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Final Report
Option I

for

Advanced ISDN Satellite Designs and Experiments

12 September 1992

Final Report

Option I

NASA SCAR Contract NASW-4520, 13 Sep 1990

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SECTION 1

INTRODUCTION

1.1 Background

Integrated Services Digital Networks (ISDNs) are for the most part being implemented on the terrestrial networks of the U.S. Part of the reason that satellites have not been used to date arises from the concerns about performance constraints imposed by satellite propagation delays and compatibility issues particularly dealing with protocols. This final report for advanced ISDN satellite designs and experiments addresses these issues,

1.2 The ISDN Communications Satellite Need

Satellites can play a vital roles in delivering integrated digital services. Satellites will contribute the most in applications where terrestrial networks are limited, inflexible and unreliable. Such applications include global and overseas connections, public safety emergency communications, remote areas, and connections to replace temporarily terrestrial links that fail due to accidents or storms. The need, then, is for ISDN communications satellite options to include their use to connect the present day islands of ISDN, to restore priority ISDN service due to the loss of terrestrial connectivity, to provide ISDN services to disperse locations, and to permit mobile applications of ISDN service. Though none of these needs compete directly with the terrestrial ISDN base, ISDN communications satellites have a special niche in the designs of ISDN communication networks.

1.3 The ISDN Communications Satellite Research

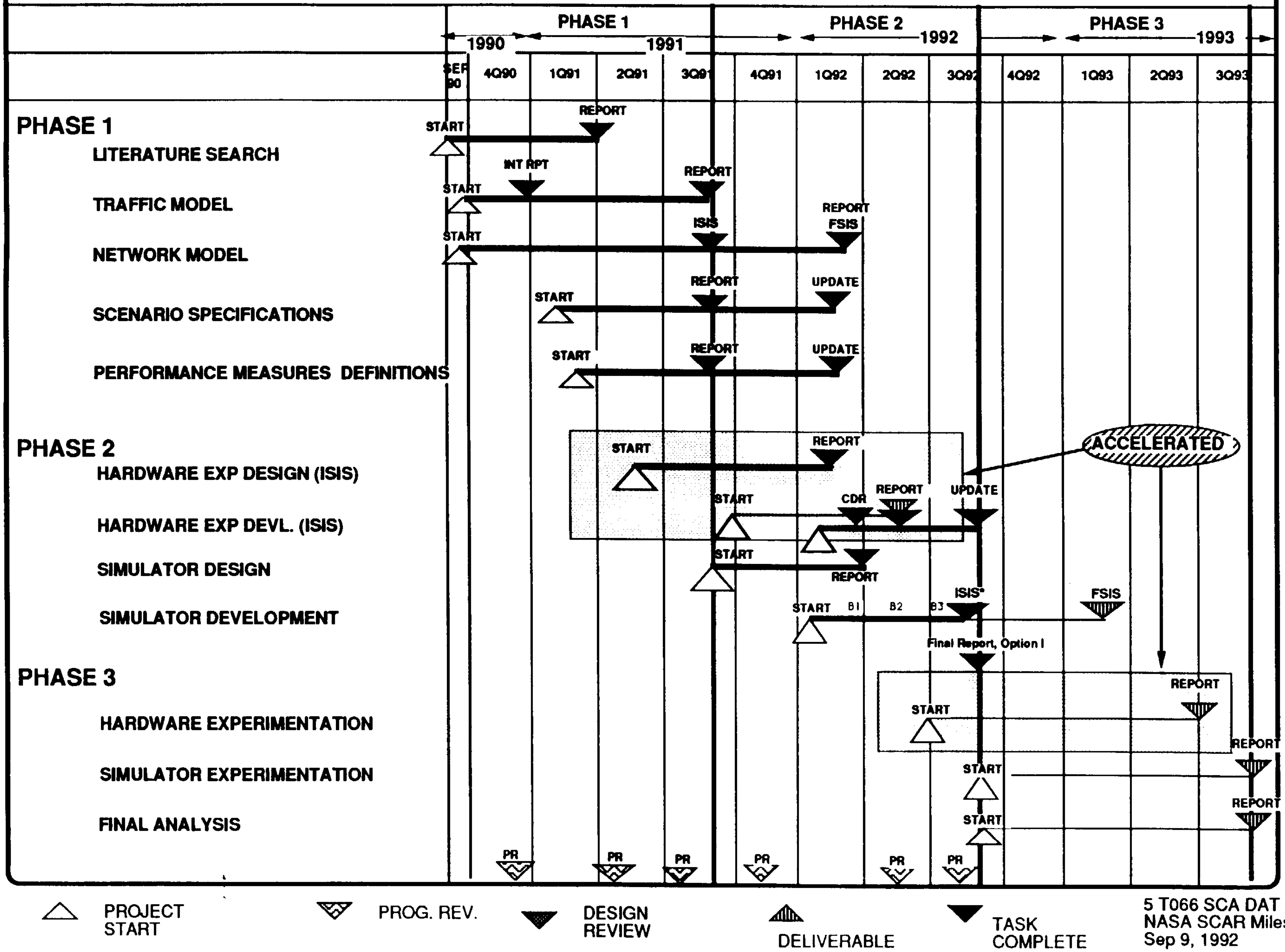
The research conducted in support of ISDN communications satellites was broad based and multidimensional. It addressed all engineering aspects of ISDN communications satellite design including on-board processing, transmitter power, antenna features, protocol processing, on-board capacity, etc. Its dimensionality included an academic literature search, a software simulation, and a hardware development. All were focussed in determining the engineering parameters for an advanced ISDN communications satellite design.

1.4 The ISDN Communications Satellite Schedule

The NASA SCAR research was organized into three phases: a study phase, an implemented phase, and an experimental phase. Table 1.4-1, "NASA SCAR Milestones (Accelerated)", updated September 9, 1992 shows the schedule for each phase and task for the NASA SCAR effort. The accelerated portion highlights the original intent to provide the hardware soon enough to meet the ACTS launch schedule. All the task have met their technical objectives and are in a position to embark on the experimentation phase of the program. Six technical program reviews were conducted during the effort using coordinated agenda. Minutes of each technical program review were generated and published including a list of attendees; copies of the material presented at these reviews were provided to all attendees.

Table 1.4-1 NASA SCAR Milestones (Accelerated)

As revised on September 9, 1992



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NASA SCAR Milestones
Sep 9, 1992

Figure 1.4-1, "NASA SCAR Overview of ISDN Satellite Design", shows the relationship between each task. The literature search task ensured that contemplated NASA SCAR ISDN communications satellite research and design was not being duplicated by other efforts. The tow main thrusts of the ISDN communications satellite design include a software effort and a separate but complimentary hardware effort. The data generated from the software simulation would be compared to the experimental data derived from the hardware efforts. Performance measures were researched in order to provide realistic criteria to evaluate the results. Also a series of mini-studies were undertaken to ensure comparability between the software and hardware results as well as between the GTE discrete event protocol simulation and the NTIA stochastic simulation. Each task is described separately in subsequent sections.

1.5 Scope

This final report documents the complete NASA SCAR research and results for both the basic period of performance and Option I. The process and methodology is described in Figure 1.5-1, "NASA/SCAR Approaches for Advanced ISDN Satellites". The Interim Service ISDN Satellite (ISIS) represents satellite systems like the Advanced Communications Technology Satellite (ACTS) orbiting switch.

ACTS will be controlled by a Master Ground Station (MGS) shown in Figure 1.5-2, "Closed User-Oriented Scenario". A user of the ACTS satellite orbiting switch requests services from the MGS, a combination of the NASA Ground Station (NGS) and the Master Control Station (MCS). The MGS, in turn, commands the satellite to switch the appropriate communication channel.

The ultimate aim of this element of the SCAR Program is to move these MGS functions on-board the next generation ISDN communications satellite as shown in Figure 1.5-3, "Advanced ISDN Satellite". This capability represents a Full Service ISDN Satellite (FSIS) design for fully supporting ISDN from space. The technical and operational parameters for such an advanced ISDN communications satellite design will be obtained from an engineering software model of the major subsystems of the ISDN communications satellite architecture. Discrete event simulation experiments will be performed with the model using various Traffic Model derived scenarios, design parameters, and operational procedures.

The Broadband Service ISDN Satellite (BSIS) in Fig 1.5-1 represent ISDN communications satellite support of Asynchronous Transfer Mode (ATM), Frame Relay, and other broadband communications technologies of the future.

1.6 Document Overview

This final report begins by reviewing the NASA SCAR Research Objectives in Section 2, and explaining the logic and providing a description for each phase.

A summary of the research, results, and deliverables for the efforts for Phase 1, the basis period of contractual performance are presented in:

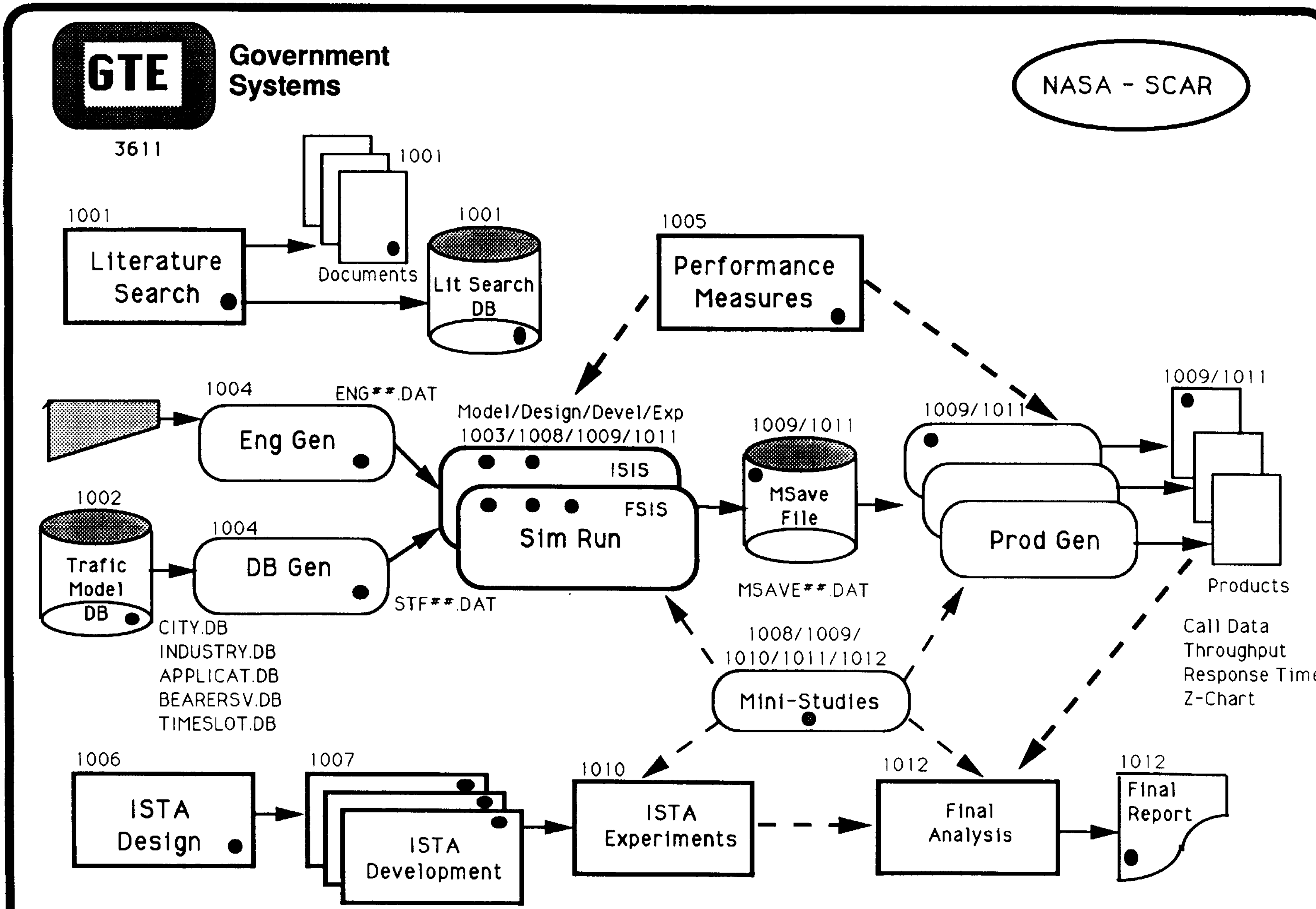

Figure 1.4-1 NASA SCAR Overview of ISDN Satellite Design

● Completed ● Started

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NASA SCAR Overview
September 9, 1992

ISIS Interim Service ISDN Satellite	FSIS Full Service ISDN Satellite	BSIS Broadband Service ISDN Satellite
• ACTS-like Satellite Design and Transponder	• New ISDN Satellite Design with onboard Class 5 Switch and SS7 Network Interface	• Advanced ISDN Satellite Design with onboard Class 5 Switch and SS7 Network Interface and layered protocol
• Provide Narrowband ISDN Services (Basic Rate Access)	• Provide Narrowband ISDN Services (Basic/Primary Rate Access)	• Provide Broadband ISDN Services (Primary Rate Access)
• Provide remote access ISDN Satellite Terminals using ISDN Satellite Terminal Adapter	• Provide nationwide single hop single CONUS earth coverage antenna satellite link connectivity to an interexchange node for ISDN Satellite Terminals (up to 10,000 ISAT)	• Provide nationwide single hop, multiple high gain hopping beams, forward error control, optical processing, and "zero delay" satellite link interexchange node connectivity
• Will use D channel signaling but NOT SS7	• Will use D channel signaling with SS7	• Will use D channel signaling with SS7
• Will use ACTS call control and Baseband Switching Architecture	• Will use SS7 call control with minimum call set-up time and efficient satellite BW utilization	• Will center design around ATM fast packet switching techniques

Figure 1.5-1 NASA/SCAR Approaches for Advanced ISDN Satellites

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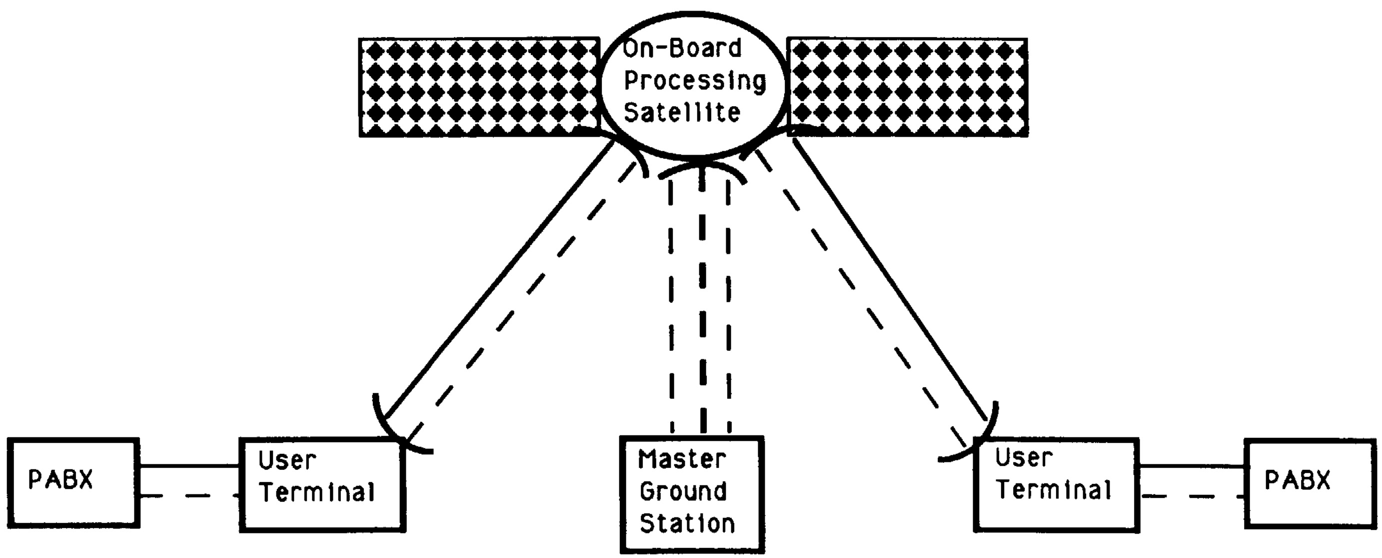

Figure 1.5 -2 Closed User-Oriented Scenario

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Satel/MCC Figure
September 8, 1992

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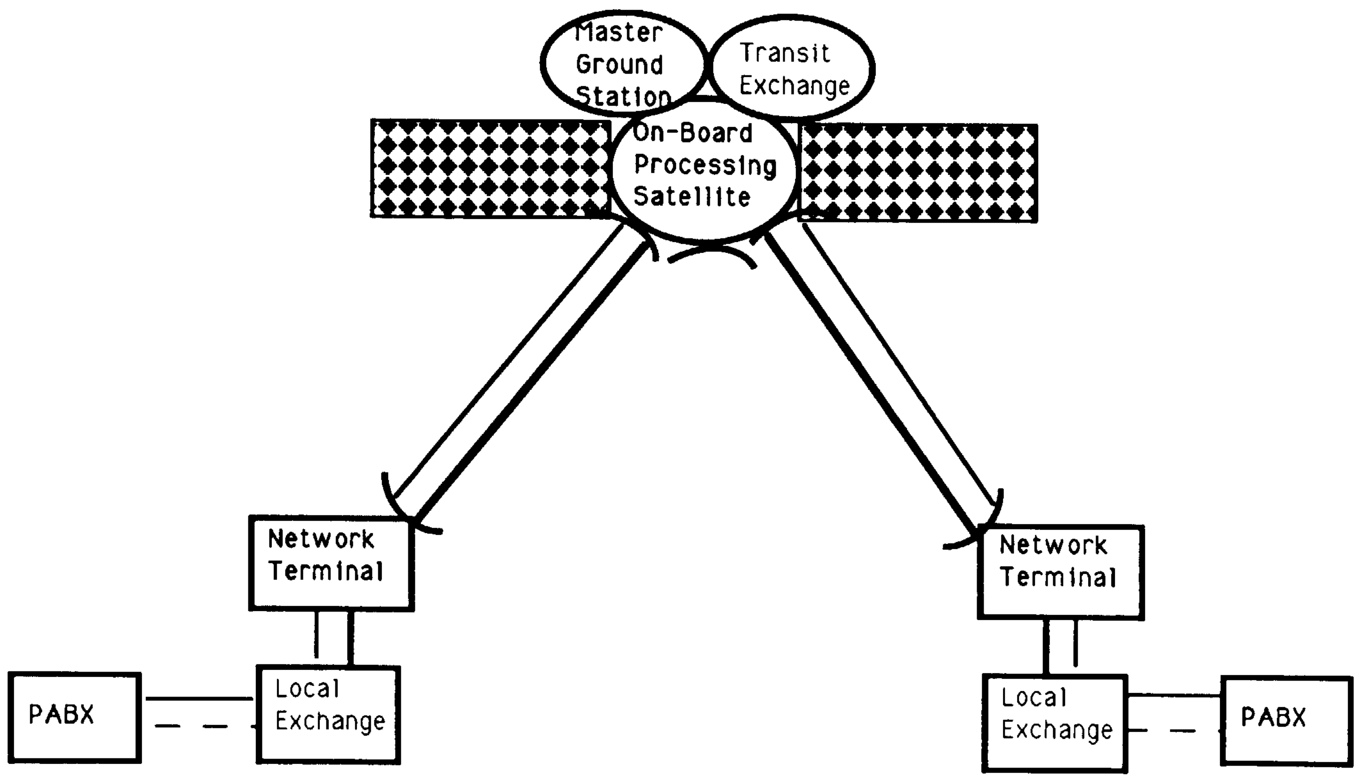

Figure 1.5-3 Advanced ISDN Satellite

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Adv ISDN Satel
September 8, 1992

Section 3. Literature Search
Section 4 Traffic Model
Section 5 Network Model
Section 6 Scenario Specifications
Section 7 Performance Measures

A summary of the research, results, and deliverables for the efforts for Phase 2, the Option I period of contractual performance are presented in:

Section 8. Hardware Experiment Design
Section 9 Hardware Experiment Development
Section 10 Simulator Design
Section 11 Simulator Development

A summary of the results, and conclusions are presented in Section 12.

Several appendices are included to provide more details on the Scenario Traffic File (STF), Process Array Structure, the Traffic Model Database, the Q.931 Protocol Simulation, the Measurement Save (MSave) file, and the products of: ISDN Satellite Call Data, ISDN Satellite Response Time, ISDN Satellite Throughput, and Z-Chart Trace.

SECTION 2

RESEARCH OBJECTIVES

2.1 NASA SCAR Research Objectives

The objectives of this element of the NASA Satellite Communications Applications Research (SCAR) Program are to develop new advanced on-board satellite capabilities that will enable the provision of new services, namely interim and full Integrated Services Digital Network (ISDN) services via satellite and to provide a system analysis of futuristic satellite communications concepts, namely broadband services via satellite.

This aspect of the NASA SCAR Program provides a research and development effort to:

1) develop basic technologies and concepts to use the on-board processing and switching capabilities of advanced satellites that will enable the provision of interim and full ISDN services and

2) provide a systems and requirements analysis of future satellite communications concepts based on a new generation of broadband switching and processing satellites.

2.2 The ISDN Communications Satellite Approaches

The research conducted in this study used three ISDN communications satellite approaches. The first approach leveraged off the Advanced Communications Technology Satellite (ACTS) to provide interim service ISDN satellites (ISIS). The ISIS represents a satellite like the ACTS orbiting switch. ACTS is controlled by a Master Ground Station (MGS). A user of the ACTS satellite orbiting switch request services from the MGS, a combination of the NASA Ground Station (NGS) and the Master Control Station (MCS). The MGS, in turn, commands the satellite to switch the appropriate communication channel.

The second approach moves these MGS functions on-board the next generation ISDN communications satellite to develop the full service ISDN satellite (FSIS) architecture. The FSIS would include on-board processing capable of reading and analyzing the CCITT ISDN protocols and autonomously setup and disconnect ISDN communications traffic. Some elements of the system signalling #7 (SS7) protocol would be included in this FSIS design.

The third approach addresses the broadband service ISDN satellite architecture capable of employing frame relay, asynchronous transfer mode, and optical processing technologies.

2.3 The ISDN Communications Satellite Team

The integrated team approach developed for the ISDN Communications Satellite Team included principals investigators from JPL, GTE, NTIA, and CU. Thee Jet Propulsion Laboratory (JPL) performed the NASA contractor technical representative (COTR) functions. GTE Government Systems provided the prime contractor responsibilities including the program management and technical integration of the research efforts. The University of Colorado (CU) used its Interdisciplinary Telecommunications Program resources as a subcontractor to GTE. While the Institute of Telecommunications of the National Telecommunications and Information Administration (NTIA) were funded directly by NASA but integrated their research with the team.

All team members are research organizations and have extensive facilities and active research and development program in ISDN, satellite communications, fiber optics transmission and digital signal processing. Each team member brought a unique perspective to the team. GTE brought the telecommunications service provider's perspective. CU brought a futuristic perspective. In an educational environment, CU's focus is on long-term more basic research. NTIA brought a U.S. policy and international standards perspective. The establishment of standards is essential for implementing world-wide satellite-based ISDN services.

GTE focused its research on the ISIS hardware in terms of designing and implementing an ISDN Satellite Terminal Adapter (ISTA) capable of providing basis rate interface ISDN across a 160 kbps satellite channel. GTE modeled the ISIS and FSIS network and implemented a discrete event simulation for CCITT protocol for ISDN call control on a call-by-call basis.

NTIA develops a circuit-switched network model simulation using stochastic traffic to provide a more global view of network interactions. CU performed the literature search, developed a traffic model of the the ISDN user, and contributed to the mini-studies and advanced satellite concepts.

2.4 The ISDN Communications Satellite Deliverables

The deliverables for this NASA SCAR effort included the generation of weekly activity reports for the COTR. Monthly and Quarterly Progress Reports to include NASA Forms 553M and 533Q were also generated and published to the designated NASA representatives The following specific deliverables were provided at the dates indicated:

Traffic Model Report (Interim)	31 Dec 1990
Literature Search Report	30 Mar 1991
Scenario Specification and Performance Measures (Interim)	1 Sep 1991
ISIS Network Model Report	15 Sep 1991
Traffic Model Report (Final)	30 Sep 1991
Scenario Specification and Performance Measures (Final)	28 Feb 1992
Hardware Experiment Design Report	28 Feb 1992
FSIS Network Model Report	1 Mar 1992
Simulator Design Report	30 Mar 1992
ISIS Hardware Experiment Development Report (Interim)	30 Apr 1992
ISIS Simulator Development	30 Aug 1992
ISIS Hardware Experiment Development Report (Final)	12 Sep 1992
Final Report, Option I (This Report)	12 Sep 1992

As a means of tracking the ISDN communications satellite simulation software development, GTE generated and published four software builds that included an executable simulation program and an accompanying User's Guide:

Build 0 Model/Simulation	7 Jun 1992
FSIS Build 1	15 Mar 1992
FSIS Build 2	22 May 1992
FSIS Build 3	15 Jul 1992

SECTION 3

LITERATURE SEARCH

3.1 Literature Search Objective

The objective of the Literature Search task was to ensure that the planned NASA SCAR effort under this contract would not duplicate research that had been or was being performed by other organizations. The details of this task were published in Literature Search Report (Final), dated 30 March 1991 and the major findings are summarized in this section.

3.2 Literature Search Task

Under subcontract to the Contel Technology Center (CTC), now GTE Government System, the Interdisciplinary Telecommunications Program (ITP) of University of Colorado (CU) accomplished a background literature search of on-going research and development efforts regarding advanced satellite designs and experiments for ISDN services. The literature search of technical databases provided information to avoid duplication of other research. It also provides the foundation knowledge for the SCAR project.

In performing this task, the CU queried a number of on-line technical databases and solicited widely for sources to ensure complete and thorough coverage of the available literature. They identified topics for categorizing the SCAR literature search data:

- Advanced Communications Technology Satellite (ACTS)
- ISDN and Satellites
- ISDN Standards
- Broadband ISDN
- Frame Relay and Switching
- Computer Networks and Satellites
- Satellite Orbits and Technology
- Satellite Orbits
- Satellite Transmission Quality
- Networks
- Network Configurations

The search culled more than 300 pertinent articles for which citations and abstracts were obtained. To make the results of this *literature search* more available to all SCAR Team members, the CU generated of a computer database to store data about these article by: keywords, authors, dates, sources, index numbers, etc. Though not part of the original plan, the additional cost were deemed modest compared to the potential benefits to the SCAR Project and was approved by the CTC and NASA.

3.3 Literature Search Output

CU delivered the final version of the literature search database of all articles and abstracts located while accomplishing the *Literature Search,* Task 1. A final report of this literature search was submitted to NASA on March 30, 1991 successfully completed this task.. It included a Bibliographic Analysis of the publications reviewed, a hard copy of the SCAR Technical Literature Search Database, and a SCAR Data Base disk containing a compiled dBase III Plus version of the literature search data.

3.4 Literature Search Conclusions

As a result of this literature search, it was concluded that the research and investigation contemplated by this NASA SCAR project was not being duplicated elsewhere. It was also concluded that sufficient technical information was available for a comprehensive, in depth evaluation of the ISDN potential for communications satellite and that advanced ISDN communications satellite designs were possible.

SECTION 4

TRAFFIC MODEL

4.1 Traffic Model Objective

The objective of this modeling and simulation project is to design and develop software models that can be used to simulate those aspects of the ISDN communications satellite with sufficient fidelity to assist in its design. This end-to-end simulation included sufficient functionality to demonstrate the interactions between each modeling and simulation phases: database generation, scenario generation, engineering data generation, simulation run, and product generation. These models and simulation details are discussed in subsequent sections.

The objective of the Traffic Model task was to generate a suitable representation of the ISDN community for the ISDN network models. The ISDN traffic for various classes of users must provide a meaningful traffic load as a function of ISDN services, type of application, geographical dispersion, and time. The details of this task were published in Traffic Model for Advanced Satellite Designs and Experiments for ISDN Services (Interim Status Report), dated 24 December 1991 and .Traffic Model for Advanced Satellite Designs and Experiments for ISDN Services (Task Completion Report), date 30 September 1991 and the major results are summarized in this section.

4.2 Traffic Model Task

The major modeling and simulation phases for this NASA SCAR Project are depicted in Figure 4.2-1, "NASA SCAR Simulation Phases". Each of these phases is described in the following sections as an overview of the modeling and simulation process as well as to provide the proper context for the Traffic Model.

The Database Generation (DbGen) program assembles the major ISDN user characteristics into a machine readable database. For this NASA SCAR effort that database consists of the Traffic Model database of ISDN user characteristics. That database is an input to the scenario generation process. A full description of this Traffic Model database is presented in Section 4.3.

The Scenario Generation (ScenGen) program selects entries from the user Traffic Model database and engineering parameter databases to generates a list of time ordered, initiating discrete events. The discrete event list is call a Scenario Traffic File (STF). The STF is used to exercise that satellite design with requests for ISDN communication services dictated by the Traffic Model.

The Engineering Data Generation (EngGen) program permits the selection of engineering parameter values for each communication element used in the simulation of ISIS and FSIS communications satellite designs

The Simulation Run (SimRun) program consists of a model of the real world communications network of the major ISDN communications satellite components. For this NASA SCAR effort two models are envisioned ISIS and FSIS. Models of the Interim Service ISDN Satellite (ISIS) and the Full Service ISDN Satellite (FSIS) will be exercised using discrete event simulation techniques and STFs derived from the Traffic Model.

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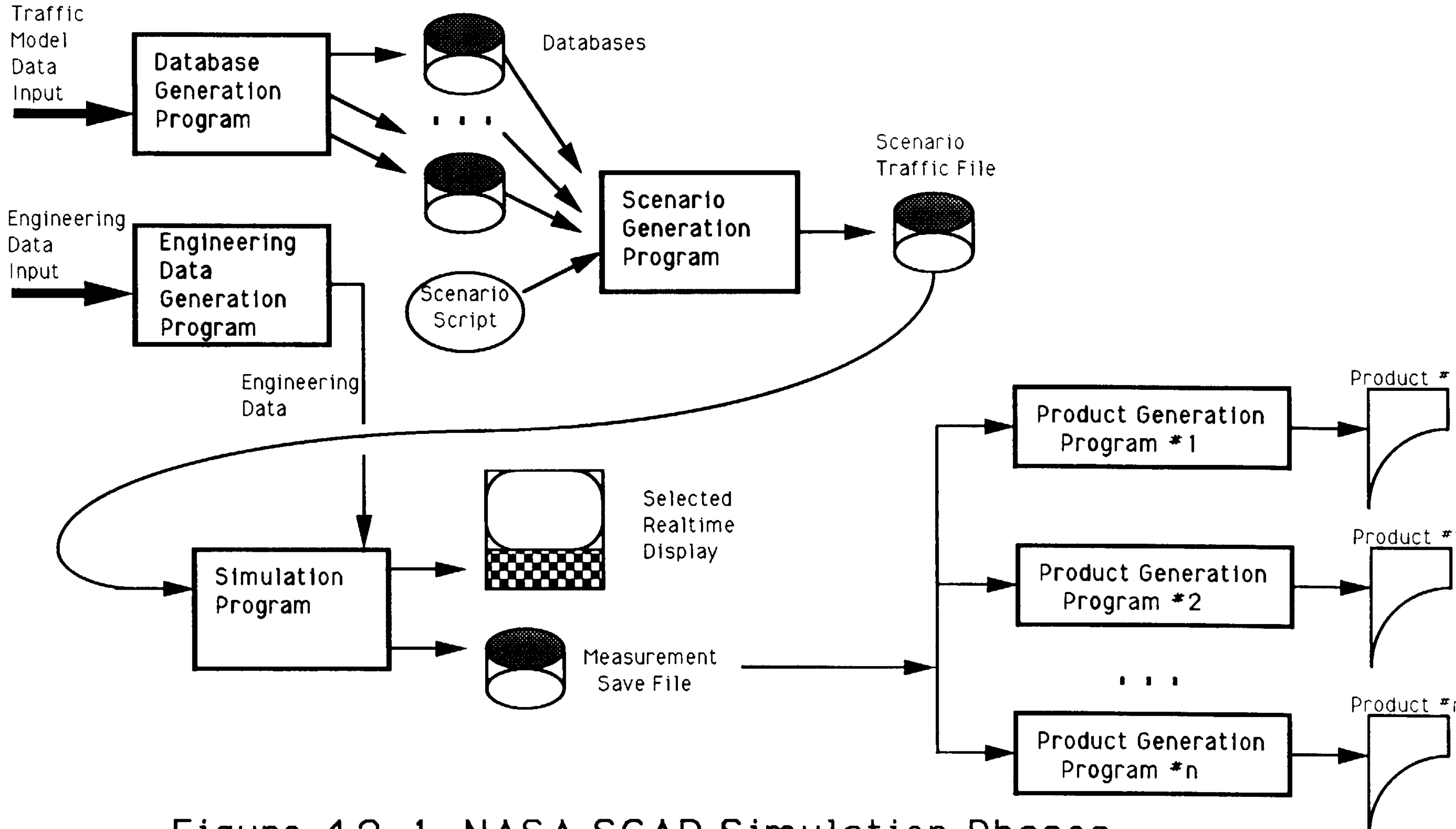

Figure 4.2-1 NASA SCAR Simulation Phases

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SCAR Simulation Phases Brf
September 8, 1992

Each of these ISDN communications satellite components is represented by a block diagram. The SimRun program essentially reads each discrete event from the (STF); takes the appropriate action; and logs that action and the corresponding results in a measurement save (MSAVE) file. The appropriate action taken by the simulation includes allocating and releasing ISDN communications satellite resources, denying specific services, add discrete events to the traffic file, and calling other processes in-turn.

The Product Generation (ProdGen) program reads the data in the MSAVE file and analyses these data in accordance with specific algorithms. It is envisioned that there will be as many product generation programs as there are issues to be studied: throughput, response time, trace, delay, call blocking, busy-minute, busy-hour, etc. The performance measures cited in previous reports will be used a criteria to evaluated the design parameters, operational procedures and degree of compliance to ISDN communication standards.

The Traffic Model was obtained, in part, through surveys of prospective users conducted by the University of Colorado and through academic extrapolation of available user data..

4.3 Traffic Model Output

This Traffic Model consists of a number of databases: the City Reference DB, ISDN User vs Industry DB, Application vs Industry DB, Application vs Time DB, and Application vs Bearer Services DB. The following sections describes each Traffic Model database in detail.

4.3.1 City Reference Database (SCAR DB1). This database, Table 4.3.1-1, "City Reference Database", identifies the percentage of ISDN users that are associated with the population of fifty-two major cities. Due to paucity of specific ISDN user information this percentage factor will be used as multiplier of population to infer the number of ISDN users in that region. When more concrete ISDN user data become available that percentage factor will be adjusted accordingly. For the foreseeable future an average value of 3.3% of the general population are viewed as ISDN users. The percentage range of that ISDN user population is between 3% and 5%.

The geographic coordinates of these of these cities together with their US time-zone are included in the Traffic Model in order to provide a sub-point reference for communications satellite operations. The location data permits the modeling of terrestrial/space networks that account for antenna hopping, satellite hand-over, and multiple satellite views. A view of the geographical distribution of these CONUS Traffic Model Cities is shown in Figure 4.3.1-1, "CONUS City Locations for NASA SCAR Traffic Model Database". Those cities outlined with an ellipse identify the ACTS-east cities. Those cities outline with a rectangle identify the "ACTS-west" cities and the blackened squares depict the fixed antenna cities. The east/west ACTS city clusters are separated by a dashed line. The figure shows that the NASA SCAR traffic model is well aligned with the cities of interest for ACTS. That traffic model database represents the ISDN traffic for these cities and is the principal input to the scenario generation process.

4.3.2 ISDN User versus Industry Database (SCAR DB2). This database, Table 4.3.2-1, "ISDN User vs Industry", apportions the ISDN traffic among twenty-one industries. These data permit the scenario selection on an industry-by-industry basis. This database in used in conjunction with the City Reference Database to further decompose the ISDN service use in terms of industry affiliation. The bold assumption made is that each city has the same industry distribution.

Table 4.3.1-1 City Reference Database

SCAR Database 1.

CITYNAME	POPULATION ,000	LATITUDE deg	LONGITUDE deg	ISDNPCT %	TIMEZONE #
Honolulu	838	21	-157	3.30	-5
Anchorage	227	61	-150	3.10	-4
Seattle-Tacoma	2,421	47	-122	3.40	-3
Portland-Vancouver	1,414	45	-122	3.10	-3
San Francisco-Oakland-San Jose	6,042	37	-122	4.00	-3
Sacramento	1,385	38	-121	3.30	-3
Los Angeles-Anaheim-Riverside	13,770	34	-118	4.50	-3
San Diego	2,370	32	-117	3.30	-3
Phoenix	2,030	33	-112	3.30	-2
Salt Lake City-Ogden	1,065	40	-111	3.10	-2
Denver-Boulder	1,858	39	-103	3.10	-2
Houston-Galveston	3,641	32	-100	3.40	-1
San Antonio	1,323	30	-98	3.10	-1
Oklahoma City	964	35	-97	3.20	-1
Dallas-Fort Worth	3,766	32	-97	3.40	-1
Kansas City	1,575	39	-94	3.10	-1
Minneapolis-St. Paul	2,388	44	-93	3.30	-1
St. Louis	2,467	38	-90	3.20	-1
Memphis	979	35	-90	3.10	-1
New Orleans	1,307	29	-90	3.10	-1
Milwaukee-Racine	1,572	42	-87	3.10	-1
Chicago-Gary Lake County	8,181	41	-87	3.90	0
Indianapolis	1,237	39	-86	3.10	0
Nashville	972	36	-86	3.10	-1
Birmingham	923	33	-86	3.10	-1
Louisville	967	38	-85	3.10	0
Cincinnati-Hamilton	1,728	39	-84	3.20	0
Dayton-Sprigfield	948	39	-84	3.20	0
Atlanta	2,737	33	-84	3.20	0
Detroit-Ann Arbor	4,620	42	-83	3.30	0
Columbus	1,344	39	-83	3.10	0
Tampa-St. Petersburg-Clearwater	1,995	27	-82	3.20	0
Cleveland-Akron-Lorain	2,769	41	-81	3.30	0
Jacksonville	898	30	-81	3.10	0
Orlando	971	28	-81	3.20	0
Pittsburgh-Beaver Valley	2,284	40	-80	3.20	0
Charlotte-Gastonia-Rocky Hill	1,112	35	-80	3.10	0
Miami-Fort-Lauderdale	3,001	25	-80	3.30	0
Greensboro-Winston-Salem-High	925	36	-79	3.10	0
Buffalo-Niagara Falls	1,176	42	-78	3.20	0
Rochester	980	43	-77	3.20	0
Washington	3,734	38	-77	3.30	0
Richmond-Petersburg	844	37	-77	3.20	0
Baltimore	2,342	39	-76	3.20	0
Philadelphia-Winington-Trenton	5,963	39	-75	3.80	0
Norfolk-Virginia Beach-Newport News	1,380	36	-74	3.20	0
Hartford-New Britain-Middleton	1,068	42	-73	3.00	0
Albany-Schenectady-Troy	851	42	-73	3.20	0
New York-New Jersey-Long Island	18,120	40	-73	5.00	0
Boston-Lawrence-Salem	4,110	42	-71	3.30	0
Providence-Pawtucket-Fall River	1,125	41	-71	3.00	0
San Juan-Caguas-Ponce, PR	550	18	-66	3.20	1
	52 Count			5.00 Max	
				3.29 Avg	
				3.00 Min	

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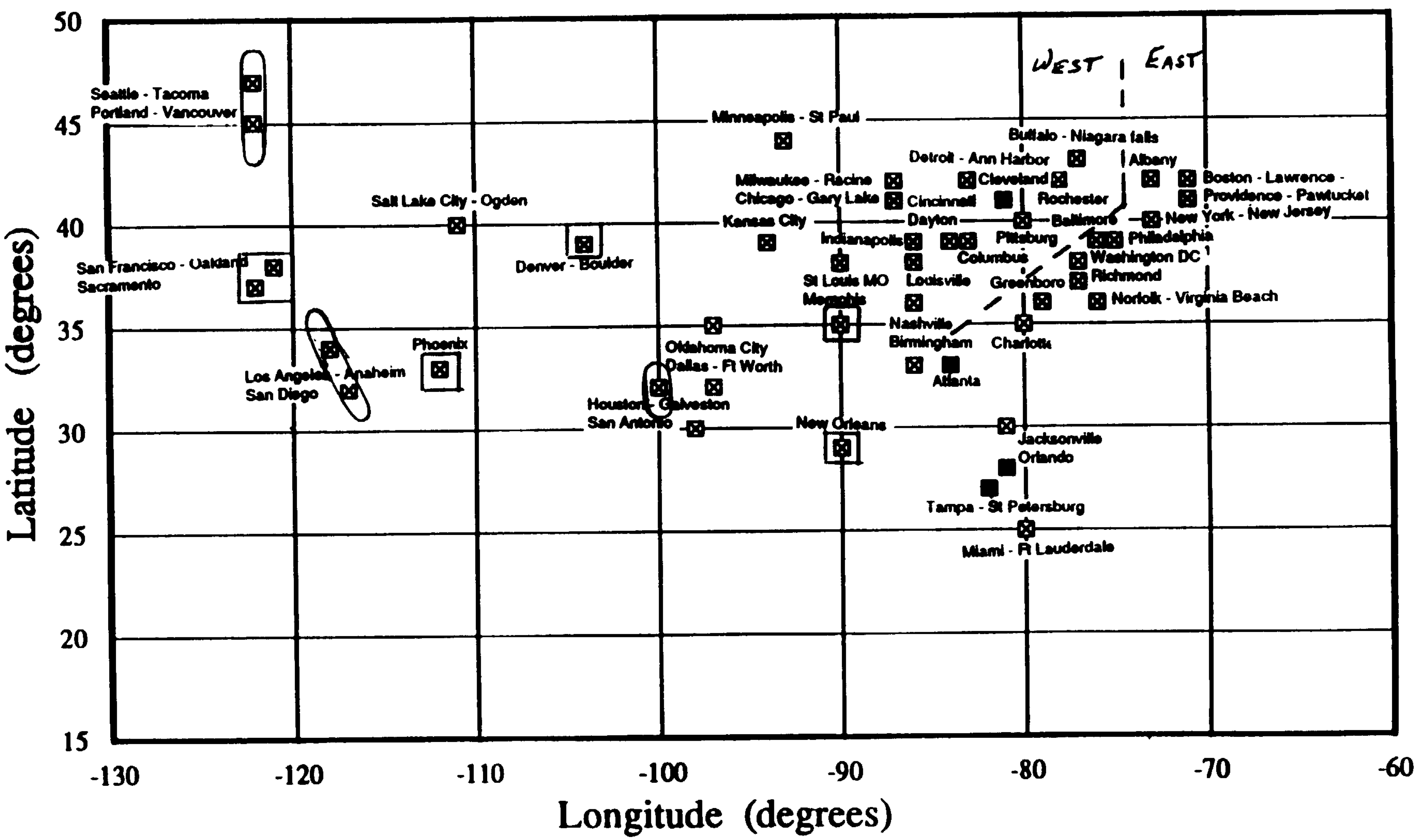

Figure 4.3.1-1 CONUS City Locations for NASA SCAR Traffic Model Database

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TrafModel City Loc Map
September 8, 1992

Table 4.3.2-1 ISDN User vs Industry
SCAR Database 2.

Industry	*ISDN* %
BROADCAST	4.0
COMMUNICATION	10.0
CONSTRUCTION	2.0
DATA PROCESSING	2.0
EDUCATION	6.0
ENERGY	2.0
FINANCIAL	8.0
FOOD SERVVICE	2.0
GOVERNMENT	8.0
LEGAL	6.0
LODGING	4.0
MANUFACTURING	6.0
MEDICAL	6.0
MILITARY	10.0
PUBLISHING	4.0
RECREATION	4.0
RESIDENTIAL	2.0
RETAIL	4.0
TRANSPORT	6.0
UTILITY	2.0
WHOLESALE	2.0
---	-- Check
21 Count	100.0 Normalization

A further Traffic Model refinement could add an other City vs Industry database which would require that 1130 data elements be added to the present 684 data elements. The present Traffic Model is deemed adequate for the present effort.

4.3.3 Application versus Industry Database (SCAR DB3). This database, Table 4.3.3-1, "Application vs Industry Database", further apportions the industry into applications of communication services. This added data granularity permits the selection of scenarios tailored on an application basis. The nine applications are spread across each of the twenty-one industries on a percentage basis too permit each application to contribute in a normalized fashion. This normalization process provides a degree comparison of communication utility among industries. The Communications Check Sum indicate how much aggregate communication is used by each industry. The top and bottom communication users listed below add a degree of credibility to this process:

Finance	90.0	Top Communication Users
Communications	85.0	
Government	78.0	
Military	66.0	
Publishing	62.0	
...	...	
Energy	25.5	Bottom Communication Users
Food Service	23.0	
Construction	17.5	
Recreation	17.0	
Utility	15.0	

4.3.4 Application versus Time Database (SCAR DB4). This database, Table 4.3.4-1, "Applications vs Time Database", associates daily time-slots for issuing ISDN service requests on an application basis. This data allows the generation of traffic distributions that are appropriate to the application being used in a scenario. The hours in a day are divided into four unequal time slots along the line of a typical work day: 0001-0800, 0801-1200, 1201-1800, and 1801-2400. The applications are distributed in the same normalized fashion as described before. This database shows that these 8, 4, 6, and 6 hour-periods break up the communication day into the following comparative importance: 79.5, 252.9, 392.0, and 176.5 according to their Communications Check Sum. These data indicate that most communication traffic is sent between 1201 and 1800 hours.

4.3.5 Application vs ISDN Bearer Service Database (SCAR DB5). This database, Table 4.3.5-1, "Application vs ISDN Bearer Service, Message Length Database", associates ISDN bearer services with the selected scenario applications. For this SCAR program the following ISDN bearer services have been selected: circuit switched (64 kbps and 128 kbps), D-Channel X.25, B-Channel Frame Relay, and Telemetry. The applications are distributed among these ISDN services in the same normalized fashion as before. The Communications Check Sum indicate the relative demands on these ISDN bearer services:

CS64 KBPS	415.0
CS128KBPS	155.0
DX25	152.0
BFRAMERELY	123.0
TELEMETRY	55.0

Table 4.3.3-1 Application vs Industry Database

SCAR Database 3.

Total 21

APPLICATION	BROADCAST	COMMUNICATION	CONSTRUCTION	DATAPROCESSING	EDUCATION	ENERGY	FINANCIAL	FOODSERVICE	GOVERNMENT	LEGAL	LODGING	MANUFACTURING	MEDICAL	MILITARY	PUBLISHING	RECREATION	RESIDENTIAL	RETAIL	TRANSPORT	UTILITY	WHOLESAL	Check Normalization
	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%
Voice(interactive)	3.0	6.0	3.0	2.0	5.0	3.0	7.0	4.0	4.0	8.0	5.0	5.0	5.0	5.0	5.0	3.0	6.0	5.0	8.0	2.0	6.0	100.0
Voice(message)	0.5	5.0	2.5	1.0	5.0	3.0	10.0	2.5	7.5	10.0	5.0	5.0	5.0	3.0	5.0	2.5	10.0	5.0	5.0	2.5	5.0	100.0
Facsimile	1.0	10.0	5.0	1.0	5.0	2.5	11.0	5.0	11.5	11.0	0.5	5.0	7.0	4.0	10.0	0.5	1.5	1.0	2.5	2.5	2.5	100.0
FileTransfer	0.5	11.0	2.5	11.0	5.0	5.0	9.0	2.5	9.0	5.0	2.5	2.5	3.0	9.0	7.0	1.0	1.0	3.0	4.5	3.0	3.0	100.0
VideoBroadcasting	10.0	8.0	0.5	5.0	8.0	1.0	3.0	1.0	9.0	1.0	6.0	3.0	8.0	10.0	11.0	3.0	3.0	1.0	5.0	1.0	2.5	100.0
VideoConference	6.0	12.0	1.0	1.0	10.0	3.0	10.0	1.0	10.0	7.0	4.0	4.0	6.0	10.0	7.0	1.0	1.0	1.0	3.0	1.0	1.0	100.0
InteractiveData	2.0	15.0	1.0	10.0	10.0	3.0	10.0	2.0	8.0	5.0	1.0	5.0	3.0	10.0	5.0	1.0	3.0	2.0	1.0	1.0	2.0	100.0
Transaction	2.0	8.0	1.0	4.0	2.0	2.0	15.0	2.0	12.0	4.0	5.0	4.0	2.0	8.0	4.0	4.0	1.0	9.0	4.0	1.0	6.0	100.0
Teletex	3.0	10.0	1.0	3.0	3.0	3.0	15.0	3.0	7.0	3.0	5.0	3.0	3.0	7.0	8.0	1.0	1.0	5.0	5.0	1.0	10.0	100.0
Communications Check Sum:	28.0	85.0	17.5	38.0	53.0	25.5	90.0	23.0	78.0	54.0	34.0	36.5	42.0	66.0	62.0	17.0	27.5	32.0	38.0	15.0	38.0	900.0
																						900.0

Table 4.3.4-1 Application vs Time Database

SCAR Darabase 4

APPLICATION	0001-0800 mid/8am 8 hours TIMENO1 %	0801-1200 8am/noon 4 hours TIMENO2 %	1201-1800 noon/6pm 6 hours TIMENO3 %	1801-2400 6pm/mid 6 hours TIMENO4 %	Check Normaization %
Voice(interactive)	2.5	32.0	51.0	14.5	100.0
Voice(message)	2.5	32.0	51.0	14.5	100.0
Facsimile	2.5	32.0	51.0	14.5	100.0
FileTransfer	52.0	3.0	5.0	40.0	100.0
VideoBroadcasting	10.0	25.0	30.0	35.0	100.0
VideoConference	2.5	32.0	51.0	14.5	100.0
InteractiveData	2.5	32.0	51.0	14.5	100.0
Transaction	2.5	32.0	51.0	14.5	100.0
Teletex	2.5	32.0	51.0	14.5	100.0
Communications Check Sum:	79.5	252.0	392.0	176.5	900.0
					900.0

Table 4.3.5-1 Application vs ISDN Bearer Service, Message Length Database

SCAR Database 5.

APPLICATION	CS64KBPS	CS128KBPS	DX25	BFRAMERELY	TELEMETRY	Check Normalization	Messsage HOLDTIME	Message Length
	%	%	%	%	%	%	min	kbytes
Voice(interactive)	100.0	0.0	0.0	0.0	0.0	100.0	3.0	0
Voice(message)	100.0	0.0	0.0	0.0	0.0	100.0	1.5	0
Facsimile	80.0	15.0	2.0	3.0	0.0	100.0	0.0	160
FileTransfer	30.0	20.0	30.0	15.0	5.0	100.0	0.0	216
VideoBroad	25.0	40.0	0.0	35.0	0.0	100.0	0.0	9600
VideoConfe	30.0	40.0	0.0	30.0	0.0	100.0	0.0	57600
Interactivedata	20.0	10.0	40.0	10.0	20.0	100.0	0.0	27
Transaction	20.0	20.0	40.0	10.0	10.0	100.0	0.0	27
Teletex	10.0	10.0	40.0	20.0	20.0	100.0	0.0	75
Communications Check Sum:	415.0	155.0	152.0	123.0	55.0	900.0		
						900.0		

This database also associates the message length and message hold-time with each application. These message duration values provide a measure of the length of time each ISDN bearer service is used.

4.3.6 Traffic Model E-R Diagram The Traffic Model database is described in terms of an Entity-Relationship diagram. As shown in Figure 4.3.6-1, "NASA SCAR E-R Diagram for Traffic Model", six entities are joined with relative simple relationship to form the data model for the SCAR Traffic Model. In this entity-relationship diagram cities are identified with industries that have applications that in turn have time slot, bearer service, and message duration relationships. The text adjacent to the entity boxes and relationship nodes are the name of the corresponding Traffic Model database. The number in parentheses indicates the number of data elements in that database. The number inside each entity box indicate the record count for that entity. The corresponding Traffic Model data elements describe the entity they represent in sufficient detail to generate a family of scenarios for any ISDN traffic load.

4.4 Traffic Model Conclusions

The Traffic Model developed was deemed adequate for this NASA SCAR effort to generate scenarios for the Interim Service ISDN Satellite (ISIS) and the Full Service ISDN Satellite (FSIS) architectures. Additional Traffic Model data will be necessary for addressing user

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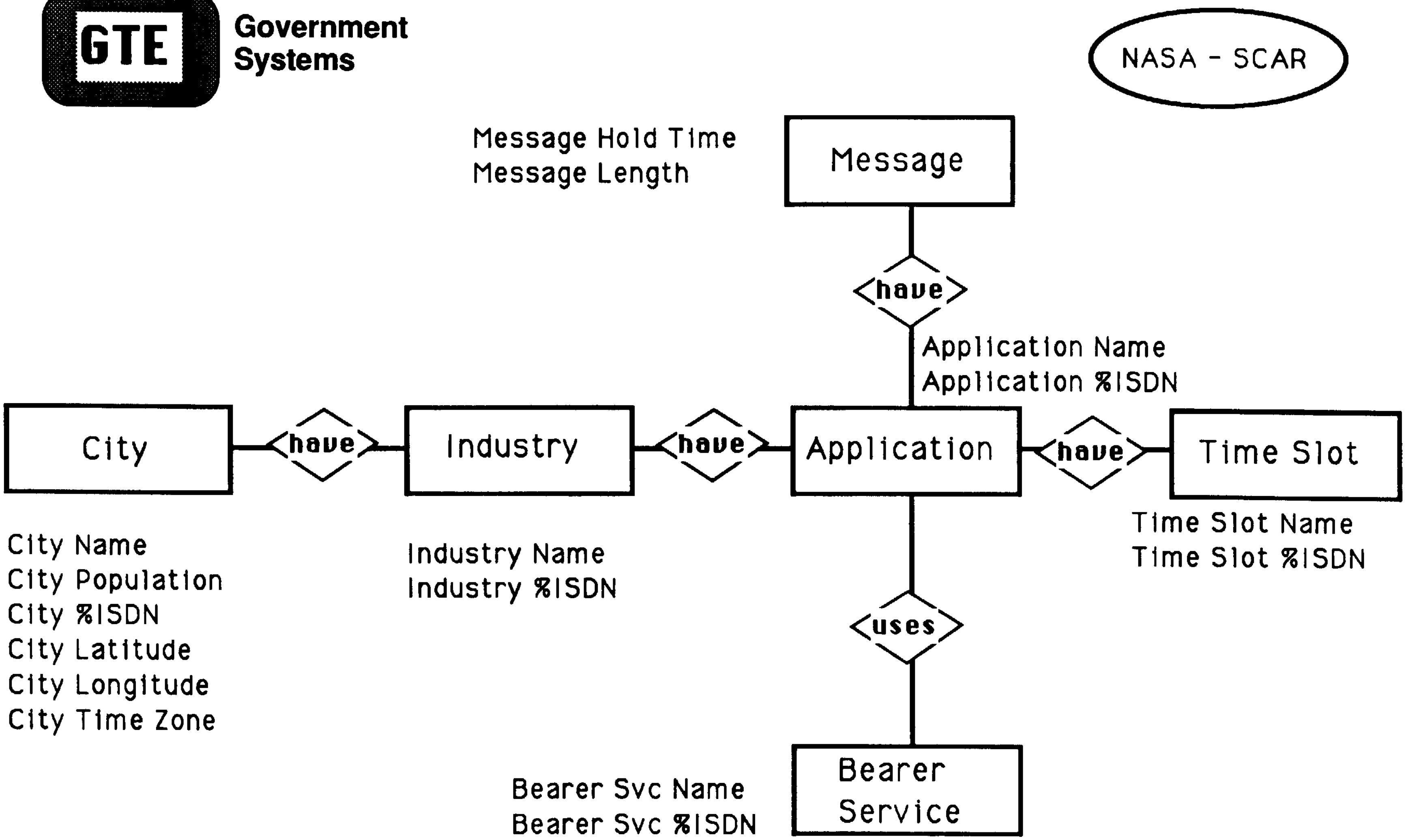

Figure 4.3.6-1 NASA SCAR E-R Diagram for Traffic Model

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Traffic Model ER Diag
September 8, 1992

SECTION 5

NETWORK MODEL

5.1 Network Model Objective

The objective of the Network Model task was to devise a communication network architecture to represent an acceptable ISDN communications satellites network architectures capable of providing engineering parameters suitable for satellite designs. The details of this task were published in Interim Service ISDN Satellite (ISIS) Network Model for Advanced Satellite Designs and Experiments (Task Completion Report), dated 13 September 1991 and Full Service ISDN Satellite (FSIS) Network Model for Advanced Satellite Designs and Experiments Task Completion Report, dated 1 September 1992 and the major results are summarized in this section.

Experimental research must be based a sound foundations: a clear understanding of the system under study. That understanding for this NASA SCAR effort included using network modeling and simulation of an ISDN communications satellite to addressing its design. This network modeling delineated the network architecture (as defined by the network methodology, the number and kinds of communications elements and how those elements are configured), network operations (including link and network layer protocols and how network functions are distributed among communications elements), and system constraints (imposed both by the network and by the operational requirements).

5.2 Network Model Task

Figure 5.2-1, "Generic Network Model Block Diagram", shows the major subsystems for a communications satellite with two satellite terminals each supporting three users. For this model the subsystems associated with the satellite terminals consist of an uplink transmitter and transmitting antenna, a downlink receiver and receive antenna, three users generating traffic, and a multiplexer/demultiplexer that combines and separates this traffic. The satellite is modeled by corresponding receivers, transmitters, antennas, an on-board switch, and an on-board processor that decodes received commands, controls the switch, and generates response traffic.

Each of the communications subsystems in the network model design is represented by a software module that performs the functions of that communications component. Figure 5.2-2, "SCAR Network Model Systems", shows the generic network model presented in Fig 5.2-1 as interconnected software modules. Each module has parameters (p) inputs that determines that module's characteristics. For an antenna: p includes such things as the gain, beamwidth, scan rate, dwell time, etc. For a receiver: p includes frequency, burst rates, receiver threshold, receiver delay, etc. For a processor: protocol repertoire, processing time, clock frequency, number of ISDN resources, etc. In general each model module has a p-set that determines the design characteristics. These p's are input via the traffic file before the simulation run begins. They determine the design baseline for the communication subsystems.

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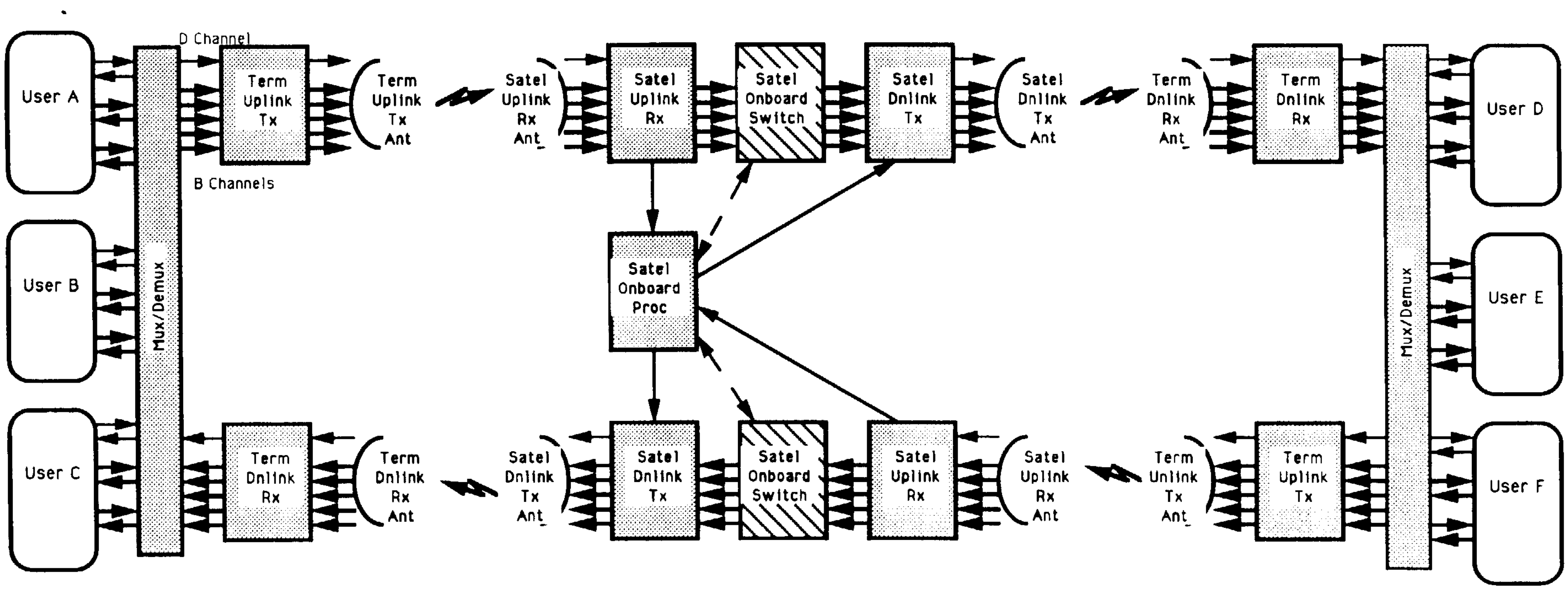

Figure 5.2-1 Generic Network Model Block Diagram

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Generic Netwo Model Block Diagram
September 9, 1992

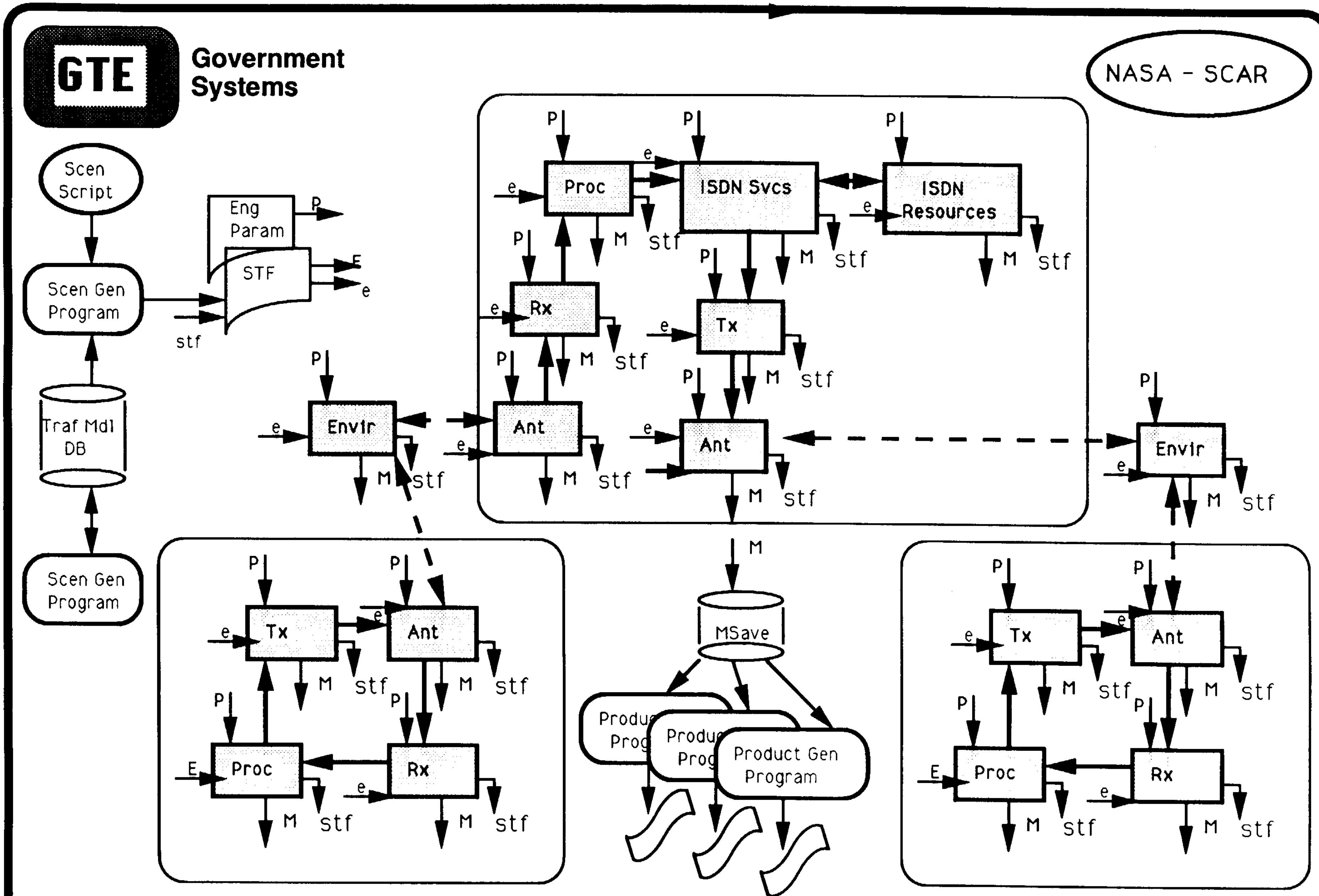

Figure 5.2-2 SCAR Network Model Systems

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SCAR Netwo Model Sys
September 9, 1992

The initial discrete events (E) are part of the STF and are executed as a function of time depending on the scenario that generated them. Each of the precipitating events (E) is destined for a particular module in the simulation. That module processes discrete events (E) and takes actions accordingly. Many of these actions include generating response events (e) for another module. The response events (e) are integrated in time order with the initial events (E) via the (stf) to be executed at their respective times. For ISDN protocols, a single initial discrete event (E) will generate many sequential response events (e). The simulation process continues the execution of the time ordered event list of Es and es until the simulation ends. The technical data generated by the simulation is obtained from a Measurement Save (MSave) file. Every time an discrete event is presented to a module its identity and its time of arrival is saved on the MSave file (M). Also, all resource allocations, resource releases, resource denials, event generations, and the status of every module is saved on the MSave file (M) together with the time of their occurrence, The MSave file has a complete time ordered history of every event, action, and status of every module for the entire simulation. That MSave file can be analyzed to generate any technical and operational product imaginable.

5.3 Network Model Output

The Figure 5.3-1, "Multi-Terminal NASA SCAR ISDN Satellite Network Model", generically depicts a satellite-based switch that provides communications services between terminals on the left. This same model is also capable of connecting central offices on the right. Such a model can be used as a generic vehicle for analyzing the connectivity and protocol messages flow for both ISIS and FSIS communication architectures.

5.3.1 ISIS Network Model Output The modeling context of the previous sections are now applied to an ISIS Network Model for an ACTS-like system. This ISIS model baseline uses the "Approach 2A" Alternative described in the ACTS ISDN Study Mid-Term Review presented to NASA Lewis Research Center, by COMSAT Laboratories, on June 21, 1991. The "Approach 2A" nomenclature is also used when possible. The ISIS Network Model will focus on the ISDN circuit switched protocols: call control (Q.931/I.451), LAPD (Q.921/I441), PRI (I.I431), BRI (I.430), and SS7 (ISUP). The ISIS model will leave issues such as network management, packet switching, and physical level (layer 1) fault isolation to the subsequent FSIS Network Model phase. The D Channel protocol messages and their associated timing, propagation, processing, and execution are the main concerns of the ISIS model The B channels are modeled as resources to be allocated and released in proportion to their availability.

As illustrated in Figure 5.3.1-1, "ACTS/ISDN Signal Flow", the ISIS system will provide the ISDN user access to ACTS via VSATs connected with ISDN Satellite Terminal Adapters (ISTAs). The ACTS will be controlled by a Master Ground Station (MGS) consisting of a NASA Ground Station (NGS) and the Master Control Station (MCS). The ISIS Network Model will use D channel signalling and those parts of the ISUP as described in "Approach 2A". This approach will enable an advanced satellite like ACTS to provide nation-wide, narrowband ISDN. The ISIS model will use the proposed ACTS call controls and baseband processor switching architecture.

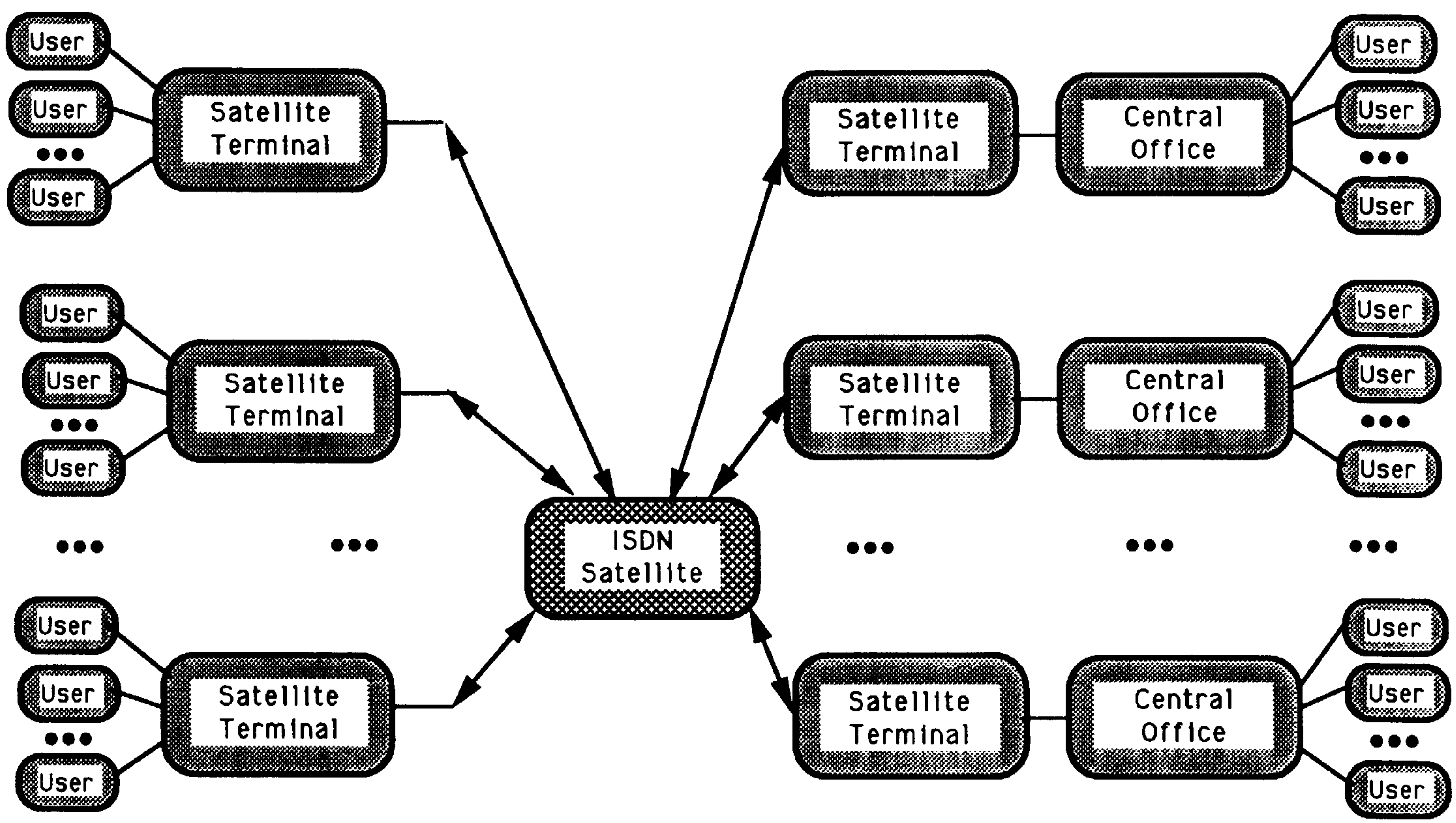

Figure 5.3-1 Multi-Terminal NASA SCAR ISDN Satellite Network Model

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Multi Term ISDN Satel Model
September 9, 1992

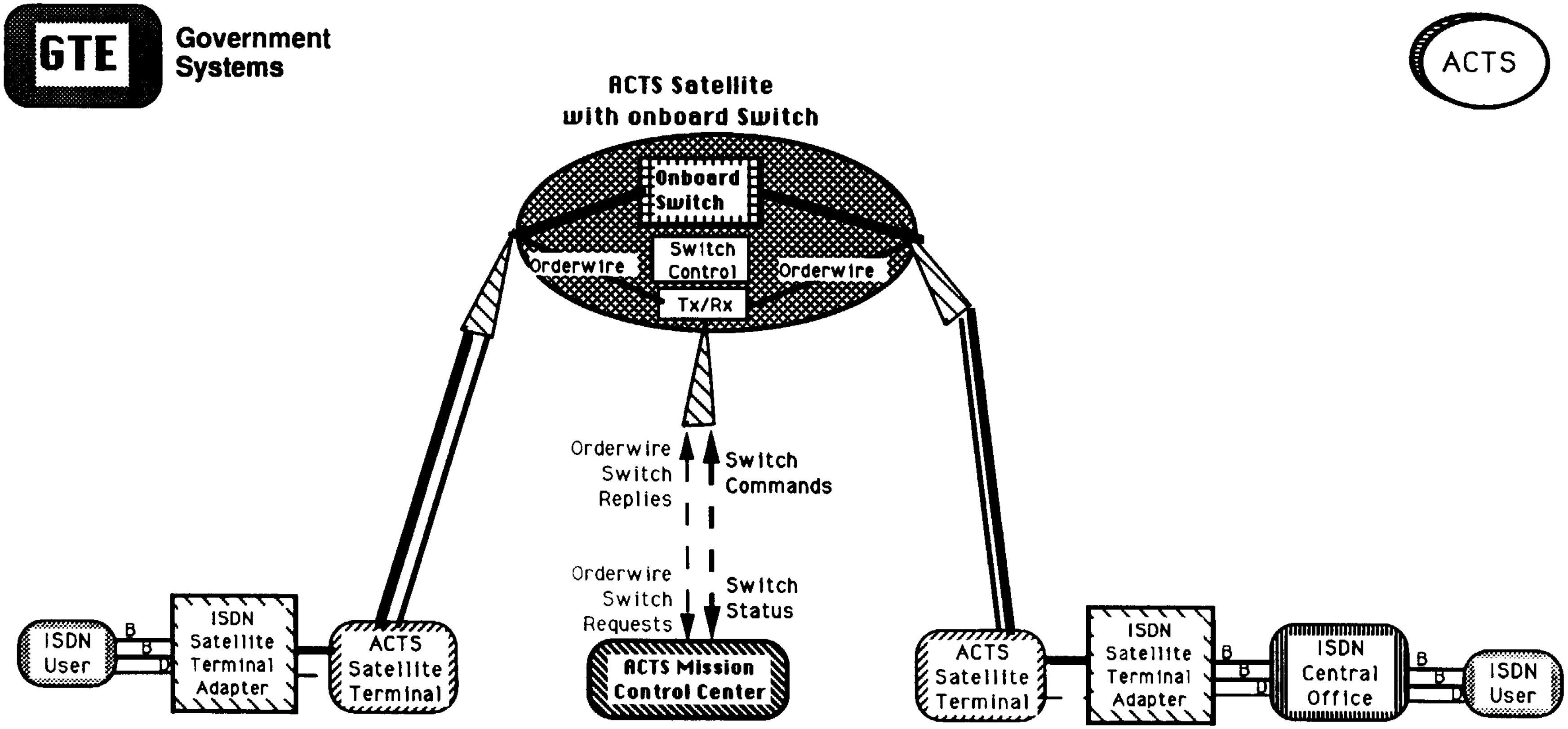

Figure 5.3.1-1 ACTS/ISDN Signal Flow

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ACTS/ISDN Signal Flow
September 9, 1992

The ISIS Network Model consists of a number of VSATs connected to ACTS via a single hop. The VSATs will exchange narrowband ISDN traffic on a demand access, circuit switched basis. The purpose is to investigate the throughput, response time, blocking probability, and robustness of ISIS Network Model in a benign environment to provide a performance measures baseline for the FSIS Network Model and to investigate protocol timing issues at the lower layer levels. Particular attention will focus on the timing and time-outs associated with the ISDN physical layer protocol.

Figure 5.3.1-2, "ISIS Communication Components", shows the FSIS Model decomposed into communication components which in turn will be decomposed into model processes.

5.3.2 **FSIS Network Model Output** The modeling context of the previous sections are now applied to an FSIS Network Model. Like the ISIS model, the FSIS model uses as its baseline, the "Approach 2A" Alternative described in the ACTS ISDN Study Mid-Term Review presented to NASA Lewis Research Center, by COMSAT Laboratories, on June 21, 1991. The FSIS Network Model focuses on the ISDN circuit switched protocols: call control (Q.931), LAPD (Q.921), PRI (I.I431), BRI (I.430), and SS7 (ISUP). The FSIS model will leave issues such as network management, packet switching, and physical level (layer 1) fault isolation to the subsequent FSIS Network Model phase. The D Channel protocol messages and their associated timing, propagation, processing, and execution are the main concerns of the FSIS model. The B channels are modeled as resources to be allocated and released in proportion to their availability.

As illustrated in Figure 5.3.2-1, "FSIS/SCAR Model Systems", the FSIS system will provide the ISDN user access via VSATs connected with ISDN Satellite Terminal Adapters (ISTAs). The FSIS Network Model will use D channel signalling and those parts of the ISUP as described in "Approach 2A". This approach will enable an advanced satellite to provide nation-wide, ISDN using an on-board call control and B-channel switching architecture. The ultimate aim of this aspect of this SCAR Program is to move all ISDN functions on-board the satellite for the next generation ISDN communications satellite design.

The FSIS Network Model consists of a number of VSATs connected to an ISDN satellite via a single hop. The VSATs will exchange ISDN traffic on a demand access, circuit switched basis. The purpose is to investigate the throughput, response time, blocking probability, and robustness of FSIS Network Model in a benign environment to provide a performance measures baseline for the FSIS Network Model and to investigate protocol timing issues at the lower layer levels. Particular attention will focus on the timing and time-outs associated with the ISDN physical layer protocol. The FSIS model will also deal with issues such as: packet switching on the B and D channels, full SS7 protocols, weather, and direct connectivity to an ISDN public switched network (IPSN).

Figure 5.3.2-2, "FSIS Communication Components", shows the FSIS Model decomposed into communication components which in turn will be decomposed into model processes.

The ultimate aim of this aspect of this SCAR Program is to move the ISDN functions on-board the satellite for the next generation ISDN communications satellite design. The ISIS model will provide a starting point for that design. Those technical and operational parameters for the ISDN advanced communications satellite design will be further developed as part of the Full Service ISDN Satellite (FSIS) network model in the next phase of this SCAR Program.

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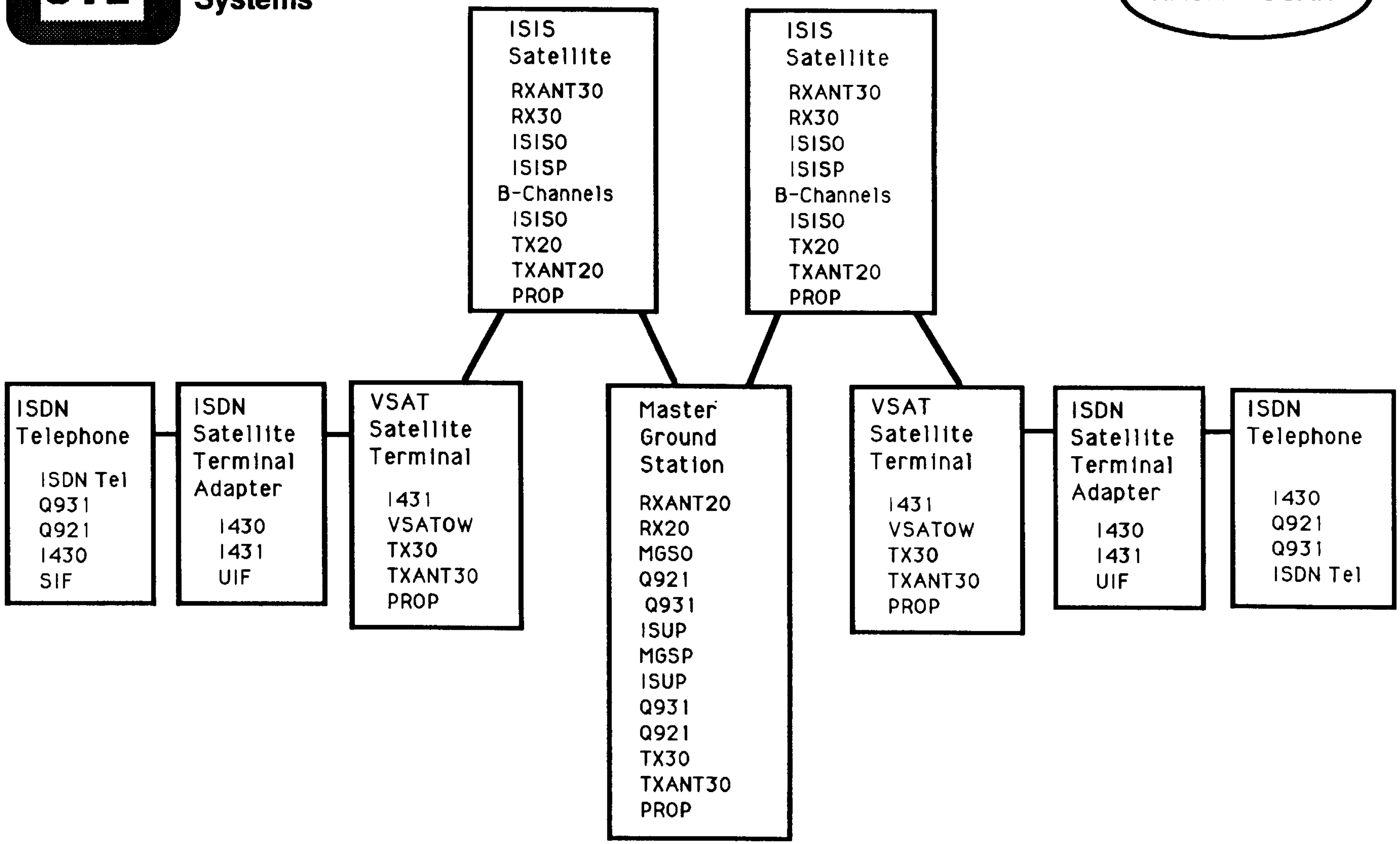

Figure 5.3.1-2 ISIS Simulation Communication Components

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ISIS Net Mdl Proceses
September 9, 1992

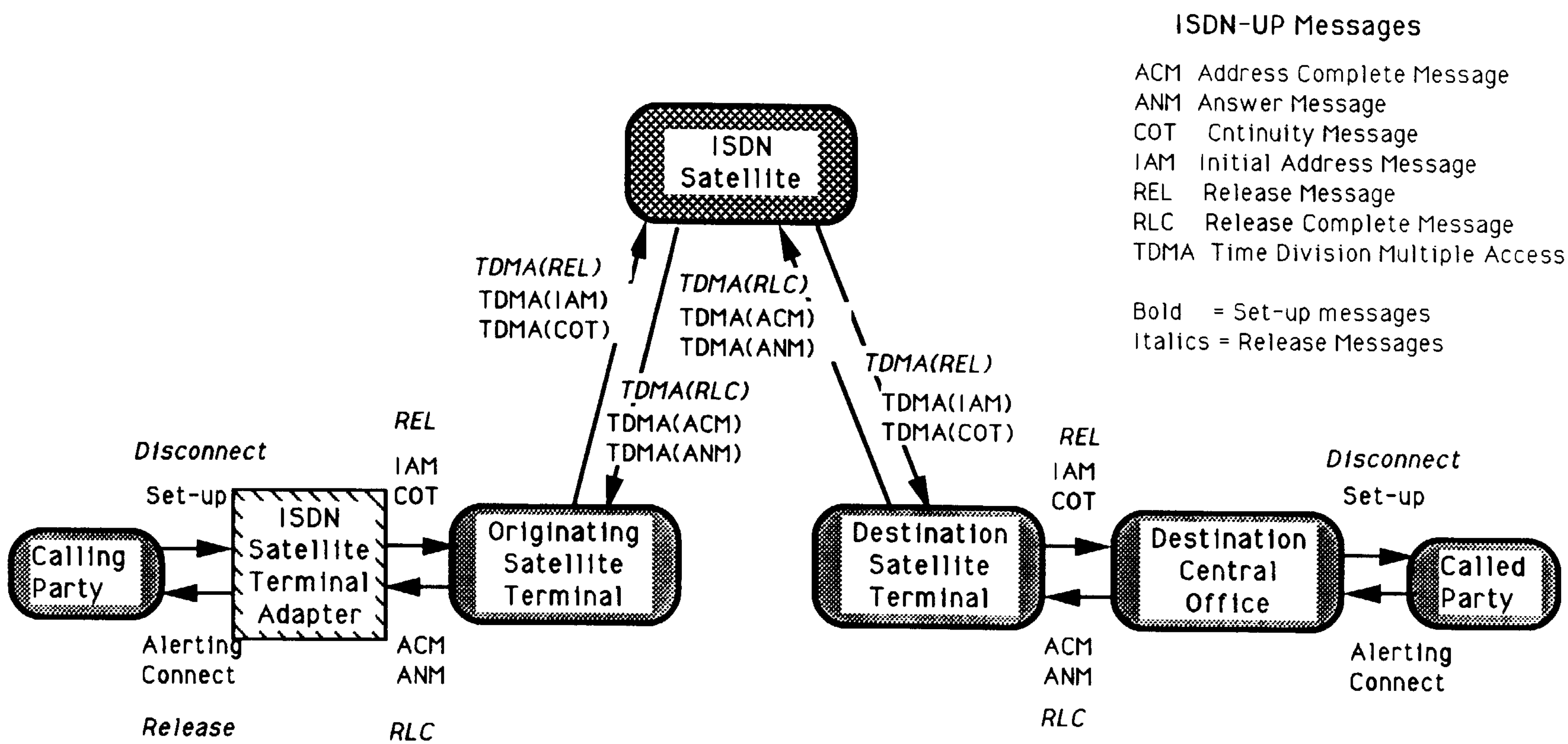

Figure 5.3.2-1 FSIS/SCAR Model Systems

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FSIS SCAR Model Systems
September 9, 1992

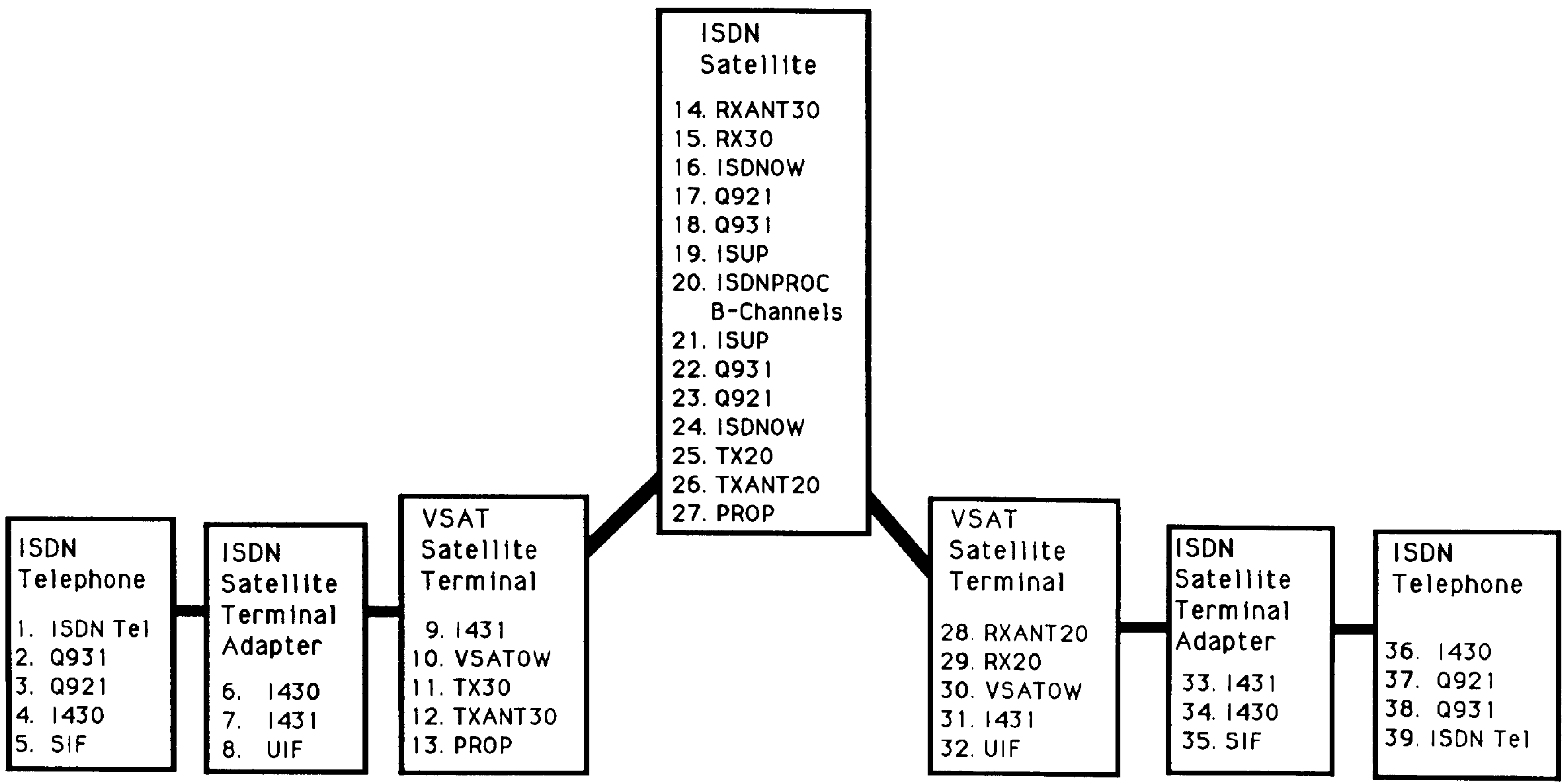

Figure 5.3.2-2 FSIS Network Model Communication Components

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FSIS Commu Components
September 9, 1992

In both cases, ISIS and FSIS, the design analyses will be obtained from an engineering software models of the major subsystems of the ISDN communications satellite architecture and their appropriate ground terminations. Discrete event simulation experiments will be performed with the model using various traffic scenarios, design parameters, and operational procedures and performance measures.

5.3.3 ISIS/FSIS Network Model Components As shown in Figures 5.3.1-1 and 5.3.2-2 -1 both the ISIS and FSIS models consist of similar communication components. These components include: the ISDN satellite, the VSAT user terminals, ISDN Satellite Terminal Adapters (ISTAs), ISDN telephone users, the earth/space propagation and the ISDN interfaces. The following sections will describe each of these model communication components.

5.3.3.1 ISDN Satellite Component The ISDN satellite component represents the ISDN switching capabilities in space. For this NASA SCAR research two different ISDN satellite architectures were modeled - the ISIS and the FSIS Network Models.

The ISIS Network Model is bases on the Advanced Communications Technology Satellite (ACTS) as a switch in orbit. That ACTS orbiting switch is presently controlled by a Master Ground Station (MGS) which consists of a combination of the NASA Ground Station (NGS) and the Master Control Station (MCS) - (NGS/MCS). From an ISDN traffic view, the ACTS orbiting switch consists of a baseband processor (BBP) that is capable of relaying communications protocols to the MGS and receiving switching commands from the MGS.

A user of the ACTS satellite requests services from the MGS using ISDN protocols. Those ISDN protocols are routed to the MGS via a number of ISDN and SS7 protocol conversion processes. These protocols are converted to inbound order-wire (IBOW) messages for processing and action. The MGS process these IBOW messages and issues the appropriate BBP command messages to the the ACTS satellite via outbound order-wire (OBOW) messages.

The ACTS satellite operations are modeled by an uplink receiving antenna (RxAnt 30) and receiver (Rx 30) that are connected to the ACTS orderwire processor (ACTSOW). See Figure 4.5-1. The ACTSOW routes the IBOW to the ACTS downlink and the OBOW to the on-board baseband processor (ACTSBBP). The ACTSBBP acts on all OBOW commands and sends BBP status messages to the MGS via the ACTS downlink. The ACTS downlink is modeled by a downlink transmitter (Tx20) and an associated downlink transmitting antenna (TxAnt20). Both the downlink and uplink propagation are modeled by propagation (Prop) process that delays these messages as a function of distance between the satellite and the ground terminal.

The FSIS Network Model represents the advanced ISDN communications satellite design under the NASA SCAR Program uses as its design starting point an ISDN switch in orbit. A user of the ISDN satellite requests services using ISDN protocols. Those ISDN protocols are routed to the satellite via the VSATs and ISTAs using a number of ISDN protocols and SS7 protocol conversion processes. These protocols are converted into ISDN switch requests on board the satellite.

The ISDN satellite operations are modeled by an uplink receiving antenna (RxAnt 30) and receiver (Rx 30) that are connected to the on-board ISDN orderwire processor (ISDNOW). The ISDNOW either routes the protocol messages to the ISDN satellite downlink or to the on-board processor (ISDNPROC). The ISDNPROC acts on all protocol messages destined for this satellite. The ISDN downlink is modeled by a downlink transmitter (Tx20) and an associated downlink transmitting antenna (TxAnt20). Both the downlink and uplink propagation are modeled by propagation (Prop) process that delays these protocol messages as a function of distance between the satellite and the ground terminal.

5.3.3.2 ISDN Master Ground Station Component

The ACTS Master Ground Station (MGS) receives IBOW and the BBP status messages from the ACTS satellite. It processes these messages and then generates and transmits the appropriate OBOW and BBP command messages to the ACTS satellite.

The MGS operations are modeled by a downlink receiving antenna (RxAnt20) and receiver (Rx20) that are connected to the MGS orderwire processor (MGSOW). The MGSOW routes the IBOW to the MGS processor (MGSProc). The MGSProc processes all IBOW and generates OBOW and BBP command messages that are uplinked to the ACTS satellite. The MGS uplink is modeled by an uplink transmitter (Tx30) and an associated uplink transmitting antenna (TxAnt30). Both the downlinks and uplinks propagation are modeled by the propagation (Prop) process that delays the signal as a function of distance between the satellite and the ground terminal.

5.3.3.3 VSAT Component The VSAT user terminal represents the ISDN user entry into the ISDN communications satellite. For the FSIS Network Model, the VSAT is generic terminal capable of converting I431 protocol to uplink signals and converting downlink signals to I431 protocol. The VSAT connects the user with U-interface and connects to the ISDN satellite with a propagation (Proc) interface. As such the VSAT represents the exchange termination (ET) for the user. The VSAT converts ISDN protocol messages into TDMA uplink signals in one direction and converts the downlink signals to ISDN protocols in the other direction.

The VSAT operations are modeled by a TDMA downlink receiving antenna (RxAnt20) and receiver (Rx20) that are connected to the VSAT orderwire processor (VSATOW). The VSATProc translates all downlink signals into I431 protocols messages. The I431 process provides the 1544 kbps primary rate ISDN interface at the U-interface level.

The VSAT TDMA uplink operations are modeled in similar manner to convert ISDN protocols to uplink signals. The ISDN protocols come to the I431 process via the U interface. The VSATOW converses the I431 protocol into a TDMA format for uplink transmission via Tx30 and TxAnt30 to ISDN communications satellite.

Both the downlink and uplink propagation are modeled by the propagation (Prop) process that delays the protocol messages as a function of distance between the satellite and the ground terminal.

5.3.3.4 ISDN Satellite Terminal Adapter Component The ISDN satellite terminal adapter (ISTA) represents the user's NT2 and NT1 connection between the user at the S-interface and the exchange termination (ET) at the U-interface. It represents protocol conversion necessary for aggregating a number of BRI services in a PRI link for ultimate translation into a TDMA uplink. For a downlink the ISTA also converts a PRI connection into a BRI service connections.

The ISTA operations are modeled by a Layer 1, physical protocol conversion process (I430), as shown in Figure 5.3.3.4-1. "Layer Protocol Activation/Deactivation" at the S-interface. These protocols are converted up and down the OSI layers to match the S-interface BRI protocols to the U-interface PRI protocols. The translation process converts

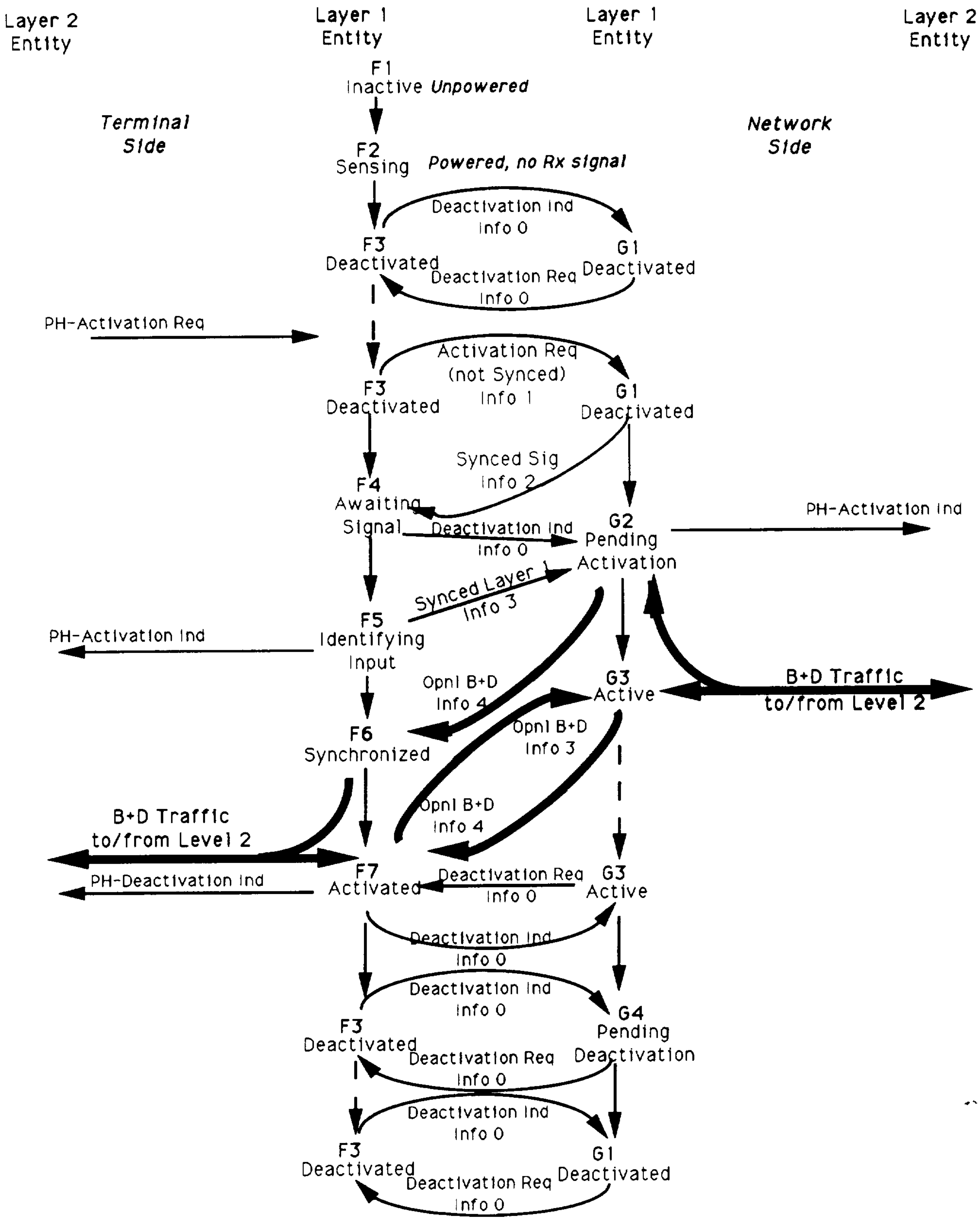

Figure 5.3.3.4-1 Layer 1 Protocol Activation/Deactivation

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Layer 1 Proto Act/Deact
September 9, 1992

I430 protocols into I431 protocols in the S-interface to U-interface direction. The reverse sequence of processes models the U-interface to S-interface direction.

5.3.3.5 ISDN Telephone User Component For the FSIS Network Model the ISDN telephone represents the source and sink of all ISDN call connections. The off-hook and on-hook conditions are used as a starting point for the call connection protocol sequences that are converted along the OSI layer chain to the S-interface of the network termination (NT).

The ISDN Telephone operations are modeled by a human interface process (ISDNTel) that provides the on-hook and off-hook conditions. These ISDNTel processes act as sources by generating a Layer 3 protocol sequence using the Q931 messages that are converted down the OSI layers by the Q931, Q921 and I430 processes to S-Interface signals. The reverse sequence of these processes models the S-interface to ISDNTel direction.

5.3.3.6 Propagation Component Both the downlink and uplink in the ISIS and FSIS Network Models account for the time delay experienced by a signal as it propagates between the ISDN satellite and any ground terminal. A significant amount of time is spent in signal propagation.

Propagation is modeled by a single propagation (Prop) process that delays the signal as a function of distance between the satellite and the ground terminal. That distance depends on the satellite orbit and topology and the terminal distribution. These propagation distances change dramatically as a function of time and points of origin and destination.

5.3.3.7 S-Interface Components The S-interface component provides the BRI connectivity between the ISDN user and the ISTA. This connection is similar to most wiring configuration which can be used to connect to an NT. These configurations can be divided into three types:

- A single installation where only one terminal is connected to an NT
- A multi-terminal installation where several terminals are connected to an NT1 via a passive bus
- A multi-terminal installation where several terminals are connected to an NT1 or an NT2 in a star configuration

At the outset the FSIS Network Model will use a single point installation between the ISDN Telephone and the VSAT. This will permit the use of up to 1000m of cable to assure maximum of 6 dB attenuation at 96 kHz. This cable length will provide a signal round trip delay of 10 to 42 microseconds from the transmitter to the receiver.

The S-interface is modeled by a single process (SIF) that delays the message as a function of the round trip delay. For the FSIS Network Model all protocol messages are sent on the D channel and therefore have a constant delay once the D channel contention has been resolved.

5.3.3.8 U-Interface Components The U-interface component provides the transfer of information that takes place on the two wire circuit between the ISTA and the VSAT. For the FSIS Network Model, echo cancelling is used. Echo cancelling is characterized by simultaneous transmission in both direction, full duplex, elimination of echo, and a bit rate of 160 kbps. The 144 kbps are used for the 2B+D BRI information and the other 16 kbps is used for synchronization, operations, and maintenance.

The U-interface is modeled by a single process (UIF) that delays the messages as a function of its BRI rate. For the FSIS Network Model all protocol messages are sent on the D channel and therefore have a constant delay.

5.4 Network Model Conclusions

The Network Model permits the complete end-to-end protocol studies capable of determining the major ISDN communications satellite parameters using discrete event simulation. The model is applicable to the the Interim Service ISDN Satellite (ISIS) and the Full Service ISDN Satellite (FSIS). The ultimate aim of this aspect of the SCAR Program is the design of a new advanced ISDN communications satellite. The technical and operational parameters for this ISDN advanced communications satellite design will be obtained from an engineering software model of the major subsystems of the ISDN communications satellite architecture. Discrete event simulation experiments will be performed with these ISIS and FSIS models using various traffic scenarios, technical parameters, and operational procedures. The data from those simulations will be analyzed using the performance measures discussed in previous NASA SCAR reports.

SECTION 6

SCENARIO SPECIFICATIONS

6.1 Scenario Specifications Objective

The objective of the Scenario Specification task was to create a number of communication scripts that would provide a traffic load on the network that could be used to demonstrate and stress engineering parameters for a selected communication environment. The details of this task were published in "Scenarios and Performance Measures for Advanced Satellite Designs and Experiments for ISDN Services (Interim Status Report)", dated 1 September 1991 and ."Scenarios and Performance Measures for Advanced Satellite Designs and Experiments for ISDN Services (Update Report)", dated 28 February 1992 and the major results are summarized in this section.

6.2 Scenario Specifications Task

The ISDN communications satellite end-to-end simulation is shown in Figure 6.2-1, "End-to-end ISDN Communications Satellite Simulation Architecture". Each program is physically and functionally separated by input/output data files. This separation ensures that each program is independent and that each project phase is separate from the others. The only link between these programs is the data file they share.

The Scenario Generation (ScenGen) program reads the traffic model database that describes potential ISDN users and the statistical information describing the ISDN services requested. See Figure 6.2-2, "Scenario Generation Program". This Traffic Model consists of a number of databases: the City Reference DB, ISDN User vs Industry DB, Application vs Industry DB, Application vs Time DB, and Application vs Bearer Services DB. The Traffic Model and these databases are fully described in Section 4.

6.2.1 Scenario Generation Process: The scenario generation process uses the data from the traffic model databases described in Section 4. and generates a scenario traffic file (STF) of initial discrete events for the discrete event simulations described in Section 10. The STF consists of a time-ordered list of requests for a service and a release of that service when completed. For example, The STF discrete event requesting a circuit-switched B-Channel from Baltimore to Chicago at 0800 am that lasts 31 minutes looks like:

RqstTime	CallRef#	Action	Resources	Orig City	Dest City	TermTime
0800	**1012**	**Rqst**	**CS64**	**Balt**	**Chi**	**0831**

6.2.2 Scenario Generation Algorithm. The scenario generation program takes the data from the traffic model database and generates the corresponding STF entries. For example, to generate ISDN calls from Baltimore to Chicago the scenario script must have selected these two cities and possibly other cities. The following algorithm generates the associated ISDN service requests:

1. From SCAR DB1 the population of Baltimore is cited as 2,342,000 with 3.2% of them being daily ISDN users. Therefore, the number of daily ISDN service calls from Baltimore is 74,944.

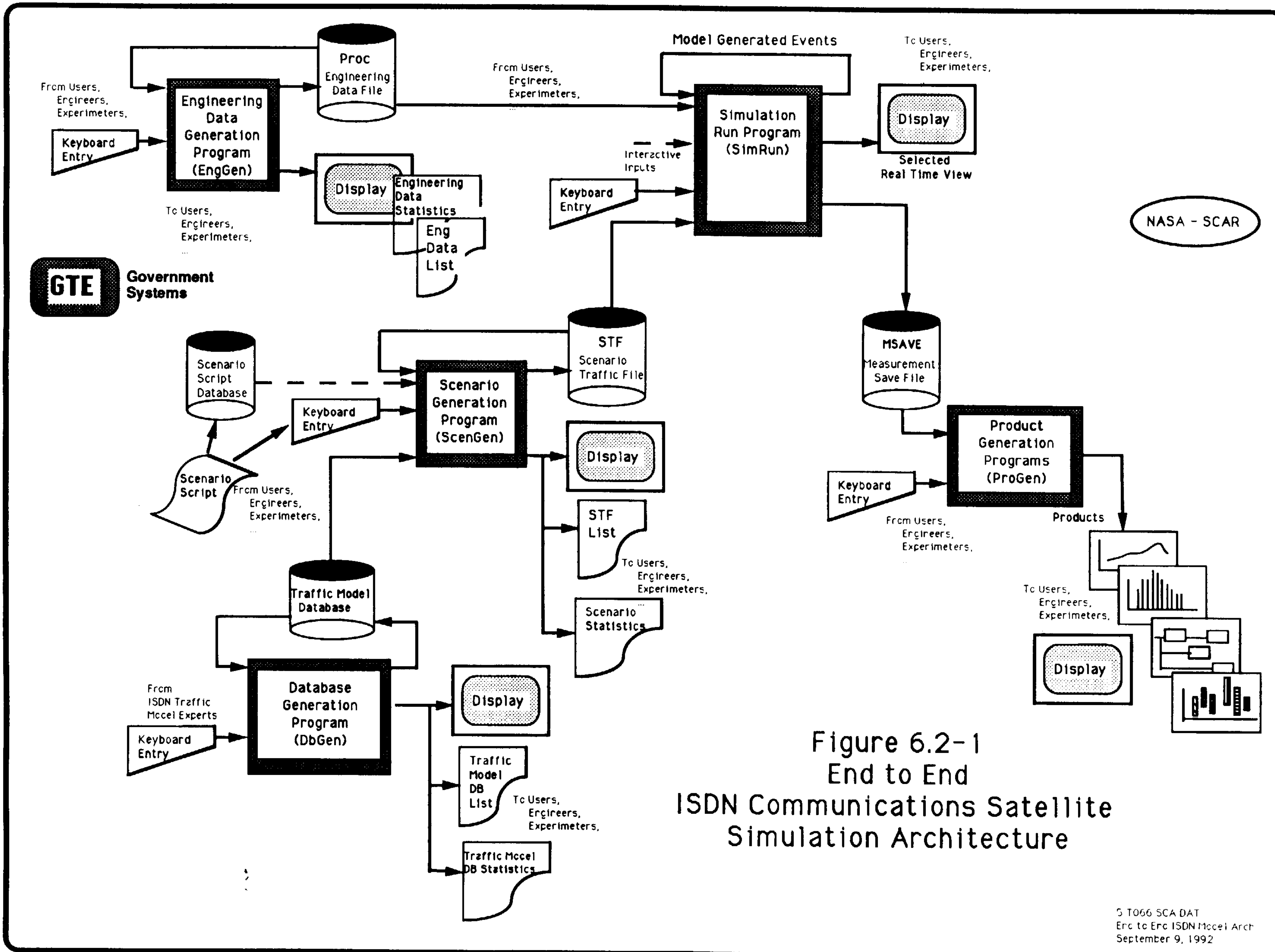

Figure 6.2-1
End to End
ISDN Communications Satellite
Simulation Architecture

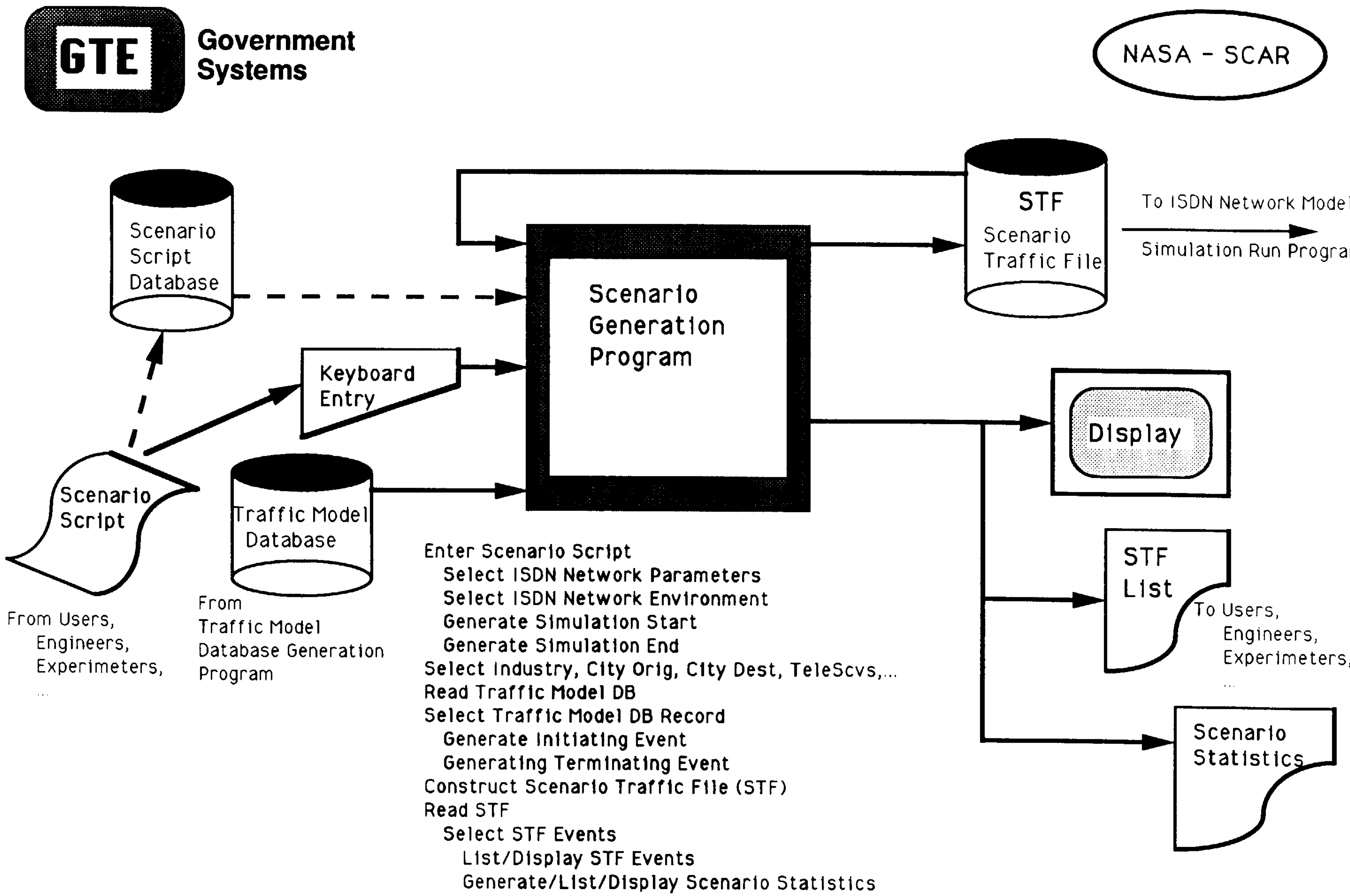

Figure 6.2-2 Scenario Generation Program

2. If the scenario script selected, only the following Baltimore industries having the corresponding ISDN percentages in SCAR DB2 then the total daily ISDN service calls from Baltimore by industries would amount to:

	ISDN%	ISDN Calls
Broadcast	4.0%	2,998
Communication	10.0%	7,494
Education	6.0%	4,497

3. If the scenario script further restricted the applications to Voice(Interactive), Voice(Message), and Facsimile, then these Baltimore ISDN service calls are further partitioned by this matrix from SCAR DB3:

	Voice(I)	Voice(M)	Facsimile
Broadcast	3.0%	0.5%	1.0%
Communication	6.0%	5.0%	10.0%
Education	5.0%	5.0%	5.0%

The resulting ISDN service calls from Baltimore in those areas are:

	Voice(I)	Voice(M)	Facsimile
Broadcast	90	15	30
Communication	450	375	750
Education	225	225	225

4. If the scenario script again further restricts the applications to following bearer services: CS64KBPS, CS128KBPS, and DX25 as cited in SCAR DB5, then the following Baltimore ISDN service calls are associated with the ISDN bearer services:

	CS64KBPS	CS128KBPS	DX25
Voice(Interactive)	*100%*	*0%*	*0%*
Broadcast	90	0	0
Communication	450	0	0
Education	225	0	0

	CS64KBPS	CS128KBPS	DX25
Voice(Message)	*100%*	*0%*	*0%*
Broadcast	15	0	0
Communication	375	0	0
Education	225	0	0

	CS64KBPS	CS128KBPS	DX25
Facsimile	*80%*	*15%*	*2%*
Broadcast	24	5	1
Communication	600	113	15
Education	180	34	5

5. These three applications have the same call distribution over time, see SCAR DB4:

Time (hours)	0001- 0800 Time 1	0801- 1200 Time 2	1201- 1800 Time 3	1801- 2400 Time 4
Voice(Interactive)	2.5%	32.0%	51.0%	14.5%
Voice(Message)	2.5%	32.0%	51.0%	14.5%
Facsimile	2.5%	32.0%	51.0%	14.5%

The number of call in each time slots T1/T2/T3/T4 for each Baltimore ISDN service call category is:

	CS64KBPS	CS128KBPS	DX25
Voice(Interactive)	*100%*	*0%*	*0%*
Broadcast	45	0	0
	2/28/46/14	0/0/0/0	0/0/0/0
Communication	450	0	0
	11/144/220/65	0/0/0/0	0/0/0/0
Education	225	0	0
	6/72/114/33	0/0/0/0	0/0/0/0

	CS64KBPS	CS128KBPS	DX25
Voice(Message)	*100%*	*0%*	*0%*
Broadcast	15	0	0
	0/5/8/2	0/0/0/0	0/0/0/0
Communication	375	0	0
	9/120/191/55	0/0/0/0	0/0/0/0
Education	225	0	0
	6/72/114/33	0/0/0/0	0/0/0/0

	CS64KBPS	CS128KBPS	DX25
Facsimile	*80%*	*15%*	*2%*
Broadcast	24	5	1
	1/8/12/3	0/2/3/0	0/0/1/0
Communication	600	112	15
	15/192/306/87	3/36/58/16	0/5/8/2
Education	180	34	5
	4/58/92/26	1/11/17/5	0/2/3/0

Within each of these time-slots the ISDN service calls are assumed to be uniformly distributed. In our example, the 45 ISDN calls from Baltimore that are associated with the broadcast industry that use the CS64KBPS ISDN bearer service fall into a 1/14/23/7 time-slot distribution pattern. This means that :

1 ISDN call will be selected from a uniform distribution between 0001-0800 hrs,
14 ISDN calls will be selected from a uniform distribution between 0801-1200 hrs,
23 ISDN calls will be elected from a uniform distribution between 1201-1800 hrs, and
7 ISDN calls will be selected from a uniform distribution between 1801-2400 hrs.

A sequence number is produced by the ScenGen program to uniquely identify each call. The resulting is a partially populated STF for initiating these 45 ISDN service calls from Baltimore::

RqstTime	CallRef	Action	Rersour	OrigCity	DestCity	TermTime
0700	0001	Rqst	CS64	Balt	*	where:
						* = represents a city selected from a uniform distribution of those cities selected by the scenario script.
0815	0002	Rqst	CS64	Balt	*	tbd
0830	0003	Rqst	CS64	Balt	*	tbd
...						
2347	0045	Rqst	CS64	Balt	*	tbd

6. The termination time, tbd's in the list above, for a particular service depends on the length of time that service is used. The length of time associated with the use of these ISDN bearer services is proportional to the hold-time for that service. SCAR DB5 cites these hold-times as a function of the application. For our example of the 45 CS64KBPS messages the hold-time is 3 minutes. Using a uniform distribution with a parametric value of 3, hold-times are determined for each ISDN call. That hold-time is added to the call request event time to determine the call termination event time. The resulting STF is shown below:

RqstTime	CallRef	Action	Rersour	OrigCity	DestCity	TermTime
0700	0001	Rqst	CS64	Balt	*	0702

* = represents a city selected from a uniform distribution of those cities selected by the scenario script.

RqstTime	CallRef	Action	Rersour	OrigCity	DestCity	TermTime
0815	0002	Rqst	CS64	Balt	*	0818
0830	0003	Rqst	CS64	Balt	*	0831
...						
2347	0045	Rqst	CS64	Balt	*	2349

This STF suitably represents the ISDN user traffic for the SCAR network models and simulations. There are sufficient degrees of freedom to permit a number of tailored scenarios to determine the ISDN communications satellite design parameter limits, test subsystems and procedure and stress the overall system. An example of scenario profile for four cities: Baltimore, Chicago, Los Angeles, and San Francisco using the industries of broadcast, construction, communications, data processing, and education across all bearer services is shown in Figure 6.2-3, "Scenario Generation Example".

6.3 Scenario Specifications Output

Scenario specification consists of descriptive text that presents the objectives, goals, strategy, and the selected scenario components that are to be used to generate a given scenario. These specifications can be decomposed into scenario scripts that are used in conjunction with the ScenGen program and the traffic model database. Each scenario has a reason for being. They address a specific aspect of the NASA SCAR design for an advanced ISDN communications satellite. The ISDN satellite topology, design parameters, and environment are part of the simulation initial conditions for the subsequent scenario discrete events requesting and relinquishing ISDN bearer services.

Four types of scenarios were defined for the NASA SCAR Program: checkout, baseline, stress, and special scenarios. A checkout scenario will be used to verify the functionality of various sets of ISDN subsystems of the satellite design. The objectives here are to quickly and easily demonstrate that the actions and protocols that accompany a specific ISDN bearer service are modeled and simulated properly and are operating as described in the standards. Five checkout scenarios are planned for this NASA SCAR Program: CS64, CS128, DX25, BFRAMERELY, and TELEMETRY. These checkout scenario address the bearer services that are identified in the traffic model database.

A baseline scenario will be developed and used as standard for all NASA SCAR Program simulations. The purpose is to provide a benchmark that will produce comparable results as the advanced ISDN communications satellite design evolves. This baseline scenario should include a sufficient variety of ISDN traffic to adequately gauge the satellite design. Stress scenarios will be developed to determine the limits of the ISDN communications satellite design. The objective is to find the break points in the design in order to determine

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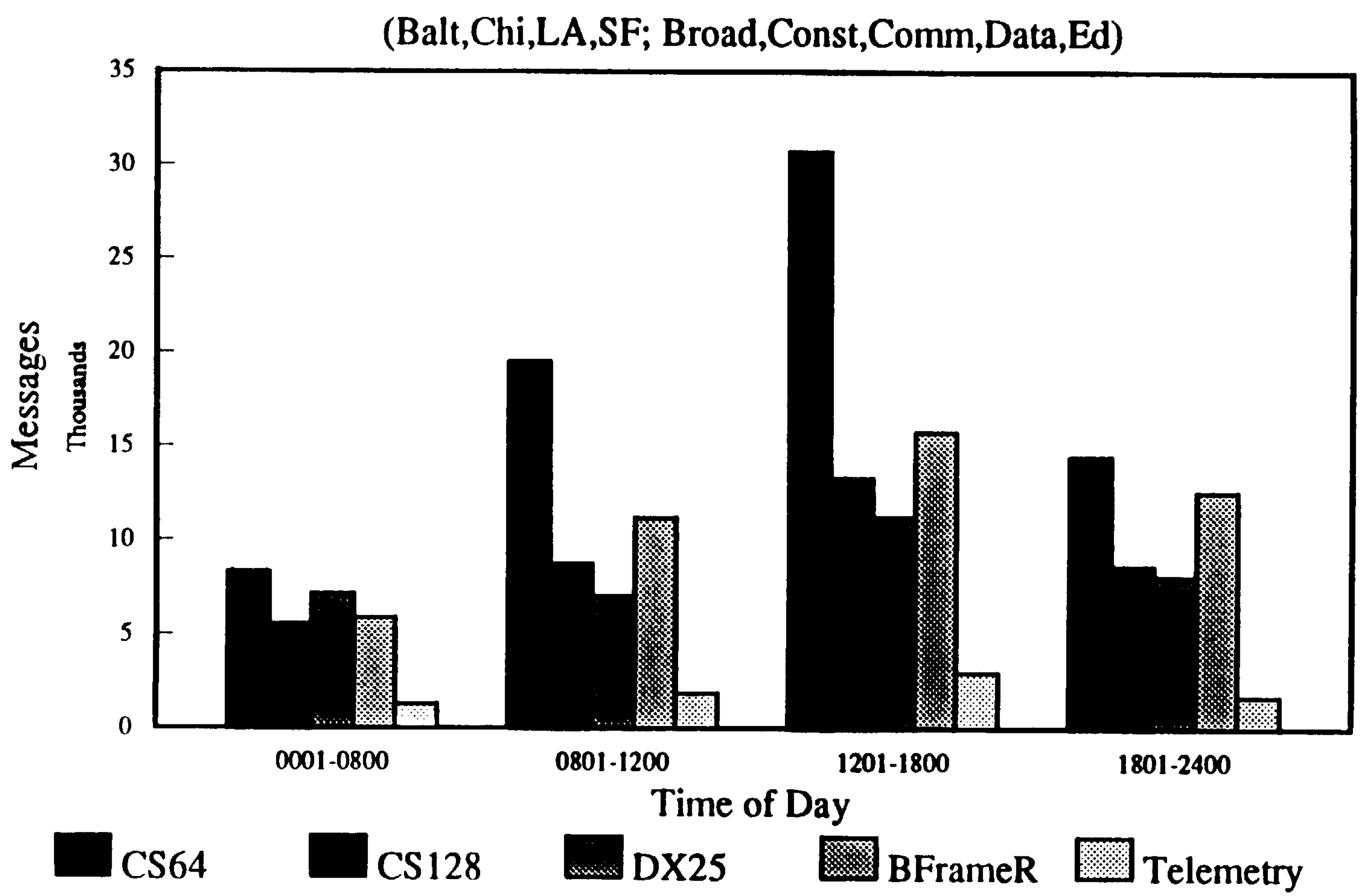

Figure 6.2-3 Scenario Generation Example

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Scen Gen Exam Profile
September 9, 1992

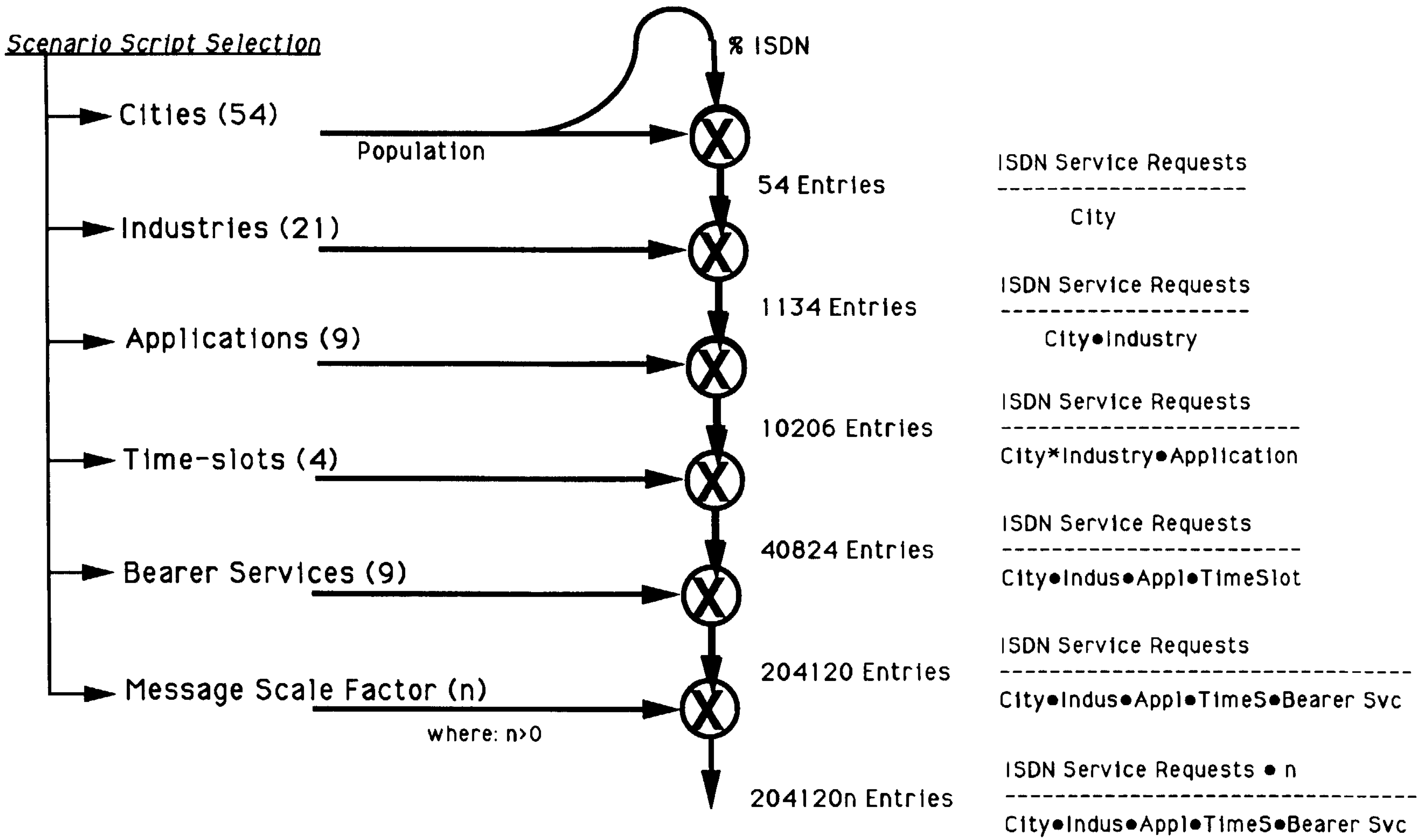

Figure 6.3-1 Scenario Script Selection Options

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SCen Script Selec Options
September 9, 1992

the engineering and operating envelop for the system. Three stress scenarios are planned: traffic stress, environment stress, and link breakdown stress. The traffic stress scenario will the message scale factor to systematically increase the traffic of an ISDN message distribution until a failure occurs. The environment stress scenario will systematically add weather losses to the system to determine the utility of weather mitigating techniques. The link-breakdown stress scenario will systematically disable single communication links to simulate a link-breakdown in order to determine the system robustness.

Special scenario will be developed on a demand basis to investigate specific attributes of the ISDN communications satellite design. At least one special scenario will be developed for this NASA SCAR Program.

The rationale for a scenario script must include a list of traffic model database components that are to participate in the scenario. Figure 6.3-1, "Scenario Script Selection Options", shows the database architecture for the traffic model indicating the scenario selection options that are available. Once these options are selected, the ScenGen program automatically implements the algorithm presented in Section 6.2 to generate a STF for the ISDN network model simulation. By selecting combinations of cities, industries, applications, time-slots, and bearer services 204,120 ISDN message elements can be formed into any distribution of ISDN message traffic. A message scale factor is used to sculpture this ISDN message distribution to suit the traffic load desired.

The scenario selection process, as part of ScenGen, consists of:

- Selecting the cities
- Selecting the industries
- Selecting the applications
- Selecting the time-slots
- Selecting the bearer services
- Choosing a message factor.

6.4 Scenario Specifications Conclusions

The scenario generating capability developed for this NASA SCAR Project was deemed more than adequate to providing the necessary user characteristics for discrete event simulations experiments using the ISIS and FSIS models.

SECTION 7

PERFORMANCE MEASURES

7.1 Performance Measures Objective

The objective of the Performance Measures task was to determine the criteria by which ISDN communications satellite design parameters would be evaluated and compared. The details of this task were published in "Scenarios and Performance Measures for Advanced Satellite Designs and Experiments for ISDN Services (Interim Status Report)", dated 1 September 1991 and ."Scenarios and Performance Measures for Advanced Satellite Designs and Experiments for ISDN Services (Update Report)", dated 28 February 1992 and the major results are summarized in this section.

As shown in Figure 7.1-.1, "Performance Measures - Introduction", the performance measure definitions effects all aspects of this SCAR program. Performance measures will be used to evaluate both the hardware and software for the advanced ISDN communications satellite design. As such these performance measure must be associated with observables that can quantified and impartially measured. In general these performance measures must be in line with CCITT standards especially as they pertain to satellite service in ISDN.

7.2 Performance Measures Task

These performance measures must be integrated into both the scenario generations process to focus attention on what is to be measured and on the modeling and simulation software to ensure that the parameters necessary for these measures are included in the design. Using the user perspective, these performance standards are derived for communication links in end-to-end connections.

Performance measures must identify with those elements of the system that are critical to the system performance. They must also provide a quantitative unit of measure for these element performance. The development of these performance measures forces a systematic approach to the technical definitions of the system modeling/simulation objectives. They provide the basis for the design for the system simulations and lead to the documentation of the technical objectives of the system model and simulation.

7.3 Performance Measures Output

Four categories of performance measures were identified for the NASA CAR advanced ISDN communications satellite system: throughput, response time, blocking probability, and robustness. Each is discussed in turn.

7.3.1 Throughput Throughput refers to the communications capacity to transfer a quantifiable amount of communications traffic. It can be quantified in several unit of measure: bits per seconds, messages per seconds, frame pers seconds, number of simultaneous channels, etc.

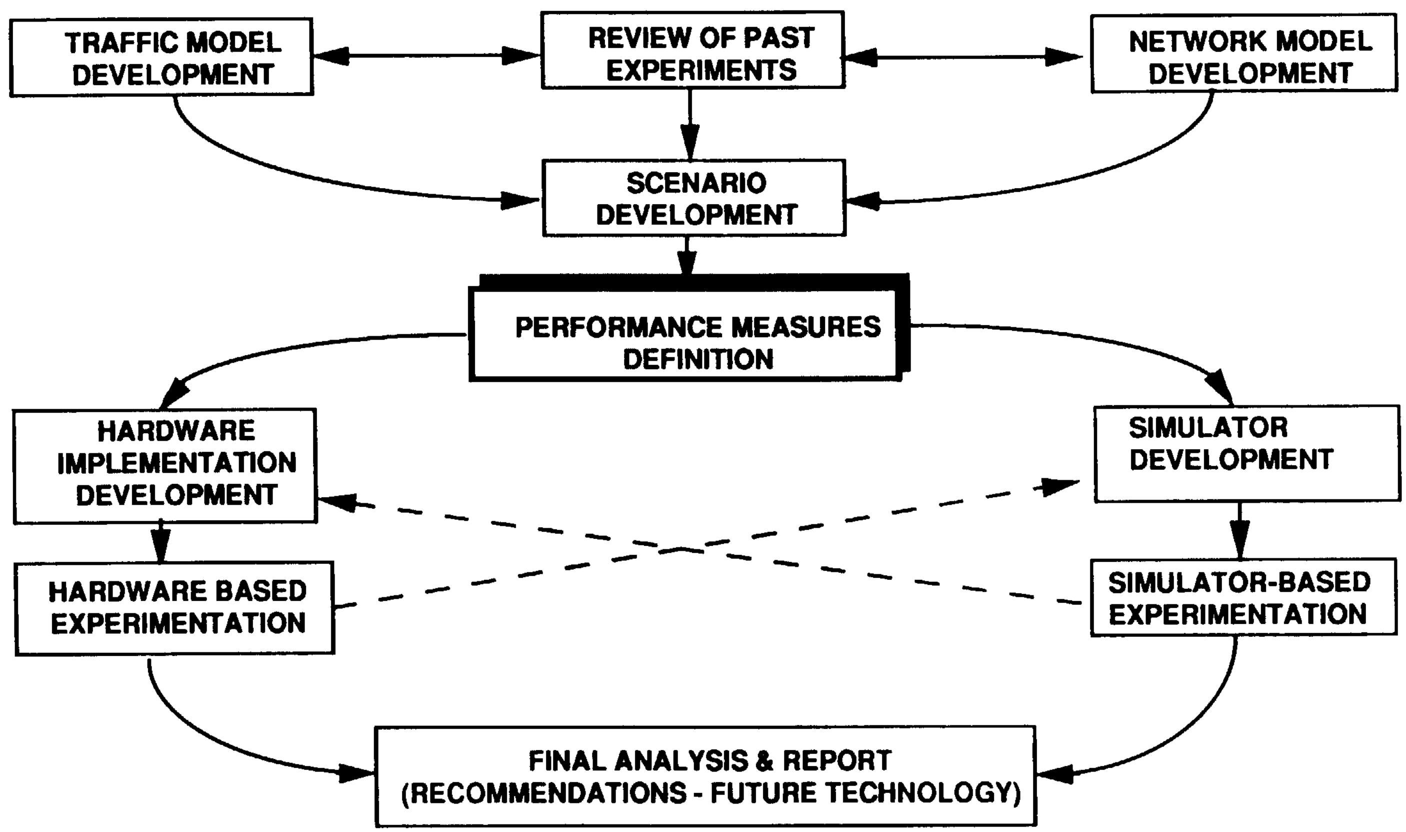

Figure 7.1-1 Performance Measures - Introduction

A number of ISDN communications satellite design factors contribute to the communications throughput. The intrinsic ISDN channel capacity of the B-Channel and D-Channel and their bundling into a T1 structure form a natural restriction on throughput. The satellite connectivity further constrains this potential ISDN throughput. Satellite antenna gains, beam widths, and dwell capabilities mitigate the communications capacity. The uplink/downlink accesses using TDMA slots, FDMA frequencies, and CDMA codes restrict the number of ISDN channels that can be serviced. In term of protocol and traffic queuing the buffer sizes and the processor speeds meaningfully affect the throughput.

Throughput evaluations apply at all level of communications and therefore affect all major modeling and simulation modules. Since in a satellite environment the traffic shares many of the communication links with the control protocol, both traffic and protocol throughput must be considered in the analysis of throughput. The throughput performance measure will be the number of B-Channels that be simultaneously supported or the bits per second of uplink and downlink capacity.

7.3.2 **Response Time** Response time refers to the speed at which a system can supply throughput.. It can be quantified in the time required to set up a circuit, the time from the sending to the receipt of a packet, the time from keyboard selection to screen response, etc.

Response time in a satellite communications system is principally limited by the propagation delays between the ground stations and the satellite. Processing time delays contribute in proportion to software that must be executed to support communications. In an ISDN software intensive system this means that much attention must be given to software execution times. The satellite antenna reaction and revisit times add linearly to the response time. The time it takes for an uplink access is limited by framing time and contention resolution time of the modulation scheme and the contention algorithm. Response time is also extended by the time-outs within the ISDN and SS7 protocols, and by the coding delays that accompany error detection and error corrections.

Though the response time is principally involved with the set up time of an ISDN communications channel it permeates every communication subsystem and every model and simulations module. Every stage of protocol processing and traffic moving takes time that can be accumulated into response time. The response times at all first level interfaces are most visible but the response times associated with decision logic depth for ISDN and SS7 protocol processing in the on-board processor (OBP) could be of comparable magnitude. The measure of response time will be the time it takes set up an ISDN service from the time it was requested.

7.3.3 **Blocking Probability** Blocking probability refers to the likelihood that a given call request can not be satisfied. It is quantified by a probability number between zero and unity. The objective is to seek the lowest blocking probability for a given design.

The factors that contribute to the communications blocking probability generally deal with limits on available resources: channels, buffers, or time. Though the capacity of the D-Channel for control could limit the assignment of the bearer service B-Channels, the ISDN architecture has generally provide sufficient control channel margin. In an ISDN communications satellite architecture, however, the number of B-channel resources that can be allocated is more limited than in the terrestrial environment. The denial of uplink access is not generally considered part of the blocking probability. It acts like the line-finder access to telephone exchanges and is more associate with availability. But in advanced ISDN communications satellites where the OBPs control the assignment of the bearer services, B-Channels, and the downlink transmission paths, call blocking can occur when any of these resources are unavailable.

From an application point of view the blocking probability is associated with the ability of the OBP to assign the resources to complete an ISDN service. At that decision point the OBP logs the request for ISDN service as being blocked, and takes the appropriate steps to inform the requesting party. A more general view of blocking probability would include denial of uplink access and unavailability of intermediate buffers, but there are no mechanisms in the real world for accumulating these statistics or informing the party being blocked. The measure of blocking probability will be the number or percentage of ISDN service requests that are denied by the OBP due to the lack of resources.

7.3.4 **Robustness** Robustness refers to ability of the system to recover from any finite state transitions. A number of factors can be associated with robustness. Robustness must counter many forms of inadvertent events and states. Each of these undesirable events and states must rectified but unique singular solutions. To recover from an undesired logic state the solution relies on prevention software to avoid that logic state or special time-out or correction software to exit the undesired logic state. Buffer or stack overflows must correctable on the spot, in real-time, and with minimal information loss. Locked up capacity on the B-Channels and D-Channels must be resolved by early detection and the selective shedding of load. The protocol must capable of positive recovery from any loss of response usually after some time-out period. Erroneous routing must resolved by default options or centralized review by the OBP for action.

Though most effects of robustness can be resolved by the OBP many unpredictable actions or operations will require reviewing and redressing to recover from undesirable events or states. The measure of robustness will be the number ISDN communications anomalies that occur after the network model and simulation has been checked out and debugged for the advanced ISDN communications satellite.

7.4 Performance Measures Conclusions

The selection of these performance measures is essential for the success of this research. Their integration into the design, model, and simulation of an advanced ISDN communications satellite is shown in Table 7.4.1, "NASA SCAR Performance Measures Matrix".

As such these performance measures determine the complexity of the design, model, simulation and analysis associated with the NASA SCAR Program. Therefore, these performance measures must be prioritized as to the relative importance to allow some flexibility in controlling scope of the NASA SCAR effort.

Table 7.4-1 NASA SCAR Performance Measures Matrix

	Throughput	Response Time	Blocking Probability	Robustness
Satellite Antenna	Gain Beamwidth Dwell	Reaction Time Revisit Time		Gain
Uplink	TDMA Slots FDMA Frequency	Propagation Time Framing Time Contention Time	Contention Blocks	Receiver Sensitivity Weather
Downlink	FDMA Frequency Transmitter Power	Propagation Time	Transmission Channels	Weather
Modulation	CDMA Codes	Coding Delays		Coding Lockup
Processor	Buffer Size Stack Size	Processing Time Buffering Time Logic Depth		Logic hangup Buffer overflow Stack overflow Erroneous routing
ISDN	# of D-Channel # of B-Channel	Protocol Timeouts	D-Channel Capacity # of B-Channel Protocol Blocks	D-Channel Lockup B-Channel Lockup Protocol Races
Measures:	Bits per second Msgs per second Frames per second # simultaneous channels	subsystem delay seconds end-to-end delay seconds setup seconds	# of Svcs Denied % of Svcs Denied	# of anomalies type of anomolies

SECTION 8

HARDWARE EXPERIMENT DESIGN

8.1 Hardware Experiment Design Objective

The objective of the Hardware Experiment Design task was to develop a suitable experiment to demonstrate the concept of ISDN communications over satellite links. The details of this task were published in Interim Service ISDN Satellite (ISIS) Hardware Experiment Design for Advanced Satellite Designs and Experiments (Task Completion Report)", dated 28 February 1992 and the major results are summarized in this section.

The objective of the ISDN Hardware Experiment is to demonstrate the feasibility of using typical communications satellites to connect ISDN users to ISDN exchanges via a non-ISDN Communications Satellite Link. Figure 8.1-1, "ISIS Hardware Experiment" shows the top view of a user terminal connected to a #5ESS Switch via line termination and network termination. The ISTA converts the ISDN Basic Access Superframe Structure into Satellite Link Access HDLC Frame Structure suitable for transmission via satellite using the RS-449 interface. The ISTA design must also be capable of reversing the process on the network side of the satellite connection.

8.2 Hardware Experiment Design Task

The technical and operational parameters for the advanced ISDN communications satellite design will be obtained from a software engineering model of the major subsystems of the ISDN communications satellite architecture. Discrete event simulation experiments will be performed with the model using various traffic scenarios, design parameters, and operational procedures.

The data from these simulations will be analyzed using the NASA SCAR performance measures discussed in previous reports. Data from hardware experiments will used to verify the model results. In order to associate modeling and simulation results with real-world data, some ISDN hardware design and development were undertaken. Hardware development was limited to the ISIS approach. Figure 8.2-1, "ISIS System Configuration for Remote Access", illustrates the ISIS system configuration. The ISDN Satellite Terminal Adapter (ISTA) hardware was designed to interface with the Type 1 network termination (NT1) at the user site via the ISDN U-interface and the line termination (LT) unit of the ISDN switch. This task completion report associates the ISTA hardware development directly with the design.

Figure 8.2-2, "ISDN Typical Terrestrial/Satellite Links", shows customer premises connected to an ISDN switch at a local telephone exchange by a U-interface using the 2B1Q line code with 3.5 miles of twisted pair copper wire. This connection between the NT1 unit and the line termination (LT) provides the user with all the access for basic rate ISDN services. Replacing this copper wire with a satellite link requires matching both the NT1 and the LT termination in terms of bit transfer, protocol timing and data rate adaption related to CCITT time-out values. Both the satellite and the corresponding ground system must be capable of supporting the typical ISDN 160 Kbps basic access rate. The ISTA ensures that the protocol and user data conversions permit the timely support of the ISDN protocol and data.

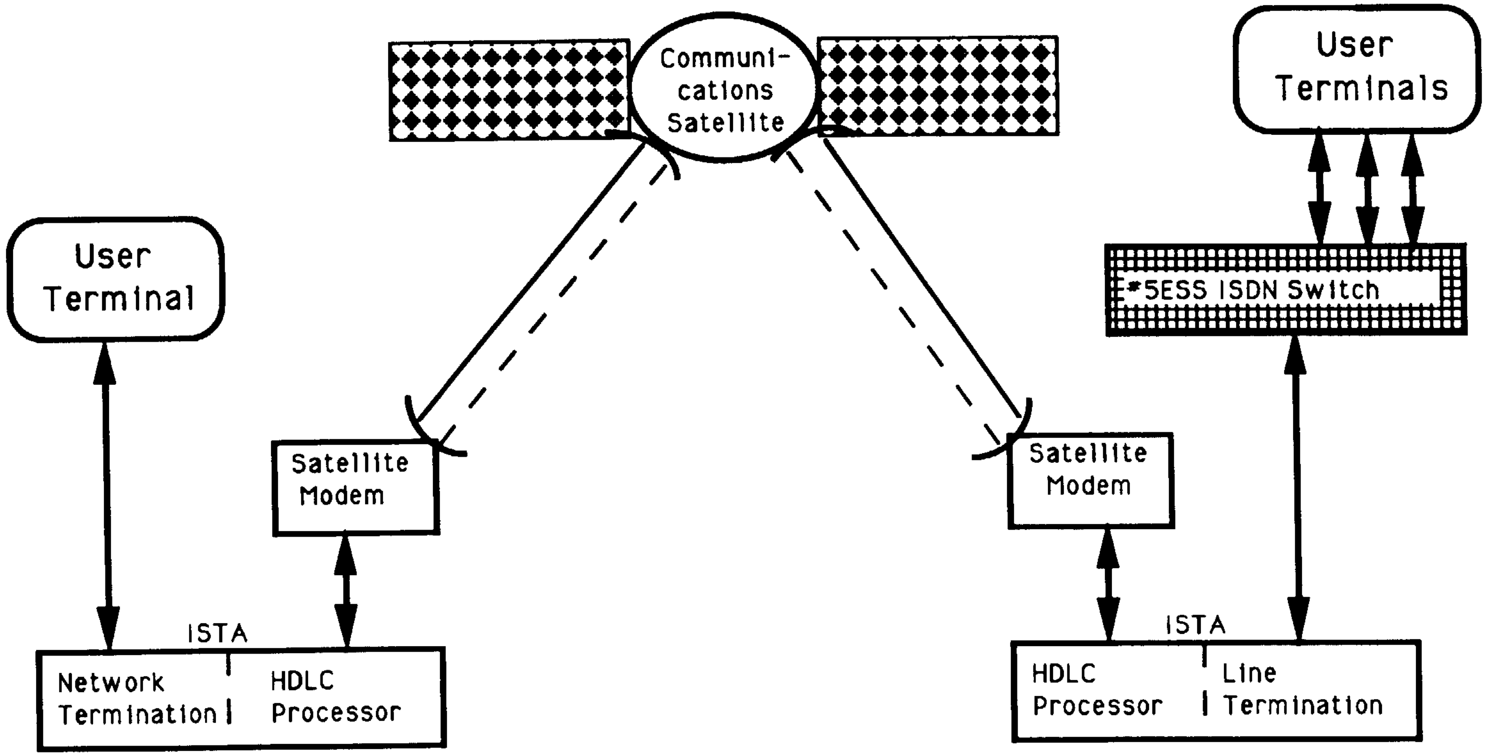

Figure 8.1-1 ISIS Hardware Experiment

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ISIS Hardw EXperiment
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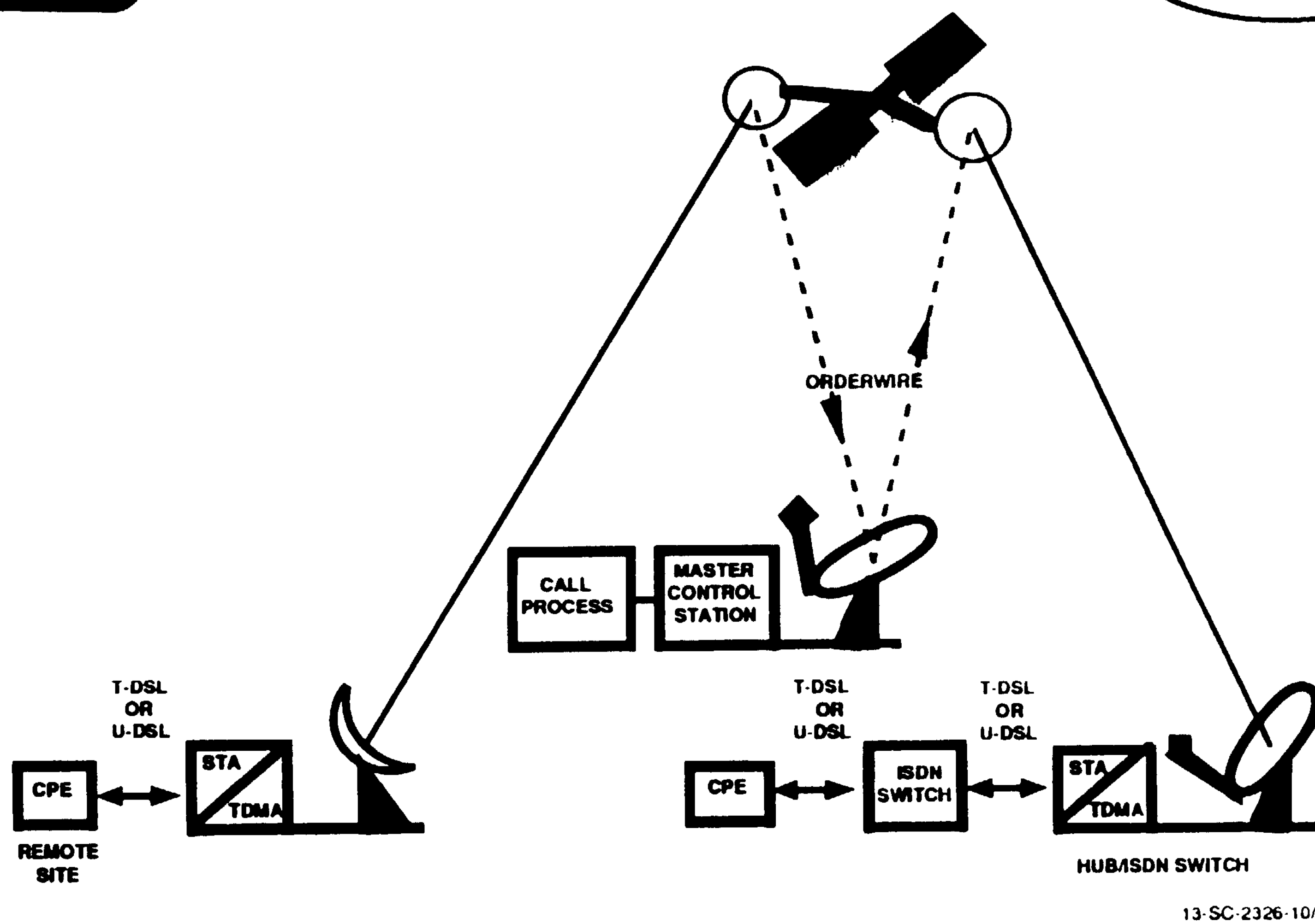

Figure 8.2-1 ISIS System Configuration for Remote Access

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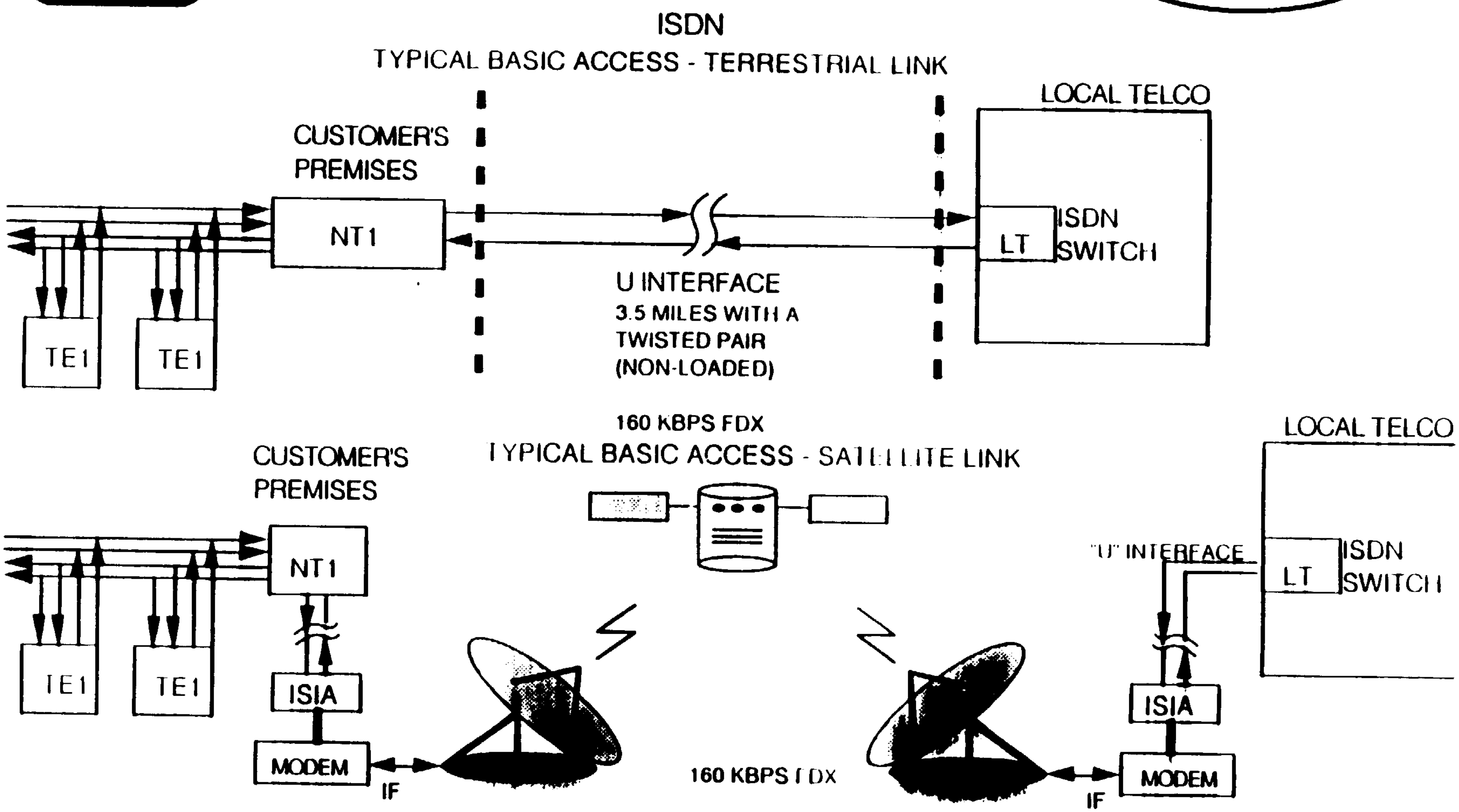

Figure 8.2-2 ISDN Typical Terrestrial/Satellite Links

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ISDN Typical Terres/Satel
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8.3 Hardware Experiment Design Output

One of the postulated demonstrations of the ISTAs is to provide ISDN connectivity between the NASA Lewis Complex in Ohio and the Centreville Virginia Central Office's #5ESS switch connected to the GTE Chantilly Facility. Figure 8.3-1, "Potential ISDN Satellite Connectivity", shows a compressed video image at NASA Lewis, Cleveland, Ohio being transmitted to GTE Chantilly, Virginia via ISTA equipped ground terminals. Tests of throughput and response-time can be made using this configuration or other similar configuration. The principal message for this report is that the ISTA provides the necessary conversion between the ISDN world and the communications satellite world.

Figure 8.3-2, "Typical Remote Site ISDN Application with ISTA" shows a more detail view of the application of these ISTA devices. The twisted pair connection with 2B1Q line code to the NT1 or the ISDN switch provide generic access to typical telephone company services. Whereas, the RS-449 connectivity to satellite modems permit the use of communications satellites as communication components of any ISDN network. The ISDN access extends to multimedia and video teleconferencing services

8.4 Hardware Experiment Design Conclusions

These ISDN communication experiments with ISTA are all plausible. Laboratory versions of these experiments have been demonstrated using satellite delay line simulators.

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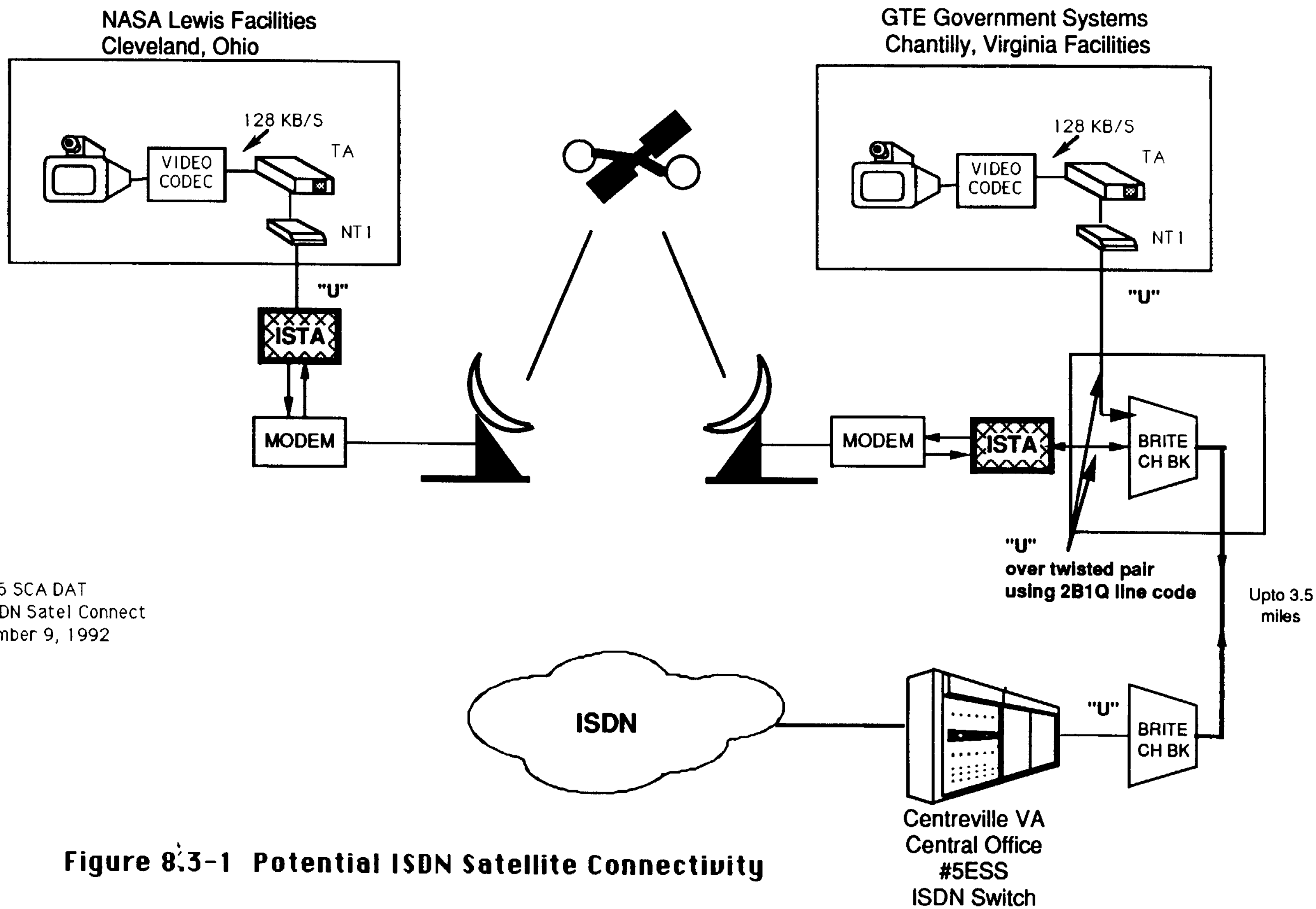

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Figure 8.3-1 Potential ISDN Satellite Connectivity

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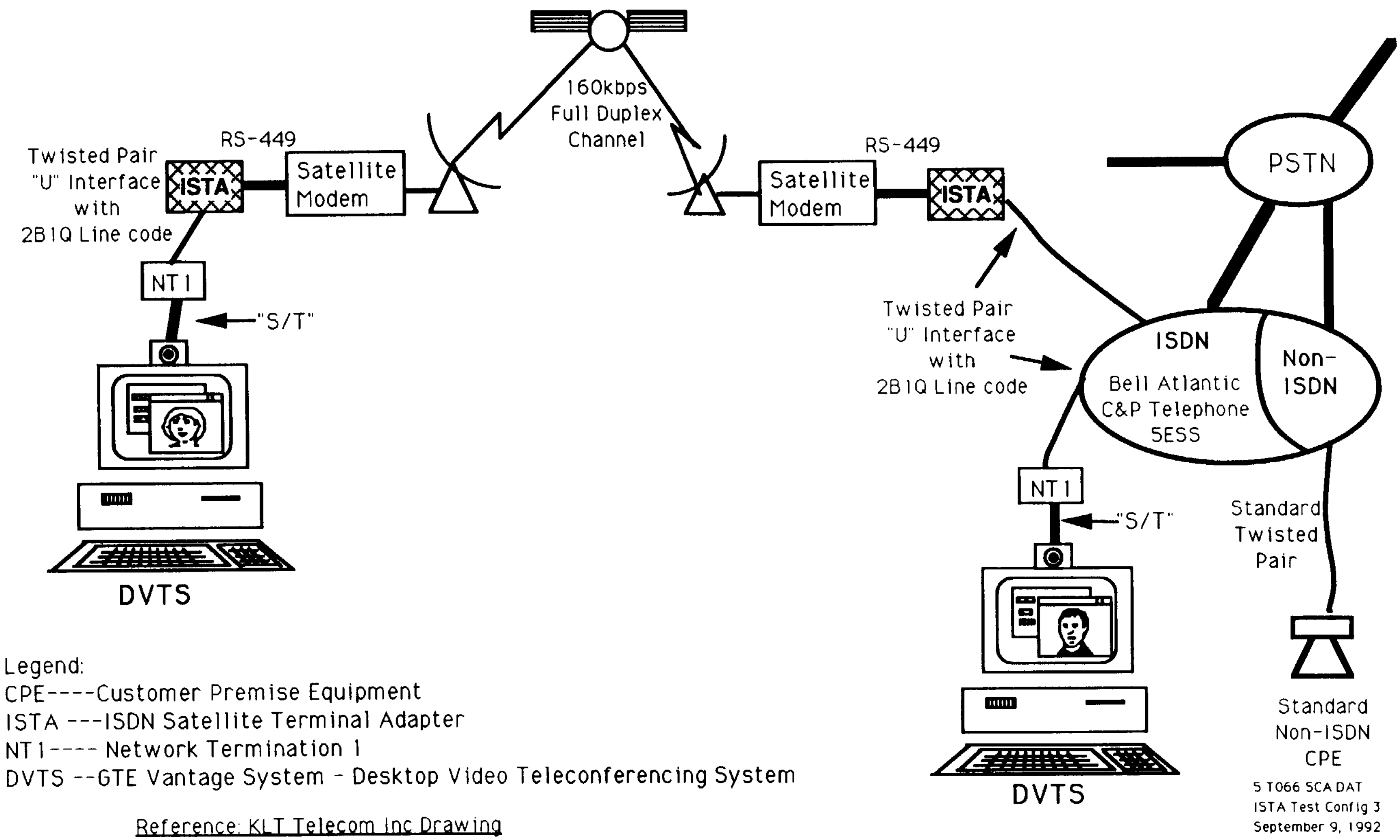

Legend:
CPE----Customer Premise Equipment
ISTA ---ISDN Satellite Terminal Adapter
NT1---- Network Termination 1
DVTS --GTE Vantage System - Desktop Video Teleconferencing System

Reference: KLT Telecom Inc Drawing

Figure 8.3-2 Typical Remote Site ISDN Application with ISTA

SECTION 9

HARDWARE EXPERIMENT DEVELOPMENT

9.1 Hardware Experiment Development Objective

The objective of the Hardware Experiment Development task was to implement the design of the ISDN hardware and to preform laboratory tests using the ISTA hardware. The details of this task were published in Interim Service ISDN Satellite Experiment Development for Advanced Satellite Designs and Experiments (Task Completion Report)", date 30 April 1992.and "Interim Service ISDN Satellite Experiment Development for Advanced Satellite Designs and Experiments (Task Completion Report Update)", date 12 September 1992 and the major results are summarized in this section.

9.2 Hardware Experiment Development Task

At the top level, the ISTA interfaces the U-interface with the RS-449 interface at the 160 Kbps rate. Figure 9.2-1, "ISDN Satellite Terminal Adapter (ISTA) Subsystem Diagram", shows the ISTA between the user terminal and the Low Bit Rate Terminal (LBR-2). The expanded view at the LT and RS-449 level, and the development using the MC145472, the MC68302, and RS-449 Driver/Receiver chip set are discussed in subsequent sections.

Figure 9.2-2, "ISTA Functional Block Diagram", shows both the CPE side and the switch side of the ISTA. For the CPE side the U-interface connects the user NT1 to a line terminal that is connected to a HDLC processor that converts the basic access frames to the RS-449 frames for the communications satellite. On the switch side of the ISTA the RS-449 frames are converted by the HDLC processor to provide ISDN basic access frames between the NT unit and the LT unit of the #5ESS ISDN Switch. Figure 9.2-3, "Specific ISTA Network and Line Terminations", depict the ISTA device with its development parameters.

Each side of the ISTA has its unique frame structure to accommodate their respective protocols. Figure 9.2-4, "ISTA Frame Structures", shows both frame structures. The ISDN Basic Access Superframe Structure uses a format of 1920 bits. The transmission across the U-interface is organized into groups of eight 12(2B+D) frames, called superframes. A frame consists of three fields:

Synchronization word (SW): Used for physical layer synchronization and frame alignment. It consist of a pattern of 18 bits.

User Data (12(2B+D): 12 groups of 2B and D information. Each group contains 8 B1 bits, 8 B2 bits, and 2 D bits resulting in 216 bits of user data.

Overhead Data: These bits are used for physical channel maintenance, error detection and power status. A total of 6 bits are used per frame.

As shown in Fig 9.2-4 the inverted synchronization word (ISW) identifies the first frame in the superframe; its is a pattern of 18 bits that is merely the inverse of the normal synchronization word. The superframe organizes the 6 overhead bits of each frame into a block of 48 bits

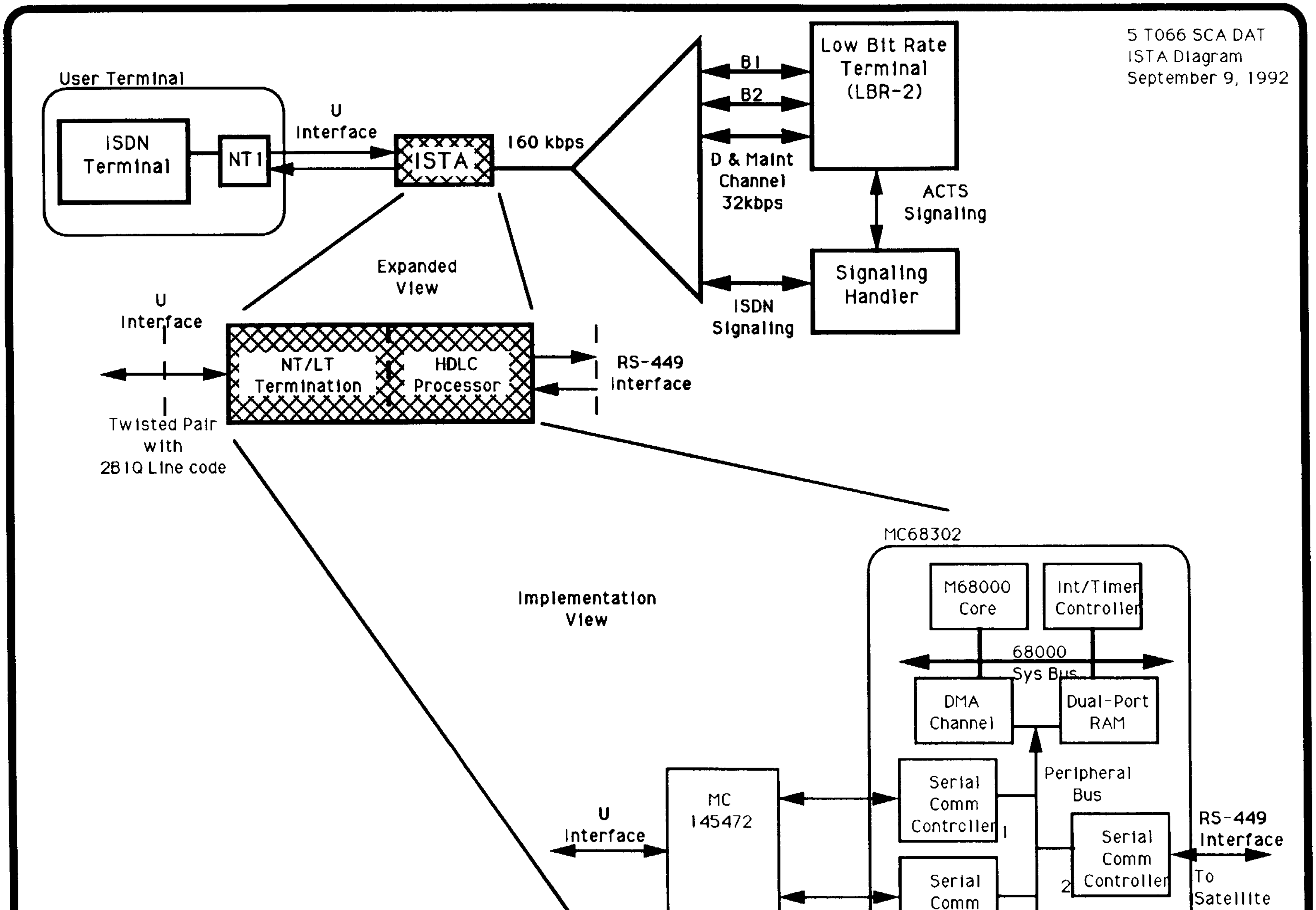

Figure 9.2-1
ISDN Satellite Terminal Adapter (ISTA)
Subsystem Diagram

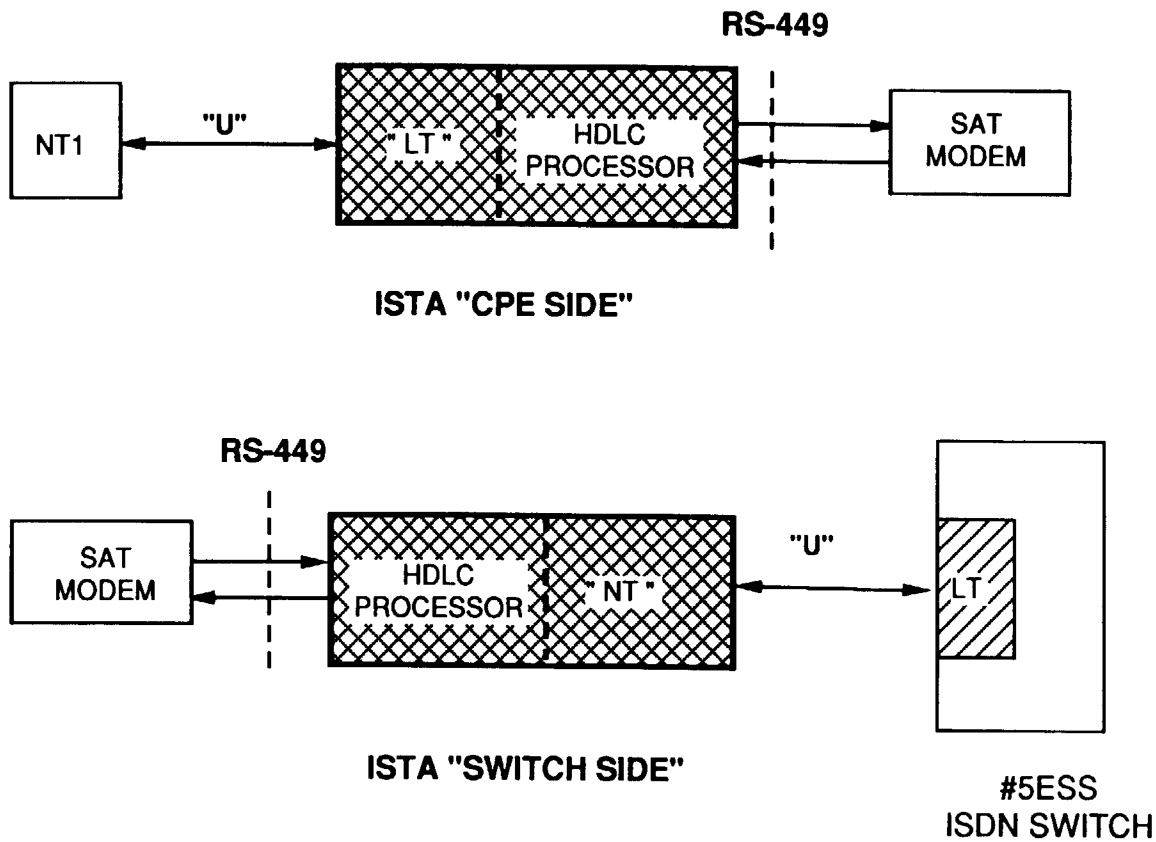

Figure 9.2-2 ISTA Functional Block Diagram

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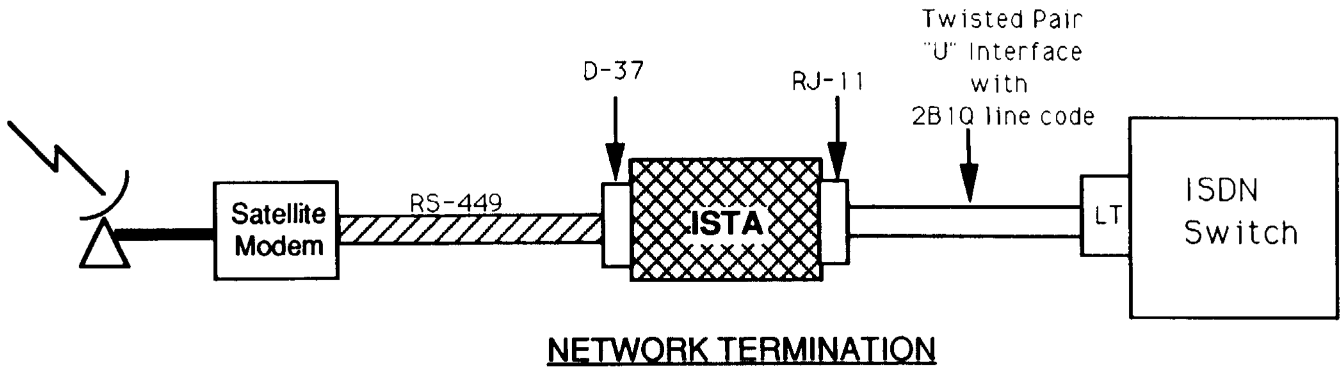
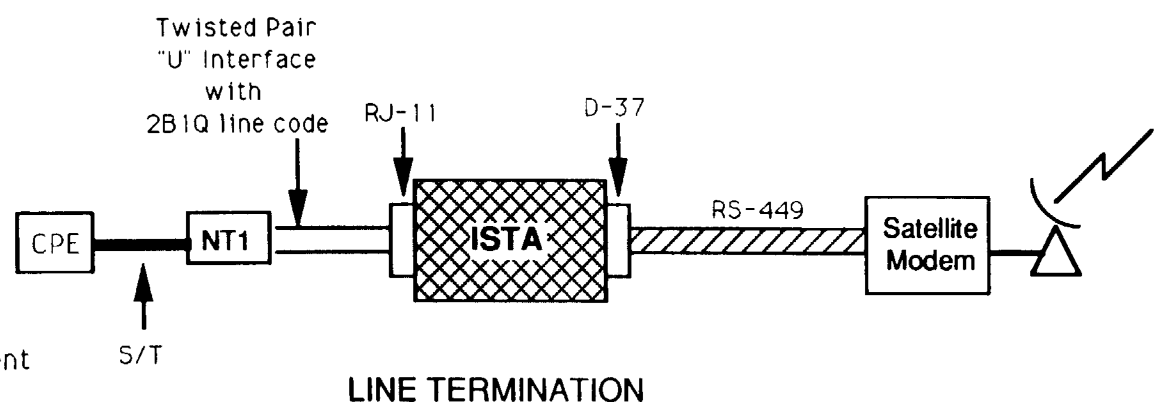
September 9, 1992

GTE Government Systems

NASA - SCAR





Legend:
CPE---- Customer Premise Equipment
NT1----- Network Termination 1
LT------- Line Termination
ISTA --- ISDN Satellite Terminal Adapter

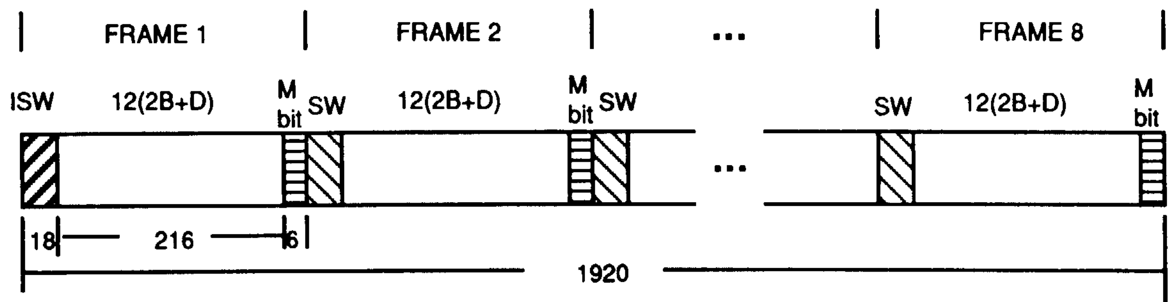
Reference: KLT Telecom Inc Diagram

5 T066 SCA DAT
ISTA Termination Diags
September 9, 1992

Figure 9.2-3 Specific ISTA Network and Line Terminations

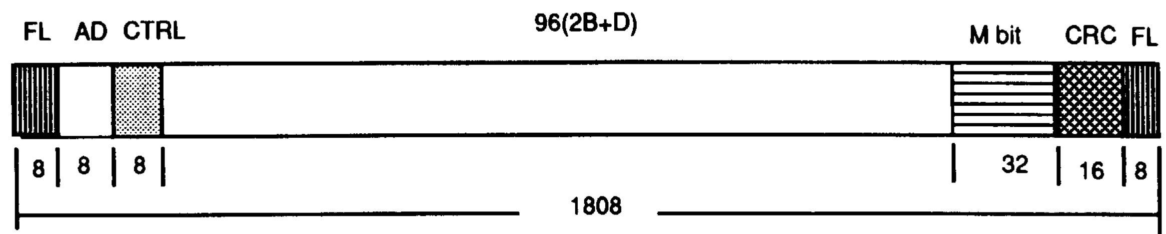
Government Systems

NASA - SCAR



ISDN Basic Access Superframe Structure

B = 8 bits
D = 2 bits
Data Rate = 160 Kbps



Satellite Link Access HDLC Frame Structure

Figure 9.2-4 ISTA Frame Structures

5 T066 SCA DAT
ISDN Frame Structures
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The satellite link access HDLC frame structure consists of 1808 bits apportioned in a different manner. The eight frames of user information are combined into a single frame of 1728 bits for the 96(2B+D). The overhead bits are collected into Flag, Control, CRC, M-bits and Fill. The fill is used to perform rate adaption between the terrestrial and satellite protocols.

9.3 Hardware Experiment Development Output

Three ISTAs have been constructed. They have been successful tested under a number of laboratory conditions. The ISTA is a rectangular box, 6" x 8" x 1", with all connectors on the rear 1" X 6" panel and the indicator lights and single NT/LT switch on the front panel. the size of three cigarette packs and weight approximately one pound. The ISTA is made up of single printed circuit board with a chips set and containing the protocol conversion software in a ROM. All connectors, indicator lights, and switch are also mounted on the circuit board.

9.3.1 ISTA Chip Set The ISTA design shown in Figure 9.3.1-1, "ISTA Hardware Block Diagram", includes using the MC145472 ISDN U-Interface Transceiver, the MC68302 Multi-Protocol Processor and added RAM/ROM for suitable memory. The serial communication controllers on the MC68302 are connected to RS-449 drivers and receivers used to drive the ISDN U-interface transceiver. The third serial communications controller connected to the same MC68302 peripheral bus as the other two communications controllers provides HDLC frames to the RS-449 line Tx/Rx function.

This same ISTA design is capable of supporting the CPE side and the switch side of the interface. To synchronize with satellite timing the U145472 derives timing from the received satellite clock pulses using in a phase lock loop to control the ISDN U-interface transceiver when the ISTA is used on the switch side - Switch to Satellite interface. The same loop timing switch is open when the ISTA is used on the CPE side - NT1 to Satellite interface.

9.3.2 ISTA Software The ISTA design uses off-the-shelf chip sets that require principally pin to pin circuit connectivity. These chips, however, rely on digital instructions to perform their transmission, reception, and protocol frame conversion processes. Figure 9.3.2-1, "ISTA Software Flow Diagram", depicts the top level flow diagram for the ISTA software. After the sequential initialization of the MC68302, the HDLC Comm, the 2B+D Comm and the SCP the software selects the U interface initialization depending on the ISTA switch setting. After all these initialization on both ISTAs the respective software starts the appropriate activation procedure and waits for an interrupt.

These interrupt service routines include:

* M4 Bits Processing
* Activation/Deactivation
* Embedded Operation Channel Processing
* IDL "2B+D" Tx and Rx Buffer Processing
* HDLC Tx and Rx Buffer Processing

GTE Government Systems

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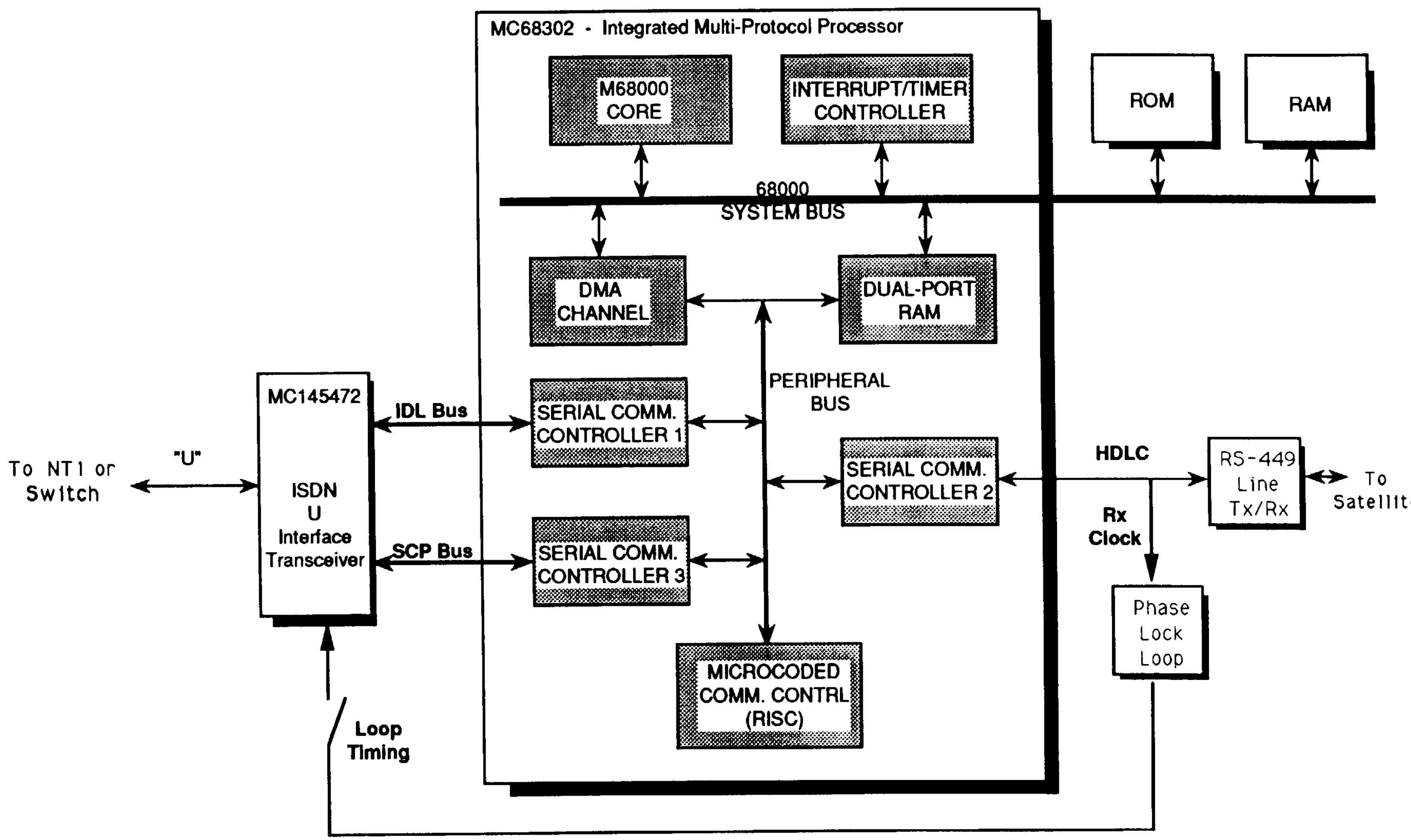

5 T066 SCA DAT
ISTA Hardware Block Diag
September 9, 1992

Figure 9.3.1-1 ISTA Hardware Block Diagram

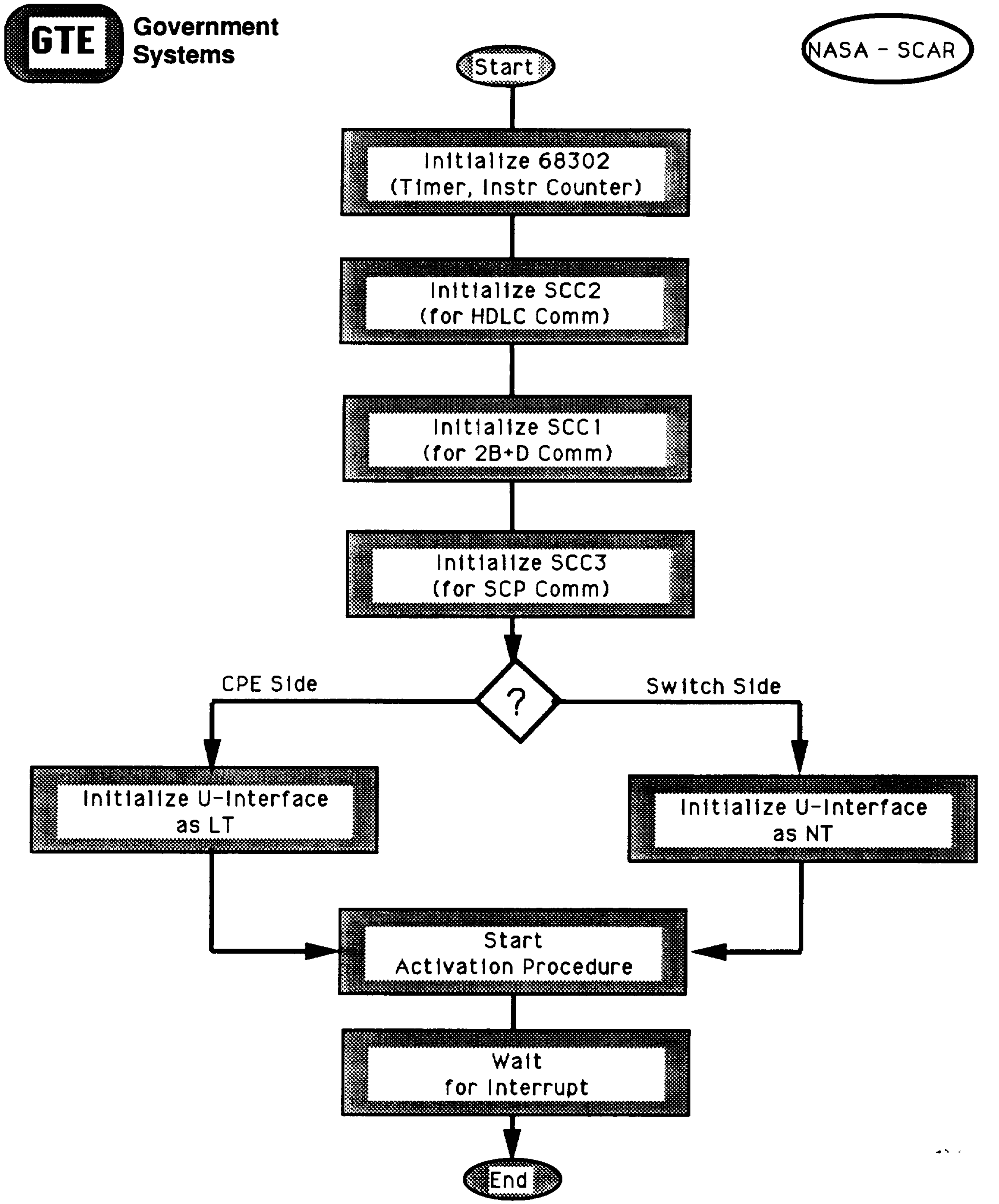

Figure 9.3.2-1 ISTA Software Flow Diagram

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ISTA Software Flow Diag
September 9, 1992

9.3.3 ISTA Tests Figure 9.3.3-1, "ISDN Satellite Terminal Adapter Experimental Network Tests" shows two test views for the ISTAs. The outside connectivity shows the potential ISDN ISTA hardware experiment configuration discussed in Section 8. The inner connectivity of Fig 9.3.3-1 depicts the laboratory test configuration used for the functional acceptance Tests (FAT) for the ISTAs. Two laboratory test sessions were formally held for the ISTAs - one on August 19, 1992 and one on September 3 1992.

Laboratory Tests on August 19, 1992 - The successful functional tests of two ISTAs were held on August 19, 1992. These tests consisted of several telephone calls through the two ISTAs connected in series on each side of to a 'satellite delays simulator', see Fig 9.3.3-1. The connection from the ISTA's to the simulator were via RS-449 interfaces. NT1 "U" interfaces, using twisted pair and 2B1Q line code, connected the other side of the ISTAs to an ISDN telephone and the ISDN 5ESS Switch by a Basic Rate Interface (BRI) ISDN line to the Centreville VA central office, respectively. The ISDN telephone calls were received by over a similar BRI ISDN line connected to the Centreville central office. These tests were conducted using 250 msecs of delay tp represent the nominal round trip ISDN communication delay from geo-synchronous orbit.

Similar functional tests were conducted, with up to 100 msecs of delay, demonstrating video teleconferencing and multi-media services over ISDN. Attempts to demonstrate these services with geo-synchronous delays failed in the v.120 protocol area. V.120 (I.465) uses similar procedures as HDLC. Flag stuffing is used to accommodate idle time. Recommendation V.120, ANSI standard T1.406, is intended for circuit-mode applications - usually applied to terrestrial networks. To date, the V.120 protocol has implemented solely on a terrestrial basis. We believe that the accommodation of satellite delays would require increasing some of the timers associated with that protocol.

Laboratory Tests on September 10, 1992 - On September 10, 1992, similar functional tests were held. The ISTA was tested for recovery from certain failure mode: loss of power, loss of satellite link, and inadvertent NT/LT switch toggle. The ISTA resynchronized within 10 seconds in all cases. As with the previous tests several telephone calls were made through all combinations of the ISTAs connected in series with 'satellite delays simulator' set at 250 msecs.

9.4 Hardware Experiment Development Conclusions

The ISTA are functional and capable of demonstrating the uses of ISDN voices services over satellite links. Some limitation exists for multi-media and video teleconferencing beyond 100 msecs. It is believed that the implementation using a more robust protocol than HDLC at the lower layers would solve some of these timing issues.

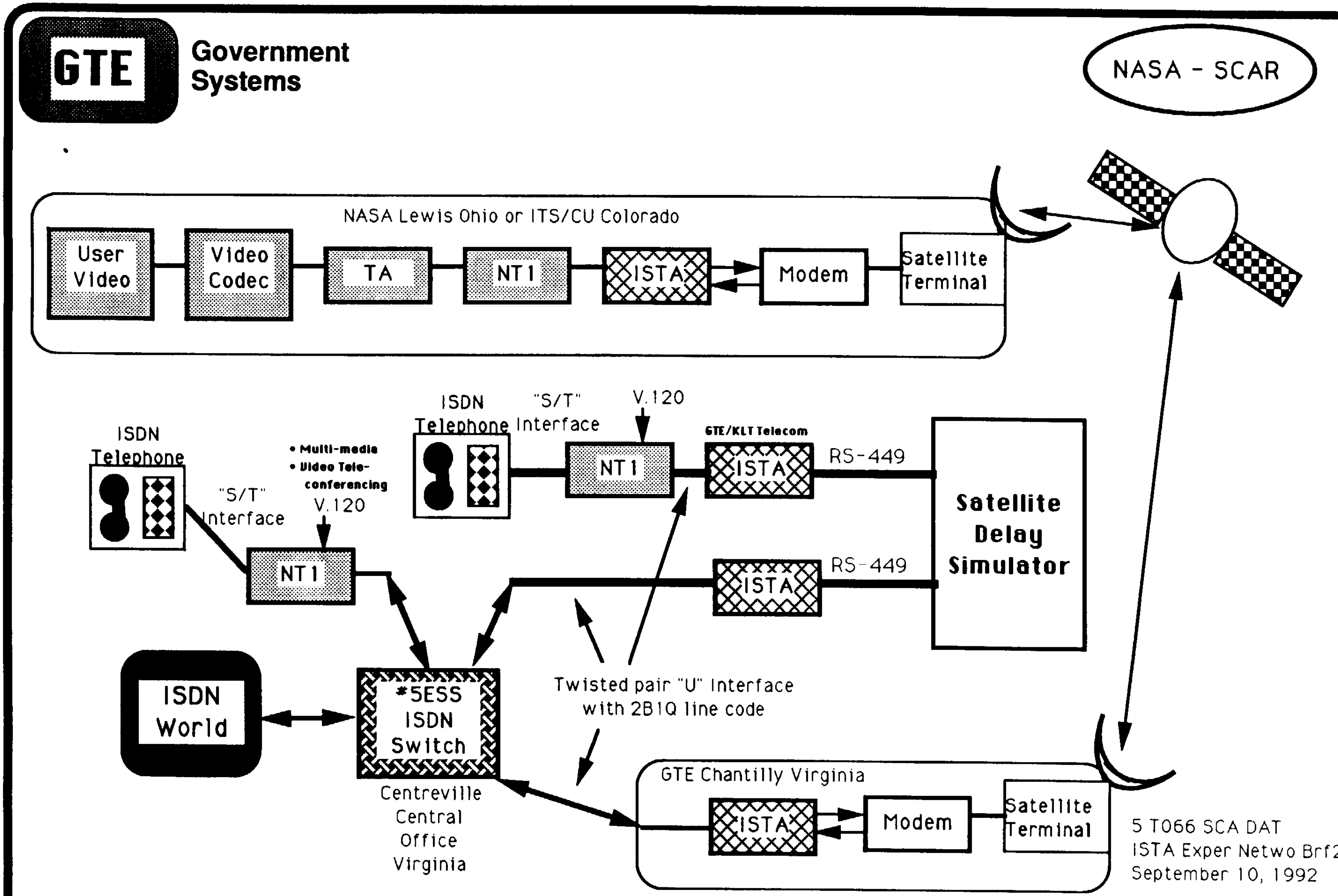

Figure 9.3.3-1 ISDN Satellite Terminal Adapter Experimental Network Tests

SECTION 10

SIMULATOR DESIGN

10.1 Simulator Design Objective

The objective of the Simulator Design task was to design a suitable software simulation of the previously developed models to permit determination and evaluations of ISDN communications satellite parameters. The details of this task were published in Simulator Design for Advanced Satellite Designs and experiments (Task Completion Report), dated 30 March 1992 and the major results are summarized in this section.

The objective of this SCAR simulation project was to design and develop software models to be used to simulate those aspects of an ISDN communications satellite with sufficient fidelity to assist in determining design parameters. This simulation effort assists in the development new advanced on-board satellite capabilities that will enable the provision of new services of an interim and full ISDN communication satellite. Figure 10.1-1., "ISDN Communications Satellite Simulation Top View", indicates the inputs and outputs expected of the SCAR simulation as well as the characteristics of the simulation, itself.

ISDN protocols, procedures, standards and user traffic form the input basis for the simulation. Together with the SS7 technology, the OSI methodology, and the satellite environment this ISDN aspect of communications satellite design is challengingly constrained. The SCAR ISDN communication satellite simulation uses discrete event based simulation of communication protocol flows through an engineering model to generated results traceable to the technical design parameters The SCAR simulation outputs will be capable of demonstrating the viability of an ISDN satellite design and provide the rationale for recommending specific engineering parameters and changes to published ISDN standards.

10.2 Simulator Design Task

This end-to-end simulation is divided into distinct simulation phases: database generation, scenario generation, engineering data generation, simulation run, and product generation shown previously in Figure 4.2-1., "SCAR Simulation Phases". The ISDN communications satellite end-to-end simulation also previously depicted in Figure 6.2-1, "End-to-End Model Architecture" shows that each program is physically and functionally separated by input/output data files. This separation ensures that each simulator program is independent. The only link between these programs is the data file they share. Each program is briefly described in the following sections in order to provide an overview of the simulation design process.

10.2.1 Database Generation Program The Database Generation (DbGen) program assembles the major ISDN user characteristics into a machine readable database. For this NASA SCAR effort the traffic model consists of a number of databases: the City Reference DB, ISDN User vs Industry DB, Application vs Industry DB, Application vs Time DB, and Application vs Bearer Services DB. Figure 4.3.1-1, "CONUS City Locations for NASA SCAR Traffic Model Database", showed the cities that are part of the traffic model. Those cities outlined with an ellipse identify the ACTS-east cities. Those cities outline with a rectangle identify the "ACTS-west" cities and the blackened squares depict the fixed antenna cities.

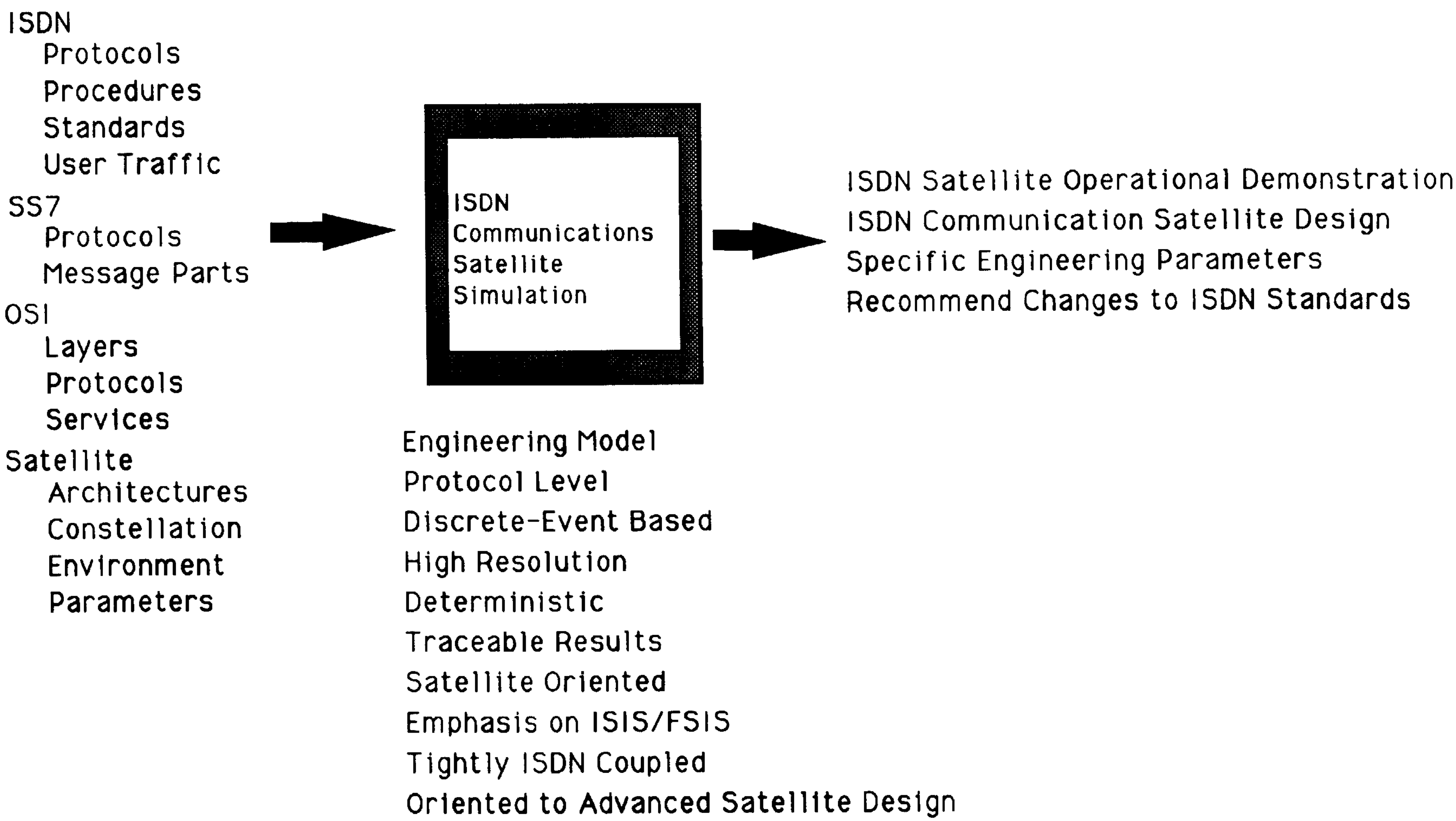

Figure 10.1-1 ISDN Communications Satellite Simulation Top View

The east/west city clusters are separated by a dashed line. The figure shows that the NASA SCAR traffic model is well aligned with the cities of interest for ACTS. The traffic model database represents the ISDN traffic for these cities and is the principal input to the scenario generation process. The traffic model databases data are presented in Appendix C, "SCAR Traffic Model Database Data"

10.2.2 Scenario Generation Program The Scenario Generation (ScenGen) program selects the traffic model database entries that describes a scenario of ISDN users together with the statistical information of the ISDN services requested. The ScenGen program uses entries from the user traffic model database and engineering parameter databases to generate a list of time ordered, initiating discrete events. The discrete event list is call a Scenario Traffic File (STF). The STF is used to initialize the model for a specific advanced ISDN communications satellite design and to exercise that satellite design using the requests for ISDN services dictated by the ISDN user traffic.

10.2.3 Engineering Data Generation Program The Engineering Data Generation (EngGen) program permits the satellite engineer to select parameters for the advanced ISDN communications satellite being designed. Such engineering values as transmitter power, antenna size and gain, on-board processing speeds, buffer sizes, timer values form the basis of a satellite design. Physical constraints such as orbital position, propagation delays, and environmental conditions also the communications aspects of the design. These and all parametric values that affect the advanced satellite design are selectable using EngGen. The output is a matrix of values, ProcAr, that is loaded into the simulation before it is started. The values control the protocol setup and tear-down procedures for the specific ISDN service selected by the STF.

10.2.4 Simulation Run Program The Simulation Run (SimRun) program consists of a model of the real world communications network of the major ISDN communications satellite components. Each of these ISDN communication components is represented by a block diagram within the overall architecture. As shown in Figure 10.2.4-1, "Simulation Run Program", the SimRun program essentially reads each discrete event from the (STF), takes the appropriate action, and logs that action and the corresponding results in a measurement save (MSave) file. The appropriate action taken by the simulation includes allocating and releasing communication resources, denying specific services, and calling other processes in-turn.

10.2.5 Product Generation Program The Product Generation (ProdGen) program reads the data in the MSave file and analyzes these data in accordance with specific algorithms. It is envisioned that there will be as many product generation programs as there are ISDN communications satellite issues to be studied: throughput, response time, trace, delay, call blocking, busy-minute, busy-hour, etc. Each ProdGen program is tailored to a particular area of ISDN communications satellite design. Performance measures will be used as criteria to evaluate the design parameters, operational procedures and degree of ISDN communications standard compliance of the particular ISDN communications satellite design.

10.2.6 Generic Simulation Run Software ISDN is based on the Open System Interconnection (OSI) Reference Model. Though the simulator design will focus on the second (data link) and third (network) layers to evaluate the performance of routing, acknowledgement, congestion control, and other protocol driven functions, this design will also address the time-out issues relate to the first (physical) layer. Although physical characteristics of the system will not be directly simulated, the effects of the physical conditions will be parametrically simulated.

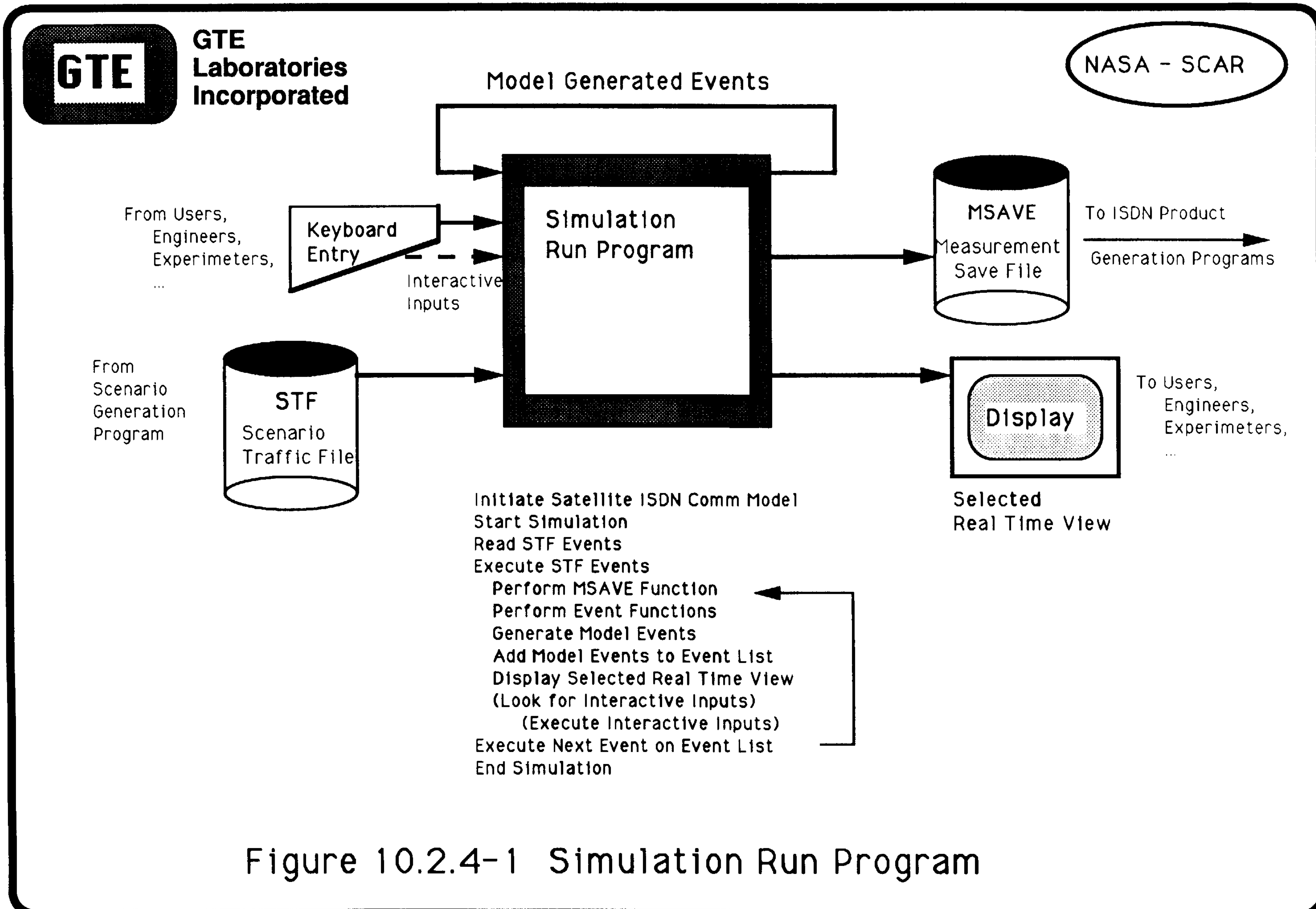

Figure 10.2.4-1 Simulation Run Program

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Simul Run Top Level Diag
September 10, 1992

For example, the cases involving heavy rain, severe signal degradation, and higher error rates are examined in terms of protocol performance when multiple transmission are required. Instead of calculating a link budget where all signal losses and gains are summed and converting the signal-to-noise ratio and to a bit-error rate, the simulator will take the power loss associated for that error rate as input. Such simulation techniques reduce the complexity of the simulator design, while providing the same level of information about layer protocols and their timers.

Figure 5.2-1, "Generic Network Model Block Diagram", showed the major subsystems of a communications architecture for a generic ISDN communications satellite simulating two satellite terminals each supporting three users. For this simulation, these subsystem models associated with the satellite terminals consist of an uplink transmitter and transmitting antenna, a downlink receiver and receive antenna, three users generating traffic, and a multiplexer/demultiplexer that combines and separates this traffic. The satellite is modeled by corresponding receivers, transmitters, antennas, an on-board switch, and an on-board processor that decodes received commands, controls the switch, and generates response traffic.

10.3 Simulator Design Output

In both cases, ISIS and FSIS, the simulation analyses will be obtained from engineering software models of their major subsystems of the ISDN communications satellite architecture and their appropriate ground terminations. Discrete event simulation experiments will be performed with these models using various traffic scenarios, design parameters, and operational procedures and performance measures.

10.3.1 Definition and Purpose Both ISIS and FSIS simulations consist of a number of VSATs connected to an ISDN satellite via a single hop. The VSATs will exchange ISDN traffic on a demand access, circuit switched basis. The purpose is to investigate the throughput, response time, blocking probability, and robustness of these two ISDN satellite architectures in a benign environment to provide a performance measures baseline and to investigate protocol timing issues at the lower layer levels. Particular attention will focus on the timing and time-outs associated with the ISDN physical layer protocol. These simulations will also deal with issues such as: packet switching on the B and D channels, full SS7 protocols, weather, and direct connectivity to an ISDN public switched network (IPSN).

10.3.2 Simulation Structures Both the ISIS and FSIS simulation will be described in the same context. A top view of the architecture is presented at the communication component level. This provides visibility into the architecture and links for these major communication components of the engineering models that are used to represent them. The next view treats these models as simulation processes and connects them in an end-to-end diagram representing the protocol flow. To ease the routing algorithm for the simulation a sequential number was ascribed to each process, Process Index (PI). This PI integer uniquely defines the specific occurrence of the process, its neighbors at that time, and the direction of protocol flow. The last view tabulates these processes into a pictorial matrix that associates each of them with their unique process index. The sequential aspects of this representation form a sort of process index "racetrack" pattern that can be used to visualize the protocol hand-off from one PI element to next.

For the FSIS architecture, seven major communication components are connected by six interfaces. Figure 5.3.2-1., "FSIS Simulation Communication Components", showed the ISDN Telephone, ISDN Satellite Terminal Adapter, VSAT Satellite Terminal and the FSIS Satellite connected by the S-Interfaces, U-Interfaces, and Propagation. Figure 10.3.2-1., "FSIS End-to-End Simulation Processes", are connected into a network using the Process Index (PI) as a sequence identification mechanism for tracking protocol flow. The processes are aligned with the major communication components depicted at the top of the page. Figure 10.3.2-2., "FSIS Simulation Communication Components and Model Processes Racetrack", lists all the simulation processes along with their PI numbers. The FSIS simulation architecture statistics include:

4 types of major Communication Components
16 types of simulation modules (processes)
77 process indexes
4.8 factor of software reuse (77 / 16)

For the ISIS architecture, nine major communication components are connected by eight interfaces. Figure 5.3.1-2., "ISIS Simulation Communication Components", showed the ISDN Telephone, ISDN Satellite Terminal Adapter, VSAT Satellite Terminal, the FSIS Satellite, and the Master Ground Station connected by the S-Interfaces, U-Interfaces, and Propagation. Figure 10.3.2-3., "ISIS End-to-End Simulation Processes", are connected into a network using the Process Index (PI) as a sequence identification mechanism for tracking protocol flow. Figure 10.3.2-4., "ISIS Simulation Communication Components and Model Processes Racetrack", lists all the simulation processes along with their PI numbers. The reference numbers are keyed to the text in this section that provide more detail about both the communication components and the processes. The ISIS simulation architecture statistics include:

5 types of major Communication Components
18 types of simulation modules (processes)
109 process indexes
6.0 factor of software reuse (109 / 18)

The commonality factor between the ISIS and FSIS architectures is 89% (16 common modules of 18 modules). The following sections describes each of these ISIS and FSIS communication components in terms of their implementing modeling processes.

10.3.3 ISIS and FSIS Satellite Communication Component The advanced ISDN communications satellite design under the NASA SCAR Program uses as its design starting point an ISDN switch in orbit. A user of the ISDN satellite requests services using ISDN protocols. These ISDN protocols are routed to the satellite via the VSATs and ISTAs . Depending on the communication satellite design, ISIS or FSIS, these ISDN protocols processed differently.

For ISIS, the ISDN satellite operations are modeled by an uplink receiving antenna (RxAnt 30) and receiver (Rx 30) that are connected to the on-board ISDN orderwire processor (ISISO). The ISISO either routes the protocol messages to the VSAT satellite downlink or to the MGS satellite downlink. The MGS acts on all protocol messages destined for this satellite. The ISIS on-board processing acts on the commands form the MGS to switch the allocated B-channels as directed by order wire commands. Both the VSAT and MGS downlinks are modeled by a downlink transmitter (Tx20) and an associated downlink transmitting antenna (TxAnt20).

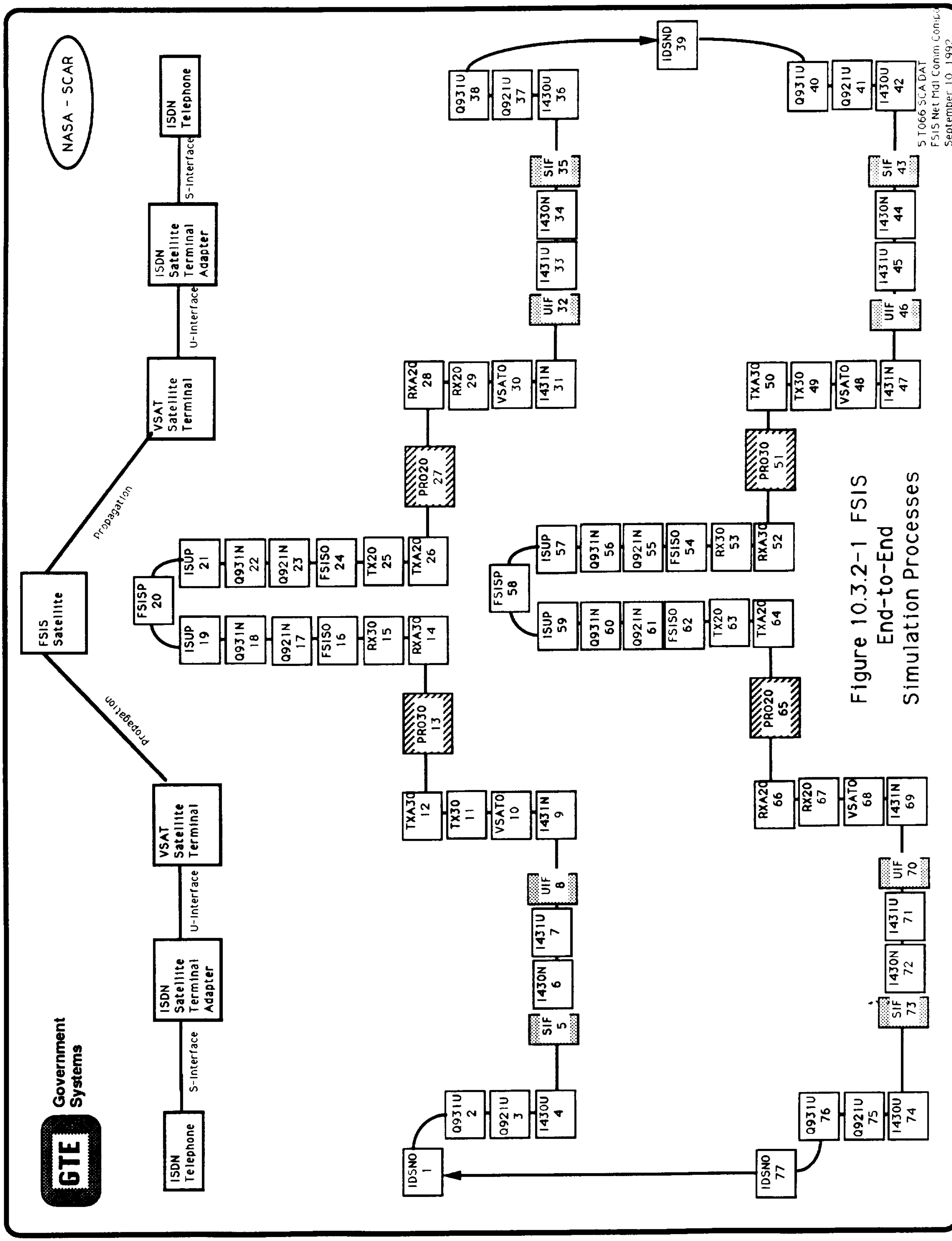

Figure 10.3.2-1 FSIS End-to-End Simulation Processes

Comm Component: Para # 4.3.5	Process Index (PI)		Model Processes:	FSIS Rpt	Model Processes:		
ISDN Tel	1	|	ISDNO (Tel)	Para # 4.4.5	ISDNO (Tel)		77
	2	|	Q.931U (User)	4.4.11	Q.931U (User)	^	76
	3	V	Q.921U (User)	4.4.10	Q.921U (User)	|	75
	4		I430U	4.4.3	I430U	|	74
4.3.7	5		SIF	4.4.14	SIF		73
4.3.4							
ISTA	6		I430N	4.4.3	I430N		72
	7		I431U	4.4.4	I431U		71
4.3.8	8		UIF	4.4.17	UIF		70
4.3.3							
VSAT	9	|	I431N	4.4.4	I431N		69
	10	|	VSATO (OW)	4.4.18	VSATO (OW)	^	68
	11	V	Tx (30)	4.4.12	Rx (20)	|	67
	12		TxAnt (30)	4.4.13	RxAnt (20)	|	66
4.3.6	13		Propa (30)	4.4.9	Propa (20)		65
4.3.1							
FSIS ISDN	14		RxAnt (30)	4.4.16	TxAnt (20)		64
Comm Satellite	15		Rx (30)	4.4.15	Tx (20)		63
Poss Bypass	16		FSISO (OW)	4.4.2	FSISO (OW)		62
	17		Q.921N (Network)	4.4.10	Q.921N (Network)		61
	18		Q.931N (Network)	4.4.11	Q.931N (Network)		60
	19	|	ISUP	4.4.6	ISUP	^	59
CC/ResMgt/ResAlloc	20	|	FSISP (Proc)	BCh 4.4.1	FSISP (Proc)	|	58
	21	V	ISUP	4.4.6	ISUP	|	57
	22		Q.931N (Network)	4.4.11	Q.931N (Network)		56
	23		Q.921N (Network)	4.4.10	Q.921N (Network)		55
Poss Bypass	24		FSISO (OW)	4.4.2	FSISO (OW)		54
	25		Tx (20)	4.4.12	Rx (30)		53
	26		TxAnt (20)	4.4.13	RxAnt (30)		52
4.3.6	27		Propa (20)	4.4.9	Propa (30)		51
4.3.3							
VSAT	28		RxAnt (20)	4.4.16	TxAnt (30)		50
	29	|	Rx (20)	4.4.15	Tx (30)	^	49
	30	|	VSATOW	4.4.18	VSATOW	|	48
	31	V	I431N	4.4.4	I431N	|	47
4.3.8	32		UIF	4.4.17	UIF		46
4.3.4							
ISTA	33		I431U	4.4.4	I431U		45
	34		I430N	4.4.3	I430N		44
4.3.7	35		SIF	4.4.14	SIF		43
4.3.5							
ISDN Tel	36		I430U	4.4.3	I430U		42
	37	|	Q.921U (User)	4.4.10	Q.921U (User)	^	41
	38	|	Q.931U (User)	4.4.11	Q.931U (User)	|	40
	39	V	ISDND (Tel)	4.4.5	ISDND (Tel)	|	

Figure 10.3.2-2. FSIS Simulation Communication Components and Model Processes Racetrack

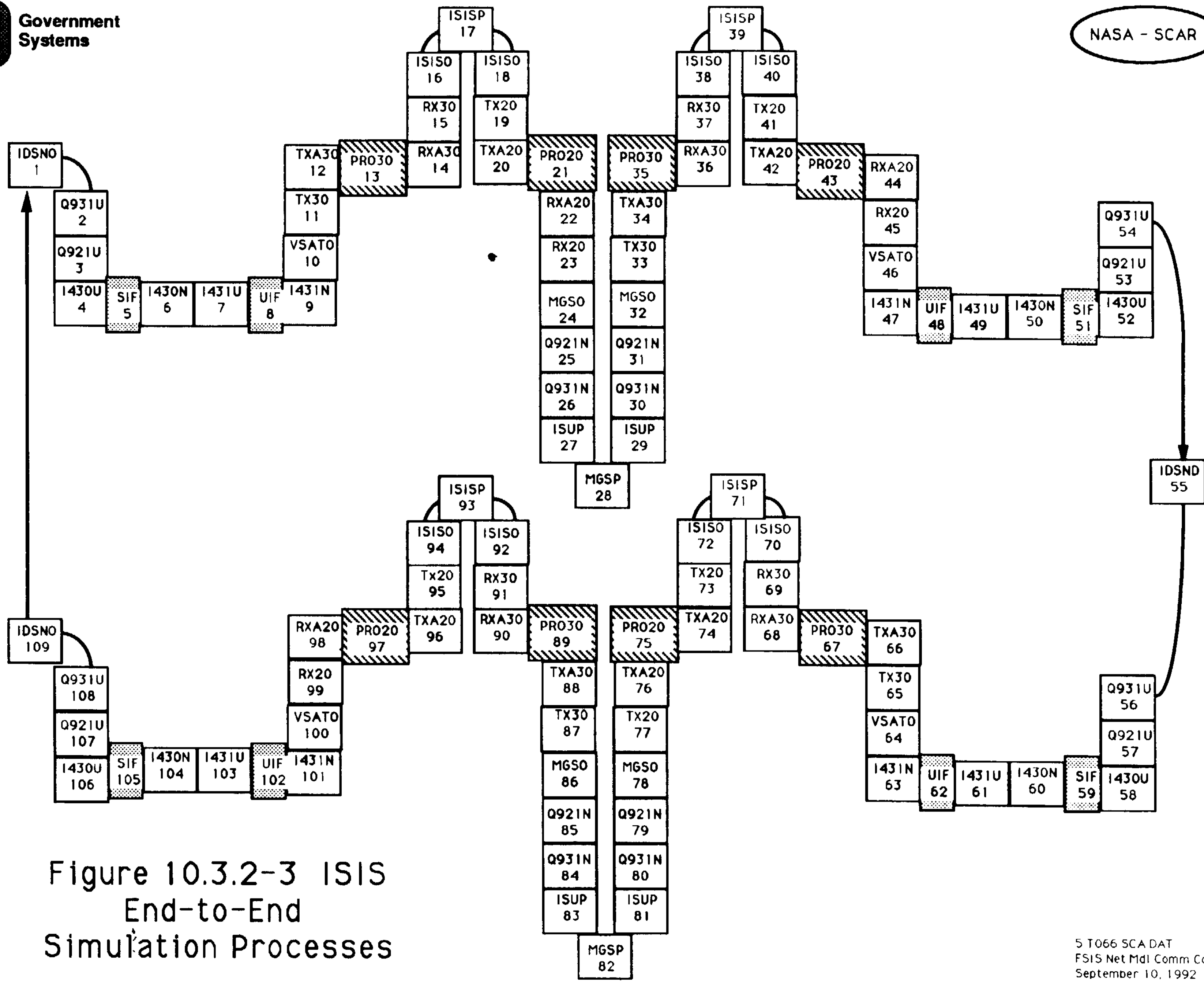

Figure 10.3.2-3 ISIS
End-to-End
Simulation Processes

5 T066 SCA DAT
FSIS Net Mdl Comm Compo
September 10, 1992

Comm Component: Para # 4.3.5	Process Index (PI)		Model Processes:		Sim Rpt	Model Processes:		PI
ISDN Tel	1	|	ISDNO (Tel)	Para #	4.4.5	ISDNO (Tel)		109
	2	|	Q.931U (User)		4.4.11	Q.931U (User)	^	108
	3	V	Q.921U (User)		4.4.10	Q.921U (User)	|	107
	4		I430U		4.4.3	I430U	|	106
4.3.7	5		SIF		4.4.14	SIF		105
4.3.4								
ISTA	6		I430N		4.4.3	I430N		104
	7		I431U		4.4.4	I431U		103
4.3.8	8		UIF		4.4.17	UIF		102
4.3.3								
VSAT	9	|	I431N		4.4.4	I431N		101
	10	|	VSATO (OW)		4.4.18	VSATO (OW)	^	100
	11	V	Tx (30)		4.4.12	Rx (20)	|	99
	12		TxAnt (30)		4.4.13	RxAnt (20)	|	98
4.3.6	13		Propa (30)		4.4.9	Propa (20)		97
4.3.1								
ISIS ISDN	14		RxAnt (30)		4.4.16	TxAnt (20)		96
Comm Satellite	15		Rx (30)		4.4.15	Tx (20)		95
Poss Bypass	16	|	ISISO (OW)		4.4.2	ISISO (OW)	^	94
ResAlloc	17	|	ISISP (Proc)	BCh	4.4.1	ISISP (Proc)	|	93
Poss Bypass	18	V	ISISO (OW)		4.4.2	ISISO (OW)	|	92
	19		Tx (20)		4.4.12	Rx (30)		91
	20		TxAnt (20)		4.4.13	RxAnt (30)		90
4.3.6	21		Propa (20)		4.4.9	Propa (30)		89
4.3.2								
Master Ground	22		RxAnt (20)		4.4.16	TxAnt (30)		88
Station MGS	23		Rx (20)		4.4.15	Tx (30)		87
Poss Bypass	24		MGSO (OW)		4.4.7	MGSO (OW)		86
	25		Q.921N (Network)		4.4.10	Q.921N (Network)		85
	26		Q.931N (Network)		4.4.11	Q.931N (Network)		84
	27	|	ISUP		4.4.6	ISUP	^	83
CC/ResMgt/GenProto+-	28	|	MGS (Proc)		4.4.8	MGS (Proc)	|	82
	29	V	ISUP		4.4.6	ISUP	|	81
	30		Q.931N (Network)		4.4.11	Q.931N (Network)		80
	31		Q.921N (Network)		4.4.10	Q.921N (Network)		79
Poss Bypass	32		MGSO (OW)		4.4.7	MGSO (OW)		78
	33		Tx (30)		4.4.12	Rx (20)		77
	34		TxAnt (30)		4.4.13	RxAnt (20)		76
4.3.6	35		Propa (30)		4.4.9	Propa (20)		75
4.3.1								
ISIS ISDN	36		RxAnt (30)		4.4.16	TxAnt (20)		74
Comm Satellite	37		Rx (30)		4.4.15	Tx (20)		73
Poss Bypass	38	|	ISISO (OW)		4.4.2	ISISO (OW)	^	72
ResAlloc	39	|	ISISP (Proc)	BCh	4.4.1	ISISP (Proc)	|	71
Poss Bypass	40	V	ISISO (OW)		4.4.2	ISISO (OW)	|	70
	41		Tx (20)		4.4.12	Rx (30)		69
	42		TxAnt (20)		4.4.13	RxAnt (30)		68
4.3.6	43		Propa (20)		4.4.9	Propa (30)		67
4.3.3								
VSAT	44		RxAnt (20)		4.4.16	TxAnt (30)		66
	45	|	Rx (20)		4.4.15	Tx (30)	^	65
	46	|	VSATOW		4.4.18	VSATOW	|	64
	47	V	I431N		4.4.4	I431N	|	63
4.3.8	48		UIF		4.4.17	UIF		62
4.3.4								
ISTA	49		I431U		4.4.4	I431U		61
	50		I430N		4.4.3	I430N		60
4.3.7	51		SIF		4.4.14	SIF		59
4.3.5								
ISDN Tel	52		I430U		4.4.3	I430U		58
	53	|	Q.921U (User)		4.4.10	Q.921U (User)	^	57
	54	|	Q.931U (User)		4.4.11	Q.931U (User)	|	56
	55	V	ISDND (Tel)		4.4.5	ISDND (Tel)	|	

Figure 10.3.2-4 ISIS Simulation Communication Components and Model Processes Racetrack

Both the downlink and uplink propagation are modeled by propagation (Prop) process that delays these protocol messages as a function of distance between the satellite and the respective ground terminal.

For FSIS, the ISDN satellite operations are modeled by an uplink receiving antenna (RxAnt 30) and receiver (Rx 30) that are connected to the on-board ISDN orderwire processor (FSISO). The FSISO either routes the protocol messages to the ISDN satellite downlink or routes them through the protocol conversion modules: Q921N, Q931N, and ISUP to the on-board protocol processor (FSISP). The FSISP acts on all protocol messages destined for this satellite. Reply protocol messages follow a reverse protocol excursion back to their destination. The ISDN downlink is modeled by a downlink transmitter (Tx20) and an associated downlink transmitting antenna (TxAnt20). Both the downlink and uplink propagation are modeled by propagation (Prop) process that delays these protocol messages as a function of distance between the satellite and the ground terminal.

10.4 Simulator Design Conclusions

This Simulator Design task provided the complete end-to-end protocol architecture for both ISIS and FSIS suitable for discrete event simulation. The simulation processes are applicable to both the ISIS and the FSIS designs. The ultimate aim of this aspect of the SCAR Program is the design of a new advanced ISDN communications satellite. The technical and operational parameters for this ISDN advanced communications satellite design will be obtained from an engineering software model of the major subsystems of the ISDN communications satellite architecture. Discrete event simulation experiments will be performed with these ISIS and FSIS models using various traffic scenarios, technical parameters, and operational procedures. The data from these simulations will be analyzed using the performance measures discussed in previous NASA SCAR reports.

The research in the simulator design task was satisfactorily completed and the results are capable of supporting the NASA SCAR Program. The implementation of the ISIS and FSIS Network architectures using this ISDN communications satellite simulation will use the SIMSCRIPT II.5 simulation language.

SECTION 11

SIMULATOR DEVELOPMENT

11.1 Simulator Development Objective

The objective of the Simulator Development task was to implement the software simulation previously design to permit the experimentation that demonstrate the viability of various ISDN communications satellite designs. The details of this task were published in "Interim Service ISDN Satellite (ISIS) Simulator development for Advanced Satellite Designs and Experiments (Task Completion Report)", dated 20 August 1992. Also, in order to permit oversight in the ISDN communications satellite simulation software several software "builds" were produced these included working simulation software and a User's Guides. Some of the material presented here were part of the User's Guides for: Build 0 Model/Simulation, dated 7 Jun 1992; FSIS Build 1, dated 15 Mar 1992; FSIS Build 2, dated 22 May 1992; and FSIS Build 3, dated 15 Jul 1992.

This NASA SCAR effort uses network modeling and simulation as the principal vehicle for determining the parameters of an ISDN communications satellite design. This network modeling and simulation must clearly delineate the network architecture (as defined by the network methodology, the number and kinds of communications elements and how those elements are configured), the network operations (including link and network layer protocols and how network functions are distributed among communications elements), and the system constraints (imposed both by the network and by the operational requirements).

Discrete event simulator designs for both ISIS and FSIS were initially defined based on the Phase I network model of the these communications architectures. The traffic model database and the scenarios, also developed in Phase I, were used to define ISIS and FSIS the designs using these simulator inputs. The simulator design outputs were based on the performance measures established in Phase I and will be used to evaluate overall ISDN communications satellite system design.

11.2 ISIS and FSIS Simulation Processes

This section describes the software simulation processes that make up the communication components of both the ISIS and FSIS Network architectures. As shown in Figure 11.2-1, "ISIS/FSIS Simulation Data Flow", the SimRun program is the heart of the ISDN communications satellite simulation software. The '.DAT' files that connect its software program provide both program independence controlled data flow. All the simulation processes SIMSCRIPT II.5 modules within the SimRun program. The ISIS and FSIS end-to-end simulation architectures using these processes as depicted in Figures 10.3.2-2 and 10.3.2-4, respectively. These processes are the software modules that implement the communication functions being modeled. As indicated previously, each of these processes/modules is re-used in a number of the communication components that make up the ISIS and FSIS Network Models. The same description format is used in order to provide a direct comparison between the processes.

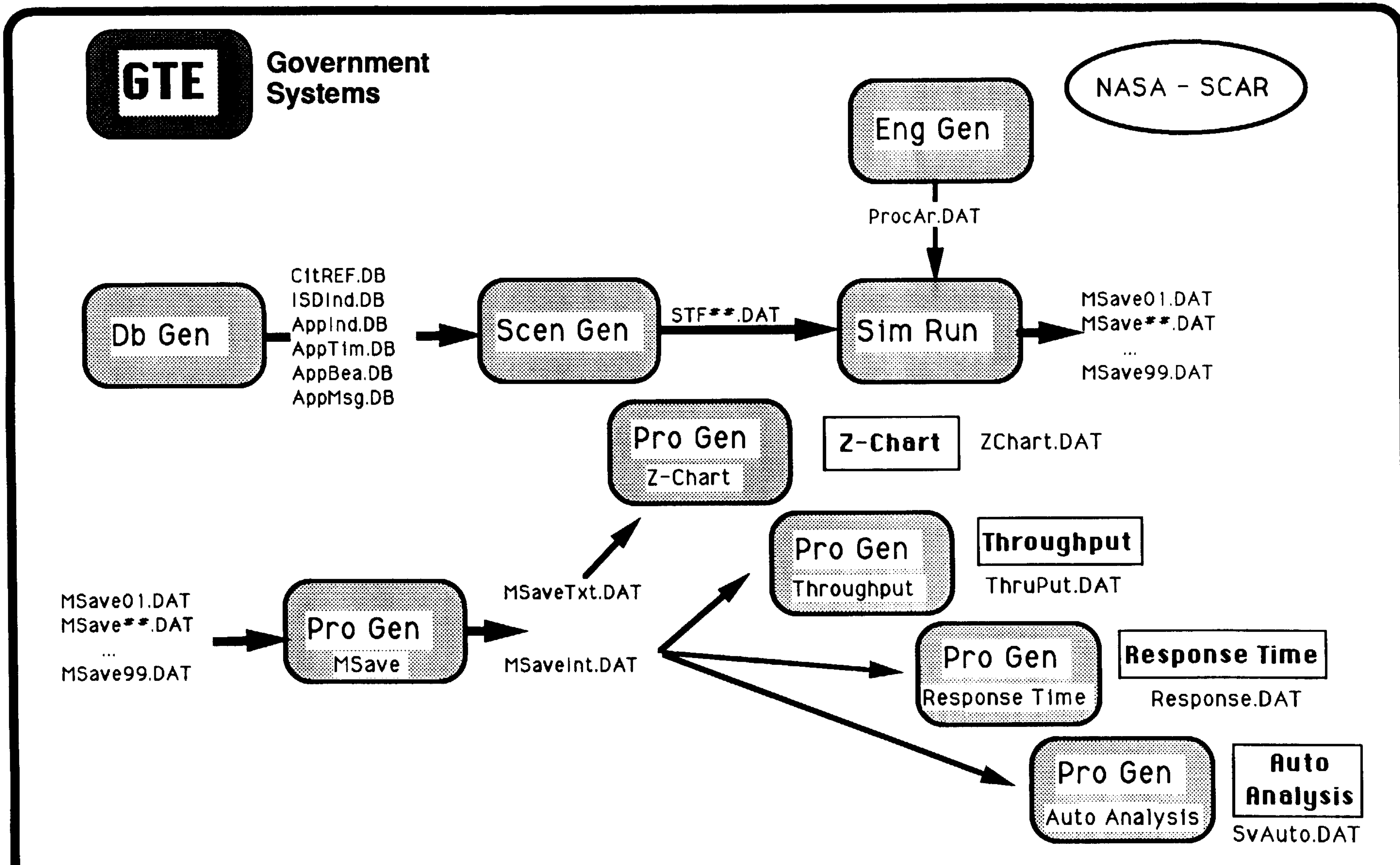

Figure 12.2-1 ISIS/FSIS Simulation Data Flow

5 T066 SCA DAT
ISIS/FSIS Simul Data Flow
September 10, 1992

11.2.1 ISDN Protocol Process -- ISISP/FSISP The ISDN Protocol Processor process accepts ISUP command messages; takes the appropriate call control action of assigning and relinquishing B-channel resources; sends appropriate ISUP status messages. It also blocks calls when resources are not available and generates call retries.

11.2.2 Order Wire Process -- ISISO, FSISO The Order Wire Process accepts TDMA signals from the VSAT via the uplink receiver (Rx30) and converts them to ISDN basic access frames and routes them to the Q921 process. The protocol conversion process continues up the the Q931 and ISUP layers to the ISDN Protocol Processor (FSISP). On the other side the ISISO, FSISO and MGSO processes accepts ISDN basic access frames from the Q921 process, convert them to TDMA signals and routes them to the satellite downlink transmitter.

11.2.3 I430 Process The I430 process is based on the CCITT Recommendation I.430, Basic User Interface - Layer 1 Specification, for the point-to-point operation at Layer 1 for a single transmitter (source) and receiver (sink) are active at one time. The nominal transmitted bit rate at the interface is cited as 192 kbps in both direction of transmission. The activation/deactivation sequence shown in Figure 5.3.3.4-1, "Layer 1 Protocol Activation/Deactivation" is used. The processing of associated management primitives is reserved for future implementations. The I430 process will propagate all higher layer messages without error to and from the S-interface via the Info3 and Info4 transmissions in F7-Activated and G3-Active states.

11.2.4 I431 Process The I431 process is based on the CCITT Recommendation I.431, Primary Rate User-Network Interface - Layer 1 Specification, for the point-to-point operation at Layer 1 for a single transmitter (source) and receiver (sink) are active at one time. The nominal transmitted bit rate at the interface is cited as 1544 kbps in both direction of transmission. The interfaces for the primary rate user-network interface is active at all times. No activation/deactivation are applied to the interface. The F1-Operational State and the G1-Operational State are assumed to be active. The other fault condition states are left for future implementations.

11.2.5 ISDN Telephone Process -- ISDNO, ISDND The ISDN Telephone process is based on human interface that requests and terminates ISDN telephone calls. The ISDNO process acts as a source by generating a Layer 3 protocol sequence that triggers the Q931 process. The timing and content of these initiating messages are obtained from the scenario traffic file (STF).

11.2.6 ISUP Process The ISUP process provides its end-user with the capability to establish, supervise, and terminate basic bearer services. As currently defined, the ISUP is restricted to 64 kbps switched connections. The message structures and functional procedures for carrying out ISUP tasks are given in CCITT Recommendations Q.730, Q761 to Q.764, and Q.766. For the FSIS Network Model, the ISUP functions are performed within the ISDN Satellite. For ISIS the ISUP functions are performed by the MGS.

11.2.7 MGS Order Wire Process -- MGSO The Mission Ground Station (MGS) order wire process accepts TDMA signals from the ISIS satellite downlink receiver and converts them to ISDN basic access frames and routes them to the Q921 process. The protocol conversion process continues up the the Q931 and ISUP layers to the ISDN Protocol Processor (MGSP). On the other side, the MGSO process accepts ISDN basic access frames from the Q921 process, convert them to TDMA signals and routes them to the ISIS satellite uplink transmitter (Tx30).

11.2.8 MGS Processor Process The Mission Ground Station (MGS) ISDN Protocol Processor process accepts ISUP command messages; takes the appropriate order wire call control action of assigning and relinquishing B-channel resources; sends appropriate ISUP status messages.

11.2.9 Propagation Process The Propagation (Prop) process models all space propagation aspects for both the ISIS and FSIS Network Model. The distance between transmitter and receiver reduces the amount of energy (SigPropEnergy) available at the receiver. The weather conditions also affect the SigPropEnergy and are included in this Prop process. The notation "**" is used to represent 20Ghz, 30Ghz, or other frequencies as appropriate.

11.2.10 Q921 Process The Q921 process provides data link peer-to-peer exchange of information of the Link Access Procedures on the D-channel, LAPD. The CCITT Recommendation Q.921, ISDN User-Network Interface - Data Link Layer Specification provide a description of the procedures and function of LAPD. This LAPD protocol is used in the IDSNO and ISDND, ISTA, and the VSAT communication components to assure error free peer-to-peer protocol message exchanges in the D-channel.

11.2.11 Q931 Process The Q931 process provides procedures for establishing, maintaining, and clearing network connections at the ISDN user-network interface. Messages are exchanged over the D-channel. The CCITT Recommendation Q.931, ISDN User-Network Interface Layer 3 Specification for Basic Call Control provide a description of the procedures and functions. For the ISIS Network Model this Q.931 protocol is used in the ISDN0, ISDND, ISTA, and the VSAT communications component to assure error free peer-to-peer protocol message exchanges in the D channel. The Q931 protocol implementation is described in Appendix D, "Q.931 Protocol Simulation".

11.2.12 Rx ** Process The Rx** process models all receivers of both the ISIS and FSIS Network Architectures. The "**" notation is place holder for 20Ghz, 30Ghz, or other frequencies that represent the downlink and uplink frequencies of the Network Models. The receivers have a sensitivity parameter that set the energy values below which a signal is not accepted. For signal energy below the receiver sensitivity the whole message is consider loss. That message is logged to the MSave file as a lost message together with the time/subsystem that failed it. The message is not propagated.

11.2.13 RxAnt ** Process The RxAnt** process models all receiver antennas of the FSIS Network Model. The "**" notation is place holder for 20Ghz, 30Ghz, or other frequencies that represent the downlink and uplink frequencies of the ISIS or FSIS Network architectures. The receiver antennas have a number of parameters that reflect its design. RxAnt**BW represents the antenna beam; RxAnt**G sets the antenna gain; RxAnt**Lat and RxAnt**Lon indicate the antenna subpoint location; RxAnt**Dwell represents the antenna dwell time at a location; RxAnt**HopFreq represents its hop frequency; and RxAnt**Scan provides the antenna scan rate. To be received by the corresponding receiver the transmitted energy must coincide with all these antenna parameters.

11.2.14 SIF Process The SIF process models the S-interface between the user ISDN Telephone and the ISDN Satellite Terminal Adapter (ISTA). For the FSIS Network Model, the SIF Process provides basic rate ISDN (BRI) connectivity for the I.430 Basic Access Frames.

11.2.15 Tx ** Process The Tx** process models all transmitters of the FSIS Network Model. The "**" notation is place holder for 20Ghz, 30Ghz or other frequencies that represent the ISIS and FSIS downlink and uplink frequencies. The transmitters are modeled as isotropic radiators that added to the signal being transmitted with SigPropEnergy value. This value is mitigated by the TxAnt**, propagation (Prop) and RxAnt** processes, and finally used by the Rx** process to accept the message..

11.2.16 TxAnt ** Process The TxAnt** process models all transmitter antennas of the FSIS network Model. The "**" notation is place holder for 20Ghz, 30Ghz or other frequencies that represent the ISIS and FSIS downlink and uplink frequencies. The transmitter antennas have a number of parameters that reflect its design. TxAnt**BW represents the antenna beam; TxAnt**Gain sets the antenna gain; TxAnt**Lat and TxAnt**Lon indicate the antenna subpoint location; TxAnt**Dwell represents the antenna dwell time at a location; TxAnt**HopFreq represents its hop frequency; and TxAnt**Scan provides the antenna scan rate. To be received by the corresponding receiver antenna, the transmitted antenna energy must coincide with all these antenna parameters.

11.2.17 UIF Process The UIF process models the U-interface between the ISDN Satellite Terminal Adapter (ISTA) and the VSAT. For the FSIS Network Model, the UIF process provides primary rate ISDN (PRI) connectivity for the I431 signals.

11.2.18 VSAT Order Wire Process The VSAT Order Wire process accepts ISDN Basic Access Frame and converts them to TDMA Signal and conversely.

11.3 ISIS/FSIS Simulation Run (SimRun) Outputs

All the selected display data are updated throughout the simulation execution as the call setup and call termination processes are activated. When selected, the histogram continually plots the call requests as function of time providing excellent visibility into the scenario evolution. In the minimal graphics mode only the percent of simulation completeness is displayed.

11.3.1 Run-time Z-Chart Display The Z-Chart Trace plots the output showing the migration of the "Rqst" and "Term" protocols through the set-up and termination processes. The Z-Chart ordinate represent the Process Index (PI) number associated with each communication function/process. The time elapsed within each communication function (PI) is plotted along the abscissa. The result is a time history trace of communication processes activated as a function of time it took for them to perform their respective functions.

In relation to the Z-Chart Trace the simulation progress from process to process is depicted as a time-line constantly edging towards increasing time. The longer times are associated with propagation and are plotted as long steps among more evenly spaced inter-process steps. The call connection (Rqst) display is depicted as a number of line segments connected by long steps representing all the VSAT/ISDN Satellite propagation links used in the call setup procedures. The "Seconds of Day" window in the output graphic displays the exact time down to millisecond of the data being plotted on the Z-Chart Trace graphic.

11.3.2 Run-time Bearer Services Display Bearer services are displayed as their resources are allocated and deallocated for the circuit switched 64 Kbps (CS64), circuit switched 128 Kbps (CS128), X.25 access on the D-Channel (DX25), B-Channel Frame Relay (BFR) and telemetry (TLM). Call status are displayed in terms of number of total calls attempted, the number of calls in the call reference buffer, the number of calls blocked, and the percentage of calls blocked.

As mentioned above, the MSave file, when selected, provides the principal post simulation data for analyses. These data are read directly by the ProGen program and combined into a single MSave for analysis.

11.3.3 ISIS/FSIS Product Generation (ProGen) Outputs The FSIS Build 3 ProGen outputs consist of six data files: MSaveInt.DAT, MSaveTxt.DAT, ZChart.DAT, CallData.DAT, ThruPut.DAT, and RespTime.DAT. These products apply equally well for both the ISIS and FSIS architectures. Each data file is generated under menu control within the ProGen software for both ISIS and FSIS.

11.3.3.1 MSave Integer Data The **MSaveInt.DAT** file is a single file containing selected MSave##.DAT files generated by the SimRun Program. These original MSave files were saved in smaller increments to save on array space within SimRun software. But, for ProGen, the MSave data are more easily analyzed using a single combined MSave file.

11.3.3.2 MSave Text Data The **MSaveTxt.DAT** file consists of the identical data as the MSaveInt.DAT. The "Int" version contains the integer values generated by the SimRun software. Whereas, the "Txt" version contains the text equivalent of the combined MSave file data that will be used by the ProGen software.

11.3.3.3 Z-Chart Product The **ZChart.DAT** file is a matrix of MSaveTxt.DAT data plotted to show the protocol interactions among the various protocol entities as a function of time. Three of these Z-Charts have been plotted to show the variation of protocol interactions that result from a blocked call, a call connection and a call disconnection. The are described in Appendix I, "Description of Z Chart Trace".

11.3.3.4 Call Data Product The Call Data Product, **CallData.DAT**, consists of a tabular representation on a call by call basis. The Call Reference Number, Request Time, Blocked Time, Connection Time, Disconnect Request Time, Disconnect Time and Bearer Service are read from the MSave data. The Call Duration is calculated from the Call Connect Time and Call Disconnect Time in seconds. This Call Data Product provides a quick view of the simulation results. It is used a sanity check of the scenario; a quick estimate of the traffic duration; and a view of the blocked traffic and its recovery. The Call Data Product for both the STF01.DAT and STF06.DAT scenarios are described in Appendix F, "Basic ISDN Satellite Call Data Product".

11.3.3.5 Response Time Product The Response Time Product, **RespTime.DAT,** consists of a tabular representation on a call by call basis. The Call Reference Number, Request Time, Blocked Time, Connection Time, Disconnect Request Time, and Disconnect Time are read from the MSave data. The Connection Response Time and the Disconnection Response Time are calculated from the Call Request Time and the Call Connect Time, and the Disconnect Request Time and Call Disconnect Time in milliseconds, respectively.

This Response Time Product provides a view of the both these response times on a call by call basis. For the present FSIS model the results are identical for all calls and all scenarios due to the fixed delays associated with each communication process being presently models. These times fall within each respective protocol timer and thereby provide the first order viability for ISDN satellites even in geo-synchronous orbits. The Response Time

Product for both the STF01.DAT and STF06.DAT scenarios are described in Appendix G, "ISDN Satellite Response Time Product".

11.3.3.6 Throughput Product The Throughput Product, **ThruPut.DAT,** displays the change in ISDN throughput bandwidth as a function of the allocation of ISDN satellite communication resources. The Throughput display consists of CallREf#, Simulation Time, Bearer Service, Action, Throughput (Kbps), Number of D-Channels in use, and Number of B-Channels in use.

This Throughput Product provides a view of the simulation throughput results. It provides the ability to track the ISDN satellite throughput as a function of time; provides estimates of the peak traffic; and provides visibility into the satellite quiet periods.

All these files can displayed under menu control and are also capable of being output to a printer using Word Perfect® 5.1. These data and products will serve as the bases for further ISDN communication satellite analyses. The throughput data can be plotted using Lotus® 1-2-3 Spreadsheet software as shown in Appendix H. "ISDN Satellite Throughput Product".

11.4 Simulator Development Conclusions

The research in the simulator development task has been satisfactorily completed and the results are capable of supporting the NASA SCAR Program in its design of an advanced ISDN communications satellite. The implementation of the FSIS Network architecture into SIMSCRIPT II.5 code has resulted into the delivery of four software builds: Build o Model/Simulation, FSIS Build 1, FSIS Build 2, and FSIS Build 3. The simulation software is capable generating satellite design parameters from real-world communication satellite simulations.

SECTION 12

RESULTS AND CONCLUSIONS

12.1 Results

As indicated above, all the objectives of the undertaken NASA SCAR tasks were fully achieved. The goals of the Basic and Options I contractual effort have been met. Both the ISDN Communications Satellite Simulation Software and ISTA Hardware are ready for software and hardware experimentation.

12.2 Status

Technically this program is ready for experiments using both the ISDN communications simulation software and the ISDN satellite terminal adapter hardware.

12.3 Constraints

The present cost sharing constraints in this austere funding environment have precluded the possibility possibility of conducting hardware and software experiments using these tools developed by this NASA SCAR Program..

12.4 Future Possibilities

This research in providing ISDN services through satellites has matured to the extent that they can now be viewed as engineering investigations rather than R&D. Using the tools develop in this program, a contract to study specific designs could be postulated without the constraint of cost sharing. Such engineering analyses could generate specific parametric data ranges for ISDN communications satellite designs

12.5 Conclusions

This NASA SCAR effort is deemed successful in that it achieved all the goals it undertook. The viability of satellites as a component in ISDN networks of the future has been strengthened and the hardware and simulation tools generated as a result of this program permit both the concept demonstrations and the design of ISDN communications satellites. As shown in Figure 12.5-1, "Typical ISDN Configuration with ISIS, FSIS and BSIS Overlay", the ultimate goal is to assure that ISDN communication satellites are viable communication options for ISDN networks of the future.

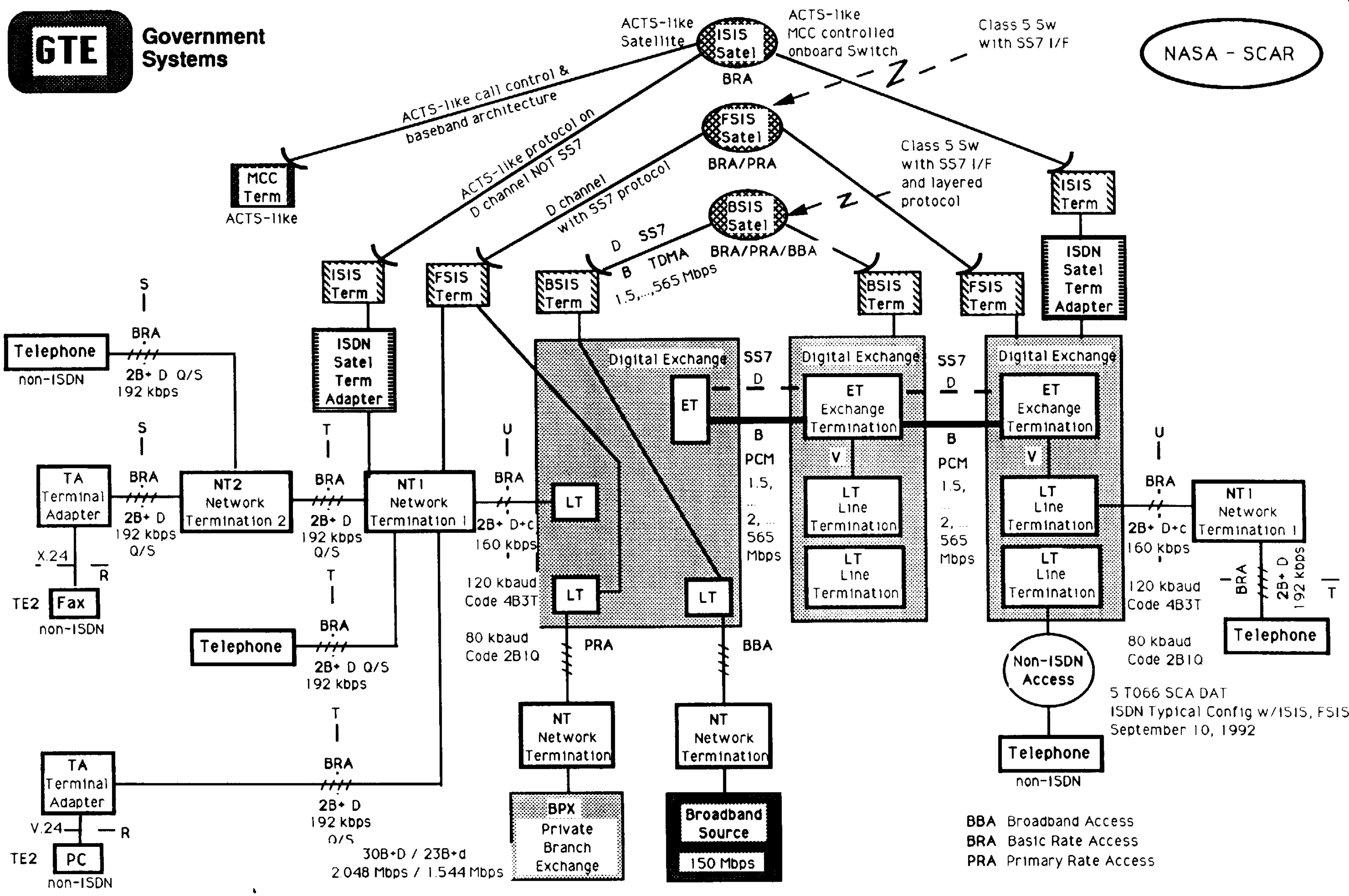

Figure 12.5-1 Typical ISDN Configuration with ISIS, FSIS and BSIS Overlay

APPENDIX A

Scenario Traffic File (STF) Structure

One of the STFs used in FSIS Build 3 is provided in this appendix. STF01.DAT depicts a single B-Channel, CS64, request scenario of 3 minute calls between Washington DC and Los Angeles CA from 1601 seconds-of-day until 39631 seconds-of-day. Nearly 200 hundred call requests are made over this period of ten hours. The accompanying histogram shows the traffic scenario structure.

The STF is a sequence of records that reflects the actions of an input ISDN communications scenario. Each STF record represents a call request, "Rqst", and a call termination, "Term", in the scenario sequence. The STF is a time ordered list of these Rqst/Term events that is presented to the discrete event simulation as initiating events for a particular scenario. This STF list is read by the SIMSCRIPT II.5 discrete event simulation program by an external process. The external process, called STF, activates the initiating protocol requester process ISDNO - ISDN Originator. That protocol is passed from process to process being analyzed and acted upon along the way. For FSIS Build 3, a single STF initiating event activates over 200 internal events for every "Rqst" event and 100 internal events for every "Term" event when the call is connected. If a call is blocked (125 internal events), the FSISP process uses **retry algorithm** that adds 1 minute to both the call Rqst and Call Term times before it re-activates the call Rqst.

Even though only four fields are visible in the STF presented in this appendix, five fields actually make up each record of the STF. The first field "STF" is used by SIMSCRIPT II.5 to identify it as the external file it belongs to. Since process STF is the external process reading this file, this "STF" field must precede each record.

The second field "1601." of the first record is a real variable representing the simulation time in seconds. The action of the external process STF is to activate process ISDNO at that time as part of the simulation.

The next six characters after the decimal point form the Call Reference Number for that event record. The Call Reference Number uniquely identifies the service being requested and is used for every action concerning the call. The I6 format blanks leading zeroes and the following field, which is also I6, blends into the Call Reference Number making look like a single number. The first 8 records in the STF presented have the following Call Reference Numbers:

94, 95, 96, 97, 98, 99,1,100

The next field is a combination of a number of integer sub-fields. The field:

115224

is decomposed into the following information elements:

1 represents the Operation being requested.
In this case 1 stands for "Rqst".
Whereas, a 2 in that position would mean "Term"

1 represent the bearer service being requested.
For FSIS Build 3:
1 :: CS64 means a single B-Channel, 64 Kbps
2 :: CS128 means two B-Channels,128 Kbps
3 :: DX25 means uses existing signal channel, D-Channel, 16 Kbps
4 :: BFR mean B Frame Relay uses two B-Channels, 128 Kbps
5 :: TLM means telemetry uses existing signal channel, 16 Kbps

52 represents the originating city identification with scenario generation. 52 = Washington DC

24 represents the destination city identification with scenario generation. 24 = Los Angeles

The last field, 1860., represents the termination time for the call in seconds-of-day. If the call request is successfully connected then this Term time is used to activate a call termination sequence using that value of time.

The **Term time** is derived from the Traffic Model database known as SCAR Database 5. shown in this appendix. The Term time for "Voice" applications is given in minutes. That value is used for the Scenario Generation, ScenGen, software to randomly pick a Term time about that value. For the other applications message length in KiloByte per seconds. For those applications the equivalent B-Channel time is calculated, randomized, and used as the Term time. If the application is used in other than a single B-Channel link, the FSIS Processor, FSISP, adjusts the Term time accordingly.

The first record of the STF is decoded as follows:

Request a single B-channel from Washington DC to Los Angeles at 1601 seconds-of-day (26min 41sec after mid-night)
using Call Reference Number #94, and

Terminate the service associate
with Call Reference Number #94.
at 1860 seconds-of-day (31min 00sec after mid-night).

The result is that a B-Channel was allocated to Call Reference #94 for 4 minutes and 19 seconds.

STF01.DAT

STF	1601.	94115224	1860*
STF	3201.	95115252	3377*
STF	4801.	96115224	5075*
STF	6401.	97115252	6690*
STF	8001.	98115224	8138*
STF	9601.	99115252	9758*
STF	11111.	1112452	11159*
STF	11201.	100115224	11429*
STF	11421.	2112424	11642*
STF	11731.	3112452	11880*
STF	12041.	4112424	12178*
STF	12351.	5112452	12627*
STF	12661.	6112424	13026*
STF	12801.	101115252	12979*
STF	12971.	7112452	13152*
STF	13281.	8112424	13504*
STF	13591.	9112452	13832*
STF	13901.	10112424	14102*
STF	14211.	11112452	14506*
STF	14401.	102115224	14653*
STF	14521.	12112424	14694*
STF	14831.	13112452	14956*
STF	15141.	14112424	15303*
STF	15451.	15112452	15491*
STF	15761.	16112424	15854*
STF	16001.	103115252	16246*
STF	16071.	17112452	16162*
STF	16381.	18112424	16623*
STF	16691.	19112452	16852*
STF	17001.	20112424	17219*
STF	17311.	21112452	17346*
STF	17601.	104115224	17696*
STF	17621.	22112424	17840*
STF	17931.	23112452	17984*
STF	18241.	24112424	18457*
STF	18551.	25112452	18835*
STF	18861.	26112424	19058*
STF	19171.	27112452	19478*
STF	19201.	105115252	19403*
STF	19481.	28112424	19797*
STF	19791.	29112452	20027*
STF	20101.	30112424	20238*
STF	20411.	31112452	20729*
STF	20721.	32112424	20931*
STF	20801.	106115224	21012*
STF	21031.	33112452	21268*
STF	21341.	34112424	21489*
STF	21651.	35112452	21715*
STF	21961.	36112424	22281*
STF	22271.	37112452	22425*
STF	22401.	107115252	22594*
STF	22581.	38112424	22690*
STF	22891.	39112452	23057*
STF	23201.	40112424	23389*

STF	23511.	41112452	23749*
STF	23821.	42112424	23972*
STF	24001.	108115224	24075*
STF	24131.	43112452	24291*
STF	24441.	44112424	24741*
STF	24751.	45112452	24862*
STF	25061.	46112424	25296*
STF	25371.	47112452	25574*
STF	25601.	109115252	25821*
STF	25681.	48112424	25888*
STF	25991.	49112452	26029*
STF	26301.	50112424	26439*
STF	26611.	51112452	26885*
STF	26921.	52112424	27125*
STF	27201.	110115224	27627*
STF	27231.	53112452	27505*
STF	27541.	54112424	27720*
STF	27851.	55112452	27938*
STF	28161.	56112424	28420*
STF	28471.	57112452	28542*
STF	28781.	58112424	29057*
STF	28801.	111115252	29064*
STF	29091.	59112452	29344*
STF	29401.	60112424	29498*
STF	29711.	61112452	29828*
STF	30021.	62112424	30251*
STF	30331.	63112452	30445*
STF	30641.	64112424	30673*
STF	30951.	65112452	31130*
STF	31261.	66112424	31414*
STF	31571.	67112452	31681*
STF	31881.	68112424	32155*
STF	32191.	69112452	32436*
STF	32501.	70112424	32589*
STF	32811.	71112452	32856*
STF	33121.	72112424	33233*
STF	33431.	73112452	33678*
STF	33741.	74112424	33762*
STF	34051.	75112452	34210*
STF	34361.	76112424	34400*
STF	34671.	77112452	34724*
STF	34981.	78112424	35269*
STF	35291.	79112452	35375*
STF	35601.	80112424	35820*
STF	35911.	81112452	36023*
STF	36221.	82112424	36512*
STF	36531.	83112452	36757*
STF	36841.	84112424	37121*
STF	37151.	85112452	37227*
STF	37461.	86112424	37622*
STF	37771.	87112452	37951*
STF	38081.	88112424	38304*
STF	38391.	89112452	38562*
STF	38701.	90112424	38996*

STF	39011.	91112452	39308*
STF	39321.	92112424	39459*
STF	39631.	93112452	39823*

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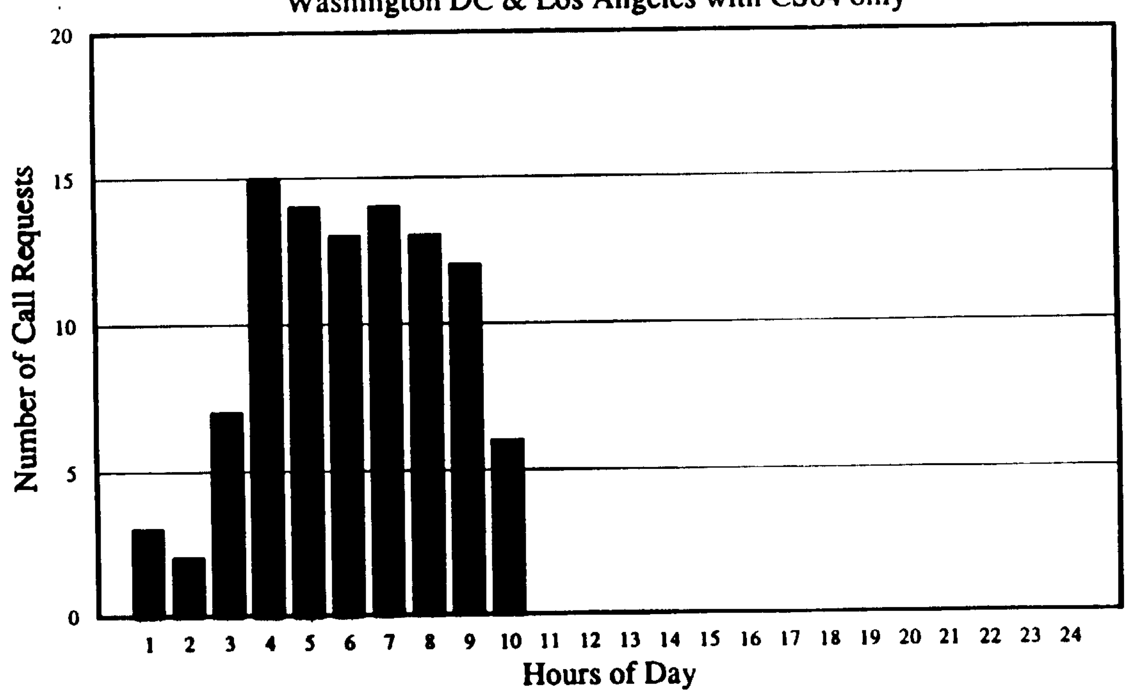
ISDN Satellite Build 3 Traffic Scenario

Washington DC & Los Angeles with CS64 only



Wash DC & Los Angeles, Comm, Voice(I)
8 T063 SR_ B03 STF01HST.123 Jul 6, 1992 (with Wrap-around)

8 T034 SCA DAT
GTE/Gov Sys Template
August 21, 1991

APPENDIX B

Process Array (ProcAr) Structure

A copy of the ProcAr used in FSIS Build 3 is provided in this appendix.

The ProcAr is a matrix of engineering data that determines all the parameters associated with the discrete event simulation. Each row of the ProcAr represents parameters associated with the Process Index (PI) identified in the first element of that row. Up to 9 parameters can be associated with each PI.

Since PI's represent a diversity of communication functions, such as protocol analysis, receiving, transmitting, allocating, each row consists of a diversity of technical parameters.

For protocol analysis such parameters as timer values, state number are important. For the receiving function such things as receiver threshold, noise figures, BER are meaningful. For the transmitting the functions of power gain and transmitting frequency play an important part. In essence, each record has parameters that pertain exclusively to that PI.

For example, only one software module is used for the receiving function, Rx. But that receiving function takes on the characteristic provided by the ProcAr record values for the PI position it is model. It uses difference values for a 20GHz receiver than it does for a 30GHz receiver. ProcAr technical parameters for a space based transmitters and ground based transmitters will be determined by the PI position they play in the simulation.

The first column of the ten column ProcAr shown in this appendix contains the PI number. The second column shows the delay time, in milliseconds, required for that PI to perform all its tasks. Of particular interest is the value 57 for PI's: 13, 27, 51, and 65 actually represents 5.7 msecs per 1000 miles of propagation distance. Those PI's use the propagation process that multiplies this value by the distance in miles between a particular transmitter and receiver combination. For FSIS Build 3, that distance value was calculated for each transmitted signal using the coordinates of the transmitting city and the location of a geo-synchronous satellite at 94 degrees west (-94) longitude at the the equator and a 22,000 mile altitude. These satellite parameters are determine by PI=78 in ProcAr matrix. A number of entries in ProcAr include the power losses, antenna gains, and receiver thresholds were obtained from ACTS data. Timer values were obtained from the CCITT "Blue Book" for protocol associated with the Q.931, Q.921, I430, and I431.

ISDNO	D(msec								
1	10	0	0	0	0	0	0	0	0
Q931U	D(msec	UgInit	UgT303	UgT310	UdInit	UdT313			
2	10	0	4000	10000	0	4000	0	0	0
Q921U	D(msec								
3	1	0	0	0	0	0	0	0	0
I430U	D(msec	F-Init	T3(mse						
4	1	3	30000	0	0	0	0	0	0
SIFXX	D(msec								
5	1	0	0	0	0	0	0	0	0
I430N	D(msec	G-Init	T1(mse						
6	1	1	100	0	0	0	0	0	0
I431U	D(msec								
7	1	0	0	0	0	0	0	0	0
UIFXX	D(msec								
8	1	0	0	0	0	0	0	0	0
I431N	D(msec								
9	1	0	0	0	0	0	0	0	0
VSATO	D(msec								
10	2	0	0	0	0	0	0	0	0
TXX30	D(msec	F(GHz)	P(dBW)						
11	1	30	66	0	0	0	0	0	0
TXA30	D(msec	F(GHz)	P(dB)	BW(deg	HR(Mse				
12	1	30	0	10	0	0	0	0	0
PRO30	D.msec	F(GHz)	P.db/K						
13	57	30	-96	0	0	0	0	0	0
RXA30	D(msec	F(GHz)	P(dB)	BW(deg	HR(Mse				
14	1	30	28	40	0	0	0	0	0
RXX30	D(msec	F(GHz)	P(dB)	T(dBW)					
15	1	30	50	-70	0	0	0	0	0
FSISO	D(msec								
16	5	0	0	0	0	0	0	0	0
Q921N	D(msec								
17	1	0	0	0	0	0	0	0	0
Q931N	D(msec	NgInit	NdT303	NdT310	NdInit				
18	10	0	4000	10000	0	0	0	0	0
ISUPX	D(msec								
19	10	0	0	0	0	0	0	0	0
FSISP	D(msec	F(MHz)	CRBMx(	CRBAv(	BChMx(	BChAv(			
20	10	10	2	2	5	5	0	0	0
ISUPX	D(msec								
21	10	0	0	0	0	0	0	0	0
Q931N	D(msec	NgInit	NdT303	NdT310	NdInit				
22	10	0	4000	10000	0	0	0	0	0
Q921N	D(msec								
23	1	0	0	0	0	0	0	0	0
FSISO	D(msec								
24	5	0	0	0	0	0	0	0	0
TXX20	D(msec	F(GHz)	P(dBW)						
25	1	20	64	0	0	0	0	0	0
TXA20	D(msec	F(GHz)	P(dB)	BW(deg	HR(Mse				
26	1	20	0	10	5	0	0	0	0
PRO20	D.msec	F(GHz)	P.dB/K						
27	57	20	-94	0	0	0	0	0	0
RXA20	D(msec	F(GHz)	P(dB)	BW(deg	HR(Mse				
28	1	20	30	10	0	0	0	0	0
RXX20	D(msec	F(GHz)	P(dB)	T(dBW)					
29	1	20	50	-70	0	0	0	0	0
VSATO	D(msec								
30	2	0	0	0	0	0	0	0	0
I431N	D(msec								
31	1	0	0	0	0	0	0	0	0
UIFXX	D(msec								
32	1	0	0	0	0	0	0	0	0
I431U	D(msec								
33	1	0	0	0	0	0	0	0	0
I430N	D(msec	G-Init	T1(mse						

34	1	1	100	0	0	0	0	0	0
SIFXX	D(msec								
35	1	0	0	0	0	0	0	0	0
I430U	D(msec	F-Init	T3(mse						
36	1	3	30000	0	0	0	0	0	0
Q921U	D(msec								
37	1	0	0	0	0	0	0	0	0
Q931U	D(msec	UgInit	UgT303	UgT310	UdInit	UdT313			
38	10	0	4000	10000	0	4000	0	0	0
ISDND	D(msec	T214	T114	T714	T614				
39	10	5	35	5	5	0	0	0	0
Q931U	D(msec	UgInit	UgT303	UgT310	UdInit	UdT313			
40	10	0	4000	10000	0	4000	0	0	0
Q921U	D(msec								
41	1	0	0	0	0	0	0	0	0
I430U	D(msec	F-Init	T3(mse						
42	1	3	30000	0	0	0	0	0	0
SIFXX	D(msec								
43	1	0	0	0	0	0	0	0	0
I430N	D(msec	G-Init	T1(mse						
44	1	1	100	0	0	0	0	0	0
I431U	D(msec								
45	1	0	0	0	0	0	0	0	0
UIFXX	D(msec								
46	1	0	0	0	0	0	0	0	0
I431N	D(msec								
47	1	0	0	0	0	0	0	0	0
VSATO	D(msec								
48	2	0	0	0	0	0	0	0	0
TXX30	D(msec	F(GHz)	P(dBW)						
49	1	30	66	0	0	0	0	0	0
TXA30	D(msec	F(GHz)	P(dB)	BW(deg	HR(Mse				
50	1	30	0	10	0	0	0	0	0
PRO30	D.msec	F(GHz)	P.db/K						
51	57	30	-96	0	0	0	0	0	0
RXA30	D(msec	F(GHz)	P(dB)	BW(deg	HR(Mse				
52	1	30	28	40	0	0	0	0	0
RXX30	D(msec	F(GHz)	P(dB)	T(dBW)					
53	1	30	50	-70	0	0	0	0	0
FSISO	D(msec								
54	5	0	0	0	0	0	0	0	0
Q921N	D(msec								
55	1	0	0	0	0	0	0	0	0
Q931N	D(msec	NgInit	NdT303	NdT310	NdInit				
56	10	0	4000	10000	0	0	0	0	0
ISUPX	D(msec								
57	10	0	0	0	0	0	0	0	0
FSISP	D(msec	F(MHz)	CRBMx(	CRBAv(	BChMx(	BChAv(			
58	10	10	2	2	5	5	0	0	0
ISUPX	D(msec								
59	10	0	0	0	0	0	0	0	0
Q931N	D(msec	NgInit	NdT303	NdT310	NdInit				
60	10	0	4000	10000	0	0	0	0	0
Q921N	D(msec								
61	1	0	0	0	0	0	0	0	0
FSISO	D(msec								
62	5	0	0	0	0	0	0	0	0
TXX20	D(msec	F(GHz)	P(dBW)						
63	1	20	64	0	0	0	0	0	0
TXA20	D(msec	F(GHz)	P(dB)	BW(deg	HR(Mse				
64	1	20	0	10	5	0	0	0	0
PRO20	D.msec	F(GHz)	P.dB/K						
65	57	20	-94	0	0	0	0	0	0
RXA20	D(msec	F(GHz)	P(dB)	BW(deg	HR(Mse				
66	1	20	30	10	0	0	0	0	0
RXX20	D(msec	F(GHz)	P(dB)	T(dBW)					
67	1	20	50	-70	0	0	0	0	0

VSATO	D(msec								
68	2	0	0	0	0	0	0	0	0
I431N	D(msec								
69	1	0	0	0	0	0	0	0	0
UIFXX	D(msec								
70	1	0	0	0	0	0	0	0	0
I431U	D(msec								
71	1	0	0	0	0	0	0	0	0
I430N	D(msec	G-Init	T1(mse						
72	1	1	100	0	0	0	0	0	0
SIFXX	D(msec								
73	1	0	0	0	0	0	0	0	0
I430U	D(msec	F-Init	T3(mse						
74	1	3	30000	0	0	0	0	0	0
Q921U	D(msec								
75	1	0	0	0	0	0	0	0	0
Q931U	D(msec	UgInit	UgT303	UgT310	UdInit	UdT313			
76	10	0	4000	10000	0	4000	0	0	0
ISDNO	D(msec								
77	10	0	0	0	0	0	0	0	0
SATEL	D(msec	Lat(de	Lon(de	Alt(mi					
78	5	0	-94	22000	0	0	0	0	0
SPARM	D(msec	MSRc(#							
79	0	100	0	0	0	0	0	0	0

APPENDIX C

TRAFFIC MODEL DATABASE DATA

This Traffic Model consists of a number of databases: the City Reference DB, ISDN User vs Industry DB, Application vs Industry DB, Application vs Time DB, and Application vs Bearer Services DB. Each has been presented and described in Section 4. A summary is provided here for completeness.

The "City Reference Database", DB1, identifies the percentage of ISDN users that are associated with the population of fifty-four major cities. Due to paucity of specific ISDN user information this percentage factor will be used as multiplier of population to infer the number of ISDN users in that region. The geographic coordinates of these of these cities together with their US time-zone are included in the Traffic Model in order to provide a sub-point for communications satellite operations. A view of the geographical distribution of these CONUS Traffic Model Cities is shown in "NASA SCAR Traffic Model".

The "ISDN User vs Industry", DB2, apportions the ISDN traffic among twenty-one industries. These data permit the scenario selection on an industry-by-industry basis. This database in used in conjunction with the City Reference Database to further decompose the ISDN service use in terms of industry affiliation.

The "Application vs Industry Database", DB3, further apportions the industry into applications of communication services. This added data granularity permits the selection of scenarios tailored on an application basis. The nine applications are spread across each of the twenty-one industries on a percentage basis too permit each application to contribute in a normalized fashion.

The "Applications vs Time Database", DB4, associates daily time-slots for issuing ISDN service requests on an application basis. These data allows the generation of traffic distributions that are appropriate to the application being used in a scenario. The hours in a day are divided into four unequal time slots along the line of a typical work day: 0001-0800, 0801-1200, 1201-1800, and 1801-2400.

The "Application vs ISDN Bearer Service, Message Length Database", DB5, associates ISDN bearer services with the selected scenario applications. For this SCAR program the following ISDN bearer services have been selected: circuit switched (64 kbps and 128 kbps), D-Channel X.25, B-Channel Frame Relay, and Telemetry. This database also associates the message length and message hold-time with each application. These message duration values provide a measure of the length of time each ISDN bearer service is used.

APPENDIX D

Q.931 PROTOCOL SIMULATION

The Q931 process provides procedures for establishing, maintaining, and clearing network connections at the ISDN user-network interface. Messages are exchanged over the D-channel. The CCITT Recommendation Q.931, ISDN User-Network Interface Layer 3 Specification for Basic Call Control provide a description of the procedures and functions.

This protocol like all other protocols will be simulated at the message element level. All aspects of the protocol necessary set-up and tear-down specific ISDN services will implemented. The protocols depicted by the Specification Design Language (SDL) diagrams are converted to initial state in ProcAr matrix. Intervening Q931 protocol messages change those states until all are activate and the requested ISDN service is provided. .

The principal operations of this ISDN communications satellite model and simulation revolves around the timely processing Q931 protocols as described in the CCITT "Blue Book". Figure 5.3.2-2, "FSIS Network Model Communication Components" and Figure 5.3.1-2, "ISIS Network Model Communication Components" show the overall structure and interaction between each communication process for the FSIS and ISIS simulation implementation. This section focuses on the Q931 processes: Q931U and Q931N, the origination, ISDNO, and destination, ISDND points, and the on board processor, FSISP.

Figure 8.1, "Q931 Protocol Connection SDL Interaction Diagram" and Figure 8.2, "Q931 Protocol Disconnection SDL Interaction Diagram", in this appendix, can be traced directly to the CCITT "Blue Book". The origination and destination areas are each represented by two OSI, Layer 3, Q931 protocol entities - Q931U on the user side and Q931N on the network side. This results in four site for Q931 protocol states that must be transition for states U0 and N0 to U10 and N10 for call connection and back to U0 and N0 for call disconnects. The exchange of timely protocol Q931 protocol messages accomplish this action.

For call connection, Figure 8.1 shows an "Off Hook" condition shown as ProtoMsg=1 being converted by Q931U into "SetU Msg" and subsequently being transmitted to the Q931Ns and FSISP on board the ISDN satellite and ultimately received by the Q931U and ISDN destination processes. Since, for simulation purposes, the destination always available, the ISDND responds with a timely sequence of "CalP Msg", "Alrt Msg" and "Conn Msg" which follow their return paths through the satellite to the originator. If resources are not available on-board the satellite when it receives the "Conn Msg", the call is blocked and the prior protocol messages run their course and are eventually not propagated due time-outs or non-response. When resources are available on the satellite "Conn Msg" are converted to "ConA Msg" and the requested communication path is established and dedicated until it is terminated other actions.

For call disconnection, Figure 8.2 shows an "On Hook" condition shown as ProtoMsg=2 being converted by Q931U into "DConn Msg" and subsequently being transmitted to the Q931Ns and FSISP on-board the ISDN satellite and ultimately received by the Q931U and ISDN destination processes. Resources are disconnected at the satellite upon receipt of the "DConn Msg" but Q931 protocol exchanges continues on both the origination and destination sides before the D-Channels can be released.

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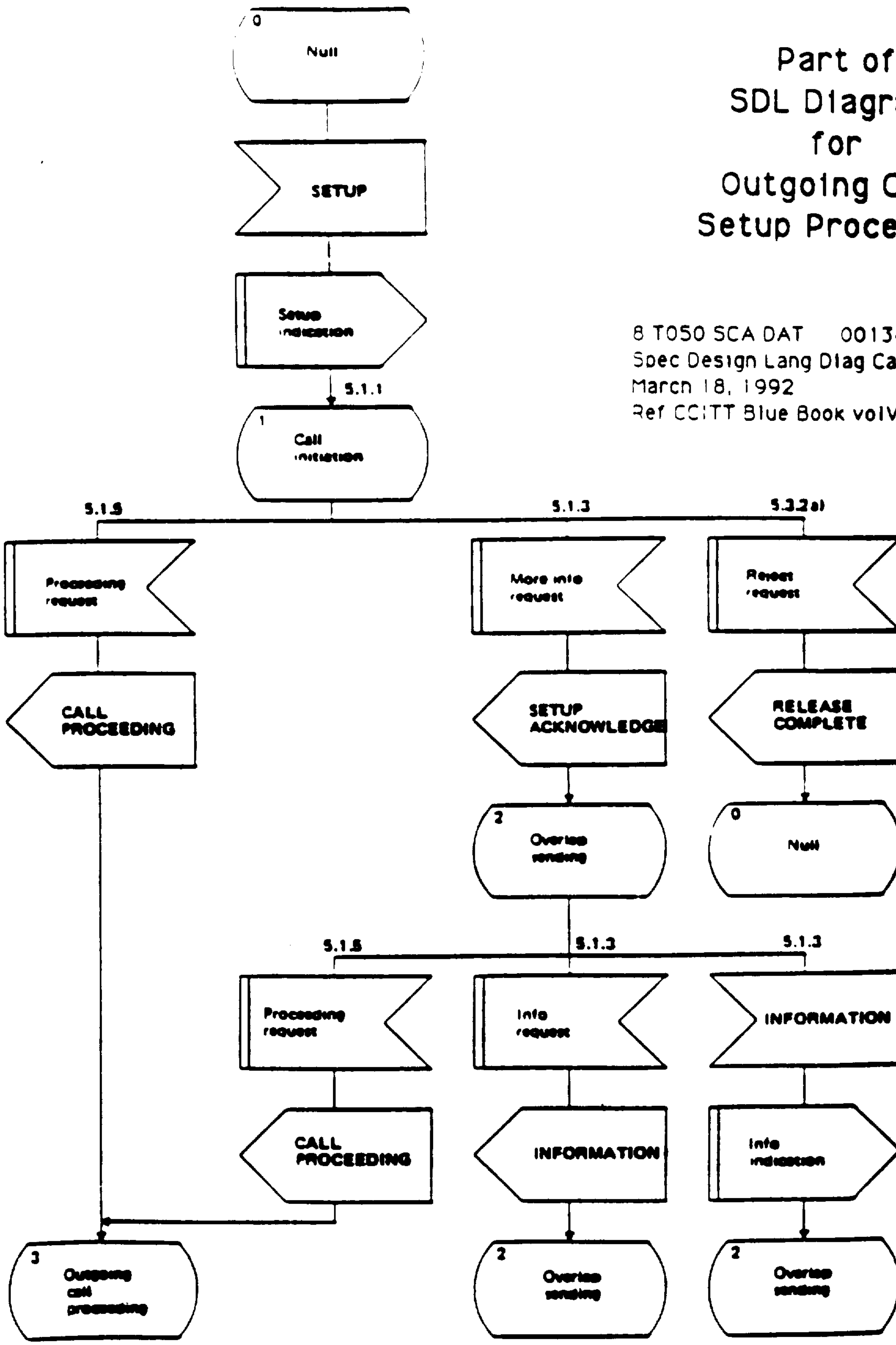
Part of SDL Diagram for Outgoing Call Setup Procedure

8 T050 SCA DAT 00134-00
Spec Design Lang Diag Call Setup Proc
March 18, 1992
Ref CCITT Blue Book vol VIII Rec Q.931



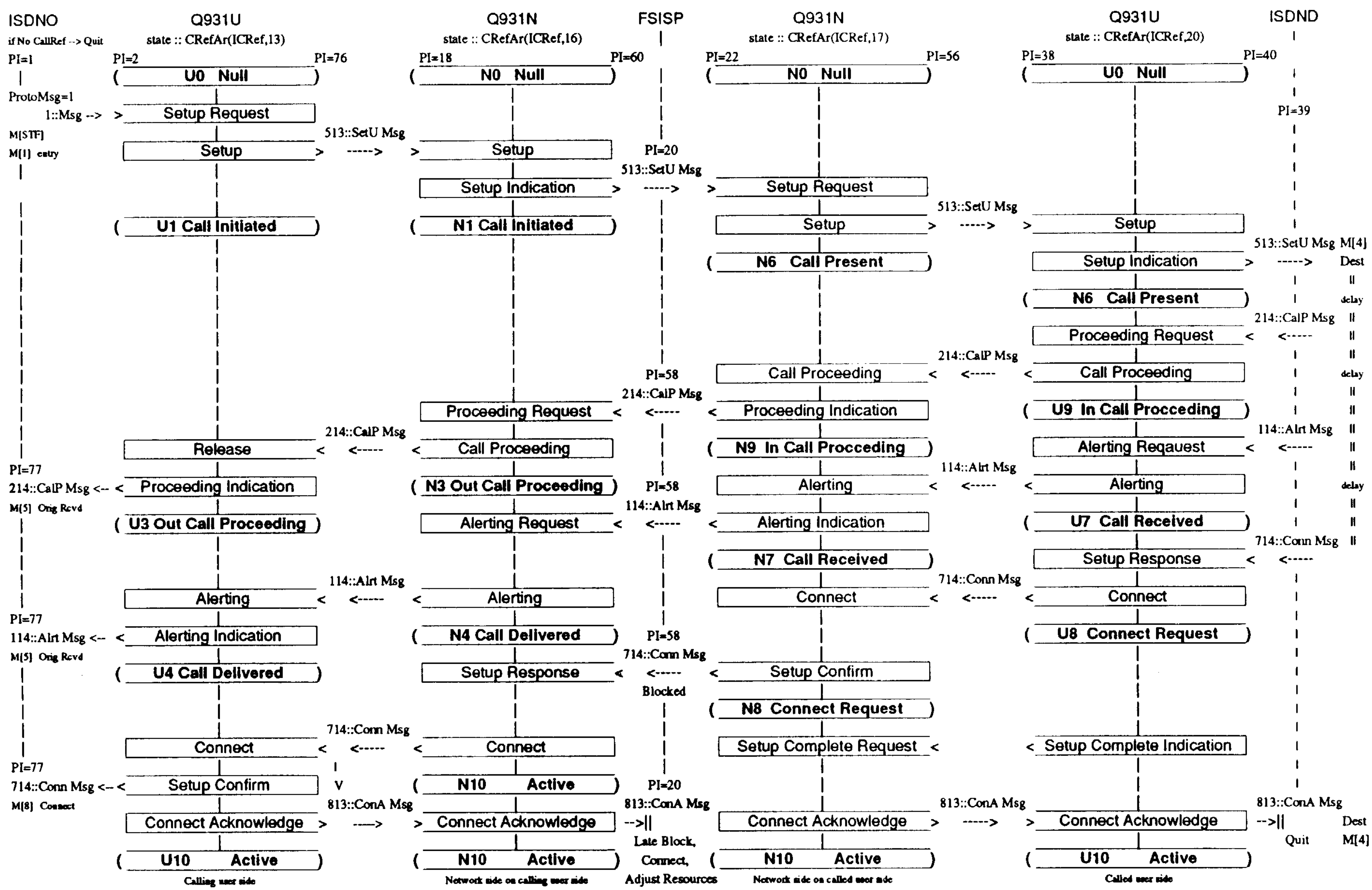


Figure 8.1 Q931 Protocol Connection SDL Interaction Diagram

Q931 Protocol adapted from CCITT BLue Book, vol. VI.11, 1988

The ISDN destination responds to the "DConn Msg" with a "Rel Msg" that eventually results in a "RelC Msg" to both Q931 entities on the destination side. Similarly on the origination side converts the "DConn Msg" into a "RelC Msg" that clears all the circuits including the D-Channel signalling access.

Figure 8.3. "Major ISDN Satellite Transition Points", in this appendix, shows the major resource allocations in terms of D and B channel activities and corresponding simulation status numbers (#). At an initial Rqst a signalling D-Channel is allocated and status is (1). This assumes one is available, no contention algorithm has been implemented. If the call is blocked (7) the D-Channel is released (11). Otherwise it remains active for the duration of call. When a call is connected its status is changed to (8). The initiation of a Term does not itself affect the connectivity until a the "DConn Msg" reaches the satellite. Then the allocated resources are disconnected (9) and when all affected circuits are cleared the D-Channels are released (11).

These ISDN communication satellite simulation break points are contrived for the present simulation and will be refined as necessary to fit the real-world.

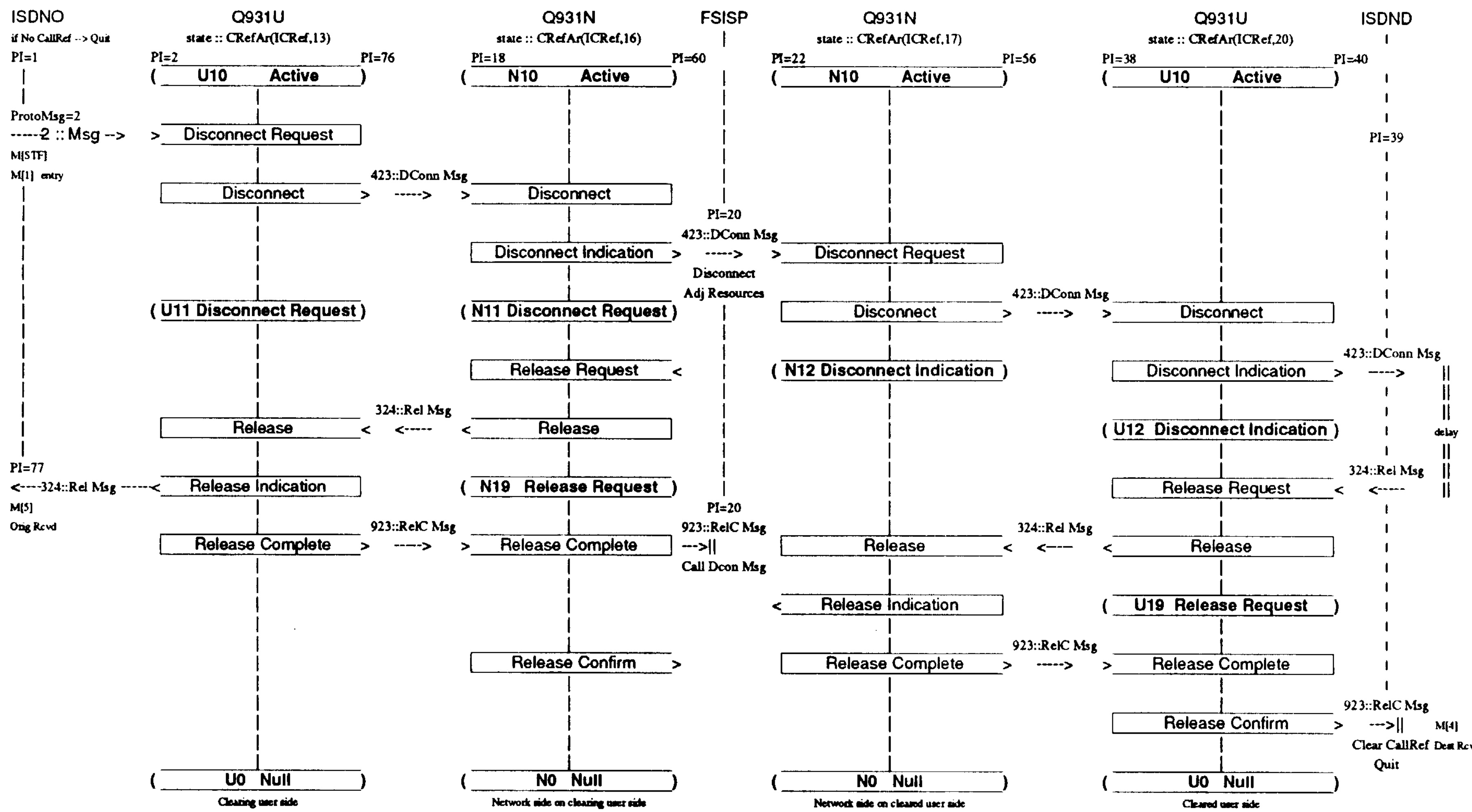


Figure 8.2 Q931 Protocol Disconnection SDL Interaction Diagram

Q931 Protocol adapted from CCITT BLue Book, vol. VI.11, 1988

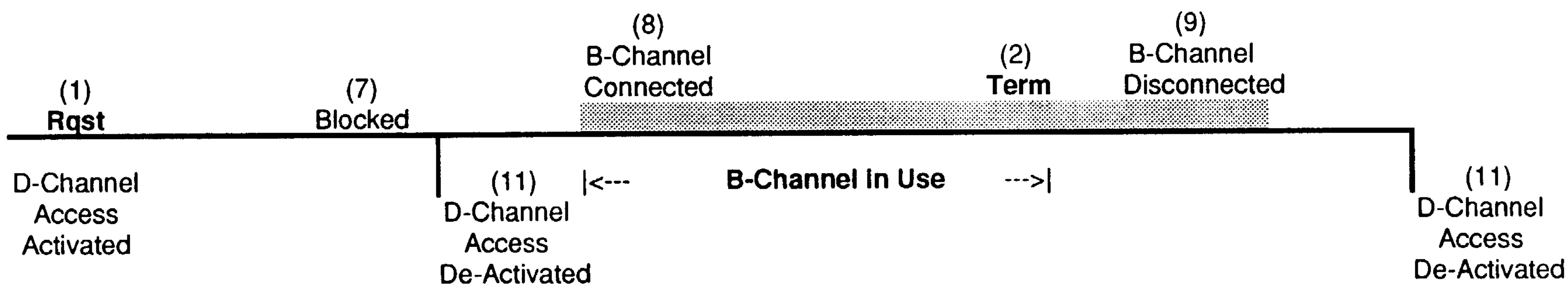


Figure 8.3 Major ISDN Satellite Transition Points

APPENDIX E

Measurement Save (MSave) File Structure

Three MSave files generated by the FSIS Build 3 are provided in this appendix -- "MSaveInt.DAT" and "MSaveInt.DAT"(STF01.DAT), "MSaveInt"(full CRef #7), and "MSaveInt"(STF06.DAT).

These Measurement Save (MSave) files contain the time sequenced data generated by the SimRun simulation program. Every time a communication process is activated an entry is made in MSave. Also, all significant events, such as protocol entity state changes, call connections, disconnections and blocking are saved in MSave. Periodically the internal MSave array is saved to disk as MSAVE##.DAT. Where ## represents a sequential digit starting with 1. These MSave files are the principal data sources for post simulation analyses. The contain all the data can be obtained from a particular simulation.

The MSave contains all data that is relevant to call processing in an ISDN era. The data within MSave can be used to calculate throughput, response time, blocking probability, and robustness. By using these performance measures an advanced ISDN satellite can be postulated and tested using these simulation techniques.

For MSaveInt.DAT, the MSave record consists of five fields: the simulation time, the call reference number, the PI, the protocol msg, and a state/status indicator.

For example the **first field is the simulation time** for the record of the MSave file in the appendix shows the simulation time in milliseconds-of-day:
11111010 milliseconds after midnight

The **second field is call reference** number associated with this call:
1 is the Call Reference Number

The **third field identifies** the number of the PI concatenated with the bearer service:
-11 is decoded as:

(-), the negative sign is a flag indicating that this record is a STF record.
1 indicates that this for PI=1
1 indicates that the CS64 Bearer service.

N.B. A positive number in this position indicates that the event is an internal event and represents the PI number.

The **forth field contains** the concatenated indexes for the origination and destination cities, if this is a STF record

2452
25 :: Los Angeles CA
52 :: Washington DC

or otherwise

contains the protocol message being transmitted at that time. The protocol messages were derived in part for the CCITT Q931 protocol messages, p72 Fascicle VI.11-Rec. Q931:

Bit position	87654321	#	Protocol Msg (use #)
	00000001	1	Alerting
	00000010	2	Call Processing
	00000111	7	Connect
	00001111	15	Connect Acknowledge (use 8)
	00000011	3	Progress
	00000101	5	Setup
	00001101	13	Set Acknowledge (use 6)
	01000101	37	Disconnect (use 4)
	01001101	45	Release (use 7)
	01011010	58	Release Complete (use 9)

This digit was used as the most significant digit of a three digit number indicating the Layer 3 protocol message. The center digit is set to "1" indicating messages used in the setup procedure. Whereas, this digit is set to 2 for call termination protocol messages. The least significant digit of the three digit number was set to either 3 or 4 depending on the Layer 1 flow of the protocol message. Protocol messages for FSIS Build 3 include:\

114	Alrt	Alerting
214	CalP	Call Processing
513	SetU	Setup
614	SetC	Setup Complete
714	Conn	Connect
813	ConA	Connect Acknowledge
324	Rel	Release
423	DCon	Disconnect
923	RelC	Release Complete

The **fifth field** represents the Term time in seconds, if this a STF record:

11159 indicates that the call will terminated at
11159 seconds after midnight,.

or otherwise

represents the status or state of the PI. For FSIS Build 3 negative numbers represent states of various protocol entities such F1...F7, G1...G3, U0...U10, and N0...N10. The active states for these protocol entities are F7, G3, U10, and N10. Whereas, positive values indicate program status such as entry, exit, not in case, timer overflow, etc.

For MSaveTxt.DAT, the MSave record consists of the same five fields: the simulation time, the call reference number, the PI, the protocol msg, and a status indicator with the integer values replaced by text abbreviation to be more mnemonically pleasing.

MSaveInt.DAT from STF01.DAT
3-4 hours >> 11111/010 ms.day -- 14506/506 ms.day

The following MSave file data was generated using the STF01.DAT scenario traffic file with the ISDN Satellite Simulation of the FSIS Model. STF01.DAT requests only single B-Channels between Washington DC and Los Angeles CA using the data from Traffic Model previously generated as part of this NASA SCAR effort.

For that simulation run, SimRun, the STF01.DAT was started a 3 hours and ended at 4 hours. Only the MSave option was selected - NOT the Full option. The MSave data consisting of the nearly 200 data records shown here were generated. Using this partial MSave option only a minimal amount of data is saved. These data deal with the request, termination, connection, and blocking of calls.

This particular section of MSave data was selected using the Product Generation, ProGen, program by employing the <M>Save input data menu option. Under that <M>Save input data option, <R>ead was selected; no was responded to the "Find number of MSave files (yes)?" question; the value 24 was entered for MSaveFnNuMn; and the value 33 for MSaveFnNuMx.

The data selected spans the simulation time from 11111/010 msecs of day to 14506/506 msecs of day (ms.day) and includes Call Reference Number (CRef#) 7. CRef #7, using D-Channel access, first requested a B-Channel at 12971/010 ms.day but was blocked at 12971/614 ms.day and the D-Channel access is released A retry was generated for a minute later at 13031/624 ms.day and was connected to a B-Channel at 13032/578 ms.day. After a 3 minute telephone call, CRef #7 hung up at 13213/010 ms.day, was disconnected from the B-Channel at 13213/95 ms.day, and all circuits cleared at 13213/506 ms.day and the D-Channel released.

ISDN Satellite Call Data, Response Time, and Throughput Products were generated from these MSave data are presented in Appendices F, G, and H, respectively.

11111010	1	-11	2452	11159
11111193	1	20	513	1
11111564	1	58	214	1
11111569	1	58	114	1
11111604	1	58	714	1
11111954	1	20	813	1
11111964	1	20	813	8
11111964	1	20	-1	111
11159010	1	-21	2452	11159
11159185	1	20	423	1
11159195	1	20	423	9
11159195	1	20	-1	-111
11159496	1	20	923	1
11159506	1	20	923	11
11201010	100	-11	5224	11429
11201193	100	20	513	1
11201564	100	58	214	1
11201569	100	58	114	1
11201604	100	58	714	1
11201954	100	20	813	1
11201964	100	20	813	8
11201964	100	20	-1	111
11421010	2	-11	2424	11642
11421193	2	20	513	1
11421564	2	58	214	1
11421569	2	58	114	1
11421604	2	58	714	1
11421954	2	20	813	1
11421964	2	20	813	8
11421964	2	20	-1	111
11429010	100	-21	5224	11429
11429185	100	20	423	1
11429195	100	20	423	9
11429195	100	20	-1	-111
11429496	100	20	923	1
11429506	100	20	923	11
11642010	2	-21	2424	11642
11642185	2	20	423	1
11642195	2	20	423	9
11642195	2	20	-1	-111
11642496	2	20	923	1
11642506	2	20	923	11
11731010	3	-11	2452	11880
11731193	3	20	513	1
11731564	3	58	214	1
11731569	3	58	114	1
11731604	3	58	714	1
11731954	3	20	813	1
11731964	3	20	813	8
11731964	3	20	-1	111

11880010	3	-21	2452	11880
11880185	3	20	423	1
11880195	3	20	423	9
11880195	3	20	-1	-111
11880496	3	20	923	1
11880506	3	20	923	11
12041010	4	-11	2424	12178
12041193	4	20	513	1
12041564	4	58	214	1
12041569	4	58	114	1
12041604	4	58	714	1
12041954	4	20	813	1
12041964	4	20	813	8
12041964	4	20	-1	111
12178010	4	-21	2424	12178
12178185	4	20	423	1
12178195	4	20	423	9
12178195	4	20	-1	-111
12178496	4	20	923	1
12178506	4	20	923	11
12351010	5	-11	2452	12627
12351193	5	20	513	1
12351564	5	58	214	1
12351569	5	58	114	1
12351604	5	58	714	1
12351954	5	20	813	1
12351964	5	20	813	8
12351964	5	20	-1	111
12627010	5	-21	2452	12627
12627185	5	20	423	1
12627195	5	20	423	9
12627195	5	20	-1	-111
12627496	5	20	923	1
12627506	5	20	923	11
12661010	6	-11	2424	13026
12661193	6	20	513	1
12661564	6	58	214	1
12661569	6	58	114	1
12661604	6	58	714	1
12661954	6	20	813	1
12661964	6	20	813	8
12661964	6	20	-1	111
12801010	101	-11	5252	12979
12801193	101	20	513	1
12801564	101	58	214	1
12801569	101	58	114	1
12801604	101	58	714	1
12801954	101	20	813	1
12801964	101	20	813	8
12801964	101	20	-1	111
12971010	7	-11	2452	13152
12971193	7	20	513	1
12971564	7	58	214	1
12971569	7	58	114	1

12971604	7	58	714	1
12971614	7	58	714	7
12971614	7	58	714	11
12979010	101	-21	5252	12979
12979185	101	20	423	1
12979195	101	20	423	9
12979195	101	20	-1	-111
12979496	101	20	923	1
12979506	101	20	923	11
13026010	6	-21	2424	13026
13026185	6	20	423	1
13026195	6	20	423	9
13026195	6	20	-1	-111
13026496	6	20	923	1
13026506	6	20	923	11
13031624	7	-11	2452	13213
13031807	7	20	513	1
13032178	7	58	214	1
13032183	7	58	114	1
13032218	7	58	714	1
13032568	7	20	813	1
13032578	7	20	813	8
13032578	7	20	-1	111
13213010	7	-21	2452	13213
13213185	7	20	423	1
13213195	7	20	423	9
13213195	7	20	-1	-111
13213496	7	20	923	1
13213506	7	20	923	11
13281010	8	-11	2424	13504
13281193	8	20	513	1
13281564	8	58	214	1
13281569	8	58	114	1
13281604	8	58	714	1
13281954	8	20	813	1
13281964	8	20	813	8
13281964	8	20	-1	111
13504010	8	-21	2424	13504
13504185	8	20	423	1
13504195	8	20	423	9
13504195	8	20	-1	-111
13504496	8	20	923	1
13504506	8	20	923	11
13591010	9	-11	2452	13832
13591193	9	20	513	1
13591564	9	58	214	1
13591569	9	58	114	1
13591604	9	58	714	1
13591954	9	20	813	1
13591964	9	20	813	8
13591964	9	20	-1	111
13832010	9	-21	2452	13832
13832185	9	20	423	1
13832195	9	20	423	9

13832195	9	20	-1	-111
13832496	9	20	923	1
13832506	9	20	923	11
13901010	10	-11	2424	14102
13901193	10	20	513	1
13901564	10	58	214	1
13901569	10	58	114	1
13901604	10	58	714	1
13901954	10	20	813	1
13901964	10	20	813	8
13901964	10	20	-1	111
14102010	10	-21	2424	14102
14102185	10	20	423	1
14102195	10	20	423	9
14102195	10	20	-1	-111
14102496	10	20	923	1
14102506	10	20	923	11
14211010	11	-11	2452	14506
14211193	11	20	513	1
14211564	11	58	214	1
14211569	11	58	114	1
14211604	11	58	714	1
14211954	11	20	813	1
14211964	11	20	813	8
14211964	11	20	-1	111
14506010	11	-21	2452	14506
14506185	11	20	423	1
14506195	11	20	423	9
14506195	11	20	-1	-111
14506496	11	20	923	1
14506506	11	20	923	11
0	6	20	813	1

MSaveInt.DAT from STF01.DAT
3-4 hours >> 11111/010 ms.day -- 14506/506 ms.day
/// Call Reference #7 Only ///

The following MSave file data was generated using the STF01.DAT scenario traffic file with the ISDN Satellite Simulation of the FSIS Model. STF01.DAT requests only single B-Channels between Washington DC and Los Angeles CA using the data from Traffic Model previously generated as part of this NASA SCAR effort.

For that simulation run, SimRun, the STF01.DAT was started a 3 hours and ended at 4 hours. The MSave option was selected, both MSave and Full were checked on the input graphic. The MSave data consisting of the 4500 data records were generated. Using this full MSave option all the data that can be save during the SimRun is saved. These data deal with every process in the simulation and account of such things as delay, transmitted/received power, thresholds, timers, time-outs, etc. During this SimRun 14 calls requesting a B-Channel were made. Each call lasted approximated 3 minutes and one call was blocked, Call Reference #7, resulting in a blocking factor of 7.14%..

This particular section of MSave data was edited, using the Word Perfect® 5.1 word processor, to retain only the data related to Call Reference #7, CRef #7. CRef #7 first requested a B-Channel at 12971/010 ms.day but was blocked at 12971/614 ms.day. A retry was generated for a minute later at 13031/624 ms.day and was connected at 13032/578 ms.day. After a 3 minute telephone call, CRef #7 hung up at 13213/010 ms.day, was disconnected from the B-Channel at 13213/195 ms.day, and all circuits cleared at 13213/711 ms.day.

Every protocol message exchange is shown. Every propagation element is modeled. And, all call processing aspects are presented. About 125 processes are encounter before a call is determined blocked. More than 200 processes are traversed before a call is connected, and at least 50 protocol exchanges are needed to disconnect the B-Channels with a 100 exchanges before all the circuit connections are cleared. ISDN Satellite Call Data, Response Time, and Throughput Products were generated from these MSave data are presented in Appendices F, G, and H, respectively.

Complete MSave data for Call Rererecne #7
of STF01.DAT; part of MSaveInt.DAT.

12971000	7	1	1	1	
12971010	7	-11	2452	13152	<-- initiate RQST
12971020	7	2	1	0	
12971020	7	3	513	1	
12971022	7	4	1	-4	
12971022	7	5	1	1	
12971024	7	6	2	-2	
12971024	7	73	2	1	
12971026	7	4	3	-6	
12971026	7	5	3	1	
12971028	7	6	-4	1	
12971028	7	6	4	-3	
12971028	7	73	4	1	
12971030	7	74	-8	3	
12971030	7	4	513	-7	
12971030	7	5	513	1	
12971031	7	6	513	-3	
12971032	7	7	513	1	
12971033	7	8	513	1	
12971034	7	9	513	1	
12971035	7	10	513	1	
12971037	7	11	513	1	
12971038	7	12	513	1	
12971039	7	13	513	1	
12971165	7	14	513	1	
12971166	7	15	513	1	
12971167	7	16	513	1	
12971172	7	17	513	1	
12971183	7	18	513	0	
12971183	7	19	513	1	
12971193	7	20	513	1	
12971203	7	21	513	1	
12971223	7	22	513	0	
12971223	7	23	513	1	
12971224	7	24	513	1	
12971229	7	25	513	1	
12971230	7	26	513	1	
12971231	7	27	513	1	
12971357	7	28	513	1	
12971358	7	29	513	1	
12971359	7	30	513	1	
12971361	7	31	513	1	
12971362	7	32	513	1	
12971363	7	33	513	1	
12971364	7	34	513	-3	
12971365	7	35	513	1	
12971367	7	36	513	-7	
12971367	7	37	513	1	

12971378	7	38	513	0
12971378	7	39	513	1
12971398	7	40	214	-600
12971398	7	41	214	1
12971400	7	42	214	-7
12971400	7	43	214	1
12971401	7	44	214	-3
12971402	7	45	214	1
12971403	7	46	214	1
12971403	7	40	114	-900
12971403	7	41	114	1
12971404	7	47	214	1
12971405	7	42	114	-7
12971405	7	43	114	1
12971405	7	48	214	1
12971406	7	44	114	-3
12971407	7	45	114	1
12971407	7	49	214	1
12971408	7	46	114	1
12971408	7	50	214	1
12971409	7	51	214	1
12971409	7	47	114	1
12971410	7	48	114	1
12971412	7	49	114	1
12971413	7	50	114	1
12971414	7	51	114	1
12971438	7	40	714	-700
12971438	7	41	714	1
12971440	7	42	714	-7
12971440	7	43	714	1
12971441	7	44	714	-3
12971442	7	45	714	1
12971443	7	46	714	1
12971444	7	47	714	1
12971445	7	48	714	1
12971447	7	49	714	1
12971448	7	50	714	1
12971449	7	51	714	1
12971536	7	52	214	1
12971537	7	53	214	1
12971538	7	54	214	1
12971541	7	52	114	1
12971542	7	53	114	1
12971543	7	55	214	1
12971543	7	54	114	1
12971548	7	55	114	1
12971554	7	56	214	-600
12971554	7	56	-331	303
12971554	7	57	214	1
12971559	7	56	114	-900
12971559	7	56	-5	310
12971559	7	57	114	1
12971564	7	58	214	1
12971569	7	58	114	1

12971574	7	59	214	1	
12971576	7	52	714	1	
12971577	7	53	714	1	
12971578	7	54	714	1	
12971579	7	59	114	1	
12971583	7	55	714	1	
12971594	7	60	214	-100	
12971594	7	61	214	1	
12971594	7	56	714	-700	
12971594	7	56	813	-800	
12971594	7	56	813	-1000	
12971594	7	57	714	1	
12971594	7	23	813	1	
12971595	7	62	214	1	
12971595	7	24	813	1	
12971599	7	60	114	-300	
12971599	7	61	114	1	
12971600	7	63	214	1	
12971600	7	25	813	1	
12971600	7	62	114	1	
12971601	7	64	214	1	
12971601	7	26	813	1	
12971602	7	65	214	1	
12971602	7	27	813	1	
12971604	7	58	714	1	
12971605	7	63	114	1	
12971606	7	64	114	1	
12971607	7	65	114	1	
12971614	7	58	714	7	<-- Call Blocked
12971614	7	58	714	11	
12971728	7	66	214	1	
12971728	7	28	813	1	
12971729	7	67	214	1	
12971729	7	29	813	1	
12971730	7	68	214	1	
12971730	7	30	813	1	
12971732	7	69	214	1	
12971732	7	31	813	1	
12971733	7	70	214	1	
12971733	7	32	813	1	
12971733	7	66	114	1	
12971734	7	67	114	1	
12971734	7	71	214	1	
12971734	7	33	813	1	
12971735	7	68	114	1	
12971737	7	69	114	1	
12971738	7	70	114	1	
12971739	7	71	114	1	

13031614	7	1	1	1	
13031624	7	-11	2452	13213	<-- initiate RQST
13031634	7	2	1	0	
13031634	7	3	513	1	

13031636	7	4	1	-4
13031636	7	5	1	1
13031638	7	6	2	-2
13031638	7	73	2	1
13031640	7	4	3	-6
13031640	7	5	3	1
13031642	7	6	-4	1
13031642	7	6	4	-3
13031642	7	73	4	1
13031644	7	74	-8	3
13031644	7	4	513	-7
13031644	7	5	513	1
13031645	7	6	513	-3
13031646	7	7	513	1
13031647	7	8	513	1
13031648	7	9	513	1
13031649	7	10	513	1
13031651	7	11	513	1
13031652	7	12	513	1
13031653	7	13	513	1
13031779	7	14	513	1
13031780	7	15	513	1
13031781	7	16	513	1
13031786	7	17	513	1
13031797	7	18	513	0
13031797	7	19	513	1
13031807	7	20	513	1
13031817	7	21	513	1
13031837	7	22	513	0
13031837	7	23	513	1
13031838	7	24	513	1
13031843	7	25	513	1
13031844	7	26	513	1
13031845	7	27	513	1
13031971	7	28	513	1
13031972	7	29	513	1
13031973	7	30	513	1
13031975	7	31	513	1
13031976	7	32	513	1
13031977	7	33	513	1
13031978	7	34	513	-3
13031979	7	35	513	1
13031981	7	36	513	-7
13031981	7	37	513	1
13031992	7	38	513	0
13031992	7	39	513	1
13032012	7	40	214	-600
13032012	7	41	214	1
13032014	7	42	214	-7
13032014	7	43	214	1
13032015	7	44	214	-3
13032016	7	45	214	1
13032017	7	46	214	1
13032017	7	40	114	-900

13032017	7	41	114	1
13032018	7	47	214	1
13032019	7	42	114	-7
13032019	7	43	114	1
13032019	7	48	214	1
13032020	7	44	114	-3
13032021	7	45	114	1
13032021	7	49	214	1
13032022	7	46	114	1
13032022	7	50	214	1
13032023	7	51	214	1
13032023	7	47	114	1
13032024	7	48	114	1
13032026	7	49	114	1
13032027	7	50	114	1
13032028	7	51	114	1
13032052	7	40	714	-700
13032052	7	41	714	1
13032054	7	42	714	-7
13032054	7	43	714	1
13032055	7	44	714	-3
13032056	7	45	714	1
13032057	7	46	714	1
13032058	7	47	714	1
13032059	7	48	714	1
13032061	7	49	714	1
13032062	7	50	714	1
13032063	7	51	714	1
13032150	7	52	214	1
13032151	7	53	214	1
13032152	7	54	214	1
13032155	7	52	114	1
13032156	7	53	114	1
13032157	7	55	214	1
13032157	7	54	114	1
13032162	7	55	114	1
13032168	7	56	214	-600
13032168	7	56	-331	303
13032168	7	57	214	1
13032173	7	56	114	-900
13032173	7	56	-5	310
13032173	7	57	114	1
13032178	7	58	214	1
13032183	7	58	114	1
13032188	7	59	214	1
13032190	7	52	714	1
13032191	7	53	714	1
13032192	7	54	714	1
13032193	7	59	114	1
13032197	7	55	714	1
13032208	7	60	214	-100
13032208	7	61	214	1
13032208	7	56	714	-700
13032208	7	56	813	-800

13032208	7	56	813	-1000
13032208	7	57	714	1
13032208	7	23	813	1
13032209	7	62	214	1
13032209	7	24	813	1
13032213	7	60	114	-300
13032213	7	61	114	1
13032214	7	63	214	1
13032214	7	25	813	1
13032214	7	62	114	1
13032215	7	64	214	1
13032215	7	26	813	1
13032216	7	65	214	1
13032216	7	27	813	1
13032218	7	58	714	1
13032219	7	63	114	1
13032220	7	64	114	1
13032221	7	65	114	1
13032228	7	59	714	1
13032248	7	60	714	-400
13032248	7	61	714	1
13032249	7	62	714	1
13032254	7	63	714	1
13032255	7	64	714	1
13032256	7	65	714	1
13032342	7	66	214	1
13032342	7	28	813	1
13032343	7	67	214	1
13032343	7	29	813	1
13032344	7	68	214	1
13032344	7	30	813	1
13032346	7	69	214	1
13032346	7	31	813	1
13032347	7	70	214	1
13032347	7	32	813	1
13032347	7	66	114	1
13032348	7	67	114	1
13032348	7	71	214	1
13032348	7	33	813	1
13032349	7	72	214	-3
13032349	7	34	813	-3
13032349	7	68	114	1
13032350	7	73	214	1
13032350	7	35	813	1
13032351	7	69	114	1
13032352	7	74	214	-7
13032352	7	75	214	1
13032352	7	36	813	-7
13032352	7	37	813	1
13032352	7	70	114	1
13032353	7	71	114	1
13032354	7	72	114	-3
13032355	7	73	114	1
13032357	7	74	114	-7

13032357	7	75	114	1	
13032363	7	76	214	-100	
13032363	7	76	-729	303	
13032363	7	77	1	1	
13032363	7	38	813	-800	
13032363	7	38	-311	313	
13032363	7	38	813	-1000	
13032363	7	39	813	1	
13032368	7	76	114	-300	
13032368	7	76	-5	310	
13032368	7	77	1	1	
13032373	7	39	813	4	
13032373	7	77	214	5	
13032378	7	77	114	5	
13032382	7	66	714	1	
13032383	7	67	714	1	
13032384	7	68	714	1	
13032386	7	69	714	1	
13032387	7	70	714	1	
13032388	7	71	714	1	
13032389	7	72	714	-3	
13032390	7	73	714	1	
13032392	7	74	714	-7	
13032392	7	75	714	1	
13032403	7	76	714	-400	
13032403	7	76	813	-1000	
13032403	7	77	1	1	
13032403	7	3	813	1	
13032405	7	4	813	-7	
13032405	7	5	813	1	
13032406	7	6	813	-3	
13032407	7	7	813	1	
13032408	7	8	813	1	
13032409	7	9	813	1	
13032410	7	10	813	1	
13032412	7	11	813	1	
13032413	7	77	714	8	
13032413	7	12	813	1	
13032414	7	13	813	1	
13032540	7	14	813	1	
13032541	7	15	813	1	
13032542	7	16	813	1	
13032547	7	17	813	1	
13032558	7	18	813	-1000	
13032558	7	19	813	1	
13032568	7	20	813	1	
13032578	7	20	813	8	<-- Call Connected
13032578	7	20	-1	111	

13213000	7	1	1	1	
13213010	7	-21	2452	13213	<-- initiate TERM
13213020	7	2	2	-1000	
13213020	7	3	423	1	

13213022	7	4	423	-7	
13213022	7	5	423	1	
13213023	7	6	423	-3	
13213024	7	7	423	1	
13213025	7	8	423	1	
13213026	7	9	423	1	
13213027	7	10	423	1	
13213029	7	11	423	1	
13213030	7	12	423	1	
13213031	7	13	423	1	
13213157	7	14	423	1	
13213158	7	15	423	1	
13213159	7	16	423	1	
13213164	7	17	423	1	
13213175	7	18	423	-1000	
13213175	7	19	423	1	
13213175	7	61	324	1	
13213176	7	62	324	1	
13213181	7	63	324	1	
13213182	7	64	324	1	
13213183	7	65	324	1	
13213185	7	20	423	1	
13213195	7	20	423	9	<-- Call Disconnected
13213195	7	20	-1	-111	
13213195	7	21	423	1	
13213215	7	22	423	-1000	
13213215	7	23	423	1	
13213216	7	24	423	1	
13213221	7	25	423	1	
13213222	7	26	423	1	
13213223	7	27	423	1	
13213309	7	66	324	1	
13213310	7	67	324	1	
13213311	7	68	324	1	
13213313	7	69	324	1	
13213314	7	70	324	1	
13213315	7	71	324	1	
13213316	7	72	324	-3	
13213317	7	73	324	1	
13213319	7	74	324	-7	
13213319	7	75	324	1	
13213330	7	76	324	-1100	
13213330	7	76	923	0	
13213330	7	77	1	1	
13213330	7	3	923	1	
13213332	7	4	923	-7	
13213332	7	5	923	1	
13213333	7	6	923	-3	
13213334	7	7	923	1	
13213335	7	8	923	1	
13213336	7	9	923	1	
13213337	7	10	923	1	
13213339	7	11	923	1	
13213340	7	77	324	5	

13213340	7	12	923	1
13213341	7	13	923	1
13213349	7	28	423	1
13213350	7	29	423	1
13213351	7	30	423	1
13213353	7	31	423	1
13213354	7	32	423	1
13213355	7	33	423	1
13213356	7	34	423	-3
13213357	7	35	423	1
13213359	7	36	423	-7
13213359	7	37	423	1
13213370	7	38	423	-1000
13213370	7	39	423	1
13213390	7	40	324	-1200
13213390	7	41	324	1
13213392	7	42	324	-7
13213392	7	43	324	1
13213393	7	44	324	-3
13213394	7	45	324	1
13213395	7	46	324	1
13213396	7	47	324	1
13213397	7	48	324	1
13213399	7	49	324	1
13213400	7	50	324	1
13213401	7	51	324	1
13213468	7	14	923	1
13213469	7	15	923	1
13213470	7	16	923	1
13213475	7	17	923	1
13213486	7	18	923	-1900
13213486	7	18	923	0
13213486	7	19	923	1
13213496	7	20	923	1
13213506	7	20	923	11
13213528	7	52	324	1
13213529	7	53	324	1
13213530	7	54	324	1
13213535	7	55	324	1
13213546	7	56	324	-1200
13213546	7	56	923	0
13213546	7	23	923	1
13213547	7	24	923	1
13213552	7	25	923	1
13213553	7	26	923	1
13213554	7	27	923	1
13213680	7	28	923	1
13213681	7	29	923	1
13213682	7	30	923	1
13213684	7	31	923	1
13213685	7	32	923	1
13213686	7	33	923	1
13213687	7	34	923	-3
13213688	7	35	923	1

13213690	7	36	923	-7
13213690	7	37	923	1
13213701	7	38	923	-1900
13213701	7	38	923	0
13213701	7	39	923	1
13213711	7	39	923	4

MSaveInt.DAT from STF06.DAT
8-9 hours >> 28800/010 ms.day -- 29782/505 ms.day

The following MSave file data was generated using the STF01.DAT scenario traffic file with the ISDN Satellite Simulation of the FSIS Model. STF01.DAT requests all possible bearer services permitted: CS64, CS128, DX25, BFR and TLM between Washington DC and Denver CO using the data from Traffic Model previously generated as part of this NASA SCAR effort.

For that simulation run, SimRun, the STF06.DAT was started a 8 hours and ended at 9 hours. Only the MSave option was selected - NOT the Full option. The MSave data consisting of the 350 data records shown here were generated. Using this partial MSave option only a minimal amount of data is saved. These data deal with the request, termination, connection, and blocking of calls.

This particular section of MSave data was selected using the Product Generation, ProGen, program by employing the <M>Save input data menu option. Under that <M>Save input data option, <R>ead was selected; no was responded to the "Find number of MSave files (yes)?" question; the value 1 was entered for MSaveFnNuMn; and the value 4 for MSaveFnNuMx.

The data selected spans the simulation time from 28800/010 msecs of day to 29782/505 msecs of day (ms.day). This simulation run included 30 call covering all the five bearer services of the Traffic Model. Each call lasted from seconds to minutes. There were ten blocked calls that were retried a minute later.

ISDN Satellite Call Data, Response Time, and Throughput Products were generated from these MSave data are presented in Appendices F, G, and H, respectively.

28800010	401	-13	5252	28814
28800010	402	-14	5215	28814
28800193	401	20	513	1
28800193	402	20	513	1
28800563	402	58	214	1
28800564	401	58	214	1
28800568	402	58	114	1
28800569	401	58	114	1
28800603	402	58	714	1
28800604	401	58	714	1
28800954	402	20	813	1
28800954	401	20	813	1
28800964	402	20	813	8
28800964	402	20	-4	111
28800964	401	20	813	8
28800964	401	20	-3	111
28801010	18	-11	1515	28828
28801010	348	-15	1515	28858
28801010	370	-11	5215	29043
28801010	395	-11	5252	28823
28801010	400	-12	5215	28818
28801193	18	20	513	1
28801193	348	20	513	1
28801193	370	20	513	1
28801193	395	20	513	1
28801193	400	20	513	1
28801563	18	58	214	1
28801563	348	58	214	1
28801563	370	58	214	1
28801563	400	58	214	1
28801564	395	58	214	1
28801568	18	58	114	1
28801568	348	58	114	1
28801568	370	58	114	1
28801568	400	58	114	1
28801569	395	58	114	1
28801603	18	58	714	1
28801603	348	58	714	1
28801603	370	58	714	1
28801603	400	58	714	1
28801604	395	58	714	1
28801613	18	58	714	7
28801613	18	58	714	11
28801613	370	58	714	7
28801613	370	58	714	11
28801613	400	58	714	7
28801613	400	58	714	11
28801614	395	58	714	7
28801614	395	58	714	11
28801954	348	20	813	1
28801964	348	20	813	8
28801964	348	20	-5	111
28806010	1106	-15	5215	28834
28806193	1106	20	513	1

28806563	1106	58	214	1
28806568	1106	58	114	1
28806603	1106	58	714	1
28806954	1106	20	813	1
28806964	1106	20	813	8
28806964	1106	20	-5	111
28814010	402	-24	5215	28814
28814185	402	20	423	1
28814195	402	20	423	9
28814195	402	20	-4	-111
28814496	402	20	923	1
28814506	402	20	923	11
28833010	1071	-14	5252	28851
28833193	1071	20	513	1
28833564	1071	58	214	1
28833569	1071	58	114	1
28833604	1071	58	714	1
28833954	1071	20	813	1
28833964	1071	20	813	8
28833964	1071	20	-4	111
28851010	1071	-24	5252	28851
28851185	1071	20	423	1
28851195	1071	20	423	9
28851195	1071	20	-4	-111
28851496	1071	20	923	1
28851506	1071	20	923	11
28856010	401	-23	5252	28856
28856185	401	20	423	1
28856195	401	20	423	9
28856195	401	20	-3	-111
28856496	401	20	923	1
28856506	401	20	923	11
28861623	18	-11	1515	28889
28861623	370	-11	5215	29104
28861623	400	-12	5215	28879
28861624	395	-11	5252	28884
28861806	18	20	513	1
28861806	370	20	513	1
28861806	400	20	513	1
28861807	395	20	513	1
28862176	18	58	214	1
28862176	370	58	214	1
28862176	400	58	214	1
28862178	395	58	214	1
28862181	18	58	114	1
28862181	370	58	114	1
28862181	400	58	114	1
28862183	395	58	114	1
28862216	18	58	714	1
28862216	370	58	714	1
28862216	400	58	714	1
28862218	395	58	714	1
28862567	18	20	813	1
28862567	370	20	813	1

28862567	400	20	813	1
28862568	395	20	813	1
28862577	18	20	813	8
28862577	18	20	-1	111
28862577	370	20	813	8
28862577	370	20	-1	111
28862577	400	20	813	7
28862577	400	20	813	11
28862578	395	20	813	7
28862578	395	20	813	11
28889010	18	-21	1515	28889
28889185	18	20	423	1
28889195	18	20	423	9
28889195	18	20	-1	-111
28889495	18	20	923	1
28889505	18	20	923	11
28918010	1106	-25	5215	28918
28918185	1106	20	423	1
28918195	1106	20	423	9
28918195	1106	20	-5	-111
28918496	1106	20	923	1
28918506	1106	20	923	11
28922587	400	-12	5215	28940
28922588	395	-11	5252	28945
28922770	400	20	513	1
28922771	395	20	513	1
28923140	400	58	214	1
28923142	395	58	214	1
28923145	400	58	114	1
28923147	395	58	114	1
28923180	400	58	714	1
28923182	395	58	714	1
28923190	400	58	714	7
28923190	400	58	714	11
28923532	395	20	813	1
28923542	395	20	813	8
28923542	395	20	-1	111
28945010	395	-21	5252	28945
28945185	395	20	423	1
28945195	395	20	423	9
28945195	395	20	-1	-111
28945496	395	20	923	1
28945506	395	20	923	11
28957010	324	-14	1515	29000
28957193	324	20	513	1
28957563	324	58	214	1
28957568	324	58	114	1
28957603	324	58	714	1
28957613	324	58	714	7
28957613	324	58	714	11
28983200	400	-12	5215	29001
28983383	400	20	513	1
28983753	400	58	214	1
28983758	400	58	114	1

28983793	400	58	714	1
28983803	400	58	714	7
28983803	400	58	714	11
29001010	172	-12	1515	29036
29001193	172	20	513	1
29001563	172	58	214	1
29001568	172	58	114	1
29001603	172	58	714	1
29001613	172	58	714	7
29001613	172	58	714	11
29017623	324	-14	1515	29061
29017806	324	20	513	1
29018176	324	58	214	1
29018181	324	58	114	1
29018216	324	58	714	1
29018226	324	58	714	7
29018226	324	58	714	11
29026010	98	-11	1515	29047
29026010	263	-13	1552	29047
29026193	98	20	513	1
29026193	263	20	513	1
29026563	98	58	214	1
29026564	263	58	214	1
29026568	98	58	114	1
29026569	263	58	114	1
29026603	98	58	714	1
29026604	263	58	714	1
29026954	98	20	813	1
29026954	263	20	813	1
29026964	98	20	813	8
29026964	98	20	-1	111
29026964	263	20	813	8
29026964	263	20	-3	111
29029010	348	-25	1515	29029
29029185	348	20	423	1
29029195	348	20	423	9
29029195	348	20	-5	-111
29029495	348	20	923	1
29029505	348	20	923	11
29043813	400	-12	5215	29062
29043996	400	20	513	1
29044366	400	58	214	1
29044371	400	58	114	1
29044406	400	58	714	1
29044416	400	58	714	7
29044416	400	58	714	11
29047010	98	-21	1515	29047
29047185	98	20	423	1
29047195	98	20	423	9
29047195	98	20	-1	-111
29047495	98	20	923	1
29047505	98	20	923	11
29061623	172	-12	1515	29097
29061806	172	20	513	1

29062176	172	58	214	1
29062181	172	58	114	1
29062216	172	58	714	1
29062226	172	58	714	7
29062226	172	58	714	11
29078236	324	-14	1515	29122
29078419	324	20	513	1
29078789	324	58	214	1
29078794	324	58	114	1
29078829	324	58	714	1
29078839	324	58	714	7
29078839	324	58	714	11
29104010	370	-21	5215	29104
29104185	370	20	423	1
29104195	370	20	423	9
29104195	370	20	-1	-111
29104426	400	-12	5215	29123
29104496	370	20	923	1
29104506	370	20	923	11
29104609	400	20	513	1
29104979	400	58	214	1
29104984	400	58	114	1
29105019	400	58	714	1
29105370	400	20	813	1
29105380	400	20	813	8
29105380	400	20	-2	111
29110010	263	-23	1552	29110
29110185	263	20	423	1
29110195	263	20	423	9
29110195	263	20	-3	-111
29110495	263	20	923	1
29110505	263	20	923	11
29122236	172	-12	1515	29158
29122419	172	20	513	1
29122789	172	58	214	1
29122794	172	58	114	1
29122829	172	58	714	1
29122839	172	58	714	7
29122839	172	58	714	11
29123010	400	-22	5215	29123
29123185	400	20	423	1
29123195	400	20	423	9
29123195	400	20	-2	-111
29123496	400	20	923	1
29123506	400	20	923	11
29138849	324	-14	1515	29183
29139032	324	20	513	1
29139402	324	58	214	1
29139407	324	58	114	1
29139442	324	58	714	1
29139793	324	20	813	1
29139803	324	20	813	8
29139803	324	20	-4	111
29182849	172	-12	1515	29219

29183010	324	-24	1515	29183
29183032	172	20	513	1
29183185	324	20	423	1
29183195	324	20	423	9
29183195	324	20	-4	-111
29183402	172	58	214	1
29183407	172	58	114	1
29183442	172	58	714	1
29183495	324	20	923	1
29183505	324	20	923	11
29183793	172	20	813	1
29183803	172	20	813	8
29183803	172	20	-2	111
29219010	172	-22	1515	29219
29219185	172	20	423	1
29219195	172	20	423	9
29219195	172	20	-2	-111
29219495	172	20	923	1
29219505	172	20	923	11
29317010	99	-11	1552	29341
29317010	264	-13	1515	29362
29317193	99	20	513	1
29317193	264	20	513	1
29317563	264	58	214	1
29317564	99	58	214	1
29317568	264	58	114	1
29317569	99	58	114	1
29317603	264	58	714	1
29317604	99	58	714	1
29317954	264	20	813	1
29317954	99	20	813	1
29317964	264	20	813	8
29317964	264	20	-3	111
29317964	99	20	813	8
29317964	99	20	-1	111
29341010	99	-21	1552	29341
29341185	99	20	423	1
29341195	99	20	423	9
29341195	99	20	-1	-111
29341495	99	20	923	1
29341505	99	20	923	11
29437010	173	-12	1552	29468
29437193	173	20	513	1
29437564	173	58	214	1
29437569	173	58	114	1
29437604	173	58	714	1
29437954	173	20	813	1
29437964	173	20	813	8
29437964	173	20	-2	111
29468010	173	-22	1552	29468
29468185	173	20	423	1
29468195	173	20	423	9
29468195	173	20	-2	-111
29468495	173	20	923	1

29468505	173	20	923	11
29497010	264	-23	1515	29497
29497185	264	20	423	1
29497195	264	20	423	9
29497195	264	20	-3	-111
29497495	264	20	923	1
29497505	264	20	923	11
29545010	325	-14	1552	29559
29545193	325	20	513	1
29545564	325	58	214	1
29545569	325	58	114	1
29545604	325	58	714	1
29545954	325	20	813	1
29545964	325	20	813	8
29545964	325	20	-4	111
29559010	325	-24	1552	29559
29559185	325	20	423	1
29559195	325	20	423	9
29559195	325	20	-4	-111
29559495	325	20	923	1
29559505	325	20	923	11
29601010	7	-11	1552	29782
29601193	7	20	513	1
29601564	7	58	214	1
29601569	7	58	114	1
29601604	7	58	714	1
29601954	7	20	813	1
29601964	7	20	813	8
29601964	7	20	-1	111
29608010	100	-11	1515	29642
29608010	265	-13	1552	29653
29608193	100	20	513	1
29608193	265	20	513	1
29608563	100	58	214	1
29608564	265	58	214	1
29608568	100	58	114	1
29608569	265	58	114	1
29608603	100	58	714	1
29608604	265	58	714	1
29608954	100	20	813	1
29608954	265	20	813	1
29608964	100	20	813	8
29608964	100	20	-1	111
29608964	265	20	813	8
29608964	265	20	-3	111
29642010	100	-21	1515	29642
29642185	100	20	423	1
29642195	100	20	423	9
29642195	100	20	-1	-111
29642495	100	20	923	1
29642505	100	20	923	11
29782010	7	-21	1552	29782
29782185	7	20	423	1
29782195	7	20	423	9

29782195	7	20	-1	-111
29782495	7	20	923	1
29782505	7	20	923	11
29788010	265	-23	1552	29788
29788185	265	20	423	1
29788195	265	20	423	9
29788195	265	20	-3	-111
29788495	265	20	923	1
29788505	265	20	923	11
0	172	20	923	1

APPENDIX F

Basic ISDN Satellite Call Data Product

This appendix presents the Call Data Product relatable to both the ISIS and FSIS simulation models using a scenario traffic file generated from the Traffic model. These models were developed earlier in this SCAR Program and were subjects of other reports.

The Call Data Product is generated by the Product Generation (ProGen) software written in Simscript II.5. ProGen uses the MSave file data presented in Appendix E. To generate the Call Data Product from these MSave data ProGen is executed using the FSIS Build 3.

Before ProGen can generate the Call Data Product a suitable MSaveInt.DAT file must be available as a disk file. The <M>Save main menu option of ProGen allows the selection of MSave data to analyzed. Once selected with the <R>ead option, these data can be reviewed using the <D>isplay option and saved using the <S>ave option.

Selecting the main menu <C>all Data Generation option displays the 'Analyzing Data' while reading and processing the data stored in the MSaveInt.DAT file. The Call Data Product generation is automatic. The results are shown for STF01.DAT and STF06.DAT scenario presented in Appendix A.

The Call Data Product can be saved on request. The specific outputs were generated using the Word Perfect® 5.1 word processor software.

The Call Data Product consists of a tabular representation on a call by call basis. The Call Reference Number, Request Time, Blocked Time, Connection Time, Disconnect Request Time, Disconnect Time and Bearer Service are read from the MSave data. The Call Duration is calculated from the Call Connect Time and Call Disconnect Time in seconds.

This Call Data Product provides a quick view of the simulation results. It provides a sanity check of the scenario; a quick estimate of the traffic duration; and a view of the blocked traffic and its recovery.

The CallRT01.DAT Call Data Product summarizes the FSIS simulation using the STF01.DAT scenario traffic file. It shows that only CS64 bearer services were requested and used for an average of 3 minutes, as dictated by the Traffic Model. The single blocked call was retired on minute later and was successful. The Response Time portion of this page will be discussed later in the Response Time Product, Appendix G.

The CallData.DAT Call Data Product summarizes the FSIS simulation using the STF06.DAT scenario traffic file. It shows that all five permitted bearer services were requested and used for times ranging from tens to hundreds of seconds. No attempt is being made here to account for the wisdom or economics a call lasting tens of seconds. That rationale will be left for later studies using the ISDN satellite simulation. The data were derived from the Traffic Model. That model may need refinement when new ISDN traffic data becomes available. There were 15 blocked call situations. CRef #395 was blocked twice and CRef #400 was blocked five times before being successful. All calls were retired one minute after being blocked.

[GTE] Program ProGen -- Product Generation (NASA/SCAR)

Basic ISDN Call Data

CallRef ####	RqstTime (ms.day)	BlkdTime (ms.day)	ConnTime (ms.day)	DConnRTime (ms.day)	DConnTime (ms.day)	Duration (secs)	BearerSvcs (text)
1	11111010	0	11111964	11159010	11159195	48	CS64
100	11201010	0	11201964	11429010	11429195	228	CS64
2	11421010	0	11421964	11642010	11642195	221	CS64
3	11731010	0	11731964	11880010	11880195	149	CS64
4	12041010	0	12041964	12178010	12178195	137	CS64
5	12351010	0	12351964	12627010	12627195	276	CS64
6	12661010	0	12661964	13026010	13026195	365	CS64
101	12801010	0	12801964	12979010	12979195	178	CS64
7	12971010	12971614	0	0	0	0	CS64
7	13031624	0	13032578	13213010	13213195	182	CS64
8	13281010	0	13281964	13504010	13504195	223	CS64
9	13591010	0	13591964	13832010	13832195	241	CS64
10	13901010	0	13901964	14102010	14102195	201	CS64
11	14211010	0	14211964	14506010	14506195	295	CS64

[GTE] Program ProGen -- Product Generation (NASA/SCAR)

Response Time Call Data

CallRef ####	RqstTime (ms.day)	BlkdTime (ms.day)	ConnTime (ms.day)	DConnRTime (ms.day)	DConnTime (ms.day)	Conn R/T (msecs)	DConn R/T (msecs)
1	11111010	0	11111964	11159010	11159195	954	185
100	11201010	0	11201964	11429010	11429195	954	185
2	11421010	0	11421964	11642010	11642195	954	185
3	11731010	0	11731964	11880010	11880195	954	185
4	12041010	0	12041964	12178010	12178195	954	185
5	12351010	0	12351964	12627010	12627195	954	185
6	12661010	0	12661964	13026010	13026195	954	185
101	12801010	0	12801964	12979010	12979195	954	185
7	12971010	12971614	0	0	0	0	0
7	13031624	0	13032578	13213010	13213195	954	185
8	13281010	0	13281964	13504010	13504195	954	185
9	13591010	0	13591964	13832010	13832195	954	185
10	13901010	0	13901964	14102010	14102195	954	185
11	14211010	0	14211964	14506010	14506195	954	185

[GTE] Program ProGen -- Product Generation (NASA/SCAR)

Basic ISDN Call Data

CallRef ####	RqstTime (ms.day)	BlkdTime (ms.day)	ConnTime (ms.day)	DConnRTime (ms.day)	DConnTime (ms.day)	Duration (secs)	BearerSvcs (text)
401	28800010	0	28800964	28856010	28856195	56	DX25
402	28800010	0	28800964	28814010	28814195	14	BRF
18	28801010	28801613	0	0	0	0	CS64
348	28801010	0	28801964	29029010	29029195	228	TLM
370	28801010	28801613	0	0	0	0	CS64
395	28801010	28801614	0	0	0	0	CS64
400	28801010	28801613	0	0	0	0	CS128
1106	28806010	0	28806964	28918010	28918195	112	TLM
1071	28833010	0	28833964	28851010	28851195	18	BRF
18	28861623	0	28862577	28889010	28889195	28	CS64
370	28861623	0	28862577	29104010	29104195	243	CS64
400	28861623	28862577	0	0	0	0	CS128
395	28861624	28862578	0	0	0	0	CS64
400	28922587	28923190	0	0	0	0	CS128
395	28922588	0	28923542	28945010	28945195	23	CS64
324	28957010	28957613	0	0	0	0	BRF
400	28983200	28983803	0	0	0	0	CS128
172	29001010	29001613	0	0	0	0	CS128
324	29017623	29018226	0	0	0	0	BRF
98	29026010	0	29026964	29047010	29047195	21	CS64
263	29026010	0	29026964	29110010	29110195	84	DX25
400	29043813	29044416	0	0	0	0	CS128
172	29061623	29062226	0	0	0	0	CS128
324	29078236	29078839	0	0	0	0	BRF
400	29104426	0	29105380	29123010	29123195	19	CS128
172	29122236	29122839	0	0	0	0	CS128
324	29138849	0	29139803	29183010	29183195	44	BRF
172	29182849	0	29183803	29219010	29219195	36	CS128
99	29317010	0	29317964	29341010	29341195	24	CS64
264	29317010	0	29317964	29497010	29497195	180	DX25
173	29437010	0	29437964	29468010	29468195	31	CS128
325	29545010	0	29545964	29559010	29559195	14	BRF
7	29601010	0	29601964	29782010	29782195	181	CS64
100	29608010	0	29608964	29642010	29642195	34	CS64
265	29608010	0	29608964	29788010	29788195	180	DX25

APPENDIX G

ISDN Satellite Response Time Product

This appendix presents the Response Time Product related to the simulation run of the FSIS model using a scenario traffic file generated from the Traffic model. Both models were developed earlier in this program and were subjects of other reports.

The Response Time Product is generated by the Product Generation (ProGen) software written in Simscript II.5. ProGen uses the MSave file data presented in Appendix E. To generate the Response Time Product from these MSave data ProGen is executed using the FSIS Build 3 MSave data.

Before ProGen can generate the Response Time Product a suitable MSaveInt.DAT file must be available as a disk file. The <M>Save main menu option of ProGen allows the selection of MSave data to analyzed. Once selected with the <R>ead option, these data can be reviewed using the <D>isplay option and saved using the <S>ave option.

Selecting the main menu <R>esponse Time Generation option displays the 'Analyzing Data' while reading and processing the data stored in the MSaveInt.DAT file. The Response Time Product generation is automatic. The results are shown for STF01.DAT and STF06.DAT scenario presented in Appendix A.

The Response Time Product can be saved on request. The specific outputs were generated using the Word Perfect® 5.1 word processor software.

The Response Time Product consists of a tabular representation on a call by call basis. The Call Reference Number, Request Time, Blocked Time, Connection Time, Disconnect Request Time, and Disconnect Time are read from the MSave data. The Connection Response Time and the Disconnection Time calculated from the Call Request Time and the Call Connect Time, and the Disconnect Request Time and Call Disconnect Time in milliseconds, respectively.

This Response Time Product provides a view of the both these response times on a call by call basis. For the present FSIS model the results are identical for all calls and all scenarios due to the fixed delays associated with each communication process being presently models. These times fall within each respective protocol timer and thereby provide the first order viability for ISDN satellites even in geo-synchronous orbits.

When such things as non-stationary satellites, antenna hopping patterns, and uplink contention algorithms are added to the simulation these response will wary from call to call depending on the call origination, destination, and communication path.

The CallRT01.DAT Response Time Product summarizes the FSIS simulation using the STF01.DAT scenario traffic file. It shows that only CS64 bearer services were requested. In all cases the Connection Response Time was 954 msecs and the Disconnection Response Time was 185 msecs.

The RespTime.DAT Response Time Product summarizes the FSIS simulation using the STF06.DAT scenario traffic file. It shows that all five permitted bearer services were requested. Again, In all cases the Connection Response Time was 954 msecs and the Disconnection Response Time was 185 msecs.

The Response Time Product is a useful to determine the amount of setup used to connect and disconnect calls. As modeling and simulation refinements occur, the Response Time Product will provide a primary tool for determining the envelope of engineering options for the ISDN communication satellite design.

[GTE] Program ProGen -- Product Generation (NASA/SCAR)

Basic ISDN Call Data

CallRef ####	RqstTime (ms.day)	BlkdTime (ms.day)	ConnTime (ms.day)	DConnRTime (ms.day)	DConnTime (ms.day)	Duration (secs)	BearerSvcs (text)
1	11111010	0	11111964	11159010	11159195	48	CS64
100	11201010	0	11201964	11429010	11429195	228	CS64
2	11421010	0	11421964	11642010	11642195	221	CS64
3	11731010	0	11731964	11880010	11880195	149	CS64
4	12041010	0	12041964	12178010	12178195	137	CS64
5	12351010	0	12351964	12627010	12627195	276	CS64
6	12661010	0	12661964	13026010	13026195	365	CS64
101	12801010	0	12801964	12979010	12979195	178	CS64
7	12971010	12971614	0	0	0	0	CS64
7	13031624	0	13032578	13213010	13213195	182	CS64
8	13281010	0	13281964	13504010	13504195	223	CS64
9	13591010	0	13591964	13832010	13832195	241	CS64
10	13901010	0	13901964	14102010	14102195	201	CS64
11	14211010	0	14211964	14506010	14506195	295	CS64

[GTE] Program ProGen -- Product Generation (NASA/SCAR)

Response Time Call Data

CallRef ####	RqstTime (ms.day)	BlkdTime (ms.day)	ConnTime (ms.day)	DConnRTime (ms.day)	DConnTime (ms.day)	Conn R/T (msecs)	DConn R/T (msecs)
1	11111010	0	11111964	11159010	11159195	954	185
100	11201010	0	11201964	11429010	11429195	954	185
2	11421010	0	11421964	11642010	11642195	954	185
3	11731010	0	11731964	11880010	11880195	954	185
4	12041010	0	12041964	12178010	12178195	954	185
5	12351010	0	12351964	12627010	12627195	954	185
6	12661010	0	12661964	13026010	13026195	954	185
101	12801010	0	12801964	12979010	12979195	954	185
7	12971010	12971614	0	0	0	0	0
7	13031624	0	13032578	13213010	13213195	954	185
8	13281010	0	13281964	13504010	13504195	954	185
9	13591010	0	13591964	13832010	13832195	954	185
10	13901010	0	13901964	14102010	14102195	954	185
11	14211010	0	14211964	14506010	14506195	954	185

[GTE] Program ProGen -- Product Generation (NASA/SCAR)

Response Time Call Data

CallRef ####	RqstTime (ms.day)	BlkdTime (ms.day)	ConnTime (ms.day)	DConnRTime (ms.day)	DConnTime (ms.day)	Conn R/T (msecs)	DConn R/T (msecs)
401	28800010	0	28800964	28856010	28856195	954	185
402	28800010	0	28800964	28814010	28814195	954	185
18	28801010	28801613	0	0	0	0	0
348	28801010	0	28801964	29029010	29029195	954	185
370	28801010	28801613	0	0	0	0	0
395	28801010	28801614	0	0	0	0	0
400	28801010	28801613	0	0	0	0	0
1106	28806010	0	28806964	28918010	28918195	954	185
1071	28833010	0	28833964	28851010	28851195	954	185
18	28861623	0	28862577	28889010	28889195	954	185
370	28861623	0	28862577	29104010	29104195	954	185
400	28861623	28862577	0	0	0	0	0
395	28861624	28862578	0	0	0	0	0
400	28922587	28923190	0	0	0	0	0
395	28922588	0	28923542	28945010	28945195	954	185
324	28957010	28957613	0	0	0	0	0
400	28983200	28983803	0	0	0	0	0
172	29001010	29001613	0	0	0	0	0
324	29017623	29018226	0	0	0	0	0
98	29026010	0	29026964	29047010	29047195	954	185
263	29026010	0	29026964	29110010	29110195	954	185
400	29043813	29044416	0	0	0	0	0
172	29061623	29062226	0	0	0	0	0
324	29078236	29078839	0	0	0	0	0
400	29104426	0	29105380	29123010	29123195	954	185
172	29122236	29122839	0	0	0	0	0
324	29138849	0	29139803	29183010	29183195	954	185
172	29182849	0	29183803	29219010	29219195	954	185
99	29317010	0	29317964	29341010	29341195	954	185
264	29317010	0	29317964	29497010	29497195	954	185
173	29437010	0	29437964	29468010	29468195	954	185
325	29545010	0	29545964	29559010	29559195	954	185
7	29601010	0	29601964	29782010	29782195	954	185
100	29608010	0	29608964	29642010	29642195	954	185
265	29608010	0	29608964	29788010	29788195	954	185

APPENDIX H

ISDN Satellite Throughput Product

This appendix presents the Throughput Product related to the simulation run of the FSIS model using a scenario traffic file generated from the Traffic model. Both models were developed earlier in this NASA SCAR program and were subjects of other reports.

The Throughput Product is generated by the Product Generation (ProGen) software written in Simscript II.5. ProGen uses the MSave file data presented in Appendix E. To generate the Throughput Product from these MSave data ProGen is executed using the FSIS Build 3, User Instructions presented in Appendix C.

Before ProGen can generate the Throughput Product a suitable MSaveInt.DAT file must be available as a disk file. The <M>Save main menu option of ProGen allows the selection of MSave data to analyzed. Once selected with the <R>ead option, these data can be reviewed using the <D>isplay option and saved using the <S>ave option.

Selecting the main menu <T>hroughput Generation option displays the 'Analyzing Data' while reading and processing the data stored in the MSaveInt.DAT file. The Throughput Product generation is automatic. The results are shown for STF01.DAT and STF06.DAT scenario presented in Appendix A.

The Throughput Product can be saved on request. The specific outputs were generated using the Word Perfect® 5.1 word processor software.

The Throughput Product consists of a tabular representation on a call event by call event basis. Each time a call is Requested, Connected, Terminated, Blocked, or the D-Channel, the ISDN Satellite Throughput is changed. The Throughput Product displays these event changes as a function of time and amount of ISDN Satellite bandwidth being used at that time.

The present algorithm for calculating throughput consists of:

1) Adding a D-Channel (16 Kbps) when any call is requested to support signalling.
2) Adding a B-Channel (64 Kbps) when a CS64 is connected, Conn.
3) Adding two B-Channels (128 Kbps) when CS128 or BFR services are connected.
4) Not adding any bandwidth for DX25 or TLM bearer services are connected. It is assumed that the signalling D-Channel is used to support these services.
5) Subtracting the bandwidth indicated for the bearer services above when they are disconnected, Dcon.
6) Subtracting a D-Channel at the end of all call clearing for each bearer service.
7) Subtracting a D-Channel when a call is blocked,

The Throughput bandwidth changes with each event cited, above. The Throughput product displays the resultant bandwidth as a function of event changes. The Throughput display consists of CallREf#, Simulation Time, Bearer Service, Action, Throughput (Kbps), Number of D-Channels in use, Number of B-Channels in use.

This Throughput Product provides a view of the simulation throughput results. It provides the ability to track the ISDN satellite throughput as a function of time; an estimate of the peak traffic; and a view of the satellite quiet periods.

The 11111/010 ms.day Throughput Product summarizes the FSIS simulation using the STF01.DAT scenario traffic file. It shows that only CS64 bearer services were requested. It shows the use and release of bandwidth in 16 Kbps and 64 Kbps values. The largest throughput was 176 Kbps with seven periods of zero throughput. An event time plot accompanies these data to provide a pictorial view of throughput as a function of events. As expected for the input data used there is a degree of periodicity to the throughput pattern.

The 28800/010 Throughput Product summarizes the FSIS simulation using the STF06.DAT scenario traffic file. It shows that all five permitted bearer services were requested and thereby provided multiple bandwidth steps in the throughput sum. With the use of DX25 and TLM more activity is seen in the D-Channels rather than the B-Channels. Restricting the present simulation to only two B-Channels did cause more blocking than normally expected.

The corresponding event graph of the throughput data shows its build-up and decay. The second graph shows these same data strictly as a function of time. The throughput minimum never drops below 48 Kbps during the steady state and reaches a maximum of 240 Kbps. More than likely, an increase in numbers of B-Channels would have increased the throughput capacity and would have reduced the blocking percentage.

The Throughput Product can be analyzed in many ways to determine averages, peak periods, and idle times. Like the Response Time Product, the Throughput Product will provide a basic tool for determining the envelope of engineering options for the ISDN communication satellite design..

[GTE] Program ProGen -- Product Generation (NASA/SCAR)

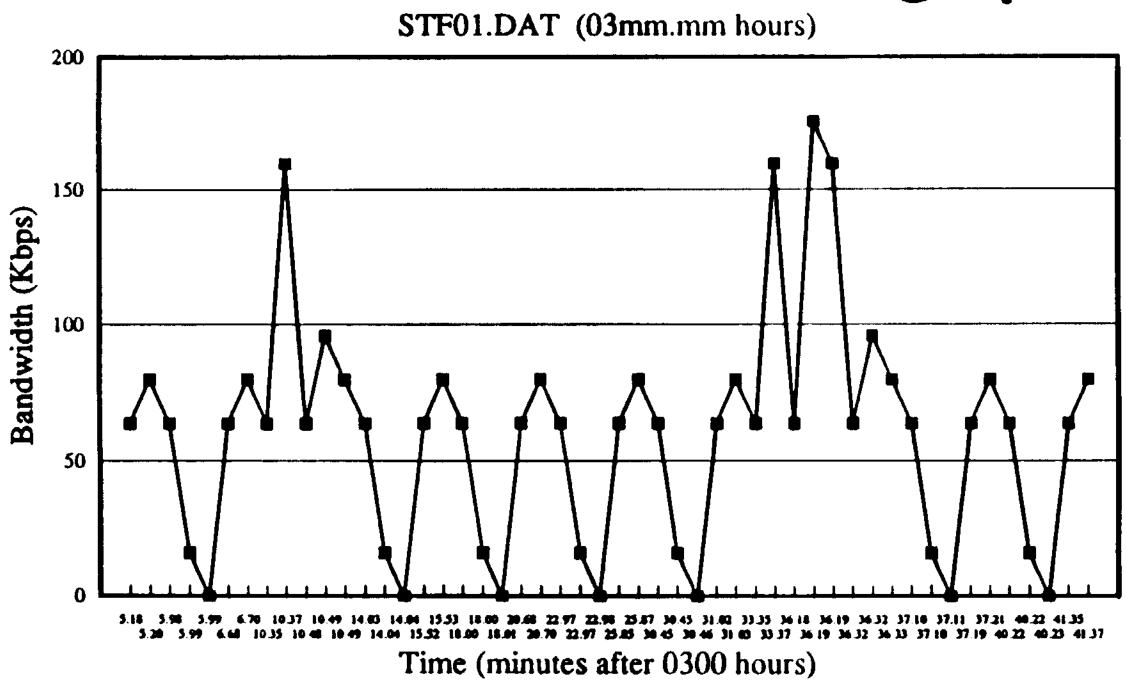
Throughput Call Data

CallRef# (####)	RqstTime (ms.day)	BearerSvc (text)	Action (text)	Throughput (Kbps)	D-Used (##)	B-Used (##)
1	11111010	CS64	Rqst	16	1	0
1	11111964		Conn	80	1	1
1	11159010	CS64	Term	80	1	1
1	11159195		Dcon	16	1	0
1	11159506		-D	0	0	0
100	11201010	CS64	Rqst	16	1	0
100	11201964		Conn	80	1	1
2	11421010	CS64	Rqst	96	2	1
2	11421964		Conn	160	2	2
100	11429010	CS64	Term	160	2	2
100	11429195		Dcon	96	2	1
100	11429506		-D	80	1	1
2	11642010	CS64	Term	80	1	1
2	11642195		Dcon	16	1	0
2	11642506		-D	0	0	0
3	11731010	CS64	Rqst	16	1	0
3	11731964		Conn	80	1	1
3	11880010	CS64	Term	80	1	1
3	11880195		Dcon	16	1	0
3	11880506		-D	0	0	0
4	12041010	CS64	Rqst	16	1	0
4	12041964		Conn	80	1	1
4	12178010	CS64	Term	80	1	1
4	12178195		Dcon	16	1	0
4	12178506		-D	0	0	0
5	12351010	CS64	Rqst	16	1	0
5	12351964		Conn	80	1	1
5	12627010	CS64	Term	80	1	1
5	12627195		Dcon	16	1	0
5	12627506		-D	0	0	0
6	12661010	CS64	Rqst	16	1	0
6	12661964		Conn	80	1	1
101	12801010	CS64	Rqst	96	2	1
101	12801964		Conn	160	2	2
7	12971010	CS64	Rqst	176	3	2
7	12971614		Blkd	176	3	2
7	12971614		-D	160	2	2
101	12979010	CS64	Term	160	2	2
101	12979195		Dcon	96	2	1
101	12979506		-D	80	1	1
6	13026010	CS64	Term	80	1	1
6	13026195		Dcon	16	1	0
6	13026506		-D	0	0	0
7	13031624	CS64	Rqst	16	1	0
7	13032578		Conn	80	1	1
7	13213010	CS64	Term	80	1	1
7	13213195		Dcon	16	1	0
7	13213506		-D	0	0	0
8	13281010	CS64	Rqst	16	1	0
8	13281964		Conn	80	1	1

GTE Government Systems

NASA - SCAR

ISDN Satellite Throughput



c:\sim\progen\TPPlot01.wk3
July 7, 1992

8 T034 SCA DAT
GTE/Gov Sys Template
August 21, 1991

[GTE] Program ProGen -- Product Generation (NASA/SCAR)

Throughput Call Data

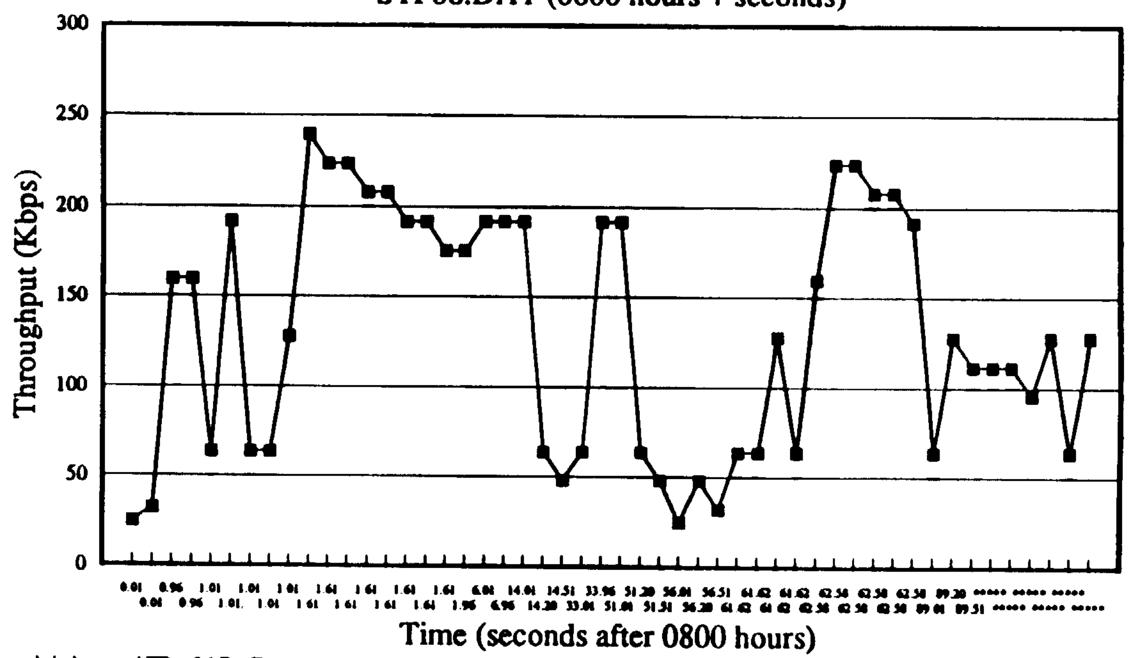
CallRef# (####)	RqstTime (ms.day)	BearerSvc (text)	Action (text)	Throughput (Kbps)	D-Used (##)	B-Used (##)
401	28800010	DX25	Rqst	16	1	0
402	28800010	BRF	Rqst	32	2	0
402	28800964		Conn	160	2	2
401	28800964		Conn	160	2	2
18	28801010	CS64	Rqst	176	3	2
348	28801010	TLM	Rqst	192	4	2
370	28801010	CS64	Rqst	208	5	2
395	28801010	CS64	Rqst	224	6	2
400	28801010	CS128	Rqst	240	7	2
18	28801613		Blkd	240	7	2
18	28801613		-D	224	6	2
370	28801613		Blkd	224	6	2
370	28801613		-D	208	5	2
400	28801613		Blkd	208	5	2
400	28801613		-D	192	4	2
395	28801614		Blkd	192	4	2
395	28801614		-D	176	3	2
348	28801964		Conn	176	3	2
1106	28806010	TLM	Rqst	192	4	2
1106	28806964		Conn	192	4	2
402	28814010	BRF	Term	192	4	2
402	28814195		Dcon	64	4	0
402	28814506		-D	48	3	0
1071	28833010	BRF	Rqst	64	4	0
1071	28833964		Conn	192	4	2
1071	28851010	BRF	Term	192	4	2
1071	28851195		Dcon	64	4	0
1071	28851506		-D	48	3	0
401	28856010	DX25	Term	48	3	0
401	28856195		Dcon	48	3	0
401	28856506		-D	32	2	0
18	28861623	CS64	Rqst	48	3	0
370	28861623	CS64	Rqst	64	4	0
400	28861623	CS128	Rqst	80	5	0
395	28861624	CS64	Rqst	96	6	0
18	28862577		Conn	160	6	1
370	28862577		Conn	224	6	2
400	28862577		Blkd	224	6	2
400	28862577		-D	208	5	2
395	28862578		Blkd	208	5	2
395	28862578		-D	192	4	2
18	28889010	CS64	Term	192	4	2
18	28889195		Dcon	128	4	1
18	28889505		-D	112	3	1
1106	28918010	TLM	Term	112	3	1
1106	28918195		Dcon	112	3	1
1106	28918506		-D	96	2	1
400	28922587	CS128	Rqst	112	3	1
395	28922588	CS64	Rqst	128	4	1
400	28923190		Blkd	128	4	1

GTE Government Systems

NASA - SCAR

ISDN Satellite Throughput

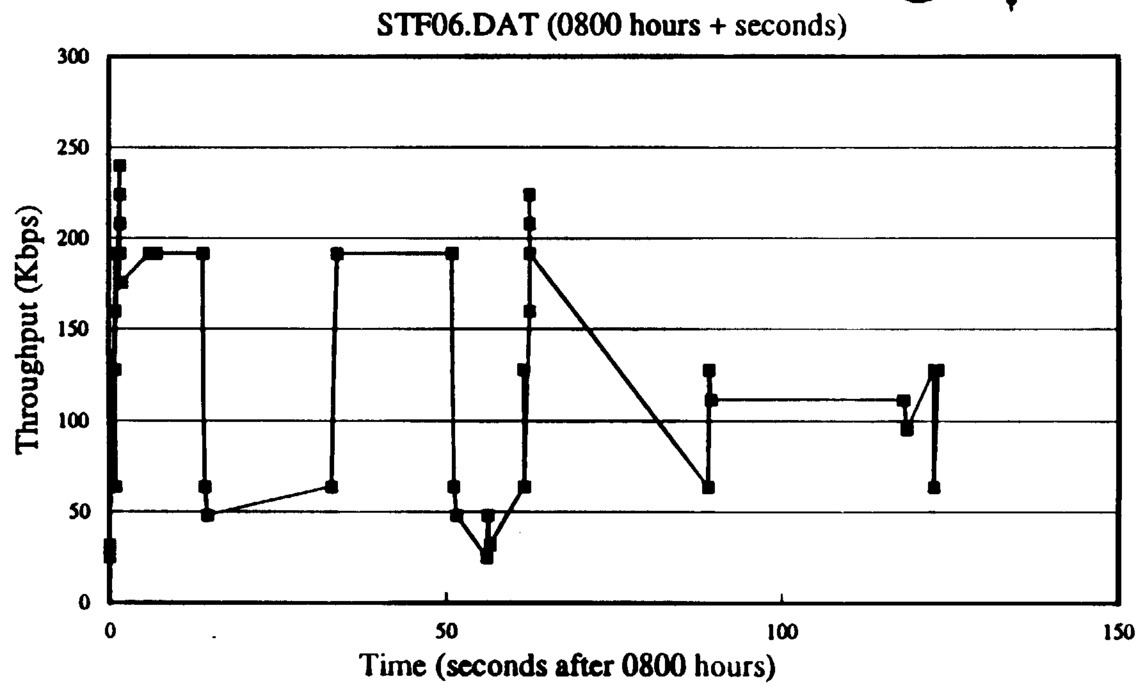
STF06.DAT (0800 hours + seconds)



c:\sim\progen\TPxy06.DAT
July 8, 1992

8 T034 SCA DAT
GTE/Gov Sys Template
August 21, 1991

ISDN Satellite Throughput



c:\sim\progen\TPxy06.DAT
July 8, 1992

APPENDIX I

Description of Z-Chart Trace

The Z-Chart Trace plots the output showing the migration of the "Rqst" and "Term" protocols through the various processes (process indexes :: PIs) for the setup and termination of a telephone call. Two types of Z-Chart outputs are generated in FSIS Build 3. One of them is generated during the SimRun execution and provides a *real-time Z-Chart* view of the protocol migrations. The other Z-Chart output is derived from the MSave data generated by SimRun, *MSave derived Z-Chart.*

The **real-time Z-Chart** is depicted by an ordinate representing the Process Index (PI) number associated with each communication function/process. The time elapsed with each communication function (PI) is plotted along the abscissa. The result is a time history trace of communication processes activated as a function of time it took for them to perform their respective functions.

In relation to the Z-Chart Trace the simulation progress from process to process is depicted as a time-line constantly edging towards increasing time. The longer times associated with propagation are plotted as long steps among more evenly spaced smaller steps. The call connection (Rqst) display is depicted as line segments connected by long steps representing the VSAT/ISDN satellite propagation links. The "Seconds of Day" window in the output graphic displays the exact time down to millisecond of the data being plotted on the Z-Chart Trace graphic.

The Z-Chart window was set 75 msecs wide in order to sufficiently resolve these milliseconds events. Therefore, it is extremely unlikely that both the call "Rqst" and the "Term" for the same call can be seen in the same window. Also, due to the discrete event aspects of the simulation the call set up and the call termination seem to appear on sequential windows. This is an illusion. For call ranging minutes in duration hundreds of blank windows are traversed between the "Rqst" and the "Term" but are not displayed on the Z-Chart Trace .

The **MSave derived Z-Chart** is generated by the Product Generation (ProGen) software that uses the MSave##.DAT files generated by the SimRun software. Several steps are necessary to generate the hard copy output provided in this appendix.

The "MSave input data" option of the main ProGen menu allows the generation of combined MSave files for both integer values "MSaveInt.DAT" and text versions "MSaveTxt.DAT". These MSave files, once generated and saved, can now be used to generate the Z-Chart data and files using the "Z-Chart: Generation" option of the ProGen main menu. For FSIS Build 3, the Z-Chart product is saved as "ZChart.DAT" and was read using Word Perfect® 5.1. The output was generated after reducing the text font to "Small".

The Z-Chart depicts the major protocol processes on the top abscissa and the time in seconds-of-day on the ordinate down the page. Text symbols are plotted in the matrix element that corresponds to time and process. For example the first element shows an ISDN Originator requesting "Rqst" service by going off hook "OffH". That fact is detected by the Q931U protocol process which is in state U0. The Q931U process sends a Info1 "I1" with the content of "setup" protocol message to the Q921U protocol process. For this simulation the Q921U is assumed to have received an error free protocol message that it delivers to the I430U protocol process. Since this is the first protocol message received by the I430U interface it finds a deactivated interface and therefore goes through the Info1/Info2/Info3/Info4 protocol sequence to activate the interface. Q931 protocols: Setup, Call Proceeding, Alerting, Connect, Connect Acknowledge, etc. are progressed along each PIs until all the protocol entities are in the active state and a B-Channel is assigned. That B-Channel remains assigned to this call until released by a "Term" protocol message sequence.

For FSIS Build 3, the center bar of the Z-Chart represent on board the satellite. Q921N, Q931N, Q931N, and Q921N account for the protocol processing on the satellite. Z-Charts, generated by ProGen, are included for call blocked, call connected, and call disconnected situations.

Z-Chart for Call Reference Number 7 of STF01.DAT
The call is blocked; a minute later it is retried and successfully connected and subsequently disconnected.

Sim time	IDSN	931U	921U	430U	430N	921N	931N	931N	921N	430N	430U	921U	931U	ISDN
12971000	Rqst	OffH												
12971020		(U0)	I1											
12971020			(++)	SetU										
12971022				(F4)	I1									
12971024				I2	(G2)									
12971026				(F6)	I3									
12971028				I4	(G3)									
12971030				(F7)	SetU									
12971031					(G3)	SetU								
12971172						(++)	SetU							
12971183							(N0)	SetU						
12971193														
12971223								(N0)	SetU					
12971223									(++)	SetU				
12971364										(G3)	SetU			
12971367											(F7)	SetU		
12971367												(++)	SetU	
12971378													(U0)	SetU
12971378														
12971398												CalP	U06)	
12971398											CalP	(++)		
12971400										CalP	(F7)			
12971401									CalP	(G3)				
12971403												Alrt	U09)	
12971403											Alrt	(++)		
12971405										Alrt	(F7)			
12971406									Alrt	(G3)				
12971438												Conn	U07)	
12971438											Conn	(++)		
12971440										Conn	(F7)			
12971441									Conn	(G3)				
12971543								CalP	(++)					
12971548								Alrt	(++)					
12971554							CalP	N06)						
12971559							Alrt	N09)						
12971564														
12971569														
12971583								Conn	(++)					
12971594						CalP	N01)							
12971594					CalP	(++)								
12971594							Conn	N07)						
12971594							ConA	N08)						
12971594							ConA	N10)						
12971594									(++)	ConA				
12971599						Alrt	N03)							
12971599					Alrt	(++)								
12971604														
12971614							Call	Blkd						
12971614														

Sim time	IDSN	931U	921U	430U	430N	921N	931N	931N	921N	430N	430U	921U	931U	ISDN
13031614	Rqst	OffH												
13031634		(U0)	I1											
13031634			(++)	SetU										
13031636				(F4)	I1									
13031638				I2	(G2)									
13031640				(F6)	I3									
13031642				I4	(G3)									
13031644				(F7)	SetU									
13031645					(G3)	SetU								
13031786						(++)	SetU							
13031797							(N0)	SetU						
13031837								(N0)	SetU					
13031837									(++)	SetU				
13031978										(G3)	SetU			
13031981											(F7)	SetU		
13031981												(++)	SetU	
13031992													(U0)	SetU
13032012												CalP	U06)	
13032012											CalP	(++)		
13032014										CalP	(F7)			
13032015									CalP	(G3)				
13032017												Alrt	U09)	
13032017											Alrt	(++)		
13032019										Alrt	(F7)			
13032020									Alrt	(G3)				
13032052												Conn	U07)	
13032052											Conn	(++)		
13032054										Conn	(F7)			
13032055									Conn	(G3)				
13032157								CalP	(++)					
13032162								Alrt	(++)					
13032168							CalP	N06)						
13032173							Alrt	N09)						
13032197								Conn	(++)					
13032208						CalP	N01)							
13032208					CalP	(++)								
13032208							Conn	N07)						
13032208							ConA	N08)						
13032208							ConA	N10)						
13032208									(++)	ConA				
13032213						Alrt	N03)							
13032213					Alrt	(++)								
13032248						Conn	N04)							
13032248					Conn	(++)								
13032349				CalP	(G3)									
13032349										(G3)	ConA			
13032352			CalP	(F7)										
13032352		CalP	(++)											
13032352											(F7)	ConA		
13032352												(++)	ConA	
13032354				Alrt	(G3)									
13032357			Alrt	(F7)										
13032357		Alrt	(++)											
13032363	Orig												U08)	ConA
13032363													U10)	ConA
13032373														Dest
13032389				Conn	(G3)									
13032392			Conn	(F7)										
13032392		Conn	(++)											
13032403	Orig													
13032403			(++)	ConA										
13032405				(F7)	ConA									
13032406					(G3)	ConA								
13032547						(++)	ConA							
13032558							N10)	ConA						
13032578							Call	Conn						

Sim time	IDSN	931U	921U	430U	430N	921N	931N	931N	921N	430N	430U	921U	931U	ISDN
13213000	Rqst	OffH												
13213020		U10)	I2											
13213020			(++)	DCon										
13213022				(F7)	DCon									
13213023					(G3)	DCon								
13213164						(++)	DCon							
13213175							N10)	DCon						
13213175					Rel-	(++)								
13213185														
13213195							Call	DCon						
13213195														
13213215								N10)	DCon					
13213215									(++)	DCon				
13213316				Rel-	(G3)									
13213319			Rel-	(F7)										
13213319		Rel-	(++)											
13213330														
13213330														
13213330	Orig													
13213330			(++)	RelC										
13213332				(F7)	RelC									
13213333					(G3)	RelC								
13213340	Orig													
13213356										(G3)	DCon			
13213359											(F7)	DCon		
13213359												(++)	DCon	
13213370													U10)	DCon
13213370														
13213390												Rel-	U12)	
13213390											Rel-	(++)		
13213392										Rel-	(F7)			
13213393									Rel-	(G3)				
13213475						(++)	RelC							
13213486							N19)	RelC						
13213486							(N0)	RelC						
13213496														
13213506														
13213535								Rel-	(++)					
13213546							Rel-	N12)						
13213546							RelC	(N0)						
13213546									(++)	RelC				
13213687										(G3)	RelC			
13213690											(F7)	RelC		
13213690												(++)	RelC	
13213701													U19)	RelC
13213701													(U0)	RelC
13213701														
13213711														Dest