# *Mariner* Mars 1971/*Pioneer 10* Multi-Mission Level Modeling Runs Using the SFOF Mark IIIA Central Processing System Model

H. S. Simon
SFOF/GCF Development Section

*Simulation models are currently being used for Space Flight Operations Facility (SFOF) development at the Jet Propulsion Laboratory. This article documents the results of a series of modeling runs made during January and February 1972. The model contained a majority of the SFOF Mark IIIA Central Processing System capabilities required to simultaneously support the orbital phase of the Mariner Mars 1971 mission and the early cruise phase of the Pioneer 10 mission.*

## I. Introduction

Simulation models are currently being developed in the SFOF/GCF Development Section to support the design and implementation of the SFOF Mark IIIA Central Processing System (CPS). SFOF Mark IIIA modeling studies began in May 1969 when it was learned that NASA would be providing JPL with IBM 360 Model 75 digital computers to form the nucleus of the SFOF Mark IIIA CPS.

The IBM Computer System Simulator (CSS) program was selected for model development activities since it runs on the 360/75 and the program itself applies specifically to computer systems. The results of previous modeling studies that were performed during the early stages of SFOF Mark IIIA development are described in Refs. 1 and 2.

This article summarizes the results of seven modeling runs made during January and February 1972 to evaluate the performance of the SFOF Mark IIIA CPS, configured to simultaneously support the orbital phase of the *Mariner* Mars 1971 mission and the early cruise phase of the *Pioneer 10* mission. A more detailed summary is contained in JPL IOM 9181-35-72, dated February 16, 1972 (JPL internal document).

## II. Objectives

There were several objectives associated with this series of modeling runs:

(1) Use the model to analyze the overall performance of the Central Processing System under conditions of dual mission loading.

(2) Alleviate problem areas (primarily main memory core lockout) by changing the hardware and software characteristics of the model.

(3) Determine the effect of heavy external loading on the system and change the model characteristics in order to support this level of loading.

## III. Model Description

The SFOF Mark IIIA hardware configuration that was modeled is shown in Fig. 1. The following changes were made to this normal configuration:

(1) *Runs 3, 6, and 7.* A 4-megabyte IBM 2301 drum was installed on channel 1 of the 2860-2. The 2314 disk files were relocated to channels 2 and 5.

(2) *Run 4.* The Large Capacity Storage (LCS) was expanded from 2 to 4 megabytes. The read/write storage cycle in the model, for a double word, was reduced from 8 to 4 microseconds to reflect the two-way interleaving addressing structure.

The line assignments for the 2909-3 input and output high-speed data (HSD) subchannels were arbitrarily chosen.

The software configuration that was modeled defined the functional capabilities at the following levels:

| | |
|---|---|
| Operating System: | JPLOS, Version 3.0 |
| Applications Software: | Mission Build, Model 5, Version 18 |

The allocation of disk resident load modules and data tables for each of the runs are shown in Table 1. In the model, information from a Model 5, Version 25 listing was used as the basis for organizing the data on the mission disk packs.

The size and residency of permanently allocated system core is shown in Table 2.

The Statistics Gathering System (SGS) that functions under the control of the 360/75 operating system provided timing information from the "live" system that was used to calibrate the model. In addition, data obtained from listings, flow charts, and other design information provided a percentage of manual calibration. It is estimated that the model used for this series of runs received approximately 30% SGS and 60% manual calibration.

## IV. Description of Modeling Runs

The seven runs were executed in the following sequence:

| Run | Hardware configuration | System activity | Results |
|---|---|---|---|
| 1 | Normal | Processing and display of real-time input data, E140 site playback data, and TTY recall data. | Ran to completion. No problems or anomalies observed. |
| 2 | Normal | Same processing as for Run 1, *and* the generation of Predicts and Sequence of Events files. | Terminated by core lockout. |
| 3 | Drum | Same as for Run 2. | Same as for Run 2. |
| 4 | 4 megabytes of LCS | Same as for Run 2. | Ran to completion. No problems or anomalies observed. |
| 5 | Normal | Processing and display of real-time input data and the generation of Predicts and SOE files. Playback and recall data were eliminated from the script. | Terminated by core lockout. |
| 6 | Drum | Same as for Run 2. | Terminated due to backlogging of queues in the model. System heading for core lockout. |
| 7 | Drum | Same as for Run 5. | Ran to completion. No problems or anomalies observed. |

## V. Environment and Sequence of Events

The types and number of simulated input data streams are listed in Table 3.

Other significant events, with their occurrence in time relative to the beginning of the run ($t_0$), were:

(1) $t_0$ + 25 seconds. Predicts (phi-factor) file generation of 2 passes for each of 4 stations.

(2) $t_0$ + 70 seconds. Telemetry SDR recall for *Mariner*.

(3) $t_0$ + 70 seconds. Sequence of Events file generation of approximately 360 lines of data.

(4) $t_0$ + 100 seconds. Telemetry SDR recall for *Pioneer*.

(5) $t_0$ + 150 seconds. Recall of 100 records of *Mariner* tracking data from the 490 Communications Processor.

Additionally, a commanding sequence to DSS 14 for *Mariner*, consisting of manual entry, transmission, and enabling of a command block, was executed during each run. A TCP stack-loading sequence to DSS 51 for *Pioneer* was also simulated. Pseudo-residuals were calculated for all input tracking streams.

Table 4 lists the displays that were initialized during each run.

## VI. Results

The results of the seven runs are summarized in Tables 5 through 11. Each of the snap intervals represents one minute of simulated real time. A glossary of terms used in these tables appears in Table 12.

The following is a summary of significant items:

(1) Runs 1, 4, and 7 were considered successful in that they executed to completion (a minimum of 5 one-minute snap intervals).

(2) Runs 2, 3, 5, and 6 terminated prematurely due to main memory core lockout conditions.

(3) Run 1 was the base run. There were no significant problems or anomalies observed during this run.

(4) Runs 2 and 3 both terminated at approximately 50 seconds into the third snap. Core lockout occurred about 20 seconds after the recall of tracking data from the Communications Processor was initiated.

(5) A higher CPU utilization occurred during the third snap interval of Run 3 (82% vs 45% for Run 2). This reflects the increase in execution of user tasks resulting from the relocation of JOBLIB load modules to the drum and marking them non-LCS allocatable.

(6) Only minor changes were made to the software functions in the model for Run 4. An improvement in system performance would be expected if significant changes were made to take advantage of the additional 2 megabytes of LCS.

(7) The elimination of E140 playback and CP recall data did not prevent core lockout from occurring during Run 5 when the normal configuration was utilized. Making Sequence of Events load modules non-LCS allocatable and eliminating playback and recall resulted in no significant difference. System performance was not degraded by in-line execution of the Sequence of Events generator (SEG) load modules. Approximately 300 kbytes of LCS were made available during this run. CPU utilization during snap intervals 4 and 5 decreased drastically due to lack of main memory core. During interval 5, the entire CPU utilization is attributable to the system's unsuccessful searches for available core.

(8) During Runs 6 and 7, a quantity of load modules was left on disk pack 133 and marked LCS allocatable. All other M3A5.RTDS.GO load modules were placed on the drum and marked non-LCS allocatable.

(9) Run 6 was terminated approximately 10 seconds into the fifth snap as a result of queues in the model overflowing. While core lockout was not the immediate cause of the run termination, there was much purging required to satisfy GETMAIN requests. The resulting delay led to data being backlogged. The backlog increased at such a rate that even if queue overflow had not occurred it is reasonable to assume that core lockout would have occurred before the backlog could have been processed.

(10) The same hardware configuration was utilized for Runs 6 and 7. Elimination of E140 playback and CP recall data from Run 7 removed the catalyst that caused core lockout in Run 6.

(11) By eliminating the playback and recall data, and placing some of the JOBLIB load modules on drum, it was possible to complete Run 7 without the loss of other real-time input data.

(12) The tapes on Channel C, used primarily for data logging, were utilized approximately 25%.

(13) Printer 460, used to display the telemetry latest available data (LAD) dump, is the only device that approaches saturation for each run.

(14) The outbound HSD channel to Ames was also very active, with a channel utilization of near 70% for each run.

(15) Input/output (I/O) channel and subchannel utilization figures indicate there were no serious problems in this area.

(16) The maximum backlog of output queues, related to the line printer, for six of the seven runs was 20 kbytes.

## VII. Conclusions

Based upon the assumptions made for each run, Run 7 provided the best overall results as summarized below. The run was operationally terminated after 6½ snap intervals due to the expiration of available 360/75 computer time.

(1) Operating system overhead was a lower percentage of total CPU utilization.

(2) Highest amount of phi-factor file and SEG program execution.

(3) No main core user requests had to wait.

(4) No load modules purged from LCS.

(5) Main core and LCS usage less than maximum.

(6) No tasks had to wait while storage management attempted to satisfy their core requests.

(7) No backlogging or loss of data.

The very high level of CPU utilization prevalent in Run 7 can be attributed to (1) use of LCS for user GETMAINs with an accompanying increase in execution time, and (2) the presence of the SEG and PREDICTS load modules, which once in core will absorb most of the CPU time not used by the real-time subsystems.

Generally, main core is the limiting resource in the system. The CORE=(LCS, MAIN) option results in improved overall system performance when used on a system-wide basis. The additional main core freed up allows load modules to be more readily loaded and decreases the number of main core purges required. In order to avoid "overuse" of LCS, it is necessary to exercise sound judgment when marking load modules non-LCS allocatable in order to have LCS available for *user* GETMAINS.

The runs show that tasks which buffer large amounts of data in core (either directly or indirectly by queuing it for someone else) will cause a heavily loaded system to collapse. The recall of tracking data from the CP is the obvious example on the input side of the system, but telemetry playback can have the same effect if data are arriving faster than they can be processed.

In order to study the core lockout problem resulting from the fragmentation of core over a period of time, longer modeling runs would be required.

## References


1. Simon, H. S., "SFOF Mark IIIA Central Processing System Model Development," in *The Deep Space Network Progress Report,* Technical Report 32-1526, Vol. I, pp. 95–102. Jet Propulsion Laboratory, Pasadena, Calif., Feb. 15, 1971.

2. Simon, H. S., "*Mariner* Mars 1971 Launch Phase Study Using the SFOF Mark IIIA Central Processing System Model," in *The Deep Space Network Progress Report,* Technical Report 32-1526, Vol. III, pp. 179–186. Jet Propulsion Laboratory, Pasadena, Calif., June 15, 1971.

Table 1. Allocations of frequently accessed load modules and data tables

| Load modules and data tables | Run 1 | Run 2 | Run 3 | Run 4 | Run 5 | Run 6 | Run 7 |
|---|---|---|---|---|---|---|---|
| Tracking | | | | | | | |
| SDR data table | 132 | 132 | 232 | 132 | 132 | 232 | 232 |
| Telemetry | | | | | | | |
| *Mariner* load modules | 133 | 133 | Drum | 133 | 133 | 133 | 133 |
| *Mariner* SDR data table | 232 | 232 | 532 | 232 | 232 | 532 | 532 |
| *Pioneer* load modules | 133 | 133 | Drum | 133 | 133 | Drum | Drum |
| *Pioneer* SDR data table | 133 | 133 | 233 | 133 | 133 | 233 | 233 |
| Monitor and Ops Control | | | | | | | |
| Load modules | 133 | 133 | Drum | 133 | 133 | 133 | 133 |
| *Pioneer* | | | | | | | |
| Data table | 134 | 134 | 234 | 134 | 134 | 234 | 234 |
| Near real-time processors | | | | | | | |
| PREDICTS load modules | 133 | 133 | Drum | 133 | 133 | Drum | Drum |
| PREDICTS data tables (1) | 133 | 133 | 233 | 133 | 133 | 233 | 233 |
| PREDICTS data tables (2) | 233 | 233 | 533 | 233 | 233 | 533 | 533 |
| SEG data tables (2) | 133 | 133 | 233 | 133 | 133 | 233 | 233 |
| SEG data tables (1) | 134 | 134 | 234 | 134 | 134 | 234 | 234 |
| SEG data tables (2) | 233 | 233 | 533 | 233 | 233 | 533 | 533 |
| UI display and output load modules | 133 | 133 | Drum | 133 | 133 | 133 | 133 |
| Format modules | 133 | 133 | Drum | 133 | 133 | Drum | Drum |
| RTSPOOL | 237 | 237 | 537 | 237 | 237 | 537 | 537 |
| MDR WRITE | 237 | 237 | 537 | 237 | 237 | 537 | 537 |

Table 2. Permanently allocated system core

| Description | Size, kbytes | Residence |
|---|---|---|
| Nucleus | 124 | Main |
| Nucleus | 46 | LCS |
| System queue area | 30 | Main |
| Trace table | 14 | Main |
| Resident job queue | 10 | LCS |
| LINKLIB directory | 88 | LCS |
| SVCLIB directory | 56 | LCS |
| Master scheduler | 22 | Main |
| RTDS.GO directory | 50 | LCS |
| RESIDENT RTPRGLIB | 42 | LCS |
| RT error message LMs | 16 | LCS |
| Non-UPDA data tables | 898 | LCS |

Table 3. Simulated input data streams

| Type | Spacecraft | Station | Rate | Via |
|---|---|---|---|---|
| E140 | *Mariner* | 14 | 33⅓ bps | HSD |
| O420 | *Mariner* | 14 | 50 bps | HSD |
| E140 Playback[a] | *Mariner* | 62 | 33⅓ × 8 bps | HSD |
| Tracking | *Mariner* | 14 | 1 sample/min | CP[b] |
| Tracking | *Mariner* | 62 | 1 sample/min | CP |
| Tracking recall | *Mariner* | 62 | 46 samples/sec | CP |
| Perf/status | N/A | 14 | 12 blocks/min | HSD |
| Summary | N/A | 14 | 2 blocks/min | HSD |
| Perf/status | N/A | 62 | 12 blocks/min | HSD |
| Summary | N/A | 62 | 2 blocks/min | HSD |
| F384 | *Pioneer* | 51 | 2048 bps | HSD |
| Tracking | *Pioneer* | 42 | 1 sample/min | HSD |
| Tracking | *Pioneer* | 51 | 1 sample/min | CP |
| Perf/status | N/A | 42 | 12 blocks/min | HSD |
| Summary | N/A | 42 | 2 blocks/min | HSD |
| Perf/status | N/A | 51 | 12 blocks/min | HSD |
| Summary | N/A | 51 | 2 blocks/min | HSD |
| Status | N/A | GCF | 3 blocks/min | CP |
| AGC | *Pioneer* | 42 | 1 block/74 sec | HSD |

[a]E140 playback rate = 8 times original data rate.
[b]CP = UNIVAC 490 Communications Processor.

Table 4. Initialized displays

| User | Display device | Quantity | Active displays |
|---|---|---|---|
| *Mariner* | DTV channels | 35 | 32 |
| | F-132 printers | 9 | 18 |
| | TTY printers | 14 | 19 |
| *Pioneer* | DTV channels | 18 | 26 |
| | F-132 printers | 6 | 41 |
| | TTY printers | 10 | 23 |
| DSN | DTV channels | 17 | 18 |
| | F-132 printers | 4 | 5 |
| | TTY printers | 18 | 21 |

Table 5. Statistics from Run 1

| Item measured | SNAP1 | SNAP2 | SNAP3 | SNAP4 | SNAP5 |
|---|---|---|---|---|---|
| *CPU utilization (total)* | 58% | 67% | 77% | 76% | 67% |
| Applications | 21% | 24% | 26% | 26% | 24% |
| Operating system overhead | 37% | 43% | 50% | 48% | 42% |
| *CPU utilization (task breakdown)* | | | | | |
| Tracking Subsystem | 2% | 1% | 7% | 6% | 1% |
| Telemetry Subsystem | 11% | 18% | 15% | 15% | 17% |
| Command Subsystem | 0.2% | 0.1% | 0.2% | 0.4% | 0.5% |
| Monitor and Ops Control Subsystem | 8% | 9% | 9% | 9% | 9% |
| User Interface Subsystem | 30% | 31% | 36% | 36% | 24% |
| Operating system tasks | 7% | 7% | 8% | 8% | 7% |
| *Main core usage* | | | | | |
| Average in use | 630K | 726K | 806K | 792K | 784K |
| Average amount allocated | 932K | 961K | 972K | 970K | 961K |
| Number of purges | 10 | 21 | 70 | 63 | 39 |
| Number of requests that had to wait | 0 | 0 | 0 | 0 | 0 |
| Number of LM's scatter loaded | 0 | 0 | 0 | 0 | 0 |
| *LCS usage* | | | | | |
| Maximum | 1995K | 2043K | 2039K | 2044K | 2046K |
| Average | 1920K | 2001K | 1995K | 2009K | 2026K |
| LCS GETMAIN'ed core (average) | 142K | 174K | 175K | 191K | 204K |
| Number of LM's purged from LCS | 0 | 10 | 3 | 0 | 11 |
| *I/O utilization* | | | | | |
| 2860-2 Selector Channel | | | | | |
| Channel 1 (disk) | 6% | 9% | 24% | 19% | 11% |
| Channel 2 (disk) | 5% | 16% | 12% | 12% | 13% |
| Channel 6 (LCS) | 12% | 16% | 23% | 22% | 18% |
| 2870 Multiplexer Channel | | | | | |
| Selector subchannel 1 (tapes) | 23% | 24% | 26% | 24% | 23% |
| Selector subchannel 4 (*Pioneer* devices) | 0% | 0% | 0% | 0% | 0% |
| Printer (0F9) | 13% | 33% | 13% | 12% | 12% |
| 2909-3 Asynchronous Data Channel | | | | | |
| HSD08 (output subchannel to Ames) | 79% | 71% | 72% | 77% | 71% |
| Subchannel 46x | 0% | 0% | 0% | 0% | 0% |
| Printer (460) | 85% | 93% | 93% | 93% | 93% |
| *Task queues* | | | | | |
| CPU | | | | | |
| Number | 10004 | 13546 | 16128 | 15627 | 13829 |
| Average time | 6 ms | 5 ms | 6 ms | 6 ms | 4 ms |
| Core | | | | | |
| Number | 0 | 0 | 0 | 0 | 0 |
| *Task response times* | | | | | |
| Tracking | 196 ms | 224 ms | 161 ms | 179 ms | 123 ms |
| Telemetry | 131 ms | 193 ms | 274 ms | 276 ms | 229 ms |
| Monitor and Ops Control | 417 ms | 244 ms | 206 ms | 249 ms | 236 ms |
| *Backlog* | | | | | |
| Tracking data | 0 | 0 | 41 | 0 | 0 |

Table 6. Statistics from Run 2

| Item measured | SNAP1 | SNAP2 | SNAP3[a] |
|---|---|---|---|
| *CPU utilization (total)* | 76% | 95% | 45% |
| Applications | 34% | 41% | 13% |
| Operating system overhead | 43% | 53% | 31% |
| *CPU utilization (Task breakdown)* | | | |
| Tracking Subsystem | 2% | 1% | 2% |
| Telemetry Subsystem | 11% | 18% | 8% |
| Command Subsystem | 0.2% | 2% | 2% |
| Monitor and Ops Control Subsystem | 9% | 10% | 5% |
| User Interface Subsystem | 31% | 32% | 15% |
| Operating system tasks | 7% | 8% | 7% |
| Predicts (phi-factor file) generation | 12% | 21% | 5% |
| Sequence of events generation | — | 1% | 1% |
| *Main core usage* | | | |
| Average in use | 690K | 884K | 1007K |
| Average amount allocated | 944K | 970K | 1011K |
| Number of purges | 28 | 739 | 767 |
| Number of requests that had to wait | 0 | 30 | 55 |
| Number of LM's scatter loaded | 0 | 101 | 108 |
| *LCS usage* | | | |
| Maximum | 2045K | 2044K | 2041K |
| Average | 1975K | 2020K | 2018K |
| LCS GETMAIN'ed core (average) | 173K | 218K | 220K |
| Number of LM's Purged from LCS | 38 | 45 | 2 |
| *I/O utilization* | | | |
| 2860-2 Selector Channel | | | |
| Channel 1 (disk) | 25% | 24% | 8% |
| Channel 2 (disk) | 16% | 18% | 4% |
| Channel 6 (LCS) | 16% | 28% | 19% |
| 2870 Multiplexer Channel | | | |
| Selector subchannel 1 (tapes) | 34% | 28% | 16% |
| Selector subchannel 4 (*Pioneer* devices) | 0% | 0% | 0% |
| Printer (0F9) | 14% | 50% | 28% |
| 2909-3 Asynchronous Data Channel | | | |
| HSD08 (output subchannel to Ames) | 80% | 71% | 35% |
| Subchannel 46x | 0% | 0% | 0% |
| Printer (460) | 78% | 93% | 39% |
| *Task queues* | | | |
| CPU | | | |
| Number | 12878 | 17210 | 7393 |
| Average time | 8 ms | 11 ms | 0 ms |
| Core | | | |
| Number | 0 | 527 | 671 |
| Average time | — | 21 ms | 310 ms |
| *Task response times* | | | |
| Tracking | 256 ms | 3328 ms | 2832 ms |
| Telemetry | 141 ms | 273 ms | 894 ms |
| Monitor and Ops Control | 456 ms | 301 ms | 398 ms |
| *Backlog* | | | |
| Tracking data | 0 | 0 | 99 |
| Telemetry data | 0 | 15 | 10 |
| *Input TTY and HSD lost* | 0 | 0 | 117 |

[a]Core lockout occurred 50 seconds into snap interval 3.

## Table 7. Statistics from Run 3

| Item measured | SNAP1 | SNAP2 | SNAP3[a] |
|---|---|---|---|
| *CPU utilization (total)* | 82% | 92% | 82% |
| Applications | 38% | 45% | 43% |
| Operating system overhead | 42% | 46% | 38% |
| *CPU utilization (task breakdown)* | | | |
| Tracking Subsystem | 1% | 1% | 2% |
| Telemetry Subsystem | 14% | 16% | 11% |
| Command Subsystem | 0.2% | 0.2% | 0.2% |
| Monitor and Ops Control Subsystem | 13% | 13% | 14% |
| User Interface Subsystem | 39% | 42% | 29% |
| Operating system tasks | 7% | 7% | 7% |
| Predicts (phi-factor file) generation | 5% | 9% | 7% |
| Sequence of events generation | — | 1% | 11% |
| *Main core usage* | | | |
| Average in use | 653K | 835K | 945K |
| Average amount allocated | 950K | 974K | 985K |
| Number of purges | 16 | 66 | 82 |
| Number of requests that had to wait | 0 | 0 | 23 |
| Number of LM's scatter loaded | 0 | 9 | 72 |
| *LCS usage* | | | |
| Maximum | 1504K | 1564K | 1603K |
| Average | 1462K | 1519K | 1559K |
| LCS GETMAIN'ed core (average) | 216K | 273K | 313K |
| Number of LM's purged from LCS | 0 | 0 | 0 |
| *I/O utilization* | | | |
| 2860-2 Selector Channel | | | |
| Channel 1 (drum) | 23% | 46% | 74% |
| Channel 2 (disk) | 5% | 5% | 12% |
| Channel 5 (disk) | 14% | 11% | 7% |
| Channel 6 (LCS) | 12% | 11% | 9% |
| 2870 Multiplexer Channel | | | |
| Selector subchannel 1 (tapes) | 31% | 29% | 22% |
| Selector subchannel 4 (*Pioneer* devices) | 0% | 0% | 0% |
| Printer (0F9) | 13% | 34% | 6% |
| 2909-3 Asynchronous Data Channel | | | |
| HSD08 (output subchannel to Ames) | 74% | 68% | 53% |
| Subchannel 46x | 0% | 0% | 0% |
| Printer (460) | 78% | 84% | 84% |
| *Task queues* | | | |
| CPU | | | |
| Number | 12307 | 15228 | 11465 |
| Average time | 13 ms | 16 ms | 10 ms |
| Core | | | |
| Number | 0 | 0 | 0 |
| *Task response times* | | | |
| Tracking | 282 ms | 670 ms | 1201 ms |
| Telemetry | 240 ms | 383 ms | 725 ms |
| Monitor and Ops Control | 630 ms | 531 ms | 658 ms |
| *Backlog* | | | |
| Tracking | 0 | 0 | 96 |
| Telemetry | 0 | 16 | 93 |

[a]Core lockout occurred 51 seconds into snap interval 3.

Table 8. Statistics from Run 4

| Item measured | SNAP1 | SNAP2 | SNAP3 | SNAP4 | SNAP5 |
|---|---|---|---|---|---|
| *CPU utilization (total)* | 87% | 99% | 99% | 100% | 99% |
| Applications | 42% | 51% | 47% | 46% | 46% |
| Operating system overhead | 44% | 47% | 50% | 52% | 51% |
| *CPU utilization (task breakdown)* | | | | | |
| Tracking Subsystem | 1% | 1% | 5% | 8% | 5% |
| Telemetry Subsystem | 14% | 18% | 15% | 13% | 15% |
| Command Subsystem | 0.2% | 0.2% | 0.2% | 0.4% | 1% |
| Monitor and Ops Control Subsystem | 13% | 13% | 13% | 14% | 14% |
| User Interface Subsystem | 42% | 43% | 43% | 46% | 46% |
| Operating system tasks | 7% | 8% | 8% | 8% | 7% |
| Predicts (phi-factor file) generation | 7% | 15% | 10% | 7% | 8% |
| Sequence of events generation | — | 1% | 1% | 1% | 1% |
| *Main Core Usage* | | | | | |
| Average in use | 646K | 809K | 925K | 950K | 956K |
| Average amount allocated | 936K | 960K | 985K | 988K | 995K |
| Number of purges | 13 | 73 | 224 | 310 | 404 |
| Number of requests that had to wait | 0 | 0 | 4 | 8 | 17 |
| Number of LM's scatter loaded | 0 | 5 | 26 | 37 | 75 |
| *LCS Usage* | | | | | |
| Maximum | 2364K | 2639K | 2638K | 2718K | 2745K |
| Average | 2148K | 2518K | 2606K | 2670K | 2714K |
| LCS GETMAIN'ed core (average) | 217K | 273K | 290K | 311K | 328K |
| Number of LM's purged from LCS | 0 | 0 | 0 | 0 | 0 |
| *I/O utilization* | | | | | |
| 2860-2 Selector Channel | | | | | |
| Channel 1 (disk) | 16% | 9% | 12% | 17% | 11% |
| Channel 2 (disk) | 11% | 12% | 11% | 11% | 8% |
| Channel 6 (LCS) | 15% | 18% | 27% | 32% | 29% |
| 2870 Multiplexer Channel | | | | | |
| Selector subchannel 1 (tapes) | 35% | 30% | 29% | 29% | 27% |
| Selector subchannel 4 (*Pioneer* devices) | 0% | 0% | 0% | 0% | 0% |
| Printer (0F9) | 13% | 46% | 34% | 11% | 10% |
| 2909-3 Asynchronous Data Channel | | | | | |
| HSD08 (output subchannel to Ames) | 79% | 72% | 66% | 77% | 76% |
| Subchannel 46x | 0% | 0% | 0% | 0% | 0% |
| Printer (460) | 85% | 93% | 92% | 88% | 86% |
| *Task queues* | | | | | |
| CPU | | | | | |
| Number | 12471 | 15014 | 15818 | 15860 | 15832 |
| Average time | 14 ms | 19 ms | 20 ms | 23 ms | 19 ms |
| Core | | | | | |
| Number | 0 | 0 | 10 | 15 | 98 |
| Average time | — | — | 42 ms | 30 ms | 26 ms |
| *Task response times* | | | | | |
| Tracking | 319 ms | 334 ms | 314 ms | 322 ms | 297 ms |
| Telemetry | 241 ms | 341 ms | 493 ms | 626 ms | 485 ms |
| Monitor and Ops Control | 583 ms | 368 ms | 373 ms | 441 ms | 378 ms |
| *Backlog* | | | | | |
| Tracking data | 0 | 0 | 71 | 28 | 0 |
| Telemetry data | 0 | 0 | 15 | 52 | 50 |
| Monitor and Ops Control data | 0 | 0 | 10 | 0 | 0 |

## Table 9. Statistics from Run 5

| Item measured | SNAP1 | SNAP2 | SNAP3 | SNAP4 | SNAP5[a] |
|---|---|---|---|---|---|
| *CPU utilization (total)* | 70% | 92% | 89% | 33% | 6% |
| Applications | 32% | 45% | 41% | 14% | 0% |
| Operating system overhead | 37% | 46% | 47% | 8% | 6% |
| *CPU utilization (task breakdown)* | | | | | |
| Tracking Subsystem | 2% | 1% | 1% | 1% | 0% |
| Telemetry Subsystem | 6% | 14% | 14% | 2% | 0% |
| Command Subsystem | 0.2% | 0.2% | 0.3% | 1% | 0% |
| Monitor and Ops Control Subsystem | 8% | 10% | 10% | 4% | 0% |
| User Interface Subsystem | 29% | 31% | 29% | 10% | 0% |
| Operating system tasks | 7% | 7% | 7% | 5% | 6% |
| Predicts (phi-factor file) generation | 15% | 27% | 24% | 3% | 0% |
| Sequence of events generation | — | 1% | 2% | 5% | 0% |
| *Main core usage* | | | | | |
| Average in use | 663K | 869K | 966K | 1016K | 1024K |
| Average amount allocated | 947K | 973K | 991K | 1016K | 1024K |
| Number of purges | 32 | 195 | 767 | 1231 | 0 |
| Number of requests that had to wait | 0 | 5 | 80 | 90 | 0 |
| Number of LM's scatter loaded | 0 | 30 | 176 | 99 | 0 |
| *LCS Usage* | | | | | |
| Maximum | 2042K | 2047K | 2045K | 2043K | 2024K |
| Average | 1965K | 2027K | 2030K | 2023K | 2024K |
| LCS GETMAIN'ed core (average) | 148K | 193K | 195K | 206K | 207K |
| Number of LM's purged from LCS | 17 | 32 | 24 | 0 | 0 |
| *I/O Utilization* | | | | | |
| 2860-2 Selector Channel | | | | | |
| Channel 1 (disk) | 19% | 23% | 25% | 8% | |
| Channel 2 (disk) | 17% | 19% | 13% | 4% | |
| Channel 6 (LCS) | 13% | 24% | 31% | 9% | |
| 2870 Multiplexer Channel | | | | | |
| Selector subchannel 1 (tapes) | 31% | 29% | 25% | 8% | |
| Selector subchannel 4 (*Pioneer* devices) | 0% | 0% | 0% | 0% | |
| Printer (0F9) | 13% | 33% | 12% | 0% | |
| 2909-3 Asynchronous Data Channel | | | | | |
| HSD08 (output subchannel to Ames) | 77% | 76% | 66% | 8% | |
| Subchannel 46x | 0% | 0% | 0% | 0% | |
| Printer (460) | 78% | 86% | 92% | 26% | |
| *Task queues* | | | | | |
| CPU | | | | | |
| Number | 10206 | 15050 | 14812 | 4072 | |
| Average time | 10 ms | 10 ms | 8 ms | 14 ms | |
| Core | | | | | |
| Number | 0 | 11 | 358 | 1080 | |
| Average time | — | 16 ms | 36 ms | 554 ms | |
| *Task response times* | | | | | |
| Tracking | 207 ms | 341 ms | 1109 ms | 3726 ms | |
| Telemetry | 188 ms | 211 ms | 337 ms | 7763 ms | |
| Monitor and Ops Control | 450 ms | 314 ms | 256 ms | 4059 ms | |
| *Backlog* | | | | | |
| Tracking data | 0 | 0 | 0 | 0 | |
| Telemetry data | 0 | 0 | 12 | 71 | |
| Monitor and Ops Control data | 0 | 0 | 0 | 3 | |
| *Input TTY and HSD lost* | 0 | 0 | 0 | 116 | |

[a]Core lockout occurred 10 seconds into snap interval 5.

## Table 10. Statistics from Run 6

| Item measured | SNAP1 | SNAP2 | SNAP3 | SNAP4 | SNAP5[a] |
|---|---|---|---|---|---|
| *CPU utilization (total)* | 83% | 95% | 97% | 97% | 97% |
| Applications | 40% | 46% | 44% | 42% | 48% |
| Operating system overhead | 42% | 47% | 51% | 53% | 48% |
| *CPU utilization (task breakdown)* | | | | | |
| Tracking Subsystem | 1% | 1% | 7% | 9% | 4% |
| Telemetry Subsystem | 14% | 17% | 14% | 11% | 8% |
| Command Subsystem | 0.2% | 0.2% | 0.2% | 1% | 7% |
| Monitor and Ops Control Subsystem | 13% | 14% | 14% | 14% | 14% |
| User Interface Subsystem | 40% | 43% | 44% | 45% | 29% |
| Operating system tasks | 7% | 8% | 8% | 7% | 6% |
| Predicts (phi-factor file) generation | 5% | 10% | 6% | 5% | 13% |
| Sequence of events generation | — | 1% | 2% | 2% | 14% |
| *Main core usage* | | | | | |
| Average in use | 653K | 835K | 937K | 980K | 990K |
| Average amount allocated | 927K | 969K | 990K | 996K | 992K |
| Number of purges | 15 | 73 | 257 | 919 | 1264 |
| Number of requests that had to wait | 0 | 1 | 13 | 88 | 15 |
| Number of LM's scatter loaded | 0 | 5 | 36 | 206 | 57 |
| *LCS usage* | | | | | |
| Maximum | 1747K | 1815K | 1838K | 1800K | 1878K |
| Average | 1695K | 1773K | 1804K | 1843K | 1863K |
| LCS GETMAIN'ed core (average) | 216K | 275K | 306K | 344K | 364K |
| Number of LM's purged from LCS | 0 | 0 | 0 | 0 | 0 |
| *I/O utilization* | | | | | |
| 2860-2 Selector Channel | | | | | |
| Channel 1 (drum) | 19% | 25% | 27% | 31% | 42% |
| Channel 2 (disk) | 5% | 6% | 11% | 14% | 15% |
| Channel 5 (disk) | 14% | 15% | 15% | 21% | 22% |
| Channel 6 (LCS) | 13% | 16% | 26% | 31% | 24% |
| 2870 Multiplexer Channel | | | | | |
| Selector subchannel 1 (tapes) | 31% | 29% | 30% | 26% | 20% |
| Selector subchannel 4 (*Pioneer* devices) | 0% | 0% | 0% | 0% | — |
| Printer (0F9) | 13% | 51% | 11% | 5% | — |
| 2909-3 Asynchronous Data Channel | | | | | |
| HSD08 (output subchannel to Ames) | 74% | 71% | 69% | 66% | 28% |
| Subchannel 46x | 0% | 0% | 0% | 0% | 0% |
| Printer (460) | 78% | 93% | 86% | 76% | 49% |
| *Task queues* | | | | | |
| CPU | | | | | |
| Number | 12003 | 15320 | 15686 | 15364 | 2531 |
| Average time | 13 ms | 16 ms | 16 ms | 19 ms | 13 ms |
| Core | | | | | |
| Number | 0 | 1 | 26 | 530 | 366 |
| Average time | — | 10 ms | 17 ms | 28 ms | 44 ms |
| *Task response times* | | | | | |
| Tracking | 285 ms | 353 ms | 314 ms | 414 ms | 716 ms |
| Telemetry | 234 ms | 332 ms | 525 ms | 1015 ms | 1657 ms |
| Monitor and Ops Control | 599 ms | 375 ms | 340 ms | 556 ms | 796 ms |
| *Backlog* | | | | | |
| Tracking data | 0 | 0 | 71 | 38 | 35 |
| Telemetry data | 0 | 12 | 34 | 118 | 149 |

[a]Model queue overflow due to backlog; 10 seconds into snap interval 5.

## Table 11. Statistics from Run 7

| Item measured | SNAP1 | SNAP2 | SNAP3 | SNAP4 | SNAP5 |
|---|---|---|---|---|---|
| *CPU utilization (total)* | 78% | 98% | 94% | 97% | 99% |
| Applications | 40% | 53% | 50% | 52% | 55% |
| Operating system overhead | 36% | 43% | 43% | 43% | 43% |
| *CPU utilization (task breakdown)* | | | | | |
| Tracking Subsystem | 1% | 1% | 1% | 1% | 0.3% |
| Telemetry Subsystem | 7% | 15% | 15% | 14% | 15% |
| Command Subsystem | 0.2% | 0.1% | 0.2% | 0.3% | 0.5% |
| Monitor and Ops Control Subsystem | 13% | 13% | 13% | 14% | 13% |
| User Interface Subsystem | 38% | 40% | 40% | 42% | 42% |
| Operating system tasks | 6% | 7% | 7% | 7% | 7% |
| Predicts (phi-factor file) generation | 9% | 19% | 15% | 15% | 14% |
| Sequence of events generation | — | 1% | 1% | 2% | 7% |
| *Main core usage* | | | | | |
| Average in use | 619K | 767K | 784K | 791K | 801K |
| Average amount allocated | 937K | 980K | 957K | 969K | 961K |
| Number of purges | 12 | 46 | 52 | 55 | 67 |
| Number of requests that had to wait | 0 | 0 | 0 | 0 | 0 |
| Number of LM's scatter loaded | 0 | 0 | 0 | 0 | 1 |
| *LCS usage* | | | | | |
| Maximum | 1723K | 1770K | 1770K | 1834K | 1850K |
| Average | 1668K | 1736K | 1743K | 1787K | 1817K |
| LCS GETMAIN'ed core (average) | 189K | 239K | 245K | 288K | 319K |
| Number of LM's purged from LCS | 0 | 0 | 0 | 0 | 0 |
| *I/O utilization* | | | | | |
| 2860-2 Selector Channel | | | | | |
| Channel 1 (drum) | 15% | 14% | 20% | 22% | 26% |
| Channel 2 (disk) | 5% | 4% | 3% | 5% | 2% |
| Channel 5 (disk) | 16% | 17% | 15% | 15% | 14% |
| Channel 6 (LCS) | 10% | 13% | 14% | 14% | 14% |
| 2870 Multiplexer Channel | | | | | |
| Selector subchannel 1 (tapes) | 31% | 28% | 27% | 27% | 29% |
| Selector subchannel 4 (Pioneer devices) | 0% | 0% | 0% | 0% | 0% |
| Printer (0F9) | 13% | 33% | 13% | 12% | 12% |
| 2909-3 Asynchronous Data Channel | | | | | |
| HSD08 (output subchannel to Ames) | 74% | 70% | 75% | 74% | 72% |
| Subchannel 46x | 0% | 0% | 0% | 0% | 0% |
| Printer (460) | 71% | 93% | 93% | 93% | 93% |
| *Task queues* | | | | | |
| CPU | | | | | |
| Number | 9899 | 13134 | 12905 | 13305 | 13759 |
| Average time | 13 ms | 18 ms | 13 ms | 15 ms | 12 ms |
| Core | | | | | |
| Number | 0 | 0 | 0 | 0 | 0 |
| *Task response times* | | | | | |
| Tracking | 290 ms | 273 ms | 507 ms | 226 ms | 136 ms |
| Telemetry | 254 ms | 206 ms | 211 ms | 222 ms | 183 ms |
| Monitor and Ops Control | 550 ms | 299 ms | 283 ms | 287 ms | 227 ms |

**Table 12. Glossary of terms**

| | |
|---|---|
| *CPU utilization (total)* | Percentage of the snap interval the 360/75 CPU was in use, i.e., not idle or waiting. |
| Applications | Percentage of the snap interval the CPU was in use by a user program. |
| Operating system overhead | Percentage of the snap interval the processor was in use by the operating system servicing user requests or interrupts. |
| *Main core usage* | |
| Average in use | Average amount of core in use during the snap. |
| Average amount allocated | Average amount of core in use plus the average amount allocated for inactive load modules. |
| Number of purges | The number of times during the snap that purge attempts were made to free inactive load modules to satisfy a GETMAIN request. |
| Number of requests that had to wait | The number of GETMAIN requests which caused the calling task to be delayed until sufficient main storage became available. |
| Number of load modules scatter loaded | The number of load modules loaded into main storage in segments rather than as single blocks, due to excessive fragmentation of available storage. |
| *LCS usage* | The maximum and average amount of LCS used during the snap. |
| GETMAIN'ed core | The average amount of LCS allocated via the LCS option of GETMAIN calls. |
| Load modules purged from LCS | The number of load modules that were purged from LCS in order to satisfy other LCS requests. |
| *I/O Utilization* | |
| Channel utilization | Percentage of the snap interval the channel was busy. For the disk channels, the channel is not made busy by seek operations. |
| Subchannel and device utilization | Percentage of the snap interval the subchannel or device was busy. |
| *Task queues* | |
| Number (No.) | |
| CPU | Number of times tasks were queued for control of CPU. (Zero-time entries are included.) |
| Core | Number of times tasks waited while storage management attempted to satisfy their core requests. |
| Average time | The average time in milliseconds that tasks were queued for the reasons stated above. |
| *Task response times* | The average time all tasks in the indicated category required to process a unit of work, i.e., from the time the unit (RTQEL) is activated to the final EXIT under the task. |
| *Backlog* | The number of unprocessed work units at the end of the snap. |
| *Input TTY and HSD Lost* | The number of teletype and high speed data messages discarded by the I/O interrupt processor due to its inability to obtain core. |
| Core = (*LCS, MAIN*) | When executing a user GETMAIN, attempts are first made to obtain core from LCS, before main memory. |

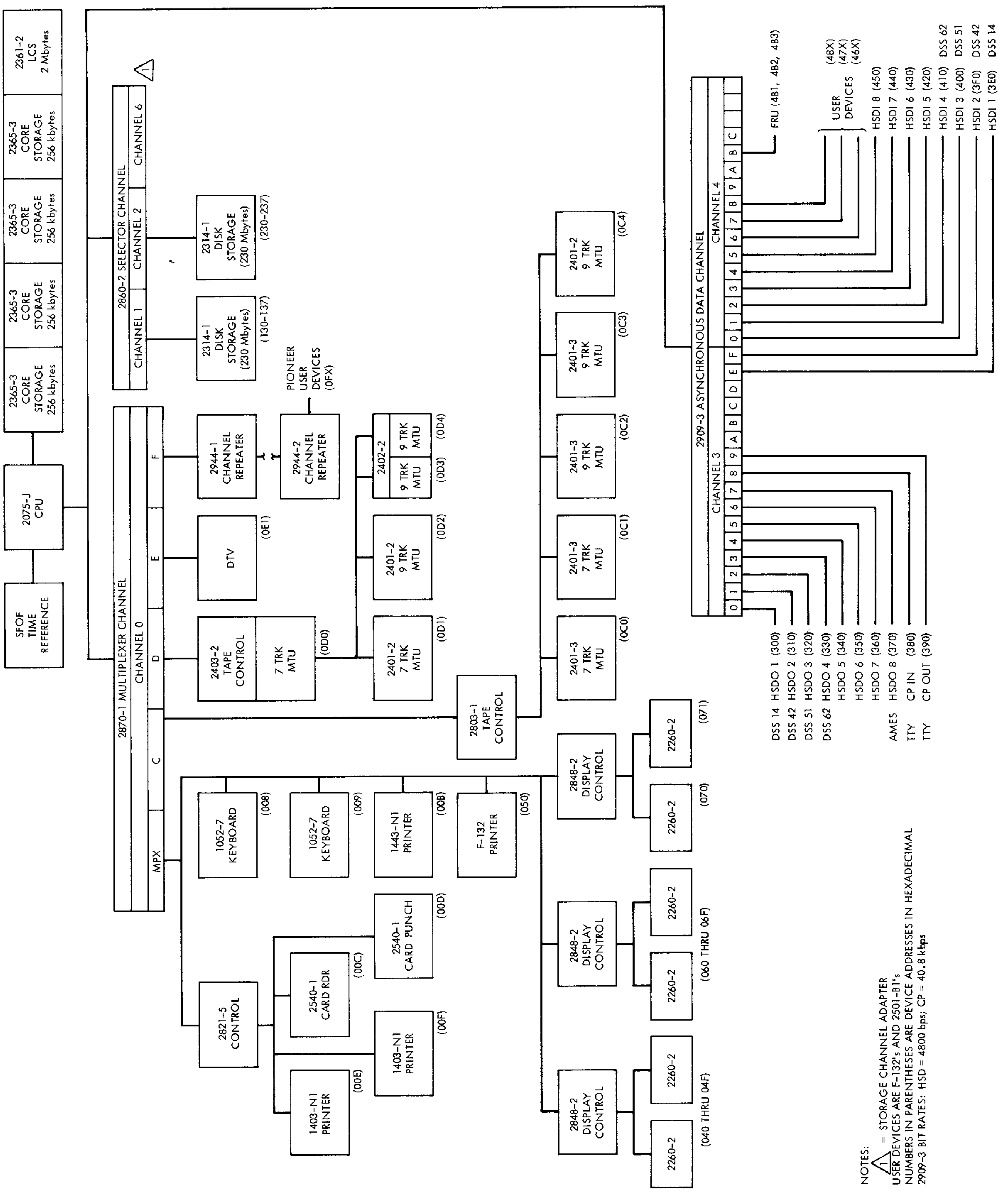


**Fig. 1. SFOF Mark IIIA hardware configuration**