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SPECIFICATIONS FOR ASAP AND SATURN SIMULATION SYSTEM

By J. W. Hilliard
Computation Laboratory

NASA

George C. Marshall Space Flight Center
Marshall Space Flight Center, Alabama

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TECHNICAL MEMORANDUM X-53800

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ABSTRACT

Presented in this report are the functional specifications for two computer programs as follows:

1. A computer program, ASAP and Saturn Simulation, that will simulate Automatic Storage And Playback (ASAP) and Saturn telemetry formats. Tables and figures are included to help define eight provisions required of this program.

2. A computer program, Predicted Data Tape, that will convert the Instrumentation Program and Components List card data to paper tape. This tape will contain the input data for the ASAP and Saturn Simulation Program. Tables, figures, and an Appendix are included to help define input, output, and three provisions required of this program.

Purposes and Procedures are also explained.

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SCIENCE AND ENGINEERING DIRECTORATE

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DEFINITION OF ABBREVIATIONS

Abbrevations		Definition
ASAP	-	Automatic Storage And Playback
ATM	-	Apollo Telescope Mount
CAL	-	Calibration
CH	-	Channel
DDAS	-	Digital Data Acquisition System
GR	-	Group
H	-	Hollerith
ID	-	Identification
IDTS	-	Instrumentation Data Test Station
INT	-	Interrupt
KBPS	-	Kilobits per second
kHz	-	Kilohertz
LOCAT	-	Location
MUX	-	Multiplexer
NRZ(L)	-	Non-return to zero (level)
PCM	-	Pulse code modulation
S027	-	Scientific experiment number 027
SS	-	Sense switch
VIS	-	Vehicle Instrumentation Simulator
X	-	Printer skip

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SPECIFICATIONS FOR ASAP AND SATURN SIMULATION SYSTEM

SUMMARY

Presented in this report are the functional specifications for two computer programs as follows:

1. A computer program, ASAP and Saturn Simulation, that will simulate Automatic Storage And Playback (ASAP) and Saturn telemetry formats. Tables and figures are included to help define eight provisions required of this program.

2. A computer program, Predicted Data Tape, that will convert the Instrumentation Program and Components List card data to paper tape. This tape will contain the input data for the ASAP and Saturn Simulation Program. Tables, figures, and an Appendix are included to help define input, output, and three provisions required of this program.

Purposes and Procedures are also expalined.

INTRODUCTION

This document contains functional specifications for the simulation of on-board Saturn PCM telemetry systems. This simulation is accomplished by the Vehicle Instrumentation Simulator (VIS), see Figure 1 for hardware configuration. The VIS along with supporting documentation [1] and a simulation program, Mark III VIS, was purchased by NASA from Systems Engineering Laboratories on March 14, 1966, to provide the Quality and Reliability Assurance Laboratory with a vehicle substitute to check out ground equipment before the vehicle arrived for testing. The system performed satisfactorily to specifications.

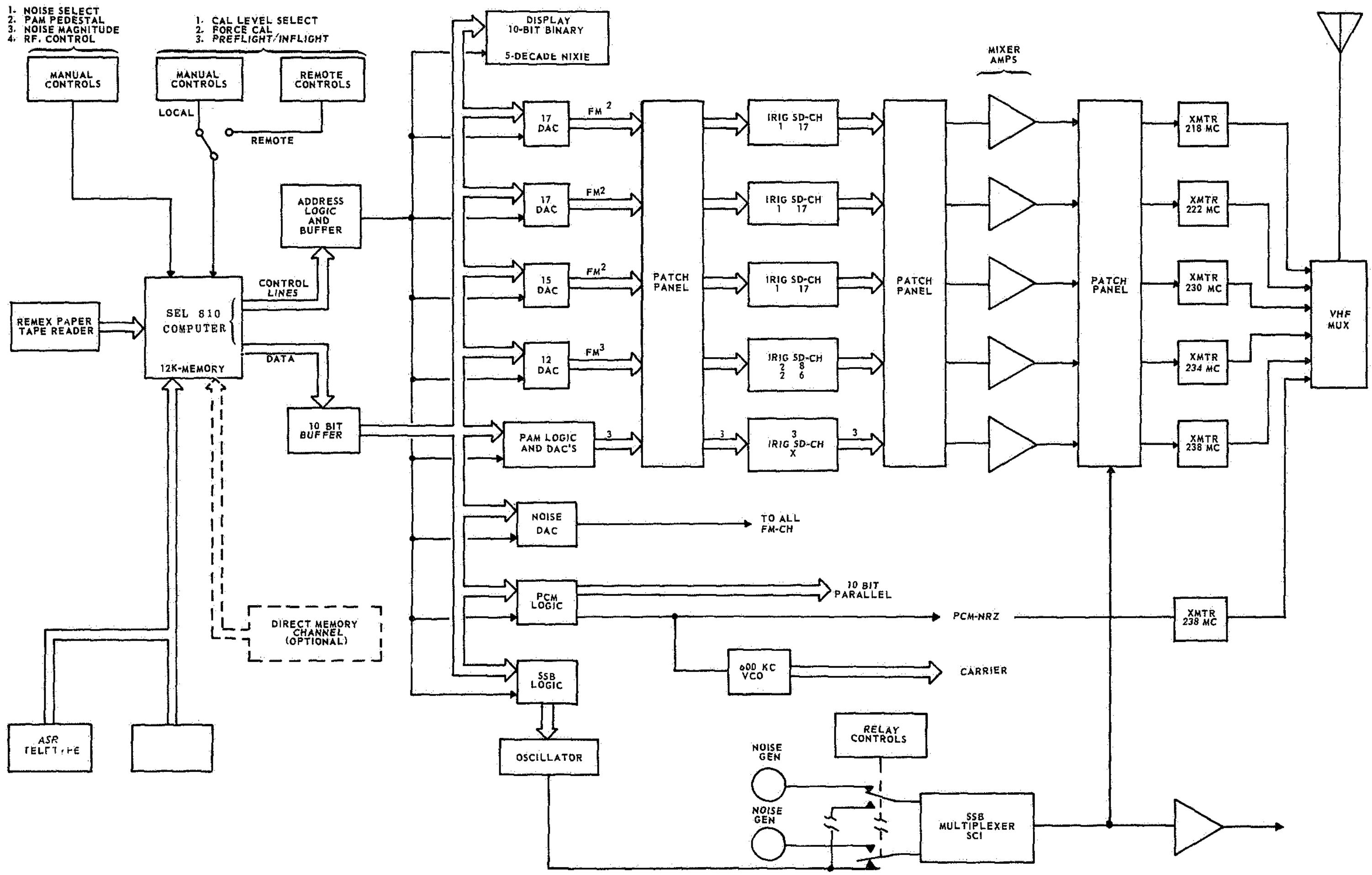


FIGURE 1. HARDWARE CONFIGURATION FOR VIS

Unfortunately, Saturn telemetry requirements have changed. Mark III VIS will not simulate new experimental measurements and Automatic Storage and Playback (ASAP) formats. Specifications delineated in this document are for a program that will simulate new telemetry requirements.

The ASAP portion of this new program will consist of two different formats, Apollo Telescope Mount (ATM) and S027 X-ray. These two different formats simulate the playback of two types of vehicle telemetry configurations that have a common on-board PCM format. Saturn, the common format, will be simulated for 85 minutes and the ASAP format simulated for five minutes, the total time represents duration of a full orbit.

Since the S027 X-ray format can be placed in the first four frames of the ATM format, the program will be coded to accommodate either ASAP format.

The Predicted Data Tape Program will not be a simulation program. Its purpose will be to convert the input cards to paper tape since the VIS control computer, SEL 810, has a paper tape reader but no card reader. This program will be run on the SDS 930 computer.

Data tables for the ASAP and Saturn format plus the simulation program will require most of the SEL 810 computer's 12K of memory; therefore, the Predicted Data Tape Program was chosen to be independent of the simulator. The following additional requirements can be allocated to the predicted data tape program since this program will be a separate event:

1. input and print routines

2. analog to digital conversion

3. bit identification

4. telemetry sync identification

5. output data to paper tape.

The predicted data tape program will eliminate the large input routine in the simulator program and reduce the amount of input paper tape that is presently being used with the Mark III VIS Program.

The author wishes to express appreciation to Jonathan Scheidt for his assistance in the preparation of this document.

ASAP AND SATURN SIMULATION PROGRAM

Purpose

The purpose of the ASAP and Saturn Simulator Program is to simulate the on-board PCM telemetry system for either ATM and Saturn or S027 and Saturn formats. All three formats, ATM, S027, and Saturn, are serviced by the 3.6 kHz system priority interrupt. The sampling rate for all three formats is the same, two words per interrupt, 72 KBPS serial NRZ(L) transmission, one word following the other.

ATM format definition: (See Figure 2 for sync identification.)

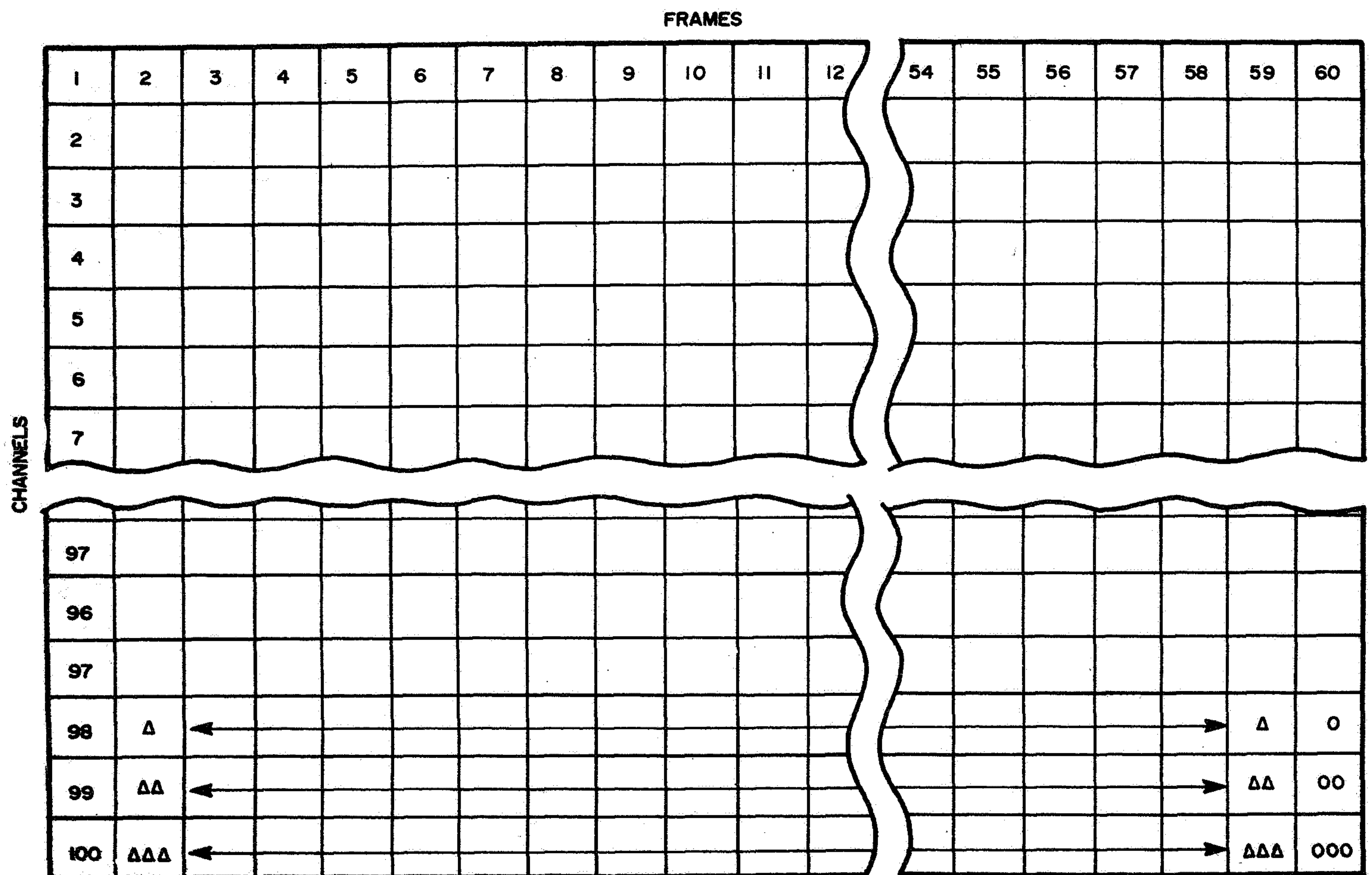
1. 60 frames per master frame
2. 100 words per frame
3. 10 bits per word
4. 5/6 second in duration.

SO27 format definition: (See Figure 3 for sync identification.)

1. 4 frames per master frame
2. 100 words per frame
3. 10 bits per word
4. 250 milliseconds in duration.

Saturn format definition: (See Figure 4 for sync identification.)

1. 30 frames per master frame
2. 30 A group words per frame
3. 30 B group words per frame
4. 10 bits per word
5. 1/4 second in duration.



Δ FRAME SYNC 1011011110
ΔΔ FRAME SYNC 1010001001
ΔΔΔ FRAME SYNC 1100000110
O MASTER FRAME SYNC 0100100001
OO MASTER FRAME SYNC 0101110110
OOO MASTER FRAME SYNC 0011111001

FIGURE 2. ATM FORMAT

FRAMES

CHANNELS	1	2	3	4
1				
2				
3				
4				
96				
97				
98	Δ	Δ	Δ	O
99	ΔΔ	ΔΔ	ΔΔ	OO
100	ΔΔΔ	ΔΔΔ	ΔΔΔ	OOO

Δ	FRAME SYNC	1011011110
ΔΔ	FRAME SYNC	1010001001
ΔΔΔ	FRAME SYNC	1100000110
O	MASTER FRAME SYNC	0100100001
OO	MASTER FRAME SYNC	0101110110
OOO	MASTER FRAME SYNC	0011111001

FIGURE 3. S027 FORMAT

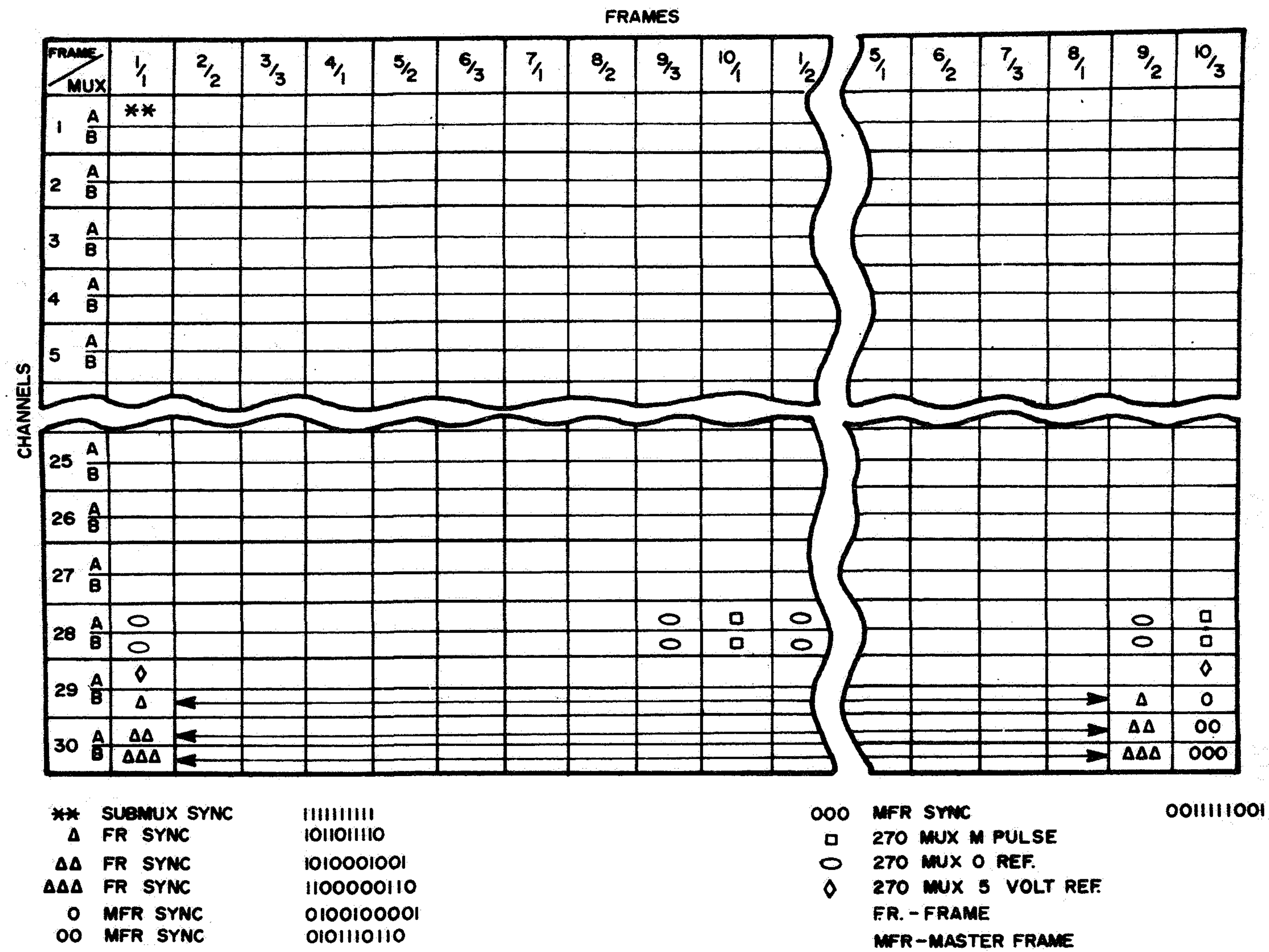


FIGURE 4. SATURN FORMAT

Table I describes each format data table length. The data for ATM and S027 formats will not be in memory together. Only Saturn format data can occupy memory with ATM or S027 format data.

TABLE I. PCM DATA TABLES

ATM	S027	SATURN	HIGH[1]	LOW[1]	SUBMUX[2]
Word 1[3]	Word 1	Word 1	Word 1	Word 1	Word 1
Word 2	Word 2	Word 2	Word 2	Word 2	Word 2
Word 3	Word 3	Word 3	Word 3	Word 3	Word 3
.	.	.	.	.	.
.	.	.	.	.	.
.	.	.	.	.	.
Word 6000	Word 400	Word 1800	.	.	Word 180

1. These tables will vary in length according to input but they should not exceed 510 locations.

2. This table will contain 180 locations.

3. This word, if it is the starting address of the first data table, may begin at $xx513_8$ (where xx is a memory map).

Procedure

This program will be written in SEL 810 assembly language (MNEMBLER) and assembled on the GE-235 computer by an existing program that will assemble SEL 810 instructions. The output from this assembly will be the ASAP and Saturn Simulation Program on binary paper tape ready to be loaded in the SEL 810 computer, control unit for the Vehicle Instrumentation Simulation (VIS). After the simulation program tape has been read into memory by the SEL 810 Remex paper tape reader, the Predicted Data Tape will replace it. Instructions from the control panel will start the simulation program and data will be read directly into memory without any processing by equations or formulas. See section on Predicted Data Tape Program for specifications. Figure 5 contains a general flow chart of the simulation program.

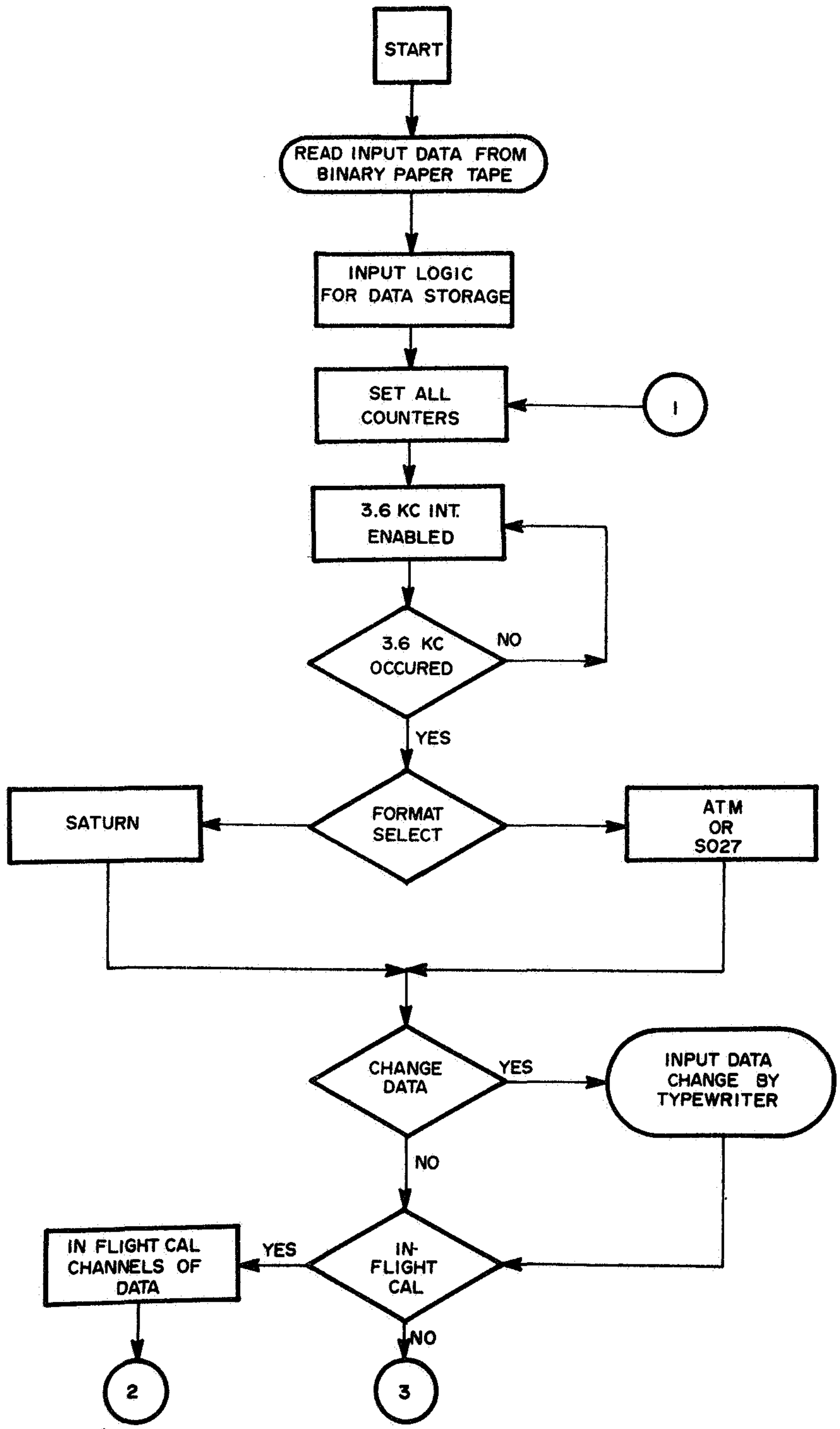


FIGURE 5. GENERAL FLOW CHART FOR ASAP AND SATURN SIMULATION PROGRAM

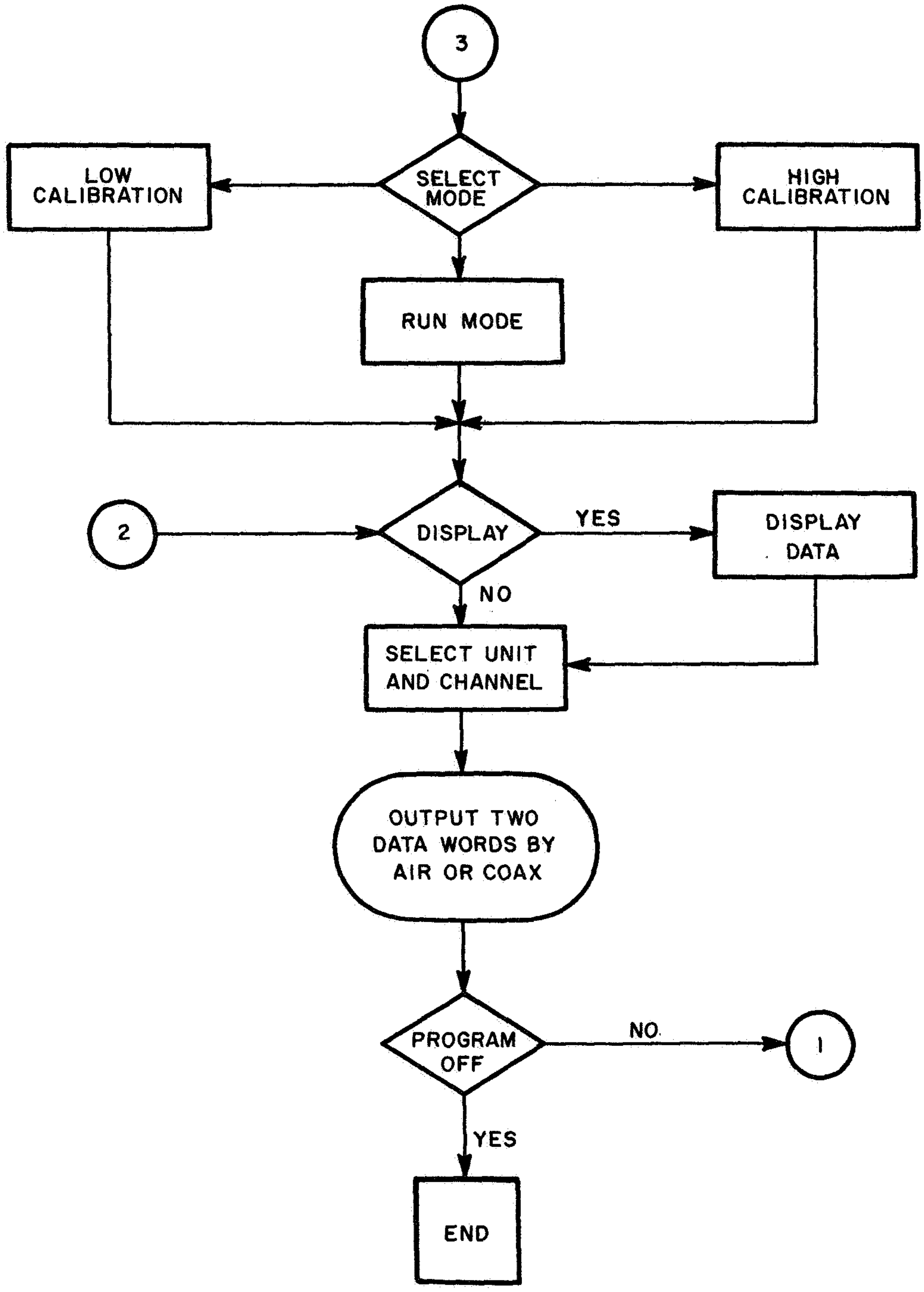


FIGURE 5. (Continued)

Provisions

The ASAP and Saturn Simulation Program will accomplish the following:

1. Provide for sub-multiplexing one or more Saturn PCM channels.

Only the Saturn format will have sub-multiplexed channels. Although initial requirements are for only one sub-multiplexed channel, three will be provided.

Input data will determine sub-multiplexing requirements. Methodically, bit 5 of the SEL 810 computer word will determine if the Saturn format time slot is to be sub-multiplexed. See Figure 6 for sub-multiplexing format. Figure 7 describes word identification by extra bits.

Sub-multiplexing format definition: (See Figures 4 and 6 for sync identification.)

a. 60 Saturn master frames per sub-multiplexer master frame.

b. 4 sub-frames per sub-multiplexer master frame.

c. 15 sub-channels per sub-frame.

d. 10 bits per word.

2. Provide for adding noise only to analog values during simulation.

Noise may be requested from the control panel by two switches, noise selector and noise magnitude. The selector switch will be set to the PCM position and the magnitude switch will allow the operator a choice of 2^1, 2^2, 2^3, 2^4, 2^5, 2^6, or 2^7 values, see Table II.

Random noise will be calculated by a random number generator and its magnitude scaled into a value that will represent 0 to 660 millivolts. The results of this scaled value and the switch magnitude value will be added to the analog value. Analog values in the Saturn and ASAP formats will be identified by bit 4 or the SEL 810 computer word, see Figure 7.

3. Provide for changing pre-selected analog values into high or low calibration mode during simulation.

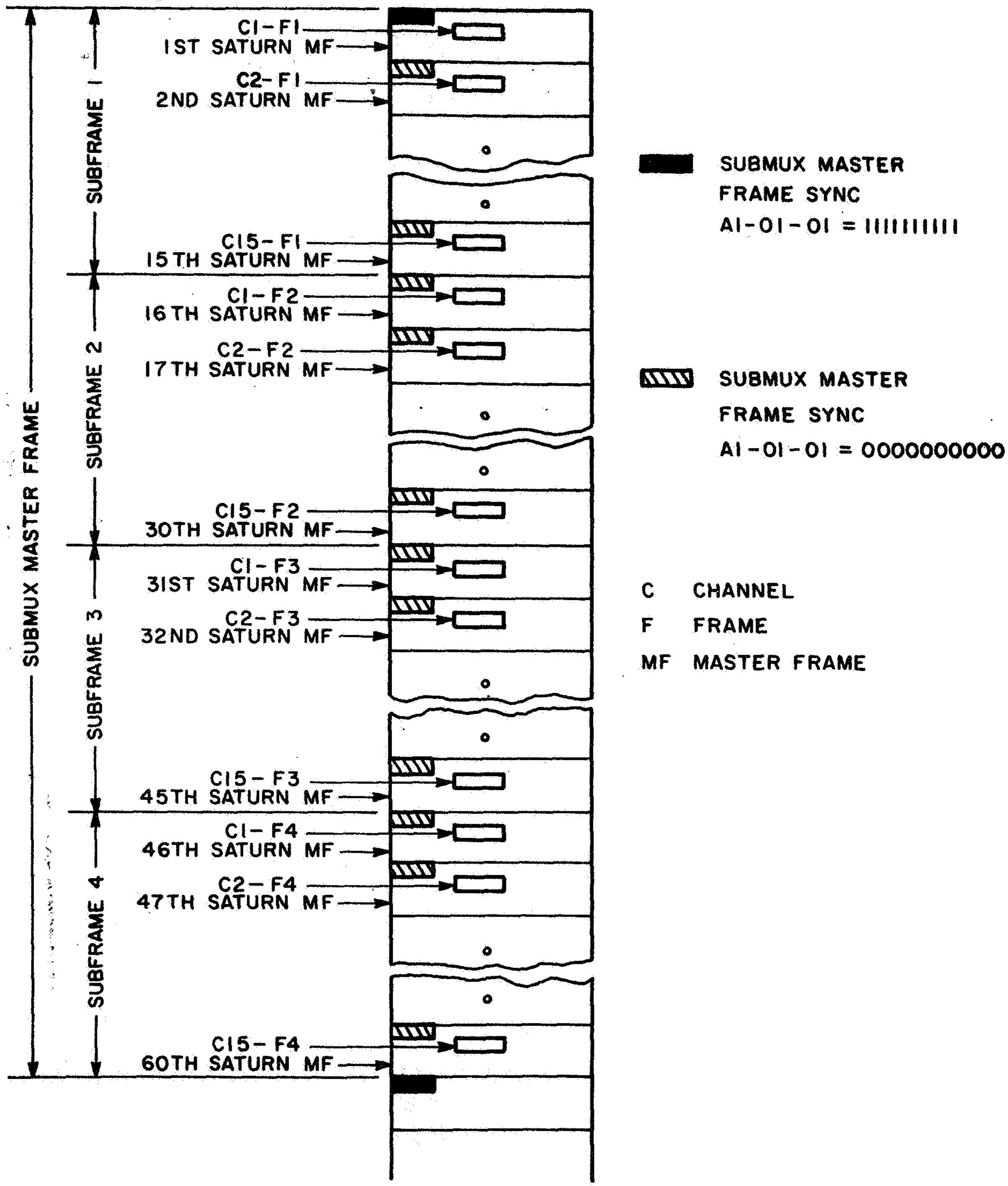
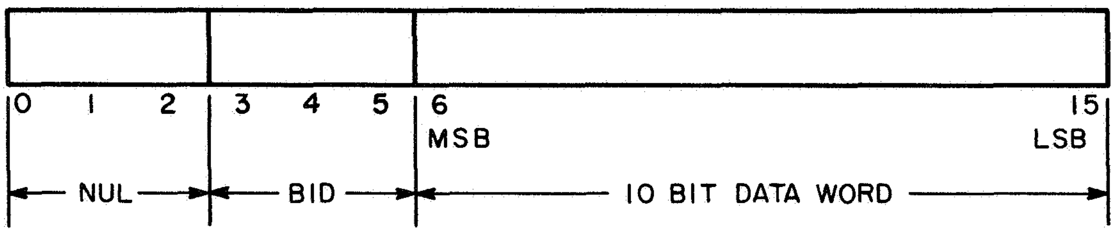


FIGURE 6. SUB-MULTIPLEXER FORMAT

SEL 810 WORD FORMAT



NUL – NOT USED

BID – BIT IDENTIFICATION

BIT 3 – HIGH OR LOW CALIBRATION ID.

BIT 3 = 1 IF HIGH OR LOW MODE

BIT 3 = 0 IF NO HIGH OR LOW MODE

BIT 4 – ANALOG ID.

BIT 4 = 1 IF ANALOG VALUE

BIT 4 = 0 IF NOT ANALOG VALUE

BIT 5 – SUBMUX ID.

BIT 5 = 1 IF SUBMUXED

BIT 5 = 0 IF NOT SUBMUXED

MSB – MOST SIGNIFICANT BIT

LSB – LEAST SIGNIFICANT BIT

FIGURE 7. SEL 810 WORD IDENTIFICATION

TABLE II. NOISE AND INFLIGHT CALIBRATION SWITCH SETTINGS

NOISE SWITCH	
Data Word	Switch Position Constant
200_8	0%
100_8	2^{1}%
40_8	2^{2}%
20_8	2^{3}%
10_8	2^{4}%
4	2^{5}%
2	2^{6}%
LEVEL SELECTION SWITCH	
40200_8	0%
40100_8	25%
40040_8	50%
40020_8	75%
40010_8	100%
	Per Cent of Full Scale (+5V)
24	0
268	25
512	50
755	75
999	100

When high or low calibration mode is required the operator will make two sense switch settings, one setting will be for providing calibration and the other setting will specify either the high or low calibration mode.

Two memory tables will be required for this provision: (See Table I.)

a. Table for high calibration values.

b. Table for low calibration values.

Only a portion of the analog values will be pre-selected for high and low calibration before simulation and the input data will identify those portions. The simulator program will identify high and low calibrated analog values with bit 3 of the SEL 810 computer word.

During simulation, a counter will be incremented every time bit 3 is a binary 1. The counter number will determine the proper (high or low) calibration mode value, in the table, to be transmitted.

4. Provide for changing analog data for one measurement during simulation.

5. Provide for changing discrete data for one measurement with an option for changing a specified bit or complete word during simulation.

6. Provide for displaying one channel on the front panel display registers during simulation.

The typewriter is required to implement provisions 4, 5, and 6. A sense switch setting will be made to connect the typewriter to the eight character input channel if a change or display is required. When the sense switch is reset the typewriter will be disconnected. Suggested input messages, defined in Table III, are as follows:

a. Provision 4 GM-CH-FR, V

b. Provision 5 GM-CH-FR-BT, V

c. Provision 6 GM-CH-FR, I

The option required in provision 5 will be accomplished by the computer analysis of BT and V. See Table IV and paragraph 7 in the Appendix.

TABLE III. TYPEWRITER INPUT FORMAT

Character	Definition
G	A or B group words
M	Multiplexer (0, 1, 2, or 3)
-	Dash for separation
CH	Channel (01 through 30)
FR	Frame (01 through 30)
BT	Bits (01 through 10)
V*	Value of input
I	Indicator (Nixie or incandescent)

*V will be input four different ways:

1. Analog values - $xxxx_{10}$
2. Digital values - $yyyy_8$
3. Discrete value - OFF
4. Discrete value - ON

7. Provide for switching from one format to the other during simulation.

This provision will allow the operator a choice of selecting a sense switch setting to change the computer flow from one current format to the beginning of another.

8. Provide for inflight calibration during simulation.

This provision will be requested from the control panel, by means of the the level selection and force calibration switches, which can be used to request inflight calibration. The level selection switch allows the operator to choose 0%, 25%, 50%, 75%, or 100% of full scale (+5V). When the force calibration switch is depressed, entry to the inflight calibration routine will be accomplished by a 140 millisecond system priority interrupt. See Table II for selection switch commands.

Output

All output will be by air link or coax cable to the Instrumentation Checkout Complex (ICC). Output will be PCM/DDAS, 72KBPS Serial NRZ(L) data. See Table V for system unit and channel assignments.

TABLE IV. BT AND V OPTION IN PROVISION 5

BT	V	Comments
00	Octal[1]	Total word change
02	Discrete[2]	Bit position 2 from MSB to LSB of the 10 bit data word changes.

MSB - Most significant bit

LSB - Least significant bit

1. Octal values are of the form $lxxx_8$ where 1 will always be 0_8 or 1_8 and xxx_8 will be octal values.

2. Discrete values will be typed as ON or OFF.

TABLE V. FUNCTION CODES

Unit	Channel	Function
5	1, 2, & 3	Unit 5 selects PCM logic — Channel 1 indicates data is from PCM channels 1-27, 29, or 30. Channel 2 indicates data is from channel 28 and is last word of frame. Channel 3 indicates data is from channel 28 and is last word of master frame (10 channels).
7	1, 2, & 3	Unit 7 selects display logic — Channel 1 gates the data to the binary incandescent indicators. Channel 2 gates the data to the 1000's and 100's Nixie indicators. Channel 3 gates the data to 10's and units Nixie indicators.
8	1 & 2	Unit 8 selects inflight logic — Channel 1 starts inflight calibration. Channel 2 stops inflight calibration.

Comments

The data for S027 format can be placed in the first four frames of the ATM format; therefore, these specifications cover the requirements for ATM and Saturn, plus S027 and Saturn. The program will be coded to include the simulation for either system.

PREDICTED DATA TAPE PROGRAM

Purpose

The purpose of the Predicted Data Tape Program is to convert the PCM card input data to paper tape for input to the ASAP and Saturn Simulation Program.

Procedure

The Predicted Data Tape Program will be written in META-SYMBOL machine language and assembled on the SDS 930 computer. There will be no processing the data by equations or formulas, but the data will be translated to the appropriate digital representation of the input value. The output paper tape of this program will be input for the ASAP and Saturn Simulation Program. Figure 8 contains a general flow chart of the Predicted Data Tape Program.

Provisions

The Predicted Data Tape Program will accomplish the following:

1. Provide bit identification for sub-multiplexing values, analog values, and values with high and low calibration.

Bit identification will not be conducted from the control panel. The program will decode input data and assign proper bit identification. Figure 7 defines bit identification for the SEL 810 computer word. For the SDS 930 computer word, bit identification will be assembled the same except bits 13 through 23 which will be omitted, see Figure 9.

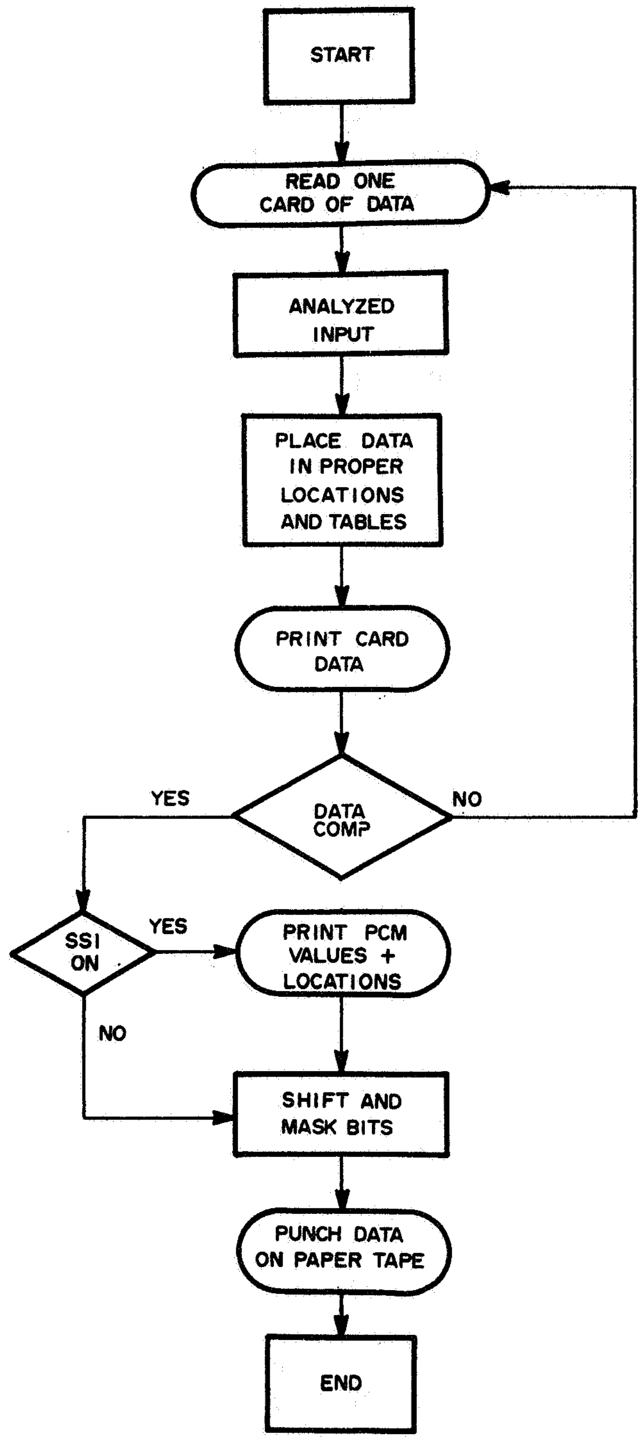


FIGURE 8. GENERAL FLOW CHART FOR PREDICTED DATA TAPE PROGRAM

0 1 2	3 12	13 23
BIT ID	10 BIT DATA WORD	NOT USED

ID - IDENTIFICATION

FIGURE 9. SDS 930 COMPUTER WORD FORMAT

The Appendix describes the format of input data and how different values will be flagged.

2. Provide sync identification for all formats.

Since sync identification words are constant for all simulations by the VIS, they will be stored in permanent addresses.

Refer to Figures 2, 3, 4, and 6 for sync values.

3. Provide the necessary input, control cards, and coding so this program can be added to the Instrumentation Data Test Station (IDTS) System Library Tape.

The IDTS System Library Tape can contain one hundred instrumentation checkout programs. For more information of the IDTS System Library Tape, see Reference 2 and 3.

Input

All input data will be on standard eighty column data cards which are used with various checkout programs; hence, some of the columns that have data will be omitted. See Figure 10 for format of input data cards. Figure 11 describes the title columns shown in Figure 10. The Appendix describes and gives examples of each character under column headings PCM TELEMETRY, MEASUREMENT NUMBER, AND ASAPS ADDRESS.

Input formats for S027 are not included in this specification since the data has not been defined.

SUBMUX FR - CH (2–5)	PCM TELEMETRY (12–22)	MEASUREMENT NUMBER (24–31)	ASAPS ADDRESS (41–51)	HI TOL (63–64)	LO TOL (65–66)	RUN TOL (67–68)	HIGH (69–72)	LOW (73–76)	RUN (77–80)
	A3-03-08-00	D001-701				20			4500
	A3-14K02-02	K070-701	A045A404-02						ON
3-02	A1-11S07-00	C160-701	A027A032-00			10			2500

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FIGURE 10. INPUT DATA CARD FORMAT

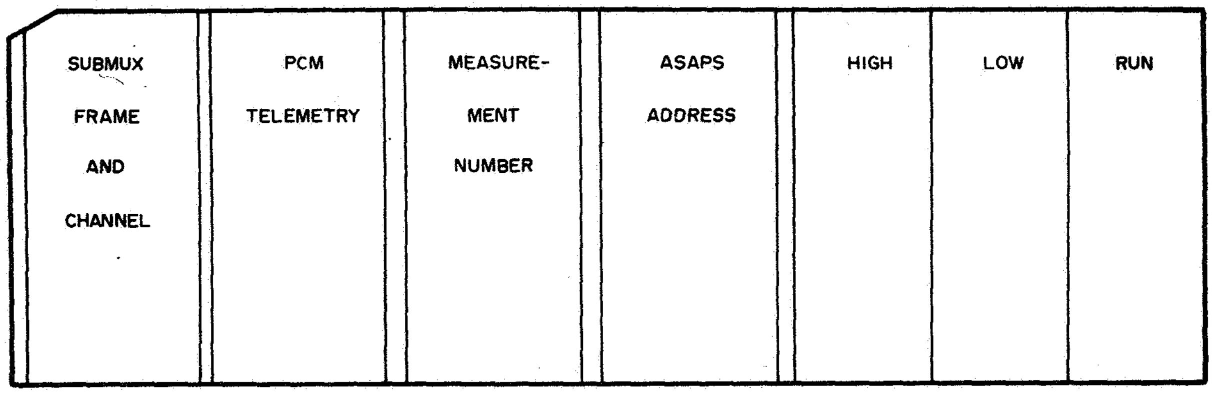


FIGURE 11. INPUT DATA CARD COLUMNS

The operator will use the teletype to define which ASAP format is input and what pertinent information is desired on the line printer.

Table VI lists the data card characters under each heading. The characters described below the column headings are for the input data card.

TABLE VI. INPUT DATA CARD CHARACTERS

Character	Column Title
1	Blank
2-5	SUBMUX FRAME AND CHANNEL
6-11	Blank
12-22	PCM TELEMETRY
23	Blank
24-31	MEASUREMENT NUMBER
32-40	Blank
41-51	ASAPS ADDRESS
52-62	Blank
63-68	Omit
69-72	HIGH
73-76	LOW
77-80	RUN

SUBMUX FRAME AND CHANNEL column

Character 1 describes the frame for sub-multiplexing.

Character 2 is a dash (-) for separation.

Character 3 and 4 designate the channel for sub-multiplexing.

PCM TELEMETRY column

Characters 1, 2, and 3, described in the Appendix will be omitted from the data cards.

Character 6 of this column will be a dash (-) or a letter defining the type of value (analog or discrete). See paragraph 7d in the Appendix.

MEASUREMENT NUMBER column

Prefixes a and b, discussed in the Appendix will not be considered.

ASAPS ADDRESS column

Characters 1, 2, and 3, described in the Appendix, will be omitted from the input data card.

HIGH and LOW columns

Only certain analog measurements have high and low calibration values. These values will be given in the high and low columns on the data card if they are to be input. The high and low columns will be blank if there is no calibration value with an analog measurement.

RUN column

This column will contain three types of input, analog, discrete, and octal. See Table VII.

TABLE VII. INPUT DATA TYPES

PCM TELEMETRY CHARACTER 5	TYPE OF SPECIFICATION
L, S, -	Analog (voltage)[1]
J, K, M, N, U, G	Discrete (ON or OFF) or Octal ($1xxx_8$)[2]

1. These values will be in voltage measurements with the decimal point assumed to be between the first and second digit.

2. These values will always contain a 0_8 or 1_8 for the first digit and 0_8 through 7_8 for the last three digits.

Output

The three types of output for the Predicted Data Tape Program are as follows:

1. Output of all input by line printer. Output format is shown in Table VIII.

2. Output of all data tables plus the octal location of each value by line printer. Output format is shown in Tables IX, X, and XI. Allow the operator a sense switch setting for the option of output 2.

3. Output of all data tables plus a starting address of each table on paper tape. Output for the paper tape will be in binary. Four tape frames will contain the PCM value plus the identification bits. See Figure 12.

TABLE VIII. OUTPUT FORMAT OF INPUT (Information printed on line printer)

MEASUREMENT NUMBER	PCM TELEMETRY	SUBMUX FRAME AND CHANNEL	ASAPS ADDRESS	HIGH	LOW	RUN
—	—	—	—	—	—	—
—	—	—	—	—	—	—
—	—	—	—	—	—	—
•	•	•	•	•	•	•
•	•	•	•	•	•	•
•	•	•	•	•	•	•

NOTES: Center all data below appropriate headings. Reserve the right one-third of the printer page for comments.

At the beginning of this format, allow the operator an option to type any identification and pertinent information.

TABLE IX. FORMAT OF ATM OUTPUT

4X	3H	2X	10 H FRAME 1				2X	10 H FRAME 10		
	CH		DATA $XXXX_8$	1X	LOCAT $XXXXX_8$	FRAMES 2-9 ⟷		DATA $XXXX_8$	1X	LOCAT $XXXXX_8$
	1									
	2									
	3									
	4									
	↕									
	97									
	98									
	99									
	100									

THIS FORMAT WILL BE REPEATED FIVE TIMES SO THE TOTAL SIXTY FRAMES CAN BE PRINTED. CENTER ALL DATA UNDER APPROPRIATE HEADINGS AND IDENTIFY EVERY FRAME. PRINT ALL DATA IN OCTAL.

TABLE X. FORMAT OF S027 OUTPUT

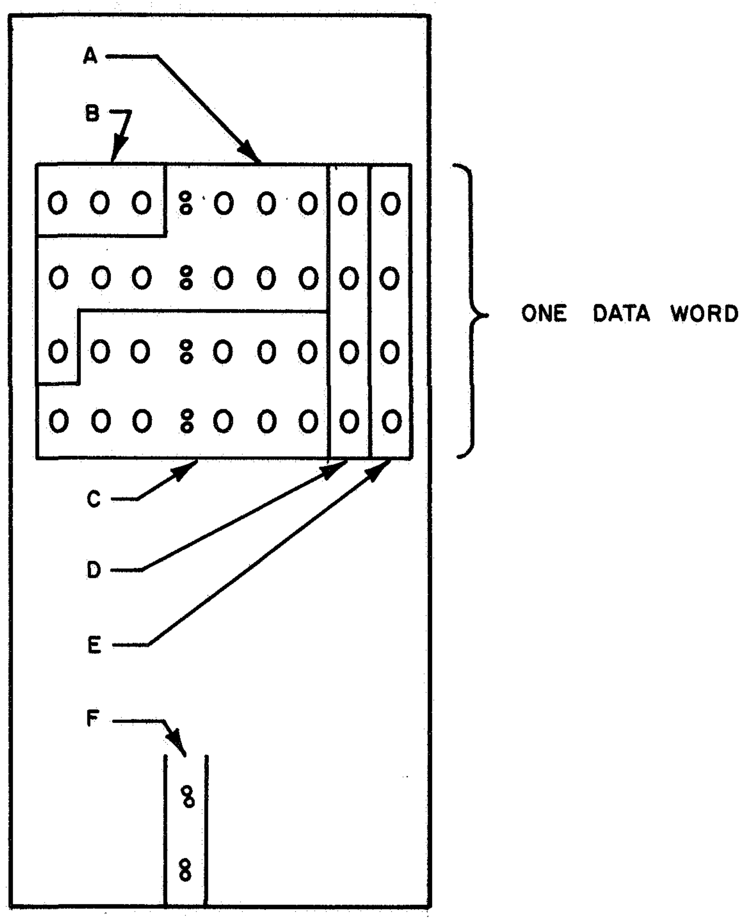
36X	3H	2X	10H FRAME 1				2X	10H FRAME 4		
	CH		DATA $XXXX_8$	1X	LOCAT $XXXXX_8$	FRAMES 2 - 3 ↔		DATA $XXXX_8$	1X	LOCAT $XXXXX_8$
	1									
	2									
	3									
	4									
	↕									
	97									
	98									
	99									
	100									

THIS FORMAT WILL NOT BE REPEATED. CENTER ALL DATA UNDER APPROPRIATE HEADINGS. PRINT ALL DATA IN OCTAL.

TABLE XI. FORMAT OF SATURN OUTPUT

3X	5H MUX 1		2X	10H FRAME 1				2X	10X FRAME 10		
	CH	GR		DATA $XXXX_8$	1X	LOCAT $XXXXX_8$	FRAMES 2-9 ⟷		DATA $XXXX_8$	1X	LOCAT $XXXXX_8$
	1	A									
		B									
	2	A									
		B									
	3 ↕	A									
		B									
	28	A									
		B									
	29	A									
		B									
	30	A									
		B									

THIS FORMAT WILL BE REPEATED SO THE TOTAL THIRTY FRAMES CAN BE PRINTED. CENTER ALL DATA UNDER APPROPRIATE HEADINGS AND IDENTIFY EVERY FRAME IN THE FORMAT. PRINT ALL DATA IN OCTAL.



A TEN BIT DATA WORD
B BIT IDENTIFICATION
C NOT USED
D PARITY ON THE SDS 930
E NOT PUNCHED ON THE SDS 930
F SPROCKET CHANNEL

FIGURE 12. OUTPUT PAPER TAPE FORMAT

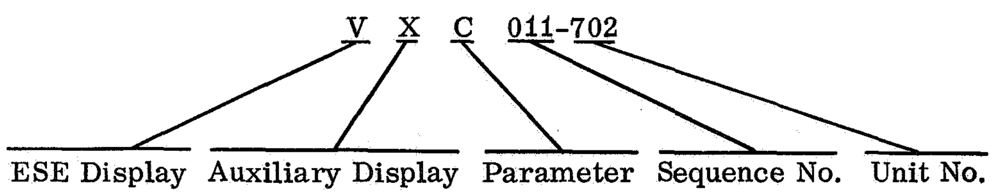
APPENDIX

DESCRIPTION OF THE "INSTRUMENTATION PROGRAM AND COMPONENTS" DATA LIST

This Appendix describes the instrumentation program and components list. The following notes illustrate and describe the columns of data contained in Figure A-1.

1. MEASUREMENT NUMBER CODE

Each measurement is identified by an alphanumeric code which consists of eight basic characters and appropriate prefixes. Example:



a. A "V" prefix identifies an ESE Display Measurement.

b. An "X" prefix identifies an Auxiliary Display Measurement.

c. Character 1 is a letter which designates the parameter in accordance with Table A-I.

d. Characters 2 through 4 are a grouping which designates the sequential number of a measurement within a parameter.

e. Character 5 is always a dash for separation.

f. Characters 6 through 8 are a grouping which designates the unit of the vehicle from which the measurement originates (see Fig. A-2).

2. MEASUREMENT NAME, COMPONENT NAME, COMPONENT NUMBER

The first line of this column lists the abbreviated name of each measurement. Subsequent lines list the name of the appropriate transducer and signal conditioner; and component numbers as referenced to design documentation.

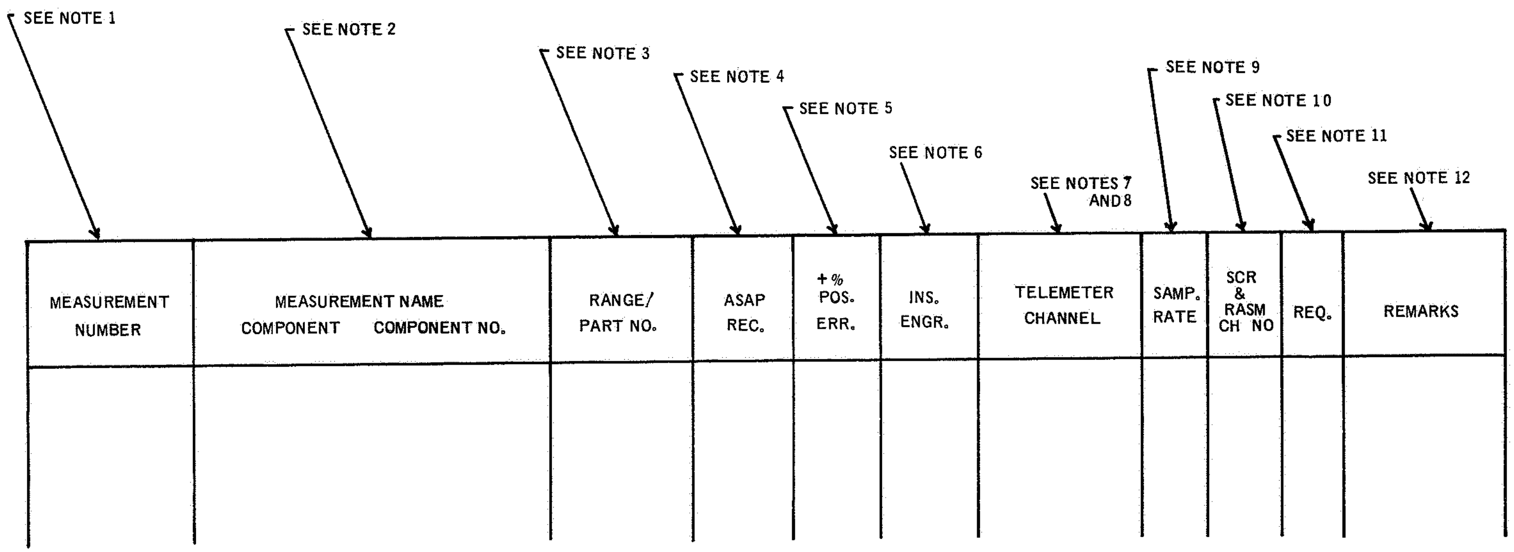


FIGURE A-1. FLIGHT MEASUREMENTS DATA

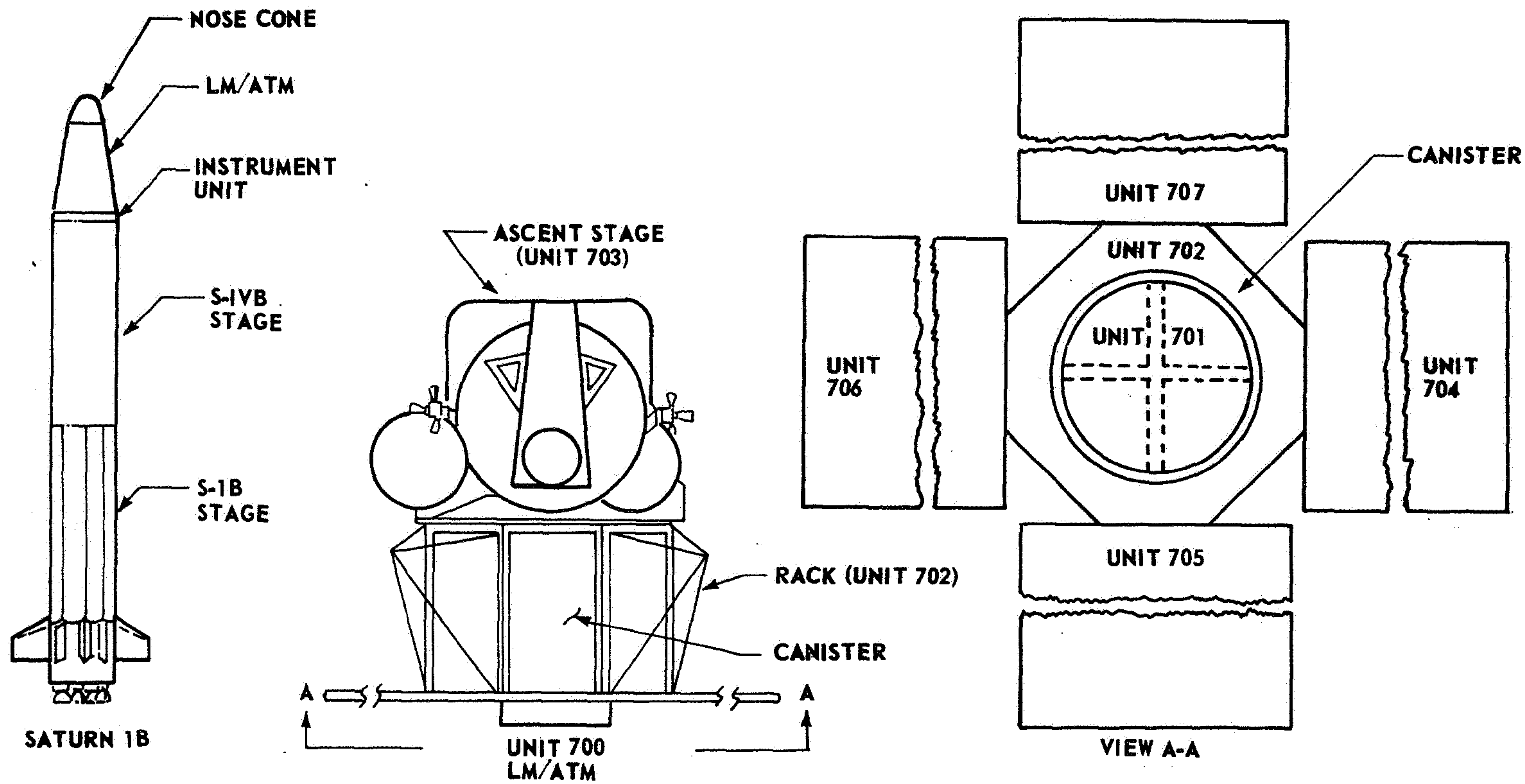


FIGURE A-2. UNIT NUMBER IDENTIFICATION

TABLE A-I. PARAMETER CODE AND UNITS OF MEASURE

Code	Parameter	Units	Abbreviations
A	Linear Acceleration	master/second^2	m/s^2
C	Temperature	degree Celsius	°C
C	Heat Flux	watt/centimeter^2	W/cm^2
D	Pressure	Newton/centimeter^2	N/cm^2
M	Frequency	hertz	Hz
F	Flow Rate (volume)	decimeter^3/second	dm^3/s
F	Flow Rate (mass)	milligram/second	mg/s
S	Strain	meter/meter	m/m
T	Speed	revolution/second	rev/s
G	Distance (linear displacement)	meter	m
G	Distance (angular displacement)	degree	deg
R	Angular Velocity	degree/second	deg/s
M	Voltage	volt	V
M	Current	ampere	A
M	Power	watt	W
E	Vibration	g	g
B	Sound Intensity	decibel	db
K	Event	volt	V

3. RANGE/PART NUMBER

The first line of this column lists the measurement range in SI units, corresponding to full scale telemeter input (unless otherwise noted). Abbreviations are given in Table A-II. When applicable, the second line lists the range in terms of full scale signal conditioner input. Subsequent lines list the part numbers of the transducers and signal conditioners.

4. ASAP RECORD

An "X" in this column indicates that a measurement is selected and recorded by the Auxiliary Storage and Playback (ASAP) Assembly.

5. PERCENT POSSIBLE ERROR

The estimated end-to-end percent possible error of each measurement is listed in this column.

6. INSTRUMENTATION ENGINEER

This column lists a code number which identifies the instrumentation design engineer responsible for each measurement and/or component. For experiment data, the experiment contact engineer is listed (See Table A-III).

7. TELEMETER CHANNEL

The first line of this column lists the telemeter channel assignment for each measurement as defined by an alphanumeric code of 14 characters. See Figure A-3 for a schematic of the telemetry subsystem. Examples of channel assignments are given in Table A-IV. A detailed description of the telemeter channel code is as follows:

a. Character 1

Character 1 is a letter which designates the stage of the vehicle from which a measurement is telemetered. The letter R identifies the ATM Rack.

TABLE A-II. ABBREVIATIONS

Word	Abb.	Word	Abb.
Accelerometer	ACCEL	Clock, Amplifier and Switch Assembly	CASA
Acquisition	ACQ	Input	I/P
Actuator	ACTR	International System of Units	SI
Aluminum	Al	Kennedy Space Center	KSC
Amplitude	AMP	Long Wave	LW
Aperture	APT	Lunar Module	LM
Apollo Telescope Mount	ATM	Marshall Space Flight Center	MSFC
Assembly	ASSY	Measurement	MEAS
Attitude	ATT	Message	MSG
Auxiliary Storage and Playback (Assembly)	ASAP	Module	MOD
		Multiplexer	MUX
Beryllium	Be	Number	NO.
Camera	CAMR	Output	O/P
Channel	CH	Package	PKG
Charge	CHG	Pointing Control System	PCS
Circuit	CKT	Position	POS
Command	COMD	Power	PWR
Configuration	CONFIG	Pressure	PRESS
Control	CONT	Principal Investigator	PI
Command Control Electronic Assembly	CCEA	Proportional	PROP
		Pulse Code Modulation	PCM
Control Moment Gyro	CMG	Radio Frequency	RF
Converter	CONV	Receiver	RECD
Counter	CNTR	Record	REC
Current	CUR	Regulator	REG
Deflection	DEFL	Remote Analog Sub-multiplexer	RASM
Detector	DET		
Differential	DIFF	Reserved	RES
Discharge	DISCH	Selector	SEL
Discrete	DISC	Sensor	SENS
Electrical Support Equipment	ESE	Sequence	SEQ
		Signal Conditioning Rack	SCR
Electronics	ELECT	Switch	SW
Experiment	EXP	Telescope	TLSC
Forward	FWD	Temperature	TEMP
Frequency Modulation	FM	Torquer	TQR
Horizon Sensor	HS	Verification	VER
Indicate	IND		
Information Correlation Assembly	ICA	Vibration	VIB

TABLE III. INSTRUMENTATION ENGINEER

Code No.	Name	PI	Telephone No.
1	Mr. Ponder	AS&E	876-9696
2	Mr. Harwell	HAO	877-2546
3	Mr. Power	HCO	876-8322
4	Mr. Burke	GSFC	876-8434
5	Mr. Franks	NRL	876-1655
6	Mr. Lewter		876-8323
7	Mr. Zimmerman		876-2780
8	Mr. Sutherland		876-2486
9	Mr. Hamlet		876-2477
10	Mr. Erb		876-2486
11	Mr. Davis		876-3283
12	Mr. Beasley		876-5275
13	Mr. Thomas		876-2230
14	Mr. Stephens		876-5479
15	Mr. Coffey		876-5275
16	Mr. Swindall		876-1071
17	Mr. Bordelon		876-4564
18	Mr. Harris		876-4388
19	Mr. Schultz		876-4388

b. Characters 2 and 3

Characters 2 and 3 are a letter and number which identify the RF data link as well as the type and sequential number of the primary telemeter which utilizes the link. The letter P designates a PCM/FM type telemeter.

c. Characters 4 and 5

Characters 4 and 5 are a letter and number which serve the dual purpose of physically identifying a multiplexer and an element of the PCM programming format (address).

(1) Multiplexer Identification:

A multiplexer is physically identified as "AO" if it is defined as "AO" in the PCM programming format in the normal flight mode. A given multiplexer can be A0, A1, A2, A3, B0, B1, B2 or B3 depending on how it is programmed in the normal flight mode.

TABLE A-IV. PCM TELEMETER CHANNEL ASSIGNMENT EXAMPLEX

DESCRIPTION CHARACTER	1	2	3	4	5	6	7	8	9	10	11	12	13	14
4 SPS Analog Direct to 270 MUX	R	P	1	A	1	-	0	4	-	0	1	-	0	0
40 SPS Analog Direct to 270 MUX	R	P	1	A	1	-	0	4	-	0	0	-	0	0
12 SPS Analog Direct to 270 MUX	R	P	1	B	0	-	0	4	-	0	1	-	0	0
120 SPS Analog Direct to 270 MUX	R	P	1	B	0	-	0	4	-	0	0	-	0	0
4 SPS Discrete through No. 1 410 MUX	R	P	1	A	1	-	0	4	J	0	1	-	0	1
40 SPS Discrete through No. 1 410 MUX	R	P	1	A	1	-	0	4	J	0	0	-	0	1
12 SPS Discrete through No. 1 410 MUX	R	P	1	B	0	-	0	4	J	0	1	-	0	1
120 SPS Discrete through No. 1 410 MUX	R	P	1	B	0	-	0	4	J	0	0	-	0	1
4 SPS Digital Word through No. 1 410 MUX	R	P	1	A	1	-	0	4	J	0	1	-	0	0
40 SPS Digital Word through No. 1 410 MUX	R	P	1	A	1	-	0	4	J	0	0	-	0	0
12 SPS Digital Word through No. 1 410 MUX	R	P	1	B	0	-	0	4	J	0	1	-	0	0
120 SPS Digital Word through No. 1 410 MUX	R	P	1	B	0	-	0	4	J	0	0	-	0	0
24 SPS Digital Word through No. 1 410 MUX	R	P	1	B	0	-	0	4	J	0	1	-	0	0
	R	P	1	B	0	-	0	4	J	0	6	-	0	0
4 SPS Analog through 102A RASM	R	P	1	A	1	-	0	4	L	0	1	-	0	0
12 SPS Analog through 102A RASM	R	P	1	B	0	-	0	4	L	0	1	-	0	0
1/15 SPS Analog through Experimenter's SUB-MUX	R	P	1	A	1	-	0	4	S	0	1	-	0	0

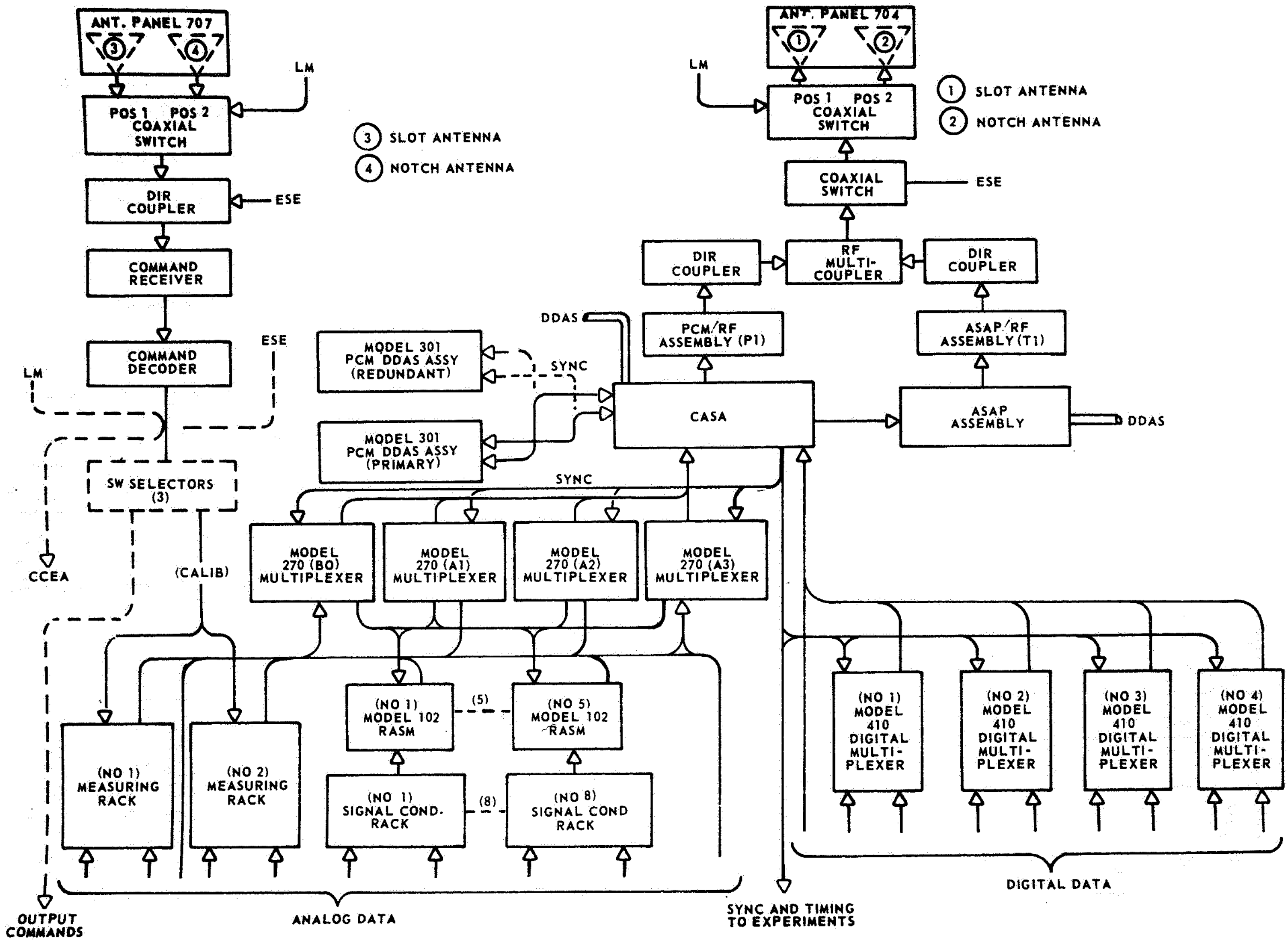


FIGURE A-3. INSTRUMENTATION AND COMMUNICATION SYSTEM BLOCK DIAGRAM (ATM)

(2) PCM Programming Format:

The letters "A" and "B" each define one-half of the PCM wavetrain (group). "A" and "B" operate at a basic rate of 3600 words/second and are interlaced for 7200 words/second in the PCM format. The numbers 0, 1, 2, and 3 are used with the letters A and B to define a part of the PCM programming format as follows:

A0 12 or 120 samples/second
B0 12 or 120 samples/second
A1 4 or 40 samples/second
A2 4 or 40 samples/second
A3 4 or 40 samples/second

d. Character 6

Character 6 is a letter or dash (-) to indicate whether or not the assigned measurement is at anytime switched to another channel or address. A dash (-) indicates that no switching occurs; the letter V indicates that switching does occur. The remarks column and/or General Notes Section of the IP&CL defines the exact switching condition.

e. Characters 7 and 8

Characters 7 and 8 are the numbers 01 through 27 which identify the main channel of a Model 270 multiplexer or the equivalent PCM address for digital data.

f. Character 9

Character 9 is a letter or dash (-) to identify the type multiplexing or measurement routing as follows:

G Discrete measurement routed direct to PCM/DDAS Model 301 Assembly.
J Discrete measurement routed to Number 1 Model 410 Multiplexer.
K Discrete measurement routed to Number 2 Model 410 Multiplexer.
L Analog measurement routed to a Model 102A Submultiplexer (RASM).
M Discrete measurement routed to Number 3 Model 410 Multiplexer.
N Discrete measurement routed to Number 4 Model 410 Multiplexer.

S Analog measurement routed to Model 270 Multiplexer from experimenter's sub-multiplexer.

U Discrete measurement routed directly to Model 270 Multiplexer.[1]
Dash Analog measurement routed directly to a Model 270 Multiplexer.

g. Characters 10 and 11

Characters 10 and 11 are the numbers 00 through 10 which identify Model 270 multiplexer frame or the equivalent PCM address for digital data. The 00 indicates all ten sub-channels or frames are used.

h. Character 12

Character 12 is a dash (-) for separation.

i. Characters 13 and 14

Characters 13 and 14 are the numbers 00 through 10 which identify a particular digital bit. The 00 indicates all 10 bits are used.

NOTE: The numbers 01 through 10 correspond to the Most Significant Bit (2^9) through the Least Significant Bit (2^0), i.e., MSB = Bit 01, LSB = Bit 10.

8. ASAP CHANNEL

The second line of this column lists the ASAP channel assignment for each measurement indicated by an "X", in column 5, as defined by an alpha-numeric code of 14 characters. Examples of channel assignments are given in Table A-V. A detailed description of the ASAP channel code is as follows:

a. Character 1

Character 1 is a letter which designates the stage of the vehicle from which a measurement is telemetered. The letter R identifies the ATM rack.

---

1. In this case, bit identification will be given by Characters 13 and 14. This includes, but is not restricted to, measurements routed through discrete summing devices.

TABLE A-V. ASAP ASSEMBLY CHANNEL ASSIGNMENT EXAMPLES

Description Character	1	2	3	4	5	6	7	8	9	10	11	12	13	14
3 SPS Analog	R	T	1	A	0	0	4	A	0	0	1	-	0	0
4 SPS Analog	R	T	1	A	0	0	4	A	1	0	1	-	0	0
24 SPS Digital	R	T	1	0	0	0	1	A	1	0	1	-	0	0
	R	T	1	0	0	1	8	A	1	0	1	-	0	0
	R	T	1	0	0	3	8	A	1	0	1	-	0	0
	R	T	1	0	0	5	5	A	1	0	1	-	0	0
	R	T	1	0	0	7	0	A	1	0	1	-	0	0
	R	T	1	0	0	8	5	A	1	0	1	-	0	0
1 SPS Discrete	R	T	1	A	0	0	4	A	4	0	1	-	0	1
4 SPS Discrete	R	T	1	A	0	0	4	A	1	0	1	-	0	1
1/15 SPS Analog (Exp. SUB-MUX, 15 CH.)	R	T	1	A	0	3	4	A	4	0	1	-	0	0
1/15 SPS Analog (Exp. SUB-MUX, 60 CH.)	R	T	1	A	0	0	4	A	0	0	1	-	0	0

b. Characters 2 and 3

Characters 2 and 3 are a letter and number which identify the sequential number of the ASAP Assy as well as the type RF data link being utilized. The letter "T" designates an ASAP/FM type telemeter.

c. Characters 4 and 5

Characters 4 and 5 are a letter and number or 00 which identify the word repetition rate at which a measurement is recorded. An A, B, C, D, or F indicates that a measurement is recorded in more than one word per frame and that the word repetition rate is regular. The 00 indicates that the measurement is recorded at an irregular rate in more than one word per frame.

For example:

A0 - Indicates a measurement is recorded in only one word per frame.

A1 - Indicates a measurement is recorded in all words per frame.

A2 - Indicates a measurement is recorded in every other word per frame.

B1 - Indicates a measurement is recorded in every 11th word per frame.

C1 - Indicates a measurement is recorded in every 21st word per frame.

d. Characters 6 and 7

Characters 6 and 7 are the numbers 01 through 97 which identify the first word in which a measurement is recorded.

e. Characters 8 and 9

Characters 8 and 9 are a number and letter or 00 which identify the frame repetition rate at which a measurement is recorded. An A, B, or C indicates that a measurement is recorded in more than one frame per master frame and that the word repetition rate is regular. The 00 indicates that the measurement is recorded at an irregular rate in more than one frame per master frame.

For example:

A0 - Indicates a measurement is recorded in only one frame per master frame.

A1 - Indicates a measurement is recorded in all frames.

A2 - Indicates a measurement is recorded in every other frame per master frame.

B1 - Indicates a measurement is recorded in every 11th frame per master frame.

C1 - Indicates a measurement is recorded in every 21st frame per master frame.

f. Characters 10 and 11

Characters 10 and 11 are the numbers 01 through 60 which identify the first frame in which a measurement is recorded.

g. Character 12

Character 12 is a dash for separation.

h. Characters 13 and 14

Characters 13 and 14 are the numbers 00 through 10 which identify a particular bit. The 00 indicates all 10 bits are used.

NOTE: The numbers 01 through 10 correspond to the Most Significant Bit (2^9) (2^9) through the Least Significant Bit (2^0), i.e., MSB = Bit 01, LSB = Bit 10.

9. SAMPLING RATE

The first line of this column lists the rate at which each measurement is being transmitted real time, in terms of samples per second. When applicable, the second line of this column lists the rate at which the measurement is being stored on the tape recorder, in terms of samples per second.

10. SIGNAL CONDITIONING RACK AND REMOTE ANALOG SUBMULTIPLEXER CHANNEL NUMBER

When applicable, the first line of this column lists the signal conditioning rack input channel to which a measurement is assigned (01 through 20, with "A" or "B" suffixes). When applicable, the second line of this column lists the remote analog submultiplexer input channel to which a measurement is assigned (01 through 60).

11. REQUESTER

This column lists a code number which identifies the requester of each measurement. For experiment data, the PI agency is listed (See Table A-VI).

12. REMARKS

The remarks column contains miscellaneous information concerning a measurement. Flight control and LM displayed measurements are identified in this column. Measuring rack and channel assignments are listed in this column. Signal conditioning rack and RASM component numbers are listed in this column. The model 410 multiplexer data group for the digital input is listed in this column.

FLIGHT MEASUREMENTS

The Flight Measurements Section of this document includes a listing of all measurements which originate onboard the vehicle.

The Instrumentation Equipment Section lists all flight instrumentation equipment except that specified in the Flight Measurements Section. Radio frequency assignments are listed in this section.

For the convenience of the users of this document, Tables A-VII and A-VIII list the numbers of the instrumentation electrical schematics and transducer installation drawings. These two tables are provided for information only.

TABLE A-VI. REQUESTER

Code No.		Telephone No.
1	High Altitude Observatory, Exp. (S052)	
2	Naval Research Laboratory, Exp. (S053)	
3	Harvard College Observatory, Exp. (S055)	
4	Goddard Space Flight Center, Exp. (S056)	
5	American Science & Engineering, Inc., Exp. (S054)	
6	R-ASTR-N Mr. Vick	877-8233
7	R-ASTR-G Mr. Ferrell	876-1870
8	R-ASTR-I Mr. Malone	876-4388
9	R-ASTR-E Mr. Fuller	876-6903
10	R-ASTR-E Mr. Baker	876-1518
11	R-ASTR-E Mr. Miller	876-1493
12	R-ASTR-I Mr. Power	876-8322
13	R-ASTR-I Mr. Coffey	876-5275
14		
15		
16	R-P&VE-P Mr. Hueter	876-7829
17	R-ASTR-I Mr. Stephens	876-5479
18	R-ASTR-I Mr. Lewter	876-8323

TABLE A-VII. INSTRUMENTATION ELECTRICAL SCHEMATICS[1]

TABLE A-VIII. TRANSDUCER INSTALLATION DRAWINGS

1. Information only.

REFERENCES

1. Anon.: Mark III VIS Program Description and Operation. Systems Engineering Laboratory Inc., 1966, NASA Contract NAS 8-13874.

2. Anon.: Instrumentation Data Test Station (IDTS). NASA Technical Manual, 1967, 2-QH-IB-200E-301 (PIT).

3. Anon.: Instrumentation Data Test Station. Dynatronics, Inc., volumes I and III of V, 1965.

APPROVAL

SPECIFICATIONS FOR ASAP AND SATURN SIMULATION SYSTEM

By J. W. Hilliard

The information in this report has been reviewed for security classification. Review of any information concerning Department of Defense or Atomic Energy Commission programs has been made by the MSFC Security Classification Officer. This report, in its entirety, has been determined to be unclassified.

This document has also been reviewed and approved for technical accuracy.

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