DATA REDUCTION COMPLEX
ANALOG-TO-DIGITAL DATA PROCESSING REQUIREMENTS
FOR
ONSITE TEST FACILITIES

JOB ORDER 86-029

Prepared By

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Houston, Texas

Contract NAS 9-12200
For
INSTITUTIONAL DATA SYSTEMS DIVISION

National Aeronautics and Space Administration

LYNDON B. JOHNSON SPACE CENTER

Houston, Texas

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ABBREVIATIONS AND ACRONYMS

A/D	Analog-to-digital
CCT	Computer-compatible tape
CY	Calendar year
DC	Direct current
DRC	Data Reduction Complex
FM	Frequency modulation
FM&SP	Frequency modulation and special processing
FY	Fiscal year
GP I	Group I
HAO	Health Applications Office
Hz	Hertz
IDSD	Institutional Data Systems Division
ips	Inches per second
IRIG	Inter-Range Instrumentation Group
mm/s	Millimeters per second
MMU	Manned Maneuvering Unit
NOAA	National Oceanic and Atmospheric Administration
SBS	Serial bit stream
SESL	Space Environment Simulation Laboratory
s/s	Samples per second
TTA	Thermochemical Test Area
VATF	Vibration and Acoustic Test Facility
WBFM	Wide band frequency modulation

1. PURPOSE AND SCOPE

The purpose of this document is to describe the analog-to-digital processing requirements of onsite test facilities. Identification of the source and medium of all input data to the DRC and the destination and medium of all output products of the analog-to-digital processing will be made. Additionally, preliminary input and output data formats are presented along with the planned use of the output products.

Inputs to this document were obtained from customer interface and from documentation generated in response to Shuttle Requirements/Implementation Working Group queries. This information should be treated as preliminary and subject to change.

2. BACKGROUND

This document is intended to satisfy the Shuttle Requirements/ Implementation Working Group Action Item R-052. This action item requested Vibration and Acoustic Test Facility (VATF) processing requirements as well as all other onsite requirements which impact the Shuttle Frequency Modulation and Special Processing (FM&SP) Subsystem. These requirements are herein presented in Level B type document detail.

3. SYSTEM REQUIREMENTS

3.1 INPUT DATA

The analog recording techniques used by the onsite test facilities employ both IRIG standard methods and methods not conforming to IRIG standards. The data acquisition capabilities for each facility are described in this section. Only those facilities with known requirements are discussed.

3.1.1 VIBRATION AND ACOUSTIC TEST FACILITY (VATF)

The primary systems used in the VATF for recording raw test data are standard 14-track analog tape recorders. Eight recorders are available for operating in the direct record, single carrier, frequency modulated (FM) mode. The standard Inter-Range Instrumentation Group (IRIG) Intermediate Band is used in this mode which provides frequency response capabilities of DC to 10 kHz at recording speeds of 30 ips and DC to 20 kHz at 60 ips. Standard VATF configuration provides 96-channel capability by recording data on 12 tracks per tape and reference frequency and IRIG "B" time on the other 2 tracks. Channel center frequency parameters currently in use are:

- 108.0 kHz carrier center frequency, $\pm$ 40% deviation and 100 kHz reference frequency for recording at 60 ips.
- 54.0 kHz carrier center frequency, $\pm$ 40% deviation and 50 kHz reference frequency for recording at 30 ips.

In addition to the direct record capabilities, the VATF has four VIDAR, constant bandwidth, FM multiplex systems. Each system provides six data channels per composite for recording on one tape track. A total of 312 channels of DC to 2.5 kHz data are recorded on 13 tracks of each of the four data tapes. The non-IRIG standard subcarrier channel center frequencies are 62.5 kHz, 100.0 kHz, 137.5 kHz, 175.0 kHz, 212.5 kHz, and 250 kHz.

The reference frequency of 287.5 kHz is recorded as part of the composite.

3.1.2 SPACE ENVIRONMENT SIMULATION LABORATORY (SESL)

The FM acquisition capability for the SESL Orbiter Base Heating Test consists of three VIDAR, constant bandwidth, FM multiplex systems. Two of the systems record data on 13 tracks with six data channels per composite on each track. The third system records on 12 tracks with five data channels per composite on each track (track 13 is not used). All systems use track 14 for tape speed control. The non-IRIG standard subcarrier channel center frequencies for the six-channel composite are 62.5 kHz, 100.0 kHz, 137.5 kHz, 175.0 kHz, 212.5 kHz, and 250.0 kHz. The reference frequency of 287.5 kHz is recorded as part of the composite. Center frequencies for the five-channel composite are 50.0 kHz, 80.0 kHz, 110.0 kHz, 140.0 kHz, and 170.0 kHz with the 200.0 kHz reference frequency recorded in the composite.

3.1.3 THERMOCHEMICAL TEST AREA (TTA)

The acquisition systems used in the TTA consist of standard 14-track analog tape recorders for direct recording of raw test data.

Four recorders are available for operating in the direct record, single carrier, FM mode. The standard IRIG Wideband Group I is used in this mode and provides frequency response capability of DC to 20 kHz at a recording speed of 30 ips. Standard TTA recording configuration provides 12 data channel capability per recorder by recording data on 12 tracks and reference frequency and IRIG "B" time on the other 2 tracks. The channel center frequency is 108.0 kHz, $\pm$ 40% deviation with a 100 kHz reference frequency for recording at 30 ips.

3.1.4 SHUTTLE MANNED MANEUVERING UNIT (MMU) MUSCLE STUDY

The recording system used in the Shuttle MMU Muscle Study consists of a standard 1/2-inch 7-track analog tape recorder. This recorder operates in the direct record, single carrier, FM mode. The standard IRIG Low Band is used in this mode which provides frequency response capabilities of DC to 625 Hz at recording speed of 3-3/4 ips. Usual system configuration enables the recording of six data channels and IRIG "B" time.
Carrier center frequency for the system is 3.375 kHz with $\pm$ 40% deviation.

3.1.5 HEALTH APPLICATIONS OFFICE (HAO) SCREWWORM STUDY

Input to the Institutional Data Systems Division (IDSD) for supporting the HAO Screwworm Study is by analog tape containing data collected by the National Oceanic and Atmospheric Administration (NOAA). The analog tapes received from NOAA have been direct recorded at 60 ips and contain data on tracks 2 and 4, IRIG "B" time on track 8, and NASA 28-bit time code on track 14.

3.1.6 RABBIT MORPHINE TEST

The Rabbit Morphine Test data is processed for the Life Sciences Directorate from 1/2-inch, 7-track analog tapes. One channel of data is direct recorded on each track at a tape speed of 7-1/2 ips.

3.1.7 ZERO 'g' EFFECT

The Zero 'g' Effect test data is processed for the Engineering and Development Directorate from test tapes recorded on a KC-135 aircraft. The data tapes received in IDSD are 1/2-inch, 7-track analog tapes. Three channels of data are direct recorded at a tape speed of 7-i/2 ips on three tracks of the tape with IRIG "B" time recorded on a fourth track.

3.2 PROCESSING REQUIREMENTS

While the details of processing vary for each facility, the basic

process requires analog-to-digital conversion and formatting a digital tape into a serial bitstream or PHASE I format compatible to existing software on the UNIVAC processors. Details of the serial bitstream format may be found in NASA Memorandum 71-FD56-324; CAD's Serial Bitstream (SBS) Data Format, December 15, 1971. The PHASE I format is outlined in C&AD Procedures Manual; Standard CAAD Data Reduction PHASE I Tape Descriptor and Data Files, pp. 3.d.3.1.1 through .10, January 1966, Reprinted January 1968.

3.2.1 VATF

Each track of the VATF FM multiplexed tape requires demultiplexing. Each demultiplexed data channel and each data channel on the direct recorded tapes require digitization to a 12-bit resolution. VATF processing utilizes the following digitizing capabilities:

- Three channels at 16,666 samples per second (s/s)
- From 1 to 20 multiplexer positions at selected rates of from 50 to 40,000 s/s
- Two multiplexer positions at 25,000 s/s
- Six channels of data at 8,333 s/s

Each digitized data channel will be output to either PHASE I or serial bitstream formatted computer-compatible tape (CCT).

Standard 50-channel oscillograph, softcopy capability is required. Optical galvanometer frequency response required is from DC to 1200 Hz or from DC to 2500 Hz per channel with available chart speeds from 0.1 to 160 ips.

Based on existing and projected VATF data processing workloads and the possibility that their analog-to-digital (A/D) processing capability may not be operational during FY78, hardware system design efforts must consider improved A/D capabilities for increasing throughput and reducing digital processing computer time.

Methods for increasing throughput must include improved system

capability for reducing the number of passes of the analog tape in the digitizing process. Although multiple passes may not be entirely eliminated, a significantly increased A/D sampling rate would tend to reduce the problem.

An additional capability of the A/D system should include simultaneous sample and hold logic. Satisfying the phase correlation accuracy requirements of 5 degrees for multiple channels by digital processing requires considerable computer time and complex software techniques. The computer time used in the phase correlation process would be eliminated by the use of a sample and hold digitizing system.

3.2.2 SESL

A set of three SESL FM data tapes will be received by IDSD for each test firing, and up to nine tests may be recorded on a set. Each of the analog tapes requires demultiplexing and digitizing at a rate of 2000 s/s and requires that the calibration values (0% and 100% full scale) and digitized data be stored. A second phase of processing is required to output a digital CCT containing all data and calibrations grouped by test firing.

3.2.3 TTA

Each TTA test analog tape requires the digitization of each data channel. The digitizing rate will be selectable from 10 s/s to 25,000 s/s for each channel and output to a PHASE I or serial bitstream formatted CCT.

Standard oscillograph softcopy capability is required. Optical galvanometer frequency response will either be from DC to 1200 Hz or from DC to 2500 Hz per channel with available chart speeds from 0.1 to 160 ips.

3.2.4 SHUTTLE MMU MUSCLE STUDY

Each Shuttle MMU Muscle Study Test analog tape requires the digitization of each data channel. Digitization will be at the rate of 1000 s/s per channel and output to a PHASE I or serial bitstream formatted CCT. Standard oscillograph softcopy capability is required. Optical galvanometer frequency response will be either DC to 1200 Hz or DC to 2500 Hz per channel with available chart speeds from 0.1 to 160 ips.

3.2.5 HAO SCREWWORM STUDY

The processing requirement for the HAO Screwworm Study is for analog tape dubbing. In the dubbing process, it is required that a set of six NOAA analog tapes be combined into one analog tape. The analog tape copies are to be made at twice real time (120 ips) and are to be direct copies. The analog tape dub format for NOAA copies is outlined in "Health Applications Office Analog Tape Copying and Handling Procedures," LEC-2088.

3.2.6 RABBIT MORPHINE TEST

Processing requirements for the 1/2-inch, 7-track analog tape consists of copying the tape to a 14-track tape while "painting" IRIG "B" time on an eighth track. Digitization of data is required at a rate of 10,000 s/s per channel to a 12-bit digital resolution and formatting a PHASE I CCT.

All data channels and time will also be displayed on brush chart records. These records will be 8-channel analog strip charts with frequency response from DC to 100 Hz and available chart speeds from 0.2 mm/s to 200 mm/s.

3.2.7 ZERO 'g' EFFECT

Processing requirements for the Zero 'g' Effect tape consist of digitizing each data channel at a rate of 5000 s/s to a 12-bit digital resolution and outputting the digital data to a PHASE I

CCT.

Oscillograph softcopy capability is required for the displaying of each data channel and time from each test tape received. Optical galvanometer frequency response will either be from DC to 1200 Hz or from DC to 2500 Hz per channel with available chart speeds from 0.1 to 160 ips.

3.3 OUTPUT REQUIREMENTS

Output products are described in this section.

3.3.1 VATF

For each VATF test run, there are oscillograph requirements. No standard oscillograph setups are employed, and usually the number of channels on a single record will not exceed 12.

CCT's are also a required output. These CCT's will be in a serial bitstream format which are compatible with subsequent EXEC II or EXEC 8 processing.

3.3.2 SESL

Output requirements for the SESL Orbiter Base Heating tests consist of a serial bitstream CCT which will be used in subsequent EXEC 8 processing.

3.3.3 TTA

Output requirements for the TTA tests consist of the digital data being formatted on a PHASE I or serial bitstream CCT for subsequent EXEC II or EXEC 8 processing.

Oscillograph records of data channels on the test tape are also required on a special request basis.

3.3.4 SHUTTLE MMU MUSCLE STUDY

Shuttle MMU Muscle Study test output will consist of digital data formatted on a PHASE I or serial bitstream CCT for subsequent EXEC II or EXEC 8 processing.

Oscillograph records are also required for each test tape received and will consist of each data channel recorded and time.

3.3.5 HAO SCREWWORM STUDY

The processing output of the HAO Screwworm Study is a NOAA analog tape copy containing the data from six NOAA analog tapes. The original tapes are returned to NOAA and the tape copies are delivered to the HAO Project Engineer in Building 17.

3.3.6 RABBIT MORPHINE TEST

Output for each test consists of a PHASE I CCT to be used in subsequent EXEC II processing. A brush chart recording of each data channel and time is required for each tape received.

3.3.7 ZERO 'g' EFFECT

Output for the Zero 'g' Effect tests consists of a PHASE I CCT for subsequent EXEC II processing. An oscillograph recording of each data channel and time is required for each test tape received.

TABLE 3-1. - ONSITE TEST PROCESSING REQUIREMENTS

Facility	A/D	Strip Charts	CCT	Tape Copy	Response
VATF	X	O'Grams	SBS		1 week
SESL	X		SBS		24 - 48 hours
THERMOCHEMICAL	X	O'Grams	PHASE I		24 hours
MMU MUSCLE STUDY	X	O'Grams	PHASE I		1 week
HAO SCREWWORM STUDY				X	1 week
RABBIT MORPHINE TEST	X	Brush	PHASE I		1 week
ZERO 'g' EFFECT	X	O'Grams	PHASE I		1 week

TABLE 3-2. - FM RECORD CAPABILITY OF THE ONSITE TEST FACILITIES

Facility	Type of System	Channel Center Frequency (kHz)	Ref. Freq. (kHz)	Present Digitizing Rate (s/s)	Time Code	Total No. Channels per Facility	Remarks
Vibro-Acoustic Test Facility (Bldg. 49)	VIDAR FM-Multiplex 6 channels/track composite	62.5 100.0 137.5 175.0 212.5 250.0 DC to 2.5 kHz	287.5	8333 to 25,000	IRIG "B"	72 till late '76 then 200 from late '76 to early '79 for panel tests.	There are 4 of these systems in the VATF. Reference individual tests configuration for actual number of channels recorded. The reference frequency is part of the composite.
	FM direct	108 kHz ±40% at 60 ips DC to 20 kHz 54 kHz ± 40% at 30 ips DC to 10 kHz	100.0 50.0	16,333 to 25,000	IRIG "B"	12 till late '76 then up to 56 for remainder of panel tests.	There are 8 recorders in the VATF, giving a maximum capacity of 96 FM-direct record channels. This assumes they only use 12 tracks per tape with ref. freq. and time on the other 2.
SESL	VIDAR FM-Multiplex 6 channels/track composite	62.5 100.0 137.5 175.0 212.5 250.0	287.5	2000	IRIG "B"	156	There is 1 of these systems in the SESL. However to accommodate specific test recording requirements, they will borrow a similar system from the VATF. Reference should be made to specific test configurations for actual number of channels recorded.
	VIDAR FM-Multiplex 5 channels/track composite	50.0 80.0 110.0 140.0 170.0	200.0	2000	IRIG "B"	60	There is 1 of these systems in SESL. Reference should be made to specific test configuration for actual number of channels recorded.

TABLE 3-2. - FM RECORD CAPABILITY OF THE ONSITE TEST FACILITIES (concluded)

Facility	Type of System	Channel Center Frequency (kHz)	Ref. Freq. (kHz)	Present Digitizing Rate (s/s)	Time Code	Total No. Channels per Facility	Remarks
Thermochemical	FM-Direct (WBFM GPI)	108.0 ± 40% at 30 ips	100.0	10 to 25,000	IRIG "B"	48	The Thermochemical facility can record 12 channels; 4 tape recorders.
MMU Muscle Study	FM Ampex SP300	3.375 3-3/4 ips		1000	IRIG "B"	6	7-track 1/2-inch tape.
HAO Screwworm Study	FM-Direct				IRIG "B"	4/NOAA analog tape	4 tracks from 6 NOAA tapes copied on 1 JSC 14-track tape; 12 mins. from 3 NOAA tapes are followed by 12 mins. from 3 more NOAA tapes.
Rabbit Morphine Test	FM-Direct	7-1/2 ips		10,000		7	IRIG "B" time code is painted on 14-track copy.
Zero 'g' Effect	FM-Direct	7-1/2 ips		5000	IRIG "B"	4	7-track 1/2-inch tape.

4. TEST SUPPORT REQUIREMENTS

4.1 SCHEDULES

Test schedules contained herein are based on information from documents generated in response to Shuttle Requirements/Implementation Group queries and from customer inputs (see Table 4-1).

4.1.1 VATF

Orbiter Acoustic Fatigue Tests

- 20 articles
- 89 to 200 measurements
- 6 tests per article minimum
- Duration: through February 1979
- Maximum of 24 analog tapes per article

OMS Engine

- 2 articles
- 150 measurements
- 4 tests per article minimum
- Duration from February 1977 through April 1977 and November 1978 through December 1978
- Maximum of 12 tapes per article

4.1.2 SESL

- VIDAR FM tapes
- Up to 13 tracks per tape
- Up to 6 channels per track
- 30 tapes during FY77
- Sample rate of 2000 s/s required

This is expected to be a relatively short (3 to 6 months) duration series of tests. Estimates indicate it will start in late FY76 and continue through the early part of FY77.

4.1.3 TTA

- Wideband Group I FM tapes
- Up to 12 track per tape
- Up to 1 channel per track
- 35 tapes during FY76
- 35 tapes during FY77
- Selectable sample rate from 10 s/s to 25,000 s/s required

4.1.4 MMU MUSCLE STUDY

- 1/2-inch analog tapes
- 7 tracks per tape
- 1 data channel per track
- 12 tapes during FY76
- Sample rate of 1000 s/s

4.1.5 HAO SCREWWORM STUDY

- NOAA 14-track analog tapes
- 4 tracks for dubbing
- 1 data channel per track
- 14 tapes per week maximum
- Expected to terminate September 1976

4.1.6 RABBIT MORPHINE TEST

- 1/2-inch analog tapes
- 7 tracks per tape
- 1 data channel per track
- Insufficient information available to determine duration and loading impact

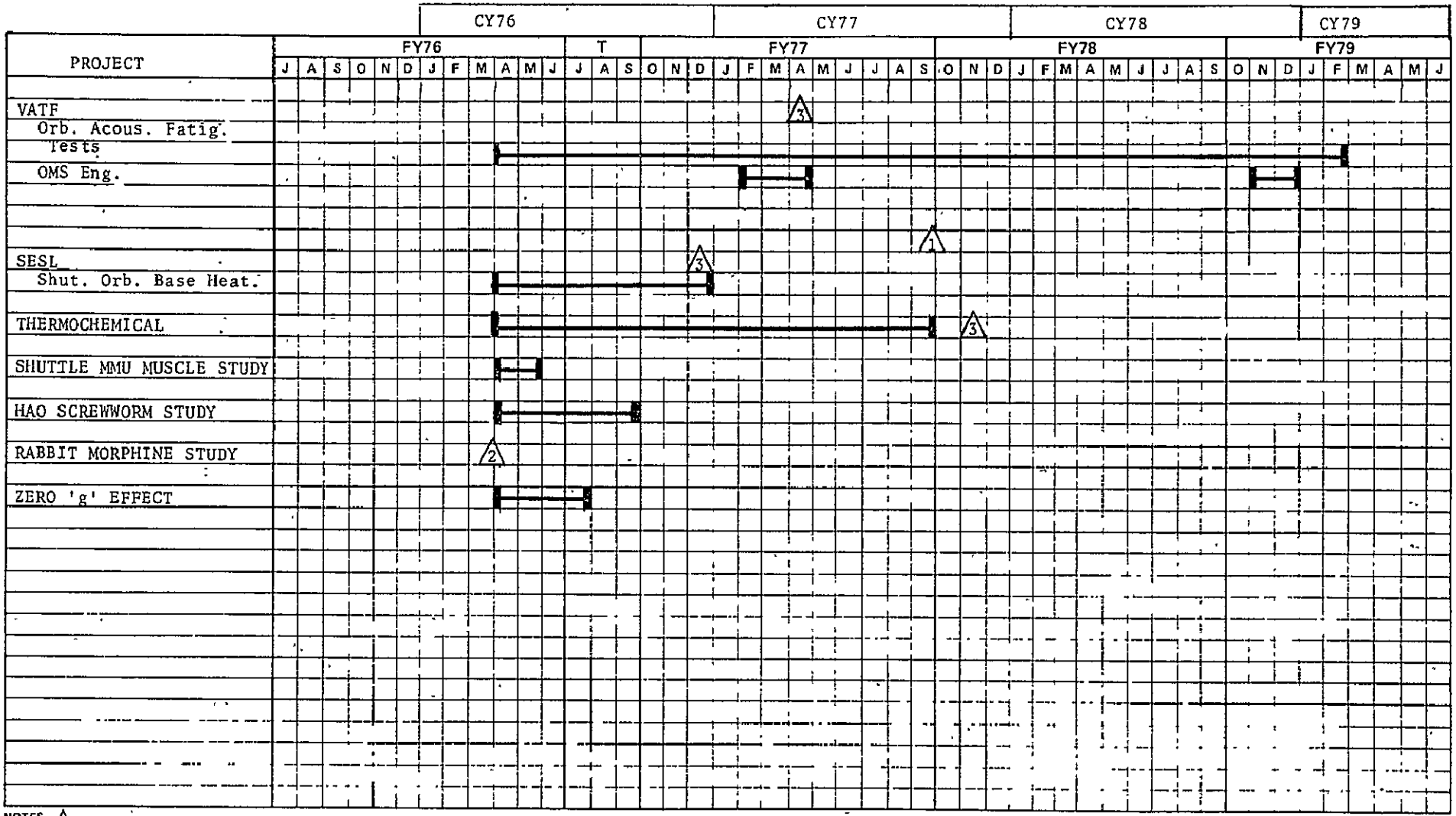
4.1.7 ZERO 'g' EFFECT

- 1/2-inch analog tapes
- 4 data track per tape
- 1 data channel per track
- Insufficient information available to determine duration and loading impact

4.2 RESPONSE TIME

Each facility has requested a maximum turnaround time in order not to impact test schedules. Table 3-1 contains the current, maximum turnaround times requested by each facility.

TABLE 4-1. – ONSITE TEST FACILITY DATA PROCESSING SUPPORT SCHEDULE



NOTES.

1. VATF scheduled to provide their own A/D processing.
2. Insufficient data available to determine test duration.
3. Although testing will continue in these facilities after the indicated programs, insufficient information is available to determine schedules and workloads.