ENGINEERING TECHNOLOGY FOR NETWORKS

PROGRESS REPORT
July 31, 1991

Submitted to:

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

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Submitted by:

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1. INTRODUCTION

In January 1990, the National Aeronautics and Space Administration (NASA) renewed its grant with Center for Systems Engineering and Computing (CSEC), Howard University. This new Grant [No.: NAG 5 995] has as its primary focus 'space network (SN) modeling and evaluation'. A secondary objective is to develop a research and training capability in systems engineering at Howard University which directly relates to NASA's needs.

This document reports on the activities conducted and the results achieved by CSEC, under the referenced grant, during the period February 1, 1991 through July 31, 1991.

2. PROJECT OBJECTIVES AND PLANS

2.1 SHORT-TERM PLANS FOR SPACE NETWORK MODELING AND EVALUATION

A research plan has been developed for space network modeling and evaluation. This plan spans the period January 1990 through December 1992 and includes the following tasks:

- Network Modeling
  - Developing Measures and Metrics for the SN
  - Modeling of the Network Control Center (NCC)
  - Using Knowledge Acquired form the NCC to Model the SNC
  - Modeling the SN
- Space Network Resource Scheduling.

2.1.1 TASK ONE: NETWORK MODELING

A. Technical Objective - The objective of this task is to investigate the overall behavior of the Space Network (SN) ground segments, subjected to the introduction of a new network element, through simulation and modeling.

The result of such a modeling effort will provide a means by which emerging systems engineering technologies potentially applicable to the SN ground segments could be evaluated and assessed.

B. Background - At present, there exists no established mechanism to evaluate emerging systems engineering technologies or concepts for the NCC, the White Sands Ground Terminal (WSGT), and the NASA Ground Terminal (NGT). During the next decade, all of these ground elements of the SN will undergo significant changes in order to improve user services. These improvements will be accomplished using new and emerging technologies. Methods and techniques are clearly needed to evaluate and assess candidate technologies. Future systems, such as the Advanced Tracking and Data Relay Satellite (ATDRS), the Second TDRSS Ground Terminal (STGT), and the Space Network Center (SNC) will benefit from this research.

C. Approach - The primary emphasis on the systematic approach to network technology assessment is the use of quantitative techniques. First, a set of measures/metrics, which will permit one to assess the state of a network with regard to its performance, reliability, service capacity, configuration optimality, and other characteristics must be identified and described. This set must then be carefully analyzed to ensure that the metrics are not coupled and are independent of each other. Next, using the defined metrics, the SN ground segment will be modeled to obtain the "baseline" data.

This modeling will be carried out using a comprehensive simulation tool such as Data Systems Dynamic Simulator (DSDS) and Optimized Network Engineering Tools (OPNET). The developed model will be refined to increase the simulation fidelity and calibrate using "observed" data. Candidate technologies, such as the new INTEL 80486 processors for a new data formatter or the "Black Box" alternative to fulfill the STGT capabilities at the NCC, could be assessed and evaluated using this model. The results from such assessments will be invaluable to the decision-making process of introducing new features into the SN. With two sets of data quantitatively indicating the "before-and-after" effects of introducing the new technology into the system, a sound technical decision can then be made whether the technology under study should ultimately be implemented as an element of the SN.

D. Milestone Schedule - This task was initiated in May 1990, with personnel from Howard University and Virginia Polytechnic Institute (VPI). The definition of the initial set of metrics has been completed. The SN modeling effort was also initiated in May 1990, with a completion date scheduled for December 1992. Technology assessment phase will begin upon completion of the modeling effort, i.e. in January 1993.

2.1.2 TASK TWO: SN RESOURCE SCHEDULING

A. Technical Objective - The objective of this task is to investigate the SN scheduling problem with the goal of reducing the scheduling requirements of the networks.

B. Background - The current SN is constrained by bandwidth limitation. SN resource scheduling functions currently reside in the NCC, and are clearly separated into forecast and active scheduling periods. Under this task, recently proposed scheduling concepts and existing scheduling systems (military, airlines, other

NASA, telephone companies, and other industry, etc.) will be evaluated to determine potential applicability to the SN scheduling problem. In addition, the basic premise of separating scheduling functions into forecast and active periods will be re-examined from the database design view point.

C. Approach - The research on scheduling will be conducted in five steps, as follows:

(1) The first step is to identify and examine existing scheduling systems and the associated problems that they address. Results of this step will be evaluated to identify concepts, techniques, and algorithms that may be relevant to the SN scheduling problem.

(2) The second step is to scrutinize the existing problem definition and the corresponding functional and technical requirements of the SN scheduling. The schedulable TDRSS resources include: the links, bandwidth, and antennas for both forward and return links for multiple access (MA), S-band single access (SSA), and K-band single access (KSA) services as well as tracking service using one-way doppler and MA and SA two-way range and doppler. If required, modifications will be made to the problem definition and the requirements, in order to fully address the SN scheduling needs of the 90's and beyond.

(3) The third step will be to investigate demand/assignment as an alternative approach to resource scheduling. This approach is somewhat analogous to that used by telephone companies. Included in this area is the possible use of packetized messages wherein a message header is used to route traffic. Of particular interest is the Consultative Committee for Space Date Systems (CCSDS) recommendation for space data system standards. A primary CCSDS Path service objective is the optimization of the utilization of space channel bandwidth. The basic unit of transmission for CCSDS Path service data is the CCSDS packet.

(4) The fourth step is to examine all the proposed techniques in the area of generic scheduling. These techniques will include the use of Network Planning and Analysis System (NPAS) as a prescheduler; the Resource Management/Decision Support System (RM/DSS) from Information Sciences, Inc.; Jet Propulsion Laboratory's (JPL's) RALPH System; and Goddard Space Flight Center (GSFC) Code 520's ROSE algorithm.

(5) The fifth step is to develop, if feasible, an overall strategy, procedure, and algorithms for the SN resource scheduling which will encompass both generic and specific scheduling for forecast and active periods. Using the SN model developed under Task 1, the strategy, procedure, and

algorithms can then be tested for their performance and accuracy in a simulated environment.

D. <u>Milestone Schedule</u> - This task was started in May 1990. Steps One and Two which are interrelated were scheduled to be completed by March 1991. Step Three was expected to be completed by December 1991. Steps Four and Five are scheduled to be completed by December 1992 and December 1993, respectively.

2.2 SCOPE OF ACTIVITIES PLANNED FOR THE REPORTING PERIOD

The activities planned for this reporting period included four subtasks as follows:

- Network Modeling

  (1) Updating the measures and metrics for the NCC;
  (2) Upgrading the preliminary models of the NCC;
  (3) Transferring the knowledge and experience gained in modeling the NCC to developing preliminary performance models of the SNC

- Space Network Resource Scheduling

  (4) Researching resource scheduling techniques.

The project is organized with Howard University as the prime grantee and VPI as the subgrantee. Howard has primary responsibility for Subtasks Two: developing preliminary models of the NCC and Subtask Three: transferring the knowledge and experience gained in modeling the NCC to developing preliminary performance models of the SNC; VPI has primary responsibility for Subtask Four: researching resource scheduling techniques; and Howard and VPI share responsibility for Subtask One: defining an initial set of measures and metrics for the NCC.

3. DETAILED ACTIVITIES CONDUCTED DURING THE REPORTING PERIOD [FEBRUARY 1 THROUGH JULY 31, 1991]

3.1 PROJECT PLANNING AND REVIEW

- Conducted weekly planning and working meetings with the Technical Officer at the ND. A copy of the milestone chart is presented in Appendix A;
- Conducted weekly planning and technical meetings of the technical staff at Howard;
- Conducted periodic planning and technical meetings and

discussions with VPI; and

- Conducted periodic meetings with the Technical Officer and other managers of the ND.

3.2 MEASURES AND METRICS

- Updated the measures and metrics selected for the NCC. A proposed set of measures is included as Appendix B.

3.3 MODELING

- Conducted extensive reviews of the technical literature to clearly understand the operations and information flow patterns of the NCC;

- Conducted discussions and meetings with technical personnel within ND in an attempt to characterize the NCC;

- Updated separate message manuals for internal and external messages of the NCC. Copies of these manuals are included as Appendix C;

- Upgraded the preliminary model of the NCC using OPNET. Specific tasks included:

    (1) Specifying the level of detail of the model--determining which specific processors will be modeled;

    (2) Designing network base models [Ethernet/TCP/IP];

    (3) Developing node and process models for Ethernet media access and TCP/IP;

    (4) Testing base models;

    (5) Evaluating runtime performance of base models;

    (6) Reducing the complexity of the base models to improve runtime;

    (7) Designing the top level models, using the base models;

    (8) Characterizing the workload in terms of message generation, message processing and network services;

    (9) Developing message format;

    (10) Developing message generation and message processing algorithms and models;

(11) Testing message generation/processing models;

(12) Testing complete model with test data; and

(13) Testing model with actual data.

- Made a technical presentation on the project activities to personnel of the ND. An outline of the presentation is included as Appendix D;
- Provided support to the staff of Code 532 in connection with a technical review of this project at the division level;
- Compiled information on the NCC in support of the modeling effort; and
- Compiled information on the SN in support of future modeling activities.

3.4 APPLICATION TO SNC

- Held periodic discussions with the project manager to stay up to date on developments in the design of the SNC.

3.5 RESOURCE SCHEDULING TECHNIQUES

- Conducted a preliminary review of the literature on resource scheduling techniques. Papers developed by VPI in that regard are presented in Appendix E.

3.6 ACHIEVEMENT OF ANCILLARY OBJECTIVES

- This project provided partial support to two faculty at Howard and one at VPI;
- It supported two graduate and one undergraduate students at Howard and one graduate student at VPI; and
- Two graduating students from the Systems and Computer Science Department, Howard University were interviewed by senior staff for possible positions with the ND.

APPENDIX A: MILESTONE CHART

ORIG. SCHED. DATE: 6/27/91
LAST SCHED. CHANGE: 9/23/91
STATUS AS OF: 9/23/91
RESPONSIBILITY: E. RICHMOND/532

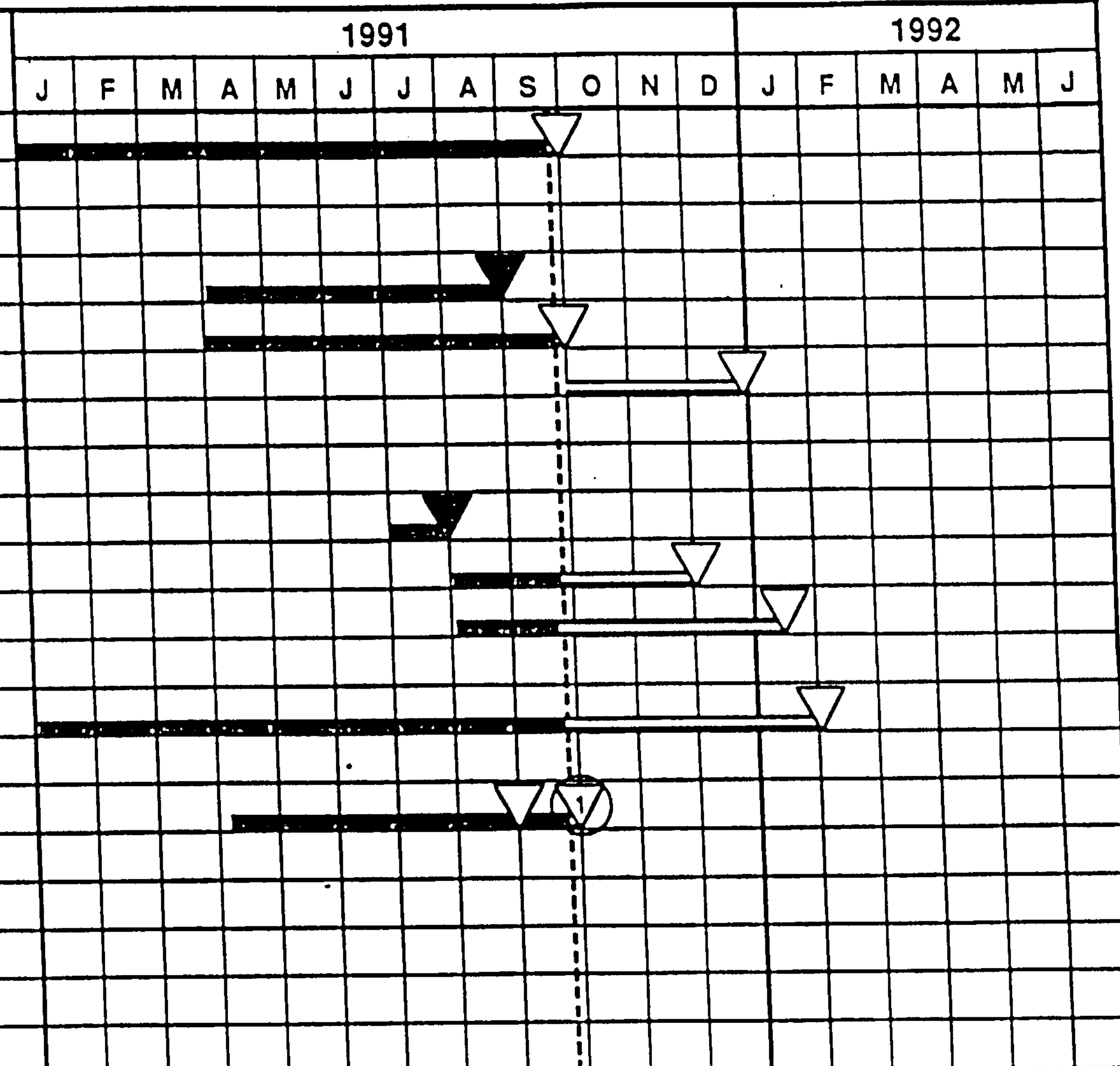
NETWORK CONTROL SYSTEMS BRANCH/532

Howard U.: SN MESSAGE FLOW MODELING

Phase 1: NCC Model

LEVEL 3

	MILESTONES
1	DOCUMENT NCC (internal/external) MESSAGES
2	
3	*DESIGN & DEVELOP NCC MODEL*
4	EXTERNAL MESSAGE DRIVER
5	NCC SUBSYSTEMS MODELS(CCS, SPS, ITS)
6	INTEGRATE & VALIDATE SUBMODELS
7	
8	*DESIGN & DEVELOP DYNAMIC GRAPH. I/F*
9	DESIGN INTERFACE
10	PROTOTYPE USER INTERFACE
11	DEVELOP INTERFACE
12	
13	DERIVE PERFORMANCE METRICS
14	
15	DEVELOP MESSAGE FREQUENCY PROFILE
16	
17	
18	
19	
20	



NOTE: LINE 15: WAIT UNTIL STS-48 COMPLETION TO MAKE PRODUCTION RUNS USING CCS LOG TAPES.

APPENDIX B: MEASURES AND METRICS

1. MEASURES OF PERFORMANCE FOR THE NETWORK CONTROL CENTER

The suggested scheme for measuring the performance of the Network Control Center (NCC) incorporates two types of indicators:

1. Indicators of <u>the quality of the product/service</u> i.e. the 'quality' of the schedules produced by the NCC and/or the 'quality' of the service to the users, and

2. Indicators of the NCC's <u>operational effectiveness</u> i.e. its 'effectiveness' in processing requests, developing schedules, and disseminating results

1.1 INDICATORS OF THE QUALITY OF THE PRODUCT/SERVICE

The following are suggested as indicators of the quality of the product/service provided by the NCC:

- Availability of each schedulable resource
- Utilization of the available Space Network (SN) resources
- Percentage of all requests satisfied
- Percentage of requests for SN resources satisfied
- Percentage of emergency requests accepted
- Frequency of unrequested changes to the users requests for SN resources

1.2 INDICATORS OF THE NCC'S OPERATIONAL EFFECTIVENESS

The NCC has established specific quantifiable requirements that it must achieve in providing services to SN users. These requirements have been analyzed as a basis for selecting the following indicators of the operational effectiveness of the NCC:

1.2.1 Utilization of NCC's Communications Capacity

- Average communications capacity utilized by incoming messages (single user).
- Percentage of times that incoming messages (single user) exceeds 56 kilobits per second.
- Average communications capacity utilized by incoming messages multiple user.
- Percentage of times that incoming messages (multiple user) exceeds 112 kilobits per second.

- Average communications capacity utilized by outgoing messages (single user).
- Percentage of times that outgoing messages (single user) exceeds 56 kilobits per second.
- Average communications capacity utilized by outgoing messages multiple user.
- Percentage of times that outgoing messages

(multiple user) exceeds 112 kilobits per second.

1.2.2 Acknowledgements and Response Time

- Percentage of times the NCC fails to send response to originator of specific schedule request within one (1) minute of receipt of request.
- Percentage of times the NCC fails to schedule an event or identify all conflicting events within 25 seconds of receipt of a request.
- Percentage of times the NCC's search for a substitute event exceeds (2) minutes.

1.2.3 Specific Requests Processing

- Average Processing Time for Specific Schedule Requests (Seconds).
- Percentage of time that a single event: add, delete, or cancel request without NCC operator intervention exceeds 25 Seconds.
- Percentage of time that a replace request without NCC operation intervention takes more than 50 seconds.
- Percentage of time that a multiple time shift request without NCC operation intervention exceeds 50 seconds times the number of events processed.
- Percentage of time that a multiple delete or a multiple cancel request without NCC operation intervention exceeds 25 seconds times the number of events processed.
- Percentage of time the search for an event that is affected by a change in predicted spacecraft visibility exceeds five (5) seconds.
- Percentage of times a reconfiguration message transmitted to the SN element and the SDPF, or a rejection message to a valid configuration request takes more than five (5) seconds.
- Percentage of times NCC's transmittal of performance data to a users exceeds eight (8) seconds from the time it is received in an ODM or FIMS message.

1.2.4 Other Operational Effectiveness Measures

The following are suggested as indicators of the operational effectiveness of the NCC:

- Overall Average processing time--all requests
- Average processing time at CCS--all requests
- Average processing time at ITS--all requests
- Average processing time at SPS--all requests

- Overall Average delay--all requests
- Average delay at CCS--all requests
- Average delay at ITS--all requests
- Average delay at SPS--all requests

- Overall Average processing time--all Responses
- Overall Average delay--all Responses

- Overall Average Utilization--all Subsystems (CCS, ITS, SPS)
- Average utilization--CCS
- Average utilization--ITS
- Average utilization--SPS

- Average Time to compose the active schedule
- The average number of requests process per unit of time
- Processing time for emergency requests

- LAN Utilization, etc.
- Others

APPENDIX C: MESSAGE MANUALS

1. INTRODUCTION

The NCC is an element of the National Aeronautics and Space Administration (NASA) Spaceflight Tracking and Data Network (STDN). The STDN is a network that uses a Tracking and Data Relay Satellite System (TDRSS) as the primary source of support for orbiting spacecraft. The new STDN consists of a relay satellite system and several ground stations. All of the STDN ground stations are linked to the NCC at Goddard Space Flight Center (GSFC) which serves as the central control facility of the STDN. The NCC is responsible for network scheduling, acquisition and tracking support, data quality assurance, performance monitoring, overall coordination of STDN.

This document will serve to list and describe the internal messages of the NCC, and the external message passed between the NCC and the ground stations. Seven ground stations make up the system, they are:

1) Flight Dynamics Facility (FDF)
2) Johnson Space Center (JSC)
3) NASA Communication Network (NASCOM)
4) NASA Ground Terminal (NGT)
5) Payload Operations Control Center (POCC)
6) Sensor Data Processing Facility (SDPF)
7) White Sands round Terminal (WSGT)

All messages entering and leaving the NCC will be grouped by segments. To perform the functions of Service Planning., Control, and Assurance for the SN, the NCC will require the capability to communicate by high speed messages, secure facsimile, voice, and teletype. The primary mode of communication will be high speed messages and the others serve as supplementary and/or backup communication capability.

2. BACKGROUND

High Speed Messages

The NCCDS has the capability of receiving and transmitting (both automatically and in response to operator request) formatted high speed data messages via secured and non-secure communications circuits. All incoming and outgoing messages are in the standard NASCOM 4800-bit block format, as defined in NASCOM Interface Standard for Digital Data Transmission (NISDDT).

Message Handling Requirements

NCC requirements for handling electronic messages are as follows:

1. Acknowledgement

As specified in the applicable interface control documentation, the NCCDS shall determine whether incoming messages have been received correctly or in error. For correctly received messages that indicate that an acknowledgement is requested , the NCCDS shall transmit an acknowledgement with in 2 seconds of receipt. Messages received in error shall not be acknowledged. The NCCDS shall check each correctly received message to determine if is a retransmitted message. If so the NCCDS shall determine if a previous transmission of the same message has been correctly received. If so the retransmitted message will be acknowledged but shall not be otherwise processed.

2. Validation Checking

As specified in the preceding sections, the NCCDS will have the capability to detect invalid messages, alert the operator, and selectively log the message.

3. Message Routing. The NCCDS shall:

Automatically route correctly received incoming messages to the appropriate functions/positions. When a destination function or position is temporarily unavailable, the NCCDS shall retain correctly received incoming messages for routing to that function or position at a later time. The NCCDS shall be capable of retaining each such message for at least two hours. Within 5 seconds of the System Supervisor's (SS) request, the NCCDS shall present a summary of such retained messages. Retained messages shall be summarized by source, type, and class. The NCCDS shall provide the SS with capability to selectively purge such retained messages by specifying one or more of source, type, class, and appropriate time related parameters (e.g requested event start time in a specific schedule add request). Send and receive all high-speed messages to and from unsecured facilities through the RAP subsystem that is currently prime.

For each secured facility having a high-speed message interface with the NCC, send and receive all high-speed messages to and from that facility using the protected circuit dedicated to that interface.

4. Message Metering

The NCCDS shall be capable of metering the transmission of high speed message blocks so that the transmission rate to any destination does not exceed the maximum rate specified for that destination. The maximum transmission rate for each destination will be specified in terms of a minimum time interval between the initiation of the transmission of two successive high speed message blocks to that destination. For all messages except stand-alone acknowledgements, the NCCDS's message block transmission algorithm shall use these specified minimum time intervals to control the initiation of message transmissions to each destination. Stand-alone acknowledgement messages may be transmitted as soon as generated.

5. Message Logging.

The NCCDS shall be capable of controlling the logging and delogging of all incoming and outgoing messages from a central pint under operator control. Specific logging requirements are contained in section 8 STDN 203.13.

6. Retransmission

As specified by the applicable interface control documentation, the NCCDS shall be capable of formatting outgoing messages to indicate that acknowledgement is requested. For messages for which acknowledgement is not received within 5 seconds of transmission the NCCDS shall retransmit the message. The message shall indicate that it is a retransmission. If acknowledgement of the first retransmission is not received within 5 seconds of retransmission the NCCDS shall retransmit the message a second time. If acknowledgement of the second retransmission of a message is not received within 5 seconds of retransmission, the NCCDS shall send action alerts to the NCC console operator responsible for the acknowledged message and to the SS.

7. Acknowledgement Reporting

In all instances where the transmission of an individual high-speed message is initiated by, or requested by an NCC operator, the NCCDS shall, within 5 seconds of receipt of the acknowledgement of the transmission, present an information alert to the originating console operator.

In those instances where the transmission of a stream, sequence, or batch of high-speed messages is originated by, or requested by a NCC console operator, the NCCDS will report the receipt of acknowledgements as specified elsewhere in this document.

3. EXTERNAL MESSAGES

3.1 EXTERNAL MESSAGES BETWEEN NCC AND FDF

The FDF provides orbit-related data for unclassified spaceflight missions from early planning through to end of the operational phase. The FDF is responsible for receiving, validating (in real time), calibrating, and archiving STDN tracking data. Based on tracking data received, the FDF will provide the spacecraft/payload NASA transponder frequency history to each user. The FDF provides orbit data used in developing trajectory information, acquisition data, and scheduling aids. For each spacecraft, the FDF generates a predicted spacecraft view period for station, where a station may be a TDRS or GN site. The FDF also acts as the operations control center for the Bilateral Transponder System (BTRS). The NCC request additional data when needed.

MESSAGE NAME : IMPROVED INTERRANGE VECTORS (IIRV) - INFLIGHT

ORIGINATION : FDF DESTINATION : NCC

TYPE/CLASS : 03/09

MESSAGE LENGTH : 1 FREQUENCY :

GROUP : OPM

DESCRIPTION : Details the forces which perturb the spacecraft's orbit.

MESSAGE NAME : USER ORBIT PREDICTION FORCE MODEL

ORIGINATION : FDF DESTINATION : NCC

TYPE/CLASS : 03/09

MESSAGE LENGTH : 1 FREQUENCY :

GROUP :

DESCRIPTION : This message provides the capability to define a subset of the user orbit prediction force model by specifying which components of the force model are to be used.

MESSAGE NAME : USER PREDICTION

ORIGINATION : FDF DESTINATION : NCC

TYPE/CLASS : 03/09

MESSAGE LENGTH : 1 FREQUENCY :

GROUP : OPM

DESCRIPTION : Details the forces which perturb the spacecraft's orbit.

MESSAGE NAME : IMPROVED INTERRANGE VECTORS (IIRV) - NOMINAL

ORIGINATION : FDF DESTINATION : NCC

TYPE/CLASS : 03/10

MESSAGE LENGTH : 1 FREQUENCY :

GROUP : OPM

DESCRIPTION : Provides spacecraft position and velocity vectors to used in scheduling.

MESSAGE NAME : IMPROVED INTERRANGE VECTOR MESSAGE (IIRV)

ORIGINATION : FDF DESTINATION : NCC

TYPE/CLASS : 03/10

MESSAGE LENGTH : 1 FREQUENCY :

GROUP : OPM

DESCRIPTION : An IIRV contains the spacecraft position and velocity vectors for the given epoch time, the IIRV also contains information indicating whether it is a nominal or real-time message.

MESSAGE NAME	:	IMPROVED INTERRANGE VECTORS (IIRV) - INFLIGHT			
ORIGINATION	:	FDF	DESTINATION	:	NCC
TYPE/CLASS	:	03/15			
MESSAGE LENGTH	:	1	FREQUENCY	:	
GROUP	:	OPM			
DESCRIPTION	:	Provides spacecraft position and vectors to be used in scheduling.			

MESSAGE NAME	:	ACKNOWLEDGEMENT			
ORIGINATION	:	FDF	DESTINATION	:	NCC
TYPE/CLASS	:	03/60			
MESSAGE LENGTH	:	1	FREQUENCY	:	
GROUP	:				
DESCRIPTION	:	Sent upon the reception of a complete message requiring an acknowledgement.			

MESSAGE NAME	:	COMMUNICATION TEST			
ORIGINATION	:	FDF	DESTINATION	:	NCC
TYPE/CLASS	:	91/03			
MESSAGE LENGTH	:	1	FREQUENCY	:	
GROUP	:				
DESCRIPTION	:	Used to verify the existence of an operational communication link.			

MESSAGE NAME : ACKNOWLEDGEMENT

ORIGINATION : NCC DESTINATION : FDF

TYPE/CLASS : 03/14

MESSAGE LENGTH : 1 FREQUENCY :

GROUP :

DESCRIPTION : Sent upon reception of a complete message requiring an acknowledgement.

MESSAGE NAME : COMMUNICATION TEST

ORIGINATION : NCC DESTINATION : FDF

TYPE/CLASS : 91/03

MESSAGE LENGTH : 1 FREQUENCY :

GROUP :

DESCRIPTION : Used to verify the existence of an operational communication link.

MESSAGE NAME : ACQUISITION FAILURE NOTIFICATION

ORIGINATION : NCC DESTINATION : FDF

TYPE/CLASS : 92/63

MESSAGE LENGTH : 1 FREQUENCY :

GROUP :

DESCRIPTION : When an attempt to provide a return service requested in a Scheduling Order Data Message (SHO) does not occur due to inability of TDRS to acquire the user spacecraft, an Acquisition Failure Notification is sent from the NCC to FDF.

MESSAGE NAME	:	USER SCHEDULE TRANSMISSION SUMMARY			
ORIGINATION	:	NCC	DESTINATION	:	FDF
TYPE/CLASS	:	94/06			
MESSAGE LENGTH	:	1	FREQUENCY	:	
GROUP	:				
DESCRIPTION	:	This is transmitted by the NCC to the user immediately following the last User Schedule Message in a transmission of the weekly schedule or in response to a schedule retransmission request.			

MESSAGE NAME	:	ACQUISITION DATA REQUEST			
ORIGINATION	:	NCC	DESTINATION	:	FDF
TYPE/CLASS	:	97/01			
MESSAGE LENGTH	:	1	FREQUENCY	:	
GROUP	:				
DESCRIPTION	:	This message is used by the NCC to request additional or missing acquisition data.			

MESSAGE NAME	:	TRACKING AND DATA SCHEDULE			
ORIGINATION	:	NCC	DESTINATION	:	FDF
TYPE/CLASS	:	97/10			
MESSAGE LENGTH	:	1	FREQUENCY	:	
GROUP	:				
DESCRIPTION	:	Schedule for BTRS calibrations.			

MESSAGE NAME : LAUNCH DELAY NOTIFICATION

ORIGINATION : NCC DESTINATION : FDF

TYPE/CLASS : 97/11

MESSAGE LENGTH : 1 FREQUENCY :

GROUP :

DESCRIPTION : In case of delay of an SN-supported launch, the NCC will provide the FDF with a notification of the new launch date/time. The notification of new launch date/time will be transmitted in launch delay notification message format.

MESSAGE NAME : EMERGENCY ROUTINE VERIFICATION SERVICE RECOMMEND.

ORIGINATION : NCC DESTINATION : FDF

TYPE/CLASS : 98/15

MESSAGE LENGTH : 1 FREQUENCY :

GROUP :

DESCRIPTION : Emergency Routine Verification Service Recommendation are transmitted from the NCC, under operator control, to request a user to relinquish a schedule event in order that a service suspected to be faulty may be tested by the TDRS.

MESSAGE NAME	:	SCHEDULE RESULT MESSAGE			
ORIGINATION	:	NCC	DESTINATION	:	FDF
TYPE/CLASS	:	99/02			
MESSAGE LENGTH	:	1	FREQUENCY	:	
GROUP	:				
DESCRIPTION	:	The Schedule Result Message is sent from the NCC to the FDF in response to a Schedule Request. The message describes the results of the NCC processing of an add, delete replace or cancel. The NCC will transmit a message with appropriate code.			

3.1 EXTERNAL MESSAGES BETWEEN NCC AND JSC

The JSC provides command control and systems monitoring capabilities for the Space Transportation System (STS). To support the STS, the MCC is required to interface with NCC to schedule the STDN, NASCOM, and Department of Defense (DOD) resources. The NCC will receive and display performance data and transmit ground control messages requests (GCMR's) that results in certain reconfiguration of the space network.

The NCC will receive performance data from the TDRSS and STGT and provide this information to the MCC once every 5 seconds in the format described in this document. At the MCC, the performance data will be routed to the network communications interface common (NCIC), which performs certain validation checks on the network header, and routes this data to the mission operations computer (MOC). The MOC interprets, formats, and provides performance data for use by the flight control team. Acknowledgement protocol will not be invoked on performance messages.

The JSC will generate GCMR's which results in certain configuration changes in the SN. These GCMR's are generated within the MOC as a result of operator action and are interfaced (in the 4800-bit block form) via MDM. The GCMR's will be routed to the NCC by NASCOM, where certain validation is performed prior to transmission of the corresponding ground control message to the SN. The NCC processing of the GCMR's will be a real-time function. Message protocol will be invoked, and the GCM status and dispositions will be provided by the NCC.

MESSAGE NAME	:	FORWARD LINK EIRP RECONFIGURATION			
ORIGINATION	:	JSC	DESTINATION	:	NCC
TYPE/CLASS	:				
MESSAGE LENGTH	:	1	FREQUENCY	:	
GROUP	:	GCMR			
DESCRIPTION	:	Provides the JSC with the capability to reconfigure the SSA and KSA Forward EIRP between normal and high power mode on the TDRS.			

MESSAGE NAME : FORWARD LINK SWEEP
ORIGINATION : JSC
DESTINATION : NCC
TYPE/CLASS :
FREQUENCY :
MESSAGE LENGTH : 1
GROUP :
DESCRIPTION : Provides the JSC with the capability to request a Forward Link Sweep.

MESSAGE NAME : SPECIFIC SCHEDULE REQUEST MESSAGE
ORIGINATION : JSC
DESTINATION : NCC
TYPE/CLASS :
FREQUENCY :
MESSAGE LENGTH : 1
GROUP :
DESCRIPTION : This is used to add or delete shuttle event for network resources.

MESSAGE NAME : DOPPLER COMPENSATION INHIBIT REQUEST
ORIGINATION : JSC
DESTINATION : NCC
TYPE/CLASS :
FREQUENCY :
MESSAGE LENGTH : 1
GROUP : GCM
DESCRIPTION : Provides the JSC with the capability to inhibit forward link doppler compensation on a specific link.

MESSAGE NAME	:	KSA RETURN LINK			
ORIGINATION	:	JSC	DESTINATION	:	NCC
TYPE/CLASS	:				
MESSAGE LENGTH	:	1	FREQUENCY	:	
GROUP	:				
DESCRIPTION	:	Provides the JSC with the capability to reconfigure the KSA Return Link.			

MESSAGE NAME	:	SSA RETURN LINK			
ORIGINATION	:	JSC	DESTINATION	:	NCC
TYPE/CLASS	:				
MESSAGE LENGTH	:	1	FREQUENCY	:	
GROUP	:	GCMR			
DESCRIPTION	:	Provides the JSC with the capability to reconfigure the SSA Return Link.			

MESSAGE NAME	:	SSA FORWARD			
ORIGINATION	:	JSC	DESTINATION	:	NCC
TYPE/CLASS	:				
MESSAGE LENGTH	:	1	FREQUENCY	:	
GROUP	:	GCMR			
DESCRIPTION	:	Provides the JSC with the capability to reconfigure the SSA Forward Link.			

MESSAGE NAME	:	KSA FORWARD LINK			
ORIGINATION	:	JSC	DESTINATION	:	NCC
TYPE/CLASS	:				
MESSAGE LENGTH	:	1	FREQUENCY	:	
GROUP	:	GCMR			
DESCRIPTION	:	Provides the JSC capability to reconfigure the KSA Forward Link.			

MESSAGE NAME	:	EXPANDED USER FREQUENCY UNCERTAINTY REQUEST			
ORIGINATION	:	JSC	DESTINATION	:	NCC
TYPE/CLASS	:				
MESSAGE LENGTH	:	1	FREQUENCY	:	
GROUP	:	GCMR			
DESCRIPTION	:	Provides the JSC with the capability of expanding the frequency uncertainty of the referenced schedule return event.			

MESSAGE NAME	:	STATUS MESSAGE			
ORIGINATION	:	JSC	DESTINATION	:	NCC
TYPE/CLASS	:				
MESSAGE LENGTH	:	1	FREQUENCY	:	
GROUP	:	OPM			
DESCRIPTION	:	On receipt of GCM the JSC will send an operation planning message to the NCC indicating either that the GCM was rejected or accepted.			

MESSAGE NAME : RECONFIGURATION REQUEST

ORIGINATION : JSC DESTINATION : NCC

TYPE/CLASS :

MESSAGE LENGTH : 1 FREQUENCY :

GROUP : GCMR

DESCRIPTION : These are four messages providing the JSC with the capability to request a reconfiguration to the specified services.

MESSAGE NAME : REACQUISITION REQUEST

ORIGINATION : JSC DESTINATION : NCC

TYPE/CLASS : 98/03

MESSAGE LENGTH : 1 FREQUENCY :

GROUP : GCMR

DESCRIPTION : Provides the JSC with the capability to request reacquisition of service.

MESSAGE NAME : SSA SHUTTLE RETURN SERVICE DQM

ORIGINATION : NCC DESTINATION : JSC

TYPE/CLASS :

MESSAGE LENGTH : 1 FREQUENCY :

GROUP : UPD

DESCRIPTION : Message continuously monitors the quality of data of return data and clock signals.

MESSAGE NAME : KSA SHUTTLE RETURN SERVICE

ORIGINATION : NCC   DESTINATION : JSC

TYPE/CLASS :

MESSAGE LENGTH : 1   FREQUENCY :

GROUP : UPD

DESCRIPTION : This packet contains the operations data for KSA shuttle return services.

MESSAGE NAME : KSA SHUTTLE RETURN SERVICE DQM

ORIGINATION : NCC   DESTINATION : JSC

TYPE/CLASS :

MESSAGE LENGTH : 1   FREQUENCY :

GROUP : UPD

DESCRIPTION : This packet contains DQM data for KSA shuttle return service.

MESSAGE NAME : SSA SHUTTLE RETURN SERVICE MESSAGE

ORIGINATION : NCC   DESTINATION : JSC

TYPE/CLASS :

MESSAGE LENGTH : 1   FREQUENCY :

GROUP : UPD

DESCRIPTION : This service contains the operation data for SSA Shuttle return service.

MESSAGE NAME : KU - BAND ACCESS FORWARD SERVICE

ORIGINATION : NCC DESTINATION : JSC

TYPE/CLASS :

MESSAGE LENGTH : 1 FREQUENCY :

GROUP : UPD

DESCRIPTION : This message contains the operation data for KU -Band access Service.

MESSAGE NAME : S-BAND SINGLE ACCESS FORWARD SERVICE

ORIGINATION : NCC DESTINATION : JSC

TYPE/CLASS :

MESSAGE LENGTH : 1 FREQUENCY :

GROUP : UPD

DESCRIPTION : This packet contains the operation data for a s-band single access forward service.

MESSAGE NAME : SINGLE ACCESS

ORIGINATION : NCC DESTINATION : JSC

TYPE/CLASS :

MESSAGE LENGTH : 1 FREQUENCY :

GROUP : UPD

DESCRIPTION : This is used if the user has an active single access service.

MESSAGE NAME : ACQUISITION FAILURE NOTIFICATION

ORIGINATION : NCC DESTINATION : JSC

TYPE/CLASS :

MESSAGE LENGTH : 1 FREQUENCY :

GROUP : UPD

DESCRIPTION : When TDRS fails to acquire the signal from a user spacecraft, an acquisition failure is sent to the JSC.

MESSAGE NAME : SCHEDULE MESSAGES

ORIGINATION : NCC DESTINATION : JSC

TYPE/CLASS :

MESSAGE LENGTH : 1 FREQUENCY :

GROUP :

DESCRIPTION : This user schedule is generated by the NCC and transmitted to the JSC.

MESSAGE NAME : SCHEDULE RESULT MESSAGE

ORIGINATION : NCC DESTINATION : JSC

TYPE/CLASS :

MESSAGE LENGTH : 1 FREQUENCY :

GROUP :

DESCRIPTION :

MESSAGE NAME	:	GCM STATUS		
ORIGINATION	:	NCC	DESTINATION :	JSC
TYPE/CLASS	:	98/01		
MESSAGE LENGTH	:	1	FREQUENCY :	
GROUP	:	GCM		
DESCRIPTION	:	These messages indicates acceptance or reason for rejection of user transmitted GCMR.		

MESSAGE NAME	:	DISPOSITION MESSAGE		
ORIGINATION	:	NCC	DESTINATION :	JSC
TYPE/CLASS	:	98/02		
MESSAGE LENGTH	:	1	FREQUENCY :	
GROUP	:	GCM		
DESCRIPTION	:	Indication to the TSC of whether or not an acknowledgement was received from the SN.		

3.3 EXTERNAL MESSAGES BETWEEN NCC AND NASCOM

NASCOM provides common carrier communication services among the TDRSS ground segment (including NGT), Johnson Space Center (JSC), and GSFC using a wideband data system interfaced through a Multiplexer/Demultiplexer (MDM) system and a Statistical Multiplexer (SM) system. As part of NASCOM, MDM and SM units are located at the TDRSS ground segment, JSC, and GSFC. The MDM baseline composite transmission service will be 6 mb/sec from NGT and 2.5 mb/sec to the TDRSS ground segment. Spacecraft data with rates up to 2 mb/sec will normally be transmitted from the TDRSS ground segment by MDM. Spacecraft telemetry data with higher rates will be transmitted by the SM which is capable of transmitting up to four channels of data simultaneously with a maximum composite data rate of 48 mb/sec. Data from TDRSS ground segment is transmitted to JSC and GSFC simultaneously. Data to the TDRSS ground segment from GSFC and JSC will be transmitted via the MDM only. In addition, NASCOM provides TV, voice, TTY, and systems control circuits.

NASCOM operates within the STDN in accordance with a schedule provided by the NCC and reconfigures equipment in response to direction from the NCC. NASCOM provides the NCC with the status of services and also provides a postevent performance summary.

NASCOM will also provide multiple 56-kb/sec circuits or a 224-kb/sec circuit among the GN, GSFC, JSC, and the NCC. Additional circuits will be provided to support the communication interfaces among the NCC, GSFC, DOD control centers, and other NASA control centers.

MESSAGE NAME : NASCOM SCHEDULE ACCEPT/REJECT

ORIGINATION : NASCOM DESTINATION : NCC

TYPE/CLASS : 90/03

MESSAGE LENGTH : 1 FREQUENCY :

GROUP :

DESCRIPTION : Used to notify the NCCDS if an event can be supported or not.

MESSAGE NAME : NASCOM RECONFIGURATION ACCEPT/REJECT

ORIGINATION : NASCOM DESTINATION : NCC

TYPE/CLASS : 90/07

MESSAGE LENGTH : 1 FREQUENCY :

GROUP :

DESCRIPTION : Reports to the NCC the acceptance os rejection of an Nascom Reconfiguration request.

MESSAGE NAME	:	NASCOM STREAM STATUS REPORT			
ORIGINATION	:	NASCOM	DESTINATION	:	NCC
TYPE/CLASS	:	90/08			
MESSAGE LENGTH	:	1	FREQUENCY	:	
GROUP	:				
DESCRIPTION	:	Used to report changes in NASCOM data stream status.			

MESSAGE NAME	:	NASCOM COMMUNICATIONS STATUS REPORT			
ORIGINATION	:	NASCOM	DESTINATION	:	NCC
TYPE/CLASS	:	90/09			
MESSAGE LENGTH	:	1	FREQUENCY	:	
GROUP	:				
DESCRIPTION	:	Used to report changes in NASCOM equipment status.			

MESSAGE NAME	:	NASCOM POSTEVENT REPORT			
ORIGINATION	:	NASCOM	DESTINATION	:	NCC
TYPE/CLASS	:	90/10			
MESSAGE LENGTH	:	1	FREQUENCY	:	
GROUP	:				
DESCRIPTION	:	Used to report the performance of every data stream in the event.			

MESSAGE NAME : ACKNOWLEDGEMENT

ORIGINATION : NCC   DESTINATION : NASCOM

TYPE/CLASS : 03/14

MESSAGE LENGTH : 1   FREQUENCY :

GROUP :

DESCRIPTION : Sent upon reception of a complete message requiring an acknowledgement.

MESSAGE NAME : NASCOM EVENT SCHEDULE

ORIGINATION : NCC   DESTINATION : NASCOM

TYPE/CLASS : 90/01

MESSAGE LENGTH : 1   FREQUENCY :

GROUP :

DESCRIPTION : Notifies Nascom of all scheduled services which involve data flow by sending a NES for each event.

MESSAGE NAME : NASCOM EVENT CANCEL

ORIGINATION : NCC   DESTINATION : NASCOM

TYPE/CLASS : 90/02

MESSAGE LENGTH : 1   FREQUENCY :

GROUP :

DESCRIPTION : Notifies Nascom that a pending or active event is canceled.

MESSAGE NAME	:	NASCOM EVENT SCHEDULE UPDATE			
ORIGINATION	:	NCC	DESTINATION	:	NASCOM
TYPE/CLASS	:	90/04			
MESSAGE LENGTH	:	1	FREQUENCY	:	
GROUP	:				
DESCRIPTION	:	Used to notify NCCDS if an event can be supported or not.			

MESSAGE NAME	:	NASCOM EVENT SCHEDULE EMERGENCY			
ORIGINATION	:	NCC	DESTINATION	:	NASCOM
TYPE/CLASS	:	90/05			
MESSAGE LENGTH	:	1	FREQUENCY	:	
GROUP	:				
DESCRIPTION	:	Notifies Nascom of updates to the specified Schedule. NCC will automatically send NESU whenever there is a schedule update greater than 45 minutes.			

MESSAGE NAME	:	NASCOM RECONFIGURATION REQUEST			
ORIGINATION	:	NCC	DESTINATION	:	NASCOM
TYPE/CLASS	:	90/06			
MESSAGE LENGTH	:	1	FREQUENCY	:	
GROUP	:				
DESCRIPTION	:	Used to provide emergency scheduling changes or addition within 45 minutes of the event start time.			

MESSAGE NAME	:	COMMUNICATION TEST MESSAGE			
ORIGINATION	:	NCC	DESTINATION	:	NASCOM
TYPE/CLASS	:	91/03			
MESSAGE LENGTH	:	1	FREQUENCY	:	
GROUP	:				
DESCRIPTION	:	Used to verify the existence of an operational communication link.			

3.4 EXTERNAL MESSAGES BETWEEN NCC AND NGT

The NGT provides the interface between the NASCOM/common carrier and the TDRSS services. The NGT receives schedule messages based upon user requests. The NGT Scheduling System (NSS) schedules and allocates selected NGT resources based on these messages and provides status back to the NCC. The NGT Control and Status System (NCSS) will control and configure the NGT equipment. The NGT also sends data monitoring results and status reports to the NCC. The NCC uses data monitoring results for fault isolation and TDRSS data accountability.

MESSAGE NAME	:	ACKNOWLEDGEMENT			
ORIGINATION	:	NGT	DESTINATION	:	NCC
TYPE/CLASS	:	03/60			
MESSAGE LENGTH	:	1	FREQUENCY	:	
GROUP	:				
DESCRIPTION	:	Sent upon the reception of a complete message requiring an acknowledgement.			

MESSAGE NAME : NGT SCHEDULE SYSTEM-SCHEDULE STATUS

ORIGINATION : NGT DESTINATION : NCC

TYPE/CLASS : 86/51

MESSAGE LENGTH : 1 FREQUENCY :

GROUP :

DESCRIPTION : NSS Schedule Status messages are transmitted by the NGT to the NCC in response to NSS Add and Delete messages. Additional NSS Schedule Status messages are transmitted as necessary to reflect the NGT capability to support a schedule event.

MESSAGE NAME : NGT SCHEDULING SYSTEM- RECONFIGURATION ACC/REJECT

ORIGINATION : NGT DESTINATION : NCC

TYPE/CLASS : 86/54

MESSAGE LENGTH : 1 FREQUENCY :

GROUP :

DESCRIPTION : NSS Reconfiguration Accept/Reject messages are transmitted from NGT to NCC in response to a NGT Service Reconfiguration Request. These messages indicate that the NGT has accepted or rejected the referenced reconfiguration request and if rejected, the reason for rejection.

MESSAGE NAME : FAULT ISOLATION & MONITORING SYSTEM REPORTS

ORIGINATION : NGT DESTINATION : NCC

TYPE/CLASS : 88/03

MESSAGE LENGTH : 11 FREQUENCY : 5

GROUP :

DESCRIPTION : FIMS messages are used to transmit FIMS Data quality information, collected from the channels monitored, to the NCC.

MESSAGE NAME	:	ADMINISTRATIVE MESSAGE			
ORIGINATION	:	NGT	DESTINATION	:	NCC
TYPE/CLASS	:	88/54			
MESSAGE LENGTH	:	1	FREQUENCY	:	
GROUP	:				
DESCRIPTION	:	Administrative message are used to exchange free format alphanumeric text between the NGT and NCC.			

MESSAGE NAME	:	COMMUNICATION TEST MESSAGE			
ORIGINATION	:	NGT	DESTINATION	:	NCC
TYPE/CLASS	:	91/03			
MESSAGE LENGTH	:	1	FREQUENCY	:	
GROUP	:				
DESCRIPTION	:	This is used to verify connection between the NGT and the NCC. When acknowledgements to transmitted messages are not received.			

MESSAGE NAME	:	ACKNOWLEDGEMENT			
ORIGINATION	:	NCC	DESTINATION	:	NGT
TYPE/CLASS	:	03/14			
MESSAGE LENGTH	:	1	FREQUENCY	:	
GROUP	:				
DESCRIPTION	:	Sent upon the reception of a complete message requiring an acknowledgement.			

MESSAGE NAME : NGT SCHEDULING SYSTEM - NORMAL

ORIGINATION : NCC DESTINATION : NGT

TYPE/CLASS : 86/01

MESSAGE LENGTH : 1 FREQUENCY :

GROUP :

DESCRIPTION : NSS Event Add are used to transmit normal event from NCC to NGT when the event start time is more 45 minutes in the future from the time the event was added to the NCC data base.

MESSAGE NAME : SCHEDULING SYSTEM - PREMIUM

ORIGINATION : NCC DESTINATION : NGT

TYPE/CLASS : 86/02

MESSAGE LENGTH : 1 FREQUENCY :

GROUP :

DESCRIPTION : NSS Event Add message is used to transmit emergency schedule events from NCC to the NGT. A schedule event will be transmitted as an emergency event when the start time is less than 45 minutes but more than 5 minutes in the future from the time the event was added to the NCC data base.

MESSAGE NAME : NGT SCHEDULING SYSTEM - EVENT DELETION

ORIGINATION : NCC DESTINATION : NGT

TYPE/CLASS : 86/03

MESSAGE LENGTH : 1 FREQUENCY :

GROUP :

DESCRIPTION : NSS Event Delete messages are used by the NCC to delete events from the NGT schedule. Event may be deleted up to and including the time that they are active.

MESSAGE NAME	:	NGT SCHEDULING SYSTEM - SERVICE RECONFIGURATION			
ORIGINATION	:	NCC	DESTINATION	:	NGT
TYPE/CLASS	:	86/04			
MESSAGE LENGTH	:	1	FREQUENCY	:	
GROUP	:				
DESCRIPTION	:	These messages are sent to the NGT as directives to change one or more data streams within an ongoing service of a user event. The reconfiguration are specified on a service level and are limited to changes to the TDRSS interface channel, data rate and data stream ID for each data with in the service.			

MESSAGE NAME	:	ADMINISTRATIVE			
ORIGINATION	:	NCC	DESTINATION	:	NGT
TYPE/CLASS	:	88/01			
MESSAGE LENGTH	:	1	FREQUENCY	:	
GROUP	:				
DESCRIPTION	:	Administrative messages are used to exchange free text format text from NCC to NGT.			

MESSAGE NAME	:	COMMUNICATION TEST			
ORIGINATION	:	NCC	DESTINATION	:	NGT
TYPE/CLASS	:	91/03			
MESSAGE LENGTH	:	1	FREQUENCY	:	
GROUP	:				
DESCRIPTION	:	Used to verify the existence of an operational communication link.			

3.5 EXTERNAL MESSAGES BETWEEN NCC AND POCC

MESSAGE NAME : ACKNOWLEDGEMENT

ORIGINATION : POCC   DESTINATION : NCC

TYPE/CLASS :

MESSAGE LENGTH : 1   FREQUENCY :

GROUP :

DESCRIPTION : Sent upon the reception of a complete message requiring an acknowledgement.

MESSAGE NAME : COMMUNICATION TEST MESSAGE

ORIGINATION : POCC   DESTINATION : NCC

TYPE/CLASS : 91/03

MESSAGE LENGTH : 1   FREQUENCY :

GROUP : UPD

DESCRIPTION : To test the NCCDS/User POCC communication link.

MESSAGE NAME : USER PERFORMANCE DATA REQUEST

ORIGINATION : POCC   DESTINATION : NCC

TYPE/CLASS : 92/04

MESSAGE LENGTH : 1   FREQUENCY :

GROUP :

DESCRIPTION : Allows user to select or deactivate operation data messages.

MESSAGE NAME : CONFIGURATION CODE ID LIST

ORIGINATION : POCC DESTINATION : NCC

TYPE/CLASS : 93/01

MESSAGE LENGTH : 1 FREQUENCY :

GROUP :

DESCRIPTION :

MESSAGE NAME : REACQUISITION REQUEST

ORIGINATION : POCC DESTINATION : NCC

TYPE/CLASS : 98/03

MESSAGE LENGTH : 1 FREQUENCY :

GROUP : GCMR

DESCRIPTION : Provides the user the capability to request a service compatible link reacquisition procedure.

MESSAGE NAME : USER RECONFIGURATION REQUEST

ORIGINATION : POCC DESTINATION : NCC

TYPE/CLASS : 98/04

MESSAGE LENGTH : 1 FREQUENCY :

GROUP : GCMR

DESCRIPTION : Provides the user the capability to request a reconfiguration of a specified service.

MESSAGE NAME	:	FORWARD LINK SWEEP REQUEST			
ORIGINATION	:	POCC	DESTINATION	:	NCC
TYPE/CLASS	:	98/05			
MESSAGE LENGTH	:	1	FREQUENCY	:	
GROUP	:	GCMR			
DESCRIPTION	:	Provides the user the capability to request a forward link sweep on the designated service.			

MESSAGE NAME	:	FORWARD LINK EIRP			
ORIGINATION	:	POCC	DESTINATION	:	NCC
TYPE/CLASS	:	98/06			
MESSAGE LENGTH	:	1	FREQUENCY	:	
GROUP	:	GCMR			
DESCRIPTION	:	Provides the user the capability to request a reconfiguration of the SSA or KSA forward Link EIRP between normal and high power at TDRSS.			

MESSAGE NAME	:	EXPANDER USER FREQUENCY UNCERTAINTY REQUEST			
ORIGINATION	:	POCC	DESTINATION	:	NCC
TYPE/CLASS	:	98/07			
MESSAGE LENGTH	:	1	FREQUENCY	:	
GROUP	:	GCMR			
DESCRIPTION	:	Provides the user the capability to expand the frequency uncertainty of the referenced ongoing return service.			

MESSAGE NAME : DOPPLER COMPENSATION INHIBIT REQUEST

ORIGINATION : POCC DESTINATION : NCC

TYPE/CLASS : 98/08

MESSAGE LENGTH : 1 FREQUENCY :

GROUP : GCM

DESCRIPTION : Provides the user with the capability to request that Forward Link Doppler Compensation on specified link be inhibited.

MESSAGE NAME : SCHEDULE ADD REQUEST

ORIGINATION : POCC DESTINATION : NCC

TYPE/CLASS : 99/10

MESSAGE LENGTH : 1 FREQUENCY :

GROUP :

DESCRIPTION : Used to request addition of an event to the schedule.

MESSAGE NAME : SCHEDULE DELETE REPORT

ORIGINATION : POCC DESTINATION : NCC

TYPE/CLASS : 99/11

MESSAGE LENGTH : 1 FREQUENCY :

GROUP :

DESCRIPTION : Used by POCC to request deletion of an event from the schedule.

MESSAGE NAME	:	ACKNOWLEDGEMENT			
ORIGINATION	:	NCC	DESTINATION	:	POCC
TYPE/CLASS	:				
MESSAGE LENGTH	:	1	FREQUENCY	:	
GROUP	:				
DESCRIPTION	:	Sent upon the reception of a complete message requiring an acknowledgement.			

MESSAGE NAME	:	SN OPERATION DATA MESSAGE			
ORIGINATION	:	NCC	DESTINATION	:	POCC
TYPE/CLASS	:	91/03			
MESSAGE LENGTH	:	1	FREQUENCY	:	5
GROUP	:	OPM			
DESCRIPTION	:	These messages are sent to the users when event support is ongoing. This is sent for a spacecraft or vehicle.			

MESSAGE NAME	:	Communication Test Message			
ORIGINATION	:	NCC	DESTINATION	:	POCC
TYPE/CLASS	:	91/03			
MESSAGE LENGTH	:	1	FREQUENCY	:	
GROUP	:	UPD			
DESCRIPTION	:	Used to verify the communication link between the NCC and the POCC.			

MESSAGE NAME : RETURN CHANNEL TIME DELAY DATA

ORIGINATION : NCC DESTINATION : POCC

TYPE/CLASS : 92/52

MESSAGE LENGTH : 1 FREQUENCY :

GROUP :

DESCRIPTION : Used to transmit return channel time delay measurement data from NCC to user.

MESSAGE NAME : RETURN CHANNEL TIME DELAY MEASUREMENT ME

ORIGINATION : NCC DESTINATION : POCC

TYPE/CLASS : 92/62

MESSAGE LENGTH : 1 FREQUENCY :

GROUP :

DESCRIPTION : Used to transmit return channel time delay measurement data, range zero set, and range extractor unit measurements from the NCC to the POCCS.

MESSAGE NAME : ACQUISITION FAILURE NOTIFICATION

ORIGINATION : NCC DESTINATION : POCC

TYPE/CLASS : 92/63

MESSAGE LENGTH : 1 FREQUENCY :

GROUP :

DESCRIPTION : Notifies the user that return services did not occur due to the in ability of TDRSS to acquire user spacecraft.

MESSAGE NAME	:	TIME TRANSFER			
ORIGINATION	:	NCC	DESTINATION	:	POCC
TYPE/CLASS	:	92/66			
MESSAGE LENGTH	:	1	FREQUENCY	:	
GROUP	:				
DESCRIPTION	:	Used to transmit time transfer data from NCC to user.			

MESSAGE NAME	:	CONFIRM NORMAL SCHEDULE			
ORIGINATION	:	NCC	DESTINATION	:	POCC
TYPE/CLASS	:	94/01			
MESSAGE LENGTH	:	1	FREQUENCY	:	
GROUP	:				
DESCRIPTION	:	Generated for Forecast Week transmission or when nonemergency add executed during active time frame.			

MESSAGE NAME	:	CONFIRM PREMIUM SUPPORT SCHEDULE			
ORIGINATION	:	NCC	DESTINATION	:	POCC
TYPE/CLASS	:	94/02			
MESSAGE LENGTH	:	1	FREQUENCY	:	
GROUP	:				
DESCRIPTION	:	Generated when a schedule add is executed within 45 minutes of event start time.			

MESSAGE NAME : CONFIRM SIMULATION SCHEDULE

ORIGINATION : NCC DESTINATION : POCC

TYPE/CLASS : 94/03

MESSAGE LENGTH : 1 FREQUENCY :

GROUP :

DESCRIPTION : Generated when simulation event is added an active time frame.

MESSAGE NAME : GCM STATUS MESSAGE

ORIGINATION : NCC DESTINATION : POCC

TYPE/CLASS : 98/01

MESSAGE LENGTH : 1 FREQUENCY :

GROUP : GCM

DESCRIPTION : Generated when GCMR receipt acknowledgement received or when Operation Message (OPM) status acceptance/rejection message SN site.

MESSAGE NAME : GCM DISPOSITION

ORIGINATION : NCC DESTINATION : POCC

TYPE/CLASS : 98/02

MESSAGE LENGTH : 1 FREQUENCY :

GROUP : GCM

DESCRIPTION : Transmitted to the user to indicate whether or not an acknowledgement was received from WSGT.

MESSAGE NAME : FREE TEXT MESSAGE

ORIGINATION : NCC   DESTINATION : POCC

TYPE/CLASS : 98/09

MESSAGE LENGTH : 1   FREQUENCY :

GROUP :

DESCRIPTION : Provides the capability for the exchange of free text information between the NCC and secured user.

MESSAGE NAME : SCHEDULE DELETION NOTIFICATION

ORIGINATION : NCC   DESTINATION : POCC

TYPE/CLASS : 99/01

MESSAGE LENGTH : 1   FREQUENCY :

GROUP :

DESCRIPTION : Used to notify user of pending or final deletion of an event.

MESSAGE NAME : SCHEDULE ACCEPT/REJECT NOTIFICATION

ORIGINATION : NCC   DESTINATION : POCC

TYPE/CLASS : 99/02

MESSAGE LENGTH : 1   FREQUENCY :

GROUP :

DESCRIPTION : Sent to user in response to a schedule request. 1404, 2303

MESSAGE NAME	:	TDRS PERFORMANCE DATA			
ORIGINATION	:	NCC	DESTINATION	:	POCC
TYPE/CLASS	:	99/03			
MESSAGE LENGTH	:	1	FREQUENCY	:	
GROUP	:	UPD			
DESCRIPTION	:	TDRS Performance Data requested by user POCC for Schedule Event. No acknowledgement required.			

3.6 EXTERNAL MESSAGES BETWEEN NCC AND SDPF

The SDPF is a user support facility that processes telemetry data for earth-orbiting free-flyer payloads. The SDPF provides for data input capture, accounting, decommutation, and storing and forwarding of standard products. The SDPF also processes image data and provides rectification, calibration, and user/experimenter products such as computer-compatible tapes, film, prints, and plots. Project-unique requirements and unique data products can be provided to a user under formalized agreements.

In response to requests from users with the SDPF specified as a destination for return service data, the NCC schedules the flow of data to SDPF and provides the SDPF with schedules. The SDPF prepares to receive the process and telemetry data based on the schedule. In response to request from users to reconfigure on going services, the NCC notifies the SN elements and the SDPF will adjust to any reconfiguration affecting the flow of return data to the SDPF

MESSAGE NAME	:	ACKNOWLEDGEMENT			
ORIGINATION	:	SDPF	DESTINATION	:	NCC
TYPE/CLASS	:	03/14			
MESSAGE LENGTH	:	1	FREQUENCY	:	
GROUP	:				
DESCRIPTION	:	Sent upon reception of a complete message requiring an acknowledgement.			

MESSAGE NAME : COMMUNICATION TEST

ORIGINATION : SDPF DESTINATION : NCC

TYPE/CLASS : 91/03

MESSAGE LENGTH : 1 FREQUENCY :

GROUP :

DESCRIPTION : Used to verify the existence of an operational communication link.

MESSAGE NAME : ACKNOWLEDGEMENT

ORIGINATION : NCC DESTINATION : SDPF

TYPE/CLASS : 03/14

MESSAGE LENGTH : 1 FREQUENCY :

GROUP :

DESCRIPTION : Sent upon reception of a complete message requiring an acknowledgement.

MESSAGE NAME : NASCOM EVENT SCHEDULE (NES)

ORIGINATION : NCC DESTINATION : SDPF

TYPE/CLASS : 90/01

MESSAGE LENGTH : 1 FREQUENCY :

GROUP :

DESCRIPTION : NES contains information of all scheduled services which involve data flow. This NES message is also use NCCDS to schedule Nascom resources needed to support an SN event. Each NES will add an event to the SDPF.

MESSAGE NAME : NASCOM EVENT CANCEL (NEC)

ORIGINATION : NCC DESTINATION : SDPF

TYPE/CLASS : 90/02

MESSAGE LENGTH : 1 FREQUENCY :

GROUP :

DESCRIPTION : The NEC is used to cancel resource allocations previously scheduled by an NES or to cancel an active event. May be transmitted at any time prior to or during an event.

MESSAGE NAME : NASCOM EVENT SCHEDULE UPDATE (NESU)

ORIGINATION : NCC DESTINATION : SDPF

TYPE/CLASS : 90/04

MESSAGE LENGTH : 1 FREQUENCY :

GROUP :

DESCRIPTION : NES sent greater than 45 minutes prior to event start time.

MESSAGE NAME : NASCOM EVENT SCHEDULE EMERGENCY (NESE)

ORIGINATION : NCC DESTINATION : SDPF

TYPE/CLASS : 90/05

MESSAGE LENGTH : 1 FREQUENCY :

GROUP :

DESCRIPTION : NESE is functionally identical to a NES message except that the NESE is used when the start of the event being scheduled is less than 45 minutes but a least 5 minutes away from the time that the message is transmitted to Nascom CSS.

MESSAGE NAME : NASCOM RECONFIGURATION REQUEST (NRR)

ORIGINATION : NCC DESTINATION : SDPF

TYPE/CLASS : 90/06

MESSAGE LENGTH : 2 FREQUENCY :

GROUP : GCM

DESCRIPTION : NRR is a ground control message use to reconfigure data streams in an active service of an ongoing event. Each service within an event requires a separate NRR message.

MESSAGE NAME : COMMUNICATION TEST

ORIGINATION : NCC DESTINATION : SDPF

TYPE/CLASS : 91/03

MESSAGE LENGTH : 1 FREQUENCY :

GROUP :

DESCRIPTION : Used to verify the existence of an operational communication link.

MESSAGE NAME : SCHEDULE RESULT MESSAGE

ORIGINATION : NCC DESTINATION : SDPF

TYPE/CLASS : 99/02

MESSAGE LENGTH : 1 FREQUENCY :

GROUP :

DESCRIPTION :

3.7 EXTERNAL MESSAGES BETWEEN NCC AND WSGT

WSGT operate in accordance with a schedule provided by the NCC and changes ongoing service parameters in response to NCC instructions. TDRS antenna pointing angles and Doppler compensation information are determined from detailed spacecraft orbit data. WSGT compute this information by propagating a state vector using a predefined force model. Both the state vector and force model are provided by the NCC. WSGT inform the NCC of the status and quality of ongoing services and also of equipment status. Based on WSGT requests, the NCC schedules WSGT Preventive Maintenance (PM) on a service basis.

MESSAGE NAME : ACKNOWLEDGEMENT

ORIGINATION : WSGT   DESTINATION : NCC

TYPE/CLASS : 03/06

MESSAGE LENGTH : 1   FREQUENCY :

GROUP : OPM

DESCRIPTION : Sent upon the reception of a complete message requiring an acknowledgement.

MESSAGE NAME : SHO STATUS

ORIGINATION : WSGT   DESTINATION : NCC

TYPE/CLASS : 03/51

MESSAGE LENGTH : 1   FREQUENCY :

GROUP : SHO

DESCRIPTION :

MESSAGE NAME	:	RETURN CHANNEL TIME			
ORIGINATION	:	WSGT	DESTINATION	:	NCC
TYPE/CLASS	:	03/52			
MESSAGE LENGTH	:	1	FREQUENCY	:	
GROUP	:	OPM			
DESCRIPTION	:				

MESSAGE NAME	:	PREVENTATIVE MAINTENANCE REQUEST			
ORIGINATION	:	WSGT	DESTINATION	:	NCC
TYPE/CLASS	:	03/53			
MESSAGE LENGTH	:	1	FREQUENCY	:	
GROUP	:	OPM			
DESCRIPTION	:	Used to request TDRSS preventive maintenance.			

MESSAGE NAME	:	SPECIAL REQUEST OR INFORMATION			
ORIGINATION	:	WSGT	DESTINATION	:	NCC
TYPE/CLASS	:	03/54			
MESSAGE LENGTH	:	1	FREQUENCY	:	
GROUP	:	OPM			
DESCRIPTION	:	Used to send free-form alphanumeric text.			

MESSAGE NAME	:	TDRS MANEUVER REQUEST			
ORIGINATION	:	WSGT	DESTINATION	:	NCC
TYPE/CLASS	:	03/59			
MESSAGE LENGTH	:	1	FREQUENCY	:	
GROUP	:	OPM			
DESCRIPTION	:	Used to request approval for a TDRS spacecraft maneuver.			

MESSAGE NAME	:	STATE VECTOR REJECTION			
ORIGINATION	:	WSGT	DESTINATION	:	NCC
TYPE/CLASS	:	03/61			
MESSAGE LENGTH	:	1	FREQUENCY	:	
GROUP	:	OPM			
DESCRIPTION	:				

MESSAGE NAME	:	STATUS			
ORIGINATION	:	WSGT	DESTINATION	:	NCC
TYPE/CLASS	:	03/62			
MESSAGE LENGTH	:	1	FREQUENCY	:	
GROUP	:	OPM			
DESCRIPTION	:	Used to accept or reject OPM.			

MESSAGE NAME : ACQUISITION FAILURE NOTIFICATION

ORIGINATION : WSGT DESTINATION : NCC

TYPE/CLASS : 03/63

MESSAGE LENGTH : 1 FREQUENCY :

GROUP : OPM

DESCRIPTION : Provides notification that TDRS cannot acquire a user spacecraft.

MESSAGE NAME : COMMUNICATION TEST

ORIGINATION : WSGT DESTINATION : NCC

TYPE/CLASS : 91/03

MESSAGE LENGTH : 1 FREQUENCY :

GROUP :

DESCRIPTION : Used to verify the existence of an operational communication link.

MESSAGE NAME : EMERGENCY

ORIGINATION : NCC DESTINATION : WSGT

TYPE/CLASS : 02/01

MESSAGE LENGTH : 1 FREQUENCY :

GROUP : SHO

DESCRIPTION : Describe the services contained in an emergency SHO.

MESSAGE NAME	:	NORMAL			
ORIGINATION	:	NCC	DESTINATION	:	WSGT
TYPE/CLASS	:	02/01			
MESSAGE LENGTH	:	1	FREQUENCY	:	
GROUP	:	SHO			
DESCRIPTION	:	Describes services contained in a normal SHO.			

MESSAGE NAME	:	SIMULATION			
ORIGINATION	:	NCC	DESTINATION	:	WSGT
TYPE/CLASS	:	02/03			
MESSAGE LENGTH	:	1	FREQUENCY	:	
GROUP	:	SHO			
DESCRIPTION	:	Describes the services contained in a routine verification SHO.			

MESSAGE NAME	:	ROUTINE VERIFICATION			
ORIGINATION	:	NCC	DESTINATION	:	WSGT
TYPE/CLASS	:	02/04			
MESSAGE LENGTH	:	1	FREQUENCY	:	
GROUP	:	SHO			
DESCRIPTION	:	Describes the service contained in a routine verification SHO.			

MESSAGE NAME : EMERGENCY ROUTINE VERIFICATION (ERVS)

ORIGINATION : NCC DESTINATION : WSGT

TYPE/CLASS : 02/05

MESSAGE LENGTH : 1 FREQUENCY :

GROUP : SHO

DESCRIPTION : Describes the services contained in a emergency routine verification SHO.

MESSAGE NAME : SPECIAL REQUEST

ORIGINATION : NCC DESTINATION : WSGT

TYPE/CLASS : 03/01

MESSAGE LENGTH : 1 FREQUENCY :

GROUP : OPM

DESCRIPTION : Used to send free-form alpha-numeric text messages.

MESSAGE NAME : REACQUISITION REQUEST

ORIGINATION : NCC DESTINATION : WSGT

TYPE/CLASS : 03/02

MESSAGE LENGTH : 1 FREQUENCY :

GROUP : OPM

DESCRIPTION : Used to initiate a reacquisition.

MESSAGE NAME : RECONFIGURATION REQUEST

ORIGINATION : NCC DESTINATION : WSGT

TYPE/CLASS : 03/03

MESSAGE LENGTH : 1 FREQUENCY :

GROUP : OPM

DESCRIPTION : Used to reconfigure equipment supporting a user spacecraft.

MESSAGE NAME : FORWARD LINK SWEEP REQUEST

ORIGINATION : NCC DESTINATION : WSGT

TYPE/CLASS : 03/04

MESSAGE LENGTH : 1 FREQUENCY :

GROUP : OPM

DESCRIPTION : Used to initiate a sweep of forward link carrier frequency.

MESSAGE NAME : FORWARD LINK EIRP RECONFIGURATION REQUEST

ORIGINATION : NCC DESTINATION : WSGT

TYPE/CLASS : 03/06

MESSAGE LENGTH : 1 FREQUENCY :

GROUP : OPM

DESCRIPTION : Used to set the SSA or KSA EIRP to normal or high power.

MESSAGE NAME : EXPANDER USER FREQUENCY UNCERTAINTY REQUEST

ORIGINATION : NCC DESTINATION : WSGT

TYPE/CLASS : 03/07

MESSAGE LENGTH : 1 FREQUENCY :

GROUP : OPM

DESCRIPTION : Used to increase receiver bandwidth for DG1, mode 2 and DG2.

MESSAGE NAME : USER ORBIT PREDICTION FORCE MODEL

ORIGINATION : NCC DESTINATION : WSGT

TYPE/CLASS : 03/09

MESSAGE LENGTH : 1 FREQUENCY :

GROUP : OPM

DESCRIPTION : Provides information that the TDRSS uses to propagate a stable vector.

MESSAGE NAME : IMPROVED INTERRANGE VECTOR (IIRV) NOMINAL

ORIGINATION : NCC DESTINATION : WSGT

TYPE/CLASS : 03/10

MESSAGE LENGTH : 1 FREQUENCY :

GROUP : OPM

DESCRIPTION :

MESSAGE NAME	:	ACKNOWLEDGEMENT			
ORIGINATION	:	NCC	DESTINATION	:	WSGT
TYPE/CLASS	:	03/14			
MESSAGE LENGTH	:	1	FREQUENCY	:	
GROUP	:	OPM			
DESCRIPTION	:	Sent upon reception of a complete message requiring an acknowledgement.			

MESSAGE NAME	:	DELTA-T-ADJUSTMENT			
ORIGINATION	:	NCC	DESTINATION	:	WSGT
TYPE/CLASS	:	03/18			
MESSAGE LENGTH	:	1	FREQUENCY	:	
GROUP	:	OPM			
DESCRIPTION	:	Used to adjust the epoch time parameter within state vectors.			

MESSAGE NAME	:	PERIODIC SHO - NORMAL			
ORIGINATION	:	NCC	DESTINATION	:	WSGT
TYPE/CLASS	:	08/01			
MESSAGE LENGTH	:	1	FREQUENCY	:	
GROUP	:	SHO			
DESCRIPTION	:				

MESSAGE NAME	:	PERIODIC SHO - SIMULATION			
ORIGINATION	:	NCC	DESTINATION	:	WSGT
TYPE/CLASS	:	08/03			
MESSAGE LENGTH	:	1	FREQUENCY	:	
GROUP	:	SHO			
DESCRIPTION	:				

MESSAGE NAME	:	PERIODIC SHO - ROUTINE VERIFICATION			
ORIGINATION	:	NCC	DESTINATION	:	WSGT
TYPE/CLASS	:	08/04			
MESSAGE LENGTH	:	1	FREQUENCY	:	
GROUP	:	SHO			
DESCRIPTION	:				

MESSAGE NAME	:	COMMUNICATION TEST			
ORIGINATION	:	NCC	DESTINATION	:	WSGT
TYPE/CLASS	:	91/03			
MESSAGE LENGTH	:	1	FREQUENCY	:	
GROUP	:	OPM			
DESCRIPTION	:	Used to verify existence of an operational link.			

4. INTERNAL MESSAGES

4.1 INTERNAL MESSAGES BETWEEN THE CCS AND ITS

This interface is through the dual-rail Intersegment Local Area Network (LAN) and can be on either rail of the LAN at any particular time. Each message passed between the ITS and CCS is uniquely identified by a combination of the NCC Function Type, the NCC Command Code / Function Code, and the NCC Command Subcode. The function type is used to identify the segments involved. The ITS / CCS interface is identical to the ITS / SPS interface with the exception of the function type. The ITS can identify the sending segment (CCS or SPS) of a message by its function type or the LAN connection on which the message was received because LAN connections are unique rather than shared.

MESSAGE NAME : Alert Additional Data Display

ORIGINATION : CCS DESTINATION : ITS

FUNCTION TYPE : 5 FUNCTION CODE : 5

MESSAGE LENGTH : var COMMAND SUBCODE :

DESCRIPTION : This message is sent to the ITS to request that a display be sent to the screen of the ITS.

MESSAGE NAME : Alert Message - Action Alert

ORIGINATION : CCS DESTINATION : ITS

FUNCTION TYPE : 5 FUNCTION CODE : 1

MESSAGE LENGTH : COMMAND SUBCODE : 2

DESCRIPTION : One of three Alert Messages. These messages are sent to the IT for display in the Alert Areas of the screen.

MESSAGE NAME : Alert Message- Information Alert

ORIGINATION : CCS DESTINATION : ITS

FUNCTION TYPE : 5 FUNCTION CODE : 1

MESSAGE LENGTH : 72 B COMMAND SUBCODE : 1

DESCRIPTION : Alert messages are of three types [Information Alert, Action Alert, and Action-Alert-with-Associated Data]. Alert Messages are sent to the ITS for display in the Alert Areas of the screen. The primary screen has display areas for one Action Alert and two Information-Alerts. Action Alerts are queued on the SPS and Information Alerts are queued on the ITS. An Action Alert is replaced upon operator acknowledgement, and an Information Alert is replaced upon an Information Alert Timeout.

MESSAGE NAME : Alert Messages :- Action Alert With Associated Data

ORIGINATION : CCS DESTINATION : ITS

FUNCTION TYPE : 5 FUNCTION CODE : 1

MESSAGE LENGTH : COMMAND SUBCODE : 3

DESCRIPTION : Same for other alert messages.

MESSAGE NAME : Background Display Request

ORIGINATION : CCS DESTINATION : ITS

FUNCTION TYPE : 5 FUNCTION CODE : 25

MESSAGE LENGTH : var COMMAND SUBCODE :

DESCRIPTION : This message is sent to the ITS to request that a display be sent to the screen of the ITS.

MESSAGE NAME : Coordinated Universal Time :- Maintenance

ORIGINATION :	CCS	DESTINATION :	ITS
FUNCTION TYPE :	5	FUNCTION CODE :	40
MESSAGE LENGTH :	16	COMMAND SUBCODE :	2

DESCRIPTION : This message is sent periodically at whatever time interval is needed to keep the ITS UTC in sync with the real UTC. It is also sent at startup/restart protocol in order to initialize UTC on the ITS.

MESSAGE NAME : Coordinated Universal Time :- Transition

ORIGINATION :	CCS	DESTINATION :	ITS
FUNCTION TYPE :	5	FUNCTION CODE :	40
MESSAGE LENGTH :	16 B	COMMAND SUBCODE :	1

DESCRIPTION : This message is sent by the CCS to all ITS nodes on the LAN. This will be done periodically at whatever time interval is needed to keep the ITS UTC in sync with the real UTC. It is also sent as part of the start up/restart protocol in order to initialize UTC on the ITS.

MESSAGE NAME : Display Allowable Console Position :- Bit Map

ORIGINATION :	CCS	DESTINATION :	ITS
FUNCTION TYPE :	5	FUNCTION CODE :	55
MESSAGE LENGTH :	var	COMMAND SUBCODE :	

DESCRIPTION : This message specifies which logged on positions are allowed access to each display.

MESSAGE NAME	:	Display Data Return ASCII			
ORIGINATION	:	CCS	DESTINATION	:	ITS
FUNCTION TYPE	:	5	FUNCTION CODE	:	27
MESSAGE LENGTH	:	var	COMMAND SUBCODE	:	
DESCRIPTION	:	This message is sent to the CCS in response to data entries made in a display by the operator.			

MESSAGE NAME	:	Display Data Return In Error ASCII			
ORIGINATION	:	CCS	DESTINATION	:	ITS
FUNCTION TYPE	:	5	FUNCTION CODE	:	12
MESSAGE LENGTH	:	var	COMMAND SUBCODE	:	
DESCRIPTION	:	This message is sent from the SPS to the ITS in response to an erroneous Display Data Return ASCII message. A bit in the error bit map is for the position of the prompt text on the screen as defined by the Display Template.			

MESSAGE NAME	:	Display Data Send ASCII For Consecutive Dynamic Update.			
ORIGINATION	:	CCS	DESTINATION	:	ITS
FUNCTION TYPE	:	5	FUNCTION CODE	:	29
MESSAGE LENGTH	:	var	COMMAND SUBCODE	:	
DESCRIPTION	:	This message is sent to the ITS to request that a display be sent to the screen of the ITS.			

MESSAGE NAME : Display Data Send ASCII For Initial Dynamic Display.

ORIGINATION : CCS | DESTINATION : ITS

FUNCTION TYPE : 5 | FUNCTION CODE : 28

MESSAGE LENGTH : var | COMMAND SUBCODE :

DESCRIPTION : This message is sent to the ITS to request that a display be sent to the screen of the ITS.

MESSAGE NAME : Display Data Send ASCII Message For New Display

ORIGINATION : CCS | DESTINATION : ITS

FUNCTION TYPE : 5 | FUNCTION CODE : 3

MESSAGE LENGTH : var | COMMAND SUBCODE :

DESCRIPTION : This message is sent to the ITS to request that a display be sent to the screen of the ITS. For displays that need foreground data, the application will send that data as part of this message. The format of the data area of the message is dependent on the display number.

MESSAGE NAME : Freeze Dynamic Updates Command

ORIGINATION : CCS | DESTINATION : ITS

FUNCTION TYPE : 5 | FUNCTION CODE : 31

MESSAGE LENGTH : var | COMMAND SUBCODE :

DESCRIPTION : This message is sent to the ITS to request that a display be sent to the screen of the ITS.

MESSAGE NAME	:	Host IT Transition Control Message :- Down			
ORIGINATION	:	CCS	DESTINATION	:	ITS
FUNCTION TYPE	:	5	FUNCTION CODE	:	60
MESSAGE LENGTH	:	12 B	COMMAND SUBCODE	:	2
DESCRIPTION	:	This message is sent as a result of the CCS receiving an "Open Success" indication for an attempted LAN connection. The LAN Configuration Message specifies the function (prime or backup) of the LAN pathways from the CCS computer to/from the ITS computer.			

MESSAGE NAME	:	Host IT Transition Control :- LAN Configuration Message.			
ORIGINATION	:	CCS	DESTINATION	:	ITS
FUNCTION TYPE	:	5	FUNCTION CODE	:	60
MESSAGE LENGTH	:	12 B	COMMAND SUBCODE	:	1
DESCRIPTION	:	This message is sent as a result of the CCS receiving an "Open Success" indication for an attempted LAN connection. The LAN Configuration Message specifies the function (prime or backup) of the LAN pathways from the CCS computer to/from the ITS computer.			

MESSAGE NAME	:	Host IT Transition Control :- Template Error			
ORIGINATION	:	CCS	DESTINATION	:	ITS
FUNCTION TYPE	:	5	FUNCTION CODE	:	60
MESSAGE LENGTH	:	12 B	COMMAND SUBCODE	:	3
DESCRIPTION	:	This message is sent as a result of the CCS receiving an "Open Success" indication for an attempted LAN connection. The LAN Configuration Message specifies the function (prime or backup) of the LAN pathways from the CCS computer to/from the ITS computer.			

MESSAGE NAME	:	Logoff Accepted			
ORIGINATION	:	CCS	DESTINATION	:	ITS
FUNCTION TYPE	:	5	FUNCTION CODE	:	41
MESSAGE LENGTH	:	4 B	COMMAND SUBCODE	:	51

DESCRIPTION : This message is sent to the ITS as a result of a valid logoff by the console operator.

MESSAGE NAME	:	Logon Accepted			
ORIGINATION	:	CCS	DESTINATION	:	ITS
FUNCTION TYPE	:	5	FUNCTION CODE	:	41
MESSAGE LENGTH	:	1120 B	COMMAND SUBCODE	:	50

DESCRIPTION : This message is sent to the ITS to signal a valid logon by the console operator. This message gives to the ITS the list of default rapid access displays for the positions. This message also sends to the ITS the password sequence number and a figure.

MESSAGE NAME	:	Pending Alert Display			
ORIGINATION	:	CCS	DESTINATION	:	ITS
FUNCTION TYPE	:	5	FUNCTION CODE	:	4
MESSAGE LENGTH	:	var	COMMAND SUBCODE	:	

DESCRIPTION : This message is sent to the ITS to request that a display be sent to the screen of the ITS.

MESSAGE NAME	:	Service Message To It		
ORIGINATION	:	CCS	DESTINATION :	ITS
FUNCTION TYPE	:	5	FUNCTION CODE :	2
MESSAGE LENGTH	:	22	COMMAND SUBCODE :	0

DESCRIPTION : Service Messages are sent to the ITS for display in the Service Messasge Area of the screen. Numbered service messages are possible, but the sender may optionally send self-generated service text.

MESSAGE NAME	:	Template Compare Command		
ORIGINATION	:	CCS	DESTINATION :	ITS
FUNCTION TYPE	:	5	FUNCTION CODE :	52
MESSAGE LENGTH	:		COMMAND SUBCODE :	1

DESCRIPTION : This message contains the date of the last time the Template TIP files for the current configuration level were modified. The ITS is expected to compare this date with the date saved from the last time the Template Compare Request was received. If the dates do not match, the Display Directory Message will contain compilation time information associated with each displays template object currently stored on the ITS.

MESSAGE NAME	:	Template Objects		
ORIGINATION	:	CCS	DESTINATION :	ITS
FUNCTION TYPE	:	5	FUNCTION CODE :	54
MESSAGE LENGTH	:		COMMAND SUBCODE :	

DESCRIPTION : A Template Object Message is sent to the ITS by the CCS for each display in the 11 display directory that is not consistent with the CCS Display Directory. This message contains the templates that are used by the ITS in generating displays and managing data entries.

MESSAGE NAME : Terminate Dynamic Display Command

ORIGINATION : CCS DESTINATION : ITS

FUNCTION TYPE : 5 FUNCTION CODE : 30

MESSAGE LENGTH : var COMMAND SUBCODE :

DESCRIPTION : This message is sent to the ITS to request that a display be sent to the screen of the ITS.

MESSAGE NAME : Unfreeze Dynamic Updates Command

ORIGINATION : CCS DESTINATION : ITS

FUNCTION TYPE : 5 FUNCTION CODE : 32

MESSAGE LENGTH : var COMMAND SUBCODE :

DESCRIPTION : This message is sent to the ITS to request that a display be sent to the screen of the ITS.

MESSAGE NAME : Action Alert Acknowledgement from IT Operator

ORIGINATION : ITS DESTINATION : CCS

FUNCTION TYPE : 5 FUNCTION CODE : 6

MESSAGE LENGTH : var COMMAND SUBCODE :

DESCRIPTION : This message is sent by the ITS to the CCS to acknowledge a Display Data Send ASCII Message.

MESSAGE NAME	:	Display Directory			
ORIGINATION	:	ITS	DESTINATION	:	CCS
FUNCTION TYPE	:	5	FUNCTION CODE	:	53
MESSAGE LENGTH	:	var	COMMAND SUBCODE	:	

DESCRIPTION : This message is sent by the ITS to the CCS in response to the ITS receiving a Template Compare Request message from the SPS. It contains a return status flag indicating if the Template Configuration Date as contained in the Template Compare Request matched on the ITS and CCS. If no match the display Directory Message contains a list of displays in use on the ITS and compilation dates for each display. The CCS uses these dates to determine if new Template Objects should be sent.

MESSAGE NAME	:	IT Host Transition Control :- Deactivate			
ORIGINATION	:	ITS	DESTINATION	:	CCS
FUNCTION TYPE	:	5	FUNCTION CODE	:	61
MESSAGE LENGTH	:		COMMAND SUBCODE	:	2

DESCRIPTION : This message is sent by the ITS to the CCS in response to a request in the LAN Configuration Message. The Profile Message contains the logon state relative to each screen.

MESSAGE NAME	:	IT Host Transition Control - Profile			
ORIGINATION	:	ITS	DESTINATION	:	CCS
FUNCTION TYPE	:	5	FUNCTION CODE	:	61
MESSAGE LENGTH	:		COMMAND SUBCODE	:	1

DESCRIPTION : This message is sent by the ITS to the CCS in response to a request in the LAN Configuration Message. The Profile Message contains the logon state relative to each screen.

MESSAGE NAME	:	Loop Test :- Life Test			
ORIGINATION	:	ITS	DESTINATION	:	CCS
FUNCTION TYPE	:	5	FUNCTION CODE	:	62
MESSAGE LENGTH	:	var	COMMAND SUBCODE	:	1
DESCRIPTION	:	This message is sent in response to a request in the LAN Configuration Message.			

MESSAGE NAME	:	Loop Test :- Life Test Response			
ORIGINATION	:	ITS	DESTINATION	:	CCS
FUNCTION TYPE	:	5	FUNCTION CODE	:	62
MESSAGE LENGTH	:		COMMAND SUBCODE	:	2
DESCRIPTION	:				

MESSAGE NAME	:	Pending Action Alerts Display Request			
ORIGINATION	:	ITS	DESTINATION	:	CCS
FUNCTION TYPE	:	5	FUNCTION CODE	:	22
MESSAGE LENGTH	:		COMMAND SUBCODE	:	
DESCRIPTION	:	This message is sent by the ITS to the CCS.			

4.2 INTERNAL MESSAGES BETWEEN THE SPS AND CCS

MESSAGE NAME	:	Authorized User IDs/Passwords			
ORIGINATION	:	SPS	DESTINATION	:	CCS
FUNCTION TYPE	:	7	FUNCTION CODE	:	20
MESSAGE LENGTH	:	var	COMMAND SUBCODE	:	
DESCRIPTION	:	This message is sent to the CCS to transfer all authorized user IDs and Passwords.			

MESSAGE NAME	:	Current Site Status Response			
ORIGINATION	:	SPS	DESTINATION	:	CCS
FUNCTION TYPE	:	7	FUNCTION CODE	:	1
MESSAGE LENGTH	:	0 B	COMMAND SUBCODE	:	3
DESCRIPTION	:	This message is sent from the SPS to the CCS during communication synchronization. It contains an acknowledgement of the previous CCS Site Status Message.			

MESSAGE NAME	:	Display Directory Message			
ORIGINATION	:	SPS	DESTINATION	:	CCS
FUNCTION TYPE	:	7	FUNCTION CODE	:	46
MESSAGE LENGTH	:	var	COMMAND SUBCODE	:	na
DESCRIPTION	:	This message is sent to the CCS as a result of the SPS receiving a Display Directory Request Message from the CCS. It contains a list of displays in use on the SPS and compilation dates for each display. The CCS will use the compilation dates to determine which new template objects should be requested.			

MESSAGE NAME : Event And Service Information Message

ORIGINATION : SPS DESTINATION : CCS

FUNCTION TYPE : 7 FUNCTION CODE : 30

MESSAGE LENGTH : var COMMAND SUBCODE :

DESCRIPTION : The detailed event portion of this message requires modifications to compensate for the change from the 36 bit U1100 to the 32 bit VAX.

MESSAGE NAME : Event Termination Message
From SSQ4 to EMQ8

ORIGINATION : SPS DESTINATION : CCS

FUNCTION TYPE : 7 FUNCTION CODE : 31

MESSAGE LENGTH : 44 B COMMAND SUBCODE : 0

DESCRIPTION : This message from SSQ4 to EMQ8 signals the termination of an event.

MESSAGE NAME : Service Parameter Message

ORIGINATION : SPS DESTINATION : CCS

FUNCTION TYPE : 7 FUNCTION CODE : 24

MESSAGE LENGTH : var COMMAND SUBCODE :

DESCRIPTION : This message transfers service parameter data from the SPS to the CCS. If the parameter values for a given service type and parameter type do not change for subsequent spacecraft the verification method for the spacecraft will be set as "same".

MESSAGE NAME :	SPS Application Routing Information			
ORIGINATION :	SPS	DESTINATION	:	CCS
FUNCTION TYPE :	7	FUNCTION CODE	:	1
MESSAGE LENGTH :	var	COMMAND SUBCODE	:	4

DESCRIPTION : This message is sent from the SPS to the CCS during communication synchronization.

MESSAGE NAME :	SPS System Configuration			
ORIGINATION :	SPS	DESTINATION	:	CCS
FUNCTION TYPE :	7	FUNCTION CODE	:	1
MESSAGE LENGTH :	12 B	COMMAND SUBCODE	:	1

DESCRIPTION : This message is sent to the CCS during Communication synchronization. This message contains the SPS System Level (Operational, Test, Development), SPS Role Configuration (Prime, Backup) and SPS Software Execution Level, which specifies the data base to use.

MESSAGE NAME :	SPS System Parameter Transfer Message			
ORIGINATION :	SPS	DESTINATION	:	CCS
FUNCTION TYPE :	7	FUNCTION CODE	:	1
MESSAGE LENGTH :	0 B	COMMAND SUBCODE	:	2

DESCRIPTION : This message is sent from the SPS to the CCS during communication synchronization. It contains an acknowledgement to the previous CCS System Parameter Transfer Message.

MESSAGE NAME	:	SPS-IT Logon/Logoff Status			
ORIGINATION	:	SPS	DESTINATION	:	CCS
FUNCTION TYPE	:	7	FUNCTION CODE	:	1
MESSAGE LENGTH	:	var	COMMAND SUBCODE	:	5
DESCRIPTION	:	This message is sent to the CCS during communication synchronization. It contains all the It Logon/Logoff Status as SPS views it.			

MESSAGE NAME	:	Static Data Transfer Message			
ORIGINATION	:	SPS	DESTINATION	:	CCS
FUNCTION TYPE	:	7	FUNCTION CODE	:	23
MESSAGE LENGTH	:	var	COMMAND SUBCODE	:	
DESCRIPTION	:	This message is sent by the SPS to the CCS to request transfer of static data to CCS.			

MESSAGE NAME	:	Template Compare Message			
ORIGINATION	:	SPS	DESTINATION	:	CCS
FUNCTION TYPE	:	7	FUNCTION CODE	:	45
MESSAGE LENGTH	:	12 int	COMMAND SUBCODE	:	1
DESCRIPTION	:	This message contains the data of the last time the template TIP files for the current configuration level were modified. If this date does not match with other data at the CCS, the CCS sends a Display Directory Request to continue the synchronization process.			

MESSAGE NAME	:	Template Object Message			
ORIGINATION	:	SPS	DESTINATION	:	CCS
FUNCTION TYPE	:	7	FUNCTION CODE	:	47
MESSAGE LENGTH	:	var	COMMAND SUBCODE	:	NA

DESCRIPTION : This message is sent by the SPS to the CCS for each display in the CCS display that is not current with the SPS Display Directory. It contains any one of the templates that are used by the CCS supporting ITS displays and display data entries.

MESSAGE NAME	:	Valid SICs and Spacecraft Names			
ORIGINATION	:	SPS	DESTINATION	:	CCS
FUNCTION TYPE	:	7	FUNCTION CODE	:	21
MESSAGE LENGTH	:	var	COMMAND SUBCODE	:	

DESCRIPTION : These messages transfer valid SICs and Spacecraft names from the SPS to the CCS.

MESSAGE NAME	:	Valid TDRS - ID			
ORIGINATION	:	SPS	DESTINATION	:	CCS
FUNCTION TYPE	:	7	FUNCTION CODE	:	22
MESSAGE LENGTH	:	40 B	COMMAND SUBCODE	:	

DESCRIPTION : This message transfers valid SICs and Spacecraft names from the SPS to the CCS.

MESSAGE NAME	:	CCS Application Routing Information			
ORIGINATION	:	CCS	DESTINATION	:	SPS
FUNCTION TYPE	:	6	FUNCTION CODE	:	1
MESSAGE LENGTH	:	var	COMMAND SUBCODE	:	4
DESCRIPTION	:	This message is sent from the CCS to the SPS during communication synchronization. It contains the CCS Application Routing Information.			

MESSAGE NAME	:	CCS System Configuration			
ORIGINATION	:	CCS	DESTINATION	:	SPS
FUNCTION TYPE	:	6	FUNCTION CODE	:	1
MESSAGE LENGTH	:	12	COMMAND SUBCODE	:	1
DESCRIPTION	:	This is the first message sent to the SPS during communication synchronization. This message contains the CCS System Level (Operational, Test, Development) and CCS Role Configuration (Prime, Backup).			

MESSAGE NAME	:	CCS System Parameters Transfer			
ORIGINATION	:	CCS	DESTINATION	:	SPS
FUNCTION TYPE	:	6	FUNCTION CODE	:	1
MESSAGE LENGTH	:	var	COMMAND SUBCODE	:	2
DESCRIPTION	:	This message is sent from the CCS to the SPS during communication synchronization. It contains the CCS to SPS I am alive interval and the ITS connection addresses.			

MESSAGE NAME	:	CCS-IT Logon/Logoff Status			
ORIGINATION	:	CCS	DESTINATION	:	SPS
FUNCTION TYPE	:	6	FUNCTION CODE	:	1
MESSAGE LENGTH	:	var	COMMAND SUBCODE	:	5
DESCRIPTION	:	This message is sent from the CCS to the SPS during communication synchronization. It contains the ITS Logon/Logoff Status as the CCS views it.			

MESSAGE NAME	:	Current Site Table Transfer			
ORIGINATION	:	CCS	DESTINATION	:	SPS
FUNCTION TYPE	:	6	FUNCTION CODE	:	1
MESSAGE LENGTH	:	var	COMMAND SUBCODE	:	3
DESCRIPTION	:	This message is sent from CCS to the SPS during communication synchronization. It contains all the current site status.			

MESSAGE NAME	:	Display Directory Request Message			
ORIGINATION	:	CCS	DESTINATION	:	SPS
FUNCTION TYPE	:	6	FUNCTION CODE	:	46
MESSAGE LENGTH	:	0 B	COMMAND SUBCODE	:	NA
DESCRIPTION	:	This message is sent by the CCS to the SPS if the compilation dates for the templates in the two segments do not match. It signals SPS to return the Display Directory Message.			

MESSAGE NAME	:	Template Compare Request Message			
ORIGINATION	:	CCS	DESTINATION	:	SPS
FUNCTION TYPE	:	6	FUNCTION CODE	:	45
MESSAGE LENGTH	:	0 B	COMMAND SUBCODE	:	1
DESCRIPTION	:	This message is sent from the CCS to the SPS at the beginning of the template synchronization process. It signals SPS to return the Template Compare Message containing the compilation dates for the templates on SPS.			

MESSAGE NAME	:	Template Object Request			
ORIGINATION	:	CCS	DESTINATION	:	SPS
FUNCTION TYPE	:	6	FUNCTION CODE	:	47
MESSAGE LENGTH	:	var	COMMAND SUBCODE	:	NA
DESCRIPTION	:	This message is sent by the CCS to the SPS to request template objects for which the compilation dates do not match. The request contains the templates needed by the template number.			

4.3 INTERNAL MESSAGES BETWEEN THE SPS AND ITS

This interface is through a Local Area Network (LAN) to which the SPS and each Intelligent terminal is connected. Each message passed between the ITS and the SPS are uniquely defined by a combination of the NCC Function Type, the NCC Command / Function Code, and the NCC Command Subcode.

MESSAGE NAME	:	Alert Additional Data Display			
ORIGINATION	:	SPS	DESTINATION	:	ITS
FUNCTION TYPE	:	1	FUNCTION CODE	:	5
MESSAGE LENGTH	:	var	COMMAND SUBCODE	:	
DESCRIPTION	:	This message is sent to the ITS to request that a display be sent to the screen of the ITS.			

MESSAGE NAME	:	Alert Message -Action Alert With Data			
ORIGINATION	:	SPS	DESTINATION	:	ITS
FUNCTION TYPE	:	1	FUNCTION CODE	:	1
MESSAGE LENGTH	:	72 B	COMMAND SUBCODE	:	3
DESCRIPTION	:	Same as Information Alert.			

MESSAGE NAME	:	Alert Message To IT - Action Alert			
ORIGINATION	:	SPS	DESTINATION	:	ITS
FUNCTION TYPE	:	1	FUNCTION CODE	:	1
MESSAGE LENGTH	:	72 B	COMMAND SUBCODE	:	2
DESCRIPTION	:	Same as Information Alert.			

MESSAGE NAME	:	Alert Message to IT - Information Alert			
ORIGINATION	:	SPS	DESTINATION	:	ITS
FUNCTION TYPE	:	1	FUNCTION CODE	:	1
MESSAGE LENGTH	:	72 B	COMMAND SUBCODE	:	1
DESCRIPTION	:	Alert messages are of three types [Information Alert, Action Alert and Action Alert with Associated Data]. Alert Messages are sent to the ITS for display in the Alert Areas of the screen. The primary screen has display areas for one Action Alert and two Information Alerts. Action Alerts are queued on the SPS and Information Alerts are queued on the ITS. An Action Alert is replaced upon operator acknowledgement, and an Information Alert is replaced upon an Information Alert Timeout.			

MESSAGE NAME : Background Display Request

ORIGINATION : SPS | DESTINATION : ITS

FUNCTION TYPE : 1 | FUNCTION CODE : 25

MESSAGE LENGTH : var | COMMAND SUBCODE :

DESCRIPTION : This message is sent to the ITS to request that a display be sent to the screen of the ITS.

MESSAGE NAME : Coordinated Universal Time : Maintenance

ORIGINATION : SPS | DESTINATION : ITS

FUNCTION TYPE : 1 | FUNCTION CODE : 40

MESSAGE LENGTH : 16 B | COMMAND SUBCODE : 2

DESCRIPTION : This message is sent periodically at whatever time interval is needed to keep the ITS UTC in sync with the real UTC. It is also sent at startup/restart protocol in order to initialize UTC on the ITS.

MESSAGE NAME : Coordinated Universal Time : Transition

ORIGINATION : SPS | DESTINATION : ITS

FUNCTION TYPE : 1 | FUNCTION CODE : 40

MESSAGE LENGTH : 16 B | COMMAND SUBCODE : 2

DESCRIPTION : This message is sent periodically to all ITS nodes on the LAN at whatever time interval is needed to keep the ITS UTC in sync with the real UTC. It is also sent at startup/restart protocol in order to initialize UTC on the ITS.

MESSAGE NAME : Display Allowable Console Posit Bit Map

ORIGINATION : SPS DESTINATION : ITS

FUNCTION TYPE : 1 FUNCTION CODE : 55

MESSAGE LENGTH : var COMMAND SUBCODE :

DESCRIPTION : This message specifies which logged-on positions are allowed access to each display.

MESSAGE NAME : Display Data Return In Error ASCII

ORIGINATION : SPS DESTINATION : ITS

FUNCTION TYPE : 1 FUNCTION CODE : 12

MESSAGE LENGTH : var COMMAND SUBCODE :

DESCRIPTION : This message is sent from the SPS to the ITS in response to an erroneous Display Data Return ASCII Message. A bit in the Error Bit Map is set for the position of the prompt text on the screen as defined by the display template.

MESSAGE NAME : Display Data Send ASCII for Consecutive Dynamic Update

ORIGINATION : SPS DESTINATION : ITS

FUNCTION TYPE : 1 FUNCTION CODE : 29

MESSAGE LENGTH : var COMMAND SUBCODE :

DESCRIPTION : This message is sent to the ITS to request that a display be sent to the screen of the ITS.

MESSAGE NAME	:	Display Data Send ASCII-Initial Dynamic Display			
ORIGINATION	:	SPS	DESTINATION	:	ITS
FUNCTION TYPE	:	1	FUNCTION CODE	:	28
MESSAGE LENGTH	:	var	COMMAND SUBCODE	:	

DESCRIPTION : This message is sent to the ITS to request that a display be sent to the screen of the ITS. For displays that need foreground data, the application will send that data as part of the message. Format of data for message is dependent on display number.

MESSAGE NAME	:	Display Data Send-ASCII for new display			
ORIGINATION	:	SPS	DESTINATION	:	ITS
FUNCTION TYPE	:	1	FUNCTION CODE	:	3
MESSAGE LENGTH	:	var	COMMAND SUBCODE	:	

DESCRIPTION : This message is sent to the ITS to request that a display be sent to the screen of the ITS. For displays that need foreground data, the application will send that data as part of this message. The format of the data area of the message is dependent on the display number.

MESSAGE NAME	:	Freeze Dynamic Updates Command			
ORIGINATION	:	SPS	DESTINATION	:	IT
FUNCTION TYPE	:	1	FUNCTION CODE	:	31
MESSAGE LENGTH	:	Var	COMMAND SUBCODE	:	

DESCRIPTION : This message is sent to the ITS to request that a display be sent to the screen of the ITS.

MESSAGE NAME	:	Host-IT Transition Control : Down			
ORIGINATION	:	SPS	DESTINATION	:	ITS
FUNCTION TYPE	:	1	FUNCTION CODE	:	60
MESSAGE LENGTH	:	12 B	COMMAND SUBCODE	:	2
DESCRIPTION	:				

MESSAGE NAME	:	Host-IT-Transition-Control LAN Configuration.			
ORIGINATION	:	SPS	DESTINATION	:	ITS
FUNCTION TYPE	:	1	FUNCTION CODE	:	60
MESSAGE LENGTH	:	12 B	COMMAND SUBCODE	:	1
DESCRIPTION	:	This message is sent as a result of the SPS receiving an "Open Success" indication for an attempted LAN connection. The LAN Configuration Message specifies the function (prime or backup) of the LAN pathways from the SPS computer to/from the ITS computer.			

MESSAGE NAME	:	Host-IT-Transition-Control :Template Error			
ORIGINATION	:	SPS	DESTINATION	:	ITS
FUNCTION TYPE	:	1	FUNCTION CODE	:	60
MESSAGE LENGTH	:	12 B	COMMAND SUBCODE	:	3
DESCRIPTION	:				

MESSAGE NAME	:	Logoff Accepted			
ORIGINATION	:	SPS	DESTINATION	:	ITS
FUNCTION TYPE	:	1	FUNCTION CODE	:	41
MESSAGE LENGTH	:	4 B	COMMAND SUBCODE	:	51

DESCRIPTION : This message is sent to the ITS as a result of a valid logoff by the console operator.

MESSAGE NAME	:	Logon Accept			
ORIGINATION	:	SPS	DESTINATION	:	IT
FUNCTION TYPE	:	1	FUNCTION CODE	:	41
MESSAGE LENGTH	:	1120 B	COMMAND SUBCODE	:	50

DESCRIPTION : This message is sent to the ITS to signal a valid logon by the console operator. This message gives to the ITS the list of default rapid access displays for the position. This message also sends to the ITS the password sequence number and the logon position that must be included in any profile message.

MESSAGE NAME	:	Loop Test - Life Test Response			
ORIGINATION	:	SPS	DESTINATION	:	IT
FUNCTION TYPE	:	1	FUNCTION CODE	:	62
MESSAGE LENGTH	:	var	COMMAND SUBCODE	:	2

DESCRIPTION : This message is sent in response to a request in the LAN Configuration Message.

MESSAGE NAME	:	Loop Test : Life Test			
ORIGINATION	:	SPS	DESTINATION	:	ITS
FUNCTION TYPE	:	1	FUNCTION CODE	:	62
MESSAGE LENGTH	:	var	COMMAND SUBCODE	:	1
DESCRIPTION	:	This message is sent in response to a request in the LAN Configuration Message.			

MESSAGE NAME	:	Pending Alerts Display			
ORIGINATION	:	SPS	DESTINATION	:	ITS
FUNCTION TYPE	:	1	FUNCTION CODE	:	4
MESSAGE LENGTH	:	var	COMMAND SUBCODE	:	
DESCRIPTION	:	This message is sent to the ITS to request that a display be sent to the screen of the ITS.			

MESSAGE NAME	:	Service Message To IT-Text Included			
ORIGINATION	:	SPS	DESTINATION	:	ITS
FUNCTION TYPE	:	1	FUNCTION CODE	:	2
MESSAGE LENGTH	:	72 B	COMMAND SUBCODE	:	0
DESCRIPTION	:	Service Messages are sent to the ITS for display in the Service Message Area of the screen. Numbered service messages are possible, but the sender may optionally send self-generated service text.			

MESSAGE NAME	:	Template Compare Command			
ORIGINATION	:	SPS	DESTINATION	:	IT
FUNCTION TYPE	:	1	FUNCTION CODE	:	52
MESSAGE LENGTH	:		COMMAND SUBCODE	:	1
DESCRIPTION	:	This message contains the date of the last time the Template TIP files for the current configuration level were modified. The ITS is expected to compare this date with the date saved from the last time the Template Compare Message was received. If the dates do not match, the Display Directory Message will contain compilation time information associated with each displays template currently stored on the ITS.			

MESSAGE NAME	:	Template Object			
ORIGINATION	:	SPS	DESTINATION	:	ITS
FUNCTION TYPE	:	1	FUNCTION CODE	:	54
MESSAGE LENGTH	:	var	COMMAND SUBCODE	:	
DESCRIPTION	:	A Template Object Message is sent to the ITS by the SPS for each display in the 11 display directory that is not consistent with the SPS Display Directory. This message contains the templates that are used by the IT in generating displays and managing data entries.			

MESSAGE NAME	:	Terminate Dynamic Display Commands			
ORIGINATION	:	SPS	DESTINATION	:	ITS
FUNCTION TYPE	:	1	FUNCTION CODE	:	30
MESSAGE LENGTH	:	var	COMMAND SUBCODE	:	
DESCRIPTION	:	This message is sent to the ITS to request that a display be sent to the screen of the ITS.			

MESSAGE NAME : Unfreeze Dynamic Updates Command

ORIGINATION : SPS DESTINATION : ITS

FUNCTION TYPE : 1 FUNCTION CODE : 32

MESSAGE LENGTH : var COMMAND SUBCODE :

DESCRIPTION : This message is sent to the ITS to request that a display be sent to the screen of the ITS.

MESSAGE NAME : Action Alert Acknowledgement From IT Operator

ORIGINATION : ITS DESTINATION : SPS

FUNCTION TYPE : 1 FUNCTION CODE : 6
MESSAGE LENGTH : var COMMAND SUBCODE :

DESCRIPTION : This message is sent by the ITS to the SPS to acknowledge a Display Data Send ASCII Message.

MESSAGE NAME : Display Data Return ASCII
(ie operator data entries.)

ORIGINATION : ITS DESTINATION : SPS

FUNCTION TYPE : 1 FUNCTION CODE : 27

MESSAGE LENGTH : var COMMAND SUBCODE :

DESCRIPTION : This message is sent to the SPS in response to data entries made in a display by the operator. It contains those entries plus information associated with particular entries for any non-mandatory data entry fields. In addition to being sent as a result of the operator indicating an end of data display this message may be saved by the ITS and sent again in response to the Prior Display and Rapid Access Retrieve Commands.

MESSAGE NAME : Display Directory

ORIGINATION : ITS DESTINATION : SPS

FUNCTION TYPE : 1 FUNCTION CODE : 53

MESSAGE LENGTH : var COMMAND SUBCODE :

DESCRIPTION : This message is sent as a result of the ITS receiving a Template Compare Request Message. This message contains return status flag indicating if the date in the request matched on the SPS and ITS. If no match occurs this message contains a list of displays in use on the ITS and the compilation date for each display. The SPS will use the compilation dates to determine if new template objects should be sent to the ITS.

MESSAGE NAME : IT-Host-Transition Control : Deactivate

ORIGINATION : ITS DESTINATION : SPS

FUNCTION TYPE : 1 FUNCTION CODE : 61

MESSAGE LENGTH : var COMMAND SUBCODE : 2

DESCRIPTION : Sent in response to a request in the LAN Configuration.

MESSAGE NAME : IT-Host-Transition Control : Profile

ORIGINATION : ITS DESTINATION : SPS

FUNCTION TYPE : 1 FUNCTION CODE : 61

MESSAGE LENGTH : var COMMAND SUBCODE : 1

DESCRIPTION : This message is sent by the ITS to the SPS in response to a request in the LAN Configuration Message. The Profile Message contains the logon state relative to each screen.

MESSAGE NAME	:	Pending Action Alerts Display Request			
ORIGINATION	:	ITS	DESTINATION	:	SPS
FUNCTION TYPE	:	1	FUNCTION CODE	:	22
MESSAGE LENGTH	:	var	COMMAND SUBCODE	:	
DESCRIPTION	:	This message is sent by the ITS to the SPS.			

APPENDIX D: OUTLINE OF THE TECHNICAL PRESENTATION

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PROJECT REVIEW

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
GODDARD SPACE FLIGHT CENTER
GREENBELT, MARYLAND 20770
JUNE 14,1991
2:00 P.M.

CSEC, HOWARD UNIVERSITY
ASSISTED BY
SEDL, VIRGINIA TECH.

SYSTEMS ENGINEERING RESEARCH FOR NETWORKS
PROJECT REVIEW

PROJECT TEAM

HOWARD UNIVERSITY
DR. TEPPER GILL , PROJECT MANAGER
DR. ARTHUR PAUL, CO-PRINCIPAL INVESTIGATOR
MR. NORMAN BENJAMIN, RESEARCH ASSOCIATE
MR. LOUIS LATOUCHE, GRADUATE STUDENT
MS. MARY CHARLES, UNDERGRADUATE STUDENT

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DR. WOLTER FABRYCKY, VIRGINIA TECH., PI
MR. WILLIAM HOEHN, RESEARCH ASSISTANT

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SYSTEMS ENGINEERING RESEARCH FOR NETWORKS
PROJECT REVIEW

AGENDA

1.INTRODUCTION AND BACKGROUND
2.GOALS AND OBJECTIVES
3.CURRENT RESEARCH
PERFORMANCE METRICS AND MEASURES
- THEORETICAL APPROACH
- OPERATIONAL APPROACH
NCC EXTERNAL AND INTERNAL MESSAGES
PERFORMANCE MODEL(S)
RESOURCE SCHEDULING
4.BYPRODUCTS
5.PROBLEMS ENCOUNTERED
6.QUESTIONS AND ANSWERS

SYSTEMS ENGINEERING RESEARCH FOR NETWORKS
PROJECT REVIEW

1.INTRODUCTION AND BACKGROUND

SYSTEMS ENGINEERING RESEARCH FOR NETWORKS
PROJECT REVIEW

2. GOALS & OBJECTIVES

SHORT TERM [MAY 90 - AUG 91]

MID-TERM [SEPT 91 - AUG 92]

LONG-TERM [MAY 92 -]

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PROJECT REVIEW

3. CURRENT RESEARCH

ESTABLISHING PERFORMANCE METRICS AND MEASURES FOR THE NCC
- THEORETICAL APPROACH
- OPERATIONAL APPROACH

DEVELOPING PERFORMANCE MODEL(S) OF THE NCC

NCC RESOURCE SCHEDULING INVESTIGATIONS

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ESTABLISHING PERFORMANCE METRICS AND MEASURES
FOR THE NCC
THEORETICAL APPROACH

PERFORMANCE MEASURES SHOULD BE LINKED TO USER SATISFACTION.

USERS PERCEIVE PERFORMANCE IN 3 AREAS (SERVICE LEVELS):

1) PSYCHOLOGICAL (e.g. RESPONSE TIME)
2) THROUGHPUT (HOW MUCH CAN BE DONE IN A PERIOD OF TIME)
3) COST BENEFIT (WHAT THE USER RECEIVES FOR DOLLARS SPENT)

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PROJECT REVIEW

ESTABLISHING PERFORMANCE METRICS AND MEASURES
FOR THE NCC
THEORETICAL APPROACH

9 MEASURES OF NETWORK PERFORMANCE CAN BE IDENTIFIED AND DERIVED FROM SERVICE LEVELS:

1) TRANSFER RATE
2) AVAILABILITY
3) RELIABILITY
4) ACCURACY
5) CHANNEL-ESTABLISHMENT TIME
6) NETWORK DELAY
7) LINE TURNAROUND TIME
8) TRANSPARENCY
9) SECURITY

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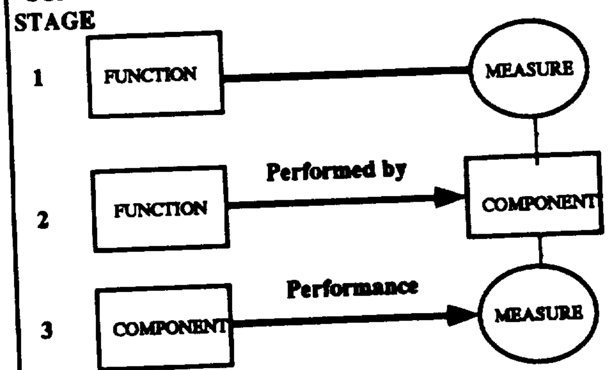
ESTABLISHING PERFORMANCE METRICS AND MEASURES FOR THE NCC
THEORETICAL APPROACH

CONCEPTUAL MODEL FOR PERFORMANCE MEASURES



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ESTABLISHING PERFORMANCE METRICS AND MEASURES FOR THE NCC
THEORETICAL APPROACH

MEASUREMENT AREAS TO BE FURTHER INVESTIGATED

- DEVELOPMENT OF A SINGLE MEASURE OF PERFORMANCE
- LEVEL OF ORGANIZATION AFFECTS MEASURES REQUIRED TO MAKE DECISIONS
- COST SHOULD BE BALANCED AGAINST PERFORMANCE LEVELS
- THE NORMALIZATION OF PERFORMANCE MEASURES SO THAT ALL MEASURES RELATE TO A SINGLE SCALE
- DECISION MAKING AFTER MEASURES ARE COMPLETED
- DETERMINING EXPECTED PERFORMANCE FOR SYSTEMS UNDER DEVELOPMENT

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ESTABLISHING PERFORMANCE METRICS AND MEASURES FOR THE NCC
OPERATIONAL APPROACH

REVIEWED:

- QUEUEING THEORY AND PRINCIPLES OF SIMULATION
- TECHNIQUES FOR PERFORMANCE EVALUATION
- NCC'S OPERATIONAL REQUIREMENTS

CONDUCTED:

- INTERVIEWS
- BRAINSTORMING SESSIONS

PARTICIPATED IN WORKSHOP

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PROJECT REVIEW

ESTABLISHING PERFORMANCE METRICS AND MEASURES FOR THE NCC
OPERATIONAL APPROACH

ESTABLISHED STRUCTURE

- QUALITY OF THE SERVICES
- OPERATIONAL EFFECTIVENESS

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PROJECT REVIEW

ESTABLISHING PERFORMANCE METRICS AND MEASURES FOR THE NCC
OPERATIONAL APPROACH

SAMPLE INDICATORS OF THE QUALITY OF THE SERVICE

- AVAILABILITY OF RESOURCES THAT CAN BE SCHEDULED
- UTILIZATION OF AVAILABLE SN RESOURCES
- PERCENTAGE OF ALL REQUESTS SATISFIED
- PERCENTAGE OF REQUESTS FOR SN RESOURCES SATISFIED
- PERCENTAGE OF EMERGENCY REQUESTS ACCEPTED
- QUALITY/COMPLEXITY OF POCC INTERFACE
- STABILITY OF PUBLISHED SCHEDULE
- AVAILABILITY OF PUBLISHED INFORMATION

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PROJECT REVIEW

ESTABLISHING PERFORMANCE METRICS AND MEASURES FOR THE NCC
OPERATIONAL ANALYSIS

INDICATORS OF NCC'S OPERATIONAL EFFECTIVENESS

- UTILIZATION OF NCC'S COMMUNICATION CAPACITY
- SUB-SYSTEM UTILIZATION
- ACKNOWLEDGEMENTS AND RESPONSE TIME
- SPECIFIC REQUESTS PROCESSING
- OTHER OPERATIONAL EFFECTIVENESS MEASURES

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PROJECT REVIEW

ESTABLISHING PERFORMANCE METRICS AND MEASURES FOR THE NCC OPERATIONAL ANALYSIS

SAMPLE INDICATORS OF UTILIZATION OF NCC'S COMMUNICATION CAPACITY

- AVERAGE CAPACITY UTILIZED BY INCOMING MESSAGES (SINGLE USER)
- PERCENTAGE OF TIMES THAT INCOMING MESSAGES (SINGLE USER) EXCEEDS 56 KB/SEC
- AVERAGE COMMUNICATIONS CAPACITY UTILIZED BY INCOMING MESSAGES (MULTIPLE USER)
- PERCENTAGE OF TIMES THAT INCOMING MESSAGES (MULTIPLE USER) EXCEEDS 448 KB/SEC

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ESTABLISHING PERFORMANCE METRICS AND MEASURES FOR THE NCC OPERATIONAL ANALYSIS

SAMPLE INDICATORS OF SUB-SYSTEM UTILIZATION

- OVERALL AVERAGE UTILIZATION--ALL SUBSYSTEMS (CCS,ITS,SPS,LAN)
- AVERAGE UTILIZATION--CCS
- AVERAGE UTILIZATION--ITS
- AVERAGE UTILIZATION--SPS

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ESTABLISHING PERFORMANCE METRICS AND MEASURES FOR THE NCC OPERATIONAL ANALYSIS

SAMPLE INDICATORS OF ACKNOWLEDGEMENT AND RESPONSE TIMES

- PERCENTAGE OF TIMES THE NCC FAILS TO SCHEDULE AN EVENT OR IDENTIFY ALL CONFLICTING EVENTS WITHIN 25 SECONDS OF A RECEIPT OF A REQUEST
- PERCENTAGE OF TIMES THE NCC'S SEARCH FOR A SUBSTITUTE EVENT EXCEEDS 2 MINUTES

SYSTEMS ENGINEERING RESEARCH FOR NETWORKS
PROJECT REVIEW

ESTABLISHING PERFORMANCE METRICS AND MEASURES FOR THE NCC OPERATIONAL ANALYSIS

SAMPLE INDICATORS OF SPECIFIC REQUEST PROCESSING

- AVERAGE PROCESSING TIME FOR SPECIFIC SCHEDULE REQUESTS (SECONDS)
- PERCENTAGE OF TIME THAT A SINGLE EVENT: ADD, DELETE, CANCEL REQUEST WITHOUT NCC OPERATOR INTERVENTION EXCEEDS 25 SECONDS
- PERCENTAGE OF TIME THAT A REPLACE REQUEST WITHOUT NCC OPERATION INTERVENTION TAKES MORE THAN 50 SECONDS

SYSTEMS ENGINEERING RESEARCH FOR NETWORKS
PROJECT REVIEW

ESTABLISHING PERFORMANCE METRICS AND MEASURES
FOR THE NCC
OPERATIONAL ANALYSIS

SAMPLE INDICATORS OF OTHER OPERATIONAL EFFECTIVENESS MEASURES

- OVERALL AVERAGE PROCESSING TIME -- ALL REQUESTS
- OVERALL AVERAGE DELAY -- ALL REQUESTS
- OVERALL AVERAGE PROCESSING TIME -- ALL RESPONSES
- OVERALL AVERAGE DELAY -- ALL RESPONSES

SYSTEMS ENGINEERING RESEARCH FOR NETWORKS
PROJECT REVIEW

NCC EXTERNAL AND INTERNAL MESSAGES

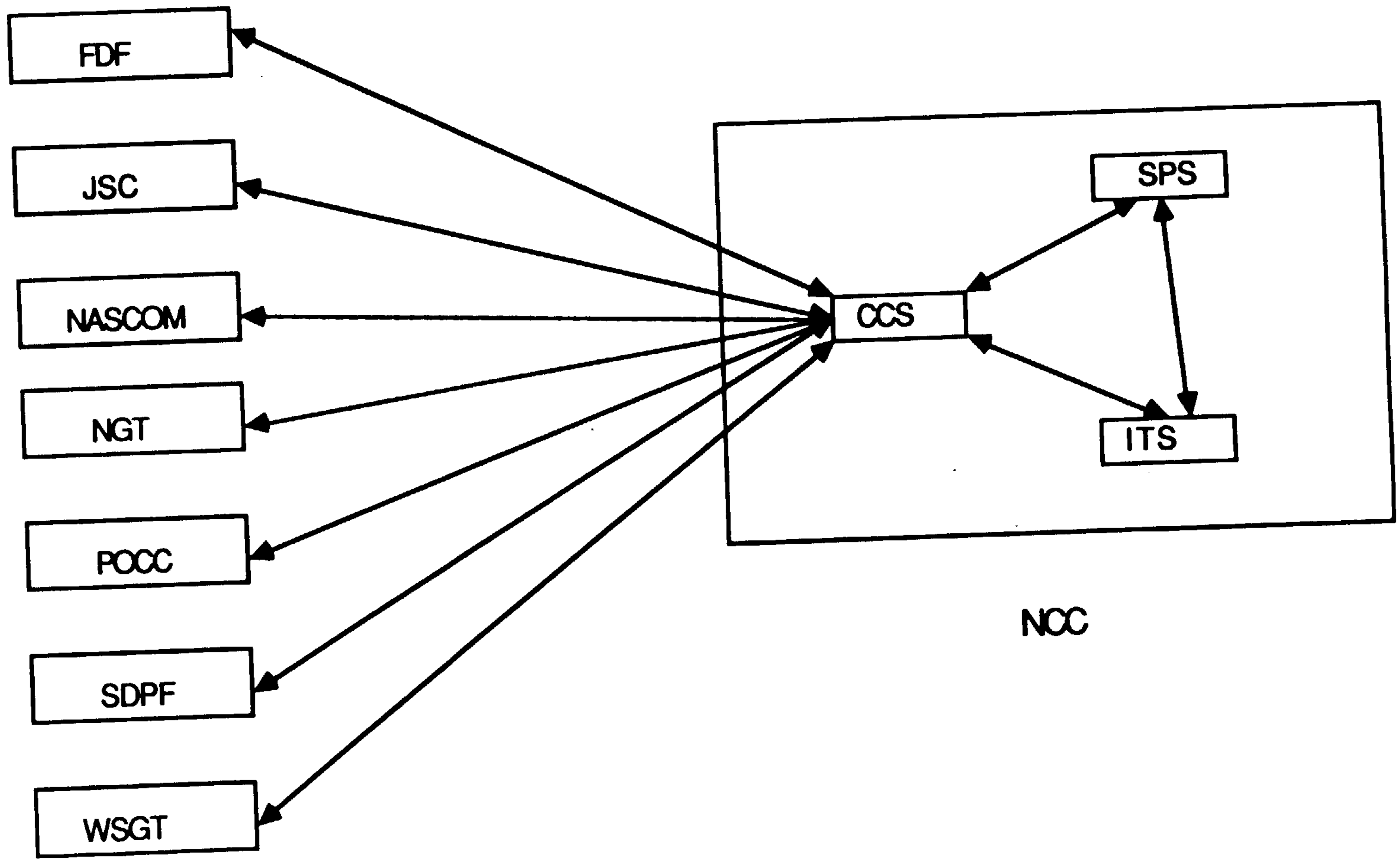
HIGH SPEED MESSAGES

MESSAGE DATABASE

MESSAGE MANUAL

MESSAGE GENERATOR

NCC EXTERNAL AND INTERNAL MESSAGE FLOW



SYSTEMS ENGINEERING RESEARCH FOR NETWORKS
PROJECT REVIEW

NCC EXTERNAL AND INTERNAL MESSAGES

HIGH SPEED MESSAGES

MESSAGE HANDLING REQUIREMENTS

1. ACKNOWLEDGEMENT
2. VALIDATION CHECKING
3. MESSAGE ROUTING
4. MESSAGE METERING
5. MESSAGE LOGGING
6. RE-TRANSMISSION
7. ACKNOWLEDGEMENT REPORTING

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PROJECT REVIEW

NCC EXTERNAL AND INTERNAL MESSAGES

MESSAGE DATABASE

DEVELOPMENT
USES

MESSAGE MANUAL

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NCC EXTERNAL AND INTERNAL MESSAGES

MESSAGE GENERATOR

FUNCTION

DESIGN

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SYSTEMS ENGINEERING RESEARCH FOR NETWORKS
PROJECT REVIEW

DEVELOPING PERFORMANCE MODEL(S) OF THE NCC
(VIA SIMULATION)

TASKS

1. NCC SYSTEM DESCRIPTION
2. SYSTEM ABSTRACTION AND MODEL DESCRIPTION
3. SAMPLE DATA COLLECTION
4. SIMULATION PROGRAM DEVELOPMENT
5. DEBUGGING AND INSTRUMENTATION OF MODEL
6. VERIFICATION
7. VALIDATION

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DEVELOPING PERFORMANCE MODEL(S) OF THE NCC
(VIA SIMULATION)

NCC SYSTEM DESCRIPTION

- DESCRIPTION OF NCC AND ITS COMPONENTS
- NCC OPERATION FROM A PERFORMANCE VIEWPOINT
- SERVICES PROVIDED TO THE NCC USERS
- NCC SYSTEM ASPECTS THAT ARE CRITICAL TO PERFORMANCE

DEVELOPING PERFORMANCE MODEL(S) OF THE NCC

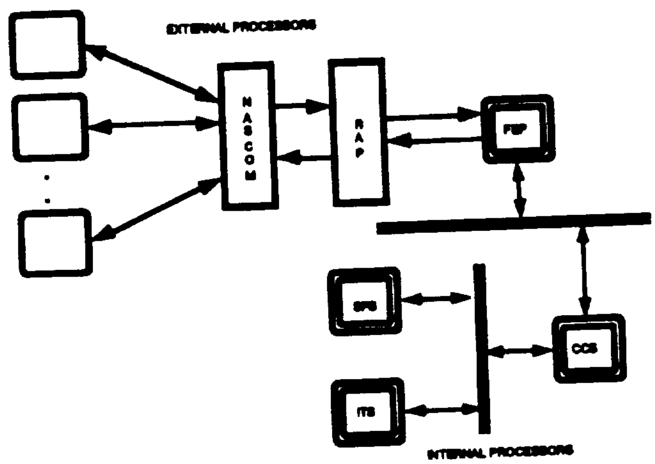
SYSTEM ABSTRACTION AND MODEL DESCRIPTION

- NCC SYSTEM REPRESENTATION
  NCC COMPONENTS TO BE MODELED
  * ITS, SPS, CCS
  * INTERSEGMENT LAN
  EXTERNAL COMPONENTS TO BE MODELED
  * POCCs, NASCOM, RAP, FDF, JSC, NGT, SDPF, WSGT

- REPRESENTATION OF WORK DONE BY NCC
  * MESSAGE TRAFFIC

- SIMULATION TOOL SELECTION (OPNET)

SIMULATION PROGRAM DEVELOPMENT
NETWORK VIEW

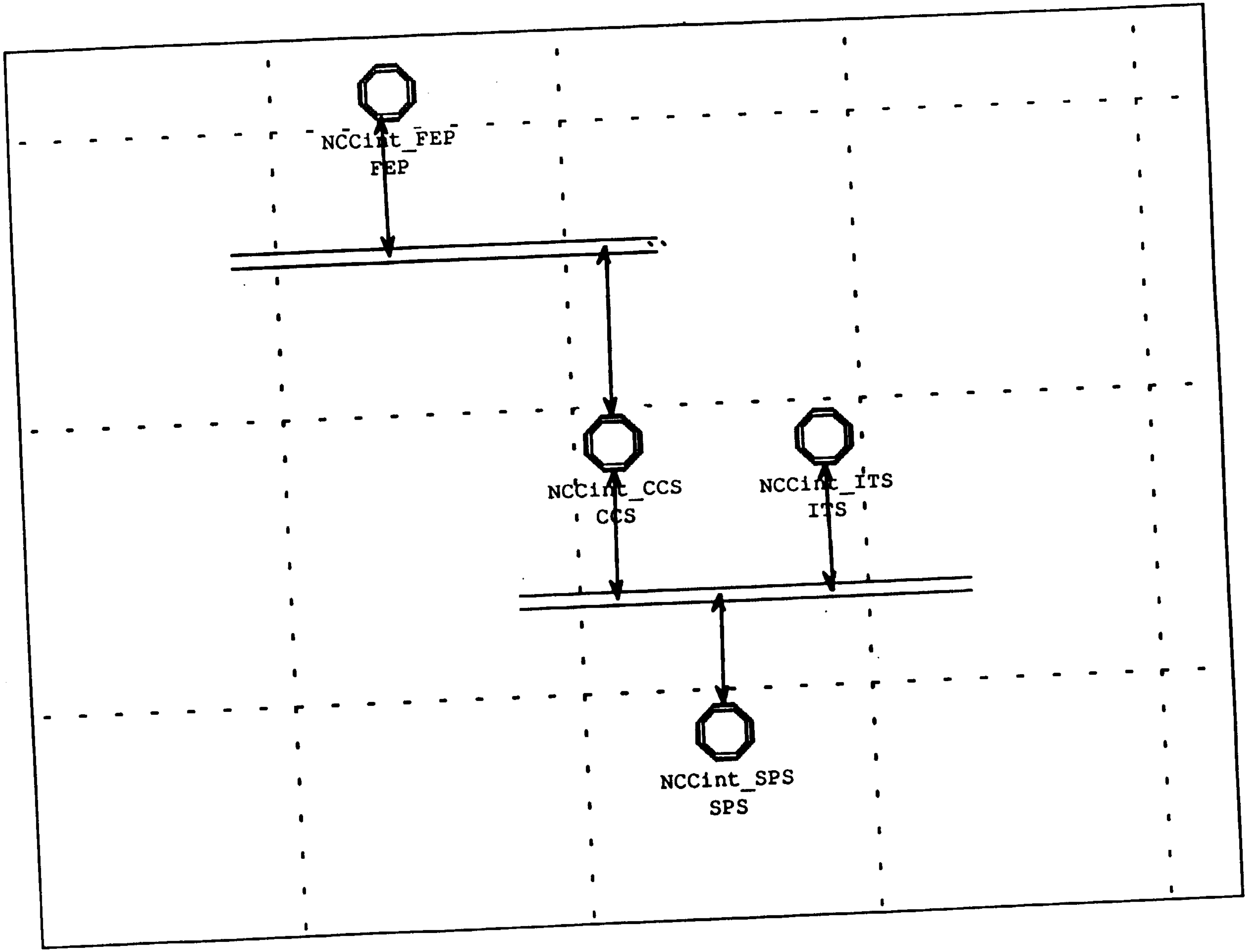


DEVELOPING PERFORMANCE MODEL(S) OF THE NCC

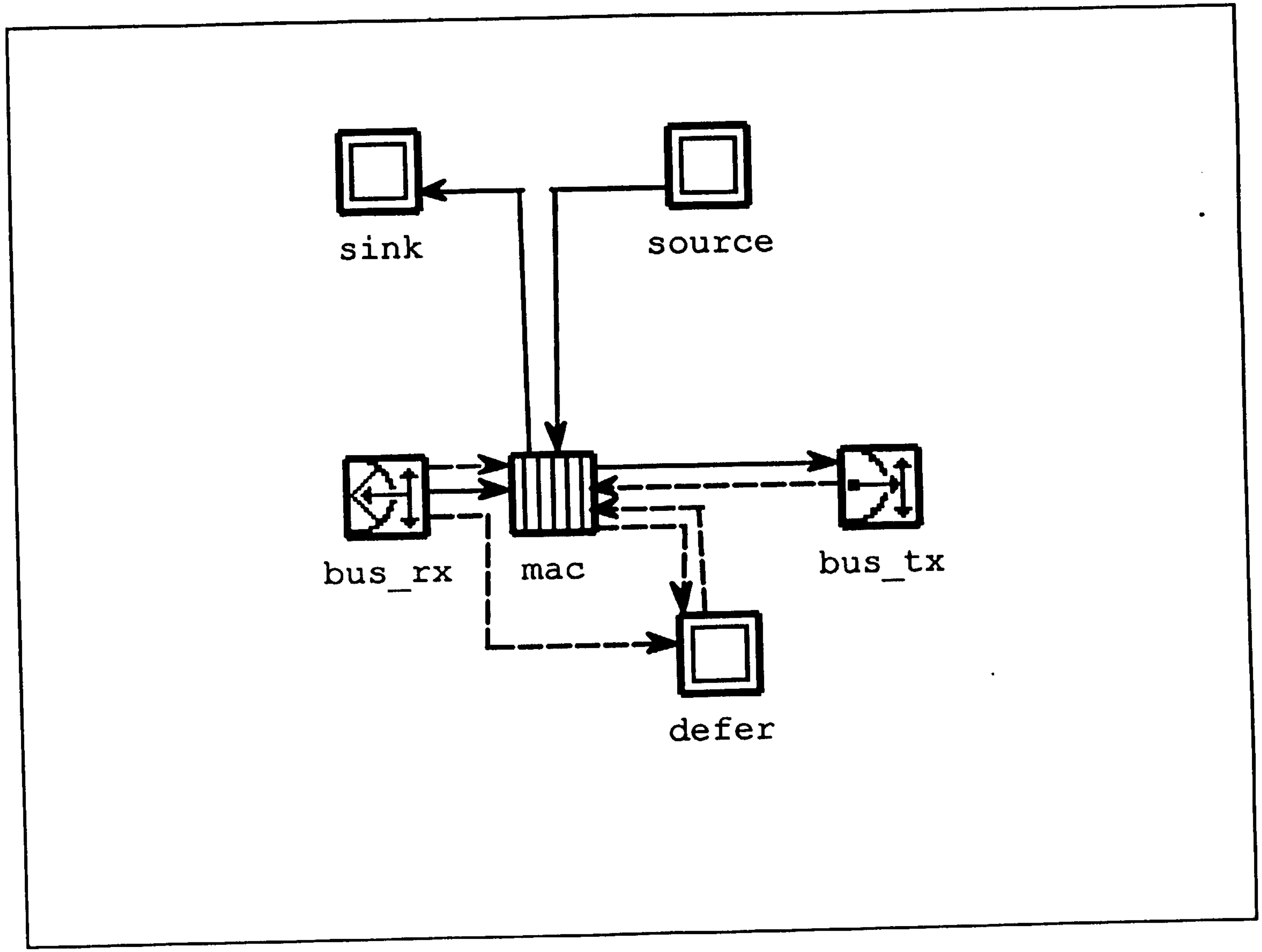
SAMPLE DATA COLLECTION

- WILL BE OBTAINED FROM LOG TAPE SUMMARY AND INTERSEGMENT LAN PERFORMANCE ANALYSIS
- USED TO DETERMINE DISTRIBUTIONS AND OTHER STATISTICAL MEASUREMENTS THAT WILL BE USED IN THE MODEL
- TO ASSIST IN THE VERIFICATION AND VALIDATION OF THE MODEL

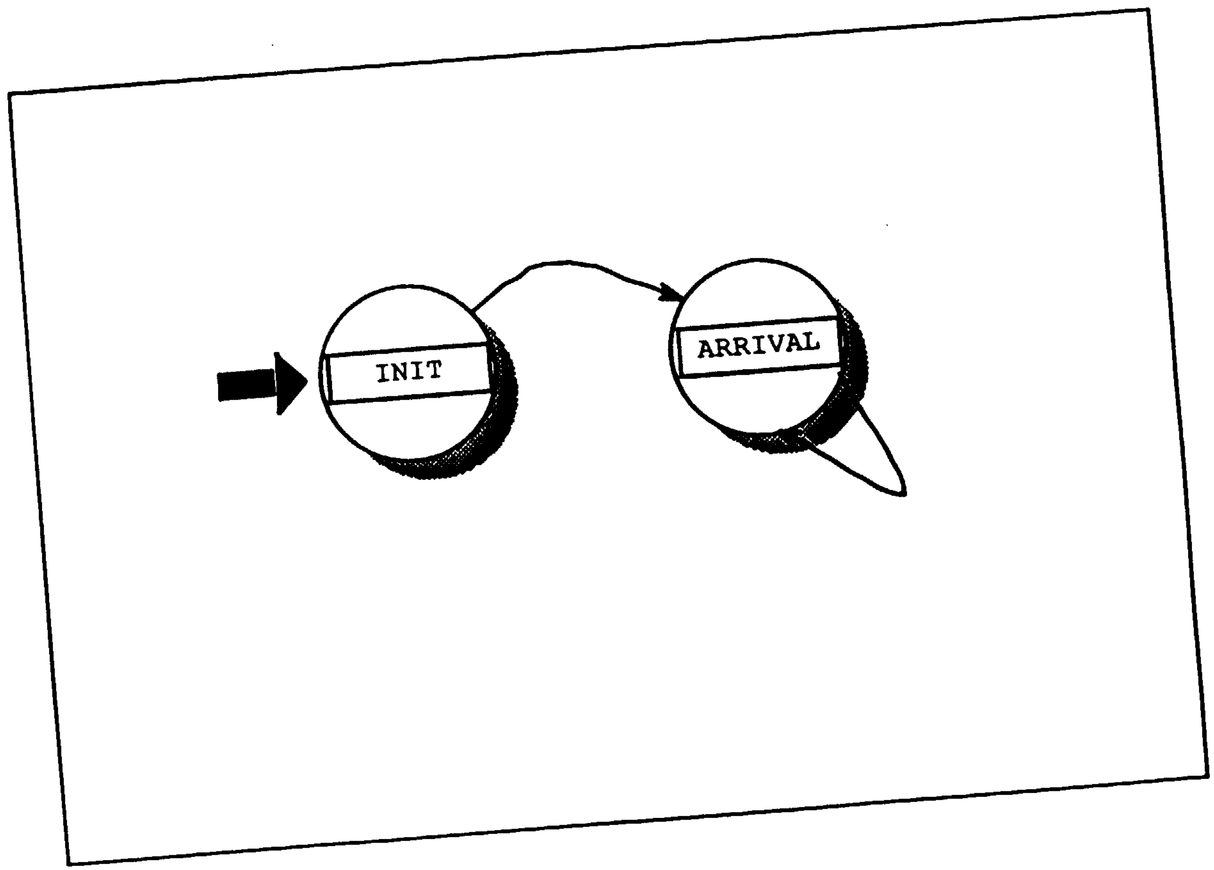
NCC INTERNAL PROCESSORS



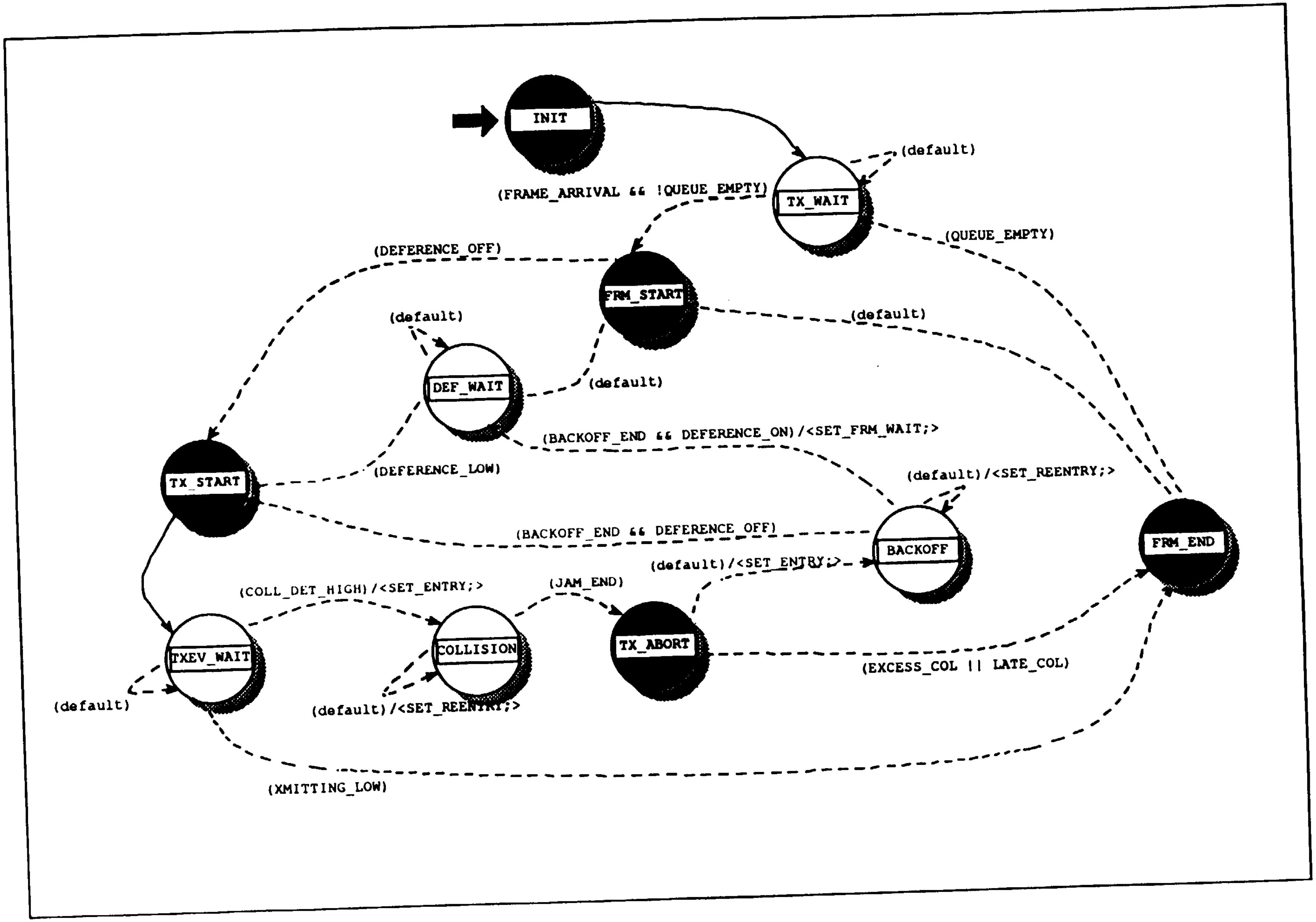
NODE REPRESENTATION OF THE SPS

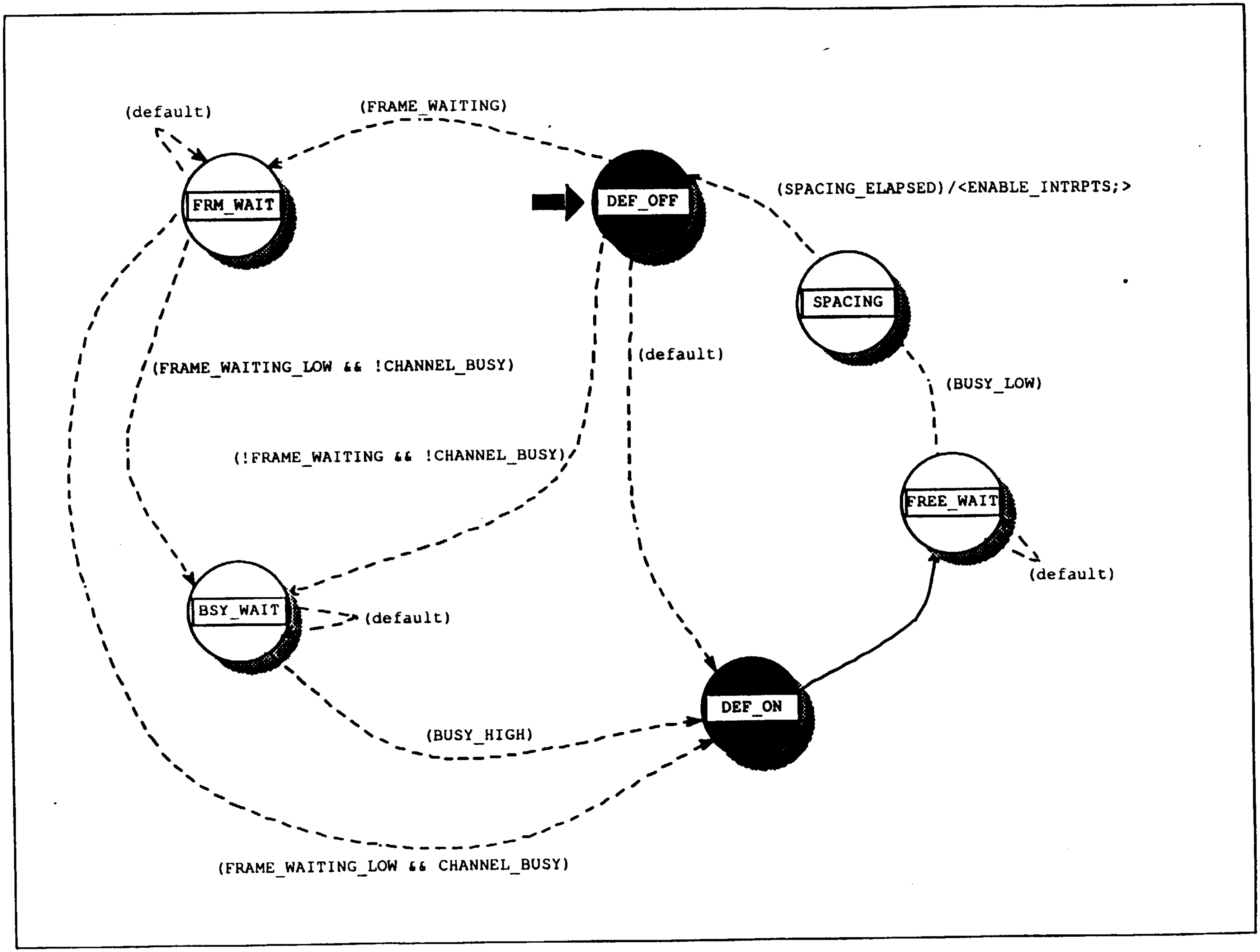


MESSAGE GENERATOR



BUS ACCESS PROCEDURE





(default)
(FRAME_WAITING)
FRM_WAIT
DEF_OFF
(SPACING_ELAPSED)/<ENABLE_INTRPTS;>
SPACING
(default)
(FRAME_WAITING_LOW && !CHANNEL_BUSY)
(BUSY_LOW)
(!FRAME_WAITING && !CHANNEL_BUSY)
FREE_WAIT
BSY_WAIT
(default)
(default)
DEF_ON
(BUSY_HIGH)
(FRAME_WAITING_LOW && CHANNEL_BUSY)

DEVELOPING PERFORMANCE MODEL(S) OF THE NCC

SIMULATION PROGRAM DEVELOPMENT

- DETERMINE OPNET ELEMENTS TO BE USED
- NCC MODEL INSTRUMENTATION
  (DEFINED BY THE INDICATORS OF THE NCC'S OPERATIONAL EFFECTIVENESS)
- NCC MODEL DEBUGGING

DEVELOPING PERFORMANCE MODEL(S) OF THE NCC

VERIFICATION
(PROVE THAT THE SIMULATION PROGRAM IS A VALID IMPLEMENTATION OF THE MODEL)

VALIDATION
(DEMONSTRATE THAT THE SIMULATION PROGRAM IS A REASONABLE REPRESENTATION OF THE SYSTEM)

NCC RESOURCE SCHEDULING INVESTIGATIONS

- SCHEDULING ALGORITHMS REVIEWED
  (APRIL 25, 1991 PAPER)
- MODELING APPROACHES
  (MAY 28, 1991 PAPER)
- TOWARDS AN ANALYTICAL MODEL FOR SN SCHEDULING
  (ENGR 5104 PAPER)

NCC RESOURCE SCHEDULING INVESTIGATIONS

SHOULD NASA USE SIMULATION OR ANALYTICAL

APPROACHES TO EVALUATE SCHEDULING PRACTICES?

- ANALYTIC MODELS MAY RESULT IN A LOWER COST THAN SIMULATION
- HOWEVER ANALYTIC MODELS MAY TAKE LONGER TO DEVELOP
- THEREFORE BOTH APPROACHES SHOULD BE FURTHER INVESTIGATED TO DETERMINE WHERE BENEFICIAL INROADS AND INSIGHTS MAY BE OBTAINED

SYSTEMS ENGINEERING RESEARCH FOR NETWORKS
PROJECT REVIEW

NCC RESOURCE SCHEDULING INVESTIGATIONS

ANALYTIC MODELS DEVELOPED FOR COMPUTER OPERATING SYSTEMS MAY BE USED TO BETTER UNDERSTAND NETWORK SCHEDULING. A POSSIBLE APPROACH IS TO:

- INVESTIGATE COMPUTER OPERATING SYSTEM SCHEDULING OF PRIORITIES BY DISCRETE QUEUES
- INCORPORATE TIME WINDOWS INTO DISCRETE QUEUEING ALGORITHMS
- VIEW TDRS RESOURCE REQUESTS AS A SINGLE CHANNEL, SINGLE TDRS
- CONSIDER CHAINING OF SATELLITES AND MULTIPLE CHANNELS
- CONSIDER VISIBILITY CONSTRAINTS

CSEC, HOWARD UNIVERSITY
ASSISTED BY
SEDL, VIRGINIA TECH.

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SYSTEMS ENGINEERING RESEARCH FOR NETWORKS
PROJECT REVIEW

NCC RESOURCE SCHEDULING INVESTIGATIONS

ANOTHER POSSIBLE APPROACH TO SCHEDULING EVALUATION IS THE USE OF A SYSTEM DYNAMICS MODEL.

- A SYSTEMS DYNAMICS MODEL MAY BE DEVELOPED IN CONJUNCTION WITH OTHER ANALYTIC MODELS
- A SYSTEMS DYNAMICS MODEL WILL PROVIDE A GRAPHICAL REPRESENTATION OF NETWORK SCHEDULING AND RESOURCES
- SYSTEMS DYNAMICS MODEL IS INHERENTLY LINKED TO OTHER ANALYTIC MODELS

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6/14/91

4. BYPRODUCTS

- STUDENT EXCHANGE
- INSTITUTIONAL INTERACTION
- SOFTWARE TOOLS
- LAB DEVELOPMENT

SYSTEMS ENGINEERING RESEARCH FOR NETWORKS
PROJECT REVIEW

5. PROBLEMS ENCOUNTERED

6. QUESTIONS AND ANSWERS

APPENDIX E: PAPERS PREPARED BY VPI ON RESOURCE SCHEDULING

SYSTEMS ENGINEERING RESEARCH
FOR THE SPACE NETWORK

Space Network Scheduling Algorithms Reviewed

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In Cooperation with Howard University
April 25, 1991

INTRODUCTION

This paper presents a critique of papers published in academic journals relevant to network scheduling. Its purpose is to aid NASA personnel responsible for Tracking and Data Relay Satellite System (TDRSS) resource scheduling. This paper is a step towards the completion of Task 2.C.1, as outlined in "Engineering Technology for Networks Progress Report, January 1991."

At this time, "schedulable resources for TDRSS are the links, bandwidth, and antennas for both forward and return links for multiple access (MA), S-band single access (SSA), and K-band single access (KSA) services as well as tracking service using one-way doppler and MA and SA two-way range and doppler (Engineering Technology for Networks Progress Report, January 1991)." Algorithms for scheduling recently discussed in academic journals are explored to determine if they can be applied towards the improvement of TDRSS resource scheduling.

RECENT SCHEDULING SYSTEM HISTORY

SCHEDULE REQUESTS

Scheduling of TDRSS services is initiated when users submit a request for a block of time to the Network Control Center (NCC). Users are composed of NASA entities as well as other government agencies needing to communicate with both manned and unmanned space vehicles. Requests can either occur as <u>specific requests</u> or as <u>generic requests</u>. A specific request is a request submitted by an user requesting service for a single transaction (or event) occurring within a specific time window. A generic request is a request which a user submits for a number of single transactions to be scheduled on a repeating basis. Generic requests expand into two or more request instances. That is, request instances are the individual transactions which when summed make up a single generic request.

SCHEDULER SELECTION CRITERIA

In April of 1989, the conclusion of an attempt to find an automated resource scheduler was reached. Two systems - Jet Propulsion Laboratory's (JPL) RALPH scheduler implemented in TREES/FOREST and Code 522's ROSE scheduler implemented in Symbolics/LISP - were compared based on their abilities to "1) formulate generic requests which express the flexibility customers need, 2) [not] require customers tc specify information they're not interested in, 3) provide an easy-to-use operator interface, and 4) provide the functionality that operators need (TDRSS Scheduling Prototype--Status Report, April 19, 1989)." Of the two systems compared, the Resource Oriented Scheduling Engine (ROSE) was selected as the best alternative.

RESOURCE ORIENTED SCHEDULING SYSTEM

Currently, generic and specific requests are entered into ROSE to determine optimum schedules. At this time, ROSE creates schedules by using either maximum temporal constraints or maximum peak resource utilization selection strategies. Maximum total resource utilization and minimum total resource utilization selection strategies can be added in the future if desired. ROSE also features the four request placement strategies: 1) Quick, 2) Quick-Dynamic, 3) Compact, and 4) Best Resource Fit. When entering schedule requests, one single placement strategy is used to determine the optimum schedule.

ALTERNATIVE SCHEDULING ARCHITECTURES

Three scheduling architectures were tested by NASA and implemented using a Symbolics 3640 LISP machine. They are: 1) Repeating Expand-Scheduling Cycles, 2) External Expansion, and 3) Internal Expansion. Internal expansion architecture is inherent within JPL's RALPH scheduler while the ROSE scheduler relies on the external expansion architecture. By October of 1989 it became apparent (through testing) that the external expansion architecture produced faster results, while the internal expansion architecture scheduled more requests. It was suggested at that time that both scheduling schemes should undergo more development and testing. It was hypothesized that the best scheme could be the combination of "...the global view of inter-request dependencies (provided by the external expansion architecture) with the ability to return to an earlier decision point in the scheduling process in an effort to schedule more requests (provided by the "backtracking" in the internal expansion architecture) (Scheduling Results Analysis Report for the NCC Prototype Testing, Task 20-103)." By January of 1990, NASA, working under Task 20-103, had decided to develop a hybrid architecture combining the best attributes of the external expansion and the internal expansion architectures.

NCC PRESCHEDULER

In addition to ROSE, an NCC Prescheduler was proposed in June of 1989. The NCC Prescheduler was intended "to provide an intermediate generic scheduling capability in the NCC (NCC Prescheduler Proposal, 1989)." The idea was proposed because current methods of scheduling were thought to be inadequate for tasks required to be performed in the 1990's. The Prescheduler promised to: 1) Reduce the amount of manual conflict resolution, 2) make the schedule generation process more efficient, 3) reduce the amount of work individual Project Operations Control Centers (POCC) need to perform, and 4) improve POCC scheduling satisfaction and network resource utilization.

SCHEDULING BY THE USER

Each user has a priority code. The scheduler uses this code to determine which tasks are more important than others. Thus, selection of tasks to be performed at a specific time is governed by the priority of users vying for TDRSS services. Along with a priority, users also can specify transmission rates, transmission start and stop times, and the duration of events. In addition, users may specify that they wish to transmit information to their vehicle, receive information from their vehicle, or both send and receive information to their vehicle. Arrival of user requests may be Poisson, but this has not been confirmed at this time.

CURRENT LITERATURE REVIEW

As stated in the prior section, an evaluation of current literature relative to scheduling will be presented to determine if any recent developments will be of help to NASA's NCC staff when trying to select and develop scheduling algorithms appropriate for the second generation NCC.

SCHEDULING TO MINIMIZE COMPLETION TIME

In the journal article, "Preemptive Scheduling to Minimize Maximum Completion Time on Uniform Processors with Memory Constraints," Charles Martel presents two algorithms which can be used to find schedules on m uniform processors (P_1, P_2,...,P_m) for n independent jobs (J_1, J_2,...,J_n). Assumptions made are that the processors are identical, and that jobs can be preempted and completed immediately or later on a-- processor.

An $O(nm\log^2 m)$ time algorithm is constructed to determine C_{max}, "the earliest time by which all jobs can be completed (Martel, 1984)." The feasibility algorithm chosen by Martel uses a "...general model of parallel processors in which job J_j requires p_{ij} units of time to be completed by processor P_i." "If x_{ij} is the amount of time processor P_i executes job J_j, then J_j is completed if and only if

$$\sum_{i=i}^{m} x_{ij}/P_{ij} = 1."$$

Processors meeting this criterion are called unrelated processors.

Advantages of this algorithm are that "any constraints that prohibit a job from being run on a machine can easily be incorporated (Martel, 1984)." Thus, P_{ij} is set to infinite when job J_j cannot run on P_i.

The fact that jobs can be excluded from individual processors can play a role in the STDN since: 1) bandwidth is a function of a single channel, and 2) user spacecraft location will determine which TDRS(s) will be the processor(s). Thus, available channels can be viewed as processors, and user requests viewed as jobs. Further, TDRS location can be viewed as processors, and ability to use them will be determined by the user spacecraft location.

It should be noted that Martel's approach does not include the use of priorities. If priorities can be incorporated as a selection criterion within this approach, then the approach may become a candidate for further exploration.

APPROXIMATING THE MEAN TIME IN SYSTEM

In the journal article, "Approximating the Mean Time in a Multiple-Server Queue that uses Threshold Scheduling," Nelson and Towsley present the study of a multiple-server (with servers having different service rates) system sharing a common queue. Assumptions in this paper are that there exists a set of N heterogeneous servers (P_1, P_2,...,P_N) that serve a common queue with jobs arriving to the queue according to a time-invariant Poisson process with rate Lambda and are served in a first-come first-served (FCFS) basis.

Priorities are excluded from Nelson and Towsley's scheduling schema. Analysis will result in an algorithm to approximate the expected response time of the system using a

Markov process. Since priorities are excluded from computation (i.e., users are served in a FCFS basis) it would seem that this algorithm would have little use within SN scheduling activities.

SIMULTANEOUS SERVICE FROM A SINGLE QUEUE

In the journal article, "On Waiting Times for a Queue in Which Customers Require Simultaneous Service from a Random Number of Servers," Andrew Seila has presented a scheme in which the means and standard deviations of waiting times can be calculated. Assumptions are that: 1) arrival streams are Poisson distributed, service is requested simultaneously, servers are identical, and the congestion level, (Lambda)b_1, can be calculated.

Seila's article may not be relevant to TDRS operations since it relies on Poisson arrival rates and identical servers. However, algorithms presented in the article may be used as a basis to approximate the number of channels required for STDN operations. This may be possible if users are segregated into classes by using bandwidth and type of transmission frequently used (i.e., MA, SSA, or KSA). If this were done, it may be possible to determine user requirements individually (i.e., view the STDN as being composed of several entities, and determining server levels for each of these entities separately).

CONCLUSIONS

In order to further pursue the investigation of scheduling algorithms appropriate for the Space Network, investigators must first determine if: 1) Request arrivals are Poisson distributed, and 2) TDRS's can be treated as individual processors, and thus, excluded from some jobs. Finally, the physical characteristics of the current system must be determined. At this time the system should support 25 simultaneous users. Of these 25, NASA must determine which bandwidths, links, and antennas are being used. This will require some on site study by the investigators.

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SYSTEMS ENGINEERING RESEARCH
FOR THE SPACE NETWORK

Modelling Approaches for
Space Network Scheduling

Systems Engineering Design Laboratory
Virginia Polytechnic Institute
and State University
Blacksburg, Virginia
May 28, 1991

MODELLING OF SYSTEMS

During the design and development of complicated systems, creators are faced with the need to understand system actions and performance prior to actual system implementation. In many cases, system creators will turn to modelling to help them understand how different design configurations will affect system performance. Modelling has two distinct forms: 1) Analytical, and 2) Simulation. Analytical modelling is based on mathematical equations with statistical underpinnings. Simulation is an iterative process (usually on a computer) in which a "model" is created which attempts to accurately emulate some variables in the actual system. Sample data must be entered into the process.

COST CONSIDERATIONS

Analytical modelling is usually less expensive than simulation since large amounts of computer time is not required. However, the development of analytical models may take longer than simulation models since analytic models can usually only describe a single specific system, i.e., existing simulation models can be more easily adapted to describe new systems.

ANALYTIC MODELLING FOR SN SCHEDULING

After a careful review of network scheduling performance literature, it has become apparent that no analytic models currently exist which will accurately describe SN resource scheduling performance (Space Network Scheduling Algorithms Reviewed, 1991; Hoehn, 1991). However, because of the possibility of the lower cost of analytic modelling, and the fact that simulation scheduling algorithms will execute no faster than the actual system under study (resulting in slow feedback and high cost), we feel that analytic modelling should be investigated further to determine if it is still a viable alternative. Up to this time, a vast amount of research has been dedicated to developing analytical models for computer operating systems (COS). We feel that their is a close parallel between COS and the SN, and this similarity should be exploited if possible.

SIMILARITIES BETWEEN THE SN AND COS

Many COS's must distinguish between user priorities. That is, higher priorities will execute before any lower ones. To accomplish this, priorities are usually divided into discrete queues. In this way, the system polls queues to determine which jobs to execute first. The SN also uses priorities, so it may be possible to incorporate some COS knowledge towards the execution of jobs by priorities.

Some performance measures which COS analytic models help measure are:

" 1. Mean queue length
2. Mean waiting time before service begins
3. Mean time that a job spends in the system
4. Utilization of processor capacity
5. Relation between arrival and service distributions (Maekawa et. al., 1987)"

If a correct strategy to develop analytic models for SN resource scheduling is created and followed, then it may be possible to use these performance measures to predict SN operation performance. Appropriately, what follows is an outline of a strategy to accomplish this purpose.

PROPOSED COURSE OF SN MODELLING RESEARCH

1. Investigate current COS relative to how they treat priorities as separate queues on a first-come-first-served basis. Consider TDRS resources to be identical, and time requests specific (e.g., do not schedule relative to time windows).

2. Determine how time windows can be incorporated into the queue by priority schema mentioned above. This may mean the incorporation of a recursive approach after the initial resources are scheduled (i.e., look-back capability).

3. Consider TDRS resources needed by users to be singular (i.e., the user will not require more than one satellite at a time).

4. Consider chaining of satellites (i.e., the user requires more than one TDRS to reach their vehicle).

5. Consider visibility limitations (i.e., times that satellites can receive and broadcast data).

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SYSTEMS ENGINEERING REPORT

Towards an Analytical Model for Space Network Scheduling

William K. Hoehn
ENGR-5104

BACKGROUND

SPACEFLIGHT TRACKING AND DATA NETWORK

The Missions Operations and Data Systems Directorate (MO&DSD), located at Goddard Space Flight Center (GSFC) in Greenbelt, Maryland, "is responsible for program planning, development, and operation of the National Aeronautics and Space Administration's (NASA) near-Earth network of space and ground-based tracking and data communications facilities and systems (Network Division Systems Development Activities, 1989)." MO&DSD is responsible for the systems and services provided by the Spaceflight Tracking and Data Network (STDN). The STDN provides Tracking and Data Acquisition (T&DA) services to a diverse group of space flight projects. The MO&DSD is currently concerned with: 1) evolving space flight project requirements, 2) the need to reduce maintenance and operations costs, 3) the need to increase efficiency, 4) the replacement of obsolete systems, 5) the need to improve systems reliability and network availability, and 6) the expected increase in users vying for network services.

SPACE NETWORK

The Space Network (SN), a component of the STDN, "...was developed to provide a set of standard T&DA services to low-Earth orbiting satellites operating in the S- and Ku-band frequency ranges (Network Division Systems Development Activities, 1989)." The SN uses geostationary Tracking and Data Relay Satellites (TDRS) to provide coverage to low-Earth orbiting satellites, and manned spacecraft.

NCC

The Network Control Center (NCC) is responsible for scheduling resources available on the SN. Resources currently available include: 1) Ground Links, 2) Bandwidth, and 3) antennas. Antennas provide "...both forward and return links for multiple access (SSA), and K-band single access (KSA) services as well as tracking service using one-way doppler and MA and SA two-way range and doppler (Gill and Paul, 1991)."

HISTORY

TDRS DEPLOYMENT

After deployment of the first TDRS in 1988, it became readily apparent that TDRS's would "...dramatically increase [the coverage available to low-Earth orbiting satellites] beyond that previously afforded through ground-based tracking stations (Networks Division Systems Development Activities, 1989)." In 1988, the MO&DSD determined that the STDN operations concepts should be modified to reflect the evolving demands expected to be placed on the network. The concepts were divided into six phases, with completion of the sixth to occur in 1994. These changes, however, do not reflect changes to be made to the network when the space station comes on line in 1997.

CHANGES IN THE NCC

Automation

In the 1970's, the NCC relied on UNIVAC computer systems. By the early 80's, a new computer system (VAX) was selected and installed to provide real-time functions, while the UNIVAC's were retained to provide non-real-time functions. The changeover from UNIVAC's to VAX's took 18 months. During the changeover, it was determined that "UNIVAC applications and software was not suitable for the VAX environment, so the decision was made to convert the software to the VAX (Network Control Center Block II Project History Report, 1990)."

New Directions

At this time, the NCC is attempting to adhere to tasks specified under the STDN operations concepts. Tasks include developing a completely new system - Space Network Control Center-SNCC - by 1997 to meet expected demands resulting from the deployment of the space station. Currently, the NCC is attempting to: 1) develop top-level performance requirements for the SN, 2) gain knowledge and experience by simulating the existing SN, and 3) develop algorithms to schedule resources on the SN.

SCOPE OF THIS REPORT

TASK AREA

This report will deal with only the task of developing analytic models to aid in the scheduling of resources on the SN.

SCHEDULING BACKGROUND

NCC SCHEDULING PROCEDURES

User Requests

Scheduling of resources available on the SN is initiated when a Project Operations Control Center (POCC) submits a schedule request. The request consists of: 1) a time window, 2) a transmission rate, 3) the type of transmission, and 4) the number of events per day (Demonstration Plan for the NCC Generic Scheduler Task 29-103 Phase Two, 1989). A time window is the earliest and latest time that transmission can begin. Transmission rates inform the NCC as to how many bits will be transferred per second. Transmission rates do not have to be the same in both directions (i.e., playback can be at a lower rate than the up-link rate). The type of transmission refers to the band requested. Bands available are: (SSA+KSA)=SA, and MA. There are 2 SA and 19 MA available per TDRS. The number of times per day refers to the number of identical events to occur per day.

Prerequisite Information

Prerequisite Information Defined

In addition to the request submitted by the user, the NCC maintains a list of prerequisite information (Functional and Performance Requirements for the Network Control Center, 1986). Prerequisite information includes "...normal levels and characteristics of a user's service requirements and the visibility and network constraints on the service that can be provided. This information includes configuration codes, prototype events, generic requirements, spacecraft characteristics, the spacecraft priority list, spacecraft visibility information, and SN resource availability (Functional and Performance Requirements for the Network Control Center, 1986)." Configuration codes, prototype events, the spacecraft priority list, and spacecraft visibility information will be further described below.

Configuration Codes

The NCC can either receive or store user requested transfer rate and selected band. The package comprised of transfer rate and band is a configuration code.

Prototype Events

A prototype event is comprised of user selected "...configuration codes and their relative start times and durations (Functional and Performance Requirements for the Network Control Center, 1986)."

Spacecraft Priority List

Priorities are assigned to users by NASA management by a ranking procedure based on need (with manned spacecraft having the highest priority). Higher priorities take precedence over any priorities lower than them.

Spacecraft Visibility Information

The NCC is responsible for the storage of a "...set of information that specifies the periods when...[a user's] spacecraft will be visible to each of the operational TDRSs and within these periods the periods that are subject to sun interference in the user or TDRS antennas (Functional and Performance Requirements for the Network Control Center, 1986)." An individual user can opt not to have this information stored if they wish.

SCHEDULERS CURRENTLY UNDER STUDY

Schedulers currently under study by NASA include the Resource Oriented Scheduling Engine, and Jet Propulsion Laboratory's (JPL) RALPH. RALPH relies on internal expanding architecture, and in testing was able to schedule more requests than ROSE, although it noteably slower than ROSE. ROSE relies on external expanding architecture, and is much faster than RALPH. ROSE, however, is not able to schedule as many requests as RALPH. Current investigations include hybrid approaches to combine the best attributes of the internal expanding and the external expanding architectures. Both of these schedulers move downwards through a sequence of instructions, and given both time windows, configuration codes, priorities, and visibilty, they both schedule resources for the SN. It should be noted that both RALPH and ROSE only consider one request at a time. RALPH's internal expanding architecture enables the system to schedule more requests because it uses iteration to locate requests that can be moved to other resources so as to maximize efficiency of the SN.

SYSTEMS CONTEXT

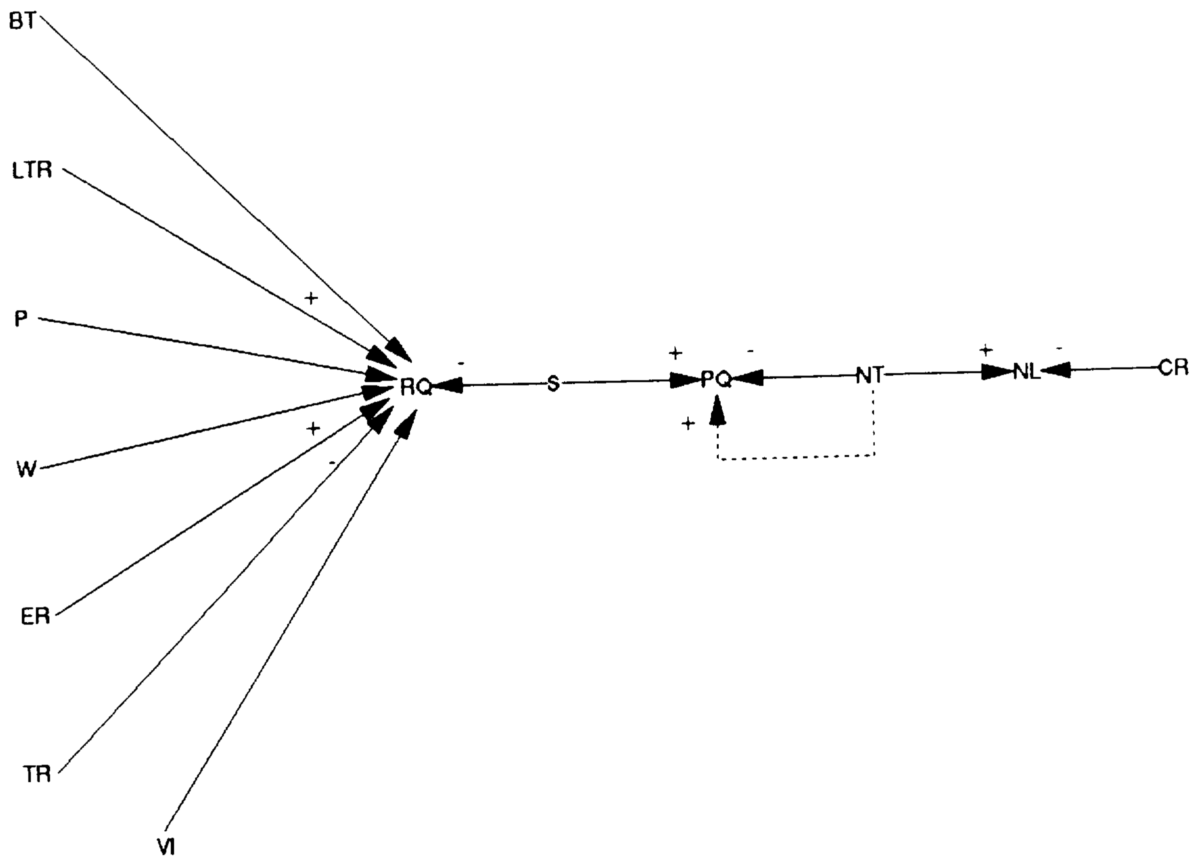
APPROACH

This scheduling problem is a systems problem. This is because in order to determine the best scheduling algorithm, a systematic approach must be taken. This approach includes viewing the SN resources, and user requests along with the resulting schedule as a conserved system. That is, SN resources are finite, and as such, an increase in requests after all resources are deployed will result in an increase in delays and schedule length (Figure 1).

EXPECTED OUTCOMES AND OUTPUTS

The desired outcomes are to determine the optimum SN resource levels given user demands, and to increase user satisfaction. Outputs from the project should be: 1) increased utilization of SN resources, 2) decreased scheduling time, and 3) less time taken-up with scheduling conflict resolution.

SYSTEMS DYNAMICS MODEL FOR THE SPACE NETWORK



BT=BAND TYPE (SA OR MA)
LTR = LENGTH OF TRANSMISSION REQUEST
P = PRIORITY
W = TIME WINDOW REQUESTED
ER = ERROR RATE
TR = TRANSMISSION RATE
RQ = REQUEST QUEUE LENGTH
S = SCHEDULE
PQ = PROCESSING QUEUE LENGTH
NT = NETWORK THROUGHPUT
NL = NETWORK LOAD
CR = COMPLETED REQUESTS
VI = VISIBILITY

NOTE: Not all arrows show signs because I am not sure how the rates will affect the model.

FIGURE 1

ANALYTICAL MODELING OF SN SCHEDULING

A SINGLE ANALYTICAL MODEL FOR SN SCHEDULING

Using systems dynamics, I would like to find an analytical model to describe the utilization of the SN's processors (i.e., network load). Figure 1 shows the relationships between user's requests (composed of BT, LTR, P, W, ER, and TR) and completed requests. Since network resources (transmission rates and band types) and user requests (time windows and priorities) are not constants, the system is composed of heterogeneous elements. This renders the use of an analytical model at this level impossible.

TWO ANALYTICAL MODELS TO DESCRIBE SN SCHEDULING

Since analytic modelling at the top level is not possible, we may be able to divide the system into 2 separate systems according to band type. This division into two levels, however, still does not answer the question of how to handle user priorities and different transmission rates.

DIFFICULTIES ASSOCIATED WITH ANALYTICAL MODELING OF THE SN

Distribution of Arrival Rates

One problem to be considered is the arrival rate of user requests. Articles studied relating to scheduling consider user requests to be randomly distributed, and thus, consider them to be a Poisson process with arrival rate Lambda (Nelson and Towsley, 1987) (Seila, 1984). It has not yet been shown that a Poisson process closely parallels arrivals of user requests at the NCC, and this assumption should not be used until more data is available.

The Assumption of Identical Processors

Another assumption discovered was that processors could be considered identical, and jobs terminated on one processor and resumed on another processor either immediately or at a later time (Martel, 1984). In the case of the SN, this would be an incorrect assumption since TDRS's (viewed as the processors) cannot provide identical service because they are constrained by their physical locations with respect to the curvature of the earth. That is, TDRS's must communicate with ground terminals, other TDRS's, and user vehicles. A single TDRS will usually be the only TDRS that can communicate directly with a user vehicle because of visibility limitations (i.e., line of site with user vehicle). Thus, TDRS's cannot be considered to be identical processors.

Threshold Policies

Threshold policies schedule "...a job from the queue on an idle server P_i only if T_i is smaller than or equal to the threshold of any idle server and if the queue length is greater than or equal to T_i (Nelson and Towsley, 1987)." Since threshold policies rely on homogeneity of processors and TDRSs are not homogeneous, the policy cannot be applied for the SN.

First-Come-First-Served Policy

First-come-first-served policies allow users requesting services first to have their job processed first (Seila, 1984). For the SN, FCFS policies can be used to resolve conflicts between users with identical priorities vying for services at the same time, but the policy cannot be used to settle disputes between users with differing priorities. Therefore, FCFS cannot be used as a primary method of distributing services to users in the SN.

POSSIBILITIES FOR ANALYTICAL MODELING

In the article, "Preemptive Scheduling to Minimize Maximum Completion Time on Uniform Processors with Memory Constraints," Martel discusses the possibility of prohibiting jobs from running on certain machines because of memory constraints. It may be possible to use this algorithm to exclude an individual TDRS from being considered as a candidate to execute a user request if visibility limitations are encountered. However, it should be noted that this algorithm does still not overcome the question of differing priorities.

CONCLUSIONS

Simulation of SN events may be a viable alternative, since it may not be possible to find a single analytical model for SN resources. Simulation of scheduling is already being done at GSFC to determine optimum scheduling architectures (Demonstration Plan for the NCC Generic Scheduler Task 29-103 Phase Two). Because users are assigned priorities, the scheduling system cannot be modeled on a FCFS basis. The inability to schedule on a FCFS basis also contributes to the need for network simulation. The SN cannot be modeled using a threshold policy since a specific TDRS is usually required to complete a user request because of visibility constraints. Again, this limitation points to the need for simulation.

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