

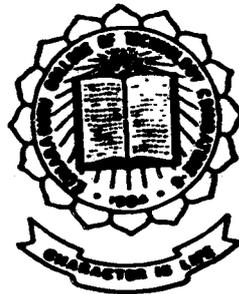
Information Processing of Satellite Data

DISSERTATION SUBMITTED IN PARTIAL FULFILMENT
OF THE REQUIREMENTS FOR THE DEGREE OF
MASTER OF COMPUTER APPLICATIONS
OF BHARATHIAR UNIVERSITY

p_255

By

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Coimbatore - 641 006

JUNE 1996

CERTIFICATE

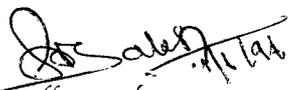
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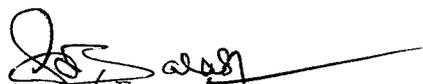
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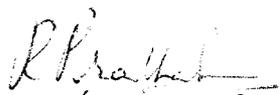
submitted to Kumaraguru College of Technology, Coimbatore (affiliated to Bharathiar University) in partial fulfillment of the requirements for the award of the Degree of Master of Computer Applications is record of original work done by Mr. DANASEKAR S.N. Reg No. 9338MO185 during his period of study in the Department of Computer Science and Engineering, Kumaraguru College of Technology, Coimbatore under my supervision and guidance and this project work has not formed the basis for the award of any Degree/Diploma/Associateship/Fellowship or similar title to any candidate of any University.


Professor and Head


Staff in-charge

Submitted for University Examination held on 11/6/1996


Internal Examiner


External Examiner

DECLARATION

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I here by declare that this project work entitled

"INFORMATION PROCESSING OF SATELLITE DATA"

submitted to kumaraguru College of Technology, Coimbatore (affiliated to Bharathiar University) is a record of original work done by me under the supervision and guidance of Mr. G. BALASUBRAMANIAN B.E., M.S., SENIOR LECTURER, Department of Computer Science and Engg, Kumaraguru College of Technology, Coimbatore and that this project work has not formed the basis for the award of any Degree / Diploma / Associateship / Fellowship / or similiar titile to any candidate of any University.

Place : Coimbatore.

Date : 11-6-96

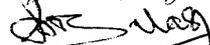
Signature of the candidate



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Countersigned by

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CERTIFICATE

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This is to certify that Sri. DANASEKAR S.N. of Kumaraguru College of Technology, Coimbatore has carried out the project work entitled " INFORMATION PROCESSING OF SATELLITE DATA ", in Mission Simulation and Display Facility Section, under Mission Planning and Analysis Division in this organization from January '96 to May '96.

I am pleased to say that he has worked hard and successfully completed the project on time to meet our requirements. I wish him all the success in his future carriers.

M. LOGANATHAN,
HEAD,
Mission Simulation and
Display Facility Section,
ISRO - Satellite Centre,
Bangalore - 560 017.

भारतीय अन्तरिक्ष अनुसंधान संगठन INDIAN SPACE RESEARCH ORGANISATION (ISRO)

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It is with great pleasure and deep reverence that I express my profound gratitude and thanks to my guide **Mr. G. BALASUBRAMANIAN B.E., M.S.,** Senior Lecturer, Department of Computer Science and Engineering, Kumaraguru College of Technology, Whose encouragement, advice and suggestions was instrumental in the successful completion of the Project.

I express my profound gratitude to **Director**, ISRO Satellite Centre, Group Director, Mission Planning and Analysis Division, for permitting me to carry out this project work in MPAD, ISAC and also providing all the necessary facilities for the same.

I express my sincere thanks to **Mr. M. LOGANATHAN M.E., HEAD**, Mission Simulation & Display Facility Section, Mission Planning & Analysis Division, for his inspiring guidance and constant encouragement during this period which enabled me to successfully complete my work. I am really grateful to him for his invaluable assistance and support at all stages.

I would like to use this opportunity to express my gratitude and thank all the people, who have helped me in the course of this project.

SYNOPSIS

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This project work entitled “ **INFORMATION PROCESSING OF SATELLITE DATA** ”, describes the real time acquisition and display of spacecraft data on a personal computers (PC) and Silicon Graphics Personal IRIS system. The real-time data are acquired on the system memory and various analog processing schemes are used to convert the data into engineering units. This engineering units, converted in real time are used to generate the displays according to the users needs like graphs, 2-D displays as well as 3-D displays. On the other hand the display also includes the real time data in numerical form.

The graphical representation of the data adds more information compared to the usual numerical data display. It facilitates the user to store the data in a separate file for future purpose, and also this software has the provision to access the stored data whenever it is needed.

The software has been developed on PC's in Dos environment and Silicon Graphics Personal IRIS system in Unix environment using ' C ' language.

Introduction

CHAPTER 1

INTRODUCTION

1.1 ABOUT THE PROJECT

This project entitled “ *INFORMATION PROCESSING OF SATELLITE DATA* ” is mainly developed with a notion to monitor the spacecraft parameters on computer terminals in various formats of page displays of numerical data, computation of minimum, maximum and standard deviations of certain parameters of interest, plotting of the data using graphs and two dimensional and three dimensional graphical display facilities. All these above said processing are done on mainframe computers and silicon graphics systems. The present approach is concentrating mainly on lower cost PC's and higher end silicon graphics personal iris system which is mainly used for 3 dimensional displays. This is mainly because the present day PC's have many features like the mainframe in performance, its easy portability and color graphic features, provides a very useful environment for such minimum work.

Telemetry data received by the earth station antenna is converted to digital signals and fed into the mainframe computer. This signal is acquired, archived and displayed in real-time for control and monitoring through the mainframe computer. This work employs a Silicon Graphics Personnel Iris system and PC for acquiring and displaying telemetry data. This data acquisition system works on silicon graphics and PC compatible hardware and "C" language software. The satellites movements are made available in silicon graphics and PC's using graphical displays. These graphical displays are generated for user interaction. One of the special features of silicon graphics is the multitasking and hence multiple windows are opened and various kinds of displays are shown simultaneously.

1.2 NECESSITY OF THE SYSTEM

This project is developed using the language ' C ', such way that it should capture and process all the data from the INSAT series and IRS Satellites. The result is then displayed using graphics as well as in text formats. The project is a absolute necessacity in the Mission Simulation Display Facility Section (**MSDFS**), Since at present there is no software running under PC and Silicon Graphics environment for the above purpose.

Previous systems have limited graphics and processing capabilities. The proposed system covers all the needs of the MSDFS, since this section is responsible for all the satellite missions. This project developed with a notion that it will be very useful for this section in displaying real-time data in graphics and text forms.

The following are the major necessities of the project :

- ◇ The main need being to be able to acquire the data and store the data.
- ◇ Effectively using the Telemetry acquisition card.
- ◇ Process and display the data in real-time.

*System Study and problem
formulation*

CHAPTER 2

SYSTEM STUDY AND PROBLEM FORMULATION

This chapter deals with the organization in which the project was carried out. The objectives of the system to be developed and the software, hardware that was used have been dealt with.

2.1 THE ORGANIZATION

The Indian space programme was formally organized in year 1972 with the setting up, by Government of India, of Space Commission and the Department of Space for providing space services in the area of communication, meteorology and resources survey and management including the development of associated satellites, launch vehicles and ground systems.

The Indian Space Research Organization (ISRO) under the Department of space plays a key role through its center in the planning and execution of national space activities which include development, launch and operation of space system and their applications.

The Department of Space also supports a national laboratory, physical research laboratory, for pursuit of space sciences and oversees the function of National Remote Sensing Agency that services the user of space based remote sensing data.

GLIMPSES OF SPACE ACHIEVEMENTS:

I. Experimental Satellites :

A. ARYABATTA, the first Indian Satellite, on April 19, 1975.

B. BHASKARA - I & II, ON June 7, 1979.

C. APPLE (Aryan Passenger Payload Experiment), the first experimental geostationary communication satellite built by India, on June 19, 1981.

D. Rohini Series. The first Rohini satellite was used to measure the performance of the launch vehicle, the second and the third carried landmark sensor payloads. The third of the Stretched Rohini series of satellites, SROSS - C, was launched by ASLV - D3 into a near orbit on May 20, 1992.

2. Satellite Application Experiments:

A. SITE - Satellite Instructional television Experiments conducted during 1975 - 1976.

B. STEP - Satellite Telecommunication Experiment Project conducted during 1977 - 1979.

C. Remote Sensing Application Experiments.

D. APPLE Utilization Programme.

3. Operational Space Services:

A. INSAT System - INSAT - 1B Satellite in August 1983 for domestic telecommunication, INSAT - 1D Satellite launched on June 12, 1990 is continuing the services of INSAT - 1B, which completed its design life of seven years in August 1990.

B. INSAT - 2 Satellites - The first test Satellite INSAT - 2A was scheduled for launch during June 1992, on the second, INSAT - 2B within a year thereafter. Three operation satellites in the INSAT - 2 series, INSAT - 2C, INSAT - 2D, INSAT - 2E are also under fabrication.

C. IRS - Indian Remote Sensing Satellite - The launch of first operational Indian remote sensing satellite, IRS - 1A, was carried out on March 17, 1988. The second satellite in the series IRS - 1B, identical to IRS - 1A was launched successfully on August 29, 1991. These two have become the mainstay of the National Natural Resources Management System,(NNMRS) for effectively managing the countries natural resources.

4. Launch Vehicles:

A. SLV3 on July 1990.

B. ASLV - The Augmented Satellite Launch Vehicle(ASLV - D#) was successfully launched from Sriharikota Range (SHAR) on May 20, 1992.

C. PSLV - The first development flight of the indigenous Satellite Launch Vehicle, PSLV, was scheduled during 1992.

D. GSLV - The development of Indian Geosynchronous Satellite Launch Vehicle, GSLV will be able to launch 2500 Kg, class Communication Satellites into Geostationary transfer orbit as begun. The first flight of GSLV is planned during 1995 - 1996.

SPACE CENTRES AND UNITS.

1. Vikram Sarabhai Space Centre(VSSC), Trivandrum.
2. Space Application Centre(SAC), Ahmedabad.
3. SHAR Centre, Sriharikotta.
4. Liquid Propulsion Systems Centre, (LPSC), Trivandrum, Bangalore and Mahendragiri(in TamilNadu).
5. Development and Educational Communication Unit, (DECU), Ahmedabad.
6. ISRO Telemetry, Tracking and Command Network (ISTRAC), with its headquarters and spacecraft control centre at Bangalore.

7. Master Control Facility at Hassan in Karnataka.
8. ISRO Inertial Systems Unit(IISU) in Trivandrum.
9. National Remote Sensing Agency (NRSA), Hyderabad.
10. Physical Research Laboratory (PRL), Ahmedabad.
11. ISRO Satellite Centre (ISAC), Bangalore.

ABOUT ISAC, BANGALORE :

This Centre is responsible for the design, Fabrication, testing and mangement of satellites systems for scientific, technological and application missions.

ISAC ORGANIZATIONAL STRUCTURE:

In order to ensure the best possible use of the resources to cater to the varying demands in a multi project environment, ISAC has adopted a flexible organisational structure.

The centre is organised in a matrix form consisting of functional RESEARCH AND DEVELOPMENT groups and project groups. It has functional groups working in specific areas of satellite technology, supported by pilot plant level facilities for fabrication and testing of spacecraft elements.

The following are the various other divisions :

1. MECHANICAL SYSTEMS AREA (MSA).
2. FACILITIES AREA.
3. SYSTEMS RELIABILITY GROUP (SRG).
4. PROGRAMME PLANNING & EVALUATION GROUP (PPEG).
5. TECHNICAL PHYSICS DIVISION.

6. ELECTRONICS SYSTEMS AREA (ESA).

2.2 SYSTEM OBJECTIVES

The requirement analysis of the system is the design of a software engineering task. Basically this system is built to acquire the real-time data from the satellites to generate the satellite parameters graphs, displaying using graphics and store the data in separate files for future reference and display the details according to the users needs.

The following are the list of major objectives :

- ☐ Establish connection to the mainframe.
- ☐ Identifying Satellites and their Data's.
- ☐ Framing the data.
- ☐ Storing the data.
- ☐ Processing the data.



Displaying the results according to the users needs.

2.3 SELECTION OF SOFTWARE

Introduction

' C ' seems a strange name for a programming language. But this strange sounding language is one of the most popular and powerful computer language today. C was an offspring of the ' Basic Combined Programming Language ' (BCPL), called ' B ', developed in the 1960's at Cambridge University. B language was modified by Dennis Ritchie and was implemented at Bell Laboratories Inc. in 1972. The new language was named C. Since it was developed along with the UNIX system, it is strongly associated with UNIX. The operating system, which was also developed at Bell Laboratories, was coded almost entirely in C.

For many years, C was used in mainly in academic environments, but eventually with the release of C compilers for the commercial use and the increasing popularity of UNIX it began to gain widespread support among computer professionals. Today, C is running under number of operating systems including MS-DOS. Since MS-DOS is a dominant operating system for micro computers, it is natural that C has begun to influence the microcomputer community at large.

Importance of C

The increasing popularity of C is probably due to its many desirable qualities. It is a robust language whose rich set of built-in-functions and operations can be used to write any complex program. The C compiler combines the capabilities of an assembly language with the features of a High-Level language and therefore well suited for writing both system software and business packages. In fact, many of the C compilers available in the market are written in C. Programs written in C are efficient and fast. This is due to its variety of data types and powerful operations. It is many times faster than BASIC. For example, a program to increment a variable from 0 to 15000 takes about one second in C while it takes more than 50 seconds in an interpreter BASIC. There are only a limited number of keywords and its strength lies in its built-in-functions. Several standard functions are available which can be used for developing programs.

C is highly portable. This means that C programs written for one computer can be run in another computer with little or no modification. Portability is important if we plan to use a new computer with the different operating system. C language is well-suited for structured programming, thus requiring the user to think of problem in terms of function modules would make a complete program. This modular structure makes program debugging, testing and maintenance easier. Another important feature of C is its ability to extend itself. A C program is basically a collection of functions that are supported by the

C library. We can continuously add our own functions to the C library. With the availability of a large number of functions the programming task becomes simple.

The Silicon Graphics system has its own graphical functions. It has a set of Display commands, Co-ordinate transformation commands, Hidden surface drawing commands and a set of lighting models.

2.4 HARDWARE PLATFORM

Configuration of TMAC (Telemetry Acquisition Card)

The TMAC system is configured around a Z80 microprocessor which handles the task of system configuration, frame synchronization and data transfer to the host processor on the PC. The software for the system is housed in a 8K x 8 PROM and the system has 8 Kbytes of Static RAM for data buffering and for storing configuration parameters. A 6.144 Mhz crystal oscillator in conjunction with an 8253 counter / timer provides the system timing for clock recovery.

Configurations of PC's

Processors	:	80386,80486.
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Main memory	:	8 MB.
Secondary memory	:	240 MB.
Floppy drives	:	1.44 MB, 1.2 MB drives.
Monitor type	:	17" SVGA color monitors.
Keyboard	:	101 keys

Configurations of Silicon Graphics Personal IRIS system

Processor	:	69020.
Main memory	:	8 MB.
Extended memory	:	16 MB.
Ports	:	Four Serial ports.

The IRIS (Integrated Raster Imaging System) workstation is a high performance and high resolution color computing system for 2 - D and 3 - D computer graphics. It provides a powerful set of graphics primitives.

System Design and Development

& VHRR). The various parameters monitored are voltages, Currents, Angles, Wheel Speeds, Time, Temperature, and ON / OFF status of all the subsystems.

Essential Requirements

The following are the basic requirements for the functioning of the system :

- Installation of telemetry acquisition card hardware on personal computer.
- The satellite data and its correctness of level and proper wave form.
- Personal computer readiness.

During the system design, the non functional requirements also to be considered to make the system more versatile.

The additional requirements considered are

- The design may require a particular implementation of language.
- Implementation of particular design methodology.

- Memory and speed consideration for real-time application.

To this system, all the above three mentioned requirements have been considered. For first requirement the language selected for the implementation of data acquisition system and for graphics display is C language.

With the second requirement, there is no user specific needs and hence a very general topdown modular design approach is carried out.

The third requirement of time and space have been considered correctly.

The environmental features which are considered during the design are :

HUMAN FACTORS

EASE OF USE

EASE OF LEARNING

RESPONSE TIME

MAINTAINABILITY

ADAPTABILITY

PORTABILITY

Overview of Acquisition and Display

The system that has been developed has two main functional modules

- ⊗ Data acquisition module

- ⊗ Process and Display module

Data Acquisition Module

The major function of data acquisition module is to have a dedicated connection to the mainframe through the Silicon Graphics as well as through the PC. The silicon graphics has a multitasking facility and hence the serial port is used to transfer data as terminal. A terminal I/O command is used for this purpose. Thus data is captured and stored in files for the processing module. In the PC side the TMAC card and its own software is used to capture data since there is no multitasking facility in PC's under Dos

environment. The TMAC card and software continuously captures and stores the data for processing.

The TMAC is a subsystem designed to plug into one of the expansion slots in an IBM PC or compatible Personal Computer and acquire PCM coded telemetry data. The card is designed to act as a front end to a PC based data processing software system which could use the acquired data for either display, storage or any other purpose.

The salient features of TMAC includes

Input data rate variable from 16 bits per second to 8000 bits per second
(software programmable).

Input data coding in either NRZ-L, NRZ-M or NRZ-S formats. Auto-search feature to automatically scan between these formats and lock on to correct format.

Built in Clock recovery circuitry for operation with or without external clock.

Software programmable framesize and frame sync code.

Narrow pulse rejection filter at input to reject noise spikes of upto a programmable width

Programmable bit mismatches in framesync, and number of verity frames to operate in noisy environments.

Wide-range Inputs capable of accepting TTL-level type, Open Collector type or Bipolar RS-232 compatible signals.

Buffered TTL open collector type outputs for daisy-chaining multiple units.

Built-in ROM based data simulator capable of storing upto 8192 bits of data for quick checkout of system.

All data transfer between the host processor and the TMAC subsystem is done through a bi-directional full handshake protocol to ensure that no overrun errors can take place during any data transfer.

Display satellites graphically positioning over the globe-map.

Move the satellites in real-time according to the processed details.

thus with this a brief overview of the system is provided above.

3.2 INPUT DESIGN

The input to the system is the telemetry data from the satellites from the space which are transmitted using a Very High Frequency waves.

Arrival rate of Telemetry

Telemetry data arrives from the spacecraft as a stream of bytes. This system generate exactly 1024 bytes of data once in every eight seconds of time. That is how system generates one subframe of 128 words in every one second. For every second the subframe ID is from 0 to 7. The data arrival is synchronous to the On Board Time (OBT) of the satellites.

Telemetry System

Frame Length	:	1024 bytes
Word Length	:	8 bits
Bit Rate	:	1024 kbps
Frame Sync Code Length	:	24 bits
Frame Sync Code	:	AC, CA, 1F (HEX)
Types of Format	:	Two selectable 1. Normal 2. Dwell
Subframe Sync Length	:	3 bits
Subframe Sync Type	:	8 frame

Spacecraft ID : 4 bits

3.3 OUTPUT DESIGN

The telemetry data is organized in a predefined format as shown in the figure in the appendix and is described below which is a major output of the software.

MASTER FRAME

A collection of 1024 bytes of data are grouped into a masterframe. Each master frame is divided into eight subframes. Each subframe containing 128 channels packed together.

SUBFRAME

All subframes contain the following fixed components :

- ◇ First three bytes (0, 1 and 2) contain the frame synchronization code.
- ◇ Third byte (3) contains the information about the format (NORMAL / DWELL) of the telemetry data.

- ◇ Fifth byte contains the subframe identification number.

- ◇ The bytes 51,52,53 and 54 contain the on board time (OBT).

Other bytes in the subframe are used for analog, status and other health parameters. The details of each component are given in the following passages.

FRAME SYNCHRONIZATION CODE

Spacecraft sends the telemetry data about health when they are operated. This data is a stream of 1024 bytes. It is important to locate where exactly information of each masterframe / subframe starts. So certain predefined fixed patterns are used for this purpose to identify start of information.

FRAME IDENTIFICATION NUMBER

Fifth byte of each subframe contains the frame ID to which actually it belongs. It carries value ranging from 0 to 7.

ON BOARD TIME

OBT is the spacecraft local time since the spacecraft is launched into its orbit. It is stored in four continuous bytes starting from the byte number 51.

OTHER HEALTH PARAMETERS

The other bytes contain health parameters such as :

- ☐ Temperature of various parts of the spacecraft.
- ☐ Battery voltage and current.
- ☐ Spacecraft orientation with respect to ground, sun and earth references.
- ☐ All subsystem's ON / OFF etc.

3.4 PROCESS DESIGN

This section gives the details of the satellites parameters. Each parameter consists of following mnemonics namely pid, parameter field, telemetry channel, status, data format, processing type and remarks. These parameters are briefly explained then.

PID (PARAMETER IDENTIFICATION NUMBER)

There is a unique identification number for each parameter. The width of pid is 4 characters in length. There are two categories, one is status parameters and another is analog parameters.

STATUS PARAMETERS

Status parameters give the exact status of the system or subsystem of satellite. That is ON or OFF , VALID or INVALID etc.,

ANALOG PARAMETERS

Analog parameters give the numerical value or message of the parameter of the system or subsystem of satellite such as current, voltage, temperature etc.

ACCESSING DATA

To initiate the data capturing the TMAC's software is loaded in the system. This program is a driver program defining the following functions, such as Initializing the TMAC card, Resetting the TMAC card, Enabling data capture process, Disabling data capture process, Transferring one subframe of data to the user area, Restoring the old mode and disabling the real-time process.

PROCESSING DATA

There are two ways to access the data for processing.

1. Real-time mode.
2. Playback mode.

In the real time mode the data is accessed from the memory of the computer, because the real-time data is directly stored in the system storage. Parallel to this mode the data is transferred to disk for future reference. So the play back mode data is retrieved from the disk and process is done.

The data processing is divided into two modes

1. Normal Processing
2. Special Processing

NORMAL PROCESSING

In normal processing the data is directly read and using conversion factors the values are obtained. The conversion formula are given below.

$$(1) M * T M C$$

$$(2) M * T M C + C$$

SPECIAL PROCESSING

Some of the spacecraft parameters are dependent on one or more of the other parameters. In order to determine the value of dependent parameter, all parameters depending on it are processed first. These extra calculation made to evaluate pid value indicates the special processing scheme.

For example, consider the pid SEL ES ROLL DEG. This parameter depends on ES FOR CONTROL. So the parameter ES FOR CONTROL is processed first. It gives two results ES1 & ES2. If the output of this ES FOR CONTROL is ES1 then SEL ES ROLL DEG value is same as ES 1 ROLL DATA DEG, otherwise SEL ES ROLL DEG value is same as ES 2 ROLL DATA. The value of ES1 & ES2 are determined in the normal processing mode.

*System Implementation and
Interpretation*

CHAPTER 4

SYSTEM IMPLEMENTATION & INTERPRETATION

4.1 IMPLEMENTATION

Implementation is the stage of the project when the theoretical design is turned into a working system. If the implementation stage is not carefully planned and controlled, it can cause chaos. Ineffective control of implementation can result in the failure of the system which is otherwise excellent. So, implementation of the new system involves careful planning, investigation of the current system and its constraints on implementation, proper education and training to the user.

The programs all the modules are checked with all type of data and these programs are working properly for those inputs. Proper security is given to the system to avoid the improper access to the system. Since, there was no existing system for the current developed system, the current system is implemented in one move for further usage. The implemented system is again tested with the same set of data which was given before the implementation. The implemented system is working properly for those inputs.

4.2 EDUCATION & TRAINING

To achieve the objectives and benefits expected from computer based systems it is essential that the people who will be involved should be confident of their role in the new system. This involves the users understanding the overall system. So, proper education and training is necessary for the users to become familiar with system.

To use the system in a more effective way, proper training and education about the system was given to a group of people and the user manual was prepared and given to the maintenance group. Moreover, necessary helping system were provided within the system at each and every stage of the system.

4.3 SYSTEM TESTING

The system has been tested for the various input values and has been found to work in accordance with the prescribed features. Various sets of different data's were used to test the system and are found to be successfully possible by the system to process them. All the different kinds of data inputs are that are supported by the software was tested and it was found that the graphical display modules are efficiently working.

- The software has been tested both for its functionality as well as its limitations.

- The various functions that have been developed have been thoroughly debugged and are found to working effectively.

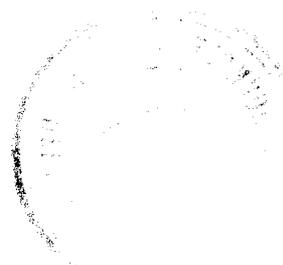
- The constraints regarding the size of the display, storage and retrieval facility etc., have also been tested.

Conclusion

CHAPTER 5

CONCLUSION

The software has been developed and has fulfilled the necessary requirements as identified in the system study. The project provided to process all the pids for the satellite data's received. It also provided a mechanism of data storage feature of the telemetry data on disc for future use in playback mode. The software was found to be very useful in evaluating the satellite simulators developed in the Mission Planning and Analysis Division by comparing the output with real spacecraft data transmitted from Ground Check-Out Clean Room. The plot graph feature provides an efficient scheme to study the performance of the spacecraft systems. It is planned to use this project work during the satellite operations by the mission group. This work is a step forward towards the trend analysis on subsystem performance study.



Scope for further Development

CHAPTER 6

SCOPE FOR FURTHER DEVELOPMENT

The system can be enhanced to support the various other satellites which are to be launched in the future. Also additional features involving display enhancement can be also developed.

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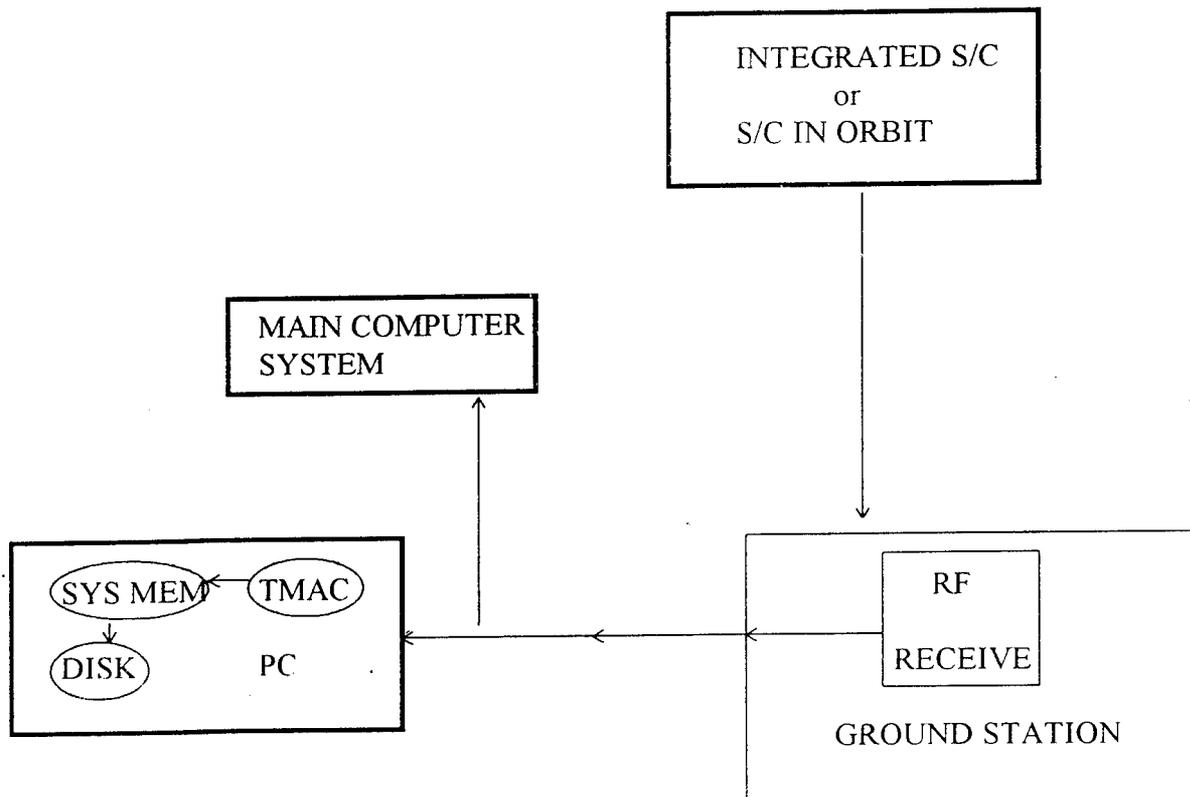
The Communication Satellite

- Mark Williamson

Obfuscated C and other Mysteries

- DON Libes

Appendix



SPACECRAFT SYSTEM

0	8	1	11	2	3	3	ff	4	ac	5	ca	6	1f	7	8
8		9		10		11		12		13		14		15	
16		17		18		19		20		21		22		23	
24		25		26		27		28		29		30		31	
32		33		34		35		36		37		38		39	
40		41		42		43		44		45		46		47	
48		49		50		51		52		53		54		55	
56		57		58		59		60		61		62		63	
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72		73		74		75		76		77		78		79	
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104		105		106		107		108		109		110		111	
112		113		114		115		116		117		118		119	
120		121		122		123		124		125		126		127	

FRAME FORMAT - INSAT 2A

0	9	1	13	2	I	3	ff	4	ac	5	ca	6	If	7	9
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16		17		18		19		20		21		22		23	
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72		73		74		75		76		77		78		79	
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88		89		90		91		92		93		94		95	
96		97		98		99		100		101		102		103	
104		105		106		107		108		109		110		111	
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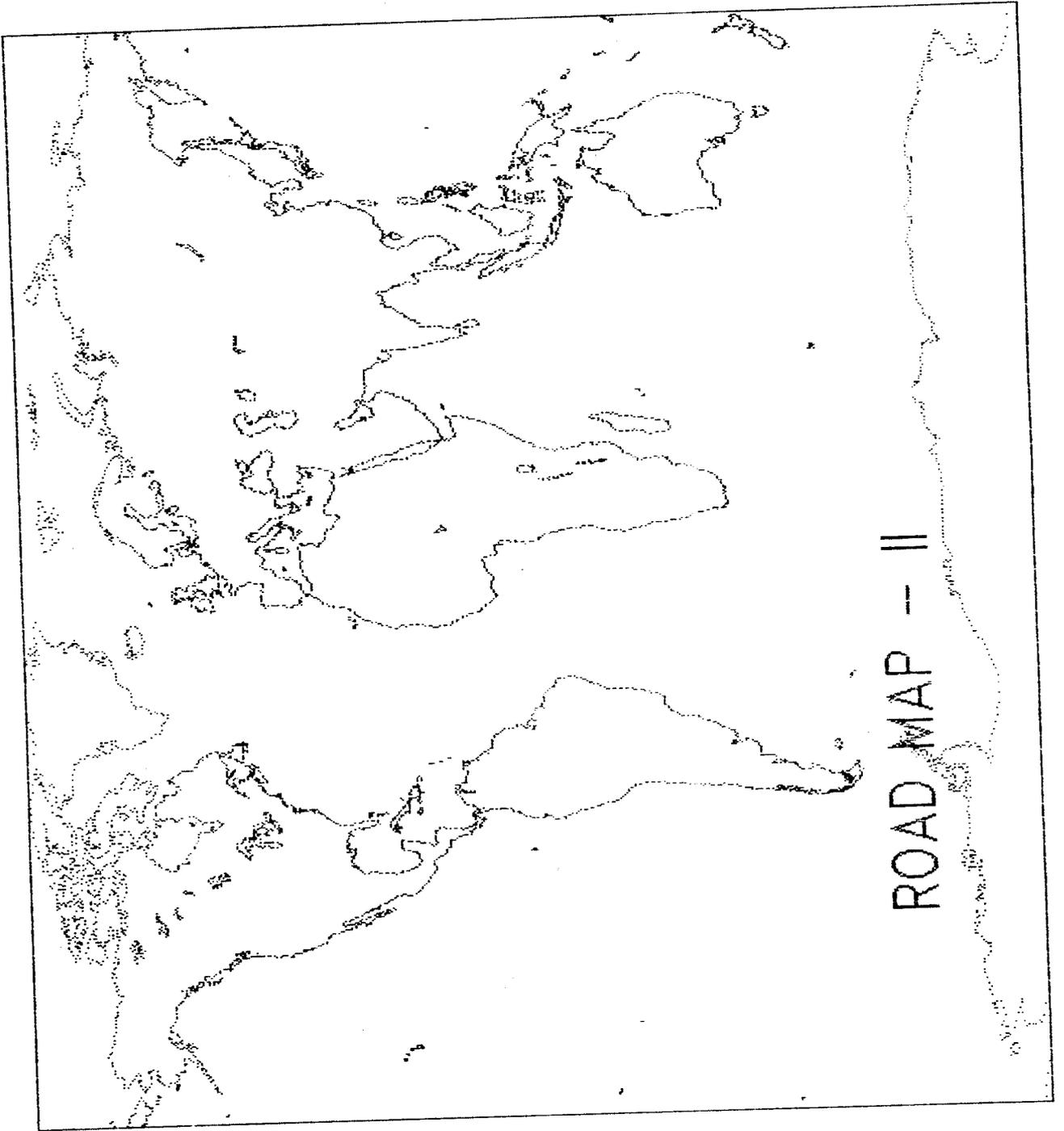
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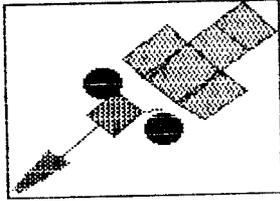
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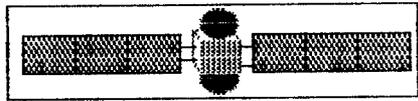
ROAD MAP - I



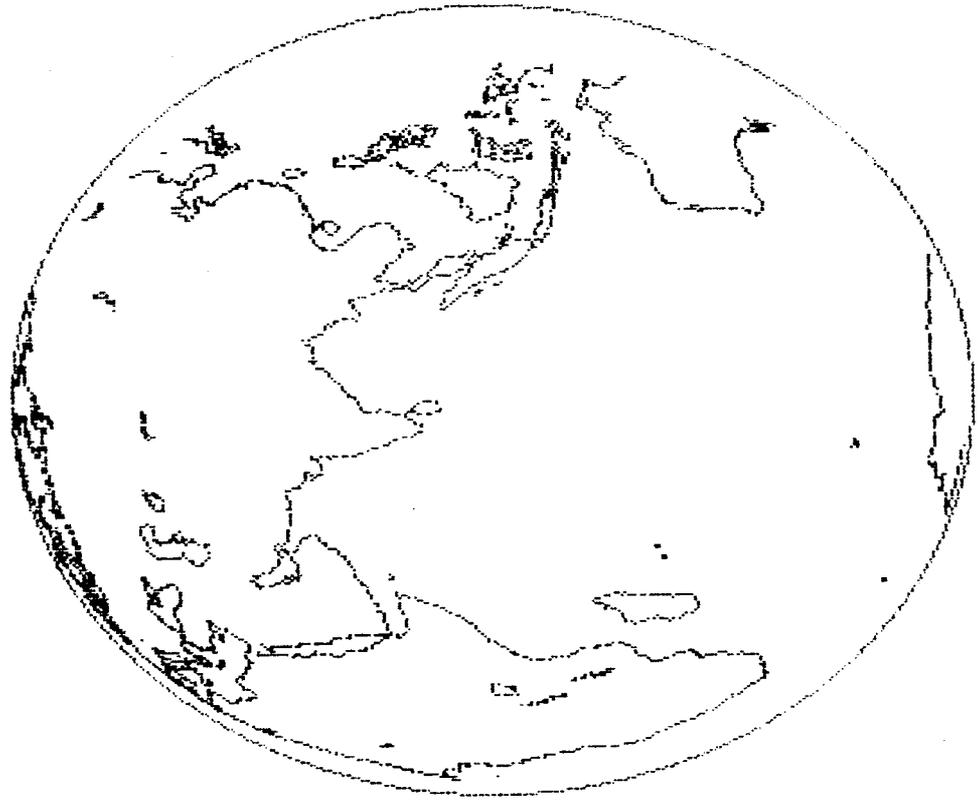
ROAD MAP -- II



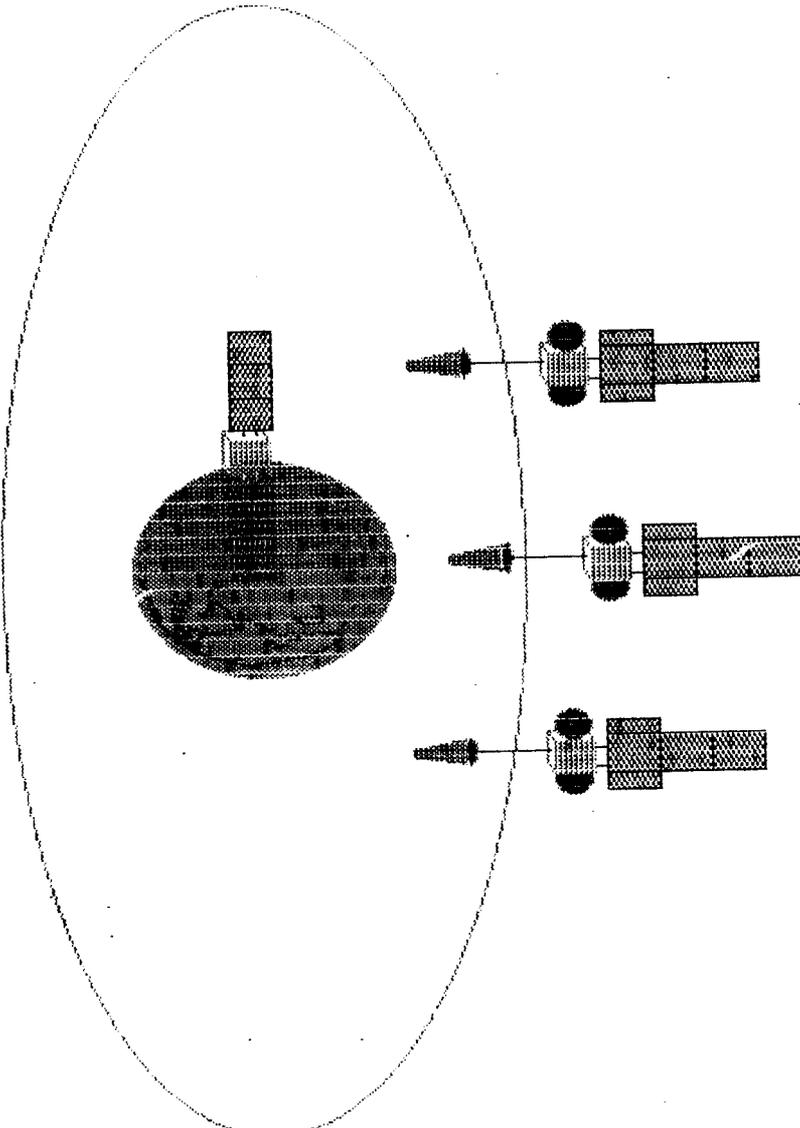
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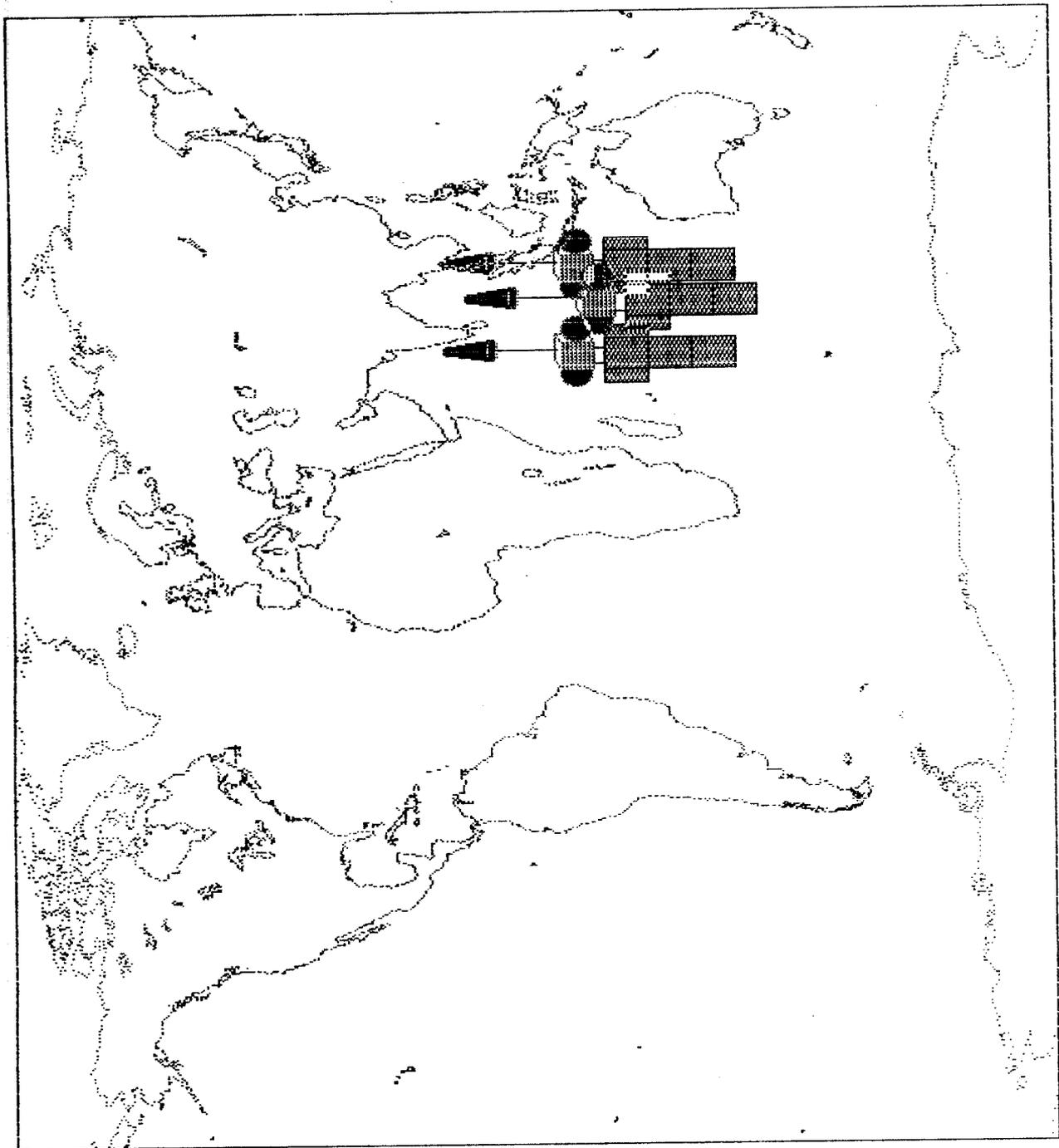
IRS - SPACECRAFT



17:16:29



SECRET



W A T C H
Use Enter, Esc OR Tab

Enter The Current Hour
Use Enter, Esc OR Tab