS 9 right approach. Philadelphia weather is ceiling measured 1000, overcast. Visibility 2 miles. Wind 070 at 15. Altimeter 2989. The ATIS is out of service, over.

Maintain 8000, heading is 030 and 2989 on the altimeter. Copied the weather. Allegheny 94

14. NOVEMBER 861 YOUR TRAFFIC IS NO LONGER A FACTOR

15. NOVEMBER 861 SLOW TO 100 KNOTS

Allegheny 72 two from the marker, cleared for the approach. Contact the tower on 118.5.

118.5 Allegheny 72

Delta 10 descend and maintain 4000 and turn right to a heading of 070

Down to 4 and right to 070 Delta 10.

16. NOVEMBER 861 TURN RIGHT HEADING 110 DEGREES

17. NOVEMBER 861 YOUR POSITION IS 6 FROM THE OUTER MARKER, CLEARED FOR ILS 9 RIGHT APPROACH.

Allegheny 94 descend to 4000

Allegheny 94 is out of 8 for 4

18. **NOVEMBER 861 CONTACT THE TOWER ON 118.5**

(After contacted by GAT pilot):

19. ROGER NOVEMBER 861. WIND IS 070 AT 12.

Allegheny 72 cleared to land	
	Allegheny 72
Delta 106, Position and hold	
	Roger, Delta 106
Allegheny 72 left turn when able, cleared to cross 9 left, ground 121.9	
	Allegheny 72
Delta 106 cleared for takeoff	
	Delta 106 is rolling
	Philadelphia tower, this is Delta 10, two from the marker.
Roger Delta 10. Wind is 070 at 11	
November 23 Golf Contact departure on 124.35 Good day	
	Good day. 23 Golf
Eastern 261 taxi to Runway 9 Left	
	Runway 9 left, Eastern 261

20. **NOVEMBER 861 CLEARED TO LAND, RUNWAY 9 RIGHT**

21. NOVEMBER 861 NEXT LEFT AND HOLD SHORT OF 9 LEFT

Eastern 261, cleared for takeoff

Here we go, Eastern 261

22. NOVEMBER 861 CROSS 9 LEFT NOW AND GROUND 121.9

(After contacted by GAT pilot):

23. NOVEMBER 12861 CLEARED TO THE RAMP

24. NOVEMBER 12861 READY TO COPY?

25. NOVEMBER 12861 IS CLEARED TO THE EAST TEXAS VOR VIA POTTSTOWN ONE DEPARTURE AND VICTOR 147 TO EAST TEXAS. EXPECT RADAR VECTORS TO ALLENTOWN. MAINTAIN 3000. SQUAWK 1321 ON DEPARTURE OVER

26. NOVEMBER 861 READBACK CORRECT GROUND 121.9

(After contacted by GAT pilot):

27. ROGER NOVEMBER 861 TAXI TO RUNWAY 9 LEFT

Delta 943. Push, gate 12

Delta 943 Taxi to 9 left Follow the Cessna.

Roger

28. NOVEMBER 861 CONTACT THE TOWER ON 118.5

(After contacted by GAT pilot):

29. NOVEMBER 12861 CLEARED FOR IMMEDIATE TAKEOFF - NO DELAY.

Delta 943 Position and hold

Roger

Delta 943 Cleared for takeoff

Roger Delta 943

30. NOVEMBER 861 CONTACT DEPARTURE ON 124.35

(After contacted by GAT pilot):

31. NOVEMBER 12861 SQUAWK IDENT

32. NOVEMBER 861 IS RADAR CONTACT CLIMB AND MAINTAIN 3000 INTERCEPT THE POTTSTOWN 1.

Philadelphia departure, Delta 943 with you.

Delta 943 Squawk Ident.
Cancel the 5000 restriction

Cancel the five, Delta 943

And Delta 943 is radar contact

Roger

Eastern 111 left to 140°.
Intercept the Elmer 1.
Contact New York Center on 135.25

140 on the heading, intercept Elmer 1, and center on 135.45 Eastern 111

Eastern 111 that's point two five for the center.

Roger 135.25 Eastern 111

Delta 943, Contact N.Y. Center on 134.8.

134.8 So long

33. NOVEMBER 861 TURN LEFT TO 270 DEGREES. YOU HAVE TRAFFIC TWO O'CLOCK, 3 MILES EASTBOUND.

Philadelphia Departure, Cherokee 61091 with you, VFR to Cape May.

November 61091 Ident on 1202. Say position and altitude.

Identing on 1202. 5,500 feet, 7 miles northwest. Over

November 091 Roger, maintain 5500. Fly a heading of 200 degrees.

Maintain 5500 and 200 on the heading. 091.

34. NOVEMBER 861 CLEAR OF TRAFFIC

35. NOVEMBER 861 YOU'RE CLEARED TO POTTSTOWN DIRECT. CONTACT NEW YORK CENTER NOW ON 135.25. GOOD DAY.

(After contacted by GAT pilot):

36. NOVEMBER 12861 SQUAWK 1327 and Ident.

37. 861 IS RADAR CONTACT

American 12 descend to 8000

Leaving 12 for 8. American 12

(After request for higher due to turbulence):

38. NOVEMBER 861 CLIMB AND MAINTAIN 6000.

American 12 traffic one o'clock. 6 miles, south bound altitude unknown.

We're looking American 12

American 12 has the traffic.

Roger

39. NOVEMBER 861 TRAFFIC 11 O'CLOCK, 4 MILES, 5000 FEET, NORTHBOUND

40. NOVEMBER 861 CLEAR OF TRAFFIC

American 12 contact Philadelphia approach on 120.15.	
	120.15 for American 12

41. NOVEMBER 861 CONTACT ALLENTOWN APPROACH ON 118.2

(After contacted by GAT pilot):

42. NOVEMBER 12861 SQUAWK 1025 AND IDENT.

43. NOVEMBER 861 IS RADAR CONTACT, ALLENTOWN ALTIMETER IS 2985

November 62 Papa Turn left heading 140	
	62 Papa turning left to 140 degrees

44. NOVEMBER 861 DESCEND AND MAINTAIN 4500

November 62 Papa right to 170	
	170, 62 Papa

45. NOVEMBER 861 CONTINUE YOUR DESCENT TO 3000

November 62 Papa descend and maintain 4000	
	You were garbled, approach. Say again please.
November 62 Papa descend to 4000	
	Roger, out of 6 for 4, 62 Papa

46. NOVEMBER 861 TURN RIGHT TO A HEADING OF 020, RADAR VECTORS FOR AN ILS RUNWAY 6 APPROACH

47. NOVEMBER 861 DESCEND AND MAINTAIN 2500 FEET

48. NOVEMBER 861 YOUR TRAFFIC IS 2 O'CLOCK, 2 MILES, 2000 FEET EASTBOUND.

49. NOVEMBER 861 REDUCE SPEED TO 110.

November 62 Papa descend to 2500 feet

Leaving 4 for 2 point 5. 62 Papa

50. NOVEMBER 861 YOU ARE TWO FROM THE MARKER, CLEARED FOR THE APPROACH. CONTACT THE TOWER ON 120.5.

(After contacted by GAT pilot):

51. ROGER NOVEMBER 12861 WIND IS 040 AT 10.

November 142 position and hold.

142

November 66 alpha next left, ground point nine

Roger 66 Alpha

November 142 cleared for takeoff

Cleared for takeoff. 142.

52. NOVEMBER 861 CLEARED TO LAND
RUNWAY 6.

53. NOVEMBER 861 NEXT LEFT, CONTACT
GROUND CONTROL ON 121.9

54. 861 IS CLEARED TO THE GATE.

APPENDIX C

DATA LINK PHASE 1-C
PILOT BRIEFING SHEET

You are about to participate in a series of simulated flights to evaluate equipment for Data Link. The simulated flights will occur in the New Jersey and eastern Pennsylvania area and will be made in a GAT-2 simulator using two man crews.

Unlike earlier tests in this series, and in which you may have participated, the current series of tests will not be limited to the presentation of short ATC messages, or to a limited repetoire of possible responses by you. In the present series of tests, we are looking at possible full Data Link systems, some with capabilities for providing hard copy printout of extended length messages such as ATIS, weather and clearances, device complements which allow you to originate a variety of requests for information from the ground, and complements which provide some or all of the information via synthetic speech (Vosyn). One of the experimental runs will, on the other hand, use no Data Link equipment; communication will simulate present practice of using voice channels, and will provide baseline data. Immediately prior to each experimental run, you will be advised as to the display complement which is to be used, and as to the types of messages that will be presented on each device. The precise instructions for each of the separate runs are listed at the end of this document, along with some practice messages which will be supplied for training purposes.

The SMATC Display

The SMATC (Short Message ATC) display consists of sixteen alpha-numeric characters arranged in two lines of eight characters each. The characters are red dot matrix LED and a dimming control is provided. Each new message sent to the SMATC will be accompanied by an audible alert (three separate tones in sequence). As explained under the "Full CDU" section below, the latest heading, altitude, and speed messages may be recalled onto the SMATC, with appropriate labels, at the pilot's discretion.

The following abbreviations will be used with the SMATC display:

ALT = MAINTAIN ALTITUDE
ALTM = ALTIMETER
APP = APPROACH
CFAP = CLEARED FOR APPROACH
CLR = CLEAR OR CLEARED
CTR = CENTER
DEP = DEPARTURE
GND = GROUND
HLD = HOLD
LND = LAND
LOC = LOCALIZER
NAV = NAVIGATION
← = TURN LEFT
→ = TURN RIGHT
NORM = NORMAL
LOM = OUTER MARKET
PSN = POSITION
RWY = RUNWAY
SHRT = SHORT
SQK = SQUAWK
TFC = TRAFFIC
TKOF = TAKEOFF
TWR = TOWER
VCTR = VECTORS
↑↑ = CLIMB TO AND MAINTAIN
↓↓ = DESCEND TO AND MAINTAIN

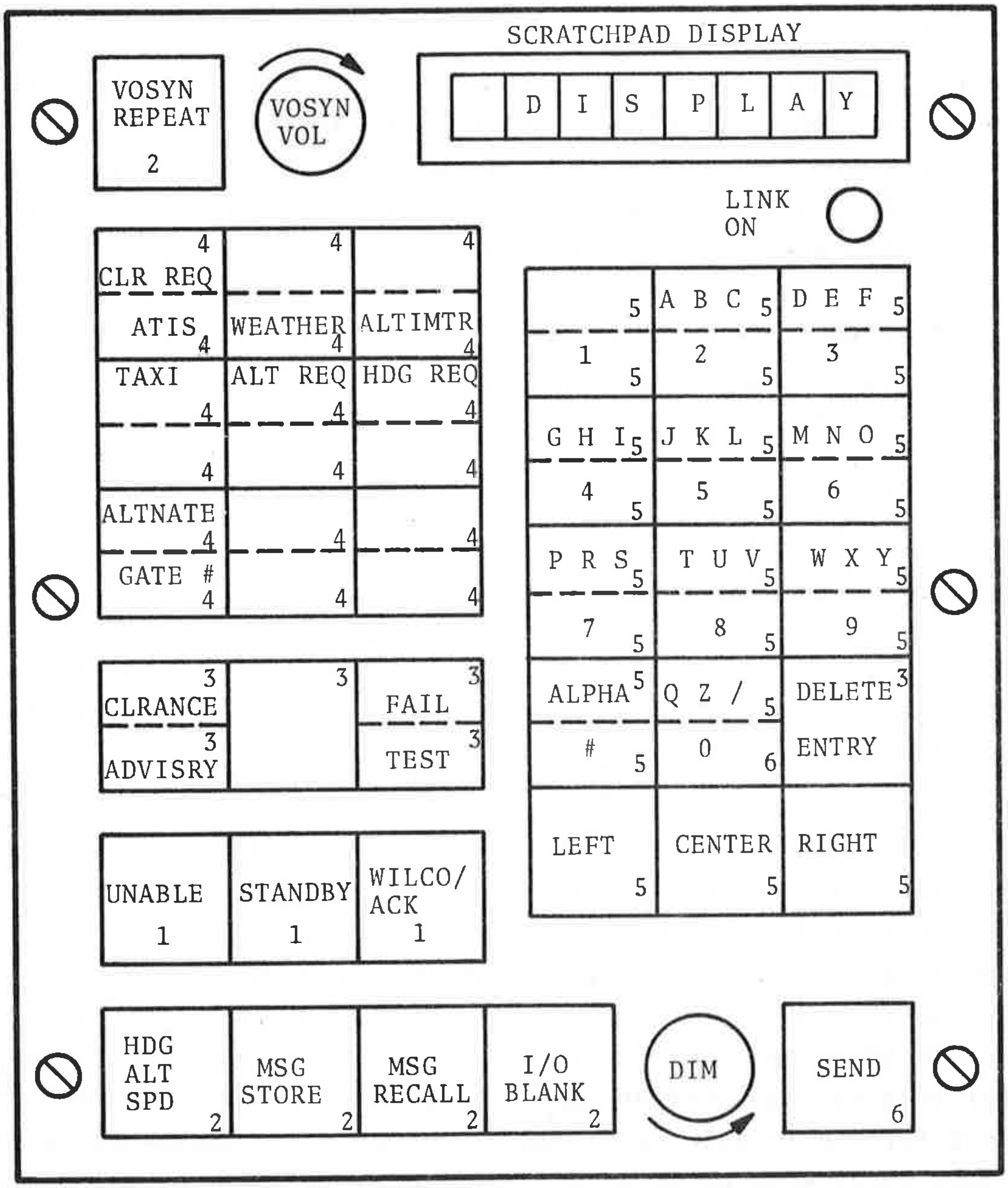
The meaning of messages containing these abbrevations should be self explanatory with the possible exception of traffic advisories. Hère, a standard format will be used for all such advisories as follows:

```
        Clock
        Position      Distance (in miles)
           \         /
        TFC 02 3
        050 NE H
       /    /   \
   Alt.  Hdg. Size (H = Heavy, L = Light)
```

Where this message is duplicated with the voice synthesizer, the spoken message would be "Traffic two o'clock, three miles, five thousand feet, north-east bound, heavy". Any unknown quantities in the visual display will be indicated by a question mark in that position within a message where that quantity would normally appear.

The Full CDU

The most complex device which you will be required to operate is the Full CDU (Control and Downlink Unit), depicted in Figure C-1. Actual operation of the device is, however, simpler than the sketch might lead you to believe, since a majority of the buttons serve two functions, and only those functions which are enabled and



Note: The number in the corner of each button in this sketch refers to the corresponding group defined in text.

Figure C-1. Full CDU Panel

operational at a given time are visible. Additionally, groups of functions are color coded for further separation and identification, as indicated in the figure.

Group 1 (green): This group contains the most used functions, the downlink responses (WILCO/ ACKNOWLEDGE, UNABLE, AND STANDBY). One of these buttons must be used to reply to every message transmitted from the ground, including those messages which contain information originally requested by the pilot, such as weather. In addition to the three buttons on the CDU, there is a WILCO/ACKNOWLEDGE button on each control column which functions in an identical manner.

Shortly after each uplink message is displayed, the WILCO button on the CDU will begin to flash off and on as a reminder to the pilot. After it (or one of the control column WILCO buttons) is pushed, it will continue to flash for several seconds, and then remain in its normal illuminated state, indicating the transmission to the ground is complete. Should the UNABLE button be pushed, it will begin flashing until the transmission is complete, and the WILCO button will stop flashing. If the STANDBY button is pressed, both it and the WILCO will continue to flash until either the UNABLE or WILCO button is subsequently pushed. A STANDBY response must always be followed by a WILCO or UNABLE.

When any of these Group 1 buttons is pushed, the corresponding response message is immediately transmitted and the "SEND" button (Group 6 below) need not be pushed. There may be an occasional impossible message, such as "Climb to 90,000 feet", to force you to use the UNABLE button. Also, for all traffic advisories, WILCO/ ACKNOWLEDGE indicates traffic located, UNABLE indicates traffic not located, and STANDBY may be used if the crew wants time to look for the traffic (followed by the WILCO or UNABLE as appropriate). Since there will be no actual traffic targets, the pilot is free to respond to traffic advisories in any of the above ways for these simulation experiments.

Group 2 (magenta): These are the housekeeping functions, which allow you to store a message, to recall a stored message, to blank out the SMATC display, to recall the latest heading speed and altitude commands, and for those display complements which include a voice synthesizer, to cause it to repeat the last Vosyn message. The group includes (lower left corner of CDU):

HDG/ALT/SPD — Recalls and displays the latest Heading, Altitude and Speed commands on the SMATC whenever it is installed, or from the Vosyn if it is installed and the SMATC is not. The stored information is automatically updated whenever a new Heading, Altitude or Speed command is given. No action on the part of the pilot is required.

MSG STORE — Allows you to store any message that you may care to. However, because the memory is only large enough to store a single message, any message which you have previously stored in this manner will be deleted.

MSG RECALL — Recalls and displays the message which you have previously stored using the MESSAGE STORE button. The stored message will be outputted on the same device (SMATC or Vosyn) on which it was originally outputted. In the case of the SMATC, a second depression will return the latest message to the display. For the Vosyn, successive depressions will repeat the stored message.

I/O BLANK — Successive depressions of this button clear the SMATC display and return the message to view.

VOSYN REPEAT — (top left corner of CDU) repeats last Vosyn message.

<u>Group 3 (yellow-green)</u>: These are the control functions. Operation is as follows:

TEST/FAIL — Operation of the TEST button initiates a series of internal tests, indicated by blinking of the lighted button. If the test is satisfactory, the light returns to steady state. Otherwise, the other half of this same button illuminates

TEST/FAIL (CONTINUED) — red and displays FAIL. During the Test, all CDU buttons which are used for these experiments will light up, all elements of the CDU scratchpad display and the SMATC display will light up, and the following test messages are outputted:

VOSYN: "Squawk Zero One Two Three Romeo"

PRINTER: "(Time)
TEST MESSAGE
SQUAWK 0123R"

CLRANCE ADVISRY — Alternate depressions of this button put the Group 4 buttons (described below) into either a CLEARANCE or ADVISORY mode and display the possible messages on the two halves of the Group 4 buttons (described below). This is also an alternate action button which determines whether the buttons in Group 5 (described below) are in the ALPHA or NUMERIC mode.

DELETE ENTRY — This deletes the last character that you have entered using any of Groups 4 & 5. It cannot delete any entry from Group 1 buttons, since transmissions occur immediately after Group 1 buttons are depressed. If you have made multiple entry errors, these can be deleted by multiple depressions of the DELETE ENTRY key.

Group 4 (blue): These are dual purpose discrete function buttons. Depending on whether the CLEARANCE or ADVISORY mode is established by the use of that button (Group 3), messages in either the general category of clearances or advisories are enabled and lit up on the top or bottom half of the buttons respectively, making it possible for you to generate those downlink messages. In the CLEARANCE mode, you may generate:

CLR REQ — Initiates a request to ATC for the delivery of your departure clearance. It requests that the

CLR REQ (CONTINUED)	flight plan be retrieved from storage and displayed on the cockpit printer or presented via the Vosyn.
TAXI	Requests taxi instructions. Reply would indicate taxiway to use and limit of clearance.
ALT REQ	Used to request clearance to a different altitude. The pilot may indicate a desire for a specific altitude by keying in a three digit number on the alphanumeric keyboard (Group 5).
HDG REQ	Used to request clearance to a new heading, such as vectors around a thunderstorm. May be further specified at the pilot's option, by keying in "R" or "L" for right or left on the alphanumeric keyboard of Group 5.
ALTNATE	Used to request clearance to a different airport. Must be followed with a three-letter code for the desired airport, keyed on the buttons of Group 5.

For the ADVISORY mode, the half-buttons which are enabled and lit are:

ATIS	Requests ATIS information for those airports which provide it. May be followed with the three-letter code for the desired airport, keyed in on the buttons of Group 5. Otherwise, destination ATIS will be provided while enroute or departure ATIS if on the ground.
WEATHER	Requests weather information. Must be followed with the three-letter code for the desired airport, keyed in on the buttons of Group 5.
ALTIMTR	Requests altimeter setting. Will provide the altimeter setting from the reporting point nearest the current aircraft position. No three-letter code required.

GATE # Requests assignment of a gate number.

For the above buttons of Group 4 which require further letter or number input using the Group 5 buttons, activation of the Group 4 button automatically puts the Group 5 buttons into the proper mode (either alpha or numeric) for that particular message. Thus, when the "Weather" button from Group 4 is pushed, for example, the Group 5 buttons automatically go into the alpha mode.

When buttons of either Groups 1 or 4 are depressed, a two-letter code appears on the scratchpad display. For the present experiment, these codes are:

WI = WIlco	AM = AltiMeter setting request
UN = UNable	GA = GAte assignment request
WA = standby (WAit)	TA = request for permission to TAxi
AT = ATis request	LT = aLTitude change request
CL = CLearance request	HD = HeaDing change request
WE = WEather information request	AR = request for alternate AiRport

The display remains illuminated until the SEND button is depressed, to allow you to review the message you have keyed in, and to correct any errors by the use of the DELETE ENTRY button. For entries with the Group 1 buttons (WILCO, UNABLE, STANDBY), the display remains on only until the simulated transmission has occurred (several seconds), and deletion of the message by you is impossible. (Should test results indicate that it is advisable, provision will be made in future experiments for the pilot to delete these messages prior to their actual transmission.)

Group 5 (uncolored): These buttons give you full alphanumeric capability. If the entry that you are about to make follows the use of a Group 4 button, the Group 5 buttons will automatically be in the appropriate alphabetic or numeric mode. Otherwise, you may change modes by the use of the ALPHA/# button. Only half of each of the buttons in Group 5 is illuminated at any one time, so that you will always know in which mode you are. Operation in the numeric mode is perfectly straightforward and your entries appear on the display as you key them in. In the alphabetic mode, first press the key containing the desired letter, and then specify which of the three letters appearing on that key you desire by pressing the

LEFT, CENTER or RIGHT buttons on the bottom row. In other words, two keystrokes are required for each letter that you wish to enter. After the second push, the letter appears on the scratchpad display. Again, you may correct errors of entry by the use of the DELETE ENTRY button, with one push for each entry that you desire to delete.

When in the ALPHA mode, the buttons of Group 5 can, at the pilot's option, be used instead of the buttons of Groups 1 and 4. Here, the same unique two-letter codes are used (see above) as were displayed when the Groups 1 or 4 buttons were used. Each code uses buttons in different rows of the keyboard, and logic is built in so that you get the two-letter code with only two keystrokes; that is, you do not need to use the LEFT, CENTER or RIGHT buttons to specify the letters. The requirement for sequential keying in two different rows is the reason why some of these codes are somewhat unusual. Weather, for example, cannot be WX, and instead is WE.

If you key in an inoperative combination, question marks will in some cases appear on the scratchpad display. In other cases, two letters may appear, but these represent codes which will not be used until later simulations for such things as company business in simulated airline operations.

Group 6 (amber): This button is a separate category, SEND, and must be used after all entries using Group 4 or Group 5 pushbuttons. It does not have to be used after the Group 1 buttons (WILCO, Standby and Unable). After depression, it will flash on and off for several seconds until the message has actually been transmitted down the link.

You are encouraged to use the full CDU on all simulated flights where it is available. For example, you may, after pushing the WEATHER button, or keying in WE, obtain the latest weather report from any of the following locations by keying in the corresponding three-letter identifier:

PHL Philadelphia, PA
PNE North Philadelphia
ACY Atlantic City, N.J.
ABE Allentown, PA.
TEB Teterboro, N.J.
RDG Reading, PA

MIV Millville, N.J.
ILG Wilmington, Del.
EWR Newark, N.J.
TTN Trenton, N.J.
WWD Wildwood, N.J. (Cape May County)

The Small CDU

On other simulated flights, the small CDU will be used. This contains the pushbuttons of Groups 1 and 2 of the full CDU, plus a TEST button (part of Group 3 of the full CDU). The small CDU does not have down link or scratchpad display capability, as is indicated in Figure C-2. Any downlink messages which you may care to originate other than UNABLE, STANDBY and WILCO/ACKNOWLEDGE will require the use of voice. The HDG/ALT/SPD, MESSAGE STORE, MESSAGE RECALL, I/O BLANK AND VOSYN REPEAT buttons function in the same manner as with the full CDU.

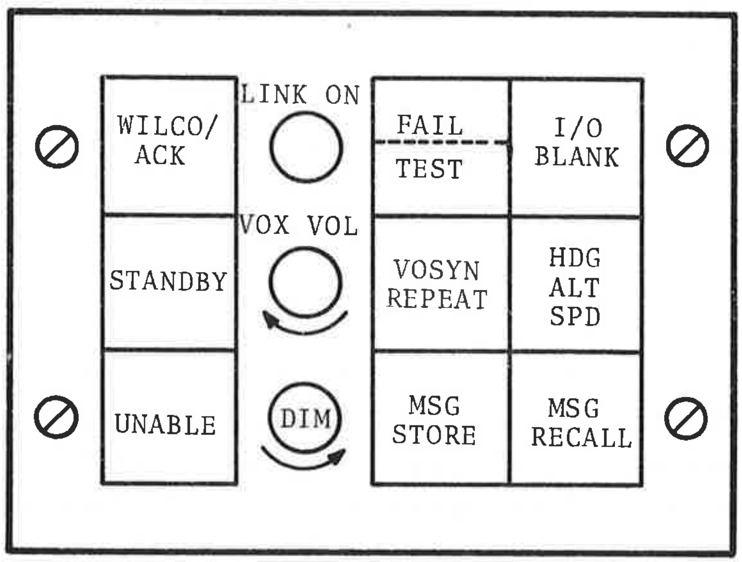


Figure C-2. The Small CDU

The Vosyn

The voice synthesizer which is being used during this series of simulated flights represents some compromise between cost and voice quality. While machines with better diction are available at much higher cost, we believe that with only a slight amount of practice you will be able to understand the output of the present machine readily. We will be interested in your assessment of this.

Within the cockpit, you will have control of Vosyn volume on the CDU. At the Vosyn itself, there is an additional control which adjusts the rate of speech. Before the simulator runs, you will be given the opportunity to listen to the Vosyn and to adjust the rate of speech to that which is comfortable for you.

The Printer

This is a standard item and no instructions as to its use should be required. You may tear off individual messages or accumulate a group of messages, as you prefer. Each message will be preceded by the time of day, and plain text will be used (i.e., no symbols or unusual abbreviations will occur). In the cases where a message appears on the printer as well as the Vosyn and/or SMATC, the printer message will not contain any additional information.

Miscellaneous Instructions

On each run, you will be assigned a position as either pilot or copilot. You should agree with your fellow crewmember as to which of you has the primary responsibility for Data Link downlink messages. Crew RESPONSE TIMES will be measured, and you are requested to acknowledge all commands and advisories as promptly as possible, but in what you would consider a normal fashion. (We do not want a "race" to the WILCO button).

To call your attention to a new message when it appears on either the SMATC or the printer, an audible alert, consisting of three different sequential tones repeated several times, will be activated. It will not be used with Vosyn messages.

During the experimental flights, except when climbing, a final, or when a speed restriction is given, please fly at about 140 knots indicated, in order to keep flight durations to a reasonable length.

Immediately prior to each simulated flight you will be briefed as to the device complement which will be available and how it is to be used. The various device complements are listed below, but no crew will fly them in the order listed.

DEVICE COMPLEMENT "A": No Data Link equipment will be used. All communications will be by voice using present-day procedures. Assume that ATIS is inoperative and that you will have to receive ATIS information from the controller.

DEVICE COMPLEMENT "B": All short messages will be outputted by the Vosyn. Long messages (clearances, ATIS, weather) will appear on the printer. The small CDU will be used, and downlink messages (other than WILCO, STANDBY and UNABLE) will require the use of voice. No SMATC will be used.

DEVICE COMPLEMENT "C": The Vosyn will speak out all messages, including long messages (clearances, ATIS, weather). The SMATC display will be limited to the continuous present of the latest Heading, Altitude and Speed commands. The small CDU will be used, and downlink messages (other than WILCO, STANDBY and UNABLE) will require the use of voice. No printer will be used.

DEVICE COMPLEMENT "D": Synthetic speech will be used only for long messages (clearances, ATIS, weather). All short messages will appear on the SMATC. You will have a full CDU for downlink capability and should try to avoid using voice except in an "emergency." No printer will be used.

DEVICE COMPLEMENT "E": Long messages (clearances, ATIS, weather) will be delivered by conventional voice. The SMATC will be used for all short messages. The small CDU will be used, and downlink messages (other than WILCO, STANDBY and UNABLE) will require the use of voice. No printer or Vosyn will be used.

DEVICE COMPLEMENT "F": The Vosyn will deliver all messages. You will have a full CDU for downlink capability and should try to avoid using voice except in an "emergency." No printer or SMATC will be used.

DEVICE COMPLEMENT "G": This complement represents maximum capability. All short messages will appear on the SMATC. Both long and short messages will be spoken by the Vosyn, and will also appear on the printer. You will have a full CDU for downlink capability and should try to avoid using voice except in an "emergency."

DEVICE COMPLEMENT "H": All short messages will appear on the SMATC. All messages will appear on the printer. You will have a full CDU for downlink capability and should try to avoid using except in an "emergency." No VOSYN will be used.

DATA LINK PHASE 1-C

CREW FAMILIARIZATION RUN

The following brief scenario is designed to demonstrate some of the features of the Data Link equipment with which you will be working. It presents some of the commands and advisories which you might expect on a flight from Philadelphia to Wilmington, Del., as well as giving you an opportunity to originate downlink messages. To save time, do not attempt to fly simulator or to do such things as change radio frequency settings; instead, concentrate on the Data Link equipment. All uplink messages will be spoken by the Vosyn and will appear on the printer; all short messages will also appear on the SMATC so that you will have an opportunity to compare the three methods of presentation.

Crew Action	Controller Action	Result
1.	Send Message #1.	
Adjust Vosyn volume. Press Vosyn REPEAT as required until volume level is satisfactory to you. Ask observer to adjust speech rate until it is satisfactory to you. Press WILCO.		Vosyn volume and speech rate are now adjusted to your preference.
2. Press TEST button on CDU.	None.	TEST button will flash off and on. When test is completed, the TEST button will return to normal illumination; otherwise FAIL appears on top half of the button and will remain on until the self test operation is again initiated. During the test, all display elements, indicators and buttons on CDU will be illuminated. Each display will present a test message as defined in the briefing sheet.
3. If CLRANCE/ADVISORY button is not in CLRANCE mode, press it. Then press CLR REQ button, and SEND.	Send Message #2.	Clearance is spoken out on the Vosyn and printed.
Acknowledge receipt with WILCO.*		

*Remember that this can be done either on the CDU or with the WILCO buttons on the control columns.

Crew Action	Controller Action	Result
4. Put CLEARANCE/ADVISY button into ADVISORY mode. Then, press ATIS button. Since you are on the ground at PHL you do not have to specify that you wish PHL ATIS. Next, press SEND.	None.	ATIS will be spoken out on the Vosyn and printed.
Acknowledge receipt with WILCO.		
5. Put CLRANCE/ADVISORY button into CLRANCE mode. Then press TAXI button.	Send Message #3.	Taxi clearance will be spoken by Vosyn, printed out and will appear on the SMATC.
Acknowledge with WILCO.		
6.	Send Message #4.	The displays will indicate frequency changeover to tower 118.5
Acknowledge with WILCO.		
7.	Send Message #5.	The displays will indicate clearance for takeoff.
Acknowledge with WILCO.		
8.	Send Message #6.	The displays will indicate a command to climb to 020, maintaining runway heading 270.
Acknowledge with WILCO.		

Crew Action	Controller Action	Result
9. Press HAS RECALL button.	None.	The SMATC will display the latest heading, altitude, and speed clearances (These would be outputted by the Vosyn if the SMATC were not installed.)
10. Press HAS RECALL a second time.	None.	The SMATC will return to displaying the latest message.
11. Press Vosyn REPEAT.	None.	The Vosyn will speak the latest message.
12.	Send Message #7.	The displays will indicate frequency changeover to PHL DEP. 119.0.
Acknowledge with WILCO. Also press MSG STORE button to put this message into storage.		
13. Request ILG weather. With dedicated function buttons in ADVISORY mode, press WEATHER button, followed by keyboard inputs of: GHI, RIGHT } I JKL, RIGHT } L GHI, LEFT } G	None.	WEILG should appear on scratchpad.

Crew Action	Controller Action	Result
Then press SEND.	None.	The VOSYN and printer will deliver Wilmington weather after a delay simulating transmission times.
Acknowledge with WILCO.		
14.	Send Message #8.	Displays will present messages requesting a left turn to 190° for a vector to V157.
Acknowledge with WILCO.		
15. Press MSG RECALL button.	None.	Displays will present the frequency for PHL DEP as previously stored.
16. Press HAS RECALL button.	None.	SMATC will display the latest heading, altitude, and speed clearances.
17.	Send Message #9.	Displays will present an advisory indicating traffic at 12 o'clock, 2 miles, 2000 feet, Westbound, light aircraft. SMATC format will be TFC 12 2 020 W L
Acknowledge with UNABLE.		
18.	Send Message #10.	Displays will present a message to resume normal navigation.
Press STANDBY and observe results. Then press WILCO.		

Crew Action	Controller Action	Result
19. Press HAS RECALL button.	None.	SMATC will indicate latest heading, altitude, and speed clearances. (No heading given because clearance for normal navigation has been received.)
20.	Send Message #11.	Displays will indicate a changeover to a frequency of 125.0, which is PHL Approach Control which also handles ILG approaches.
Acknowledge with WILCO.		
21. Request Altimeter. With function keys in the ADVISRY mode, press ALTMTR. No 3-letter identifier code is required.	None.	CDU scratchpad display will contain the altimeter code "AM".
Press SEND.	None.	Displays will output the ILG altimeter setting.
Acknowledge with WILCO.		
22. To show that the same message can be generated in a different manner, press I/O BLANK to clear the SMATC display. Then key in: ABC } MNO } AM	None.	The scratchpad should again display "AM".

Crew Action	Controller Action	Result
Press the send button.	None.	The displays will again output ILG altimeter.
Do NOT acknowledge with a WILCO as yet.		
23.	Send Message #12.	The Message Pending light on the SMATC will come on, indicating that you have not acknowledged the previous message and a new message is waiting.
Press WILCO.		MESSAGE PENDING light will go off and the new message will be displayed.
Acknowledge with WILCO.		
24.	Send Message #13.	Displays will output the message "Cleared for VOR Runway 32 Approach."
Acknowledge with WILCO.		
Then press I/O BLANK.		Message disappears from SMATC.
Again press I/O BLANK.		Message reappears on SMATC.

This completes the familiarization run. Should you desire additional practice with the CDU, feel free to do so. Weather reports from any of the eleven locations are available. Note further that there are dimming controls on the CDU and SMATC.

PILOT'S INSTRUCTIONS FOR THE FOUR SCENARIOS

Scenario I

You have filed an IFR flight plan from Greater Wilmington, Del. to Allentown-Bethehm-Easton, Pa., with an intermediate stop at Philadelphia International. Your alternate is Mercer County (Trenton), N.J. The scenario begins with your request for a clearance on the ground at Wilmington. For this clearance you must use the full CDU with device complement "H" and voice with device complement "A."

The complements are explained below.

DEVICE COMPLEMENT "A" (Conventional Voice): No Data Link equipment will be used. All communications will be by voice using present-day procedures. Assume that ATIS is inoperative and that you will have to receive ATIS information from the controller.

DEVICE COMPLEMENT "H": All short messages will appear on the SMATC. All messages will appear on the printer. You will have a full CDU for downlink capability and should try to avoid using voice except in an "emergency". No Vosyn will be used.

SCENARIO I, Device complements "A" or "H."

Scenario J

You have filed an IFR flight plan from Trenton-Robbinsville, N.J., to Greater Wilmington, Del., with an intermediate stop at Philadelphia International. Your alternate is Reading Muni., Pa. Because you are departing from an uncontrolled airport, you have received the following clearance from Flight Service via the telephone:

> "N12861 Cleared direct Columbus intersection via V157. Maintain 2500. Request further clearance when airborne. Squawk 1031. Monitor McGuire departure control on 124.15. NOTAM: Yardley VOR (ARD) out of service."

You may takeoff when ready. Please request further clearance when airborne. For this clearance, you must use the Full CDU with Device Complement "G" and voice with Device Complement "B."

The complements are explained below.

DEVICE COMPLEMENT "B": All short messages will be outputted by the Vosyn. Long messages (clearances, ATIS, weather) will appear on the printer. The small CDU will be used, and downlink messages (other than WILCO, STANDBY and UNABLE) will require the use of voice. No SMATC will be used.

DEVICE COMPLEMENT "G": This complement represents maximum capability. All short messages will appear on the SMATC. Both long and short messages will be spoken by the Vosyn, and will also appear on the printer. You will have a full CDU for downlink capability and should try to avoid using voice except in an "emergency."

SCENARIO J, Device complements "B" or "G."

Scenario K

You have filed IFR flight plan from Teterboro, N.J., to North Philadelphia, Pa. Your alternate is Philadelphia International. The scenario begins with your request for a clearance on the ground at Teterboro. For this clearance, you must use the full CDU with Device Complement "F" and voice with Device Complement "C."

The complements are explained below.

DEVICE COMPLEMENT "C": The Vosyn will speak out all messages, including long messages (clearances, ATIS, weather). The SMATC display will be limited to the continuous presentation of the latest Heading, Altitude and Speed commands. The small CDU will be used, and downlink messages (other than WILCO, STANDBY and UNABLE) will require the use of voice. No printer will be used.

DEVICE COMPLEMENT "F". The VOSYN will deliver all messages. You will have a full CEU for downlink capability and should try to avoid using voice except in an "emergency." No printer or SMATC will be used.

SCENARIO K, Device Complements "C" or "F."

Scenario L

You have filed an IFR flight plan from Cape May County (Wildwood) N.J., to Wings Field, Pa. Your alternate is Mercer County (Trenton), N.J. Because you are departing from an uncontrolled airport, you have received the following clearance from Flight Service via the telephone:

> "N12861 Cleared direct SIE. Maintain 2000. Request further clearance when airborne. Squawk 1322. Monitor Atlantic City departure control on 119.55."

You may takeoff when ready. Please request further clearance when airborne. For this clearance, you must use the Full CDU for this with Device Complement "D" and voice with Device Complement "E."

The complements are explained below.

DEVICE COMPLEMENT "D": The VOSYN will be used for long messages only (clearances, ATIS, weather). All short messages will appear on the SMATC. You will have a full CDU for downlink capability and should try to avoid using voice except in an "emergency." No printer will be used.

DEVICE COMPLEMENT "E": Long messages (clearances, ATIS, weather) will be delivered by conventional voice. The SMATC will be used for all short messages. The small CDU will be used, and downlink messages (other than WILCO, STANDBY and UNABLE) will require the use of voice. No printer or VOSYN will be used.

SCENARIO L, Device Complements "D" or "E."

APPENDIX D

QUESTIONNAIRE AND RESULTS

The two numbers after the answers to questions refer respectively to the number of responses made by general aviation pilots and by FAA/NAFEC pilots. Differences in totals resulted from failure of certain pilots to answer certain questions or from their checking more than one answer.

PHASE 1C QUESTIONNAIRE

NAME: ______________________________

DATE(S) EXPERIMENTS CONDUCTED: ______________________________

DATE YOU FILLED OUT QUESTIONNAIRE: ______________________________

FLYING EXPERIENCE:

TOTAL HOURS: ______________

INSTRUMENT HOURS: ______________

MULTI-ENGINE HOURS: ______________

Please read over prior to beginning your experimental runs. Responses are to be filled in after the completion of all 8 simulated flights. Please circle the appropriate answer. Blank pages are provided at the end for your remarks. Please key them to the number of the question. All comments, both positive and negative, are welcome and appreciated.

THESE QUESTIONS REFER TO THE SMATC DISPLAY.

1. Did you find the display readable in its present location?

Yes	15 + 8 = 23
No	1 + 0 = 1
Marginal	1 + 0 = 1

2. Would it be preferable to have two such displays, one located directly in front of each crew member?

Yes	1 + 1 = 2
No	16 + 4 = 20
Possibly	0 + 3 = 3

3. It has been suggested that two SMATC's be installed directly on the control columns. Would you prefer this?

Yes	1 + 0 = 1
No	13 + 6 = 19
Possibly	3 + 2 = 5
No opinion	0 + 0 = 0

4. Do you feel that a larger or smaller number of characters are needed on the SMATC?

Larger	1 + 0 = 1
Smaller	1 + 0 = 1
As is	14 + 6 = 20
Unsure	1 + 2 = 3

5. If so, how many?
   (One general aviation pilot, without explanation, suggested 10)

6. Was the red color of the SMATC characters acceptable?

Yes	11 + 1 = 12
No	3 + 5 = 8
Marginally	3 + 2 = 5

7. State what single color you would prefer over all others.

Red	3 + 0 = 3	Blue	0 + 1 = 1
Green	7 + 2 = 9	Yellow	3 + 1 = 4
White	3 + 2 = 5	Orange	1 + 1 = 2
Amber	0 + 2 = 2		

8. Was the readability of the display acceptable under both daylight and night conditions?

Yes	16 + 8 = 24
Daylight only	1 + 0 = 1
Night only	0 + 0 = 0
Neither	0 + 0 = 0
Unsure	0 + 0 = 0

9. Was it confusing having to WILCO at some place other than directly on the display?

Yes	5 + 1 = 6
No	12 + 6 = 18
No opinion	0 + 1 = 1

10. What character size would you like?

Larger	0 + 1 = 1
Smaller	1 + 0 = 1
As is	16 + 7 = 23

11. Was the dimming adjustment satisfactory both for the characters and for the HDG, ALT, SPD labels?

Yes	12 + 5 = 17
No	1 + 0 = 1
No opinion	4 + 1 = 5

12. Did you feel any tendency to delay your responses to the SMATC when the Vosyn was also in use?

Yes	7 + 4 = 11
No	7 + 3 = 10
No opinion	3 + 1 = 4

13. What method of alerting to a new message on the SMATC do you prefer? (Circle one, two or all.)

Audio alert	14 + 7 = 21
Flashing of SMATC	7 + 4 = 11
Flashing of WILCO	3 + 1 = 4

14. Did you ever Blank the SMATC display?

Occasionally	4 + 6 = 10
Frequently	5 + 2 = 7
No	8 + 0 = 8

15. Do you feel that the Blank button is necessary?

Yes	8 + 6 = 14
No	5 + 1 = 6
No opinion	4 + 1 = 5

16. Were there any confusing abbreviations used on the SMATC?

Yes	3 + 4 = 7
No	14 + 4 = 17

If yes, please list them and offer alternate suggestions. (Several disliked CFAP. PSN was listed by one pilot, and another mentioned occasional confusion between ALT and ALTN.)

THESE QUESTIONS REFER TO THE VOSYN

17. How would you rate the intelligibility of the Vosyn?

Good	13 + 3 = 16
Marginal	4 + 5 = 9
Unacceptable	0 + 0 = 0

18. Did you find that intelligibility improved with practice?

Yes	11 + 4 = 15
No	2 + 0 = 2
Only slightly	4 + 4 = 8

19. Apart from intelligibility, did you find the mechanical quality of the speech to be annoying?

No	12 + 5 = 17
Moderately	5 + 3 = 8
Very	0 + 0 = 0

20. Would you like the use of synthetic speech limited to periods when the pilot's eyes are busiest, such as takeoff and landing, with a visual display the remainder of the time?

Yes	3 + 0 = 3
No	12 + 5 = 17
No opinion	2 + 3 = 5

21. Do you feel that improving the intelligibility of some words might change your opinion of the Vosyn?

Yes	4 + 5 = 9
No	11 + 1 = 12
Possibly	2 + 2 = 4

If so, please list any such words you can remember.
(Navaid names were metioned most frequently, possibly because crews had not planned their flights, and were thus less familiar with the place names than they would otherwise have been.)

22. Would you like in-cockpit control of pitch and rate of speech of the Vosyn?

Yes	11 + 8 = 19
No	6 + 0 = 6
No opinion	0 + 0 = 0

23. Would you like the use of the Vosyn to be limited to certain types of message?

Yes, short messages	5 + 3 = 8
Yes, long messages	0 + 0 = 0
No, all messages	11 + 3 = 14

24. Instead of the separate audio alert, do you think it would be preferable for the Vosyn to speak the aircraft ID before each message?

Yes	3 + 3 = 6
No	14 + 5 = 19
No opinion	0 + 0 = 0

<u>THESE QUESTIONS REFER TO THE PRINTER</u>

25. How do you feel about the location of the printer during the present experiment?

Satisfactory	9 + 2 = 11
Marginal	5 + 2 = 7
Poor	3 + 4 = 7

26. Do you think that if the printer could be installed in a prime location, it might replace the SMATC?

Yes	2 + 2 = 4
No	10 + 3 = 13
Worth trying	5 + 3 = 8
No opinion	0 + 0 = 0

27. Should the use of the printer be restricted to long messages?

Yes, long messages only	8 + 2 = 10
No, all messages	8 + 4 = 12
No opinion	1 + 2 = 3

28. Would you like to see some abbreviations and/or symbols used on the printer so as to shorten the messages?

Abbreviations	1 + 2 = 3
Symbols	0 + 3 = 3
Both	3 + 2 = 5
None	12 + 1 = 13
No opinion	1 + 2 = 3

If so, please list suggestions, especially for symbols. (General aviation pilots suggested arrows, RT, LT, APP. Test pilots desired the use of weather symbols).

29. Did you let messages accumulate on the printer, or did you tear off the individual messages?

Accumulated them	9 + 3 = 12
Tore off individually	9 + 6 = 15

30. Was there any difficulty in reading the messages under night conditions?

Yes	2 + 1 = 3
No	14 + 7 = 21

31. Was the time tag on messages of any value?

Yes	5 + 5 = 10
No	11 + 1 = 12
No opinion	1 + 2 = 3

32. Is the printer sufficiently noisy as to avoid the need for any other alert?

Yes	7 + 5 = 12
No	9 + 3 = 12
No opinion	1 + 0 = 1

(Several pilots noted, however, that noise levels in the simulator were not comparable with those in actual aircraft.)

33. Would you like a signal to indicate that the printer has completed a message so that you don't tear it off too soon?

Yes	9 + 6 = 15
No	6 + 0 = 6
Probably not necessary	2 + 2 = 4
No opinion	0 + 0 = 0

34. Do you see a requirement for printing in two colors?

Yes	0 + 2 = 2
No	17 + 6 = 23

If yes, what?

(Two test pilots suggested red for urgent messages.)

THESE QUESTIONS REFER TO THE FULL CDU

35. Did the color coding help you to recognize functional groupings of buttons?

Yes	9 + 4 = 13
No	7 + 3 = 10
Not required	1 + 0 = 1

36. Was it reasonably easy to use the Full CDU with limited training?

Yes	15 + 8 = 23
No	1 + 0 = 1
Marginal	1 + 0 = 1

(One pilot commented, "If controllers can learn to use keyboards, so can pilots.")

37. How much training time do you think is required in order to feel comfortable in the use of the CDU?

(For general aviation pilots, the mean suggested time was about two hours, with a range from 15 minutes to 8 hours. For test pilots, the mean suggested time was 3-4 hours, with a range from 15 minutes to a few days.)

38. In the presence of space constraints, do you think that the dedicated function buttons could be eliminated, and all inputs made with the alphanumeric keyboard two-letter codes?

Yes	3 + 3 = 6
No	11 + 3 = 14
Not desirable	2 + 2 = 4

39. Was the requirement for left-handed keying on the co-pilot side a source of difficulty?

Yes	1 + 0 = 1
No	12 + 8 = 20
Marginal	1 + 0 = 1

40. Are you left-handed?

Yes	3 + 2 = 5
No	12 + 5 = 17
Ambidextrous	1 + 1 = 2

41. Would you settle for an alphanumeric keyboard only (no function buttons) on the right-hand side of the co-pilot?

Yes	0 + 0 = 0
No	15 + 3 = 18
Worth trying	1 + 4 = 5
No opinion	1 + 1 = 2

42. Do you feel that all downlink keying requirements other than WILCO and UNABLE should be eliminated from Data Link?

Absolutely	1 + 0 = 1
Should be	0 + 0 = 0
Probably not	3 + 1 = 4
Definitely not	12 + 3 = 15
Unsure	0 + 4 = 4

43. Please list any other discrete function buttons which you feel would be used often enough that they should be included and/or list those already included which you do not feel are necessary. (Among those suggested were bad weather reports, takeoff clearance request, enroute change request, new destination, missed approach, and hijack report).

44. Do we need a discrete function button labeled EMERGENCY which would demand priority on the voice channel?

Yes	7 + 6 = 13
No	6 + 1 = 7
No opinion	3 + 1 = 4

45. Is a discrete function button marked TRAFFIC LOCATED a logical candidate?

Yes	9 + 1 = 10
No	7 + 7 = 14
No opinion	3 + 1 = 4

46. What about a button marked FIELD IN SIGHT?

Yes	6 + 1 = 7
No	9 + 7 = 16
No opinion	1 + 0 = 1

47. On the alphanumeric keyboard, should the LEFT, CENTER and RIGHT buttons be eliminated, with that specification replaced by a second keystroke on the left, center, or right key in the <u>same</u> row of the alphanumeric keyboard as that of the first alpha entry?

Leave L.C.R.	7 + 2 = 9
Eliminate L.C.R.	1 + 0 = 1
Would have to try it	10 + 6 = 16

48. The CDU button pressure was selected with both calm and turbulent conditions in mind. What was your opinion of the pressure required for keying?

Too high, even in turbulence	1 + 3 = 4
O.K. in turb., but otherwise too high	0 + 0 = 0
About right for all conditions	14 + 5 = 19
Too low	0 + 0 = 0

49. Was there sufficient dimming control?

Yes	16 + 6 = 22
No	0 + 0 = 0
Marginal	1 + 0 = 1

50. Was the keyboard sufficiently readable under "Daylight" conditions?

Yes	16 + 8 = 24
No	1 + 0 = 1
Marginal	1 + 0 = 1

51. Would you like also to be able to use the CDU for non-Data Link entries such as radio frequency settings, transponder codes, and area nav inputs?

Yes	9 + 7 = 16
No	5 + 0 = 5
Unsure	3 + 1 = 4

52. If you knew that the use of keyed-in CDU entries would give you a faster response from the ground than if you used a voice channel, would you take the effort to use the CDU assuming the ATC system allowed such a choice?

Yes	15 + 7 = 22
No	1 + 0 = 1
Sometines	0 + 1 = 1
Unsure	1 + 0 = 1

53. Please list any suggestions you may have for improving the Full CDU?

(Among the suggestions were to add a calculator mode, eliminate requirements for a WILCO for ident requests, provide flashing of SEND buttons when a function key has been depressed, installation of the CDU on the instrument panel, putting SEND next to CL/ADV, and to number the messages in sequence.)

54. Please list any suggestions you may have for improving the training in the use of the Full CDU.

(Suggestions included (1) more practice runs, (2) longer practice without flying, (3) a practice run which provided examples of <u>all</u> possible entries, and (4) to set up a CDU simulator.)

55. Would it be preferable to have both halves of the split buttons illuminated at all times, with color coding to indicate which half was active?

Yes	5 + 4 = 9
No	11 + 1 = 12
No opinion	1 + 3 = 4

56. Should each split button be replaced by two separate buttons at the cost of an increase in CDU size?

Yes	0 + 0 = 0
No	17 + 6 = 23
No opinion	0 + 2 = 2

57. Was the division of the split buttons between "Clearance" and "Advisory" a good choice from the pilot's standpoint?

Yes	16 + 7 = 23
No	0 + 0 = 0
No opinion	1 + 1 = 2

If no, please describe a better choice.
(No other choices were suggested.)

<u>THESE QUESTIONS REFER TO THE SMALL CDU</u>

58. Do you feel that the Small CDU is all that pilots should be required to use?

Yes	2 + 1 = 3
No	7 + 5 = 12
Possibly	3 + 2 = 5

59. After having used the Full CDU, did you feel restricted when only the Small CDU was available?

Very much so	7 + 3 = 10
Not particularly	6 + 5 = 11
No opinion	0 + 0 = 0

60. Should a Small CDU be provided for both the pilot and co-pilot?

Yes	1 + 2 = 3
No	11 + 4 = 15
No opinion	1 + 2 = 3

61. Should we consider something midway in capability between the Full and Small CDU?

Yes	6 + 4 = 10
No	6 + 2 = 8
No opinion	1 + 2 = 3

(No suggestions were made as to what to delete from the CDU or add to the SCDU.)

GENERAL CONSIDERATIONS

62. Do you feel that some messages, such as "Radar contact," should not require a response?

Yes	10 + 7 = 17
No	7 + 1 = 8
No opinion	0 + 0 = 0

63. Was the audio alert sufficiently distinctive from other common audible indicators?

Yes	16 + 7 = 23
No	0 + 0 = 0
Marginal	1 + 1 = 2

64. Do you foresee any need to be able to store more than one message?

Yes	7 + 7 = 14
No	10 + 0 = 10
No opinion	0 + 1 = 1

65. As long as HDG, ALT and SPD can be retained in some manner, is it really necessary to be able to store other messages?

Yes	12 + 7 = 19
No	3 + 1 = 4
No opinion	2 + 0 = 2

66. Aside from formal in-house briefing, how much time did you spend studying the briefing sheet prior to the simulated flights?

(For general aviation pilots, times ranged from zero to three hours; most spent about one hour. Several of the test pilots failed to receive their briefing sheets in advance; the maximum time spent by any of the test pilots was one hour.)

67. Do you feel that the STANDBY button serves a useful purpose?

Yes	6 + 2 = 8
No	8 + 5 = 13
No opinion	3 + 1 = 4

68. Which method of retaining heading, altitude and speed (HAS) information did you prefer?

Recall with SMATC	15 + 5 = 20
Recall with Vosyn	1 + 0 = 1
Small display dedicated only to HAS	1 + 4 = 5

69. After a WILCO response by you to a frequency change message or a new transponder code, would you like the Data Link equipment to automatically tune your VHF transceiver or set your transponder? (With manual override capability by the pilot at his option.)

Yes	6 + 3 = 9
No	4 + 0 = 4
Worth trying	7 + 4 = 11
No opinion	0 + 0 = 0

70. What about a similar capability to set the altitude alert, and heading and speed bugs?

Yes	6 + 2 = 8
No	6 + 0 = 6
Worth trying	4 + 7 = 11
No opinion	1 + 0 = 1

71. Did you find that in a Data Link environment, the lack of background chatter over the voice link resulted in your losing information which you consider valuable?

Much info lost	0 + 1 = 1
A little info lost	7 + 3 = 10
No info lost	10 + 4 = 14

72. On the scenario which involved voice only and included conversations with other aircraft, were you aware of a potential conflict?

Yes	4 + 2 = 6
No	12 + 5 = 17

If "Yes", please identify.

(No attempt was made to introduce a conflict into the voice-only run. Apparently, on two trials the timing was such that two aircraft were cleared for landing with less than a normal interval, and two pilots noted this.)

73. Do you think the SMATC display should be built into the CDU?

Yes	0 + 1 = 1
No	10 + 3 = 13
Worth trying	5 + 3 = 8
No opinion	3 + 1 = 4

74. What about building the printer into the CDU?

Yes	3 + 1 = 4
No	6 + 1 = 7
Worth trying	6 + 5 = 11
No opinion	2 + 1 = 3

75. Do you feel that there is any need for both crew members to WILCO each message?

Yes	0 + 0 = 0
No	15 + 8 = 23
No opinion	1 + 0 = 1

DEVICE COMPLEMENTS

76. Did some of the device complements provide too much redundant information?

Yes	4 + 3 = 7
No	7 + 5 = 12
No opinion	4 + 0 = 4

If so, which ones?
(Four pilots indicated that Vosyn + SMATC + Printer was too much. Two indicated that the Vosyn was not required.)

77. Do you feel that other displays, such as a cathode ray tube capable of displaying long as well as short messages, should be evaluated?

Yes	6 + 6 = 12
No	6 + 0 = 6
No opinion	4 + 1 = 5

78. If yes, describe such a display or displays.
(General aviation pilots suggested a 4" AEDI, a CRT for long messages, something like the Raytheon CDC Radar keyboard multiplexer, and one suggested that terminal radar information should be provided. The test pilots suggested CRTs, the Kaiser AEDI, the Sperry stoland CRT and an improved NIMO CRT.)

79. Were any of the scenarios unfair to any of the device complements tested? In other words, were any of the scenarios difficult with the device complement available, but which might have been usable on a different scenario?

Yes	0 + 0 = 0
No	11 + 4 = 15
No opinion	6 + 3 = 9

Which ones?

(No unfairness was indicated.)

80. What do you think will be the effect of Data Link on crew workload?

Increase	1 + 1 = 2
Decrease	12 + 4 = 16
About the same	4 + 2 = 6
Unsure	1 + 1 = 2

81. Apart from workload, there is a confidence factor. What effect do you think that Data Link would have on your confidence that you had received all ATC commands and advisories correctly?

Increase	11 + 5 = 16
Decrease	2 + 1 = 3
No effect	1 + 0 = 1
Unsure	3 + 2 = 5

82. During this series of simulated flights, you have worked with:

1. SMATC (short messages)
2. SMATC (HDG, ALT, SPD only)
3. Vosyn, short messages only
4. Vosyn, long messages only
5. Vosyn, all messages
6. Printer, all messages
7. Printer, long messages only
8. Full CDU
9. Small CDU

In the blanks below, please list by numbers what you feel would be the ideal device complement and the minimum usable device complement for the several phases of a typical flight, assuming voice is available only for unusual or emergency conditions. (Responses to this question are tabulated in Tables D-1 through D-4.)

83. If major improvements were made to the Vosyn intelligibility, would this be likely to affect your answer to question 82?

Yes	2 + 1 = 3
No	13 + 4 = 17
Unsure	2 + 2 = 4

If yes, in what way ?

(One general aviation pilot stated that ATC clearances could be more easily copied. A test pilot stated "I think Vosyn intelligibility is great.")

TABLE D-1. NUMBER OF TIMES VARIOUS DEVICES WERE SELECTED BY 16 GENERAL AVIATION PILOTS AS REPRESENTING PARTS OF THE IDEAL DEVICE COMPLEMENT FOR VARIOUS FLIGHT PHASES

DEVICE	FLIGHT PHASE						
	ON GRND	TKOF	DEP.	EN-ROUTE	APP	LNDG	TOTAL
SMATC (short messages)	9	12	10	10	10	12	63
SMATC (HDG, ALT, SPD only)	0	4	8	6	5	3	26
Vosyn, Short messages only	3	6	3	2	3	3	20
Vosyn, Long messages only	1	2	0	1	0	0	4
Vosyn, All messages	8	6	6	7	9	8	44
Printer, all messages	9	4	6	7	6	5	37
Printer, long messages only	5	4	4	5	4	2	24
Full CDU	12	9	9	11	10	9	60
Small CDU	1	2	3	2	2	2	12
Total	48	49	49	51	49	44	290

TABLE D-2. NUMBER OF TIMES VARIOUS DEVICES WERE SELECTED BY 16 GENERAL AVIATION PILOTS AS REPRESENTING PARTS OF THE MINIMUM DEVICE COMPLEMENT FOR VARIOUS FLIGHT PHASES

DEVICE	FLIGHT PHASE						
	ON GROUND	TKOF	DEP.	EN-ROUTE	APP	LNDG	TOTAL
SMATC (short messages)	5	6	5	6	4	6	32
SMATC (HDG, ALT, SPD only)	4	8	8	8	8	6	42
Vosyn, Short messages only	4	4	2	2	4	3	19
Vosyn, Long messages only	0	0	0	1	0	0	1
Vosyn, All messages	3	1	2	2	3	3	14
Printer, All messages	0	1	2	1	1	2	7
Printer, long messages only	7	5	6	7	4	4	33
Full CDU	1	0	0	2	2	0	5
Small CDU	7	7	7	4	5	6	36
Total	31	32	32	33	31	30	189

TABLE D-3. NUMBER OF TIMES DEVICES WERE SELECTED BY 7 TEST PILOTS AS REPRESENTING PARTS OF THE IDEAL DEVICE COMPLEMENT FOR VARIOUS FLIGHT PHASES

DEVICE	FLIGHT PHASE						
	On Grnd	Tkof	Dep.	En-Route	App.	Lndg	Total
SMATC (Short messages)	5	5	6	6	6	6	34
SMATC (HDG, ALT, SPD only)	0	1	0	0	0	0	1
Vosyn, Short messages only	0	1	0	0	1	0	2
Vosyn, Long messages only	0	0	0	0	0	0	0
Vosyn, All messages	4	4	5	4	4	5	26
Printer, All messages	6	2	5	6	4	2	25
Printer, Long messages only	1	0	1	1	0	1	3
Full CDU	6	5	5	6	5	5	32
Small CDU	0	0	0	0	0	0	0
Total	22	18	22	22	20	19	123

TABLE D-4. NUMBER OF TIMES DEVICES WERE SELECTED BY 6 TEST PILOTS AS REPRESENTING PARTS OF THE MINIMUM DEVICE COMPLEMENT FOR VARIOUS FLIGHT PHASES

DEVICE	FLIGHT PHASE						
	On Ground	Tkof	Dep.	En-Route	App.	Lndg	Total
SMATC (Short messages)	2	1	1	2	2	2	10
SMATC (HDG, ALT, SPD only)	1	3	3	2	2	1	12
Vosyn, Short messages only	1	1	0	0	1	1	4
Vosyn, Long messages only	0	0	0	0	0	0	0
Vosyn, All messages	1	1	1	1	1	1	6
Printer, All messages	0	0	0	0	0	0	0
Printer, Long messages only	3	0	2	2	2	1	10
Full CDU	1	1	1	1	2	2	8
Small CDU	5	4	5	5	4	4	27
Total	14	11	13	13	14	12	77

MISCELLANEOUS COMMENTS MADE BY PILOTS, TRANSCRIBED FROM THEIR QUESTIONNAIRES:

1. I liked the Vosyn-only flight muchly and would be able to live with it, but after exposure to the other goodies, became spoiled quickly.

2. The only part I missed was the use of the small CDU during my 3-hour participation. This might help in getting more opinions. Less time spent with more pilots.

3. I liked the Vosyn. Would prefer to have it all the time.

4. Under present capabilities, one must record all frequency assignments on pencil and paper, because there is no capability for recalling freq (if STORE is used for clearance). It is easy to misdial freq or turn off correct freq by accident when attempting to dial a nav. freq.

   Consider blinking the SEND button whenever other buttons are pressed as a reminder to send. Maybe training will overcome this tendency. I had to consider pressing the buttons as sending.

   Should have to ask for takeoff clearance rather than get it automatically. Sometimes have problems getting ready to go.

5. Put WILCO buttons on shroud or instrument panel. Too close when on control column. Then, flashing of SMATC would not be required.

   In a minimum weather final approach, the flight crew may not want to be distracted by SMATC inputs.

   Believe Vosyn can be done away with altogether.

6. Scratch pad needs to be relocated to a more readable location, perhaps the glare shield.

7. Would like light in yoke button. No need to WILCO transponder changes or Ident.

8. Synthetic speech for sure at takeoff and landing. Favor printer in prime location to use of SMATC because of permanent record. Keyboard should be within easy reach of both pilots. One of the big problems is the space required. Try not to duplicate anything unless absolutely necessary. Also, if you can combine

any of these activities into another box, this should be closely looked into. Until confidence is built up, it will be hard to convince the pilot that the black box has not lost or misplaced certain info.

9. Vosyn quality readable. Improvement would be desirable but not essential. A female voice might be more discernable in the cockpit environment. Printer needs darker ribbon and white paper.

10. This is one fantastic system. For a green instrument pilot who usually has his hands full, this system (any) will make the job flying the system <u>much</u> easier. Many thanks for the opportunity to try it.

11. Efficient 2-way communication essential to flight operations. Currently, voice comm. is fairly efficient with some drawbacks which are invariably related to congestion. Any system, such as this Data Link, is an advantage or disadvantage as it improves on, or fails to improve on, voice comm. A keyboard is a good link to a computer, but it seriously slows down the transmission process, at least in the cockpit, and increases mental workload, for somewhat the same reasons, as compared with voice. Maybe it's worth it, on an interim basis. But it seems to me that the final object should be to develop a system which improves on the voice system, without throwing out the very valuable assets of voice (that is, speed and ease in translating mental action into transmittable and receivable intelligence). A keyboard and visual display are a step backward in that respect, because of the mental/physical process required to change thought into transmitted message on the sending end, and then the reverse process of changing the received message back into thought on the receiving end. It seems like we should be pressing hard on using the concept of automatic conversion of voice-to-print (and storage)-to-voice.

The keyboard could be improved, so all ideas should be evaluated. It would also be worth evaluating with a "4-way + spring-loaded-to-center-off" toggle switch to replace the "4-character button-with-LCR" arrangement.

1 A ● C B	2 D ● F E	3 G ● I H
4 J ● L K	5 M ● O N	6 P ● R Q
7 S ● U	8 V ● X	9 Y ● Ø
DELETE ENTRY ● /		

The center circle in each square is the 4-way toggle switch, in the center-off position (actually, its a 5-position toggle).

This arrangement eliminated 5 button functions and simplifies the keyboard usage. A prominent disadvantage, I suppose, is the mechanical complexity of a 5-position switch, but the human factors advantage of simplicity might make it worthwhile. Maybe this has already been tried. If not, it should be.

APPENDIX E

VORTRAX VOCABULARY
HEXADECIMAL CODES

000	A
001	ABOVE
002	ACKNOWLEDGE
004	ADF
005	AFFIRMATIVE
006	AFTER
007	AHEAD
008	AIRCRAFT
009	AIRPORT
ODC	ALLENTOWN
041	ALPHA
00A	ALTIMETER
00B	ALTITUDE
00C	AN
00D	AND
00E	APPROACH
00F	APPROVED
025	AROUND
010	AS
011	AT
070	ATIS
ODE	ATLANTIC CITY
012	BACKCOURSE
013	BEFORE
014	BELOW
015	BOUND
016	BRAKING
042	BRAVO
017	BROKEN
018	CANCEL
ODF	CAPE MAY COUNTY
01A	CEILING
01B	CENTER
01C	CHANGE
043	CHARLIE
0E0	CLAYMONT
OFE	CLEAR
01D	CLEARANCE
01E	CLEARED
01F	CLIMB
020	CLOSED
022	CONTACT
023	CONTINUE
024	CONTROL
026	CROSS
027	DEGREES
029	DELAY
044	DELTA
02A	DEPART
02B	DEPARTURE
02C	DESCEND
02D	DEW
077	DIRECT
0E2	DIX
02E	DME
02F	EAST
045	ECHO
038	EIGHT
03B	ELEVEN
03C	ESTIMATED
03D	EXCEPT
03E	EXECUTE
03F	EXPECT
040	FAIR
05B	FAST
05C	FEET
05D	FILED
05E	FINAL
035	FIVE
05F	FLIGHT
028	FOG
060	FOLLOW
034	FOUR
046	FOXTROT
0E4	FRAZER
061	FREEZING
062	FREQUENCY
ODD	FROM
063	FURTHER
064	GATE
047	GOLF
065	GOOD
066	GROUND
0F2	GUSTING
0D8	HALF
068	HAVE
069	HAZE
06A	HEADING
06B	HEAVY
06C	HIGHER
06D	HOLD
048	HOTEL
06E	HUNDRED
06F	IDENT
071	IFR
072	-ING
073	ILS
074	IMMEDIATELY
075	IN
076	INCREASE
049	INDIA
078	INFORMATION
079	INITIAL
0E5	INTENTIONS
07A	INTERCEPT
07B	INTERMITTENT
07C	INTERSECTION
07D	IS
04A	JULIET
0E6	JUNIATA
04B	KILO
07E	KNOTS
080	LAND
081	LEAVE
082	LEFT
083	LIGHT
04C	LIMA
084	LOCALIZER
085	LOCATED
086	LOW
087	LOWEST
088	MAINTAIN
0E7	MCGUIRE
089	MEASURED
0E8	MERCER COUNTY
07F	MESSAGE PENDING
04D	MIKE
08A	MILES
0E9	MILLVILLE
08B	MINIMUM
08C	MINUTE
08D	MINUTED
08E	MISSED
0EA	MODENA
019	MODERATE
08F	NAVIGATION
090	NDB
091	NEGATIVE
0EB	NEWARK
0EC	NEWCASTLE
0ED	NEW YORK CENTER
039	NINER
092	NORMAL
093	NORTH
094	NOT AVAILABLE
04E	NOVEMBER
096	OBSCURED
097	O'CLOCK

VORTRAX VOCUBLARY
HEXADECIMAL CODES

098	OF
099	OFF
09A	ON
031	ONE
095	OR
04F	OSCAR
09B	OUTER MARKER
09C	OVERCAST
050	PAPA
09D	PAST
OEF	PHILADELPHIA
09E	PIREP
09F	PLAN
0A0	POINT
0A1	POOR
0A2	POSITION
0F0	POTTSTOWN
0F1	PRINCETON
0A3	PUSHBACK
051	QUEBEC
0A4	RADAR
0A5	RADIAL
0A6	RAIN
0E1	REACHING
021	READING
0A8	RECEIVED
0A9	REDUCE
0AA	REMAIN
0AB	REPEAT
0AC	REPORT
0AD	REQUEST
0AE	RESTRICTION
0BD	RESUME
0AF	RETURN
0B0	RIGHT
052	ROMEO
0B1	RUNWAY
0B2	RVR
0B3	SAY
0B4	SCATTERED
0F5	SEA ISLE
037	SEVEN
067	SEVERE
0B5	SHORT
053	SIERRA
036	SIX
0EE	SKY
0B6	SLIPPERY
0B7	SLOW
0B8	SMOKE
0B9	SNOW
0F6	SOMERTON
0BA	SOUTH
0BB	SPEED
0BC	SQUAWK
0BE	STANDBY
0BF	START ENGINES
0C0	TAKEOFF
054	TANGO
0C1	TAXI
0C2	TAXIWAY
0C3	TEN
0C4	THAT
0C5	TEMPERATURE
0F7	TETERBORO
0F8	TEXAS
0C6	THE
0C7	THIS
0C8	THOUSAND
033	THREE
0F9	THUNDERSTORM
0C9	TOWER
0CA	TRAFFIC
0FA	TRENTON
0CB	TURBULENCE
0CC	TURN
0CD	TWELVE
032	TWO
0CE	UNABLE
055	UNIFORM
0FB	UNKNOWN
OCF	UNTIL
0D0	USE
0D1	VECTORS
0D2	VIA
0F3	VICINITY
056	VICTOR
0D3	VISIBILITY
0D4	VISUAL
0D6	VOR
0A7	WEATHER
0F4	WEST
057	WHISKEY
OFC	WILMINGTON
0D7	WIND
0FD	WINGS
0E3	WOODSTOWN
058	X-RAY
059	YANKEE
OFF	YARDLEY
OD9	YOUR
030	ZERO
05A	ZULU
ODB	Long Pause
ODA	Short Pause
003	ETX