NCCDS Performance Model

Eric Richmond
NASA, Goddard Space Flight Center,
Network Control Systems
Branch (Code 532)

Antonio Vallone
Computer Sciences Corporation
10110 Aerospace Road
Lanham-Seabrook, MD 20706

ABSTRACT

The NASA/GSFC Network Control Center (NCC) provides communication services between ground facilities and spacecraft missions in near-earth orbit that use the Space Network. The NCC Data System (NCCDS) provides computational support and is expected to be highly utilized by the service requests needed in the future years. A performance model of the NCCDS has been developed to assess the future workload and possible enhancements. The model computes message volumes from mission request profiles and SN resource levels and generates the loads for NCCDS configurations as a function of operational scenarios and processing activities. The model has been calibrated using the results of benchmarks performed on the operational NCCDS facility and used to assess some future SN service request scenarios.

INTRODUCTION

The NASA/GSFC Network Control Center (NCC) is the operational manager of the Space Network (SN) which provides communication services between ground facilities and spacecraft missions in near-earth orbit. The SN consists of a constellation of Tracking and Data Relay Satellites (TDRSs), TDRSs ground terminals, communication and computing facilities, and operation personnel.

The NCC provides the following functions:

- scheduling user support activities
- disseminating schedules to the users and to the SN support facilities
- controlling the services provided by the other SN elements
- maintaining SN status and configuration information
- disseminating service performance data
- coordinating fault isolation
- generating performance reports.

The NCC functions are supported by the NCC Data System (NCCDS) which is a distributed computer system composed of a Communication and Control Segment (CCS), a Service Planning Segment (SPS), and an Intelligent Terminal Segment (ITS) connected by local area networks. The NCCDS performs the scheduling of the SN resources and processes the messages which the SN users, the NCC, and other SN support facilities use for requesting services, for controlling the SN configuration, and monitoring the SN service performance.

The Network Control Systems Branch (Code 532) is concerned with the effect on the performance characteristics of the NCCDS [1] due to changes in the SN resources (i.e., number of TDRSs and ground terminals) and in the number and complexity of the space missions (e.g. EOS and space station) requesting SN services. The volume of message traffic and the computational effort will

increase. The NCCDS performance can be kept to an optimal level by means of changes to the NCCDS design by increasing the hardware and software capabilities and, possibly, by improving the NCC operational procedures.

A model of the NCCDS has been developed with the objective of providing a tool for assessing the impact on the NCCDS performance of workload changes due to the SN services that will be required by future missions and to the new elements that will be added to the SN in the future. This tool can also be used for evaluating the effect of possible modifications to the NCCDS design and to the NCC operational procedure, and to support the identification of the most cost-effective alternative.

NCCDS CHARACTERISTICS

The NCCDS functions included in the NCCDS performance model are summarized in Figure 1. External messages to and from the NCCDS are exchanged via the Front End LAN (FEL) and the High Speed Message Exchange (HSME) which routes the messages to CCS and SPS functions, tests the communication links, and logs the messages. The inter-segment traffic is supported by the Inter-Segment LAN (ISL).

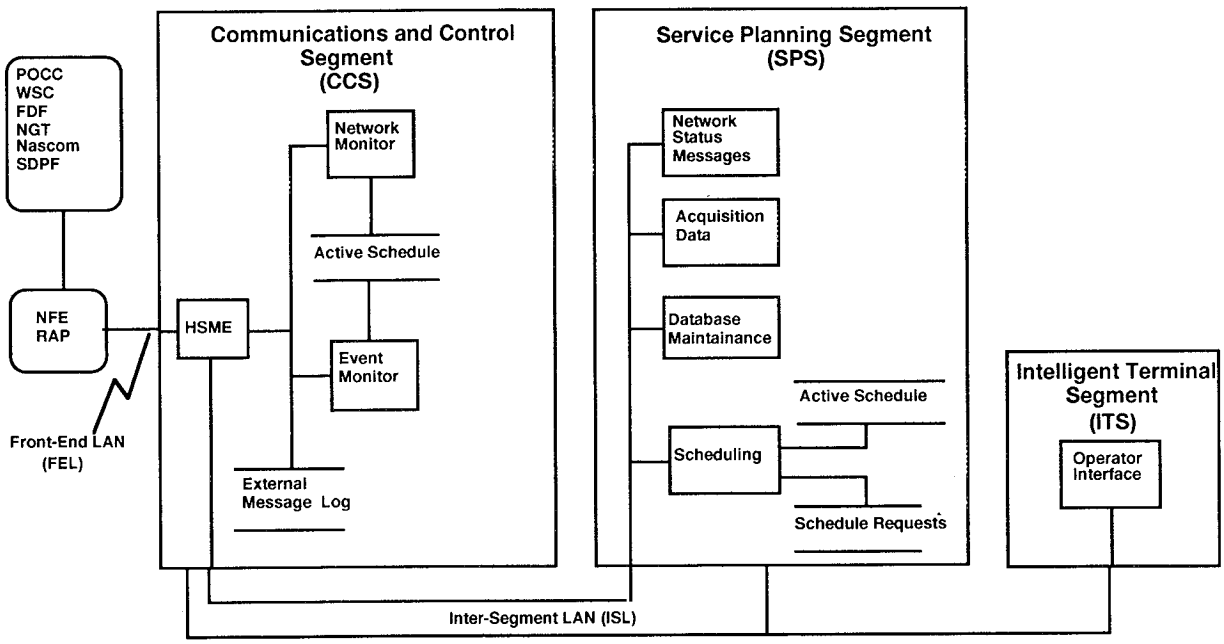

Figure-1 NCCDS Functional Architecture

CCS monitors SN status and performance, sends related data to SPS and operators (ITS) and to the SN users when requested. CCS also monitors SN use and processes users' requests for reconfiguring the space link and the ground communication link. CCS functions are coordinated

with the SN scheduled events stored in a database which is periodically updated from the SPS.

SPS receives from the Flight Dynamic Facility (FDF) acquisition data messages and transfers them to the SN Ground Terminals at White Sands Complex (WSC). SPS also performs the scheduling of users' SN resources requests for future events (forecast schedule) and for changes to the current schedule. It verifies users' requests, generates and maintains SN resource schedules, and disseminates the schedules to WSC, NASA Ground Terminal (NGT), Nascom, Sensor Data Processing Facility (SDPF), and Payload Operation Control Centers (POCCs).

The modeled NCCDS configuration includes the CCS and the SPS computer systems connected by the ISL. Each system is composed by a processing component (CPU), storage peripherals (drives and controllers of disks and tapes) for databases and log files, and the LAN interface components. The model disregards the hardware required for redundancy purposes.

MODEL STRUCTURE

The main requirements [2] for the NCCDS performance model are (1) flexibility for assessing several alternatives of SN users' needs, SN resources, and NCCDS configurations and operational procedures and (2) consistency in comparing results of the assessed alternatives. These requirements are satisfied by a model structure that separately models and integrates the NCCDS performance factors.

Figure 2 illustrates the structure of the model.

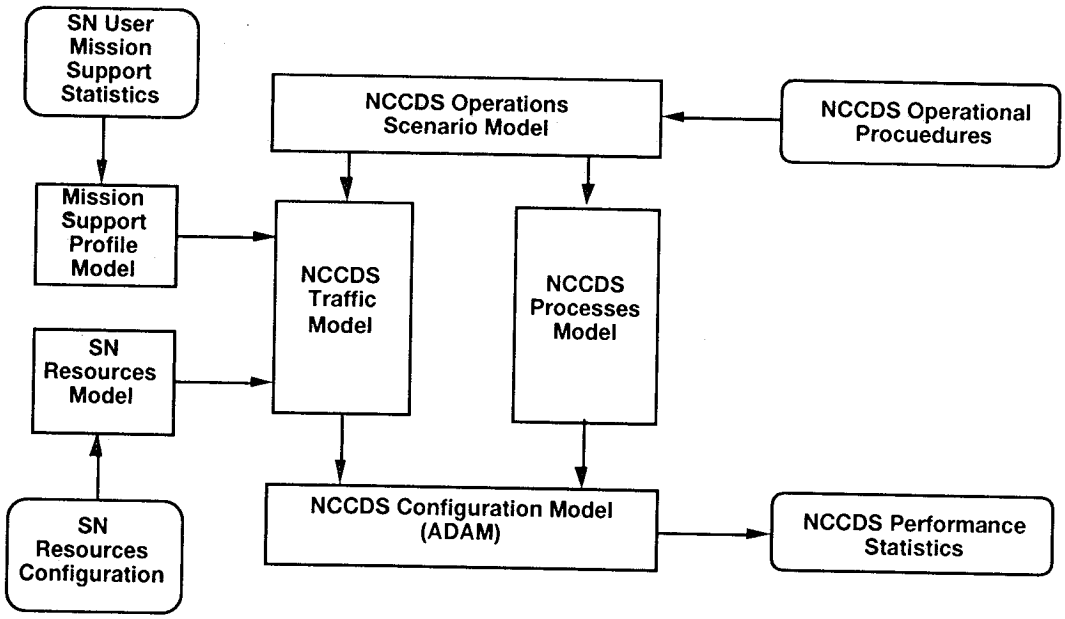

Figure-2 Model Structure

The NCCDS performance model includes the following main models:

- mission support profile model representing users' requests on the SN resources;
- SN resources model representing the number of TDRSs and ground stations;

- NCCDS traffic model representing the volume of messages transferred between the NCCDS and the outside world;
- NCCDS operational scenarios model representing the timing of message distribution and processing;
- NCCDS processes model representing the processes performed on each message and the resulting data transfer between CCS, SPS, and ITS;
- NCCDS configuration model.

The mission support profile model represents the daily average level of support provided to the SN users and is the main driver for NCCDS message traffic volumes and processing loads. Input to this model is the number events (TDRS contacts) and the length of SN resource usage (i.e., K-band Single Access, S-band Single Access, and Multiple Access). The input values may be directly obtained from the Mission Model Database (maintained by GSFC Code 534) or any hypothetical value for "what-if" analysis. Outputs from the model are parameters for the daily load to the NCCDS (i.e., the number of supported events, number of changes to the current schedule, duration of support) and parameters for the forecast scheduling process (i.e., number of requested events per week).

The SN resource model represents the SN configuration (i.e., number of TDRSs and number of antennas per TDRS). It provides values to parameters by which the traffic volume is computed.

The NCCDS traffic model represents the average volume of messages received and transmitted by the NCCDS during a nominal day. The traffic model has been derived from an analysis [3] of message flows covering typical SN request scenarios. The messages are divided in six main groups (Figure 3): schedule related messages, performance related messages, acquisition data messages, configuration related messages, Restricted Access Processor (RAP) monitoring messages and communication test messages, and acknowledgment messages. The grouping is related to the processes performed on the messages.

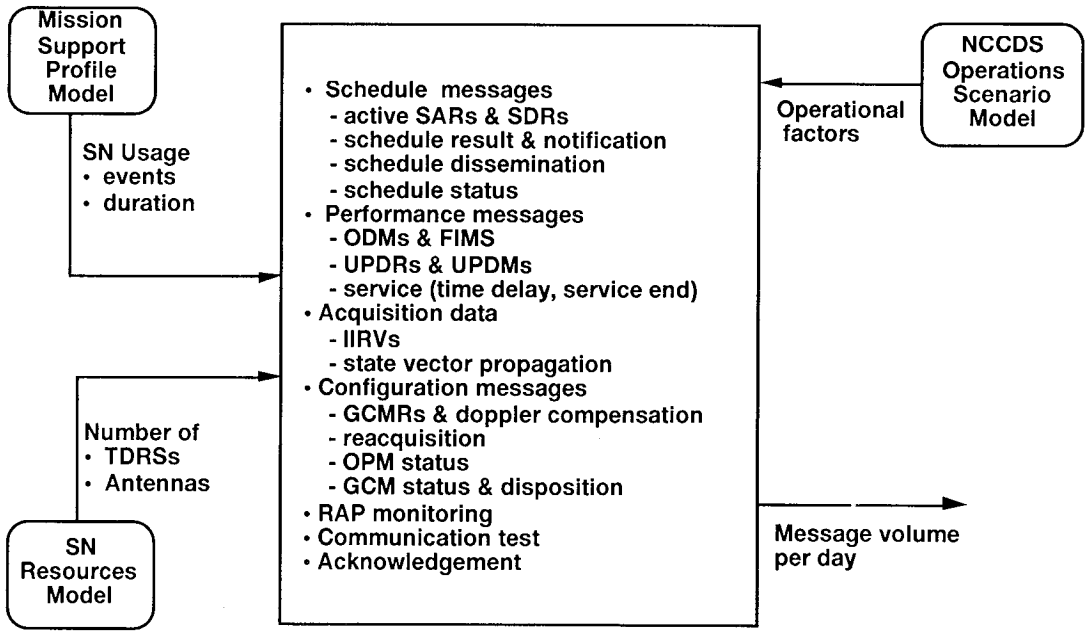

Figure-3 Traffic Model

The model of the NCCDS operations includes two classes of processes (Figure 4): functions initiated by the arrival of a message (i.e., data driven processes), and functions initiated by commands of the operator or NCCDS procedures (i.e., procedure driven processes). The first class of processes is directly driven by the average daily volume of messages computed by the NCCDS traffic model. The operators commands or NCCDS procedures that initiate the second class of processes is represented with a set of operational parameters which indicates the number of initiation per day for each process.

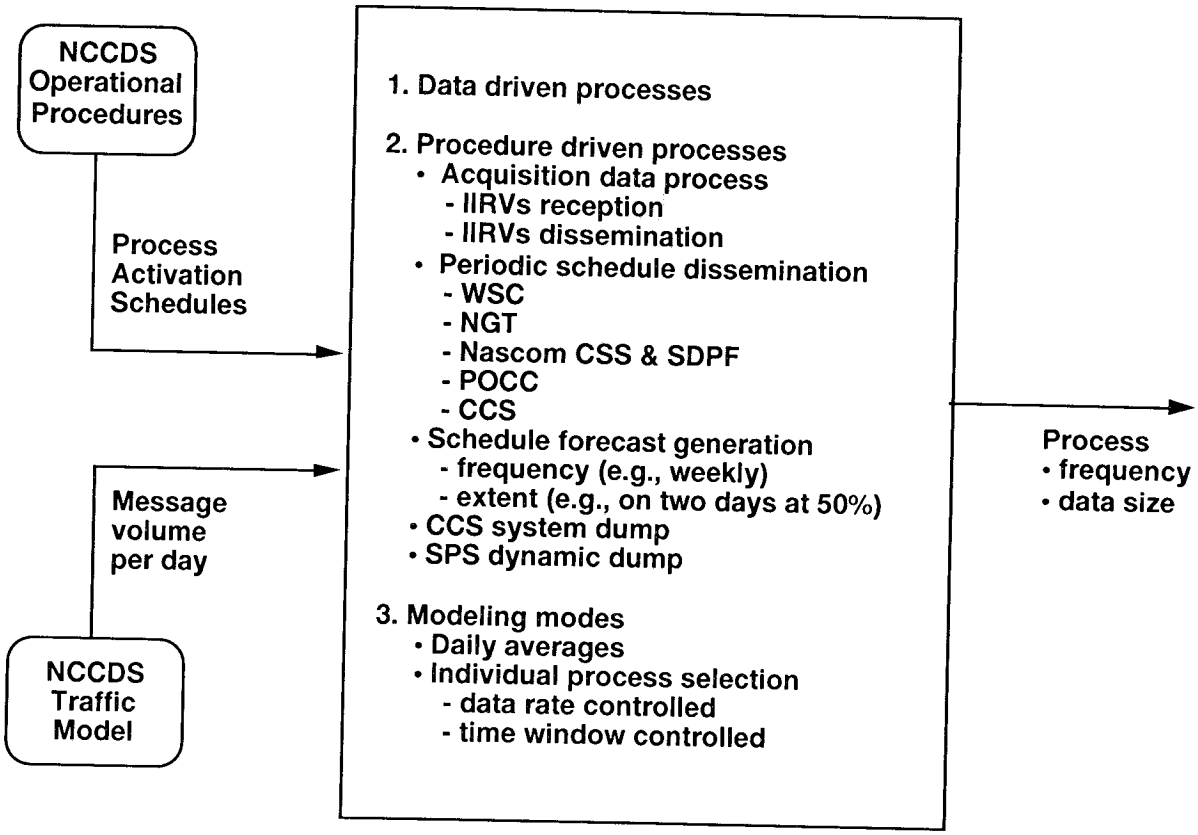

Figure-4 Operational Model

The NCCDS processes model provides the framework for generating the loads of the NCCDS resources from the message volumes computed by the NCCDS traffic model. It represents the actual activities which the NCCDS performs to process each message. Figure 5 is an example of the representation of performance related messages processing.

The NCCDS configuration model represents the NCCDS processing resources (i.e., CPUs and OSs, LANs and protocols, and data storages). It also includes the allocation of the NCCDS process to the resources.

MODEL IMPLEMENTATION

The NCCDS performance model has been implemented by means of two computational packages

running on a PC: a spreadsheet (e.g., LOTUS 1.2.3. or EXCEL) and the Automated Distributed Architecture Modeling tool (ADAM) which is an analytical queuing modeling tool. The reason for splitting the implementation on two packages was to minimize the model development effort and cost.

The spreadsheet component implements the mission support model, the SN resources model, the traffic model, and the operational model. It includes a representation of the process model and generates the parameter values which are input to ADAM.

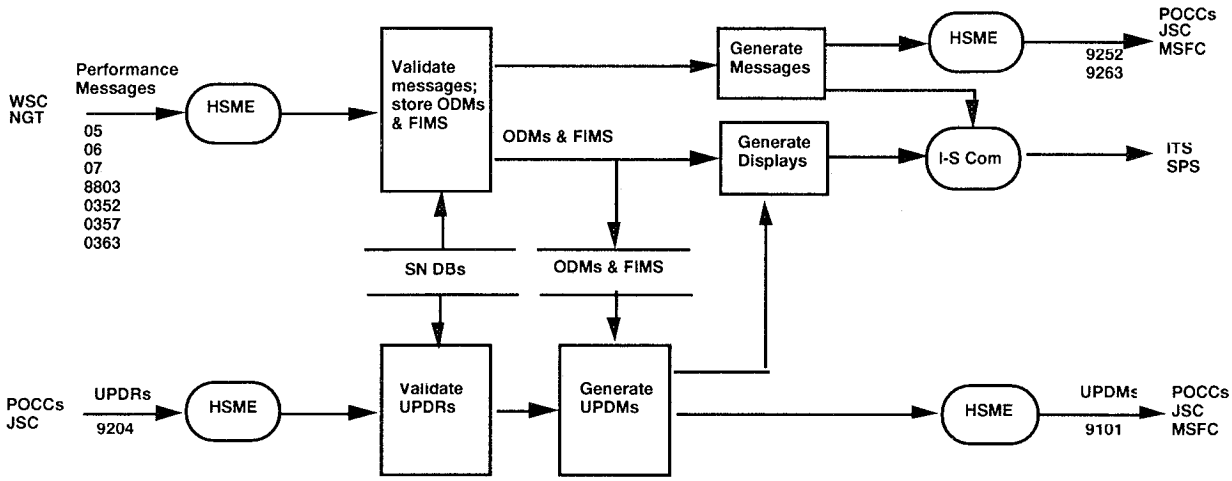

Figure-5 Performance Message Processing

ADAM [4] has been developed by Computer Sciences Corporation for assessing distributed architectures. Figure 6 illustrates ADAM structure.

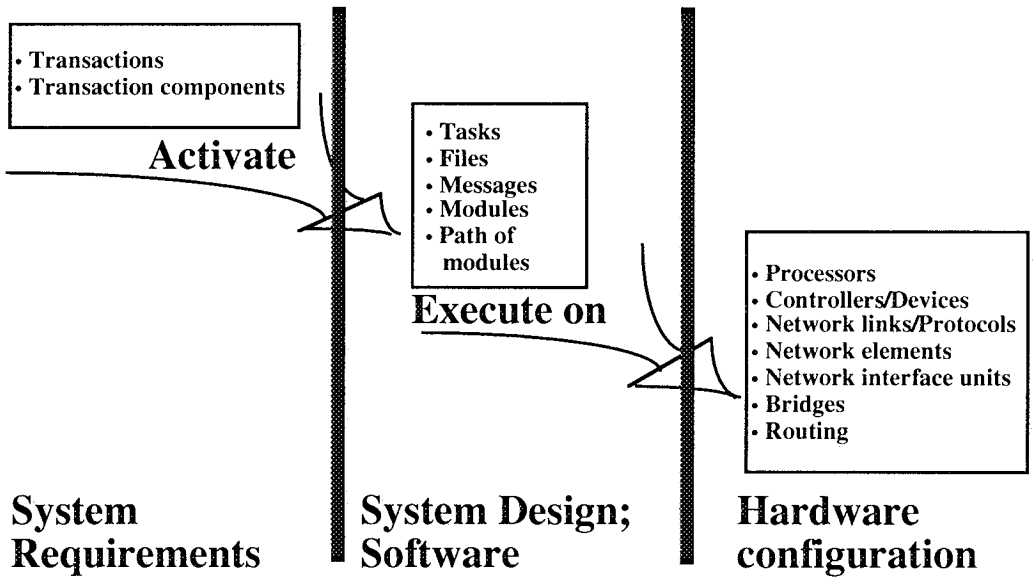

Figure-6 ADAM Structure

ADAM includes a representation of the traffic model (transaction components), of the processes (software components) and of the hardware configuration. The three representations are linked by means of allocation references from which the program computes resources workload and utilization, and service and latency times.

MODEL RESULTS

Input to the model are the characteristics of the missions which use SN services, of the SN resources configuration, and of the NCC operational procedures. The model provides traffic loads, potential bottlenecks, and message service and response times.

To date we have successfully calibrated the baseline NCCDS model representing the current equipment configuration and the data system functions. We have used actual SN resource requests [5] as input to the model and compared the model results with the results of performance monitoring executed on the operational NCCDS facility during the same period of time [6]. The CPU utilization computed by the model was 12% for CCS and 16% for SPS. This compares with monitoring measurements of 14% and 18% respectively.

We have started analysis of future SN resource requests scenarios. Figure 7 shows the CPU utilization of the CCS and the SPS when processing the workload generated by three different hypothetical mission scenarios. The SN resources (two TDRSSs) are used with 1000, 2000, and 3000 TDRSS contacts per week by 10 nominal missions. The scenario assumes a worst case day in which the Space Transportation System (STS) is flying and forecast schedule generation is also performed.

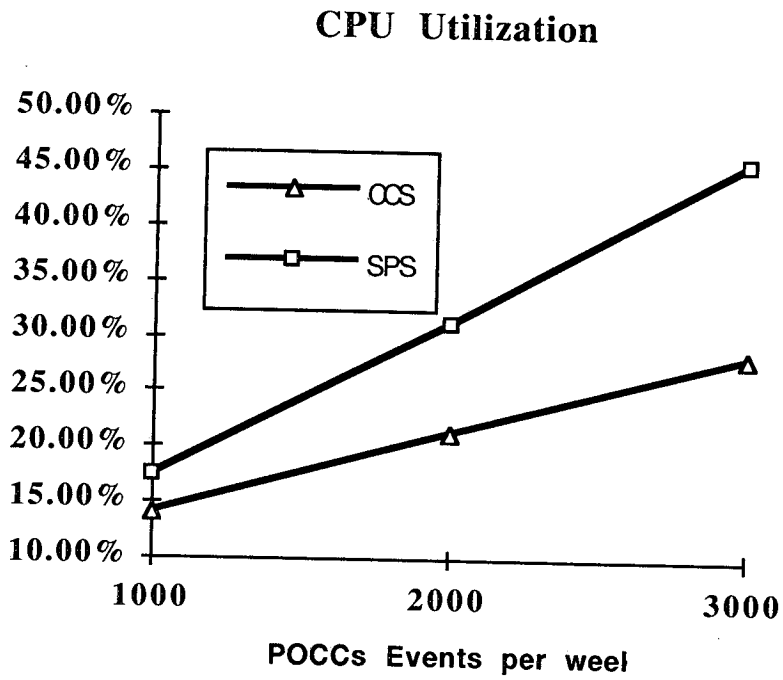

Figure-7 Model Results

The NCCDS performance model will be used for the assessment of the performance characteristics related to various uses of the Space Network services, and alternative configurations of CCS and SPS.

REFERENCES

1. Network Control Center Data System (NCCDS) Detailed Requirements, 530-DRD-NCCDS, November 1993.

2. NCCDS Performance Model - Model Requirements Specification, Contract NAS 5-31500, CSC/TA 33-600-A2, May 1993.

3. NCC Message Traffic Flow Analysis, TR 92014, September 1992.

4. Automated Distributed Architecture Modeling (ADAM). User's Guide, Contract NAS 1-17757, CSC/TM-87/6074, Version 2.0, January 1988.

5. NCC Summary of STDN Operations, December 1993.

6. Operation Data for STS Schedule Generation and Mission Launch: Periods 8/30/93 through 12/3/93.