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HOUSTON-GALVESTON VESSEL TRAFFIC SERVICE WATCHSTANDER ANALYSIS

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16. Abstract

A team of human factors specialists analyzed the performance of watchstanders in the U.S. Coast Guard Vessel Traffic Center at Houston, TX. Data collected included copies of the center's forms and logs, records of watchstander activities for a total of fifteen hours of observation, timed measurements of typical watchstander activities and computer delays, records of twelve in-depth interviews with center personnel, stress questionnaires administered to nine watchstanders, and photographs of equipment and workspace layout. Analysis of the data yielded tentative models of time utilization and the relationship of activity to traffic load and sixteen suggestions for improving operations.

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PREFACE

This is an interim report on the analysis of watchstander activities at the Houston-Galveston Vessel Traffic Service. The study was performed by the Human Factors Branch of the Department of Transportation's Transportation Systems Center (TSC) under the sponsorship of the US Coast Guard's Office of Research and Development. Further analysis of the Houston-Galveston data is planned, particularly with the transcripts of radio communications. These initial results, however, were judged to be of enough interest to warrant an early report.

The authors wish to express their sincere thanks to LCDR C.T. Johnson and LT P.R. Corpuz of the Office of Research and Development and to CDR E. Schneider and all the personnel of the Houston-Galveston VTS for the encouragement and support provided by them in every phase of this study. We also gratefully acknowledge the guidance and contributions to the report provided by Dr. H.P. Bishop, Program Manager and Chief, Human Factors Branch (DTS-532) at TSC.

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METRIC CONVERSION FACTORS

Approximate Conversions to Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
in	inches	2.5	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
		AREA		
in^2	square inches	6.5	square centimeters	cm^2
ft^2	square feet	0.09	square meters	m^2
yd^2	square yards	0.8	square meters	m^2
mi^2	square miles	2.6	square kilometers	km^2
	acres	0.4	hectares	ha
		MASS (weight)		
oz	ounces	28	grams	g
lb	pounds	0.45	kilograms	kg
	short tons (2000 lb)	0.9	tonnes	t
		VOLUME		
tsp	teaspoons	5	milliliters	ml
Tbsp	tablespoons	15	milliliters	ml
fl oz	fluid ounces	30	milliliters	ml
c	cups	0.24	liters	l
pt	pints	0.47	liters	l
qt	quarts	0.95	liters	l
gal	gallons	3.8	liters	l
ft^3	cubic feet	0.03	cubic meters	m^3
yd^3	cubic yards	0.76	cubic meters	m^3
		TEMPERATURE (exact)		
°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C

Approximate Conversions from Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
mm	millimeters	0.04	inches	in
cm	centimeters	0.4	inches	in
m	meters	3.3	feet	ft
m	meters	1.1	yards	yd
km	kilometers	0.6	miles	mi
		AREA		
cm^2	square centimeters	0.16	square inches	in^2
m^2	square meters	1.2	square yards	yd^2
km^2	square kilometers	0.4	square miles	mi^2
ha	hectares (10,000 m^2)	2.5	acres	
		MASS (weight)		
g	grams	0.035	ounces	oz
kg	kilograms	2.2	pounds	lb
t	tonnes (1000 kg)	1.1	short tons	
		VOLUME		
ml	milliliters	0.03	fluid ounces	fl oz
l	liters	2.1	pints	pt
l	liters	1.06	quarts	qt
l	liters	0.26	gallons	gal
m^3	cubic meters	35	cubic feet	ft^3
m^3	cubic meters	1.3	cubic yards	yd^3
		TEMPERATURE (exact)		
°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F

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ABBREVIATIONS

COTP	-	Captain of the Port
CRT	-	Cathode Ray Tube
DE	-	Vessel Departure Sheet
DI	-	Command Dictionary
DR	-	Dead Reckoning Plot Sheet
HOU-GAL	-	Houston-Galveston
ID	-	Identification Number
IP	-	Vessels In-Port Sheet
LLLTV	-	Low Light-Level Television
LNG	-	Liquefied Natural Gas
LOA	-	Length Overall
PPI	-	Plan Position Indicator
SOA	-	Speed of Advance
SS	-	Vessel Status Sheet
SW	-	Sector Watchstander
TR	-	Traffic Summary Sheet
TSC	-	Transportation Systems Center
VMRS	-	Vessel Movement Reporting System
VTC	-	Vessel Traffic Center
VTS	-	Vessel Traffic Service
VTS-DACS	-	VTS Data Acquisition and Control System
VU	-	Vessels Underway Sheet
WS	-	Watch Supervisor
XC	-	External Communicator

EXECUTIVE SUMMARY

As the first study in a program for the evaluation of watchstander productivity in US Coast Guard Vessel Traffic Services (VTS's), a team of human factors specialists from the Department of Transportation's Transportation Systems Center (TSC) collected and analyzed data on watchstander activities at the Houston-Galveston VTS. During the period September 19-21, 1977, the following information was obtained:

Copies of VTS forms and logs;
Detailed records of watchstander activities for a total of fifteen hours of observation;
Repeated time measurements of typical watchstander actions and computer delays;
Records of twelve in-depth interviews with VTS personnel;
Stress questionnaires administered to nine watchstanders;
Photographs of equipment and workspace layout.

The Houston-Galveston area is divided into three sectors, each served by a Sector Watchstander (SW) at a sector position in the Vessel Traffic Center (VTC). Each sector position has a control console for a VHF-FM radio communications system, a computer terminal (a keyboard and two cathode-ray-tube displays) for the VTS-Data Acquisition and Control System (VTS-DACS), and controls for surveillance aids (television or radar). Position reports and identifying data are radioed from the vessels to the SW, who manually enters the data into the VTS-DACS via the keyboard. The computer then dead-reckons and displays current vessel positions and other relevant traffic information. Subsequent positions, reported or observed on television or radar, are used to verify and (if necessary) correct the computed data. At the time of the study, the Houston-Galveston VTS was maintaining a backup tracking system that involved advancing traffic status cards along a slotted board.

The SW monitors his displays and periodically radios a traffic advisory to each vessel in his sector. The advisory is generally limited to an enumeration of traffic that the vessel will encounter, discrepancies in aids to navigation, significant weather, and channel hazards or obstructions. If conditions require it, special cautions and directions may be included in an advisory.

The SW's are supervised by a Watch Supervisor (WS) and assisted by an External Communicator (XC).

Houston-Galveston VTS records show an average annual traffic load of 250 vessels per day, 50 ships and 200 tows. During the three days of TSC observations, traffic averaged 243 vessels per day, 44 ships and 199 tows. Sector loads varied from 4 to 20 vessels during observations, with a mean load of 10 vessels. No significant incidents were reported on the observation days. Therefore we conclude that our observations were based on a reasonably representative sample of "routine" operations.

Over the fifteen hours of observation of SW activities, 6759 activities were recorded. General activity levels were highest in the sectors having the highest traffic load. Within sectors, communicating with vessels and working with Vessel Status Cards varied with the traffic load or with changes in traffic load, but the monitoring activity (use of computer-generated traffic displays, television or radar displays) was relatively independent of traffic.

The principal types of activities were also timed. Combining frequency of an activity with average time to perform the activity yields an estimate of the total amount of time involved in performing the activity. Because the time measurements varied over a wide range and were not made concurrently with the frequency observations, care must be taken to interpret the combined figures as only rough estimates. These estimates showed the following allocation of time to activities during the fifteen hours of observation of Sector Watchstanders:

Communicating with vessels	18 percent
Monitoring the computer	12 percent
Keying the computer	16 percent
Using the Vessel Status Cards	23 percent
Using radar	5 percent
Using television	23 percent
Miscellaneous activities	3 percent.

These figures indicate that in routine operations at the Houston-Galveston VTS, delivery of the primary product, traffic advisories, occupies less than two-tenths of the sector Watchstander's time; the rest of the time is devoted to supporting activities. Monitoring displays, in order to be ready to issue advisories, occupies about 40 percent of the SW's time. Working with the Vessel Status Cards takes up nearly a quarter of the time, while keying entries and requests into the computer takes over fifteen percent. The rest of the time (about three percent) goes to such miscellaneous activities as looking up data in reference files, talking to other watchstanders, and occasionally leaving the position briefly.

The comments and opinions expressed by the VTS personnel in the interviews identified some operational problems that were also reflected in the data. The principal set of problems centers on inadequacies of the VTS-DACS, including:

Inadequate integration of displayed data
Excessive keying requirements
Display delays
Request rejections
Inaccurate data.

Basically, the SW needs to know the location and identification of every vessel in his sector. To get this information from the VTS-DACS, he must look at two displays (a plan position display and a vessel listing) and mentally integrate this information. To get supplementary information (such as vessel intentions, future encounters, vessel in port, etc.) from the VTS-DACS, or to enter information, the SW must call up other displays. Since he has only two display devices, he must always lose a basic display while using any supplementary display. To change a display requires at least four keystrokes and may require up to fourteen. Because of computer memory limitations, there is a delay of at least one second, generally two seconds, and possibly ten seconds after the keying is completed before the requested information is displayed. If keying is too fast, or if power fluctuates, the computer may reject a request, forcing the SW to repeat the entire keying operation. In our limited testing, two-to-seven percent of our display requests were rejected. Finally, since changes in vessel speeds are often unreported and undetected, the displayed positions and projected positions are frequently in error.

The first consequence of these problems is that the SW fails to make full use of the capabilities of the VTS-DACS. Both the usage ratings of displays made in the interviews and the observations of watchstanders at work showed that SW's tend to use only those displays they can't avoid using, rarely calling up supplementary information. In particular, the display that should be the basis for every traffic advisory (Traffic Status Summary), requiring excessive keying and subject to excessive delay, is almost never used.

A second consequence of this situation is that the Vessel Status Card tracking and reference system is still relied on heavily for information. About one-quarter of the SW's time is spent in maintaining and using it, and it seems unlikely that it can be dropped until the VTS-DACS can be made more responsive to the SW's needs.

A second problem area concerns workspace illumination. The stress questionnaires yielded consistent reports of aching or burning eyes and tiredness, also noted in two interviews. One cause of this could be the need for frequent visual readaptation to varying levels of brightness in the visual field, particularly to glare spots in a generally dim environment.

A third area of possible problems was identified from comments in the interviews to the effect that the present arrangement of equipment inhibits interactions among SW's, prevents them from keeping up with the system-wide traffic situation, and makes group cooperation in problem situations difficult.

Consideration of these problems and additional information from the observations and interviews leads TSC to offer some recommendations. The feasibility and desirability of implementing these suggestions can not be determined from this study; however, the ideas seem worthy of note and possible further study.

a. Add additional television sites to Sector III.
b. Add a radar site to Sector II.
c. Provide additional computer display scopes at Sector Watchstander positions.
d. Reprogram the VTS-DACS display formats to eliminate unnecessary displays, to add entry time to the Vessel Departures Sheet, and to allow expansion and off-centering of the Dead Reckoning Sheet.
e. Increase the computer memory capacity to permit reduction in display delay times.
f. Add more function keys to the keyboard to reduce the number of keystrokes required for requests and commands.
g. Provide a trackball or joystick for cursor control on the VTS-DACS displays.
h. Extend the tracking algorithm to include predictions of changes in vessel speed.
i. Obtain a more stable power supply for the VTS-DACS.
j. Reorient and shield the radar PPI's to reduce glare.
k. Increase room illumination to the level of television and computer displays.
l. Mask down the brightness of self-illuminated panel buttons.
m. Conduct follow-on stress evaluations as an aid to evaluation of the twelve-hour watch schedule.
n. Study the relative merits of grouped versus segregated sector positions.
o. Provide at least one position for a full-time training instructor.

p. Establish a set of criteria for selection of personnel for VTS duty.

1. INTRODUCTION

1.1 Purpose

In order to reduce the probability of vessel collisions and groundings in crowded waterways, and to keep individual vessels apprised of the total traffic situation, the US Coast Guard is operating several Vessel Traffic Services (VTS's). To profit from the experience gained in operating these VTS's, both to improve present services and plan future services, the Coast Guard's Office of Research and Development has undertaken a broad program of analysis of VTS operations.

Human performance is basic to the operation of a VTS. The principal product of a VTS is a traffic advisory communicated by a VTS watchstander to a vessel master or pilot via VHF radio. The value of the advisory is dependent on the skills of the various watchstanders in acquiring and monitoring traffic data, in integrating the data into a coherent picture of present and anticipated traffic, and in composing and delivering a clear, concise and accurate traffic advisory. Therefore the Coast Guard has recognized that any model of VTS operations and productivity must include the influence of watchstander performance on system performance. The Coast Guard's Office of Research and Development has commissioned the Human Factors Branch of the Department of Transportation's Transportation Systems Center (TSC) to obtain and analyze data on watchstander performance and to integrate the results into models of watchstander activity and productivity.

1.2 Scope

For its first year's work on this study of VTS watchstanders, TSC has undertaken the collection and analysis of data on watchstander activities in routine operations in four operating VTS's: Houston-Galveston, Puget Sound, New Orleans and San Francisco. This report presents the initial results of the analysis of the first VTS -- Houston-Galveston.

2. DESCRIPTION OF HOUSTON-GALVESTON VESSEL TRAFFIC SERVICE

2.1 Purpose of VTS's

The Ports and Waterways Safety Act of 1972 authorizes the Coast Guard to operate vessel traffic services (VTS's) in designated areas to "...prevent collisions and groundings and to protect the navigable waters of the VTS Area from environmental harm resulting from collisions and groundings."* VTS's meet this objective "... by providing pilots and masters of vessels information concerning vessel traffic conditions and navigational hazards that would otherwise not be available to them."**

2.2 General Characteristics of HOU-GAL VTS

The Houston-Galveston Vessel Traffic Service (HOU-GAL VTS) provides a 24-hour service to three major ports (Houston, Galveston and Texas City), several sub-ports, and more than 70 miles of navigable channels. The VTS handles about 250 transits per day*** some 20 percent of which are ships, 80 percent tows (barges pushed by tug boats). Because of the narrowness of the Houston Ship Channel (300 to 400 feet) and the shallowness of Galveston Bay, there is relatively little traffic other than commercial. The commercial traffic volume is increasing; over the first two years of VTS operation (March 1975-March 1977), traffic load increased by 38 percent. Over 60 percent of the cargo tonnage in the system is dangerous -- petroleum, liquefied natural gas (LNG), acetone, chemical fertilizers and sulfuric acid --making Houston the nation's leading port in terms of dangerous and volatile cargoes.**** All of this traffic moves in narrow, shallow, often winding channels lined with some 300 docks and industrial facilities. Figure 2-1 shows the principal characteristics of the HOU-GAL VTS area, including its division into three sectors to facilitate information processing.

The HOU-GAL VTS is based on a voluntary Vessel Movement Reporting System (VMRS), in which participating vessels report their position to the Vessel Traffic Center (VTC) via VHF-FM radio from designated reporting points, and the VTC radios back advisories on traffic and related conditions. Surveillance is

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*Code of Federal Regulations, 33CFR161.101
**Puget Sound VTS Traffic Center Manual, #1.1.2
***Statistics provided by HOU-GAL VTS
****O'Hara, E. "How to Guide Ships Through a Dangerous Port: VTS Does it in Houston." Transportation USA, 3, 2, p.6-10, 1977

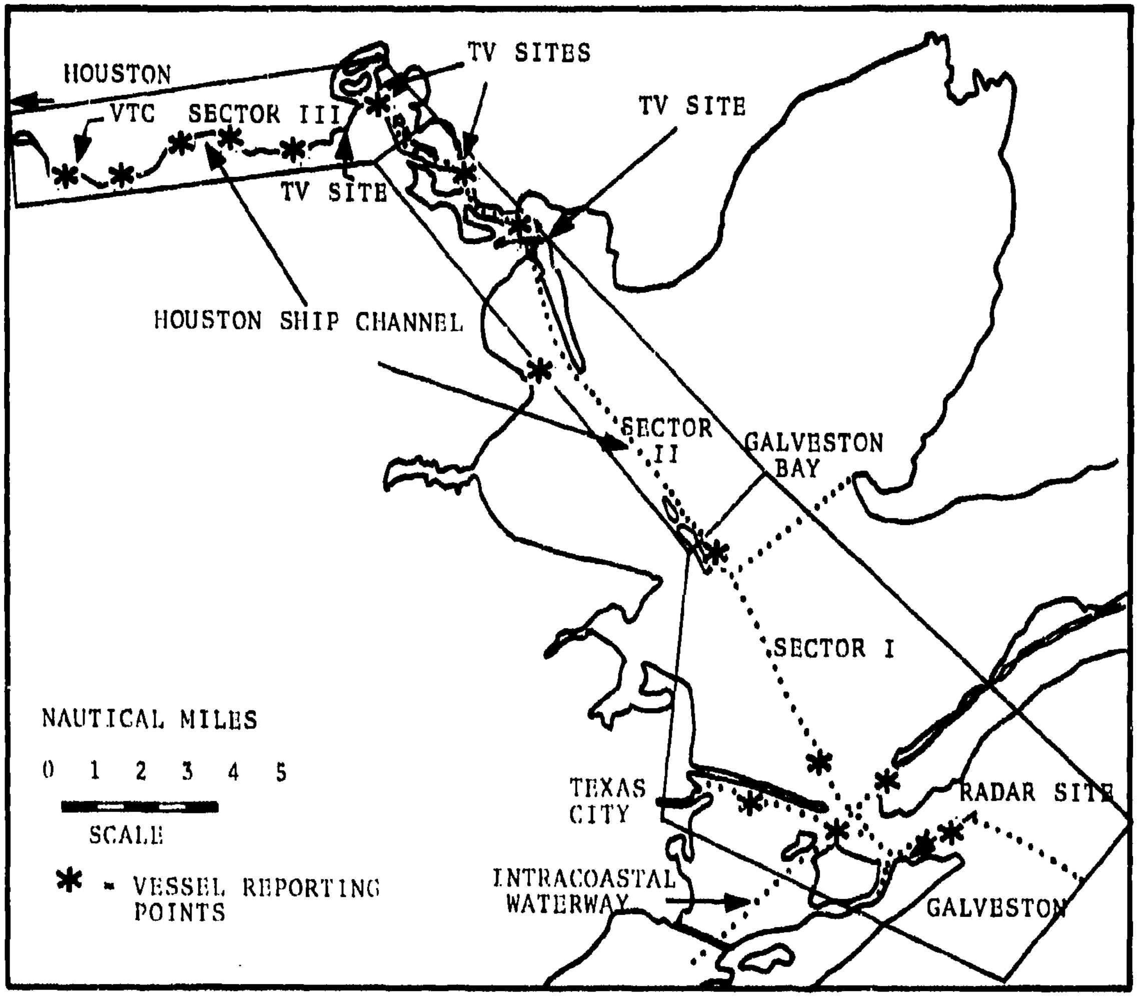


FIGURE 2-1. GENERAL CHARACTERISTICS OF THE HOU-GAL VTS AREA

aided by a precision radar site in Galveston (effective range 8 nautical miles) and four camera sites (2 cameras per site) for a closed-circuit low-light-level television (LLLTV) system along the northeastern portion of the Houston Ship Channel. To assist the Coast Guard watchstanders at the VTC, a Data Acquisition and Control System (VTS-DACS) accepts manually input information on each vessel (location, speed, destination, etc.), automatically computes a track for each vessel by dead reckoning, and presents track data and listings of summary information on cathode ray tube (CRT) displays.

2.3 Functions

A standing order of the HOU-GAL VTS lists their traffic control functions, in "marching order", as follows:

Monitor
Anticipate
Inform
Caution
Direct (only when necessary).

2.3.1 Monitoring

Monitoring the traffic situation involves creating and maintaining as accurate a picture of the current traffic situation as available data permit. This picture is based on the VMRS position reports, supplemented by whatever surveillance (radar, television) information is available.

The basic display of such information is the Dead Reckoning Plot Sheet (DR), a CRT display produced by the VTS-DACS. A DR display covers only one sector of the system; thus to survey the entire system one must either call up three successive displays on one CRT or view three separate CRT's. Since the DR display does not include identity tags, it is usually paired with a Vessels Underway Sheet (VU), displayed on a second CRT, which lists the names and basic data of vessels underway in the sector. Several other listings of traffic information are available, usually called up on the CRT used for the VU sheet. (See Section 2.6.2 for a more detailed description of available displays and Appendix A for examples).

Prior to inauguration of the VTS-DACS, the traffic picture was maintained on a large, wooden plotting board. Slits in the board represented locations in the system, and each vessel in the system was represented by a manually prepared vessel status card placed in the appropriate slit. The cards and smaller versions of the board (one for each sector) are still maintained as a backup to the DACS.

Vessels entering the system report via the VMRS, or are detected on radar or television displays and called by the VTS. The watchstander manually prepares a vessel status card containing such information as:

- Name
- ID (an identification number supplied by the computer)
- Type
- Entry Position
- Destination
- Tow Makeup
- Draft
- Length Overall (LOA)
- Beam
- Speed of Advance (SOA)

(Figure 2-2 shows a typical vessel status card).

The information on the card is entered into the DACS computer via the keyboard, using a Vessel Status Sheet (SS) on one of the CRT's. The SS contains essentially the same information as the cards plus information added by the computer (such as vessel ID and conversion of locations to quarter-mile cell numbers). If the entry contains an entry cell, exit cell and SOA, the computer immediately starts dead-reckoning the vessel's position and updating appropriate displays every 15 seconds.

Following keyboard entry, the vessel status card is time stamped and placed in the appropriate slit in the plotting board. Periodically the cards are advanced on the plotting board.

2.3.2 Anticipating

The watchstander anticipates future traffic situations by mentally extrapolating from the current situation. This involves prediction of passing and overtaking situations primarily. Present position and SOA are used to dead-reckon future positions, with modifications for expected changes. Some

NAME	NOPAL VEGA
ID	638
TYPE Lash Cont. Frt. RoRo Tkr. LNG LPG Gas Chem. Tow LH/Tug Notch O/S F/V P/C	
ENTRY POS	Sea
DESTINATION	CO22
TOW MAKE UP Pushing Abreast Tandem Astern Hip	
DRAFT	15
LOA	474
BEAM	64
SOA	
OVER	NEW CARD

FIGURE 2-2. EXAMPLE OF A VESSEL STATUS CARD

changes are based on reported intentions; others depend on the watchstander's experience--for example, knowing where vessels will typically speed up or slow down. Where available, radar and television imagery are used to verify expectations and to detect unexpected or unreported situations that require changes in anticipated events.

As an aid to dead-reckoning, the VTS-DACS will produce, on request, a Traffic Summary Sheet (TR) for a given vessel. This CRT display lists all expected encounters between the named vessel and other vessels in the system, giving for each encounter the vessel identification, time of encounter, location of encounter (cell number), and direction of movement. This display will list only vessels that have been entered into the computer and is based on linear extrapolation of the speed and location currently in memory. The watchstander may correct speed and location data in the VTS-DACS memory by keyboard entries as the traffic situation develops.

2.3.3 Informing

The watchstanders inform the vessels in the system of relevant traffic situations by providing traffic advisories. Every vessel is provided individual advisories through VHF-FM radio transmissions. An advisory may contain any or all of the following elements:

Anticipated traffic (meeting, overtaking or crossing)
Discrepancies in Aids to Navigation
Channel hazards or obstructions
Weather warnings and information
Traffic controls
Any other information which may affect vessel traffic safety or the port.

A traffic advisory is provided each vessel as it enters the VTS system, at every movement reporting point, and at any other time when it is apparent that changing conditions warrant it.

A typical traffic advisory follows: "DORLI this is HOUSTON TRAFFIC; the display shows two inbound ships above Buoy 18, one ship getting underway from Bolivar anchorage bound for Galveston, one tow coming out from Pelican Cut. Buoy 25 is off station. Over."

2.3.4 Cautioning

When an unusual event occurs, every vessel that could be affected by it is given a special advisory in sufficient time for the Master or Pilot to initiate appropriate action. Unusual events include:

Channel closures ordered by higher authority

Controlled traffic situations ordered by higher authority

Dangerous conditions in the port

Major collisions, fires, groundings, etc.

Any other situation judged dangerous by the VTC Watch Officer.

A caution advisory includes a brief description of the situation followed by timely updates. Channel conditions (closed, blocked, hazardous, etc.) are included, and the vessel is requested to report its intentions.

2.3.5 Directing

Although the HOU-GAL VTS, being a voluntary service, does not have direct authority to control traffic, each Captain of the Port (COTP) in the VTS area not only has such authority for emergency situations but must coordinate such control with the VTS. Beyond relaying orders for vessel traffic control through the VTS, the COTP's have delegated their authority to the Watch Supervisor on duty in situations requiring immediate direction and control of vessel traffic. This authority is used sparingly and must never include (or imply) direct orders for control of vessel speed or direction (such as "stop engines", "slow ahead", turn" or "back down.") A direction will generally include a statement imposing the necessary restrictions, a description of the circumstances requiring them, and the requirement that the vessel report its intentions.

Typical directing advisories follow: "SEA SPEED this is HOUSTON TRAFFIC. Due to severe channel congestion between Greens Bayou and Sims Bayou proceed at reduced speed; do not overtake the tug STARLIGHT. Report when passing Sims Bayou." "PURPLE KAY this is HOUSTON TRAFFIC. A fire has been reported in the Texas City Canal. Captain of the Port Galveston has closed the canal channel pending further investigation. You are directed not to enter the Texas City Canal. Please report your intentions."

2.3.6 Additional Functions

In addition to these basic traffic service functions, the HOU-GAL VTS will relay messages between Coast Guard units and between vessels and on-shore company installations when it does not interfere with the basic functions.

To be able to perform the VTS functions, watchstanders also perform such support functions as preparation and dissemination of records, reports and messages, and training.

2.4 Manning and Scheduling

2.4.1 General Manning

At the time of this study, the HOU-GAL VTS had a complement of 30 operational personnel, 6 officers and 24 enlisted, divided among four Watch Sections as shown in Table 2-1. Each section included one officer, at least three watchstanders qualified on all sectors, and several trainees.

2.4.2 Selection

Full Lieutenants with seagoing experience as Operations Officer on a High Endurance Cutter or a Low Endurance Cutter, or as Commanding Officer of a Patrol Boat, are needed as Watch Supervisors. Anyone with average or above average proficiency and due for a shore assignment may be selected for a VTS Watchstander assignment. Special consideration is given to those who volunteer for the assignment. In general, VTS Watchstander assignments have been made from Radarman and Quartermaster ratings.

TABLE 2-1.

HOU-GAL VTS OPERATIONAL COMPLEMENT

CDR Commanding Officer

LCDR Executive Officer

	Section 1	Section 2	Section 3	Section 4
LT	1	1	1	1
RDCS		1		
RDC	1			1
QMC			1	
RD1	2	1	1	
QM1	1		1	1
RD2	1	1	1	
QM2		1	1	1
RD3	1			2
QM3	1	1	1	1

2.4.3 Training

Training is primarily on-the-job (OJT). Briefings and orientation trips are arranged, but there is no formal schedule of classes. The training is managed by a CPO, but there are no "instructors" in the usual sense. Every trainee must complete 36 training units, designed to be accomplished in eight weeks; however, each trainee proceeds at his own pace, some finishing in six weeks, occasionally someone failing to qualify at all. Generally, it takes up to six months for a watchstander to become fully proficient.

The basic elements of the training course are:

Channel and Traffic Knowledge. Orientation rides on various vessels; study of charts, slides, photos, TV imagery, radar imagery; vessel identification; tow makeups; types of cargo; maneuvering problems, and rules of the road.

VTC Operation. Voice procedures, operation of all equipment, record keeping, charts and publications.

Examinations. Written exam by Senior Watch Officer or Training CPO; oral exam by the Commanding Officer, and practical exam by a Watch Officer.

2.4.4 Work Schedule

There is a regular rotation of the four watch sections through watches and days off. While field data were being collected for this study the VTS changed from an eight-hour watch to a twelve-hour watch. Both schedules involve the same ratio of duty to off-duty time. The new schedule is four days on, four days off, whereas the old schedule was twelve days on, four days off. Thus more time on watch with less time off on duty days have been accepted to obtain more frequent blocks of off-duty days (see Table 2-2).

Typically, during a watch, the watchstanders rotate through the three sector and the XC positions, changing position every two hours at the WS's direction.

TABLE 2-2.

HOU-GAL VTS WATCH SCHEDULES

Table Entries are Watch Sections (1-4)

New Schedule	M	T	W	T	F	S	S
Week 1							
06-18	1	1	1	1	4	4	4
18-06	2	2	2	2	3	3	3
Week 2							
06-18	4	2	2	2	2	3	3
18-06	3	1	1	1	1	4	4
Week 3							
06-18	3	3	1	1	1	1	4
18-06	4	4	2	2	2	2	3

Old Schedule							
Week 1							
00-08	1	1	1	1	2	2	2
08-16	3	3	3	3	1	1	1
16-24	4	4	4	4	3	3	3
Week 2							
00-08	2	4	4	4	4	3	3
08-16	1	2	2	2	2	4	4
16-24	3	1	1	1	1	2	2
Week 3							
00-08	3	3	1	1	1	1	2
08-16	4	4	3	3	3	3	1
16-24	2	2	4	4	4	4	3

2.5 Operating Positions

The HOU-GAL VTS provides its services by assigning various activities to the following operating (or duty) positions: Watch Supervisor (WS), Sector Watchstander (SW), and External Communicator (XC). A basic Watch Section is comprised of one WS, three SW's and one XC. In addition, an electronics technician is on call, and one or more trainees may be performing SW duties under supervision of a qualified SW.

2.5.1 Watch Supervisor

The Watch Supervisor is an officer who is responsible for the total VTS operation during a watch, having the responsibilities of Officer of the Deck (OOD) as defined in USCG Regulations (CG-300). The WS is the direct representative of the Commanding Officer, and for emergency situations has been delegated the traffic control authority of the COTP. The WS stays continually aware of all activities of the VTS during his watch. He assigns his personnel to the various operating positions, supervises their performance, and rotates position assignments as circumstances require. Circumstances beyond the scope of control of SW's are referred to the WS; in turn, he notifies the CO or other authorities of matters beyond his scope of control. He is also responsible for internal unit safety, physical security, and the training of his Watch Section personnel.

The WS has the authority to draft and release messages and is responsible for proper message composition, dissemination and filing. He must also maintain the following records: Daily Unit Log, Daily Equipment Status/Service Log, Aids to Navigation File, Daily Message Files, and Daily Vessel Tally.

2.5.2 Sector Watchstander

Each SW conducts the basic VTS functions (monitor, anticipate, inform, caution and direct) for all traffic in his sector. He monitors appropriate VHF-FM channels and communicates with pilots and masters, receiving traffic information and issuing traffic advisories, operating his radio control equipment as required. On receipt of traffic data he enters the information on Vessel Status Cards and transcribes it to the VTS-DACS memory via the terminal keyboard. He time-stamps, files or hands off Vessel Status Cards as required. He monitors traffic on the VTS-DACS CRT displays, calling up various displays via the keyboard as needed. He continually cross-checks the displayed traffic situation against all other available information (such as monitored radio communications, television, and radar displays), setting and adjusting associated equipment as required. He anticipates developing traffic problems and advises the masters and pilots in time for them to initiate corrective action. If the situation requires it, he issues such directions as not to enter certain areas, not to overtake certain traffic, not to exceed a certain speed, and the like. When the situation permits or requires it, he assists other agencies (Coast Guard units, industrial organizations, etc.) by relaying messages via his communications equipment.

2.5.3 External Communicator

The XC functions basically to assist the WS. He generally handles routine incoming enquiries about traffic in the system and other matters. At the direction of the WS, he may assist a busy SW by entering data into the VTS-DACS. In practice, when traffic is light, the XC duty functions as a relief assignment. With WS approval, the XC may eat lunch, study, or leave the room for personal matters. The XC's VTS-DACS terminal is often used for demonstrations for visitors, practice by trainees, and familiarization with the traffic situation by relieving watchstanders.

2.6 Equipment and Workspace

2.6.1 VHF-FM Radio and Communications

The HOU-GAL VTS is equipped with VHF-FM communications with a microwave relay and control system. Radio coverage is provided by three high level transmitting/receiving sites--one for each sector. Six radio frequencies (channels) have been assigned to the VTS.

Each of the five operating positions at the VTC has a communications console which includes controls for selection of sites and channels for monitoring and transmitting, along with volume and squelch controls as needed.

The channel assigned specifically for VTS communications concerning vessel traffic management is Channel 12. Using a monaural headset, each SW continuously monitors Channel 12 through the site assigned to his sector and can transmit over that channel by actuating either a press-to-talk switch on the console or a foot pedal.

Channel 13 is reserved for bridge-to-bridge communications. Since inter-vessel communications are a rich source of information about vessel traffic and intentions, the SW monitors Channel 13 via a speaker on his console. If a vessel cannot be reached on Channel 12, the SW may contact it via Channel 13 and ask it to call back on Channel 12 or Channel 6. Channel 6, for authorized operational and administrative communications with commercial vessels, is generally limited to non-VTS communications, as is Channel 14, the port operations frequency. Channel 22A is used primarily for communication with Coast Guard units.

The WS monitors Channel 16, the International Calling and Distress frequency, to detect emergencies and provide assistance as necessary. Transmission on Channel 16 is limited to situations when a vessel cannot be reached on Channels 12 or 13.

Each communications console also contains whatever telephone equipment is appropriate for the position. Figure 2-3 shows the communications console at the XC position.

2.6.2 Vessel Traffic Data Acquisition and Control System

The VTS-DACS is a computer-based system. It accepts information entered manually by watchstanders, computes vessel movements by dead reckoning, stores data, and displays information when requested by keyboard action. The computer and associated equipment are located in a separate equipment room and are connected to each VTC position via a VTS-DACS terminal. Each terminal includes two black and white CRT display units and a Command Keyboard. The WS is provided with two VTS-DACS terminals.

Seven general categories of display formats (sheets) are available for presentation on any CRT unit. These sheets are:

SS - Vessel Status Sheet for each vessel
DR - Dead Reckoning Plot Sheet for each sector
VU - Vessels Underway Sheet for each sector
IP - Vessels In-Port Sheet for each port
TR - Traffic Summary Sheet for each vessel
DE - Vessel Departures Sheet for the VTS
DI - Command Dictionary.

Examples of these formats are given in Appendix A.

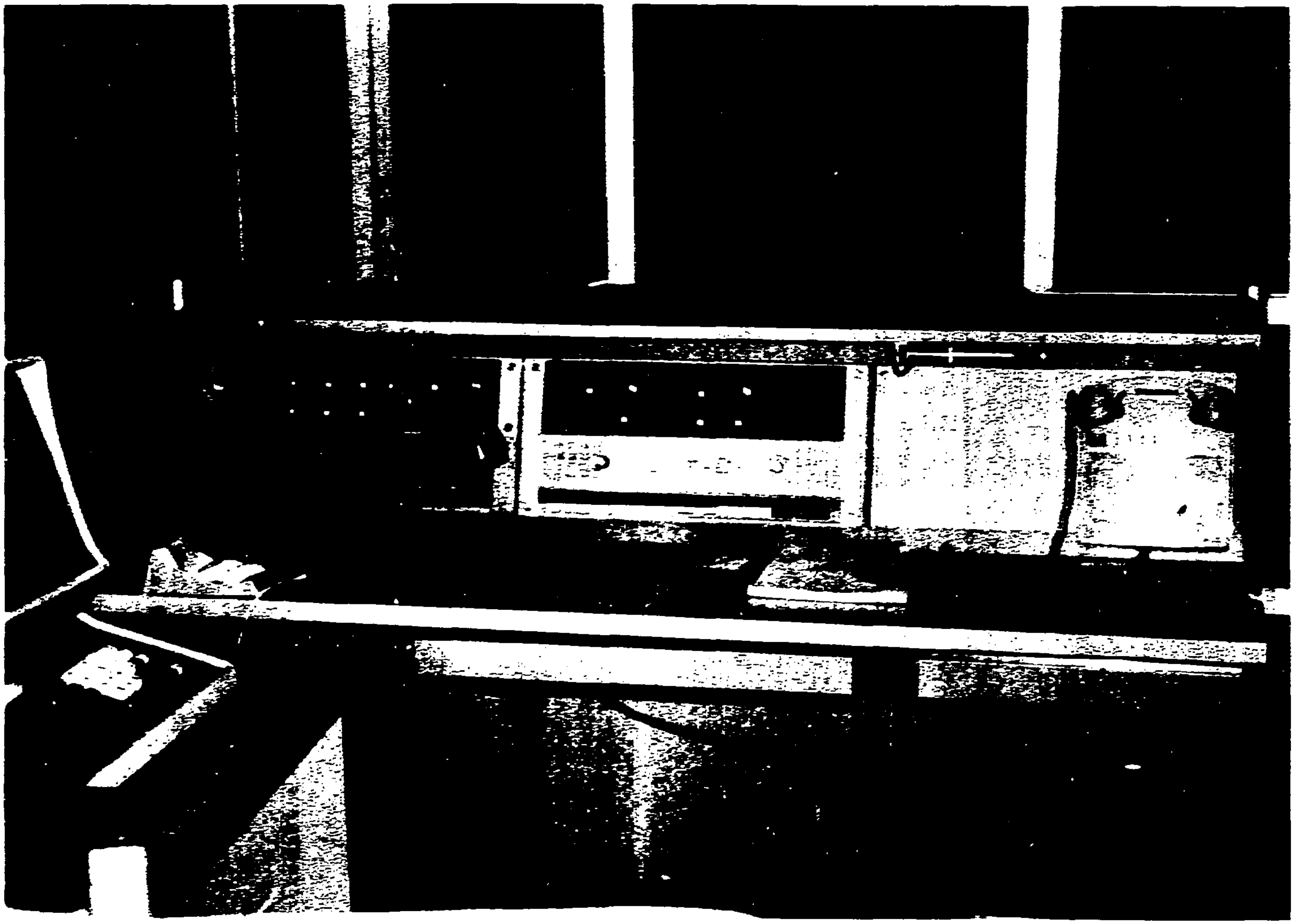


FIGURE 2-3. A COMMUNICATIONS CONSOLE

Vessel Status Sheet. This display summarizes all of the data available on a given vessel in the system. It is called up when data are initially entered, when new information must be entered, or when the watchstander wishes to refer to the information.

Dead Reckoning Plot Sheet. A separate DR sheet is available for each sector. Basically, the sector is divided into one-quarter-mile cells, each cell represented by a one-character column on the display. The DR sheet may be presented in any of four formats. Format A is always shown; it identifies key reference points and check points, indicates for each cell whether or not it is occupied by vessel traffic, including the number of vessels in the cell and direction of movement, shows sector boundaries, buoys, and other channel data, and has some space for special comments. Format A + B adds to Format A a location identification for each cell. Format A + C adds to Format A the number of each cell. Format A + B + C presents all data. Each combination may be selected by a single key action. The DR sheet is automatically updated every 15 seconds.

The watchstander generally keeps the DR sheet for his sector continually displayed on one CRT. This display is the basic pictorial plot of sector traffic and is the SW's primary reference.

Vessels Underway Sheet. This display lists every vessel in a sector, including name, ID, cell location, speed, next check point and estimated time of arrival at the next checkpoint for both inbound and outbound traffic. Unless other displays are in use, the VU sheet is continuously displayed on the SW's second CRT. It is automatically updated.

Vessels In-Port Sheet. Separate IP sheets are available for Houston, Galveston, and Texas City. Each sheet lists ships docked within the port, giving identifying data and other remarks.

Traffic Summary Sheet. This display lists, for a selected vessel and area, all of the other traffic the vessel will encounter within the area and when and where the encounters will take place (as predicted by dead-reckoning extrapolation). It is intended as a basic reference for the SW when preparing a traffic advisory. It is static when displayed, showing the status as of the time it was called up.

Vessel Departures Sheet. This display lists every vessel that has left the system during the current day (except ships docked in port). It is printed out off-line at the end of each day as a permanent record.

Command Dictionary. This display simply lists the commands that may be given the VTS-DACS via the Command keyboard.

Figure 2-4 shows a VTS-DACS terminal at one SW position and a closeup of a typical display on the CRT.

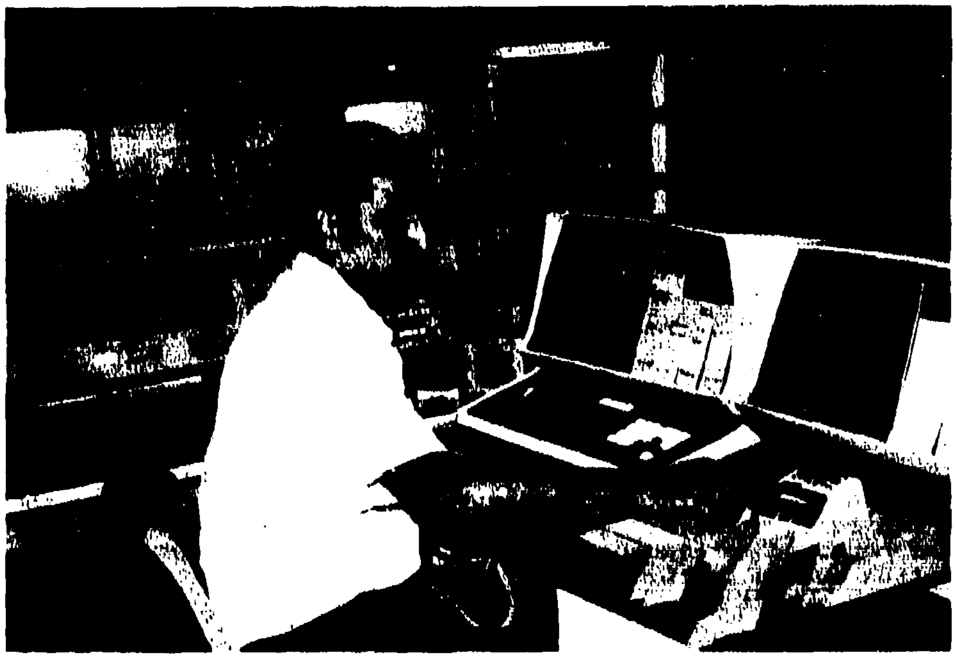
2.6.3 Television

The HOU-GAL VTS has four closed-circuit television surveillance sites. At each site two cameras are mounted so that each can be rotated through a full horizontal circle. Zoom optics permit a continuous range of adjustment of focal length. Two sites are in Sector II, two in Sector III.

At the VTC, the WS, SWII and SWIII positions each have a TV console containing four side-by-side twelve-inch monitors, set on top of the communications console. Each monitor is limited to one site. Each console has controls available and within reach of the seated watchstander to select either camera at each site, to pan or zoom each camera, and to adjust the brightness and contrast of each monitor. A TV console can be seen in the background of Figure 2-4a.

Typically the SW will set the two cameras at each of his two sites so that one looks up-channel, one down-channel, and will then arbitrarily select which camera at each site to monitor. When an event of interest occurs, he will use camera selection, pan and zoom actions to focus on the area of interest. Camera selection, pan and zoom actions at any console affect the corresponding display at the other consoles; that is, only one picture can be displayed in the VTC at a given time for a given site.

Two twenty-one-inch repeater monitors are suspended from the ceiling above the SWIII position. These are used for briefings, demonstrations for visitors, or group actions. The two pictures to be shown on the repeaters are selected by the WS. Figure 2-5 was photographed from such a repeater display.



a. Terminal

b. Closeup of Display

FIGURE 2-4. A VTS-DACS TERMINAL

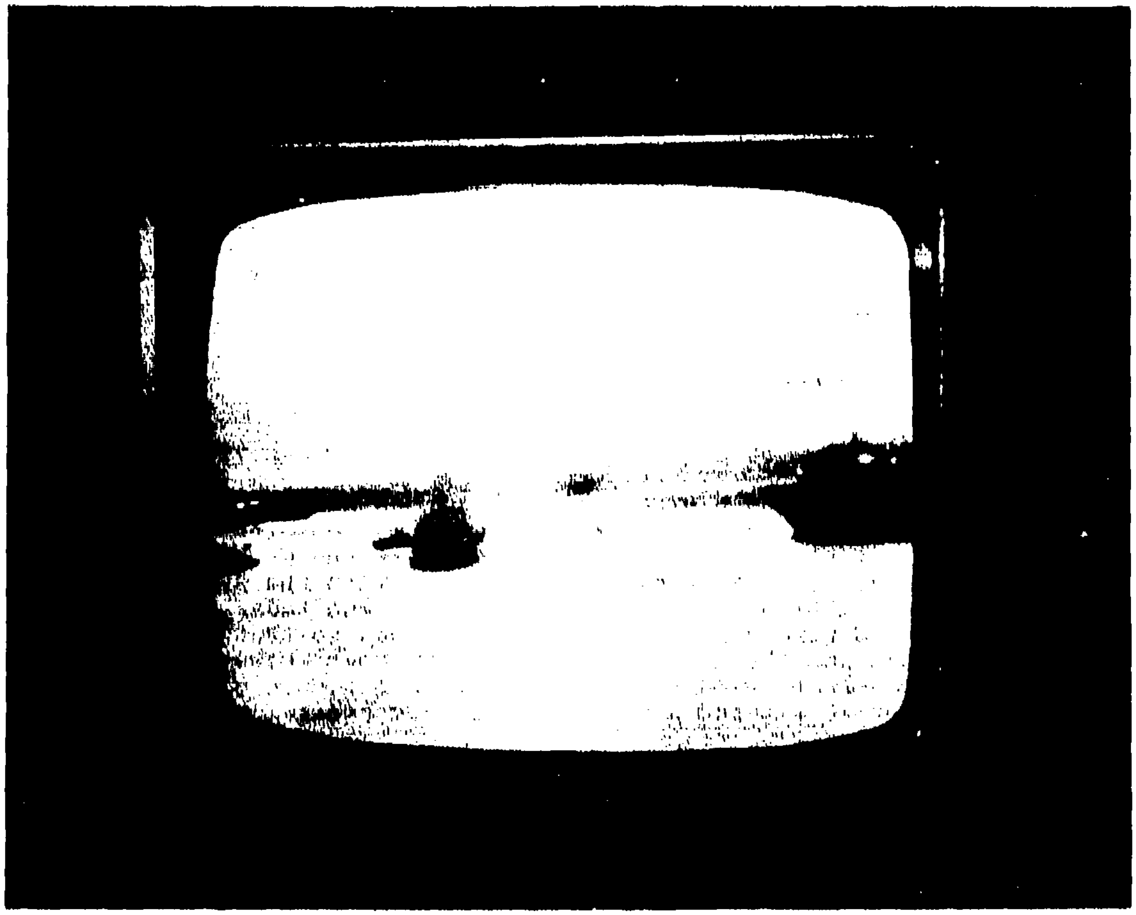


FIGURE 2-5. A TELEVISION DISPLAY

2.6.4 Radar

The HOU-GAL VTS has one high-resolution radar antenna and transmitting site located in Galveston (Sector I). The radar information is displayed in plan position indicator (PPI) format on a 16-inch CRT in each of two consoles (WS and SWI) at the VTC. Each console has off-center and range selection features as well as a cursor and brightness and contrast controls. Typically the display is set at the 8-mile range, off-centered so that Galveston is at the lower right and Texas City and the lower Houston Ship Channel can be monitored. Figure 2-6 shows a radar PPI display.

2.6.5 Workspace

The layout of basic equipment in the HOU-GAL VTC is shown in Figure 2-7.

Every position has a VTS-DACS terminal and a communications console, set at right-angles to each other. TV consoles are placed on top of the communications consoles at the WS, SWII and SWIII positions. One radar console is set between the SWI and SWII positions. The WS has communications, TV and radar consoles and two VTS-DACS terminals. SWIII is positioned so that he can see traffic passing the center through the windows; however, drapes must cover the windows during the day to reduce glare on the radar scopes. Figures 2-8 and 2-9 provide general views of the VTC layout.

2.7 Events in a Routine Transit

This study is limited to routine VTS operations. Here we will describe briefly the sequence of events as a vessel makes a normal transit through the system. This same information is diagrammed in detail in Appendix B in the form of Operational Sequence Diagrams.

2.7.1 Entry

Generally a vessel initiates a transit by calling in its intentions to the VTC via Channel 12 a short time before entering the system. The SW copies the relevant data onto a Vessel Status Card and then calls up the SS display on the VTS-DACS CRT. As information is keyed in to fill the blanks on the display, the computer provides some additional data; particularly, it assigns an ID number which the SW copies onto the card. When the vessel actually enters the system, the pilot

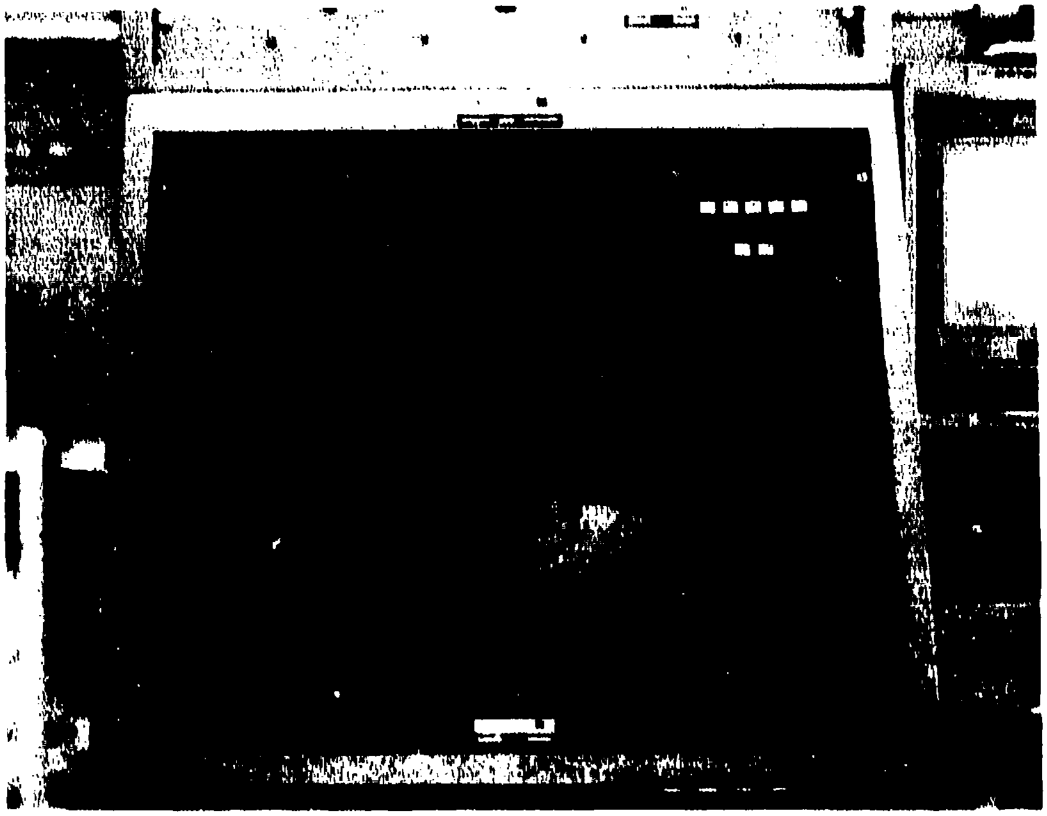
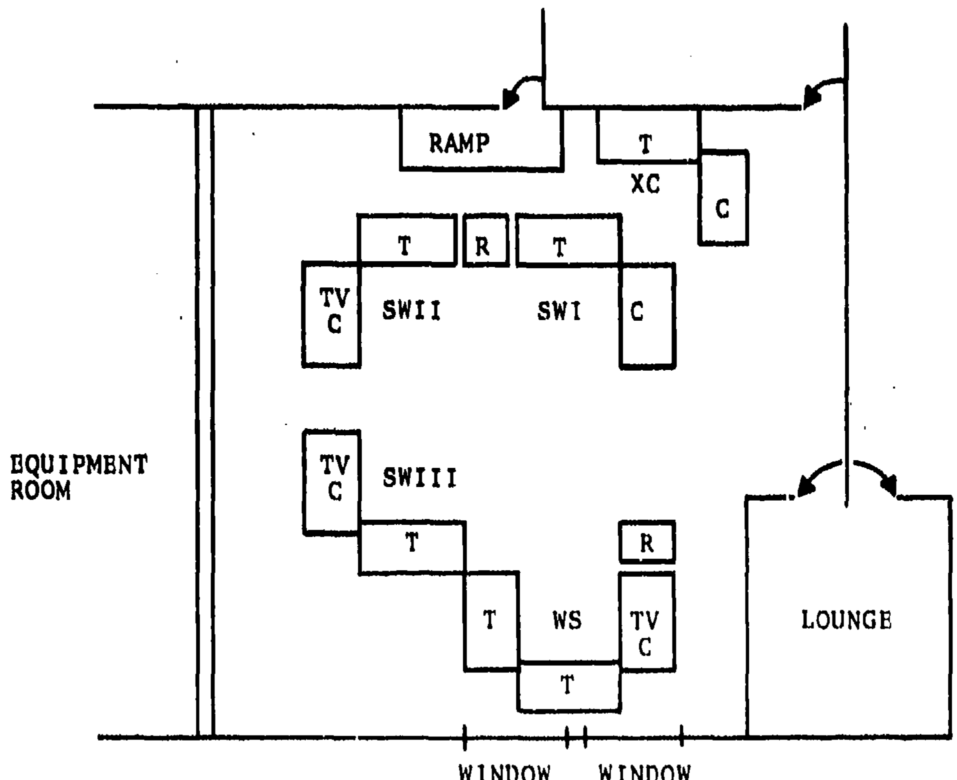


FIGURE 2-6. A RADAR PPI DISPLAY



C = Communications Console
T = VTS-DACS Terminal
TV= Television Console
R = Radar Console

FIGURE 2-7. VTC WORKSPACE LAYOUT

a. SW III

b. SW II

c. SW I

d. External Communicator

FIGURE 2-8. VTC POSITIONS

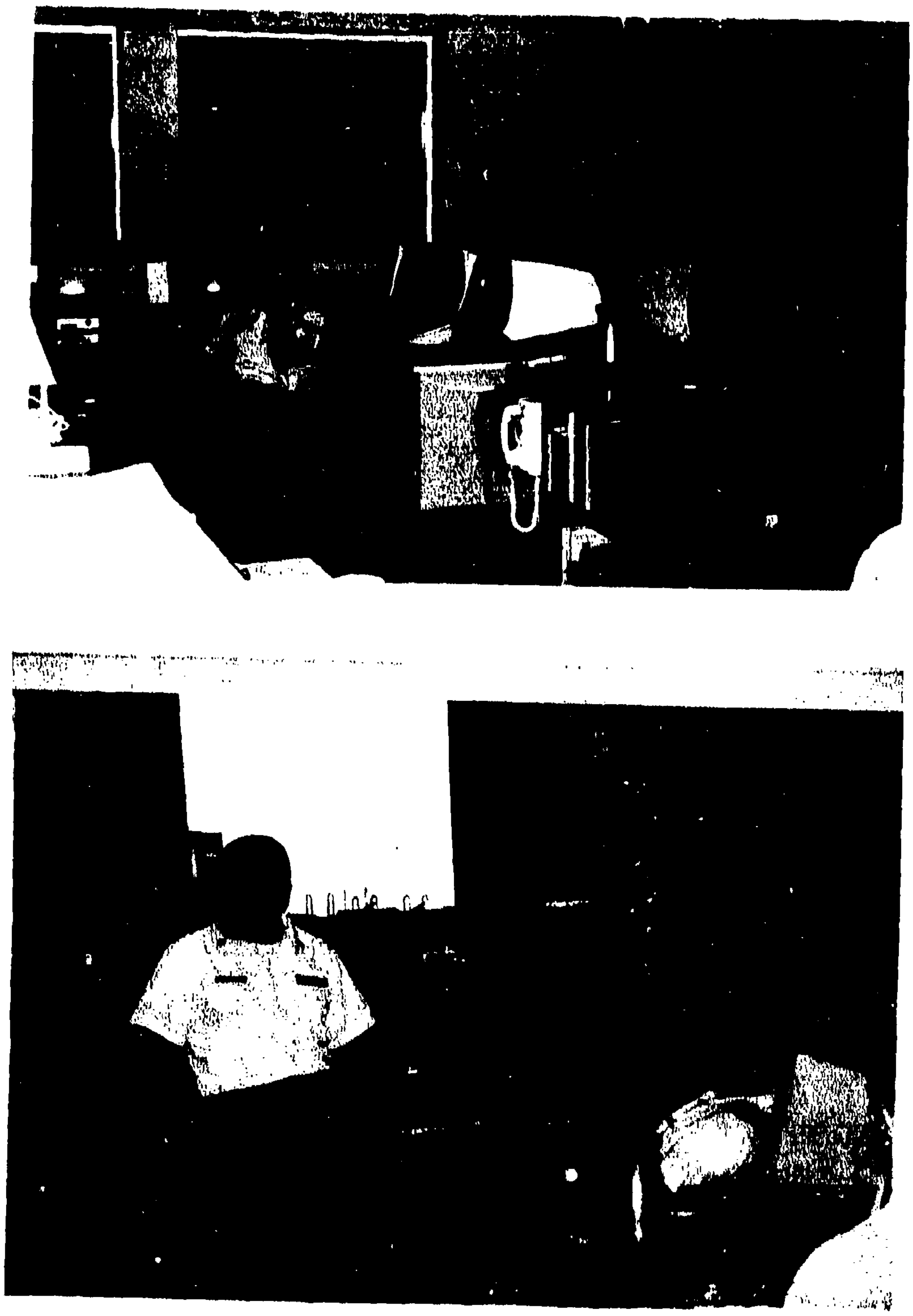


FIGURE 2-9. WATCH SUPERVISOR'S POSITION

or master notifies the VTC. The SW copies the SOA and any new data onto the card and scans his displays while listening, then acknowledges and gives a traffic advisory. Following this transmission, the SW time stamps the card and enters the new information into the VTS-DACS by keyboard. Completion of this entry starts the VTS-DACS tracking the vessel, dead-reckoning on the entered SOA and updating all data every 15 seconds.

Sometimes a vessel may fail to make the initial report, instead giving all information when entering. Sometimes, too, the SW may become aware of an unreported vessel in the system by overhearing bridge-to-bridge communications on Channel 13. In such cases, he will attempt to call the vessel and enter it into the VTS-DACS memory.

2.7.2 Transit

The HOU-GAL VTS has eleven vessel reporting points -- two on the main channel and three on side channels in Sector I, three on the main channel and one on a side channel in Sector II, and six in Sector III (see Figure 2-1). When the VTS-DACS has tracked a vessel to a reporting point, it ceases tracking, and the vessel's symbol on the DR display blinks. At about the same time, generally, the vessel will call in at the reporting point. The SW issues an advisory and, by key action, releases the VTS-DACS to continue tracking to the next reporting point. When a vessel fails to report as expected, its position is checked on TV or radar (if in range) or the SW calls the vessel to resolve the difficulty, updating the computer as necessary. The Vessel Status Card is manually advanced along the small plotting board to keep pace with the vessel's progress. In a routine transit from the sea to Houston, a vessel would make at least an entry report, eleven calls at reporting points, and an exit report.

Throughout the transit, all traffic is monitored by whatever means (radio, radar, TV) are available. When discrepancies are discovered between apparent position and computed position (on the DR display), action is taken to resolve the discrepancy, usually by manually entering corrections via the VTS-DACS keyboard. Developing situations (such as passing, overtaking or crossing encounters) are monitored, and the affected vessels are given advisories in time for them to initiate appropriate actions if required.

2.7.3 <u>Exit</u>

When a vessel radios that it is leaving the system, the SW acknowledges and executes a VTS-DACS entry that cancels out the SS sheet, removes that vessel from all active sheets, and adds it to the DE list. The SW then time stamps the Vessel Status Card and hands it to the WS, who copies the name and entry and exit points and times onto a Daily Vessel Tally log.

An exception to this exit routine is the case of an inbound ship arriving at a dock. In this case, the SW executes a docking action which retains the SS sheet, enters the ship onto the appropriate IP list, and removes it from all active sheets. He makes out a new Vessel Status Card and files it in an in-port file, then stamps and hands over the old card to the WS for logging.

3. COLLECTION OF DATA

3.1 Scope

The data collected during VTS operations at the HOU-GAL VTC included: frequency and duration of watchstander activities; display delay times in computer operations; interviews and stress questionnaires individually administered to watchstanders during break periods; tape and photographic recordings and center records obtained to cover the data-collecting periods.

Watchstander activities were observed to determine how often watchstanders perform their various tasks. Activity frequency data were collected over a three-day, mid-week period during a moderately dense traffic load. Fifteen hours of data were obtained to include five hours of data from each of the three sector positions. The data sampling included three watch crews (eleven individual watchstanders plus two trainees) and covered morning, afternoon and evening time periods. (See Table 3-1). Duration data, interviews and questionnaires were accomplished on the same days.

3.2 Procedures

3.2.1 Traffic Data

Information on vessel traffic in the system during periods of data collection was obtained from VTC records and from photographs of relevant VTS-DACS displays. At the end of each day, a hard copy of the VTS-DACS Vessel Departures (DE) Sheet (see 2.6.2) was printed out. The WS maintained a Daily Vessel Tally log (see 2.7.3) which repeated much of the data in the DE sheet and added the time that each vessel entered the system. Copies of both of these records were obtained for each day on which observations were made.

Vessel traffic information for specific time periods in individual sectors was obtained from the Vessels Underway Sheet (VU). Every fifteen minutes an experimenter in the equipment room called up the VU display on the VTS-DACS terminal there, read selected information onto one channel of a voice tape, and photographed both the VU and DR displays.

TABLE 3-1. DATA-COLLECTING SCHEDULE

Date	Time	Sector	Crew	Individual	Amount of Data Collected (min)
9/19/77	0830-0930	1	1	A	60
	0945-1015	2	1	B	30
	1025-1055	2	1	A	30
	1120-1150	3	1	A	30
	1220-1250	3	1	A	30
	1425-1525	2	1	B	60
	1545-1645	1	1	A	60
	1700-1800	3	1	C	60
					6 hrs.
9/20/77	0825-0925	1	1	A	60
	0945-1000	1	1	D	15
	1000-1045	2	1	E + T*	45
	1100-1200	3	1	B	60
	1845-1945	3	2	F	60
	2000-2100	2	2	G	60
	2105-2205	1	2	H	60
					6 hrs.
9/21/77	0830-0930	1	4	I	60
	0945-1045	2	4	J	60
	1100-1200	3	4	K + T	60
					3 hrs.

*T = trainee

3.2.2 Watchstander Activity Data

An observer, seated beside the watchstander, manually tallied the observed activities onto an Activity Log (See Fig. 3-1). The observer initiated the data-collecting session with a brief explanation of the procedure to the watchstander. When ready to start recording data, the observer signaled an experimenter in the equipment room to begin tape recording voice communications over Channel 12. For a one-hour period, the observer collected activity data at a single sector and periodically verified timing accuracy against the digital clock at the sector. At the end of the session, the observer organized the log sheets, conferred with the experimenter recording communications and moved to another sector position to repeat the data-collecting procedure.

The Activity Log was mounted on a clipboard and held by the observer while recording data. Across the top of the log were listed six major watchstander activity categories, thirty-four associated subactivities and a Remarks heading. The six major watchstander activity categories were: (1) Communications, (2) Computer, (3) Cards, (4) TV, (5) Radar and (6) Miscellaneous. (See Appendix C for explanation of categories.)

The log was divided into thirty lines, each representing a thirty-second interval; so each log sheet covered a fifteen-minute observation period. As observed, each activity was tallied in the appropriate column. A timing device signalled every thirty seconds, alerting the observer to begin recording in a new time interval by moving down to the next line. Each recorded tally represented an occurrence of an activity that had been predefined by the observer. (Definitions of beginning and ending of activities are included in Appendix C.) When an activity continued into the next thirty-second period, the tally mark was continued onto the next line. The Remarks column provided space to add information on tallied activities, such as those designated "Other".

3.2.3 Duration, Delay and Rejection Data

The observer was fully occupied tallying the various watchstander activities and could not time them beyond extending tally marks onto successive thirty-second lines. However, a second observer used a stopwatch to time separately some of the more critical activities of the watchstanders on duty. These duration measurements were done in batches--- that is, a series of measurements were taken on a single activity, followed by a series on another activity, and so on.

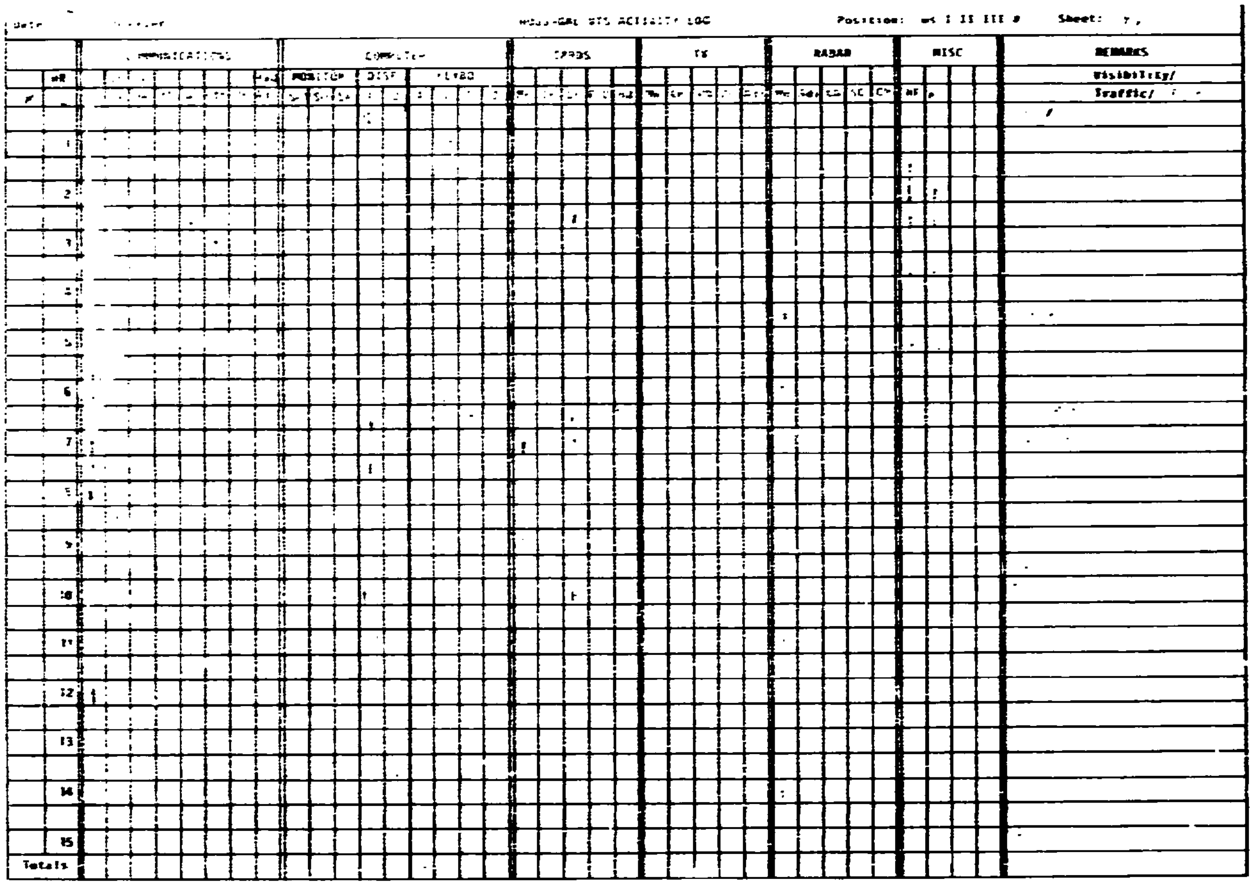


FIGURE 3-1. SAMPLE WATCHSTANDER ACTIVITY LOG SHEET
(See Appendix C for definition of headings)

Because of comments on the delay between keying a request for a display into the VTS-DACS and the appearance of the display on the CRT, display delay data were recorded in the equipment room. An experimenter seated at the console started a stop-watch as he made the first keystroke of a display request and stopped it when the complete display had appeared on the CRT. This procedure was repeated for one hundred measurements. Similarly, one hundred delay measurements were taken for each of the seven displays. For two displays, the measurements were repeated starting the watch at the last (execute) keystroke of the request entry in order to get separate estimates of keying and computer response times.

It was observed that keying too fast could cause the computer to reject an entry. To check rejection frequencies, two display requests were keyed alternately one hundred times and a record kept of rejections.

3.2.4 Interviews

Twelve individual interviews were conducted by one interviewer. Each interview generally followed the same format and covered the same topics but was open-ended in nature. The interviewer and interviewee were seated comfortably either in the lounge area or the equipment room. The interviewee was assured that he was not being evaluated--rather, that he was helping evaluate the system, and anonymity was assured. The interview proceeded as a conversation, with the interviewer observing the planned format but freely following up leads and probing interesting topics at his discretion. Interview durations ranged from 30 to 70 minutes.

3.2.5 Stress Questionnaires

A questionnaire intended to elicit information on subjective stress was administered to nine watchstanders. The questionnaire contained 30 items (20 on body functions, 10 on mood) that could be simply checked off by the subject. (A copy of the questionnaire appears in Appendix G). During the course of the interviews, generally at the end, a second experimenter administered the questionnaire. He explained its purpose briefly, let the subject read the written instructions, answered questions, and then observed as the subject checked off the items. Each subject was given a packet of 16 additional copies of the questionnaires and was asked to fill them out four times daily for the next four days and to mail them back to the experimenter in an envelope that was provided. Nine subjects completed the first questionnaire; six of them returned the completed packets.

3.2.6 Voice Communications

During each period of activity observation (3.2.2) a continuous recording of the watchstander's voice transactions on Channel 12 was made on one channel of a dual-channel magnetic tape. The experimenter in the equipment room operated the recorder and added voice annotations on the second channel.

4. RESULTS

4.1 Traffic

Data collection at the HOU-GAL VTS took place on September 19, 20, and 21, 1977. Total traffic counts for those three days (taken from the Daily Vessel Tally) were 212, 249, and 267, respectively. VTC records give a daily traffic average of about 250 vessels; thus the three days sampled had below average, average and slightly above average traffic. The total traffic consisted of 132 ships and 596 tows (18 and 82 percent respectively) compared to an annual average 20 and 80 percent. No significant incidents were reported on the observation days. We conclude that on those days traffic load constituted a reasonably representative sample of "routine" operations.

From the data on entry and exit points and times, the traffic loading was plotted for each day in each sector (Figures 4-1, 4-2 and 4-3). On these graphs the observation periods are indicated by dashed vertical lines. (The first period in Sector III covers 105 minutes, consisting of 30 minutes of observation, a 45-minute break due to equipment problems,and 30 minutes of observation; all others involved one hour of continuous observation.)

An estimate of traffic load was made for each period from the graphs by counting the number of vessel lines within the observation period. Because of variations in vessel speed, there is very likely some error in these estimates. An independent estimate of traffic load was made from the VU displays photographed every 15 minutes during observations. From these data, an average number of vessels was calculated for each period for each sector. These traffic load estimates are summarized in Table 4-1.

A vessel entering or leaving the system requires more watchstander attention than one in routine transit. Therefore, for each sector an estimate war made of the number of entries and exits occurring during the observation periods. Changes in the VU display between successive fifteen minute periods were counted from scope photographs where available. Missing data were partially compensated for by taped voice annotations. Where no data were available, the mean number of changes per period for the observed periods was assumed for the missing periods. These estimated traffic change loads are also given in Table 4-1.

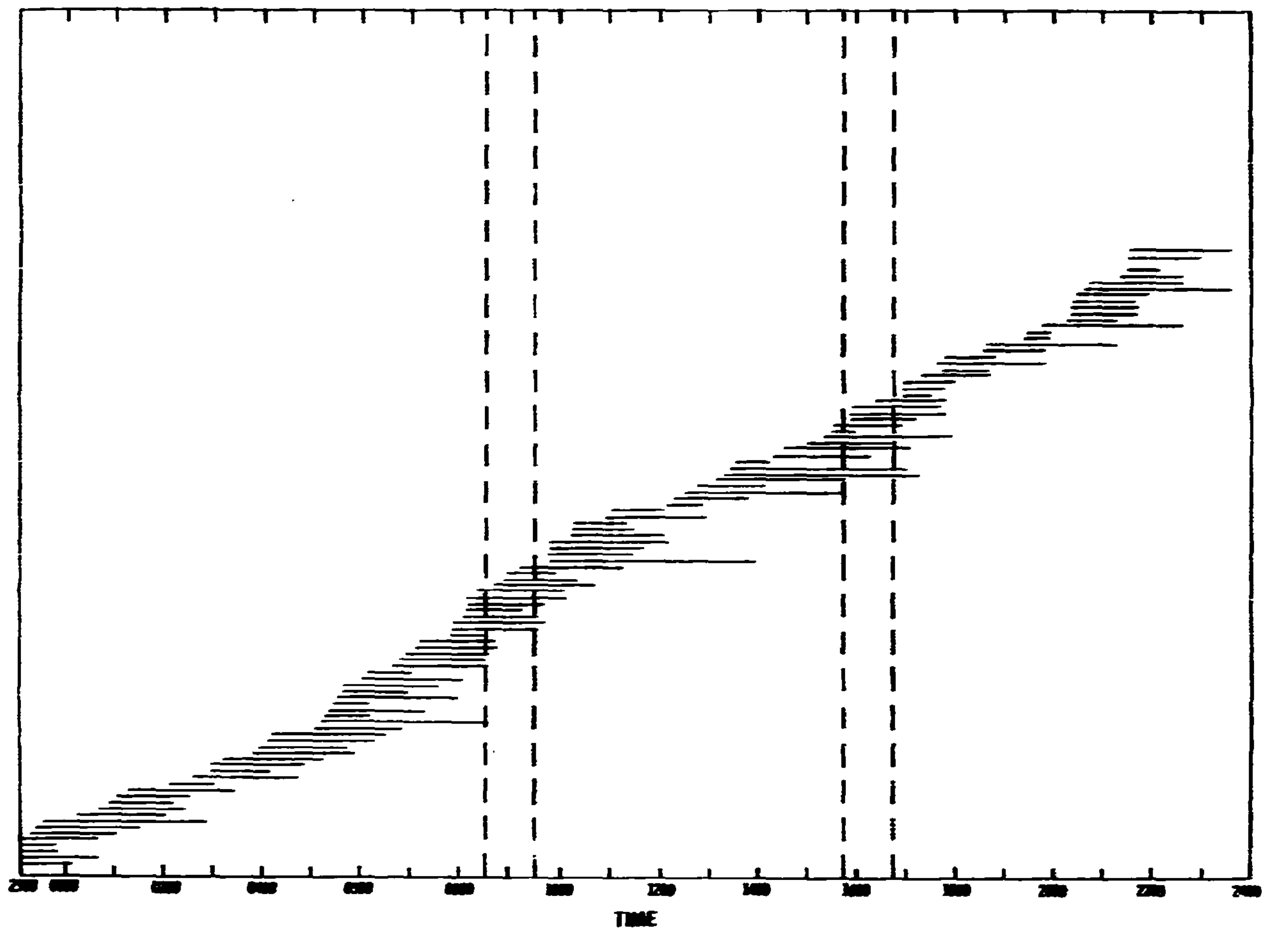


FIGURE 4-1. HOU-GAL TRAFFIC 9/19/77
a. SECTOR I

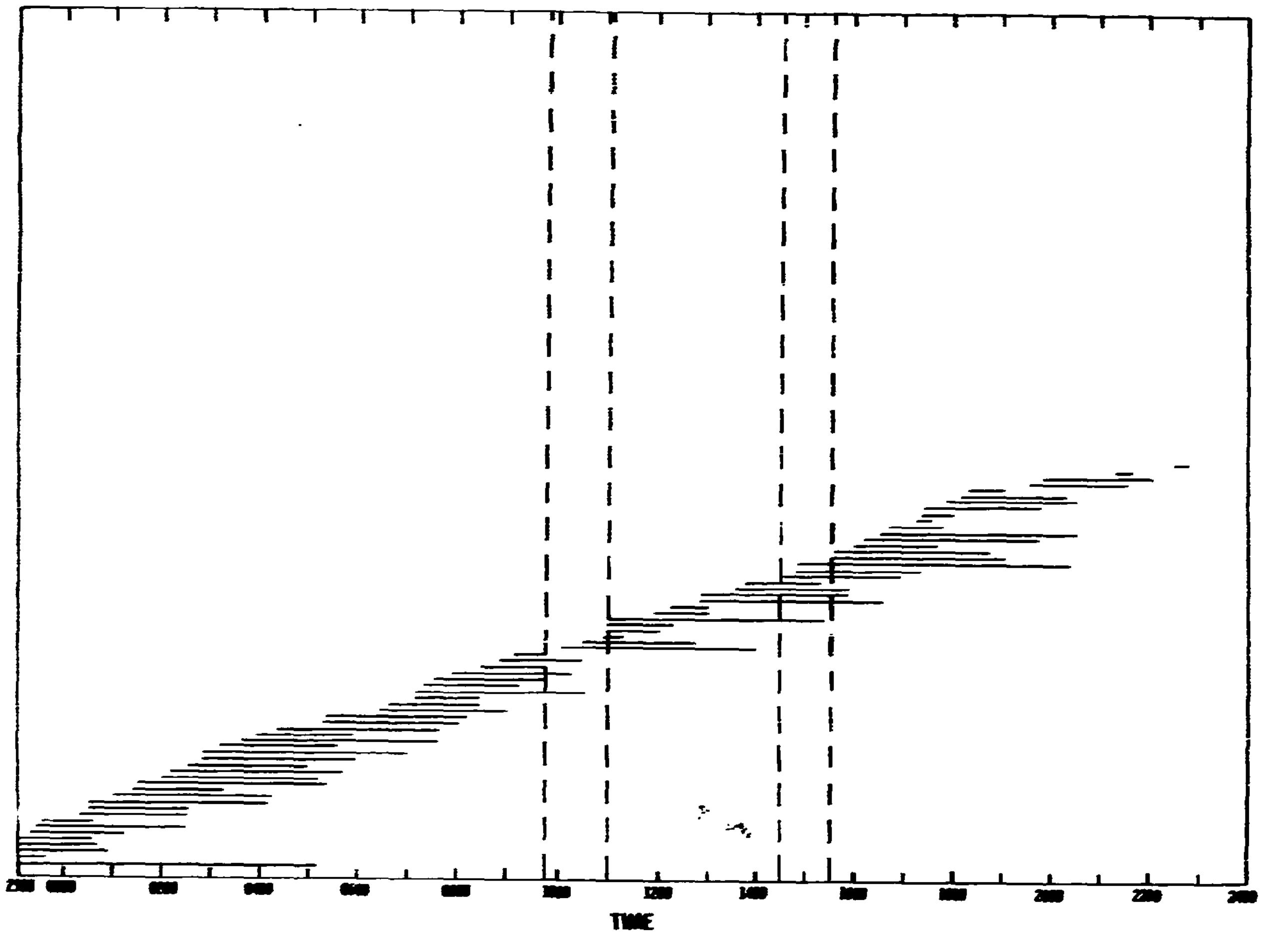


FIGURE 4-1. HOU-GAL TRAFFIC 9/19/77
b. SECTOR II

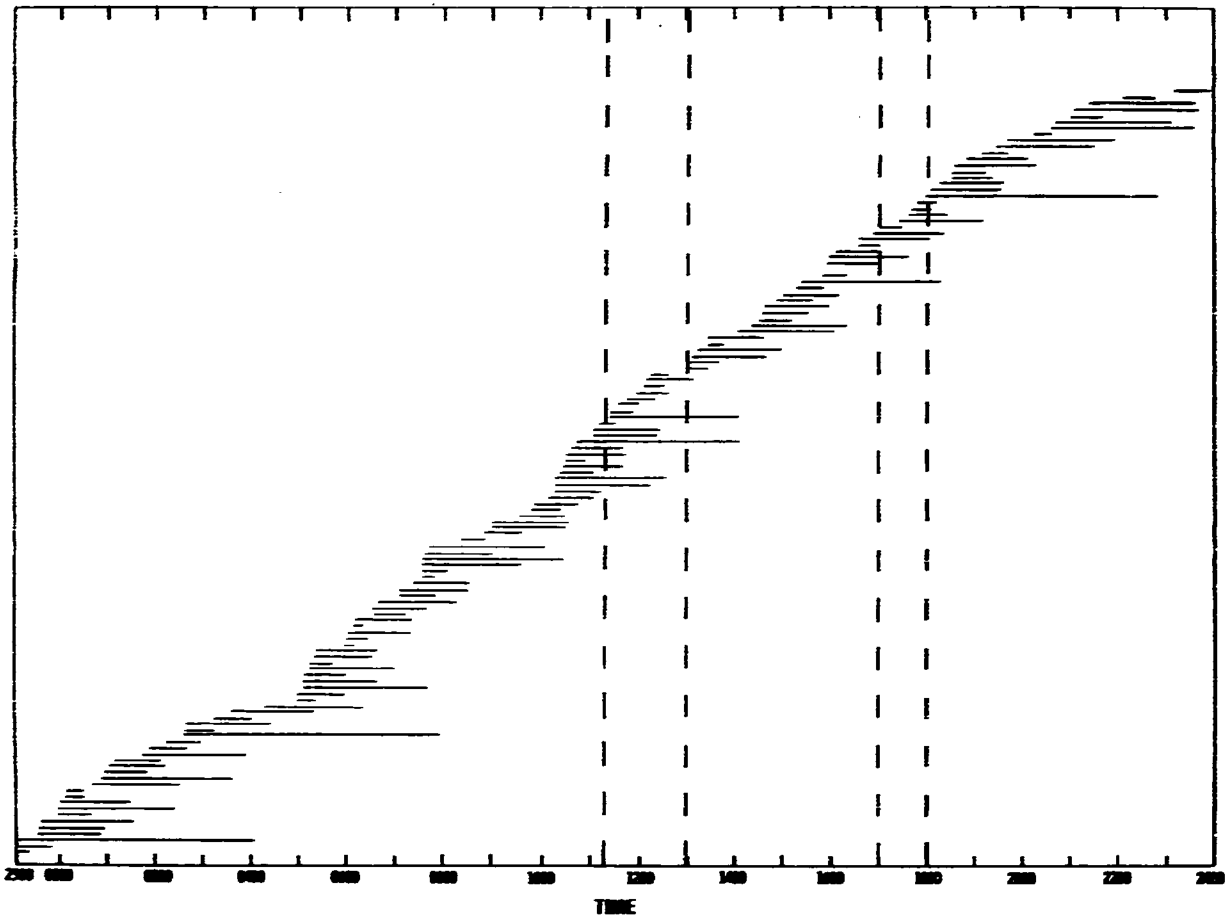


FIGURE 4-1. HOU-GAL TRAFFIC 9/19/77
c. SECTOR III

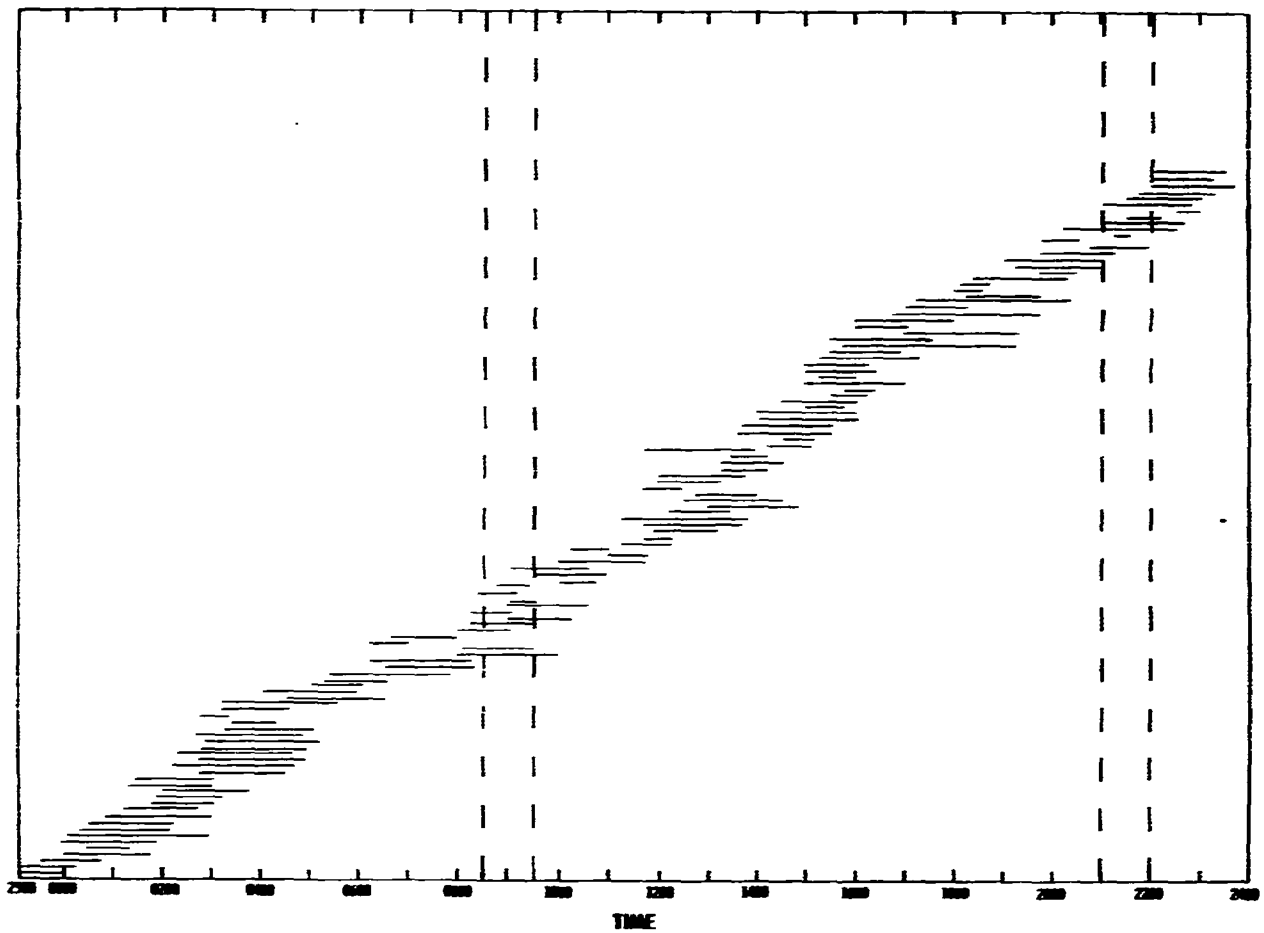


FIGURE 4-2. HOU-GAL TRAFFIC 9/20/77
a. SECTOR I

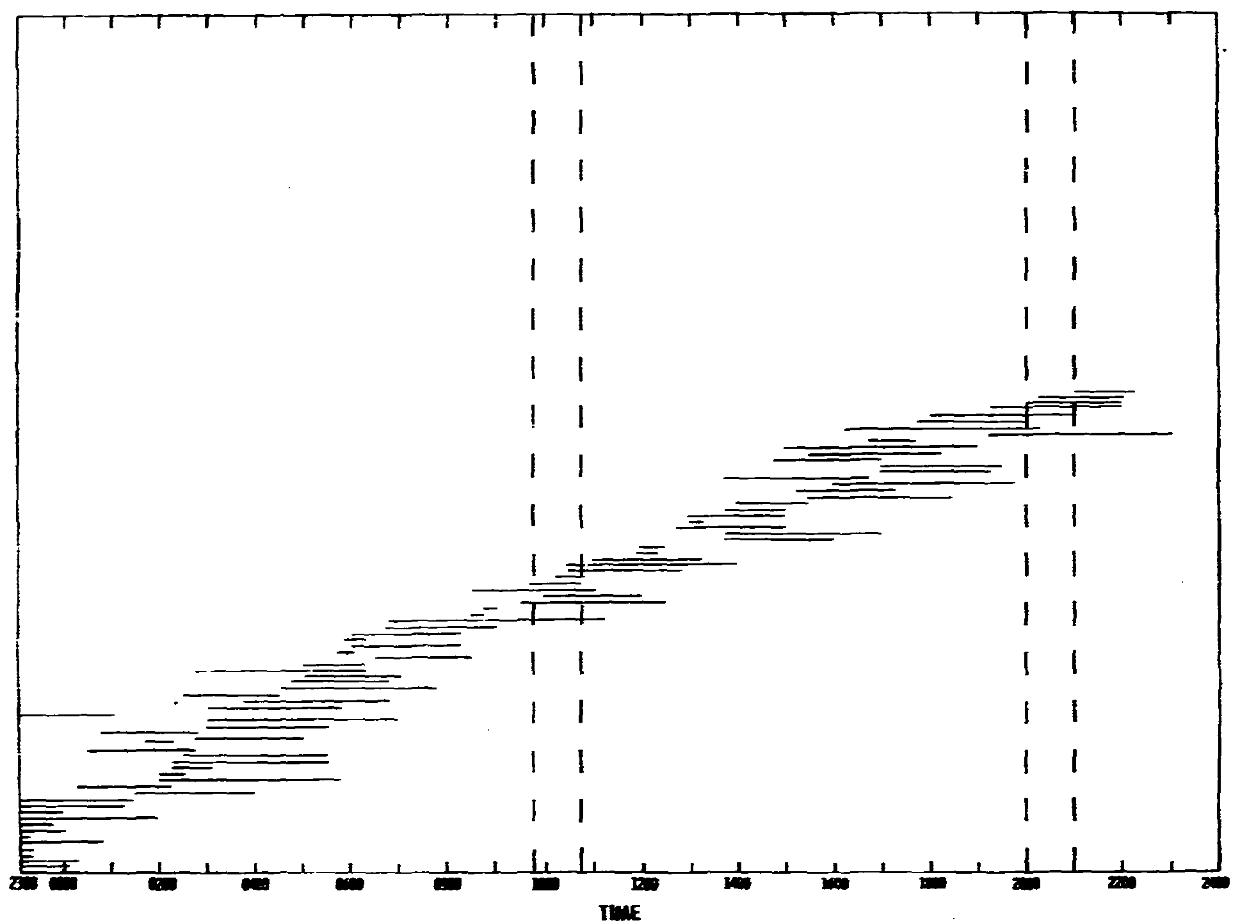


FIGURE 4-2. HOU-GAL TRAFFIC 9/20/77
b. SECTOR II

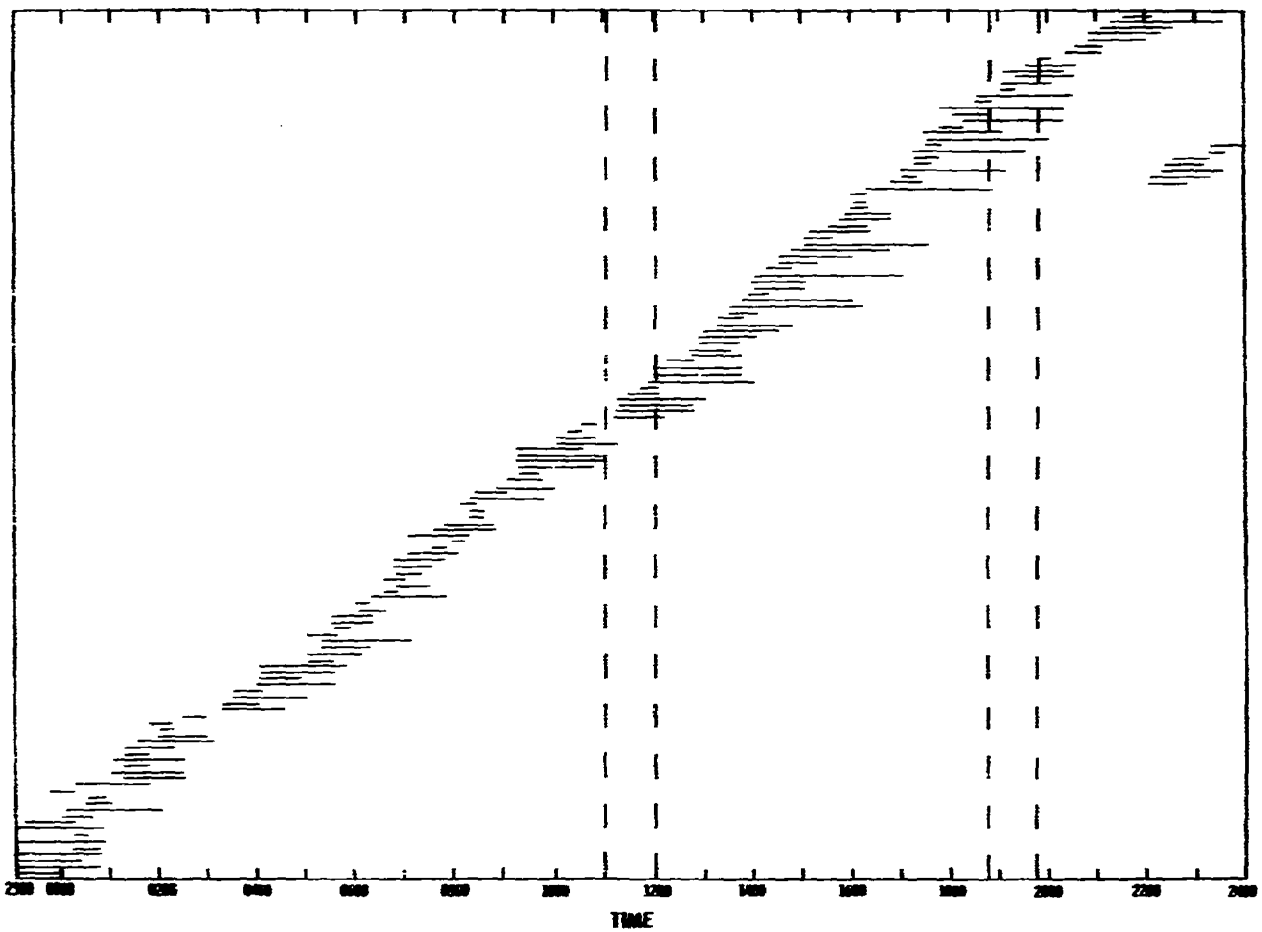


FIGURE 4-2. HOU-GAL TRAFFIC 9/20/77
c. SECTOR III

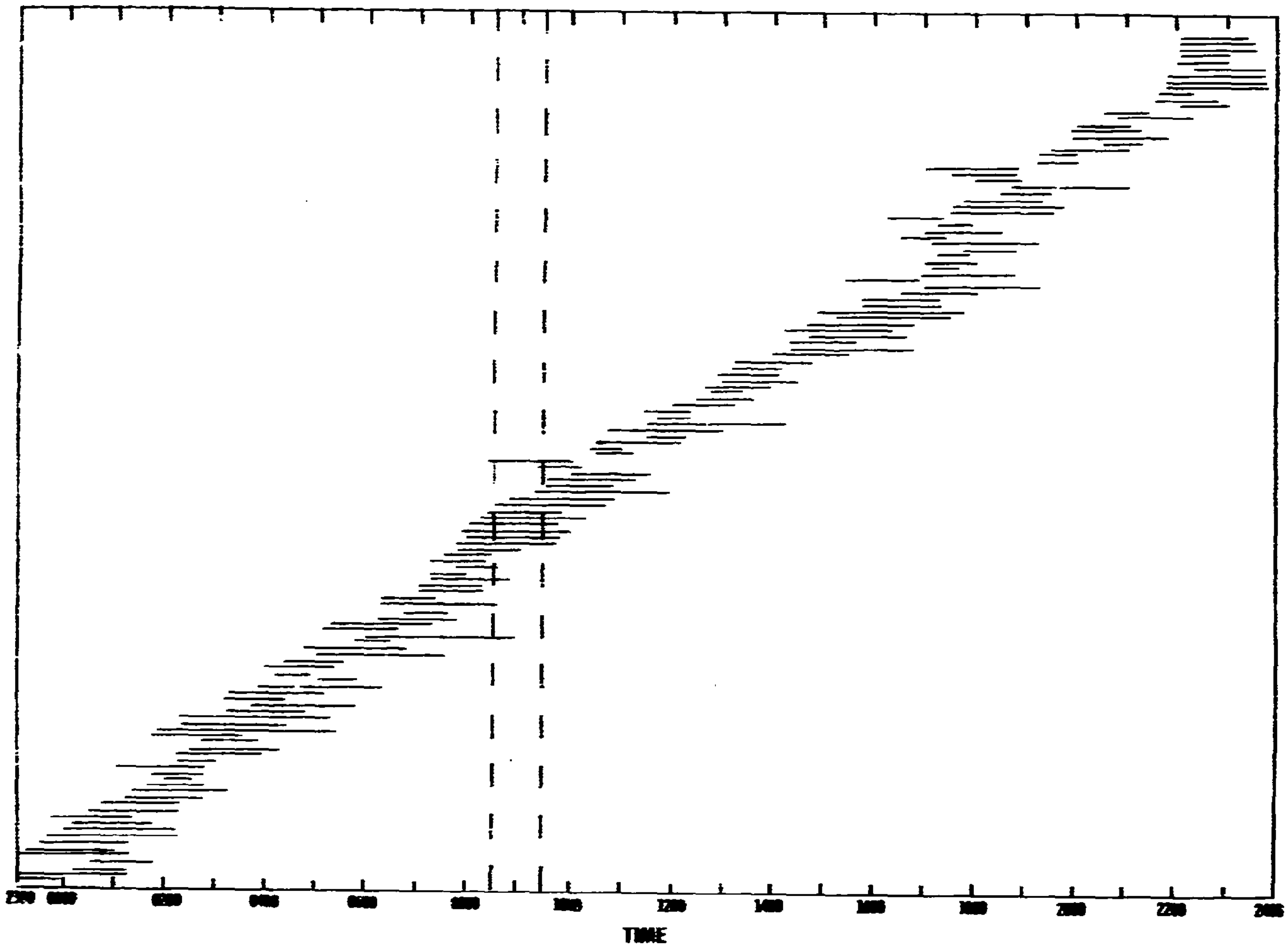


FIGURE 4-3. HOU-GAL TRAFFIC 9/21/77
a. SECTOR I

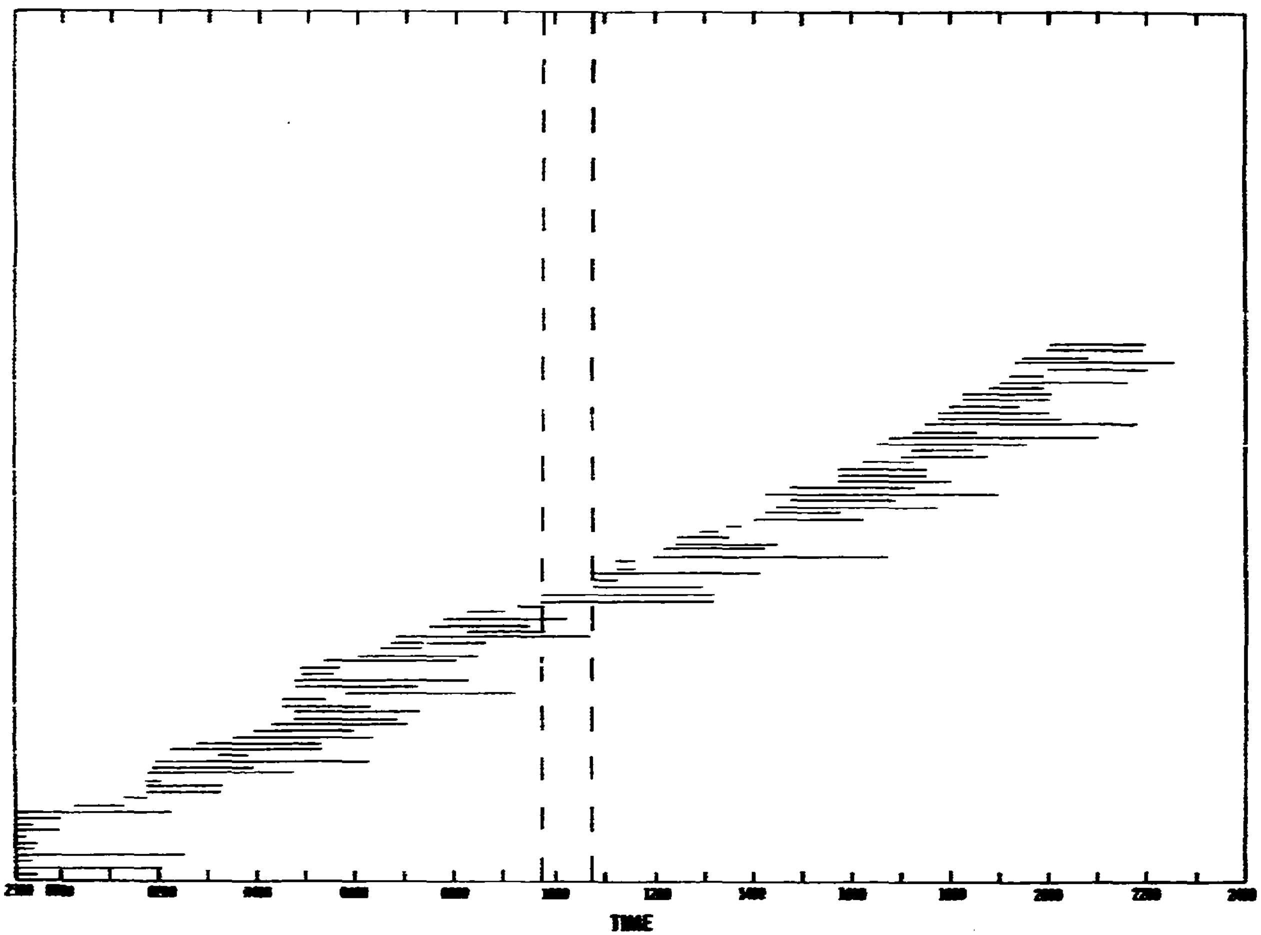


FIGURE 4-3. HOU-GAL TRAFFIC 9/21/77
b. SECTOR II

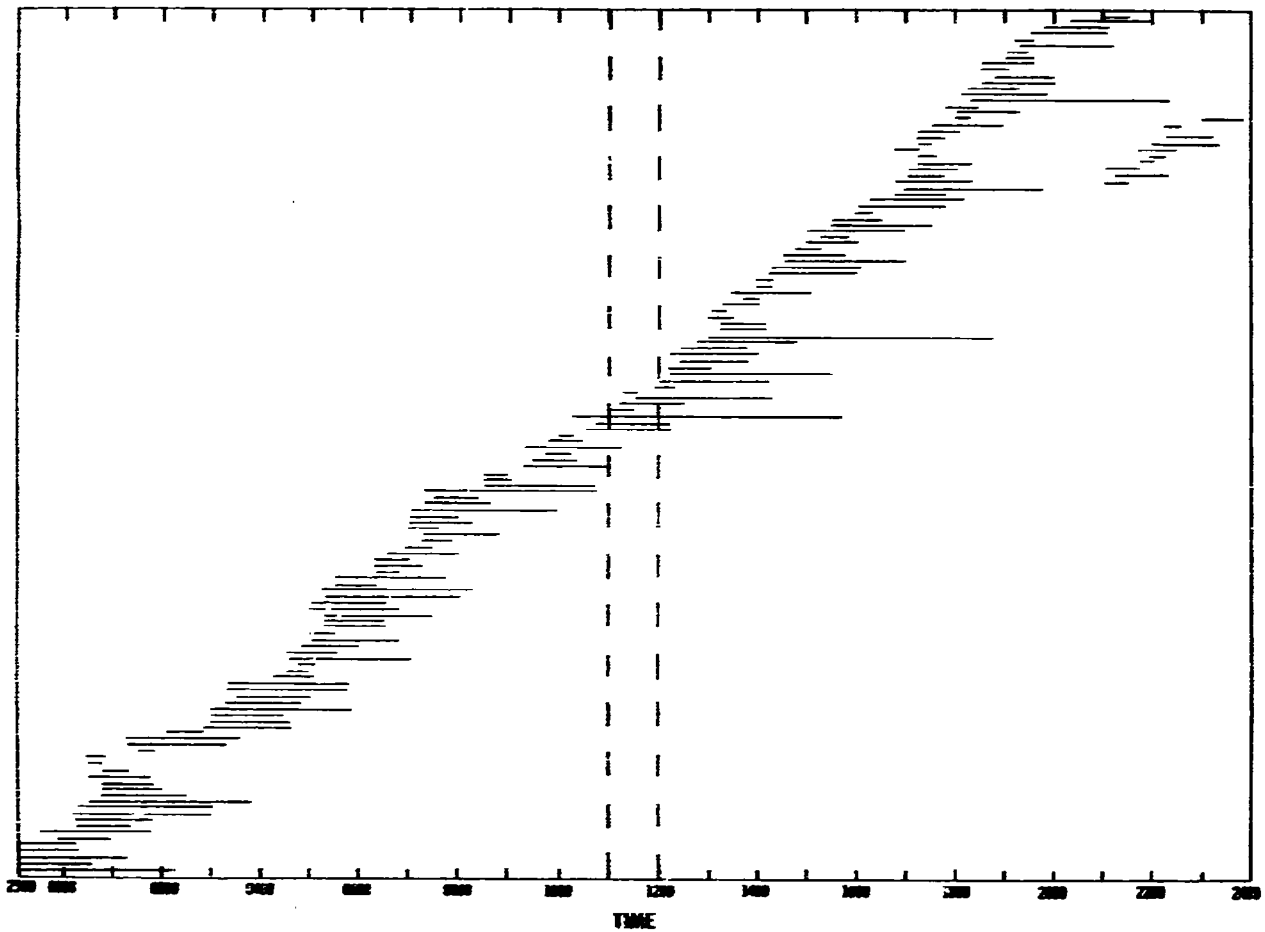


FIGURE 4-3. HOU-GAL TRAFFIC 9/21/77
c. SECTOR III

TABLE 4-1. TRAFFIC DATA FOR OBSERVATION PERIODS

	Period	Sector I	Sector II	Sector III
Total Traffic in Sectors (Estimated from Traffic Graphs)	1	14	5	17
	2	12	8	9
	3	11	8	8
	4	9	6	13
	5	13	4	8
	Total	59	31	55
	Mean	11.8	6.2	11.0
Average Traffic in Sectors from VU Displays	1	11.3	7.3	13.7
	2	9.8	7.8	9.7
	3	11.3	8.3	9.3
	4	9.8	10.3	18.5
	5	12.2	4.5	6.0
	Total	54.4	38.2	57.2
	Mean	10.9	7.6	11.4
Total Traffic Changes		57	41	66
Mean Hourly Traffic Changes		11.4	8.2	13.2

Since they were calculated from the most complete and accurate set of observed data, the average traffic figures for each sector are probably the best estimates of traffic load during observation periods. For purposes of inter-sector comparisons, we will consider that the traffic loads for Sectors I and III were about the same, with a considerably lighter load in Sector II.

4.2 Frequencies of Sector Watchstander Activities

4.2.1 General Results

The frequencies of observed watchstander activities are summarized in Table 4-2. Under "Frequencies," the total number of observations recorded on the Watchstander Activity Log over five hours of observation is given for each activity* in each sector. Under "Percents," the frequency of each activity is expressed as a percentage of total sector activity. Combined sector totals for each activity are expressed as percentages of all observed activities.

Communications with vessels (the principal product of the VTS) accounted for 4 percent of observed activities. Most of the remaining 96% of activities involved processing the data needed for advisories (data entry and retrieval) or keeping track of the data to determine whether advisories were needed (surveillance). These two support functions can not be clearly separated in the data; nearly all activities contributed to both. (The covert watchstander activities -- computation and decision making -- could not be observed at all.)

Operating and observing the VTS-DACS computer involved the greatest amount of activity (56 percent), fairly evenly divided between operating the keyboard and looking at the displays. Monitoring and operating surveillance aids (television and radar) combined to produce 21 percent of the activity. Handling and referring to Vessel Status Cards amounted to 13 percent of observed activities. The remaining 6 percent included communicating with people other than those on vessels, looking up information in reference material, and briefly leaving the position (less than 1 percent).

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*To simplify interpretation, some of the original activity categories have been combined. Frequencies for all categories for every hour of observation are given in Appendix D.

TABLE 4-2. SUMMARY OF OBSERVED ACTIVITIES

	FREQUENCIES				PERCENTS			
	I	II	III	Total	I	II	III	Total
COMMUNICATIONS				630				9
With Vessels	99	57	122	278	4	3	5	4
With Other SW's	27	32	19	78	1	2	1	1
With Other People	82	62	46	190	3	3	2	3
Adjusting Radio	22	31	31	84	1	2	1	1
VTS-DACS COMPUTER				3768				56
Keying	589	302	845	1736	25	16	34	26
Reference to Display	722	656	623	2001	31	34	26	30
Reference to Other SW's Display	7	18	6	31	-	1	-	-
CARDS				873				13
Marking	84	22	103	209	4	1	4	3
Time Punching	39	7	57	103	2	-	2	2
Reference to Cards	94	59	185	338	4	3	7	5
Moving Cards	93	56	74	223	4	3	3	3
RADAR				494				7
Monitoring	412	22		434	17	1		6
Adjusting	60			60	3			1
TELEVISION				942				14
Monitoring		310	167	477		16	7	7
Adjusting		280	185	465		15	7	7
OTHER				52				1
Using References	20	6	9	35		1	-	1
Moving from Position	5	5	7	17		-	-	-
TOTAL	2355	1925	2479	6759	35	28	37	
AVERAGE TRAFFIC LOAD	10.9	7.6	11.4	10.0	37	25	38	
TOTAL TRAFFIC CHANGES	57	41	66		35	25	40	

From sector to sector the amount of observed activity varied directly with the average number of vessels in the system and the number of vessel changes. The average traffic loads and total traffic changes from Table 4-1 have been added at the bottom of Table 4-2. When expressed as percentages they show remarkably good agreement with each other as well as with total observed activity.

4.2.2 Communications

Communicating and associated activities (radio adjustments) accounted for 9 percent of the observations, but transactions with vessels in the system amounted to only 4 percent. Although communications with vessels varied with traffic load, there were disproportionately fewer transactions in Sector II than in the other two sectors. This appears to be due to the fact that there are fewer vessel reporting points in Sector II; therefore there were fewer vessels in the system during Sector II observations and each vessel required less attention than in the other sectors. Some transits require transactions only at check points; occasionally several transactions may be necessary just to identify and locate a vessel. Generally, however, during these observations there were one or two transactions per vessel in the system per hour.

Communicating with other SW's was more frequent in Sector II, very likely because this sector receives handoffs from both adjacent sectors and thus requires more inter-sector coordination. Communications with the Watch Supervisor totalled about the same for each sector and showed no relationship to traffic load. Other conversations varied considerably but occurred most often when traffic was light; these transactions included conversations with the TSC observer.

4.2.3 VTS-DACS Computer

Activities associated with the computer dominated the SW's job (56 percent of all observed activities). The relative distribution of total computer activities across sectors exactly reflected the distribution of average traffic load. However, the number of times the SW referred to the computer displays was greater in Sector I, more nearly equal in Sections II and III. The detailed data of Appendix D show about equal numbers of references in each sector to Display 2 (which generally showed the VU but occasionally was used for calling up other formats). The variation in display references between sectors occurred with Display 1 (which almost always showed the DR format), with relatively more references in Sector I than in the other two sectors. The detailed activity log records suggest that the Sector I SW often alternately looked at his radar and his DR display. Not even the television in the other sectors provided as ready a check on the DR accuracy as did the radar for Sector I. Allowing for this extra checking with the radar, we get a generally even distribution of references to displays showing that the computer displays were being monitored regularly regardless of traffic load.

Keying activities showed considerably more variation between sectors, in line with, but disproportionate to, the variation in traffic load. Within Sectors I and II, a detailed analysis of keying activity failed to reveal any systematic variation of keying with traffic load, probably because some keying associated with routine monitoring of traffic was kept up during periods when vessels required no servicing. The general level of keying activity, however, was lower in Sector II than in Sector I, probably because there are fewer check points in Sector II. When traffic was light, keying activity in Sector III was independent of traffic load and at about the same level as in Sector I. However, there were five 15-minute periods of observation when traffic load exceeded 15 vessels in Sector III. During these periods keying activity was considerably higher. The greatest increase in keying activity was in keyboard group B, the function keys. Apparently, when traffic load exceeds 15 vessels in this sector, vessel symbols become crowded together and much extra keying is required to establish their identities.

4.2.4 Cards

Thirteen percent of observed activities involved the Vessel Status Cards. The distribution of these activities roughly reflected the distribution of traffic load. Marking cards and time stamping them were almost exclusively associated with originating and ending transits in the system (as opposed to entering or exiting to or from adjacent sectors). The disproportionately higher frequencies of these actions in Sectors I and III very likely reflect the distribution of originating and destination points. Moving cards is associated with tracking - updating positions of vessels by advancing the cards on the small tracking boards - and with handoffs between sectors. These activities follow traffic loads in general; the relatively high frequency in Sector I can be traced to a greater number of handoffs during observations. References to the cards for informaion followed traffic load; the disproportionately high frequency in Sector III occurred because, during one observation period, the SW was explaining the cards to a trainee.

4.2.5 Surveillance Aids

Monitoring surveillance aids (radar in Sector I, television in Sectors II and III) distributed fairly evenly between Sectors I and II (17 percent of all observed activities in each sector) despite the differences in traffic load. In Sector III, reference to television accounted for 7 percent of activities, because television covers only about a third of the sector. We have already noted that reference to computer Display 2 (generally the VU listing) appears to be related to surveillance. References to surveillance aids and this display combined account for 30 and 29 percent of activities in Sectors I and II respectively, but only 18 percent of activities in Sector III. Thus the SW in Sector III is not compensating for lack of surveillance aids by more monitoring of the computer displays. Did he call the vessels more often in order to maintain surveillance? Dividing communications with vessels by average traffic load we get about 10.8 transactions per vessel in Sector III, compared to 9 and 7.5 in Sectors I and II respectively. This small difference is in the right direction, but is inadequate to compensate for lack of surveillance aids. It appears, then, that when radar or television was available, the SW maintained a pattern of cross-checking between computer displays and surveillance aid, regardless of traffic load. Where aids were not available, no significant compensatory surveillance activity was observed.

Manual activity associated with the use of the radar comprised only 3 percent of the Sector I activities. Two-thirds of this activity involved operating the cursor; most of the rest was changing scale, with off-centering and adjusting of brightness and contrast very rare. On the other hand, manipulation of television controls was observed as frequently as looking at the scopes. This does not mean that a single control action was made each time the television was referred to. Rather, many passive observations were made, while at other times a single observation would be accompanied by considerable panning and zooming to zero in an area of interest. As with radar, brightness and contrast adjustments of the television were relatively rare.

4.2.6 Other Activities

About one percent of observed activities involved looking things up in reference files, such as card files and Lloyds' Register for vessel data. Occasionally a watchstander would leave his position briefly; this occurred, on the average, about once an hour and accounted for less than one percent of observed activities.

4.3 Activities of Other Personnel

4.3.1 Watch Supervisor

Using a modified activity log, an observer recorded the activities on one WS over six fifteen-minute periods. Over a third (37 percent) of the WS's activities involved communicating with people, mostly talking to the Sector Watchstanders (13 percent of all activities) or to other people in the Center (16 percent). There was some use of the telephone (5 percent) and radio (3 percent).

Using the computer accounted for 29 percent of the observed activities. The WS had four displays, three of which usually showed the DR sheets for the three sectors, the fourth showing VU for the busiest sector, or any other display the WS wished to call up. Monitoring these displays accounted for 21 percent of the observed activities; keying to call up different displays accounted for 8 percent.

Administrative actions constituted 16 percent of the observations. These included arranging and checking Vessel Status Cards (6 percent), referring to logs (5 percent), and making log entries (5 percent).

Monitoring surveillance aids accounted for 14 percent of activities, one percent on radar, the rest on television. Moving away from his position accounted for 4 percent.

In summary, during the periods of observation, the WS was primarily engaged in monitoring operations, using the computer displays somewhat more often than the surveillance aids. Along with watching operations, he conversed with the SW's and with others in the room and occasionally handled phone or radio communications. Administrative duties did not appear to interfere with his supervisory function.

4.3.2 External Communicator

During the periods of routine operations covered by this report, the XC was in a standby rather than working status. Essentially the XC duty provided a break from the more demanding SW duties, permitting the watchstander to eat lunch and even to leave the operations room. A TSC experimenter conducted interviews (see Section 4.5) with watchstanders when they were on XC duty. Therefore no attempt was made to log XC activities.

4.4 Durations, Delays and Rejections

4.4.1 Durations of Sector Watchstander Activities

Figure 4-4 shows the results of timing typical watchstander activities. Each X constitutes one observation. All activities can be seen to vary considerably in duration. To aid discussion, we have tabulated in Table 4-3 the shortest, the median, the mean and the longest duration observed for each activity.

The Watchstander Activity Log sheets were lined at 30-second intervals. During observation of activity frequencies, when an observed activity continued over additional intervals the tally mark was extended accordingly. Tallies occupying one, two, three, and four 30-second intervals were counted from the log sheets as an independent estimate of activity durations. These counts (expressed as percentages) are summarized in Table 4-4 together with the corresponding distributions from the time measurements.

A general characteristic of all observations is the occurrence primarily of short-duration activities, with a few of much longer duration. This skewing of distributions yields means that are atypically high in value; the median values (half of the observations fall above the median, half below) are more representative.

The mean length of a radio message was 21.5 seconds, with a median value of 15 seconds. The gross distribution of timed durations agreed very well with the distribution of tallies.

Computer related activities yielded a mean duration of 22.9 seconds, a median of 16 seconds. The timed durations showed a smaller proportion of activities lasting under 30 seconds than did the tallies, mainly because the observer tallied an activity each time the SW changed keyboard area or looked passively at a display, while the timing was done over the total activity associated with a computer entry. Passive viewing of computer displays was not timed.

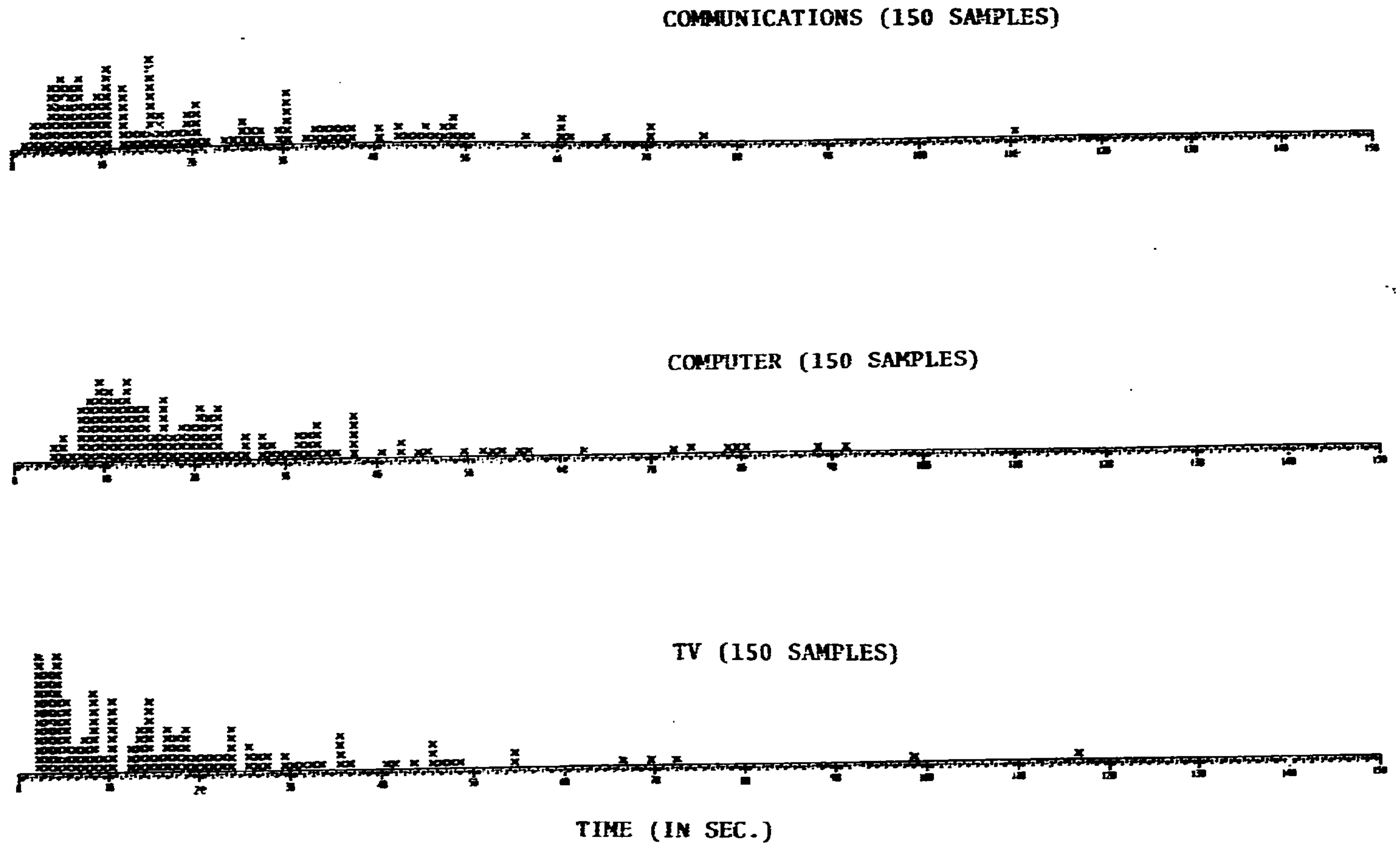

FIGURE 4-4. DURATIONS OF WATCHSTANDER ACTIVITIES

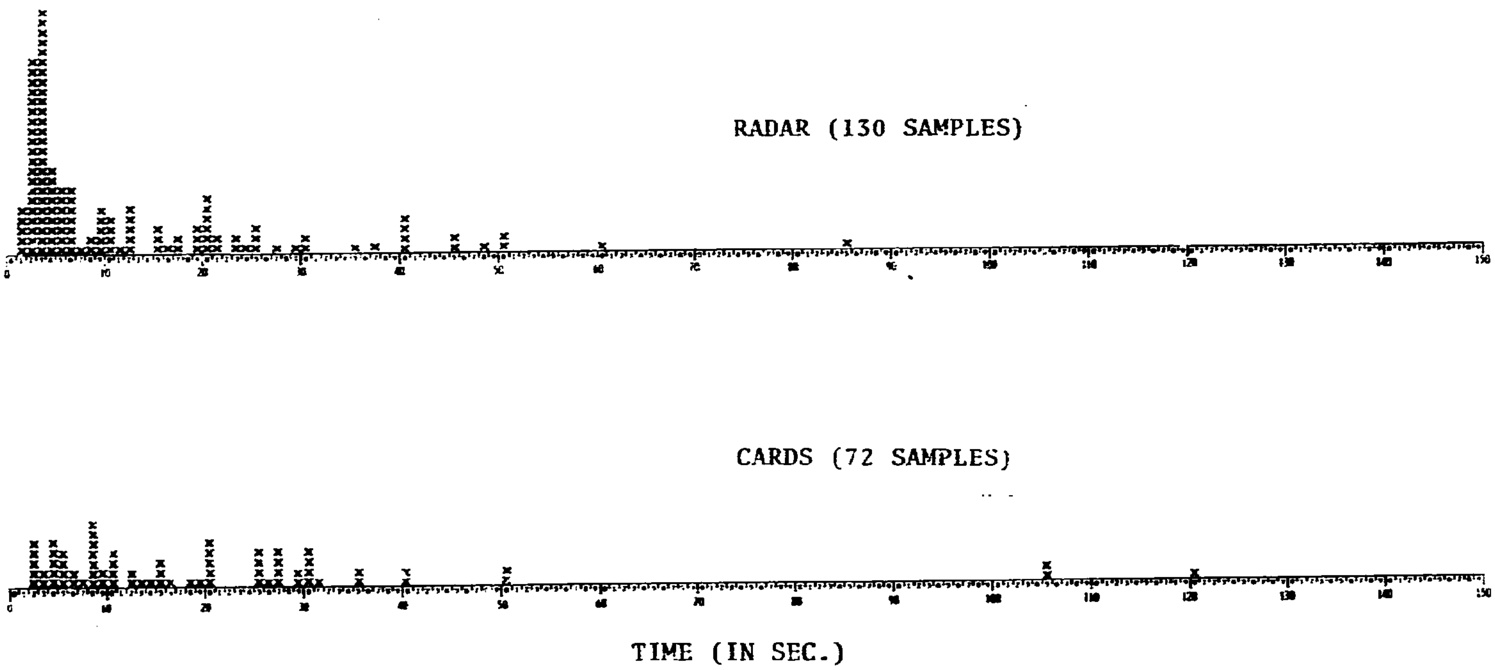

FIGURE 4-4. DURATIONS OF WATCHSTANDER ACTIVITIES (CONT.)

TABLE 4-3. DURATIONS OF WATCHSTANDER ACTIVITIES

Activity	Durations in Seconds			
	Shortest	Median	Mean	Longest
Radio Message to Vessel	1	15	21.5	110
Using Computer	4	16	22.9	91
Using Television	2	13	17.7	116
Using Radar	1	6	12.4	85
Using Vessel Status Cards	1	14	20.2	120

TABLE 4-4. DISTRIBUTION OF ACTIVITY DURATIONS

Duration Times in Seconds	Percentage of Observations	
Radio Message to Vessel	Timed	Tallied
0-30	75	71
30-60	21	21
60-90	3	6
over 90	1	2
Using Computer		
0-30	76	87
30-60	19	12
60-90	5	1
over 90	0	0
Using Television		
0-30	84	80
30-60	13	17
60-90	2	2
over 90	1	1
Using Radar		
0-30	90	73
30-60	9	24
60-90	1	3
over 90	0	0
Using Vessel Status Cards		
0-30	86	84
30-60	10	15
60-90	0	1
over 90	4	0

Television related activities (mean 17.7 seconds, median 13 seconds) took longer than radar related activities (mean 12.4 seconds, median 6 seconds), because many times the use of television involved panning and zooming of cameras as well as observation of the scopes.

The use of Vessel Status Cards occupied a mean time of 20.2 seconds, a median of 14 seconds.

4.4.2 Delays in Computer Response

Keyed requests for displayed data from the VTS-DACS computer were followed by a varying time delay before the complete display was on the scope. Delays varied with the type of display requested and even more with the additional amount of information processing that the computer happened to be engaged in at the time of the request. One hundred samples of these delays were timed for each of the seven basic sheets and for additional requests such as format change on the DR sheet and additional pages of multi-paged data. A stopwatch was started at the first keystroke of a request and stopped when the final character of the requested display appeared. Complete distributions of these measurements are given in Appendix E, and the highlights of the measures are summarized in Table 4-5, together with data on the number of keystrokes required for each entry and the frequency of usage of each display sheet.

Since the DR plot is usually kept up on one scope and not changed, its delays are not critical. However, the SS must be called up in place of the VU every time a new vessel enters the system, and the VU must then be recalled after the data entry. Apparently very little use is made of the other displays, perhaps because of the delays involved (see Section 5).

Since keying time is included in the measurements of Table 4-5, the measures were repeated for three displays, starting the watch when the last key was pressed and thus measuring only the computer-induced delay. These results are shown in Table 4-6. Using the modal times as most representative, we find modal differences averaging 1.8 seconds for pressing 4 keys, or a keying rate of 133 strokes per minute. This rate was achieved because the experimenter was repetitively pressing the same four keys. Watchstanders would be unlikely to key much faster; so we can conclude that the total callup delays of Table 4-5 are conservative estimates.

TABLE 4-5. COMPUTER DISPLAY DELAY TIMES[1]

Display	No. of keys[2]	Use Freq.[3]	Time (in sec.)[4] Min.[5]	Mode[6]	Max.[7]	Percent Rejections[8]
Dead Reckoning Plot (DR)	4	59.0%	3.2	3.9	9.5	7%
DR+	1		1.0	1.7	3.1	
Vessel Status (SS)	8	21.4	3.9	4.3	8.9	2
Vessels Underway (VU)	4	17.9	3.8	4.2	9.7	7
Vessels in-Port (IP)	4	1.1	4.0	4.1	12.2	-
PM	1		2.2	2.5	8.5	
Vessel Departures (DE)	4	0.5	1.2	3.6	9.1	4
PM	1		1.6	1.8	7.3	
Traffic Summary (TR)	10	0.0	6.5	7.1	15.1	-
Command Dictionary (DI)	4	0.0	4.9	5.2	10.6	7
PM	1		2.8	3.0	12.0	

Notes:
1. Based on 100 samples for each display
2. No. of keys required to call up a display
3. Relative use frequency based on 15 hours of activity observations
4. Time is the amount of time for a completed display to appear starting from the first key press
5. Min. = minimum time observed
6. Mode = most frequent time observed
7. Max. = maximum time observed
8. Rejections resulted from normal keying rate exceeding computer capacity or computer unable to take command (miskeying eliminated)

TABLE 4-6. SUPPLEMENTARY DELAY DATA

	No. of Keys	Time (in seconds) Min.	Mode	Max.	Diff. in Modes
Dead Reckoning Plot	4	1.2	2.0	5.7	1.9
Vessels Underway	4	2.0	2.3	7.1	1.9
Vessel Departures	4	1.6	1.9	8.8	1.7

Note: Time is the amount of time for a completed display to appear starting from the <u>final</u> key press. The difference (last column) between the modal times and the modes of Table 4-5 is an estimate of keying time.

4.4.3 Frequency of Computer Rejections

From time-to-time, the VTS-DACS computer will reject a keyed request even though there is no keying error. Some of these rejections occur when an alphanumeric key is pressed too soon after a function key; at other times, fluctuation of the computer power supply may introduce a false signal that is rejected. To determine how frequently this annoying and delaying type of event may occur, several display change requests were each keyed one hundred times and a record made of the number of rejections. These data appear in the right-hand column of Table 4-5. Although a 2 percent rejection rate might be tolerated, the 7 percent rate would be distracting, particularly if followed by a long display delay time.

4.5 Interviews

The greatest awareness of how a system operates resides in those who operate it. The individual interviews were conducted to tap this source of vital information. The detailed results of the interviews are given in Appendix F. The highlights of these results are summarized below:

a. Watchstanders generally liked the VTS duty and wouldn't mind having another tour. However, a few who had had several years of duty were bored and disliked it.

b. All interviewees believed in the value of VTS services. There was general agreement that most masters and pilots like the VTS, but that a few are strongly opposed to it.

c. Improvements most often mentioned as needed were: more television sites, more radar sites, and more computer displays.

d. Criteria for selection of personnel should include good hearing, good health, personal qualities, language skills, and experience in communications, radar, and ship handling.

e. The training program needs improvement; a full-time instructor could give more time to teaching and trainee evaluation.

f. There was a general approval of the new twelve-hour watch schedule, but some apprehension as to the possible effects of fatigue.

g. Comments on arrangement of workspace showed considerable concern for a layout that would promote a group operation, particularly the ability to check traffic in adjacent sectors and to assist one another when the workload is unevenly distributed.

h. The primary aids to traffic surveillance (radio, radar, television, and the SS, DR and VU displays) were given high ratings for importance and frequency of usage. However, the TR sheet, supposedly an aid to giving traffic advisories, received low ratings.

i. Opinion was split on the computer, although those who disliked it were aware of its potential advantages. The principal disadvantage noted was its slowness, including the amount of keying required and the delays and rejections following keyed display requests. Several interviewees remarked on inaccuracies in tracking, but with awareness that it can only be as accurate as the data the operator gives it.

j. On the average, watchstanders felt they can comfortably handle up to 20 vessels at one time, although individual opinions varied widely.

k. There is an awareness that "bad traffic" (inaccurate advisories) could cause serious incidents or accidents and some concern that masters and pilots may become too reliant on the VTS and relax their own vigilance. Incidents are rare, but, as one watchstander put it, "The potential is always there."

4.6 Stress Questionnaires

As a part of the process of developing a questionnaire for the study of job-related stress, stress questionnaires were administered to some of the interviewees. Appendix G gives a detailed description of the questionnaire, its administration, and results.

Briefly, on all items (somatic and mood) there was a consistent increase in degree of stress during the progress of a watch. The most sensitive items were aching or burning eyes and tiredness. These results correlate well with those of an FAA study of air traffic controllers, from which the present questionnaire was adapted.

When examined on a day-to-day basis, the questionnaire results showed an increase in stress for three successive days with a leveling off on the fourth day, possibly reflecting adjustment to the new twelve-hour watch schedule. Day-to-day variation was much less than the increase in stress during the watch period within each day.

5. DISCUSSION AND RECOMMENDATIONS

5.1 Communications

Communicating with vessels, the primary mission of the VTS, accounted for 4 percent of observed activities. The number of transactions with vessels varied both with traffic load and with the number of transits originating or ending in the sector; they averaged about two per vessel per hour.

A more detailed analysis of ocommunications is planned for a later date, when typed transcripts of the taped Channel 12 communications become available.

5.2 The VTS-DACS Computer

5.2.1 Display Sheets

It is standard operating procedure to keep the DR display up constantly on one display unit, using the second unit for other displays as required but generally keeping the VU sheet up when nothing else is needed. Frequency data clearly reflected this usage, along with fairly frequent use of the SS display, which must be used whenever a new vessel's data base is entered. The other displays showed relatively little use.

5.2.2 Delay Factors

The data on display delay times clearly support the complaints about slow computer response in the interviews, with delays of up to 15 seconds recorded during our sampling. Several displays also gave rejection rates of 7 percent. Coupling delays and rejections with the number of keystrokes required to call up a display, we can understand why a display is generally called up only when SOP demands it. If we picture a watchstander preparing a traffic advisory for a waiting master or pilot, we can feel his reluctance to make an entry of 10 keystrokes (taking possibly 5 seconds) to request an assisting display that will displace his VU listing and almost certainly require a wait of 7 seconds (possibly 15 seconds) after the keying before the information is displayed. Furthermore, the predicted passings and overtakings on the TR sheet are progressively more inaccurate as time to the event increases. Watchstanders are aware of places where vessels are likely to change speed, and they can make more accurate judgments than the computer's linear extrapolation by dead-reckoning. The 10-keystroke requirement for the TR display involves keying in the ID number. An alternative method is to place the cursor on the vessel on the DR display; however, one interviewee commented that it is easier to key ID than to key the cursor.

Keying is also required to enter data, to edit displays, to call up identification of vessels on the DR display, and to advance a vessel past a check point (GO or MOVE functions). There are relatively few function keys; a great many commands require two keystrokes on the alphanumeric keyboard to identify a function. Since we tallied an action each time keying changed from one area to another on the keyboard, the figure of 26 percent of all observed activities for keying may be inflated; however, there is no doubt that keying is a principal activity.

5.2.3 Routine Usage

The general picture of routine usage of the computer derived from our data shows the SW regularly monitoring the two computer displays (30 percent of all observed activities) with DR always up, VU up except when SS is required. The other formats are seldom used. Display monitoring is a means of surveillance, since it does not vary with vessel traffic load. When radar or television is available as a check, the SW makes more reference to the computer displays, alternately looking back and forth between surveillance aid and computer display.

Keying appears to be required for surveillance, for it also varies independently of traffic load at low load levels. When traffic becomes heavier (15-20 vessels in a sector) keying shows a marked increase in frequency, probably reflecting ID checks to sort out vessels close together.

5.2.4 Possible Improvements

Although there were numerous conversational remarks about watchstanders working for the computer rather than vice versa, the recorded comments of the twelve interviewees reflect an underlying respect for what the computer could do for them if improved. The principal area for improvement seems to be to increase memory capacity to reduce display delay times. Capacity might be increased also by dropping seldom-used displays. Redundancy of activities was commented on; some of this (Daily Vessel Tally) could be eliminated by reprogramming the DE listing to show time of entry.

A major weakness of the VTS-DACS is the inability to combine traffic position and identification data on the same display, thus requiring a DR sheet for position and a second display, VU, for identification and forcing the watchstander to perform continual integration of the two. Resolution limits of the VTS-DACS displays preclude adding ID tags to the DR display. However, if expanded DR displays could be programmed showing sub-sectors, ID tags could be used, and more precise position data could be displayed. Each cell in a display represents one-quarter nautical mile of channel. A vessel proceeding through a cell has its position updated every 15 seconds. At 6 knots SOA, a vessel's position is updated 10 times within one cell, yet its symbol is moved on the DR display only when it changes cells. If the DR could be expanded on command to cover a five-mile area, for example, four sub-cells per cell could be displayed, with a much more precise representation of the relative positions of vessels (a resolution of 380 feet). Any vessel with a speed under 15 knots would still be updated once per sub-cell. Such a capability would be invaluable in resolving problems where vessel density is high. This capability would be analogous to the zoom capability of television.

Another desirable capability within the limits of the VTS-DACS basic design is to off-center a DR display (at sector scale) to give the watchstander a look at approaching traffic in an adjacent sector (analogous to panning in television).

Although the TR sheet is seldom used, it has the potential for being the basic reference for traffic advisories. To realize this potential it would have to be made more accessible and more accurate. Accessibility could be improved by giving it a function key and an improved cursor control. To improve accuracy, a better tracking algorithm would be required--one that would anticipate speed changes at certain cells (such as at sharp channel bends, transition from channel to bay, and at destination).

Keying requirements can be reduced by using more function keys (with BREAK or COMMAND automatically included in the functions where they are required). A joystick or a trackball can simplify cursor operation.

In the meantime, the addition of one computer display scope at each position would increase the flexibility of cross-sector monitoring, permit the use of the SS or TR display without loss of DR and VU, and generally reduce keying requirements.

Reduction of rejected commands would require improvement of the power supply and increased tolerance to rapid keying (perhaps through more buffer memory).

These proposed improvements are ideas that have been suggested in the conversations, the observations and the data collected in this study. They are offered as suggestions for further study rather than recommendations for implementation.

5.3 Vessel Status Cards

The manual advancing of Vessel Status Cards along a plotting board as the basic means for monitoring and updating the traffic situation was adopted as a temporary measure before the VTS-DACS was installed and made operational. At the time of this study, the computer had been operational for two months. The manual system was being used (with individual sector boards) in parallel with the computer and was preferred to the computer by a third of the interviewees.

Working with the cards accounted for 13 percent of observed activities. If we assume that the watchstanders will always want to jot down incoming information before keying it into the system, we could expect the marking activities (3 percent) to continue in a system without card tracking. The remaining 10 percent of activities, evenly divided between advancing or handing off cards and referring to cards, could conceivably be eliminated by a reliable and accurate computer system. This efficiency is not likely to be realized until improvements such as those discussed in Section 5.2.4 are effected, for, even though watchstanders may increase their skill in using the VTS-DACS, the inherent tracking errors and display delays in the computer will force the use of cards as a backup system.

5.4 Surveillance Aids

The radar and television were consistently praised; their usage accounted for 21 percent of observed activities. Interviewees highly recommended acquisition of more of such equipment. Probably the greatest need at present is for more television sites on the western portion of the Houston Ship Channel (Sector III). By providing direct sensing and display of what is actually in the channel, the surveillance aids reduce the system's blind reliance on cooperative reporting, thus increasing system effectiveness and potential for maintaining safe operations.

5.5 Operational Factors

5.5.1 Stress

The administration of the stress questionnaire revealed a progressive increase in stress indications during the course of a watch period. The principal complaint was aching or burning eyes. Two interviewees noted eye problems, blamed on the displays. One said his eyes get "fuzzy" after a long period of monitoring displays. The other said his eyes get "gritty", his eye muscles ache, and it hurts to be exposed to daylight. Primarily to accommodate the low light level of the radar PPI, the operations room is kept at a dim light level day and night. The light level in the visual field is not even; television and computer displays provide bright areas, and illuminated keys on the radio and computer consoles provide numerous bright "hot spots" (see Figure 5-1). Such glare is known to cause decreased visibility and visual discomfort.* Subtle effects of character changes on computer displays and the motion of the sweep on the radar PPI may aggravate these effects.

Although the stress evaluation took place during the first days of the 12-hour watch schedule, the comments of the interviewees reflected their experience during 8-hour watches. The visual stress data show the effect to be progressive through the watch period; so the additional watch time may be aggravating an already undesirable situation. The day-to-day changes in all indices of stress indicate that the watchstanders may have been adapting to stresses induced by the longer watch periods; follow-up administrations of the questionnaire are highly desirable to determine whether stress levels have dropped as adaptation has continued.

5.5.2 Individual vs. Group Operations

Several interviewees commented on the fact that the introduction of the computer has changed the nature of the VTS operation significantly. Previously, watchstanders were grouped around the status board, where each could see the status of the entire system, could interact easily with the other watchstanders, and could help one another when one's workload became heavy. Now the watchstanders are seated back-to one another, have ready access mainly to data for their sector only,

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*Human Engineering Guide to Equipment Design (Revised Edition), Washington, D.C., U.S. Government Printing Office, 1972.

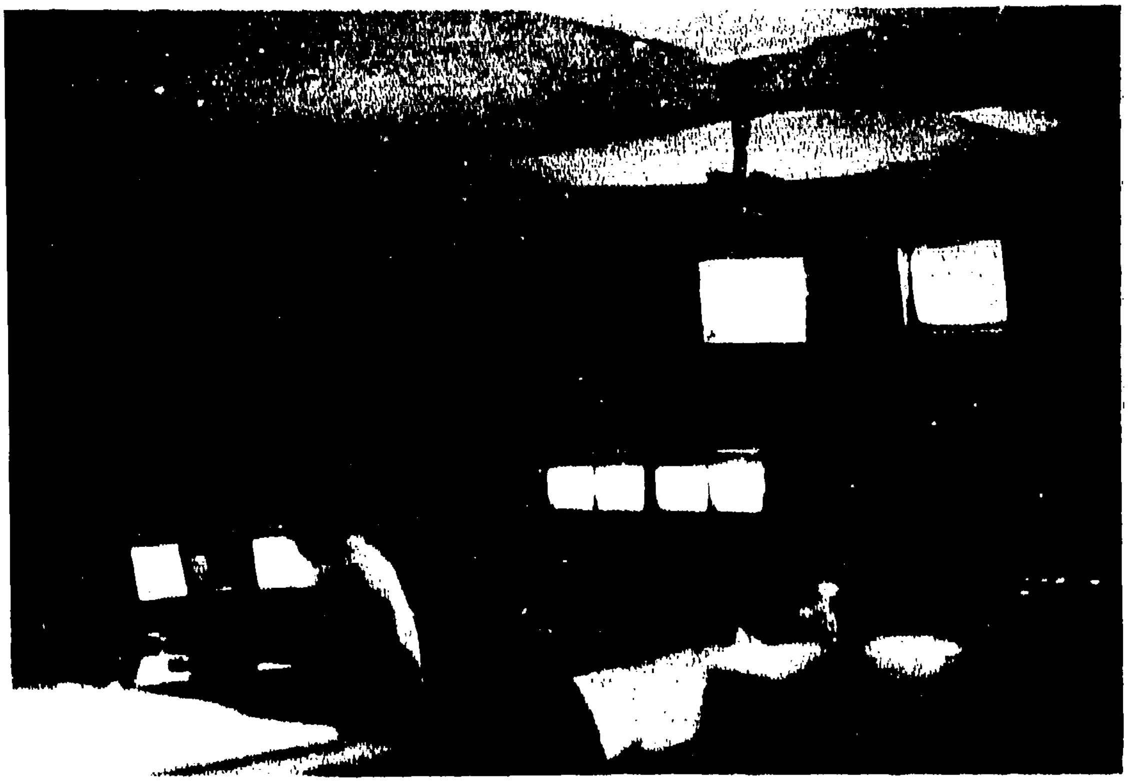

FIGURE 5-1. OPERATIONS ROOM SHOWING GLARE SPOTS

are much less aware of the traffic situation system-wide, spend much time responding to computer requirements, and are less prepared or able to assist one another. Observations (admittedly limited to routine operations) were consistent with this picture. Only one percent of observed activity involved communications between SW's and less than one-percent in mobility between positions.

The data of this study can not indicate whether the segregation of watchstanders is desirable or undesirable from the standpoint of operational effectiveness. However, it was deplored by several interviewees, who suggested rearrangement of consoles to promote more group-like operation, and is thus considered worthy of mention.

5.5.3 Possible Improvements

Factors affecting stress and morale might be relieved through changes in the workspace. Reorientation and shielding of the radar PPI's could reduce the glare of reflections on their faces and permit raising the general level of ambient lighting in the room to the level of the television and computer scopes. Translucent paint on back-illuminated control buttons could dim them to less objectionable hot-spots without affecting the information they convey. Sector positions could be rearranged to give each SW a better view of the displays at adjacent positions and to permit more interaction among watchstanders.

It should be noted here that the interviews elicited many recommendations for personnel selection and training. They are worthy of review and consideration (see Section 4.5 and Appendix F).

5.6 Modeling Considerations

5.6.1 Time Distribution

It is tempting to combine the data on frequency of activities with representative measures of activity duration to obtain a first approximation of a model of the way a sector watchstander divides his working time. Since the duration data were not taken on the same people at the same time, such a combination carries the assumption that the timed operations were essentially the same as the tallied activities, and the results must be interpreted with caution.

Accepting this caveat, we have multiplied the frequencies of Table 4-2 by the median durations of Table 4-3 where comparable activities are recorded. A correction had to be estimated for the computer keying, since complete keying transactions were timed, while a tally was recorded every time the operator moved from one zone of the keyboard to another. We assumed that the 131 tallies of duration greater than 30 seconds represented activities most like those that were timed and should thus represent 24 percent of such activities (Table 4-4). This correction yielded a reduced keying frequency of 546 entries. Since computer display monitoring was not timed, we arbitrarily adopted the median time for radar viewing as an estimate (television monitoring had a larger value because of the time used in zooming and panning). The times so obtained were converted to percents of 15 hours (total time of frequency observations) and added, the residual 3 percent being attributed to untimed miscellaneous activities. The results of these estimates are tabulated in Table 5-1.

An analysis of communications tapes (completed just before going to press) yielded the revised estimates of frequency and duration data for radio messages. Also, the frequencies of Table 5-1 differ from observed frequencies of Table 4-2 because of the correction for type of keying activity and a reduction of computer monitoring frequency to allow for the fact that each keying activity involved one-to-two concurrent glances at the computer displays. Finally, the original miscellaneous activities have been augmented by the addition of all untimed activities (communications with other than vessels, radio adjustments, and reference to other SW's displays). While the assumptions that were made do not permit us to rely on the exact time values of Table 5-1, we can accept the gross time distributions as representative of operations at HOU-GAL VTS during the times of observation. These results show that monitoring displays occupied 40 percent of the SW's time; keying into the computer took 16 percent; using the Vessel Status Cards took up nearly a quarter of his time; and about 18 percent of the time was devoted to communicating with vessels in the system (delivering the system product).

5.6.2 Activity as a Function of Workload

From the collected data, two estimates of workload were derived for each 15 minutes of observation of watchstander activities. Traffic Load is the average number of vessels in the sector during the 15-minute period. Traffic Changes were also calculated for each period by combining the number of vessels entering and leaving the sector during the period. The second measure was selected because more watchstander activity is required to enter a vessel into the system or to remove it than to track it. (Traffic changes also included passages to or from adjacent sectors, which do not require as much activity as system entries and exits.) These two workload measures were correlated to see if they are different. The correlation coefficients were

TABLE 5-1. SECTOR WATCHSTANDER ACTIVITY AND TIME DISTRIBUTIONS, HOU-GAL VTS

Activity	Number	Duration (Secs.)	Percentage Frequency	Percentage Time
Radio Message to Vessel	446	22	9	18
Monitoring Computer	1080	6	22	12
Keying Computer	546	16	11	16
Using Cards	873	14	18	23
Using Radar	494	6	10	5
Using Television	942	13	20	23
Miscellaneous	435	4	9	3
TOTAL	4816			

Note: Assumptions and corrections leading to these figures are explained in the text.

-0.15, 0.21, and 0.22 for Sectors I, II and III respectively. None of these values is statistically significant.*

All of the measures were intercorrelated to determine whether there was a consistent enough pattern of relationships to warrant construction of a multiple regression model. The conclusion was negative. Very few significant correlations were obtained with either workload measure, and these showed no consistent pattern from sector to sector. Table 5-2 summarizes the results with the principal variables.

Our inability to derive a regression model of VTS watchstander activities is largely explained by the lack of variance in traffic measures over the periods of observation. The approach could still yield a useful model given sampling over a wider variety of traffic conditions.

Some qualitative conclusions can be drawn from the variability of activities with traffic. Overall activity was greater in sectors having higher traffic loads. Activities relative to traffic monitoring were relatively independent of the amount of traffic. Communications with vessels varied with the traffic. At low levels of traffic (below 15 vessels in a sector), keying activity was independent of traffic, probably dominated by the keying required for monitoring. When the sector load was 15-20 vessels, a considerable increase in keying was observed, probably related to sorting out identities of vessels close to one another. Working with Vessel Status Cards varied with traffic.

5.7 Recommendations

Analysis of the data collected on watchstander activities and the responses recorded in interviews has revealed several areas that appear to be amenable to improvements. The feasibility and desirability of implementing these changes can

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*A correlation coefficient is an index of the degree to which two sets of measures vary together; 1.00 indicates a perfect relationship; 0 indicates no relationship, and a negative value means that one measure increases as the other decreases. Statistical significance is based on an estimate of the likelihood that the value obtained was due to chance alone rather than to a true relationship. It is customary to accept as significant only values that would have less than one chance in twenty (p less than .05) of occurring by random variation.

TABLE 5-2. CORRELATIONS OF ACTIVITY WITH TRAFFIC

Correlations with Traffic Load

	Sectors I	Sectors II	Sectors III
Communication with Vessels	.19	.54**	.86***
Keyboard Activity	-.04	-.27	.74***
Marking and Stamping Cards	-.12	-.07	.25
Total Activity with Cards	.28	.18	.22
Reference to Radar/TV	-.27	.54**	-.08
General Use of Computer	.04	.26	.65**

Correlations with Traffic Changes

	Sectors I	Sectors II	Sectors III
Communications with Vessels	.08	.19	.36
Keyboard Activity	.70**	.01	.45*
Marking and Stamping Cards	.76***	.16	.42*

Statistical Significance

* = $p < .05$
** = $p < .01$
*** = $p < .001$

not be determined from this study. We do recommend that consideration be given to these changes and that their feasibility be given study.

a. Add additional television sites to Sector III. (Fig. 2-1, 4.2.5, 4.5c, 5.4)*

b. Add a radar site to Sector II. (Fig. 2-1, 4.2.5, 4.5c, 5.4)

c. Provide additional computer display scopes at Sector Watchstander positions. (4.5c, 5.2.4)

d. Reprogram the VTS-DACS display formats to eliminate unnecessary displays, to add entry time to the Vessel Departures Sheet, and to allow expansion and off-centering of the Dead Reckoning Sheet. (4.4.2, 5.2.4)

e. Increase the computer memory capacity to permit reduction in display delay times. (4.4.2, 4.5i, 5.2.2, 5.2.4)

f. Add more function keys to the keyboard to reduce the number of keystrokes required for requests and commands. (4.4.2, 4.5i, 5.2.2, 5.2.4)

g. Provide a trackball or joystick for cursor control on the VTS-DACS displays. (5.2.4)

h. Extend the tracking algorithm to include predictions of changes in vessel speed. (4.5i, 5.2.2, 5.2.4)

i. Obtain a more stable power supply for the VTS-DACS. (4.4.3, 5.2.2, 5.2.4)

j. Reorient and shield the radar PPI's to reduce glare. (5.5.1)

k. Increase room illumination to the level of television and computer displays. (5.5.1)

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*Numbers in parentheses refer to relevant sections of this report.

l. Mask down the brightness of self-illuminated panel buttons. (5.5.1)

m. Conduct follow-on stress evaluations as an aid to evaluation of the twelve-hour watch schedule. (5.5.1)

n. Study the relative merits of grouped versus segregated sector positions. (5.5.2)

o. Provide at least one position for a full-time training instructor. (2.4.3, 4.5e)

p. Establish a set of criteria for selection of personnel for VTS duty. (2.4.2, 4.5d)

APPENDIX A

HOU-GAL VTS-DACS
DISPLAY SHEETS

Figure A-1. SS - Vessel Status Display

The Vessel Status Display contains all the required information concerning each vessel within the system. Lines 1, 3, 4, 5, 6, 7, 8, 9, 10, 11, and 15 are entered by the operator. The computer assigns an Identification Number, and using the entered data, dead-reckons future positions and automatically enters the next check point and estimated times of arrival at the destination and at the next check point.

Figure A-2. DR - Dead Reckoning Plot, Format (A)

The Dead Reckoning Plot graphically displays the location of all vessels underway within the selected sector bounds. Format (A) also provides channel orientation points, check points, sector boundaries, channel navigation points, and mooring and docking facilities.

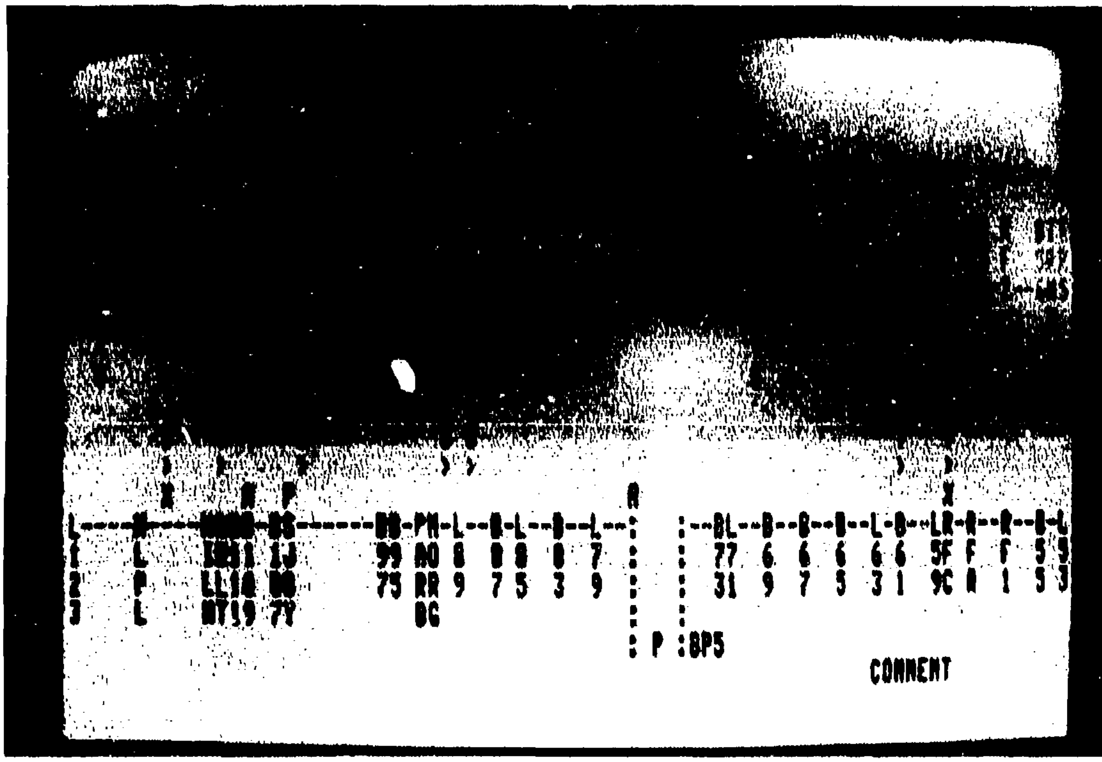


Figure A-3. DR - Dead Reckoning Plot, Format (A + B)

Format (A + B) includes Format (A) plus additional geographical and navigation reference points.

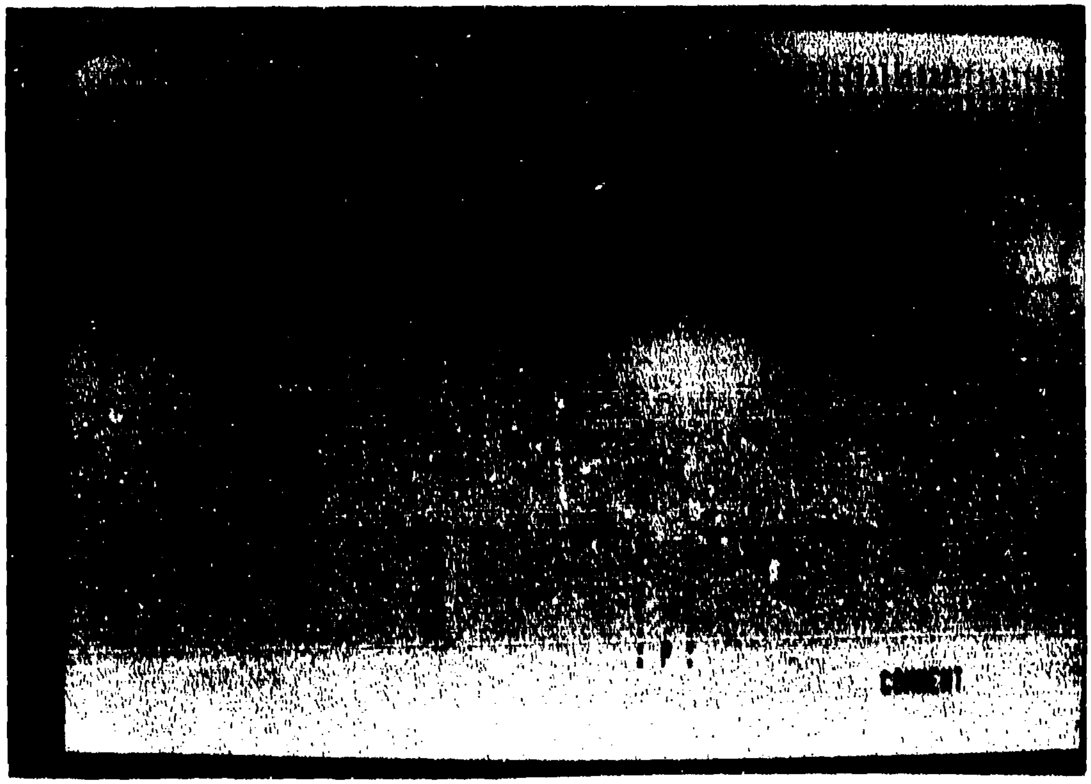


Figure A-4. DR - Dead Reckoning Plot, Format (A + C)

Format (A + C) includes Format (A) plus all cell numbers.

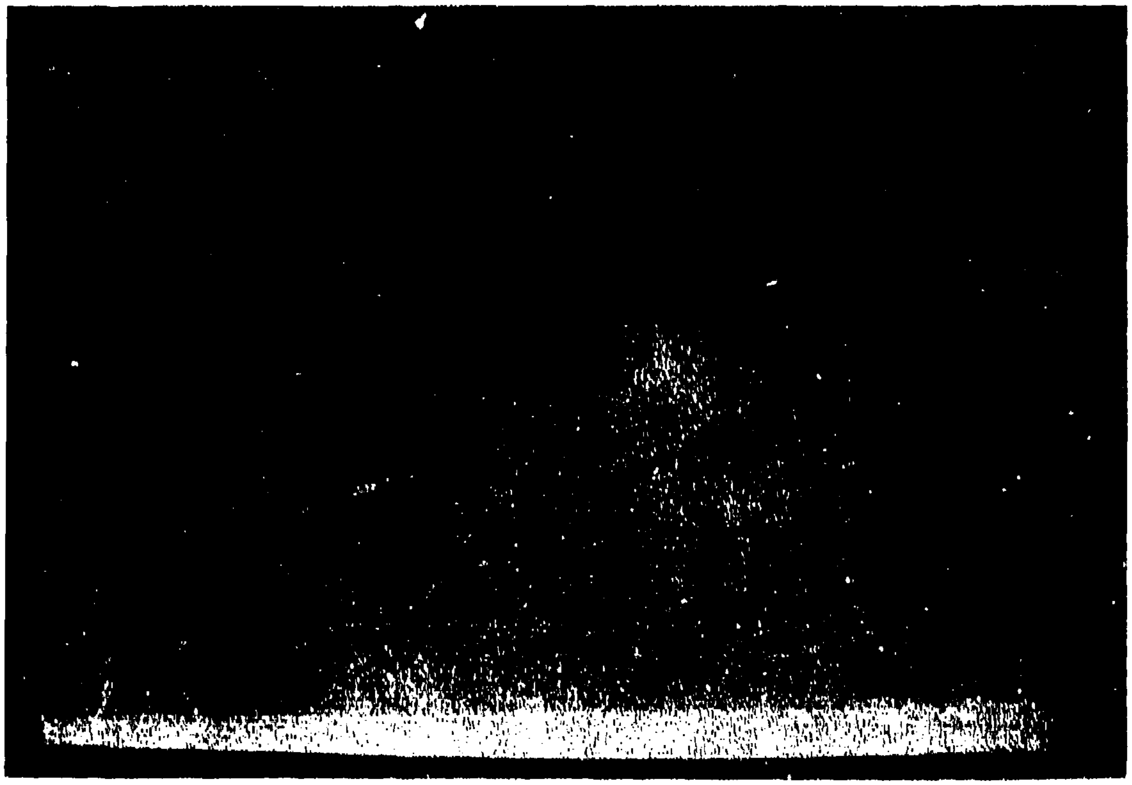


Figure A-5. DR - Dead Reckoning Plot, Format (A + B + C)

Format (A + B + C) combines all of the data of Formats (A), (B), and (C).

Figure A-6. VU - Vessels Underway Display

The Vessels Underway Display lists information concerning the inbound and outbound traffic operating within the bounds of the [illegible].

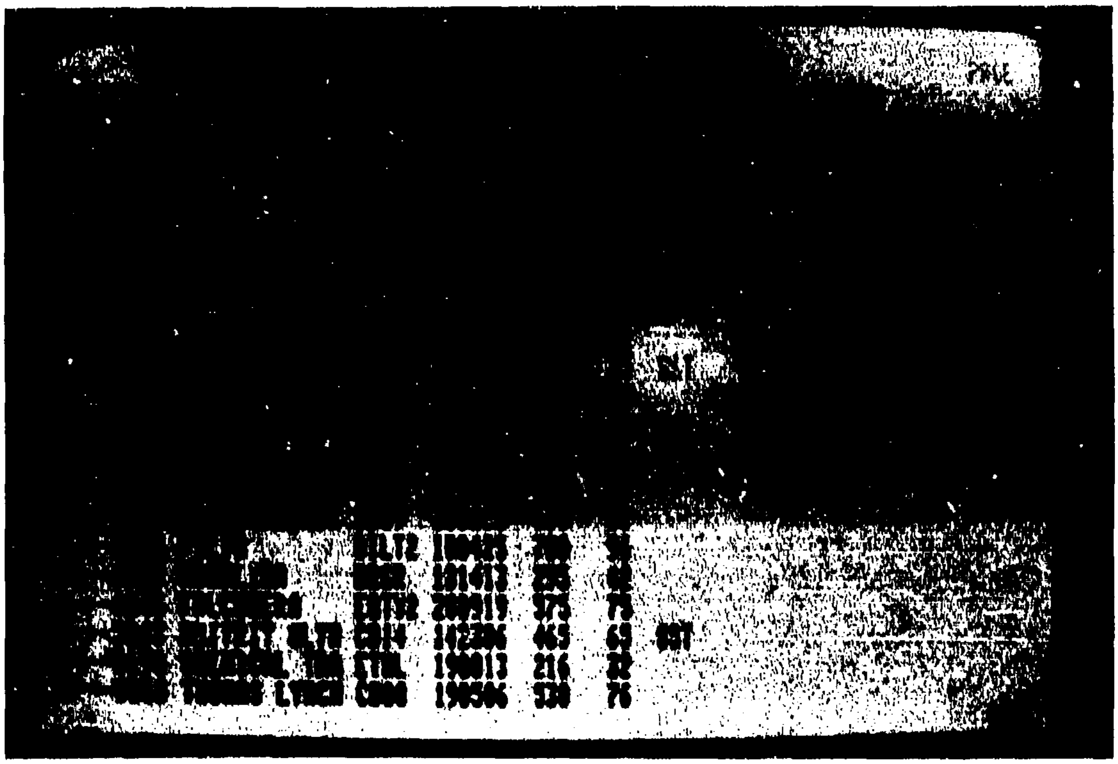


Figure A-7. IP - Vessels In-Port Display

The Vessels In-Port Display lists those vessels terminated in the port of Houston, Texas City, or Galveston. These vessels are dropped from the Dead Reckoning and the Vessels Underway Displays.

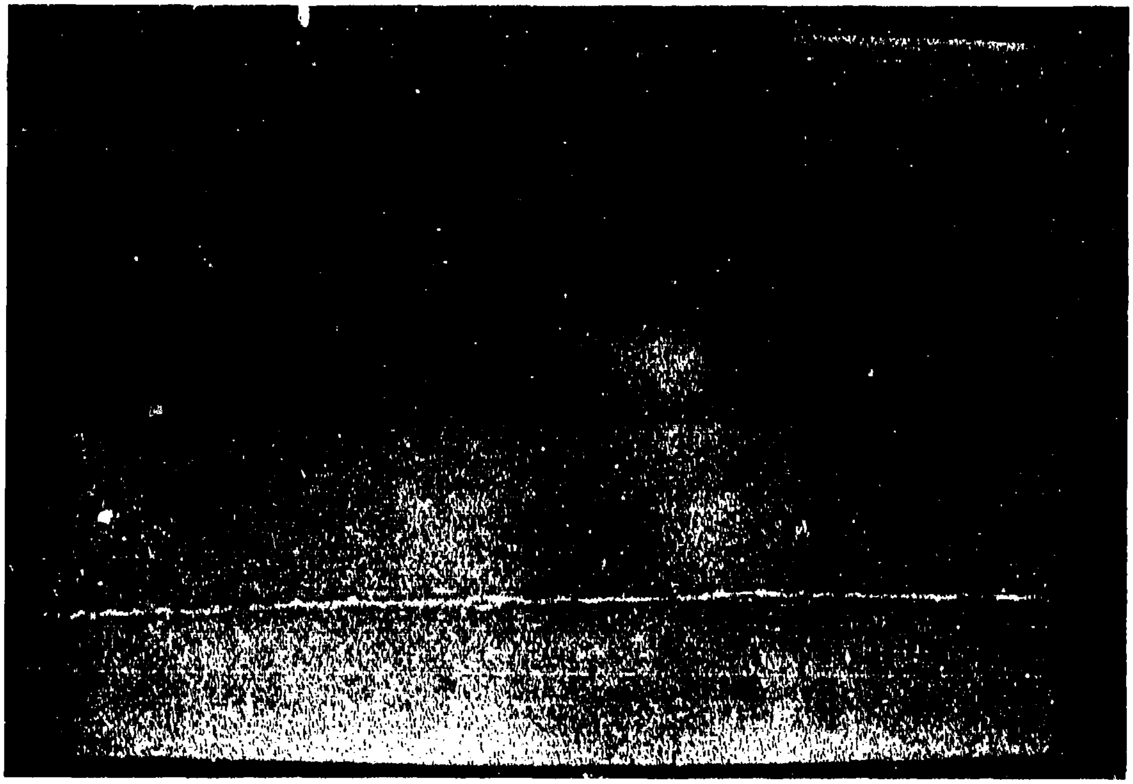


Figure A-8. TR - Traffic Summary Display

The Traffic Summary Display lists all vessels within a specified sector (or sectors) that a specified vessel will encounter, including time and cell location of each encounter. A total of 240 listings at 20 per page is possible.

Figure A-9. DE - Vessel Departures Display

The Vessel Departures Display lists those vessels terminated by exiting the entire system. These vessels are dropped from the Dead Reckoning, the Vessels Underway, and the Vessel Status Displays.

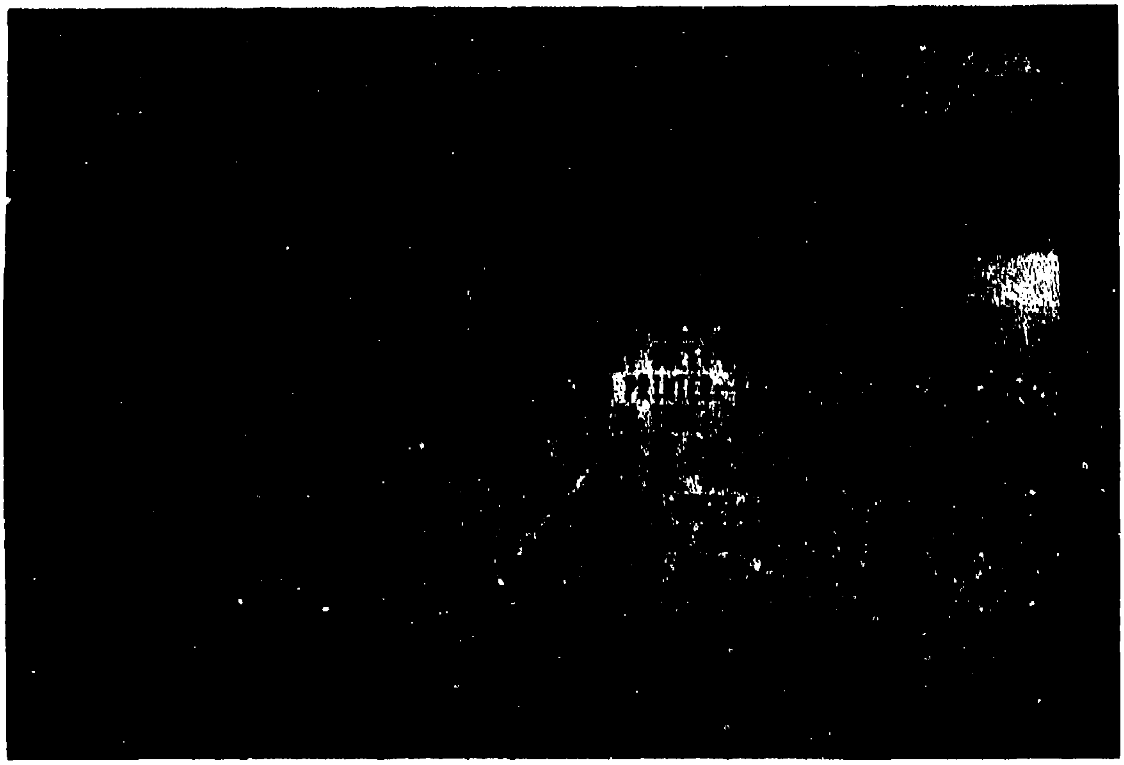


Figure A-10. DI - Command Dictionary Display

The Command Dictionary Display lists all available computer keyboard commands.

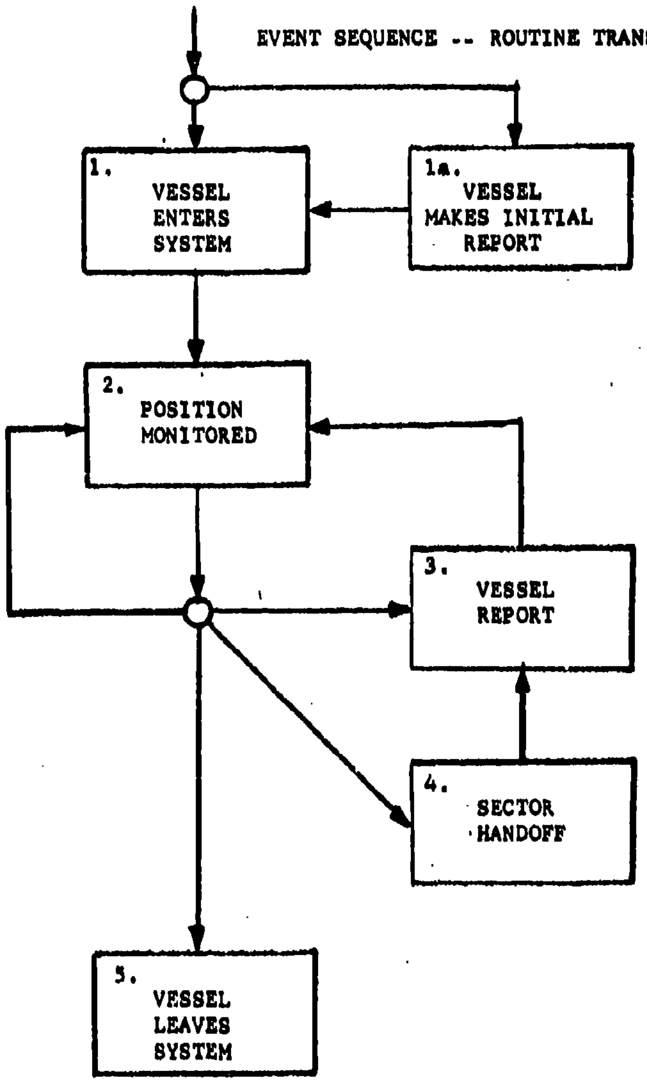
APPENDIX B

OPERATIONAL SEQUENCE DIAGRAMS

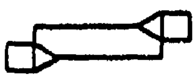
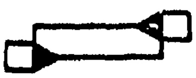
HOU-GAL VTS

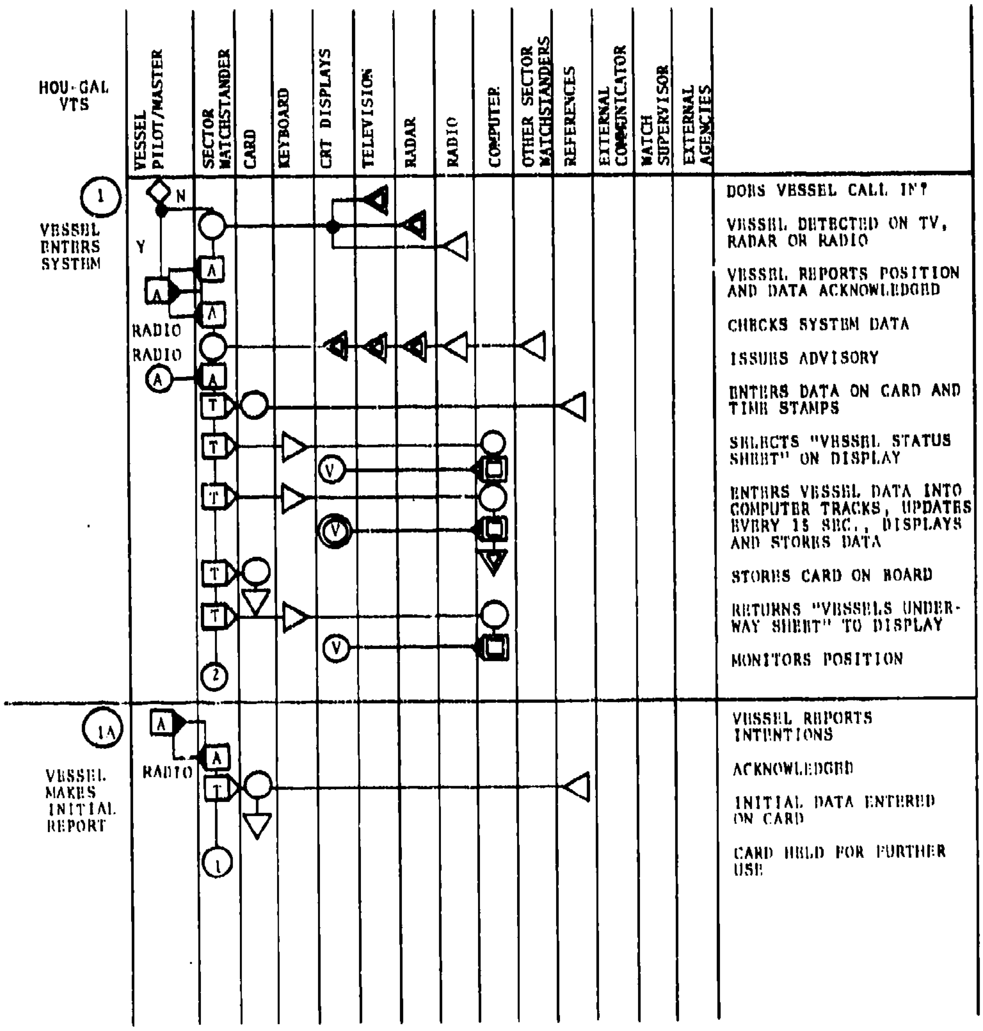
ROUTINE TRANSIT

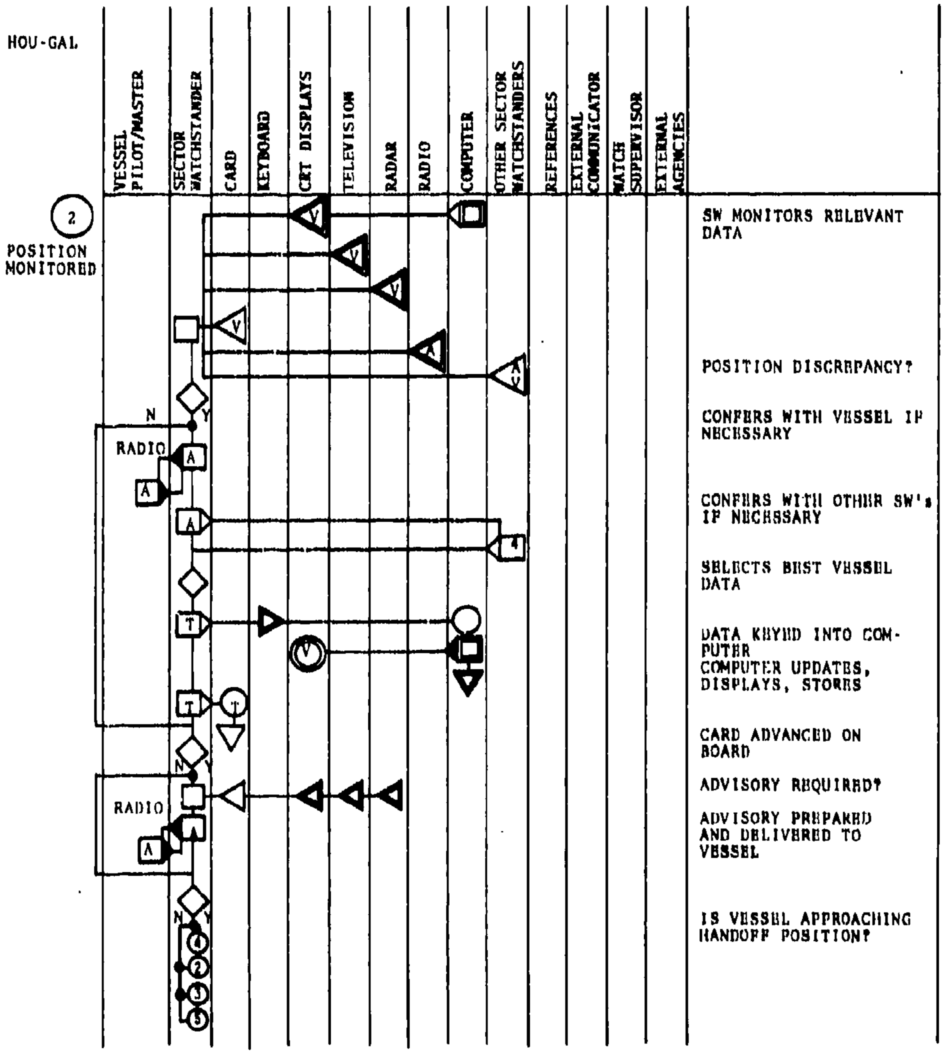
HOU-GAL VTS EVENT SEQUENCE -- ROUTINE TRANSIT



OPERATIONAL SEQUENCE DIAGRAM LEGEND

○	Information received by an operator or a system component
□	Operator action
◁	Transmission of information or action
◇	Operator decision
▣	Automatic action
◉	Automatic receipt of information
◀	Automatic transmission of information/data
▽	Manual storage, filing of information
▼	Automatic data storage
	A communications loop between two operators, talk without aids
	A communications loop between two operators, radio or interphone
A	Aurally or Vocally
T	Tactually
V	Visually
●	"Or gate"; follow one path only

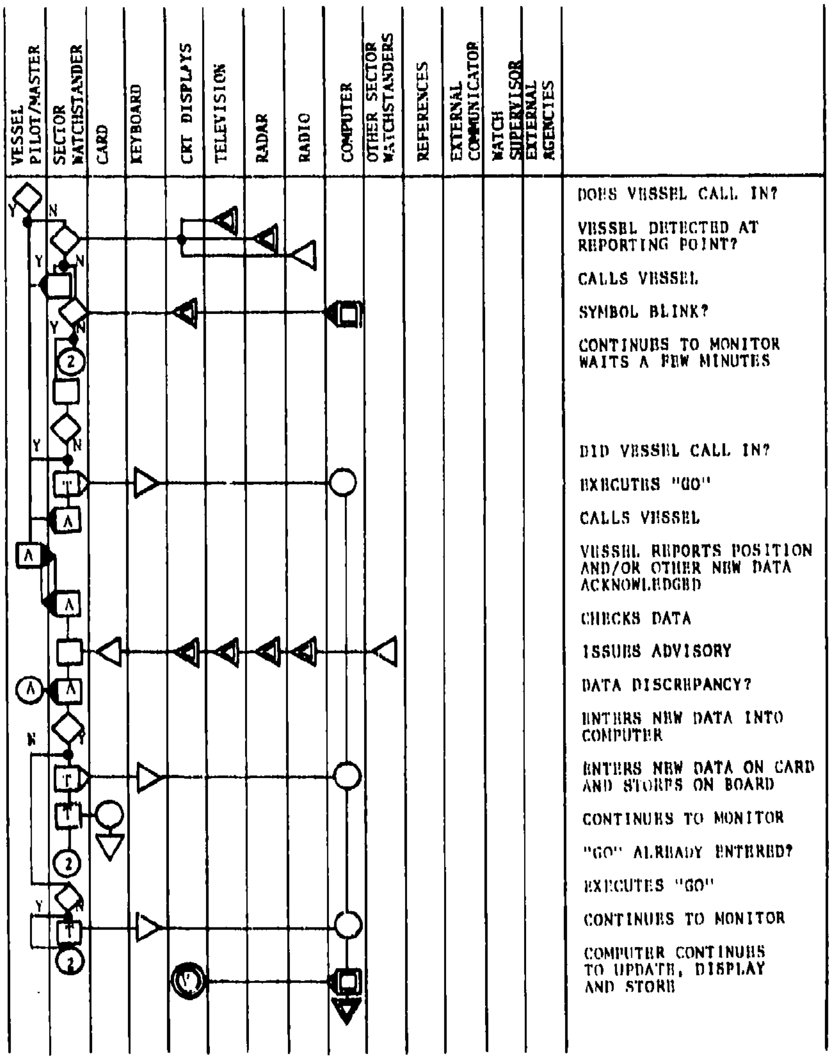

HOU-GAL VTS
VESSEL PILOT/MASTER
SECTOR WATCHSTANDER
CARD
KEYBOARD
CRT DISPLAYS
TELEVISION
RADAR
RADIO
COMPUTER
OTHER SECTOR WATCHSTANDERS
REFERENCES
EXTERNAL COMMUNICATOR
WATCH SUPERVISOR
EXTERNAL AGENCIES
1
VESSEL ENTERS SYSTEM
N
Y
RADIO
RADIO
A
T
V
2
DOES VESSEL CALL IN?
VESSEL DETECTED ON TV, RADAR OR RADIO
VESSEL REPORTS POSITION AND DATA ACKNOWLEDGED
CHECKS SYSTEM DATA
ISSUES ADVISORY
ENTERS DATA ON CARD AND TIME STAMPS
SELECTS "VESSEL STATUS SHEET" ON DISPLAY
ENTERS VESSEL DATA INTO COMPUTER TRACKS, UPDATES EVERY 15 SEC., DISPLAYS AND STORES DATA
STORES CARD ON BOARD
RETURNS "VESSELS UNDER-WAY SHEET" TO DISPLAY
MONITORS POSITION
1A
VESSEL MAKES INITIAL REPORT
RADIO
1
VESSEL REPORTS INTENTIONS
ACKNOWLEDGED
INITIAL DATA ENTERED ON CARD
CARD HELD FOR FURTHER USE

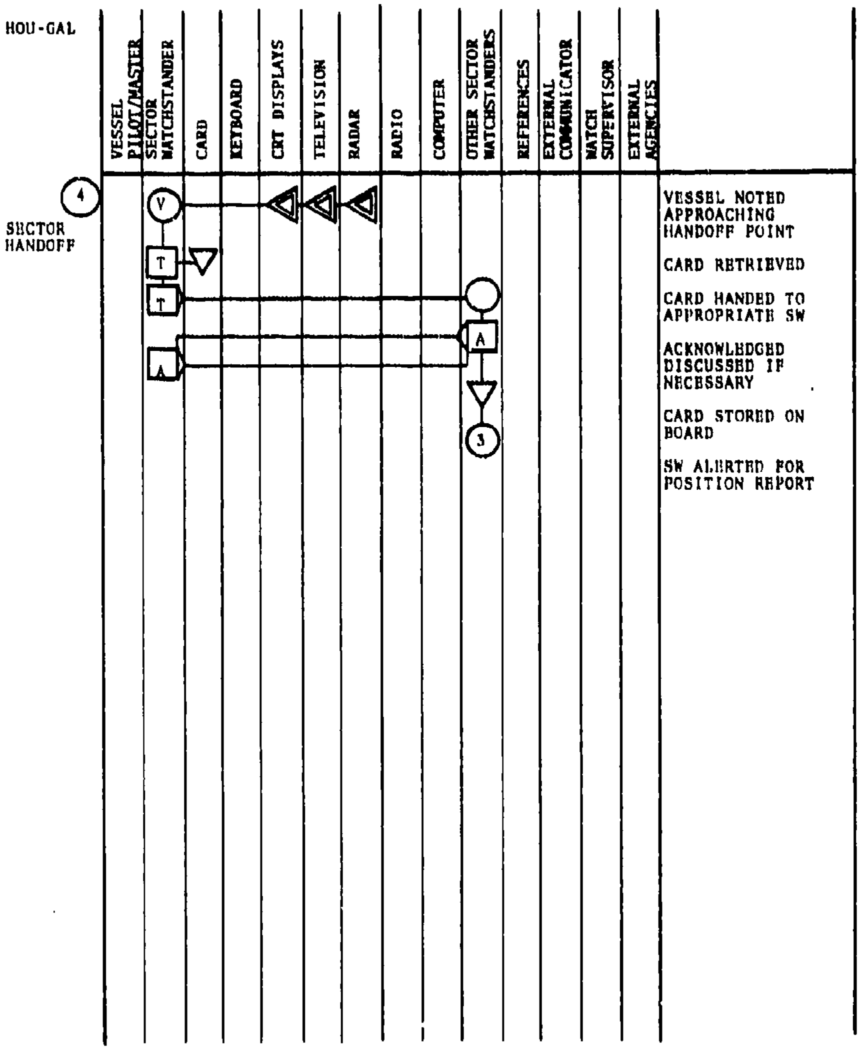

HOU-GAL
VESSEL PILOT/MASTER
SECTOR WATCHSTANDER
CARD
KEYBOARD
CRT DISPLAYS
TELEVISION
RADAR
RADIO
COMPUTER
OTHER SECTOR WATCHSTANDERS
REFERENCES
EXTERNAL COMMUNICATOR
WATCH SUPERVISOR
EXTERNAL AGENCIES
2
POSITION MONITORED
SW MONITORS RELEVANT DATA
POSITION DISCREPANCY?
N
Y
RADIO
CONFERS WITH VESSEL IF NECESSARY
CONFERS WITH OTHER SW's IF NECESSARY
SELECTS BEST VESSEL DATA
DATA KEYED INTO COMPUTER
COMPUTER UPDATES, DISPLAYS, STORES
CARD ADVANCED ON BOARD
ADVISORY REQUIRED?
RADIO
ADVISORY PREPARED AND DELIVERED TO VESSEL
IS VESSEL APPROACHING HANDOFF POSITION?

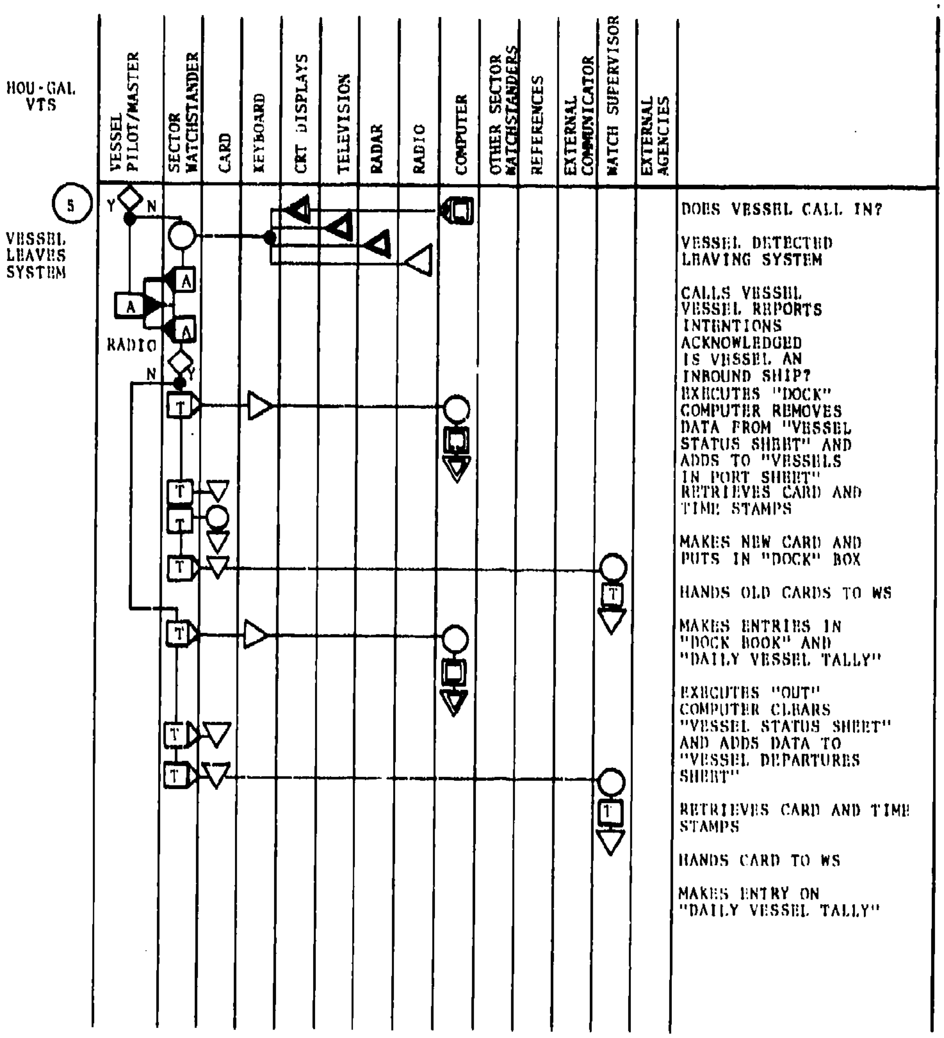
HOU-GAL

3

VESSEL REPORT




HOU-GAL
VESSEL PILOT/MASTER
SECTOR WATCHSTANDER
CARD
KEYBOARD
CRT DISPLAYS
TELEVISION
RADAR
RADIO
COMPUTER
OTHER SECTOR WATCHSTANDERS
REFERENCES
EXTERNAL COMMUNICATOR
WATCH SUPERVISOR
EXTERNAL AGENCIES
4
SECTOR HANDOFF
V
T
T
A
A
3
VESSEL NOTED APPROACHING HANDOFF POINT
CARD RETRIEVED
CARD HANDED TO APPROPRIATE SW
ACKNOWLEDGED DISCUSSED IF NECESSARY
CARD STORED ON BOARD
SW ALERTED FOR POSITION REPORT


HOU-GAL VTS
VESSEL PILOT/MASTER
SECTOR WATCHSTANDER
CARD
KEYBOARD
CRT DISPLAYS
TELEVISION
RADAR
RADIO
COMPUTER
OTHER SECTOR WATCHSTANDERS
REFERENCES
EXTERNAL COMMUNICATOR
WATCH SUPERVISOR
EXTERNAL AGENCIES
5
VESSEL LEAVES SYSTEM
Y
N
A
RADIO
T
DOES VESSEL CALL IN?
VESSEL DETECTED LEAVING SYSTEM
CALLS VESSEL
VESSEL REPORTS INTENTIONS
ACKNOWLEDGED
IS VESSEL AN INBOUND SHIP?
EXECUTES "DOCK"
COMPUTER REMOVES DATA FROM "VESSEL STATUS SHEET" AND ADDS TO "VESSELS IN PORT SHEET"
RETRIEVES CARD AND TIME STAMPS
MAKES NEW CARD AND PUTS IN "DOCK" BOX
HANDS OLD CARDS TO WS
MAKES ENTRIES IN "DOCK BOOK" AND "DAILY VESSEL TALLY"
EXECUTES "OUT"
COMPUTER CLEARS "VESSEL STATUS SHEET" AND ADDS DATA TO "VESSEL DEPARTURES SHEET"
RETRIEVES CARD AND TIME STAMPS
HANDS CARD TO WS
MAKES ENTRY ON "DAILY VESSEL TALLY"

APPENDIX C
ITEMS ON THE WATCHSTANDER ACTIVITY LOG

Date | HQUS-GAL VTS ACTIVITY LOG | Position WS I II III # | Sheet:

HR	COMMUNICATIONS	COMPUTER (MONITOR / DISP / KEYBD)	CARDS	TV	RADAR	MISC	REMARKS (Visibility / Traffic)
1							
2							
3							
4							
5							
6							
7							
8							
9							
10							
11							
12							
13							
14							
15							
Totals							

SAMPLE WATCHSTANDER ACTIVITY LOG SHEET

COMMUNICATIONS

VT - Any communication between the Watchstander and a vessel via radio. A tally was recorded on the log each time the Watchstander talked to the vessel. Should the Watchstander stop talking and perform another activity, such as marking a vessel status card, and then begin talking to the same or a different vessel, a new tally was recorded.

SW# - Communication between the Watchstander and one of the other two Sector Watchstanders, designated by sector numbers 1, 2 or 3.

XC - Communication between the Watchstander and the External Communicator. Tallies were not recorded consistently in this column because the observer was often unable to identify the External Communicator due to his high mobility. Tallies in this category were combined with the results of the "other" category listed below.

Oth - Communication between the Watchstander and any other individual (including the External Communicator).

WO - Communication between the Watchstander and the Watch Officer.

UK - Communication between the Watchstander and an unidentifiable individual. This category was deleted from the data analysis because no such activity was observed to occur.

Rad Adj - Any operation of radio controls performed by the Watchstander (such as channel selection or volume adjustment).

COMPUTER

Monitor S# - The Watchstander looked at the CRT display(s) of another Watchstander, designated by Sector numbers 1, 2 or 3. The third column entitled "S#" was not used in data collection.

Display 1,2 - The Watchstander monitored the left (1) or right (2) CRT display at his position. A tally was recorded each time the Watchstander viewed the display. A single tally was made whenever a keyboard entry was made, since this activity required observing the display. When the Watchstander interrupted his monitoring or keying activities to perform another observable activity and then resumed monitoring or keying, a new tally was recorded on the log.

The display sheet which was viewed on the CRT was indicated by an encircled number beside the tally to identify one of the seven available display sheets:

1. SS - Vessel Status plot sheet for each vessel
2. DR - Dead Reckoning plot sheet for each sector
3. VU - Vessels Underway sheet for each sector
4. IP - Vessels-in-Port sheet for each port
5. TR - Traffic Summary sheet for each vessel
6. DE - Vessel Departures sheet for the VTS
7. DI - Command Dictionary

Keyboard A - A key entry of one or more consecutive keystrokes performed by the Watchstander in the alphanumeric section (key group A) of the Command Keyboard. A tally represented one key action which began with the start of a key entry and ended when the Watchstander made a key entry at another section of the keyboard or stopped keying.

Keyboard B - A key entry of one or more consecutive keystrokes performed by the Watchstander in key group B of the Command Keyboard, composed of 12 function keys used to implement command operations. Tally procedures were the same as for "keyboard A."

Keyboard C - A key entry of one or more consecutive keystrokes performed by the Watchstander in key group C of the Command Keyboard composed of 12 function keys used for cursor operations.

Keyboard D - The Watchstander made a single keystroke to select one of the two CRT units to which keyboard entries were to be addressed.

CARDS

MK - The Watchstander marked a written entry on the Vessel Status Card. A tally was recorded each time the Watchstander was involved in writing on a card.

TP - The Watchstander time-punched a Vessel Status Card either upon vessel entry into or exit from the VTS. A tally was recorded for each time-punch activity.

CK - Watchstander referred to (or checked) one or more vessel status cards. In referring to a card, the Watchstander may have physically handled the card or simply viewed it.

F/U - The Watchstander filed one or more Vessel Status Cards or updated card positions on the plotting board at his position.

Hd - The Watchstander handed one or more Vessel Status Cards to another person or received one or more cards from another person.

TV

Mn - The Watchstander looked at the array of four TV displays at his position.

Cm - The Watchstander made a camera selection at his TV adjustment panel.

Pn - The Watchstander made one or more consecutive panning adjustments.

Zm - The Watchstander made one or more consecutive zooming adjustments.

Adj - The Watchstander made other TV adjustments (such as brightness or contrast).

RADAR

Mn - Sector I Watchstander monitored the radar display at his position. A tally was recorded each time the Watchstander viewed the display. With each radar adjustment activity, one tally was recorded since monitoring was required.

Adj - Sector I Watchstander made radar adjustments other than centering, scaling and cursor adjustments listed below. As with all adjustment activities, a tally was recorded when the Watchstander began adjusting. The activity was considered completed when the Watchstander changed from an adjustment activity to another activity, regardless of the number of specific adjustments made during this time.

CN - Sector I Watchstander centered or off-centered the sweep on his radar display. Tally specifications were the same as for "Adj" category listed above.

SC -Sector I Watchstander changed the scale on his radar display. Tally specifications were the same as for "Adj" category listed above.

CR - Sector I Watchstander operated the cursor on his radar display.

MISC

RF - The Watchstander consulted a reference (such as a book or a set of index cards).

Mb -The Watchstander left his position. A single tally mark was made for any set of activities occuring between the time he left his position and the time when he was seated again at his position.

APPENDIX D

FREQUENCIES OF OBSERVED ACTIVITIES

HOURLY FREQUENCIES BY SECTOR

Sector I

HR.	COMMUNICATIONS Vt	SW^2	SW^3	No	Oth	UK	Rad Adj	COMPUTER Monitor S3	Monitor S2	Disp 1	Disp 2	Keybd A	Keybd B	Keybd C	D	CARDS Mk	TP	CK	F/U	Hd	RADAR M_N	Adj	C_N	Sc	Cr	MISC. Rf	mb
1*	27	5	2	1	5	0	2	0	1	84	30	19	48	31	6	13	8	13	17	9	86	0	0	0	0	2	2
2*	17	1	3	4	4	0	8	0	0	82	42	23	47	36	7	18	5	14	10	7	74	2	3	3	9	2	0
3*	22	5	1	3	3	0	3	0	1	101	61	14	71	40	4	18	9	21	12	8	90	0	0	2	1	3	1
4*	20	3	0	3	34	0	4	0	3	106	71	38	54	17	6	18	6	18	8	8	98	0	2	7	17	1	0
5*	13	7	0	0	23	0	5	0	2	75	68	43	60	15	10	17	9	28	10	4	64	0	0	1	13	12	2
Σ	99	21	6	13	69	0	22	0	7	450	272	137	280	139	33	84	39	94	57	36	412	2	5	13	40	20	5
$\bar{X}$	10	4	0.7	1	14	0	4	0	1	90	54	27	56	28	7	17	8	19	11	7	82	4	1	3	8	4	1
tot Σ	230				10%			1318			56%					310			13%		472		20%			25	1%
tot $\bar{X}$	46							264								62					94					5	

HOURLY FREQUENCIES BY SECTOR

Sector II

	COMMUNICATIONS							COMPUTER								CARDS					TV					RADAR	MISC.	
							Rad	Monitor		Disp			Keybd															
HR.	Vt	SW^1	SW^3	No	Oth	UK	Adj	S1	S3	1	2	A	B	C	D	Mk	TP	CK	F/U	Hd	M_N	Cm	P_N	Zm	Adj	Mn	Rf	mb
1*	8	1	5	1	2	0	3	0	7	65	47	8	19	7	4	1	1	8	[illegible]	5	47	2	7	6	2	3	3	2
2*	18	0	0	5	3	0	17	0	0	57	24	15	42	19	2	7	1	16	8	3	67	4	31	24	0	0	0	1
3*	8	3	1	0	20	0	1	0	1	119	77	13	29	13	2	6	2	19	11	3	85	12	50	30	1	0	0	0
4*	15	3	8	3	3	0	6	3	6	93	79	16	19	2	2	2	1	7	5	7	91	5	38	31	0	7	1	2
5*	8	5	6	3	22	0	4	0	1	57	38	39	46	0	5	6	2	9	4	2	20	4	18	15	0	12	2	0
Σ	57	12	20	12	50	0	31	3	15	391	265	91	155	41	15	22	7	59	36	20	310	27	144	106	3	22	6	5
$\bar{X}$	11	2	4	2	10	0	6	6	3	78	53	18	31	8	3	4	1	12	7	4	62	5	29	21	6	4	1	1
tot Σ	182				9%			976					51%			144			7%		590		31%			33	2%	
tot $\bar{X}$	36							195								29					118					7		

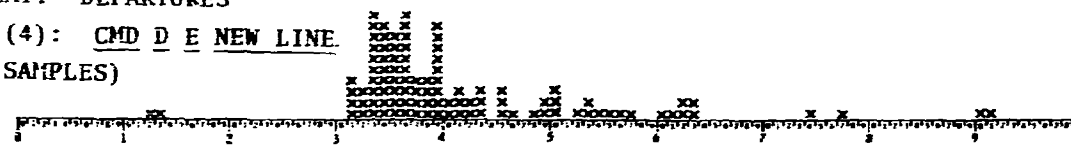
HOURLY FREQUENCIES BY SECTOR

Sector III

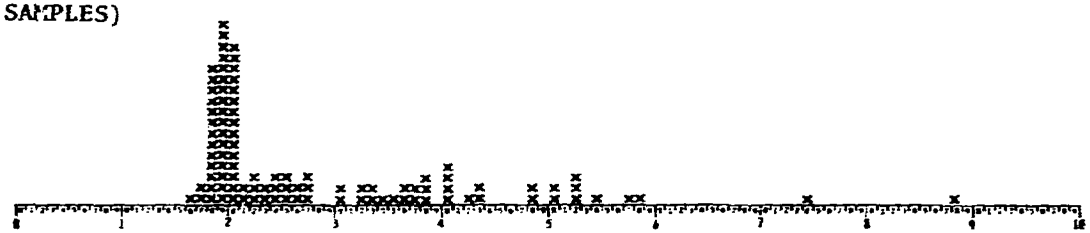
			COMMUNICATIONS					COMPUTER								CARDS					TV					MISC.	
HR.	Vt	SW^1	SW^2	No	Oth	UK	Rad Adj	Monitor S1	S2	Disp 1	2	A	Keybd B	C	D	Mk	TP	CK	F/U	Hd	M_N	Cm	Pn	Zm	Adj	Rf	mb
1*	22	1	2	0	2	0	8	0	0	53	45	41	99	39	16	20	21	22	11	5	4	2	3	3	3	4	3
2*	19	1	6	4	1	0	9	0	1	71	60	27	50	25	9	17	7	17	10	4	56	8	10	5	0	2	0
3*	23	0	0	3	9	0	7	0	2	59	42	43	89	37	12	27	9	17	11	3	28	9	13	5	0	0	2
4*	46	1	4	5	1	0	4	0	1	84	77	86	122	37	11	23	13	27	11	9	43	11	28	18	1	2	1
5*	12	1	3	3	18	0	3	0	2	69	54	38	54	7	3	16	7	45	4	5	36	7	33	26	0	1	1
Σ	122	4	15	15	31	0	31	0	6	336	287	235	414	145	51	103	57	185	48	26	167	37	87	57	4	9	7
$\bar{X}$	24	8	3	3	6	0	6	0	1	67	57	47	83	29	10	21	11	37	10	5	33	7	17	11	8	2	1
tot Σ	218			9%				1474			59%					419			17%		352			14%		16	1%
tot $\bar{X}$	43							295								84					70					3	

APPENDIX E
OBSERVED COMPUTER DELAY TIMES

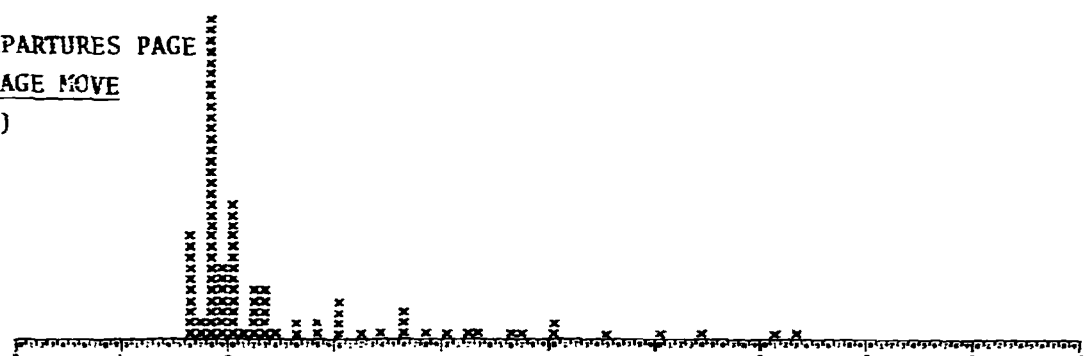
DISPLAY: DEPARTURES
KEYS (4): CMD D E NEW LINE
(100 SAMPLES)



DISPLAY: DEPARTURES
KEYS (0): LESS KEYING TIME
(100 SAMPLES)



DISPLAY: DEPARTURES PAGE
KEYS (1): PAGE MOVE
(100 SAMPLES)

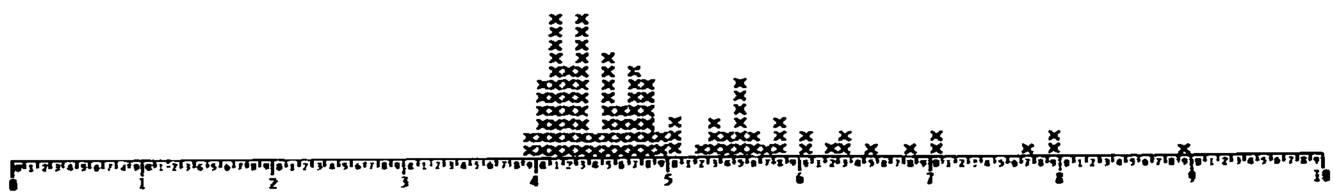


TIME (IN SEC.)

DISPLAY: VESSEL STATUS SHEET

KEYS (8): CMD S S 1 # # # NEW LINE

(100 SAMPLES)

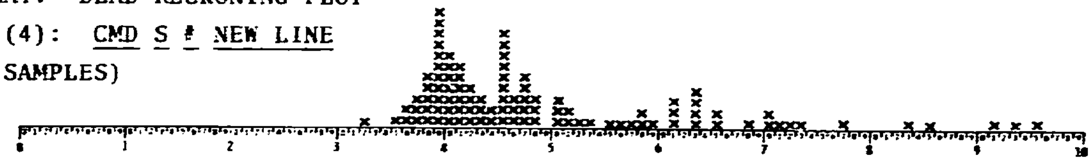


TIME (IN SEC.)

DISPLAY: DEAD RECKONING PLOT

KEYS (4): CMD S # NEW LINE

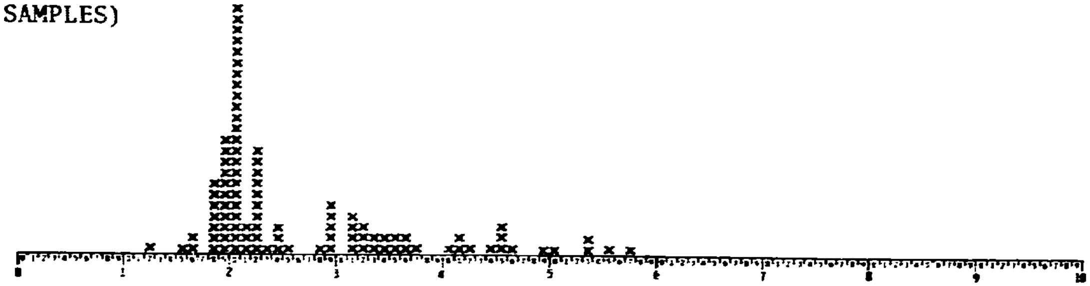
(100 SAMPLES)



DISPLAY: DR PLOT

KEYS (0): LESS KEYING TIME

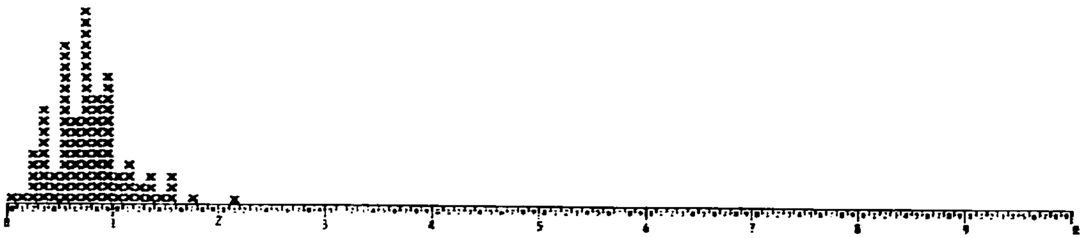
(100 SAMPLES)



DISPLAY: DR PLOT

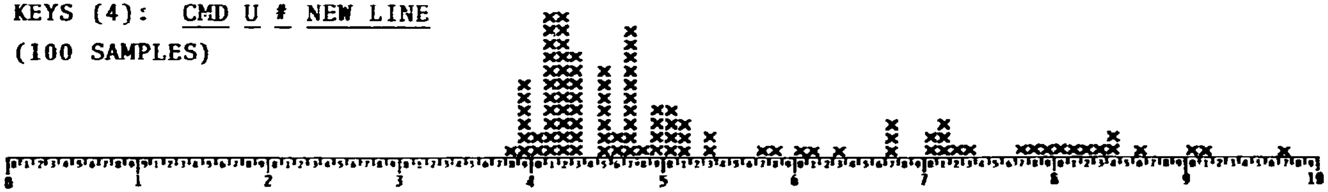
KEYS (1): +__

(100 SAMPLES)

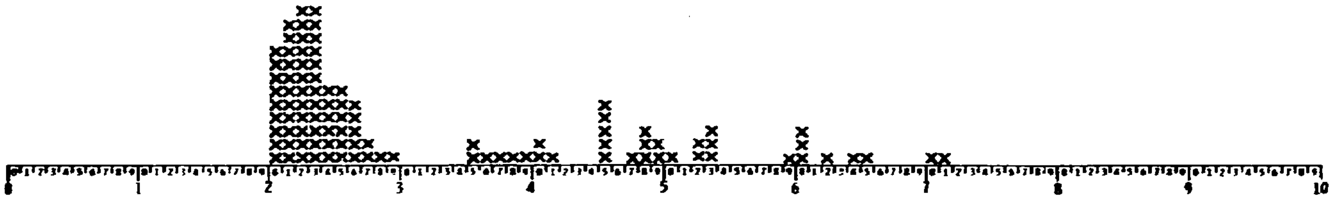


TIME (IN SEC.)

DISPLAY: VESSEL UNDERWAY
KEYS (4): CMD U # NEW LINE
(100 SAMPLES)

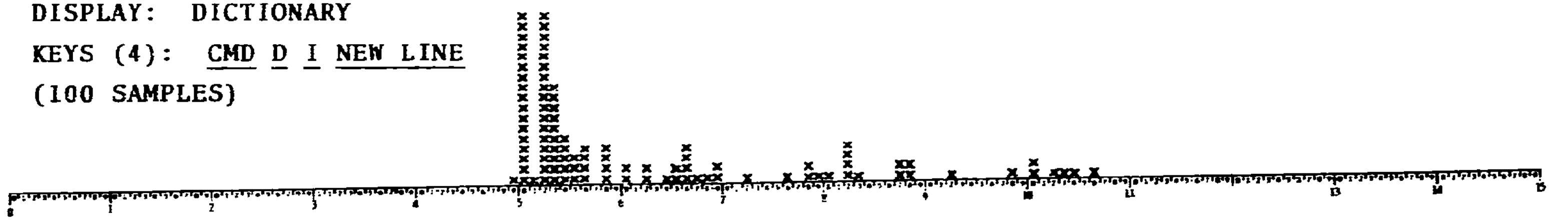


DISPLAY: VESSEL UNDERWAY
KEYS (0): LESS KEYING TIME
(100 SAMPLES)

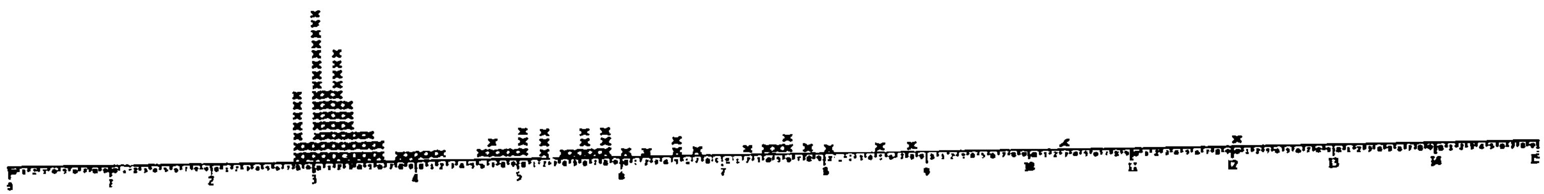


TIME (IN SEC.)

DISPLAY: DICTIONARY
KEYS (4): CMD D I NEW LINE
(100 SAMPLES)



DISPLAY: PAGE
KEYS (1): PAGE MOVE
(100 SAMPLES)

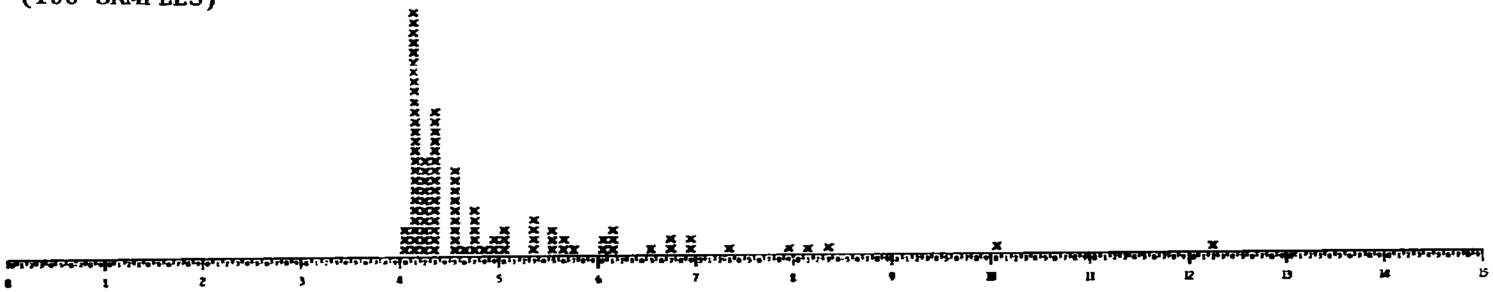


TIME (IN SEC.)

DISPLAY: VESSELS IN PORT

KEYS (4): CMD __ __ NEW LINE

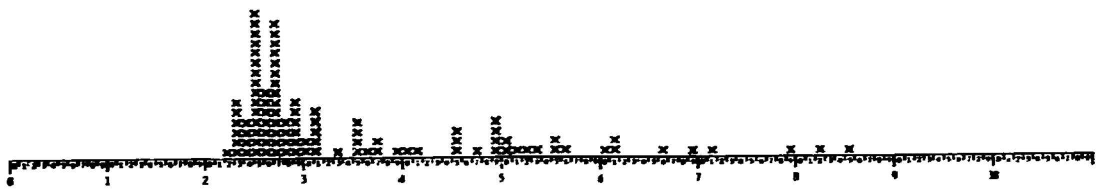
(100 SAMPLES)



DISPLAY: PAGE

KEYS (1): PAGE MOVE

(100 SAMPLES)

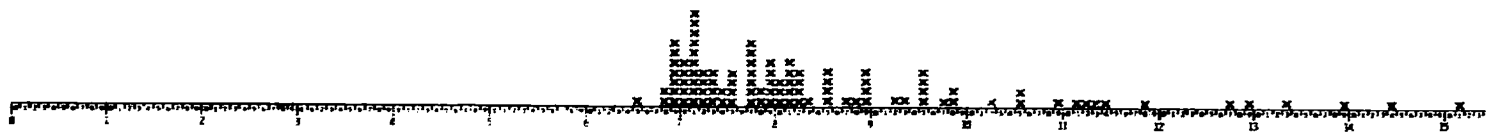


TIME (IN SEC.)

DISPLAY: TRAFFIC SUMMARY

KEYS (10): CMD I R , # # # , # NEW LINE

(100 SAMPLES)



TIME (IN SEC.)

APPENDIX F

INTERVIEWS AT HOU-GAL VTS

Individual interviews were conducted with watchstanders during the same days that activity observations were made, generally when the interviewee was on XC duty. The interviewer and interviewee were seated comfortably in an environment relatively quiet and free of interruptions (the lounge or the equipment room). The interview was conducted as a conversation. The interviewer was guided by a format in order to cover all topics, but the exact wording of questions and order of topics were varied to allow spontaneity in the interviewee's responses.

The interviewer explained the aims of the project and the interview briefly, stressing the fact that the system, not the interviewee was being evaluated. Then the interviewer asked, and encouraged discussion of, a series of questions. The nature of each question (not necessarily the exact wording used with each subject) will be given below, followed by a summary of the responses.

F.1, F.2 How long have you been in the Coast Guard? How long have you been at HOU-GAL VTS? Ten enlisted watchstanders and two watch officers were interviewed. Their answers to these two questions are tabulated in Table F-1. It can be seen that both total experience in the Coast Guard and VTS experience varied considerably. The two old-timers were relatively new to VTS work, while the majority had had only two-to-three years in the Coast Guard before assignment to the VTS.

F.3 Do you like VTS duty? Why? Nine interviewees said they liked VTS duty, two disliked it, and one was neutral. Three simply considered it a good job, three felt it was challenging, one found it rewarding, and one found it exciting. On the other hand, one interviewee disliked the work because he found it boring. Those who liked VTS duty least had been there the longest, but some with over a year at the Center still found challenges and rewards in the work.

F4. How effective is the VTS? Why? All twelve interviewees gave positive responses--that is, they found value in the work. Five responses cited the provision of services that would otherwise be unavailable. Four stressed safety and accident reduction. Two claimed that the VTS has demonstrated to

TABLE F-1.

Interviewees	Years in Coast Guard	Years HOU-GAL VTS
Officers		
0-1	4.0	1.1
0-2	14.0	0.3
Enlisted		
1	5.5	2.4
2	24.0	0.3
3	6.0	4.0
4	4.3	1.5
5	3.2	1.1
6	6.0	3.0
7	3.2	0.8
8	3.3	1.2
9	6.0	3.2
10	4.0	1.5
Low	3.2	0.3
Median	4.9	1.4
High	24.0	4.0

the Coast Guard and the community that it can do what it is intended to do. Four gave qualified responses (e.g., "Effective--considering that it isn't mandatory." "Very effective--if the public will participate.") Other comments stressed the special needs of Houston (narrow channel, need for advance vessel to ride "shotgun", and even reduction of Channel 13 chatter because they are known to be taping transactions).

F.5 How would you improve the Operation? Only one interviewee had no ideas for improvement. Five wanted more TV sites; three wanted more radar sites. Four would like to see the computer respond faster; three would like more computer displays and more information on the displays, and one said, "Get rid of the computer." One interviewee would like to see civilians (like the FAA) rather than the Coast Guard operating the service--reflecting a concern that VTS could become more of a police operation than a service. Another interviewee would like to see an improved arrangement of equipment.

F.6 How do you think pilots and masters feel about the VTS? Nine of the interviewees felt that the general attitude of pilots and masters is positive. Several pointed out that a few are very negative. Likewise, ten interviewees characterized pilots and masters as cooperative; two noted that a few are uncooperative, and one felt that a few are indifferent.

F.7 Did your attitude about the VTS change as a result of training? Three interviewees came to the VTS with no expectation as to what the duty would be like. One other found the duty to be about as expected; three initially thought the duty was worse than expected. Of these seven, five liked the duty better after training; the two who hadn't known what to expect didn't like it any better after training.

F.8 Did any previous experience help prepare you for VTS duty? Two interviewees replied, "No," one "very little." Seven cited the value of previous communications experience, five mentioned shipboard experience (handling, rules of the road, terminology, what it's like to be on a ship), and four referred to experience with radar. One interviewee specifically stated that experience in speed typing does not help, since the computer rejects fast inputs.

F.9 What parts of the job were toughest to learn? Four interviewees felt that the location of industries was the hardest thing to learn. Three others mentioned general channel knowledge. Three cited understanding accents, and two others noted special terminology. Two interviewees had difficulty in learning to talk to civilians on the radio. One cited coordination of multiple activities.

F.10 What was toughest to learn in transition to the computer? Eight interviewees simply stated that transition to the computer was easy. Four had difficulty in learning to visualize the channel and traffic from the display formats. Two people noted that slowness of computer response made it hard to operate. Two cited the effort required to enter vessels into the system.

F.11 How would you improve watchstander training? Four interviewees called for a more organized training program, with more testing and evaluation of trainee progress. Three cited a need for more training personnel, particularly an instructor with time for teaching and evaluation. Five would like to see more vessel rides on the channel; one suggested following up rides with a reinforcing experience, such as slides and questions. Two interviewees called for continued training on the use of the board as a backup in case of computer failure. One person proposed more instruction on making clear, concise advisories.

F.11a How would you select people for VTS duty? The following criteria were suggested for selection of Coast Guard personnel for VTS duty. The number in parentheses indicates the number of interviewees proposing that criterion.

- Good hearing (5)
- Good general health (5)
- Personal qualities (motivation, intelligence, willingness to learn) (4)
- Language skills (3)
- Relevant experience (communications, port traffic, ship handling, radar, knowledge of Houston area, service record) (3)
- Motor coordination (2)
- Visit to VTS before accepting assignment (1)

F.12 How do you feel about the work schedule? Interviewees were generally on their first day of the new 12-hour watch schedule when interviewed. Their responses, therefore, were estimates as to how they would like the new schedule. Of eleven responses, ten were favorable. The negative response reflected concern over fatigue effects. Two others anticipated some fatigue but felt that the extra free time made it acceptable. Five responses favored the better distribution of free time. One also indicated that there would be more continuity on the channel. It was also noted that fewer watches would result in less driving and conservation of fuel. One interviewee felt that another watch section is needed.

F.12a <u>Are you required to perform much duty in your "free" time</u>? Four interviewees experienced no duty demands on free time; six pointed out that some (an acceptable amount) of free time was used for requalification rides and in helping trainees. Two noted that the new schedule may result in more "off" time duty, but that it is worth it.

F.13 <u>Would you like a second tour of VTS duty</u>? Of the ten responses to this question, seven had no objection to a second VTS tour, three would not want another. However, several interviewees, who were leaving the Coast Guard after this tour, were speculating on how they would feel if they were staying in.

F.14 <u>Have you any ideas for improving workspace layout</u>? Two interviewees had no ideas. Four wanted the watchstanders to be closer together, to permit any watchstander to monitor all sectors and to facilitate handoffs between sectors. Four proposed arranging positions side-by-side in a line; one suggested a circle. One noted that the line arrangement would keep it a team effort. There were two proposals to remount the keyboards and CRT's into a more compact console, and two for having three CRT's at each position. One interviewee suggested rotating the Sector II radar console 90 degrees to eliminate window reflections on the faceplate.

F.15 and F.16 (Items combined into F.14)

F.17 <u>Have you any ideas for improving computer formats</u>? Eight interviewees had no ideas. Two proposed adding a third CRT. Two suggested showing the whole channel on a single display. Three cited a need for faster response--more ready access to data. Other individual suggestions were:

"Dock" and "Vessels in Port" should roll to page 1 from the last page.

Destination should be added to the "Vessels Underway" sheet.

Don't stop the vessel target at checkpoints.

Drop the "Traffic Summary."

F.18 Rate all aids for importance and usage. Interviewees were asked to rate each of twelve work aids on a five-point scale both for importance and frequency of usage. Table F-2 summarizes these ratings. They show clear agreement on the importance and frequency of usage of the computer keyboard and the display sheets (SS, DR, VU) necessary for data entry and system monitoring. Similarly, the radar, the individual television displays, and the radio were highly rated. Comments by interviewees emphasized their importance. On radar: "More improvement than the computer." "I use it continuously." "I'm blind without it." "Best thing that ever happened." On television: "You know he is there." On Channel 13: "It gives you the truth." Opinion differed more on the repeater television, averaging of medium importance and seldom used.

There was general agreement that the DE and DI sheets are unimportant and seldom used. Opinion spread more evenly on the importance of the TR sheet, ranging from high to very low, but with two-thirds of the ratings in the low and very low categories. There was more agreement, however, that usage of this display is low (eleven ratings of low or very low). The IP was rated of high importance but medium usage.

Comments on the display sheets are illuminating: On SS: "ETA's are inaccurate." On DR: "Used more than any other." On VU: "Cards take the place of VU." On IP: "Redundant to the box of cards." "Used mainly by supervisors." On TR: "Virtually useless." "Used mainly by supervisors." (One of the two supervisors interviewed rated it as used hardly ever, the other as used some). "Doesn't allow for changes in speed." "Predictions unreliable." On DE: "Redundant to the talley sheet." On DI: "Used only for training."

The Vessel Status Cards were generally rated important and very often used. Comments on cards included: "Easy to get the information." "Easy for handoff." "Good for getting statistics." "Fix the computer, and you can do away with the cards."

F.19 How do you like the computer? What are its advantages and disadvantages? Opinion split on the computer. Four interviewees liked it, five disliked it, and three were neutral. Comments of those who liked it included: "Love it." "Like it a lot." "Great." "Good." Comments of those who disliked it included: "Worthless." "Money was not spent wisely." A typical neutral comment was: "It's OK but needs changes." Table F-3 summarizes the advantages and disadvantages noted and shows the attitudes of those who noted them. It is interesting to observe that more advantages of the computer were noted by those who disliked it than by those who liked it. The principal complaint

TABLE F-2. RATINGS OF AIDS

Aid	Importance: Very High	High	Med	Low	Very Low	Usage: Very Often	Often	Some	Seldom	Hardly Ever
Computer Keyboard	12					12				
Vessel Status Sheet (SS)	11	1				9	2	1		
Dead Reckoning Sheet (DR)	11		1			11			1	
Vessels Underway Sheet (VU)	8	2	1	1		8	2	1		1
Vessels In-Port Sheet (IP)	2	6	4			2	3	4	3	
Traffic Summary Sheet (TR)		2	2	3	5			1	5	6
Vessel Departures Sheet (DE)		1	3	7	1		1	2	6	3
Command Dictionary (DI)	2		1		9				1	11
Radar	11	1				11	1			
Television - Individual	11	1				10	2			
* - Repeater	1	3	2	5			3	2	5	1
*Radio - Ch. 12	11					11				
- Ch. 13	11					10	1			
** Cards	5	2	3			6	1	2	1	

* 11 responses
** 10 responses

TABLE F-3. ADVANTAGES AND DISADVANTAGES OF COMPUTER AND BOARD

Computer							
Advantages	**L**	**D**	**N**	**Disadvantages**	**L**	**D**	**N**
Automatic Updating	2	3	1	Slow (keying, delays, rejects)	1	5	3
Accuracy	1	2	1	No better than board		2	
Computes speed	2	1		Isolates watchstander from others		1	1
Keeps marching order straight	1			Makes mistakes when speed changes		1	
Good for summary statistics	1			Hard to get destination and draft		1	
Would be good if improved		2					

Board							
Advantages	**L**	**D**	**N**	**Disadvantages**	**L**	**D**	**N**
Accurate	1			Need to advance cards	2		3
Fast	1	2	1	Doesn't adjust speed		1	
No breakdowns		1		Not accurate		2	
Permits team operation	2		4	Operation too relaxed	1		
Don't have to do things twice			1				
Can tell ships from tows			1				
Fine with computer as backup	1						

L = Like
D = Dislike
N = Neutral

about the computer is the delay incurred by the amount of keying required, the delay in the display appearance after keying, and the rejection of entries. Two of the five who disliked the computer added that they would like it if it could be improved.

F.20 <u>How would you like to return to using the board? What are its advantages and disadvantages?</u> Only three interviewees wanted to return to use of the board. Five did not like the idea, and four were neutral. Those electing to go back said they would "love" or "enjoy" it. One who did not want to go back said: "It would be like a demotion." The advantages and disadvantages noted are summarized in the lower half of Table F-3. The principal advantages of the board (noted even by some who would not want to go back to it) are the speed of information retrieval and its compatibility with group operation. The main disadvantage seems to be the requirement to advance the cards.

F.21 <u>Rate the qualities of the computer.</u> Interviewees were asked to rate the computer for accuracy, speed, ease of use, and display legibility, using a five-point scale. The ratings are summarized in Table F-4. There was good agreement that the computer responds too slowly and that the displays are legible. Accuracy was generally rated highly, but one rated it very low because of tracking inaccuracies when vessels change speed. Four interviewees commented to the effect that the computer is only as accurate as the data the operator gives it. Although legibility was no problem, two interviewees felt eye fatigue (probably due to poor contrast on the display). Another noted that one can't watch the display constantly and suggested adding an audible tone when vessels reach checkpoints. There is a spread of ratings on ease of use. The high ratings seem to imply that there is nothing difficult to learn or understand in usage; the low ratings seem to reflect the amount of keying and delays incurred--that is, the amount of effort involved in using the computer.

F.22 <u>Have you learned any "short cuts" in operating the computer?</u> Five interviewees responded, "No". Specific techniques mentioned included:

> Use SS instead of VU for changes.
> To get identity, use VU page. It is easier to key in ID than to operate the cursor on the DR display.
> Use "Break Release" instead of "New Line."
> Use "Move" instead of "Go."
> Don't run light boats (tugs without tows).

TABLE F-4. RATINGS OF COMPUTER QUALITY

Quality	Very High	High	Medium	Low	Very Low
*Accuracy	6	3	1		1
Speed			2	6	4
Ease	3	2	2	4	1
Legibility	5	6		1	

*11 responses

TABLE F-5. ESTIMATES OF NUMBER OF VESSELS THAT CAN BE HANDLED COMFORTABLY AT ONE TIME

Number of Vessels	Number of Estimates
10-14	2
15-19	6
20-24	6
25-29	0
30-34	2
Over 35	2

F.23 How many vessels can you comfortably handle at one time? Answers to this question varied considerably. The highest estimate was 40 in Sector II; the lowest, 10 in Sectors I and III (this by a WS estimating what watchstanders could handle). Table F-5 summarizes the estimates. An average figure seems to be around 20 vessels.

F.24 In what ways could a VTS be an impediment to safe traffic flow? Three interviewees suggested that vessel masters and pilots may become too dependent on the VTS and fail to take normal precautions. Three interviewees noted that the VTS can, and sometimes does, give "bad traffic" advisories. Several comments were made to the effect that if the system became mandatory, inexperienced people, in the wrong position and under pressure, would be giving commands, getting too involved in situations that should be left to others to resolve.

F.25 In your own experience, has the VTS contributed to accidents or incidents? Five interviewees mentioned one incident where a mixup in two destination names that sounded alike led to a near-collision. Three other near-accidents were cited once each. Four incidents were cited where the VTS was of particular benefit. The possibility was noted that an operator occupied with the computer may miss a mistake made by a trainee. All agreed that incidents caused or aggravated by the VTS are very rare.

APPENDIX G

STRESS QUESTIONNAIRE

Introduction

In staffing a vessel traffic service center care must be taken not to overly stress any individual watchstander. Excessive stress leads to poor morale, degenerative health, and accidents.[1] However, except for comments and observations, no indications of any stress present at vessel traffic centers has been recorded. The Federal Aviation Agency[2] has successfully established the presence of stress in air traffic controllers, a position similar to watchstanders, using a paper-and-pencil questionnaire.

To establish the presence of any measurable stress at vessel traffic centers, a modification of the FAA survey was administrated to nine watchstanders at the Houston-Galveston Center. All nine were given an initial survey and a packet of 16 to be completed according to the following schedule and mailed back. For each of four days, watchstanders were to complete one questionnaire just prior to a shift, one about halfway through, one immediately upon ending the shift, and one at least three hours later at home. Six watchstanders completed and returned all 16.

Method

The questionnaire (see Table G-1) consists of 30 items assessing the degree of stress susceptable somatic and mood states from none through moderate to severe rather than mearly their presence or absence as in the FAA survey. This modification was necessary to accommodate the smaller number of watchstanders.

Each participating watchstander was informed as to the purpose of this study. Upon agreement to participate, each received written instructions (see Table G-2). Any questions were answered, then the watchstander began completing the questionnaire. The experimenter observed the watchstander's method of answering to assure that it complied with the instructions. The questionnaire required about 2 minutes to complete.

TABLE G-1. STRESS QUESTIONNAIRE

Complete only these first two lines.

I.D.: ______________ DATE: ______________ SHIFT: ______________

TIME OF DAY	PRE	DURING	POST	HOME
TRAFFIC LOAD:	____	____	____	____
WEATHER:	____	____	____	____

Each line below represents a scale of symptoms you might experience ranging from none to severe. For each item below please mark an (X) anywhere along the line corresponding to the degree of symptom you are now experiencing. (You may go beyond the ends of the line if you wish.)

1.	Headache:	None	Moderate	Severe
2.	Constipation:	None	Moderate	Severe
3.	Sweating:	None	Moderate	Severe
4.	Twitching muscles:	None	Moderate	Severe
5.	Dizziness:	None	Moderate	Severe
6.	Poor appetite:	None	Moderate	Severe
7.	Chest pains:	None	Moderate	Severe
8.	Loose bowels:	None	Moderate	Severe
9.	Loss of temper:	None	Moderate	Severe
10.	Difficulty in breathing:	None	Moderate	Severe
11.	Aching or burning eyes:	None	Moderate	Severe

12. Indigestion or heart burn: None — Moderate — Severe

13. Difficulty in staying awake. None — Moderate — Severe

14. Stiffness or body tenseness: None — Moderate — Severe

15. Bothered by distracting noise: None — Moderate — Severe

16. Nausea or sick to your stomach: None — Moderate — Severe

17. Asthma: None — Moderate — Severe

18. Insomnia: None — Moderate — Severe

19. Nightmares: None — Moderate — Severe

Each line below represents a scale of moods you might feel ranging from none to severe. For each item below please mark an (X) anywhere along the line corresponding to the degree of mood you feel at the present moment. (You may go beyond the ends of the line if you wish.)

1. Worry: None — Moderate — Severe

2. Uncomfortable None — Moderate — Severe

3. Tense: None — Moderate — Severe

4. On edge: None — Moderate — Severe

5. Irritable: None — Moderate — Severe

6. Fidgety: None — Moderate — Severe

7. Depressed: None — Moderate — Severe

8. Upset: None — Moderate — Severe

9. Anxious: None — Moderate — Severe

10. Tired: None — Moderate — Severe

11. Drowsy None — Moderate — Severe

TABLE G-2. STRESS QUESTIONNAIRE INSTRUCTIONS

U.S. Department of Transportation
Transportation Systems Center
Kendall Square
Cambridge, MA 02142

This survey is designed to assess the physical and psychological effects you experience in connection with your work as a U.S. Coast Guard Vessel Traffic Services watchstander. Under no circumstances will your answers become a part of your personnel file or in any way affect your status in vessel traffic services work. You will be assigned an identification number so that all responses from each individual can be kept together. These data will be stored at the Transportation Systems Center until summarized. At that point there will be no further need to identify an individual's data and all forms will be destroyed.

Your task is to rate the degree of physical or psychological effects you are experiencing at the time you fill-out the rating form. You are to complete the rating form four times each working day: Just before beginning a shift, during a break or lull about half way through a shift, at the end of the shift, and at home at least three hours after a shift. You are to do this for one week.

Your specific task on each form is to rate the degree of physical or psychological effects you are presently experiencing for each item from none through severe by marking an X anywhere along the line as illustrated in the examples below. Suppose at the time you are completing the form you do not have a headache, then mark the item as shown:

1. Headache: X____________________________________|
None Moderate Severe

Suppose you do have a headache at the time you are completing the form, then depending upon its degree you might mark the item as shown:

1. Headache: |__________________________X________|
None Moderate Severe

Your cooperation is greatly appreciated. Thank you.

Results

The results are presented graphically in Figures G-1 through G-7 for the somatic items and Figures G-8 through G-15 for the mood items. Each figure presents the maximum, median, and minimum values for each instance during a day which the questionnaire was completed. The numbers on the vertical axis indicate the distance (in centimeters) along the scale from None (0 to 0.85 cm.) through Moderate (3.50 to 5.25 cm.) to severe (8.0 to 9.5 cm) at which subjects could mark each item. The most important result is that every item exhibits a worsening trend throughout the day. (Only those items for which the Post shift median exceeded the limit for None, 0.85, are shown.)

Table G-3 presents these results ordered by the magnitude of the Post shift median for those items exceeding None. Seven of the 19 somatic items and 8 out of the 11 mood items indicate appreciable stress. The most sensitive items are aching or burning eyes and tiredness.

The FAA results are also presented in rank order. Although not perfect, the two rankings agree fairly well (Spearman rank order correlation = 0.79, t (df - 17) = 8.76, $P<.0005$) lending support to the validity of the survey.

Finally, Figures G-16 and G-17 show trends of the most sensitive somatic and mood items over the four days. Both exhibit increases across the work week; however, the magnitude of these increasing trends is much less than that across periods within a day.

Summary

- This questionnaire is sensitive to both a somatic and a mood stress pattern at an active vessel traffic service center.

- This stress pattern worsens during the shift for all items.

- Aching or burning eyes and tiredness are the most sensitive of the somatic and mood items.

- The pattern of somatic stress indicators is quite similar to that found by the FAA.

TABLE G-3. STRESS QUESTIONNAIRE RESULTS

Somatic Index

No.	Item	USCG (Post Median)	FAA
1.	Aching or Burning Eyes	2.39	1
2.	Stiffness	1.27	4
3.	Difficulty in Staying Awake	1.12	5
4.	Loss of Temper	1.06	7
5.	Poor Appetite	1.03	10
6.	Twitching Muscles	0.98	9
7.	Headache	0.95	3
8.	Sweating		2
9.	Bothered by Noise		6
10.	Dizziness		15
11.	Loose Bowels		16
12.	Constipation		11
13.	Chest Pains		13
14.	Difficulty in Breathing		12
15.	Indigestion		8
16.	Insomnia		18
17.	Asthma		17
18.	Nightmares		19
19.	Nausea		14

Mood Index

No.	Item	USCG (Post Median)
1.	Tired	3.09
2.	Tense	1.64
3.	Fidgety	1.57
4.	On Edge	1.55
5.	Irritable	1.46
6.	Anxious	1.35
7.	Drowsy	1.12
8.	Uncomfortable	0.90
9.	Worry	
10.	Upset	
11.	Depressed	

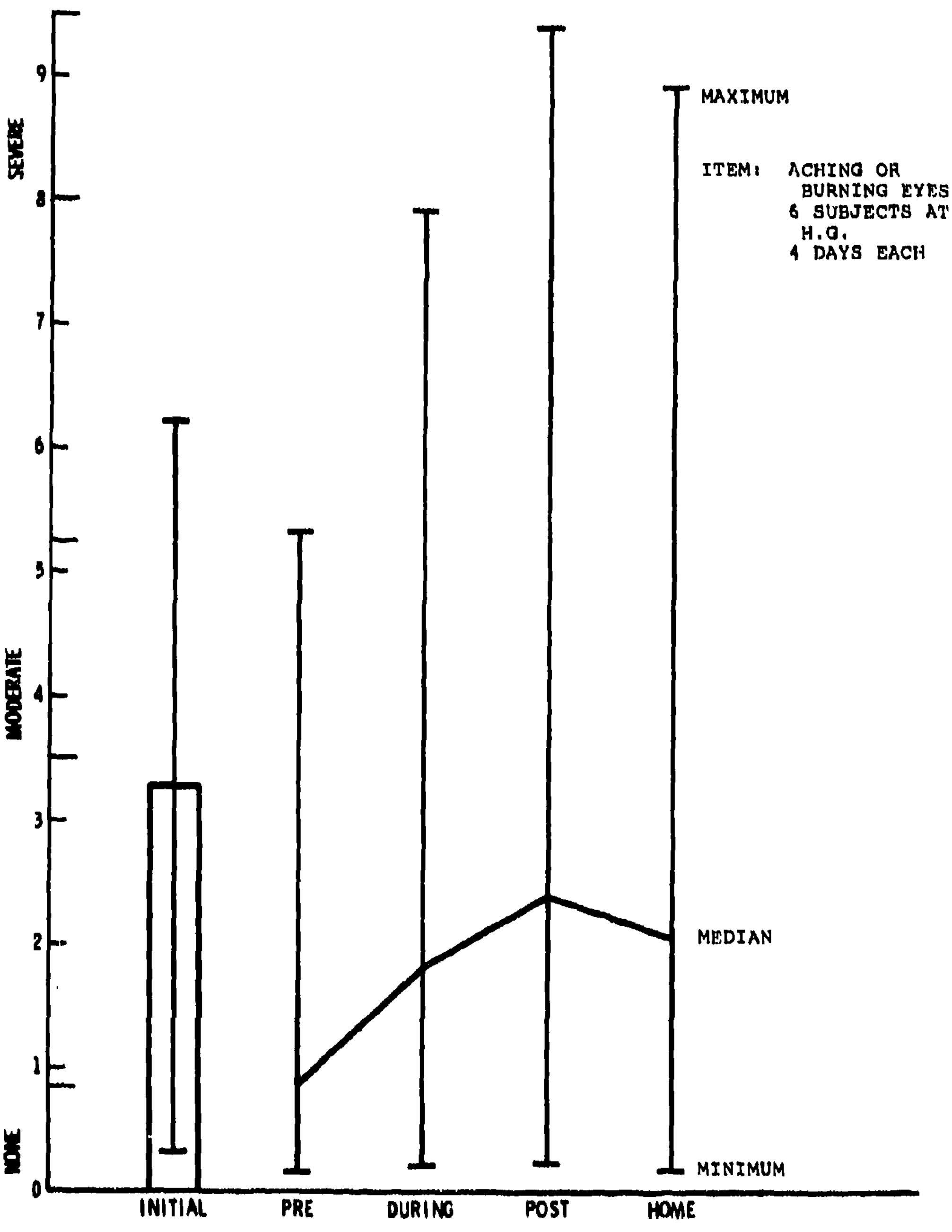


FIGURE G-1. SOMATIC ITEM: ACHING OR BURNING EYES

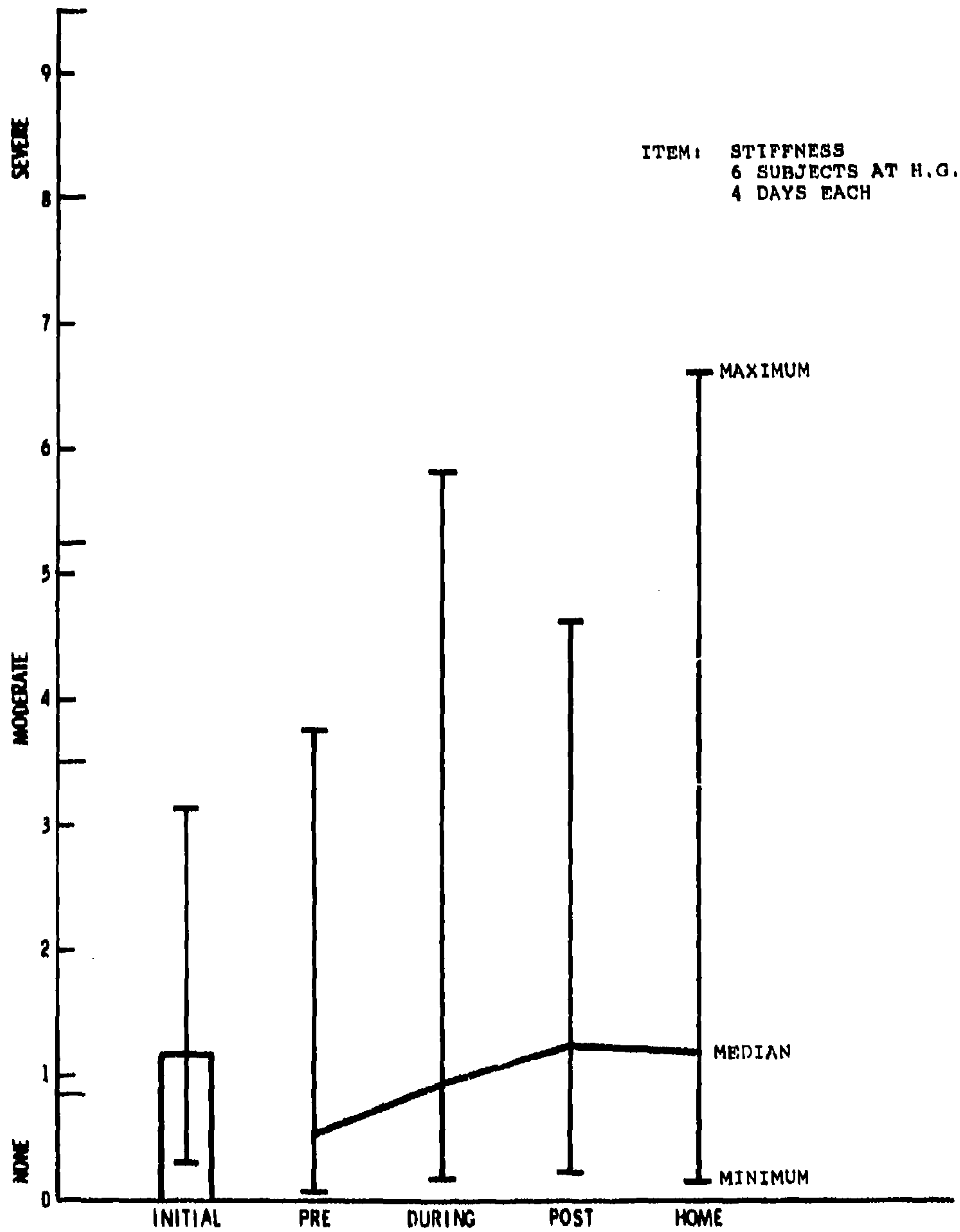


FIGURE G-2. SOMATIC ITEM: STIFFNESS

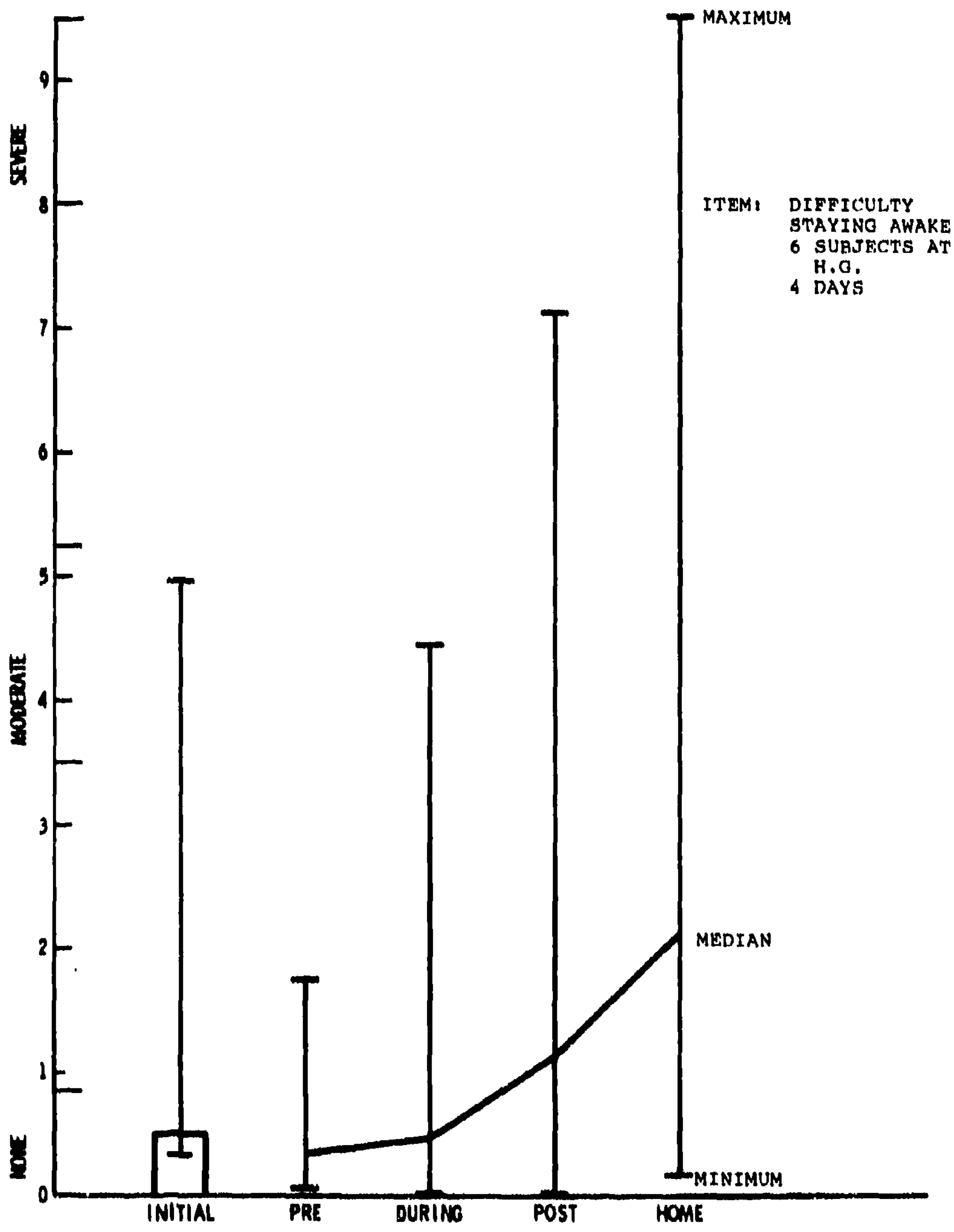


FIGURE G-3. SOMATIC ITEM: DIFFICULTY IN STAYING AWAKE

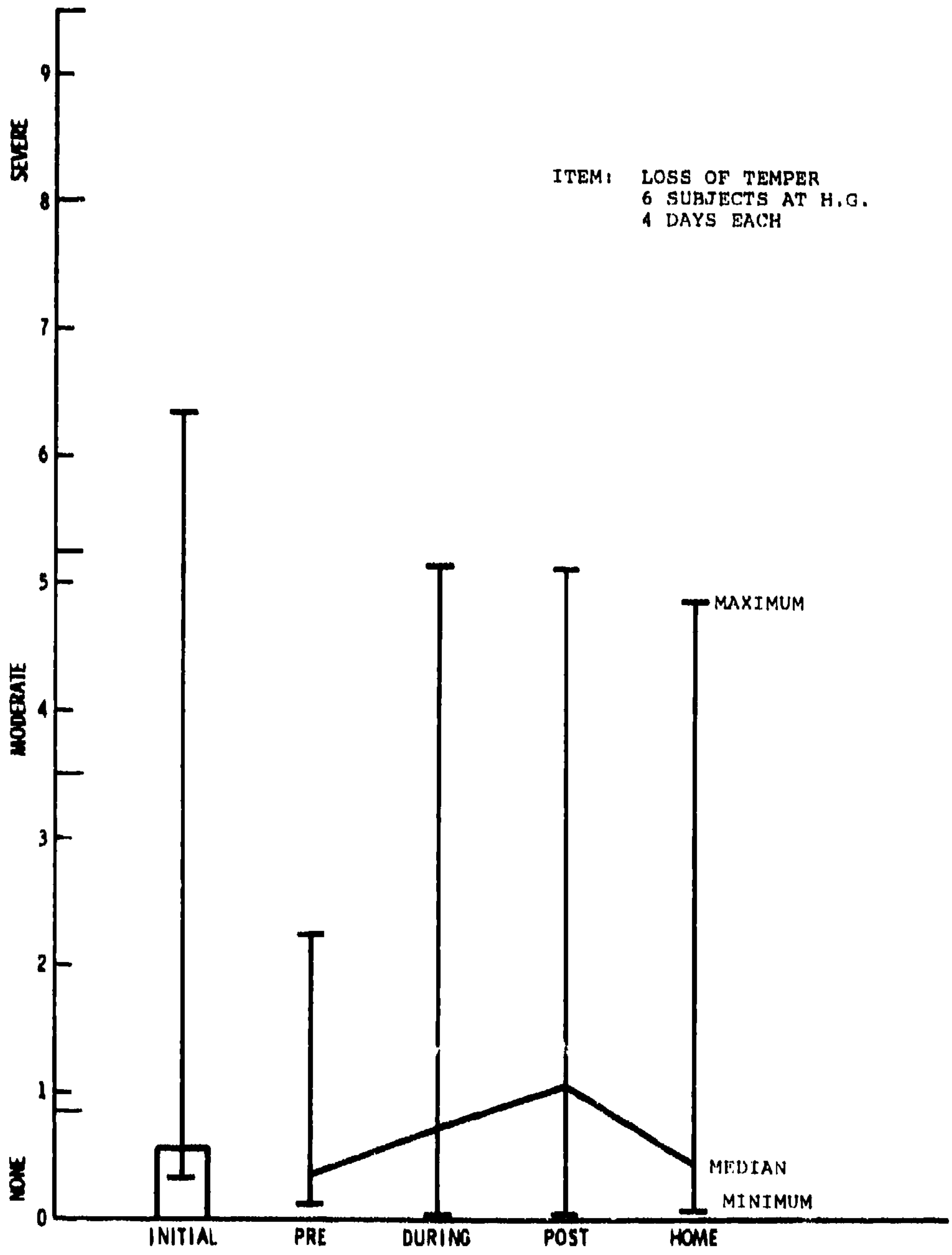


FIGURE G-4. SOMATIC ITEM: LOSS OF TEMPER

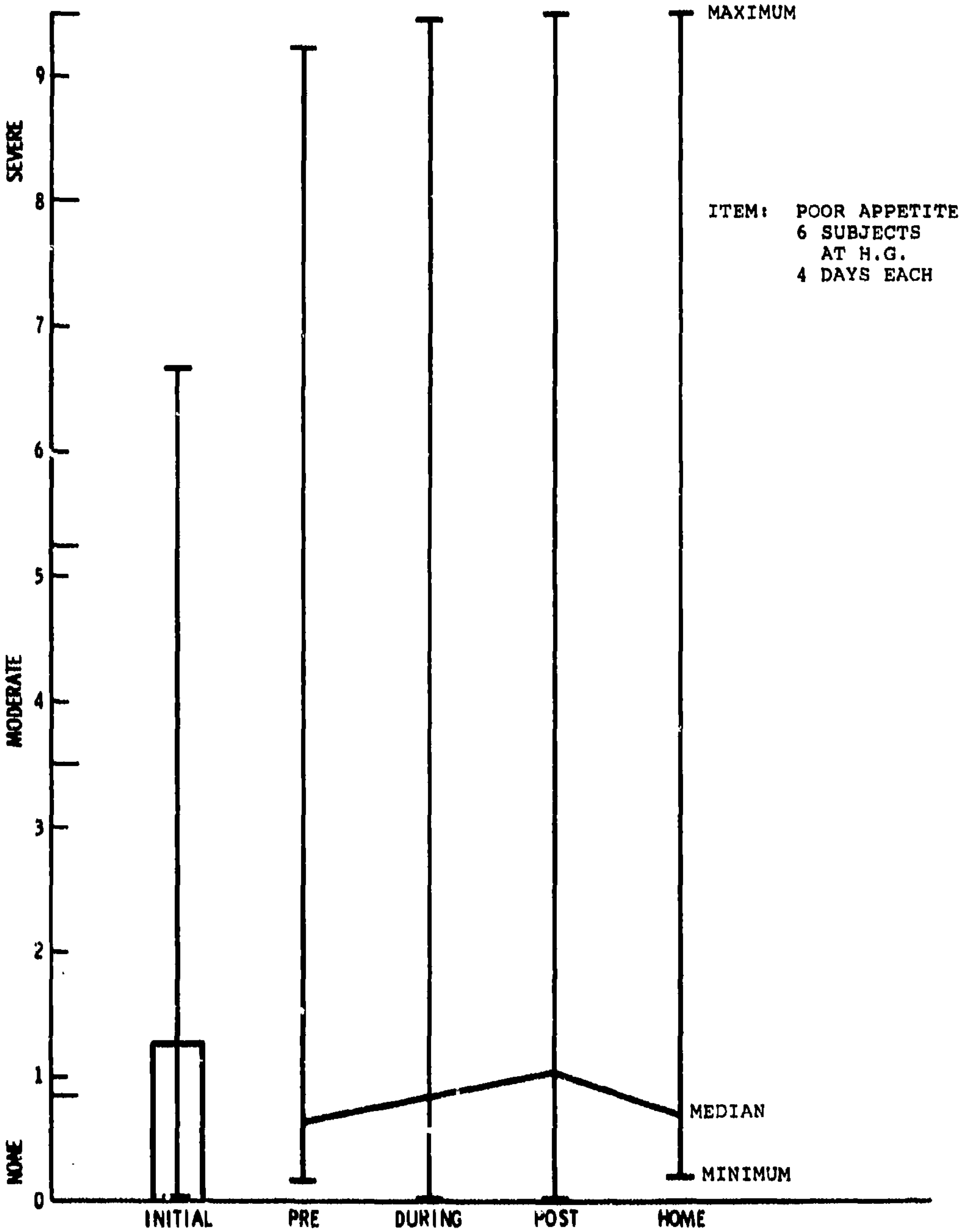


FIGURE G-5. SOMATIC ITEM: POOR APPETITE

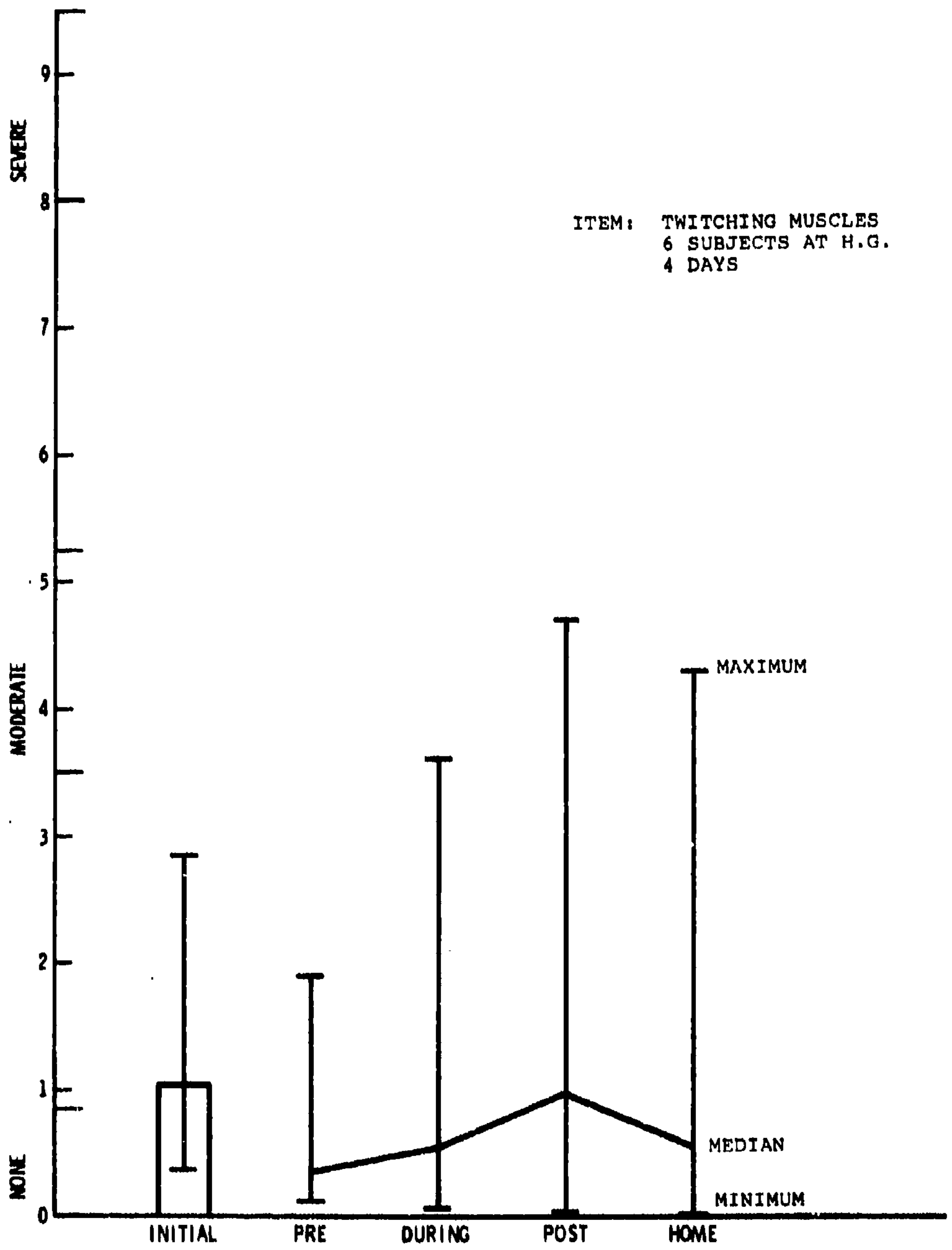


FIGURE G-6. SOMATIC ITEM: TWITCHING MUSCLES

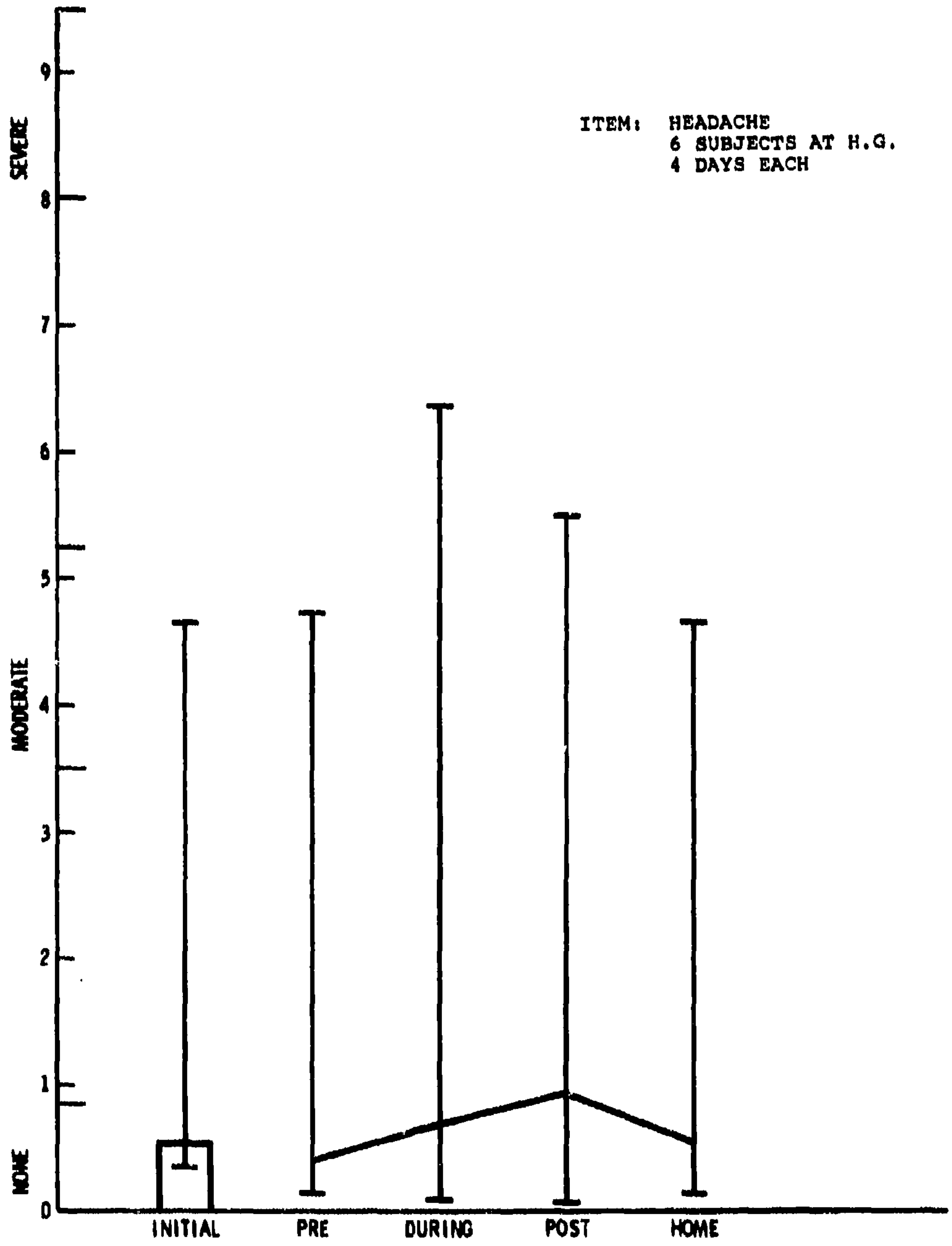


FIGURE G-7. SOMATIC ITEM: HEADACHE

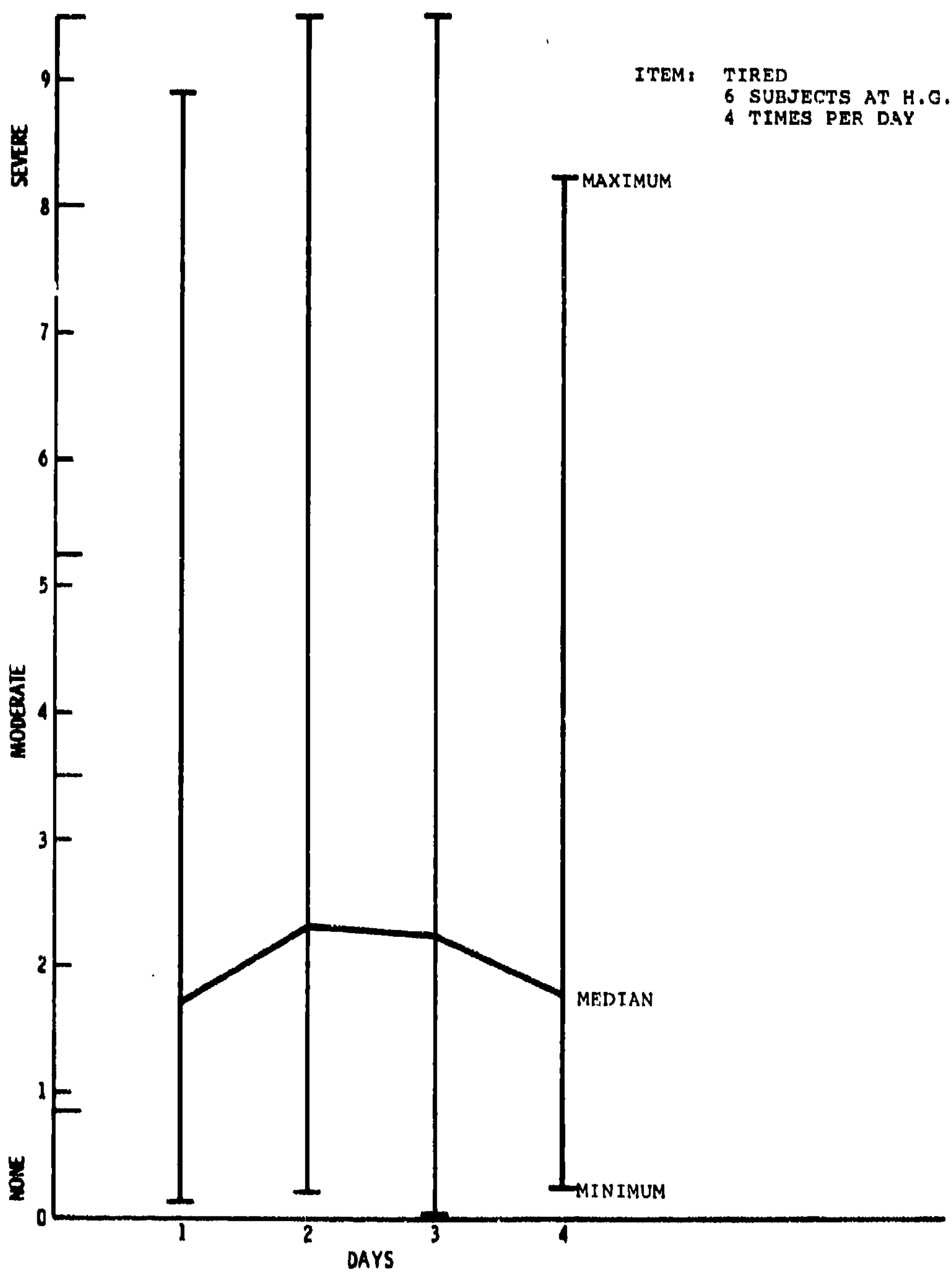


FIGURE G-8. MOOD ITEM: TIRED

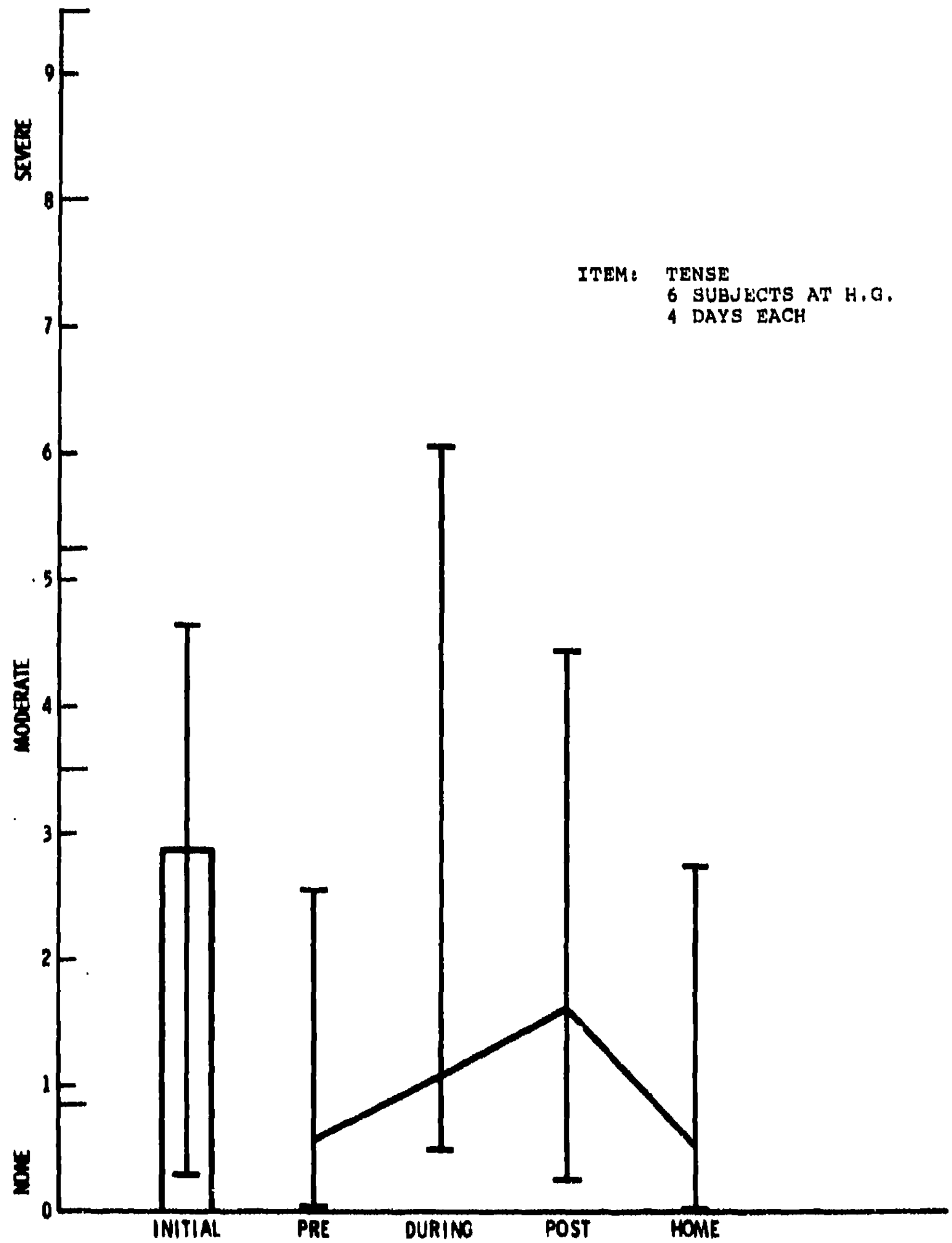


FIGURE G-9. MOOD ITEM: TENSE

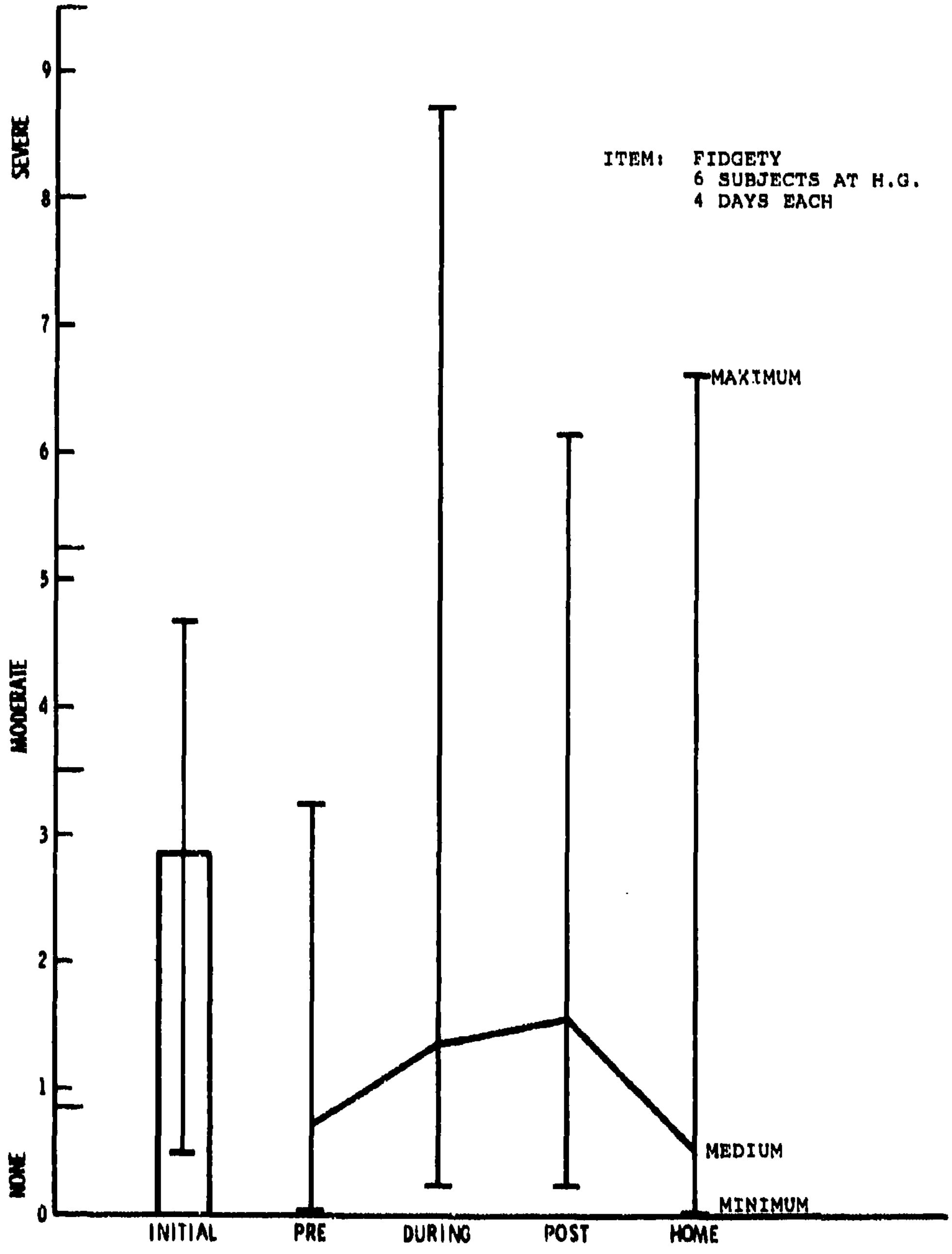


FIGURE G-10. MOOD ITEM: FIDGETY

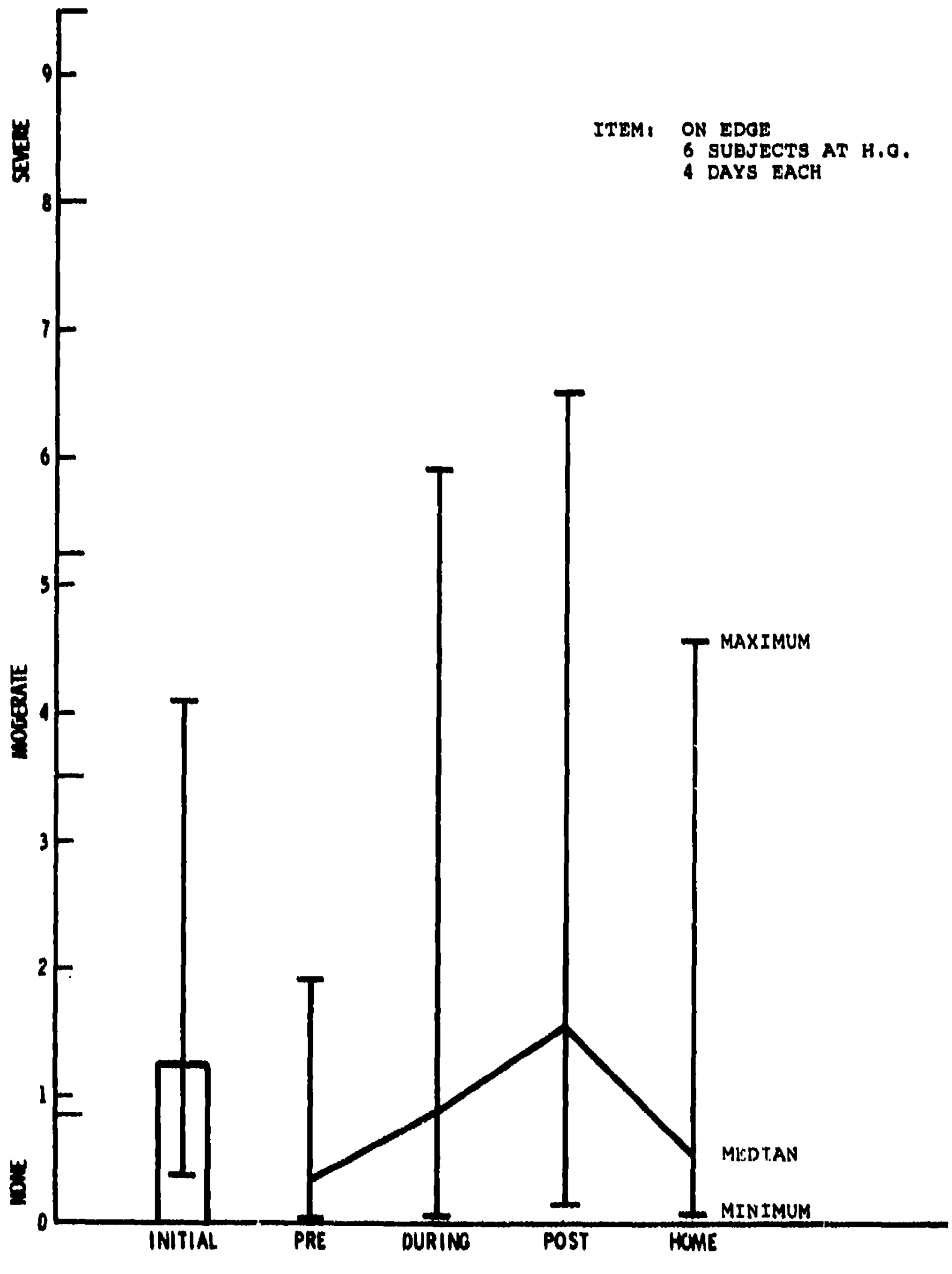


FIGURE G-11. MOOD ITEM: ON EDGE

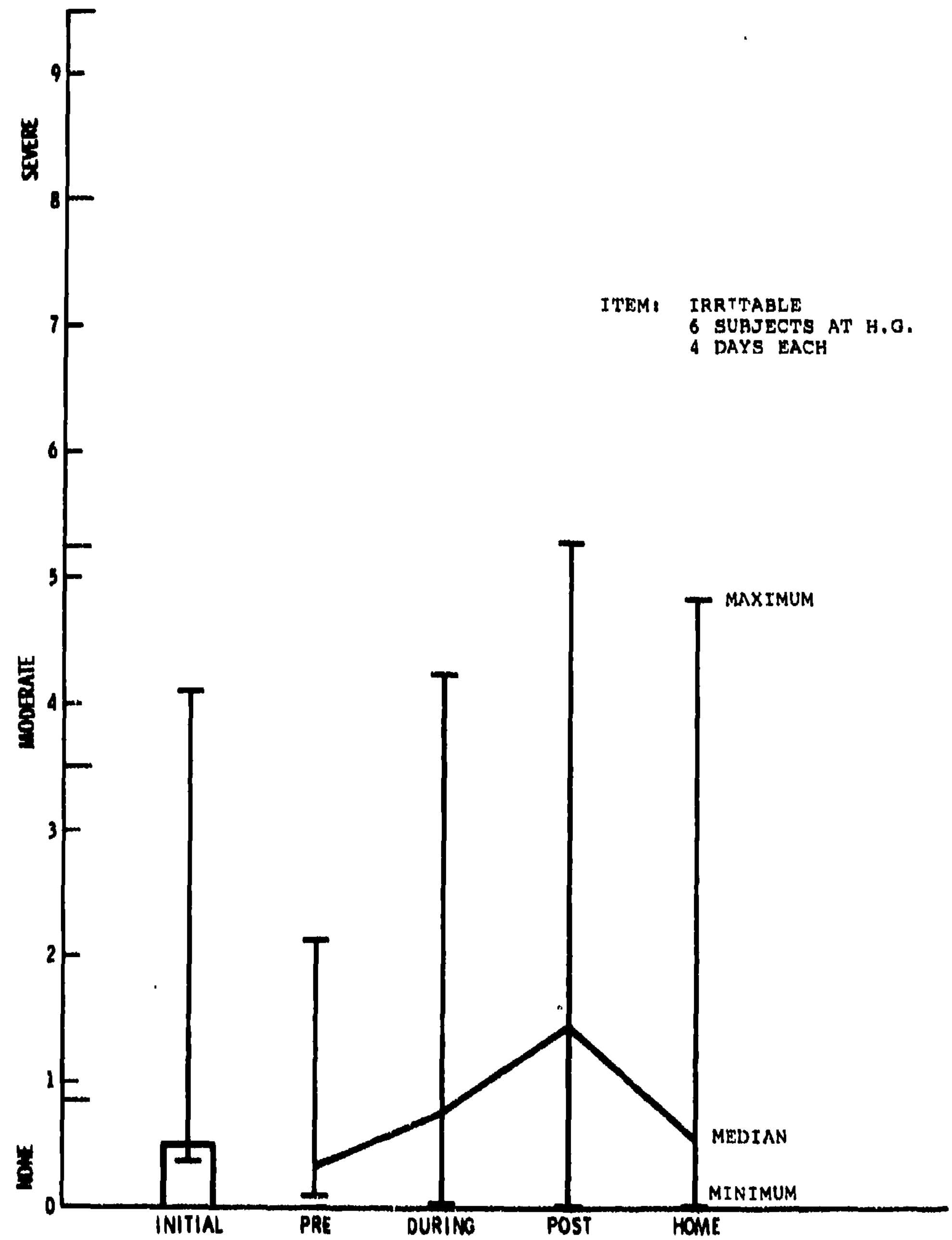


FIGURE G-12. MOOD ITEM: IRRITABLE

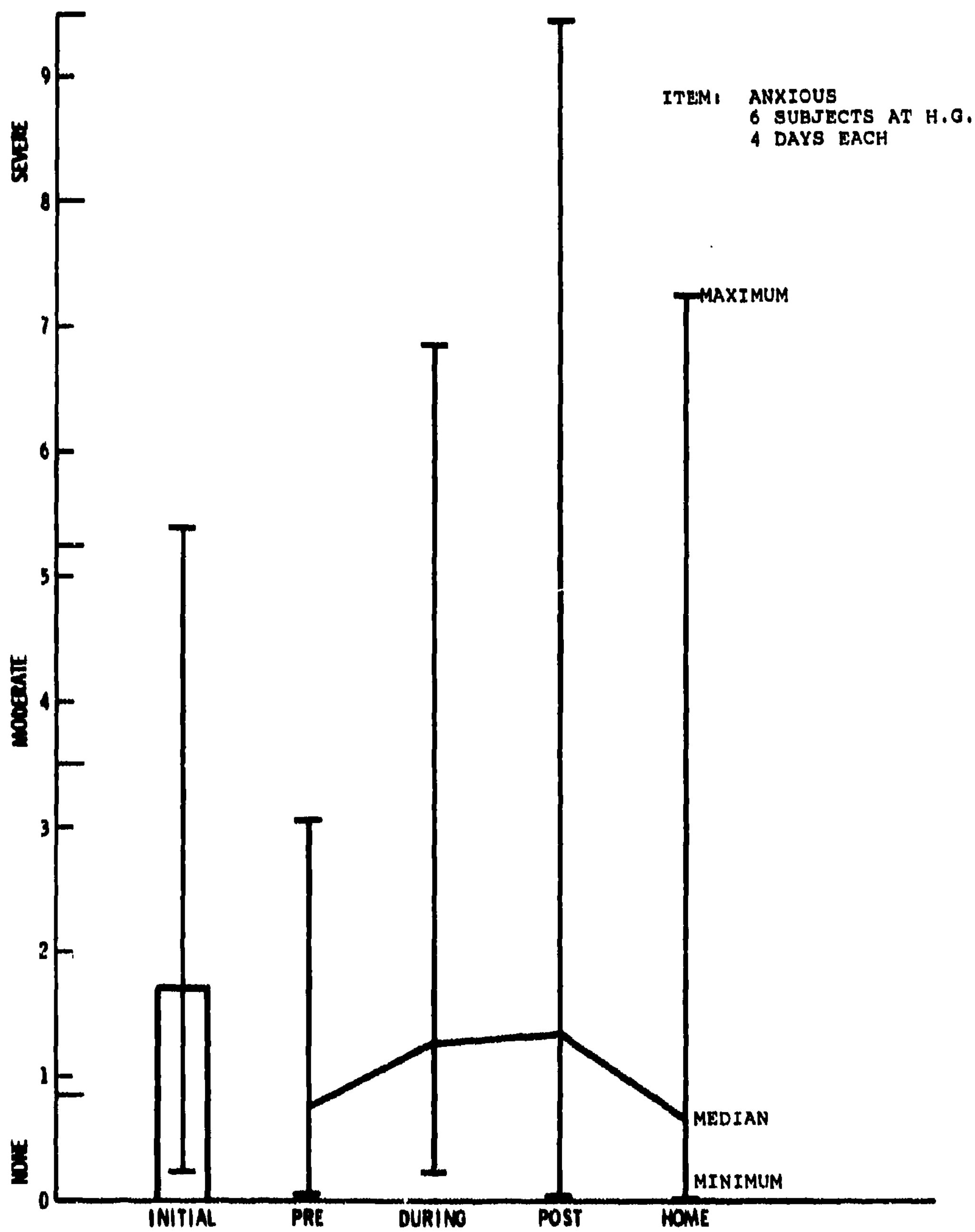


FIGURE G-13. MOOD ITEM: ANXIOUS

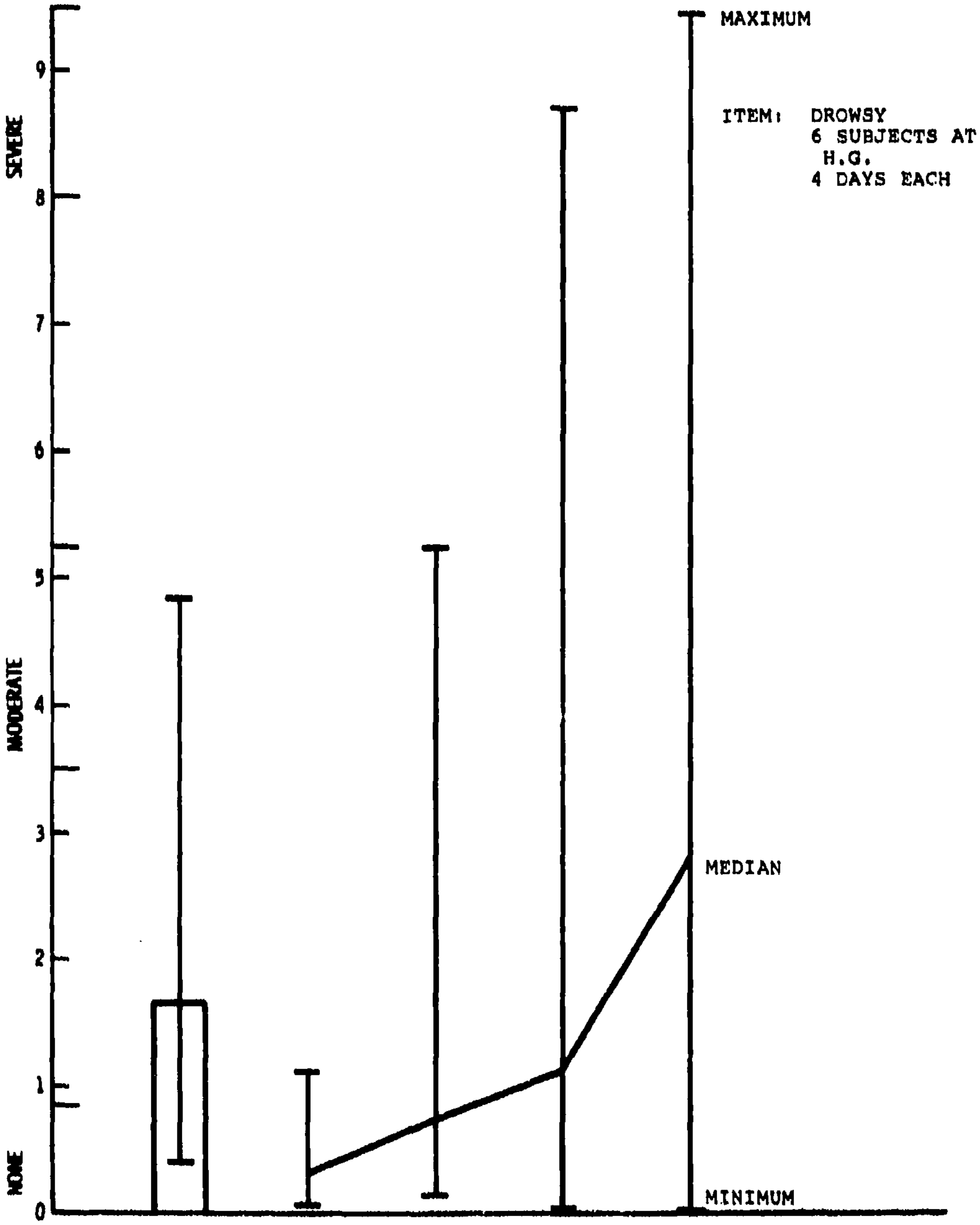


FIGURE G-14. MOOD ITEM: DROWSY

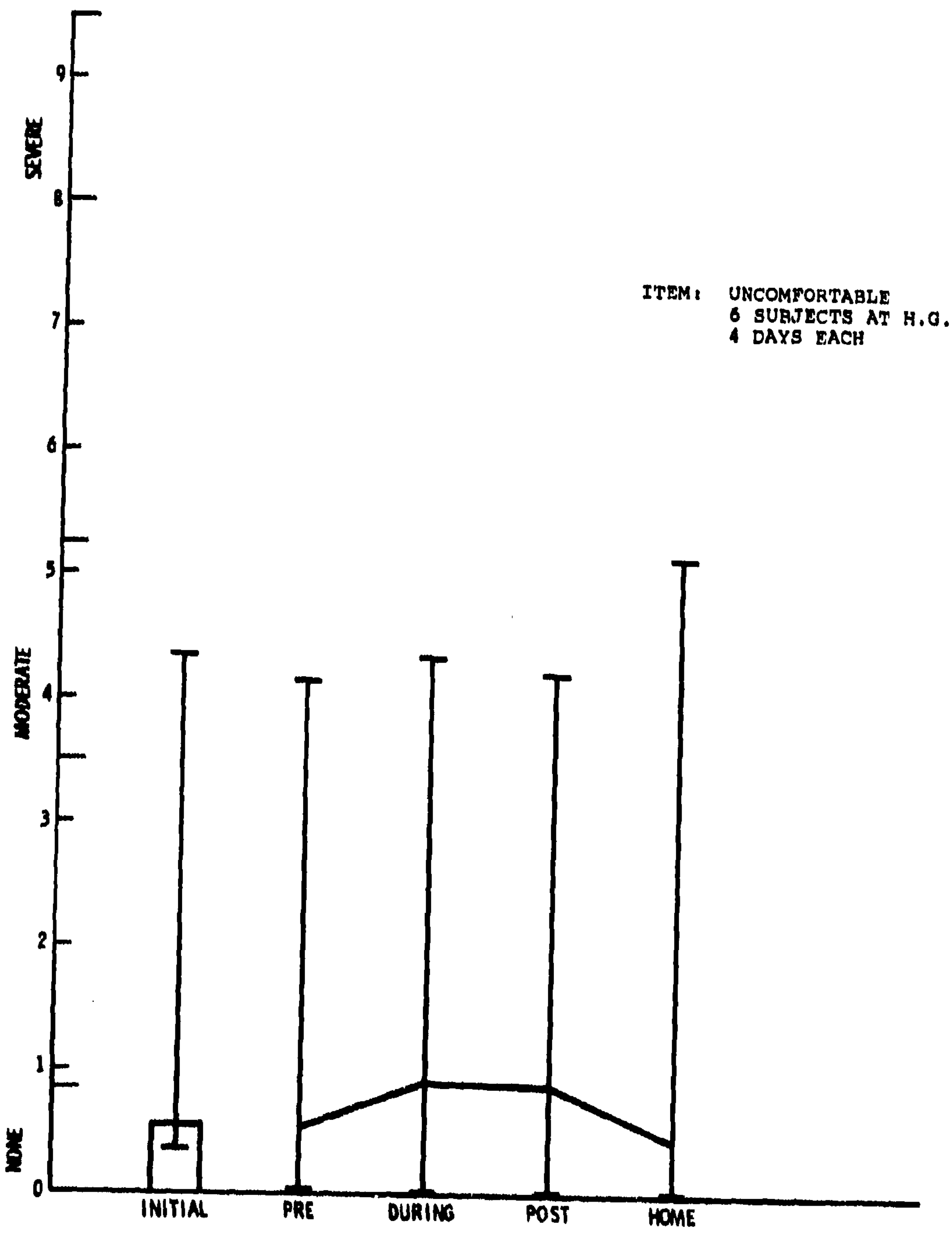


FIGURE G-15. MOOD ITEM: UNCOMFORTABLE

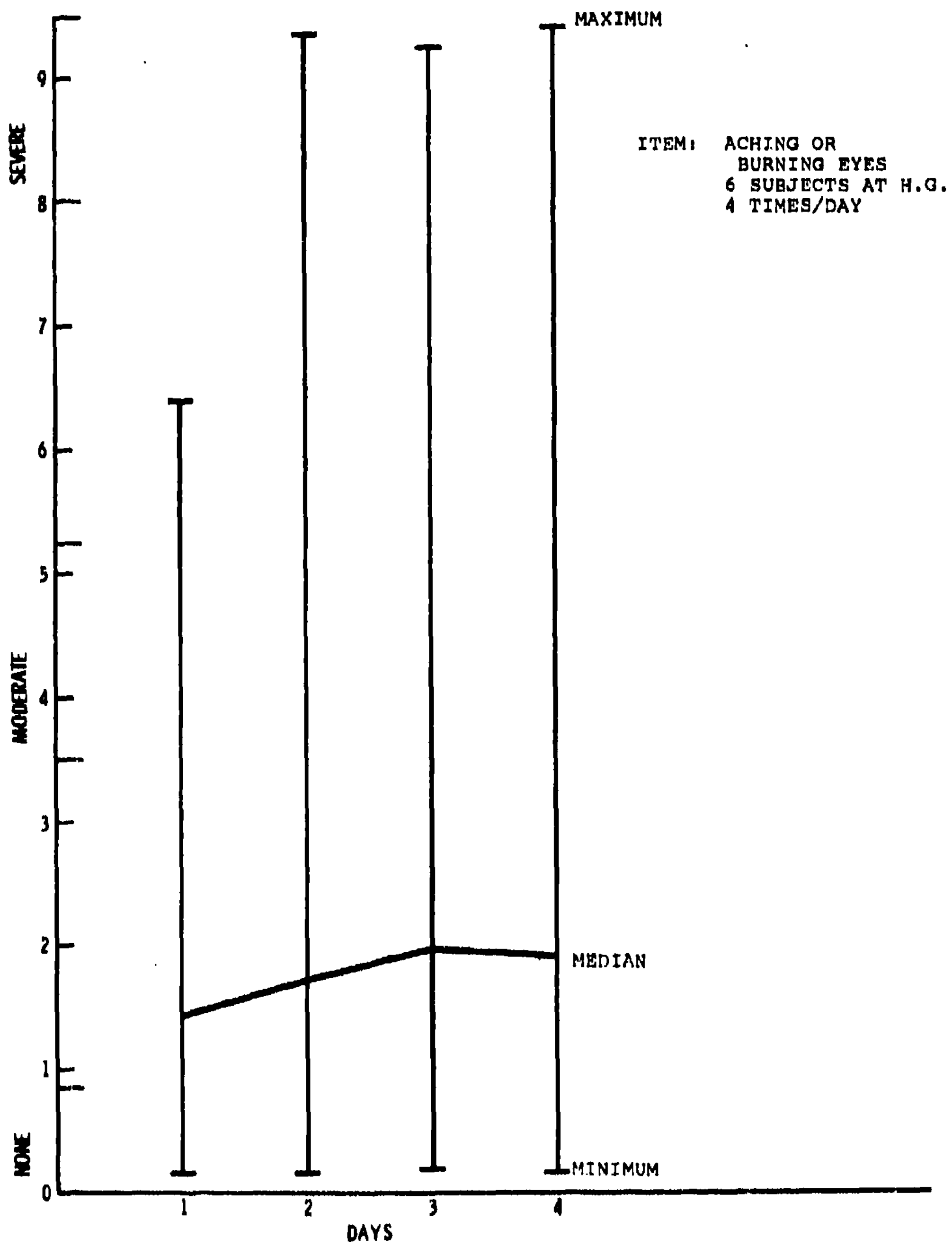


FIGURE G-16. SOMATIC ITEM: ACHING OR BURNING EYES

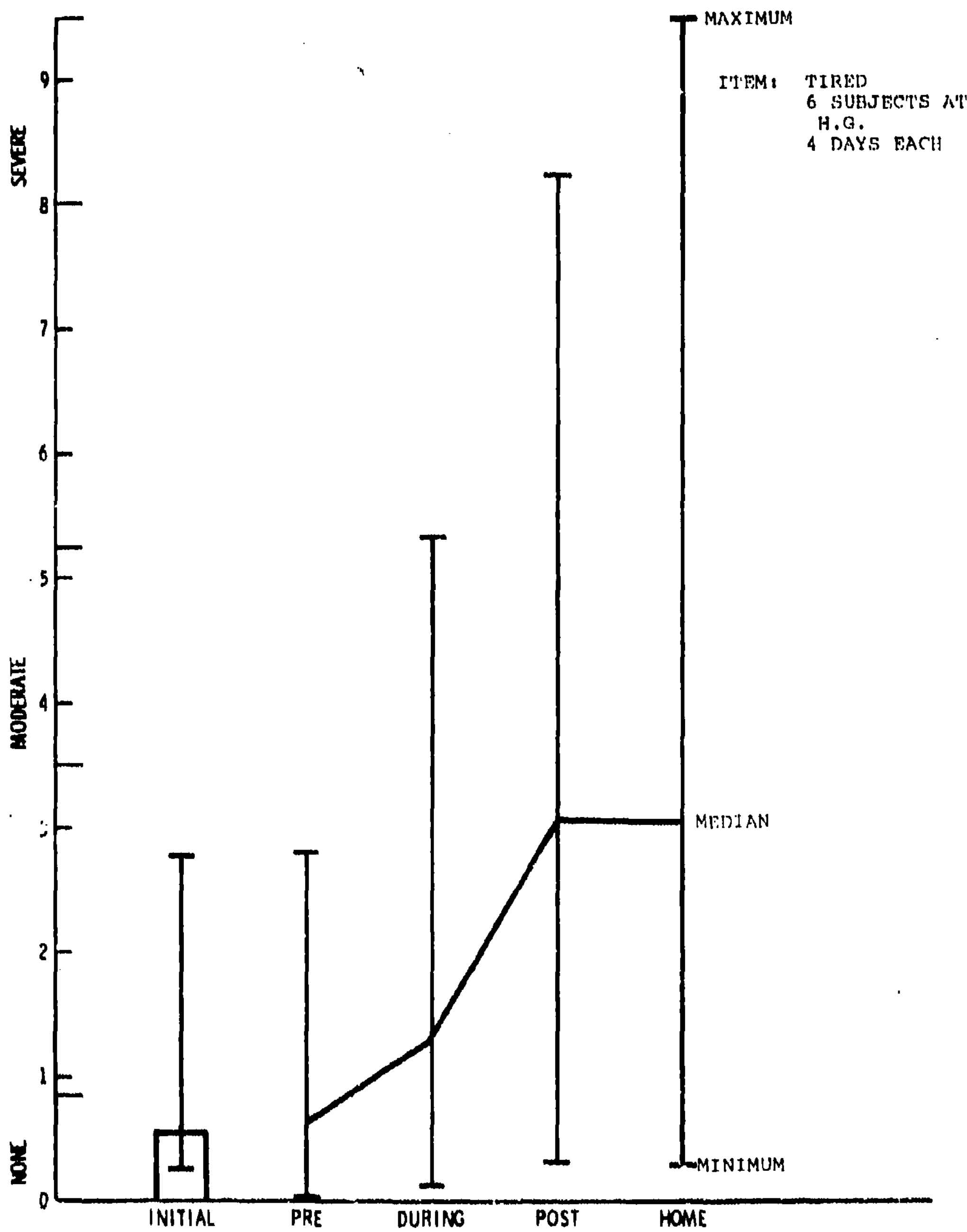


FIGURE G-17. MOOD ITEM: TIRED

- The trend across days worsens for the two leading indicators.

Recommendations

- Improve the questionnaire by eliminating insensitive items and adding others; i.e., backache and depression.

- Commence using the questionnaire to make comparisons:

  Between 8 and 12 hour shifts at Houston-Galveston
  Between pre and operational periods at New Orleans
  Between vessel traffic service centers.

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1. Caplan, R.D., Cobb, S., French, J.R.P., Van Harrison, R., Pinneau, S.R., Job Demands and Worker Health, HEW Publ. No. (NIOSH) 75-160, April 1975.

2. Hauty, G.T., Trites, D.K., Berkley, W.J., Bio-medical Survey of ATC Facilities: Incidence of Self Reported Symptomes Report (AD689806) March 1965.

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