C

CONVERGED COMMAND, CONTROL, AND COMMUNICATIONS TECHNICAL INTERCHANGE MEETING

Prepared for:

DOD/AFSMC and
DOC/ NOAA NESDIS

27 SEPTEMBER 1994

CONTRACT F04701-91-C-0068

Prepared by:

Lockheed
Missiles & Space Company, Inc.
SUNNYVALE, CALIFORNIA
94088-3504

1.10

C

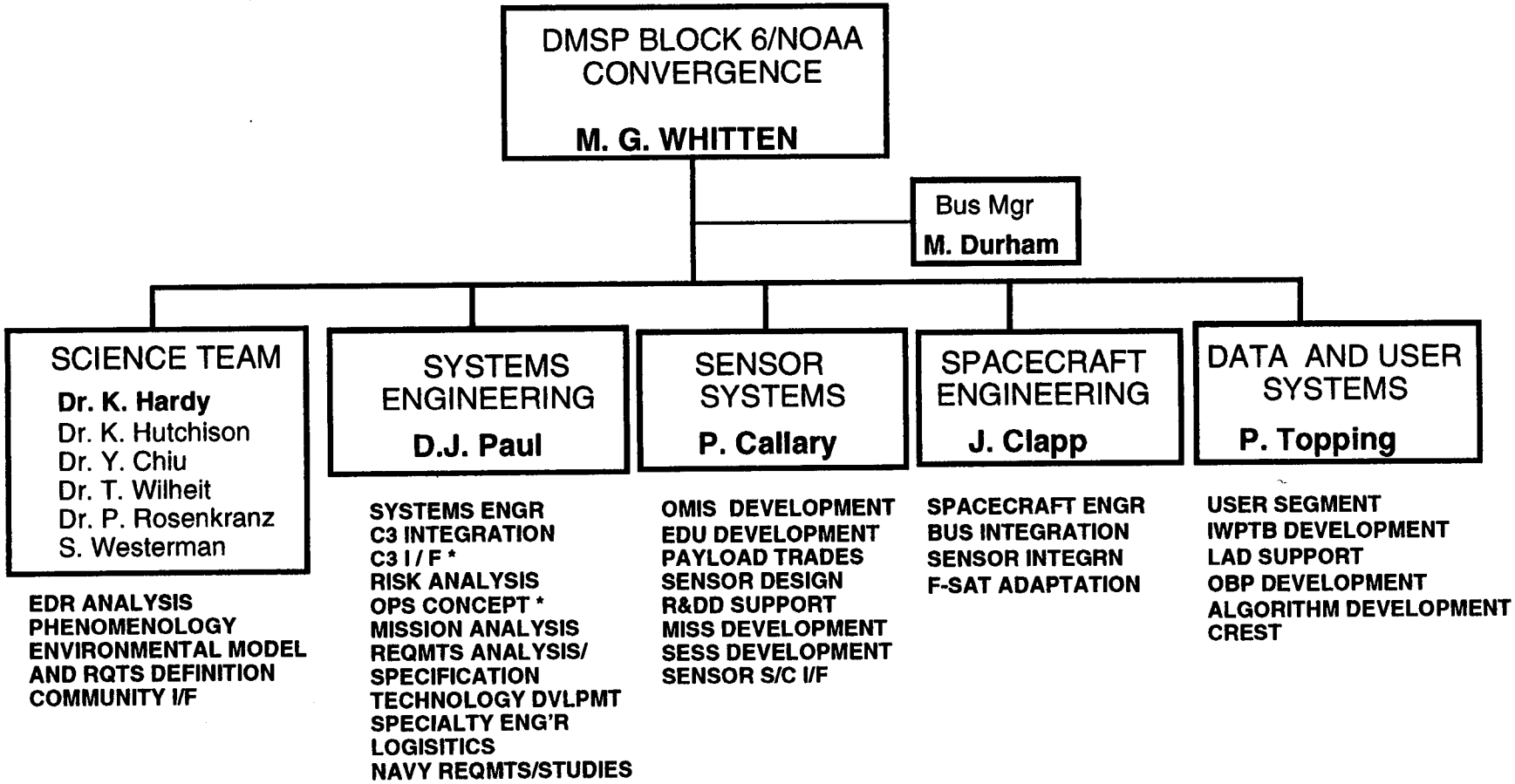
AGENDA & INTRODUCTION

D. PAUL

C AGENDA

TIME	TOPIC	PRESENTER
1000 - 1030	Agenda & Introduction	D. PAUL
1030 - 1100	IPO / SPO & NOAA Inputs	Capt. VASQUEZ
1100 - 1130	Requirements Allocation & Flowdown	R. NELSON
1130 - 1200	Timeliness Analysis Results	J. HARRISON
1200 - 1245	Lunch	
1245 - 1315	Requirements Impacts & Issues	R. NELSON
1315 - 1345	Data Compression Summary for Realtime Links	D. TOM
1345 - 1430	DRR - GUS Architecture	D. EMANUEL
1430 - 1500	C2 - SOC Analysis	R. WOLL
1500 - 1530	COTS Approach to C2	R. HAMER
1530 - 1600	C3 Segment Life Cycle Cost	D. PAUL
1600 - 1615	C3 Segment Specification Development	D. PAUL
1615 - 1630	Summary	D. PAUL

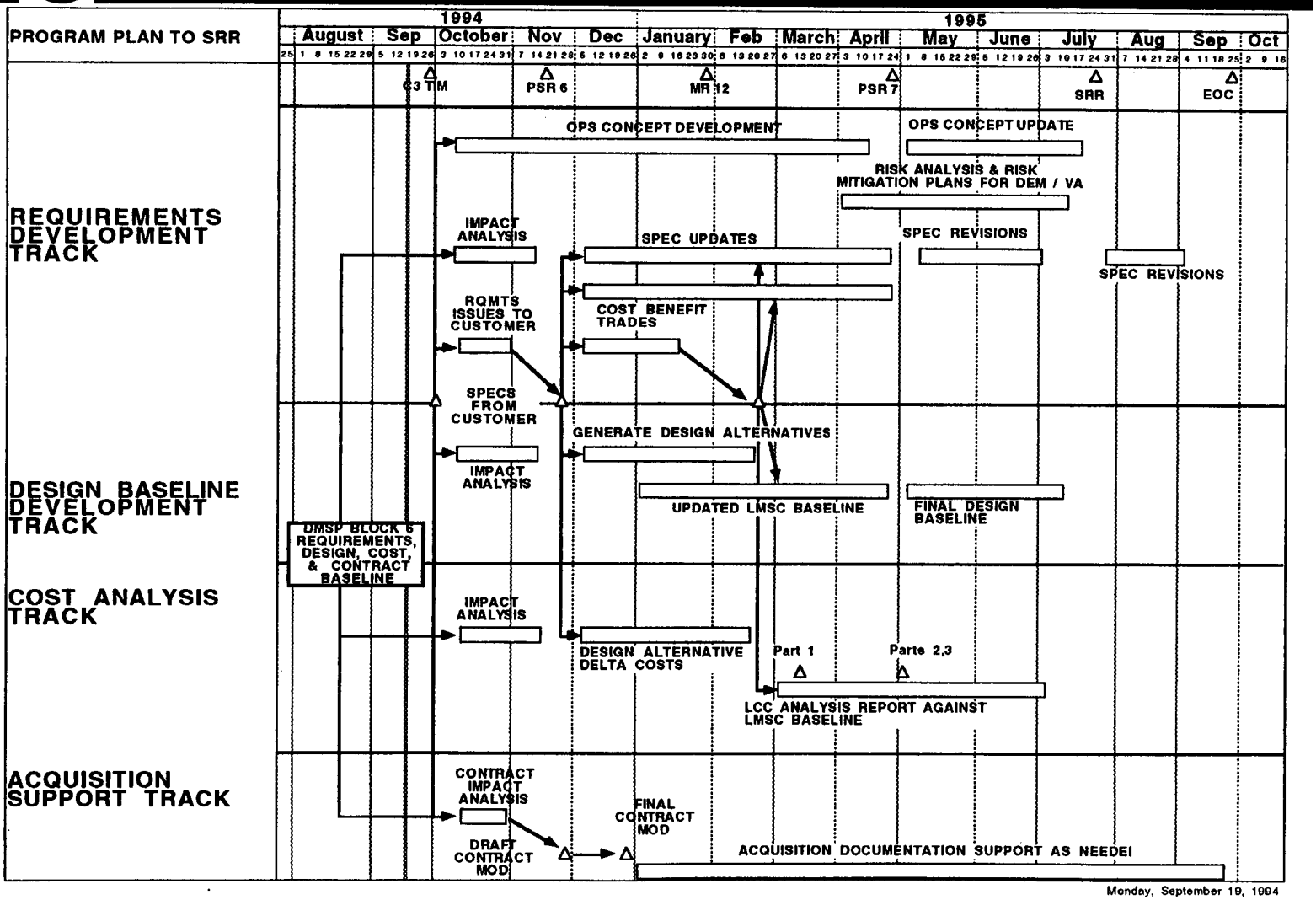
C PROGRAM ORGANIZATION



* LTOC Lockheed Technical Operations Co

PROGRAM PLAN TO SRR

C



C SYSTEM ENGINEERING FUNCTIONS

- SYSTEM ARCHITECTURE TRADES
- RISK EVALUATION
- COST TRADES
- REQUIREMENTS DEVELOPMENT AND ALLOCATION
- REQUIREMENTS GENERATION AND VALIDATION
- PROGRAM PLANNING SUPPORT
- ASSURANCE OF COMPLIANCE TO SPECS
- IDENTIFICATION OF EMERGING REQUIREMENTS
- DEFINITION OF USER INTERFACE
- MONITORING PROGRAM TECHNICAL PROGRESS
- MONITORING OPERATIONS

CONVERGED C3 TIM OBJECTIVES

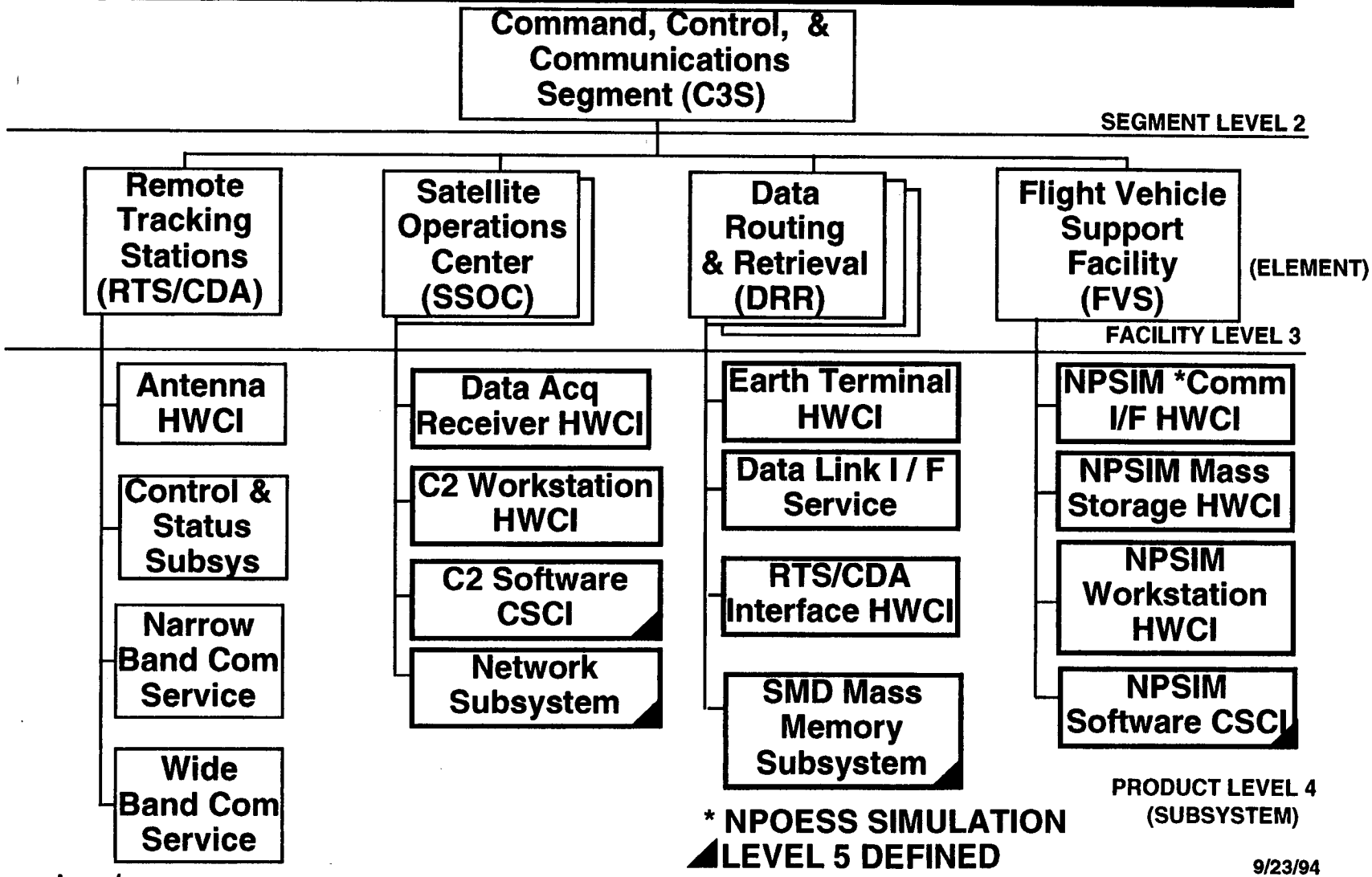
- REVIEW CONVERGED SEGMENT FUNCTIONS
- REVIEW SYSTEM / SEGMENT REQUIREMENTS
- REVIEW DRIVING REQUIREMENTS IMPACTS
  - Integrated, End - to - End Architecture
- PRESENT TRADES
  - SMD
  - DRR
  - Realtime Data Characteristics
  - COTS Benefits
- REVIEW SEGMENT BASELINE & CAPABILITIES
  - Describe Operations: Data flow, loading, and timeliness
  - SOC Configuration: Man - machine interfaces
- LIFE CYCLE COST OVERVIEW
- REVIEW C3 SEGMENT SPEC OUTLINE AND PLANS

C CONVERGED C3 SEGMENT DEFINITION

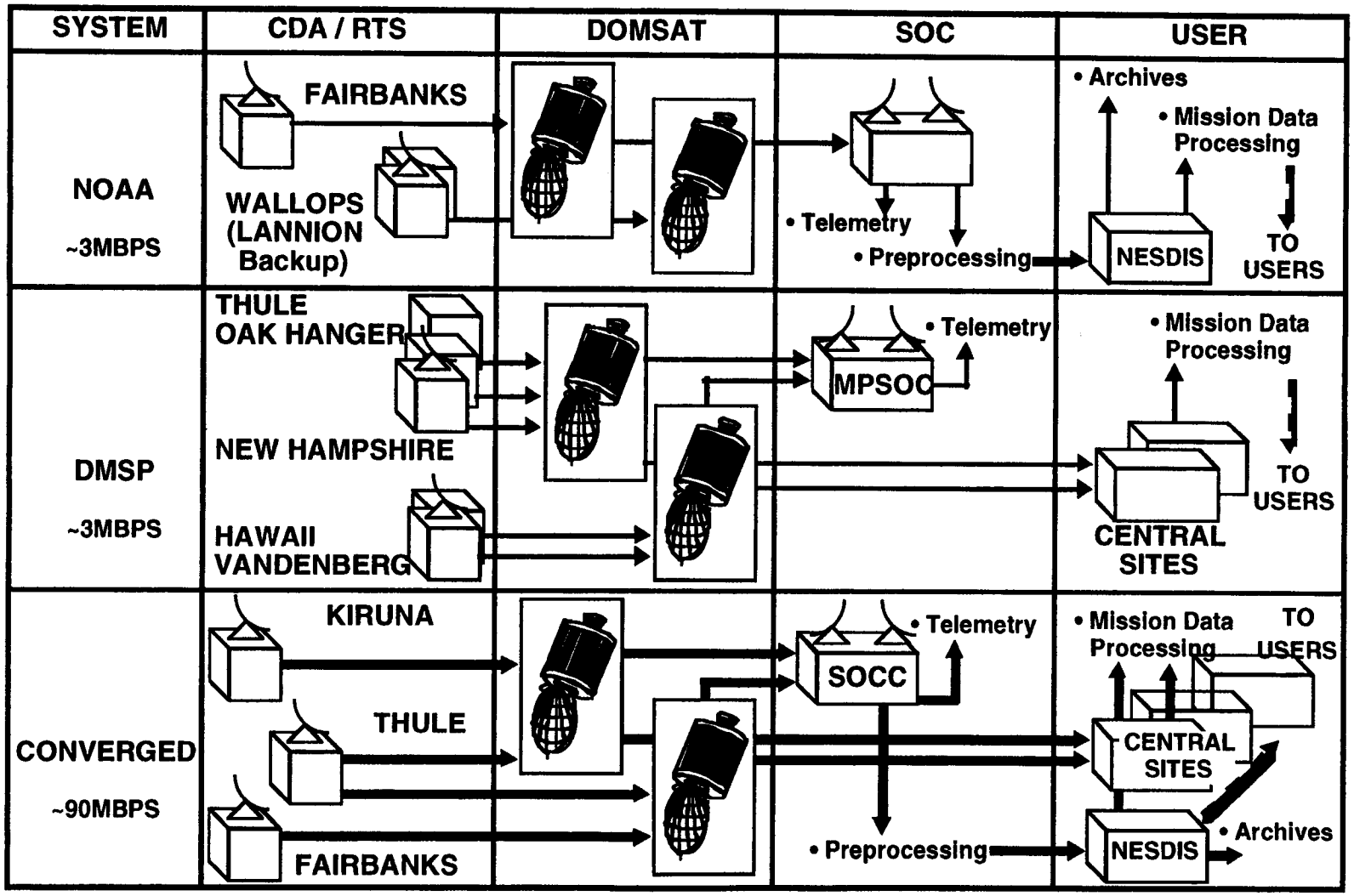
MISSION: Provide an enduring and survivable capability, through all levels of conflict consistent with the survivability of the supported forces, to collect and disseminate global meteorological, oceanographic, and solar-geophysical data required to support worldwide DoD and civilian operations and high-priority programs.

APPROACH: Through analysis and trade studies of facilities, operational procedures, and costs; optimize the use of existing capabilities and proposed upgrades into a fully converged cost effective C3 segment.

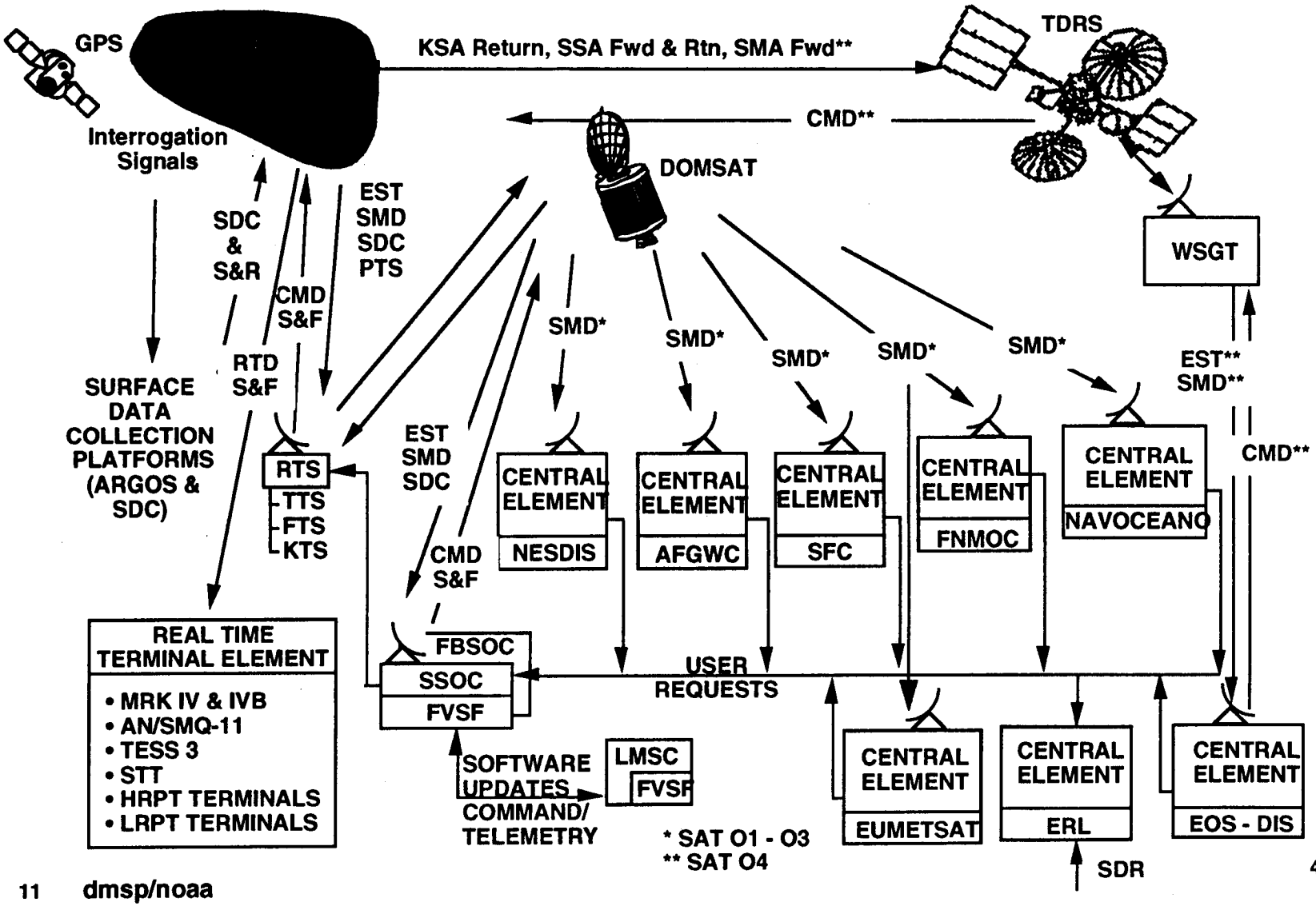
C CONVERGED C3 SEGMENT HIERARCHY



C DATA GROWTH: A TRANSITION CHALLENGE



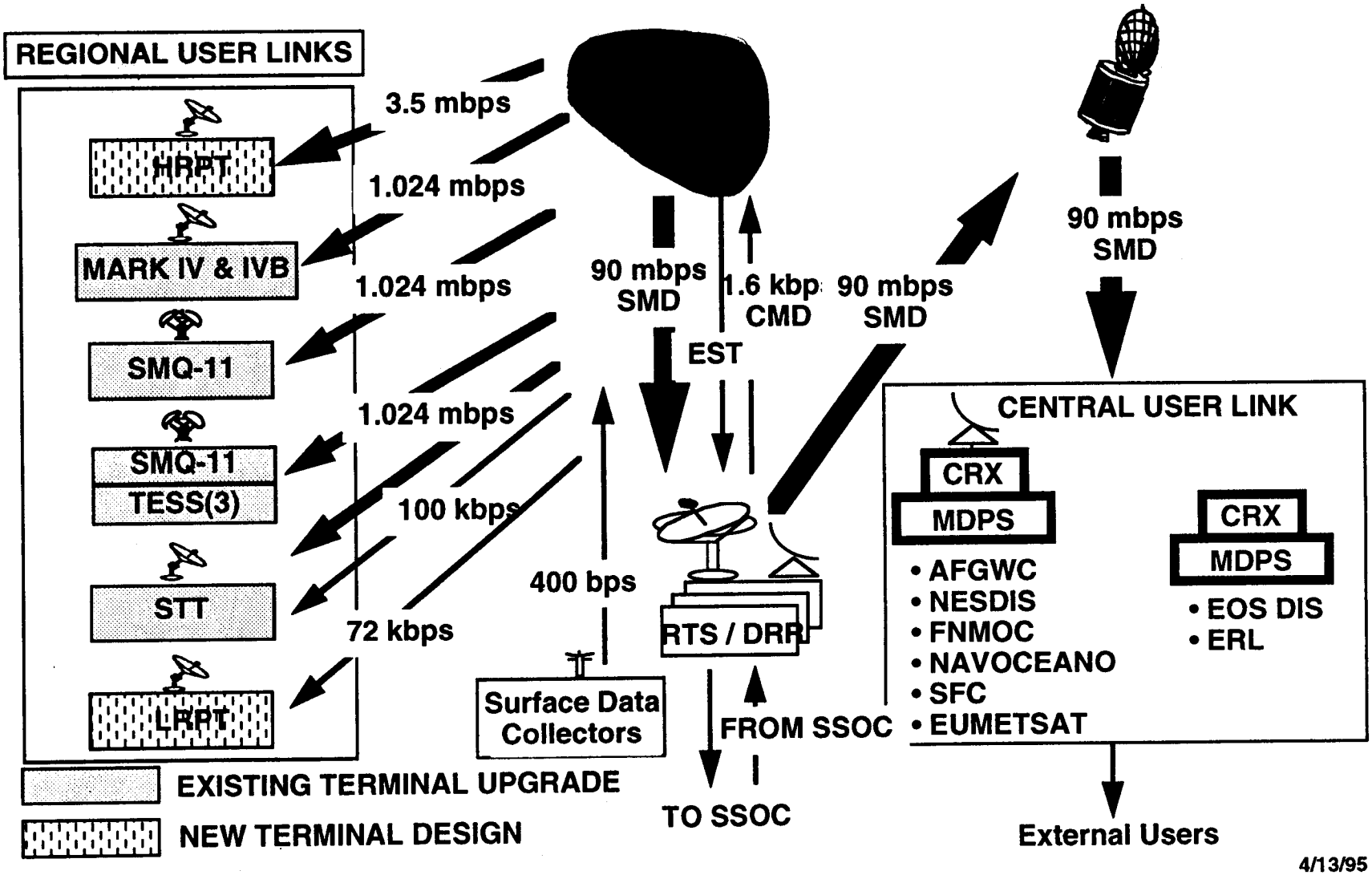
C CONVERGED SYSTEM BASELINE ARCHITECTURE



4/13/95

CONVERGED SYSTEM LINK OVERVIEW

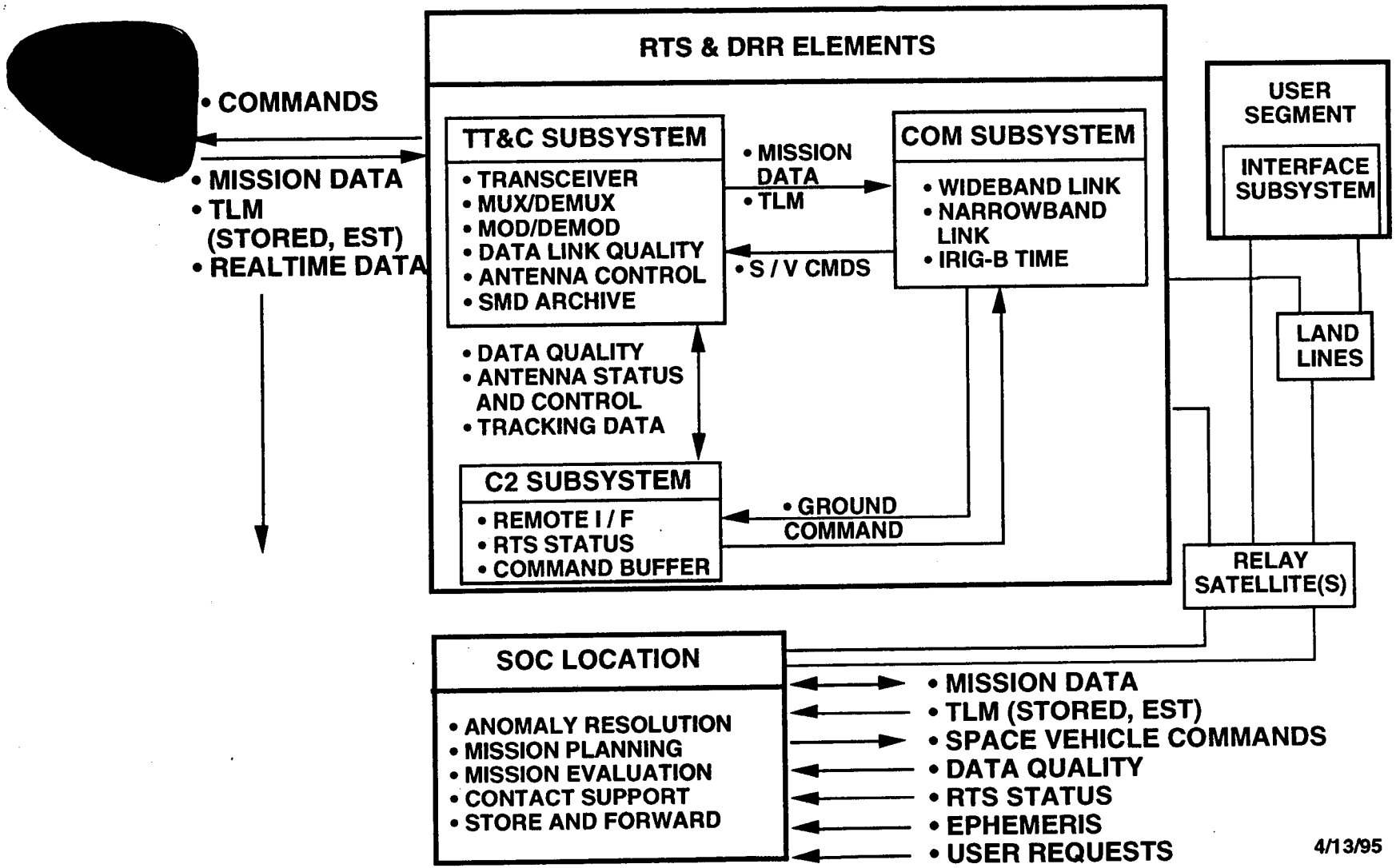
C



4/13/95

INTEGRATED OPS CONCEPT IMPACTS

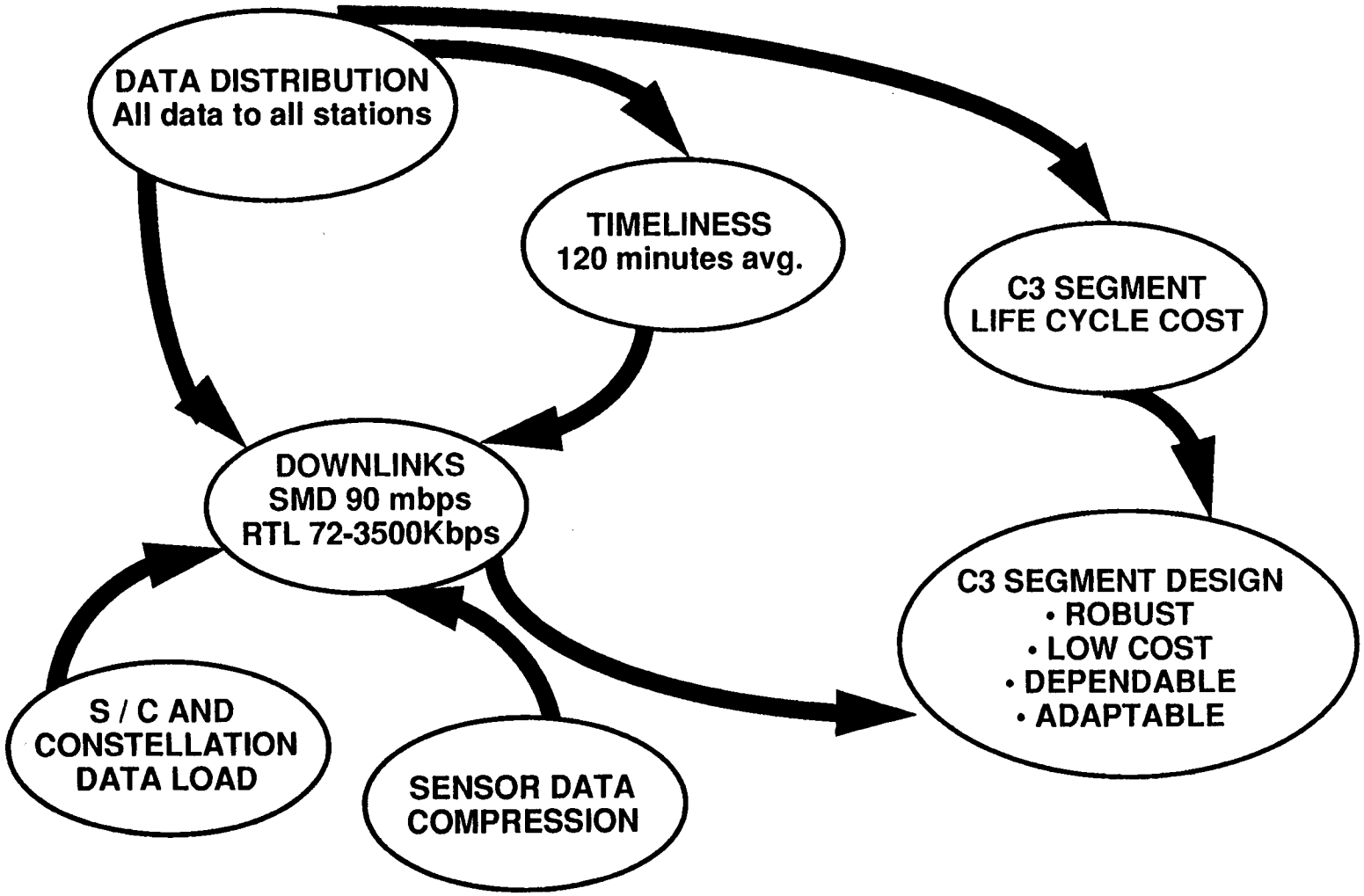
C



4/13/95

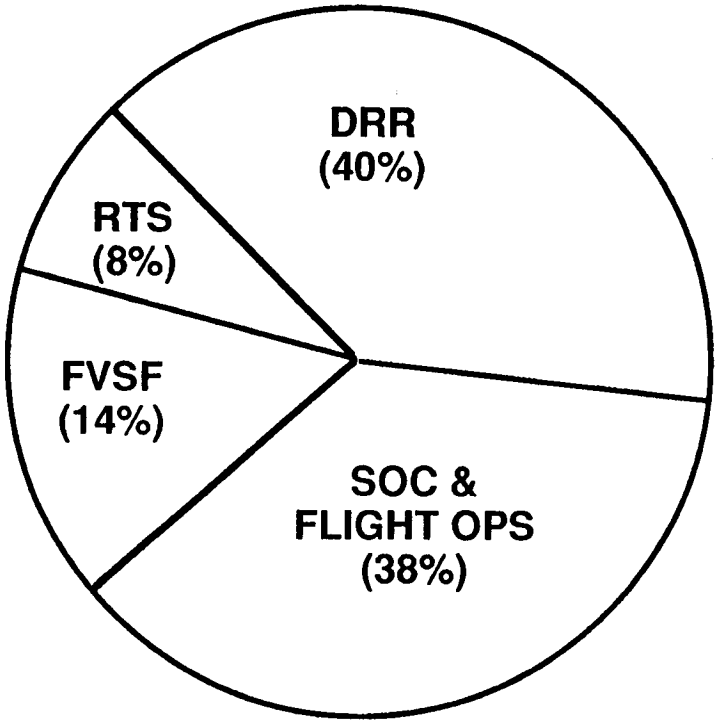
SIGNIFICANT REQUIREMENTS

C



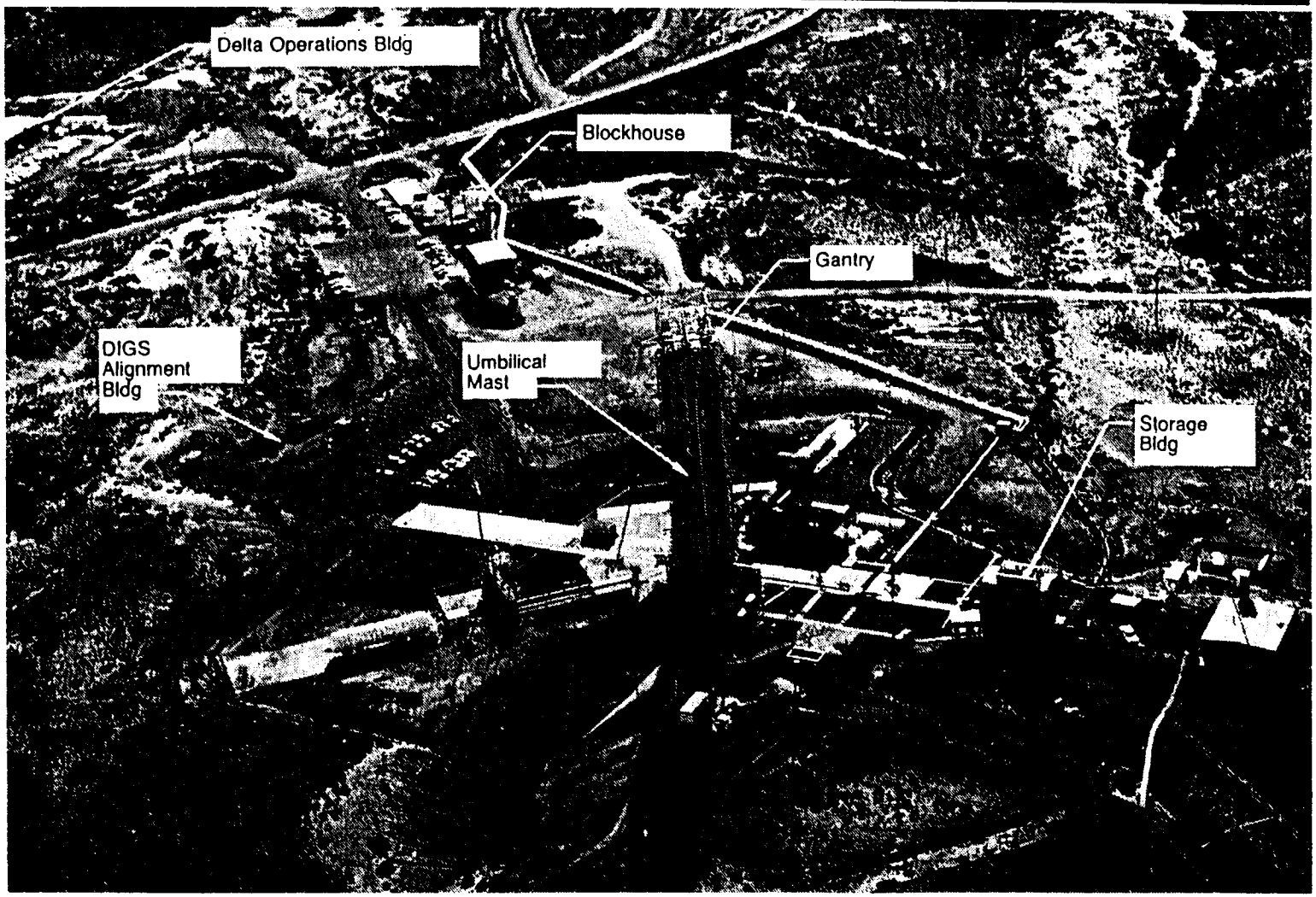
PAGE 15 IS EXEMPT FROM RELEASE AND IS REPLACED WITH THIS PAGE.

C COST OVERVIEW



COST BREAKOUT BY ELEMENT AS A PERCENTAGE OF TOTAL COST OF C3 SEGMENT

C VANDENBERG LAUNCH COMPLEX



C DISCUSSION OF BASELINE ASSUMPTIONS

- CONVERGED EDR MEASUREMENT ACCURACIES:
  Although the measurement accuracy (MA) needs of Central Users and Regional Users vary from site to site, the most stringent MA is carried as a system-wide driving requirement.

- SSOC - CONFIGURATION:
  Upgrades to the Suitland SOC for Converged C3 will be developed from the current SOC configuration and manning characteristics. FBSOC will be a duplicate of SSOC.

  The Suitland SOC will be staffed primarily with DoC operations personnel with DoD support representatives.

  A secure communication link will be established at the SSOC.

- TIMELINESS - OUR BASELINE INTERPRETS THE TIMELINESS REQUIREMENT AS FOLLOWS:
  For a 450 nmi orbit, the ground track nearly repeats every eight (8) days. Each orbit the data generation to EDR production time for the oldest bit of data is averaged during the eight day period. Average timeliness during that period will not exceed 120 minutes. (This requires the Central Sites produce EDRs within 19 minutes of data receipt on average)

- REGIONAL TERMINAL DEVELOPMENT:
  Our baseline LCC cost includes the design and development of HRPT and LRPT Regional Terminals. Also included will be the design upgrade for affected DoD terminals.

C DISCUSSION OF BASELINE ASSUMPTIONS

CONTINUED

- RTS / DRR SITE CHARACTERISTICS:
  Our baseline assumes by 2002 communication facilities at Fairbanks and Kiruna will have dual X-band capabilities for SMD and SDN S-Band for C^2. Thule will require upgrade.

- USE OF TDRSS INFRASTRUCTURE:
  Although the EOS baseline requires TDRSS to provide only C^2 for the EOS System, at present our baseline utilizes TDRSS for O4 mission data delivery and C^2.

- DATA DISTRIBUTION TO CENTRALS:
  Our lowest cost baseline approach assumes ERL will receive O1, O2, & O3 SDR archive data via tape delivery. EOS-DIS will only receive O4 SDRs. Additional satellite data sources could be added.

- STORE & FORWARD (S&F):
  The command uplink, S-band at 1.6 kbps, will relay command files and S&F data packets. We assume the S&F will contain binary imagery and the file will be no larger than 1 mb. S&F will be compressed to permit uplink transmissions of both command and S&F in the normal 8 minute pass. S&F downlink will be via realtime links.

DISCUSSION OF BASELINE ASSUMPTIONS

CONTINUED

- COMMAND AND CONTROL FREQUENCIES AND FORMAT:
  Lacking any detailed information on the EUMETSAT C^2 approach, our baseline assumes duplicate non-standard C^2 hardware will be required for EUMETSAT command contingencies.

  During normal operations, to effect positive control, the SSOC, via the RTS, upon approval from EUMETSAT, will directly command O2 via unified S-band, to downlink mission data for TTS and FTS passes. The contingency backup capability is defined as commanding the O2 vehicle into safe mode. The backup capability for O2 is for full commanding capability. (Common SMD frequencies are assumed).

  The EUMETSAT Mission Planning capability will be compatible with the Converged System Mission Planning function.

- TRANSITION:
  During the transition between DMSP / NOAA programs and the converged program, C2 will be conducted from the SSOC. Command and mission data routing will be performed through the existing AFSCN and CDA networks until the converge system is on line.

C

IPO, SPO,

&

NOAA INPUTS

C

REQUIREMENTS ALLOCATION & FLOWDOWN

R. NELSON

"APPLYING THE SYSTEM ENGINEERING PROCESS TO THE C3 SEGMENT"

REQUIREMENT - FUNCTION - FACILITY - PRODUCT ALLOCATION

C CONVERGED MISSION REQUIREMENTS

- DELIVER TIMELY, GIGABIT SIZE DATA RECORDS OF MULTI-SPECTRAL CLOUD DATA AND SPECIALIZED ENVIRONMENTAL DATA TO THE CENTRAL AND REGIONAL USER ELEMENTS

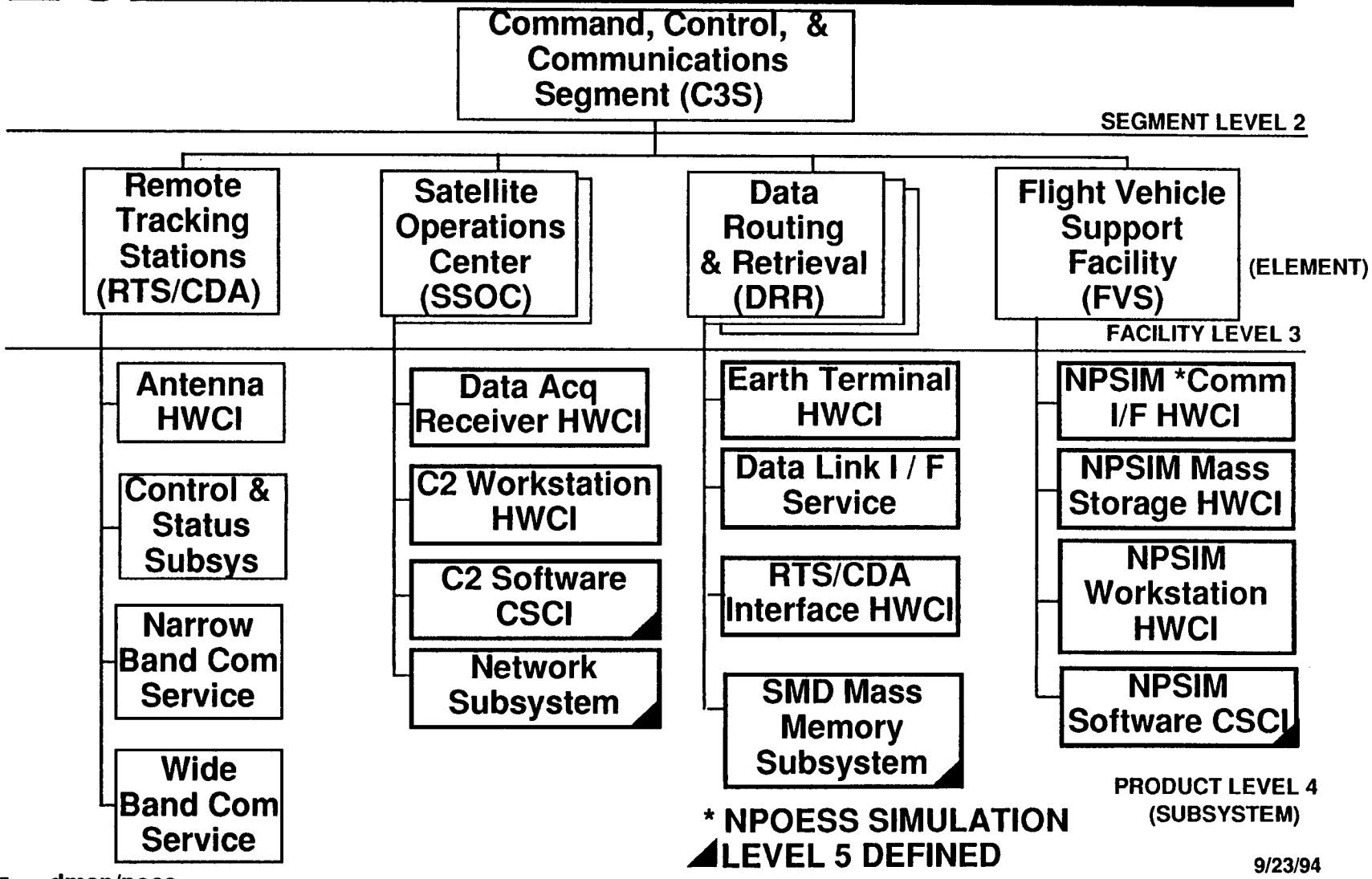
- UTILIZE EXISTING (AND PLANNED) AFSCN AND NOAA RESOURCES TO MAXIMUM EXTENT POSSIBLE

- MAXIMIZE THE UTILITY OF ENVIRONMENTAL DATA PRODUCTS FOR THE LOWEST C3 SEGMENT LIFE CYCLE COST.

C CONVERGED SYSTEM REQUIREMENTS

PARAMETER	REQUIREMENT	CHARACTERISTICS
Constellation	Orbit Type Orbit Altitude Orbit Period Nodal Crossing Time	Circular Sun-Synchronous 450 nmi (833 km) 101.6 min 0530 (All Beta) 0930, 1330, 1330
C3 Segment Elements	Command & Control Data Routing & Retrieval Satellite Operations Center Flight Vehicle Support Facility	NOAA & AFSCN CDA/ RTS sites Suitland MD., Falcon AFB backup SSOC, FBSOC & Contractor (TBR)
Data Link Types	Command & Control Telemetry Stored Sensor Data Realtime Sensor Data	Command Uplink (Store & Forward) EST Downlink (Stored Mission Data) Stored Mission Data Link Real Time Downlink - LRPT,HRPT,Low & High Data Rate Tactical Terminal
	Unique Links	SDC (ARGOS) Uplink SAR Links
Timeliness	120 min. avg. EDR production	

CONVERGED C3 SEGMENT HIERARCHY



9/23/94

CONVERGED C3 SUBSYSTEM AND SOFTWARE LEVEL 5 ITEM DEFINITION

C

C2 Software CSCI

- Telemetry, Health, & Status CSC
- Sys Config CSC
- Commanding CSC
- Scheduling & Planning CSC
- Telem Analysis CSC
- Simulation & Training CSC
- Tracking CSC (TBR)

Network Subsystem

- Workstation LAN HWCI
- Workstation - Data Acq Rx I/F HWCI
- External WAN I/F HWCI

SMD Mass Memory Subsystem

- SMDMM Workstation HWCI
- SMDMM Storage HWCI
- SMDMM Software CSCI

NPSIM Software CSCI

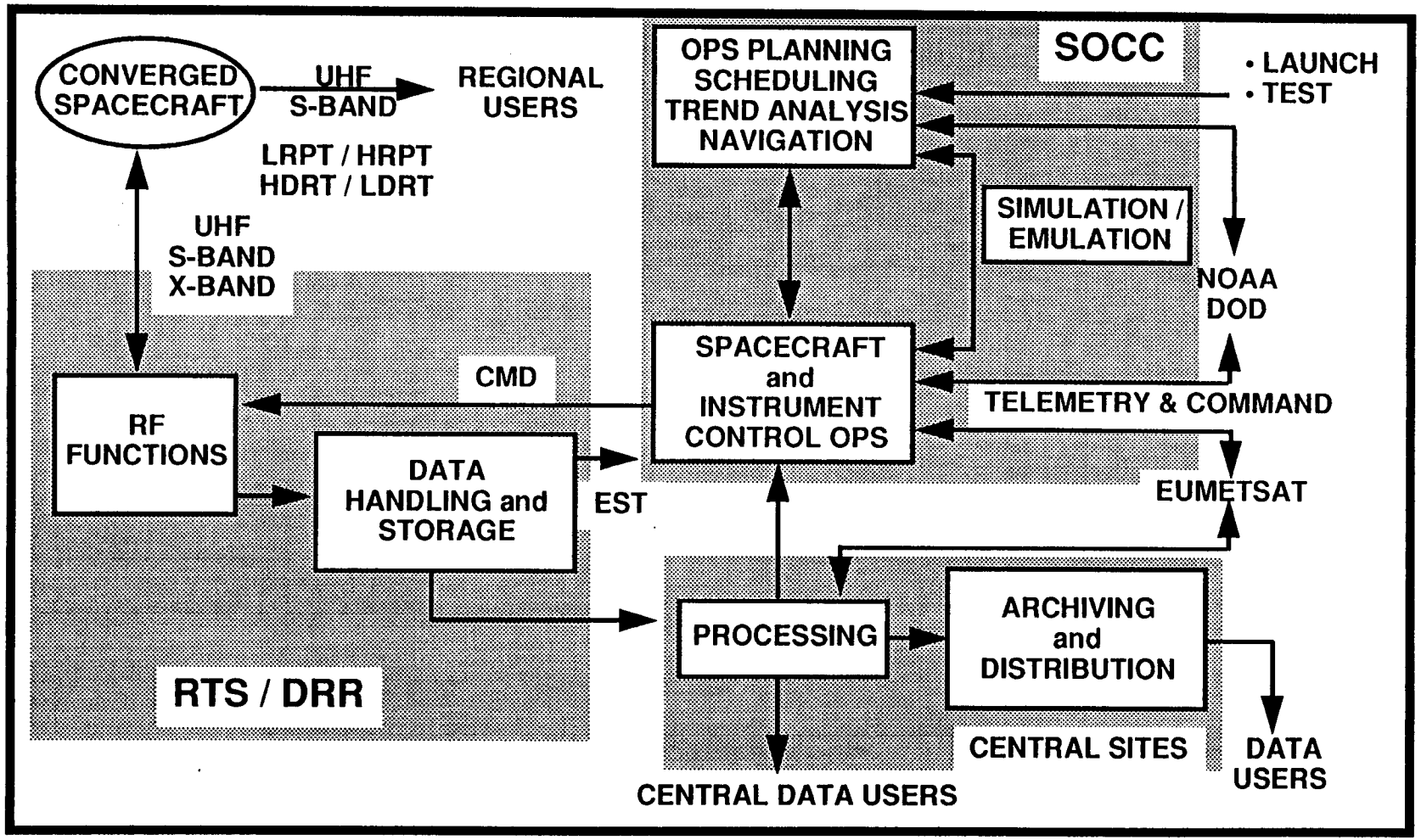
- SV Simulation CSC
- Thruster Model CSC
- Power Projection Model CSC
- Thermal Model CSC
- Generic Spacecraft Simulator CSC

ALLOCATION DRIVEN BY C^2 COTS APPROACH TO REDUCE LCC COSTS

FUNCTIONAL FLOW OVERVIEW

C

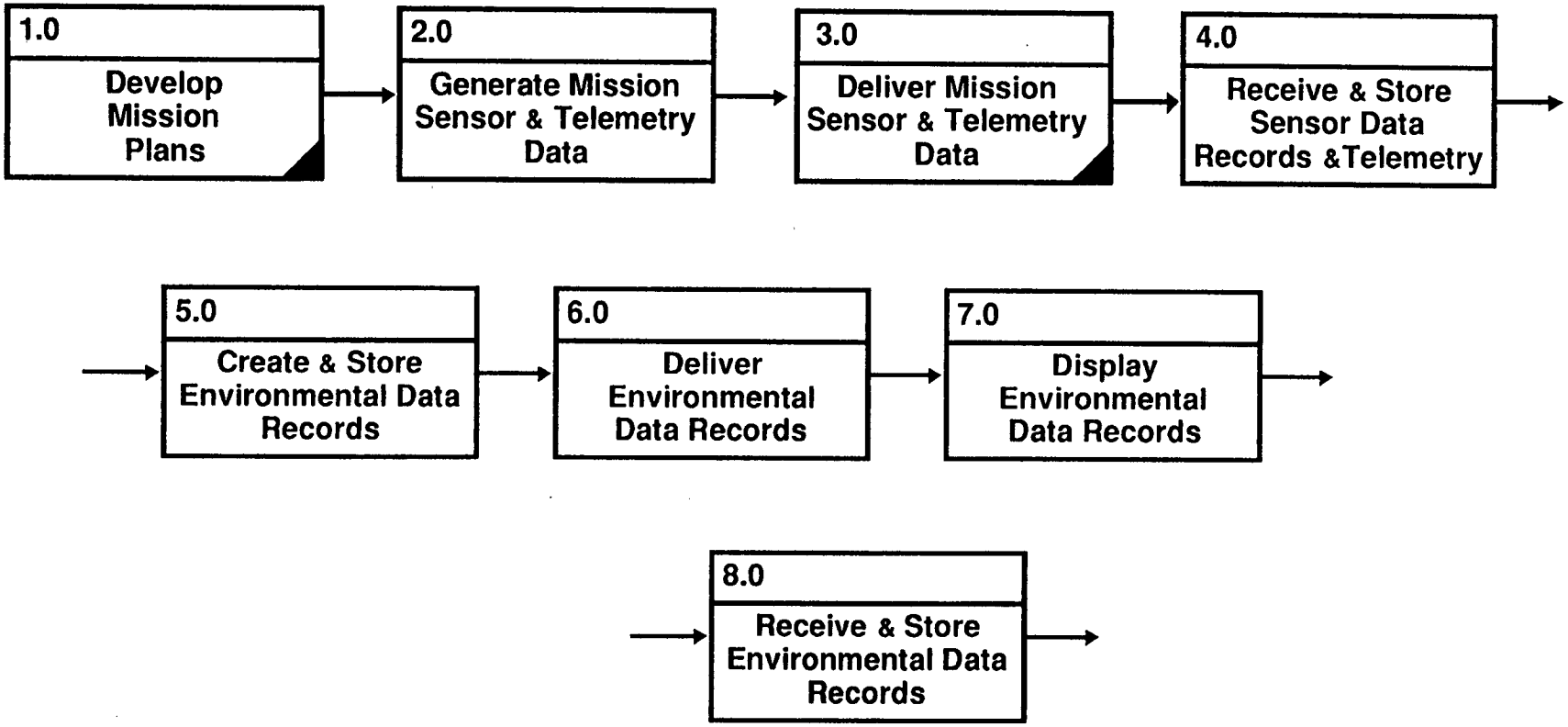
C3 SEGMENT



SYSTEM FUNCTIONAL FLOW

C

Ops State - Normal Mode*



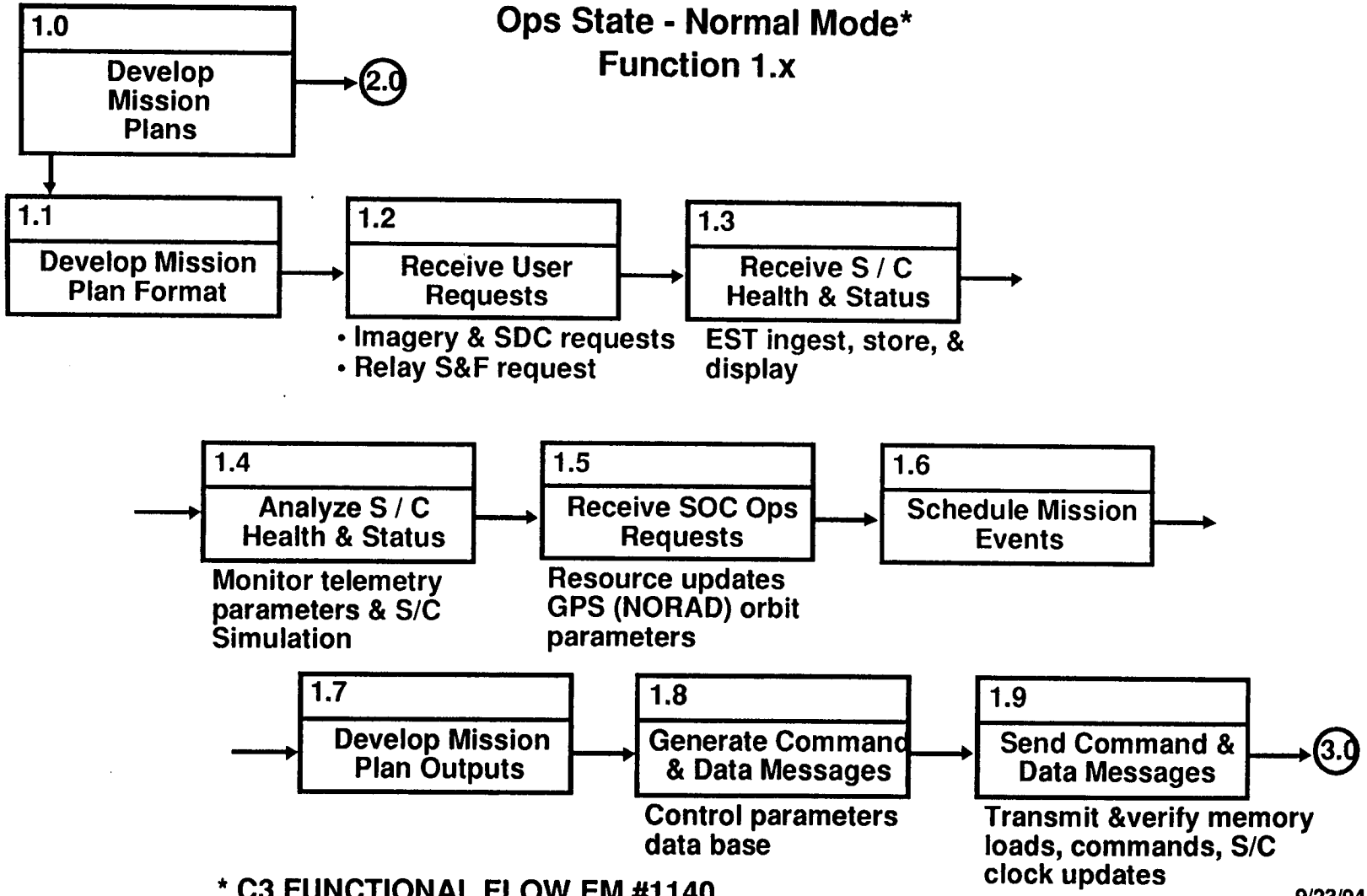
C3 FUNCTIONS
* System Functional Analysis EM #1125

NOTE: Function 6.0 is partially a C3 function for the Centralized process approach

C3 SEGMENT FUNCTIONAL FLOW

C

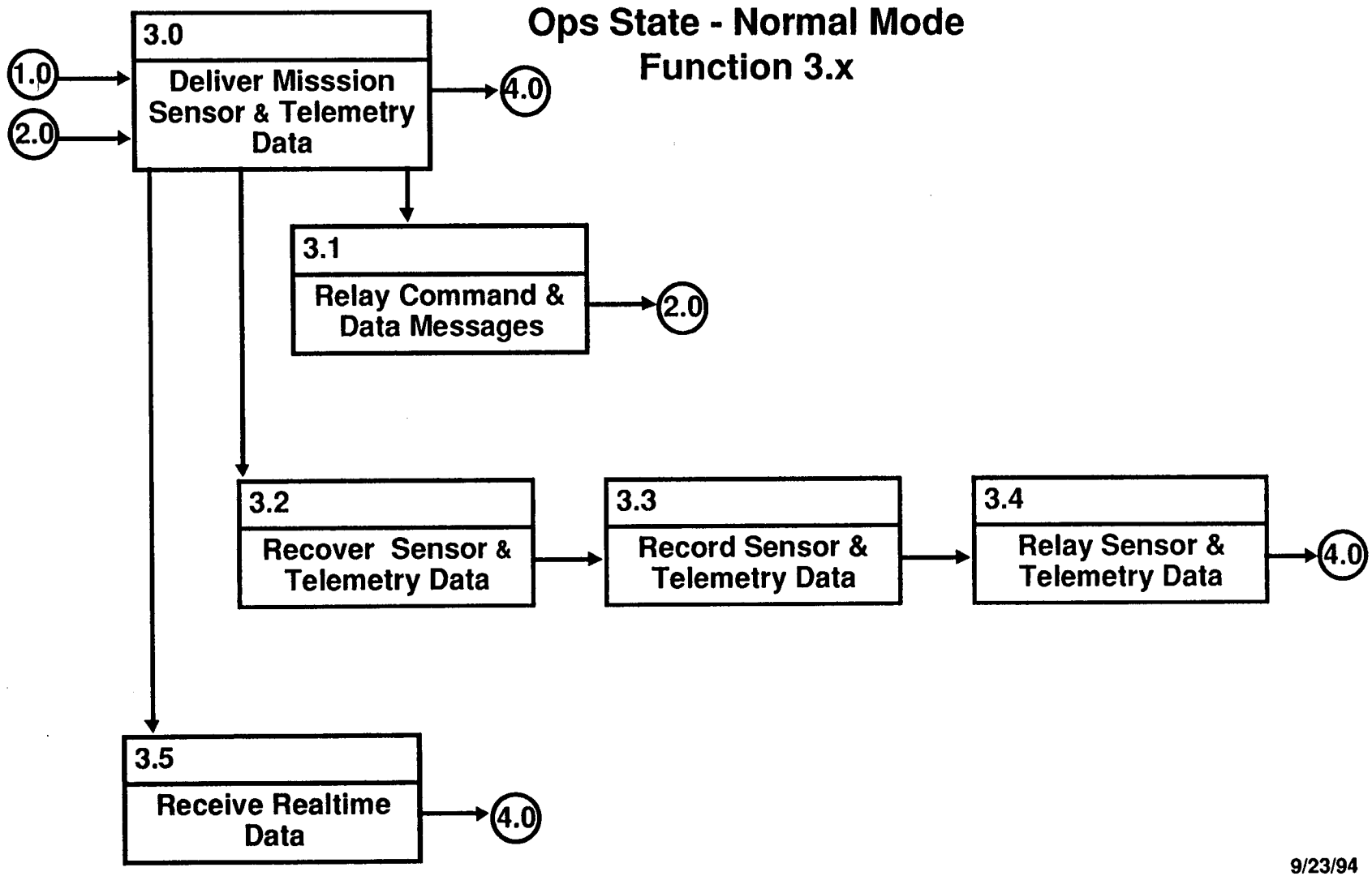
Ops State - Normal Mode*
Function 1.x



* C3 FUNCTIONAL FLOW EM #1140

C3 SEGMENT FUNCTIONAL FLOW - 2

C



C CONVERGED C3 ELEMENT FUNCTIONS

POC Allocation from Jan 94. - Reallocated

COMMAND, CONTROL, & COMMUNICATION SEGMENT C3

REMOTE TRACKING SYSTEM (RTS)
- Tracking
- Range / Timing
- Acquisition
- Ephemeris Generation

DATA ROUTING & RETRIEVAL (DRR)
- Mission Data Routing
  - Stored
  - Realtime
- Equip. Status & Telemetry
- Commands & Stored Program Upload
- SDC & SAR Data

SATELLITE OPERATIONS CENTER (SOC)
- Mission Control
- Mission Planning
- Command Generation
- Computer Memory Upload Generation
- Telemetry Analysis
- Launch/Early Orbit
- Command & Control
- Anomaly Resolution
- Store & Forward
- Launch Interface

PAYLOAD OPERATIONS CENTER (POC)
- Payload Control
- Sensor Planning
- User Request Relay
- Sensor Command Generation
- Sensor Data Analysis
- Anomaly Resolution

FLIGHT VEHICLE SIMULATION FACILITY (FVSF)
- S/C Enviro. Simulation
- Uplink/Downlink I/F Validation
- Flight Load Package Validation

CONVERGED C3 ELEMENT FUNCTIONAL ALLOCATION

C

COMMAND, CONTROL, & COMMUNICATION SEGMENT C3

REMOTE TRACKING STATION

- Tracking [1]
- Range / Timing [1]
- Acquisition
- Ephemeris [1] Generation (via GPS)
- Commands & Stored Program Upload [2]
- Equip. Status & Telemetry

SATELLITE OPERATIONS CENTER

- Mission Control & Planning
- Payload Control & Sensor Planning [3]
- User Request Relay
- Command Generation
- Computer Memory Upload Generation
- Telemetry Analysis
- Launch/Early Orbit
- Command & Control
- Anomaly Resolution
- Store & Forward
- Launch Interface
- Tracking [4]

DATA ROUTING & RETRIEVAL (DRR)

- Mission Data Routing
  - Stored
  - Realtime (Embedded EST)
- DOMSAT I / F

FLIGHT VEHICLE SUPPORT FACILITY (FVSF)

- S/C Enviro. Simulation
- Uplink/Downlink I/F Validation
- Flight Load Package Validation
- Training [4]

1 Backup Only
2 O2 Functions TBD
3 I / F to Agency POC
4 TBD Allocation

CURRENT NPOESS STATES AND MODES LISTING

C

SYSTEM STATES	SYSTEM MODES
• PRE-LAUNCH STATE	- SYSTEM TEST MODE - GROUND STORAGE MODE - TRANSPORTATION MODE - LAUNCH PREPARATION MODE
• PRE-OPERATIONAL	- LAUNCH AND ASCENT MODE - POST-LAUNCH OPERATIONS MODE - DEPLOYMENT AND INITIALIZATION - ON-ORBIT VERIFICATION AND VALIDATION
• OPERATIONAL	- NORMAL OPERATIONS MODE - AUTONOMOUS OPERATIONS MODE - ORBIT MAINTENANCE MODE - CONTINGENCY MODE
• DEGRADED OPERATIONS	- AUXILIARY MODE - PROTECTIVE MEASURES - SAFE MODE - DISPOSAL MODE

C3 STATES AND MODES REVIEW MATRIX - 1

C

C3 STATES & MODES	PRE-LAUNCH STATE		PRE-OPERATIONAL			
FUNCTIONS	SYSTEM TEST	LAUNCH PREPARATION	LAUNCH & ASCENT	POST-LAUNCH OPERATIONS	DEPLOYMENT & INITIALIZATION	ON-ORBIT VERIF. & VALIDATION
• Tracking			X	X		
• Range / Timing			X	X		
• Acquisition			X	X	X	X
• Ephemeris Relay	X	X		X	X	X
• Commands & Program Upload	X	X		X	X	X
• Mission Data Routing - Stored - Realtime						
• Equip. Status & Telemetry				X	X	X
• DCS & SAR Data						X
• Uplink/Downlink I/F	X	X		X	X	X
• Mission Control	X			X	X	X
• Mission Planning	X		X	X	X	X
• Command Generation	X			X	X	X
• Memory Upload Generation	X					X
• Telemetry Analysis	X			X	X	X
• Anomaly Resolution	X			X	X	X

"X" INDICATES A C3 FUNCTION REQUIRED

INDICATES CRITICAL FUNCTION FOR STATE & MODE

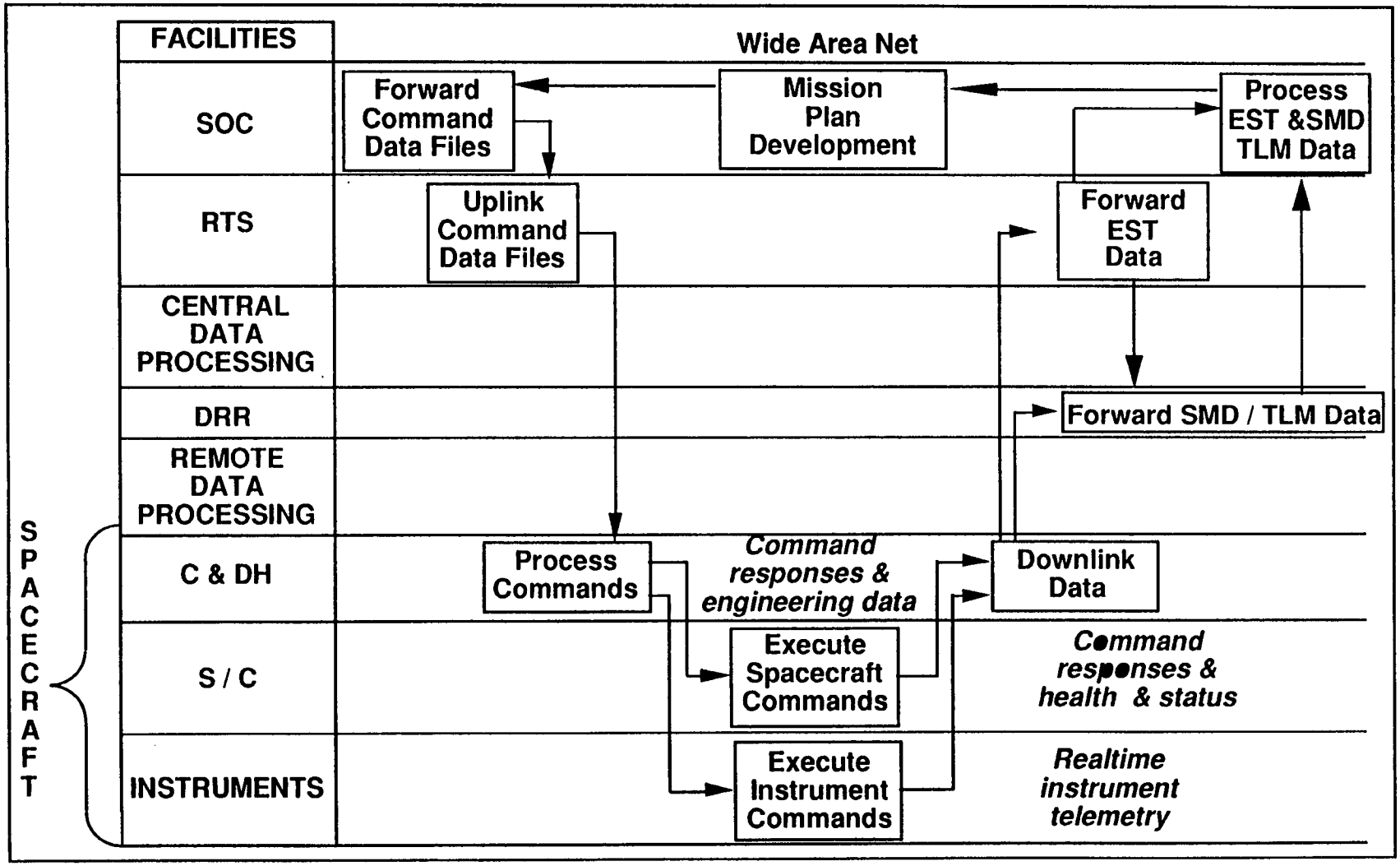
C3 STATES AND MODES REVIEW MATRIX - 2

C3 STATES & MODES	OPERATIONAL				DEGRADED OPERATIONS			
FUNCTIONS	NORMAL OPS	AUTON. OPS	ORBIT MAINT.	CONTIN. MODE	AUXILARY MODE	PROTECTIVE MEASURES	SAFE MODE	DISPOSAL MODE
• Tracking						X	X	X
• Range / Timing			X			X		X
• Acquisition	X	X		X	X	X		
• Ephemeris Relay	X		X					
• Commands & Program Upload	X		X	X	X	X		X
• Mission Data Routing								
- Stored	X	X	X	X	X	X		
- Realtime	X	X	X	X	X	X		
• Equip. Status & Telemetry	X	X	X	X	X	X		X
• DCS & SAR Data	X	X		X	X			
• Uplink/Downlink I/F	X	X	X	X	X	X	X	X
• Mission Control	X		X	X	X	X	X	X
• Mission Planning	X			X	X	X		
• Command Generation	X		X	X	X	X		X
• Memory Upload Generation	X		X	X	X			X
• Telemetry Analysis	X		X	X	X	X	X	X
• Anomaly Resolution	X				X		X	

"X" INDICATES A C3 FUNCTION REQUIRED

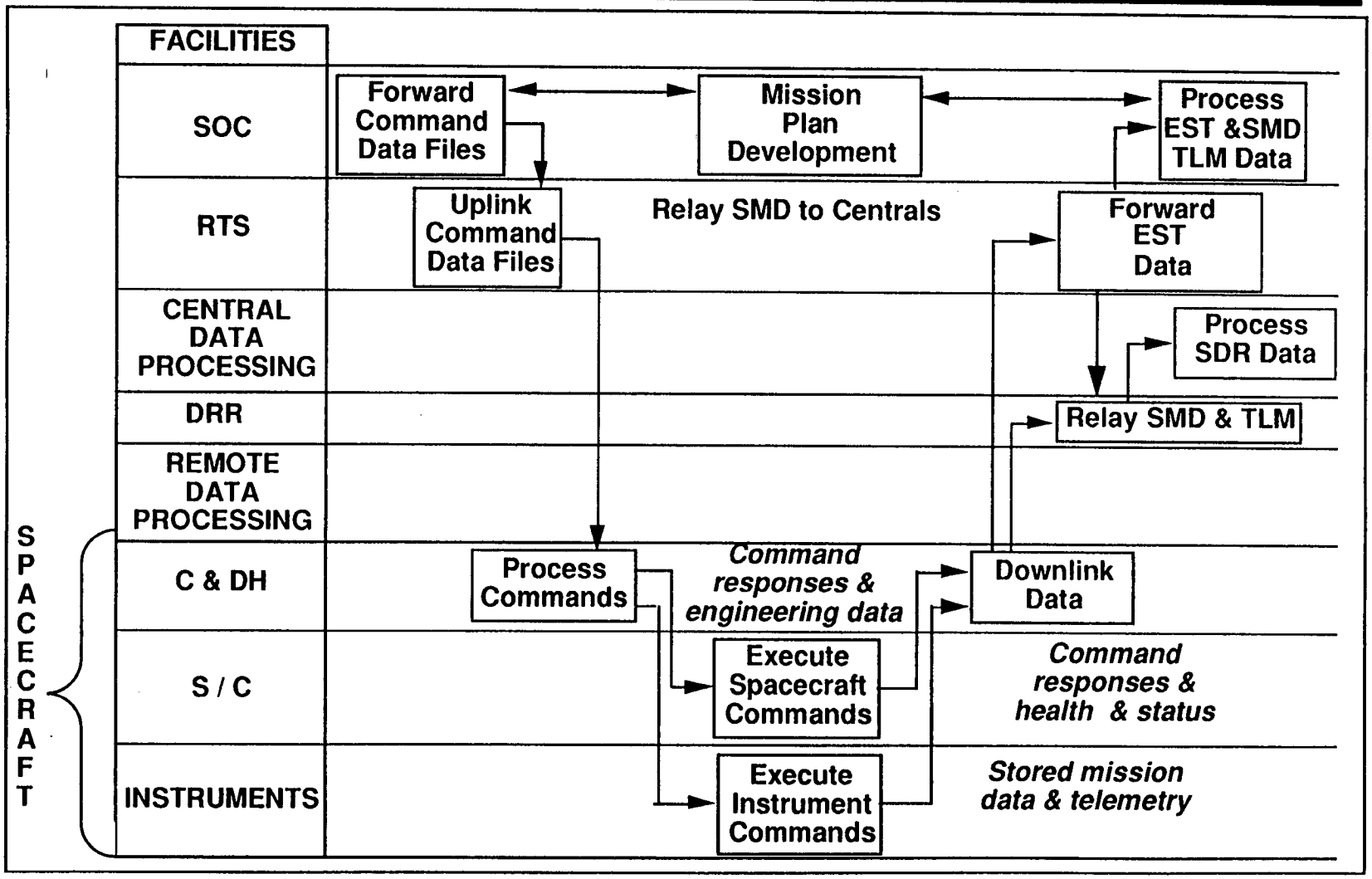
INDICATES CRITICAL FUNCTION FOR STATE & MODE

PRELIMINARY OPERATIONS CONCEPT
C COMMAND & TELEMETRY

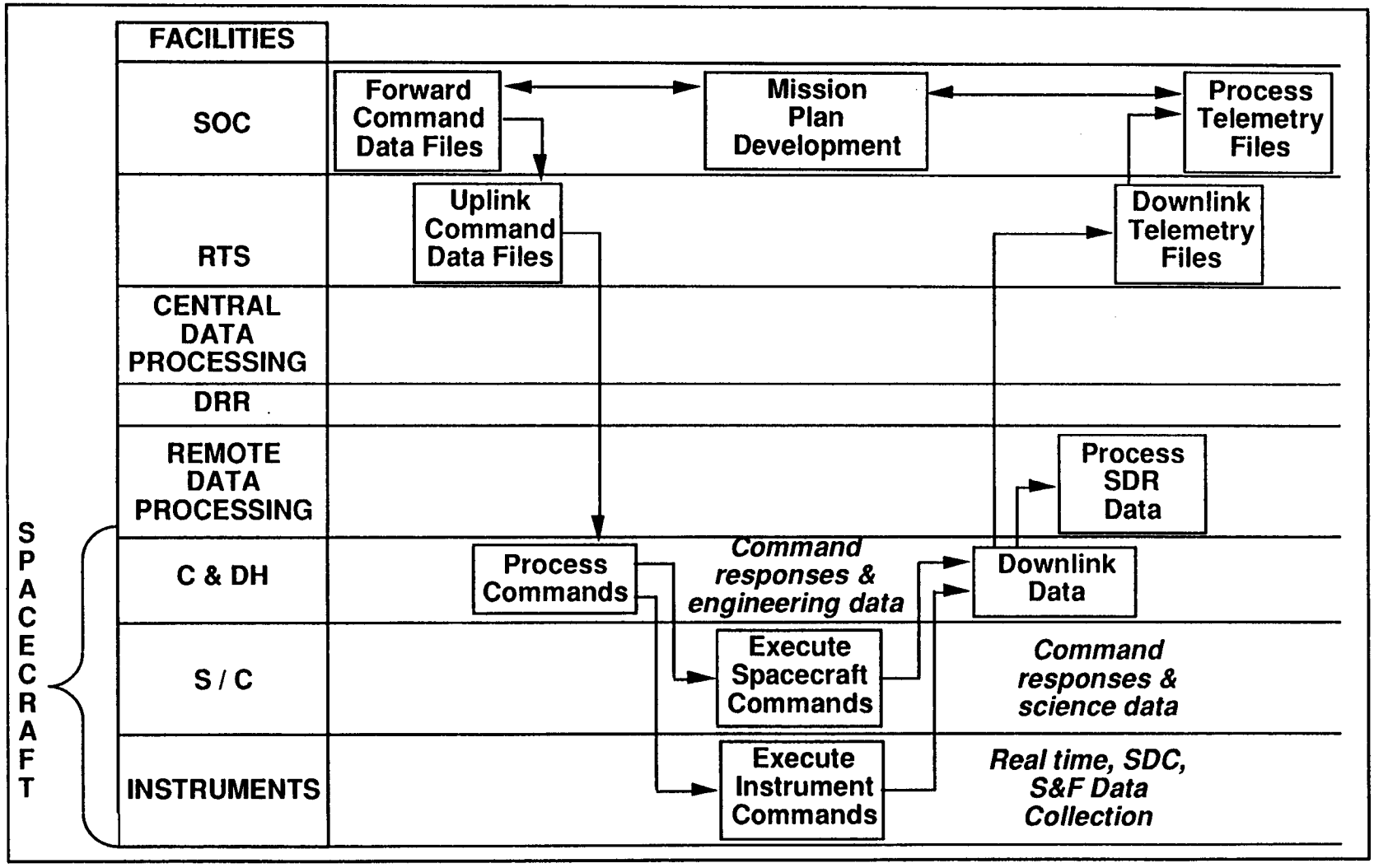


PRELIMINARY OPERATIONS CONCEPT
STORED MISSION DATA

C



PRELIMINARY OPERATIONS CONCEPT
REALTIME MISSION DATA

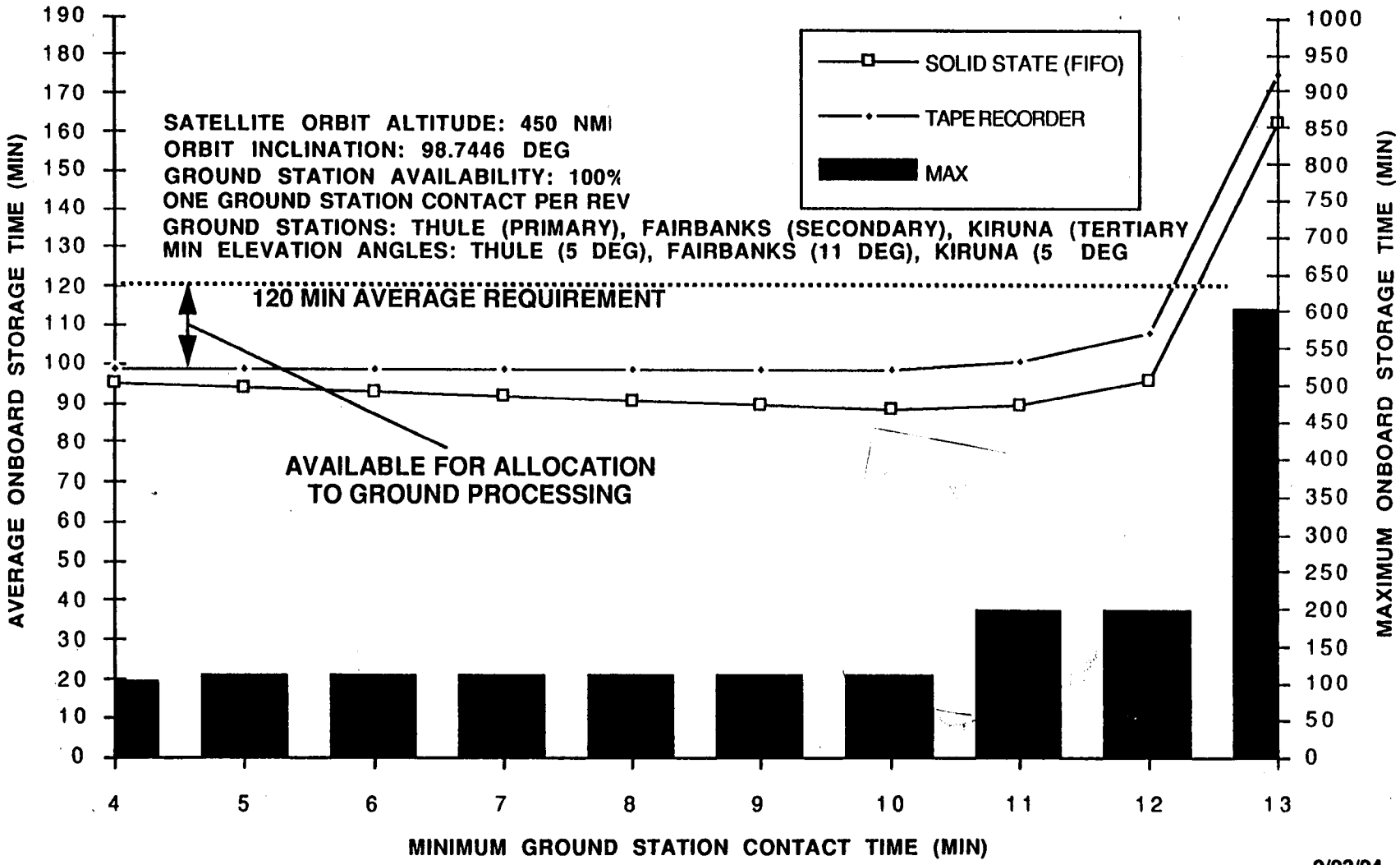


C

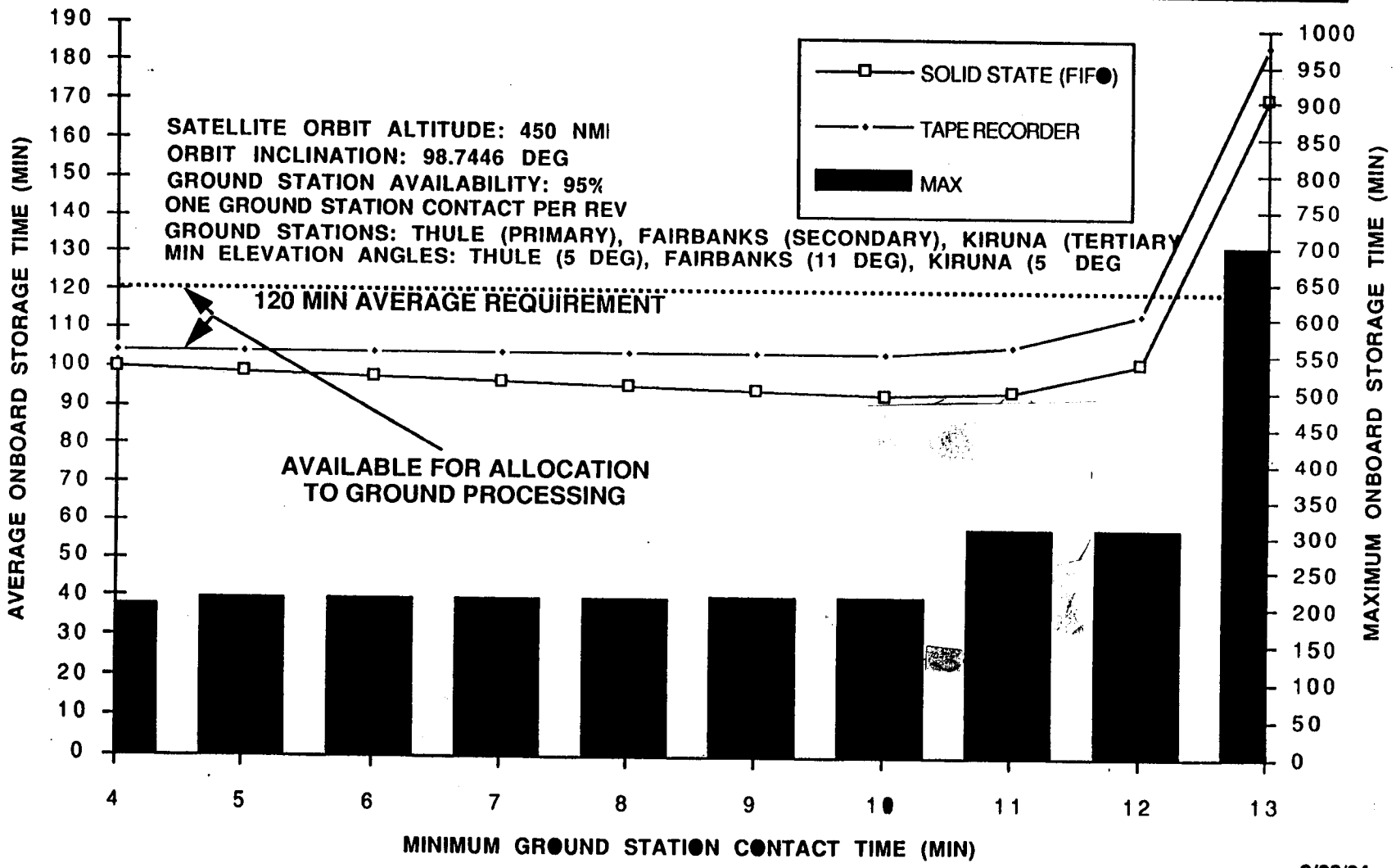
TIMELINESS ANALYSIS RESULTS

J. HARRISON

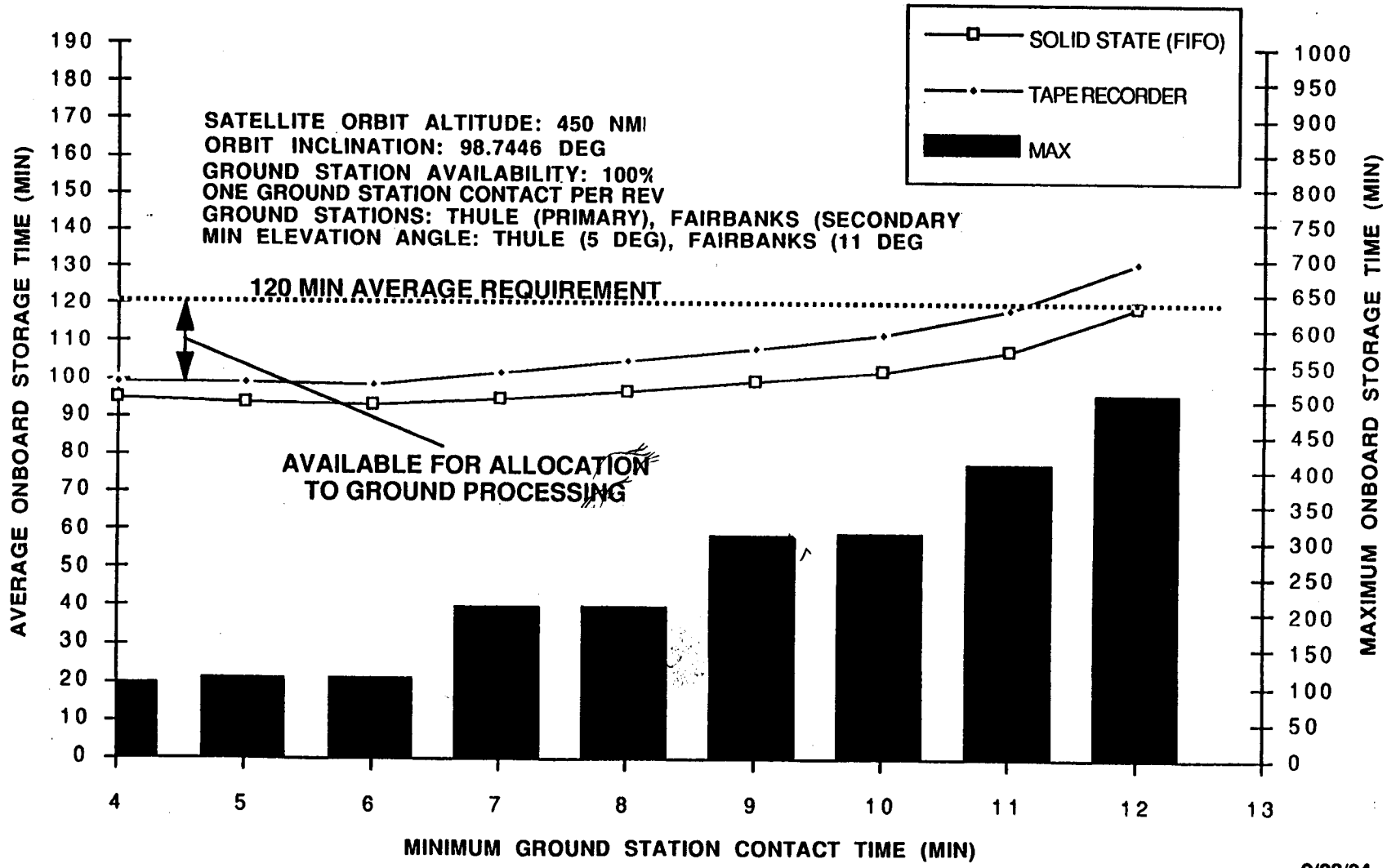
C TIMELINESS ANALYSIS RESULTS (TTS-FTS-KTS @ 100% AVAILABILITY)



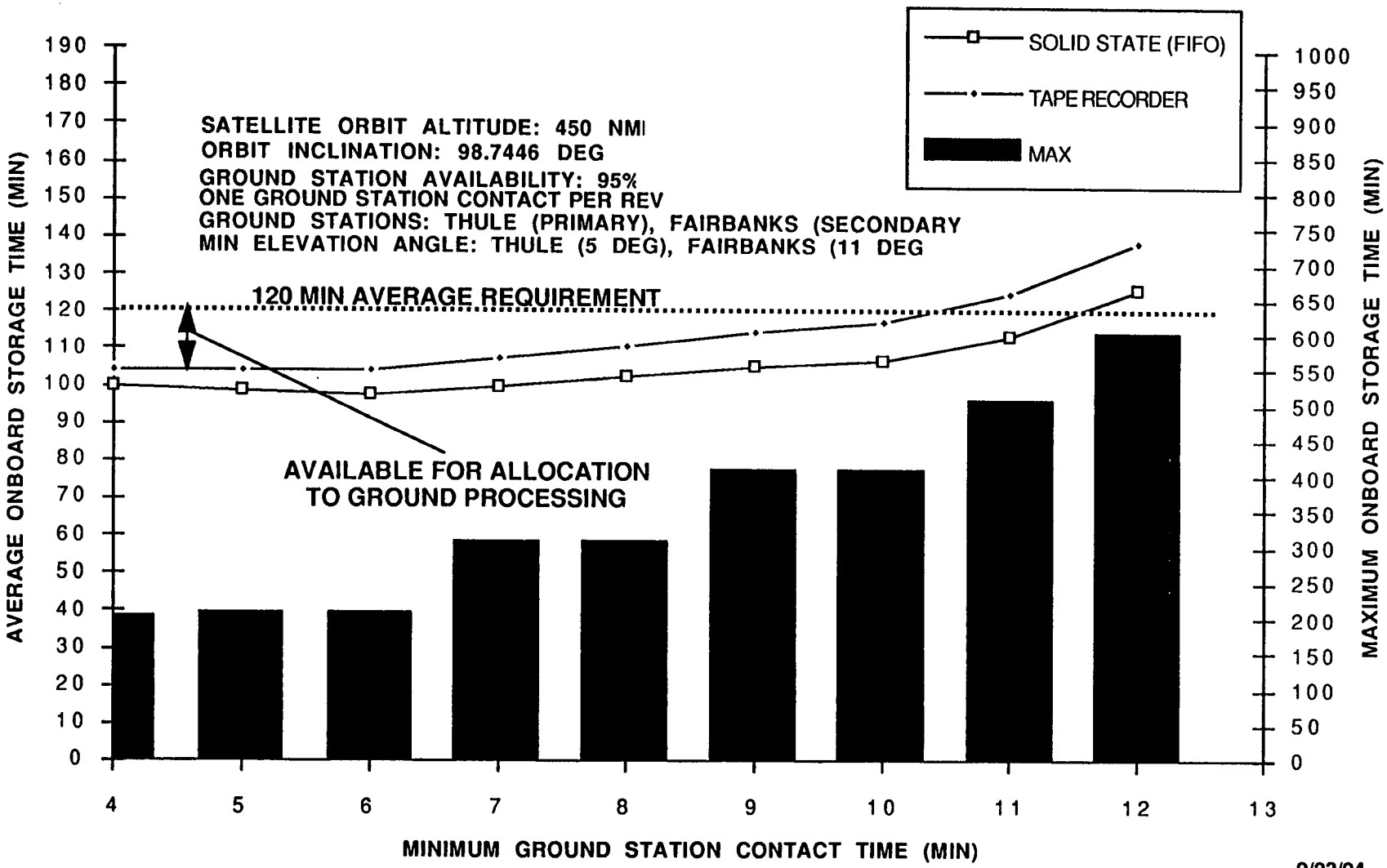
C TIMELINESS ANALYSIS RESULTS (TTS-FTS-KTS @ 95% AVAILABILITY)



C TIMELINESS ANALYSIS RESULTS (TTS-FTS @ 100% AVAILABILITY)

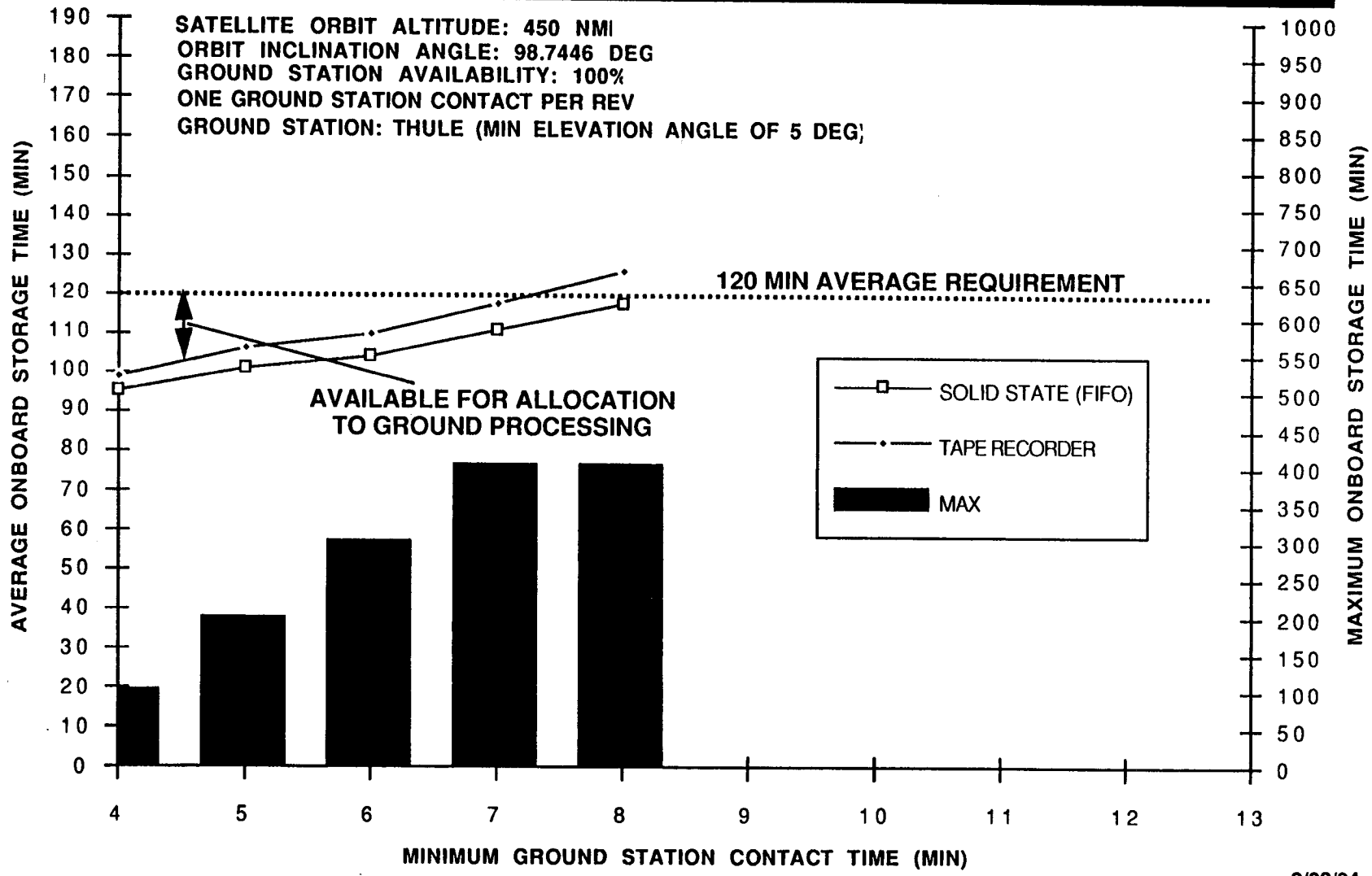


C TIMELINESS ANALYSIS RESULTS (TTS-FTS @ 95% AVAILABILITY)



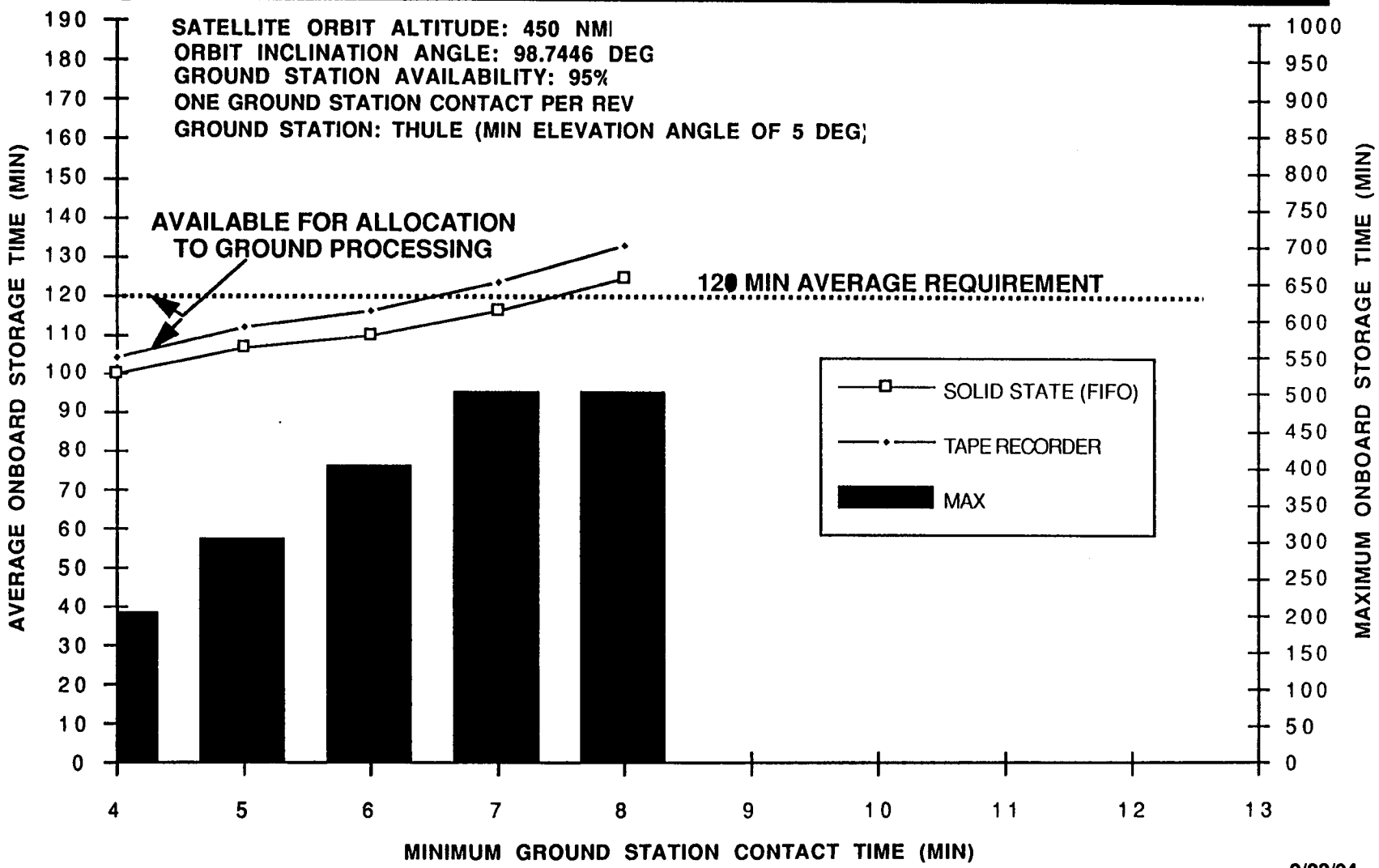
TIMELINESS ANALYSIS RESULTS (TTS @ 100% AVAILABILITY)

C



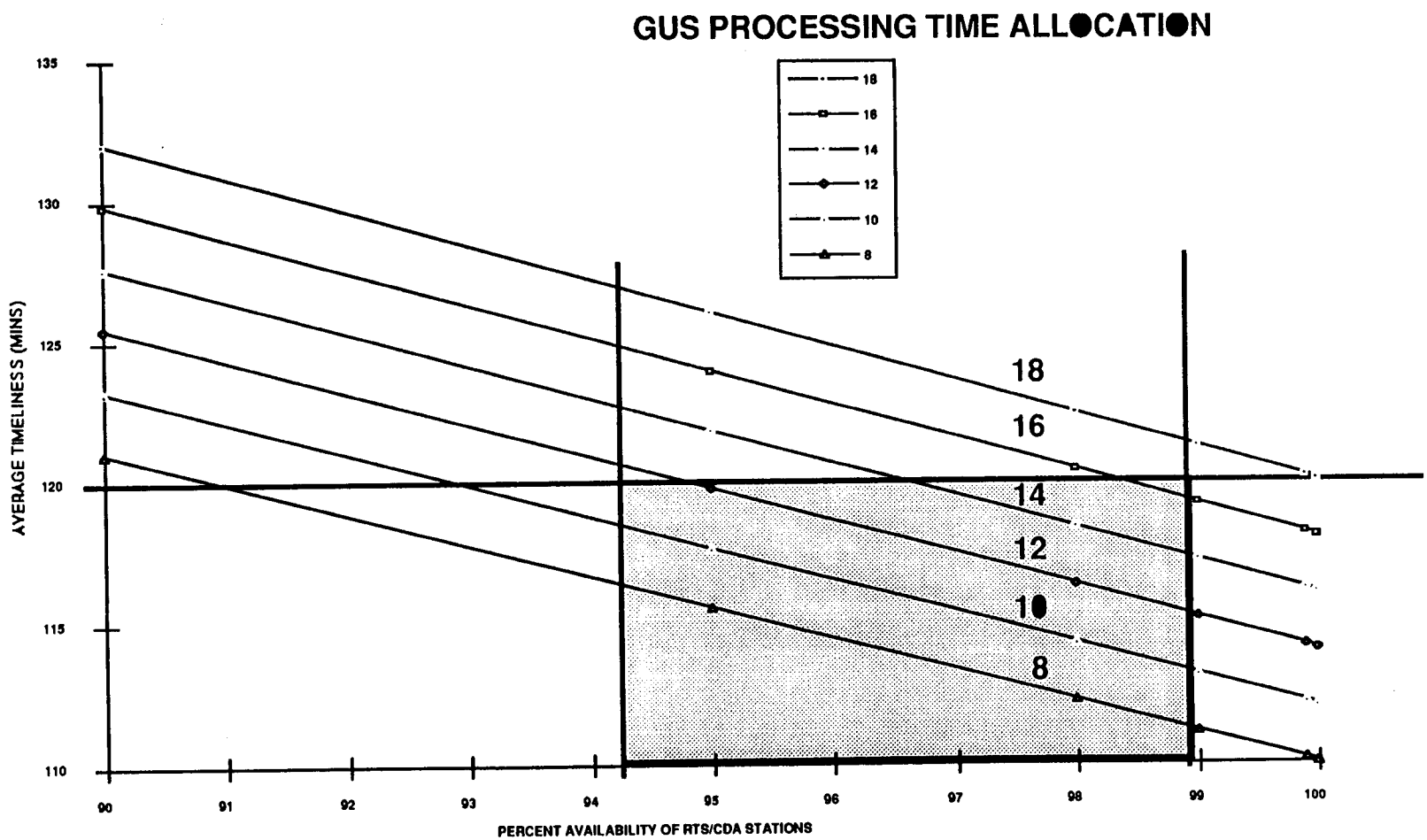
TIMELINESS ANALYSIS RESULTS (TTS @ 95% AVAILABILITY)

C



TIMELINESS VS AVAILABILITY

C



9/23/94

C REQUIREMENTS ALLOCATION & FLOWDOWN SUMMARY

- C3 REQUIREMENTS DEVELOPMENT LEADING NPOESS SPEC DEVELOPMENT
- FUNCTIONAL ANALYSIS HIGHLIGHTING KEY STATES & MODES ISSUES
- OPCONCEPT DEVELOPMENT BUILDING ON STATES, MODES, AND FUNCTIONAL ALLOCATIONS
- TIMELINESS ANALYSIS DERIVING REQUIREMENTS DOMAIN FOR SMD PROCESSING

C

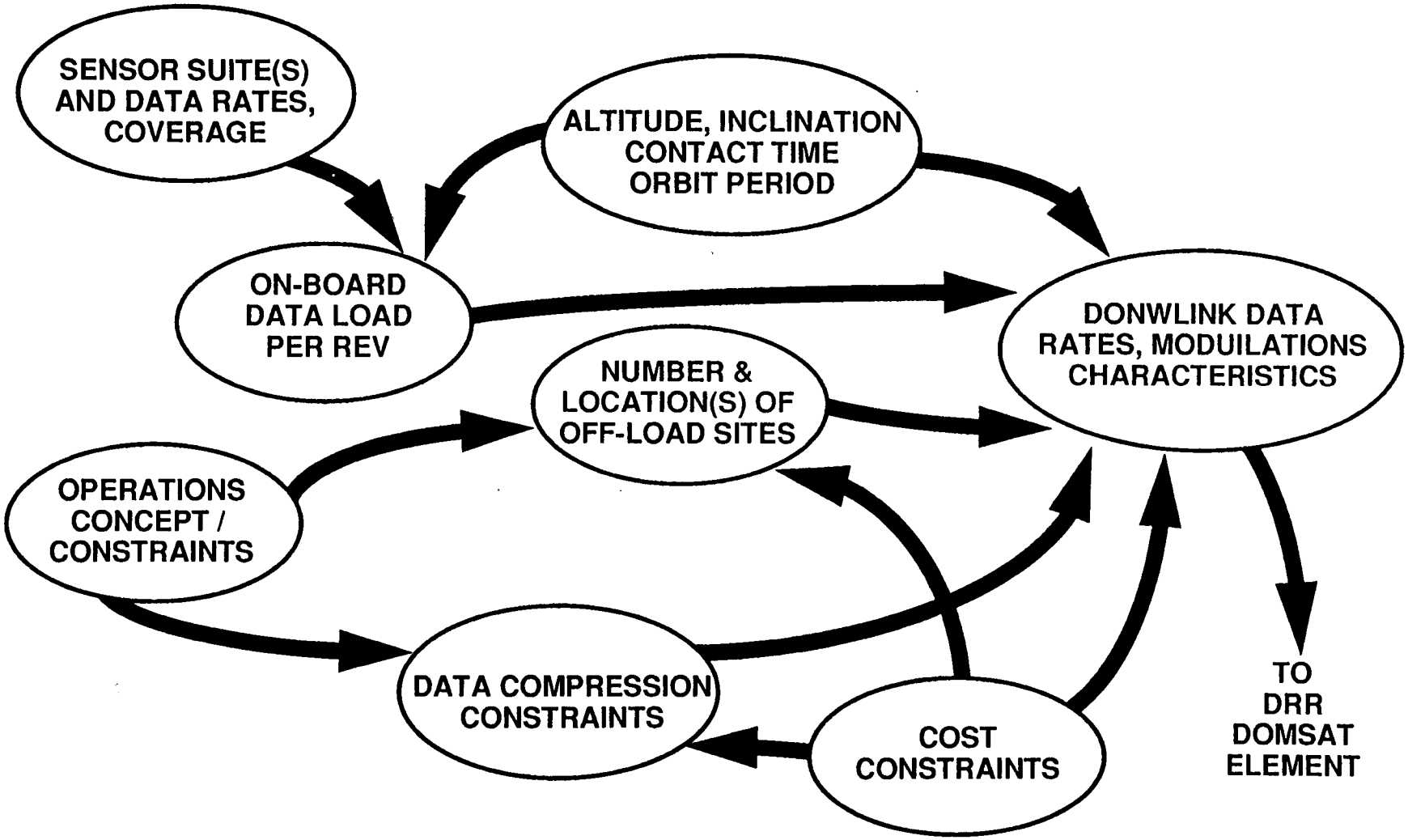
REQUIREMENTS IMPACTS & ISSUES

R. NELSON

"CLOSING-IN ON A CONSISTENT SET OF C3 SEGMENT AND ELEMENT DESIGNS"

DRR DOWNLINK FOR SMD

C



C DEVELOPMENT OF OPTIMIZED DRR

- COVERAGE & TIMELINESS ANALYZED FOR DRR CONFIGURATIONS
  - AFSCN SITES
  - NOAA SITES
  - MODIFIED AFSCN SITES
- COVERAGE AND TIMELINESS ARE SIGNIFICANT DRIVERS TO C3
  - GAPS
  - CONTACT TIME
  - DATA ACCUMULATION
- ONBOARD STORAGE REQUIREMENT, DATA RATE, AND TIMELY DATA DELIVERY TO USER ARE INFLUENCED
- RESULTS OF COVERAGE AND TIMELINESS ANALYSIS INCLUDED IN DRR TRADE AS DECISION CRITERIA
  - CONTACT TIME >8.5 MIN W/● GAPS
  - DATA TIMELINESS <12● MIN AVG
- DATA COMPRESSION ON BOARD OR ON GROUND CAN STILL INFLUENCE COST TRADES

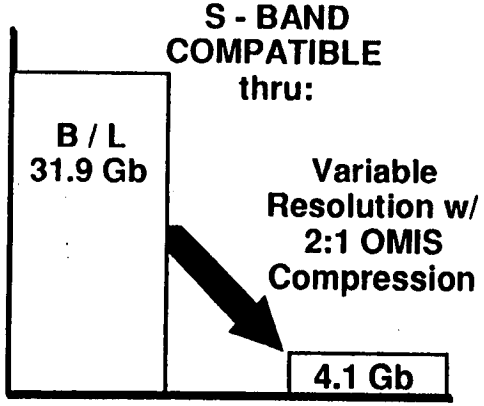
C CONFIGURATION PAYLOAD DATA RATES

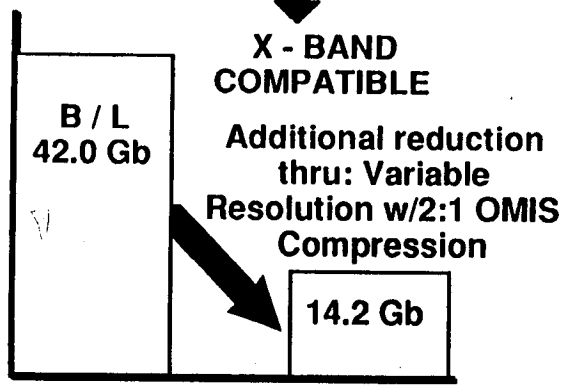
O1	O2	O3	O4
5.23 mbps	5.30 mbps	6.88 mbps	7.53 mbps

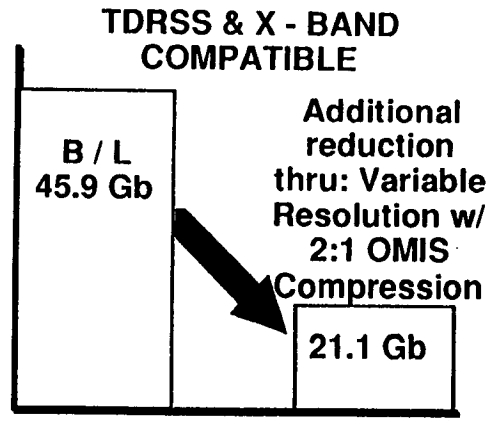
Payload	Data Rate
OMIS/VIRSR	4500 kbps
MISS	37.3 kbps
SESS	9.71 kbps
SDC	1.0 kbps

Payload	Data Rate
OMIS/VIRSR	4500 kbps
MISS	37.3 kbps
AMSU-A1	2.1 kbps
MHS	4.2 kbps
AIRS	1420 kbps
SBUV	1.0 kbps
SESS	9.71 kbps
ARGOS	2.56 kbps

Payload	Data Rate
MODIS	6500 kbps
MISS	37.3 kbps
CERES	10 kbps







C CONVERGED C3 DERIVED DATA REQUIREMENTS

PARAMETER	REQUIREMENT	DERIVED REQUIREMENT
Configuration	On Board Sensor Data Rate	Data Rate with 15% overhead
O1	4.55 mbps	5.23 mbps
O2 (EUMETSAT)	4.61 mbps	5.30 mbps
O3	5.98 mbps	6.88 mbps
O4 (EOS)	6.55 mbps	7.53 mbps
Mission Data Storage	Data for 2 orbits	82.6 Gb (91.8 with O4)
Mission Data Offload	Data for 1 orbit	
O1	27.8 Gb	31.9 Gb
O2	28.1 Gb	32.3 Gb
O3	36.5 Gb	42.0 Gb
O4	40.0 Gb	45.9 Gb
SMD Downlink	X-Band	7.455 GHz (TBR)
Data Rate (8.5 min contact without gaps)	Data for 1 orbit	90 mbps
Downlink Sites	3 CDA / RTS	TTS, FTS, KTS (TBR)
Timeliness	Data products in 120 min avg.	EDR processing <18 min. (TBR)
Data Format	TBD	CCSDS

C CCSDS DATA FORMAT ISSUE

ISSUE

- ALL NASA (EOS) & NOAA programs require command and sensor data formats conform to Consultative Committee for Space Data Systems (CCSDS)
- Format is defined in GSFC interface documentation GSFC S-480-053
- NOAA and EOS sensors, currently being developed, have adopted CCSDS as the standard for commands, telemetry, and stored data. This requirement constrains all sensors to a common 16 bit data packetized output.

IMPACTS

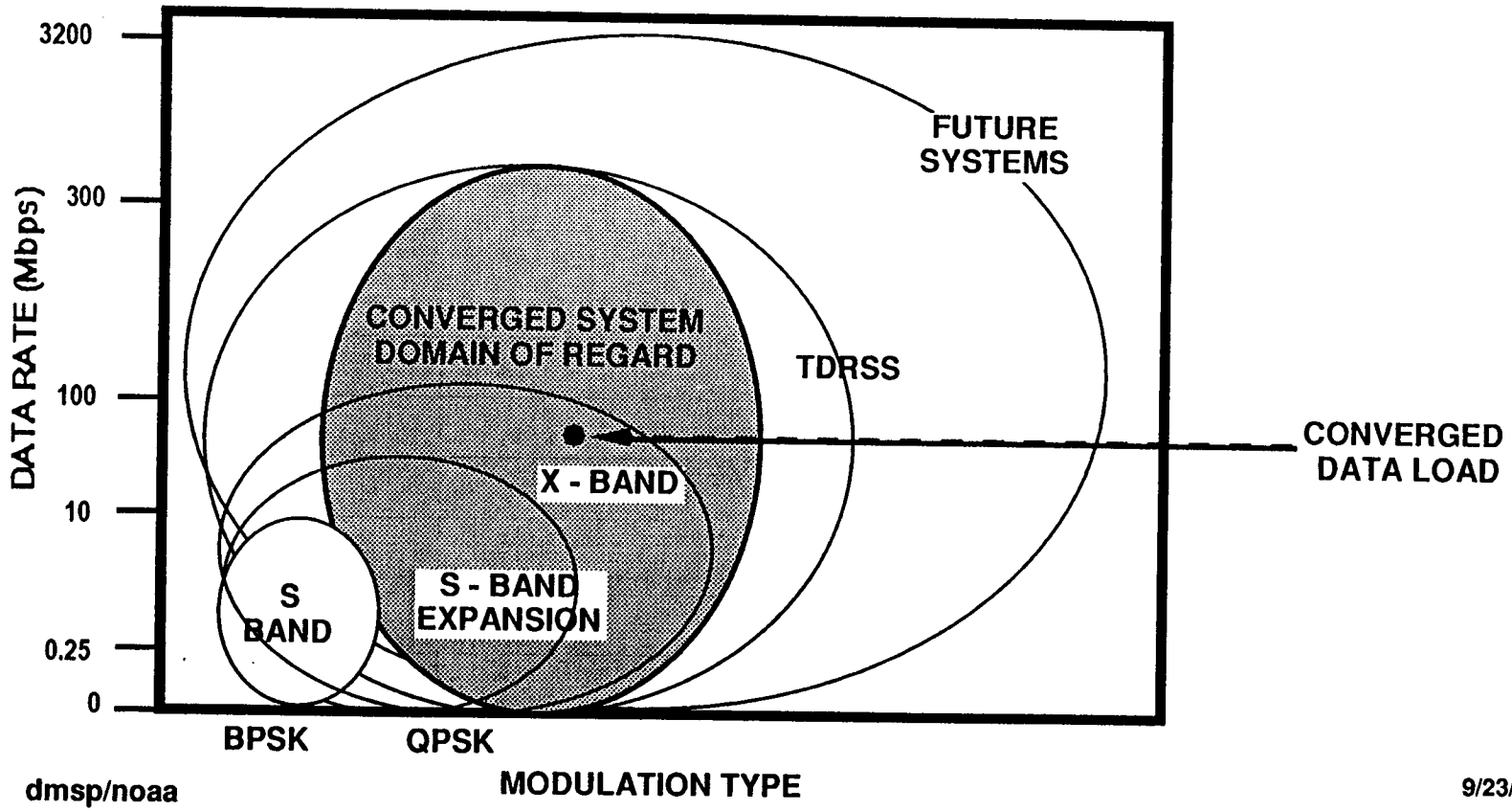
- CCSDS format increases total sensor data stream.
- CCSDS impacts ability to compress data, data storage capacity, data rates, and minimum contact time required.

RANGE OF SMD CAPABILITIES

C

FACTS:

- RTS SITES (THULE, HAWAII, NEW HAMPSHIRE, OAKHANGER, VANDENBERG) HAVE TWO 5 MHz (10 Mbps with QPSK) S-BAND CHANNELS
- ONE ORBIT OF SENSOR DATA FOR CONSTELLATION O PLACES 32 TO 46 Gb ON THE SMD
- RTS STATION ANALYSIS SHOWS MINIMUM CONTACT TIMES OF 8.5 min (with no gaps) AT 450 NMI.



C CONVERGED DRR ALTERNATIVES

- RETAIN S-BAND SMD USING INNOVATIVE DATA MANAGEMENT OPTIONS*
  - 8:1 Data Compression
  - 16:1 Data Compression
  - 4:1 Data Compression with 1.3 km resolution
  - 4:1 Data Compression & Commanded OMIS Resolution (1.0 km & 2.4 km)
- ALTERNATIVE X - BAND DRR
  - Solution defined from Constellation O requirements
  - Current design reference @ 450 nmi & 0.65 km resolution
  - Optimized DRR reduces C3 life cycle costs
  - KTA analysis highlights most efficient option at lowest cost
  - Only 1 site upgrade required for 3 DRR sites

* These options require compression of all mission data

CDRR ALTERNATIVES FOR S-BAND @ 5 MBPS

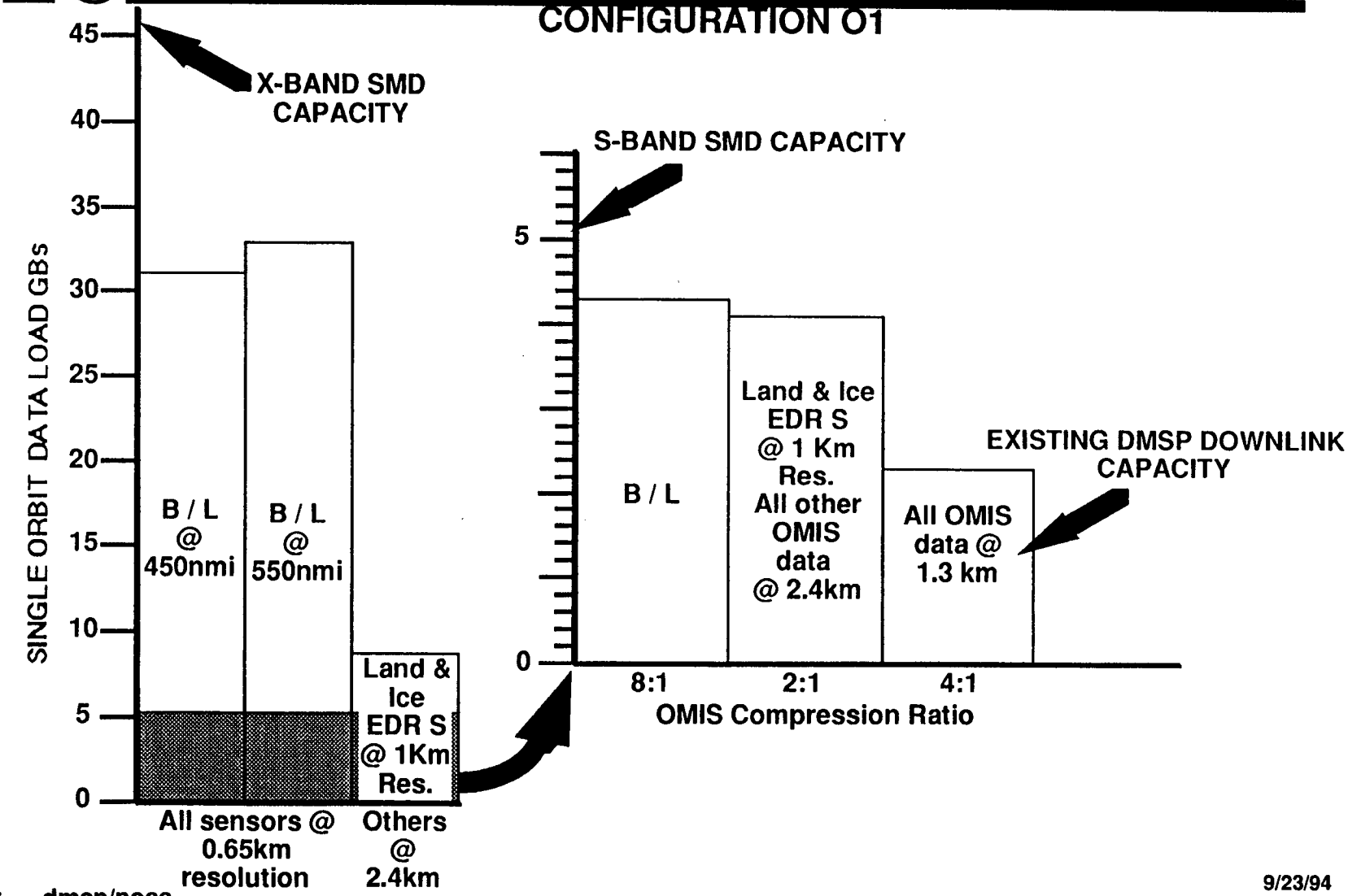
ALTERNATIVE APPROACHES	RESOLUTION (KM)		COMPRESSION RATIO		O1 39.1 (Gb)	O3 42.0 (Gb)
	OMIS	IR/mw	OMIS	IR/mw		
Baseline D Constellation with 8 Channel OMIS, SDR Resolution 0.65 KM	0.65	15-50	2:1	1:1	16.12	26.25
			2:1	2:1	15.95	21.00
			4:1	1:1	8.24	18.37
			4:1	4:1	7.97	10.50
			8:1	1:1	4.31	14.44
			8:1	8:1	3.99	5.25
			16:1	1:1	2.34	12.47
			16:1	16:1	1.99	2.62
Baseline D Constellation with 8 Channel Selectable OMIS SDR Resolution	1 & 2.4	15-50	1:1	1:1	7.84	17.97
			2:1	1:1	4.10	14.23
			2:1	2:1	3.91	8.98
			4:1	1:1	2.23	12.36
			4:1	4:1	1.95	4.48
Baseline D Constellation with 8 Channel OMIS SDR Resolution 1.3 KM	1.3	15-50	1:1	1:1	8.24	18.37
			2:1	1:1	4.31	14.44
			2:1	2:1	4.12	9.19
			4:1	1:1	2.34	14.44
			4:1	4:1	2.06	4.59
			8:1	1:1	1.35	11.45
			8:1	8:1	1.03	2.30
Baseline D Constellation w/8 Channel OMIS SDR Resolution 2.4 KM	2.4	15-50	1:1	1:1	2.34	12.47
			2:1	1:1	1.35	11.48
			2:1	2:1	1.17	6.23
			4:1	2:1	0.58	5.74

9/23/94

ALTERNATIVES FOR S-BAND SMD

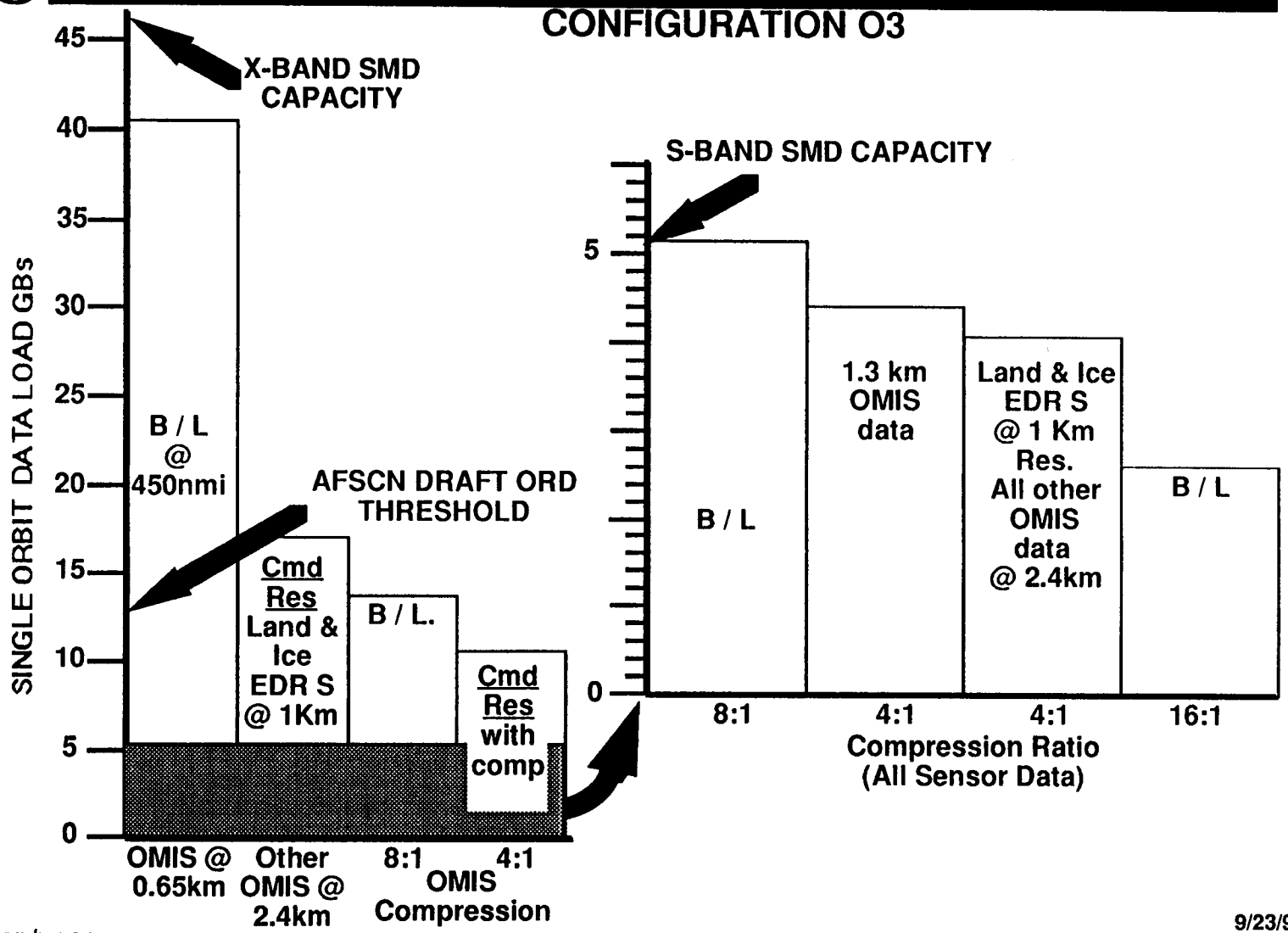
C

CONFIGURATION O1



ALTERNATIVES FOR S-BAND SMD

C



C S-BAND ASSESSMENT SUMMARY

- S-BAND DOMINANT DOWNLINK FOR TODAY
- CONSTELLATION O SENSORS GENERATE 31.9 - 45.9 Gb per ORBIT
- AN S-BAND SMD WILL DELIVER A MAXIMUM OF 5.1 GB EACH PASS
- CONVERGED DATA RATES AND COMPRESSION CONSTRAINTS REQUIRE X-BAND DOMAIN
- USE X-BAND FOR B / L DRR AND DOMSAT ELEMENT ARCHITECTURE
- DON'T ABANDON S-BAND (AS BACKUP, IF NEEDED)

C

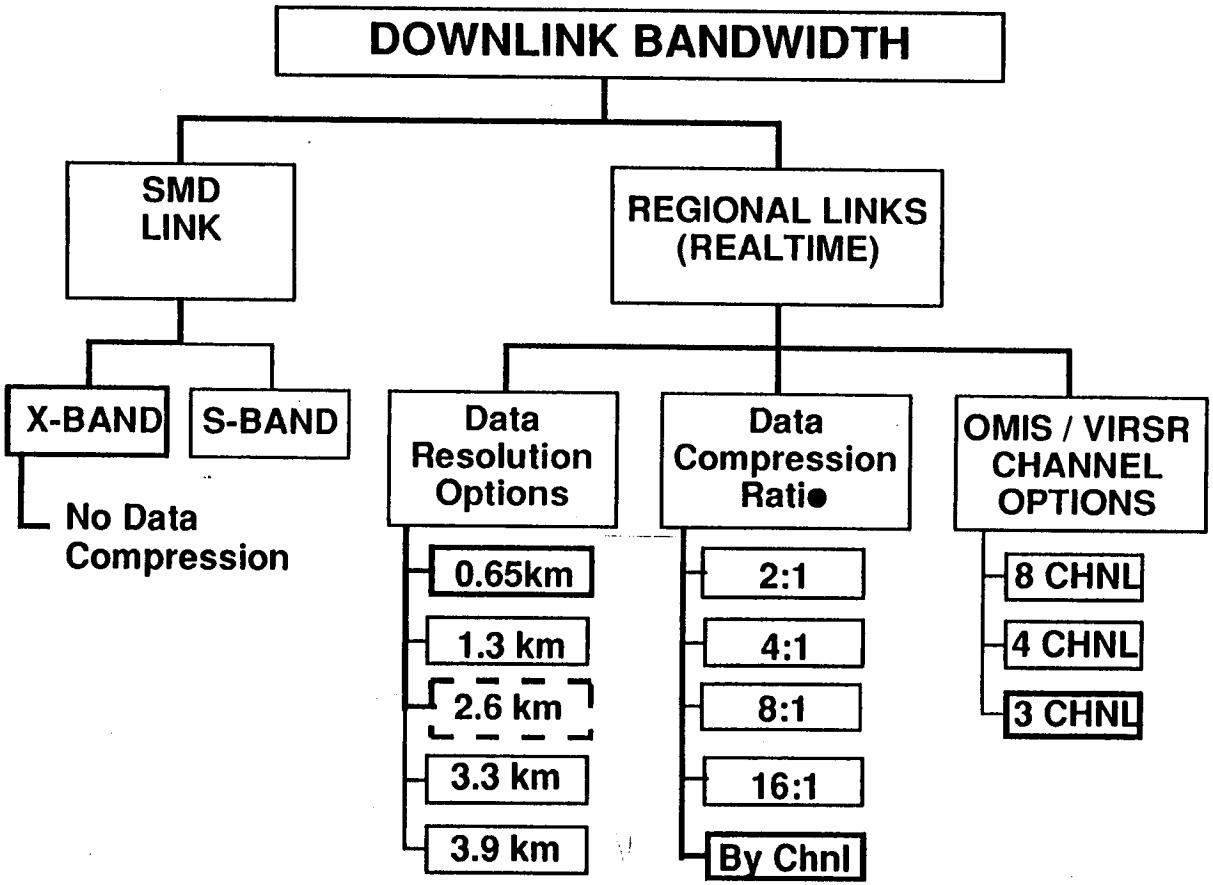
DATA COMPRESSION SUMMARY FOR REALTIME LINKS

D. TOM

"MEETING INTERFACE NEEDS OF EXISTING AND PLANNED USERS"

DOWNLINK TRADE TREE

C



BENEFITS TO GUS

- Increased B/W availability
- Minimized resolution and compression use
- Optimize link content
- Reduction in number of links

C REALTIME OMIS DATA COMPRESSION

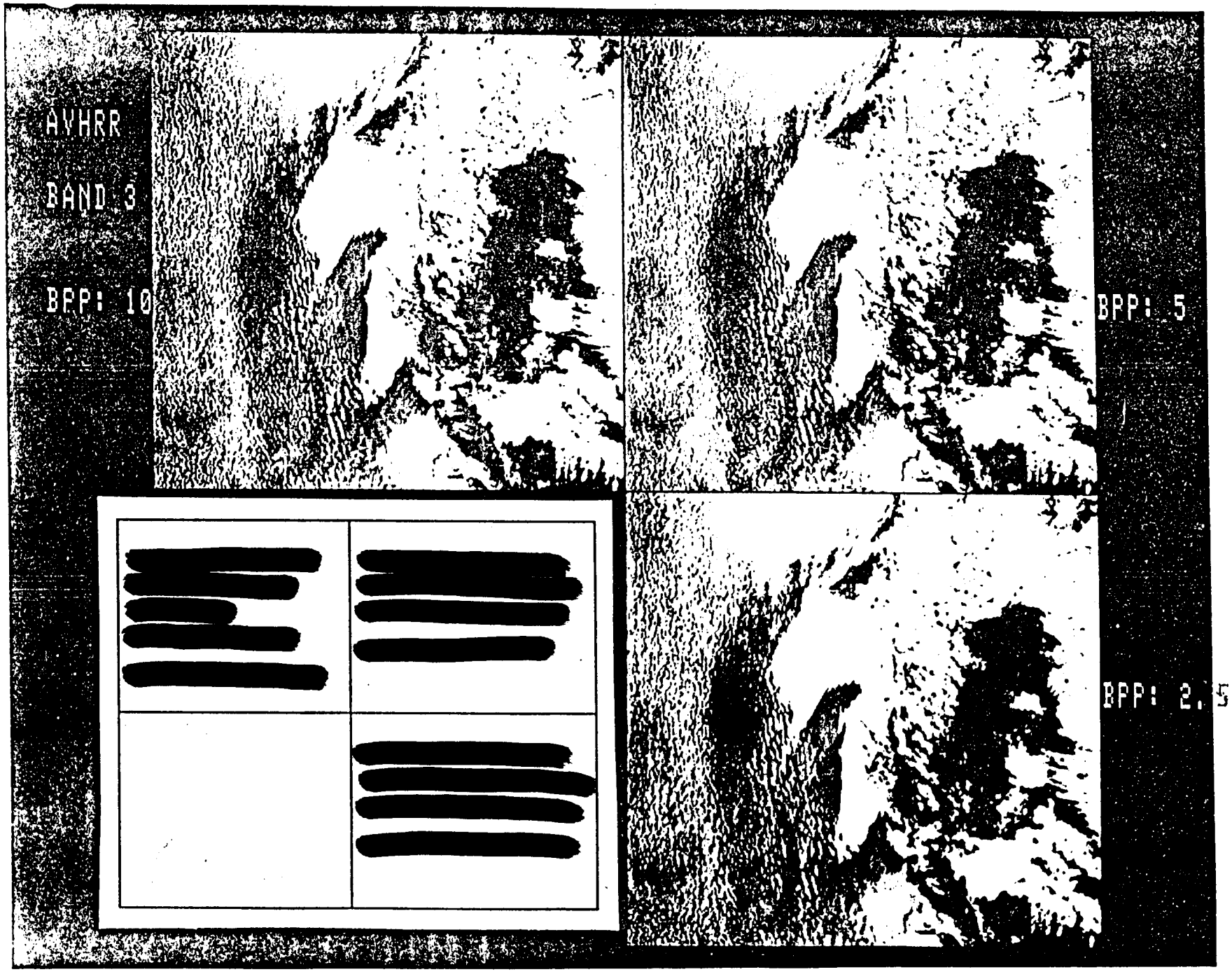
OMIS / VIRSR

BAND & CHANNEL	PIXEL ARRAY SIZE	SENSOR BUFFER READ	BITS PER PIXEL	RATE KBPS	DATA COMPRESSION	RATE KBPS
1 - Vis 0.6	10	4788	12	574.56	NET EFFECT	
2 - Vis 0.9	10	4788	12	574.56	4 : 1	143.64
3 - NIR/Vis 1.6	10	4788	12	574.56	4 : 1	143.64
4 - MW-IR 3.7	10	4788	12	574.56	4 : 1	143.64
5 - LW-IR 10	10	4788	12	574.56	LOSSLESS 2 : 1	287.28
6 - LW-IR 12	10	4788	12	574.56	LOSSLESS 2 : 1	287.28
7 - VS LLL	10	958	12	114.96	8 : 1	71.82
8 - IR 8.55	10	4788	12	574.56	NONE	114.96
					8 : 1	71.82

REALTIME LINK CHANNEL SELECTOR MULTIPLEXER

REALTIME DOWNLINKS

4134.8 KBPS STORED DATA COMPRESSED TO 1294.08 KBPS



AVHRR Data Compression Example

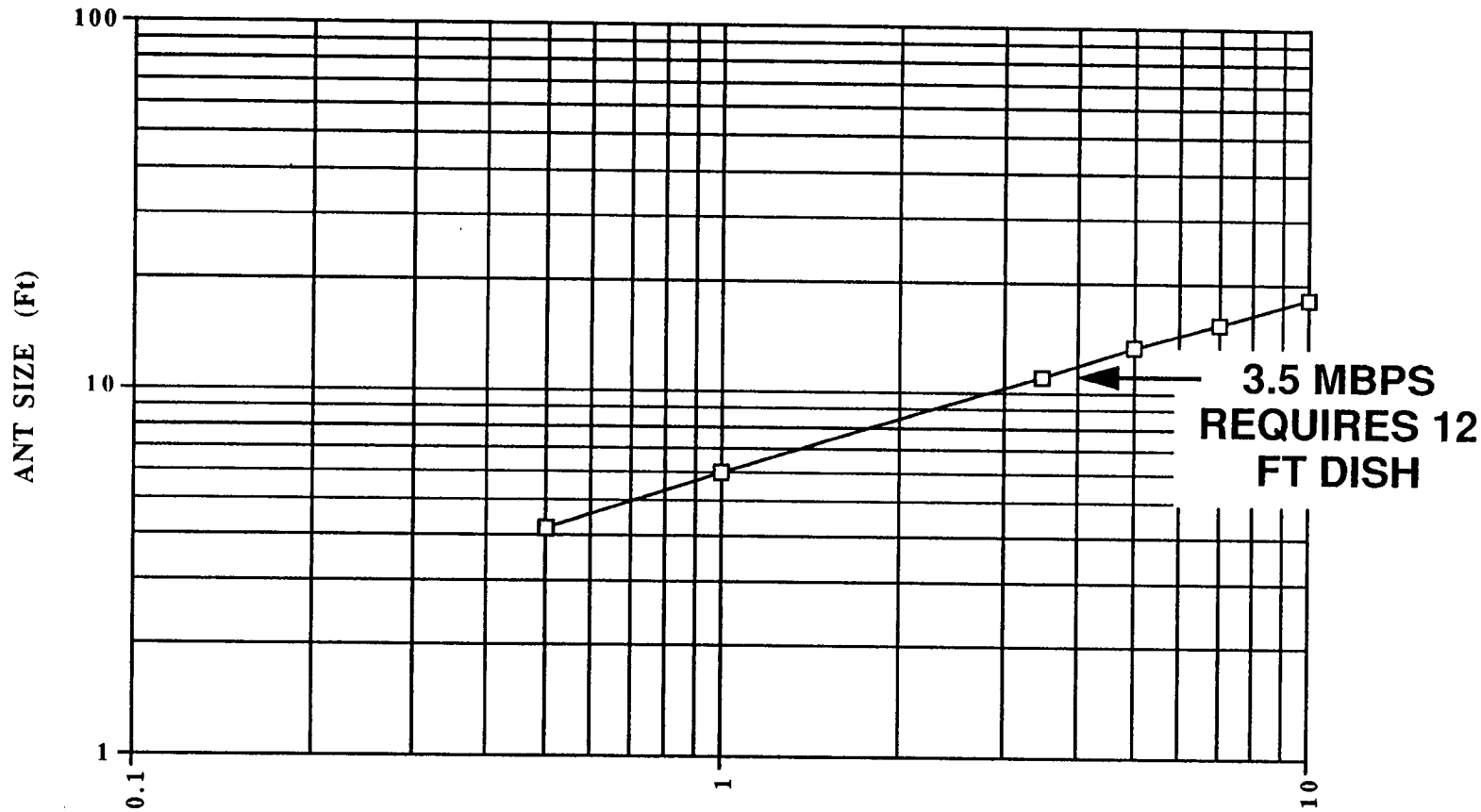
C HRPT CHARACTERISTICS

DATA RATE (MBPS)	3.5 (Total Data Rate, QPSK mod I=1.5 Mbps, Q=2.0 Mbps)
CARRIER FREQ (MHz)	1701.0
XMTR PWR (Watts)	28.0
XMT ANT GAIN-HORIZON (dB)	2.1
GND ANT DIAMETER (FT)	8.0 (2.4 Meter Dish)
GND ANT GAIN (dB)	30.2
SYSTEM G/T (dB/K)	4.5

THE LRPT TERMINAL IS PROPOSED TO HAVE A 64 - 72 KBPS DATA RATE

* Source: NOAA O,P,Q Phase A Report, NASA, 29 Jan 1992

C DATA RATE VS GROUND ANTENNA SIZE FOR HRPT TERMINAL



XMT PWR = 15 WATTS

C HRPT DOWNLINK DATA RATE MANAGEMENT ALTERNATIVES

OMIS - VIRSR RESOLUTION	DATA RATE (KBPS)				
	0.65 KM	0.65 KM	1.3 KM	1.3 KM	1.9 KM
DATA COMPRESSION RATIO	None	By Chnl	None	By Chnl	None
AIRS	1420	1420	1420	1420	1420
AMSU-A1	2.1	2.1	2.1	2.1	2.1
AMSU-A2	1.1	1.1	1.1	1.1	1.1
MHS	4	4	4	4	4
OMIS / VIRSR	4500	1294	1125	324	500
TOTAL SENSOR DATA RATE	5927	2721	2552	1751	1927
15% OVERHEAD	889	408	383	263	289
HRPT DATA RATE (KBPS)	6816	3129	2935	2014	2216

OMIS CHANNEL COMPRESSION OR A RESOLUTION OF AT LEAST 1.3 KM IS REQUIRED TO MEET HRPT DATA RATE (3.5 MBPS).

COMPRESSABILITY OF AIRS DATA REQUIRES ANALYSIS

C LRPT DOWNLINK DATA RATE MANAGEMENT ALTERNATIVES

OMIS - VIRSR RESOLUTION	DATA RATES (KBPS)			
	2.6 KM	3.3 KM	3.3 KM	3.9 KM
DATA COMPRESSION RATIO	By Chnl	None	By Chnl	None
AMSU-A1	2.1	2.1	2.1	2.1
AMSU-A2	1.1	1.1	1.1	1.1
MHS	4	4	4	4
OMIS / VIRSR	81	180	52	125
(3 Channels - #1, 3 & 5)	(36)	(69)	(23)	(48)
TOTAL SENSOR DATA RATE	88	187	59	132
15% OVERHEAD	13	28	9	20
LRPT DATA RATE (KBPS)	101	215	68	152
(3 Channels)	(49)	(87)	(35)	(63)

OMIS RESOLUTION OF LEAST 2.6 KM WITH 3 CHANNEL COMPRESSION IS REQUIRED TO MEET LRPT DATA RATE (72 KBPS).

C HIGH DATA RATE TACTICAL DOWNLINK MANAGEMENT ALTERNATIVES

OMIS - VIRSR RESOLUTION	DATA RATE (KBPS)			
	0.65 KM	0.65 KM	1.3 KM	1.3 KM
DATA COMPRESSION RATIO	None	By Chnl	None	By Chnl
MISS	37.3	37.3	37.3	37.3
OMIS / VIRSR	4500	1294	1125	324
TOTAL SENSOR DATA RATE	4537	1331	1162	361
15% OVERHEAD	680	200	174	54
HRPT DATA RATE (KBPS)	5217	1531	1336	415

OMIS / VIRSR DATA COMPRESSION BY CHANNEL PROVIDES FOR SIGNIFICANT MARGIN FOR HIGH DATA RATE (1.024 MBPS) TERMINALS.

C LOW DATA RATE TACTICAL DOWNLINK MANAGEMENT ALTERNATIVES

	DATA RATE (KBPS)			
OMIS - VIRSR RESOLUTION	2.6 KM	3.3 KM	3.3 KM	3.9 KM
DATA COMPRESSION RATIO	By Chnl	None	By Chnl	None
MISS	37.3	37.3	37.3	37.3
OMIS / VIRSR (3 Channels) #1,3 & 5	81 (36)	180 (69)	52 (23)	125 (48)
TOTAL SENSOR DATA RATE	118	217	89	162
15% OVERHEAD	18	33	13	24
HRPT DATA RATE (KBPS)	136 (84)	250 (122)	102 (69)	186 (98)

COMBINATION OF REDUCED RESOLUTION AND DATA COMPRESSION, OF 3 CHANNELS CAN BE APPLIED TO MEET THE LOW DATA RATE REQUIREMENT (100 KBPS)

C REALTIME LINK COMPRESSION SUMMARY

- ON-BOARD, BY CHANNEL COMPRESSION APPROACH MEETS USER NEEDS WITH MINIMUM COST / COMPLEXITY
- CHANNEL SELECTION, DATA RATES AND DATA CONTENT ISSUES REQUIRE FURTHER EVALUATION
- CALIBRATION AND DATA ACCURACY REQUIREMENTS NEED DEFINITION
- COMPRESSION OF MICROWAVE AND IR SOUNDER SENSOR DATA WILL BE EVALUATED
- REDUCTION OF REALTIME LINKS WILL REDUCE COMPLEXITY IN THE OBP AND REDUCE LCC
- PERFORMING FURTHER DATA COMPRESSION STUDIES

C

DRR - GUS ARCHITECTURE

D. EMANUEL

CONVERGED C3 ELEMENT FUNCTIONAL ALLOCATION

C

COMMAND, CONTROL, & COMMUNICATION SEGMENT C3

REMOTE TRACKING STATION

- Tracking [1]
- Range / Timing [1]
- Acquisition
- Ephemeris [1] Generation (via GPS)
- Commands & Stored Program Upload [2]
- Equip. Status & Telemetry

SATELLITE OPERATIONS CENTER

- Mission Control & Planning
- Payload Control & Sensor Planning [3]
- User Request Relay
- Command Generation
- Computer Memory Upload Generation
- Telemetry Analysis
- Launch/Early Orbit
- Command & Control
- Anomaly Resolution
- Store & Forward
- Launch Interface
- Tracking [4]

DATA ROUTING & RETRIEVAL (DRR)

- Mission Data Routing
  - Stored
  - Realtime (Embedded EST)
- DOMSAT I / F

FLIGHT VEHICLE SUPPORT FACILITY (FVSF)

- S/C Enviro. Simulation
- Uplink/Downlink I/F Validation
- Flight Load Package Validation
- Training [4]

1 Backup Only
2 O2 Functions TBD
3 I / F to Agency POC
4 TBD Allocation

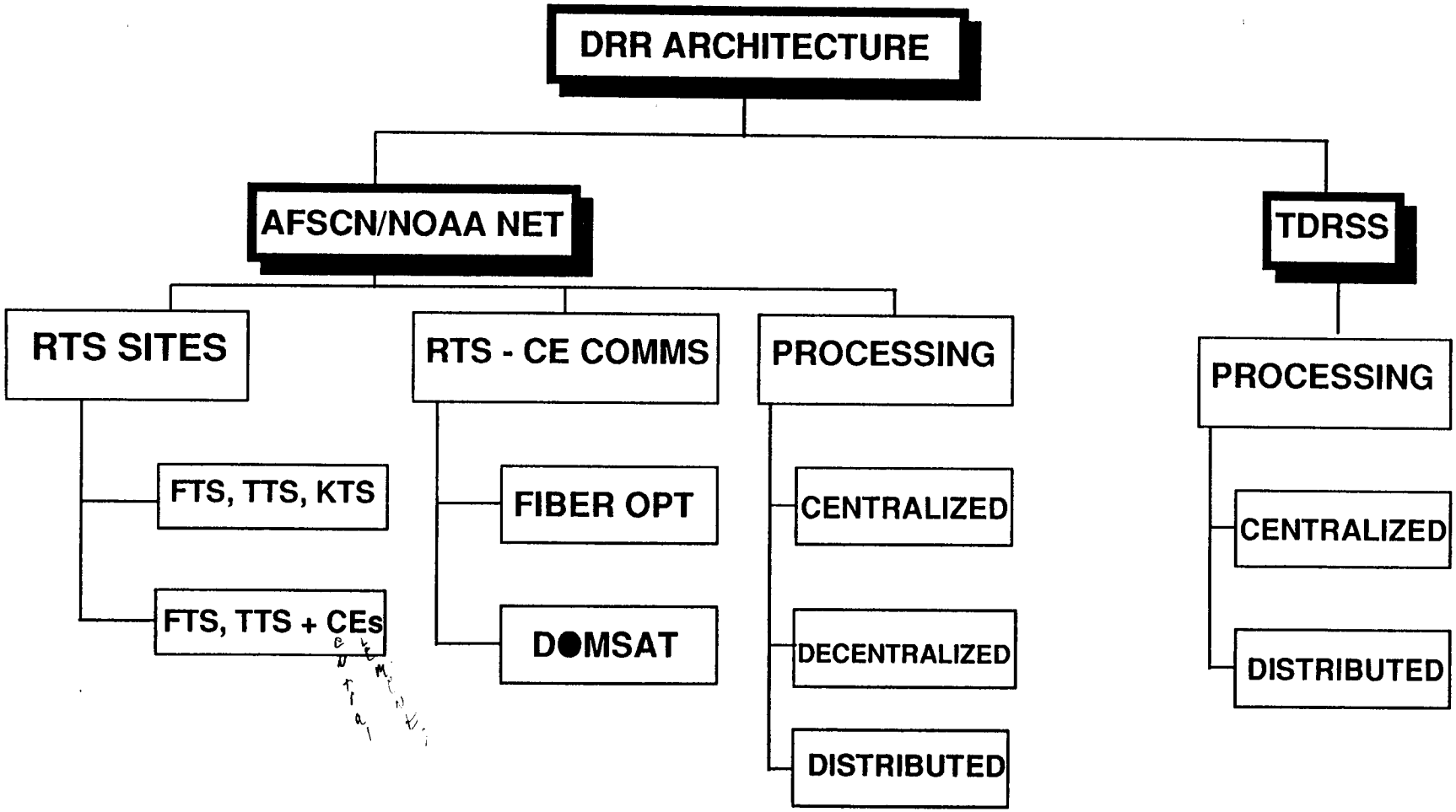
C SOURCES OF COST DATA FOR TRADE STUDY

- G.E. AMERICAN COMMUNICATIONS - DOMSAT & THULE
- ATT - FIBER OPTICS LINKS
- ALASCOM - FAIRBANKS DS-3
- SCIENTIFIC ATLANTA - TERMINALS
- LMSC TELECOMMUNICATIONS DEPT
- MacDONALD DETTWILER - TERMINAL INSTALLATION
- NASA HQ - TDRSS

* Data and rationale to be included in EM 1141

DRR TRADE TREE

C



C DRR TRADE STUDY ASSUMPTIONS

- MAXIMUM OF THREE SATELLITES MAY BE SUPPORTED SIMULTANEOUSLY.
- CENTRALIZED PROCESSING REDUCES DATA RATE TO DS-1 TO OTHER SITES.
- TWO DS-3 LINES (1 SPACECRAFT SMD) REQUIRED TO EOS-DIS; NO SMD PROCESSING AT ERL, 1 DS-1 REQUIRED.
- COMPARATIVE COMM LINK AND O&M COSTS ARE FOR A TEN YEAR PERIOD - O & M COSTS ARE FOR RTS/CDA MANNING WITH MINIMUM STAFF.
- COST OF HIGH DATA RATE LINKS WILL REMAIN CONSTANT OVER 10 YEAR LIFE CYCLE.
- ONE CONUS C-BAND DOMSAT CAN SUPPORT TTS, FTS, AND ALL CONUS SITES - DOMSAT COSTS ARE FOR TRANSPONDER LEASE AND PROCUREMENT OF SATCOM TERMINALS.
- NESDIS SHOWN AS NOTIONAL CENTRALIZED PROCESSING LOCATION - COULD BE ANY OTHER LOCATION WITHOUT SIGNIFICANT COST IMPACT .

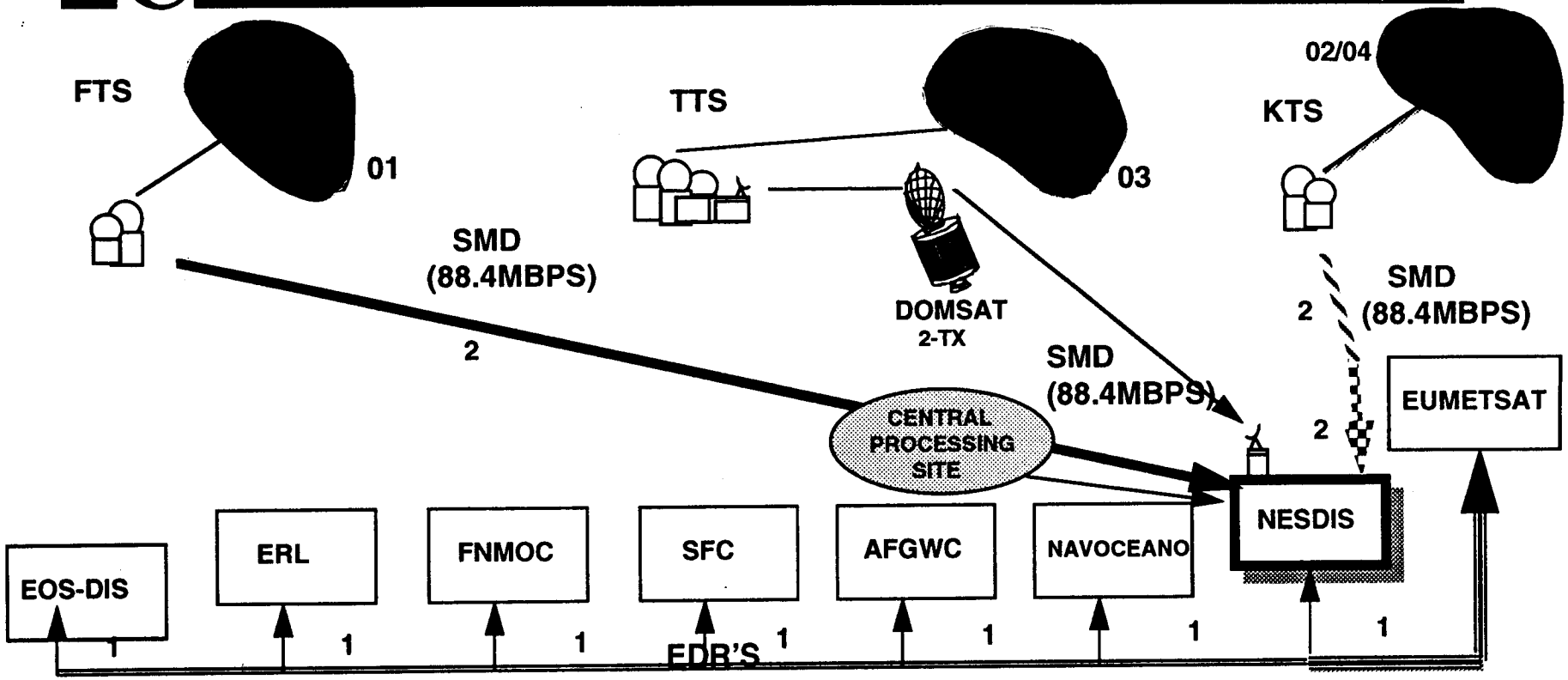
C CONFIGURATIONS EXAMINED

(EXCLUDING TDRSS)

	TRACKING STATIONS				DRR METHOD		PROCESSING		
	KIRUNA TRACKING STATION	FAIRBANKS TRACKING STATION	THULE TRACKING STATION	CENTRAL ELEMENTS EAST, WEST, MID CONUS	FIBER OPTICS (EXCEPT TTS)	DOMSAT	CENTR-ALIZED	DECENTR-ALIZED ↔	DISTRIBU-TED
A	▒	▒	▒		▒		▒		
B	▒	▒	▒		▒			▒	
C	▒	▒	▒			▒	▒		
D	▒	▒	▒			▒		▒	
E		▒	▒	▒	▒			▒	
F		▒	▒	▒	▒				▒
G		▒	▒	▒		▒		▒	
H		▒	▒	▒		▒			▒

CONFIG A: NORTHERN RTSs, FO COMS CENTRALIZED PROCESSING

C



COMMUNICATION LINK REQUIREMENTS

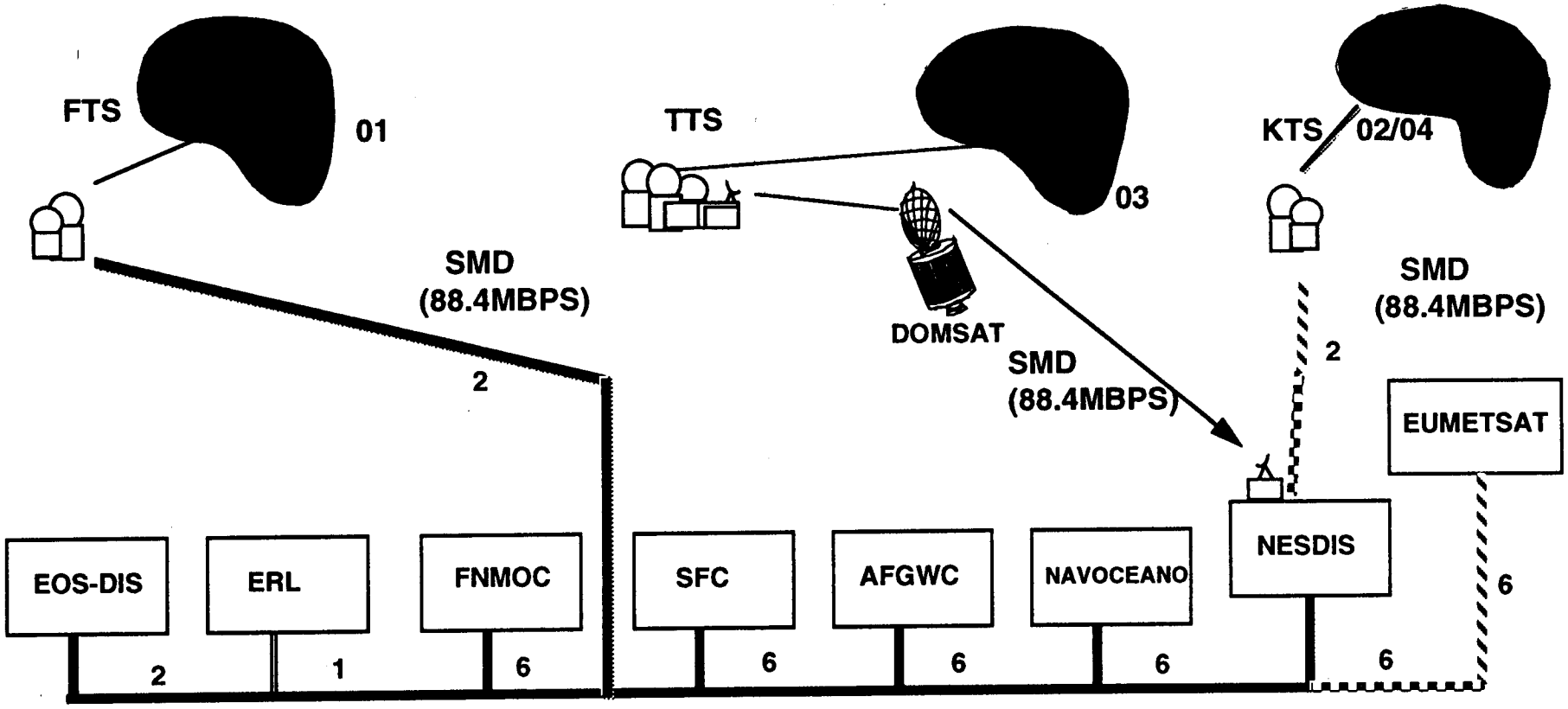
TYPE	CONUS FO (DS3)	OCONUS FO (DS3)	TRANSOCEAN FO (DS3)	DOMSAT TX/ TER		LO RATE FO (DS1)	LO RATE TRNSOCN (DS1)
QUANTITY	2	2	2	2	2	6	1

DS3 LINK RATE 44.2 MBPS DOMSAT C- BAND TRANSPONDER, SUPPORTS 1 DS3 DS1 LINK RATE 1.5 MBPS

CONVERGED SYSTEM DEFINITION

CONFIG B: NORTHERN RTSs, FO COMs DISTRIBUTED PROCESSING

C



COMMUNICATION LINK REQUIREMENTS

TYPE	CONUS FO (DS3)	OCONUS FO (DS3)	TRANSOCEAN FO (DS3)	DOMSAT TX/ TER	LO RATE FO (DS1)	LO RATE TRNSOCN (DS1)
QUANTITY	28	8	8	2 2	1	0

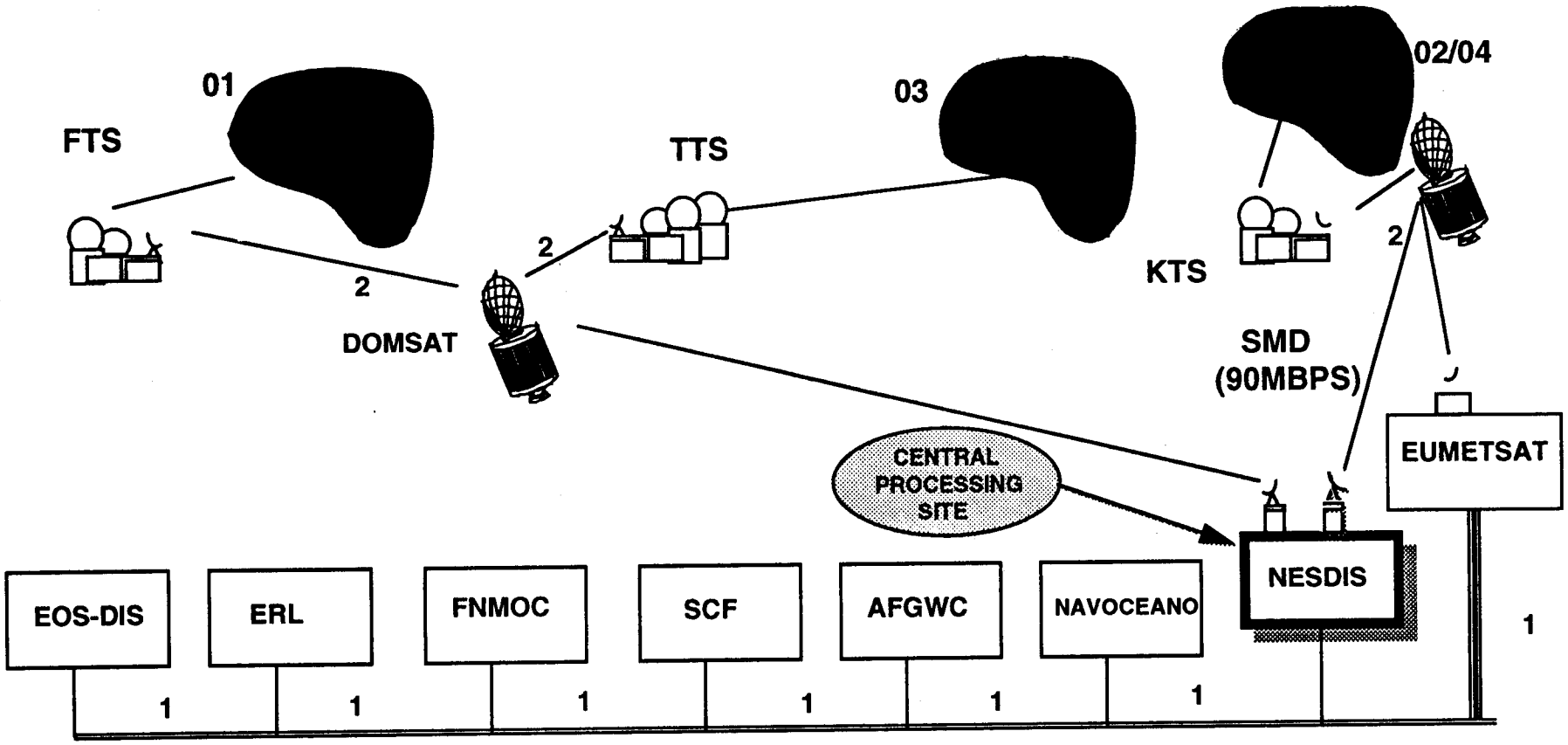
DS3 LINK RATE 44.2 MBPS DOMSAT C- BAND TRANSPONDER, SUPPORTS 1 DS3 DS1 LINK RATE 1.5 MBPS

78

CONVERGED SYSTEM DEFINITION

CONFIG C: NORTHERN RTSs, DOMSATs CENTRALIZED PROCESSING

C



COMMUNICATION LINK REQUIREMENTS

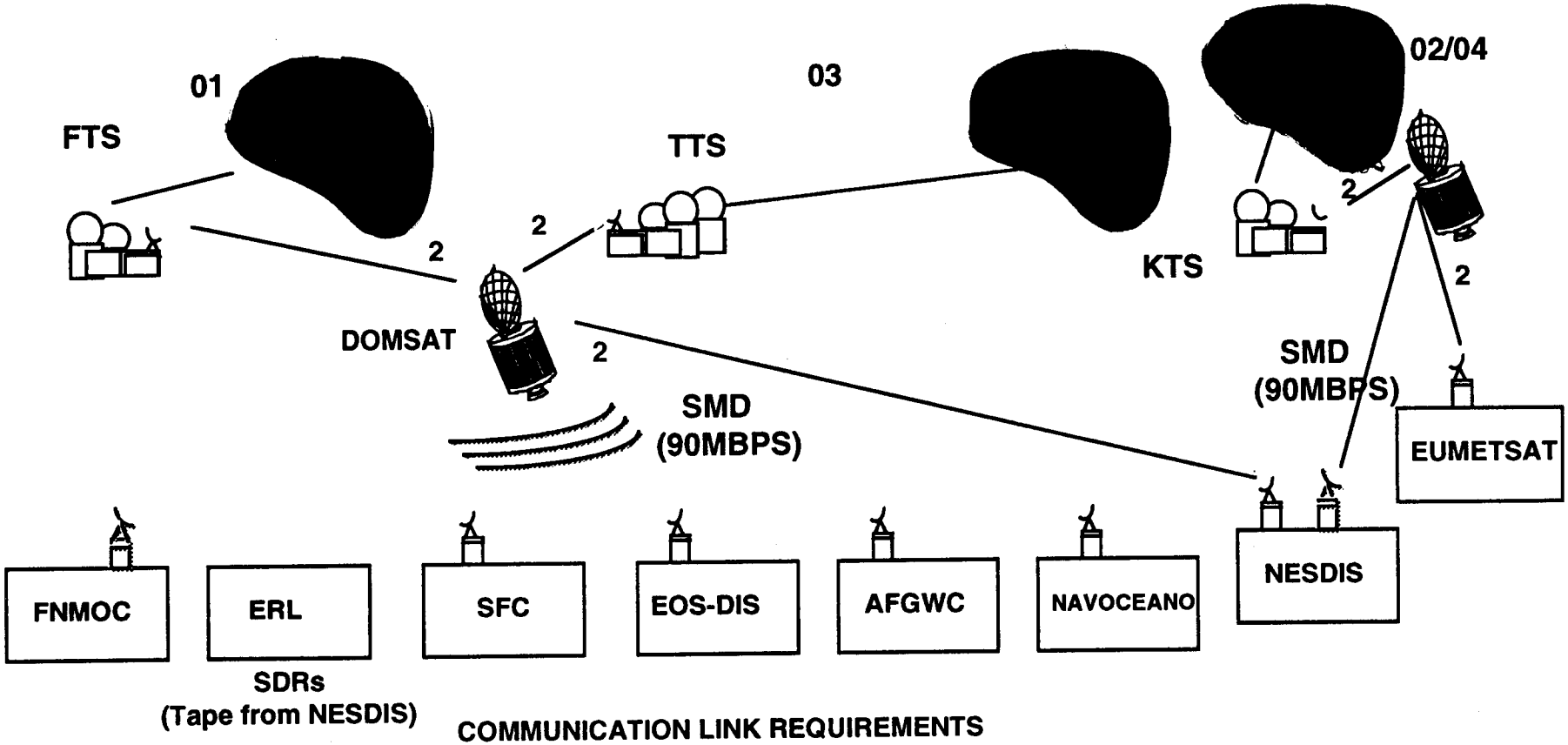
TYPE	CONUS FO (DS3)	OCONUS FO (DS3)	TRANSOCEAN FO (DS3)	DOMSAT TX/ TER		LO RATE FO (DS1)	LO RATE TRNSOCN (DS1)
QUANTITY	0	0	0	6	6	6	1

DS3 LINK RATE 44.2 MBPS DOMSAT C- BAND TRANSPONDER, SUPPORTS 1 DS3 DS1 LINK RATE 1.5 MBPS

CONVERGED SYSTEM DEFINITION

CONFIG D: NORTHERN RTSs, DOMSATs DISTIBUTED PROCESSING

C



COMMUNICATION LINK REQUIREMENTS

TYPE	CONUS FO (DS3)	OCONUS FO (DS3)	TRANSOCEAN FO (DS3)	DOMSAT TX/ TER	LO RATE FO (DS1)	LO RATE TRNSOCN (DS1)
QUANTITY	0	0	0	10 11	0	0

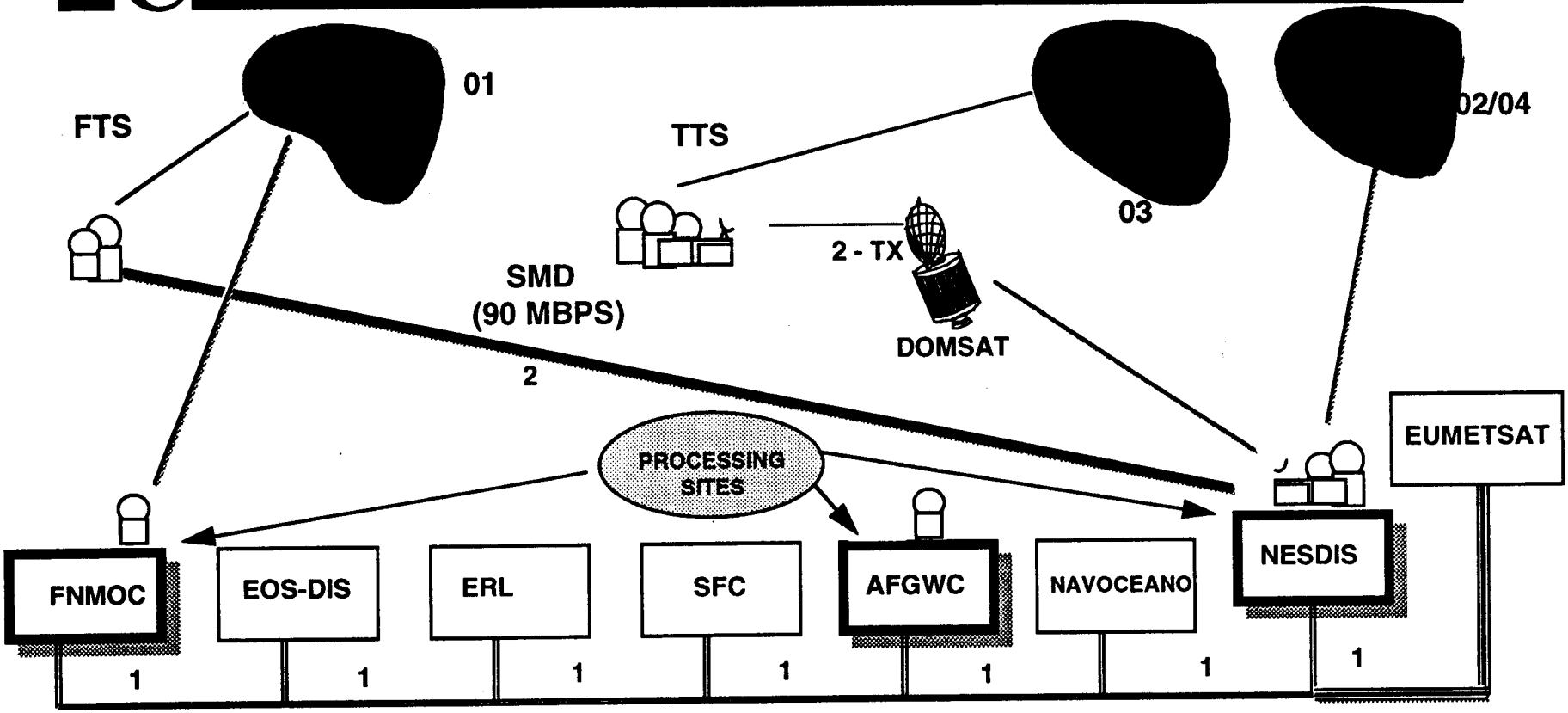
DS3 LINK RATE 44.2 MBPS DOMSAT C- BAND TRANSPONDER, SUPPORTS 1 DS3 DS1 LINK RATE 1.5 MBPS

4/13/95

CONVERGED SYSTEM DEFINITION

CONFIG E: 2 RTSs + CEs, FO COMS DECENTRALIZED PROCESSING

C



EDR'S

COMMUNICATION LINK REQUIREMENTS

TYPE	CONUS FO (DS3)	OCONUS FO (DS3)	TRANSOCEAN FO (DS3)	DOMSAT TX/ TER	LO RATE FO (DS1)	LO RATE TRNSOCN (DS1)
QUANTITY	2	0	0	2 2	6	1

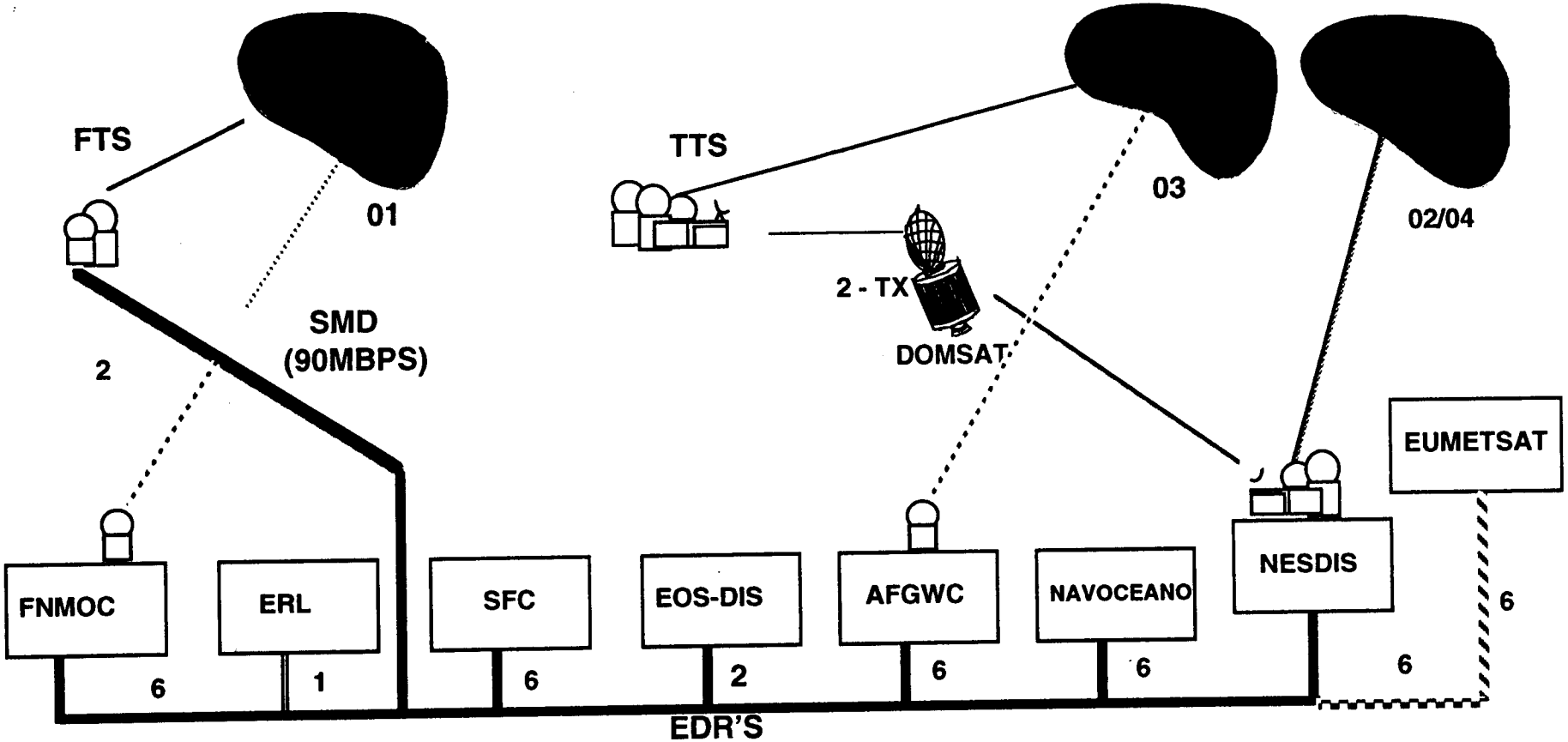
DS3 LINK RATE 44.2 MBPS DOMSAT C- BAND TRANSPONDER, SUPPORTS 1 DS3 DS1 LINK RATE 1.5 MBPS

4/13/95

CONVERGED SYSTEM DEFINITION

CONFIG F: 2 RTSs + CEs, FO COMS DISTRIBUTED PROCESSING

C



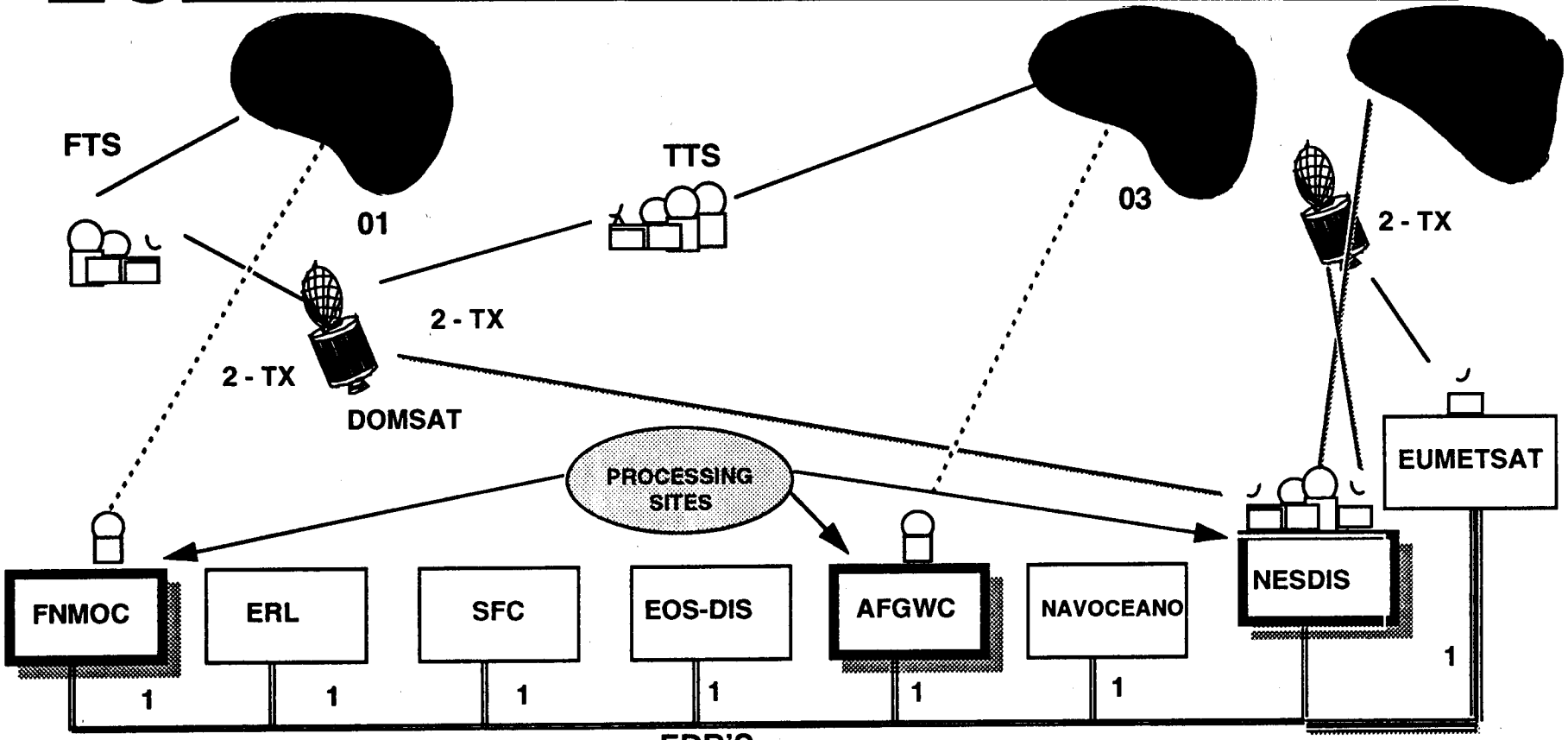
EDR'S
COMMUNICATION LINK REQUIREMENTS

TYPE	CONUS FO (DS3)	OCONUS FO (DS3)	TRANSOCEAN FO (DS3)	DOMSAT TX/ TER		LO RATE FO (DS1)	LO RATE TRNSOCN (DS1)
QUANTITY	28	6	6	2	2	1	1

dmsp/noaa DS3 LINK RATE 44.2 MBPS DOMSAT C- BAND TRANSPONDER, SUPPORTS 1 DS3 DS1 LINK RATE 1.5 MBPS

CONFIG G: 2 RTSs + CEs, DOMSATs DECENTRALIZED PROCESSING

C



EDR'S
COMMUNICATION LINK REQUIREMENTS

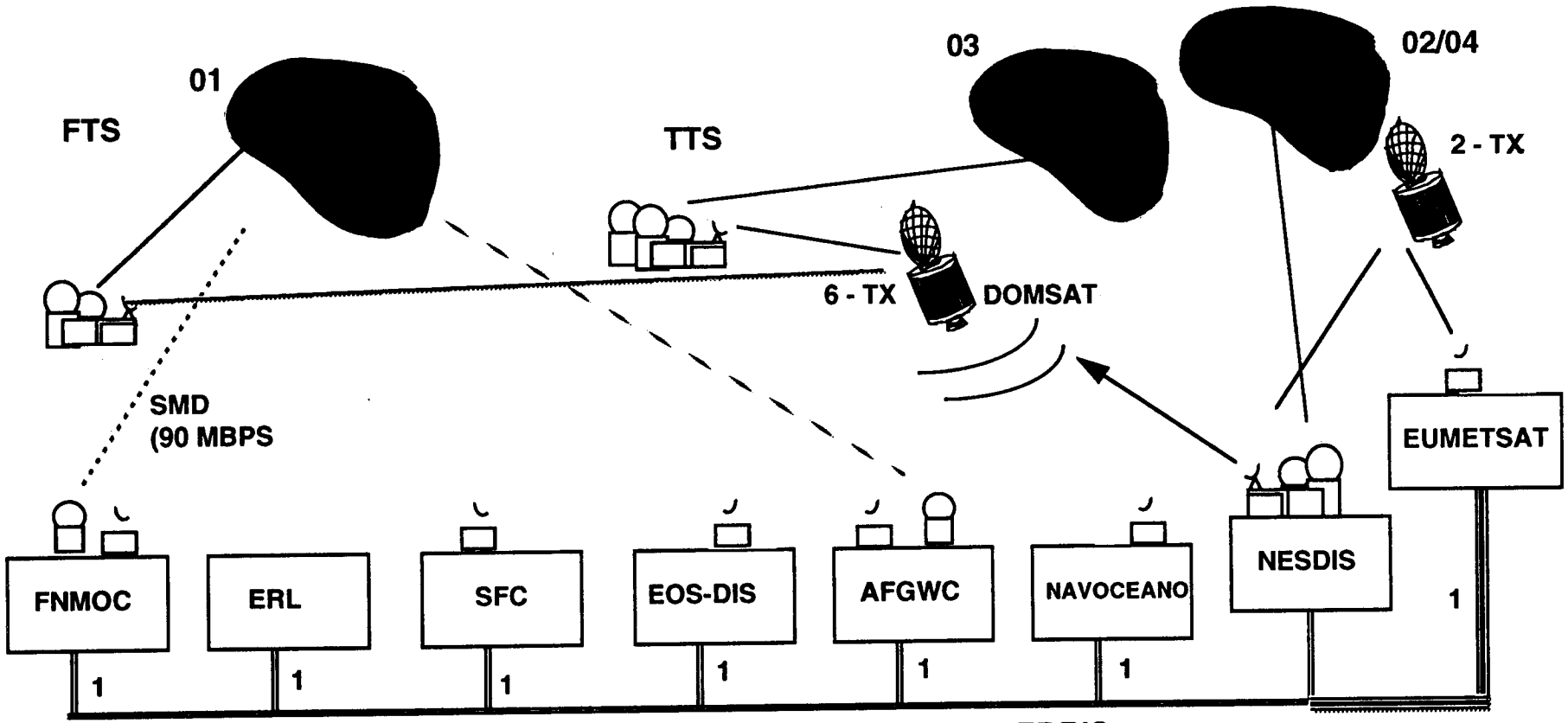
TYPE	CONUS FO (DS3)	OCONUS FO (DS3)	TRANSOCEAN FO (DS3)	DOMSAT TX/ TER	LO RATE FO (DS1)	LO RATE TRNSOCN (DS1)
QUANTITY	2	0	0	6 5	6	1

DS3 LINK RATE 44.2 MBPS DOMSAT C- BAND TRANSPONDER, SUPPORTS 1 DS3 DS1 LINK RATE 1.5 MBPS

CONVERGED SYSTEM DEFINITION

CONFIG H: 2 RTSs + CEs, DOMSATs DISTRIBUTED PROCESSING

C



COMMUNICATION LINK REQUIREMENTS

TYPE	CONUS FO (DS3)	OCONUS FO (DS3)	TRANSOCEAN FO (DS3)	DOMSAT TX/ TER	LO RATE FO (DS1)	LO RATE TRNSOCN (DS1)
QUANTITY	0	0	0	8 9	6	1

DS3 LINK RATE 44.2 MBPS DOMSAT C- BAND TRANSPONDER, SUPPORTS 1 DS3 DS1 LINK RATE 1.5 MBPS

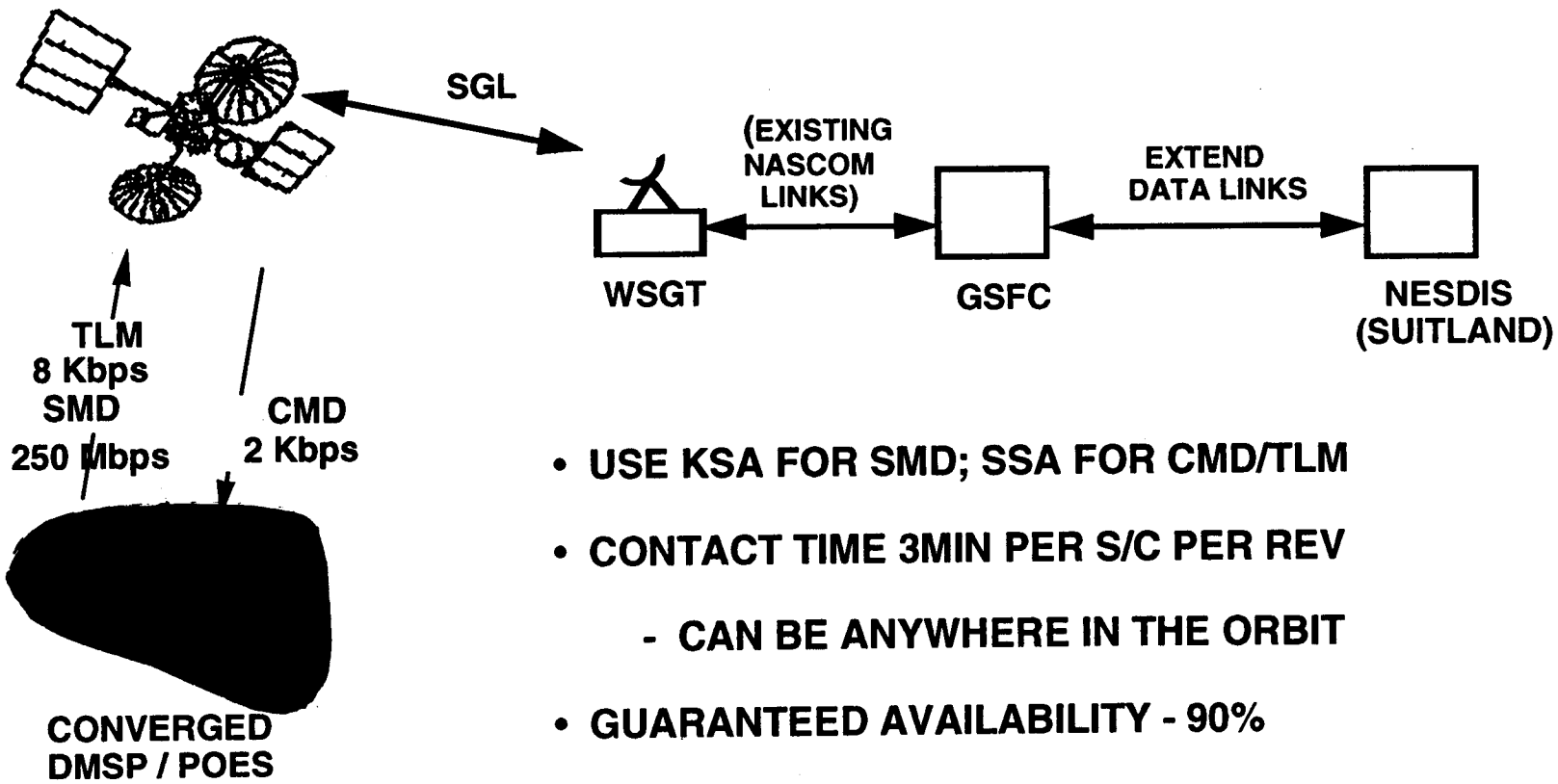
INTERIM DRR TRADE RESULTS

C

Configuration	A	B	C	D	E	F	G	H
SITES COMM PROCESSING	N RTS FO CNTR	N RTS FO DISTR	N RTS DMSAT CNTR	N RTS DMSAT DISTR	R &CE FO DECNTR	R &CE FO DISTR	R &CE DMSAT DECNTR	R &CE DMSAT DISTR
• Timeliness	120 MIN AVG	120 MIN AVG	120 MIN AVG	120 MIN AVG	TBR	TBR	TBR	TBR
• Max Data Rate (MBPS)	88.4	88.4	88.4	88.4	88.4	88.4	88.4	88.4
• Coverage	>8.5 min	>8.5 min	>8.5 min	>8.5 min	8.5 min TBR*	8.5 min TBR*	8.5 min TBR*	8.5 min TBR*
• No. Stations to Mod	1	1	1	1	1	1	1	1
• No. Stations to Man	3	3	3	3	5	5	5	5
• Comparative Costs								
- RTS Mods	.07	.07	.07	.07	.07	.07	.07	.07
- Comm Links/Term	.40	1.15	.50	.81	.34	1.11	.66	.78
- O & M	.04	.04	.05	.11	.09	.09	.11	.16
Total	.52	1.26	.63	1.00	.51	1.28	.85	1.01

* GAPS CAUSED BY CENTRAL ELEMENT STATION RECEPTION TBD

C TDRSS USE FOR CONVERGED SYSTEM

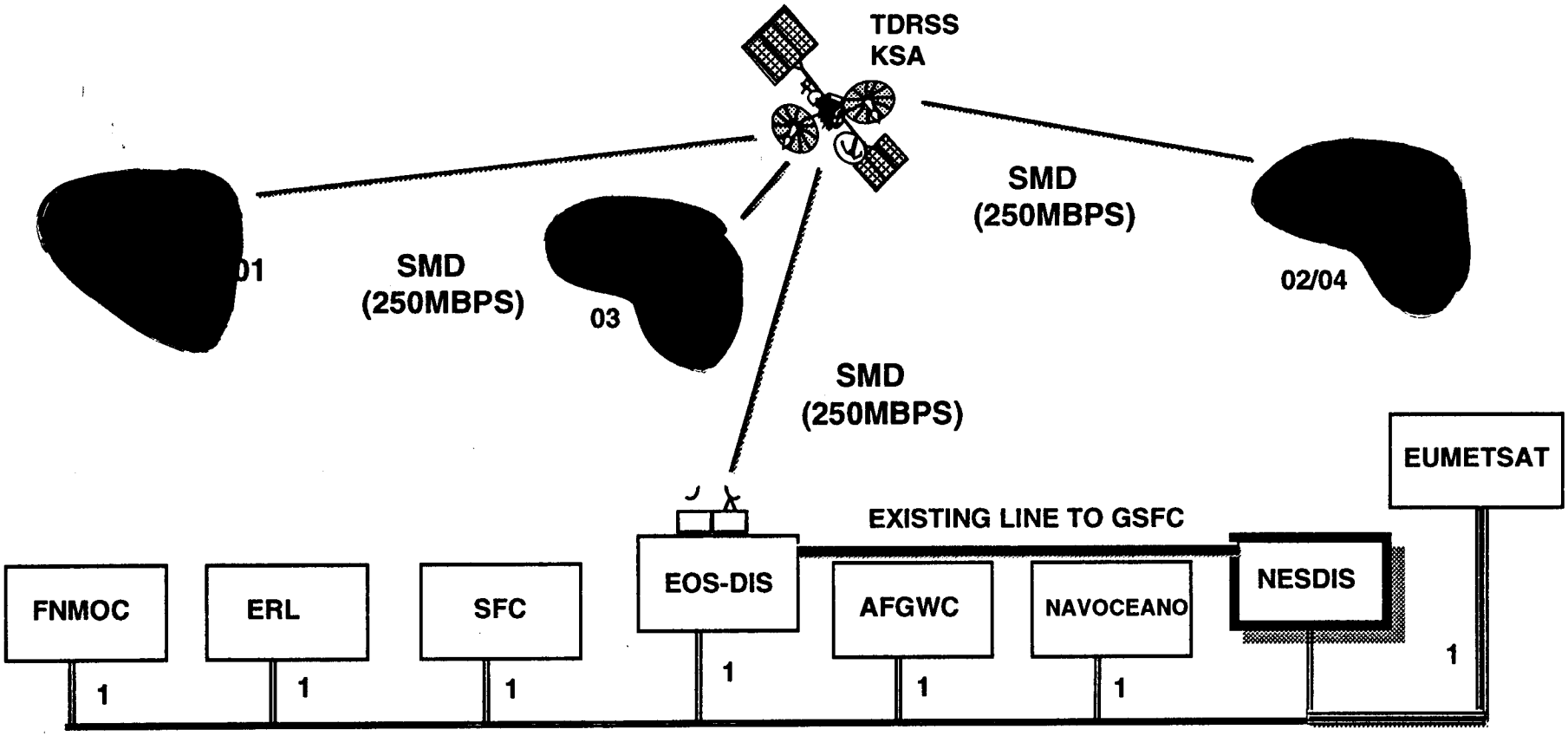


- USE KSA FOR SMD; SSA FOR CMD/TLM
- CONTACT TIME 3MIN PER S/C PER REV
  - CAN BE ANYWHERE IN THE ORBIT
- GUARANTEED AVAILABILITY - 90%
- UNSCHEDULED EMERGENCY LINK - 30 MINUTES

CONVERGED SYSTEM DEFINITION

CONFIG 1: TDRSS CENTRALIZED PROCESSING

C



COMMUNICATION LINK REQUIREMENTS EDR'S

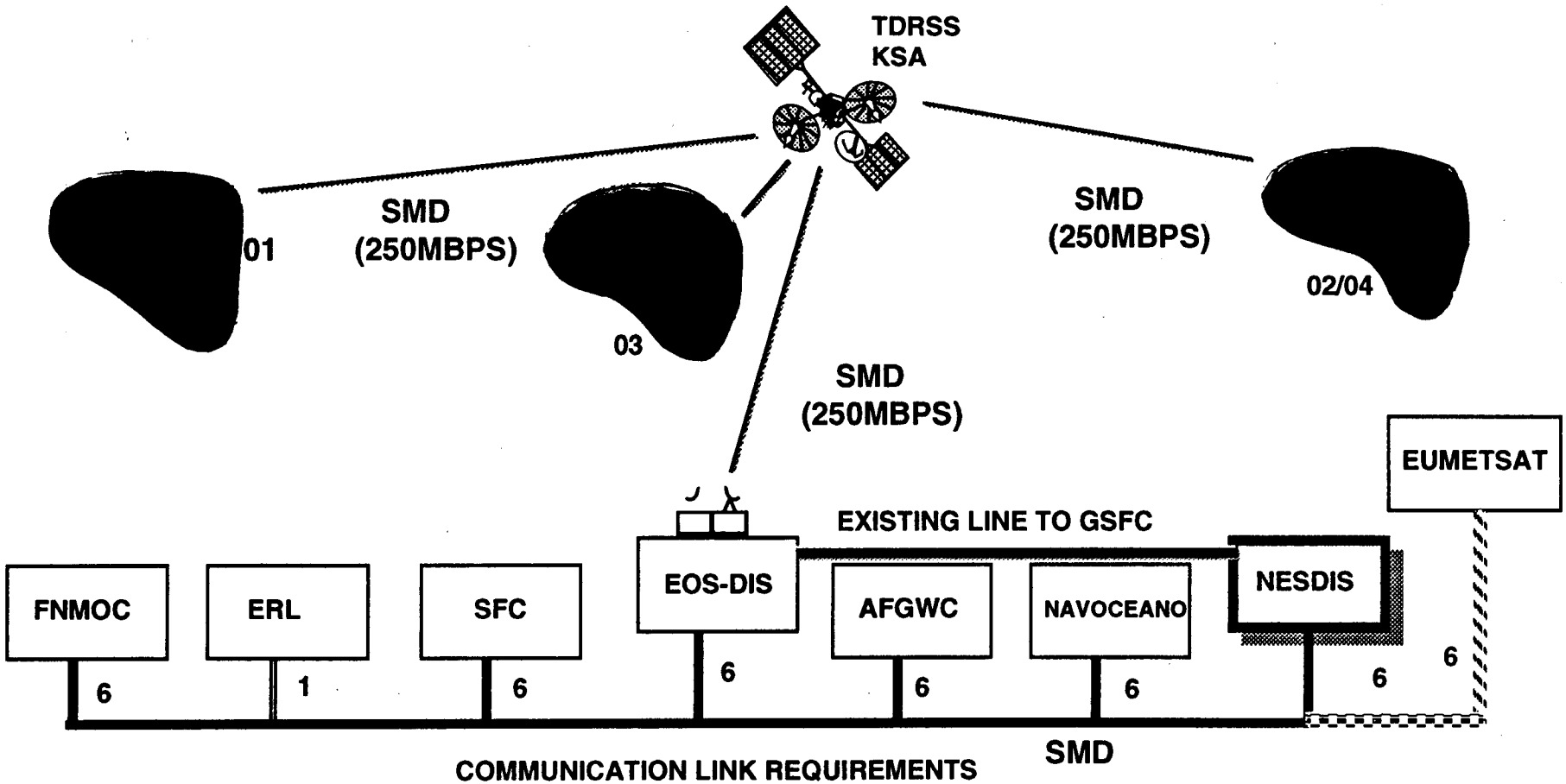
TYPE	CONUS FO (DS3)	OCONUS FO (DS3)	TRANSOCEAN FO (DS3)	DOMSAT TX/ TER	LO RATE FO (DS1)	LO RATE TRNSOCN (DS1)
QUANTITY	0	0	0	0 0	6	1

87 dmsp/noaa DS3 LINK RATE 44.2 MBPS DOMSAT C- BAND TRANSPONDER, SUPPORTS 1 DS3 DS1 LINK RATE 1.5 MBPS

CONVERGED SYSTEM DEFINITION

CONFIG 2: TDRSS FO COMS, DISTRIBUTED PROCESSING

C



COMMUNICATION LINK REQUIREMENTS

TYPE	CONUS FO (DS3)	OCONUS FO (DS3)	TRANSOCEAN FO (DS3)	DOMSAT TX/ TER		LO RATE FO (DS1)	LO RATE TRNSOCN (DS1)
QUANTITY	30	6	6	0	0	1	0

88 dmsp/noaa DS3 LINK RATE 44.2 MBPS DOMSAT C- BAND TRANSPONDER, SUPPORTS 1 DS3 DS1 LINK RATE 1.5 MBPS

TDRSS COST SUMMARY

C

	WITH $120/MIN TDRSS CHARGE	WITHOUT TDRSS CHARGE*
OPTION CENTRALIZED	.15	.03
DISTRIBUTED WITH DOMSAT DIST	.94	.81
DISTRIBUTED WITH FO DIST	.99	.86

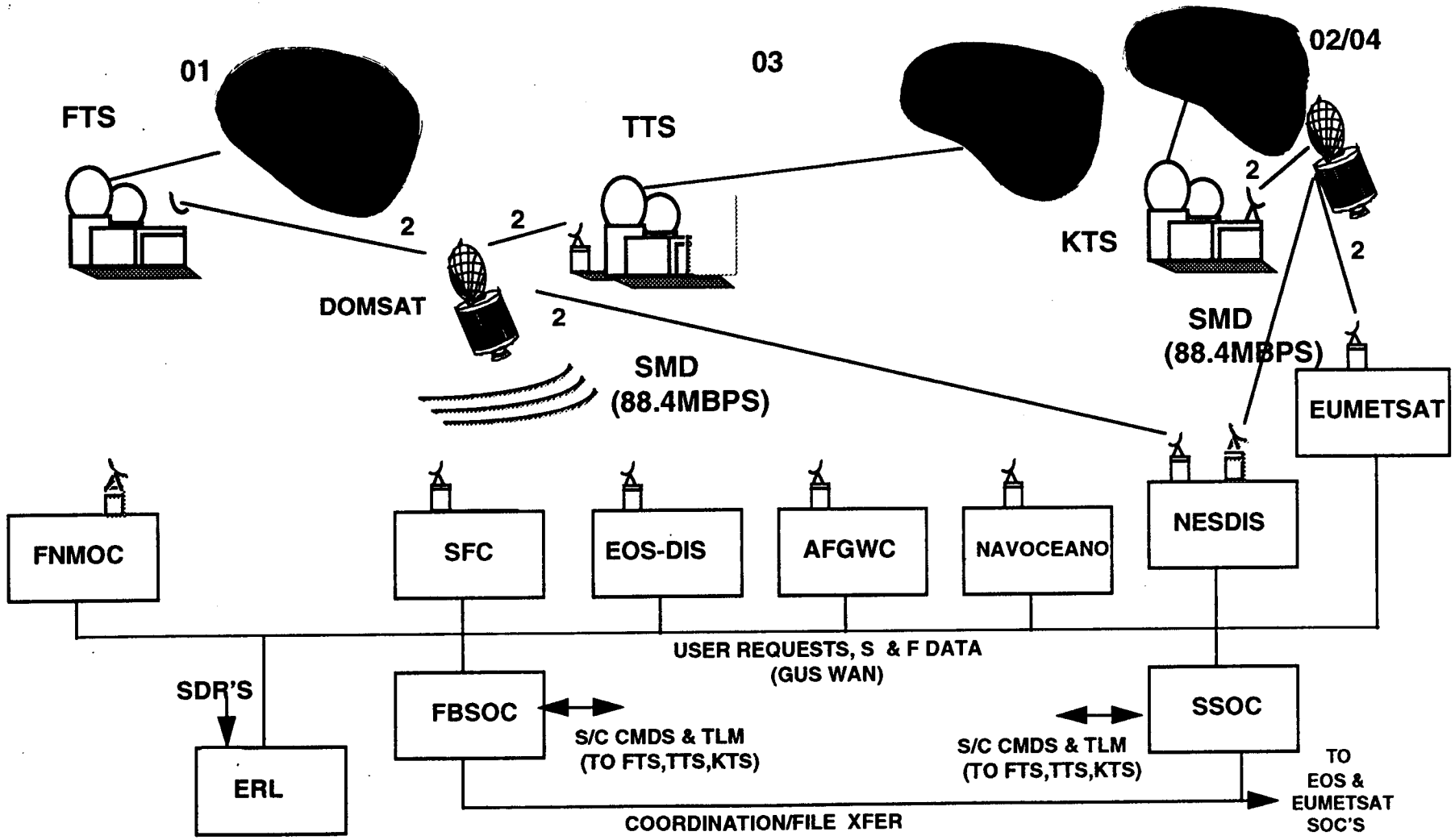
* THE NASA ADMINISTRATOR HAS THE OPTION OF WAIVING THE STANDARD TDRSS CHARGE TO PROGRAMS OF NATIONAL IMPORTANCE

DRR TRADE SUMMARY

- COMMUNICATION LINKS ARE A MAJOR LIFE CYCLE COST DRIVER
- JOINT EFFORT NEEDED TO MINIMIZE RATE/NUMBER OF LINKS
  - FURTHER EXAMINATION OF TDRSS USE
    - CONDUCT LOADING ANALYSIS
  - CONSIDER CENTRALIZED OR DECENTRALIZED PROCESSING
    - GREATLY REDUCES LIFE CYCLE COSTS (~40%)
  - REVISIT ON-BOARD DATA COMPRESSION
  - RELAX DATA TIMELINESS FOR SOME DATA TYPES
  - INVESTIGATE SHARED USE OF WIDEBAND LINKS

BASELINE ARCHITECTURE

C



4/13/95

C TRACKING STATIONS

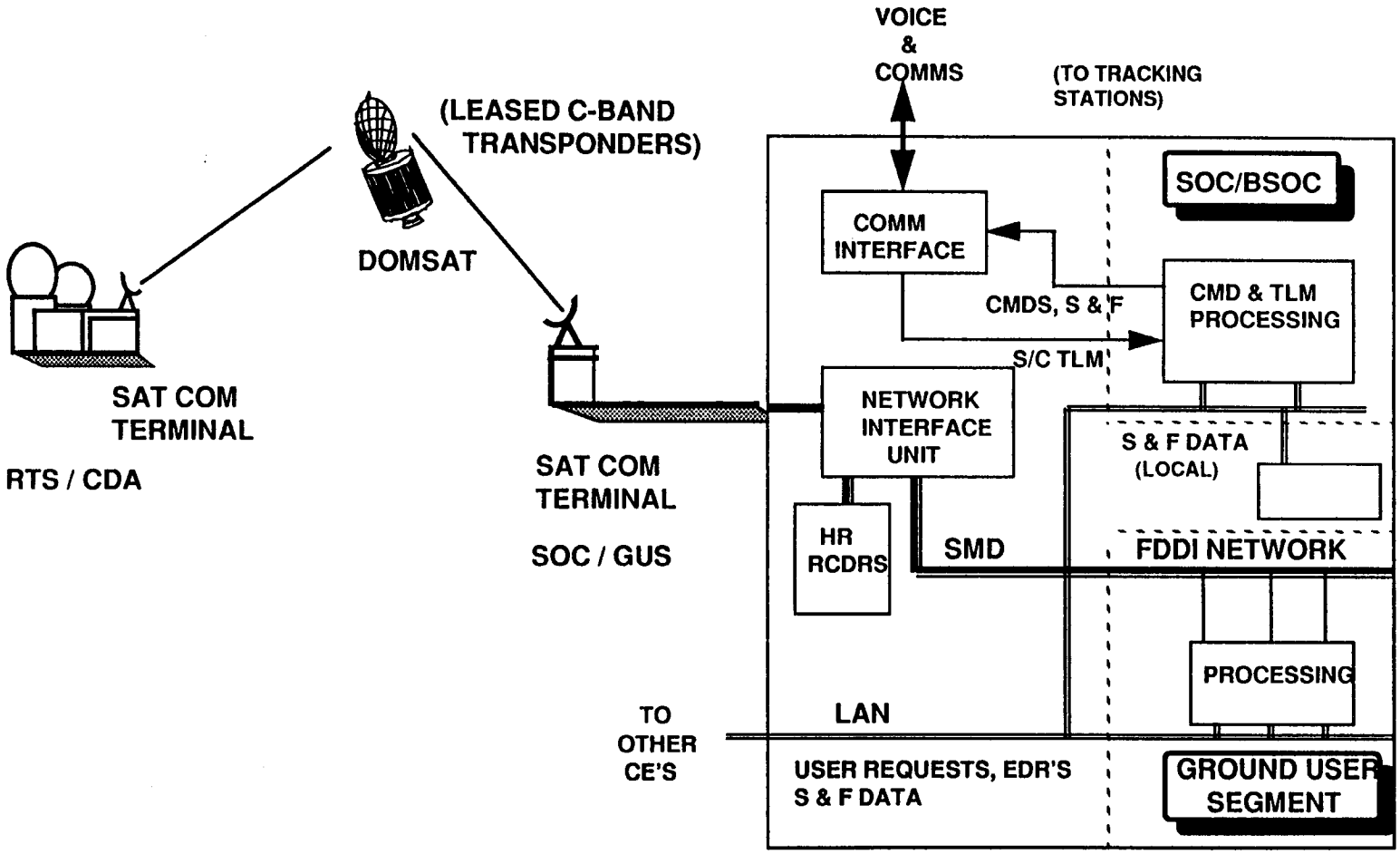
- AFSCN - TTS (Thule, Greenland)
  - Modifications required
    - » Unified S-band, SDN TT & C
    - » X-band 88.4 MBPS Payload receive capability
  - Options being considered
    - » Modify 46 ft. Antenna System
    - » Modify 10Mb ARTS System
    - » New Antenna System
  - COTS available for majority of required hardware; customized feed system may be required
  - Interfacing equipment with DR&R required

C TRACKING STATIONS (CONT'D)

- CDA'S (Fairbanks Tracking Station, Alaska - Kiruna, Sweden)
  - Our Baseline Assumes unified S-band TT&C and 88.4 MBPS X-band receive capability will exist
  - Interfacing equipment for DR&R will be required

CONVERGED SYSTEM DEFINITION

C DATA ROUTING & RETRIEVAL I / F



C DRR EQUIPMENT

- Satcom Terminals
  - Low cost COTS antenna systems available
  - COTS high speed modems
    - Support link rates up to 120 MBPS
    - Dual DS-3 channel compatible
    - Fiber optic outputs

- DOMSAT
  - DS-3 Compatible Transponders available for lease
  - C-band operations provides full CONUS coverage in broadcast mode
  - 2nd DOMSAT required to provide coverage from Kiruna

- Central Element/SOC/FBSOC
  - Command, Store & Forward and Telemetry data passed over normal low rate comm network
  - SMD routed onto high rate network (FDDI/HPPI/ATM) to Ground User Segment (COTS network hardware readily available)

C DRR EQUIPMENT (CONT'D)

- SMD Data Storage (short term)
  - COTS High Rate Cassette Recorders available
  - Accommodate data rates up to 110 MBPS
  - Provide storage capacity of 30 Gigabits per cassette

DRR RISK ASSESSMENT

C

- Technology
  - No technology development required for DRR implementation
  - Mature Hardware and data link services available/or near term scheduled
  - Adequate DOMSATs available which will support high data link rates
  - Wide choice of COTS products available

- Cost
  - High rate comm links are a major cost driver
  - Continue trade studies to reduce rate and number of high rate links
  - Investigate use of COTS products and commercial standards to reduce cost

- Requirements definition/uncertainty
  - Support requirements for EOS and EUMETSAT undefined
  - Early definition required to prevent complex overspecified costly implementation

DRR Implementation for Converged System considered low risk

C

C2 - SOC ANALYSIS

R. WOLL

CONVERGED C3 ELEMENT FUNCTIONAL ALLOCATION

C

COMMAND, CONTROL, & COMMUNICATION SEGMENT C3

REMOTE TRACKING STATION

- Tracking [1]
- Range / Timing [1]
- Acquisition
- Ephemeris [1] Generation (via GPS)
- Commands & Stored Program Upload [2]
- Equip. Status & Telemetry

SATELLITE OPERATIONS CENTER

- Mission Control & Planning
- Payload Control & Sensor Planning [3]
- User Request Relay
- Command Generation
- Computer Memory Upload Generation
- Telemetry Analysis
- Launch/Early Orbit
- Command & Control
- Anomaly Resolution
- Store & Forward
- Launch Interface
- Tracking [4]

DATA ROUTING & RETRIEVAL (DRR)

- Mission Data Routing
  - Stored
  - Realtime (Embedded EST)
- DOMSAT I / F

FLIGHT VEHICLE SUPPORT FACILITY (FVSF)

- S/C Enviro. Simulation
- Uplink/Downlink I/F Validation
- Flight Load Package Validation
- Training [4]

1 Backup Only
2 O2 Functions TBD
3 I / F to Agency POC
4 TBD Allocation

C^2 ASSUMPTIONS

- THE C2 WILL UTILIZE A UNIFIED S-BAND CAPABILITY (I.E. "GSTDN LIKE")
- THE COMMAND UPLINK RATE WILL BE NO GREATER THAN 2 KBPS
- ALL C2 DATA WILL BE CCSDS FORMATTED (CONVERGED NOAA / DMSP EOS-PM, EUMETSAT)
- ALL C2 DATA IS UNCLASSIFIED
- THE SMD - TLM (STORED EST CONTAINED IN THE SMD) WILL BE ACCESSIBLE BY THE SSOC / FBSOC
- A METHOD OF POSITIVE CONTROL (SELECTIVE DENIAL) MUST BE INCORPORATED FOR C2
- THE PRIMARY CONTROL POINT IS SUITLAND (SSOC) AND THE ALTERNATE IS FALCON (FBSOC). FOR THE BASELINE, THE FBSOC IS EQUALLY CAPABLE TO THE SSOC. HOWEVER, THIS WILL BE EXAMINED DURING THE TRADE ANALYSIS, (I.E. MANNING, CAPABILITY, OPS CONCEPT, ETC.)

C

C^2 ASSUMPTIONS (CONT.)

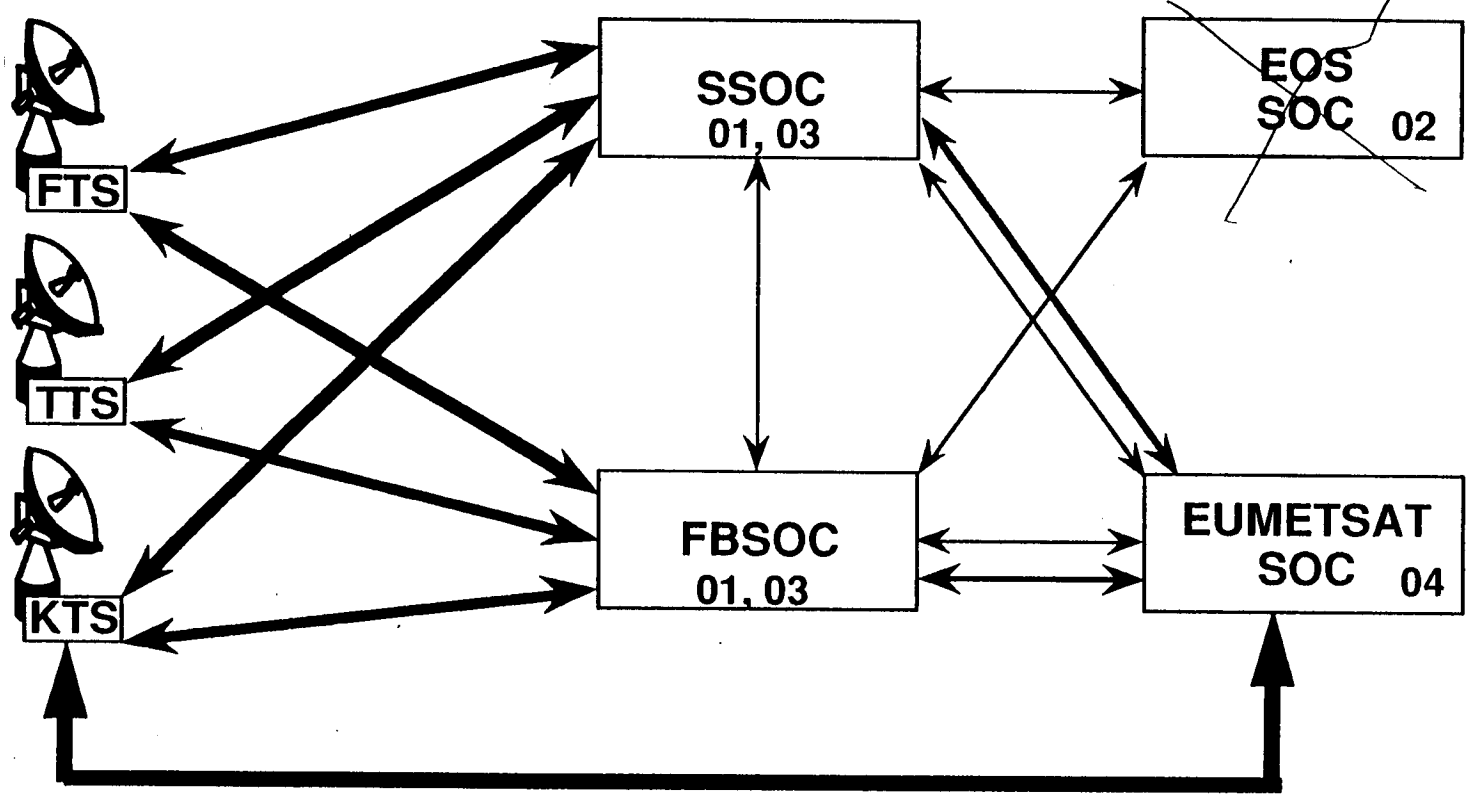
- THE INITIAL C2 SYSTEM WILL BE CAPABLE OF THREE SIMULTANEOUS CONTACTS. THIS WILL ALLOW FOR INITIAL TESTING / DEMONSTRATION
- THERE ARE NO "TIME CRITICAL" COMMANDING REQUIREMENTS (REALTIME EXECUTION TO SUB-SECOND ACCURACY)
- THE COMMAND ECHOES WILL BE AVAILABLE IN THE EST TELEMETRY
- THE SPACECRAFT WILL PROVIDE THE TELEMETRY TIME TAGGING FUNCTION
- THE "STORE AND FORWARD" FUNCTION WILL SHARE THE COMMAND UPLINK AND TACTICAL DOWNLINK FUNCTION
- THE "STORE AND FORWARD" FORMAT WILL BE IN BINARY FORMATTED FILES OF NO GREATER THAN 1 MB

C

C^2 ASSUMPTIONS(CONT.)

- THE "STORE AND FORWARD" DATA CAN BE TRANSMITTED IN SEGMENTS (LESS THAN A COMPLETE MESSAGE)
- THERE ARE NO REQUIREMENTS FOR A GROUND ORBIT DETERMINATION FUNCTION AT THE SSOC / FBSOC/ THIS WILL BE EXAMINED DURING TRADE ANALYSIS. (I.E. USE OF NORAD ELSET OR GPS PROPAGATED VECTOR FOR GROUND ANTENNA POINTING ANGLES, ETC.)
- SPACECRAFT ATTITUDE DETERMINATION/CONTROL WILL BE ACCOMPLISHED AUTONOMOUSLY ON BOARD THE SPACECRAFT
- OTHER GOVERNMENT ASSETS (AFSCN, NORAD, NASA, ESA, ETC.) WILL BE AVAILABLE FOR SUPPORT DURING LAUNCH, EARLY ORBIT AND ANOMALY (LEO&A) OPERATIONS
- CONTINGENCY OPERATIONS, AS RELATED TO THE EOS AND EUMETSAT REQUIREMENT, WILL BE LIMITED TO VEHICLE SAFING ONLY (MINIMUM VEHICLE KNOWLEDGE REQUIRED)

C² GROUND ARCHITECTURE



C² and DIRECTIVES
FILE TRANSFER (CONTINGENCY)
C²

C^2 GROUND ARCHITECTURE ASSUMPTIONS

- THERE WILL BE A "THROUGH-PUT" C2 CAPABILITY BETWEEN THE EUMETSAT SOC AND THE SSOC / FBSOC TO PROVIDE A BACKUP CAPABILITY FOR THE EUMETSAT GROUND STATION
- THERE WILL BE A FILE TRANSFER CAPABILITY ESTABLISHED BETWEEN THE EOS AND EUMETSAT SOCs
- THE "CONTINGENCY" SUPPORT REQUIRED FOR EOS AND EUMETSAT IS LIMITED TO VEHICLE SAFEING
- COMMANDING FOR SAT - O2 SMD IS VIA SSOC / FBSOC WHEN USING FTS & TTS AND EUMETSAT SOC WHEN USING KTS
- EUMETSAT MISSION PLANNING WILL INCLUDE U.S. TASKING FOR O2

DEFINITIONS

C

Authentication, command	Method of assuring proper access (authorization) to spacecraft command system
FBSOC	Backup Falcon Satellite Operations Center
C2	Command and Control (to include Uplink commands, Downlink EST and Store and Forward functions)
CCSDS	Consultative Committee for Space Data Systems - The standard format used for all data (command, EST telemetry, S & F, SMD, RTD.
Converged Vehicles	Satellites 1 & 3 (NOAA/DMSP), Satellite 2 (EOS-PM) and Satellite 4 (EUMETSAT).
DS - 1	Digital Service 1 - 1.5 MBPS
DS - 3	Digital Service 3 - 44.8 MBPS
Echoes, command	Replica of the command bits transmitted to the spacecraft.

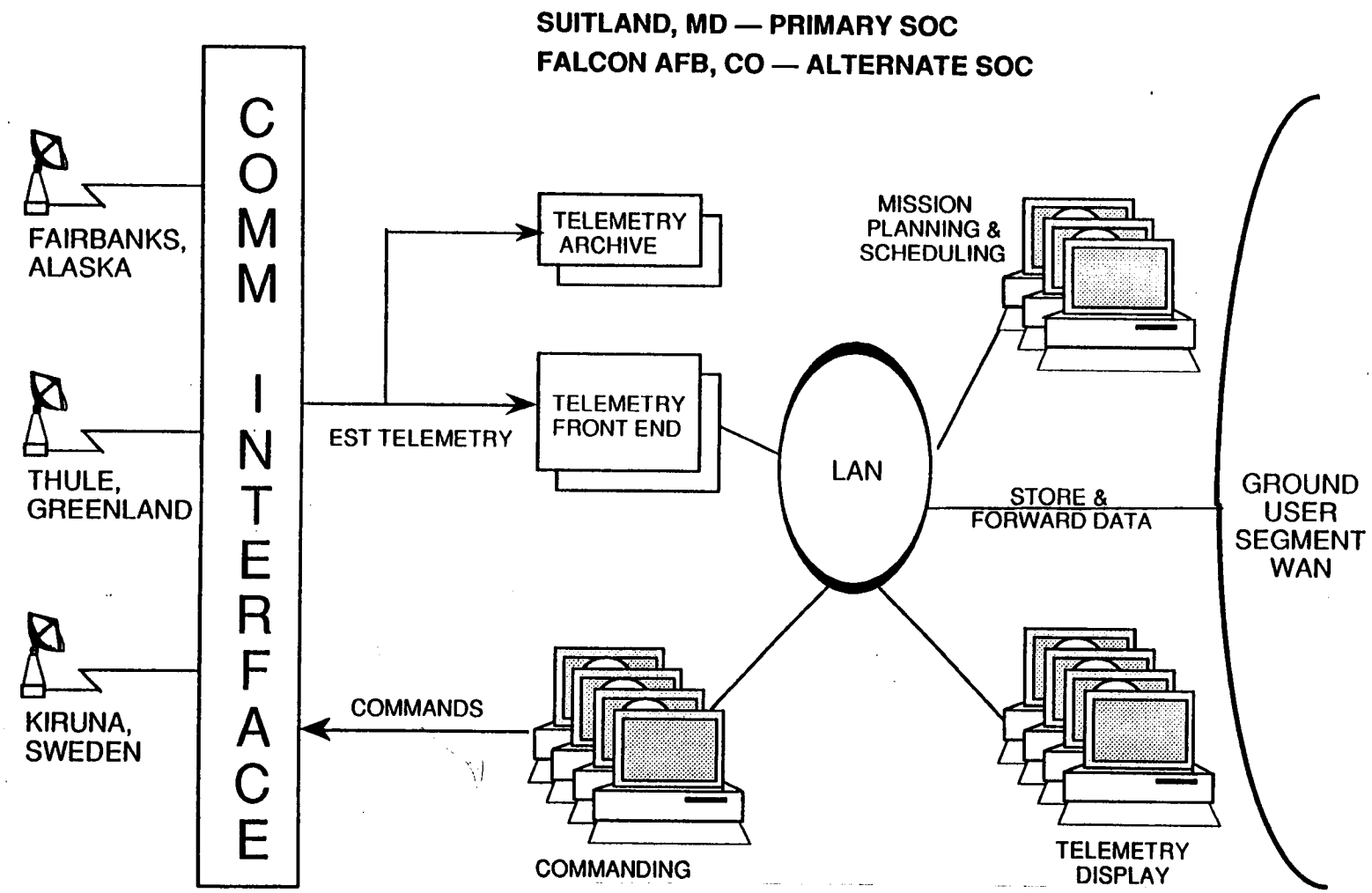
C DEFINITIONS

EST	Equipment Status Telemetry (the SOH for Sat 1 & 3)
LEO&A	Launch, Early Orbit and Anomaly, where Launch includes powered flight through orbit injection, Early orbit is the checkout of spacecraft systems to determine operation readiness, and Anomaly is anything that is not intended to occur (i.e. non-nominal orbit, loss of attitude control, inability to perform routine C2 operations, etc.).
SOH	State Of Health spacecraft telemetry. For Satellite 1 and 3, this is defined as EST.
SSOC	Suitland Satellite Operations Center
Time Critical command	A realtime command transmitted such that it can be executed in the vehicle to sub-second accuracy. (e.g. command to reset the vehicle clock)

CONVERGED SYSTEM DEFINITION

SOC Functional ARCHITECTURE

C



C2 RISK ASSESSMENT

- Technology
  - No technology development required for C2 implementation
  - Mature Hardware and software designs meet Converged requirements
  - Wide choice of COTS hardware and software products available

- Cost
  - O & M manning is a major cost driver
  - Conduct trade studies to reduce operator manning and skill levels
  - Investigate use of COTS products and commercial standards to reduce cost
  - Maximize use of common commercial equipment to reduce maintenance cost

- Requirements definition/uncertainty
  - Support requirements for EOS and EUMETSAT undefined
  - Backup control center/support requirements need further defintion
  - Early resolution required to prevent excess under-utilized duplicate support facilties

C2 Implementation for Converged System considered low risk

C2 SUMMARY PLANS

- EXPAND OPERATIONS CONCEPT
- CONTINUE C2 ARCHITECTURE TRADE STUDIES
- DEFINE COMMAND AND CONTROL ARCHITECTURE
- EVALUATE COTS FOR HW & SW
- GENERATE C2 REQUIREMENTS
- GENERATE COST ESTIMATE FOR GROUND SYSTEM
- OPTIMIZE C2 DESIGN BY COORDINATING WITH OTHER SEGMENTS

C

COTS APPROACH TO C2

R. HAMER

C ADVANCES IN C2 SYSTEMS

- COMMERCIAL - OFF - THE - SHELF (COTS) HW AND SW
  - BACKGROUND
  - INDUSTRY DIRECTION
  - DEFINITION
  - PROS AND CONS
  - EXAMPLES
- FUTURE ADVANCES
- FUTURE INTEGRATED TT&C ARCHITECTURE

C THE CASE FOR COTS SATELLITE C2 SYSTEMS

- CUSTOM DESIGNS ARE VERY EXPENSIVE - DEVELOPMENT, MAINTENANCE - EQUIPMENT IS OUTDATED WHEN SYSTEM BECOMES OPERATIONAL
  - AFSCN DSM/CCS 12 YRS >$500M ≈ 200 MAINTAINERS
- LTOC DEMONSTRATED COTS C3 SYSTEM TO GEN BARRY 1992
  - FULL COMMANDING CAPABILITY (DSCS II) WAS ADDED IN 60 DAYS USING A PREVIOUSLY DEVELOPED PROOF-OF-CONCEPT COTS BASED TELEMETRY SYSTEM
- SMC/CW DIRECTED A STUDY OF OPEN ARCHITECTURE C2 SYSTEMS - 1993
- SMC/CU SATELLITE C2 TEST BED IN OPERATIONS AT NTF
- CLEMENTINE C2 WAS OPEN ARCHITECTURE LOW COST SYSTEM
- NASA WIND, POLAR, SOHO & SMEX WILL ALL USE OPEN ARCH SYSTEMS - 1995
- SMC/CU POSITION NEW KIRTLAND SYSTEM WILL BE OPEN ARCH COTS - 1996

THE CASE FOR COTS SATELLITE C2 SYSTEMS - CONTINUED

C

- SYSTEMS ARE NOW AVAILABLE USING COTS BUILDING BLOCKS
  - MULTI VENDORS HAVE COTS PRODUCTS SPECIFICALLY FOR C2 AT LOW COST/SLOC -- TALARIAN's RTworks contains 750,000 LOC
    - SOFTWARE TECHNOLOGY INC - COMET
    - STORM INTEG - INTELLIGENT MISSION TOOLKIT / PODS
    - APPLIED TECHNOLOGY ASSOC - REAL TIME ORBIT DETERMINATION
    - WIND RIVER SYSTEMS - Vx WORKS
- COTS CAN PROVIDE 60 - 80% OF CODE NEEDED, ELIMINATING NEED FOR MUCH NEW CODE
- PRODUCTIVITY FACTORS FOR NEW CODE USING COTS TOOLS VS NEW DoD STD 2167 COMPLIANT CODE 4 - 1
- COTS CAPABLE IN 1992 - BY 1996 COTS OPTIONS WILL BE ONLY COST EFFECTIVE CHOICE IF NOT RESTRICTED BY PROCUREMENT REQUIREMENTS (Ada)

CONVERGED SYSTEM DEFINITION

C COMMENTS on SATELLITE COMMAND & CONTROL from NSIA CONFERENCE on (JUL 94)

Mr. Esker Davis, Director JPL Mission Ops, Maj Gen AFR	We need a **new paradigm** for low cost mission operations
Col. Greg Gilles Cmdr 50th Space Wg	We have to reduce the cost to operate our Satellite Control System through reductions in staff and the **cost to maintain software**.
Col. Mitch Mitchell Director Development Planning SMC/XR	Satellite control technology needs a **common ground architecture** with a multi-level secure **open architecture** and an **object oriented** system development and database.
Col. Kenneth Riley Cmdr 750th Space Group Onizuka Air St.	Conceptually, the Advanced Satellite Contro Systeml will be an, **open, distributed, workstation based architecture** that will simplify and standardize operations.
Col. Daryl Joseph Cmdr Det 2 SMC	Alternative for advanced satellite command and control is **space-based relay**. Det 2 was asked by Space Command to test feasbility of using TDRSS with DMSP SGLS link.
Dr. Tushbar Hazra Senior Eng. NASA Goddard Operations	Space Mission Control - Reality is a single system in our **office-like environment** providing spacecraft operations, command management, science processing, and data capture.
Mr. Paul Ondrus Head Mission Operations System Office NASA Goddard	Technology is allowing the compression of **all mission operations** functions into a **1 to 2 workstation set**.

C OPEN ARCHITECTURE

FOUNDATION OF FUTURE COMMAND & CONTROL SYSTEMS

MODERN SOFTWARE CODING LANGUAGES

(OOPL, RDMMS)

MULTIPLE VENDORS WITH MODULAR COMPONENTS

(ENGINEERING WORK STATIONS)

FLEXIBLE OPERATING SYSTEM (POSIX COMPLIANT)

COTS SW PRODUCTS USER TAILORED FOR SPECIFIC APPLICATIONS

(DATA ANALYSIS SW, EXPERT SYSTEMS, ORBIT SW)

USES EVOLVING INDUSTRY STANDARDS

(TCP/IP, POSIX, MOTIF, STREAMS, IEEE)

DATA DISTRIBUTION FLEXIBILITY

(ETHERNET, FDDI, ATM, SONET)

C ADVANTAGES OF COTS BASED C2 SYSTEMS

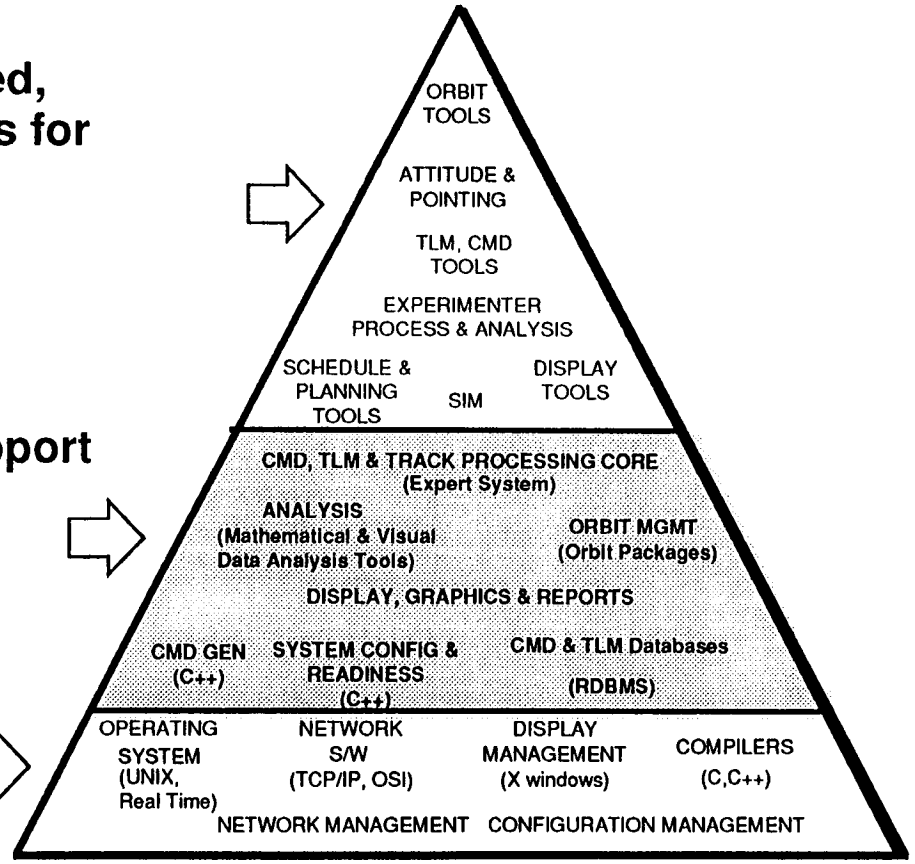
- REDUCES DEVELOPMENT SCHEDULE
- REDUCES TECHNICAL/COST RISK
- REDUCES DEVELOPMENT COST
- REDUCES SUPPORT COSTS
- TECHNOLOGY IMPROVEMENTS AVAILABLE FOR MINIMUM COST
- OPEN SYSTEMS WITH INDUSTRY STANDARDS PROVIDES CROSS-PLATFORM, CROSS VENDOR COMPATIBILITY
- COTS PRODUCTS ARE BETTER TESTED
- USE OF NON-PROPRIETARY STANDARDS BASED SYSTEMS PROVIDES FLEXIBILITY AND CONTINUED COMPETITION
- WE BELIEVE SPO NEEDS TO LOOK AT COTS FOR C2

CONVERGED SYSTEM DEFINITION

LAYERED SOFTWARE DEVELOPMENT ENVIRONMENT

C

- User Layer - customized, tailored COTS products for mission operation
- Development Layer - applications used to provide mission support capabilities
- Support Layer - the foundation of the open architecture based on industry standards



C SOFTWARE SIZE ESTIMATE

1992 COTS BASED for MULTIPLE PROGRAMS (RSC STUDY)

CSCI	C CODE (KLOC)		ADAPTIVE CODE (USING PROGRAM CUSTOMIZING TOOLS) (KLOC)									
	I/F	NEW	SYBASE	RTWKS	ADDCP	TRACE	OMNI	MATH	PV WAVE	OASIS	OASYS	TOTAL
TELEMETRY, HEALTH & STATUS	4	0	5	30	0	0	0	0	0	0	0	35
TRACKING	2	8	0	2	2	0	0	0	0	0	0	4
ON-ORBIT PLANNING & SCHEDULING	13	43	25	13	0	4	63	29	21	21	10	186
SYSTEM CONFIG & READINESS	3	40	0	4	0	0	6	5	5	0	0	20
COMMANDING	2	36	4	24	0	0	0	0	0	0	0	28
ANALYSIS	1	0	5	4	0	0	2	0	2	0	0	13
SIMULATION & TRAINING	0	0	19	24	0	0	12	7	8	0	0	70
	=====	=====	=====	=====	=====	=====	=====	=====	=====	=====	=====	=====
FUNCTION SUBTOTAL	25	127	58	101	2	4	83	41	36	21	10	356
PROJECT GRAND TOTAL	152						356					

I/F = INTERFACE "C" CODE NEW = NEW "C" CODE

ADDED CAPABILITIES IN 1994 **COMET, STK, SCL**

C SATELLITE C2 TECHNOLOGY ADVANCES

1992 NON SATELLITE CONTROL SPECIFIC COTS PRODUCTS
Work Stations - 50 MIPS

1993 BEGINNING OF SATELLITE SPECIFIC PRODUCTS
Work Stations - 100 MIPS

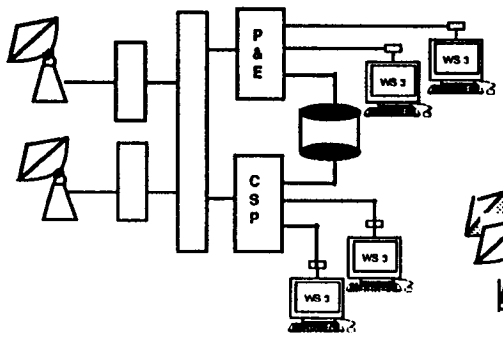
1994 INTEGRATION OF SATELLITE SPECIFIC PRODUCTS BY MULTIPLE VENDORS INTO COMPATIBLE FAMILIES
Work Stations - 200 MIPS

1995 SINGLE VENDOR COMPLETE SYSTEM
Work Stations - 400 MIPS

1996 COMPLETE MACRO FAMILY FOR GENERIC SATELLITE C2
Work Stations - 500+ MIPS

2000 INTEGRATED SATELLITE C2 STANDARD - GOVT INTEROPERABILITY

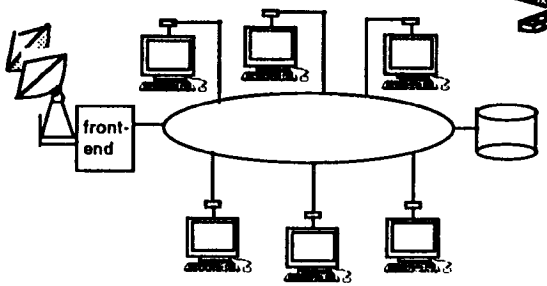
C FITAS PROJECTED C2 CHARACTERISTICS
(FUTURE INTEGRATED TT&C ARCHITECTURE STUDY)



- Centralized Command & Control

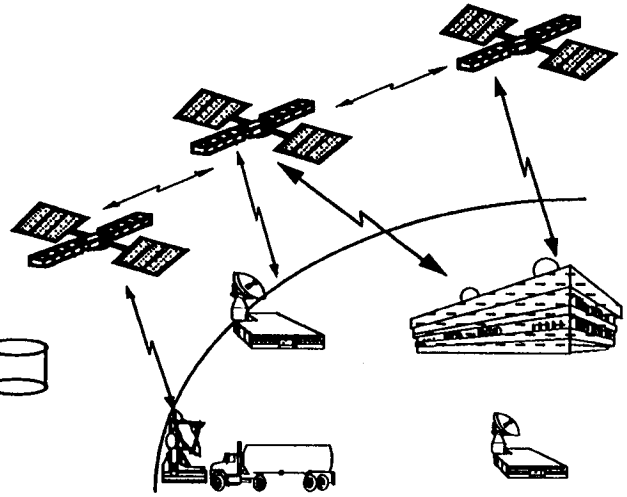
- Development Cost High
- Large MainFrame
- Custom Software for All Functions
- Non-standardized System
- Manpower & Skill Intensive
- High Maintenance Cost

Today's System



- Distributed Data Processing
- Workstations Performance
- Low Development Cost
- COTS SW for Generic Command & Control Functions
- Custom Develop Mission Unique SW
- Medium Manpower
- Non-standardization
- Low Maintenance Cost

Transition System



- Distributed Data Processing
- Central Command & Control Center
- Mix of Fixed and Mobile TT&C Sites
- Medium System Integration Cost
- Higher Workstation Performance
- COTS SW for All Functions
- Low Manpower & Skills for Operations
- Standardization for Interoperability
- Low Maintenance Cost
- Colocation of Mission & Sat Bus Functions
- Full Ground Automation
- Direct Downlinks & Crosslinks

Future's System

C CONCLUSION

- MATURE COMMERCIAL HARDWARE AND SOFTWARE ELIMINATE THE NEED FOR EXPENSIVE CUSTOM DESIGNED SATELLITE COMMAND AND CONTROL SYSTEMS
- COMMERCIAL STANDARDS ARE AVAILABLE NOW THAT ALLOW ACROSS PLATFORM DESIGNS
- PROGRAMMING TO SET OF COMMERCIAL STANDARDS
- FUTURE GAINS WILL FURTHER REDUCE COSTS / IMPROVE PERFORMANCE

HOWEVER, CONCERNED WITH

- AD SPEC
- CODE DELIV
- EVOLVING STANDARDS
- FULL MIL-STD-2167

C

FVSF ELEMENT

CONVERGED C3 ELEMENT FUNCTIONAL ALLOCATION

C

COMMAND, CONTROL, & COMMUNICATION SEGMENT C3

REMOTE TRACKING STATION

- Tracking [1]
- Range / Timing [1]
- Acquisition
- Ephemeris [1] Generation (via GPS)
- Commands & Stored Program Upload [2]
- Equip. Status & Telemetry

SATELLITE OPERATIONS CENTER

- Mission Control & Planning
- Payload Control & Sensor Planning [3]
- User Request Relay
- Command Generation
- Computer Memory Upload Generation
- Telemetry Analysis
- Launch/Early Orbit
- Command & Control
- Anomaly Resolution
- Store & Forward
- Launch Interface
- Tracking [4]

DATA ROUTING & RETRIEVAL (DRR)

- Mission Data Routing
  - Stored
  - Realtime (Embedded EST)
- DOMSAT I / F

FLIGHT VEHICLE SUPPORT FACILITY (FVSF)

- S/C Enviro. Simulation
- Uplink/Downlink I/F Validation
- Flight Load Package Validation
- Training [4]

1 Backup Only
2 O2 Functions TBD
3 I / F to Agency POC
4 TBD Allocation

FVSF REQUIREMENTS

C

- TEST AND VALIDATION OF (SSOC) OPERATIONS CONTROL CENTER

  - Realistic simulation of spacecraft model and interfaces to the ground.

- TEST AND VALIDATION OF FLIGHT CONTROL PROCEDURES

  - Testing of flight control procedures for all modes and states

- PERSONNEL TRAINING

  - Proficiency on use of S / C monitoring and control
  - Familiar with mission and S / C characteristics

- MISSION - READINESS

  - Testing of system through all potential modes of operation

- FAULT ISOLATION AND CORRECTION

C

C3 SEGMENT LIFE CYCLE COST

D. PAUL

C SYSTEM PERCENTAGES: LOW RATE COMM

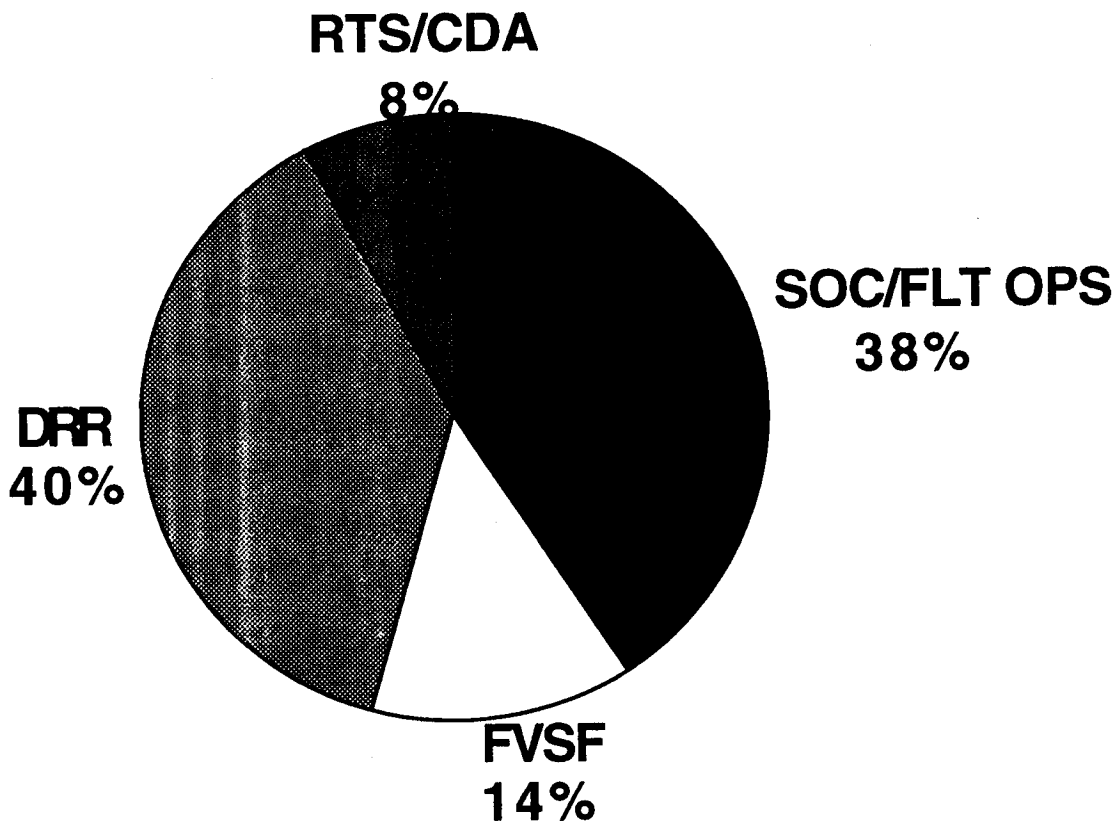
DMSP BLOCK 6 STUDY PSR #4 JUL 1993, 10 MBPS, FOUR DATA CENTRALS

1.0 Space System	4.48%
1.1 Launch Veh ****	3.91%
1.3 Space Veh	41.89%
1.5 User Seg	9.03%
1.6 PSE	3.84%
1.8 Spares	7.54%
1.9 Storage	2.13%
1.10 Syst/pgm Mgmt	8.68%
1.11 Sys Test	2.70%
1.12 Sys Data	1.21%
1.13 Sys Tng	0.50%
1.15 C3 Seg	9.10%
1.16 Flt Ops	4.98%
TOTAL	100.00%

**** Costs indicate support for launch operations only--
not the launch vehicle

PAGE 129 IS EXEMPT FROM RELEASE AND IS REPLACED WITH THIS PAGE.

C RELATIVE PERCENTAGES: HIGH RATE COMM



BASED ON TOTAL C3 SEGMENT COSTS OF [redacted] FOR 10 YEARS OF O&M

PAGE 131 IS EXEMPT FROM RELEASE AND IS REPLACED WITH THIS PAGE.

DRR / RTS EQUIPMENT PHSL - 2

C

ITEM NAME OR MODEL NUMBER	MAKE or BUY	FAIRBANKS	KIRUNA	THULE	TOTAL
TRANSMISSION SUBSYS (COND'T)					
MASS MEMORY UNIT	B	1	1	1	3
ENCRYPTOR	B	TBD	TBD	TBD	TBD
RECEIVER SUBSYSTEM					
FREQUENCY DOWN CONVERTER	B	1	1	1	3
LOW NOISE AMPLIFIER	B	1	1	1	3
TRACKING RECEIVER	B	1	1	1	1 / 3
TRACKING PRE-AMP	B	1	1	1	1 / 3
TRACKING DOWN CONVERTER	B	1	1	1	1 / 3
POSITION TRANSDUCERS	B	1	1	1	1 / 3
POSITION READOUT	B	1	1	1	1 / 3
POWER DIVIDER	B	1	1	1	1 / 3
DOMSAT LEASE					
TRANSPONDER CHANNEL (44 mbps)	L	2	2	2	6

C SAMPLE PROGRAM H/W, S/W LIST (PHSL)

1.15.2.2.2. FLIGHT VEHICLE SIMULATOR FACILITY HARDWARE

1.15.2.2.2.1	FACTORY FACILITY
1.15.2.2.2.1.1	Simulator work stations
1.15.2.2.2.1.2	Tape drives 1.2 GBYTES
1.15.2.2.2.1.3	Disk drive
1.15.2.2.2.1.4	MODEM
1.15.2.2.2.1.5	Generic S/C simulator
1.15.2.2.2.2	SUITLAND FACILITY
1.15.2.2.2.2.1	Simulator work stations
1.15.2.2.2.2.2	Tape drives 1.2 GBYTES
1.15.2.2.2.2.3	Disk drive
1.15.2.2.2.2.4	MODEM
1.15.2.2.2.2.5	Generic S/C simulator
1.15.2.2.2.2.6	Student work station
1.15.2.2.2.2.7	Instructor work station

FVSF LOWER LEVEL EQUIPMENT

C

WBS ITEM NO	NOMENCLATURE OR DESCRIPTION	WBS ITEM NO	NOMENCLATURE OR DESCRIPTION	DESIGN	HDWE	MAKE OR BUY
1.15.2.2.2.3	FBSOC FACILITY			E	E	B
1.15.2.2.2.3.1	Simulator work stations			E	E	B
1.15.2.2.2.3.2	Tape drives 1.2 GBYTES			E	E	B
1.15.2.2.2.3.3	Disk drive			E	E	B
1.15.2.2.2.3.4	MODEM			E	E	B
1.15.2.2.2.3.5	Generic S/C simulator			E	E	B
1.15.2.2.2.3.6	Student work station			E	E	B
1.15.2.2.2.3.7	Instructor work station					

FBSOC FACILITY		
Simulator work stations	SUN	SPARC 2
Tape drives 1.2 GBYTES	SI	EXEBYTE
Disk drive	SUN	500 GBYTE
MODEM	Anderson-Jacobson	9600 Bps dial
Generic S/C simulator	ISI CORP	MATRIX - C
Student work station	SUN	X750A
Instructor work station	SUN	X311L

C FACTORY AND SUITLAND FVSF EQUIPT.

		FAIR	TTS	KOR	FBSOC	SUIT	FAC	SPARE	TOT
1.15.2.2.2.1.1	Simulator work stations						2		2
1.15.2.2.2.1.2	Tape drives 1.2 GBYTES						1		1
1.15.2.2.2.1.3	Disk drive						1		1
1.15.2.2.2.1.4	MODEM						1		1
1.15.2.2.2.1.5	Generic S/C simulator						1		1
1.15.2.2.2.3	SUITLAND FACILITY								
1.15.2.2.2.2.1	Simulator work stations					1			1
1.15.2.2.2.2.2	Tape drives 1.2 GBYTES					1			1
1.15.2.2.2.2.3	Disk drive					1			1
1.15.2.2.2.2.4	MODEM					1			1
1.15.2.2.2.2.5	Generic S/C simulator					1			1
1.15.2.2.2.2.6	Student work station					2			2
1.15.2.2.2.2.7	Instructor work station					2			2

CONVERGED SYSTEM DEFINITION

SOC EQUIPMENT
DATA PROCESSING ONLY

C

WBS ITEM NO	NOMENCLATURE OR DESCRIPTION	WBS REFERENCE	SPEC. NUMBER	DESIGN	HDWE	MAKE OR BUY
1.15.2.1.2.1	DATA PROCESSING EQUIPMENT			E	E	B
1.15.2.1.2.1.1	Time/Fequency System	Loral	#9100	E	E	B
1.15.2.1.2.1.2	Data Acquistion Chassis	Loral	PRO 0550	E	E	B
1.15.2.1.2.1.2.1	FPP	Loral	FPP %%%	E	E	B
1.15.2.1.2.1.2.2	Command FPP	Loral	FPP 515	E	E	B
1.15.2.1.2.1.2.3	Bit Sync	Loral		E	E	B
1.15.2.1.2.1.2.4	Multiformat Decom	Loral	MFD 530	E	E	B
1.15.2.1.2.1.2.5	Simulator	Loral	MDS 540	E	E	B
1.15.2.1.2.1.2.6	IRIG Time Code	Loral	ETC 534	E	E	B
1.15.2.1.2.1.2.7	Bridge	Loral	BRG 550	E	E	B
1.15.2.1.2.1.2.8	Parallel I/O	Loral	PIO 575	E	E	B
1.15.2.1.2.1.2.9	Digital I/O	Loral		E	E	B
1.15.2.1.2.1.3	Wideband Recorder	Datatape	DTR-6	E	E	B
1.15.2.1.2.1.3.1	Wideband Recorder Tape	Datatape		E	E	B
1.15.2.1.2.1.3.2	Recorder Rackmount Option	Datatape		E	E	B

CONVERGED SYSTEM DEFINITION

SUITLAND MANNING REQUIREMENTS FOR NORMAL OPS (PRELIMINARY)

C

	ONE VEHICLE PLUS O4 &O2 B/U		TWO VEHICLE PLUS O4 &O2 B/U	
POSITION	PER SHIFT	TOTAL FOR 24 HOUR OPS	PER SHIFT	TOTAL FOR 24 HOUR OPS
CREW SUPERVISOR	0.5	2.3	0.5	2.3
SATELLITE CONTROLLER	1.5	6.9	2.5	11.5
TELEMETRY ANALYSIS	1	4.6	2	9.2
MISSION PLANNING	0.5	2.3	1.5	6.9
SCHEDULING	0.5	2.3	1	4.6
VEHICLE TECHS	5	5	5	5
SOC OPS TECHS.	4	4	4	4
TOTAL MANNING		27.4		43.5

TRANSITION MANNING LEVELS BY SITE (PRELIMINARY)

C

OPERATIONAL TRANSITION	FY 04	($K)	FY 05	($K)	FY 06	($K)	FY 07	($K)	FY 08	($K)	FY 09	($K)	FY 10	($K)	FY 11	($K)	FY 12	($K)	FY 13	($K)	FY 14	($K)	TOTAL
SITE/ PERSONNEL TYPE																							
24 HOUR OPERATIONS	LNCH O3O2						LNCH O4		LNCH O1		LNCH O3/O2						LNCH O4		LNCH O1				
TOTAL		7607		3146		3146		3402		3441		3441		3441		3441		3441		3441		3441	41388
SUITLAND SOC		1909		1928		1928		2184		2223		2223		2223		2223		2223		2223		2223	23510
							43																
• GOVERNMENT CIVILIAN	9	171	10	190	10	190	19	361	19	361	19	361	19	361	19	361	19	361	19	361	19	361	
• AF OFFICER	4	156	4	156	4	156	4	156	5	195	5	195	5	195	5	195	5	195	5	195	5	195	
• AF ENLISTED	6	102	6	102	6	102	11	187	11	187	11	187	11	187	11	187	11	187	11	187	11	187	
• LMSC PERSONEL	5	1000	5	1000	5	1000	5	1000	5	1000	5	1000	5	1000	5	1000	5	1000	5	1000	5	1000	
• LTOC PERSONNEL	4	480	4	480	4	480	4	480	4	480	4	480	4	480	4	480	4	480	4	480	4	480	
FALCON AFB SOC (PER YEAR)		298		298		298		298		298		298		298		298		298		298		298	3278
• GOVERNMENT CIVILIAN	1	19	1	19	1	19	1	19	1	19	1	19	1	19	1	19	1	19	1	19	1	19	
• AF OFFICER	1	39	1	39	1	39	1	39	1	39	1	39	1	39	1	39	1	39	1	39	1	39	
• AF ENLISTED	2	34	2	34	2	34	2	34	2	34	2	34	2	34	2	34	2	34	2	34	2	34	
• AF ENLISTED	2	240	2	240	2	240	2	240	2	240	2	240	2	240	2	240	2	240	2	240	2	240	
FACTORY & CONTINGENCY SPPT		5400		920		920		920		920		920		920		920		920		920		920	14600
• LMSC PERSONEL	18	3600	4	800	4	800	4	800	4	800	4	800	4	800	4	800	4	800	4	800	4	800	
• LTOC PERSONNEL	15	1800	1	120	1	120	1	120	1	120	1	120	1	120	1	120	1	120	1	120	1	120	

PERSONNEL COSTS PER YEAR IN 1994 YEAR DOLLARS	($K)
LMSC PERSONNEL	200
LTOC PERSONNEL	120
AF OFFICER*	39
AF ENLISTED*	17
GOVERNMENT CIVILIAN*	19

* PROVIDED PHASE A STUDY

EXCLUDES FEES

9/23/94

C COST WORK TO GO

- O AS PART OF THE LCC EFFORT, UPDATE CONVERGED PHSL'S TO REFLECT FINAL CONFIGURATIONS
- O FEED - BACK COST IMPACT INFORMATION TO SYSTEM DESIGNERS FOR COST-BENEFIT TRADES
- O CONTINUE TO LOOK FOR COST-EFFECTIVE EQUIPMENT AND PROCESS SUBSTITUTIONS BY LEVERAGING OTHER PROGRAM (CRSS, EOS, MILSTAR) APPROACHES INTO CONVERGED SYSTEM

C

C3 SPECIFICATION

DEVELOPMENT

CONVERGED C3 ELEMENT FUNCTIONAL ALLOCATION

C

COMMAND, CONTROL, & COMMUNICATION SEGMENT C3

REMOTE TRACKING STATION

- Tracking [1]
- Range / Timing [1]
- Acquisition
- Ephemeris [1] Generation (via GPS)
- Commands & Stored Program Upload [2]
- Equip. Status & Telemetry

SATELLITE OPERATIONS CENTER

- Mission Control & Planning
- Payload Control & Sensor Planning [3]
- User Request Relay
- Command Generation
- Computer Memory Upload Generation
- Telemetry Analysis
- Launch/Early Orbit
- Command & Control
- Anomaly Resolution
- Store & Forward
- Launch Interface
- Tracking [4]

DATA ROUTING & RETRIEVAL (DRR)

- Mission Data Routing
  - Stored
  - Realtime

(Embedded EST)

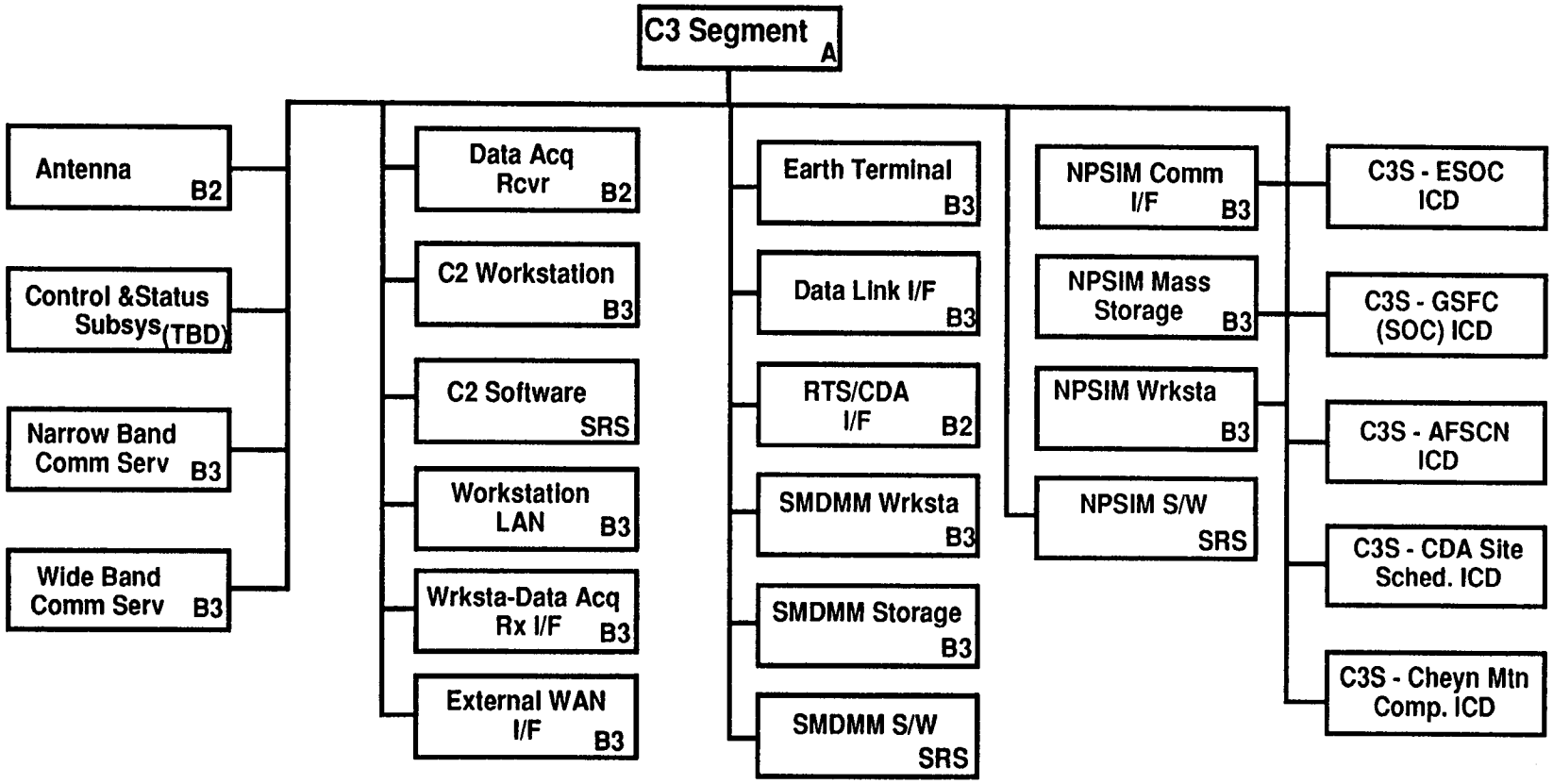
- DOMSAT I / F

FLIGHT VEHICLE SUPPORT FACILITY (FVSF)

- S/C Enviro. Simulation
- Uplink/Downlink I/F Validation
- Flight Load Package Validation
- Training [4]

1 Backup Only
2 O2 Functions TBD
3 I / F to Agency POC
4 TBD Allocation

C3 SPECIFICATION TREE



Key: A = 80008A System/Segment Spec
SRS = DI-MCCR-80025A Software Reqts Spec (COTS + some development, unit will be tested
B2 = 490A Critical Item Development Spec (COTS + some development, unit will be tested
B3 = Tailored 490A Non-Complex Item Development Spec (Off - the - Shelf, no testing at this level)
ICD = Contractor Format Interface Control Document

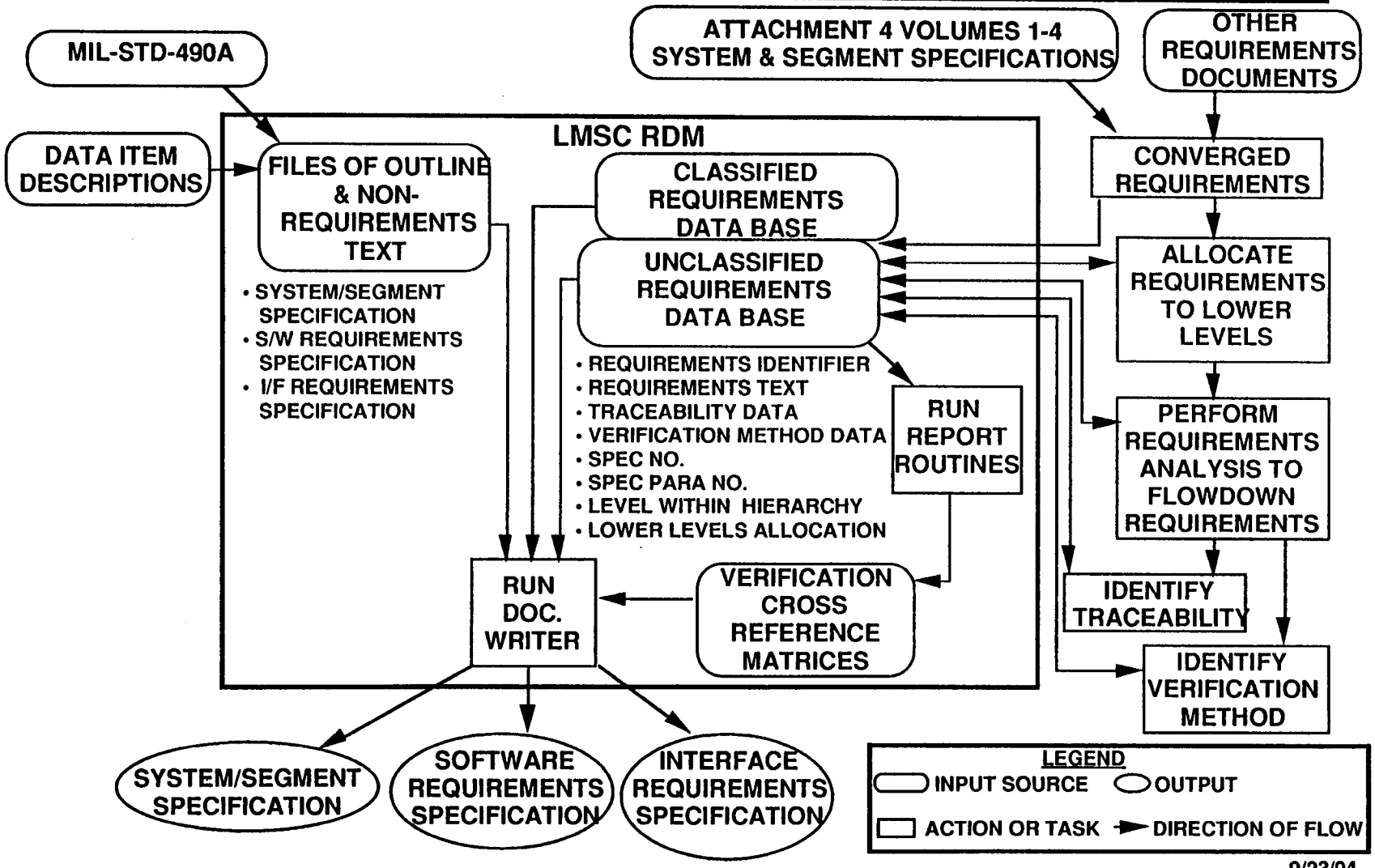
C SPECIFICATION DEVELOPMENT APPROACH

TASK STATEMENT: DEVELOP A-LEVEL SPECIFICATIONS FOR THE CONVERGED DoD / DoC POES SYSTEM

APPROACH

- Update the converged C3 requirements data base to include converged requirements from Attachment 4, Vols 1-4 & converged ORD
- Establish converged C3 requirements traceability
- Update classified requirements data base to include converged C3 requirements from Attachment 4, Vol 2, Appendix B
- Flow down A-level requirements to the element level for development of B-level requirements
- Submit draft version of converged system / C3 segment specification 90 cd prior to SRR for government review and comments
- Submit final version of system / C3 segment specification 30 cd prior to SRR with incorporation of government comments for approval
- Submit revisions in the form of change pages as required for approval

C SPECIFICATION GENERATION PROCESS



9/23/94

C

SUMMARY

C

- DATA LOADING ON O1 - O3 DRIVES
  - DOWNLINK RATES AND LINK COSTS
  - RTS / CDA AVAILABILITY REQUIREMENTS

- FOUR REALTIME DATA LINKS REPRESENT
  - MULTIPLE USER CONSTITUENCIES
  - A COMPLICATION FOR OBP
  - A COMPELLING NEED FOR DATA COMPRESSION

- C3 / GUS ARCHITECTURE ALTERNATIVES
  - CAN SAVE 30 - 50 % OF C3 LCC
  - INDICATE CENTRALIZED PROCESSING AND TDRSS CAN SAVE ~ 80% C3 LCC

C

- C2 ALTERNATIVES CAN
  - PROVIDE EUMETSAT I / F FOR O2 DRR
  - RE-ALLOCATE FVSF FUNCTIONS WITHIN SOC
  - USE GUS - WAN FOR S & F

- COTS USAGE CAN REDUCE SOC - RELATED COSTS
  - NEEDS ADA REQUIREMENTS RELAXATION
  - USES INDUSTRY STANDARDS

- NOAA - LIKE SOC MANNING REDUCES COSTS

C

APPENDIX

- B / L SUMMARY
- ACRONYM LIST

BASELINE C3 CHARACTERISTICS - 1

	PARAMETER	BASELINE	COMMENT/RQT
SOC	SOC	SOCC PRIMARY FBSOC SECONDARY	
RTS	GROUND STATIONS	KIRUNA, THULE, FAIRBANKS	AFSCN RTSs AND NOAA CDAs
DRR	COMMAND & CONTROL	PRIMARY for O1 & O3 with CONTINGENCY for O2 & O4	O2 SMD AT CDA / RTS REQUIRE COMMAND I/F
	UPLINK	DSN S-BAND 2.025Hz (Cmd)	TBR (CDAs DON'T HAVE SGLS) 1.76 - 1.84 GHz
	DOWNLINK FREQ (SEE MATRIX)	X-BAND 7.455 GHz (with EST) EST: 2.20 - 2.29 GHz HRPT: 1.704 GHz HDRT: TBD GHz LRPT: 137 - 138 MHz LDRT: TBD	TBD IN SPEC (INCLUDES EST) 2.20 - 2.29 GHz TBD TBD TBD TBD } Trade number of realtime links
	D/L DATA RATE (SENSORS & SDC,SF, & TAC WINDOW)	90 MBPS (SMD) 3.1 MBPS (HRPT) 68 KBPS (LRPT) 1.3 MBPS (HDRT) 102 KBPS (LDRT)	 3.5 MBPS SPEC* 72 KBPS SPEC* 1.024 MBPS* 100 KBPS*

* Special Study constraints 1993

C BASELINE C3 CHARACTERISTICS - 2

PARAMETER	BASELINE	COMMENT/RQT
LINK MARGIN		
SMD	8.8 dB	TBD
REALTIME	TBD	6 db @ 20° elev.
BER	$1X10^{-6}$	S/C to RTS/CDA & DOMSAT Links
COMP RATIO	NONE (SMD & HRPT)(TBR) 3:1 (LRPT)(TBR) 6:1 (HDRT)(TBR) 8:1 (LDRT)(TBR)	 LOSSLESS OMIS LOSSY MISS
DATA RELAY	O1 & O3 with CONTINGENCY ROLE for O2 EUMETSAT & O4 (TDRSS)	
FVSF	SOC, FBSOC, & LMSC	

C BASELINE C3 CHARACTERISTICS - 3

LINK TYPE	TYPE OF DATA	BAND & FREQUENCY	DATA RATE & MODULATION	COMP RATIO	RESOLUTION REDUCTION	LINK FUNCTION
SDN	Commands, S & F	2.025 GHz	1.6 Kbps BPSK	N / A	N / A	Cmd Uplink, Store & Forward
EST	Telemetry, Special Format Data	2.20 - 2.29 GHz	8.1 Kbps	N / A	N / A	EST
SMD	All Data	X - 7.455 GHz 3 @ 100 MHz	90 Mbps SQPSK	NONE	NONE	Mission Sensor & Telemetry Data
HRPT	OMIS, MHS, AMSU-A1&A2, AIRS	S BAND 1.704 GHz	3.5 Mbps UQPSK	NONE	2	Realtime Data
LRPT	OMIS (3 chnl), MHS AMSU-A!&A2	VHF 137 - 183 MHz	72 Kbps BPSK	3 :1	4	Realtime Data
HDRT	OMIS, MISS	S BAND	1.024 Mbps	6 :1	NONE	Realtime Data
LDRT	OMIS (Low Res), MISS	UHF	100 Kbps	8 :1	4	Realtime Data
ARGOS (SDC)	Surface Platform Data	VHF 460 - 470 MHz	2.56 Kbps	N / A	NONE	Surface Data Collection
SAR	Beacon	121.5, 243, 406.08, & 1533 MHz	0.4 & 2.4 Kbps	N / A	N / A	Search & Rescue

TABLE OF ACRONYMS

AFGWC	Air Force Global Weather Central
AFSCN	Air Force Satellite Control Network
AIRS	Atmospheric Infrared Sounder
AMSU-Al	Advanced Microwave Sounding Unit-Al
ARTS	Automated Remote Tracking Station
B/L	Basel ine
C2	Command and Control
C3	Command, Control, and Communications
CCSDS	Consultative Committe for Space Data Systems
CDA	Command and Data Acquisition
C&DH	Command and Data Handling
CE	Central Element
CERES	Clouds and Earth Radiant Energy System
CMD	Command
COTS	Commercial Off-The-Shelf
CRX	Central site Receiver
c s c	Computer Software Component
CSCI	Computer Software Configuration Item
DRR	Data Routing and Retrieval
EDR	Environmental Data Record
EOS-DIS	Earth Observing System - Data&Information System
ERL	Earth Resources Laboratory
ESA	European Space Agency
EST	Equipment Status Telemetry
EUMETSAT	European Meteorological Satellite
FBSOC	Falcon Back-up Satellite Operations Center
FDDI	Fiber Optic Distributed Data Interface
FNMOC	Fleet Numerical Meteorological and Oceanographic Center
FO	Fiber Optic
FTS	Fairbanks Tracking Station
FVSF	Flight Vehicle Support Facility
GPS	Global Positioning System
GUS	Ground User Segment
HRPT	High Resolution Picture Transmission
HWCI	Hardware Configuration Item
ICD	Interface Control Document
I/F	Interface
IPO	Intergrated Program Office
KTS	Kiruna Tracking Station
LAN	Local Area Network
LCC	Life Cycle Cost
LEO&A	Launch, Early Orbit & Anomaly
LMSC	Lockheed Missiles & Space Company

LRPT	Low Resolution Picture Transmission
LTOC	Lockheed Technical Operations Company
Mbps	Megabits per second
MHS	Microwave Humidity Sounder
MISS	Microwave Imager Sounder Suite
MODIS	Moderate Resolution Imaging Spectrograph
MPSOC	Multi-Purpose Satellite Operations Center
NASCOM	NASA Communications
NAVOCEANO	Naval Oceanographic Office
NCC	Net Control Center
NESDIS	National Environmental Satellite Data & Information Service
NOAA	National Oceanographic and Atmospheric Administration
NORAD ELSET	North American Air Defense Ephemeris
NPOESS	National Polar Orbitting Environmental Satellite System
O&M	Operations & Maintenance
OMIS/VIRSR	Operational Multi-Spectral Imager Suite/Visible&Infrared Sensing Radiometer
OPS	Operations
PHSL	Program Hardware & Software Lists
POC	Payload Operations Center
QPSK	Quadra-Phase Shift Keying
RF	Radio Frequency
RTD	Real-time Data
RTS	Remote Tracking Station
SAR	Search and Rescue
SBUV	Solar Backscatter Ultraviolet Radiometer
SIC	Spacecraft
SDC	Surface Data Collection
SDR	Sensor Data Record
SDN	Space Data Network
SESS	Space Environmental Sensor Suite
S&F	Store & Forward
SFC	Space Forecast Center
SMD	Stored Mission Data
SOC	Satellite Operations Center
SOH	State of Health
SPO	System Program Office
S&R	Search & Rescue
SRR	System Requirements Review
s s o c	Suitalnd Satellite Operations Center
STT	Small tactical Terminal
TBD	To Be Determined
TBR	To Be Resolved
TDRSS	Tracking and Data Relay Satellite System
TLM	Telemetry
I-r&C	Telemetry, Tracking & Command

TTS	Thule Tracking Station
WSGT	White Sands Ground Terminal
WAN	Wide Area Network