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Traffic Model

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for

Advanced Satellite Designs and Experiments

30 September 1991

Task Completion Report

NASA SCAR Contract NASW-4520, 13 Sep 1990

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16. Abstract

Traffic Model Task Completion Report for Advanced Satellite Designs and Experiments for ISDN Application. This report outlines database structure and fields for categorizing and storing ISDN user characteristics. This Traffic Model Database will be used to exercise models of ISDN Advanced Communication Satellite (both discrete event and stuchastic models) to determine design parameters and performance for the NASA Satellite Communications Applications Research (SCAR) Program.

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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 filtering the data in the Traffic Model to suit a particular set of ISDN users by:

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

SECTION 6

SUMMARY

6.1 General

This task completion report described the Traffic Model that was developed for this NASA SCAR effort to generate scenarios for 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 the model using various Traffic Model generated scenarios, technical parameters, and operational procedures. The data from those simulation experiments will be analyzed using the performance measures discussed in previous reports.

6.2 Review

After an introduction that provided the background and scope of this NASA SCAR Program, the use of modeling and simulation to determine the parameters for the advanced ISDN communications satellite design was presented. An overview of the modeling and simulation tasks included a brief description of the four software programs for the effort. Particular associations were made between the Traffic Model and the scenarios generated form it.

Two main sections of this task completion report are Traffic Model and Scenario Generation Sections. The Traffic Model described each of the databases that make the Traffic Model. The Scenario Generation described how the Traffic Model database data are used to generate Scenario Traffic Files (STFs) for the network model and simulation. These sections were followed by a Traffic Model application section.

6.3 Continuing Efforts

The present Traffic Model is adequate for the ISIS and FSIS needs of the SCAR Program. Some research is continuing at the broadband ISDN user level of the Traffic Model that will be included as an update in the latter part of this effort.

SECTION 1

INTRODUCTION

1.1 Background

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.

These objectives will be achieved in part via modeling and simulation of ISDN communications satellite designs as part of the ISDN terrestrial network. Models of the Interim Service ISDN Satellite (ISIS) and the Full Service ISDN Satellite (FSIS) will exercised using discrete event simulation techniques.

To provide meaningful results a suitable Traffic Model was devised to represent the anticipated ISDN user traffic. Since few ISDN users are presently available, a proper Traffic Model was obtained through surveys of prospective users conducted by the University of Colorado.

1.2 Scope

This task completion report documents the Traffic Model derived from the extrapolation of ISDN prospective user survey data. The process and methodology for using this Traffic Model is in the context described in Figure 1.2-1, "NASA/SCAR Approaches for Advanced ISDN Satellites". The Traffic Model data will be used to generate scenarios for network model designs that 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 1.2-2, "Closed User-Oriented Scenario". A user of the ACTS satellite orbiting switch requests services from the Master Ground Station (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 SCAR Program is to consider a full on-board-processing satellite which is somewhat equivalent to moving these MGS functions on-board the next generation ISDN communications satellite as shown in Figure 1.2-3, "Advanced ISDN Satellite". The technical and operational parameters for the advanced

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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 1.2-1 NASA/SCAR Approaches for Advanced ISDN Satellites

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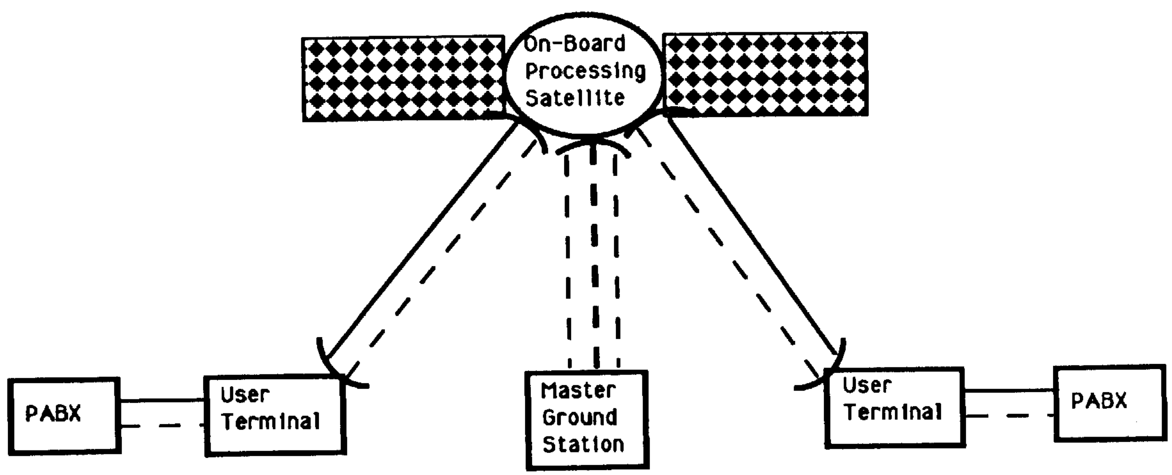

Figure 1.2-2 Closed User-Oriented Scenario

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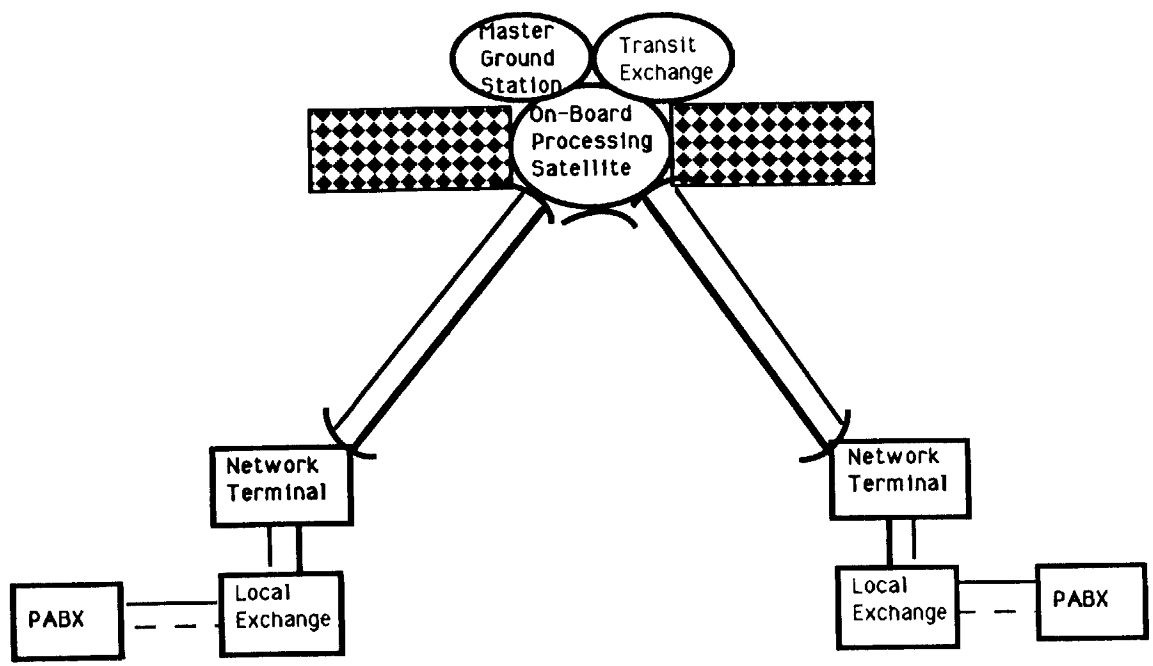

Figure 1.2-3 Advanced ISDN Satellite

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 data from these simulation experiments will be analyzed using the NASA SCAR performance measures discussed in previous reports.

1.3 Document Overview

This task completion report begins by describing the use of modeling and simulation techniques to determine the design parameters for the SCAR advanced ISDN communications satellite design. Section 2. provides an overview of the modeling and simulation tasks including a brief description of the four software programs of that effort.

Two main sections of this task completion report are Traffic Model and Scenario Generation Sections. The Traffic Model, Section 3., describes each of the databases that make the Traffic Model. The Scenario Generation, Section 4., describes how the Traffic Model database data are used to generate Scenario Traffic Files (STFs) for the network model and simulation.

Section 5. describes the application of the Traffic Model to specific scenarios and Section 6. summarizes the task completion report.

SECTION 2

MODELING AND SIMULATION

2.1 Modeling and Simulation Objective

The objective of this modeling and simulation project is to design and develop software models that can be used to simulate selected aspects of the ISDN communications satellite with sufficient fidelity to assist in its design. This end-to-end simulation will include sufficient functionality to demonstrate the interactions between each of the four modeling and simulation phases: database generation, scenario generation, simulation run, and product generation.

2.2 Major Modeling and Simulation Tasks

The major modeling and simulation tasks for this SCAR Project are depicted in Figure 2.2-1, "Task Flow Diagram for the SCAR Program". Each of these tasks 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.

2.2.1 Database Generation Program

The Database Generation (DbGen) program assembles the major ISDN user characteristics into a machine readable database. For this NASA SCAR effort 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 3.

2.2.2 Scenario Generation Program

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 initialize the model for a specific ISDN communications satellite design and to exercise that satellite design with requests for ISDN communication services dictated by the Traffic Model. The use of the Traffic Model to generate appropriate ISDN communication scenarios is discussed in Section 4.0.

2.2.3 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. 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.

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

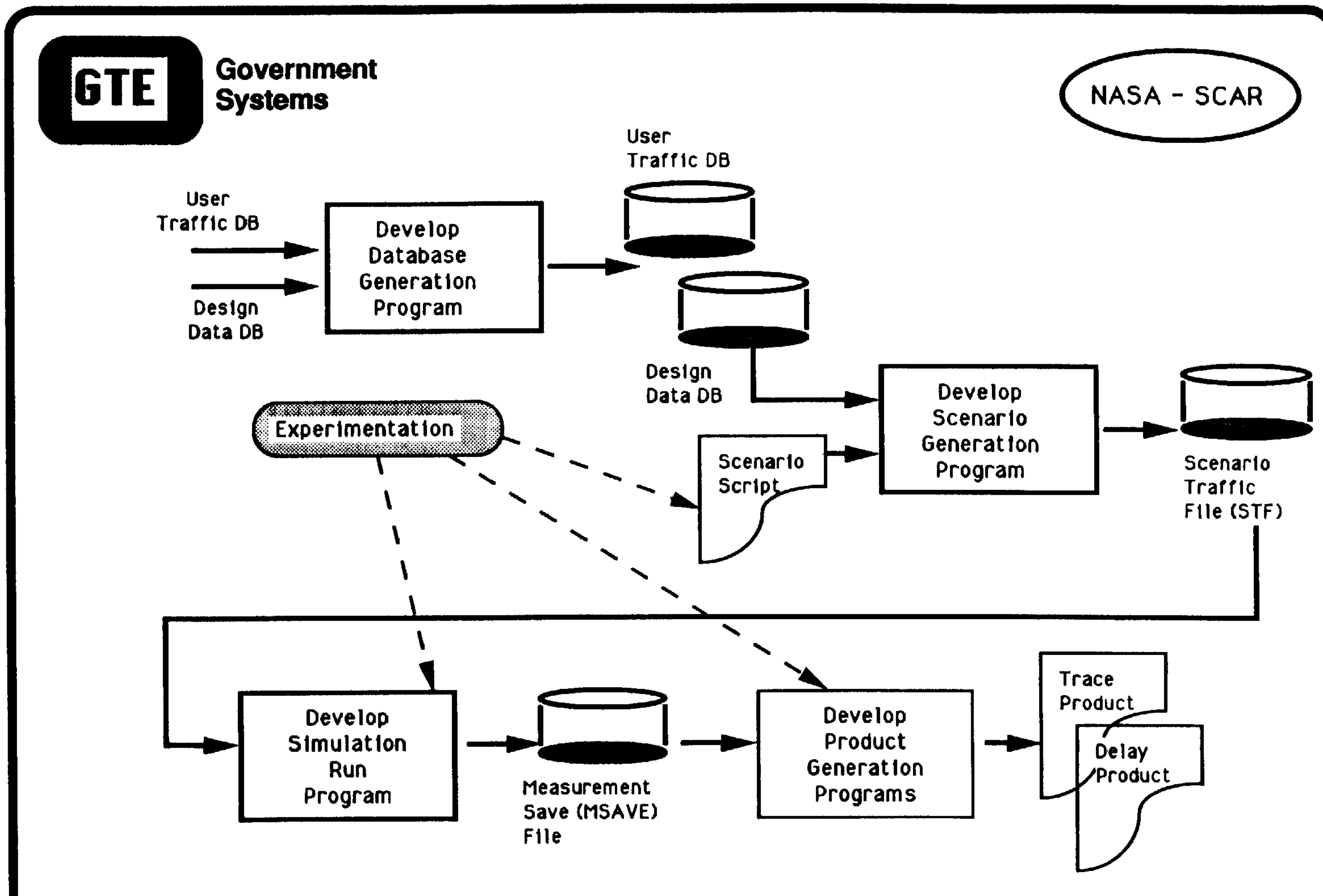

Figure 2.2-1 Task Flow Diagrams for the NASA SCAR Program

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, adding discrete events to the traffic file, and calling other processes in-turn.

2.2.4 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 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 as criteria to evaluate the design parameters, operational procedures and degree of compliance to ISDN communication standards.

SECTION 3

TRAFFIC MODEL

3.1 End-to-End Simulation Program

The ISDN satellite end-to-end simulation is shown in Figure 3.1-1 "End-to-end Model 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 files they share.

3.2 Traffic Model Database

The Scenario Generation (ScenGen) program reads the Traffic Model database that describes potential ISDN users and the statistical information of the ISDN services requested. 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.

3.2.1 City Reference Database (SCAR DB1)

This database, Table 3.2.1-1, "City Reference Database", 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. 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 5% and 3%.

The geographic coordinates of these of these cities together with their US time-zone are also included in the Traffic Model in order to provide a sub-point for communications satellite operations. These location data will permit 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 3.2.1-1, "CONUS City Locations for NASA SCAR Traffic Model Database". Those cities outlined with an ellipse identify the ACTS-east cities. Those cities outlined 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.

3.2.2 ISDN User versus Industry Database (SCAR DB2)

This database, Table 3.2.2-1, "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. A further Traffic Model refinement could add an other City vs Industry database fields 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.

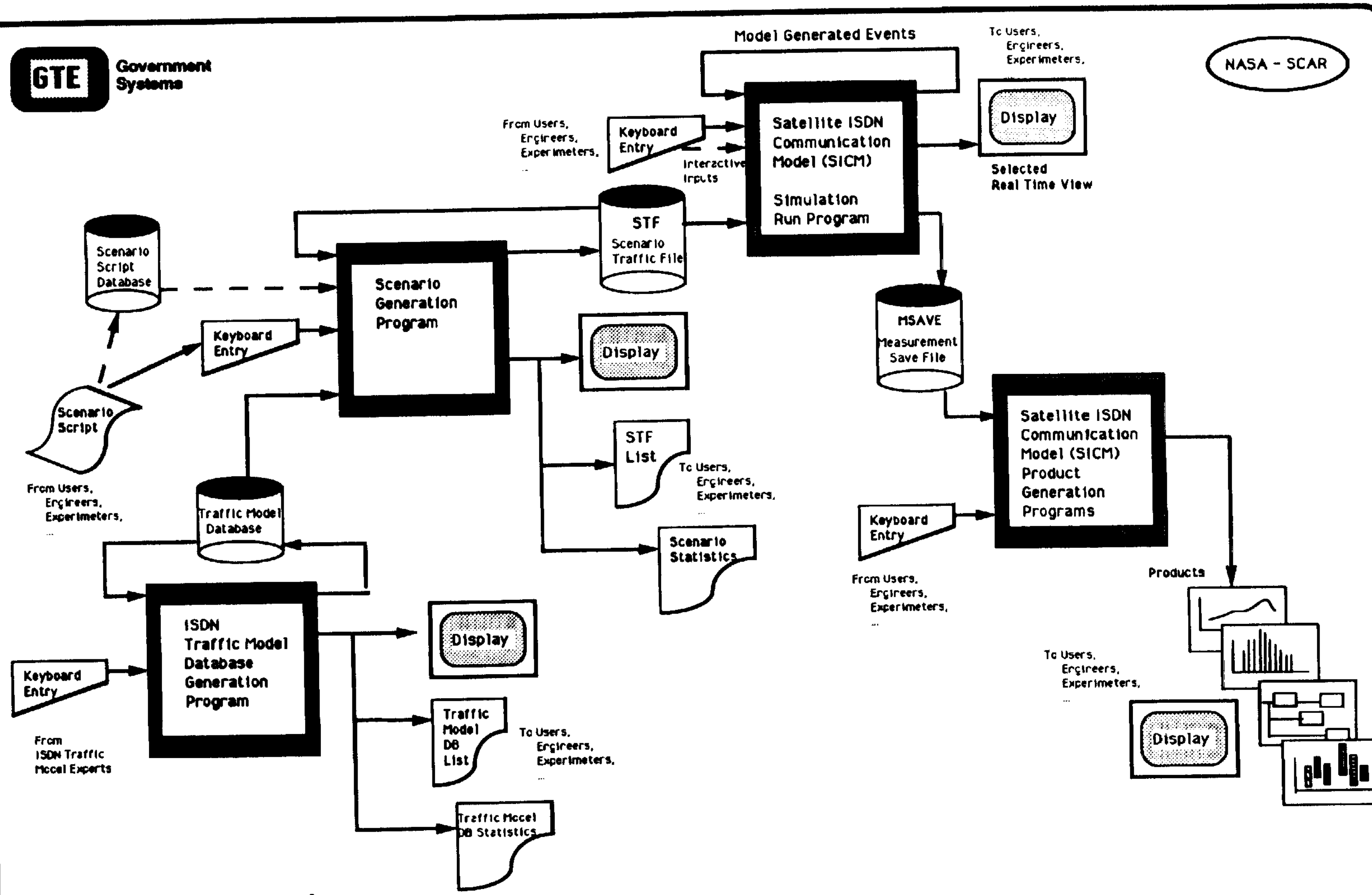

Figure 3.1-1 End to End ISDN Model Architecture

Table 3.2.1-1 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	2421	47	-122	3.40	-3
Portland-Vancouver	1414	45	-122	3.10	-3
San Francisco-Oakland-San Jose	6042	37	-122	4.00	-3
Sacramento	1385	38	-121	3.30	-3
Los Angeles-Anaheim-Riverside	13770	34	-118	4.50	-3
San Diego	2370	32	-117	3.30	-3
Phoenix	2030	33	-112	3.30	-2
Salt Lake City-Ogden	1065	40	-111	3.10	-2
Denver-Boulder	1858	39	-103	3.10	-2
Houston-Galveston	3641	32	-100	3.40	-1
San Antonio	1323	30	-98	3.10	-1
Oklahoma City	964	35	-97	3.20	-1
Dallas-Fort Worth	3766	32	-97	3.40	-1
Kansas City	1575	39	-94	3.10	-1
Minneapolis-St. Paul	2388	44	-93	3.30	-1
St. Louis	2467	38	-90	3.20	-1
Memphis	979	35	-90	3.10	-1
New Orleans	1307	29	-90	3.10	-1
Milwaukee-Racine	1572	42	-87	3.10	-1
Chicago-Gary Lake County	8181	41	-87	3.90	0
Indianapolis	1237	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	1728	39	-84	3.20	0
Dayton-Sprigfield	948	39	-84	3.20	0
Atlanta	2737	33	-84	3.20	0
Detroit-Ann Arbor	4620	42	-83	3.30	0
Columbus	1344	39	-83	3.10	0
Tampa-St. Petersburg-Clearwater	1995	27	-82	3.20	0
Cleveland-Akron-Lorain	2769	41	-81	3.30	0
Jacksonville	898	30	-81	3.10	0
Orlando	971	28	-81	3.20	0
Pittsburgh-Beaver Valley	2284	40	-80	3.20	0
Charlotte-Gastonia-Rocky Hill	1112	35	-80	3.10	0
Miami-Fort-Lauderdale	3001	25	-80	3.30	0
Greensboro-Winston-Salem-High	925	36	-79	3.10	0
Buffalo-Niagara Falls	1176	42	-78	3.20	0
Rochester	980	43	-77	3.20	0
Washington	3734	38	-77	3.30	0
Richmond-Petersburg	844	37	-77	3.20	0
Baltimore	2342	39	-76	3.20	0
Philadelphia-Winington-Trenton	5963	39	-75	3.80	0
Norfolk-Virginia Beach-Newport News	1380	36	-74	3.20	0
Hartford-New Britain-Middleton	1068	42	-73	3.00	0
Albany-Schenectady-Troy	851	42	-73	3.20	0
New York-New Jersey-Long Island	18120	40	-73	5.00	0
Boston-Lawrence-Salem	4110	42	-71	3.30	0
Providence-Pawtucket-Fall River	1125	41	-71	3.00	0
San Juan-Caguas-Ponce, PR	550	18	-66	3.20	1
54 Count				5.00 Max	
				3.29 Avg	
				3.00 Min	

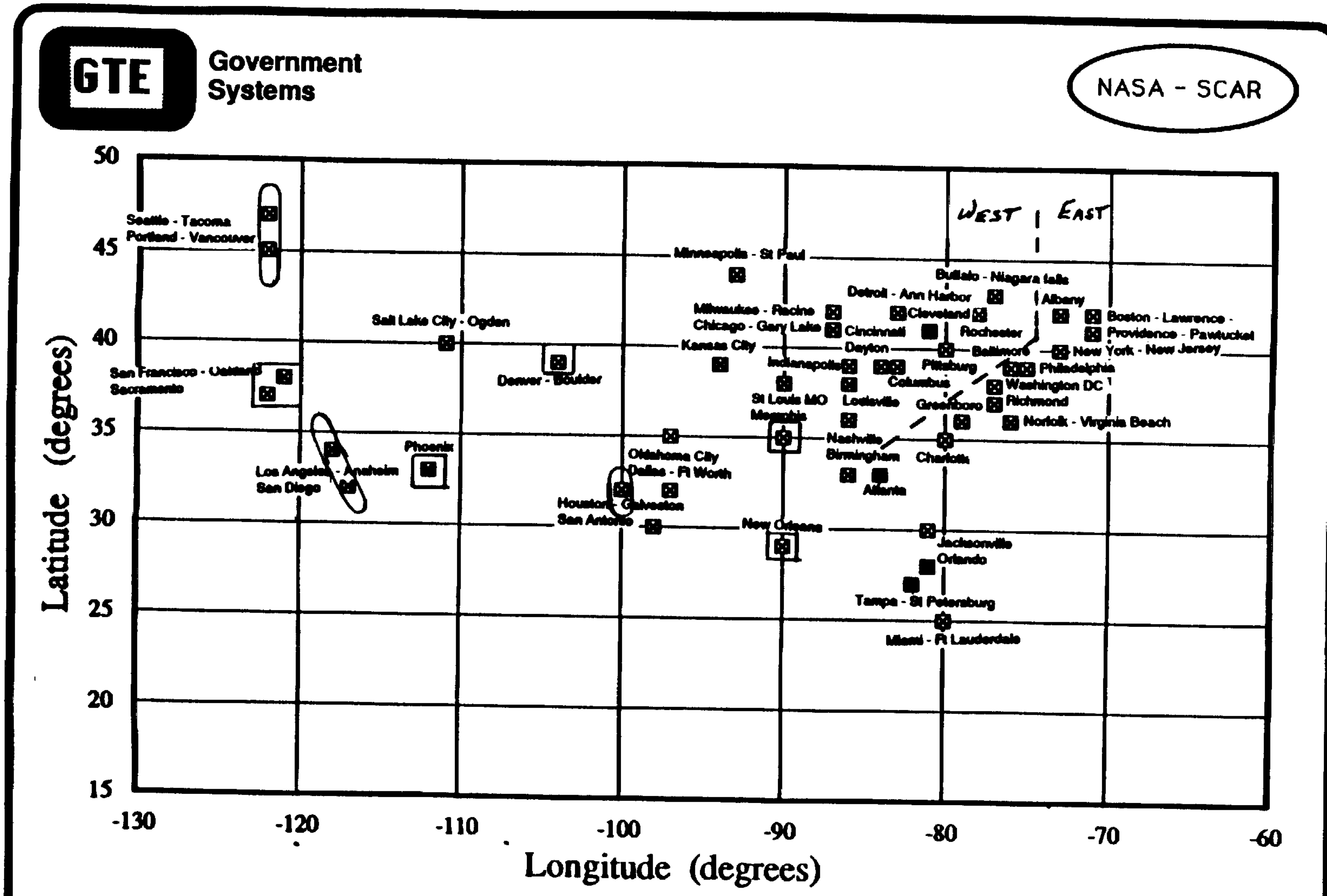

Figure 3.2.1-1 CONUS City Locations for NASA SCAR Traffic Model Database

Table 3.2.2-1 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

3.2.3 Application versus Industry Database (SCAR DB3)

This database, Table 3.2.3-1, "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 to permit each application to contribute in a normalized fashion. This normalization process provides a degree of comparison of communication utility among industries. The Communications Check Sum indicates how much aggregate communication is used by each industry. A cursory review of the data in Table 3.2.3-1 reveals that the below listed user categories fall in the top and bottom ends of the utilization distribution as shown.

This ranking agrees with the project participants intuitive feel and, therefore, adds a small degree of credibility to the data.

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	

3.2.4 Application versus Time Database (SCAR DB4)

This database, Table 3.2.4-1, "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, local time.

3.2.5 Application vs ISDN Bearer Service Database (SCAR DB5)

This database, Table 3.2.5-1, "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 3.2.3-1 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 3.2.4-1 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 Normalization %*
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 3.2.5-1 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.

3.3 Traffic Model E-R Diagram

The Traffic Model database is described in terms of an Entity-Relationship diagram. As shown in Figure 3.3-1, "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 contain 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 indicates 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.

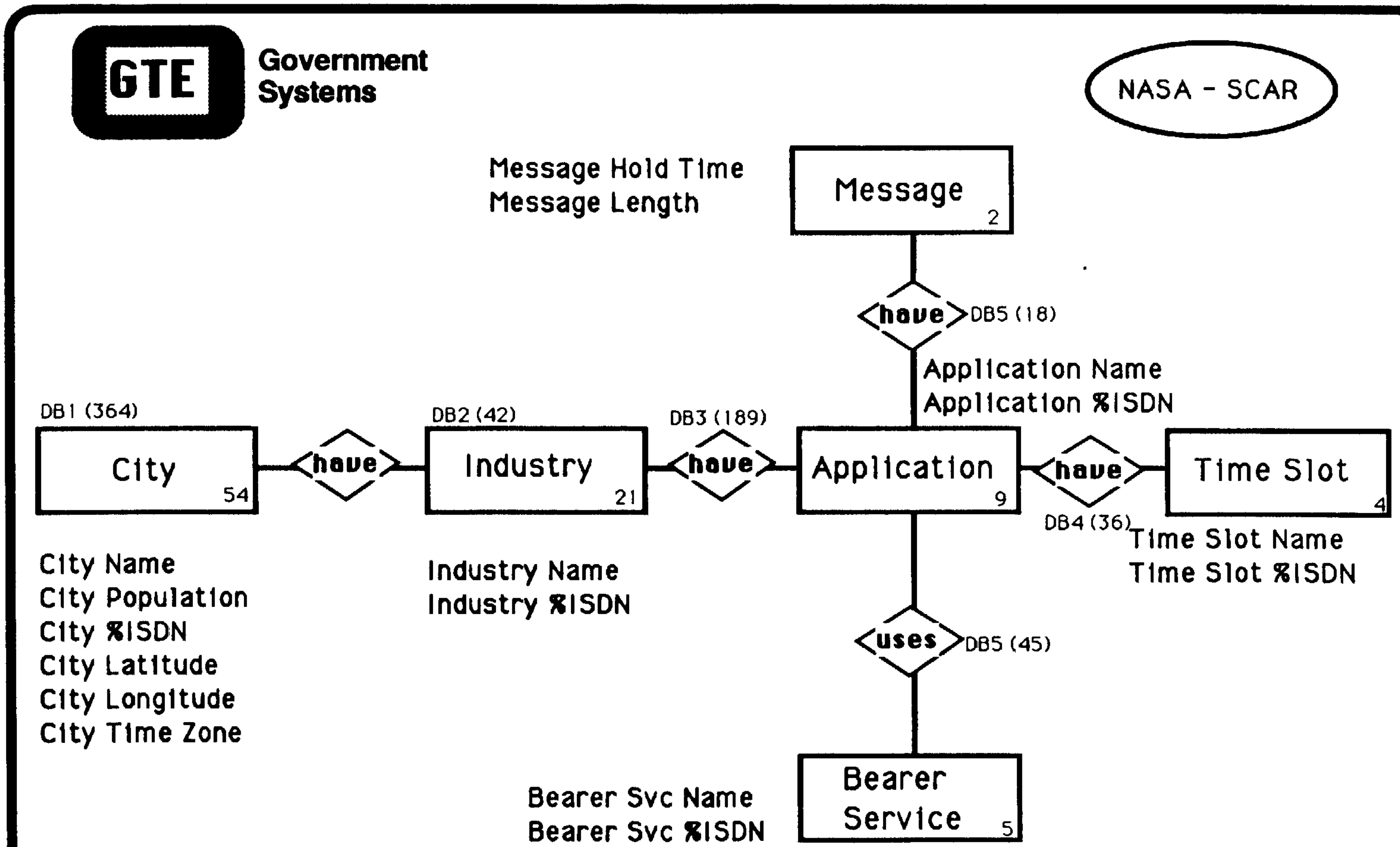

Figure 3.3-1 Entity-Relationship Diagram for the NASA SCAR Traffic Model

SECTION 4

SCANARIO GENERATION

4.1 Scenario Generation Process

The scenario generation process uses the data from the Traffic Model database, described in Section 3.0 to generate a scenario traffic file (STF) of initial discrete events for the discrete event simulations described in Section 2.2.3. 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 looks like:

Time	CallRef#	Action	Resources	Orig City	Dest City
0800	**1012**	**Rqst**	**CS64**	**Balt**	**Chi**

The corresponding discrete event terminating this call, 31 minutes after its initiation, looks like:

Time	CallRef#	Action
0831	**1012**	**Term**

In the STF discrete event terminating service the unique CallRef# is sufficient to identify the service being terminated.

4.2 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 74,994.

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 term of those applications 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	90	0	0
Communication	450	0	0
Education	225	0	0

	CS64KBPS	CS128KBPS	DX25
Facsimile	*80%*	*15%*	*2%*
Broadcast	72	2	1
Communication	360	56	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 calls 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	90 2/29/46/13	0 0/0/0/0	0 0/0/0/0
Communication	450 11/144/230/65	0 0/0/0/0	0 0/0/0/0
Education	225 6/72/114/33	0 0/0/0/0	0 0/0/0/0

	CS64KBPS	CS128KBPS	DX25
Voice(Message)	*100%*	*0%*	*0%*
Broadcast	90 2/29/46/13	0 0/0/0/0	0 0/0/0/0
Communication	250 6/77/122/35	0 0/0/0/0	0 0/0/0/0
Education	225 6/72/114/33	0 0/0/0/0	0 0/0/0/0

	CS64KBPS	CS128KBPS	DX25
Facsimile	*80%*	*15%*	*2%*
Broadcast	72 2/23/37/10	2 0/1/1/0	1 0/0/1/0
Communication	360 9/115/184/52	56 2/18/28/8	15 0/5/8/2
Education	180 5/58/91/26	34 1/11/7/5	5 0/2/2/1

Within each of these time-slots the ISDN service calls are assumed to be uniformly distributed. In our example, the 90 ISDN voice(interactive) calls from Baltimore that are associated with the broadcast industry that use the CS64KBPS ISDN bearer service fall into a 2/29/46/13 time-slot distribution pattern. This means that :

2 ISDN call will be selected from a uniform distribution between 0001-0800 hrs,
29 ISDN calls will be selected from a uniform distribution between 0801-1200 hrs,
46 ISDN calls will be elected from a uniform distribution between 1201-1800 hrs, and
13 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 STF for initiating these 90 ISDN voice(interactive) calls from Baltimore could look like:

Time	CallRef	Action	Rersour	OrigCity	DestCity
0700	0001	Rqst	CS64	Balt	*
0815	0002	Rqst	CS64	Balt	*
0830	0003	Rqst	CS64	Balt	*
...					
1148	0015	Rqst	CS64	Balt	*
1215	0016	Rqst	CS64	Balt	*
1232	0017	Rqst	CS64	Balt	*
...					
2347	0090	Rqst	CS64	Balt	*

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

6. 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 90 CS64KBPS voice(interactive) calls the hold-time is 3 minutes. Using a uniform distribution with a parametric value of 3, hold-times are determined for each ISDN call request. That hold-time is added to the call request event time to determine the call termination event time. The resulting STF is shown below. The unique CallRef# is sufficient to handle the disconnect request.

Time	CallRef	Action	Rersour	OrigCity	DestCity
0700	0001	Rqst	CS64	Balt	*
0702	0001	Term			
0815	0002	Rqst	CS64	Balt	*
0818	0002	Term			
0830	0003	Rqst	CS64	Balt	*
0831	0003	Term			
...					
1158	0015	Rqst	CS64	Balt	*
1201	0015	Term			
1215	0016	Rqst	CS64	Balt	*
1218	0016	Term			
1232	0017	Rqst	CS64	Balt	*
1233	0017	Term			
...					
1749	0038	Rqst	CS64	Balt	*
1750	0038	Term			
1816	0039	Rqst	CS64	Balt	*
1818	0039	Term			
1915	0040	Rqst	CS64	Balt	*
1918	0040	Term			
...					
2347	0090	Rqst	CS64	Balt	*
2349	0090	Term			

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

4.3 Scenario Generation Results

This STF suitably represents the ISDN user traffic for the SCAR network model and discrete event simulation. 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 4.3-1, "Scenario Generation Example".

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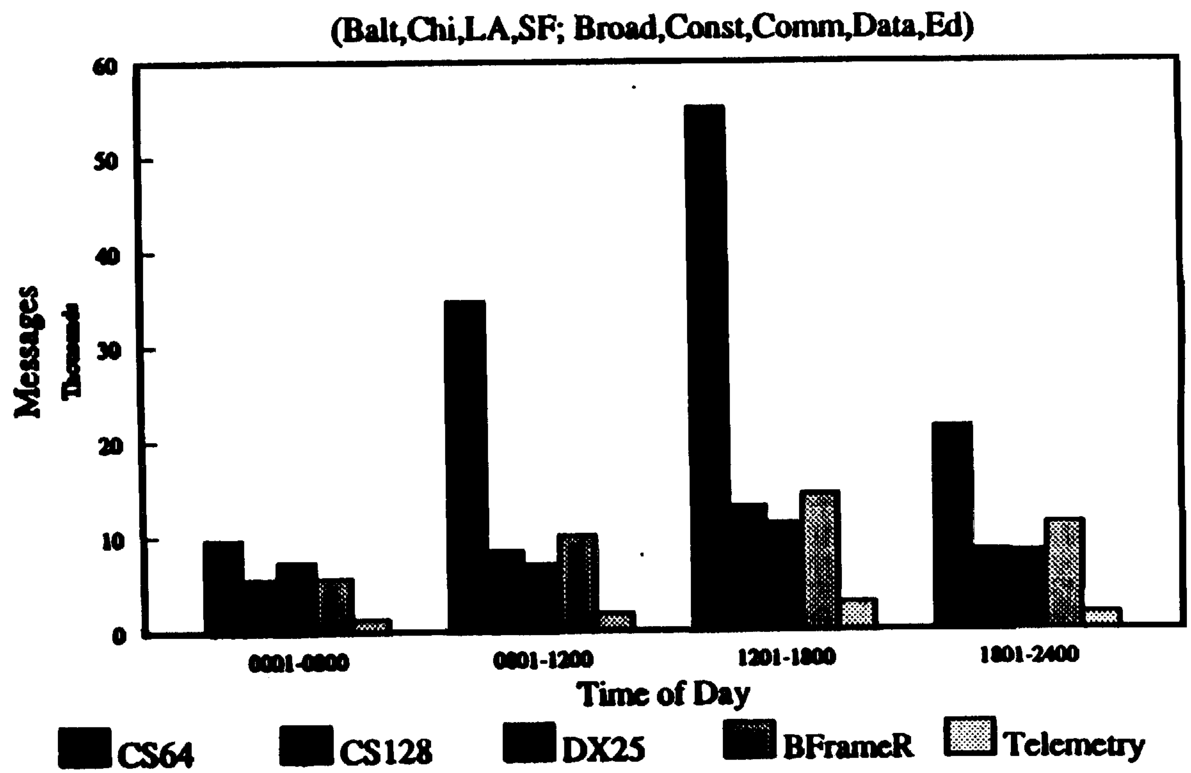

Figure 4.3-1 Scenario Generation Example

SECTION 5

APPLICATION OF TRAFFIC MODEL TO SCENARIOS

5.1 Scenario Scripts

Scenario scripts consist 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 scenario scripts 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 communication satellite topology, design parameters, and environment are part of the simulation initial conditions. The subsequent Traffic Model scenario discrete events requesting and relinquishing ISDN bearer services act in concert with these design parameters.

5.2 Scenario Scripts Types

Four types of scenarios will be used in 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 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 used as a 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 Model 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 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 use a message scale factor to systematically increase the traffic cited in the Traffic Model 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 scenarios will be developed on a demand basis to investigate specific attributes of the ISDN communications satellite design and to verify the assumptions used in the Traffic Model. At least one special scenario will be developed for this NASA SCAR Program

5.3 Scenario Scripts Options

The rationale for a scenario script must include a list of Traffic Model database components that are to participate in the scenario. Figure 5.3-1, "Scenario Selection Options for the Traffic Model", 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 4.2 to generate a STF for the ISDN network model simulation. By selecting combinations of cities, industries,

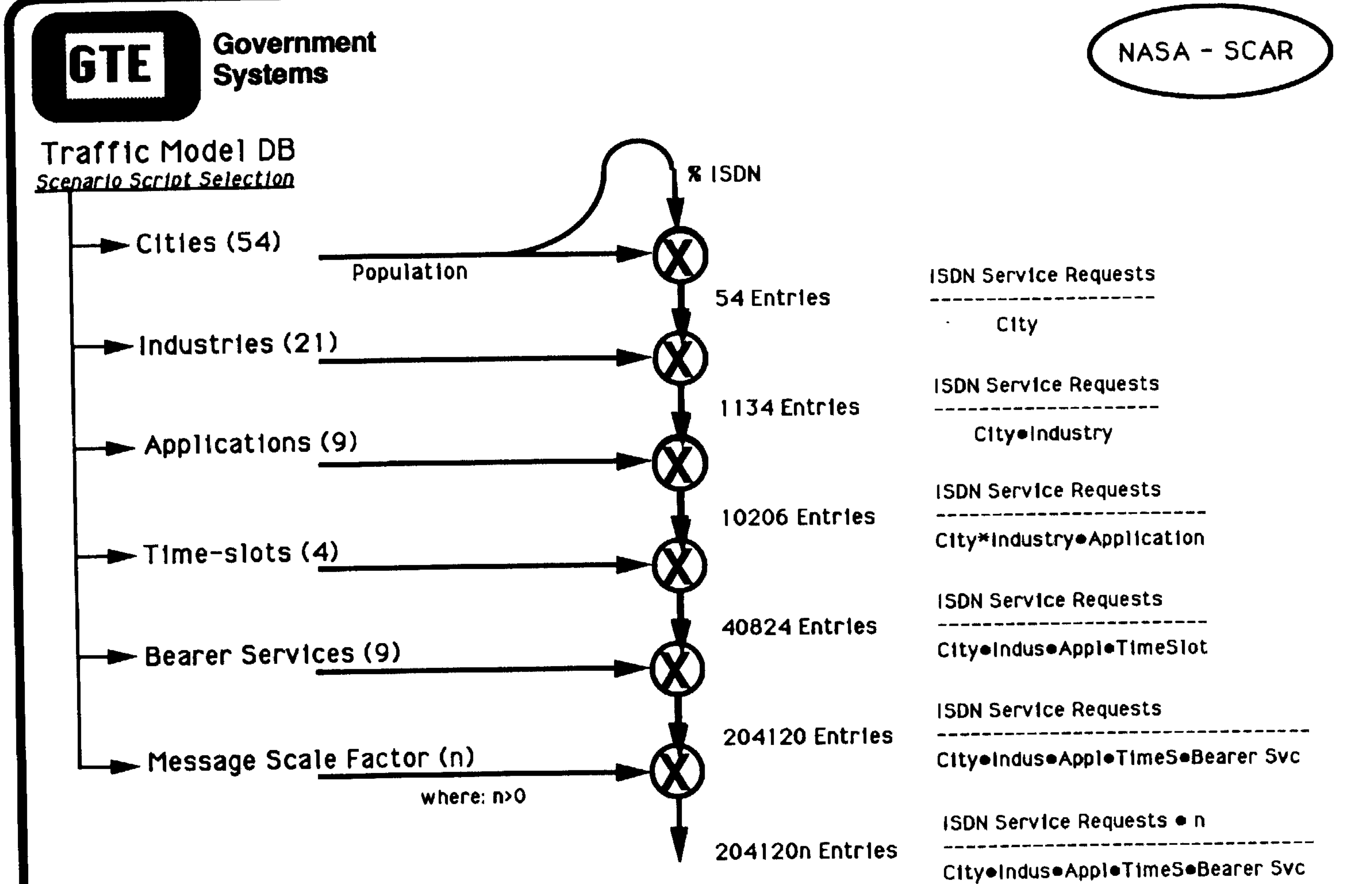

Figure 5.3-1 Scenario Script Selection Options for Traffic Model