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ADAPTATION OF TIME LINE ANALYSIS PROGRAM TO SINGLE PILOT INSTRUMENT FLIGHT RESEARCH

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ADAPTATION OF TIME LINE ANALYSIS PROGRAM TO SINGLE PILOT INSTRUMENT FLIGHT RESEARCH

by

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SUMMARY

The time line analysis program, having been developed for the National Aeronautics and Space Administration (NASA) terminal configured vehicle program by the Boeing Company, has been adapted for general aviation single pilot instrument flight research. The objective of the research is to increase the safety and utility of general aviation aircraft by reducing the workload of the single pilot crew.

A human factors data base was developed for the program, the data was coded and stored as computer files, and the program was run.

The outputs indicated that further work was necessary on the workload models. In particular, the workload model for the cognitive channel must be modified as the output workload appears to be too small. Also, in need of modification is the left hand, right hand, left foot, and right foot channels.

Since the mission used in the first runs was simplified, refinements will be needed. Included in the needed refinements are models to show the workload when in turbulence, when overshooting a radial or glideslope, and when copying air traffic control clearances.

INTRODUCTION

NASA Langley has initiated the General Aviation Single-Pilot Instrument Flight Rules (GA-SPIFR) program to study the problems of a single pilot flying general aviation aircraft under instrument flight rules. It is anticipated that the number of instrument flight rules (IFR) accidents can be reduced and the utility of general aviation aircraft significantly increased by reducing the high workloads experienced in single pilot IFR operations. Statistical accident and incident data, a time motion computer program, a general aviation simulator, and aircraft flight tests will be utilized in analyzing and reducing pilot workload.

This report will discuss the development of the time motion computer program for the general aviation SPIFR study. The parent program was developed by the Boeing Company, Seattle, Washington, for the NASA Terminal Configured Vehicle program and is referred to as the Time Line Analysis (TLA),

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reference 1. The TLA is a time-motion study of a flight crew's activities and workload during a mission. An analyst must define the mission and a data base of activities to support it. From this data the TLA produces a series of digital and graphic reports describing the crew's workload during the mission. The baseline mission was defined as a single pilot instrument flight departing and returning to the William B. Hartsfield International Airport in Atlanta, Georgia. Radio navigation, a holding pattern, radar vectors, and an instrument landing system approach were included in the mission. The mission was highly idealized and assumed no clearance copying, no turbulence, and that all tasks were performed correctly and without repetition such as intercepts of very high frequency omnirange (VOR) radials and localizer and glideslope paths.

The mission was broken down into phases. These phases included segments of the flight from takeoff through landing.

From the maneuvers required of the aircraft, air traffic control procedures, and aircraft operating checklists, a set of procedures was developed. Procedures were written for such short term activities as flight control and equipment operations.

Procedures are made up of tasks. A task is the most basic action a pilot may perform. Reading the altimeter and moving the throttle are examples of a task. Checklists, procedures, and the cockpit layout of the general aviation aircraft simulator at the Langley Research Center were studied so that no detail of the operation of the aircraft would be omitted. The spatial position of each control, indicator, or instrument in the cockpit was measured relative to a nominal eye and shoulder reference point. Task duration times were determined from pilot's reach distances and eye angles which were calculated from position data.

The mission, phase, procedure, and task data were coded on the forms described in the Time Line Analysis User's Guide (reference 2) and stored as a computer file in the NASA CDC computing system. The program data were submitted as a batch job and digital graphic reports of pilot workload were obtained.

ACKNOWLEDGEMENT

The authors wish to acknowledge the assistance of Mr. James L. Sundstrom of the Boeing Company. Mr. Sundstrom has provided valuable guidance in the development of the mission data base and in the operation of the program.

ABBREVIATIONS

ATA	Airline Transport Association
ATC	Air traffic control
CDC	Control data Cyber 175 computer
CWP	Crewman workload profile report

GA-SPIFR	General Aviation single-pilot instrument flight rules
IFR	Instrument flight rules
MSN	Mission scenario report
TLA	Time Line Analysis
VOR	Very high frequency omnirange
WLH	Workload histogram report

ANALYSIS

Data Base Development

The first step in the use of the time line analysis program (TLA) was the development of a data base. The data base consists of phases, procedures, tasks, and subsystems necessary to describe the detailed flight operations required to accomplish the mission.

Mission.- The mission is the flight to be studied. In the example for this report the mission consists of a takeoff at the William B. Hartsfield International Airport in Atlanta, Georgia, an instrument climbout, very high frequency omnirange (VOR) navigation to a holding pattern, holding, air traffic control (ATC) radar vectors to an instrument landing system approach course, an approach, and a landing (figure 1).

Since the mission was built around an existing geographical area, the flight path was plotted on a chart for visualization and planning. Attention was given to ATC procedures, normal traffic routing, and aircraft operating capabilities.

Phases.- Once the mission was defined it was divided into phases. A phase of flight reflects the actions necessary to get from one flight milestone to another. The phases of the GA mission are takeoff, climbout, cruise, holding, initial approach, intermediate approach, final approach to the outer marker, final approach between the outer marker and middle marker, final approach between the middle marker and the runway, and touchdown. Using distances measured from the plotted mission and known aircraft performance data, the start time relative to the beginning of the mission for each phase was calculated. These start times are later used as guides when precisely defining the time structure of the mission. Since many of the output reports can be generated for only the phases specified in the output request, the breakdown of the flight into phases permits close study of a phase and comparisons between phases. Also, the breakdown provides a modular data base and simplifies changes to the mission.

Procedures.- A set of procedures was developed to support the phases. A procedure is a short duration activity such as a complete instrument scan or receiving and responding to a traffic advisory. In addition to ATC procedures, all required aircraft maneuvers, aircraft operating procedures, and the aircraft operating checklists were taken into account when writing procedures. The procedures were made as general as possible so as to minimize the total number of procedures required. Instead of a specific procedure for entering a left turn or for receiving a handoff from departure control, for example, a procedure for receiving a handoff or executing a turn was designed. Also, all procedures assume that all tasks are accomplished when necessary and correctly the first time. This is not realistic; however, the idea was to begin with a simplified mission for baseline and to add refinements later.

Tasks.- A task is the simplest unit of work that the pilot can accomplish, such as reading the airspeed indicator or picking up the microphone. Development of the task data base began with the measurement of the position of every item in the NASA Langley general aviation aircraft simulator. The measurements were in the cartesian coordinate system shown in figure 2 and located with respect to the center of the attitude indicator. Every position that the pilot might look at for information or reach to was measured. For instruments that give information in several locations each location was measured. For example, the location of the center of the altimeter, the kolisman window, and the setting knob were all measured. From these measurements the eye angles and reach distances to each item were calculated. The eye angles were calculated with respect to the center of the attitude indicator, the left hand reach distances were from the left side of the control wheel centered in pitch and roll, and the right hand reach distances were from the throttle at its half open position.

Each item in the cockpit was grouped into subsystems. Examples of subsystems include electrical, engine, fuel, and trim. Pilot vision, voice, audio, and charts/checklists were listed as subsystems as were the cockpit items. The program requires that each task be associated with a subsystem and can provide reports on the activity of a particular subsystem.

From the list of the cockpit items, checklists, ATC procedures, aircraft operating procedures, and aircraft maneuvers, a task list was developed. Each task was assigned a subsystem, a code number, and a duration time, and the percentage of that duration time that impacted external vision, internal vision, left hand, right hand, left foot, right foot, cognitive, audio, and verbal human operator channels. Tasks, like procedures, were made as general as possible. Instead of three separate tasks for moving the transponder switch to off, standby, and on, for instance, one task was written to show movement of the transponder switch. Depending on the situation, a task may require different times or percentages. To account for this up to four different times or percentages can be assigned to each task. The duration times were calculated from the eye angles, reach distances, and human factors data supplied in reference 1, section 6.4. For tasks that were not covered by the human factors data such as radio communications, the duration time was estimated or timed with a stopwatch.

The value of the cognitive channel was assumed to be ten percent for each task. This was done with the knowledge that it was not realistics; however, the data necessary for determining cognitive workload is not currently available. As stated earlier, the intent was to make the program operational and to add refinements as data becomes available. Once the tasks were defined it was possible to determine the time structure of the procedures. The TLA worksheet shown in figure 3 is used for this purpose. The tasks and their situation numbers and duration times are listed in chronological order. Tasks which occurred during the same time interval were listed near each other. The task start times are relative to the beginning of the procedure.

After the procedures were completed in detail, the time structure of the phases could be determined. The same worksheet used to define the procedures, shown in figure 3, was used to define the phases. All procedure start times are relative to the beginning of the phases. The procedure duration times are calculated to the nearest tenth of a second but the computer program will accept procedure start times to only the nearest second. In determining procedure start times for this mission, therefore, any previous noninteger procedure duration times were rounded to the next higher integer. This tends to artificially lower the overall workload of the pilot by a small amount; however, this avoids workloads exceeding one-hundred percent due to unintentional task overlapping. In this manner, output workload peaks of over one hundred percent will always be due to actual overloads and not due to periodic task overlapping. With the knowledge that the output workload is less than actual, output workloads near one hundred percent can be examined as possible overloads.

The phase start times calculated earlier from the flight path plot were only guides and are used here. If the original time calculations called for the pilot to maintain straight and level flight for two minutes then enough straight and level procedures would be used to total two minutes as nearly as possible.

Events were inserted into the phases along with the procedures to describe a flight milestone such as takeoff, level off at altitude, cross an intersection, enter a holding pattern, and intercept an ILS localizer. Events are used only as markers in the mission and do not contribute to workload. There are no tasks associated with events.

Having determined the exact duration times of the phases, the start times of the phases were calculated. Once the phases were completed and their start times determined, the mission development is finished and the data base is ready to be coded.

Data Base Coding

The data base coding forms are described in reference 1 and 2.

Figure 4 shows the subsystem coding form for this scenario. The Airline Transport Association (ATA) code number required for the original application of the program is not applicable to the GA research, therefore, the ATA code number column was left blank.

The task data coding forms were completed according to the instructions in reference 2. Occasionally, two tasks are used together. Columns 75-80 were used to refer to the accompanying task in these cases. On the example form in figure 5, 1A0131 refers to subsystem 1A, task 13, situation 1. A leading zero is placed before the 13 to produce a six character code.

A sample event/procedure data coding form is shown in figure 6. The alpha characters in the code numbers were used to refer to communications (C), communications radios (CR), manual flight control (F), navigation (N), navigation radios (NR), and miscellaneous systems (S). The slide interval columns were left blank since the task sliding option of the program, described in reference 1 and 2 was not used.

Figure 7 shows a completed phase data coding form. These forms were completed as specified in reference 2.

The mission data coding form was completed as shown in figure 8. The study time interval, an analyst defined time increment, was set at 20 seconds. The task sliding option referred to above was not used in this study. Therefore, the slide interval was set at one second and the slide workload threshold at 999 percent as suggested in reference 2.

Once coded, the data base was stored as a computer file. The data base forms were keypunched along with the control cards. Figure 9 shows the deck arrangement for the control cards and data cards. The phases, events, procedures, tasks, and subsystems, were stored under the file name GADBAZ shown in the appendix. The control cards, mission data, and output requests were stored under the file name TLATST. The object program was supplied by the Boeing Company under contract number NAS1-13741 and was stored under the file name TLABN3. The data are stored with a batch job under the DUMMY file by using the deck shown in figure 10 and the name is later changed with the use of a timesharing terminal. Placing the mission data and the output requests in file TLATST permits changing the study time interval, run data, and output requests and submitting the program without accessing the data base.

The data were stored in a logical order so that modifications to the data could be made easily. Procedures were grouped according to type and tasks were grouped by subsystems. During the development and coding of the data, unanticipated procedures and tasks were occasionally required and were added to the data base. After storage these additions and modifications were made via a timeshared terminal.

Program Operation

The program is submitted with the file TLATST. It is submitted as a batch job through the use of a timesharing terminal. A listing of TLATST is shown in figure 11. In use TLATST copies to data the input mission data, then the data base (GADBAZ), and then the process card, output request, and the terminate card. This assembles the program data deck into the form shown in figure 9.

The first runs were made for data base debugging. If the output channel workload exceeds 100 percent, errors in the data base or overloads are indicated. The tasks contributing to high workloads can be found with the workload histogram report (WLH), the crewman workload profile report (CWP), and the mission scenario report (MSN). References 1 and 2 describe each of the outputs. Approximate times of high workload peaks can be determined from the time scale on the WLH. Then the exact time interval of the occurrence can be determined from the CWP by scanning down the workload column for the channel involved. After finding the time interval, the MSN is used to determine the tasks occurring during the interval. The errors included data artifacts such as misspecified start times, duration times, and situation numbers.

Only the CWP, MSN, and the WLH were seen for use in analysis. The outputs were validated with hand calculations of pilot workload at random points in the mission.

Figure 12 shows one page of the crewman workload profile report. The external vision is at zero percent and the internal vision is highly used due to the assumption of actual instrument conditions during the mission. Left hand activity is low but reasonably steady while right hand activity varies considerably and is usually high when being used. This is because the left hand is being used for the continuous tasks of maintaining straight and level flight in smooth air and the right hand is being used for discrete tasks such as tuning radios or handling the microphone. The left and right foot have identical workloads as they are always used together in the mission. Cognition levels are low and steady. This does not appear to be realistic and indicates that cognition has not yet been properly modeled. The audio and verbal channels indicate ATC communications.

Figure 13 shows a portion of the mission scenario report for the time interval covered in the crewman workload profile report shown in figure 12. The MSN is used to determine what tasks are occurring during any time interval. Together with the CWP, the MSN is useful in determining which tasks are contributing to high workloads.

The external vision WLH is shown in figure 14. External vision is only used during takeoff, landing, and during ATC traffic advisories.

Figure 15 shows the internal vision WLH. This is normally high but falls off during takeoff, landing, and ATC communications. The internal vision decreases during communications because the instrument scan falls off.

A WLH for the left hand is shown in figure 16. The large peaks are caused by such maneuvers as leveling off from a climb and executing turns. Continuous straight and level flight occurs in the areas where the plot is relatively flat. A somewhat higher workload is indicated during the approach and landing beginning at approximately 2200 seconds into the run.

The plot for the right hand, shown in figure 17, illustrates the intermitent usage of the right hand. The right hand is primarily used for the throttle, trim, radios, microphone, charts, and checklists. All other times it is assumed to be at rest or zero percent workload.

Figure 18 shows the left foot plot. Since the left foot and right foot workloads are identical, only the left foot plot is shown. As with the left hand, a higher workload is indicated during turns and final approach. The left and right foot workload model will need modification as the workload should be nearly zero during straight and level flight.

Figure 19 and 20 show the auditory and verbal channel plots, respectively. These plots primarily indicate ATC communications. In addition to communications, the auditory channel is used to check the morse code identification of radio navigational aids and to listen to the marker beacon signal during approach.

The cognitive plot is shown in figure 21. From the plot it can be seen that the ten percent cognition value per task was not realistic and that the cognition workload model will need extensive modifications.

CONCLUDING REMARKS

The time line analysis program, having been developed for the National Aeronautics and Space Administration (NASA) terminal configured vehicle program by the Boeing Company, has been adapted for general aviation single pilot instrument flight research (SPIFR).

A data base was developed for SPIFR operation, and the program was run.

The outputs indicated that further work was necessary on the workload models. In particular, the workload model for the cognitive channel should be modified as the output workload appears to be too small. More data are necessary to develop a cognitive channel workload model. Also, in need of modification is the left hand, right hand, left foot, and right foot channels.

Since the mission used in the first runs was simplified, refinements are needed. Included in the needed refinements are models to show the workload when in turbulence, when overshooting a radial or glideslope, and when copying air traffic control clearances.

REFERENCES

1. Miller, K. H: Time Line Analysis Program (TLA-1) Final Report. Boeing Document No. D6-42377-5. NASA CR-144942, April 1976.

2. Anderson, C. F.: Time Line Analysis Program (TLA) User's Guide. Boeing Document No. D6-44751. Published February 10, 1978, for period February 1976 - October 1977.

APPENDIX

GADBAZ, The Time Line Analysis Data File

Figure 22 shows the data base as stored in the computer file GADBAZ. The format of the data base results from the use of the coding forms described in references 1 and 2.

Figure 22-a shows the phase portion of the data file. The first phase, TAKEOFF RWY 8, consists of the code number TO01, the phase name, EVENT1 beginning at time zero, procedure F00001 beginning at time zero, and procedure F00002 beginning zero minutes and 20 seconds into the phase. Procedures do not have to be listed in chronological order but doing so makes it easier to read the data.

The event/procedure data is shown in figure 22-b. By observing the column designations on the coding form in figure 6, it can be seen that the first two tasks of the first procedure, CONTACT DEP. AFTER TAKEOFF, are 1P   01 and 1P   07. 1P   01 begins at zero seconds into the procedure and P1 refers to the crew member performing the task (pilot) and the task situation number.

The task data is shown in figure 22-c. Figure 5 shows the column designations of the coding form. The first task, MOVE AUD. PNL. MIKE SWITCH, has the code number 1A   01, had only one situation, and has channel workloads of 40 percent interval vision, 100 percent right hand, and 10 percent cognition.

The subsystem data is shown in figure 22-d. The first subsystem listed has the code 1A and is named COM #1.

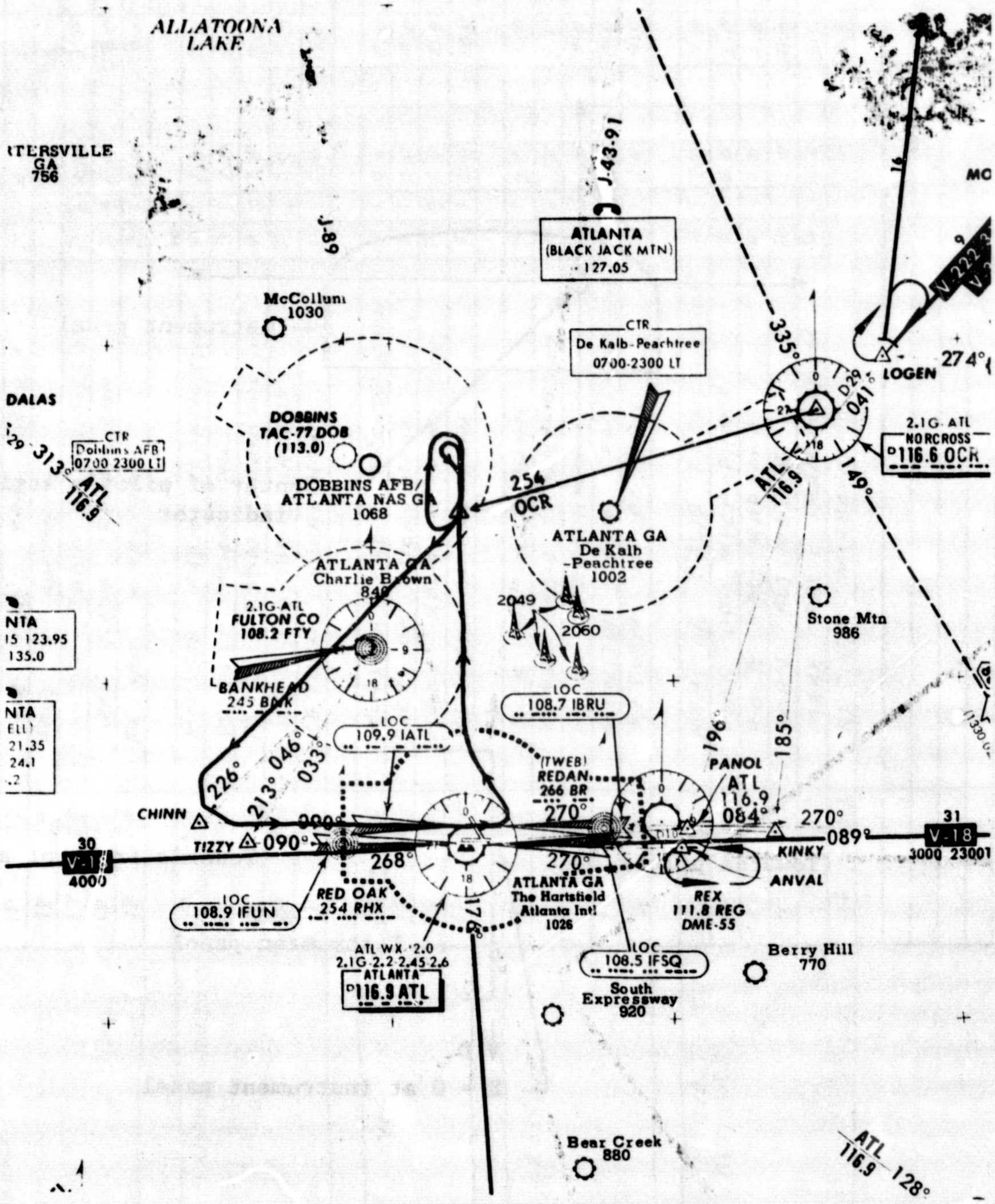
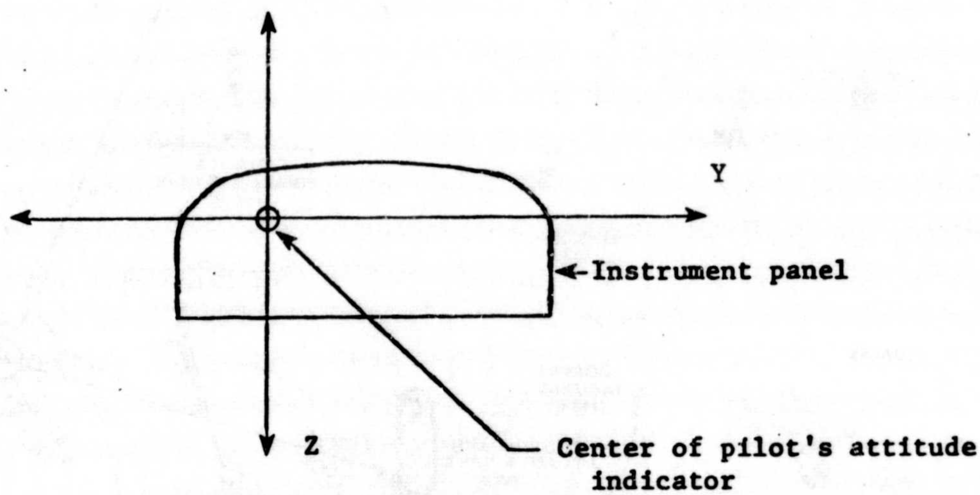


Figure 1.- Mission scenario plot. (not for navigational purposes; additions and deletions have been made to this chart)



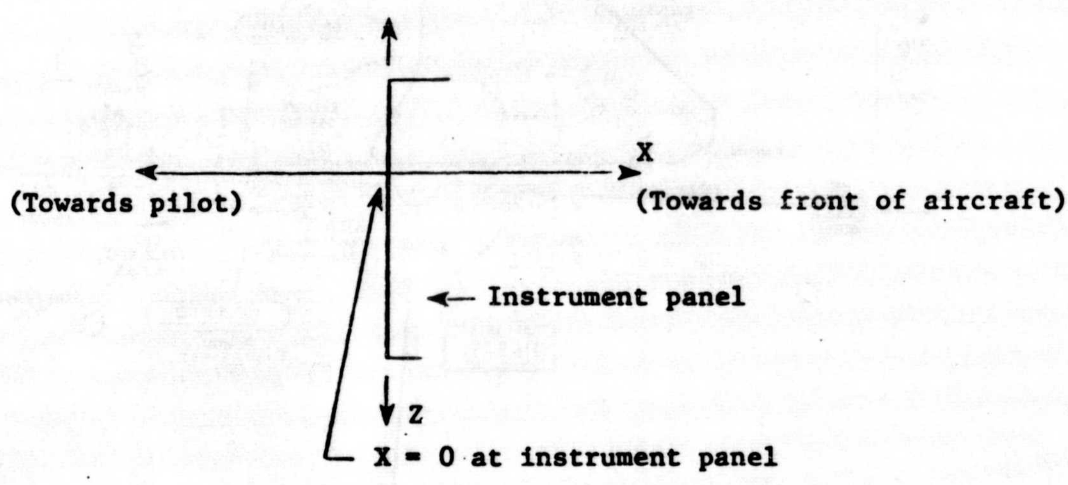


Figure 2.- Coordinate system in general aviation simulator.

TLA WORKLOAD ANALYSIS WORKSHEET

PAGE____ OF____

MISSION TITLE | CONFIGURATION

PHASE/EVENT/PROCEDURE DATA		PROCEDURE/TASK DATA						START TIME			SLIDE (SECS)	
CODE NO.	NAME/DESCRIPTION	CODE	NO.	NAME/DESCRIPTION	CREW	S I T	DURATION SECONDS	HR.	MIN.	SEC.	−	+
C00001	CONTACT DEPARTURE AFTER TAKEOFF	IP	01	PICK UP MICROPHONE	P	1	2.0			0.0		
		IP	07	MAKE RADIO TRANSMISSION	P	4	4.0			2.0		
		IP	16	HOLD MICROPHONE	P	4	7.0			6.0		
		IT	28	MONITOR RADIO TRANSMISSION	P	2	7.0			6.0		
		IP	10	MAKE RADIO TRANSMISSION	P	4	6.0			13.0		
		IP	04	RETURN MICROPHONE	P	1	2.0			19.0		
C00002	RECEIVE TRAFFIC ADVISORY	IT	28	MONITOR RADIO TRANSMISSION	P	1	6.0			0.0		
		IP	01	PICK UP MICROPHONE	P	1	2.0			6.0		
		IP	07	MAKE RADIO TRANSMISSION	P	3	3.0			8.0		
		8A	01	SCAN OUTSIDE AIRCRAFT	P	1	1.5			8.0		
		IP	04	RETURN MICROPHONE	P	1	2.0			11.0		
C00003	RECEIVE VECTOR	IT	25	MONITOR RADIO TRANSMISSION	P	1	4.0			0.0		
		IP	01	PICK UP MICROPHONE	P	1	2.0			4.0		
		IP	07	MAKE RADIO TRANSMISSION	P	4	4.0			6.0		
		IP	04	RETURN MICROPHONE	P	1	2.0			10.0		
C00004	REPORT CROSSING FIX	IP	01	PICK UP MICROPHONE	P	1	2.0			0.0		
		IP	10	MAKE RADIO TRANSMISSION	P	2	5.0			2.0		
		IP	16	HOLD MICROPHONE	P	2	2.0			7.0		
		IT	22	MONITOR RADIO TRANSMISSION	P	1	2.0			7.0		
		IP	04	RETURN MICROPHONE	P	1	2.0			9.0		
C00005	RECEIVE REQUEST TO SAY ALTITUDE	IT	22	MONITOR RADIO TRANSMISSION	P	1	2.0			0.0		
		IP	01	PICK UP MICROPHONE	P	1	2.0			2.0		
		IP	16	HOLD MICROPHONE	P	1	1.0			4.0		
		3H	01	SCAN ALTIMETER	P	1	1.0			4.0		
		IP	07	MAKE RADIO TRANSMISSION	P	2	2.5			5.0		
		IP	04	RETURN MICROPHONE	P	1	2.0			7.5		

Figure 3.- Workload analysis worksheet.

BOEING

TLA-1

SUBSYSTEM CODING FORM

Page 1 of 1

	SUBSYSTEM NAME	ATA CODE NO.
1A	CØM #1	
1B	CØM #2	
1N	TRANSPØNDER	
1P	VØICE	
1T	AUDIØ	
3A	AIRSPEED INDICATØR	
3H	ALTIMETER	
3L	VERTICAL SPEED INDICATØR	
3N	CLØCK	
3P	NEEDLE/BALL	
3R	ATTITUDE	
3U	ØAT INDICATØR	
3V	MARKER BEACØN	
4A	PRIMARY ATTITUDE CØNTRØL	
4B	PRØPULSIØN CØNTRØL	
4D	LANDING GEAR	
4E	FLAPS	
4G	TRIM	
5D	ADF/RMI	
5K	MAGNETIC CØMPASS	
5P	DME	
5U	NAV #1	
5V	NAV #2	
7B	ELECTRICAL	
7C	FUEL	
7F	ENGINE	
7G	LIGHTS	
7M	ENGINE STARTING	
7V	VACUUM	
8A	VISIØN	
8B	CHARTS/CHECKLISTS	

Figure 4.- Subsystem coding form.

BOEING
TLA-1
TASK DATA CODING FORM

TASK CODE NO.	TASK NAME AND/OR DESCRIPTION		DURATION TIME (SECONDS)	EV	IV	LH	RH	LF	RF	COG	AUD	VBL	
				CHANNEL ACTIVITY - PERCENT OF DURATION TIME									
1A 01	MØVE AUD. PNL. MIKE SWITCH	1	2.5		40		100			10			
1A 04	ADJ. CØM #1 VØL.	1	2.6		20		100			10			
1A 07	MØVE CØM #1 ØN/ØFF SWITCH	1	2.5		20		100			10			
1A 10	TUNE CØM #1	1	5.0		30		100			10			1A0131
		2	3.0		20		100			10			1A0132
		3	2.5		20		100			10			1A0133
1A 13	SCAN CØM #1 FREQ.	1	5.0		70					10			1A0101
		2	3.0		80					10			1A0102
		3	2.5		80					10			1A0103
		4	1.4		100					10			
1B 01	SCAN CØM #2 FREQ.	1	5.0		70					10			1B0101
		2	3.0		80					10			1B0102
		3	1.4		100					10			
1B 04	ADJ. CØM #2 VØL.	1	2.6		20		100			10			
1B 07	MØVE CØM #2 ØN/ØFF SWITCH	1	2.5		20		100			10			
1B 10	TUNE CØM #2	1	5.0		30		100			10			1B0011
		2	3.0		20		100			10			1BC012

Figure 5.- Task data coding form.

BOEING
TLA-1
EVENT/PROCEDURE DATA CODING FORM

PROGRAM ______ PAGE ___ OF ___
PROGRAMMER ______ DATE ______

EVENT/PROC CODE NO.	EVENT/PROCEDURE NAME OR DESCRIPTION	TASK CODE	NO.	TASK START TIME HR	MIN	SEC	SLEW (SEC) −	+	CREW MEMBER	TASK CODE	NO.	TASK START TIME HR	MIN	SEC	SLEW (SEC) −	+	CREW MEMBER
C00011	CØNTACT TØWER	1P	01			0.0			P1	1P	07			2.0			P3
		1P	19			5.0			P1	1T	28			5.0			P3
		1P	07			12.5			P1	1P	04			14.5			P1
CR0001	CHANGE TRANSCEIVERS	1A	01			0.0			P1	1T	04			2.5			P1
		1T	01			5.3			P1								
CR0002	TUNE CØM. #1	1A	13			0.0			P1	1A	10			0.0			P1
CR0003	TUNE CØM. #2	1B	01			0.0			P1	1B	10			0.0			P1
CR0004	CHANGE TRAN. CØDE	1N	16			0.0			P2	1N	19			0.0			P2
F00001	TAKEØFF RØLL	4B	07			0.0			P1	4A	16			0.0			P1
		7F	04			0.0			P1	7F	10			2.6			P1
		7F	01			5.2			P1	3A	01			7.4			P2
F00002	RØTATE AND LIFTØFF	4A	04			0.0			P1	3R	01			0.0			P3
		4A	07			4.0			P4	3R	01			4.0			P1
		3A	01			5.0			P1	3L	01			6.0			P1
		4A	10			8.0			P1	3H	01			8.2			P1
		3R	01			9.2			P3	4G	13			9.2			P1
		1N	04			12.9			P1								
F00003	REDUCE SPEED	4B	07			0.0			P2	7F	01			0.0			P2
		3R	01			2.6			P2	4A	10			2.6			P2
		3A	01			5.6			P1	3H	01			6.6			P1
		3L	01			7.6			P1	5D	01			9.8			P1
		3R	01			11.8			P1	4A	10			12.6			P1
		3A	01			12.8			P1	3H	01			13.8			P1
		3L	01			14.8			P1	4G	13			17.0			P1
		3R	01			17.0			P2	4A	07			17.6			P4
		3A	01			20.0			P1	3H	01			21.0			P1
		4A	07			21.6			P1	3L	01			22.0			P1
		4A	10			22.6			P1	5D	01			24.2			P1
		3R	01			26.2			P1								

Figure 6.- Event/procedure data coding form.

BOEING
TLA-1
PHASE DATA CODING FORM

PROGRAM ____ PAGE ____ OF ____
PROGRAMMER ____ DATE ____

PHASE CODE NO.	PHASE NAME	EVENT/PROC CODE NO.	HR	MIN	SEC	EVENT/PROC CODE NO.	HR	MIN	SEC	EVENT/PROC CODE NO.	HR	MIN	SEC	EVENT/PROC CODE NO.	HR	MIN	SEC
TØ01	TAKEØFF RWY 8	EVENT1		0	00	F00001		0	00	F00002		0	20				
CL02	CLIMBØUT	F00009		0	00	C00006		0	08	F00009		0	08	F00009		0	16
		CR0001		0	22	F00016		0	25	F00009		0	30	C00001		0	30
		F00009		0	38	F00009		0	47	EVENT2		0	55	F00006		0	55
		F00007		1	09	F00007		1	17	F00007		1	24	F00007		1	31
		F00007		1	39	F00008		1	46	F00010		1	58	F00010		2	08
		F00010		2	17	N00010		2	26	N00012		2	28	F00016		2	28
		F00010		2	29	NR0001		2	39	F00016		2	44	NR0003		2	45
		F00010		2	48	NR0004		2	57	F00016		3	02	NR0005		3	03
		F00010		3	11	EVEMT3		3	21	F00005		3	21				
CR03	CRUISE TØ HØLDING PATTERN	F00010		0	00	EVENT4		0	08	F00006		0	08	F00007		0	23
		F00007		0	31	N00001		0	38	F00007		0	40	F00008		0	48
		C00007		1	00	F00016		1	06	F00010		1	10	NR0006		1	19
		F00010		1	22	F00010		1	31	F00010		1	41	F00010		1	50
		F00010		1	59	N00002		2	09	F00010		2	11	F00010		2	20
		F00010		2	29	F00010		2	39	F00010		2	47	F00010		2	57
		N00002		3	06	F00010		3	09	F00010		3	17	F00010		3	27
		F00010		3	36	F00010		3	46	F00010		3	55	N00002		4	04
		S00002		4	06	F00010		4	21	F00010		4	30	F00010		4	40
		F00010		4	49	F00010		4	58	F00010		5	08	F00010		5	16
		N00002		5	26	F00010		5	28	F00010		5	38	F00010		5	46
H004	HØLDING, TRØYS INT.	EVENT5		0	00	N00007		0	00	C00004		0	05	F00016		0	08
		F00016		0	10	F00010		0	16	F00010		0	26	F00010		0	35
		N00004		0	45	F00010		0	46	N00008		0	56	F00006		1	00
		F00007		1	14	F00007		1	22	F00007		1	30	F00007		1	37
		F00007		1	44	F00007		1	51	F00007		1	59	F00007		2	07
		F00007		2	14	F00008		2	21	NR0003		2	34	F00010		2	37
		F00010		2	45	F00010		2	55	F00010		3	04	F00006		3	13
		F00007		3	28	N00001		3	36	F00008		3	37	F00010		3	49
		F00016		3	59	N00002		4	08	F00010		4	11	F00010		4	19
		N00002		4	29	F00006		4	21	F00007		4	45	F00007		4	53
		F00007		5	00	F00007		5	07	F00007		5	15	F00007		5	22
		F00007		5	30	F00008		5	37	N00009		5	49	F00009		5	53

Figure 7.- Phase data coding form.

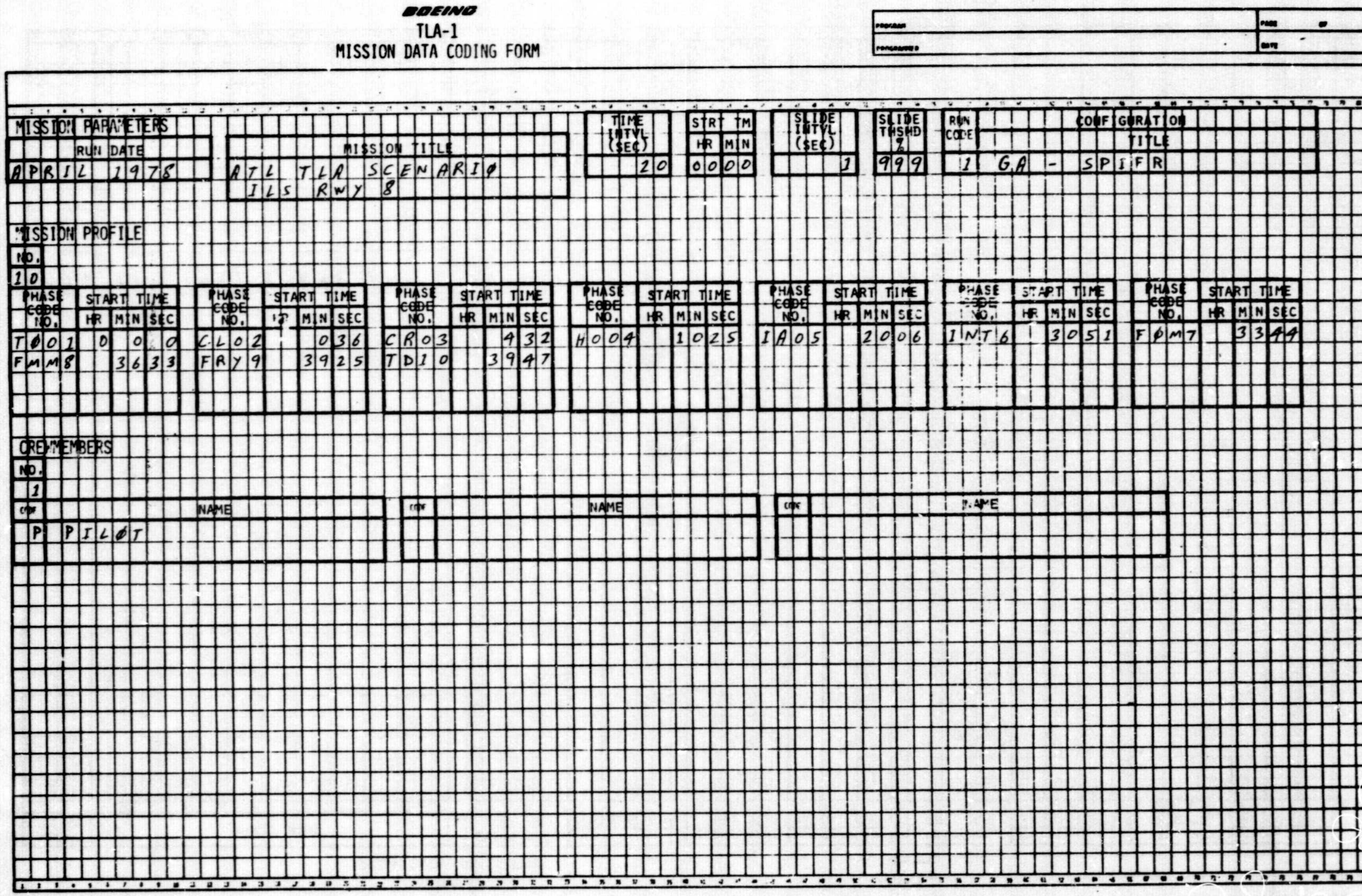


Figure 8.- Mission data coding form.

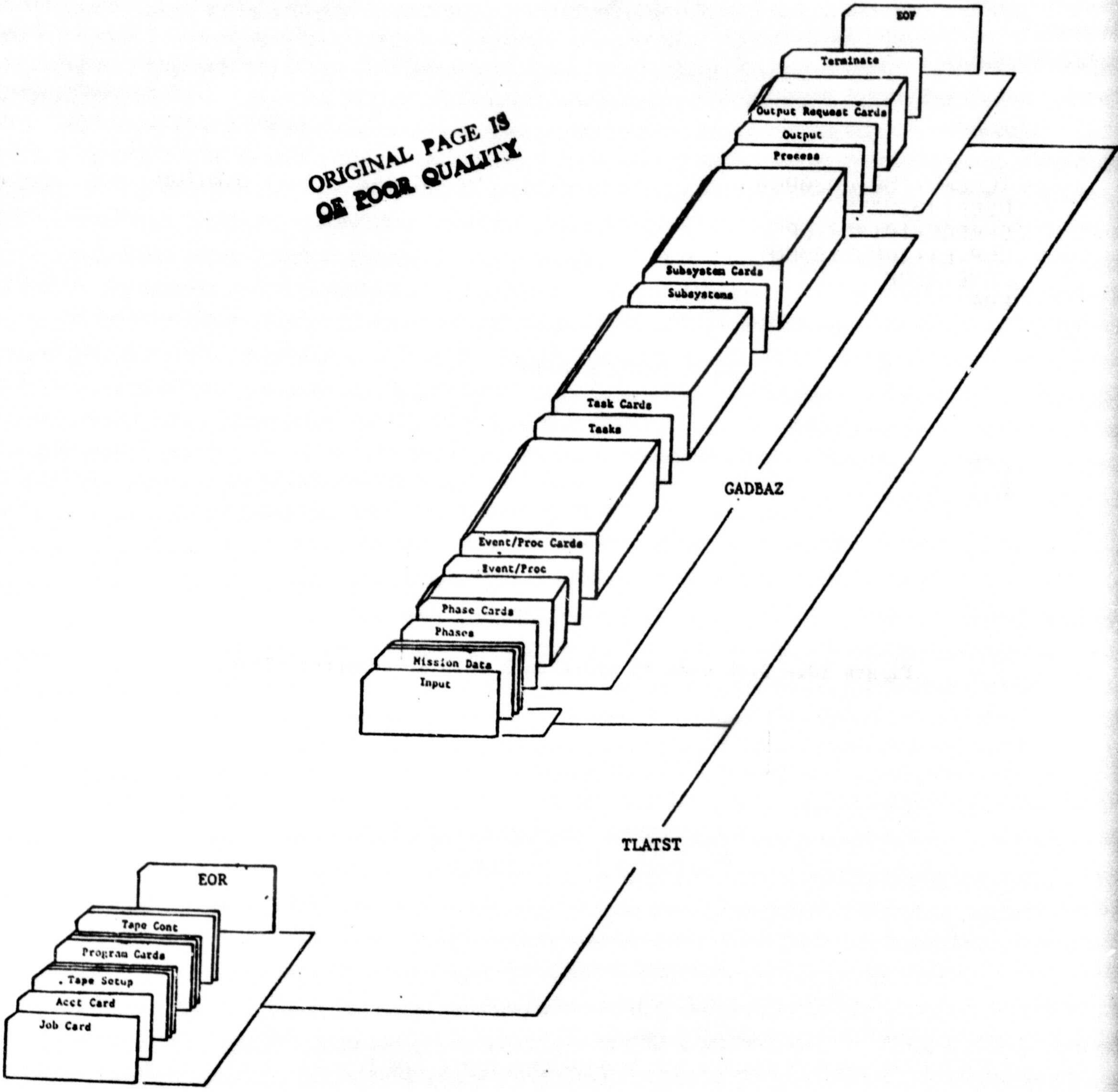


Figure 9.- Data base and control card deck arrangement.

```
TLACPY,T50,CM20000.                          RM1142        HINTON
USER,403225N.
CHARGE,101354,LRC.
COPYEI,INPUT,DUMMY.
SAVE,DUMMY.
EOR

                    DATA PLACED HERE



EOR
EOI
```

Figure 10.- Deck used to store data base in computer files.

```
/JOB
GNRLAV,T350,CM240000.                    RM 1142   D HINTON                 26

USER,403225N.
CHARGE,101354,LRC.
GET,GADBAZ.
REWIND,GADBAZ.
COPYBR,INPUT,DATA.
COPYBR,GADBAZ,DATA.
COPYBR,INPUT,DATA.
REWIND,DATA.
PACK,DATA.
GET,TLABN3.
ATTACH,LRCGOSF/UN=LIBRARY.
LDSET,LIB=LRCGOSF,PRESETA=NGINF,MAP=N.
TLABN3,DATA,PL=50000.
ATTACH,PLOT/UN=LIBRARY,NA.
REWIND,TAPE99.
PLOT.VARIAN(PVF=TAPE99,AUTO)
EXIT.
DMD.
/EOR
/NOSEQ
INPUT
APRIL  1978  ATL TLA SCENARIO        20 0000     1 999  1 GA - SPIFR
             ILS RWY 8
10
T001 0 0 0 CL02   036 CR03   432 H004  1025 IA05  2006 INT6  3051 FOM7  3344
FMM8  3633 FRY9  3925 TD10  3947
 1
 P PILOT
/SEQ
/EOR
PROCESS
OUTPUT
CWP  P U ****
MSN  P U ****
WLH  P U **** 100         IV   1
WLH  P U **** 100         EV   1
WLH  P U **** 100         LH   1
WLH  P U **** 100         RH   1
WLH  P U **** 100         LF   1
WLH  P U **** 100         AUD  1
WLH  P U **** 100         VBL  1
WLH  P U **** 100         COG  1
TERMINATE
/EOR
```


Figure 11.- TLATST.

****
* UNSHIFTED *
****

APRIL 1978

CREWMAN WORKLOAD PROFILE REPORT

MISSION - ATL TLA SCENARIO
ILS RWY 8

CONFIGURATION - GA - SPIFR

CREWMEMBER - PILOT

FLIGHT PHASE - CRUISE TO HOLDING PATTERN

TIME INTERVAL (SECONDS) START	END	EXTERNAL VISION	INTERNAL VISION	LEFT HAND	RIGHT HAND	LEFT FOOT	RIGHT FOOT	COGNITION	AUDIO	VERBAL	TOTAL VISION	TOTAL MOTOR	TOTAL COMM	AVERAGE
260.	280.	0.00	99.00	19.63	25.00	19.63	19.63	20.90	0.00	0.00	99.00	20.97	0.00	35.22
280.	300.	0.00	93.50	31.62	0.00	16.62	16.62	16.00	0.00	0.00	93.50	16.22	0.00	31.43
300.	320.	0.00	89.50	18.75	0.00	18.75	18.75	16.45	0.00	0.00	89.50	14.06	0.00	30.00
320.	340.	0.00	83.00	30.00	15.00	15.00	15.00	15.30	0.00	5.00	83.00	18.75	5.00	30.51
340.	360.	0.00	71.50	7.50	50.00	7.50	7.50	16.15	10.00	15.00	71.50	18.13	25.00	32.69
360.	380.	0.00	93.00	12.50	0.00	12.50	12.50	14.30	0.00	0.00	93.00	9.38	0.00	29.17
380.	400.	0.00	93.00	12.50	0.00	12.50	12.50	14.30	0.00	0.00	93.00	9.38	0.00	29.17
400.	420.	0.00	92.00	9.63	0.00	9.63	9.63	13.05	0.00	0.00	92.00	7.22	0.00	28.07
420.	440.	0.00	88.00	11.25	0.00	11.25	11.25	13.30	0.00	0.00	88.00	8.44	0.00	27.43
440.	460.	0.00	93.00	12.50	0.00	12.50	12.50	14.30	0.00	0.00	93.00	9.38	0.00	29.17
460.	480.	0.00	88.50	10.38	0.00	10.38	10.38	13.00	0.00	0.00	88.50	7.78	0.00	27.32
480.	500.	0.00	93.00	12.50	0.00	12.50	12.50	14.30	0.00	0.00	93.00	9.38	0.00	29.17
500.	520.	0.00	93.00	12.50	0.00	12.50	12.50	14.30	0.00	0.00	93.00	9.38	0.00	29.17

Figure 12.- Sample of crewman workload profile report.

* UNSHIFTED *

APRIL 1978

MISSION SCENARIO REPORT

MISSION - ATL TLA SCENARIO ILS RWY 8

CONFIGURATION - GA - SPIFR

CREWMEMBER - PILOT

TIME INTERVAL (SECS) SINCE MISSION START BEGINNING	END	TOTAL ACTIVITY TIME		FLIGHT PHASE EVENT/PROCEDURE TASK
272.00				CR03 CRUISE TO HOLDING PATTERN
272.00				F00010 MAINTAIN STRAIGHT AND LEVEL WITH VOR MON.
272.00	273.00	1.00	3H	01 SCAN ALTIMETER USE SIT 2 WITH 3H0071 AND 3H0042
273.00	275.20	2.20	3L	01 SCAN VERTICAL SPEED
275.20	277.20	2.00	5D	01 SCAN P RMI
276.30	281.30	5.00	4A	10 MOVE CONTROLS FOR MANUAL CONTROL
277.20	279.30	2.10	5U	01 SCAN P #1 VOR/LOC GS USE SIT 2&3 WITH 5U0131
279.30	280.30	1.00	3A	01 SCAN P AIRSPEED IND. SIT 2 FOR TAKEOFF
280.30	281.30	1.00	3R	01 SCAN P ATTITUDE IND.

Figure 13.- Sample of mission scenario report.

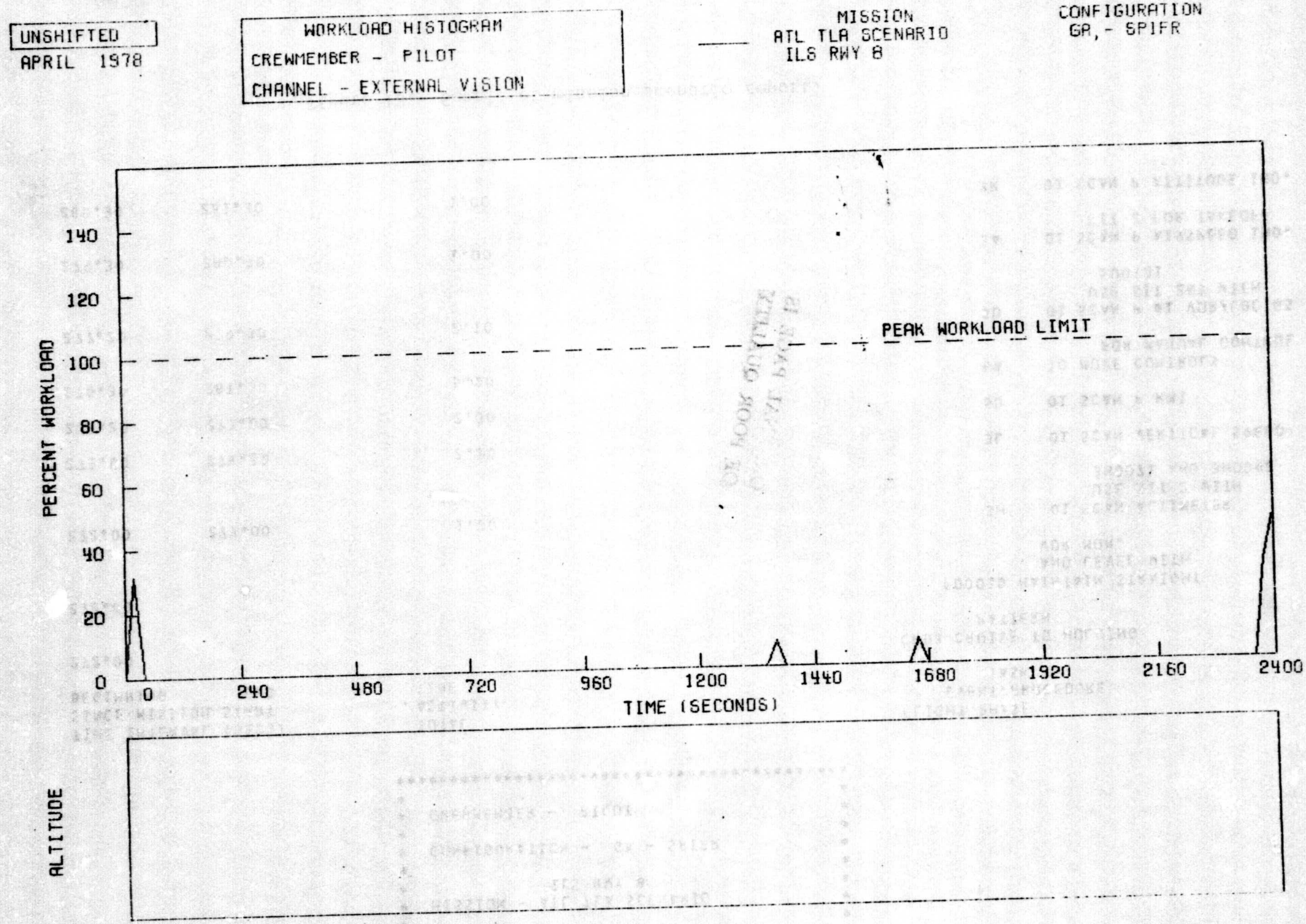


Figure 14.- External vision workload histogram report.

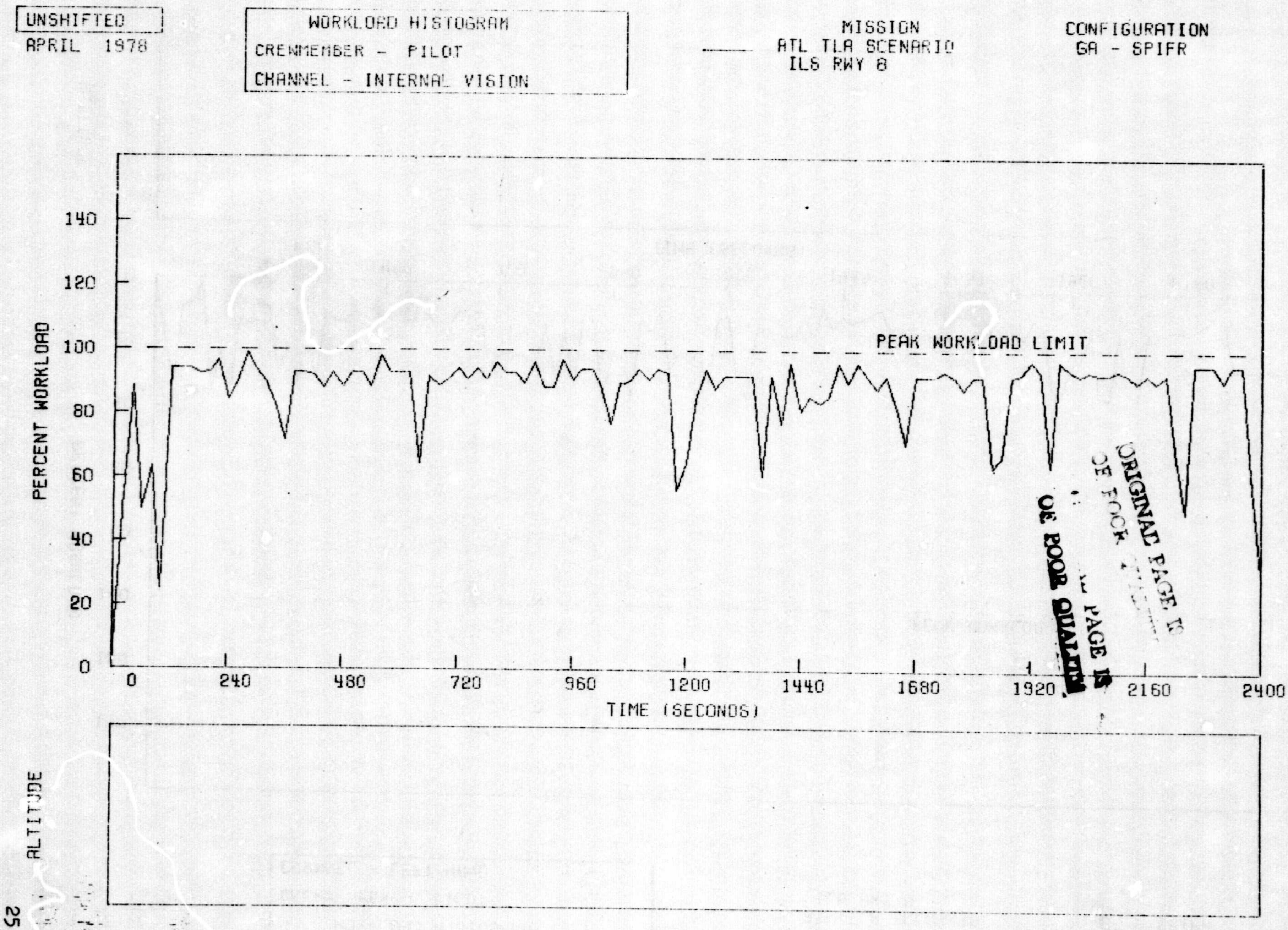


Figure 15.- Internal vision workload histogram report.

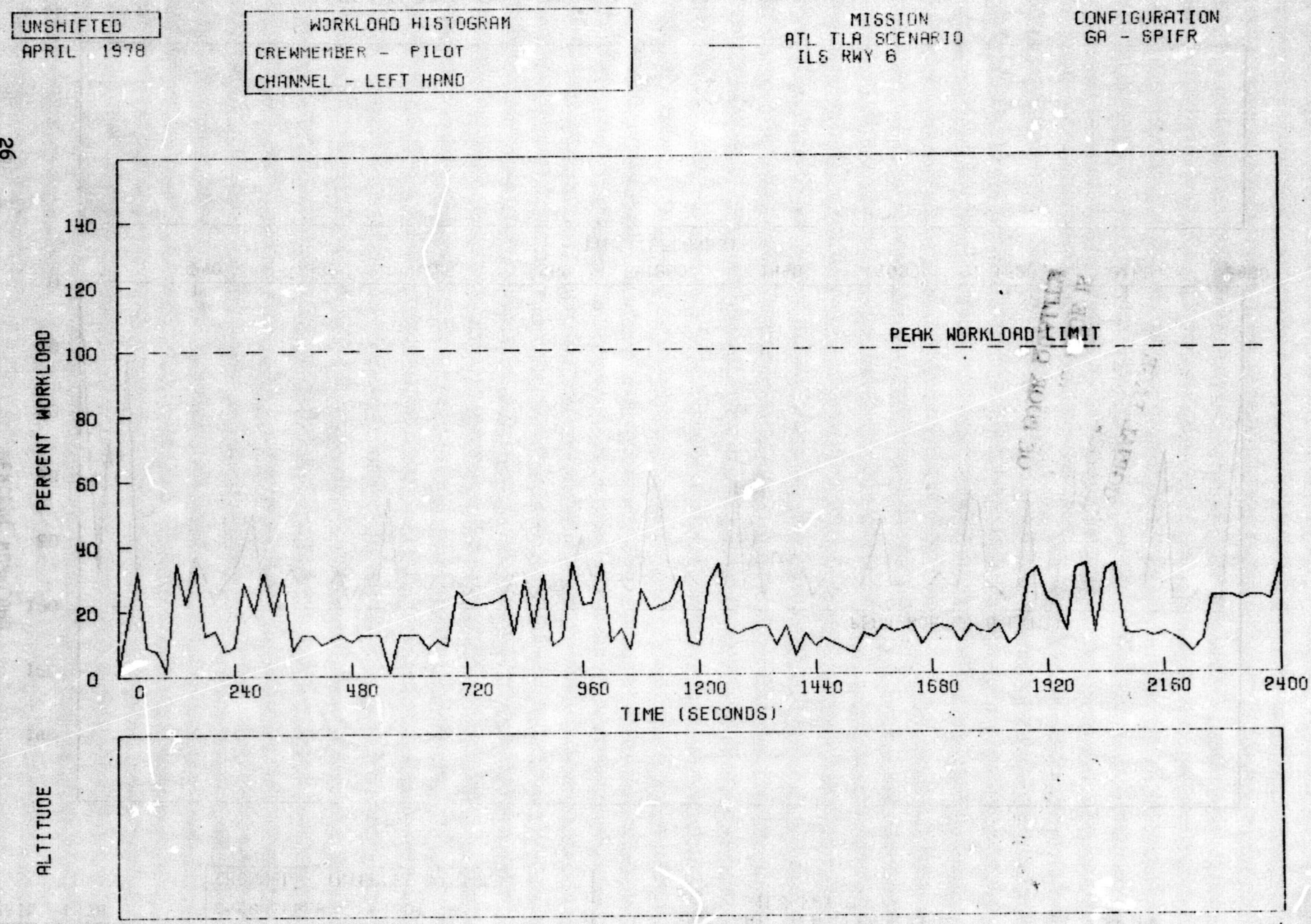


Figure 16.- Left hand workload histogram report.

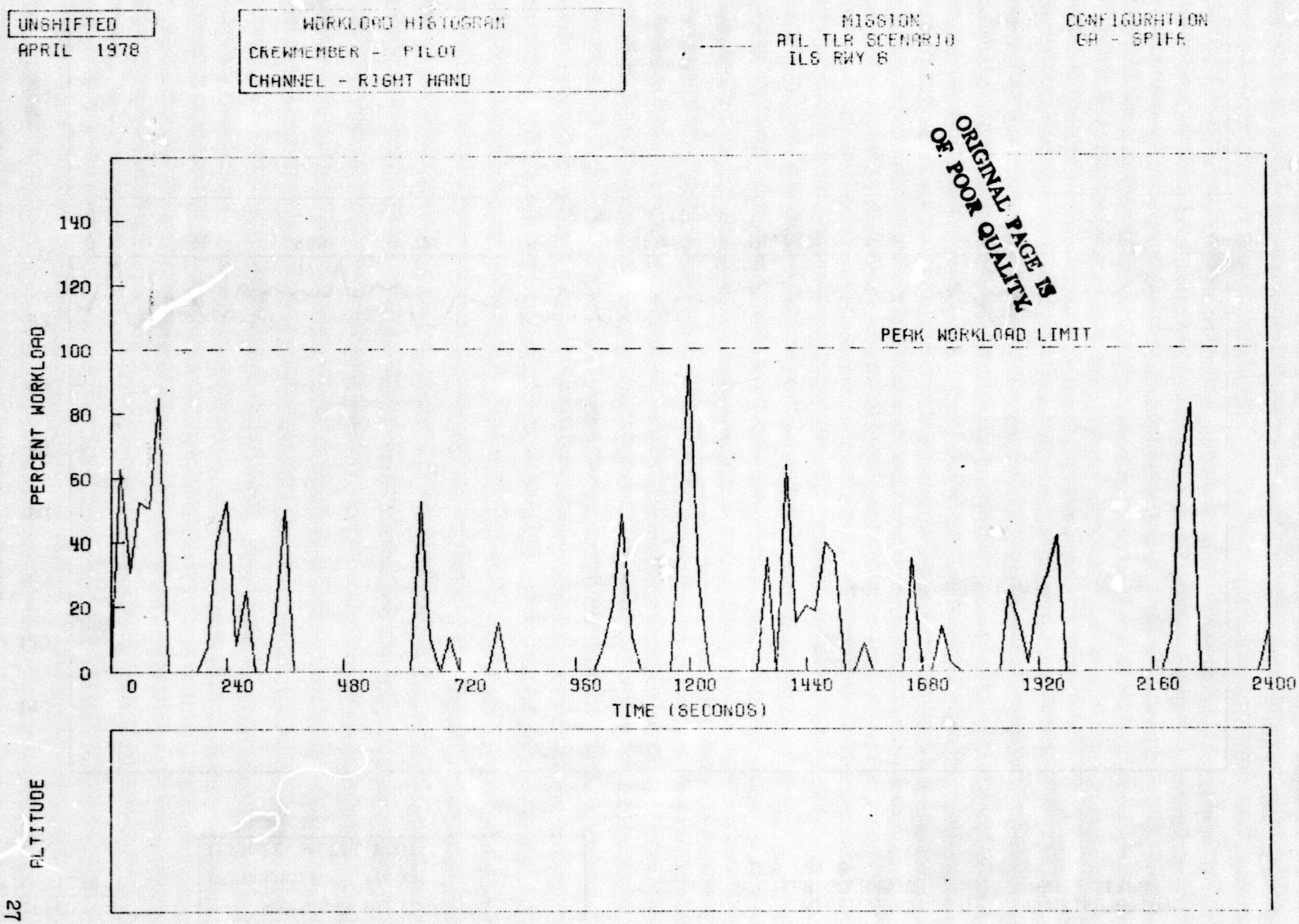


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Figure 17.- Right hand workload histogram report.

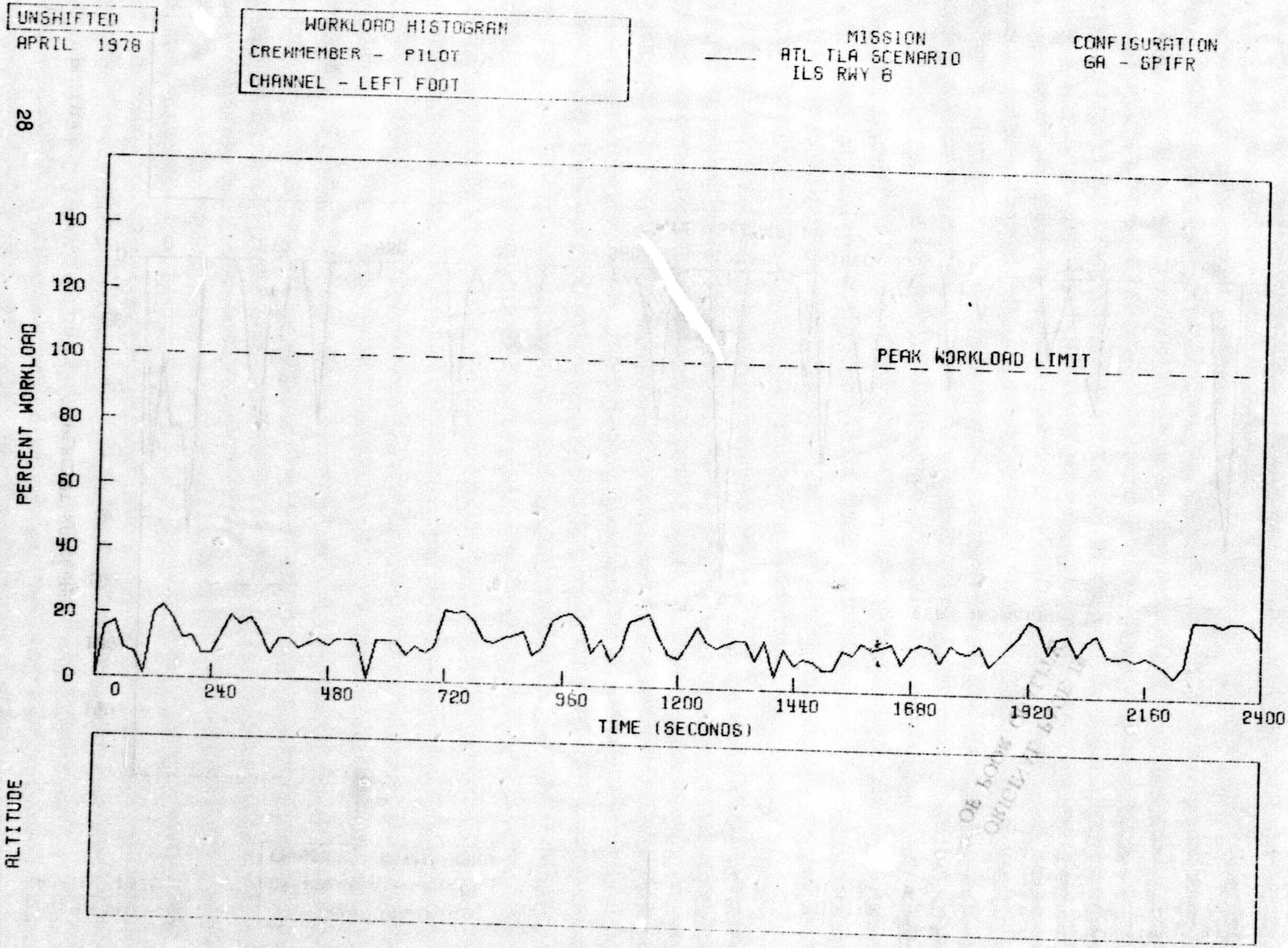

Figure 18.- Left foot workload histogram report.

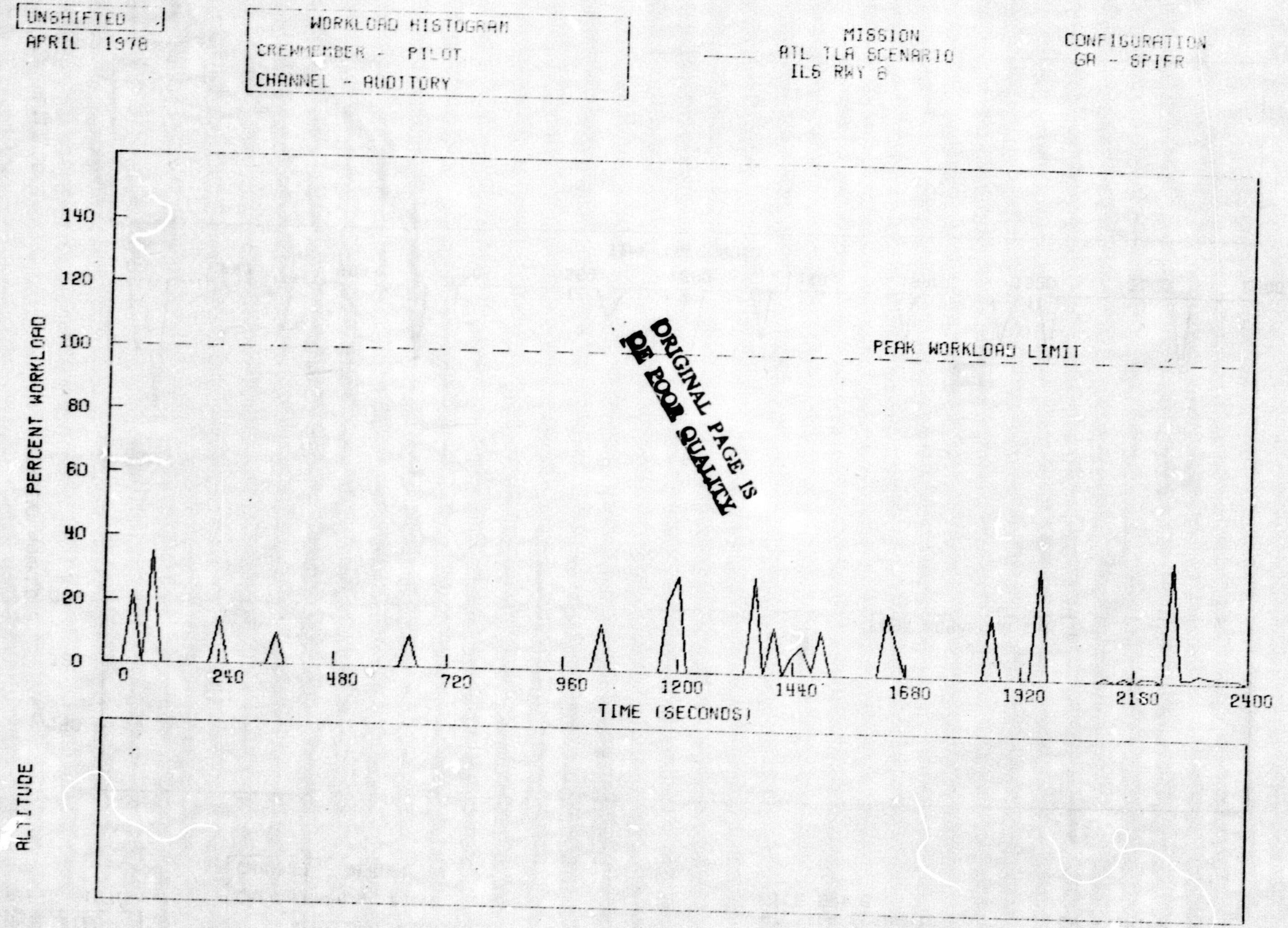

Figure 19.- Auditory workload histogram report.

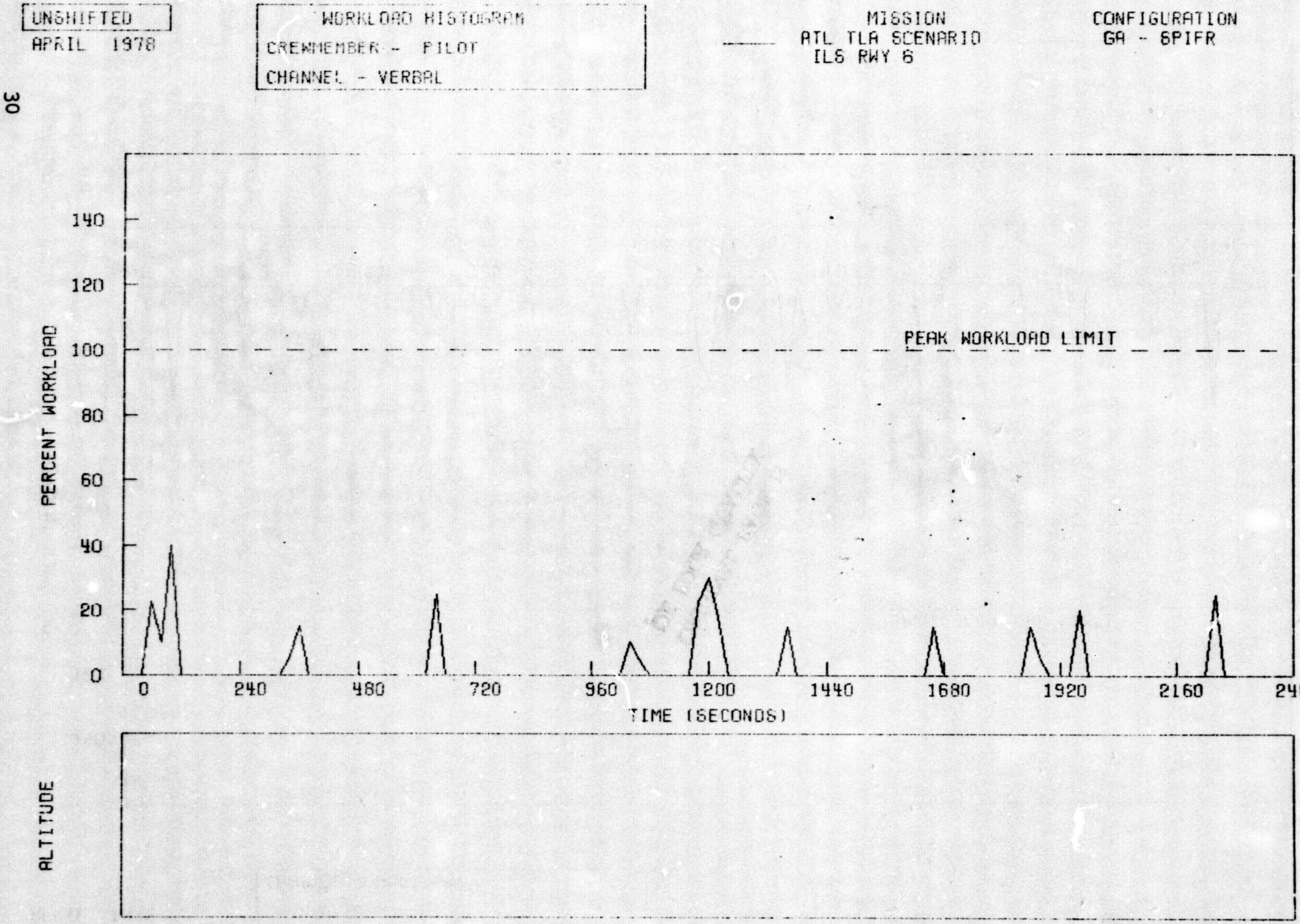

Figure 20.- Verbal workload histogram report.

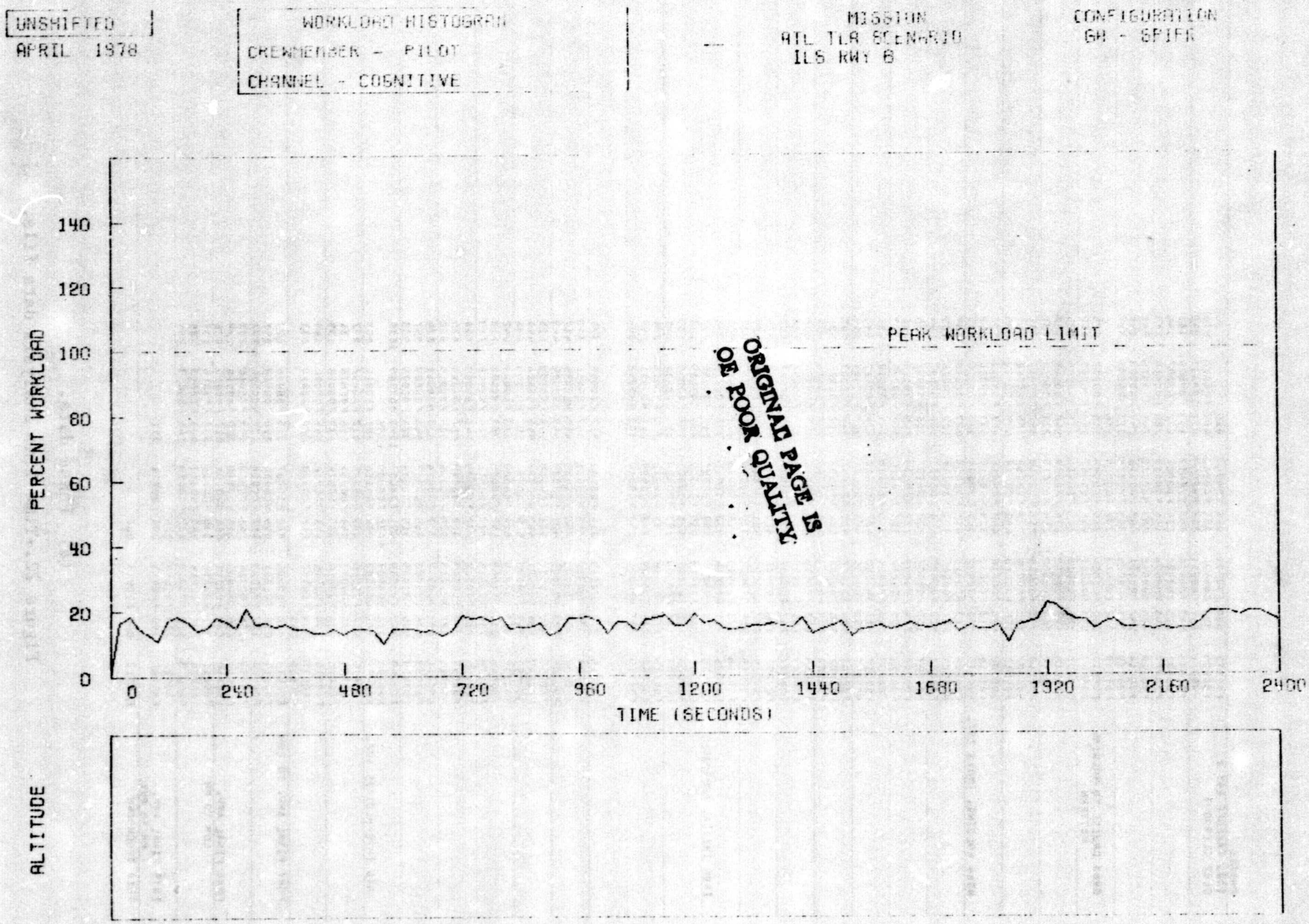

Figure 21.- Cognitive workload histogram report.

PHASES								
T001 TAKEOFF RWY 8	EVENT1	000	F00001	000	F00002	020		
CL02 CLIMBOUT	F00009	000	C00006	009	F00016	012	F00016	016
	F00016	017	CR0001	022	F00009	031	C00001	040
	F00016	043	F00016	053	EVENT2	101	F00006	101
	F00007	116	F00007	124	F00007	132	F00007	140
	F00007	148	F00008	156	F00010	209	F00010	219
	F00010	229	N00010	239	N00012	241	F00016	241
	F00010	242	NR0001	252	F00016	257	NR0003	258
	F00010	301	NR0004	311	F00016	316	NR0005	317
	F00010	326	EVENT3	336	F00005	336		
CR03 CRUISE TO HOLDING	F00010	000	EVENT4	010	F00006	010	F00007	025
PATTERN	F00007	033	N00001	041	F00007	044	F00008	052
	C00007	105	F00016	111	F00010	115	NR0006	125
	F00010	128	F00010	138	F00010	148	F00010	158
	F00010	208	N00002	218	F00010	221	F00010	231
	F00010	242	F00010	252	F00010	302	F00010	312
	N00002	322	F00010	325	F00010	335	F00010	345
	F00010	355	F00010	405	F00010	415	N00002	425
	S00002	428	F00010	443	F00010	453	F00010	503
	F00010	513	F00010	523	F00010	533	F00010	543
H004 HOLDING, TROYS INT.	EVENT5	000	N00007	000	C00004	006	F00016	009
	F00016	013	F00010	017	F00010	027	F00010	037
	N00004	047	F00010	050	N00008	100	F00006	105
	F00007	120	F00007	128	F00007	136	F00007	144
	F00007	152	F00007	200	F00007	208	F00007	216
	F00007	224	F00008	232	NR0003	245	F00010	248
	F00010	258	F00010	308	F00010	318	F00006	328
	F00007	343	N00001	351	F00008	354	F00010	407
	F00010	417	N00002	427	F00010	430	F00010	440
	N00002	450	F00006	453	F00007	508	F00007	516
	F00007	524	F00007	532	F00007	540	F00007	548
	F00007	556	F00008	604	N00009	617	F00009	621
	F00009	630	F00009	639	C00008	648	F00016	650
	F00016	653	F00016	654	F00016	655	CR0004	658
	F00009	705	F00009	714	N00008	723	F00006	728
	F00007	743	F00007	751	F00007	759	F00007	807
	F00007	815	F00007	823	F00007	831	F00008	839
	F00010	852	C00006	901	F00016	904	F00016	909
	F00016	914	CR0002	915	F00016	920	C00009	921
	F00016	923	F00016	925	F00016	927	F00016	929
	F00016	931	F00016	933	F00016	936	F00016	938
IA05 INITIAL APPROACH	EVENT6	000	F00006	000	F00007	015	F00008	023
	F00009	036	F00009	045	F00009	154	F00009	103
	F00009	112	F00009	121	F00009	130	F00009	139
	F00009	148	F00009	157	F00009	206	C00002	215
	F00016	216	F00016	218	F00016	220	F00016	224
	F00009	228	F00009	237	F00009	246	N00011	255
	F00016	257	NR0001	258	F00016	303	NR0002	304
	F00016	313	NR0003	314	F00009	317	F00009	326
	F00009	335	N00003	344	N00011	347	F00016	349
	NR0008	350	F00009	359	F00009	408	NR0004	417
	F00009	422	NR0005	431	F00009	440	NR0006	449
	F00009	452	S00002	501	F00009	516	F00009	525
	F00009	534	S00001	543	N00012	545	F00016	545
	S00001	546	F00009	548	F00009	557	F00009	606
	F00009	615	F00009	624	F00009	633	F00009	642
	F00016	651	F00009	652	F00009	701	C00002	710
	F00016	711	F00016	713	F00016	715	F00016	719
	F00009	723	F00009	732	F00009	741	F00009	750
	F00009	759	F00009	808	F00009	817	F00016	826
	N00011	827	N00013	829	F00016	829	F00016	830
	N00011	831	N00012	833	F00016	833	N00011	834
	F00009	836	N00003	845	F00009	848	F00009	857
	F00009	906	F00009	915	F00009	924	F00009	933
	F00009	942	F00009	951	F00009	1000	F00009	1009
	N00003	1018	F00009	1027	F00009	1036		
INT6 INTERMEDIATE APP.	EVENT7	000	C00003	000	F00016	001	F00016	003
	F00016	007	F00016	009	F00006	012	F00007	027
	F00008	035	F00003	048	F00004	116	EVENT8	134
	C00010	134	F00016	135	F00016	137	F00016	139
	F00016	144	F00016	145	F00016	146	F00006	149
	F00007	204	F00007	212	F00008	220	F00010	233
	F00010	243						
FOM7 FINAL APP. TO LOM	EVENT9	000	F00006	000	F00007	015	F00008	023
	F00010	036	F00010	046	N00006	056	F00010	057
	F00010	107	F00010	117	F00010	127	N00006	137
	F00010	138	F00010	148	F00010	159	F00010	208
	F00010	218	N00006	228	F00010	229	F00010	239
FMM8 FINAL APP.	EVNT10	000	F00012	000	CR0001	017	F00016	026
LOM TO MM	C00011	027	F00016	030	F00016	032	F00016	035
	F00016	037	F00016	040	F00013	044	F00013	100
	F00013	116	F00013	132	F00013	148	F00013	204
	F00013	220	F00013	236				
FRY9 FINAL APP.	EVNT11	000	F00014	000	F00014	011		
MM TO RWY								
TD10 TOUCHDOWN	EVNT12	000	F00015	000				

(a) Phase data.

Figure 22.-Time line analysis data file.

EVENT/PROC								
C00001 CONTACT DEP. AFTER	1P	01	0.0	P1	1P	07	2.0	P4
TAKEOFF	1P	16	6.0	P4	1T	28	6.0	P2
	1P	10	13.0	P4	1P	04	19.0	P1
C00002 RECEIVE TRAFFIC	1T	28	0.0	P1	1P	01	6.0	P1
ADVISORY	1P	07	8.0	P3	8A	01	8.0	P1
	1P	04	11.0	P1				
C00003 RECEIVE VECTOR	1T	25	0.0	P1	1P	01	4.0	P1
	1P	07	6.0	P4	1P	04	10.0	P1
C00004 REPORT CROSSING FIX	1P	01	0.0	P1	1P	10	2.0	P2
	1P	16	7.0	P2	1T	22	7.0	P1
	1P	04	9.0	P1				
C00005 RECEIVE REQUEST TO	1T	22	0.0	P1	1P	01	2.0	P1
SAY ALTITUDE	1P	16	4.0	P1	3H	01	4.0	P1
	1P	07	5.0	P2	1P	04	7.5	P1
C00006 RECEIVE HANDOFF	1T	25	0.0	P2	1P	01	4.5	P1
	1P	10	6.5	P1	1P	04	11.0	P1
C00007 REPORT REACHING ALT.	1P	01	0.0	P1	1P	07	2.0	P4
	1P	16	6.0	P2	1T	22	6.0	P1
	1P	04	8.0	P1				
C00008 RECEIVE TRAN. CODE	1T	22	0.0	P3	1P	01	3.0	P1
CHANGE	1P	07	5.0	P3	1P	04	8.0	P1
C00009 CONTACT APPROACH	1P	01	0.0	P1	1P	07	2.0	P4
	1P	16	6.0	P3	1T	28	6.0	P1
	1P	10	12.0	P3	1P	04	17.5	P1
C00010 RECEIVE FINAL VECTOR	1T	28	0.0	P2	1P	01	7.0	P1
AND HANDOFF TO TWR	1P	07	9.0	P4	1P	04	13.0	P1
C00011 CONTACT TOWER	1P	01	0.0	P1	1P	07	2.0	P3
	1P	19	5.0	P1	1T	28	5.0	P3
	1P	07	12.5	P1	1P	04	14.5	P1
CR0001 CHANGE TRANSCEIVERS	1A	01	0.0	P1	1T	04	2.5	P1
	1T	01	5.3	P1				
CR0002 TUNE COM. #1	1A	13	0.0	P1	1A	10	0.0	P1
CR0003 TUNE COM. #2	1B	01	0.0	P1	1B	10	0.0	P1
CR0004 CHANGE TRAN. CODE	1N	16	0.0	P2	1N	19	0.0	P2
F00001 TAKEOFF ROLL	4B	07	0.0	P1	4A	16	0.0	P1
	7F	04	2.6	P1	7F	10	5.2	P1
	7F	01	7.8	P1	3A	01	10.0	P2
	4A	16	10.0	P2				
F00002 ROTATE AND LIFTOFF	4A	04	0.0	P1	3R	01	0.0	P3
	4A	07	4.0	P4	3R	01	4.0	P1
	3A	01	5.0	P1	3L	01	6.0	P1
	4A	10	8.0	P1	3H	01	8.2	P1
	3R	01	9.2	P3	4G	13	9.2	P1
	1N	04	12.9	P1				
F00003 REDUCE SPEED	4B	07	0.0	P2	7F	01	0.0	P2
	3R	01	2.6	P2	4A	10	2.6	P2
	3A	01	5.6	P1	3H	01	6.6	P1
	3L	01	7.6	P1	5D	01	9.8	P1
	3R	01	11.8	P1	4A	10	12.6	P1
	3A	01	12.8	P1	3H	01	13.8	P1
	3L	01	14.8	P1	4G	13	17.0	P1
	3R	01	17.0	P2	4A	07	17.6	P4
	3A	01	20.0	P1	3H	01	21.0	P1
	4A	07	21.6	P1	3L	01	22.0	P1
	4A	10	22.6	P1	5D	01	24.2	P1
	3R	01	26.2	P1				
F00004 CHANGE FLAP SETTING	4E	04	0.0	P1	4E	01	0.0	P2
	3R	01	2.4	P2	4A	07	2.4	P3
	3A	01	5.4	P1	4A	07	5.4	P2
	3H	01	6.4	P1	3L	01	7.4	P1
	4A	10	7.4	P2	3R	01	9.6	P2
	4G	13	9.6	P1	3A	01	12.6	P1
	3H	01	13.6	P1	3L	01	14.6	P1
	3R	01	16.8	P1				
F00005 LEVEL OFF AT ALT.	3R	01	0.0	P1	3H	01	1.0	P1
	4A	04	2.0	P1	3R	01	2.0	P3
	3H	01	6.0	P1	4A	10	6.0	P2
	3L	01	7.0	P1	3A	01	9.2	P1
	5D	01	10.2	P1	3R	01	12.2	P1
	4B	07	13.2	P2	7F	01	13.2	P2
	4G	13	15.8	P1	3R	01	15.8	P3
	4A	07	16.0	P4				
F00006 ENTER TURN	3R	01	0.0	P1	5D	01	1.0	P1
	4A	01	3.0	P1	3R	01	3.0	P3
	3H	01	7.0	P1	3L	01	8.0	P1
	4A	10	9.4	P1	3P	01	10.2	P1
	5D	01	11.4	P1	3R	01	13.4	P1
F00007 MAINTAIN TURN	4A	10	0.0	P1	5D	01	0.0	P1
	3H	01	2.0	P1	3L	01	3.0	P1
	3P	01	5.2	P1	4A	07	5.4	P2
	3R	01	6.4	P1				
F00008 EXIT TURN	5D	01	0.0	P1	3R	01	2.0	P3
	4A	01	2.0	P1	5D	01	6.0	P1
	4A	10	7.2	P1	3H	01	8.0	P1
	3L	01	9.0	P1	3R	01	11.2	P1

(b) Event/procedure data.

Figure 22.- continued

F00009	MAINTAIN STRAIGHT	3L	01	0.0	P1	3H	01	2.2	P1
	AND LEVEL WITHOUT	3R	01	3.2	P1	4A	10	3.2	P1
	VOR MON.	5D	01	4.2	P1	3A	01	6.2	P1
		3R	01	7.2	P1				
F00010	MAINTAIN STRAIGHT	34	01	0.0	P1	3L	01	1.0	P1
	AND LEVEL WITH	5D	01	3.2	P1	4A	10	4.3	P1
	VOR MON.	5U	01	5.2	P1	3A	01	7.3	P1
		3R	01	8.3	P1				
F00011	BEGIN CLIMB/DESCENT	3R	01	0.0	P1	3H	01	1.0	P1
		4B	07	2.0	P1	7F	01	2.0	P2
		4A	04	4.6	P1	3R	01	4.6	P3
		3H	01	8.6	P1	4A	10	8.6	P2
		3L	01	9.6	P1	3A	01	11.8	P1
		5D	01	12.8	P1	3R	01	14.8	P2
		4G	13	14.8	P1				
F00012	CROSS OUTER MARKER	3V	07	0.0	P1	5U	01	0.5	P1
		3N	01	2.6	P1	4B	07	4.8	P1
		7F	01	4.8	P2	3R	01	7.4	P1
		3L	01	8.4	P1	5U	01	10.6	P1
		4A	07	12.7	P4	3R	01	12.7	P3
		4G	13	12.7	P1				
F00013	FLY ILS, OM TO MM	4A	10	0.0	P3	3R	01	0.0	P1
		3L	01	1.0	P1	5U	01	3.2	P1
		3H	01	5.3	P1	3R	01	6.3	P1
		5D	01	7.3	P1	3P	01	9.3	P1
		5U	01	10.5	P1	3R	01	12.6	P1
		3A	01	13.6	P1	3V	04	14.6	P1
F00014	FLY ILS, MM TO RWY	4A	10	0.0	P2	3R	01	0.0	P1
		8A	01	1.0	P4	5U	01	4.0	P1
		3A	01	6.1	P1	3L	01	7.1	P1
		3H	01	9.3	P1				
F00015	FLARE AND TOUCHDOWN	4A	04	0.0	P1	4B	07	0.0	P3
		8A	04	0.0	P2	4A	10	4.0	P1
		8A	04	4.0	P4				
F00016	MAINTAIN ATTITUDE	3R	01	0.0	P1	4A	07	0.0	P1
N00001	CHECK #1 VOR NEEDLE	5U	01	0.0	P1				
N00002	CHECK #2 VOR NEEDLE	5V	01	0.0	P1				
N00003	CHECK ADF ARROW	5D	14	0.0	P1	5D	15	0.5	P1
N00004	CHECK STOPWATCH IND.	3N	01	0.0	P1				
N00005	CHECK LOC/GS	5U	01	0.0	P1				
N00006	CHECK MKR BCN ON	3V	07	0.0	P1				
N00007	BEGIN HOLDING LEG,	5U	01	0.0	P1	5V	01	2.1	P1
	ON RADIAL, AT FIX	3N	10	4.2	P1				
N00008	END HOLDING LEG,	3N	01	0.0	P1	3N	10	2.2	P2
	AT TIME								
N00009	BEGIN HOLDING LEG,	5D	01	0.0	P1	3N	10	2.0	P1
	OFF RADIAL, AFTER								
	TURN								
N00010	SCAN ENROUTE CHART	8B	01	0.0	P1				
N00011	SCAN APP. PLATE	8B	07	0.0	P1				
N00012	HOLD CHART #1	8B	08	0.0	P1				
N00013	HOLD CHART #2	8B	08	0.0	P2				
NR0001	TUNE NAV #1 L.KNOB	5U	28	0.0	P1	5U	25	0.0	P1
NR0002	CHECK NAV #1 IDENT	1T	07	0.0	P1	1T	31	2.8	P1
		8B	03	2.8	P1	1T	07	5.8	P1
NR0003	ADJ. #1 OBS	5U	13	0.0	P1	5U	10	0.0	P3
		5U	01	0.0	P3				
NR0004	TUNE NAV #2 R.KNOB	5V	19	0.0	P1	5V	16	0.0	P1
NR0005	CHECK NAV #2 IDENT	1T	10	0.0	P1	1T	31	2.8	P1
		8B	03	2.8	P1	1T	10	5.8	P1
NR0006	ADJ. #2 OBS	5V	07	0.0	P1	5V	04	0.0	P3
		5V	01	0.0	P3				
NR0007	TUNE ADF	5D	13	0.0	P2	5D	16	0.0	P2
NR0008	CHECK ADF IDENT	1T	13	0.0	P1	1T	31	2.8	P1
		8B	03	2.8	P1	1T	13	5.8	P1
S00001	SCAN CHECKLIST	8B	10	0.0	P1				
S00002	CHECK ENG. INST. AND	7F	10	0.0	P1	7F	04	2.6	P1
	DG PRECESSION	7F	16	5.2	P1	7F	01	7.8	P1
		5K	01	10.8	P1	5D	01	12.6	P1
EVENT1	TAKEOFF RUNWAY 9								
EVENT2	TURN LEFT TO INT.								
	R-360 ATL VORTAC								
EVENT3	LEVEL OFF AT 3500FT.								
EVENT4	INT. R-360 ATL								
EVENT5	CROSS TROYS INT AND								
	ENTER HOLDING								
	PATTERN								
EVENT6	EXIT PATTERN WITH								
	VECTORS TO ILS								
EVENT7	RECEIVE VECTOR TO								
	180 DEG, BASE LEG								
EVENT8	RECEIVE VECTOR TO								
	120 DEG, TO INT.								
	ILS RWY 8								
EVENT9	INT. ILS RWY 8								
EVNT10	INT. G/S, BEGIN								
	DESCENT, CROSS LOM								
EVNT11	CROSS MM, EST.								
	VISUAL CONTACT								
	WITH RUNWAY								
EVNT12	CROSS RWY8 THRESHOLD								

(h) Concluded.

Figure 22.- continued

TASKS

1A	01 MOVE AUD. PNL. MIKE	1	2.5	40	100	10			
	SWITCH								
1A	04 ADJ. COM #1 VOL.	1	2.6	20	100	10			
1A	07 MOVE COM #1 ON/OFF	1	2.5	20	100	10			
	SWITCH								
1A	10 TUNE COM #1	1	5.0	30	100	10			1A0131
		2	3.0	20	100	10			1A0132
		3	2.5	20	100	10			1A0133
1A	13 SCAN COM #1 FREQ.	1	5.0	70		10			1A0101
		2	3.0	80		10			1A0102
		3	2.5	80		10			1A0103
		4	1.4	100		10			
1B	01 SCAN COM #2 FREQ.	1	5.0	70		10			1B0101
		2	3.0	80		10			1B0102
		3	1.4	100		10			
1B	04 ADJ. COM #2 VOL.	1	2.6	20	100	10			
1B	07 MOVE COM #2 ON/OFF	1	2.5	20	100	10			
	SWITCH								
1B	10 TUNE COM #2	1	5.0	30	100	10			1B0011
		2	3.0	20	100	10			1B0012
1N	01 SCAN TRANSPONDER	1	2.6	100		10			
	MONITOR LIGHT								
1N	04 MOVE TRANSPONDER	1	2.5	20	100	10			
	ON/OFF SWITCH								
1N	07 PUSH TRANSPONDER	1	2.5	20	100	10			
	TEST								
1N	10 PUSH TRANSPOWDER	1	2.3	20	100	10			
	IDENT								
1N	13 MOVE TRANSPONDER	1	2.5	20	100	10			
	MODE SWITCH								
1N	16 CHANGE TRANS. CODE	1	8.6	30	100	10			1N0191
		2	6.7	30	100	10			1N0192
		3	4.8	30	100	10			1N0193
		4	3.0	20	100	10			1N0194
1N	19 SCAN TRANS. CODE	1	8.6	70		10			1N0161
		2	6.7	70		10			1N0162
		3	4.8	79		10			1N0163
		4	3.0	80		10			1N0164
1N	22 SCAN TRANS. CODE	1	1.4	100		10			
1P	01 PICK UP MICROPHONE	1	2.0	50	100	10			
1P	04 RETURN MICROPHONE	1	2.0	50	100	10			
1P	07 MAKE RADIO TRANS.	1	2.0		100	10		100	
		2	2.5		100	10		100	
		3	3.0		100	10		100	
		4	4.0		100	10		100	
1P	10 MAKE RADIO TRANS.	1	4.5		100	10		100	
		2	5.0		100	10		100	
		3	5.5		100	10		100	
		4	6.0		100	10		100	
1P	13 MAKE RADIO TRANS.	1	7.0		100	10		100	
		2	7.5		100	10		100	
		3	8.5		100	10		100	
1P	16 HOLD MICROPHONE	1	1.0		100				
		2	2.0		100				
		3	6.0		100				
		4	7.0		100				
1P	19 HOLD MICROPHONE	1	7.5		100				
		2	8.5		100				
1T	01 MOVE AUD. PNL.	1	2.8	40	100	10			
	#1COM SWITCH								
1T	04 MOVE AUD. PNL.	1	2.8	40	100	10			
	#2COM SWITCH								
1T	07 MOVE AUD. PNL.	1	2.8	40	100	10			
	#1NAV SWITCH								
1T	10 MOVE AUD. PNL.	1	2.8	40	100	10			
	#2NAV SWITCH								
1T	13 MOVE AUD. PNL.	1	2.8	40	100	10			
	ADF SWITCH								
1T	16 MOVE AUD. PNL.	1	2.8	40	100	10			
	DME SWITCH								
1T	19 MOVE AUD. PNL.	1	2.8	40	100	10			
	MKR BCN SWITCH								
1T	22 MON. RADIO TRANS.	1	2.0			10	100		
		2	2.5			10	100		
		3	3.0			10	100		
		4	3.5			10	100		
1T	25 MON. RADIO TRANS.	1	4.0			10	100		
		2	4.5			10	100		
		3	5.0			10	100		
		4	5.5			10	100		
1T	28 MON. RADIO TRANS.	1	6.0			10	100		
		2	7.0			10	100		
		3	7.5			10	100		
		4	8.5			10	100		
1T	31 MON. IDENT.	1	3.0			10	100		880031

(c) Task data.

Figure 22.- continued.

3A	01	SCAN P AIRSPEED IND.	1	1.0		100					10		
		SIT 2 FOR TAKEOFF	2	10.0		20					10		
3A	04	SCAN CP AIRSPEED IND	1	1.6		100					10		
3H	01	SCAN ALTIMETER	1	1.0		100					10		
		USE SIT 2 WITH	2	3.0		10					10		
		3H0071 AND 3H0042											
3H	04	SCAN ALTIMETER	1	2.2		100					10		
		PRESSURE WINDOW	2	3.0		80					10		
		USE SIT 2 WITH											
		3H0012 AND 3H0071											
3H	07	SET ALTIMETER	1	3.0		10		100			10		
		USE WITH 3H0012											
		AND 3H0042											
3L	01	SCAN VERTICAL SPEED	1	2.2		100					10		
3N	01	SCAN CLOCK	1	2.2		100					10		
			2	3.0		90					10		3N0071
3N	04	WIND CLOCK	1	7.0		10	100				10		
3N	07	SET CLOCK	1	3.0		10	100				10		3N0012
3N	10	START/STOP/RESET	1	1.5		90		100			10		
		STOPWATCH SIT 2	2	2.1		80		100			10		
		FOR STOP AND RESET											
3P	01	SCAN NEEDLE/BALL	1	1.2		100					10		
3R	01	SCAN P ATTITUDE IND.	1	1.0		100					10		
			2	3.0		90					10		3R0071
			3	4.0		100					10		4A0011
3R	04	SCAN CP ATTITUDE IND	1	1.8		100					10		
			2	3.5		90					10		3R0101
3R	07	SET P ATT. IND.	1	3.0		10		100			10		3R0012
		PITCH TRIM											
3R	10	SET CP ATT. IND.	1	3.5		10		100			10		3R0042
		PITCH TRIM											
3U	01	SCAN O.A.T. GAGE	1	2.8		100					10		
3V	01	SCAN MKR BCN AIRWAYS	1	0.5		100					10	50	
3V	04	SCAN MKR BCN MM	1	0.5		100					10	50	
3V	07	SCAN MKR BCN OM	1	0.5		100					10	50	
3V	10	SCAN CP MKR BCN ARYS	1	1.2		100					10	50	
3V	13	SCAN CP MKR BCN MM	1	1.3		100					10	50	
3V	16	SCAN CP MKR BCN OM	1	1.3		100					10	50	
3V	19	MOVE MKR BCN SWITCH	1	2.9		20		100			10		
4A	01	MOVE CONTROLS	1	4.0			100		25	25	10		3R0013
		TO ENTER/EXIT TURN											
4A	04	MOVE CONTROLS	1	4.0			100		25	25	10		3R0013
		TO START/STOP											
		CLIMB/DESCENT											
4A	07	MOVE CONTROLS	1	1.0			25		25	25	10		
		FOR MANUAL CONTROL	2	2.0			25		25	25	10		
			3	3.0			25		25	25	10		
			4	4.0			25		25	25	10		
4A	10	MOVE CONTROLS	1	5.0			25		25	25	10		
		FOR MANUAL CONTROL	2	10.0			25		25	25	10		
			3	15.0			25		25	25	10		
			4	20.0			25		25	25	10		
4A	16	TRACK RWY CENTERLINE	1	2.6	50		25		25	25	10		
		ON GROUND	2	10.0	50		25	100	25	25	10		
4B	01	MOVE LEFT PROP.	1	2.6		20		100			10		7F0012
		CONTROL	2	2.6		10		50			10		7F0012
4B	04	MOVE RIGHT PROP.	1	2.6		20		100			10		7F0012
		CONTROL	2	2.6		10		50			10		7F0012
4B	07	MOVE LEFT THROTTLE	1	2.6		20		100			10		
			2	2.6		20		50			10		
			3	2.6				100			10		
4B	10	MOVE RIGHT THROTTLE	1	2.6		20		100			10		
			2	2.6		20		50			10		
4B	13	MOVE LEFT MIXTURE	1	2.6		20		100			10		
			2	2.6		20		50			10		
4B	16	MOVE RIGHT MIXTURE	1	2.6		20		100			10		
			2	2.6		20		50			10		
4B	19	SET POWER LEVER	1	3.0		10		100			10		
		FRICTION											
4D	01	SCAN GEAR UP LIGHT	1	1.1		100					10		
4D	04	SCAN NG DOWN LIGHT	1	1.1		100					10		
4D	07	SCAN L. MAIN GEAR	1	1.1		100					10		
		DOWN LIGHT											
4D	10	SCAN R. MAIN GEAR	1	1.1		100					10		
		DOWN LIGHT											
4D	13	MOVE LDN. GEAR LEVER	1	2.9		10		100			10		
4E	01	SCAN FLAP POS. IND.	1	2.4		100					10		
			2	2.5		90					10		4E0041
4E	04	MOVE FLAP SWITCH	1	2.5		10		100			10		
4G	01	SCAN ROLL TRIM POS.	1	2.0		100					10		
			2	3.7		10					10		4G0161
4G	04	SCAN PITCH TRIM IND.	1	2.4		100					10		
			2	3.7		80					10		4G0131
4G	07	SCAN YAW TRIM IND.	1	2.4		100					10		
			2	3.7		80					10		4G0101

(c) Continued.

Figure 22.- continued.

4G	10 ADJ. YAW TRIM	1	3.7		100	10	4G0072
4G	13 ADJ. PITCH TRIM	1	3.7		100	10	4G0042
4G	16 ADJ. ROLL TRIM	1	3.7		100	10	4G0012
5D	01 SCAN P RMI	1	2.0	100		10	
5D	04 SCAN CP RMI	1	2.8	100		10	
5D	07 MOVE ADF ON/OFF	1	2.5	20	100	10	
	SWITCH						
5D	10 ADJ. ADF VOL.	1	2.6	20	100	10	
5D	13 TUNE ADF	1	6.6	30	100	10	5D0161
		2	5.0	30	100	10	5D0162
		3	3.0	20	100	10	5D0163
5D	14 SCAN P #1 RMI SWITCH	1	0.5	100		10	
5D	15 SCAN P ADF ARROW	1	2.0	100		10	
5D	16 SCAN ADF FREQ.	1	6.6	70		10	5D0131
		2	5.0	70		10	5D0132
		3	3.0	80		10	5D0133
		4	1.4	100		10	
5D	19 MOVE P #1 RMI SWITCH	1	2.4	20	100	10	
5D	22 MOVE P #2 RMI SWITCH	1	2.4	20	100	10	
5D	25 MOVE CP#1 RMI SWITCH	1	2.7	20	100	10	
5D	28 MOVE CP#2 RMI SWITCH	1	2.7	20	100	10	
5K	01 SCAN MAG. COMPASS	1	2.6	100		10	
5P	01 SCAN DME	1	1.4	100		10	
		2	2.7	80		10	5P0041
5P	04 MOVE DME SWITCH	1	2.7	20	100	10	5P0012
5U	01 SCAN P #1 VOR/LOC GS	1	2.1	100		10	
	USE SIT 2&3 WITH	2	3.0	80		10	5U0102
	5U0131	3	3.0	10		10	5U0103
5U	04 SCAN CP VOR/LOC GS	1	2.6	100		10	
	USE SIT 2&3 WITH	2	3.1	80		10	5U0072
	5U0161	3	3.1	10		10	5U0073
5U	07 SCAN CP VOR	1	2.6	100		10	
	AZIMUTH CARD WINDOW	2	3.1	10		10	5U0042
	USE SIT 2&3 WITH	3	3.1	80		10	5U0043
	5U0161						
5U	10 SCAN P #1 VOR	1	2.2	100		10	
	AZIMUTH CARD WINDOW	2	3.0	10		10	5U0012
	USE SIT 2&3 WITH	3	3.0	80		10	5U0013
	5U0131						
5U	13 SET P #1 VOR OBS	1	3.0	10	100	10	
	USE WITH 5U0012 AND						
	5U0102 OR 5U0013						
	AND 5U0103						
5U	16 SET CP VOR OBS	1	3.1	10	100	10	
	USE WITH 5U0042 AND						
	5U0072 OR 5U0043						
	AND 5U0072						
5U	19 ADJ. NAV #1 VOL.	1	2.6	20	100	10	
5U	22 MOVE NAV #1 ON/OFF	1	2.5	20	100	10	
	SWITCH						
5U	25 TUNE NAV #1	1	5.0	30	100	10	5U0281
		2	3.0	20	100	10	5U0282
5U	28 SCAN NAV #1 FREQ.	1	5.0	70		10	5U0251
		2	3.0	80		10	5U0252
		3	1.4	100		10	
5V	01 SCAN P #2 VOR/LOC	1	2.1	100		10	
	USE SIT 2&3 WITH	2	3.0	80		10	5V0042
	5V0071	3	3.0	10		10	5V0043
5V	04 SCAN P #2 VOR	1	2.2	100		10	
	AZIMUTH CARD WINDOW	2	3.0	10		10	5V0012
	USE SIT 2&3 WITH	3	3.0	80		10	5V0013
	5V0071						
5V	07 SET P #2 VOR OBS	1	3.0	10	100	10	
	USE WITH 5V0012 AND						
	5V0042 OR 5V0013						
	AND 5V0043						
5V	10 ADJ. NAV #2 VOL.	1	2.6	20		10	
5V	13 MOVE NAV #2 ON/OFF	1	2.5	20	100	10	
	SWITCH						
5V	16 TUNE NAV #2	1	5.0	30	100	10	5V0191
		2	3.0	20	100	10	5V0192
5V	19 SCAN NAV #2 FREQ.	1	5.0	70		10	5V0161
		2	3.0	80		10	5V0162
		3	1.4	100		10	
7B	01 SCAN AMMETER #1	1	2.2	100		10	
7B	04 SCAN AMMETER #2	1	2.3	100		10	
7B	07 MOVE MASTER SWITCH	1	2.9	10	100	10	
7C	01 SCAN FUEL PRESSURE	1	2.4	100		10	
7C	04 SCAN FUEL GAGE #1	1	2.4	100		10	
7C	07 SCAN FUEL GAGE #2	1	2.4	100		10	
7C	10 MOVE LEFT FUEL BOOST	1	2.6	10	100	10	
	SWITCH						
7C	13 MOVE RIGHT FUEL	1	2.6	10	100	10	
	BOOST SWITCH						

ORIGINAL PAGE IS
OF POOR QUALITY

(c) Continued

Figure 22.- continued.

7F	01	SCAN TACHOMETER	1	2.2		100			10	
		USE SIT 2 WITH	2	2.6		80			10	
		4B0011 OR 4B0041 OR 4B0012 AND 4B0042								
7F	04	SCAN OIL PRESSURE #1	1	2.6		100			10	
7F	07	SCAN OIL PRESSURE #2	1	2.8		100			10	
7F	10	SCAN OIL TEMP. #1	1	2.6		100			10	
7F	13	SCAN OIL TEMP. #2	1	2.8		100			10	
7F	16	SCAN CYL. TEMP. #1	1	2.6		100			10	
7F	19	SCAN CYL. TEMP. #2	1	2.6		100			10	
7F	22	ADJ. LEFT COWL FLAP	1	3.5		40		100	10	
7F	25	ADJ. RIGHT COWL FLAP	1	3.5		40		100	10	
7G	01	MOVE STROBE LIGHT SWITCH	1	2.7		20	100		10	
7G	04	MOVE NAV. LIGHT SWITCH	1	2.7		20	100		10	
7G	07	MOVE ROT. BCN. LIGHT SWITCH	1	2.7		20	100		10	
7G	10	MOVE MAP LIGHT SWITCH	1	2.7		20	100		10	
7G	13	MOVE TAXI LIGHT SWITCH	1	2.7		20	100		10	
7G	16	MOVE LEFT LDG. LIGHT SWITCH	1	2.7		20	100		10	
7G	19	MOVE RIGHT LDG. LIGHT SWITCH	1	2.7		20	100		10	
7G	22	MOVE #1 PNL. LIGHTS	1	2.8		20		100	10	
7G	25	MOVE #2 PNL. LIGHTS SWITCH	1	2.8		20		100	10	
7G	28	MOVE RADIO LIGHTS SWITCH	1	2.8		20		100	10	
7G	31	MOVE RED/WHITE SWITCH	1	2.6		20		100	10	
7H	01	MOVE LEFT MAGNETO SWITCH	1	2.9		20	100		10	
7H	04	MOVE RIGHT MAGNETO SWITCH	1	2.9		20	100		10	
7V	01	SCAN VACUUM GAGE	1	2.6		100			10	
8A	01	SCAN OUTSIDE AIRCRAFT	1	1.5	100				10	
			2	2.0	100				10	
			3	2.5	100				10	
			4	3.0	100				10	
8A	04	SCAN OUTSIDE AIRCRAFT	1	3.5	100				10	
			2	4.0	100				10	
			3	4.5	100				10	
			4	5.0	100				10	
8B	01	SCAN ENROUTE CHART	1	2.0		100	10	50	10	
			2	3.0		100	10	50	10	
			3	4.0		100	10	50	10	
			4	5.0		100	10	50	10	
8B	03	SCAN IDENT ON CHART	1	3.0		100	10	50	10	1T0311
8B	04	FIND APP. PLATE	1	4.0		100	10	90	10	
8B	07	SCAN APP. PLATE	1	2.0		100		30	10	
			2	3.0		100		30	10	
			3	4.0		100		30	10	
			4	5.0		100		30	10	
8B	08	HOLD CHART	1	1.0				50	10	
			2	2.0				50	10	
8B	10	SCAN CHECKLIST	1	2.0		100		30	10	
			2	3.0		100		30	10	
8B	13	COPY CLEARANCE	1	2.5		100	10	100	10	
			2	3.0		100	10	100	10	
			3	3.5		100	10	100	10	
			4	4.0		100	10	100	10	
8B	16	COPY CLEARANCE	1	4.5		100	10	100	10	
			2	5.0		100	10	100	10	
			3	5.5		100	10	100	10	
			4	6.0		100	10	100	10	

(c) Concluded.

Figure 22.- continued

SUBSYSTEMS

1A COM #1
1B COM #2
1N TRANSPONDER
1P VOICE
1T AUDIO
3A AIRSPEED INDICATOR
3H ALTIMETER
3L VERTICAL SPEED INDICATOR
3N CLOCK
3P NEEDLE/BALL
3R ATTITUDE INDICATOR
3U OAT INDICATOR
3V MARKER BEACON
4A PRIMARY ATTITUDE CONTROL
4B PROPULSION CONTROL
4D LANDING GEAR
4E FLAPS
4G TRIM
5D ADF/RMI
5K MAGNETIC COMPASS
5P DME
5U NAV #1
5V NAV #2
7B ELECTRICAL
7C FUEL
7F ENGINE
7G LIGHTS
7M ENGINE STARTING
7V VACUUM
8A VISION
8B CHARTS/CHECKLISTS

(d) Subsystem data.

Figure 22.- concluded.