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NATIONAL POLAR ORBITING OPERATIONAL ENVIRONMENTAL SATELLITE SYSTEM (NPOESS)

PSR #6 and MR #13

Prepared for:

NPOESS - IPO

LOS ANGELES, CALIFORNIA
and
SILVER SPRING, MARYLAND

7-8 December 1994

CONTRACT F04701-91-C-0068

Prepared by:

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

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INTRODUCTION/ AGENDA

M. WHITTEN

PSR #6 AGENDA -- 7-8 DECEMBER 1994

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WEDNESDAY, 7 DECEMBER 1994

TIME	SUBJECT	RESPONSIBLE
0810 - 0825	GOVERNMENT CAUCUS	GOVERNMENT
0830 - 0840	INTRODUCTION/AGENDA	M. WHITTEN
0840 - 0900	PROGRAM UPDATE	IPO
0900- 1030	MANAGEMENT REVIEW	M. WHITTEN
1030 - 1040	BREAK	
1030 - 1200	SYSTEMS ENGINEERING RQMTS PROCESS, RELIABILITY, AND A-SPEC IMPACTS	D. PAUL
1200 - 1245	LUNCHEON	
1245- 1345	REQUIREMENTS ANALYSIS	J. HARRISON
1345- 1430	EDR ALGORITHM ANALYSIS	B. KENLEY
1430- 1445	BREAK	
1445-1600	C3 SEGMENT REQUIREMENTS	R. NELSON, LTOC

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THURSDAY, 8 DECEMBER 1994

TIME	SUBJECT	RESPONSIBLE
0800 - 0930	EDR REQUIREMENTS/IMPACTS	K. HARDY
0930 - 1000	SENSOR SUITE RQMTS/IMPACTS	P. CALLARY
1000 - 1015	BREAK	
1015 - 1105	EO SENSOR(S)	P.CALLARY
1105 - 1125	DATA COMPRESSION RESULTS	S. SHEN
1125 - 1150	SPACE ENVIRONMENTAL SUITE	Y. CHIU
1150 - 1245	LUNCHEON	
1245 - 1415	MICROWAVE IMAGER/SOUNDER TILT EXPERIMENT DATA	M. DAVIS
1415 - 1430	BREAK	
1430 - 1530	IDP SEGMENT IMPACTS	P. TOPPING
1530 - 1630	SPACE SEGMENT IMPACTS	J. CLAPP
1630 - 1700	GOVT CAUCUS & SUMMARY	GOVERNMENT

PSR #6 OBJECTIVES

- SUMMARIZE CONTRACT PERFORMANCE TO DATE
- SPECIAL TOPICS DISCUSSION
  - A-SPEC COMMENTS
  - EDR ERROR BUDGET
  - EDR IMPACTS
  - SENSOR IMPACTS
  - IDPS IMPACTS
  - C3 IMPACTS
  - SPACECRAFT IMPACTS
- ACTION ITEM AND REQUIREMENTS ISSUES STATUS

IPO UPDATE

- PROGRAMMATICS/SCHEDULE
- CONVERGENCE/IPO
- REQMTS/SPECIFICATIONS
- OTHER ISSUES

MANAGEMENT REVIEW SUMMARY

- M. WHITTEN

THE OPERATIONAL CONVERGED SYSTEM

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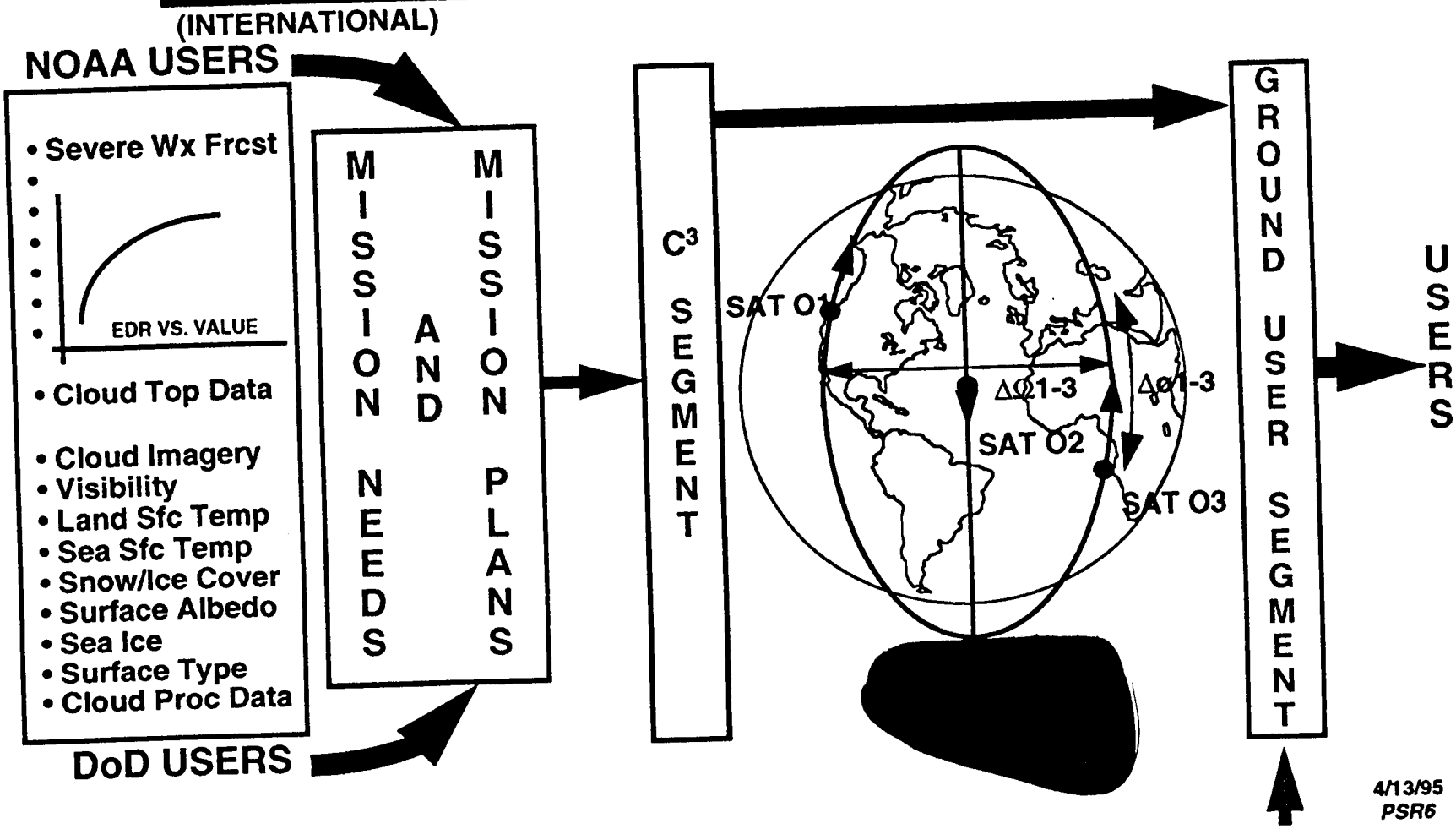
AN INTEGRATED END -TO - END SPACE AND GROUND USER SEGMENT SYSTEM



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THE CONVERGENCE CHALLENGE

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CREST ASSETS

NOSS EOS NROSS

PHASE A

DMSP BLOCK 6

NOAA O,P,Q

- BUDGET CONSTRAINTS
- EXT SYSTEM I/F - GPS,CDA, RTS
- EUROPEAN I/F
- TRANSITION
- PROOF OF PERFORMANCE

'OPTIMIZED'

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SYSTEM RQTS

BENEFITS

- SYSTEM ENGINEERING
- RESPONSIVENESS

GROWTH

- TEAM PRODUCTIVITY
- SOFTWARE DEVELOPMENT

CONVERGENCE EFFORT MODIFICATION

ALTERNATIVE GENERATION USING DESIGN REFERENCE BASELINE

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- LCC IN EM 1144
- 3 SAT CONSTELLATION (0530A, 0930D, 1330A)
- 8 CHANNEL OASIS, MISS, & SESS @ 0530
- METOP @ 0930
- 0530 + AIRS + AMSU @ 1330

DESIGN REFERENCE BASELINE (BLOCK 6 CONVERGENCE HERITAGE)

- MEETS 37 OF JUNE '94 EDRS
- RTS/CDA DOMSAT RELAY
- DISTRIBUTED EDR PROCESSING AT 6 CENTRAL SITES
- COMPRESSED DATA ON 4 TACTICAL DOWNLINKS

ALTERNATIVE A

MINIMUM DESIGN (ACHIEVES KEY PARAMETER MINIMUMS AND OTHER EDRs AS CAPABLE)

- 7 CHANNEL OASIS
- MISS
- IR SOUNDER
- SEA ICE SENSOR

ALTERNATIVE B

ENHANCED DESIGNS (ACHIEVES MINIMUMS AND SOME GOALS)

- TDRSS VS RTS/CDA DOMSAT RELAY
- CENTRALIZED VS DISTRIBUTED EDR PROCESSING
- 8 VS 12 CHANNEL OASIS VS SEAWIFS
- IR SOUNDERS
- CLIMATE MONITORING SUITE
- SURF DATA COLLECT OPTIONS
- ALTIMETER / SCATTEROMETER

ALTERNATIVE C

DESIGNS WITH NEW SENSOR COMPLEMENTS (ACHIEVES ALL FEASIBLE GOALS)

- MEETS ALL EDRS EXCEPT BATHYMETRY, BIOLUMINESCENCE , AEROSOL OPTICAL THICKNESS
- ENHANCED DESIGN PLUS:
  - 16 CHANNEL OASIS
  - LIDAR

DESIGN REFERENCE BASELINE ARCHITECTURE

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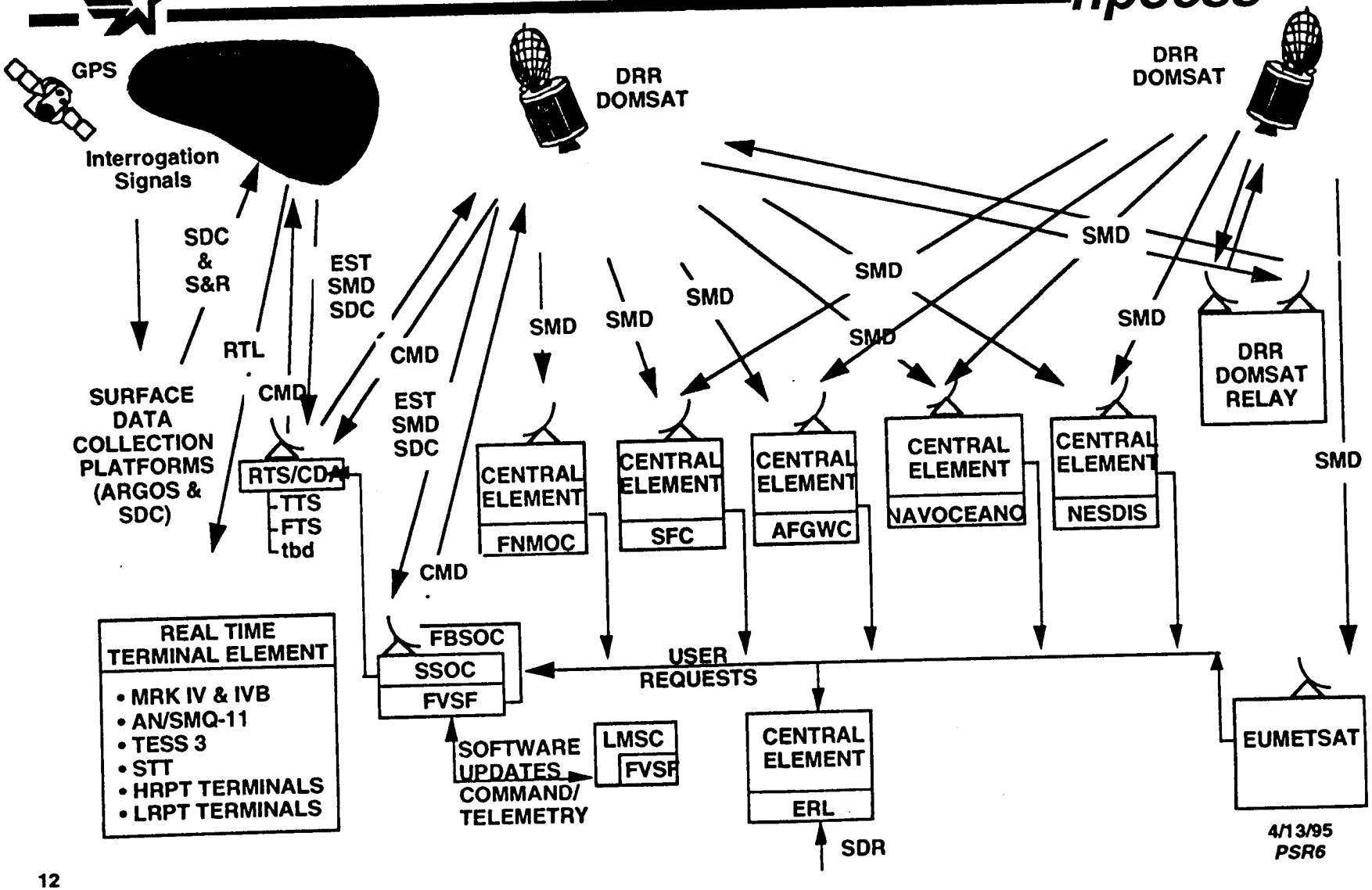

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MANAGEMENT REVIEW OVERVIEW

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PROGRAM STATUS: ON BUDGET - ON SCHEDULE

ORGANIZATION CHART/CHANGES/COMMITMENTS

CONTRACT AND SUBCONTRACT STATUS

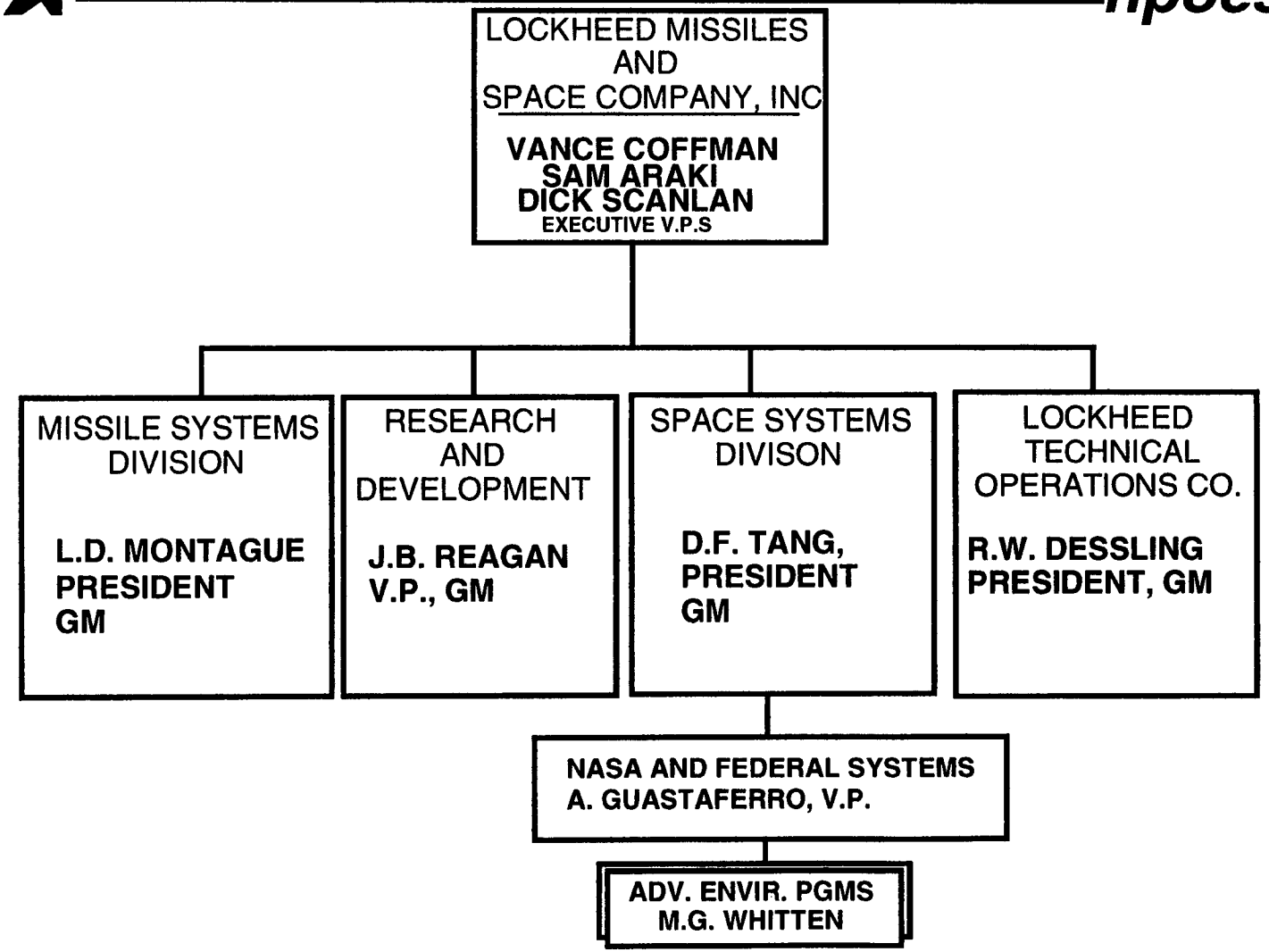
SCHEDULE UPDATES

LIFE CYCLE COST STATUS

SYSTEM ISSUES

ACTION ITEMS

ORGANIZATION



PROGRAM ORGANIZATION

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DMSP BLOCK 6/NOAA CONVERGENCE
M. G. WHITTEN

Bus Mgr
M. Durham

SCIENCE TEAM
Dr. K. Hardy
Dr. K. Hutchison
Dr. Y. Chiu
Dr. T. Wilheit
Dr. P. Rosenkranz
S. Westerman

EDR ANALYSIS
PHENOMENOLOGY
ENVIRONMENTAL MODEL AND RQTS DEFINITION
COMMUNITY I/F

SYSTEMS ENGINEERING
D.J. Paul

SYSTEMS ENGR
C3 INTEGRATION
RISK ANALYSIS
OPS CONCEPT
MISSION ANALYSIS
REQMTS ANALYSIS/ SPECIFICATION
TECHNOLOGY DVLPMT
SPECIALTY ENG'R
LOGISITICS
NAVY REQMTS/STUDIES

SENSOR SYSTEMS
P. Callary

OMIS DEVELOPMENT
EDU DEVELOPMENT
PAYLOAD TRADES
SENSOR DESIGN
R&DD SUPPORT
MISS DEVELOPMENT
SESS DEVELOPMENT
SENSOR S/C I/F

SPACECRAFT ENGINEERING
J. Clapp

SPACECRAFT ENGR
BUS INTEGRATION
SENSOR INTEGRN
F-SAT ADAPTATION

DATA AND USER SYSTEMS
P. Topping

IDPS SEGMENT
IWPTB DEVELOPMENT
SSD-D3 SUPPORT
OBP DEVELOPMENT
ALGORITHM DEVELOPMENT
CREST

TEAM RESPONSIBILITIES

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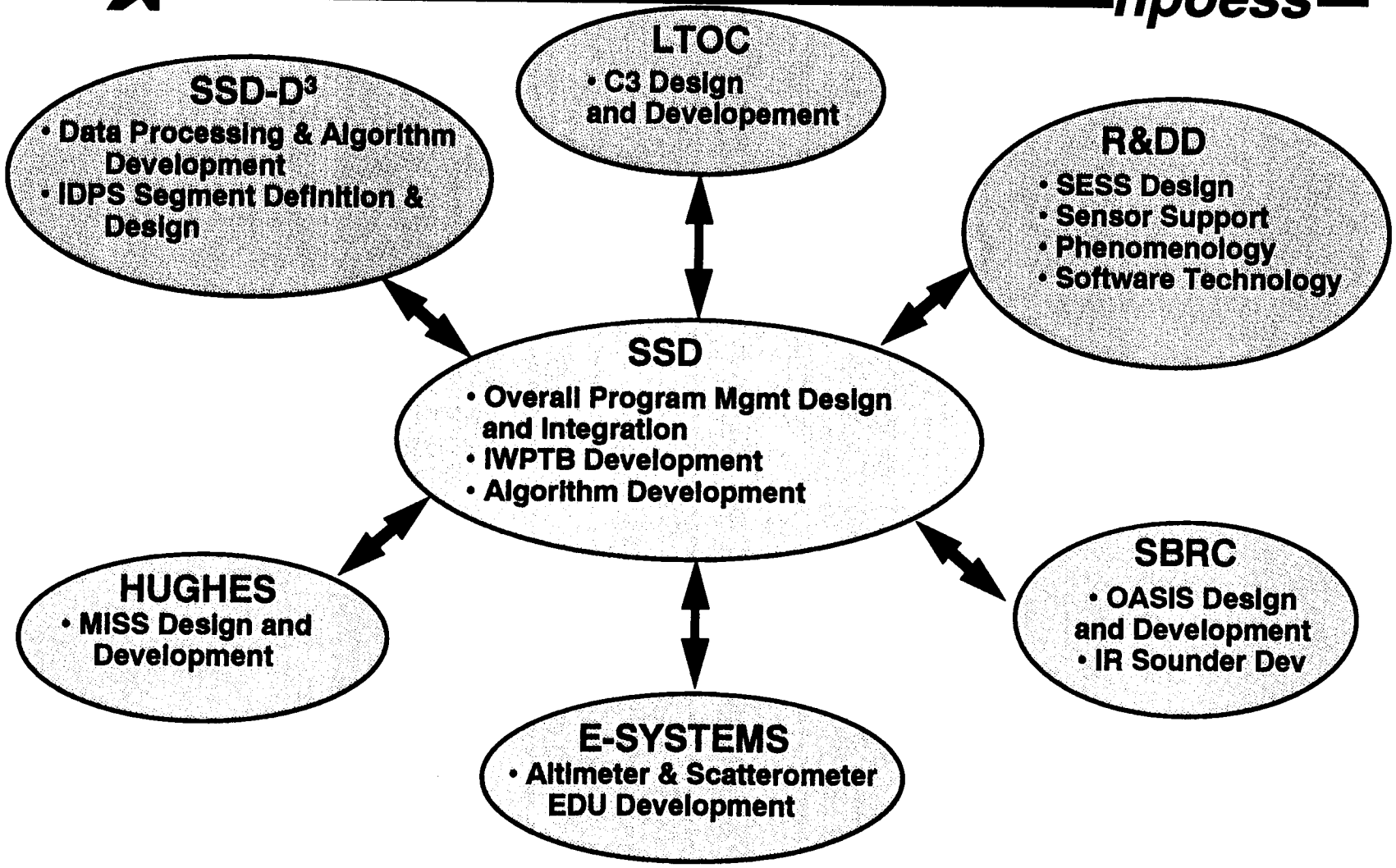

SUMMARY OF CONTRACT MODIFICATIONS

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NUMBER	DESCRIPTION
P00001-P00021	COMPLETE
P00023	PROVIDES ADDITIONAL $600K FUNDING
P00024	REVISES ATTACHMENT 6, DD FORM 254 CONTRACT SECURITY CLASSIFICATION SPECIFICATION
P00025	PROVIDES $800K ADDITIONAL FUNDING AND AUTHORIZES A NO COST CONTRACT EXTENSION TO 94 SEP 30
P00026	PROVIDES 124K ADDITIONAL FUNDING, ACTIVATES CLIN007 AND EXTENDS CONTRACT THRU 30 APR 95
P00027	ENABLING CLAUSE, REVISED SECTION H
P00028	PROVIDES ADDITIONAL 850K FUNDING

TOTAL FUNDING TO DATE - $7,924,202

CONTRACT ACCOMPLISHMENTS & ISSUES

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ACCOMPLISHMENTS

- IPO BRIEF - 30 DEC
- COMPLETED ALGORITHM AND IWPTB TIM - 4 AUG
- COMPLETED TIM WITH HUGHES - 4 NOV
- COMPLETED TIM WITH SBRC - 2 NOV
- COMPLETED C3 TIM WITH LTOC - 27 SEP
- OCT 1 A-SPEC REVIEW / IMPACT - 18 OCT
- INITIAL RESULTS ON TILT DATA ANALYSIS - 3 DEC

ISSUES

- SRR REPLAN

OMIS/VIRSR SUBCONTRACT

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OASIS Subcontractor:	Santa Barbara Research Center (SBRC) Goleta, CA
Company Relationships:	Formal Teaming Agreement Between LMSC and SBRC
Contract Type:	Fixed-Price Level-of-Effort
Subcontract Start Date:	23 May 1994
Original Period of Performance	11 Months (To 22 APRIL 95)
Contract Value:	$416K

- SBRC RESPONSIBLE FOR OASIS DEFINITION IN SUPPORT OF LMSC SYSTEM DEFINITION EFFORT
- OASIS TRADES AND ANALYSIS
- OASIS LIFE CYCLE COST EFFORT

CONVERGENCE EFFORT MODIFICATION

SBRC PROGRAM COST SUMMARY

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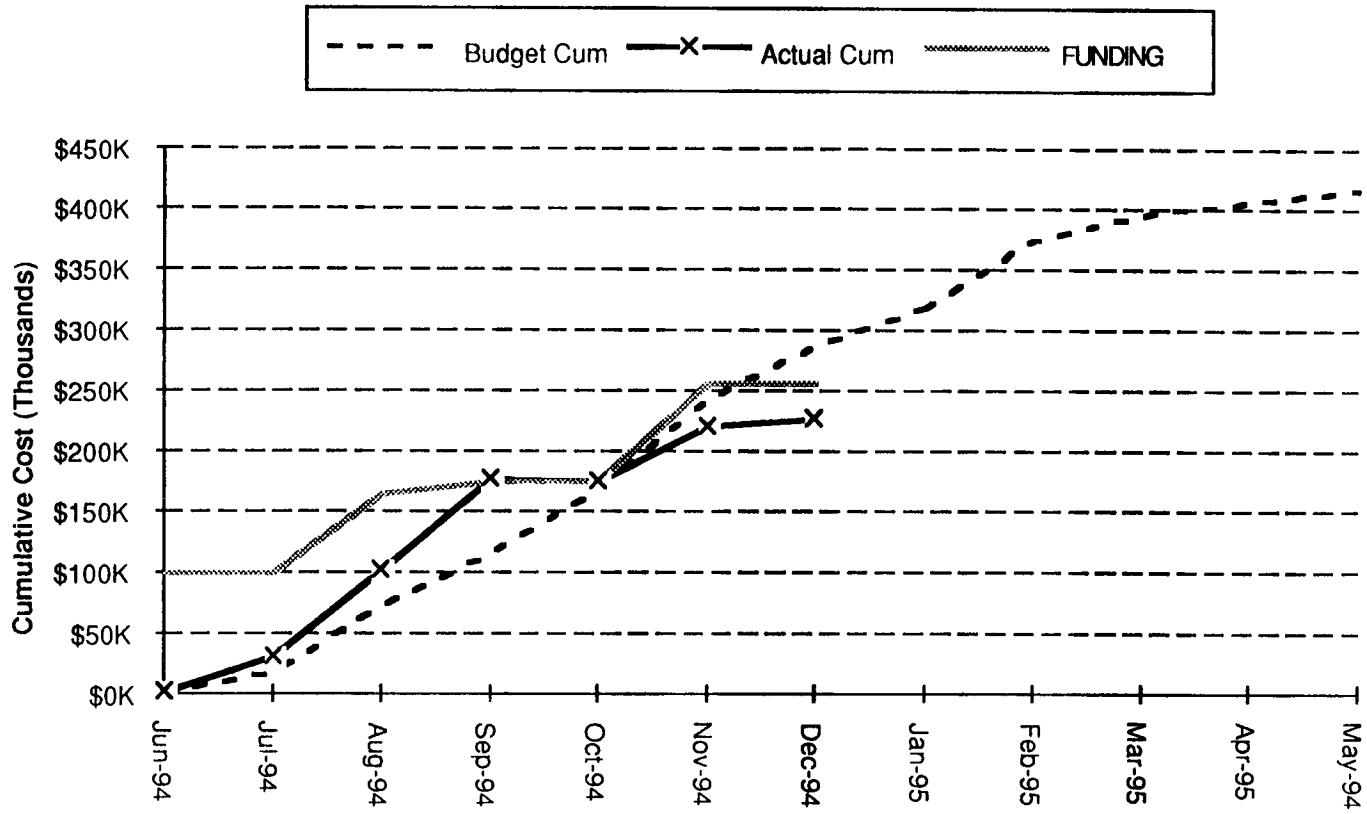
CUMULATIVE COSTS THROUGH JULY



SUBCONTRACT MANAGEMENT - HSC

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MISS SUBCONTRACTOR:	HUGHES SPACE & COMM. CO., EL SEGUNDO, CA
CONTRACT TYPE:	FIXED-PRICE, LEVEL OF EFFORT
SUBCONTRACT START DATE:	MARCH 28, 1994
PERIOD OF PERFORMANCE:	13 MONTHS (TO APRIL 1995)
NEGOTIATED VALUE:	$173K

HSC STATUS

- HSC RESPONSIBLE FOR MISS CONFIGURATION DEFINITION AND LIFE CYCLE COSTING
- 4 NOVEMBER 1994 TIM FOCUSED ON RECEIVER AND ANTENNA DESIGN TRADES
- HSC SUCCESSFULLY INFUSING HERITAGE & EXPERIENCE TO PROVIDE MICROWAVE SENSOR DESIGN OPTIONS THAT MEET USER NEEDS

HSC SUBCONTRACT COST SUMMARY

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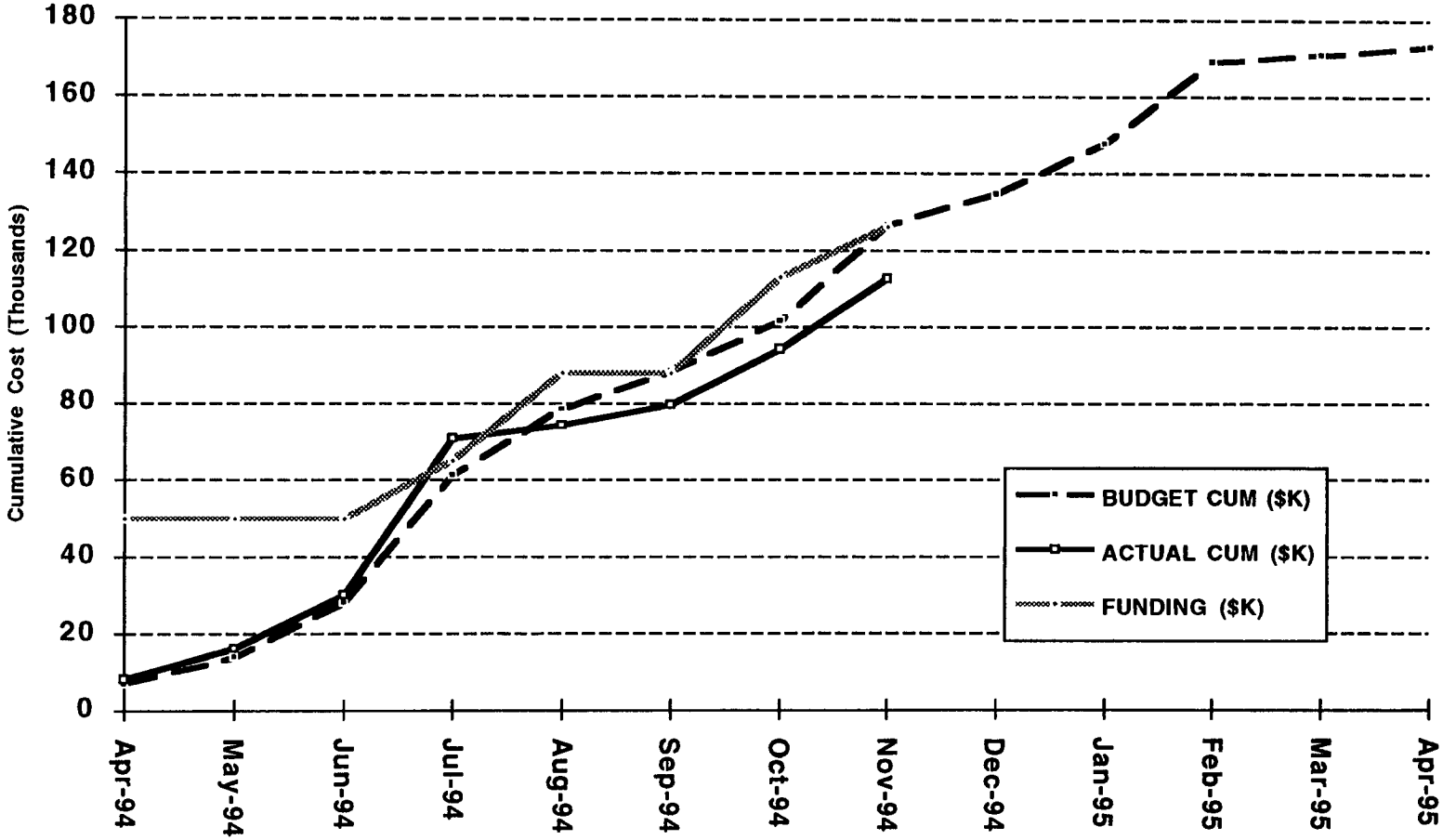
CUMULATIVE COSTS THROUGH NOVEMBER



COST STATUS

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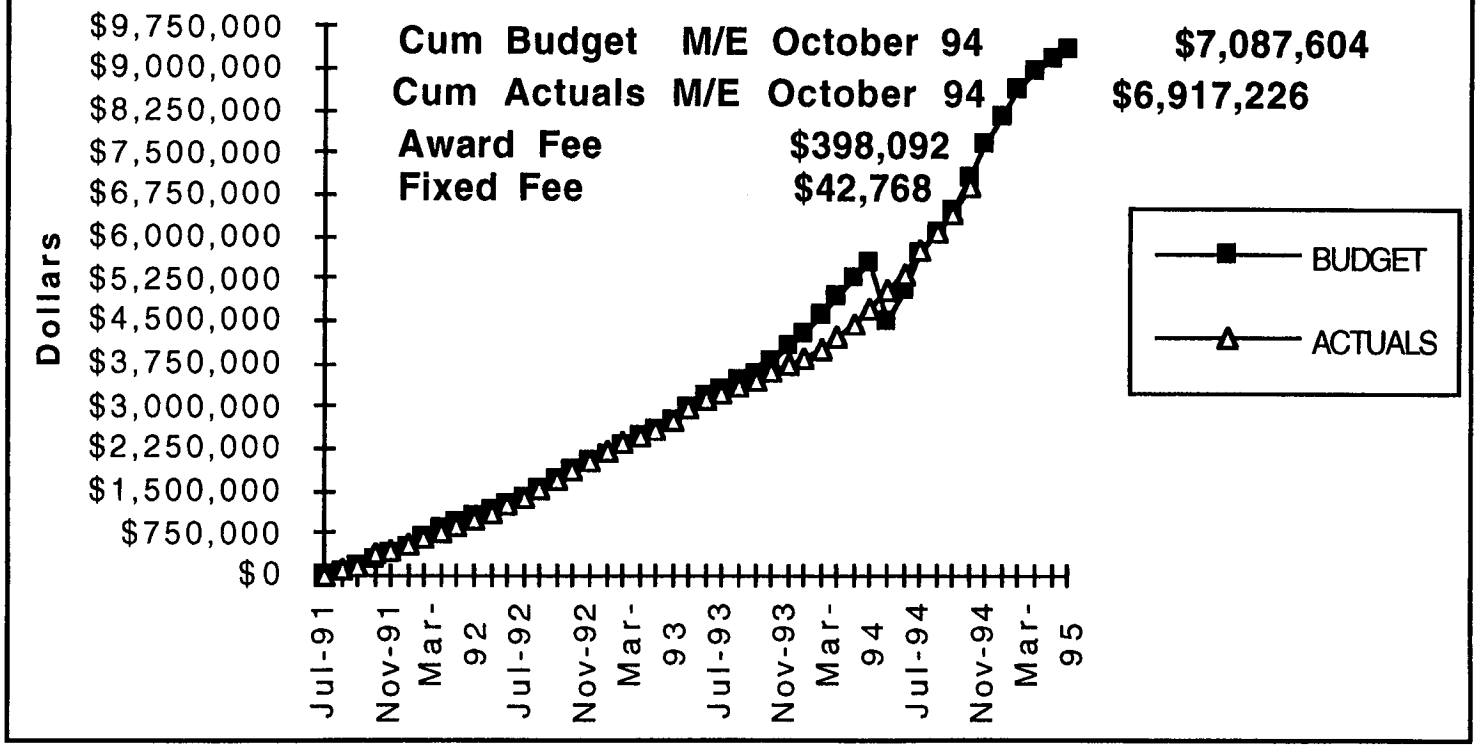
CUM BUDGET VS. CUM ACTUALS



CONVERGENCE EFFORT MODIFICATION

BASIC CONTRACT CRITICAL PATH

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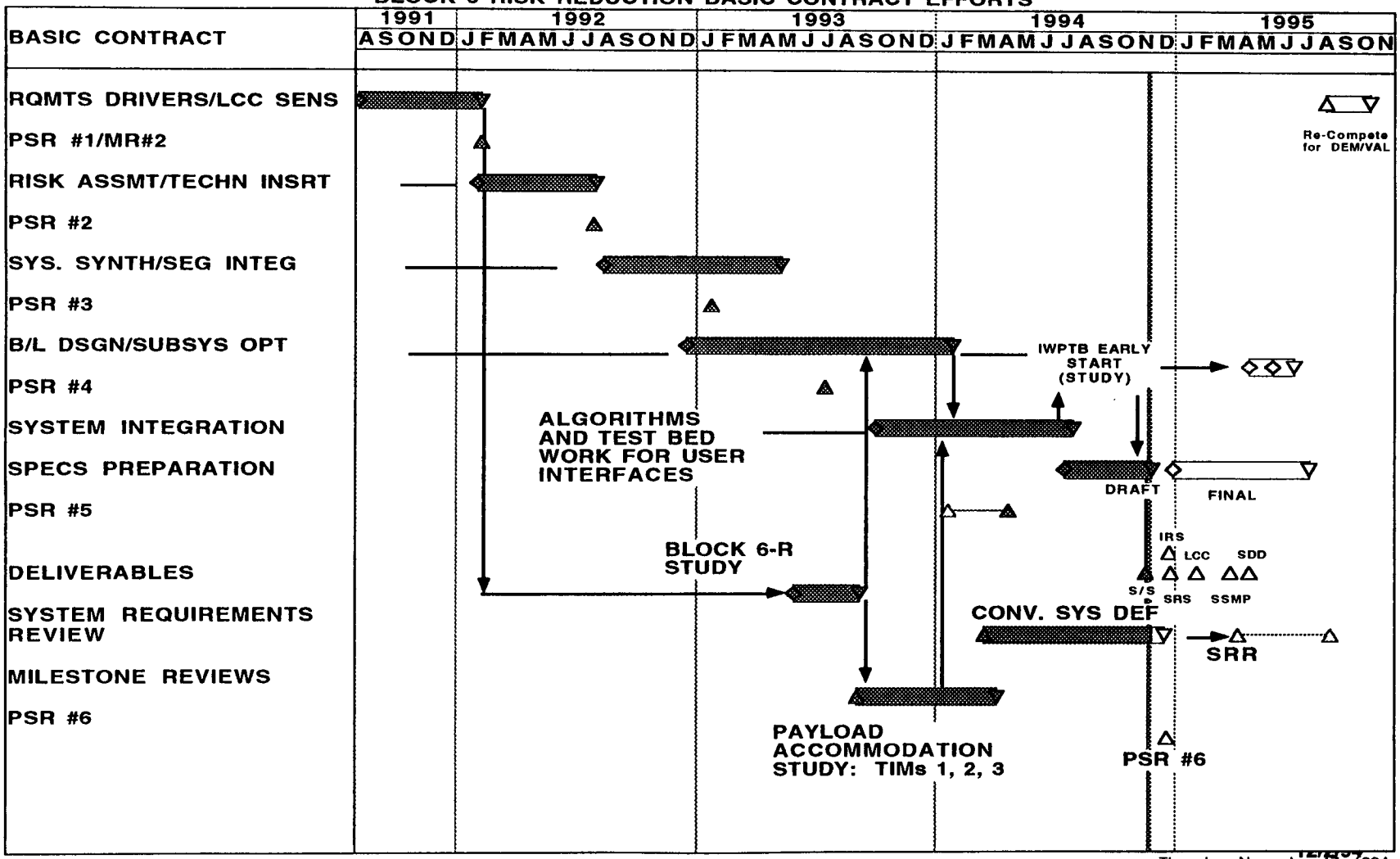
BLOCK 6 RISK REDUCTION BASIC CONTRACT EFFORTS



CONVERGENCE EFFORT MODIFICATION

N-PRIME AND METOP DRIVE C-1 NEED DATE

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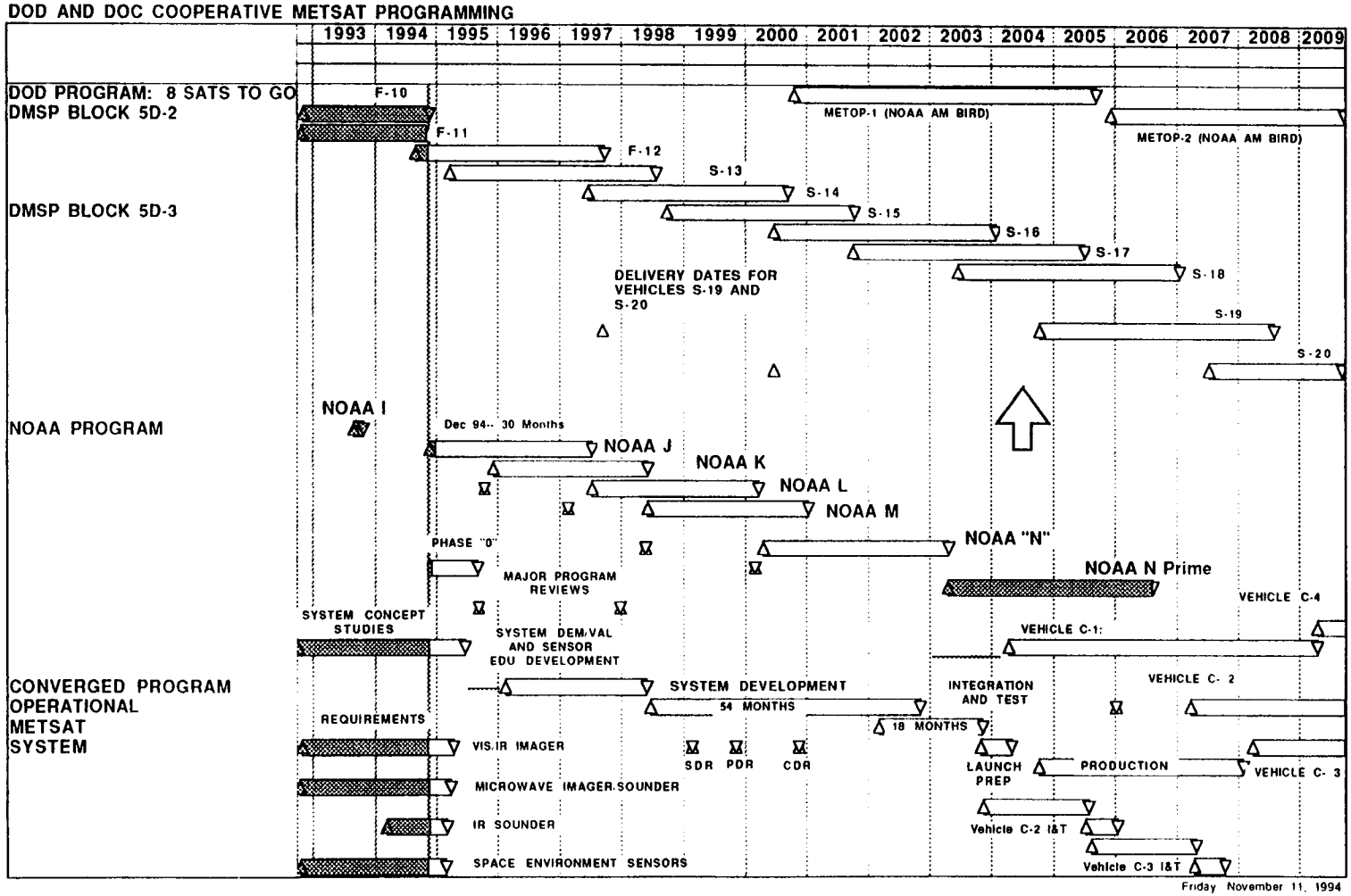

CONVERGENCE EFFORT MODIFICATION

NPOESS SCHEDULE FOR 2004 AVAILABILITY DATE

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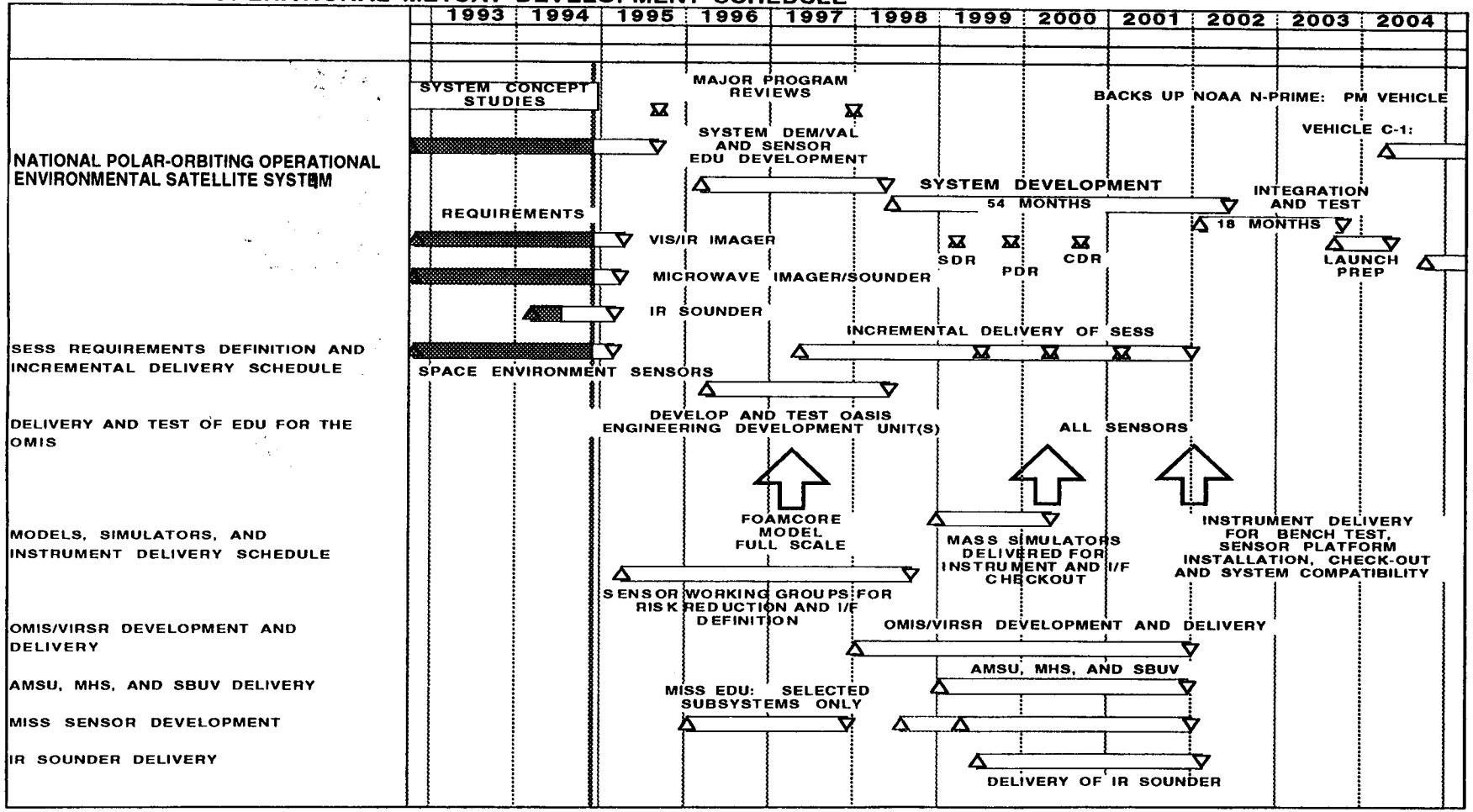
DOD AND DOC OPERATIONAL METSAT DEVELOPMENT SCHEDULE



Thursday, November 17, 1994

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CONVERGENCE EFFORT MODIFICATION

USER REQUIREMENTS ARE HEAVILY LEVERAGED AGAINST SPACE SEGMENT COST

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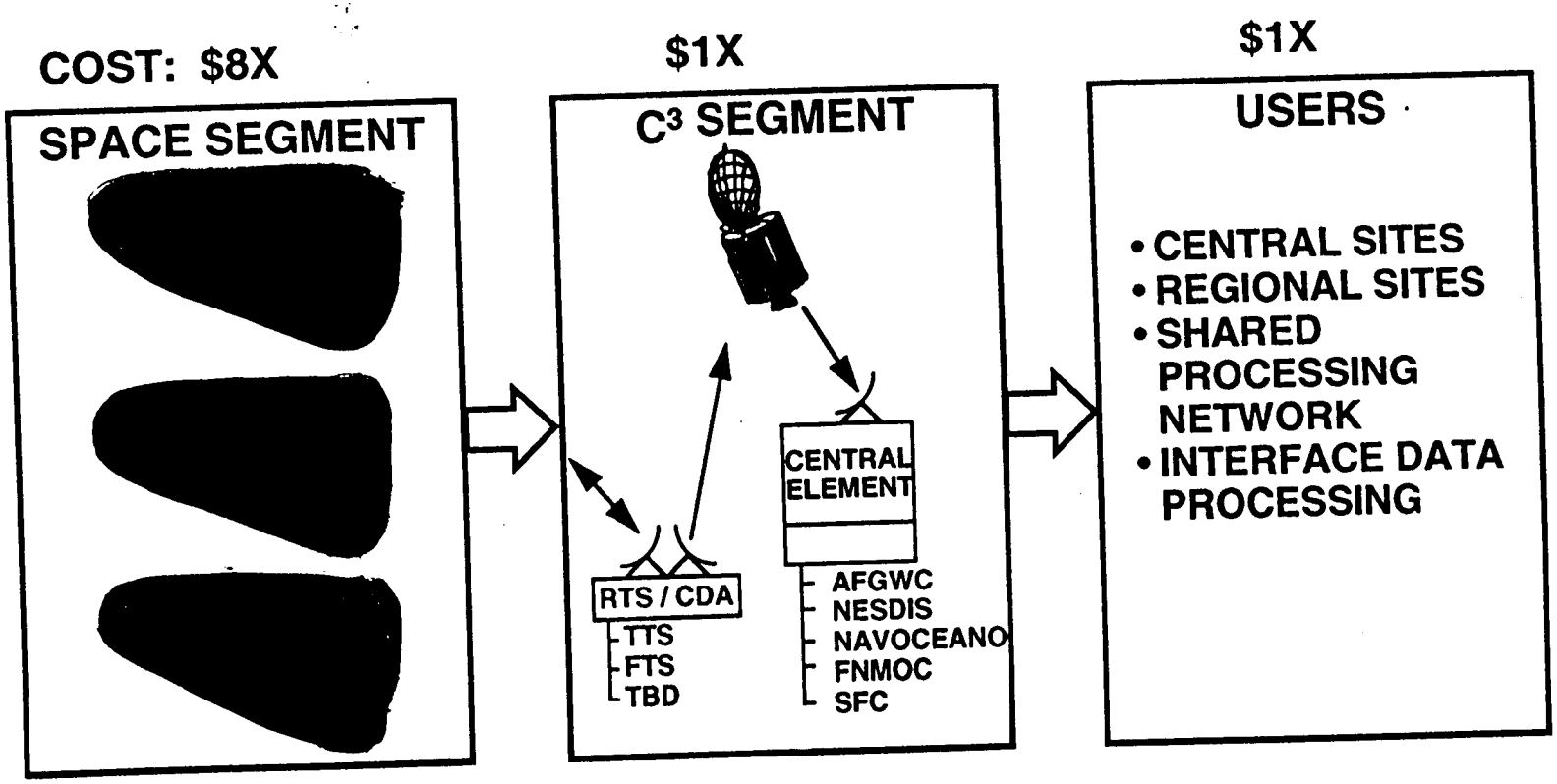

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SPACE SEGMENT LCC ASSUMPTIONS

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- U.S. PROVIDED SATELLITES O1 AND O3
  - TWO OF EACH WITH A COMMON SPARE
- SENSORS FOR EUMETSAT S/C (O2)
  - THREE SETS
- INCORPORATED SPACECRAFT CHANGES
  - INCREASED MEMORY AND DATA THROUGHPUT
  - X-BAND SMD D/L & MULTIPLE REAL-TIME LINKS
- FACTORY TO PAD LAUNCH OPERATIONS

GROUND SEGMENTS LCC ASSUMPTIONS

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- USER SEGMENT INCLUDES
  - FRONT END PROCESSORS & DBMS AT NESDIS, NOAA-ERL, AND EUMETSAT
  - PROTOTYPE DEVELOPMENT UNITS FOR HRPT & LRPT TERMINALS
  - ALGORITHMS FOR MICROWAVE SOUNDERS, AND AIRS NOT INCLUDED
- C^3 SEGMENT INCLUDES
  - ADDS USER SITE COMM TERMINALS AT NESDIS, NOAA - ERL, AND EUMETSAT
  - ADDS C^3 SITE COMM TERMINALS AT SUITLAND AND THREE RTS/CDA SITES
  - 44 MBPS DATA THROUGHPUT CAPABILITY FOR DRR
  - OPERATIONAL SOC AT SUITLAND, B/U AT CSOC
  - ASSUMES X-BAND TERMINALS ALREADY EXIST AT RTS/CDA SITES

CONVERGENCE EFFORT MODIFICATION

PLANNED LCC ACTIVITIES FOR MR #14

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- DEVELOP COST DELTAS FOR PHASE 0 ALTERNATIVES
  - UPDATE SENSOR COSTS -- ENHANCED AND NEW
  - INTEGRATE C3 - IDPS TRADE COST DELTAS
  - REVISE MISSION CONTROL OPERATIONS COSTS BY CONSIDERING EMERGING TECHNOLOGIES
  - COST SAVINGS BY INCREASED USE OF COTS AND ELIMINATION OF ADA

- RECOMMEND LCC TARGETS TO IPO
  - COST AS A KEY REQUIREMENTS PARAMETER, MINIMUM AND GOAL

SURVIVABILITY

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- REQUIREMENT
  - THE SATELLITE SHALL BE DESIGNED SUCH THAT NO MISSION DEGRADATION OCCURS AFTER EXPOSURE TO THE COMBINED NATURAL AND HOSTILE ENVIRONMENTS
  - HOSTILE ENVIRONMENT IS IN APPENDIX B
    - PREVIOUS SURVIVABILITY REQUIREMENTS LIMITED TO OMIS, MISS, AND SPACECRAFT
- ISSUES
  - THREAT ENVIRONMENT DEFINITION
  - SCOPE OF MISSION (I,E., PRIMARY MISSION - OASIS, MISS, & AIRS)
  - NOT DEGRADE VERSUS MAINTAIN FULL MISSION CAPABILITY
- IMPLEMENTATION PHILOSPHY
  - IMPROVE SYSTEM SURVIVABILITY WITH LOW RISK, LOW COST ENHANCEMENTS

SURVIVABILITY ALTERNATIVES

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ALTERNATIVE 1	ALTERNATIVE 2	ALTERNATIVE 3
HARDEN ALL PAYLOADS TO SURVIVE HOSTILE ENVIRONMENT	HARDEN S/C O1,	HARDEN S/C CONFIGURATION O1
	SURVIVABLE OASIS, MISS, AND S/C's FOR OTHER CONFIGURATIONS	SURVIVABLE OASIS, MISS, AND S/C's FOR OTHER CONFIGURATIONS
	HARDEN OTHER P/Ls TO MINIMIZE COLLATERAL DAMAGE	OASIS & MISS ON CONFIG-URATIONS O2 & O3 STILL SUSCEPTIBLE TO COLLATERAL DAMAGE
	HOSTILE ENVIRONMENT MAY DEGRADE NON-SURVIVABLE PAYLOAD PERFORMANCE	LAUNCH O1 AS GAP FILLER IF S/C CRITICAL TO US ARE DAMAGED
		CONTINGENCY USE OF SPARE VEHICLE ONLY
HIGH COST	COMPLEX INTERFACE	INITIAL COST ESTIMATE $60 - $70 M
HIGH RISK	MEDIUM RISK	LOW RISK

TOP TEN PROGRAMMATIC ISSUES

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1. CONTINUED COMMUNICATIONS WITH IPO, JARG, NOAA, NASA, DOD
2. REPLAN OF BASIC CONTRACT TO PHASE ZERO
3. MEETING 2004 AVAILABILITY DATE WITH 1QFY99 EMD START
4. ESTABLISH/DEVELOPMENT OF OPERATIONAL CONCEPT
5. MAXIMIZE RELIABILITY OF COST SAVING ESTIMATES
6. MINIMIZE LCC ALTERNATIVES THROUGH END-TO-END OPTIMIZATION
7. UNDERSTANDING DMSP-NOAA TRANSITION TO CONVERGED C3 SYSTEM
8. REQUIREMENTS RESOLUTION PROCESS, e.g. SURVIVABILITY RQTS
9. IWPTB DEVELOPMENT - END-TO-END USER PRODUCT DEMO
10. PREPARING FOR MILESTONE 1 AND DEM-VAL.

TOP TEN TECHNICAL ISSUES

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1. NEW IORD/ A-SPEC REQUIREMENTS VALIDATION/CLARIFICATION
2. EDR ANALYSIS AND ALTERNATIVE/IMPACT ASSESSMENT
3. SENSING TO SENSOR REQUIREMENTS TRANSLATION
4. SYSTEM PERFORMANCE REQTS AND OVERALL CONSTELLATION
5. RELIABILITY AND LIFETIME COMPATIBILITY: NEW VS EXISTING SENSORS
6. COMBINED OPTIMIZATION OF C3 AND IDP SEGMENTS
7. OASIS DEVELOPMENT AND RISK/COST ASSESSMENTS
8. OBP AND DATA COMPRESSION IMPLEMENTATION
9. ATMOSPHERIC SOUNDING: IR AND M/W: COREGISTRATION
10. MISS DEVELOPMENT APPROACH

SYSTEMS ENGINEERING

D. PAUL

- REQUIREMENTS PROCESS
- ALTERNATIVE DEVELOPMENT
- RELIABILITY ANALYSIS

CONVERGENCE EFFORT MODIFICATION

SSD INTEGRATES MULTIPLE DISCIPLINES FOR SYSTEM LIFECYCLE DEVELOPMENT

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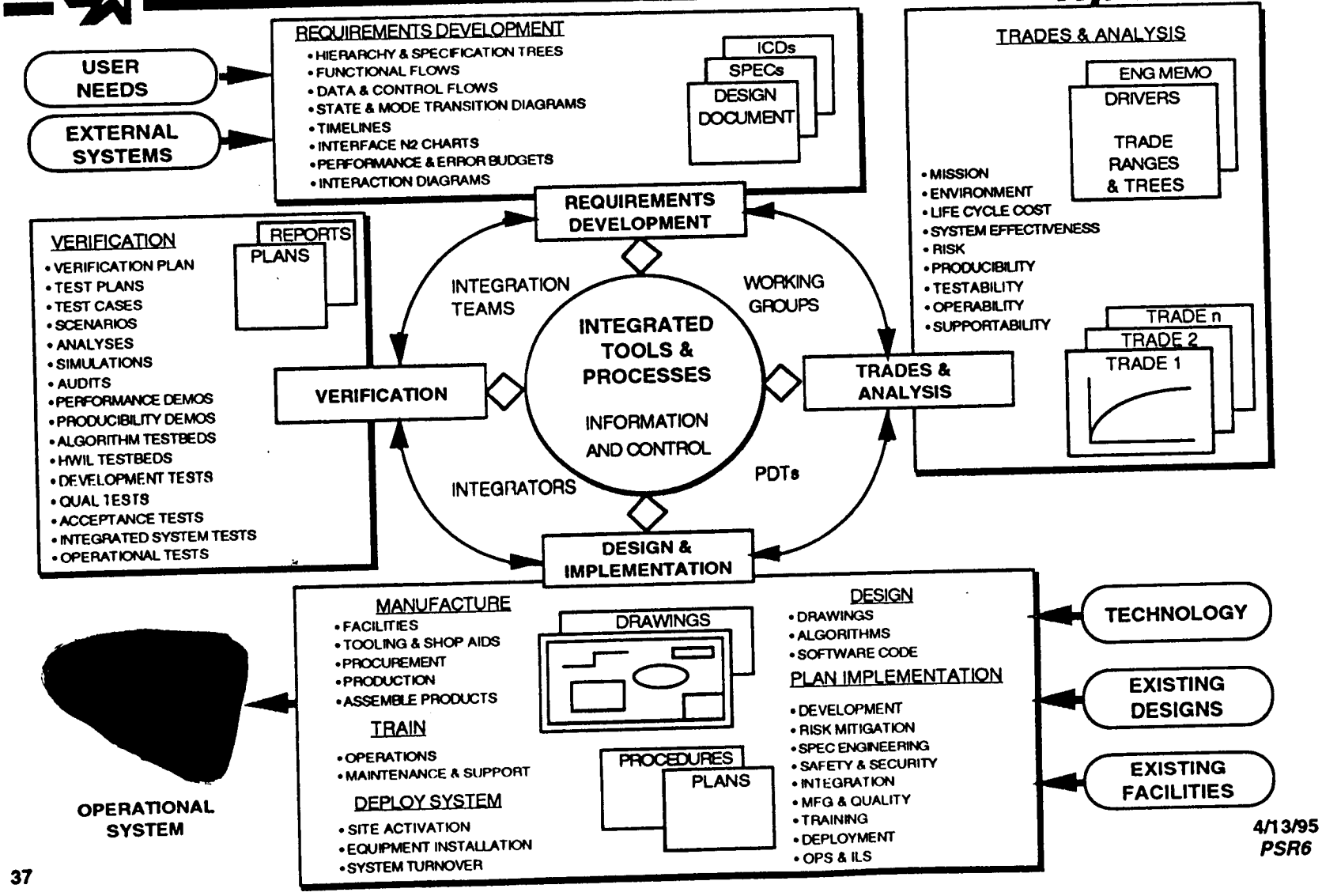

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OBJECTIVE AND GUIDELINES

- PHASE 0 OBJECTIVE
  - DEVELOP SEVERAL (3 OR 4) COST-EFFECTIVE ALTERNATIVES THAT CONVERGE EXISTING AND ADVANCED DMSP AND POES FUNCTIONS AND FACILITIES INTO A SINGLE, INTEGRATED SPACE AND GROUND SEGMENT USER SYSTEM

- GUIDELINES
  - LEVERAGE EDR "VALUE" STUDIES INTO SUPPORT FOR ALTERNATIVE DEVELOPMENT
  - BALANCE COST VS PERFORMANCE OF OPERATIONAL AND SCIENCE REQUIREMENTS
  - USE END-TO-END SYSTEM TRADES TO MINIMIZE TECHNICAL AND SCHEDULE RISK
  - ITERATE TO IDENTIFY COST EFFECTIVE SYSTEM ARCHITECTURES

CONVERGENCE EFFORT MODIFICATION

SRR PROCESS SUPPORTS ACQUISITION PROCESS

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REQUIREMENTS DEVELOPMENT

- MISSION AND REQUIREMENTS ANALYSIS
- *FUNCTIONAL FLOW ANALYSIS*
- *PRELIMINARY REQUIREMENTS ALLOCATION*
- *RELIABILITY ANALYSIS*
- *SYSTEM INTERFACE STUDIES*
- *GENERATION OF SPECIFICATION*
- TPM PLANNING

KEY

- PRIMARY EMPHASIS FOR ACQ SPT
- *LIMITED TO KEY COST-PERFORMANCE DRIVERS*

BASELINE DEVELOPMENT

- TRADE STUDIES (INCLUDING COST)
- *SYNTHESIS*
- *LOGISTICS SPT ANALYSIS*
- *EMC*
- *SURVIVABILITY/VULNERABILITY*
- ENVIRONMENTAL CONSIDERATIONS
- *HUMAN FACTORS ANALYSIS*
- MANPOWER REQUIREMENTS/ PERSONNEL ANALYSIS

PROGRAM PLANNING

- *ENGINEERING INTEGRATION*
- INTEGRATED TEST PLANNING
- *DATA MANAGEMENT PLANS*
- *CONFIGURATION MANAGEMENT PLANS*
- *PRELIMINARY MANUFACTURING PLANS*
- MILESTONE SCHEDULES

PROGRAM RISK ANALYSIS

LIFE CYCLE COST ANALYSIS

SYSTEM REQUIREMENTS REVIEW "SHALL"s

- RISK IDENT AND RANKING.
- RISK AVOID / REDUCTION & CONTROL
- SIGNIFICANT TRADE-OFFS
- *IDENTIFYING COMPUTER RESOURCES & PARTITIONING INTO HWCIs AND CSCIs.*
- *PRODUCIBILITY AND MANUFACTURING CONSIDERATIONS*
- *SIGNIFICANT HAZARD CONSIDERATION*

CONVERGENCE EFFORT MODIFICATION

COST VS PERFORMANCE END-TO-END SYSTEM TRADES

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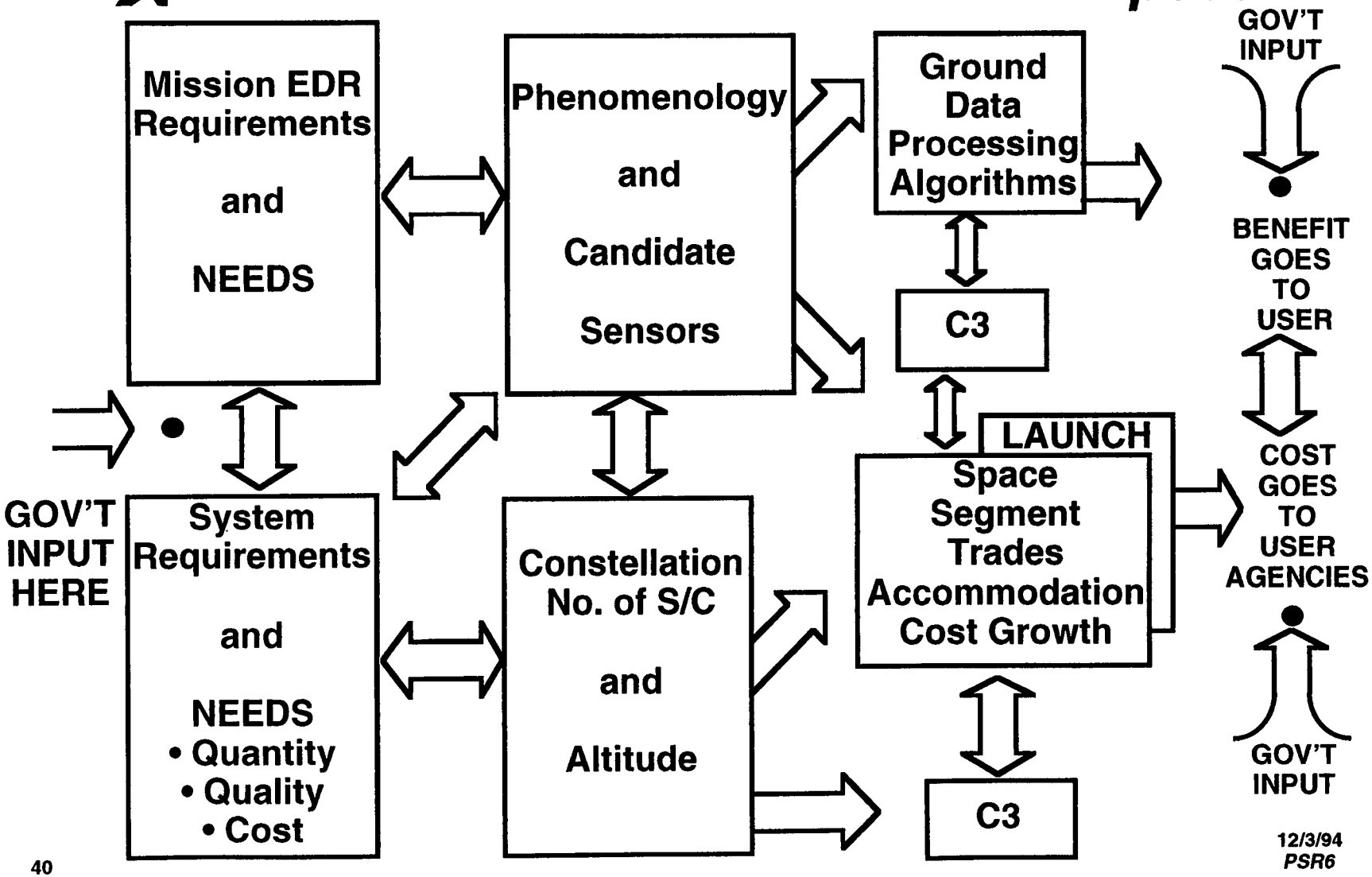

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CONVERGENCE EFFORT MODIFICATION

SSD PHASE 0 ANALYSIS AND ITERATIVE TRADES APPROACH

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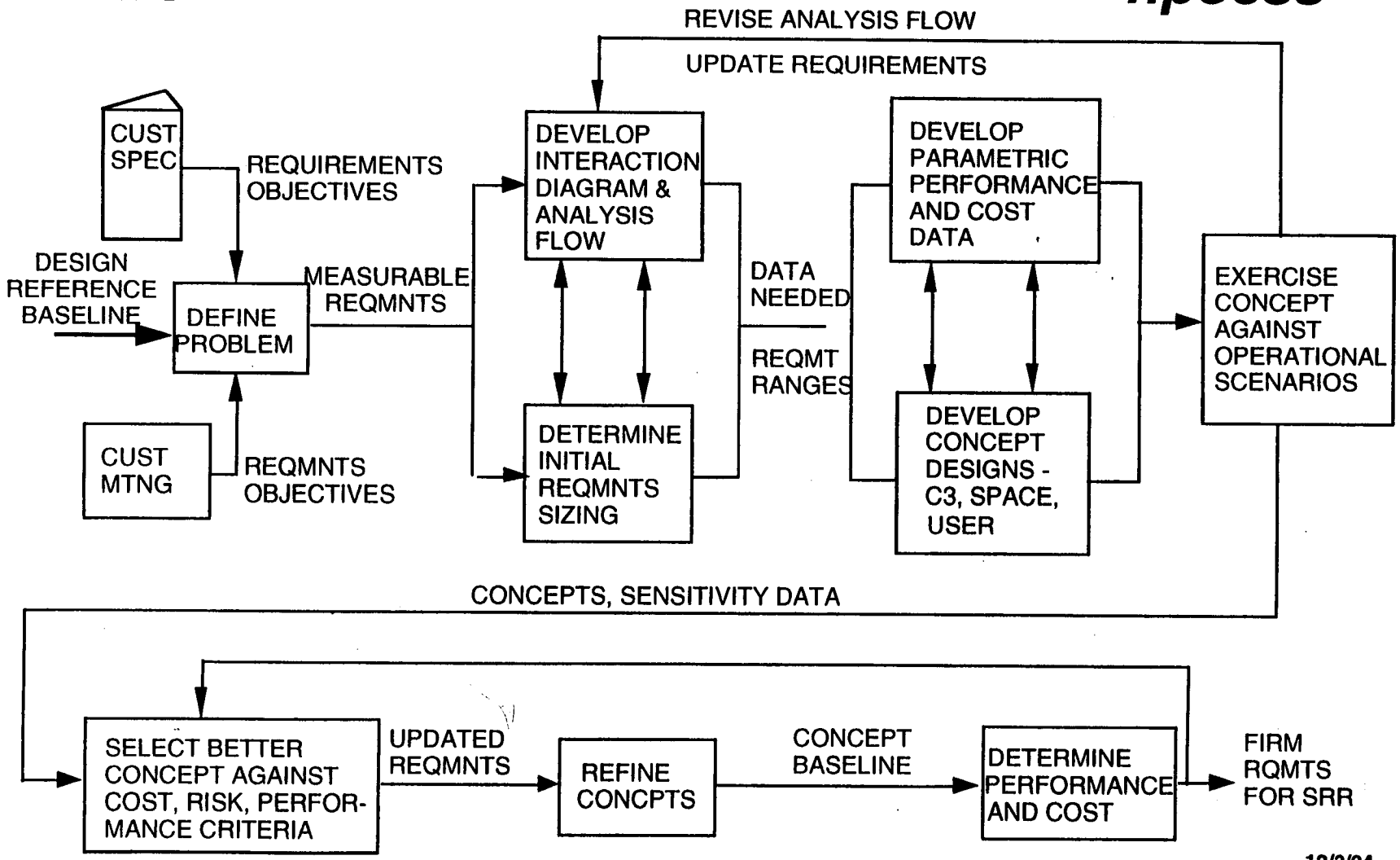


CONVERGENCE EFFORT MODIFICATION

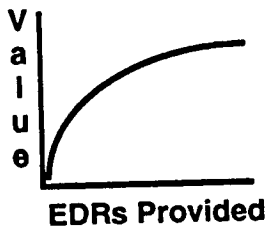
GOOD DESIGN REFERENCE BASELINES PROMOTE CONVERGENCE

AN INTEGRATED END -TO - END SPACE AND GROUND SEGMENT USER SYSTEM

(INTERNATIONAL)

NOAA USERS

- Severe Wx Frcst

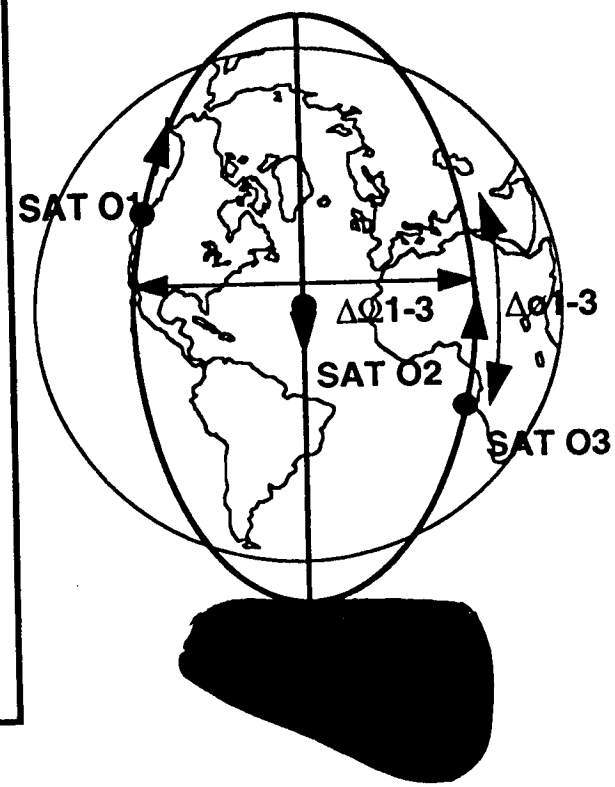


- Cloud Top Data
- Cloud Imagery
- Visibility
- Land Srfc Temp
- Sea Srfc Temp
- Snow/Ice Cover
- Surface Albedo
- Sea Ice
- Surface Type
- Cloud Proc Data

DoD USERS

MISSION NEEDS AND MISSION PLANS

C^3 SEGMENT



GROUND SEGMENT

USERS

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CONVERGENCE EFFORT MODIFICATION

ALTERNATIVE GENERATION USING DESIGN REFERENCE BASELINE

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- LCC IN EM 1144
- 3 SAT CONSTELLATION (0530A, 0930D, 1330A)
- 8 CHANNEL OASIS, MISS, & SESS @ 0530
- METOP @ 0930
- 0530 + AIRS + AMSU @ 1330

DESIGN REFERENCE BASELINE (BLOCK 6 CONVERGENCE HERITAGE)

- MEETS 37 OF JUNE '94 EDRS
- RTS/CDA DOMSAT RELAY
- DISTRIBUTED EDR PROCESSING AT 5 CENTRAL SITES
- HIGHLY COMPRESSED DATA ON 4 TACTICAL DOWNLINKS

ALTERNATIVE A

MINIMUM DESIGN (ACHIEVES KEY PARAMETER MINIMUMS AND OTHER EDRs AS CAPABLE)

- 7 CHANNEL OASIS
- MISS
- IR SOUNDER
- SEA ICE SENSOR

ALTERNATIVE B

ENHANCED DESIGNS (ACHIEVES MINIMUMS AND SOME GOALS)

- TDRSS VS RTS/CDA DOMSAT RELAY
- CENTRALIZED VS DISTRIBUTED EDR PROCESSING
- 8 VS 12 CHANNEL OASIS VS SEAWIFS
- IR SOUNDERS
- CLIMATE MONITORING SUITE
- SURF DATA COLLECT OPTIONS
- ALTIMETER / SCATTEROMETER

ALTERNATIVE C

DESIGNS WITH NEW SENSOR COMPLEMENTS (ACHIEVES ALL FEASIBLE GOALS)

- MEETS ALL EDRS EXCEPT BATHYMETRY, BIOLUMINESCENCE , AEROSOL OPTICAL THICKNESS
- ENHANCED DESIGN PLUS:
  - 16 CHANNEL OASIS
  - LIDAR

CONVERGENCE EFFORT MODIFICATION

DESIGN REFERENCE BASELINE ARCHITECTURE

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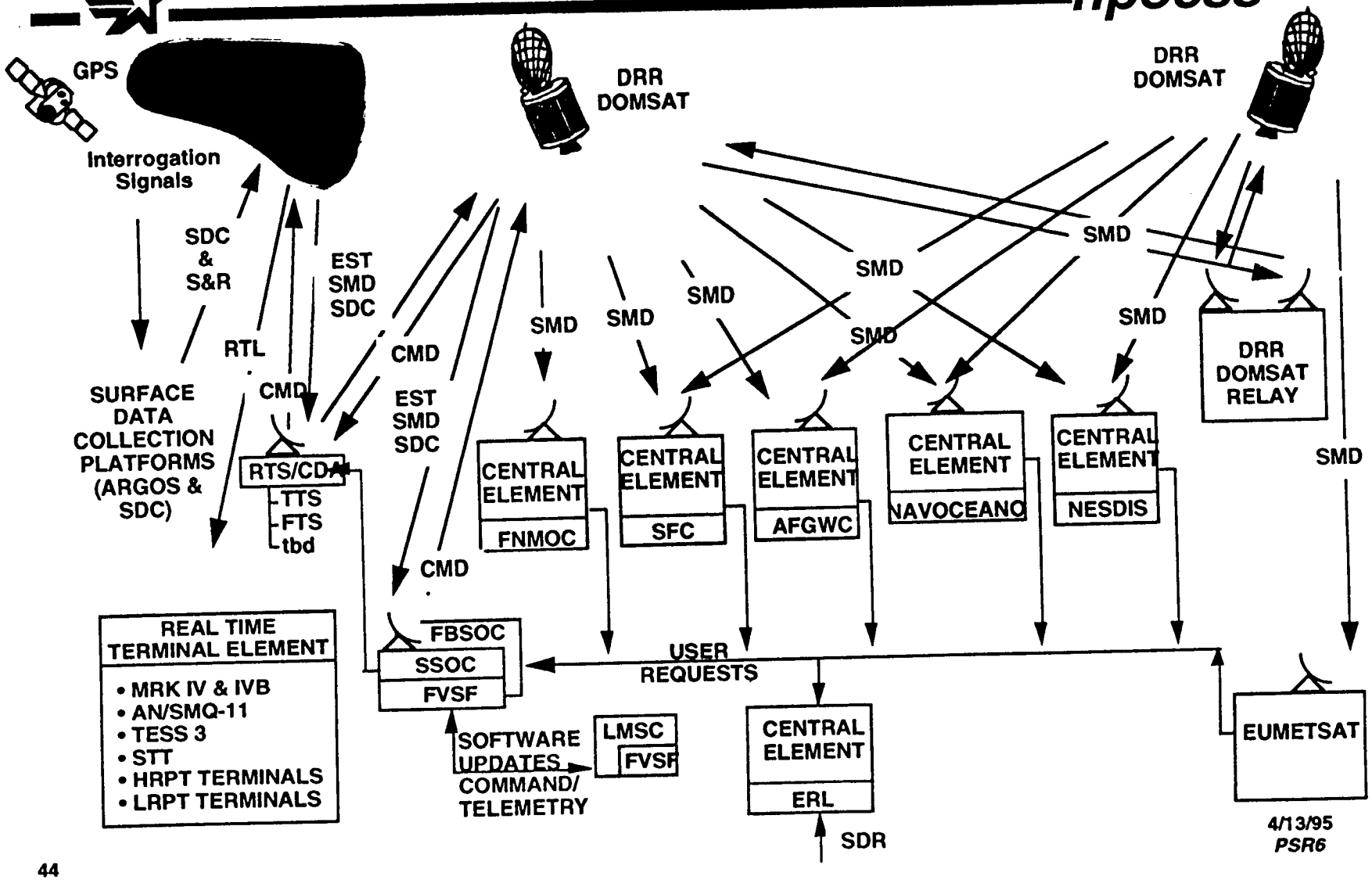

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PSR6

CONVERGENCE EFFORT MODIFICATION

DESIGN REFERENCE BASELINE CONSTELLATION PAYLOADS

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SAT01
0530A

OASIS
MISS
SESS
ARGOS/SDC
MSTRS

SAT02
0930D

OASIS
MIMR
AMSU-1
AMSU-2
MHS
SESS
S&R
ARGOS
IASI

SAT03
1330A

OASIS
MISS
AMSU-1
MHS
AIRS/ITS
SBUV
SESS
S&R
ARGOS/SDC
MSTRS

4/13/95
PSR6

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PAGE 47 IS EXEMPT FROM RELEASE AND IS REPLACED WITH THIS PAGE.

DESIGN REFERENCE BASELINE LINK OVERVIEW

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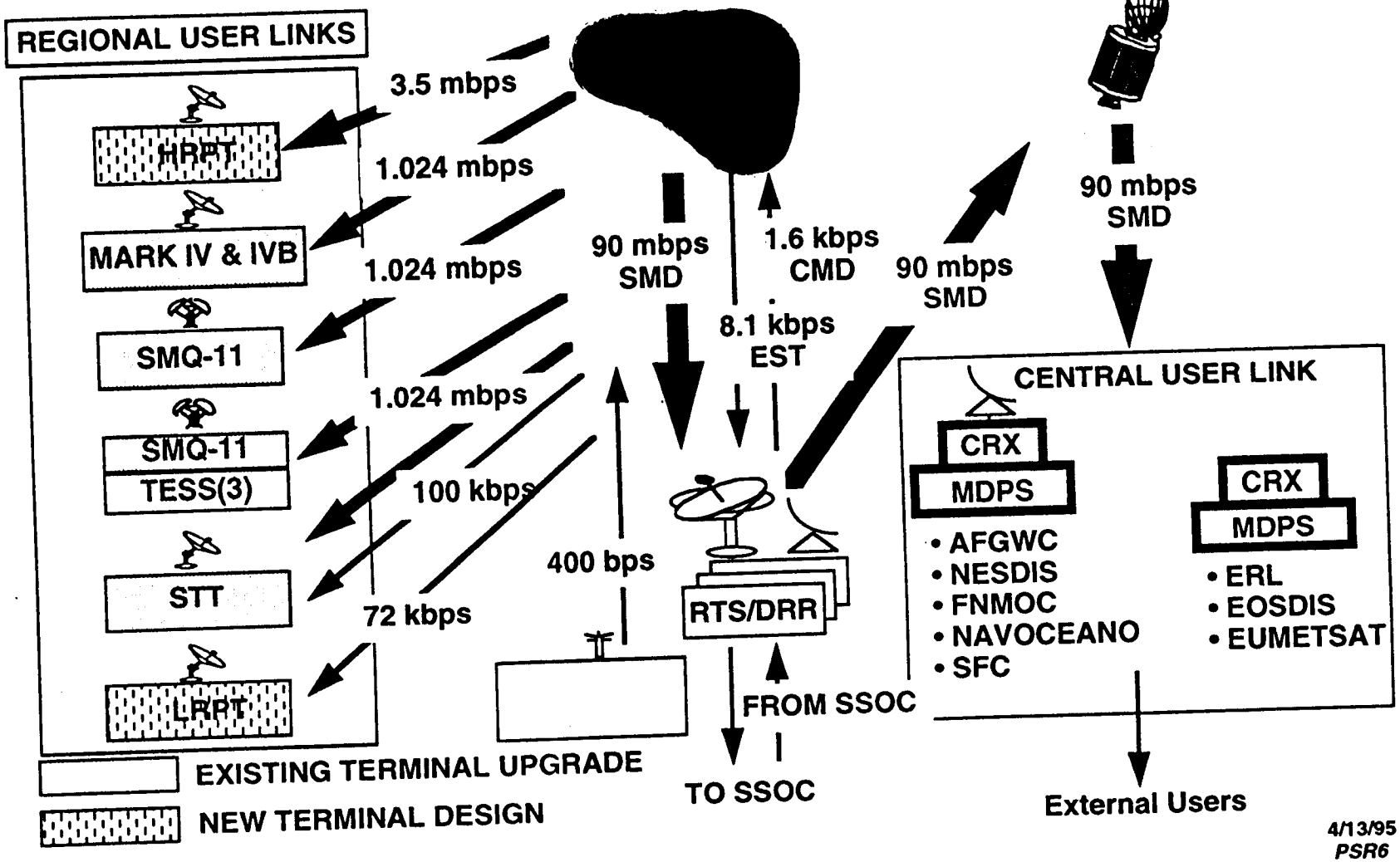

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CONVERGENCE EFFORT MODIFICATION

APPROACH FOR CONVERGENCE OF EDR REQUIREMENTS

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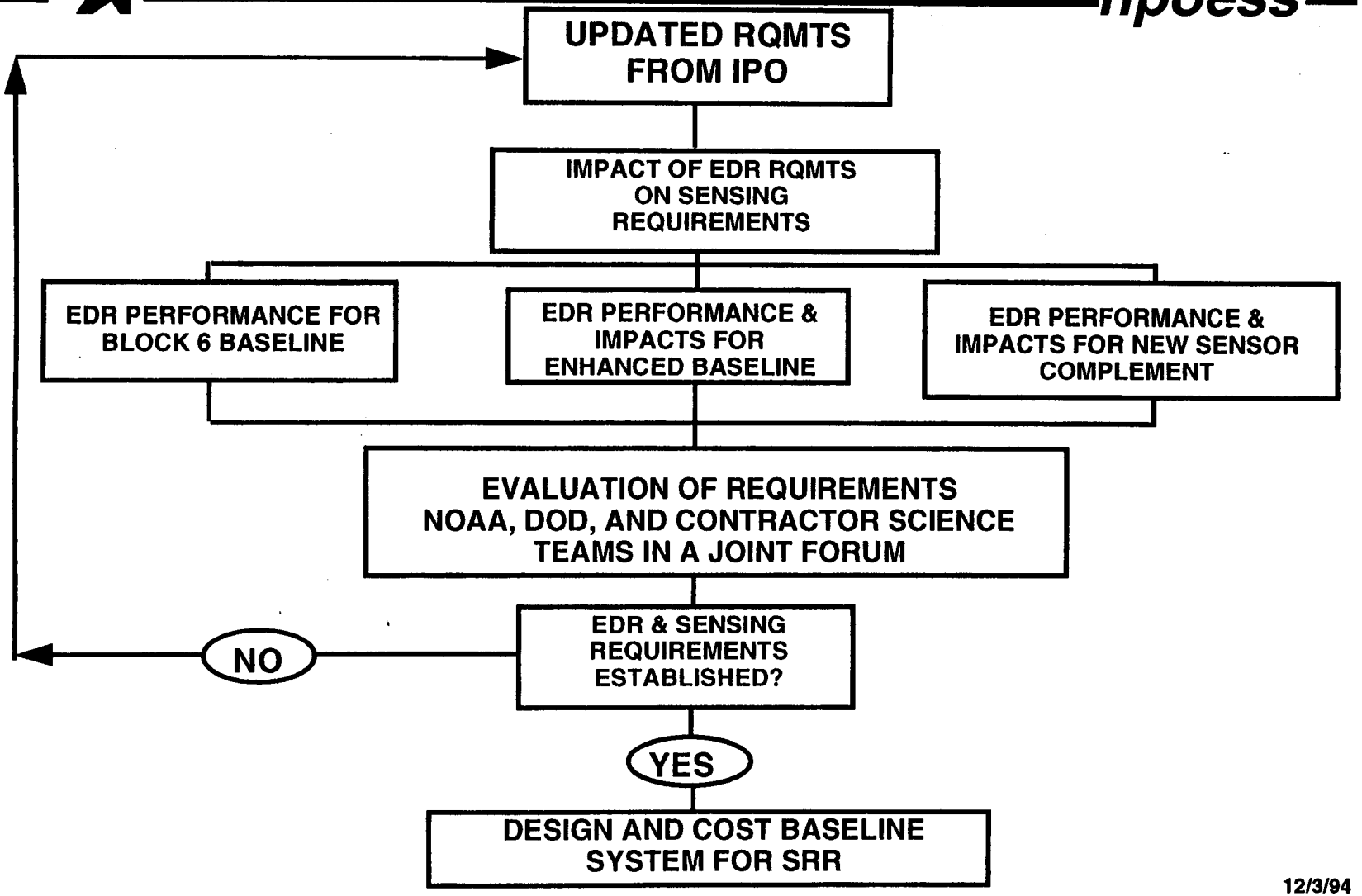

REQUIREMENTS ANALYSIS PROCESS

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Supplier "Hows"
(Domain of Alternatives)
Design Features/
Performance Measures

Customer "Wants"
(Range of Requirements)
1. Severe Wx Forecast
2. Cloud Imagery
•
•

Utility/Relationship Matrix

Measures how well "Wants" are met.

Prioritization of Customer "Wants"
1. Cost
2. Supportability
3. Mission Effectiveness
•
•

Sensitivity to Design Features
Prioritzation of relative importance of changes in design features

Key Tasks

1. **Identify operational and environmental needs**
2. **Identify customer preferences**
3. **Prioritize importance of design features**

EXAMPLE OF REQUIREMENTS ANALYSIS MATRIX

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* EDR CONTAINS A KEY PARAMETER (see Data Requirements) B/L: Indicates one of the 8-channels of the OMIS/VIRSR Baseline

	WAVELENGTH & KEY PHENOMENO (nanometers or micrometers) / EDR	402-422 chloro-phyll	433-453 chloro-phyll	545-565 sedi-ments	605-625 clouds B/L	860-880 clouds B/L	1.35-1.4 mm cirrus	1.58-1.64 snow/ ice B/L	3.55-3.93 cirrus SST B/L	10.3-11.3 clouds SST B/L	11.5-12.5 clouds SST B/L	0.4-1.0 clouds aurora B/L	8.4-8.7 cirrus SST B/L	PRIORITY	REL WGHT
20.3.1	CLOUD IMAGERY*	0	0	0	19.6	19.6	13	19.6	19.56	19.56	19.6	19.6	13.04	2	6.52
20.3.2	CLOUD COVER/LAYERS	0	0	0	12.6	12.6	8.38	12.6	12.57	12.57	12.6	4.19	8.38	6	4.19
20.4.3	SEA ICE*	0	0	0	11.5	11.5	7.64	11.5	11.46	11.46	11.5	3.82	7.64	7	3.82
20.6	SEA SURFACE TEMPERATURE*	0	0	0	7.44	7.44	7.44	11.2	11.16	11.16	11.2	0	7.44	8	3.72
20.9.17	LAND SURFACE TEMPERATURE	0	0	0	5.58	5.58	5.58	8.37	8.37	8.37	8.37	0	5.58	11	2.79
20.3.9	CLOUD TOP TEMPERATURE	0	0	0	4.48	4.48	4.48	6.72	6.72	6.72	6.72	0	4.48	13	2.24
20.9.2	ALBEDO	2.14	2.14	2.14	6.42	6.42	4.28	4.28	4.28	4.28	4.28	0	4.28	14	2.14
20.9.3.2	AURORAL IMAGERY	0	0	0	0	0	0	0	0	0	0	5.88	0	17	1.96
20.9.3.1	AURORAL BOUNDARY	0	0	0	0	0	0	0	0	0	0	5.58	0	18	1.86
20.9.42	VEGETATION/SURFACE TYPE	0	0	2.98	4.47	4.47	2.98	2.98	0	0	0	0	0	23	1.49
20.3.10	CLOUD TOP HEIGHT	0	0	0	2.24	2.24	2.24	3.36	3.36	3.36	3.36	0	2.24	27	1.12
20.9.4	BATHYMETRY (DEEP OCEAN & NR SHORE)	2.79	2.79	2.79	1.86	1.86	1.86	1.86	0.93	0.93	0.93	0	0.93	30	0.93
20.9.1.2	AEROSOL PARTICLE SIZE	0.75	0.75	0.75	2.25	1.5	0.75	0	0	0	0	0	1.5	34	0.75
20.3.6.2	CLOUD OPTICAL DEPTH/TRANSMITTANCE	0	0	0	2.25	2.25	1.5	1.5	1.5	0	0	0	1.5	36	0.75
20.9.1.4	SUSPENDED MATTER	0.75	0.75	0.75	1.5	1.5	1.5	1.5	0	0	0	0	1.5	38	0.75
20.3.3	CLOUD BASE HEIGHT	0	0	0	0.75	0.75	0.75	0.75	0.75	0	0	0	0.75	39	0.75
20.9.3.3	OPTICAL BACKGROUNDS	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	0	1.5	40	0.75
20.4.1	FRESH WATER ICE CONCENTRATIONS	0	0	0	1.95	1.95	1.3	1.95	1.95	1.95	1.95	0.65	1.3	41	0.65
20.9.23	OCEAN COLOR (CHLOROPHYLL)	1.68	1.68	1.68	1.12	1.12	1.12	1.12	0	1.12	1.12	0	0.56	43	0.56
20.9.1.3	AEROSOL OPTICAL THICKNESS ***	0	0	0	1.12	1.12	0	0	0	0	0	0	1.12	44	0.56
20.9.20	CURRENTS	1.41	1.41	1.41	0.94	0.94	0.94	0.94	0	0.94	0.94	0	0.47	47	0.47
20.3.7	CLOUD TOP PRESSURE	0	0	0	0.94	0.94	0.94	1.41	1.41	1.41	1.41	0	0.94	50	0.47
20.9.18	LITTORAL SEDIMENT TRANSPORT	0.74	0.74	1.11	0.74	0.74	0.74	0.74	0.74	0.74	0.74	0	0.74	52	0.37
20.3.4	CLOUD ICE, LIQUID EQUIVALENT	0	0	0	1.11	1.11	0.74	1.11	1.11	1.11	1.11	1.11	0.74	58	0.37
20.9.8	BIOLUMINESCENCE	0	0	0	0	0	0	0	0	0	0	0	0	63	0.19
20.3.6.1	DROPLET SIZE DISTRIBUTION INDEX	0	0	0	0.57	0.57	0.38	0.38	0.38	0	0	0	0.38	67	0.19
20.9.41	TURBIDITY	0	0	0	0	0	0	0	0	0	0	0	0	68	0.19
20.3.5.1	CLOUD ICE WATER PATH	0	0	0	0.57	0.57	0.38	0.57	0.38	0	0	0	0.38	71	0.19
	TOTALS	11.76	11.76	15.1	93.4	92.6	70.5	95.8	88.13	87.18	87.2	40.8	67.39		

*** If re-stated as Optical Depth, vice thickness, a passive system could be used, and the priority would be higher.

Value for the wavelength band: 3 for critical, 2 for important, 1 for helpful, and 0 for useless; and weighted by "RELATIVE WEIGHT".

"RELATIVE WEIGHT" IS A VALUE ASSIGNED TO EACH OF THE 72 EDRs THAT INDICATES THE EDR'S RANKING OR WEIGHT NORMALIZED TO 100.

EXAMPLE REQUIREMENTS ISSUE

COMMENT NUMBER: SYS-13
REFERENCE: Attachment 4, Vol. 1, Appendix B Section: 20.

QUESTION/CONCERN:

Part of the Data Availability requirement to the Centrals reads as follows: "95% of time, data shall be provided to Centrals at min. once per orbital period, within TBD period + 30 min. from time of observation". There are several issues associated with this requirement.

DISCUSSION:

One issue refers to the phrase "once per orbital period". We have interpreted this phrase to mean that 95% of the time, you want to be able to downlink the data in question at least once each orbit. During the other 5% of the time, the system will need to accommodate the notion that blind revs may occur between contacts with the system's ground station network.

Another issue refers to how the requirement is trying to specify the age of the oldest data to be delivered to the Centrals. We interpreted the requirement as specifying the timeframe (t) from the data's time of observation (i.e., t = 0) until all of the data is provided to the Centrals by the C3S. It seems to be the intention of the requirement that this timeframe be no greater than the sum of the orbital period which corresponds to a satellite's operational altitude and which currently is TBD minutes in length plus an additional 30 minutes for data routing from the satellite through the C3S to the Centrals.

RECOMMENDATION:

In accordance with our interpretation the requirement should read as follows (unless otherwise directed): "95% of time, all data acquired by a satellite since its last contact with a ground station shall be downlinked to the C3S at least once per orbit such that the timeframe from the data's time of observation until it is provided to the Centrals shall be no greater than an orbital period of TBD minutes plus 30 minutes."

ACTION ITEM STATUS

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ACTION ITEM NO.	ACTION ITEM DESCRIPTION	RESPONSIBLE PERSON	STATUS
L-31	• Update costs for 3 vs 7 yr sensors	Callary/Davis	Ongoing
	C3 TIM		
L-33	• Provide costs for DS-1 and DS-3 links	Nelson	ECD: PSR 6
L-34	• Show pros and cons associated with charts on pages 77-84	Nelson	ECD: PSR 6
L-35	• Add conventional data and other databases to the interface between the Central Sites and their respective users	Harrison	ECD: PSR 6
L-36	• Provide copy of Palo Alto briefing on onboard ephemeris and attitude determination using GPS	Kenley	Documented in AM-39
L-37	• Definitions for Primary, Secondary, and Tertiary	Harrison	See EM 1143; Provided to SPO on 10/18/94

ACTION ITEM STATUS (2)

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ACTION ITEM NO.	ACTION ITEM DESCRIPTION	RESPONSIBLE PERSON	STATUS
L-38	• In the briefing it was stated that Thule, Fairbanks, and Kiruna are dual sided (pg 19). Page 131 states that only one of each item is needed at each site. Please clarify.	Nelson/LTOC	ECD: PSR 6
L-39	• The FVSF was singled out to be a large cost impact. Is there a need for a simulator in all three locations (SSOC, FBSOC, KTRs)? Provide suggestions for reducing costs.	Nelson/LTOC	ECD: PSR 6

REQUIREMENTS ISSUES STATUS

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STATUS: 59 SUBMITTED 56 CLOSED 3 OPEN

RI NO.	RI SUMMARY	STATUS
43	Altimeter repeat ground tracking requirement	Open (Indefinite pending Navy review)
49	Specification of AFSCN link capabilities	Open (2-5 MHz links-1 QPSK-available for DMSP; request for up to 2 more links)
53	Storage of SDRs	Closed (LtCol Arrance ltr of 24 Aug 94)
54	OMIS transition across terminator	Closed by latest A-Spec
55	Interpretation of vertical temperature profile requirement	Closed by latest A-spec
58	DMSP 5D-capable MOSS program	Open

THIS COMPLETES BLOCK 6 REQUIREMENTS ISSUES

CONVERGENCE EFFORT MODIFICATION

CONVERGENCE REQUIREMENTS ISSUES STATUS

npoess

STATUS: 18 SUBMITTED 1 CLOSED 17 OPEN

RI NO.	RI SUMMARY	DATE OPEN	NEED DATE	12 SEP 94 RESPONSE
60	NOAA documentation/information authorization	5/27/94	6/1/94	Working TACTT issues; keep open
61	Interpretation of "sampling"for Precipitation horizontal resolution	6/9/94	ASAP	In review at SPO
62	Consideration of NOAA/GFE sensors in satellite survivability plan	6/9/94	8/1/94	In review at SPO; requires IPO input
63	Lack of cloud free specification for ice edge resolution requirement	6/30/94	7/1/94	IORD requires resolution regardless of clouds/aerosols
64	Measurement accuracy for 7 mb level	6/30/94	7/1/94	IORD req'ts > difficulty
65	Recommend to delete salinity EDR	6/30/94	7/1/94	No relief in IORD
66	Mission planning requirements	7/21/94	8/1/94	Next update of A-spec
67	Mapping Accuracy definition	7/21/94	8/18/94	In review at SPO

CONVERGENCE REQUIREMENTS ISSUES STATUS (2)

npoess

RI NO.	RI SUMMARY	DATE OPEN	NEED DATE	12 SEP 94 RESPONSE
68	SAR downlink to LUTs, not distress transmitters	08/01/94	Next Update	Next A-Spec Update
69	Need to specify capability to launch O1 at any time	08/01/94	Next Update	Next A-Spec Update
70	Specific nodal crossing times vs all beta requirement	08/01/94	Next Update	Next A-Spec Update
71	Measurement accuracy requirement for cloud cover bias	08/01/94	09/01/94	IORD requires resolution regardless of clouds/ aersols
72	Mean Mission Duration definition still based on 84 months	08/01/94	Next Update	Next A-Spec Update
73	ECDs for remaining TBSs in Space and Ground User Segment specs	08/01/94	Next Update	Next A-Spec Update
74	Relationship between Volume 1, Appendix B and Volume 2, Appendix E	08/01/94	Next Update	Appendix E for info only

CONVERGENCE REQUIREMENTS ISSUES STATUS (3)

npoess

12 SEP 94

RI NO.	RI SUMMARY	DATE OPEN	NEED DATE	RESPONSE
75	Basis on which no. of SDC platforms are to be acquired	08/01/94	Next Update	In review at SPO; requires IPO input
76	Applicability of computer resource reserve capacity requirement	08/01/94	Next Update	In review at SPO
77	Civilian terminal design included in LCC	09/14/94		20 Sep 94 - Do not include in LCC (Closed)

KEY ALTERNATIVE PARAMETERS

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	DRIVES ALTERNATIVE
O Data Availability--To Centrals, To Field Terminals	*NO. OF SATS & R/0 SITES*
O Data Access--Selectively deny TBD data-- contingencies	*ON-BOARD PROC*
O 20.1 Vertical Sampling Interval for Moisture Profile Measure in 20 mb increments Sfc to 850 Mb and 20 Mb between 850 and 100 mb	*IR SOUNDER WITH MICROWAVE AUGMNT*
O 20.2 Vertical Sampling Interval for Temperature Profile Sfc-850 Mb, 20 Mb; 850-300, 50 mb; 300-100 , 25 mb 100-10, 20 mb; 10-1, 2mb;1-0.1 mb, 0.2 mb inc; 0.1-0.01, 0.02.	*IR SOUNDER WITH MICROWAVE AUGMNT*
O 20.3.1Horizontal Spatial Resolution 0.65km constant	*EO SENSOR, DATA RATE*
O 20.3.1 Refresh: 4 hours, goal 1 hr	*NO OF SATS*
O 20.4.3 Ice Concentration Minimum 600m	*ICE SENSOR?*
O 20.5 Ozone Total Column/Profile: Precision	*SBUV/ TOMS OKAY?*
O 20.6 Sea Surface Temperature Refresh Minimum 6 Hours	*MICROWAVE IMAGER*
O 20.7 Soil Moisture Refresh: Minimum 6 Hours	*FREQUENCY TOO LOW*
O 20.8.1 Sea Surface Winds Refresh: Minimum 6 Hours	*MICROWAVE IMAGER*

MISSION AVAILABILITY ALTERNATIVES

S. GOLLY

REQUIREMENTS

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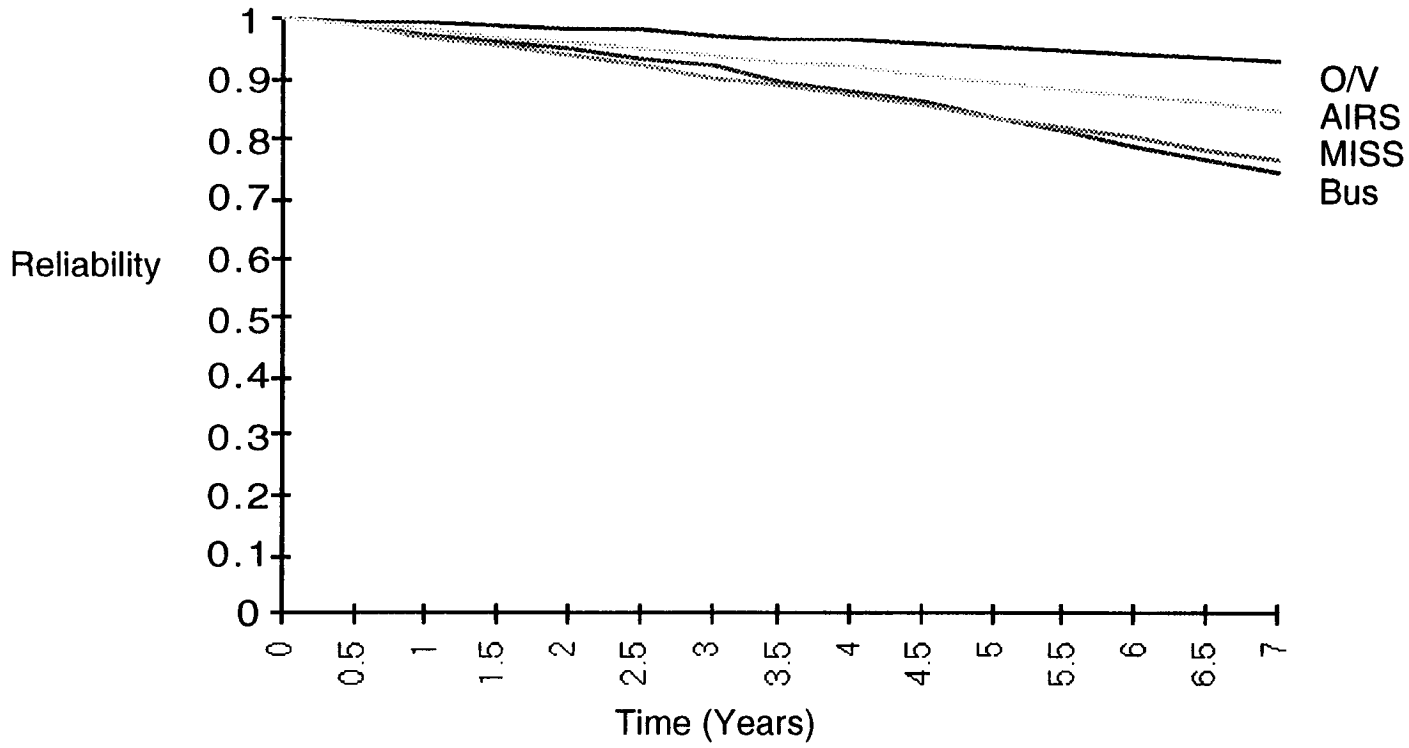
O RELIABILITY: "THE SPACECRAFT AND PAYLOAD (EXCEPT THE SES) SHALL BE DESIGNED TO HAVE AN ON-ORBIT MEAN MISSION DURATION (MMD) WHICH WILL RESULT IN A MINIMUM LIFE CYCLE COST"
- SINGLE POINT FAILURE MODES
- FAULT MANAGEMENT
- FAULT TOLERANCE

O OPERATIONAL AVAILABILITY: "THE SPACE SEGMENT (SS) SHALL MEET AN OPERATIONAL AVALILABILITY (SPACE AVAILABILITY) OF NO LESS THAN 0.95, THE EXACT AO IS TBD."

O OPERATIONAL DEPENDABILITY (DO) OF TBD.

RELIABILITY: RESULTS FROM EM1142



OMIS/VIRSR:	Alpha = 59.5	Beta = 1.29
AIRS:	Alpha = 32.6	Beta = 1.2
MISS:	Alpha = 21.5	Beta = 1.2
BUS:	Alpha = 15.0	Beta = 1.6

RELIABILITY: RESULTS FROM EM 1142

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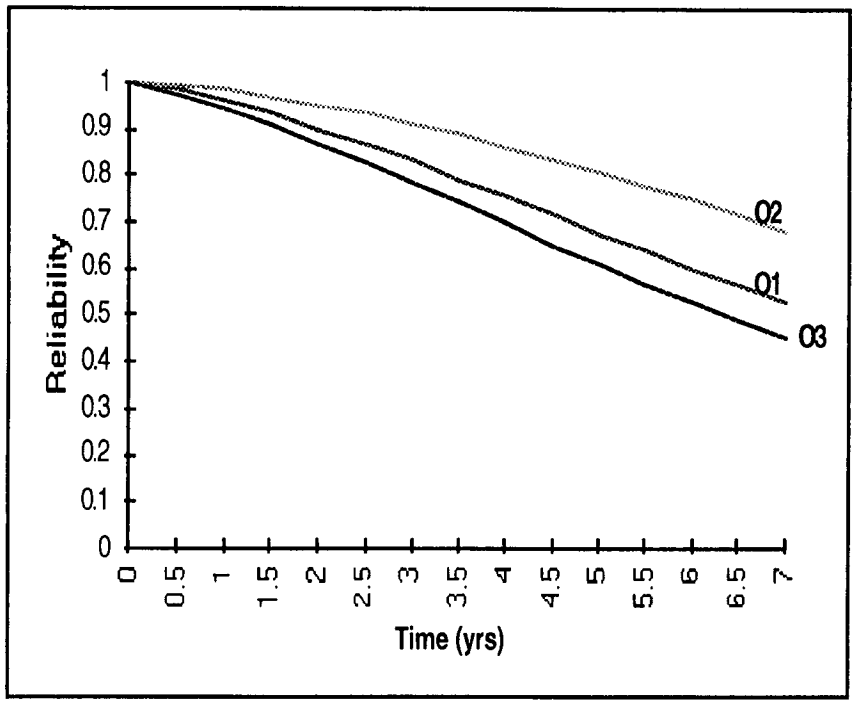

S/C-P/L MATRIX			
S/C	AIRS	O/V	MISS
O1	0	1	1
O2	0	0	1
O3	1	1	1

O1:	Alpha = 9.5	Beta = 1.46	MMD = 5.49
O2:	Alpha = 13.0	Beta = 1.62	MMD = 6.11
O3:	Alpha = 8.6	Beta = 1.31	MMD = 5.16

AVAILABILITY

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Satellite	MEAN DOWN TIME (Months)	
	60 Day Launch Call	45 Day Launch Call
O1	1.32	0.91
O2	1.09	0.73
O3	1.43	1.00

MAINTENANCE OPTIONS / LAUNCH POLICY

1. LAUNCH OF FULL UP SATELLITE ON FAILURE OF ANY CRITICAL SENSOR OR S/C BUS. MAINTAIN PRIMARY INSTRUMENT COMPLEMENT FULL UP.
2. AUGMENT EXISTING SATELLITE SENSOR COMPLEMENT ON FAILURE OF ANY CRITICAL SENSOR (SMALL SAT LAUNCH). MEET REFRESH REQUIREMENT OF 6 HRS FOR O/V (OASIS) AND MISS; 12 HRS FOR AIRS

AVAILABILITY: MAINTENANCE OPTION 1

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Primary downing events are nonrecoverable failures

$$Ao = \frac{MMD}{(MMD + MDT)}$$

O1: Ao .980 @ 60 day LC, .986 @ 45 day LC
O2: Ao .985 @ 60 day LC, .990 @ 45 day LC
O3: Ao .977 @ 60 day LC, .984 @ 45 day LC

Constellation: $Ao(\text{Constellation}) = 1 \Big/ \left(1 + \sum_{sat} MDTi \Big/ MMDi\right)$

Ao = .945 @ 60 day LC, .961 @ 45 day LC

AVAILABILITY: GAP RUNS (FROM EM 1148)

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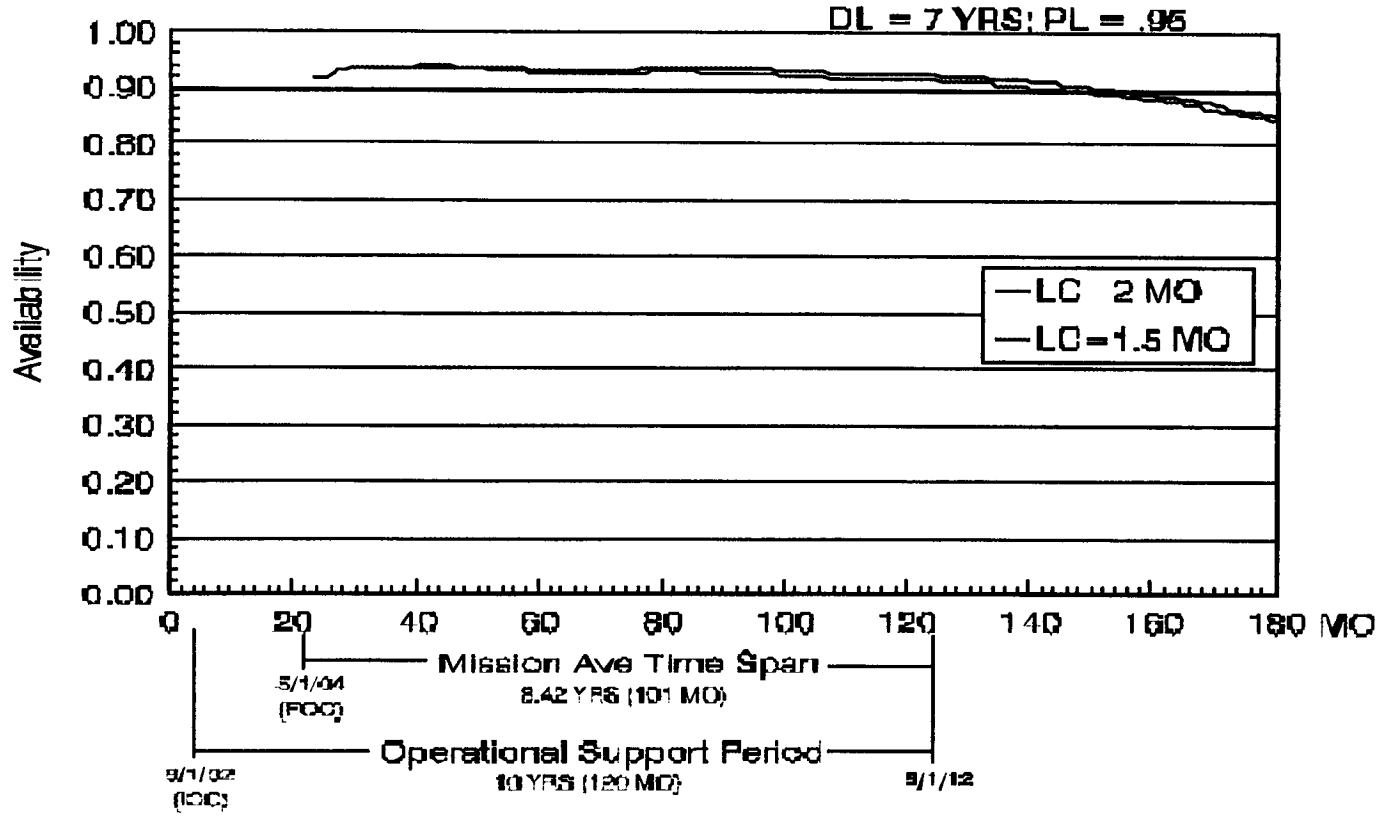
Figure 2
3 Satellite Average



AVAILABILITY: GAP RUNS - RESULTS

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EXPECTED SATELLITE SCHEDULE

Required build schedule in months from first launch vs months to respective probability of launch.
(Out to a maximum of 122 months)

	LAUNCHES			PROBABILITY OF LAUNCH	
Satellite TYPE	LAUNCH NO.	Expected TOTAL	BUILD SCHEDULE	10%	50%
01	1		21	21	21
	2		24	40	103
	3		60	98	--
		2.26			
02	1		12	14	14
	2		21	42	96
	3		72	105	--
		2.19			
03	1		0	2	2
	2		21	23	76
	3		36	71	--
	4		60	120	--
		2.86			
Total Expected (All 3 Types)		7.31			

AVAILABILITY: MAINTENANCE OPTION 2

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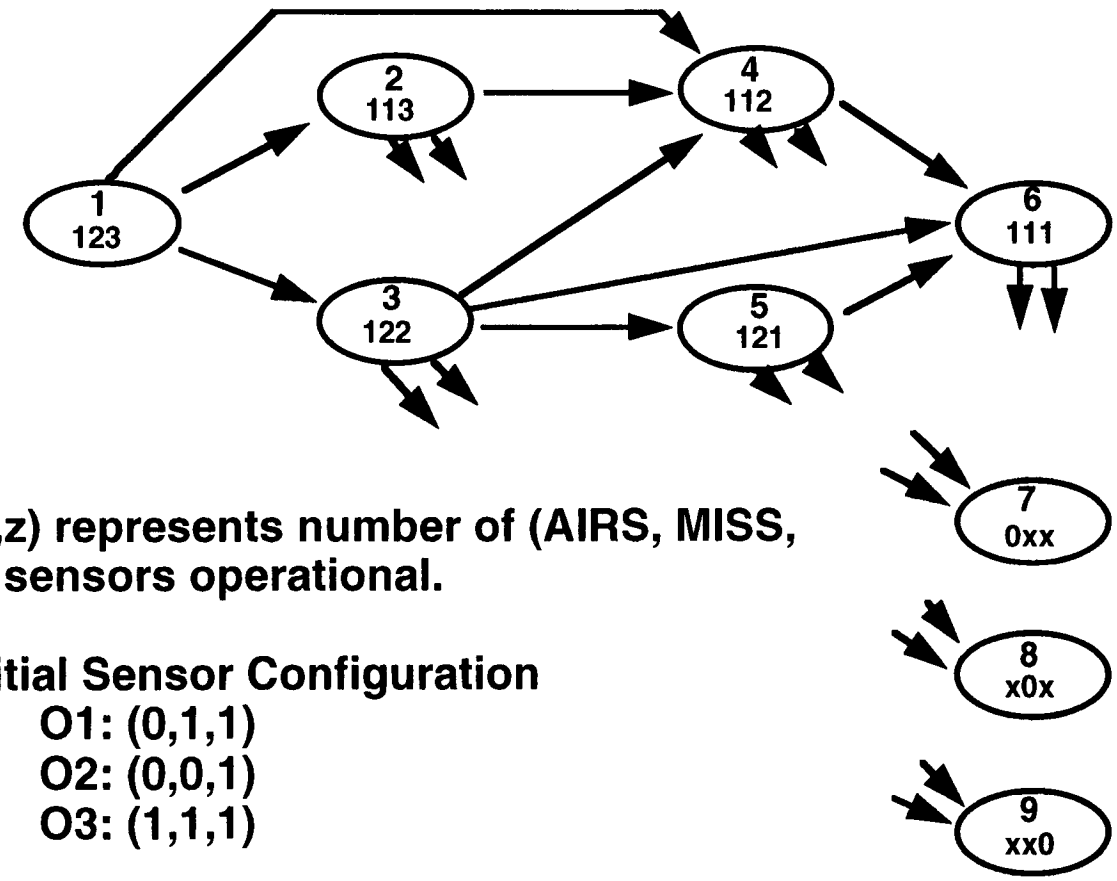
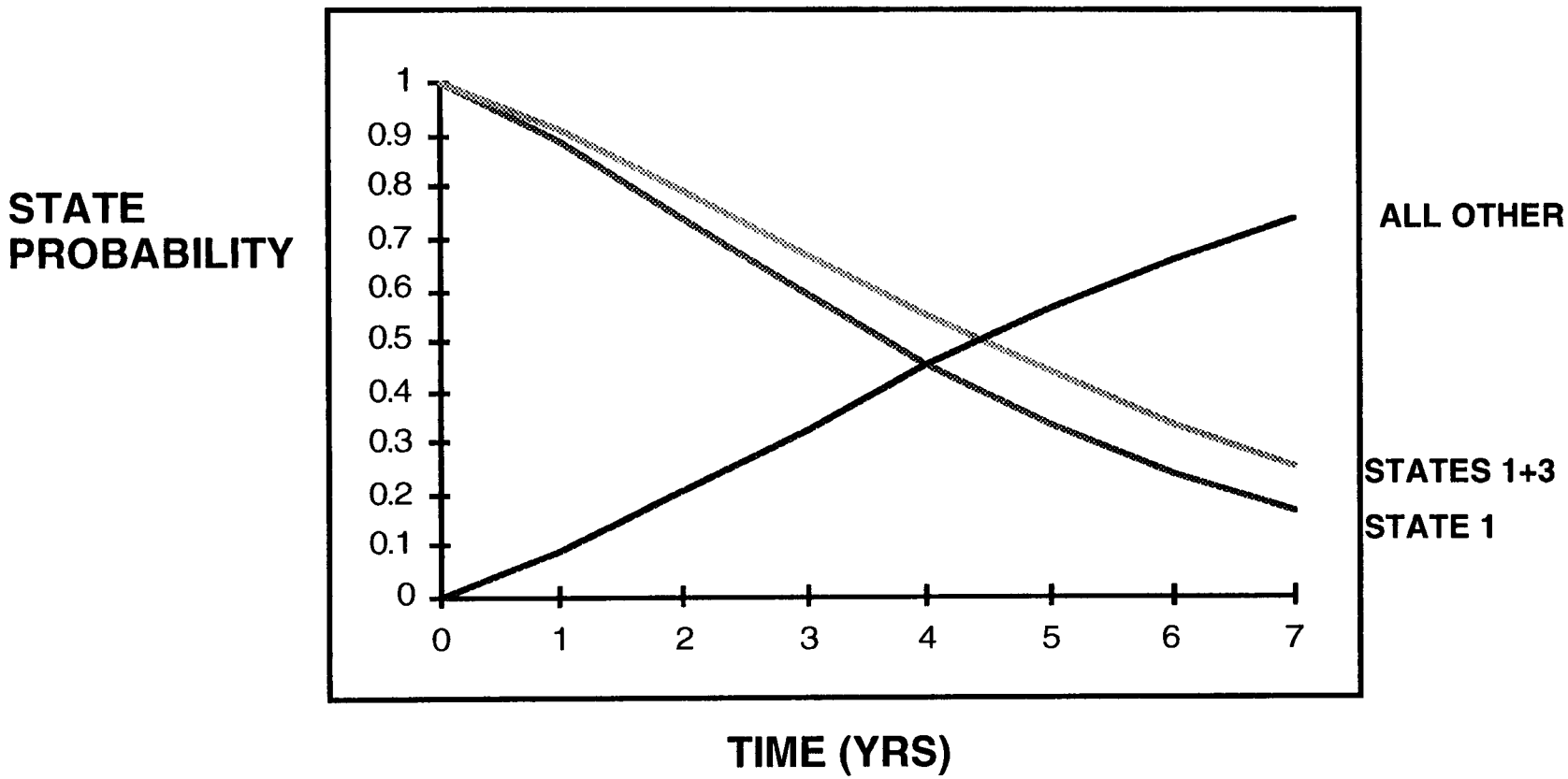
CONVERGED THREE SATELLITE CONSTELLATION THREE SENSOR STATE DIAGRAM (FOC) (LAUNCH TRANSITION NOT SHOWN)



(x,y,z) represents number of (AIRS, MISS, O/V sensors operational.

Initial Sensor Configuration
- O1: (0,1,1)
- O2: (0,0,1)
- O3: (1,1,1)

AVAILABILITY: STATE PROBABILITIES



AVAILABILITY: ESTIMATED Ao

Weighted average MDT = 1.29 @ 60 day Launch Call
= 0.89 @ 45 day Launch Call

Mean Constellation Life = $\int_0^7 dt$ (State 1+State 3 Probabilities)
= 4.32 years

$$Ao = \frac{MCL}{(MCL+MDT)}$$

Results:
Constellation: Ao = .97 @ 60 day LC, .98 @ 45 day LC
Total expected number of satellites required = 6.94

CONCLUSIONS

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- CURRENT SPACECRAFT SUBSYSTEM CONFIGURATION, BEST ESTIMATES OF SENSOR RELIABILITY, AND CONSTELLATION ALTERNATIVES ANALYZED
  - CAN EXPECT MMD VALUES FROM 5 TO 6 YEARS (7 YEAR DESIGN LIFE)
- SATELLITE REPLACEMENT POLICY ANALYZED
  - HAS IMPACT ON NUMBER OF SATELLITES REQUIRED (7 TO 8 SATELLITES)
- ADDITIONAL OPERATIONS CONCEPT WORK NEEDED
  - ESTABLISH FIRM BASIS FOR MMD REQUIREMENTS
  - REFINE REPLACEMENT ALTERNATIVES

REQUIREMENTS ANALYSIS

J. HARRISON

- LATEST DATA REFRESH ANALYSIS RESULTS
- NEW A-SPECIFICATION IMPACTS
- SYSTEM/SEGMENT SPECIFICATION STATUS
- PLANS FOR PSR 7

LATEST DATA REFRESH ANALYSIS INTRODUCTION

- REVIEW OBJECTIVES OF DATA REFRESH ANALYSIS
- DISCUSS OUR GLOBAL DATA REFRESH ANALYSIS APPROACH
- SHOW FINAL RESULTS OF 2-SATELLITE DATA REFRESH ANALYSIS

GLOBAL DATA REFRESH ANALYSIS OBJECTIVES

- SATISFY EDR MISSION REQUIREMENTS
  - GLOBAL AVERAGE DATA REFRESH PERIOD
    - * DETERMINE NO. OF SATELLITES REQUIRED
    - * DETERMINE SENSOR COVERAGE PER SATELLITE
- DETERMINE IMPACT OF SATISFYING GOAL OF USER SELECTABLE NODAL CROSSING TIMES (NCT)
- DETERMINE REFRESH PERFORMANCE OVER RANGE OF PHASING ANGLES BETWEEN 2 OR MORE SATELLITES
- CONTRIBUTE TO DETERMINING CONSTELLATION'S SATELLITE/ PAYLOAD CONFIGURATION
- CONTRIBUTE TO DETERMINING ALLOWANCES FOR NCT AND PHASING ANGLE DRIFT TOLERANCES

NPOESS SATELLITES (2 ASCENDING, 1 DESCENDING)

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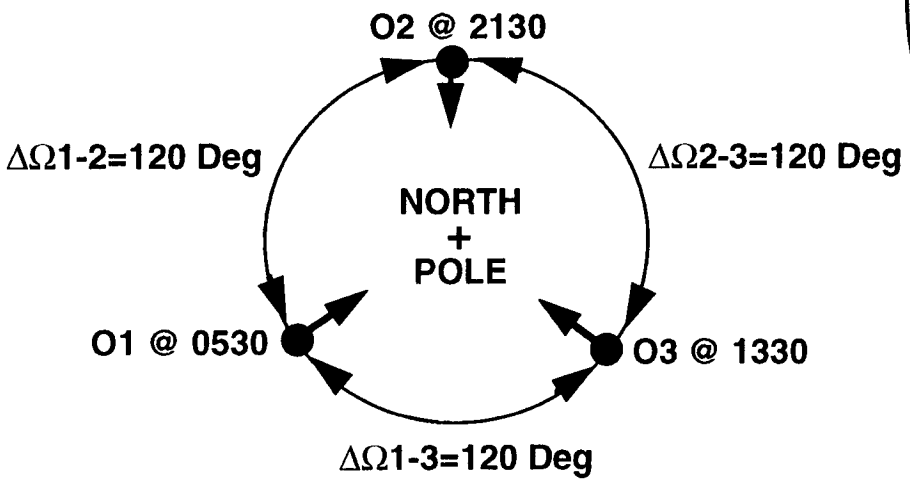
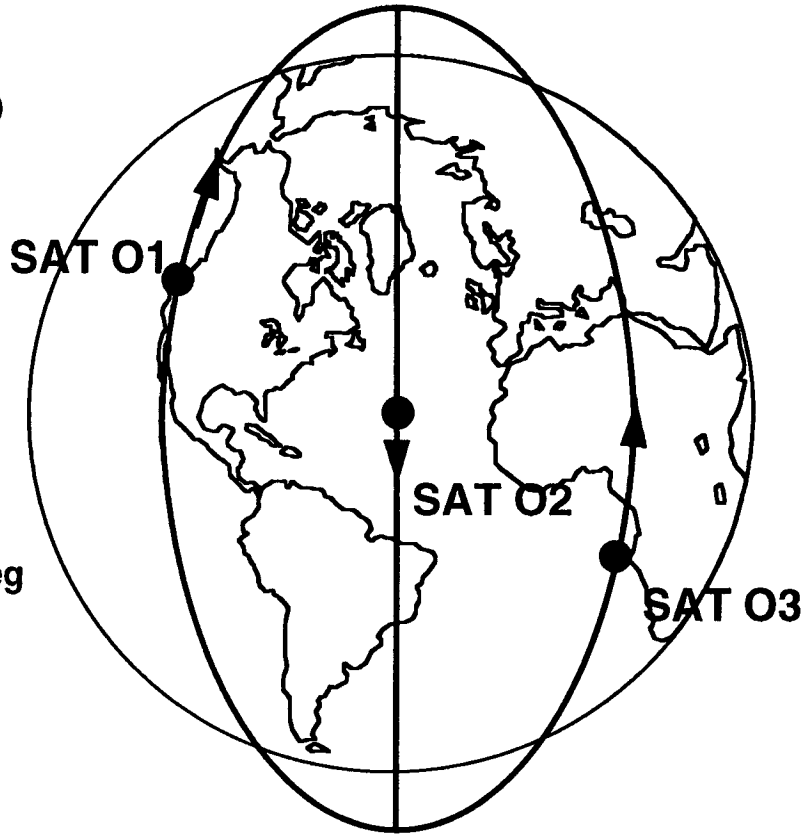
NOMINAL NODAL CROSSING TIMES (NCT):
NCT(O1)=0530 (Ascending) (Goal: User Selectable)
NCT(O2)=0930 (Descending)
2130 (Ascending)
NCT(O3)=1330 (Ascending)

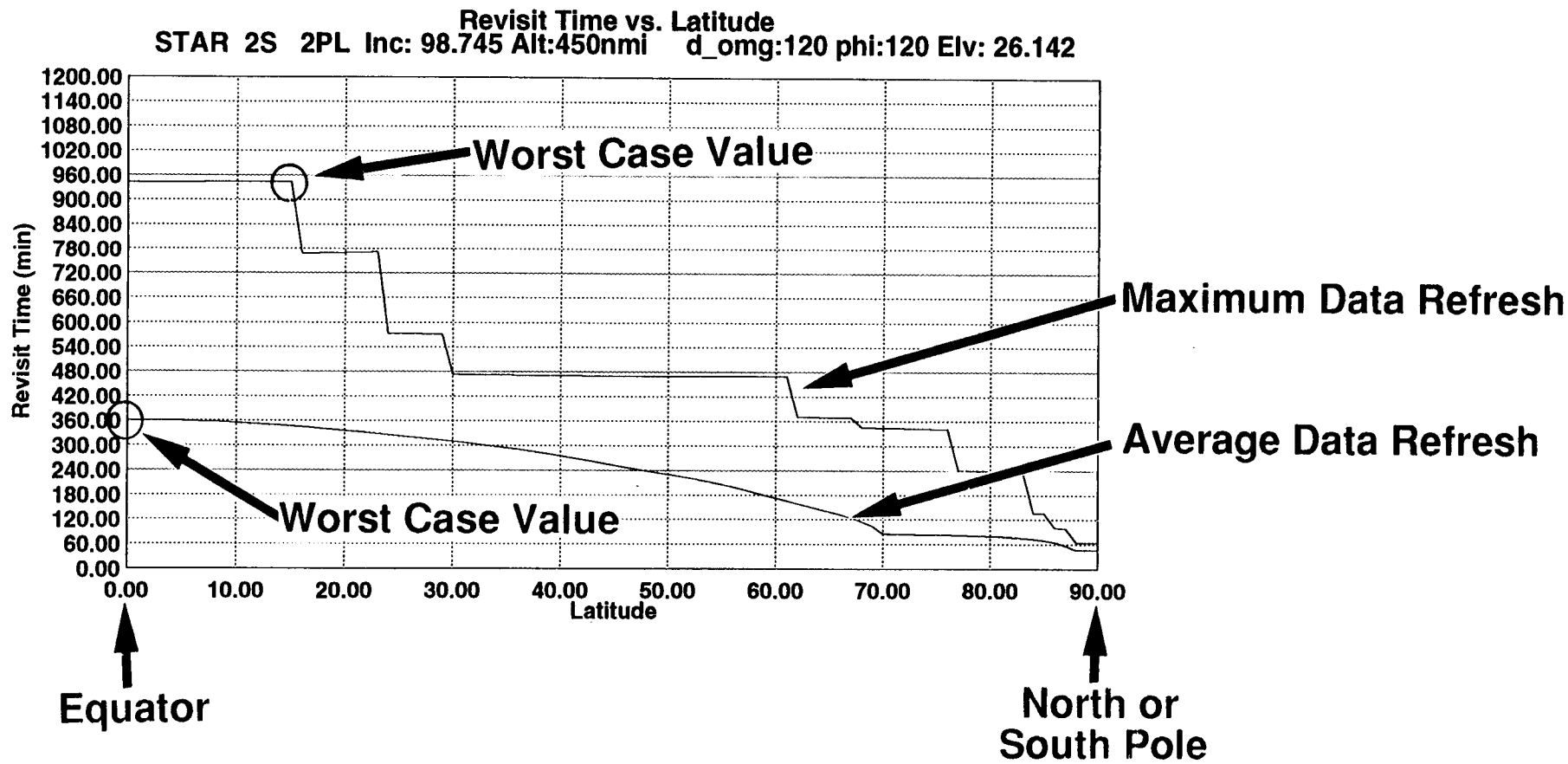


TOP VIEW



SIDE VIEW

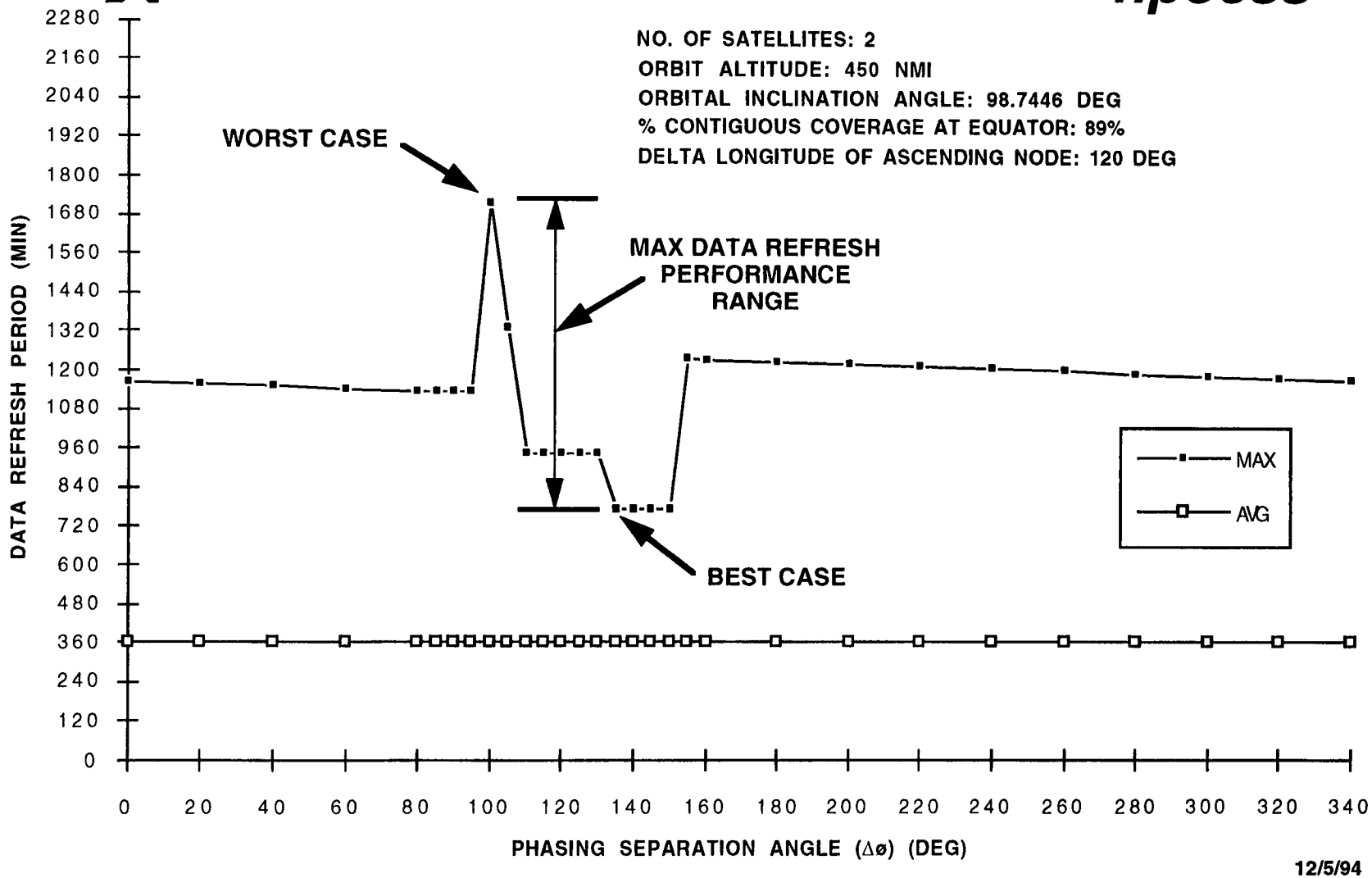
DATA EXTRACTION FROM ICAP ANALYSIS RESULTS



CONVERGENCE EFFORT MODIFICATION

DATA EXTRACTION OF MAX REFRESH VALUES OVER RANGE OF PHASING ANGLES

npoess



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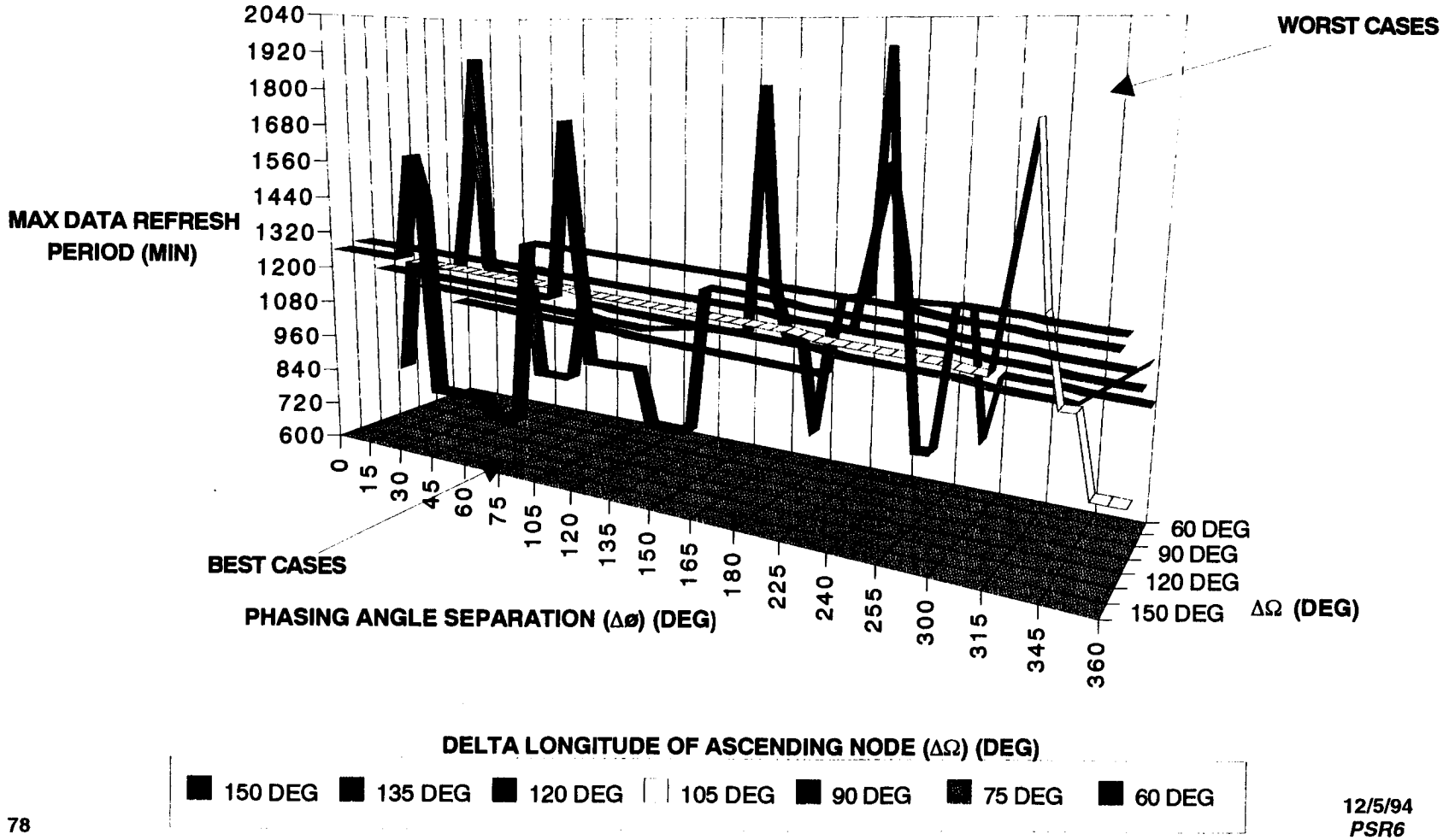
IDENTIFICATION OF BEST AND WORST MAX REFRESH CASES FOR ΔΩ AND Δø

npoess

TWO SATELLITES @ 450 NMI, EACH WITH 89% CONTIGUOUS COVERAGE

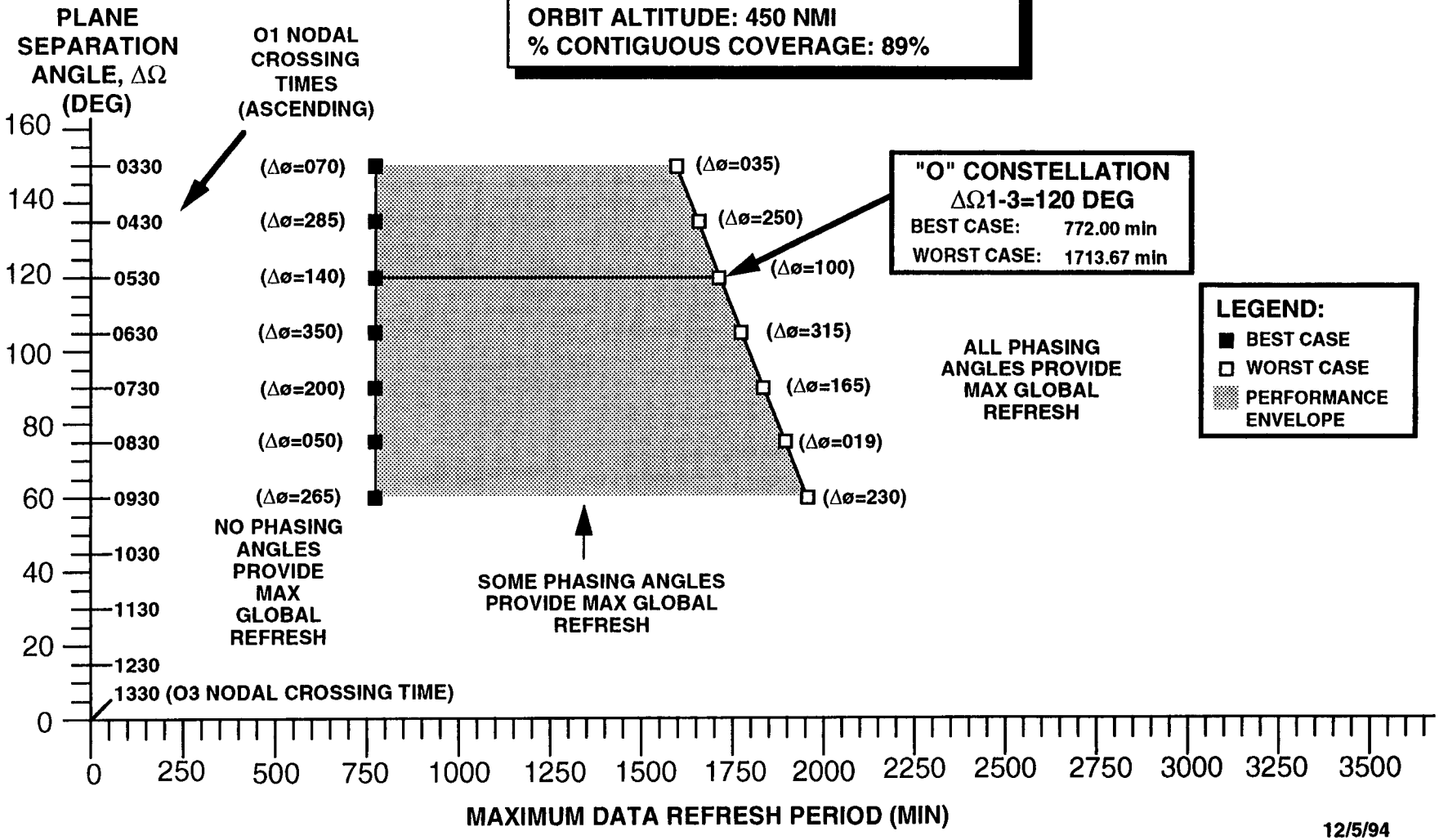


CONVERGENCE EFFORT MODIFICATION

IMPACT OF CHANGING O1 NCT ON MAX DATA REFRESH (2 SATS @ 89%)

npoess

NO. OF SATELLITES: 2
ORBIT ALTITUDE: 450 NMI
% CONTIGUOUS COVERAGE: 89%



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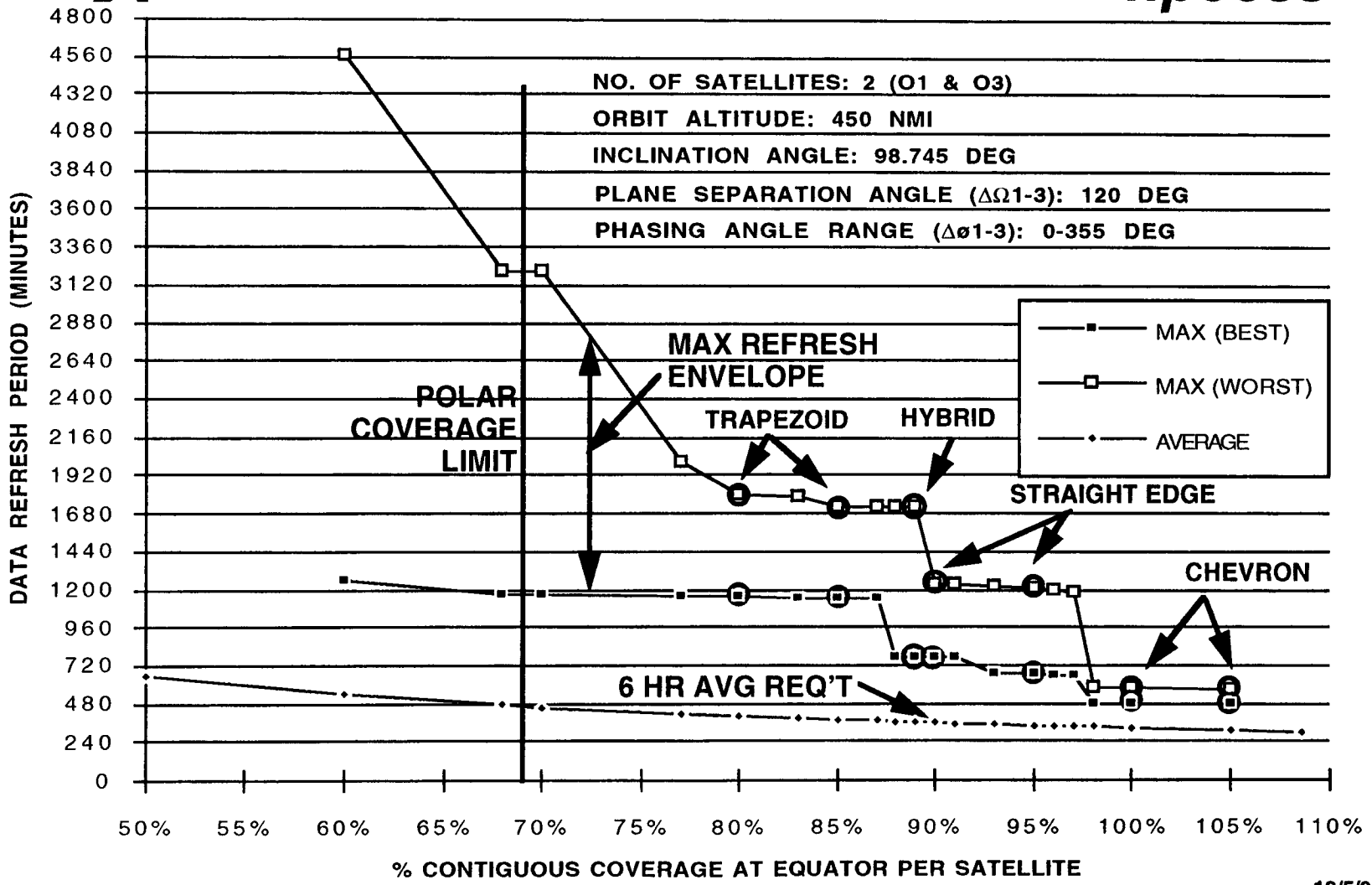
CONVERGENCE EFFORT MODIFICATION

DATA REFRESH PERFORMANCE FOR GLOBAL COVERAGE (2 SATELLITES @ 450 NMI)

npoess



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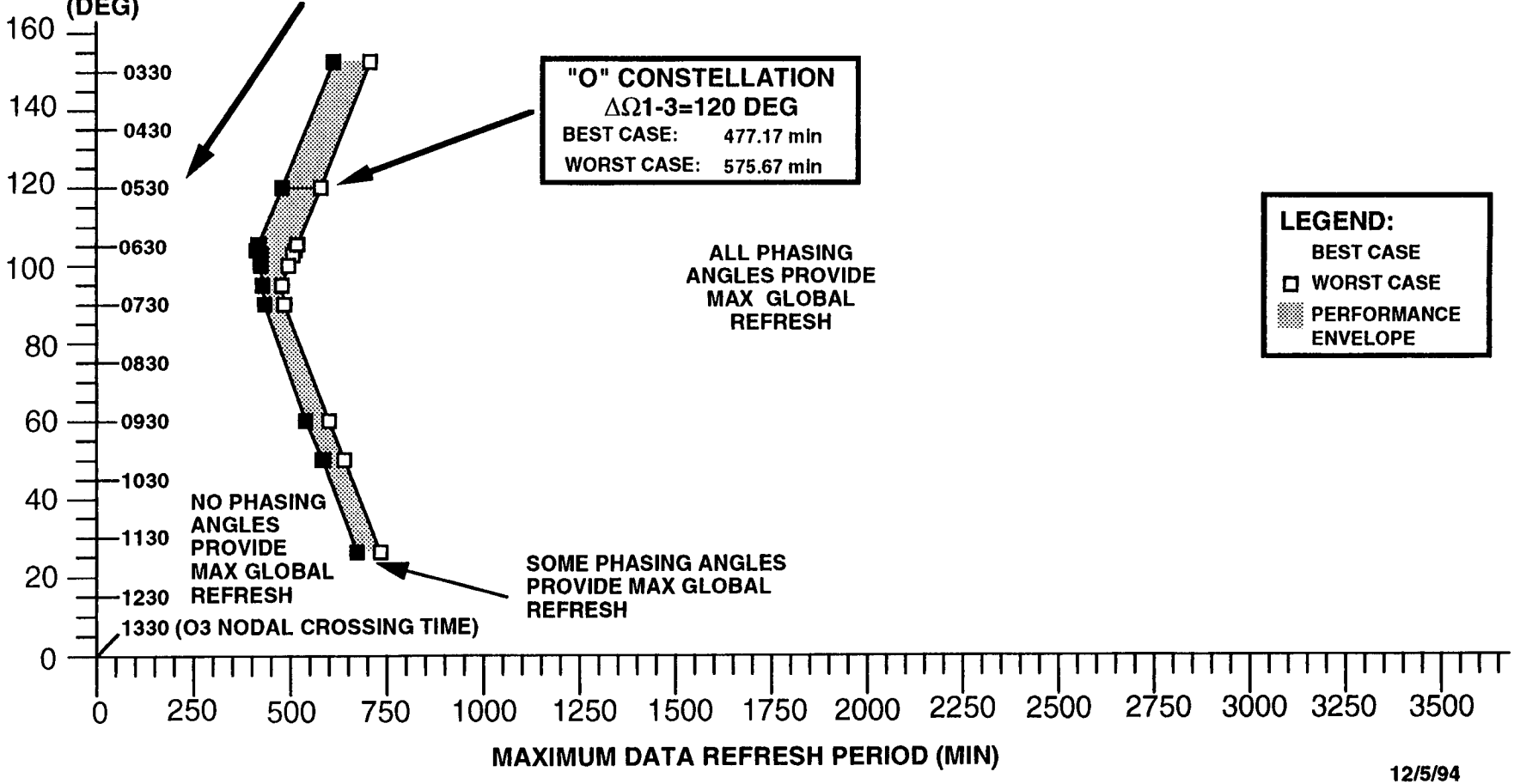
CONVERGENCE EFFORT MODIFICATION

IMPACT OF CHANGING O1 NCT ON MAX DATA REFRESH (2 SATS @ 100%)

npoess

NO. OF SATELLITES: 2
ORBIT ALTITUDE: 450 NMI
% CONTIGUOUS COVERAGE: 100%



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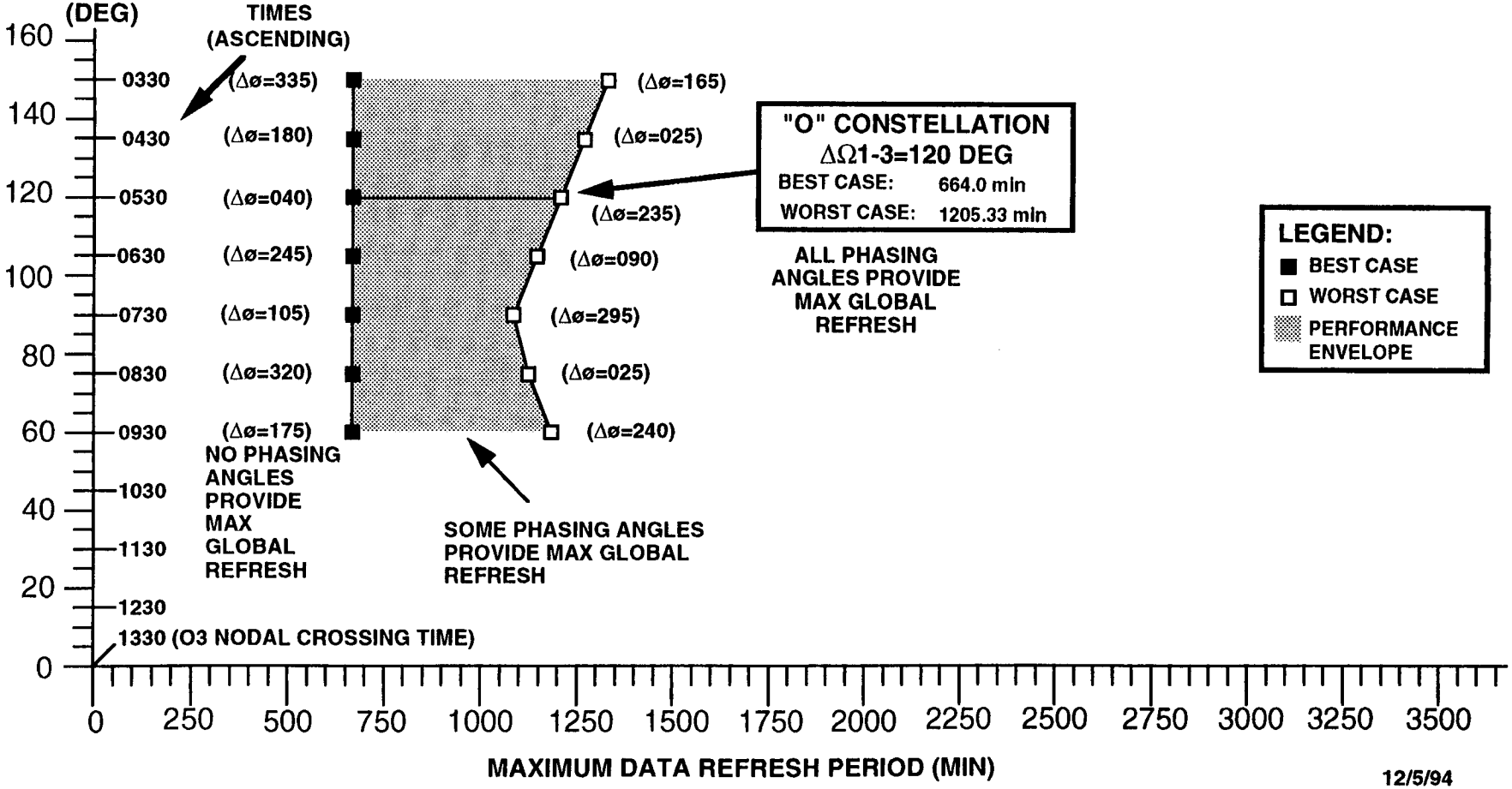
CONVERGENCE EFFORT MODIFICATION

IMPACT OF CHANGING O1 NCT ON MAX DATA REFRESH (2 SATS @ 95%)

npoess

NO. OF SATELLITES: 2
ORBIT ALTITUDE: 450 NMI
% CONTIGUOUS COVERAGE: 95%



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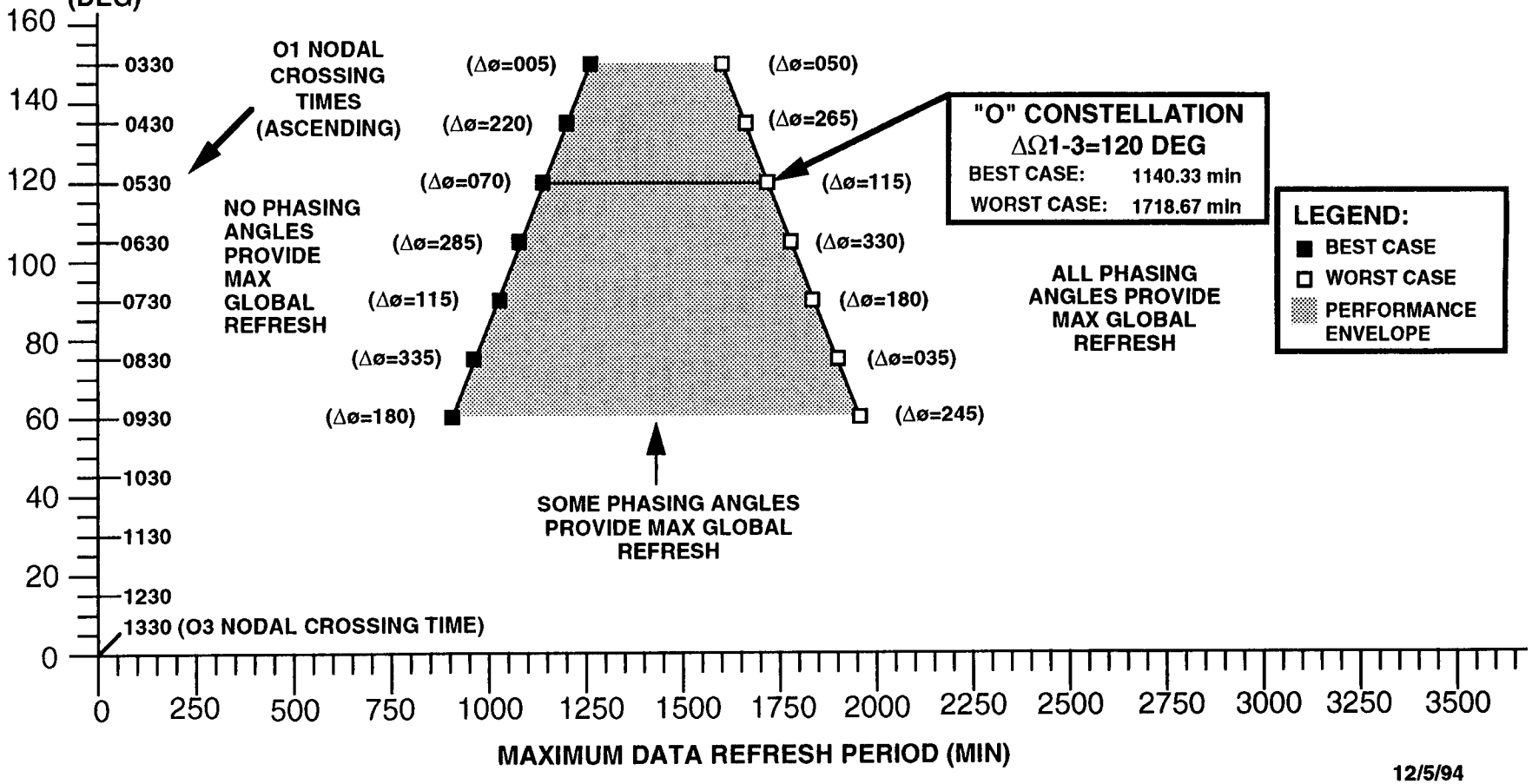
CONVERGENCE EFFORT MODIFICATION

IMPACT OF CHANGING O1 NCT ON MAX DATA REFRESH (2 SATS @ 85%)

npoess

NO. OF SATELLITES: 2
ORBIT ALTITUDE: 450 NMI
% CONTIGUOUS COVERAGE: 85%



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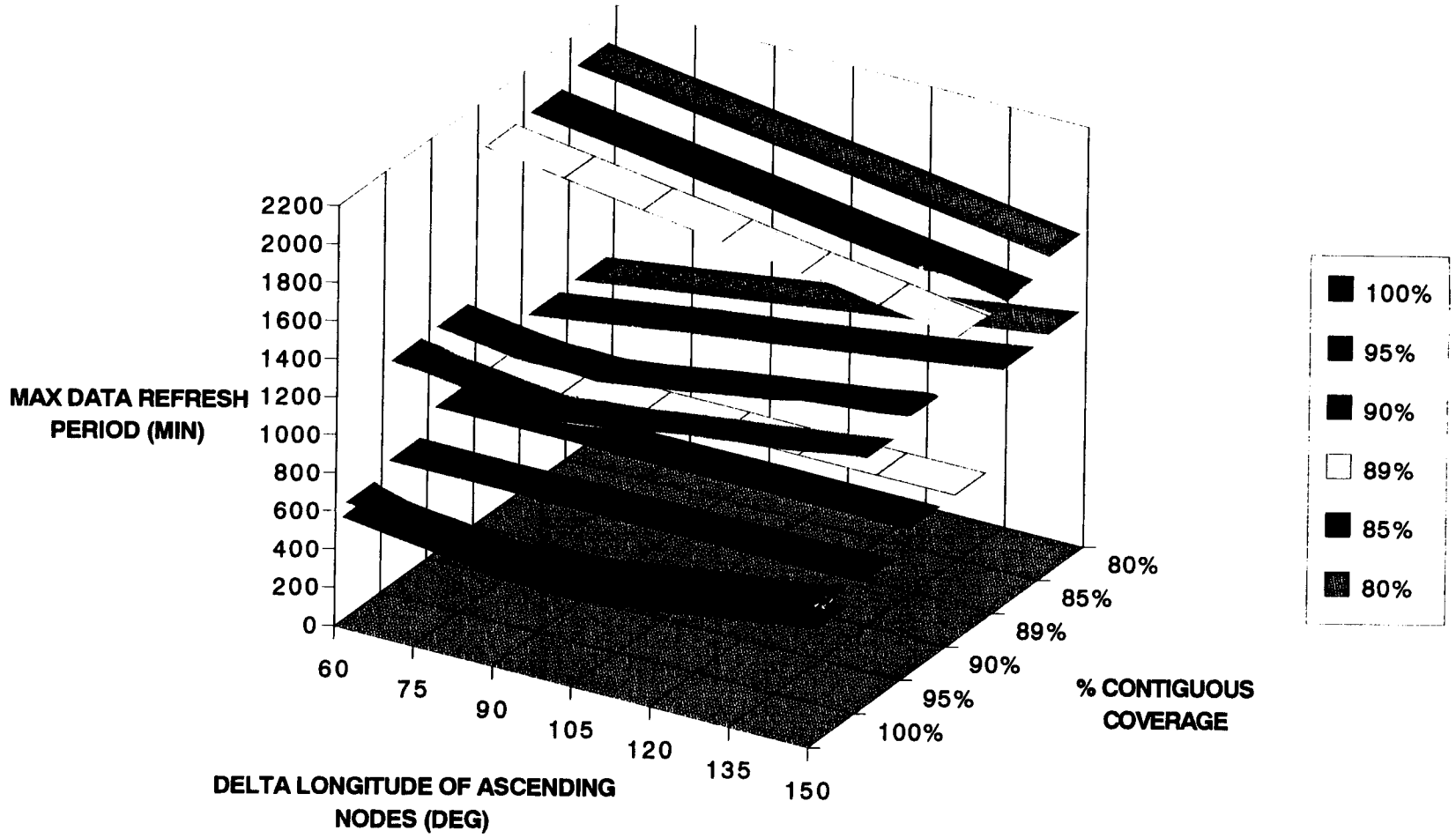
CONVERGENCE EFFORT MODIFICATION

DATA REFRESH PERFORMANCE COMPARISON (2 SATELLITES @ 450 NMI)

npoess



DATA REFRESH ANALYSIS SUMMARY/CONCLUSIONS

npoess

- TWO-SATELLITE REFRESH ANALYSIS COMPLETE
  - CHANGE IN REFRESH WITH % COVERAGE KNOWN FOR NOMINAL CONDITIONS
  - PATTERNS IDENTIFIED FOR CHANGE IN MAX REFRESH WITH NCT
  - ESTIMATE MAX REFRESH PERFORMANCE FOR OTHER % COVERAGE FACTORS

- TWO-SATELLITE AVERAGE REFRESH PERFORMANCE AFFECTED PRIMARILY BY % CONTIGUOUS COVERAGE FACTOR

- TWO-SATELLITE MAX REFRESH PERFORMANCE AFFECTED BY:
  - % CONTIGUOUS COVERAGE
  - SEPARATION IN NODAL CROSSING TIME
  - PHASING ANGLE SEPARATION

- SMALL CHANGES IN AVERAGE REFRESH PERFORMANCE CAN HAVE SIGNIFICANT IMPACT ON MAX REFRESH PERFORMANCE

- ANALYSIS DOCUMENTED IN EM NO. 1149

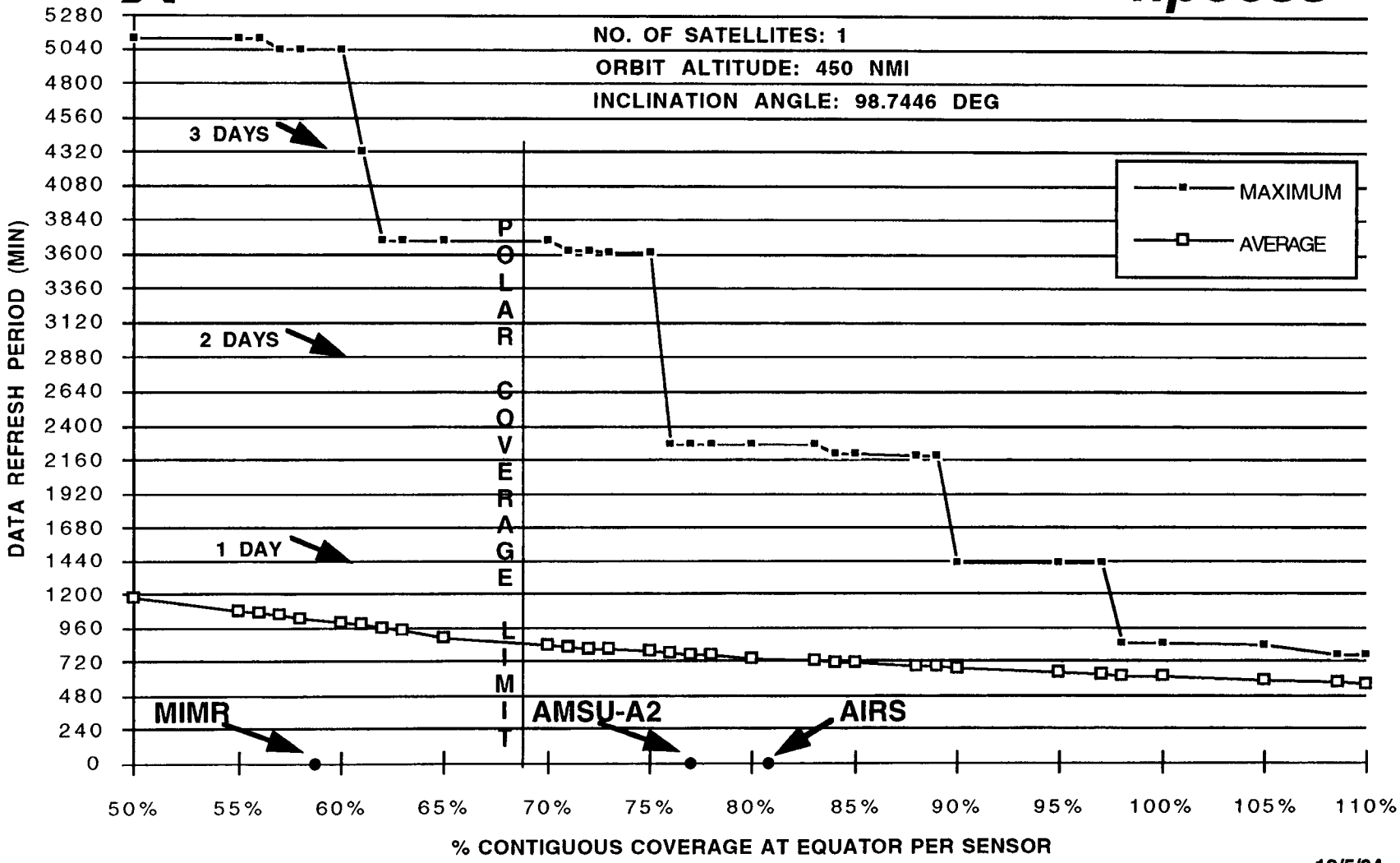
A-SPEC REQUIREMENTS IMPACTS INTRODUCTION

- REFRESH-RELATED IMPACTS
  - CONVERSION OF REFRESH REQUIREMENTS TO CONSTELLATION REQUIREMENTS
  - COST-BENEFIT OF ADDING SATELLITES TO ACHIEVE GOALS
  - GAPS PER SUCCESSIVE REVS VS % CONTIGUOUS COVERAGE
- OTHER SYSTEM-LEVEL CONSIDERATIONS
  - BASELINE GROUND STATION NETWORK TO INCLUDE ONLY AFSCN RTS/NOAA CDA ASSETS
  - NO U.S. BACKUP COMMAND AND CONTROL (C2) OF EUROPEAN O2
  - DATA AVAILABILITY REQUIREMENT INTERPRETATION
  - ADDITIONAL ISSUES AND CONCERNS

CONVERGENCE EFFORT MODIFICATION

DATA REFRESH PERFORMANCE FOR GLOBAL COVERAGE (1 SATELLITE @ 450 NMI)

npoess



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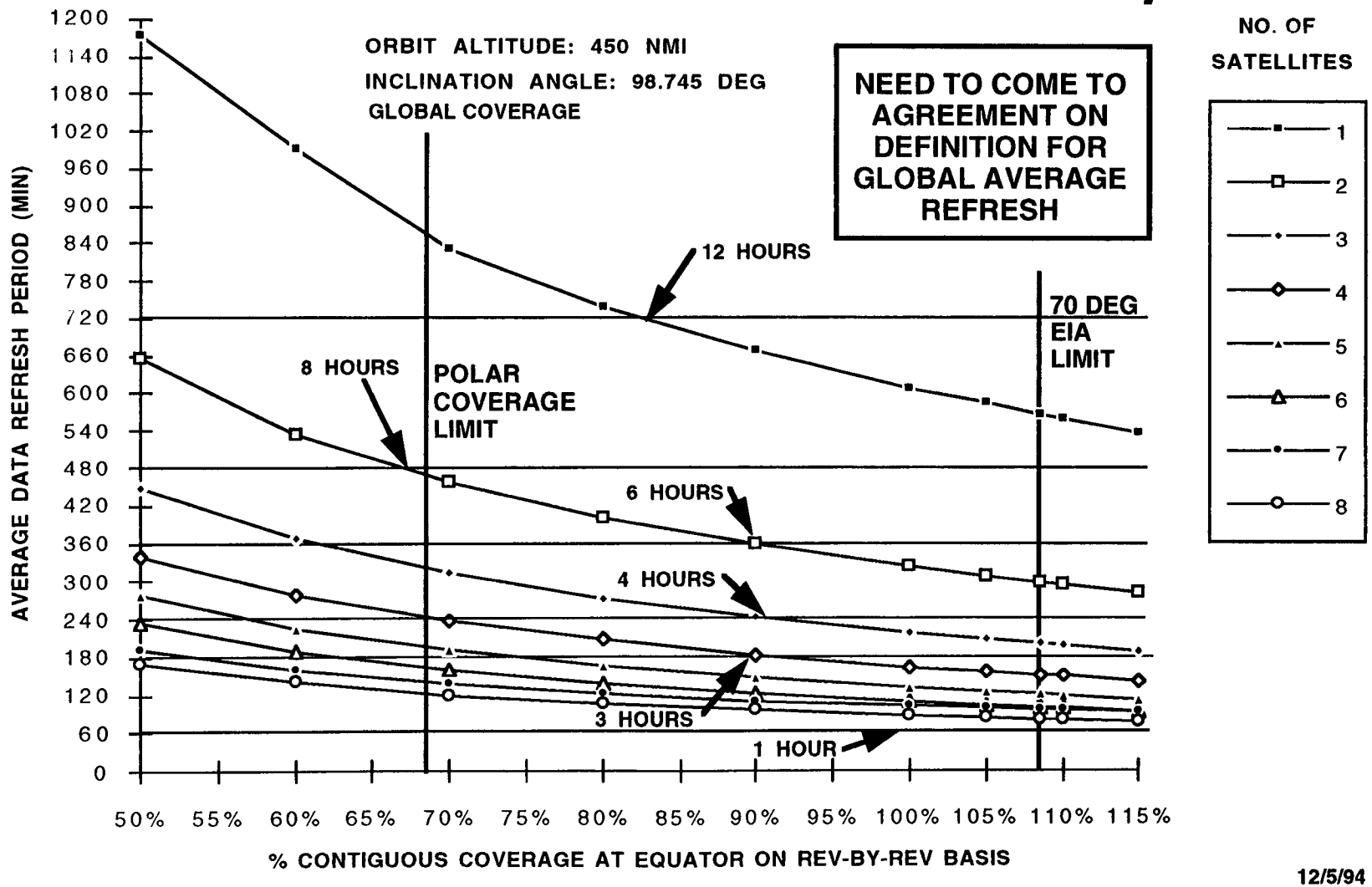
CONVERGENCE EFFORT MODIFICATION

VARIATION IN AVERAGE DATA REFRESH WITH NUMBER OF SATELLITES

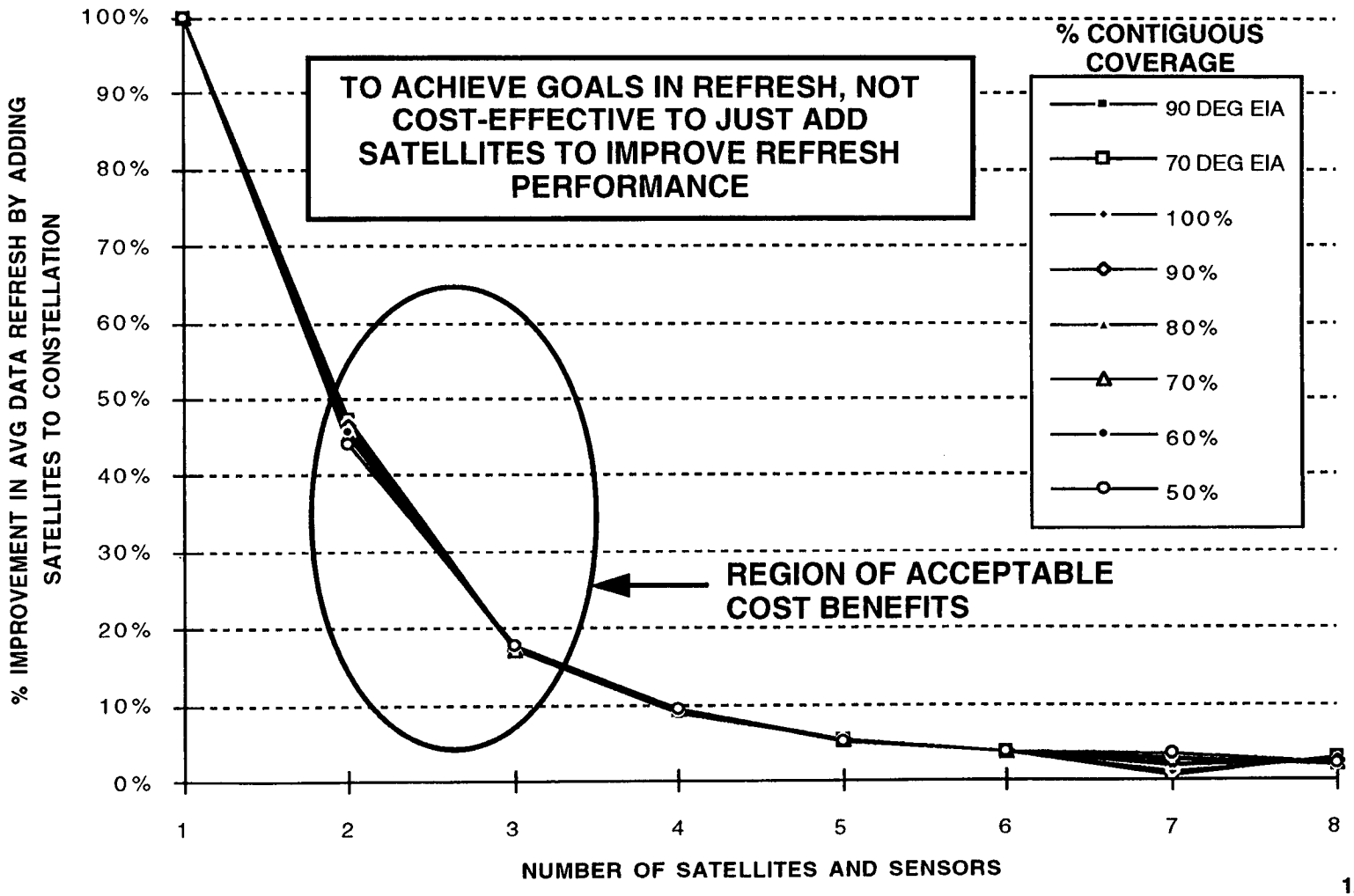
npoess



CONVERGENCE EFFORT MODIFICATION

AVERAGE REFRESH IMPROVEMENTS WITH CONSTELLATION SIZE

npoess



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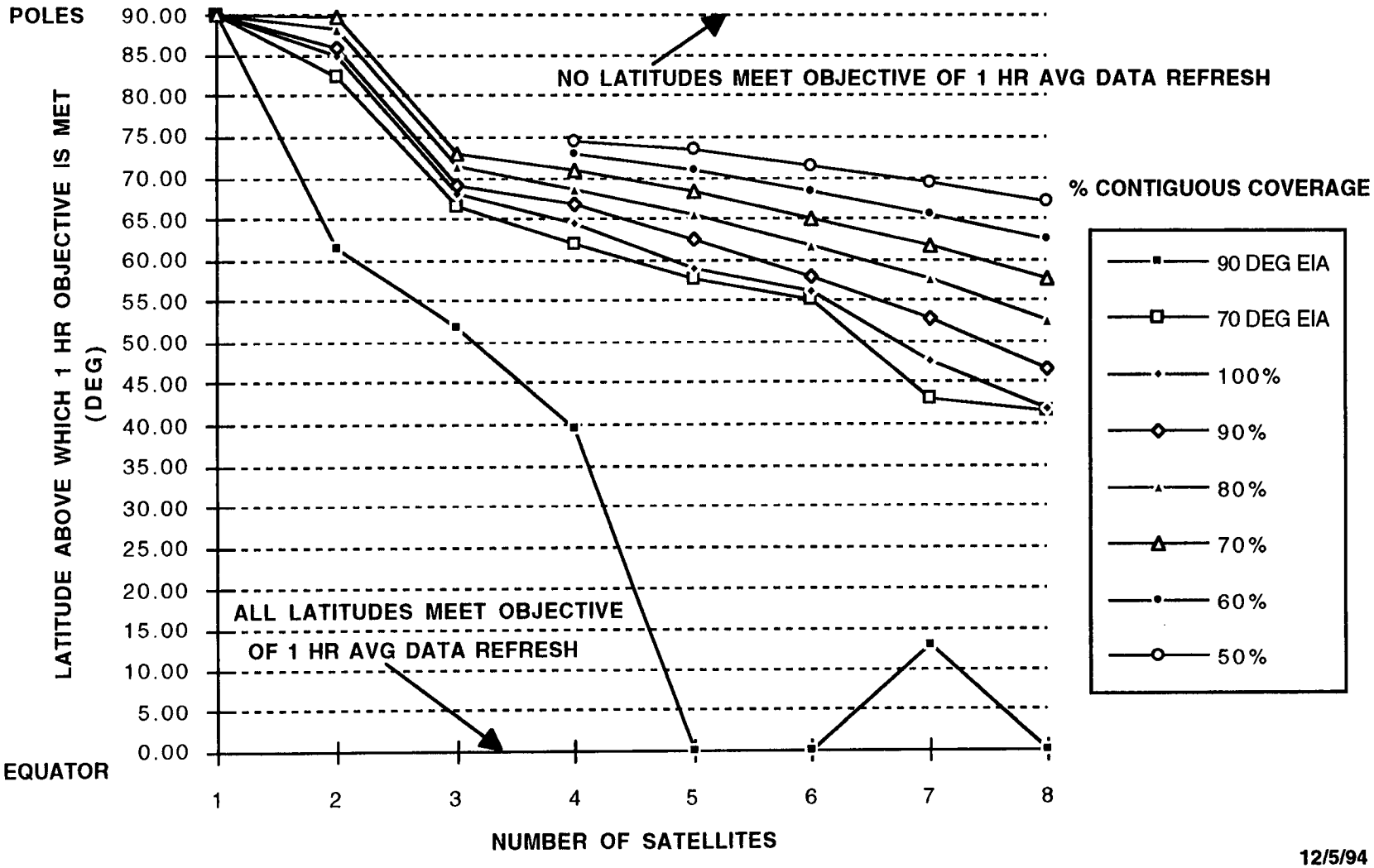
CONVERGENCE EFFORT MODIFICATION

ONE HOUR AVERAGE REFRESH AT LESS THAN GLOBAL COVERAGE

npoess



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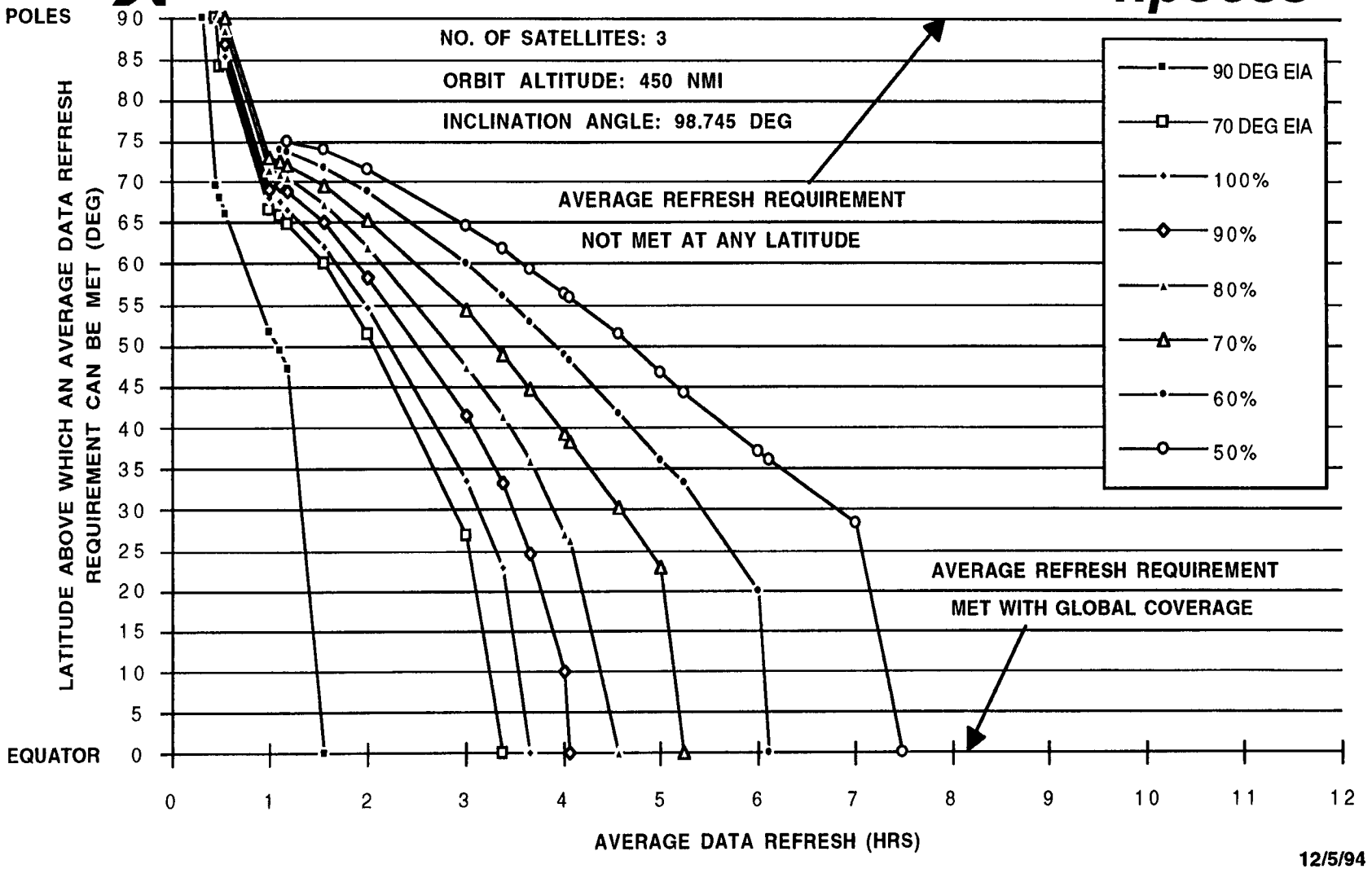
CONVERGENCE EFFORT MODIFICATION

AVERAGE REFRESH AT LESS THAN GLOBAL COVERAGE (3 SATELLITES @ 450 NMI)

npoess



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CONVERGENCE EFFORT MODIFICATION

GAPS BETWEEN SUCCESSIVE REVS VS % COVERAGE

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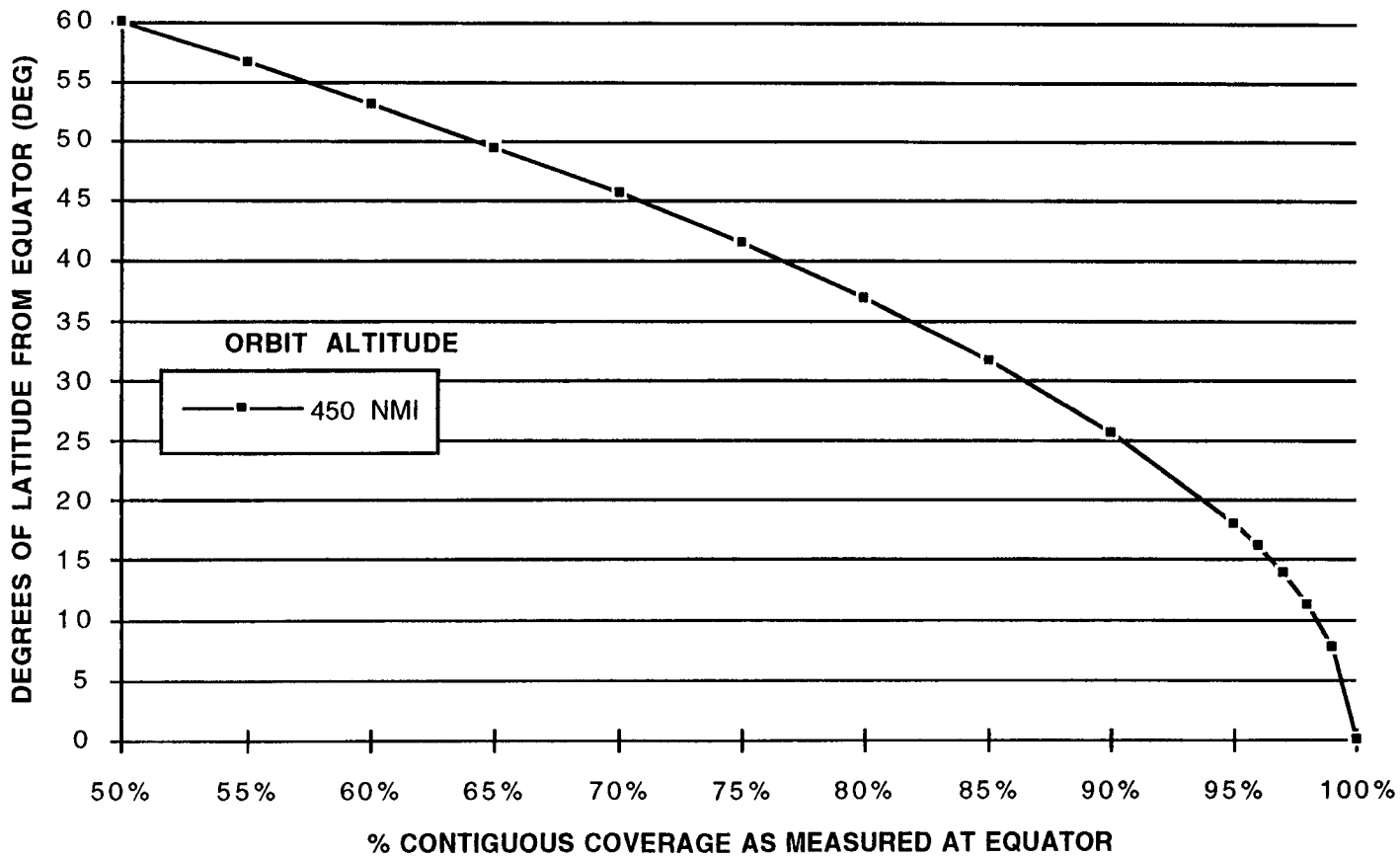
NEED TO BALANCE SIZE OF GAPS BETWEEN SUCCESSIVE REVS AND USEABILITY OF ENVIRONMENTAL DATA



TEAM APPROACH TO DEVELOP CONSTELLATION CONFIGURATION

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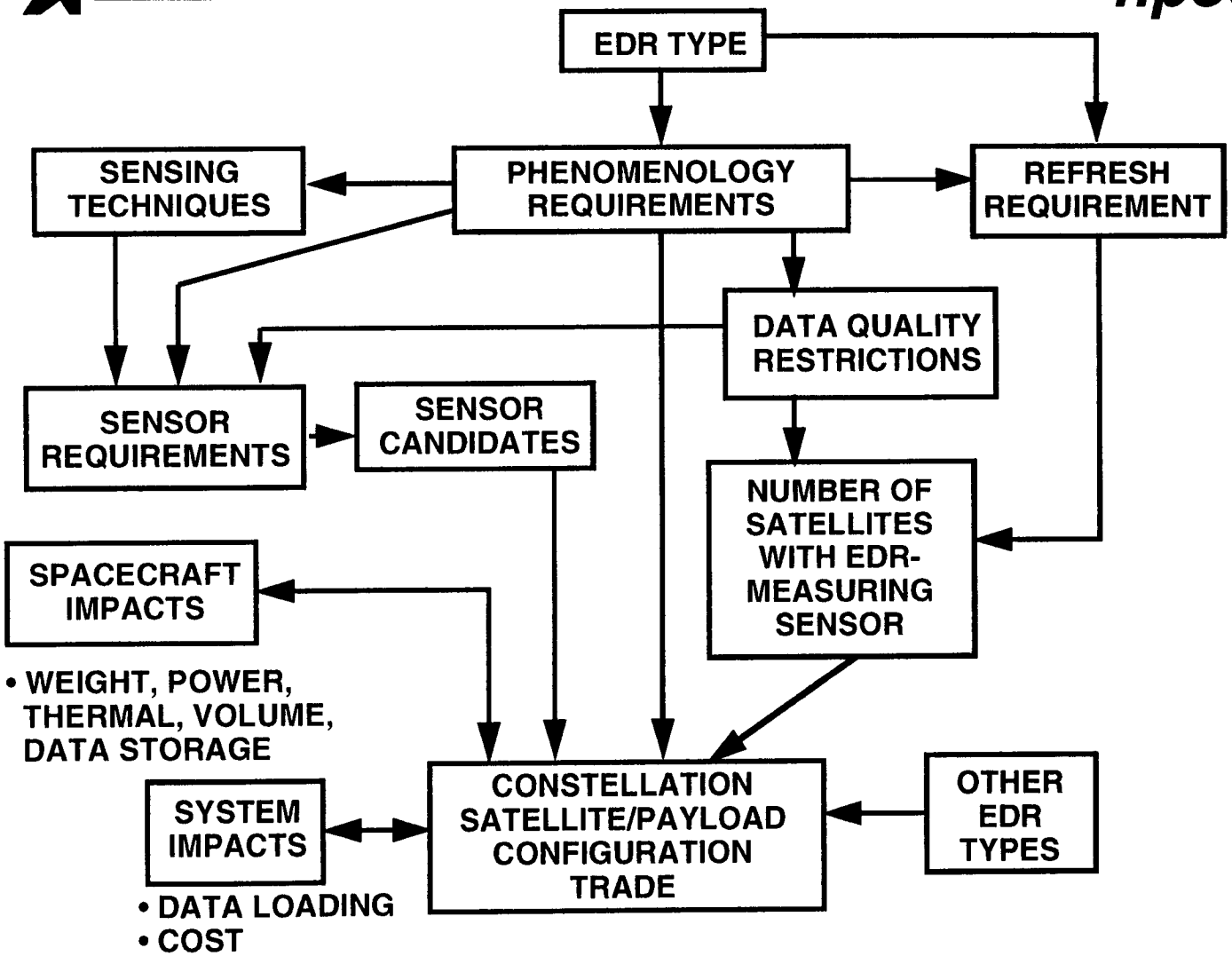

CONVERGENCE EFFORT MODIFICATION

POLICY DECISIONS IMPACT SYSTEM PERFORMANCE

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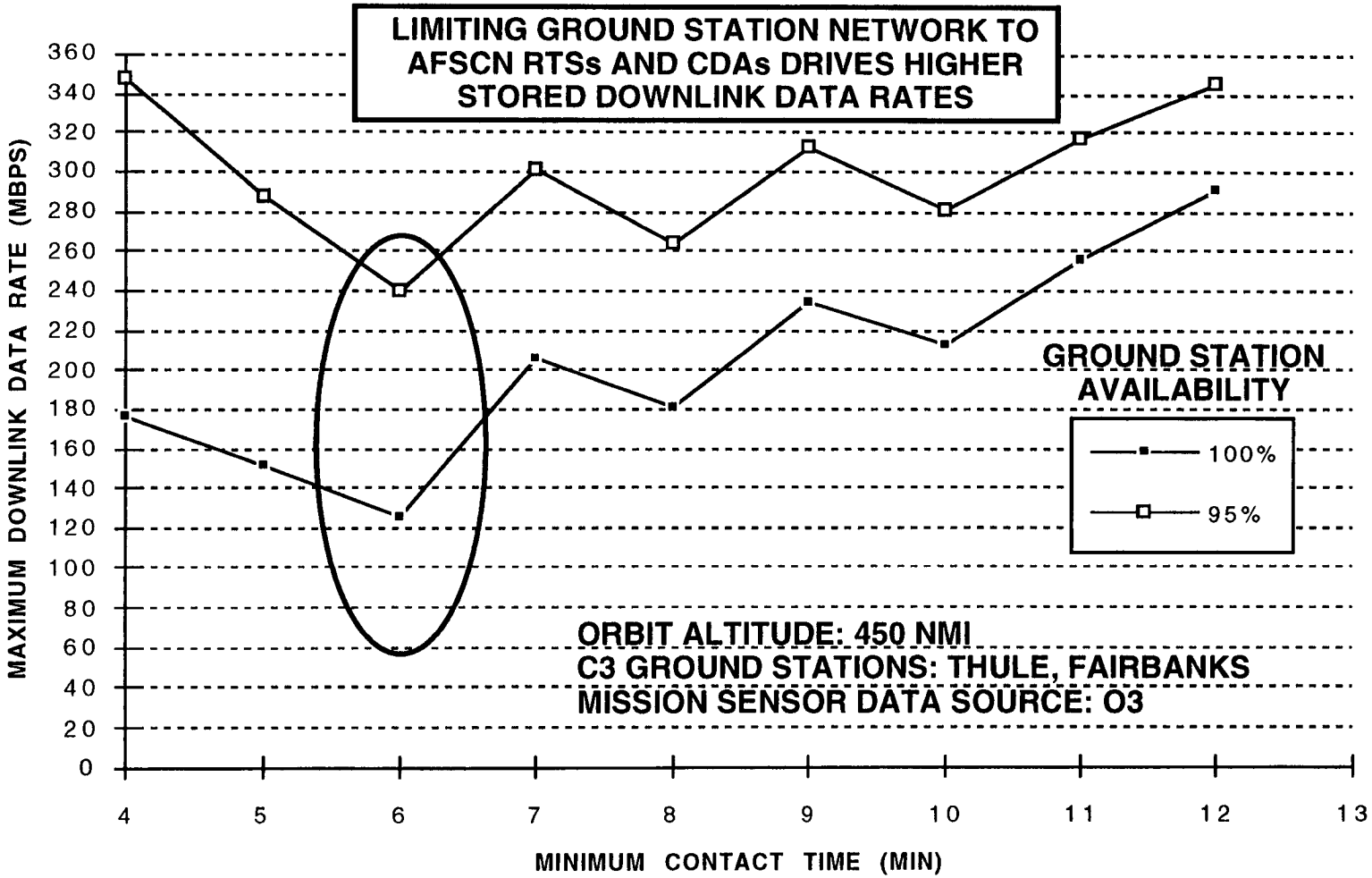
POLICY ON GROUND STATIONS	POLICY ON C2 OF EUROPEAN O2	USEABILITY OF EUROPEAN O2 IN NPOESS	DATA AVAILABILITY COMPLIANCE	DATA REFRESH COMPLIANCE
U.S. ONLY (THULE, FAIRBANKS, OTHER RTS/CDAs)	U.S. B/U O2 C2 CAPABILITY	YES	YES	YES FOR 4 HR REQ'T
	NO U.S. B/U O2 C2 CAPABILITY	EUROPEAN O2 CONTROL VIA U.S. SITES	YES	YES FOR 4 HR REQ'T
		NO EUROPEAN O2 CONTROL VIA U.S. SITES	O1 & O3 ONLY	NEEDS U.S. O2 TO MEET 4 HR
U.S. PLUS EUROPEAN (THULE, FAIRBANKS, KIRUNA)	U.S. B/U O2 C2 CAPABILITY	YES	YES *	YES FOR 4 HR REQ'T
	NO U.S. B/U O2 C2 CAPABILITY	EUROPEAN O2 CONTROL VIA U.S. SITES	YES *	YES FOR 4 HR REQ'T
		NO EUROPEAN O2 CONTROL VIA U.S. SITES	O1 & O3 ONLY *	NEEDS U.S. O2 TO MEET 4 HR

* WHEN U.S. SITES ARE NOT AVAILABLE, NEEDS 1) ESOC B/U C2 OF U.S. O1 & O3 OR 2) U.S. C2 OF O1/O3 VIA EUROPEAN SITE

O3 STORED DOWNLINK DATA RATE VARIATION FOR TTS-FAR



CONVERGENCE EFFORT MODIFICATION

POTENTIAL AFSCN CANDIDATES FOR KIRUNA REPLACEMENTS

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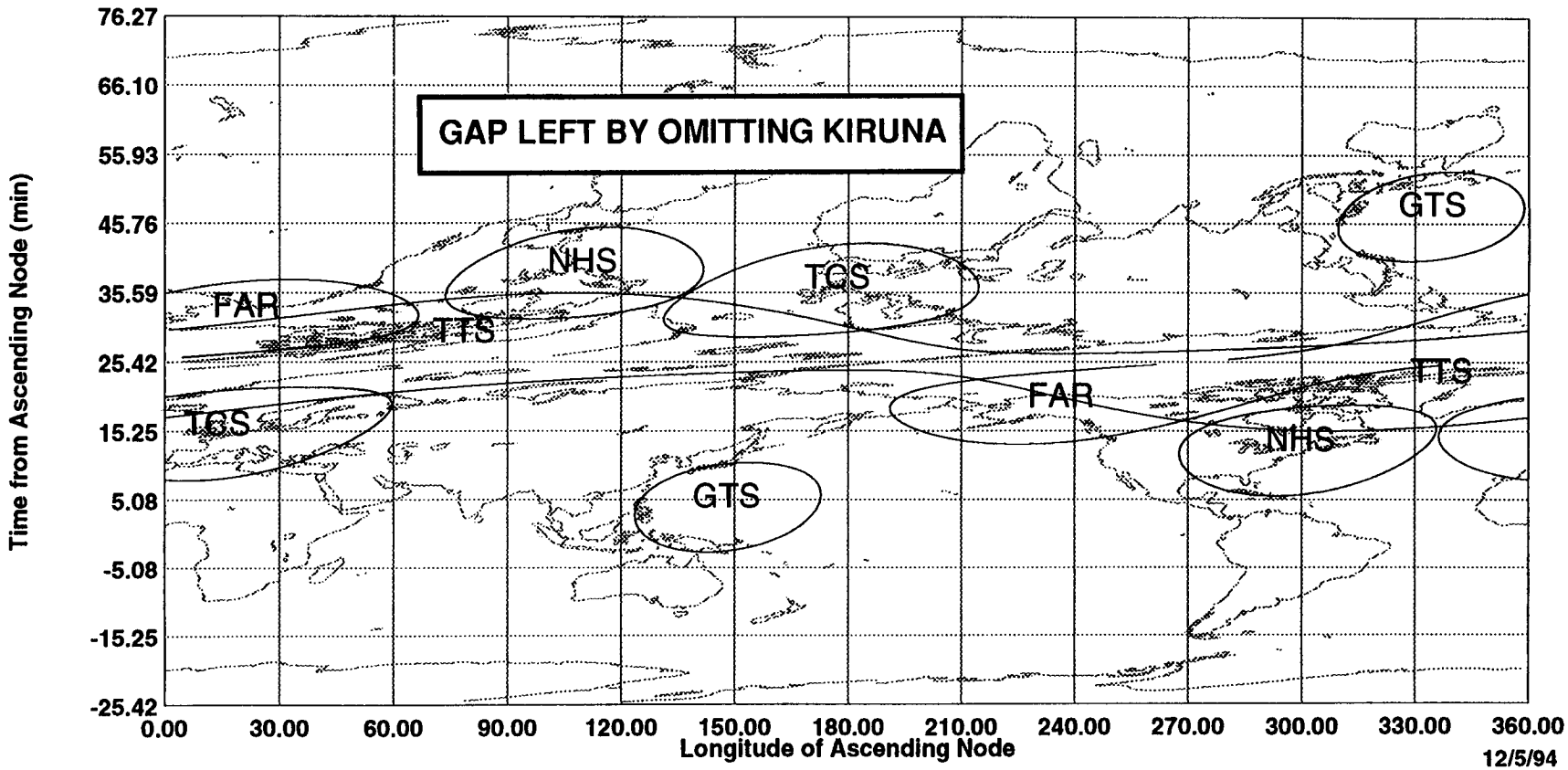
NOT INCLUDING ESA'S KIRUNA SITE IN BASELINE NETWORK COULD REQUIRE SEVERAL ADDITIONAL AFSCN STATIONS TO ACHIEVE SIMILAR PERFORMANCE

Generalized Viewbar Contours



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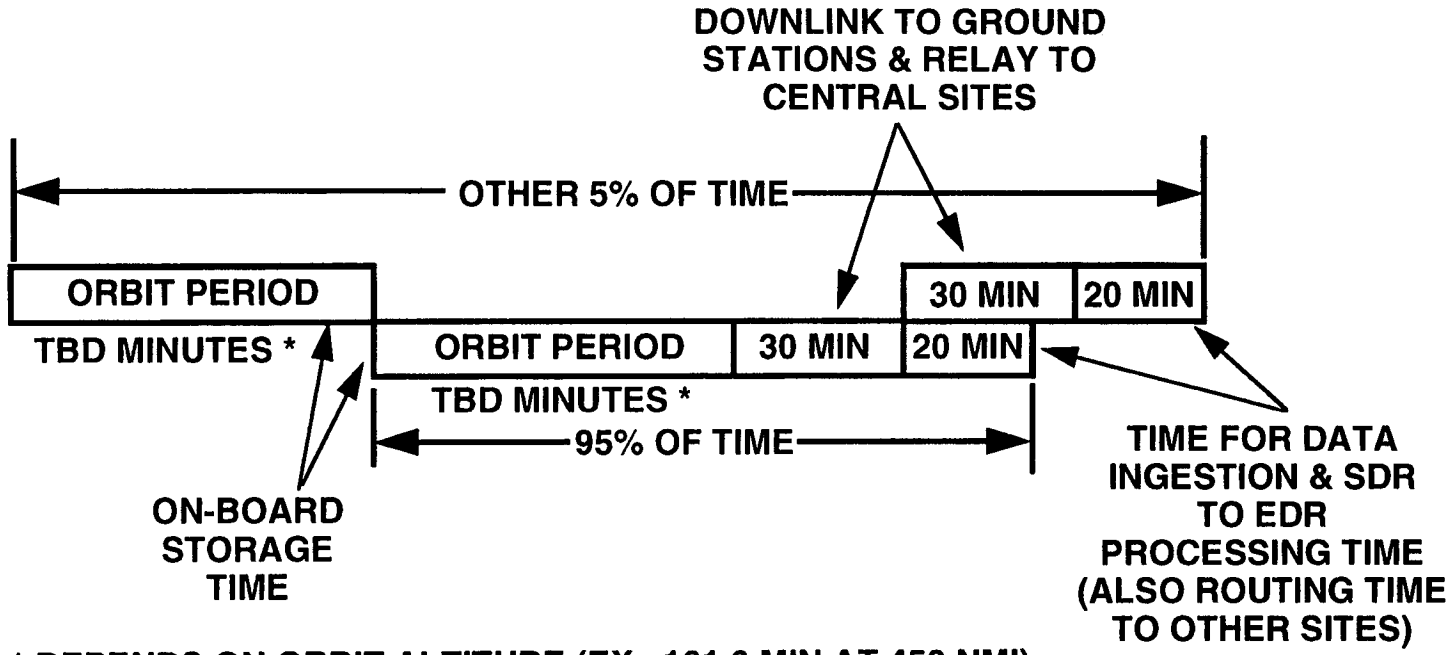
CENTRAL SITE DATA AVAILABILITY REQUIREMENT DISCUSSION



* DEPENDS ON ORBIT ALTITUDE (EX., 101.6 MIN AT 450 NMI)

INTERPRETATIONS

- 30 MIN TO DOWNLINK AND RELAY FOR EACH ORBIT'S WORTH OF DATA
- 20 MIN TO INGEST AND PROCESS EACH ORBIT PERIOD'S WORTH OF DATA

ADDITIONAL ISSUES AND CONCERNS

npoess

- NEED TO DEFINE WHICH AND HOW MUCH DATA TO GO TO FIELD USERS
  - AFFECTS DATA RATE OR COMPRESSION LEVEL FOR REALTIME DOWNLINK
  - COMMON VS DIFFERENT REALTIME DOWNLINKS
- NEED TO BETTER DEFINE REQUIREMENT FOR "2 HOURS OF PREVIOUSLY RECORDED IMAGERY TO BE AVAILABLE TO FIELD USERS"
- NEED TO BETTER DEFINE SURFACE DATA COLLECTION REQUIREMENTS:
  - WHICH PLATFORM TYPES
  - HOW MANY PLATFORMS PER TYPE AND MODEL
  - "50 PLATFORMS" ON WHAT BASIS (AT ONE TIME, PER ORBIT, DAILY)
- LACK OF NOAA COMPLIANCE DOCUMENTATION

A-SPEC REQUIREMENTS IMPACTS SUMMARY

- GRAPHS FOR ONE AND TWO-SATELLITE CONFIGURATIONS AVAILABLE FOR ANALYZING CONSTELLATION ALTERNATIVES
- TO ACHIEVE REFRESH GOALS, RECOMMEND MAXIMIZING PERFORMANCE FROM 3 SATELLITES
- NEED FOR ESA TO PROVIDE O2 MISSION DATA TO CENTRAL SITES WITHIN DATA AVAILABILITY REQUIREMENTS
- CLARIFICATION OF DATA AVAILABILITY REQUIREMENT ESSENTIAL TO SYSTEM-WIDE DATA LOADING IMPACTS
- WHAT DATA GOES TO FIELD USERS WILL DRIVE NUMBER AND CONTENT OF REALTIME DOWNLINKS
- NEED TO CLARIFY "2 HOURS OF PREVIOUSLY RECORDED IMAGERY" REQUIREMENT
- COLLECT DATA FROM ALL GLOBALLY DEPLOYED SURFACE DATA PLATFORMS OR LIMITED SET TO BE SPECIFIED
- NEED TO INCLUDE NOAA COMPLIANCE DOCUMENTATION

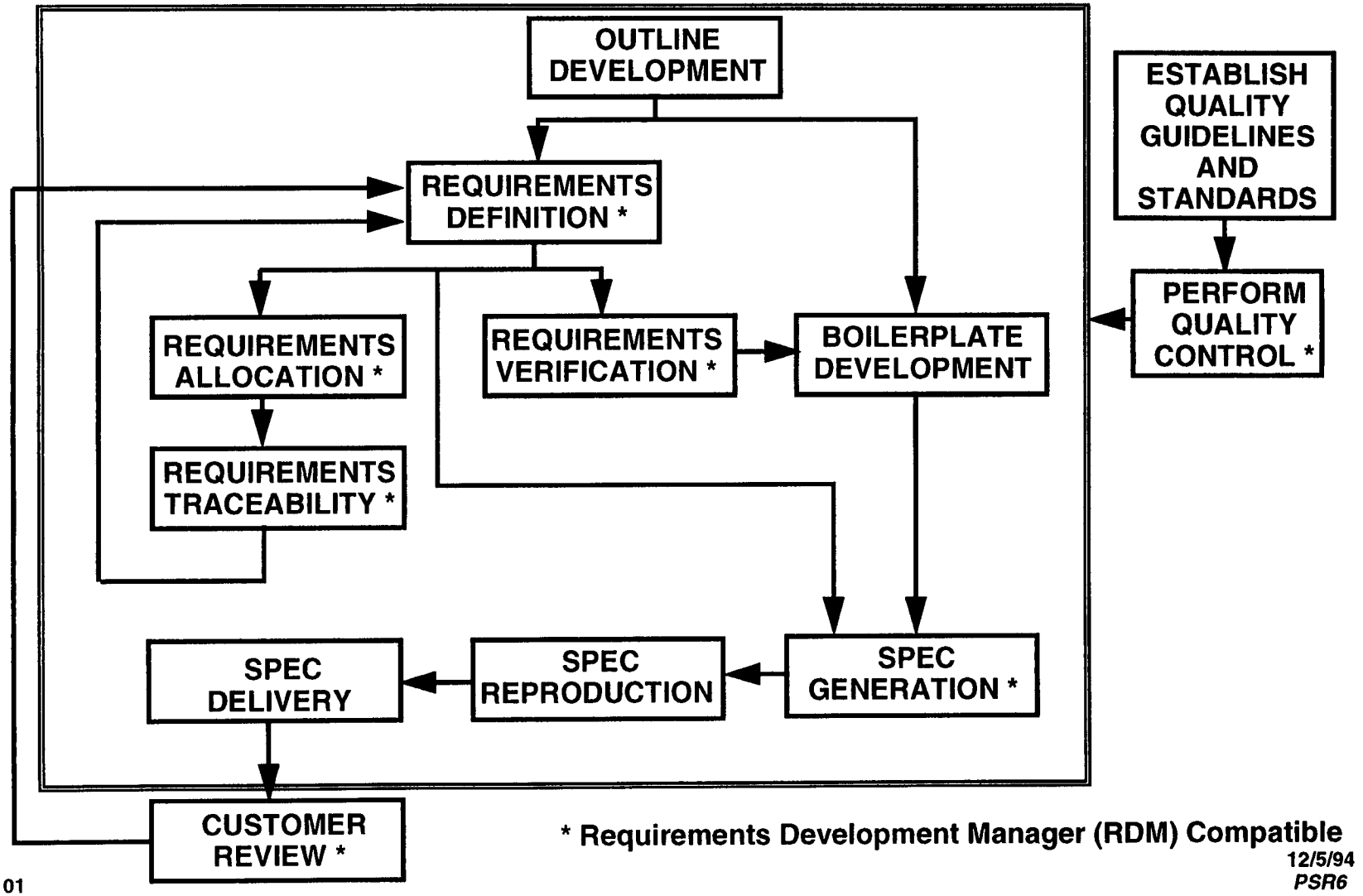
SYSTEM SPECIFICATION DEVELOPMENT INTRODUCTION

npoess

- REVIEW SPECIFICATION DEVELOPMENT PROCESS
- PROVIDE REQUIREMENTS DEVELOPMENT MANAGER OVERVIEW
- PROVIDE SPECIFICATION DEVELOPMENT STATUS
- REVIEW LATEST STATES AND MODES DEFINITIONS
- SHOW UPDATED SYSTEM DIAGRAM

SPECIFICATION DEVELOPMENT PROCESS

npoess



* Requirements Development Manager (RDM) Compatible

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REQUIREMENTS DEVELOPMENT MANAGER (RDM) OVERVIEW

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- COMPUTER-AIDED ENGINEERING APPLICATION FOR MANAGING, DISTRIBUTION, CONTROLLING, MAINTAINING REQUIREMENTS, FLOWDOWN, INTERFACES, VERIFICATION PROCEDURES, AND DEVELOPING SPECIFICATIONS AND ICD'S
- LMSC BUILT AND MAINTAINED FOR MACINTOSH AND PC-COMPATIBLES
- DESIGNED TO BE INTERACTIVE AND SUPPORTIVE OF REAL-TIME ALLOCATION AND DESIGN
- PROVIDES CONCURRENT ENGINEERING ENVIRONMENT FOR REQUIREMENTS DEVELOPMENT
- USES RELATIONAL DATA BASE SCHEMA
- IN USE BY NASA, USAF, LOCKHEED, PARTNERS AND CUSTOMERS
  - MAJOR PROJECTS (HUBBLE, MILSTAR, FEWS)
  - NUMEROUS SMALLER PROJECTS

RDM IMPLEMENTATION FOR CONVERGED SYSTEM ACTIVITIES

npoess

Support up to 451 concurrent users with 2.5 GB of data.

Support PC and Mac now; Unix W/S (early 94)

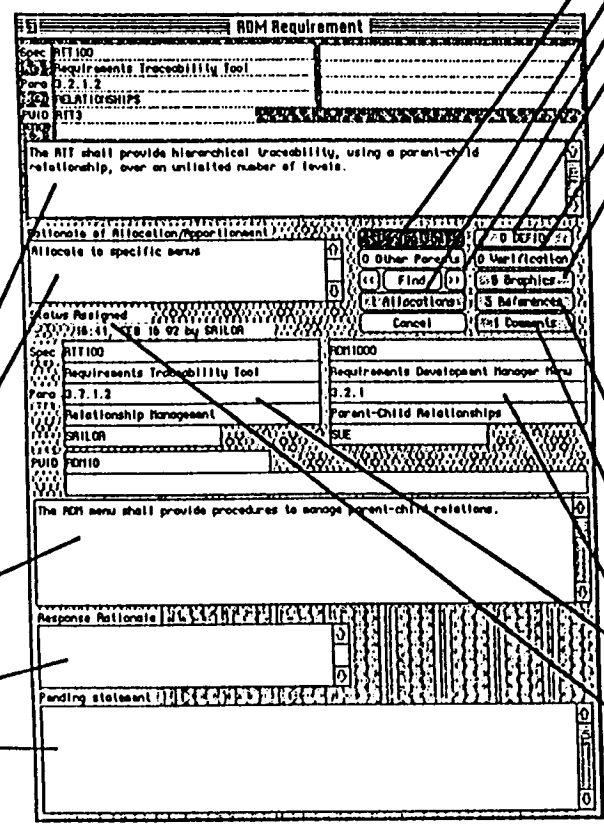
Support multiple hosts (open systems) with most ANSI SQL (relational) data base products.

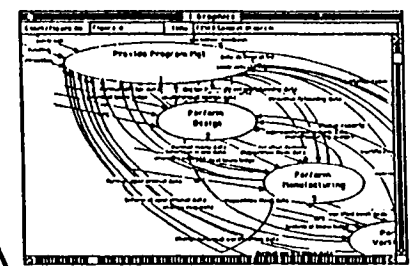
Support integration with other tools

Prepare specifications and reports

Enforce systematic and concurrent requirements development and flow down with continuous consistency checking, auditing, and browsing.

- *Instant access to:*
  - *Derivation (parent)*
  - *Allocation (child)*
  - *Next spec item*
- *Manage Interfaces*
- *Manage Verification*
- *Support text and graphics data*





- *Manage traceability of parents -*
- *with documented rationale -*
- *to children -*
- *Manage negotiations with change rationale -*
- *and requested text -*

- *Capture and retrieve reference data*
- *Enable concurrent reviews and comments*
- *Assign and control responsibility*
- *Maintain configuration control*

SYSTEM/SEGMENT SPECIFICATION DEVELOPMENT STATUS

SYSTEM SPECIFICATION

- OUTLINE ESTABLISHED
- 1 OCT 94 VERSION INCORPORATED INTO RDM
- COST-EFFECTIVE STRATEGY FOR APPENDIX B CHANGES
- INCORPORATED CHANGE SUGGESTIONS SUBMITTED 10/18
- CURRENT EMPHASIS ON:
  - APPENDIX B TBDs
  - STATES AND MODES (SEC 3.2.1)
  - SYSTEM CAPABILITIES (SEC 3.2.2)
  - EXTERNAL INTERFACES (SEC 3.2.3)

C3 SEGMENT SPECIFICATION

- PATHFINDER FOR SEGMENT SPECS
- OUTLINE ESTABLISHED AS PER DID
- 1 OCT 94 REQUIREMENTS REASSIGNED TO MODIFIED OUTLINE
- MAJOR EMPHASIS ON DEVELOPING SECS 3.2 AND 3.7

CURRENT NPOESS STATES AND MODES LISTING

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SYSTEM STATES	SYSTEM MODES
• PRE-LAUNCH STATE	- SYSTEM TEST MODE - GROUND STORAGE MODE - TRANSPORT 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
• NON-OPERATIONAL	- PROTECTIVE MEASURES - SAFE MODE - DISPOSAL MODE

RELATIONSHIP BETWEEN STATES AND MODES AND SEGMENTS

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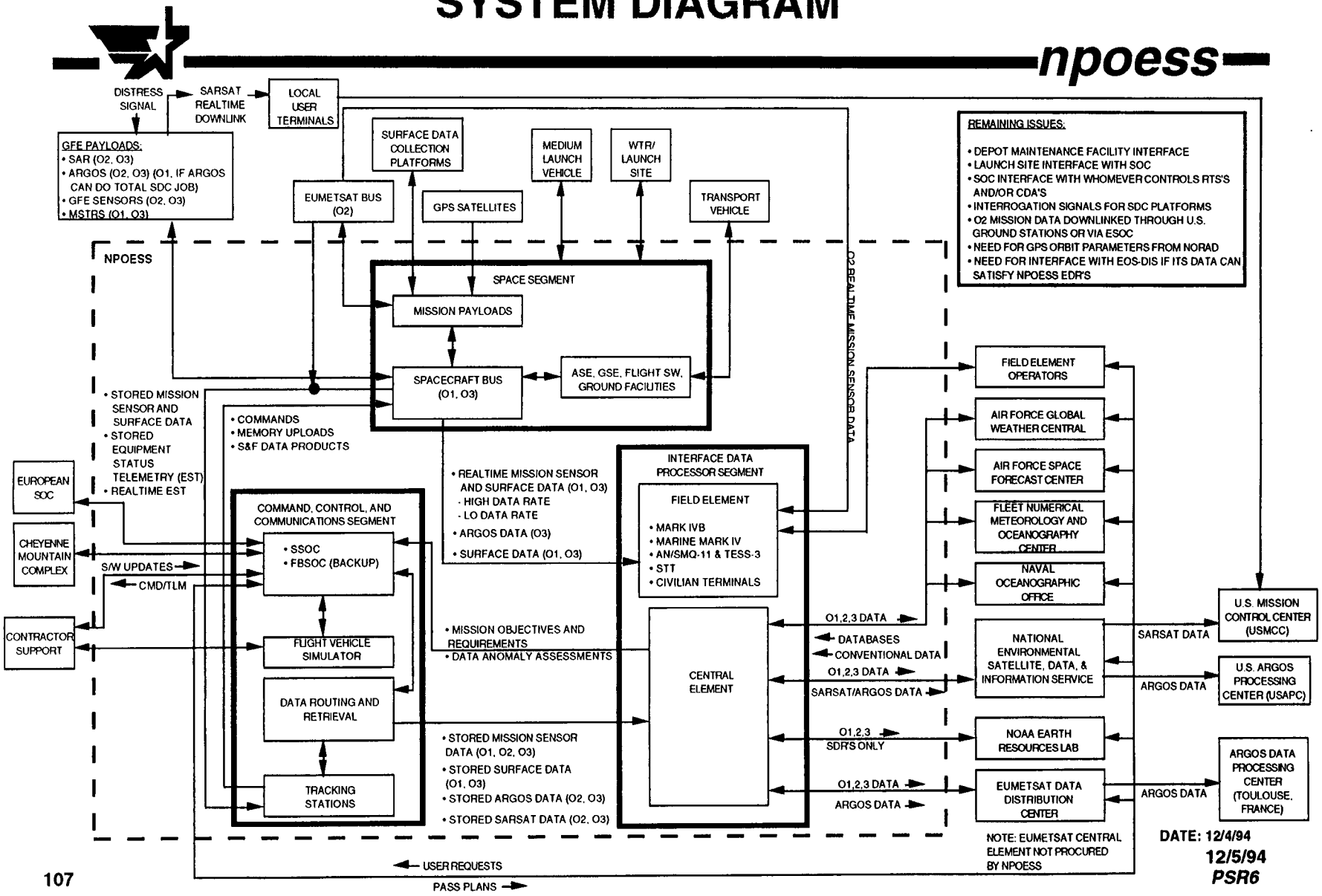
		SYSTEM STATES AND MODES							
		PRE-LAUNCH STATE					PRE-OPERATIONAL STATE		
NPOESS SEGMENTS	NPOESS ELEMENTS	SYSTEM TEST	GROUND STORAGE	TRANSPORT MODE	LAUNCH PREPARATION	LAUNCH AND ASCENT	POST-LAUNCH OPERATIONS	DEPLOY AND INITIALIZE	VERIFY AND VALIDATE
SPACE	SPACECRAFT BUS	X	X	X	X	X		X	X
	MISSION PAYLOADS	X	X	X	X	X		X	X
	SUPPORT EQUIP	X	X	X	X		X		
C3S	SOC	X			X	X		X	X
	RTS/CDA	X			X	X		X	X
	DRR	X			X	X		X	X
	FV SIMULATOR	X			X	X		X	X
IDPS	CENTRAL SITES	X			X				X
	FIELD SITES	X			X				X

		OPERATIONAL STATE				NON-OPERATIONAL STATE		
NPOESS SEGMENTS	NPOESS ELEMENTS	NORMAL OPERATIONS	AUTONOMOUS OPERATIONS	ORBIT MAINTENANCE	CONTINGENCY MODE	PROTECTIVE MEASURES	SAFE MODE	DISPOSAL MODE
SPACE	SPACECRAFT BUS	X	X	X	X	X	X	X
	MISSION PAYLOADS	X	X	X	X	X		
	SUPPORT EQUIP							
C3S	SOC	X	X	X	X	X	X	X
	RTS/CDA	X	X	X	X	X	X	X
	DRR	X	X	X	X	X	X	X
	FV SIMULATOR	X	X	X	X	X	X	X
IDPS	CENTRAL SITES	X			X			
	FIELD SITES	X	X	X	X			

CONVERGENCE EFFORT MODIFICATION

SYSTEM DIAGRAM



DATE: 12/4/94
12/5/94
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SYSTEM/SEGMENT SPECIFICATION DEVELOPMENT STATUS SUMMARY

npoess

- RDM WELL-ESTABLISHED AS OUR REQUIREMENTS MANAGEMENT TOOL
- 1 OCT 94 CHANGES INCORPORATED INTO RDM DATABASE
- DRAFT LMSC SYSTEM SPEC AVAILABLE FOR REVIEW
- SYSTEM DIAGRAM AGREES WITH LATEST A-SPEC VERSION
- STATES AND MODES DEFINED IN EM NO. 1146
- C3 SEGMENT SPEC MODELLED AFTER SYSTEM SPEC AND UNDER DEVELOPMENT

REQUIREMENTS ANALYSIS SUMMARY

- LATEST DATA REFRESH ANALYSIS RESULTS
  - FINISHED 2-SATELLITE REFRESH PERFORMANCE (EM NO. 1149)
- NEW A-SPECIFICATION IMPACTS
  - USING TOOLS TO CONVERT OF REFRESH REQUIREMENTS TO CONSTELLATION REQUIREMENTS
  - IDENTIFIED SYSTEM LEVEL IMPACTS
- SYSTEM/SEGMENT SPECIFICATION UPDATES
  - RDM DATABASE WELL-ESTABLISHED
  - DEVELOPMENT OF SYSTEM SPEC PROGRESSING
  - STATES AND MODES DEFINED (EM NO. 1146)
  - C3 SEGMENT SPEC UNDER DEVELOPMENT

PLANS FOR PSR 7

- COMPLETION OF 3 SATELLITE DATA REFRESH ANALYSIS
- CONTRIBUTE TO ANALYSIS OF CONSTELLATION SATELLITE/ PAYLOAD ALTERNATIVES
- CONTINUE WITH SYSTEM/SEGMENT SPECIFICATION DEVELOPMENT
  - UPDATE TO NEXT VERSION OF A-SPEC
  - FINISH REQUIREMENTS DEVELOPMENT FOR:
    - * SYSTEM CAPABILITIES
    - * EXTERNAL INTERFACES
    - * CHARACTERISTICS OF SUBORDINATE ELEMENTS (SEC 3.7)

EDR ALGORITHM ANALYSIS

B. KENLEY

EDR ALGORITHM ANALYSIS AGENDA

npoess

- ALGORITHM ANALYSIS AND REQUIREMENTS FLOWDOWN APPROACH
- PROCESSED CLOUD DATA FLOWDOWN TO E/O SENSOR MEASUREMENT ERRORS
- SEA AND LAND SURFACE TEMPERATURE FLOWDOWN TO E/O SENSOR MEASUREMENT ERRORS

- *BY THOROUGHLY ANALYZING THE DOMAIN AND RANGE OF NPOESS EDR REQUIREMENTS DRIVERS, WE WILL ESTABLISH A TRACEABLE, VERIFIABLE, CONSISTENT AND AFFORDABLE SET OF REQUIREMENTS FOR PHASE 0 CONCEPT ALTERNATIVE DEVELOPMENT*

EDR ALGORITHM ANALYSIS SCOPE AND OBJECTIVES

- EDR REQUIREMENTS ARE SPECIFIED USING SEVERAL PARAMETERS:

PARAMETER	ERROR BUDGET ANALYSIS METHOD
HORIZONTAL SPATIAL RESOLUTION	IDENTIFY MIN RESOLUTION
VERTICAL SPATIAL RESOLUTION	IDENTIFY MIN RESOLUTION
MEASUREMENT RANGE	TARGET SIGNATURE ANALYSIS
MEASUREMENT ACCURACY	SYSTEM ALGORITHM ANALYSIS
MEASUREMENT PRECISION	IDENTIFY MAX DATA WORD SIZE
MAPPING ACCURACY	IDENTIFY MIN MAPPING ACCY

- OBJECTIVES:

OBJECTIVE	TECHNICAL TASK
HERITAGE & TRACEABILITY	PRELIMINARY RQMTS ALLOCATION
STABILITY / SENSITIVITY	PARAMETRIC ANALYSIS & TRADES
ACHIEVABILITY RISK / COST	DRIVING DESIGN RQMTS IDENT

EDR ALGORITHM ANALYSIS APPROACH

npoess

- REVIEW THE SCIENTIFIC LITERATURE ON EDR ALGORITHMS (CLOUD PRODUCTS, SEA SURFACE TEMP, LAND SURFACE TEMP, ETC.)
- CATEGORIZE ALGORITHMS ACCORDING TO PROBLEM CLASS
- PERFORM PARAMETRIC ANALYSIS OF ALGORITHM PERFORMANCE
  - UNDERSTAND END-TO-END VERTICAL FLOWDOWN
  - IDENTIFY HORIZONTAL INTERACTION AND SYNERGIES ACROSS THE SYSTEM
- DEVELOP REQUIREMENTS RECOMMENDATIONS
  - END-TO-END FROM USER MISSION UTILITY LEVEL TO SENSING REQUIREMENTS LEVEL

ALGORITHM ANALYSIS PROBLEM CLASSES

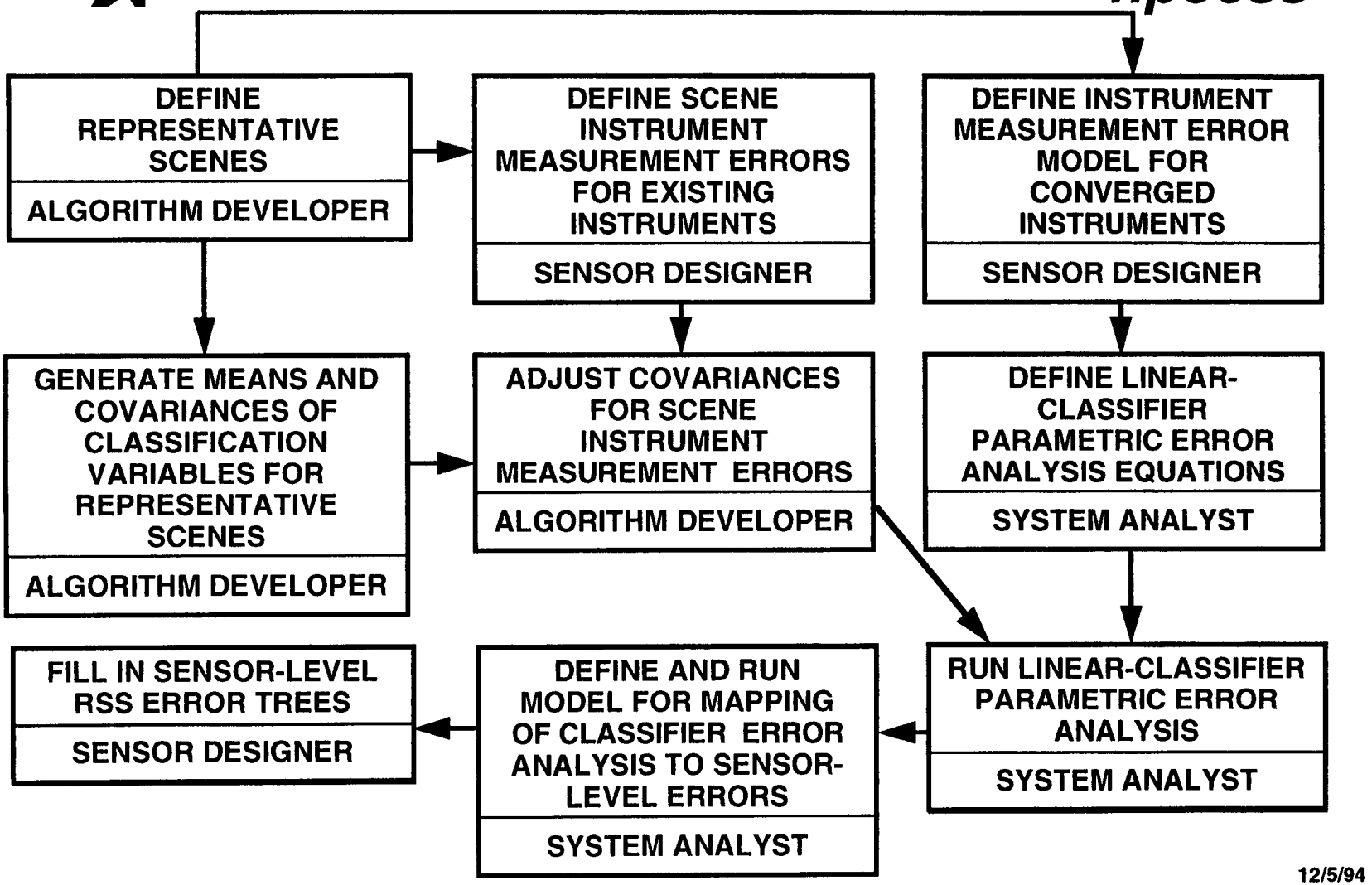
npoess

INCREASING EFFORT TO IMPLEMENT

PROBLEM CLASS	AVAILABILITY OF MODELS	PRODUCT TEAM PERSONNEL
RSS ERROR TREE	IN-HAND	SENSOR DESIGNER
PROBABILITY ANALYSIS	SIMPLE TO DO WITH A SPREADSHEET	SYSTEM ANALYST
COVARIANCE ANALYSIS	EITHER MODIFY SIMULATION OR HANDLE WITH SPREADSHEET	SYSTEM ANALYST, SENSOR DESIGNER, ALGORITHM DEVELOPER, IWPTB CODER SYSTEM ANALYST, SENSOR DESIGNER, ALGORITHM DEVELOPER
LINEAR-GAUSSIAN CLASSIFIER ERROR ANALYSIS	SPREADSHEET MODEL IN-HAND USING INPUTS FROM SIMULATION	SYSTEM ANALYST, SENSOR DESIGNER, ALGORITHM DEVELOPER
MONTE CARLO ERROR ANALYSIS	SIMULATION MODS TO VARY INPUT PARAMETERS & CAPTURE RESULTS	SYSTEM ANALYST, SENSOR DESIGNER, ALGORITHM DEVELOPER, IWPTB CODER

EXAMPLE NPOESS PARAMETRIC ANALYSIS APPROACH

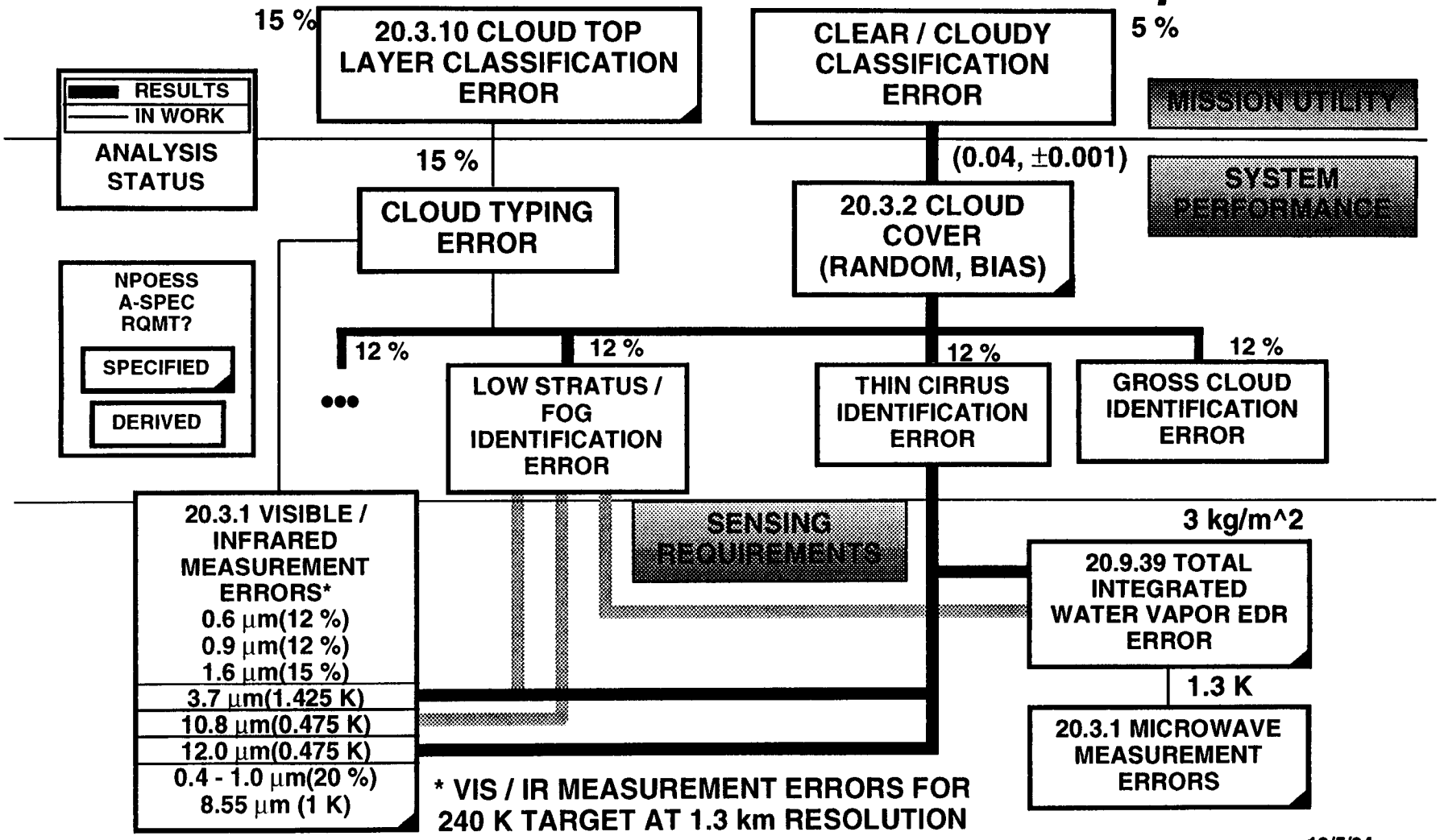
npoess



CONVERGENCE EFFORT MODIFICATION

NPOESS TOP-DOWN MEASUREMENT ERROR ALLOCATION FOR PROCESSED CLOUD DATA

npoess



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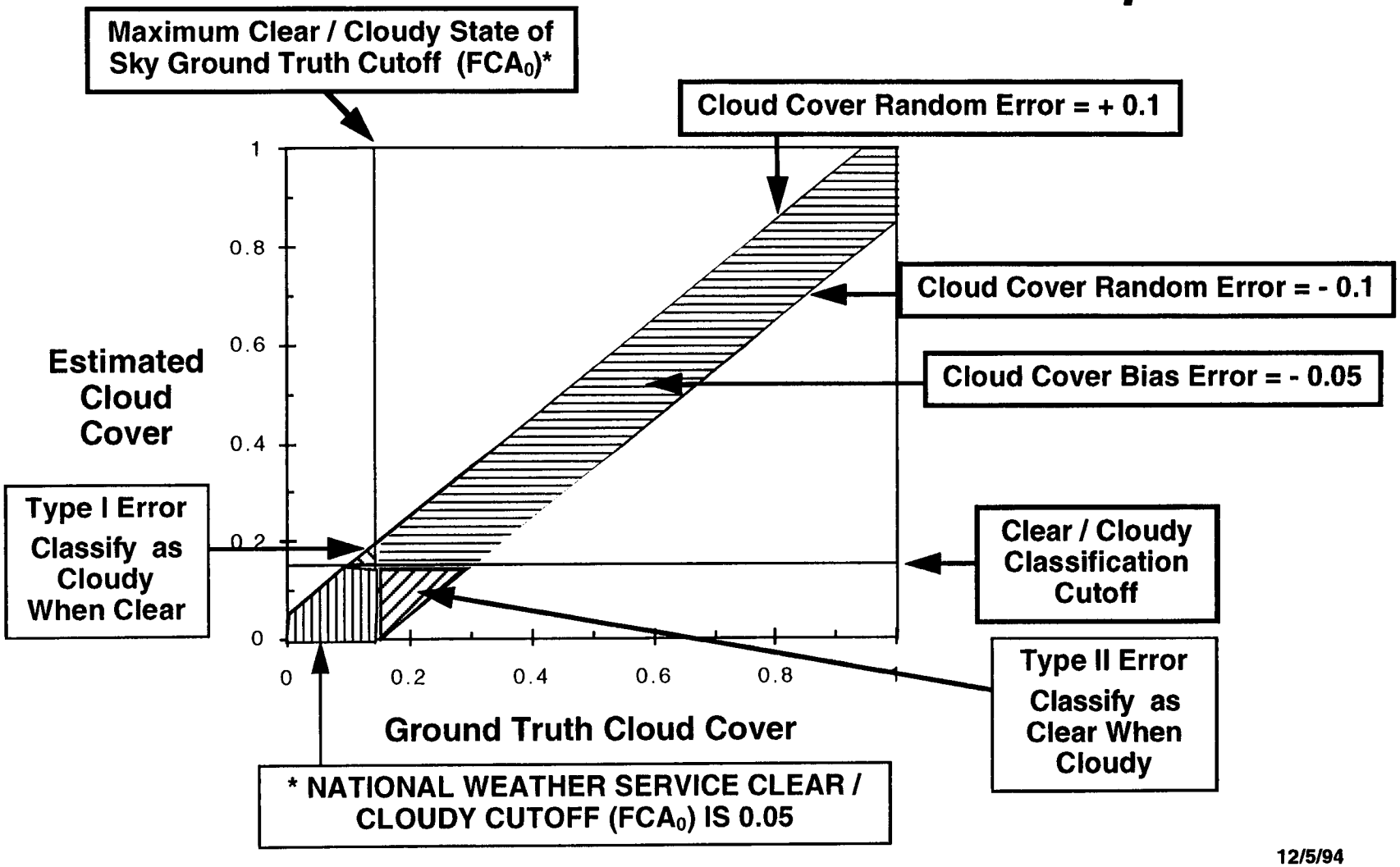
CONVERGENCE EFFORT MODIFICATION

CLEAR / CLOUDY CLASSIFICATION AND CLOUD COVER RANDOM AND BIAS ERROR DEFINITIONS

npoess



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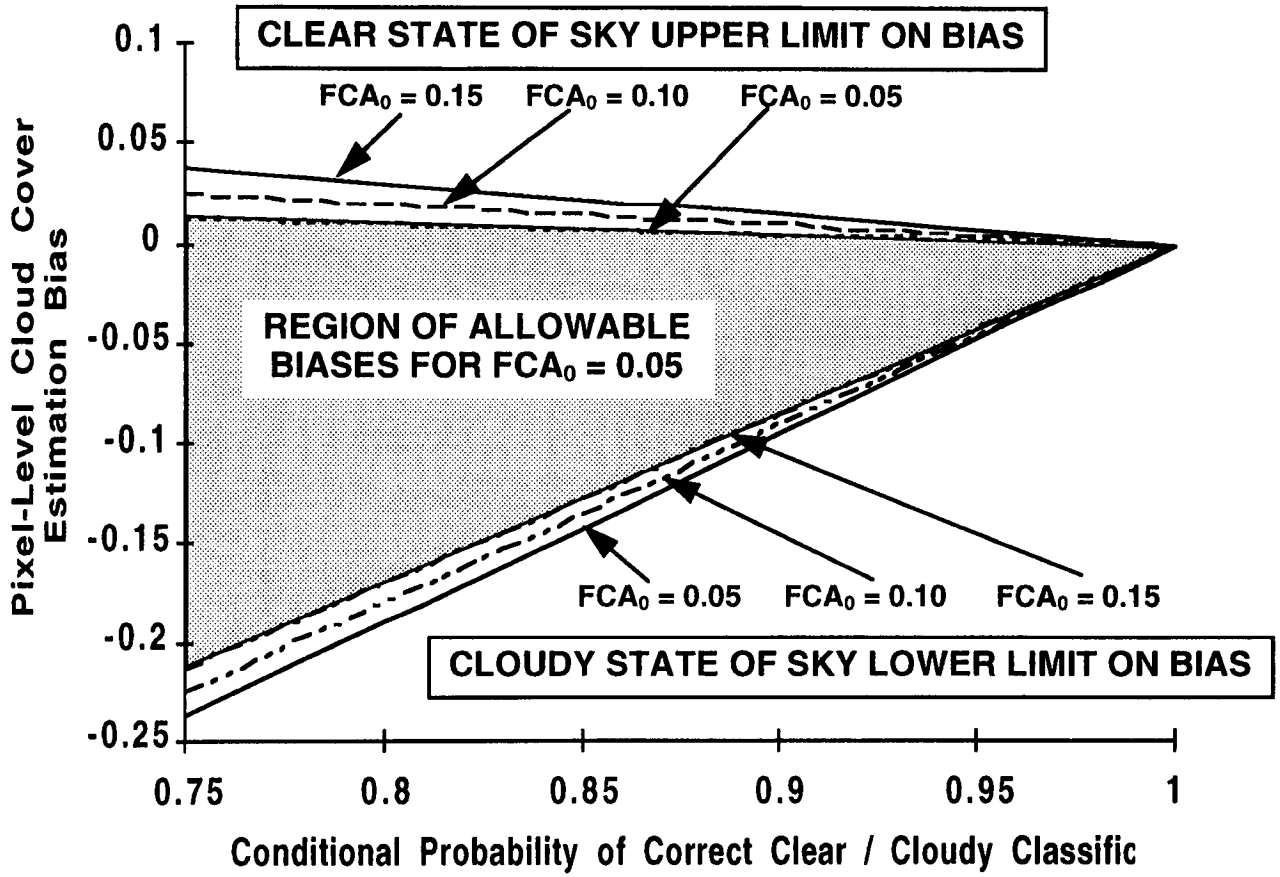
CONVERGENCE EFFORT MODIFICATION

CONSTRAINTS ON CLOUD COVER BIAS TO ACHIEVE ≥85% CLEAR/CLOUDY CLASSIFICATION ACCURACY

npoess



DEFINITIONS FOR PIXEL-LEVEL AND 25 km GRID-LEVEL ERRORS

npoess

PIXEL-LEVEL PROBABILITY TREE FOR IDENTIFICATION ERRORS:

ACTUAL PIXEL CONDITION	IDENTIFIED CONDITION	CLOUD AMOUNT ESTIMATE	ERROR IN ESTIMATE
CLEAR, fca	"CLEAR" $1-I_p$	0	0
	"CLOUDY" I_p	1	+ 1
CLOUDY, 1-fca	"CLEAR" II_p	0	- 1
	"CLOUDY" $1-II_p$	1	0

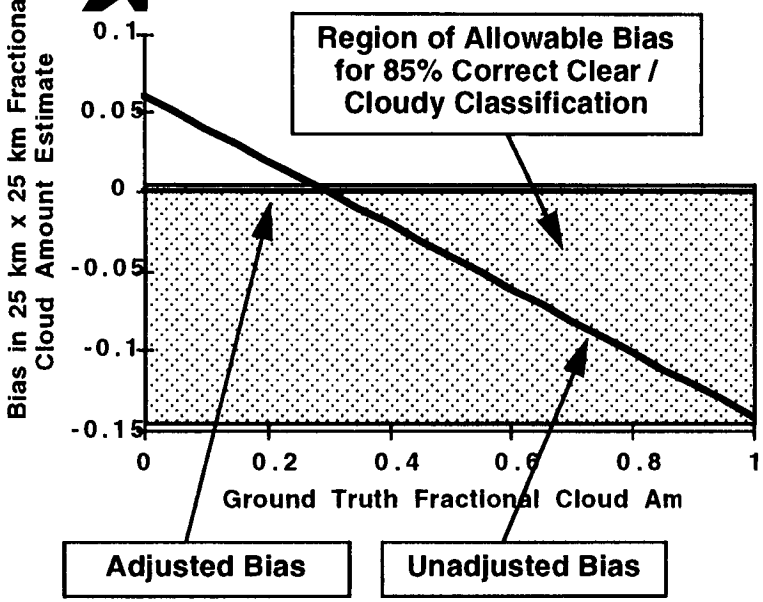
STATISTICAL CHARACTERIZATION OF 25 km BY 25 km GRID WITH 0.65 km PIXELS:

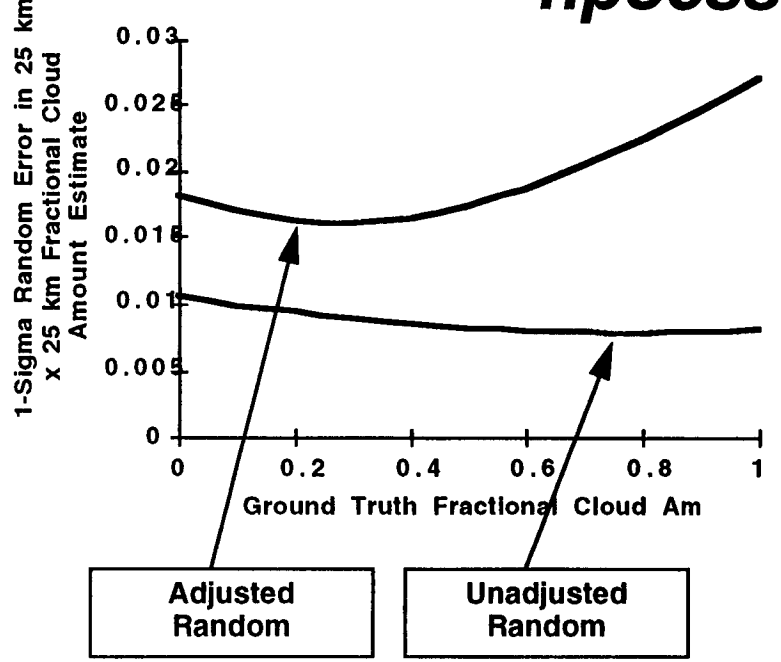
$$Bias = e_b = I_p(1-fca) - II_p fca = I_p - (I_p + II_p)fca$$

$$1-\sigma\ Random\ Error = \frac{\sqrt{fca(1-I_p)(-e_b)^2 + fca\, I_p(1-e_b)^2 + (1-fca)II_p(-1-e_b)^2 + (1-fca)(1-II_p)(-e_b)^2}}{25/0.65}$$

CLOUD COVER BIAS MUST BE ADJUSTED AT THE EXPENSE OF A SLIGHT INCREASE IN RANDOM ERROR

npoess

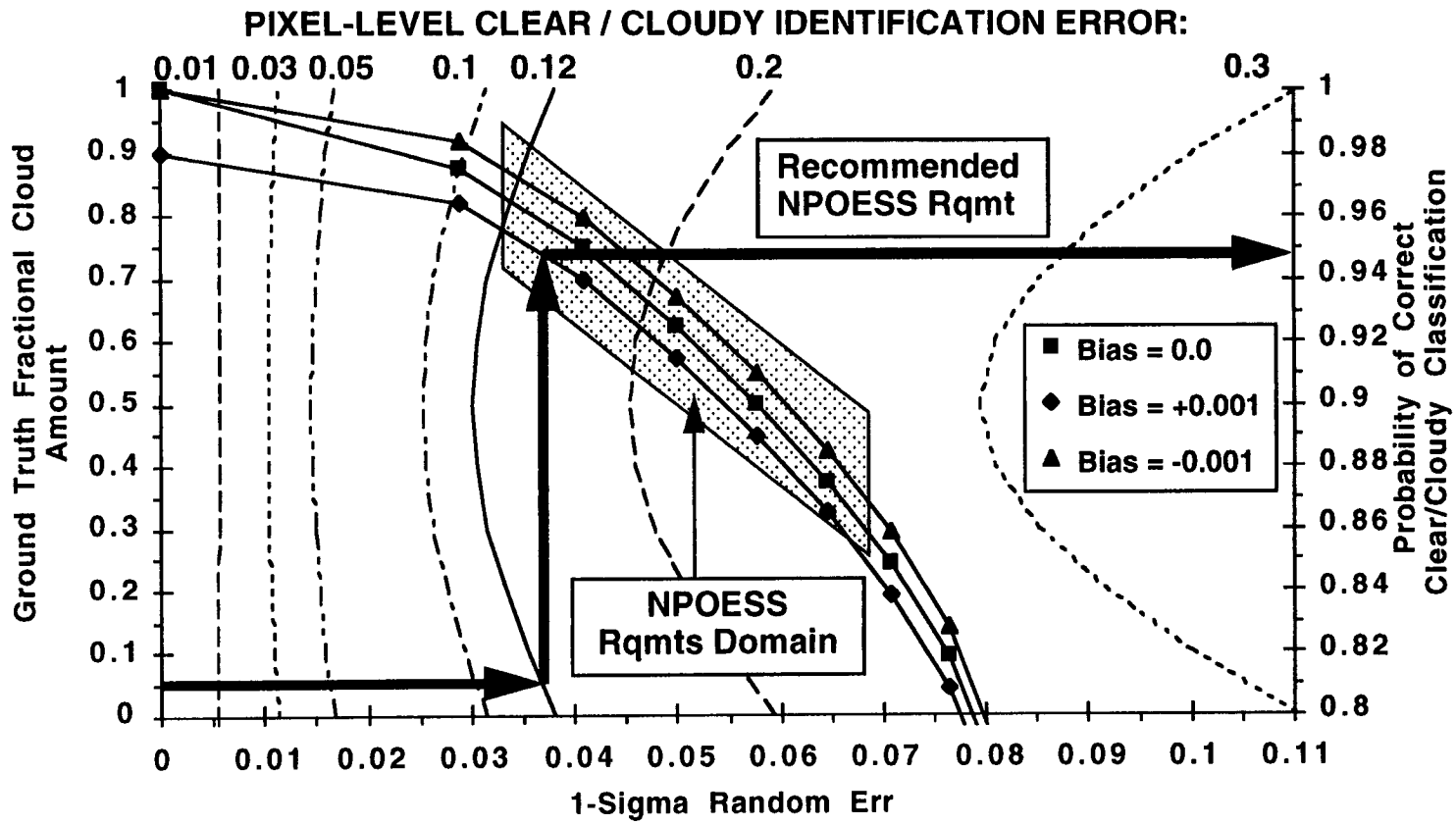




- DATA BASED ON LOCKHEED THIN CIRRUS IDENTIFICATION ALGORITHM PIXEL-LEVEL PERFORMANCE
- BIAS MUST BE ADJUSTED FOR GROUND TRUTH FRACTIONAL CLOUD AMOUNTS LESS THAN 0.3 TO ACHIEVE CLEAR / CLOUDY CLASSIFICATION PERFORMANCE
- ANALYSIS ASSUMES KNOWLEDGE OF PIXEL-LEVEL TYPE I AND II IDENTIFICATION ERRORS TO WITHIN 1-SIGMA UNCERTAINTY OF ±0.02
  - CHARACTERIZATION OF IDENTIFICATION ALGORITHM PERFORMANCE REQUIRED TO VALIDATE ASSUMPTION

END-TO-END CLEAR / CLOUDY CLASSIFICATION VS. PIXEL-LEVEL IDENTIFICATION PARAMETRICS

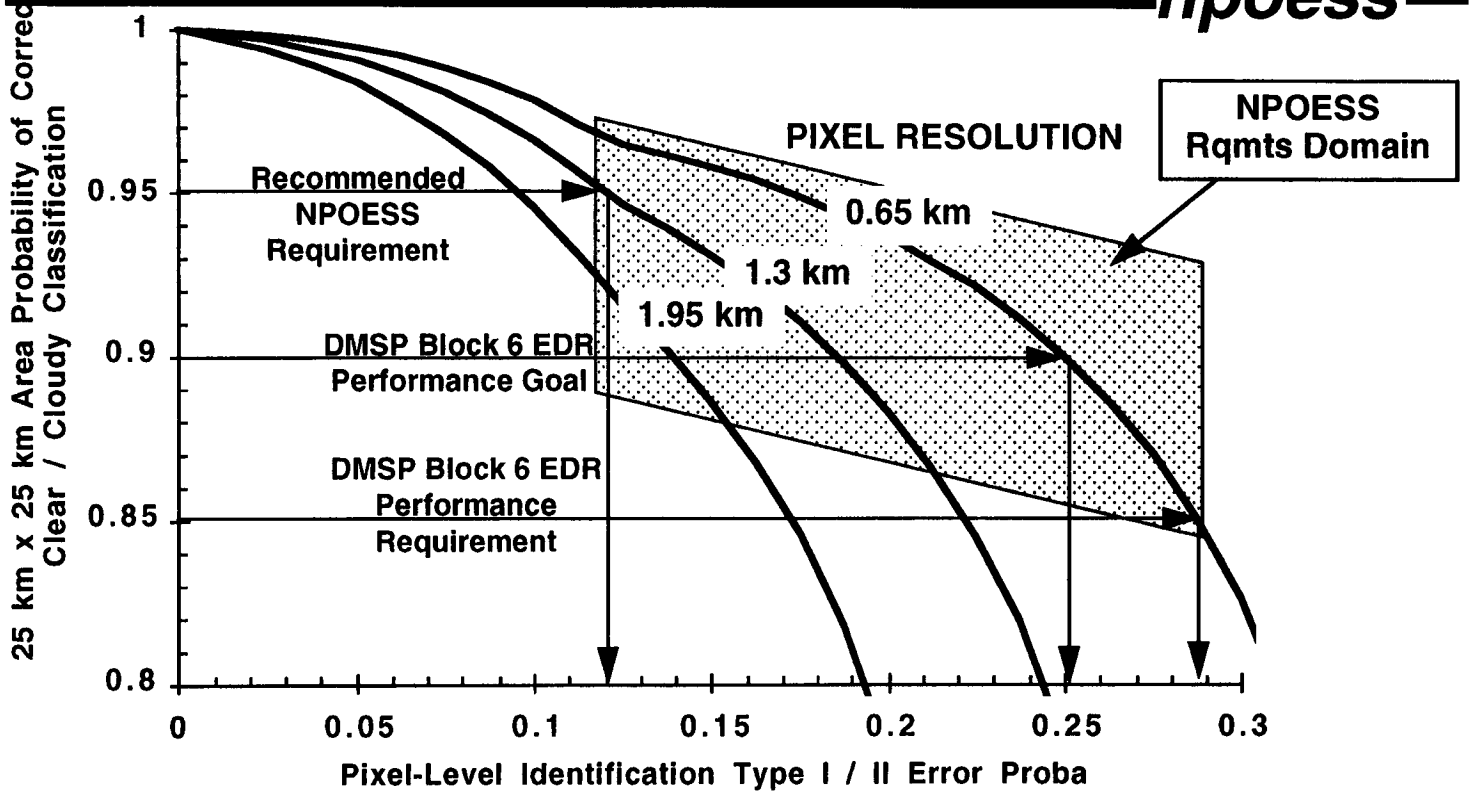
npoess



• ASSUMES PIXEL SIZE OF 1.3 km AND GRID SIZE OF 25 km x 25 km

SENSITIVITY OF RECOMMENDED REQUIREMENT TO PIXEL SIZE

npoess

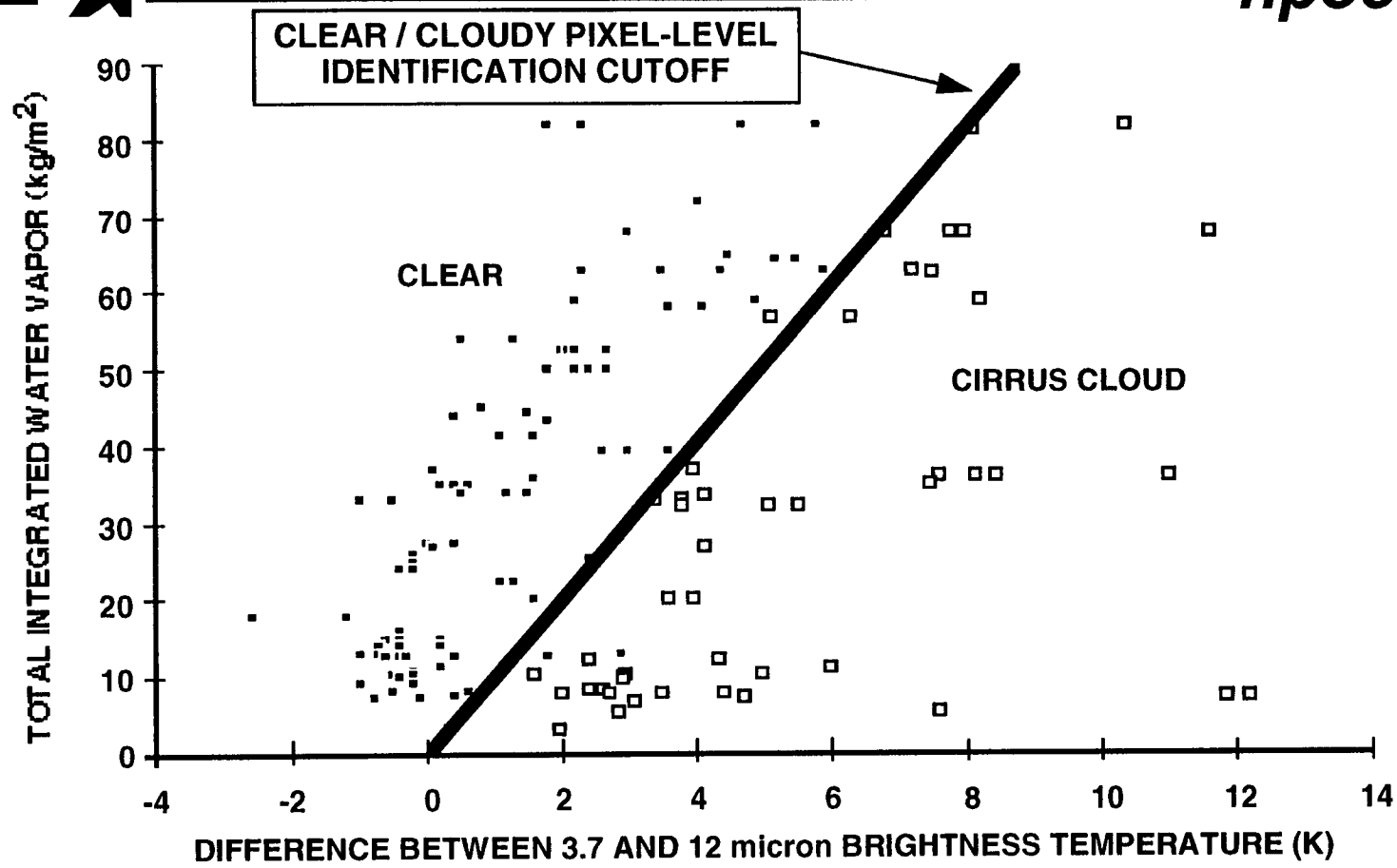


- AVERAGING OVER A 25 km x 25 km REGION PERMITS SIGNIFICANT PIXEL-LEVEL IDENTIFICATION ERRORS AND LARGER PIXEL SIZES
- REDUCTION OF BIAS IN FRACTIONAL CLOUD ESTIMATION PERMITS INCREASED PERFORMANCE WITH LARGER PIXEL SIZE

CONVERGENCE EFFORT MODIFICATION

RAW DATA FOR THIN CIRRUS IDENTIFICATION ALGORITHM ANALYSIS

npoess

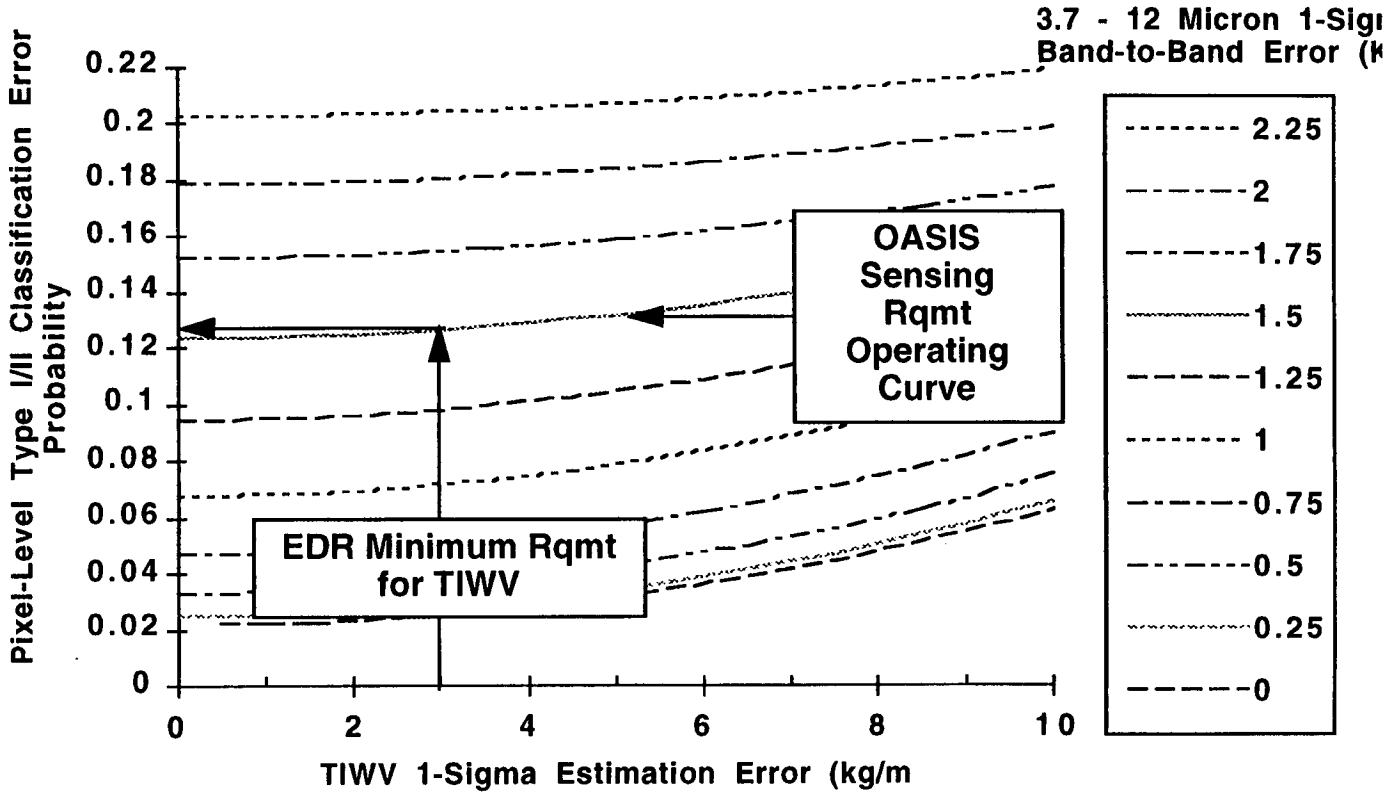


- DATA COLLECTED DURING DRY AND MOIST CONDITIONS IN FEBRUARY, MARCH, AND JULY 1992

CONVERGENCE EFFORT MODIFICATION

THIN CIRRUS PIXEL-LEVEL IDENTIFICATION ERROR VS. SENSING / EDR REQUIREMENTS

npoess

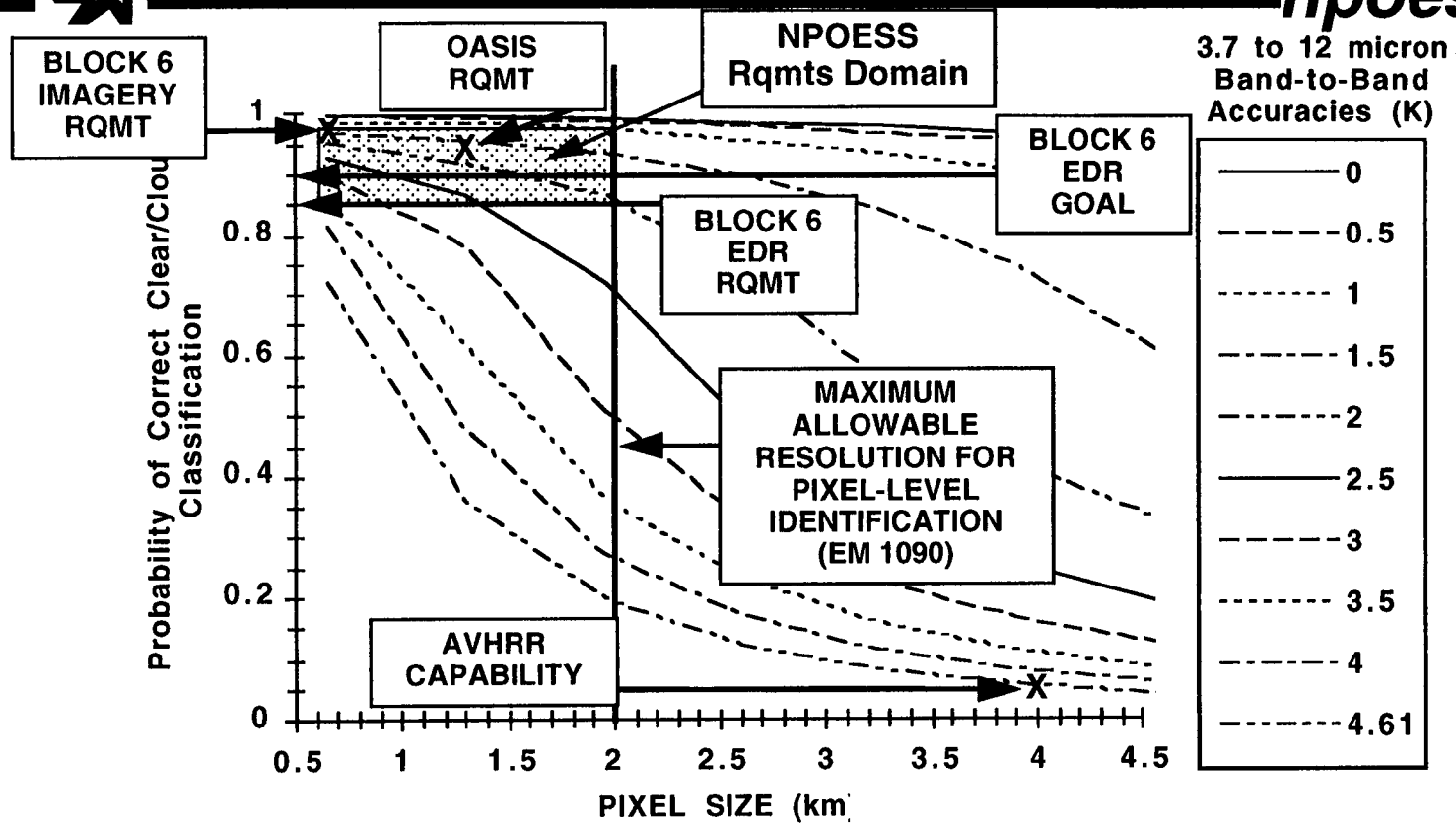


- PIXEL-LEVEL ERROR IS INSENSITIVE TO TIWV ESTIMATION ERROR
- OASIS REQUIREMENTS DOMAIN OF APPROXIMATELY 1.5 K BAND-TO-BAND ERROR YIELDS APPROXIMATELY 0.12 PIXEL-LEVEL ERROR PROBABILITY

CONVERGENCE EFFORT MODIFICATION

THIN CIRRUS END-TO-END SENSITIVITY TO PIXEL SIZE AND BAND-TO-BAND ERROR

npoess

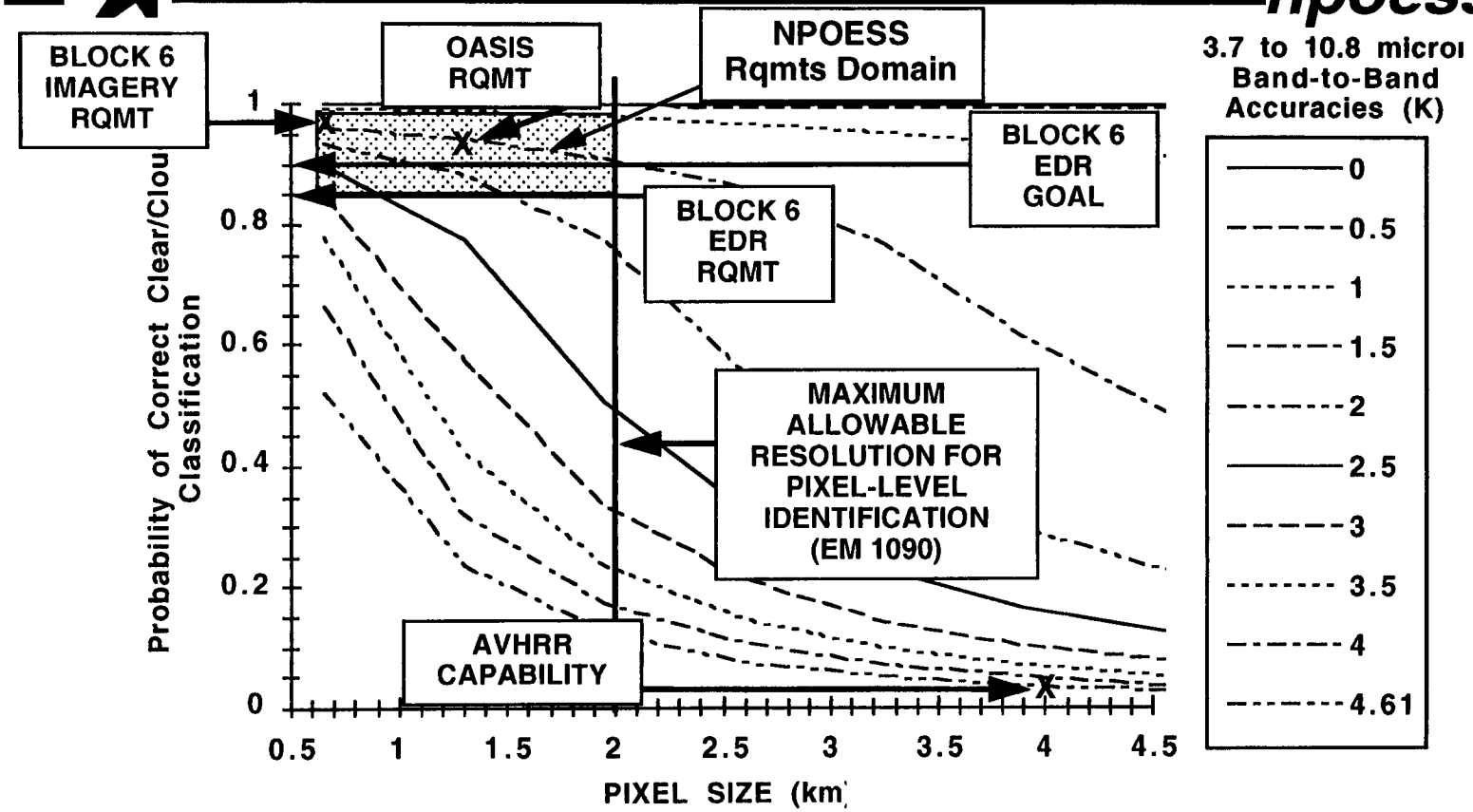


- REFERENCE TARGET IS 240 K BLACK BODY AT EDGE OF SCAN
- BLOCK 6 IMAGERY RQMT IS OVERKILL FOR THIN CIRRUS CLOUD PRODUCTS
- OASIS 1.3 km PIXEL WITH 1.5 K BAND-TO-BAND ACCURACY AT EDGE OF SCAN IS ADEQUATE

CONVERGENCE EFFORT MODIFICATION

LOW STRATUS / FOG END-TO-END SENSITIVITY TO PIXEL SIZE AND BAND-TO-BAND ERROR

npoess



- REFERENCE TARGET IS 240 K BLACK BODY AT EDGE OF SCAN
- BLOCK 6 IMAGERY RQMT IS OVERKILL FOR LOW STRATUS / FOG CLOUD PRODUCTS
- OASIS 1.3 km PIXEL WITH 1.5 K BAND-TO-BAND ACCURACY AT EDGE OF SCAN IS ADEQUATE

CONVERGENCE EFFORT MODIFICATION

PROCESSED CLOUD DATA REQUIREMENTS FLOWDOWN RECOMMENDATIONS FOR E/O SENSING

npoess

EDR REQUIREMENT	RECOMMENDED VALUE
25 km x 25 km GRID CLEAR/ CLOUDY CLASSIFICATION	0.95 PROB OF CORRECT CLASSIFY
FRACTIONAL CLOUD AMOUNT ESTIMATION ERROR	±0.001 BIAS 0.04 1-SIGMA RANDOM
PIXEL-LEVEL CLEAR/CLOUDY IDENTIFICATION ERROR	0.12 TYPE I AND II EQUAL ERROR RATE PROBABILITY

DERIVED SENSING REQUIREMENTS

3.7 TO 12 MICRON 1-SIGMA BAND-TO-BAND MEASUREMENT ERROR OF 1.5 K FOR A 240 K BLACK BODY TARGET AT 1.3 km RESOLUTION

3.7 TO 10.8 MICRON 1-SIGMA BAND-TO-BAND MEASUREMENT ERROR OF 1.5 K FOR A 240 K BLACK BODY TARGET AT 1.3 km RESOLUTION

- TOTAL INTEGRATED WATER VAPOR ESTIMATION ERROR ASSUMED TO BE LESS THAN 3 kg/m^2

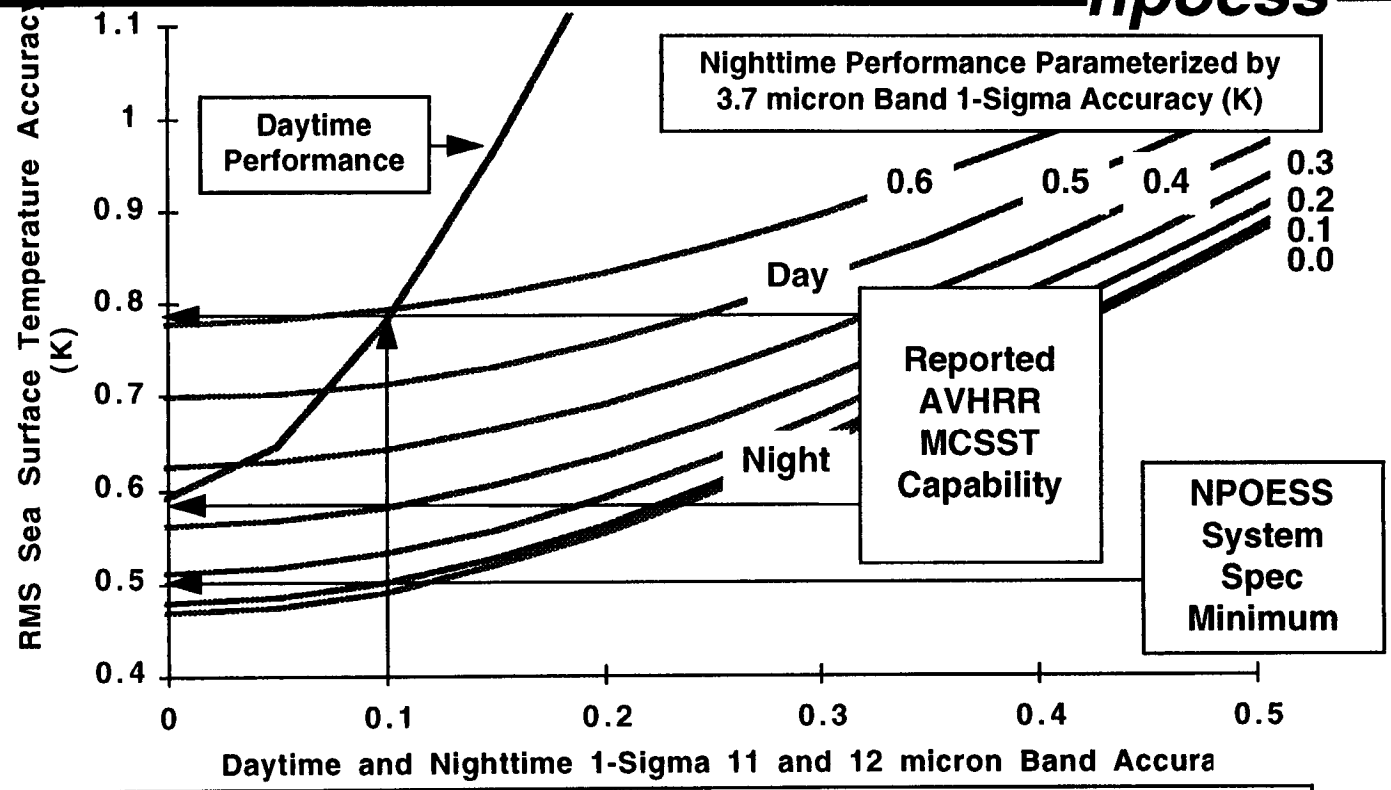
PROCESSED CLOUD DATA SUMMARY

npoess

- CLOUD COVER BIAS CAN BE REDUCED TO NEAR ZERO
  - MUST BE REDUCED TO ACHIEVE OPERATIONAL USER NEEDS FOR ACCURATE STATE OF SKY CLASSIFICATION
  - NPOESS A-SPEC MUST BE MODIFIED TO REFLECT NEAR-ZERO BIAS AND ALLOWABLE RANDOM ERROR
  - REQUIRES STATISTICAL CHARACTERIZATION OF PIXEL-LEVEL CLOUD IDENTIFICATION ALGORITHM TO VALIDATE
- E/O BAND MEASUREMENT ACCURACIES AND RESOLUTION SPECIFIED
  - FURTHER ANALYSIS REQUIRED TO ASSESS OTHER DRIVERS
    - » PIXEL-LEVEL IDENTIFICATION OF CLOUD TYPES OTHER THAN THIN CIRRUS AND LOW STRATUS / FOG
    - » CLOUD TYPING ALGORITHM DRIVERS
    - » OTHER EDRs, e.g. LAND AND SEA SURFACE TEMPERATURE
  - RECOMMEND E/O RESOLUTION REQUIREMENT OF 1.3 km FOR INPUT TO CENTRAL SITE CLOUD PRODUCT ALGORITHMS
    - » CAN REDUCE DATA VOLUME BY A FACTOR OF 4:1 RELATIVE TO DESIGN REFERENCE BASELINE
- RESULTS DOCUMENTED IN EMs (1136, 1137, 1138, AND 1139)

PRELIMINARY SEA SURFACE TEMPERATURE (SST) PARAMETRICS FOR E/O BANDS

npoess

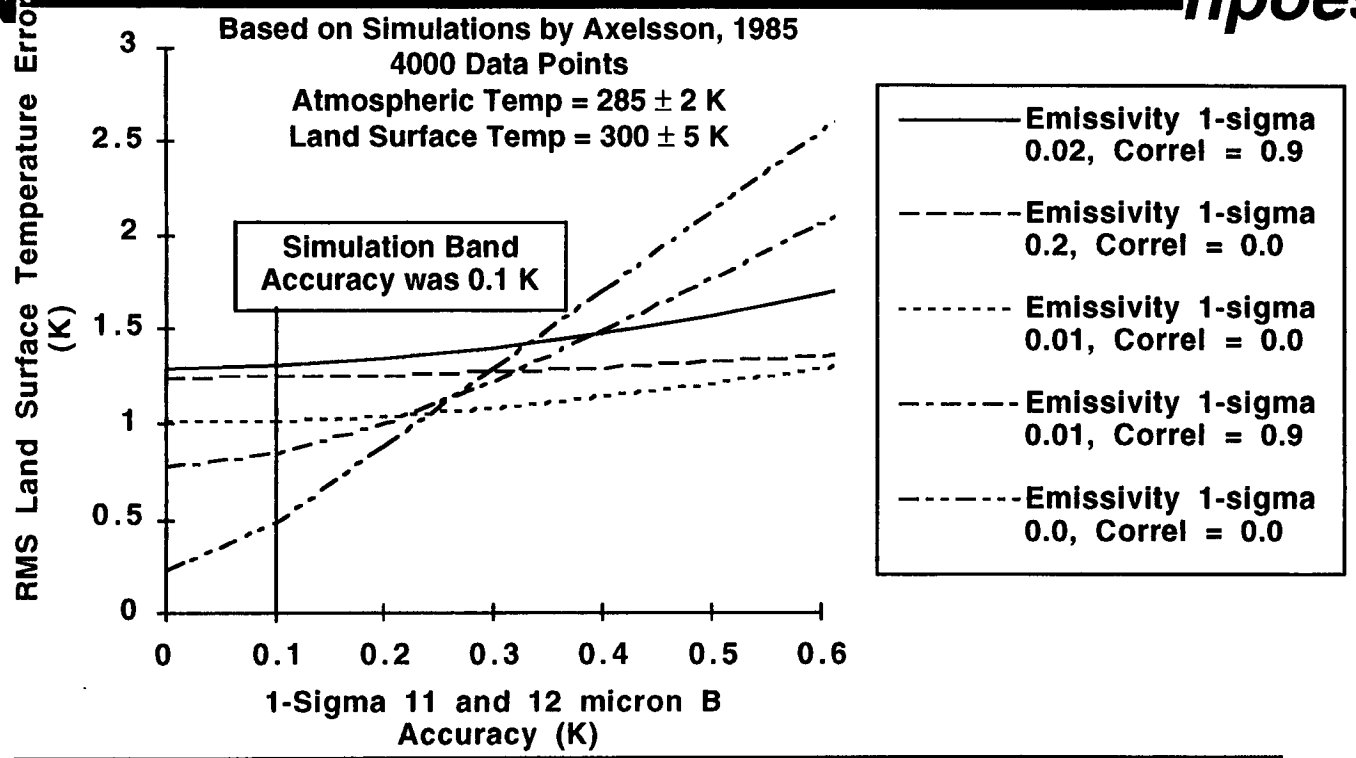


- NPOESS SYSTEM SPEC MINIMUM UNATTAINABLE USING E/O BANDS IN DAYTIME. ACHIEVABLE WITH 1-σ ERROR OF 0.1 K AT 3.7 microns AND 0.1 K AT 11/12 microns AT NIGHT.
- GOAL OF 0.25 K IS UNATTAINABLE
- BASED ON RESULTS FROM McCLAIN, ET. AL., 1983

CONVERGENCE EFFORT MODIFICATION

PRELIMINARY LAND SURFACE TEMPERATURE (LST) PARAMETRICS FOR E/O BANDS

npoess



- LST RMS ERROR OF 1.5 K APPEARS ACHIEVABLE with 0.3 K 1-SIGMA INSTRUMENT ERROR AND LESS THAN ± 0.02 UNCERTAINTY IN SURFACE EMISSITIVITY KNOWLEDGE
- SURFACE EMISSIVITY KNOWLEDGE IS A SIGNIFICANT DRIVER
- PARAMETRICS UNSTABLE BEYOND 0.25 K BAND ACCURACY
  - –ADDITIONAL MODELING AND ANALYSIS REQUIRED

SURFACE TEMPERATURE REQUIREMENTS FLOWDOWN RECOMMENDATIONS FOR E/O SENSING

EDR REQUIREMENT	RECOMMENDED VALUE
4 km x 4 km GRID SEA SURFACE TEMPERATURE ERROR	0.5 K 1-SIGMA ERROR (NIGHT TIME) 0.8 K 1-SIGMA ERROR (DAY TIME)
4 km x 4 km GRID LAND SURFACE TEMPERATURE ERROR	1.5 K 1-SIGMA ERROR

DERIVED SENSING REQUIREMENTS
3.7 MICRON 1-SIGMA MEASUREMENT ERROR OF 0.1 K FOR A 270 K TARGET AT 4 km RESOLUTION 11 AND 12 MICRON 1-SIGMA MEASUREMENT ERROR OF 0.1 K FOR A 270 K TARGET AT 4 km RESOLUTION
11 AND 12 MICRON 1-SIGMA MEASUREMENT ERROR OF 0.25 K FOR A 270 K TARGET AT 4 km RESOLUTION

SURFACE TEMPERATURE SUMMARY

npoess

- SEA SURFACE TEMPERATURE MINIMUM REQUIREMENTS NOT ACHIEVABLE WITH IMPROVEMENTS IN AVHHR BAND ACCURACIES
  - INVESTIGATION OF ALGORITHM AND SENSOR BAND UPDATES NECESSARY
    - » USE OF MULTI-SPECTRAL HIGH RESOLUTION CLOUD-CLEARING (CURRENT AVHRR REJECTS OVER 90% OF PIXELS OVER OCEAN)
    - » INVESTIGATION OF CONTRIBUTION OF ADDITIONAL OASIS BANDS MAY YIELD SIGNIFICANT IMPROVEMENTS
- LAND SURFACE TEMPERATURE MINIMUM REQUIREMENT OF 1.5 K RECOMMENDED
  - INVESTIGATION OF METHODS TO OBTAIN ACCURATE SURFACE EMISSIVITY KNOWLEDGE REQUIRED
- RESULTS DOCUMENTED IN EM 1147

EDR ALGORITHM ANALYSIS SUMMARY

npoess

- ESTABLISHED ALGORITHM ANALYSIS AND REQUIREMENTS FLOWDOWN APPROACH
- DEVELOPED TRACEABLE, VERIFIABLE, AND CONSISTENT RECOMMENDATIONS FOR CLOUD PRODUCT AND SURFACE TEMPERATURE REQUIREMENTS
  - FEASIBILITY AND AFFORDABILITY TO BE EVALUATED BY DESIGNERS
- FUTURE ACTIVITY WILL INCLUDE:
  - COMPLETION OF CLOUD PRODUCTS ANALYSIS
  - ANALYSIS OF IMAGERY, SOUNDING, AND OTHER KEY PARAMETERS

npoess

C3 REQUIREMENTS IMPACTS & ALTERNATIVE DEVELOPMENT

R. NELSON

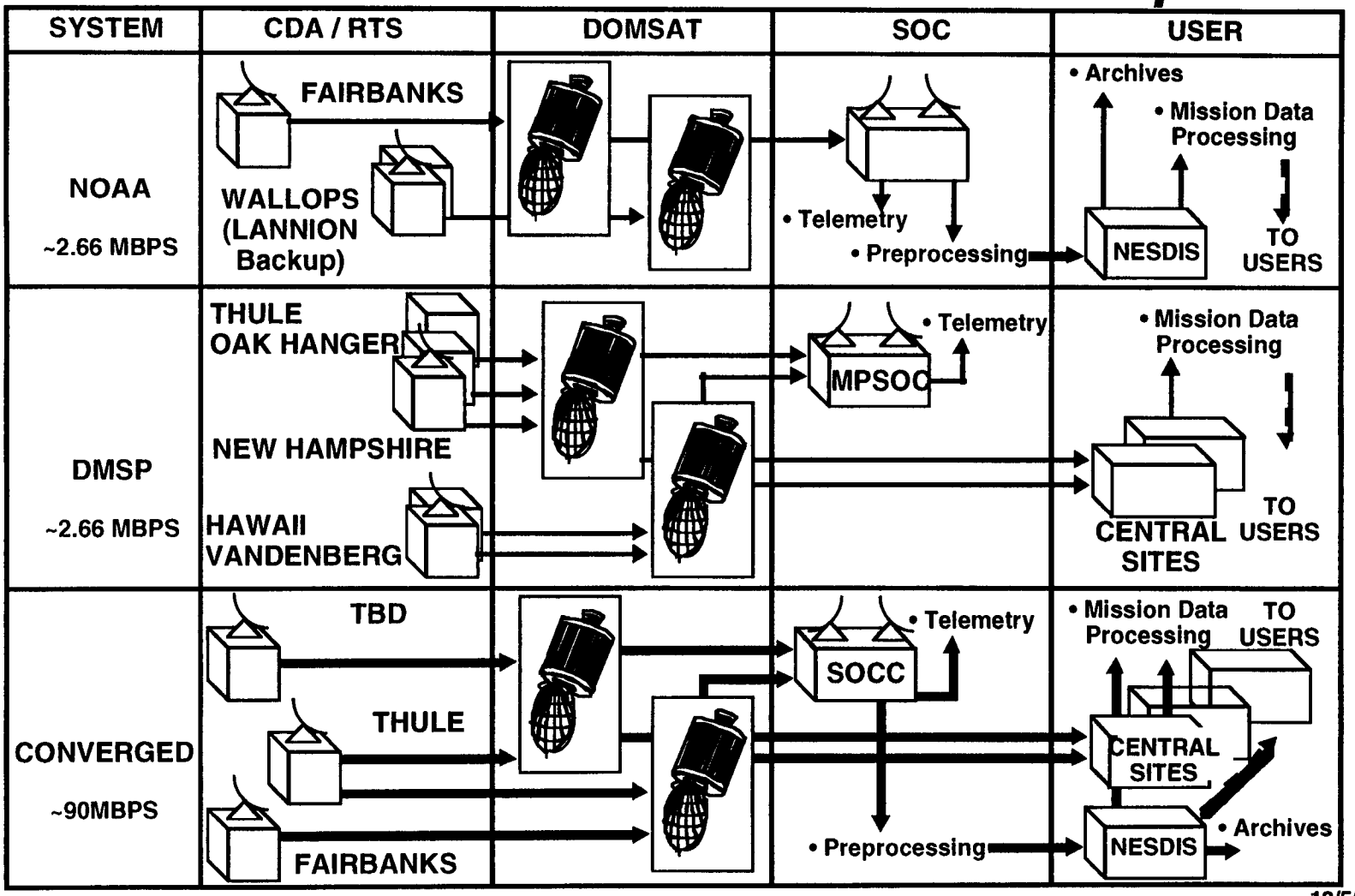
CONVERGED C3 TIM OVERVIEW

npoess

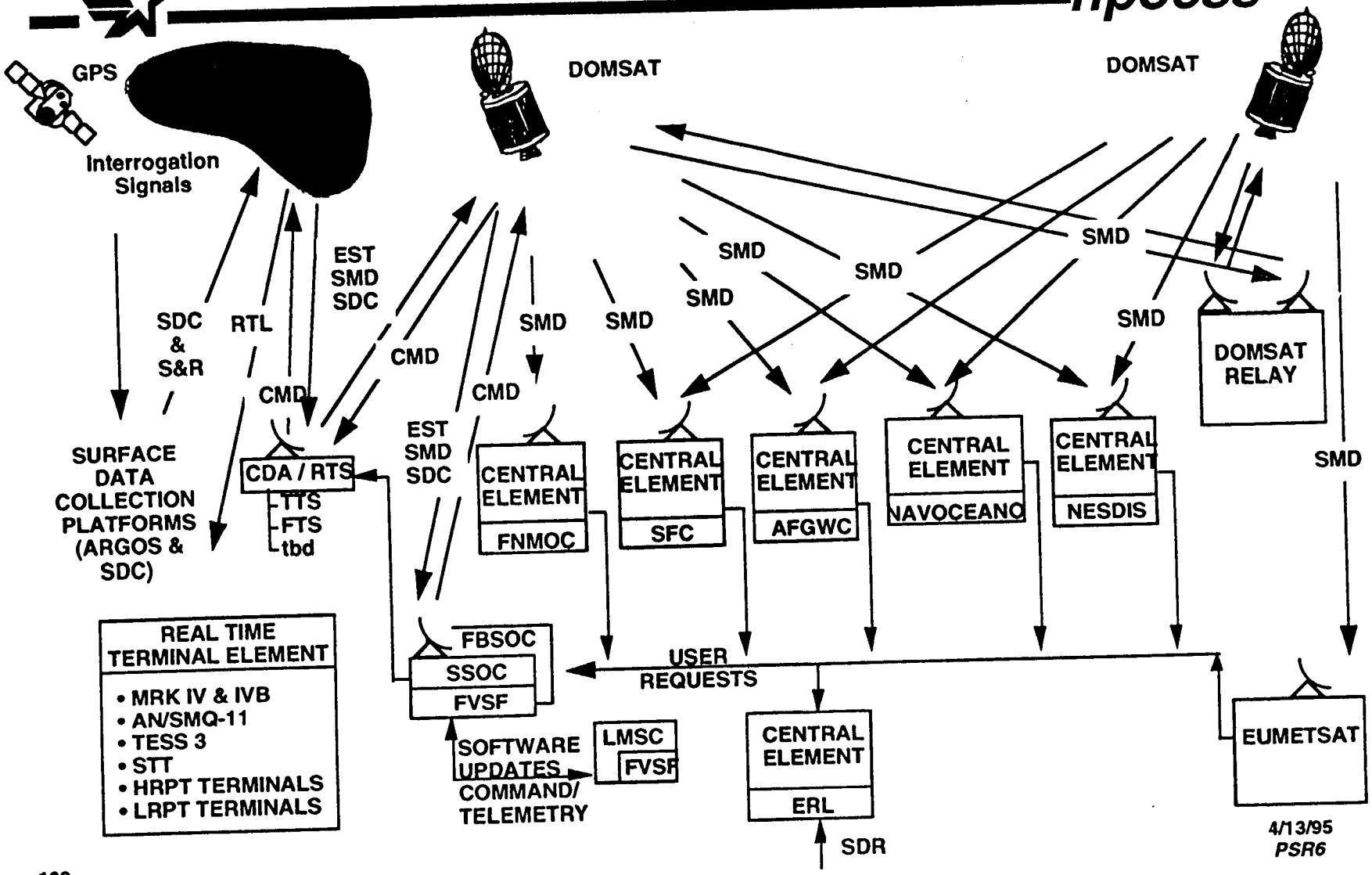
- REVIEWED CONVERGED SEGMENT FUNCTIONS
- REVIEWED SYSTEM / SEGMENT REQUIREMENTS
- REVIEWED DRIVING REQUIREMENTS IMPACTS
  - Integrated, End - to - End Architecture
- PRESENTED TRADES
  - SMD
  - DRR
  - Realtime Data Characteristics with Data Compression Options
  - COTS Benefits
- REVIEWED SEGMENT BASELINE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

DATA GROWTH: A TRANSITION CHALLENGE

npoess



CONVERGED SYSTEM BASELINE ARCHITECTURE



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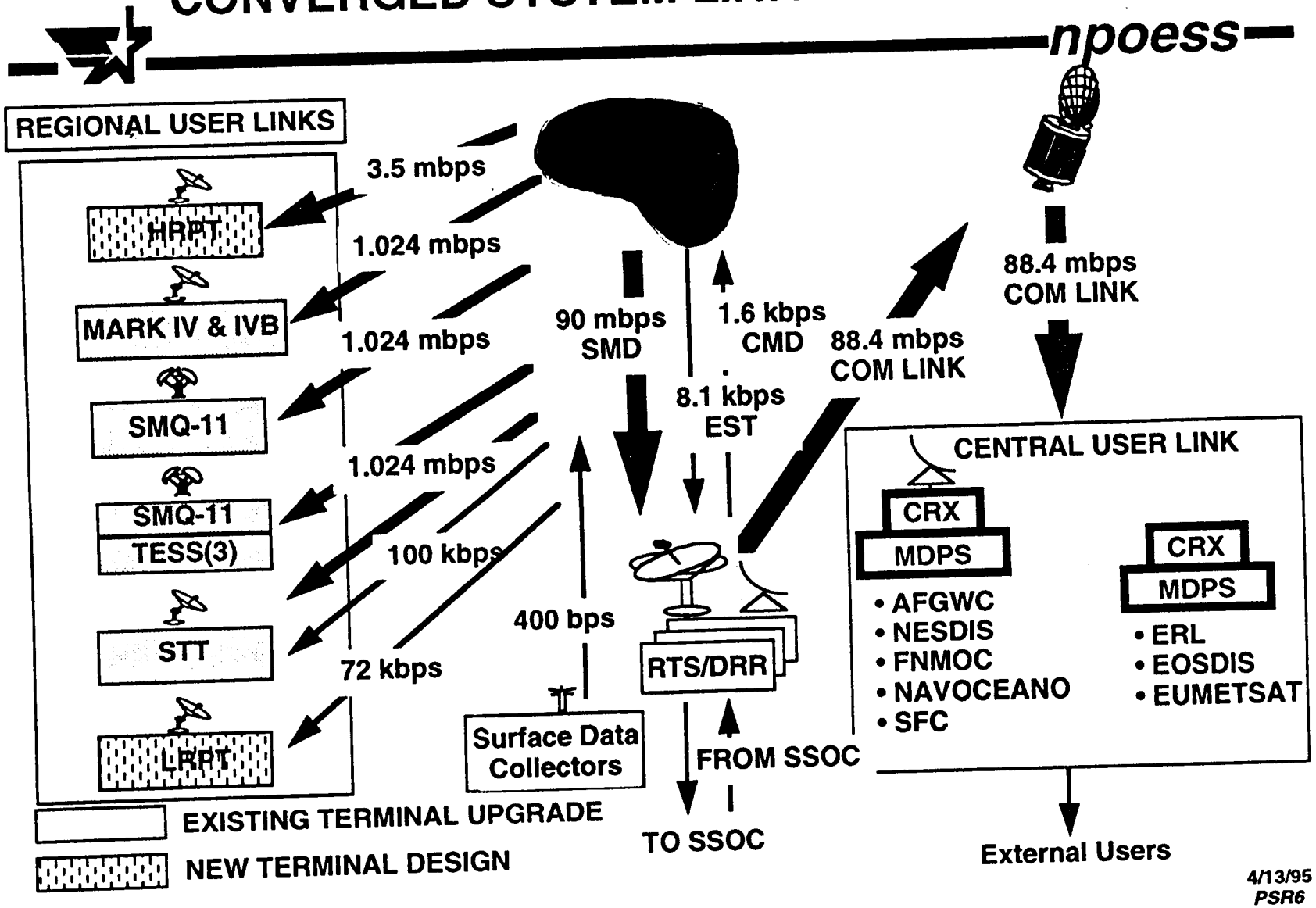
CONVERGED SYSTEM LINK OVERVIEW



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CONVERGENCE EFFORT MODIFICATION

CONVERGED C3 DERIVED DATA REQUIREMENTS

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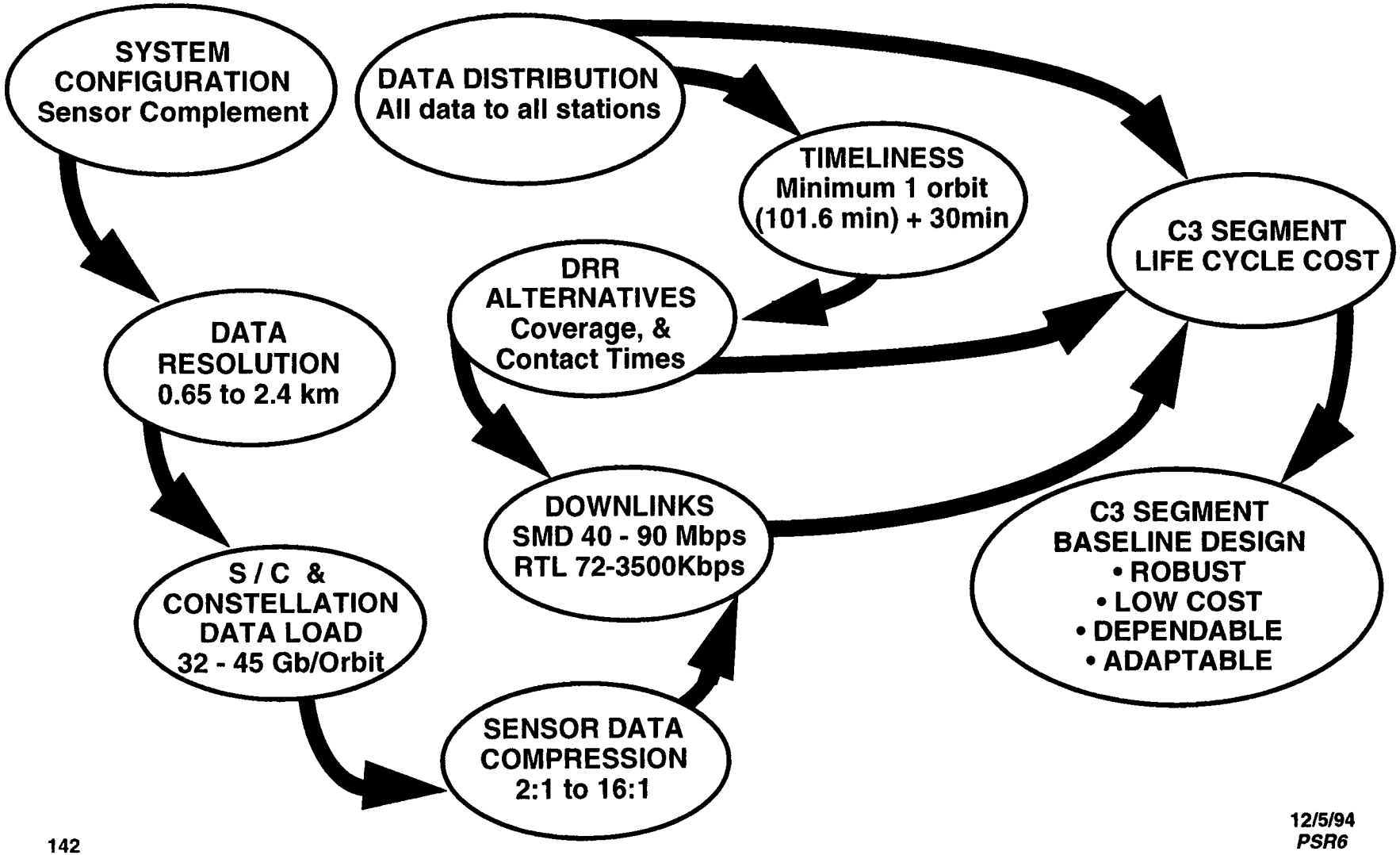
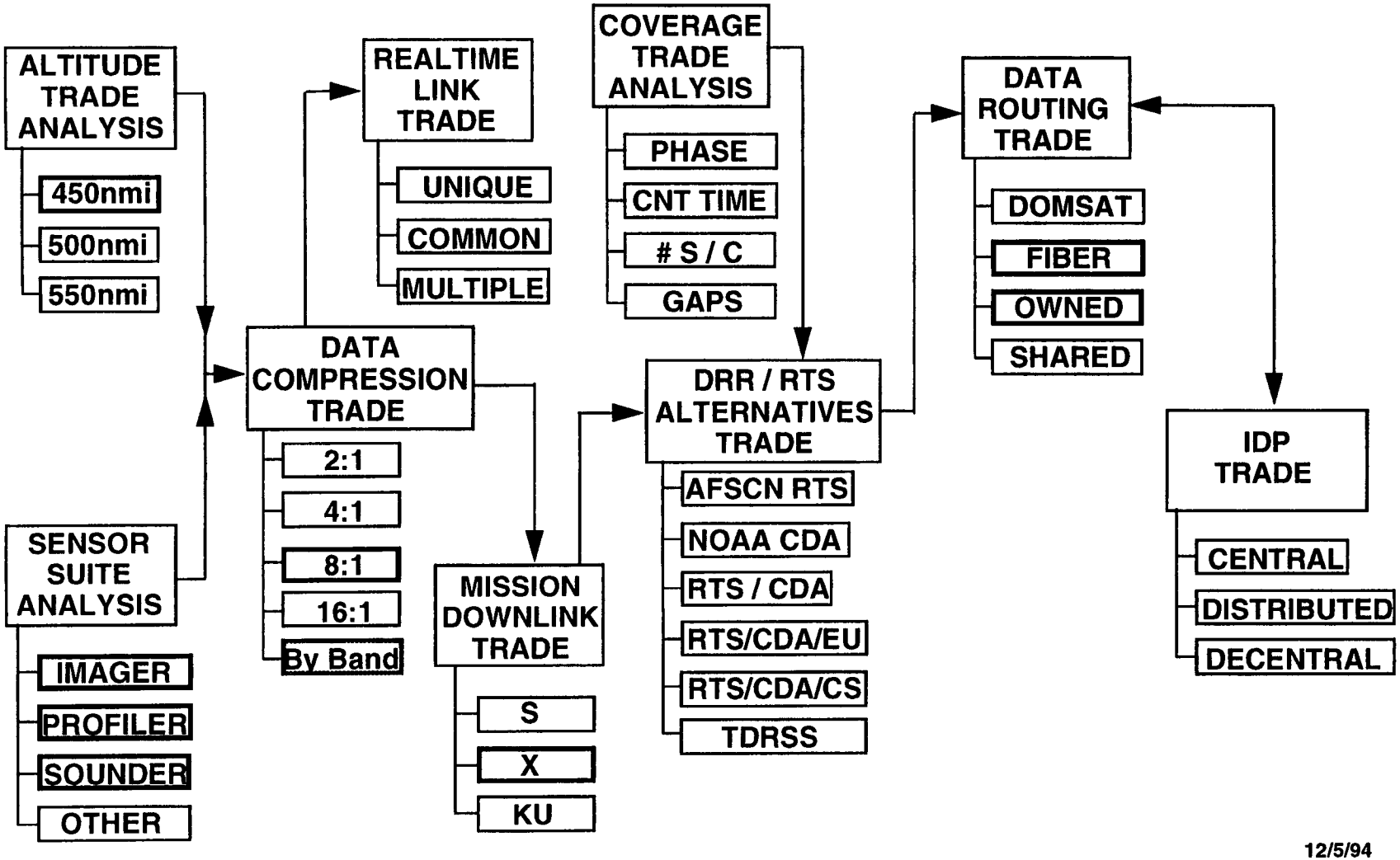
PARAMETER	REQUIREMENT	DERIVED REQUIREMENT
On Board Sensor Data Rate		Data Rate with 15% overhead
O1	4.55 mbps	5.23 mbps
O2 (EUMETSAT)	6.04 mbps	6.95 mbps
O3	5.98 mbps	6.88 mbps
Mission Data Storage	Data for 2 orbits	84.6 Gb
Mission Data Offload	Data for 1 orbit	
O1	27.8 Gb	31.9 Gb
O2	36.8 Gb	42.3 Gb
O3	36.4 Gb	41.9 Gb
SMD Downlink	X-Band	8.255 GHz (TBR)
Data Rate (8.5 min contact without gaps)	Data for 1 orbit	90 mbps
Downlink Sites	3 CDA / RTS	TTS, FTS, (TBD)
Timeliness	EDR products: 1orbit period, + 30 min routing, + 20min processing	SDR product delivery 30 min.
Data Format	TBD	CCSDS

C^3 - IDP TRADE SPACE INTERACTION DIAGRAM for C^3

npoess



C^3 - IDP TRADE FLOW



DRIVING REQUIREMENTS & IMPACTS

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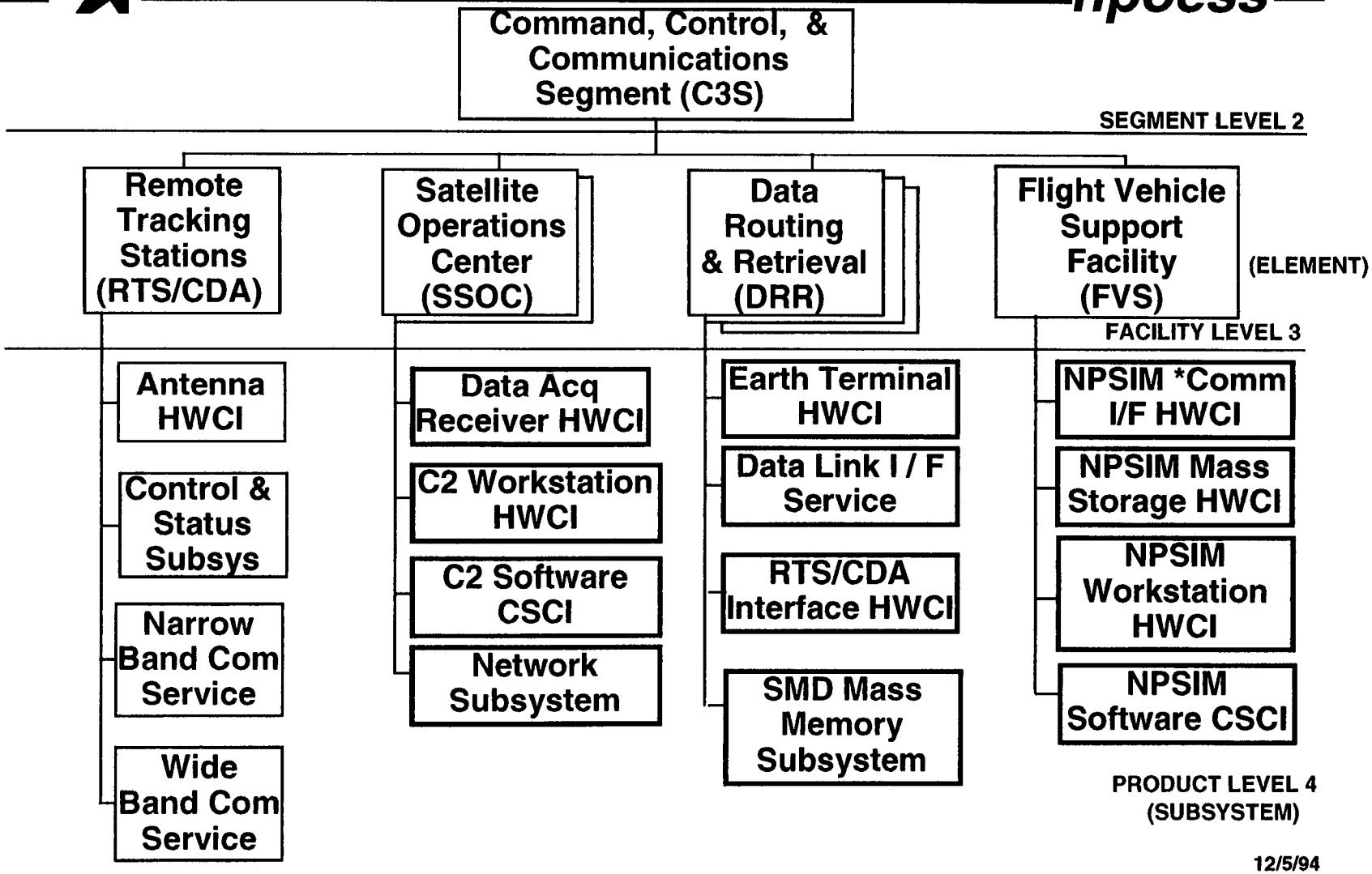
PARAMETER	JUNE 94 SPEC	OCTOBER 94 SPEC	BASELINE IMPACT
DATA REFRESH	MINIMUM SYSTEM REVISIT; 4 HOURS	3 S/C CONSTELLATION	NO IMPACT
EDR PRODUCTS	37 EDR PRODUCTS	72 EDR PRODUCTS	NO IMPACT
DATA RESOLUTION	2.6 KM REGIONAL .65 - 1.3 KM GLOBAL E/O DATA	E/O SENSOR DATA RESOLUTION - 0.65KM	INCREASE RTL DATA RATE OR COMPRESS ≥ 8 :1
DATA CAPACITY	31 - 43 GB / ORBIT	43 GB / ORBIT	NO IMPACT
DRR CONFIGURATION	100% COVERAGE (FTS, TTS, KTS)	100% COVERAGE w/o FRGN CDA	CONTACT TIME 6 MIN DATA RATE 128 MBPS
TIMELINESS	ONE ORBIT + 30 MIN TO IDPS	ONE ORBIT + 30 MIN TO IDPS	NO IMPACT
DATA RATE	90 MBPS SMD <3.5 MBPS RTL	90 MBPS SMD <3.5 MBPS RTL	NEW RTL DESIGNS
IDPS PROCESSING	ALL DATA ALL SITES	ALL DATA ALL SITES	HIGH COST

CONVERGED C3 SEGMENT HIERARCHY

npoess



COTS APPROACH TO C2

R. HAMER

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
- SMC/CW DIRECTED A STUDY OF OPEN ARCHITECTURE C2 SYSTEMS - 1993
- CLEMENTINE C2 WAS OPEN ARCHITECTURE LOW COST SYSTEM
- SMC/CU SATELLITE C2 OPEN ARCHITECTURE TEST BED IN OPERATIONS AT NTF 1994
- NASA WIND, POLAR, SOHO & SMEX WILL ALL USE OPEN ARCH SYSTEMS - 1995
- SMC/CU POSITION NEW KIRTLAND SYSTEM WILL BE OPEN ARCH COTS - 1996

USE OF COTS FOR C2 NPOESS ALTERNATIVES

- 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

CONVERGENCE EFFORT MODIFICATION

OPEN ARCHITECTURE

npoess

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)

COTS USAGE CONSIDERATIONS

npoess

- INTEGRATION REQUIRED TO GLUE PRODUCTS TOGETHER
  - Cheaper than full scale development/less specialization required
- COTS PRODUCT UPGRADES (IF ADOPTED) MAY REQUIRE RE-INTEGRATION INTO OPERATIONAL SYSTEM
  - Not necessary to install upgrades, interfaces usually not effected
- RAPID ADVANCES CAN QUICKLY OUTDATE/INCREASE PERFORMANCE POTENTIAL HDW & SW
  - Open architecture allows easy incorporation of new HW and SW
- USERS HAVE LESS CONTROL OVER COTS CHANGES (COMMERCIAL MARKET DRIVEN)
  - Large base identifies needed changes early which expedites fixes

ADVANTAGES OF COTS BASED C2 SYSTEMS

npoess

- REDUCES DEVELOPMENT SCHEDULE
- REDUCES TECHNICAL/COST RISK
- REDUCES ACQUISITION 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

SATELLITE C2 TECHNOLOGY ADVANCES

npoess

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

C3 SEGMENT SPEC CONCERNS

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- ADA (MIL-STD 1815A) STILL COMPLIANT DOCUMENT FOR NEW OR MODIFIED SOFTWARE
  - ADA / UNIX INTERFACE IS VERY COMPLEX AND MAY KILL ALL SAVINGS AVAILABLE THROUGH USE OF COTS

- PROGRAMMING LANGUAGES (3.3.11.1.1) LANGUAGE ACCEPTABLE TO BOTH AF AND NOAA
  - UNABLE TO QUOTE OR DESIGN TO THIS REQUIREMENT

- MIL-STDs INVOKED MAY NO LONGER BE APPROPRIATE WITH REQUIREMENT THAT WAIVER TO USE BE OBTAINED
  - I.E. MIL-STD 454 IS ON LIST TO BE CANCELLED BY DEFENSE STANDARDIZATION PROGRAM DIVISION

NEW SPEC ELIMINATES THESE CONCERNS

COTS CONCLUSIONS

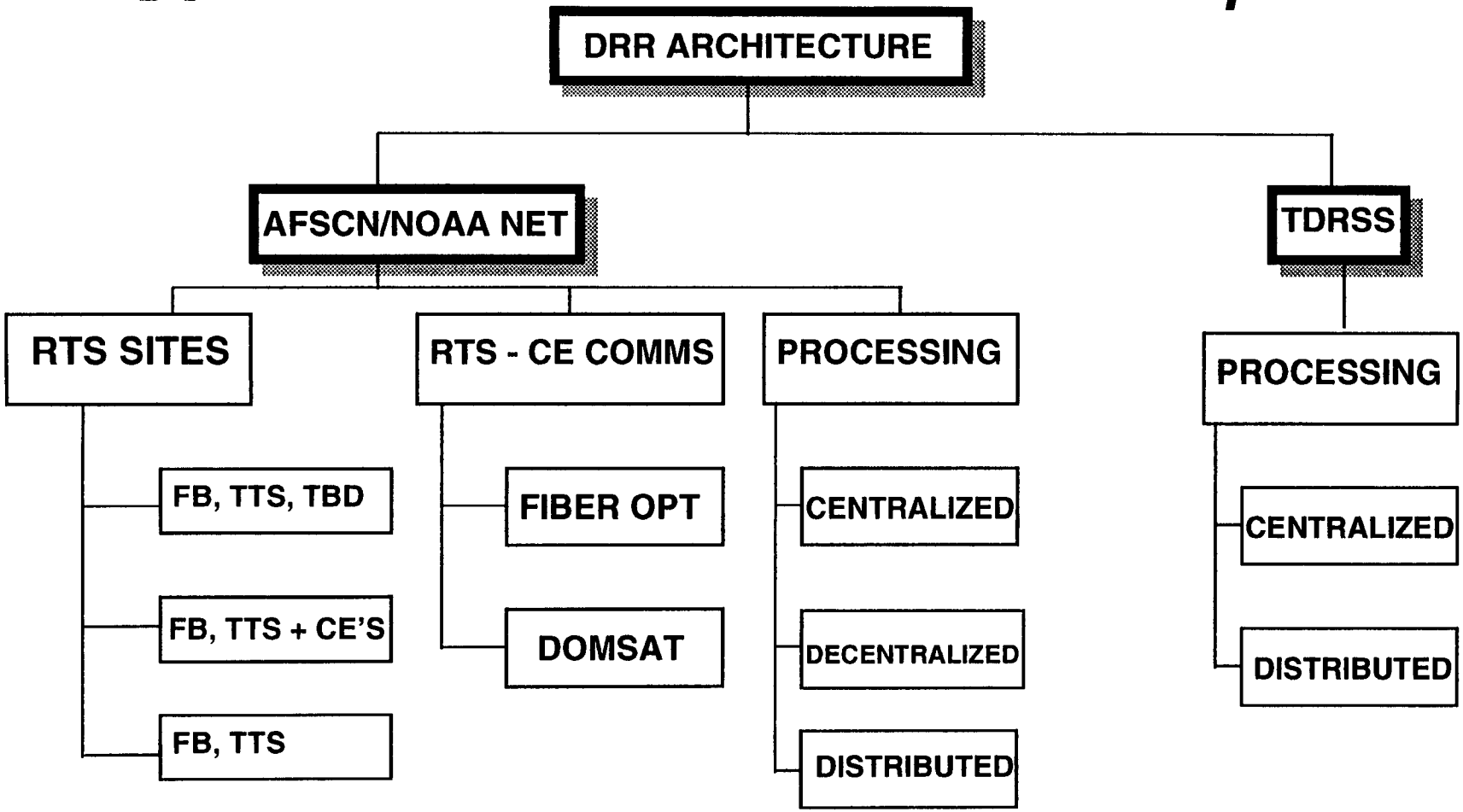
- MATURE COMMERCIAL HARDWARE AND SOFTWARE ELIMINATE THE NEED FOR EXPENSIVE CUSTOM DESIGNED SATELLITE COMMAND AND CONTROL SYSTEMS
- COMMERCIAL STANDARDS ARE AVAILABLE NOW THAT ALLOW ACROSS PLATFORM DESIGNS
- PROGRAMMING TO SET OF COMMERCIAL STANDARDS
- FUTURE GAINS WILL FURTHER REDUCE COSTS/IMPROVE PERFORMANCE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

npoess

DRR - GUS ARCHITECTURE

D. EMANUEL

DRR TRADE TREE



DRR TRADE STATUS

- 16 ARCHITECTURE OPTIONS BEING EVALUATED; 8 UTILIZING TDRSS AND 8 DOMSAT / FIBER OPTIC LINKS
- TIMELINESS AND COVERAGE EVALUATIONS IN PROCESS
- PRELIMINARY RELATIVE COST RANKING COMPLETE; REFINEMENTS NECESSARY WHEN TIMELINESS / COVERAGE EVALUATIONS ARE COMPLETED

DRR TRADE STUDY ASSUMPTIONS

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- THREE SATELLITES NEEDED TO BE SUPPORTED SIMULTANEOUSLY
- CENTRALIZED PROCESSING REDUCES DATA RATE TO DS-1 (1.5 MBPS) TO OTHER SITES
- 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 THE 10 YEARS 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 & AFGWC ASSUMED AS CENTRALIZED LOCATIONS FOR DATA PROCESSING IN CENTRALIZED CONFIGURATIONS

CONVERGENCE EFFORT MODIFICATION

EIGHT DRR ALTERNATIVES

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(EXCLUDING TDRSS)

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

CONVERGENCE EFFORT MODIFICATION

CONFIG A: NORTHERN RTS'S, FO COMS CENTRALIZED PROCESSING

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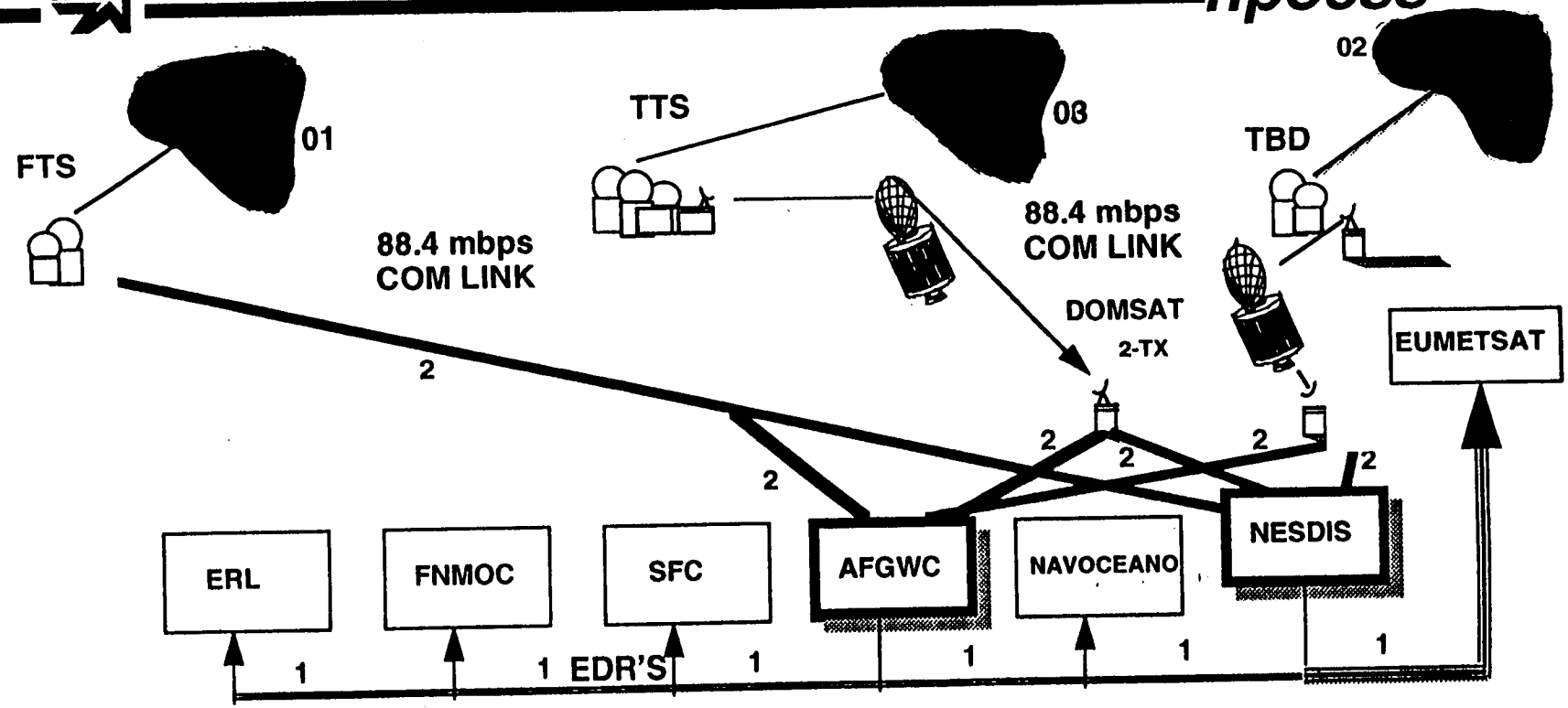


COMMUNICATION LINK REQUIREMENTS

TYPE	CONUS FO (DS3)	OCONUS FO (DS3)	TRANSOCEAN FO (DS3)	DOMSAT TX/ TER		LO RATE FO (DS1)	LO RATE TRNSOCN (DS1)
QUANTITY	12	0	0	4	4	5	1

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

12/5/94
PSR6

CONFIG A: NORTHERN RTS'S, FO COMS CENTRALIZED PROCESSING

FEATURES

COMMERCIAL DOMSAT SUPPORT TO CONUS FO NETWORK;
ALL DATA ROUTED TO BOTH PRIME AND BACKUP SITES

ADVANTAGES

NORTHERN RTS's PROVIDE COMPLETE COVERAGE;
NO GAPS, 8 MINUTE MASS TIMES

FO LINKS PROVIDE BETTER DATA QUALITY

DISADVANTAGES

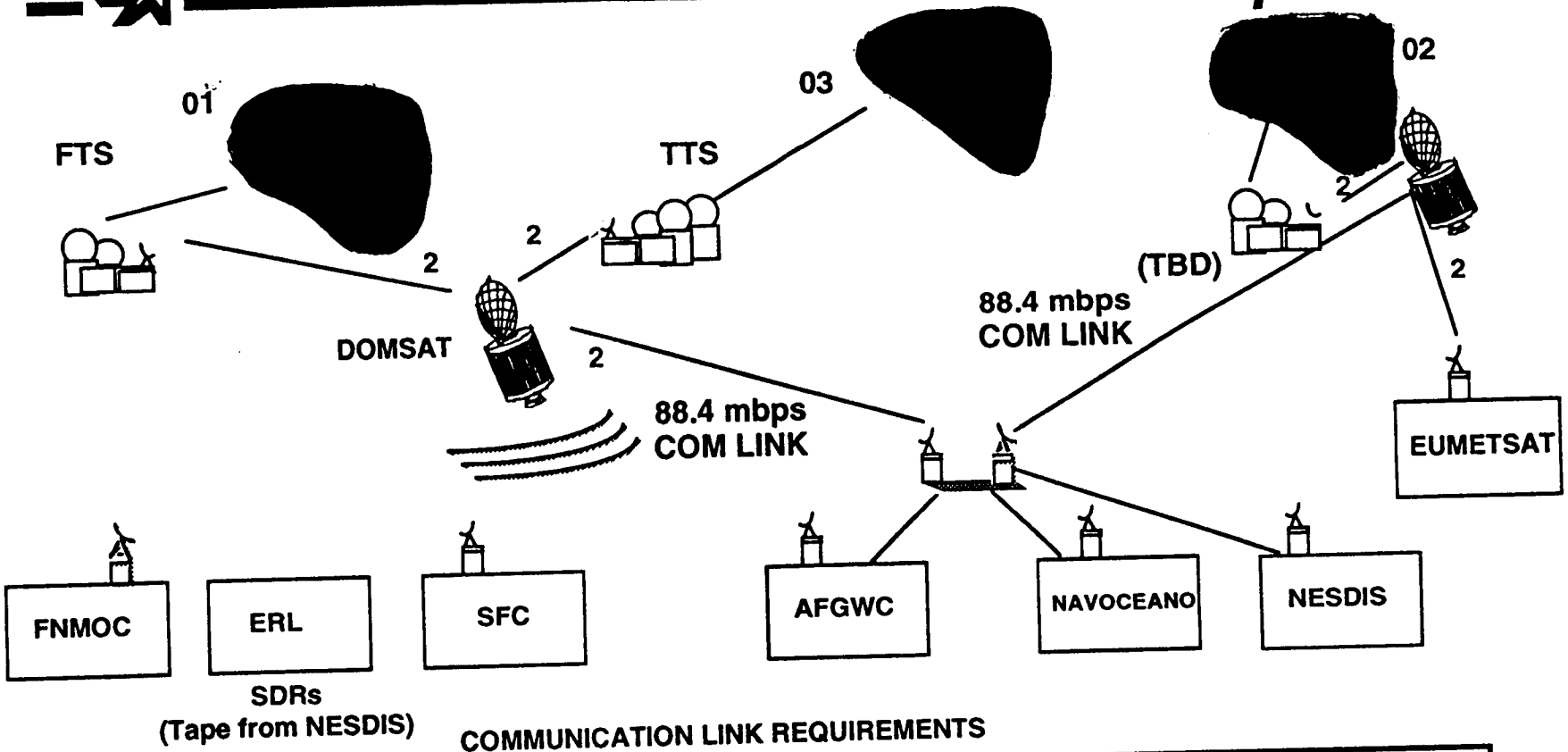
HEAVY PROCESSING LOAD AT PRIME PROCESSING SITE

EDR SIZE MAY ELIMINATE ABILITY TO USE DS-1 LINKS FOR DATA TRANSFER TO OTHER CE's AND INCREASE COST SIGNIFICANTLY

CONVERGENCE EFFORT MODIFICATION

CONFIG D: NORTHERN RTS'S, DOMSAT'S, DISTRIBUTED PROCESSING

npoess



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	12 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
PSR6

CONFIG D: NORTHERN RTS'S, DOMSAT'S, DISTRIBUTED PROCESSING

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FEATURES

ALL SITES OBTAIN DATA THROUGH A DOMSAT IN A BROADCAST MODE

A DOUBLE DOMSAT HOP IS REQUIRED TO GET DATA FROM AND TO EUROPE

EUMETSAT GETS DATA FROM 01, 02, AND 03 THROUGH DOMSAT

ADVANTAGES

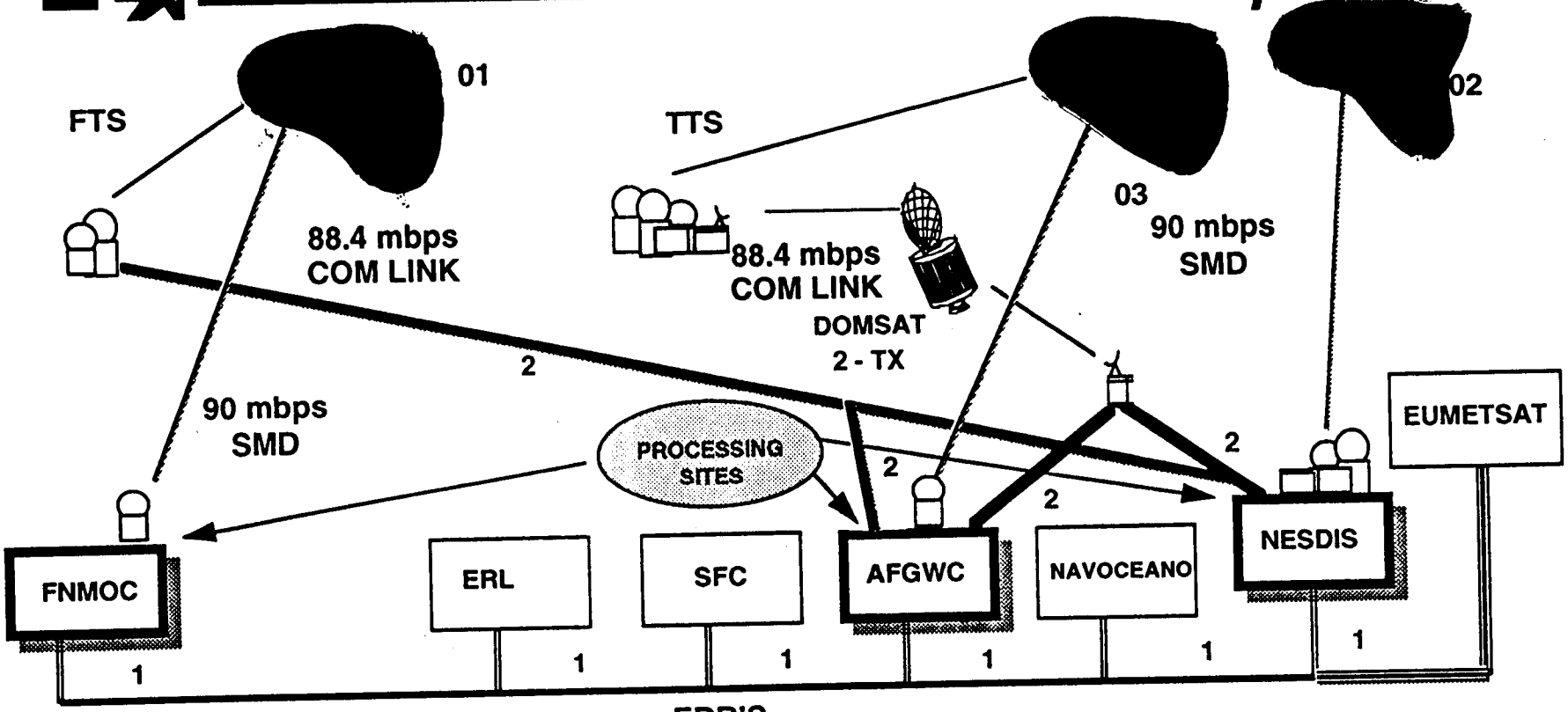
- ALL CENTRAL ELEMENTS (CE) GET ALL DATA
- INTER - CE EDR DATA LINK NOT REQUIRED

DISADVANTAGES

- REQUIRES MORE HIGH THRUPUT RATE PROCESSING CAPABILITY
- DRR FUNCTION TOTALLY DEPENDENT ON DOMSAT's

CONVERGENCE EFFORT MODIFICATION

CONFIG E: 2 RTS'S + CE'S, FO COMS DECENTRALIZED PROCESSING



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	8	0	0	2 2	5	1

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

4/13/95
PSR6

CONFIG E: 2 RTS'S + CE'S, FO COMS DECENTRALIZED PROCESSING

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FEATURES

THREE CONUS SITES HAVE TT&C TERMINALS AND PROCESS DATA THEY OBTAIN AND THEN PASS DATA TO OTHER SITES AT LOW RATES

THE PRIME AND BACKUP PROCESSING SITES HAVE DIRECT FO LINKS TO THE DOMSAT TERMINALS

ADVANTAGES

- EUROPEAN SITE NOT USED
- FEWER HIGH RATE FO LINKS; LOWEST COST
- GREATER PROCESSING FLEXIBILITY

DISADVANTAGES

- COVERAGE NOT AS GOOD; PASS TIMES LESS - REQUIRES HIGHER LINK RATES AND COSTS
- EDR SIZE MAY ELIMINATE ABILITY TO USE DS-1 LINKS FOR DATA TRANSFER TO OTHER CE's AND INCREASE COST SIGNIFICANTLY

CONVERGENCE EFFORT MODIFICATION

CONFIG F: 2 RTS'S + CE'S, FO COMS, DISTRIBUTED PROCESSING

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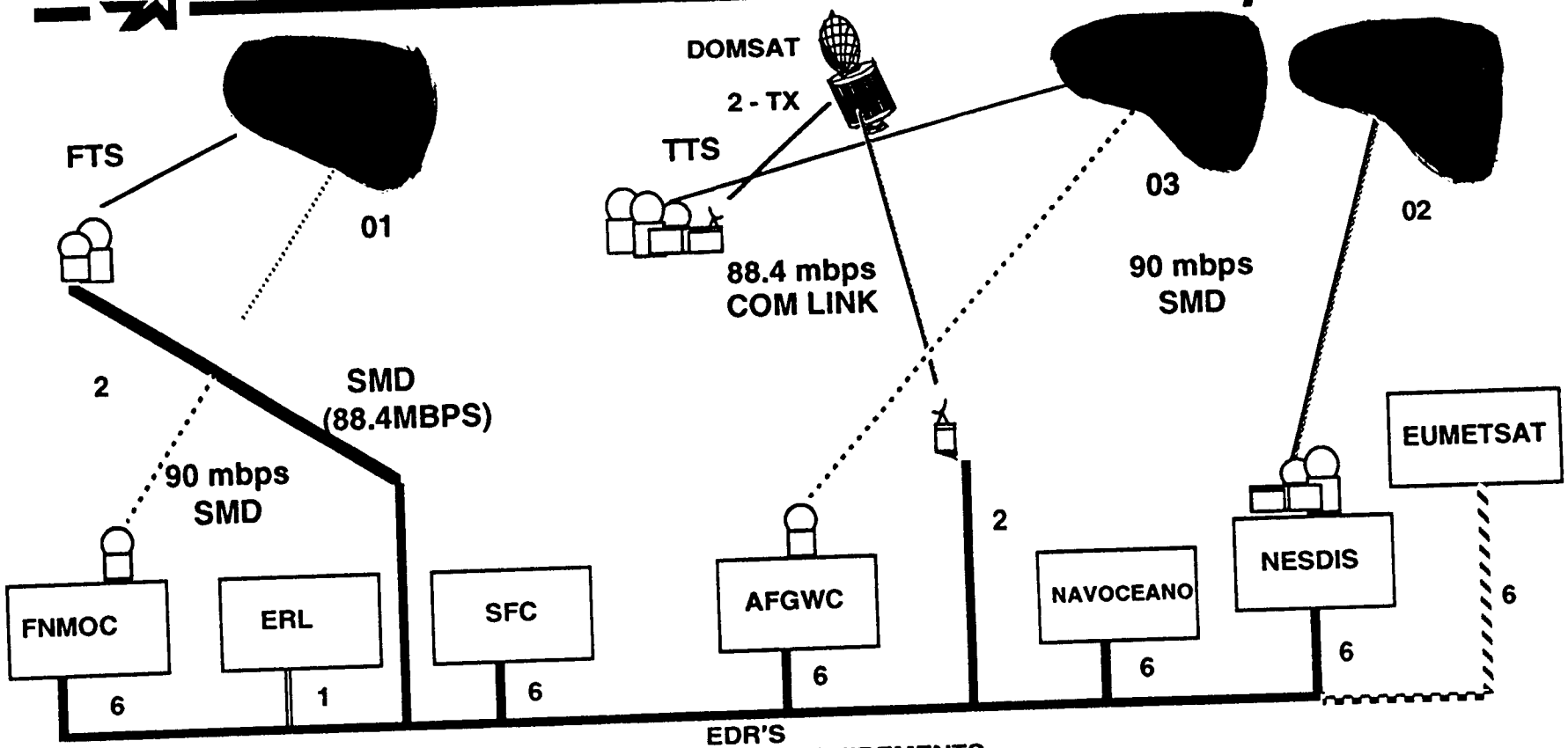

COMMUNICATION LINK REQUIREMENTS

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

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

CONFIG F: 2 RTS'S + CE'S, FO COMS, DISTRIBUTED PROCESSING

FEATURES

ALL DATA IS AVAILABLE TO ALL USERS DISTRIBUTED VIA HIGH RATE FO DISTRIBUTION SYSTEM

ADVANTAGES

- EUROPEAN SITE NOT USED
- FO LINKS PROVIDE BETTER DATA QUALITY

DISADVANTAGES

- COVERAGE NOT AS GOOD; PASS TIMES LESS; REQUIRES HIGHER LINK RATE AND COST
- LARGE NUMBER OF HIGH RATE (T3) LINKS REQUIRED; HIGHER COST

CONVERGENCE EFFORT MODIFICATION

CONFIG 1: TDRSS, CENTRALIZED PROCESSING

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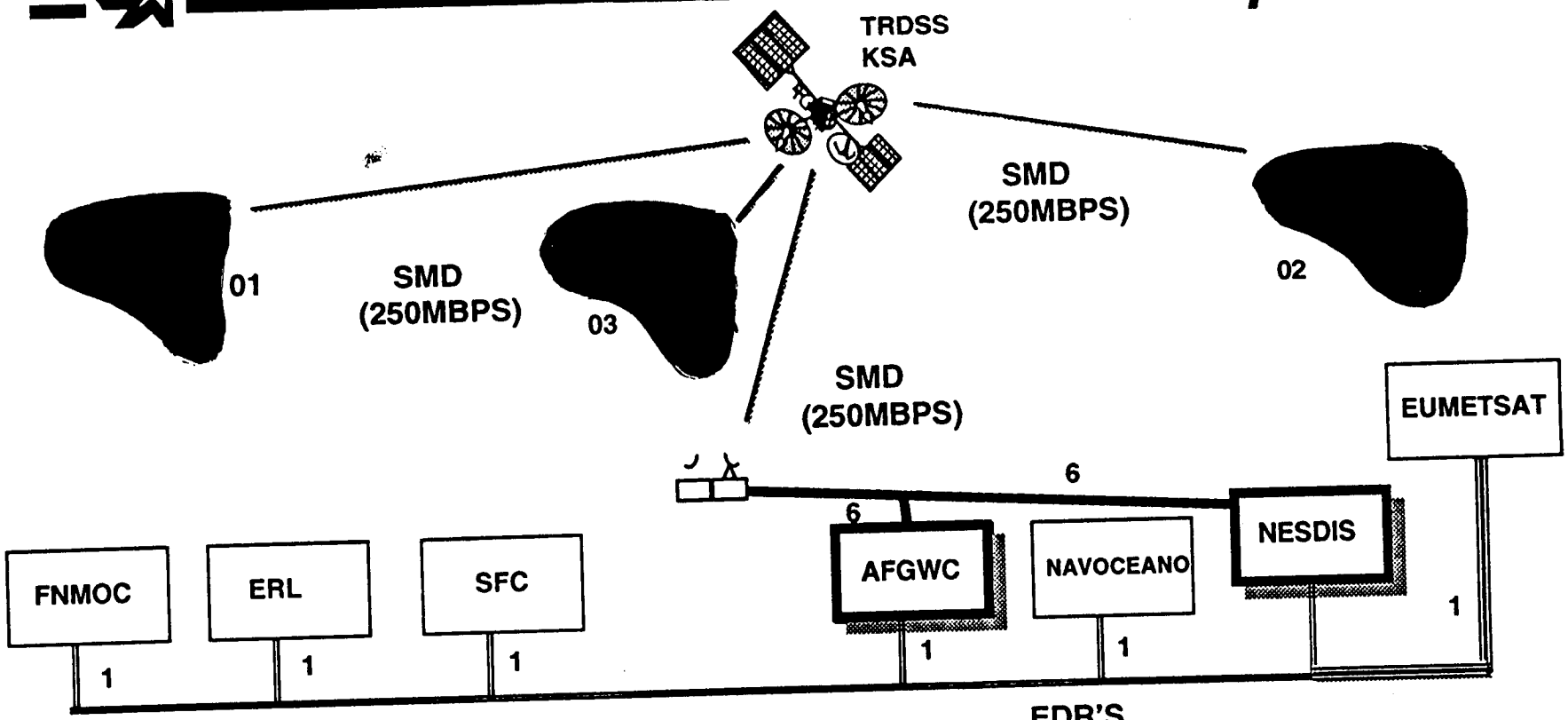

COMMUNICATION LINK REQUIREMENTS

TYPE	CONUS FO (DS3)	OCONUS FO (DS3)	TRANSOCEAN FO (DS3)	DOMSAT TX/ TER		LO RATE FO (DS1)	LO RATE TRNSOCN (DS1)
QUANTITY	12	0	0	0	0	5	1

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

4/13/95
PSR6

CONFIG 1: TDRSS, CENTRALIZED PROCESSING

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FEATURES

A SEPARATE WIDEBAND LINE REQUIRED FROM EITHER GODDARD OR WHITE SANDS TO AFGWC

ADVANTAGES

SINCE TDRSS HAS SCHEDULING FLEXIBILITY CONCURRENT PASSES WERE NOT ASSUMED THEREBY ELIMINATING NEED FOR CONCURRENT COMM LINKS

DISADVANTAGES

IF EDR SIZE ELIMINATES ABILITY TO USE DS-1 FOR DATA TRANSFER THEN COST INCREASES SIGNIFICANTLY

INTERIM DRR TRADE SUMMARY

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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	OK	OK	OK	OK	TBD	TBD	TBD	TBD
• Max Data Rate (MBPS)	88.4	88.4	88.4	88.4	TBD	TBD	TBD	TBD
• Coverage	OK	OK	OK	OK	OK	OK	OK	OK
• Stations to Mod/Add	1	1	1	1	4	4	4	4
• No. Stations to Man	3	3	3	3	5	5	5	5
• Comparative Costs								
- RTS Mods	.06	.06	.06	.06	.06	.06	.06	.06
- Comm Links/Term	.60	1.06	.74	.83	.46	1.16	.53	.66
- O & M	.04	.04	.06	.11	.08	.08	.10	.13
Total	.70	1.15	.87	1.00	.60	1.30	.69	.86
	3	7	5	6	1	8	2	4

COM COSTS vs TIMELINESS

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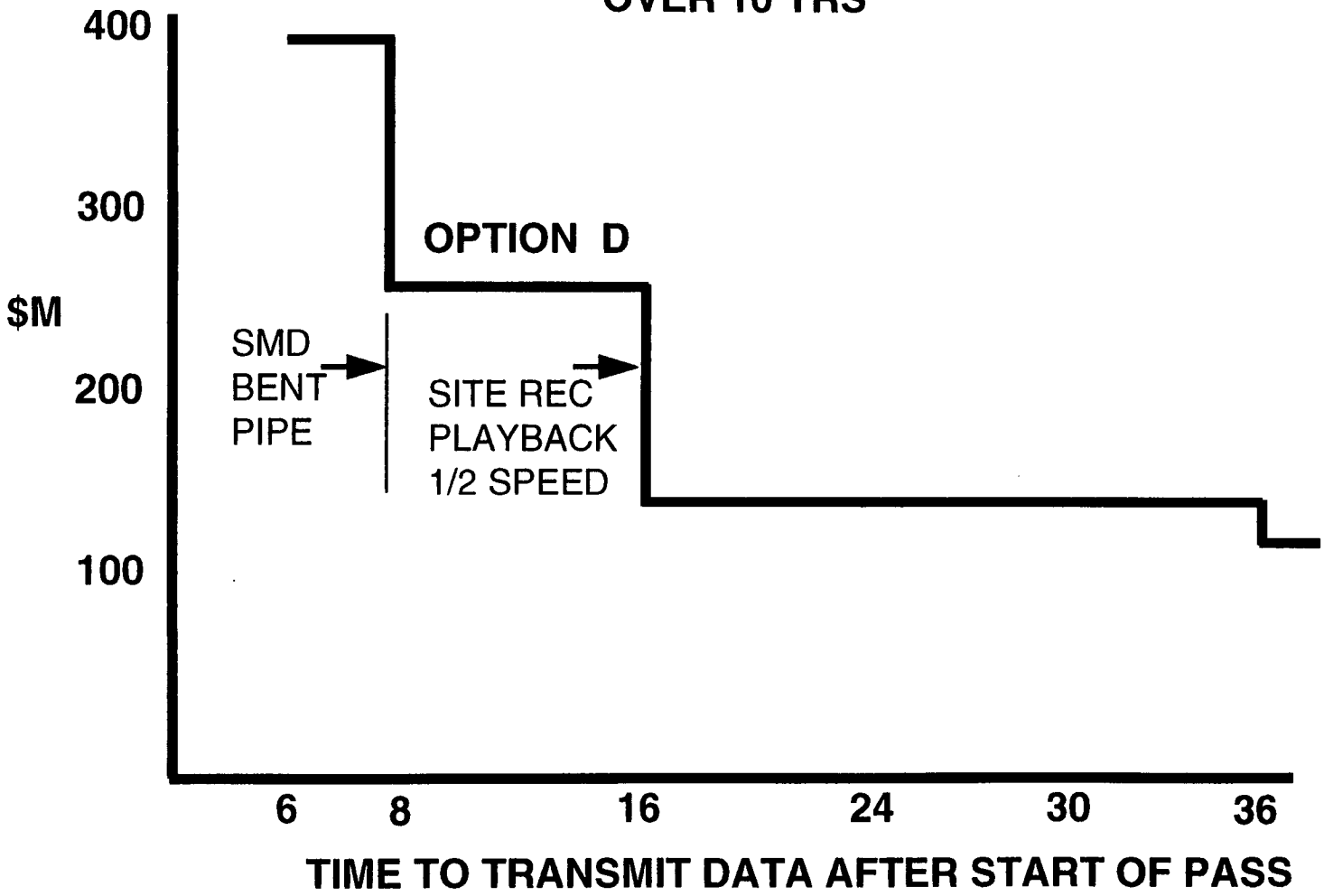
OVER 10 YRS



TDRSS COST SUMMARY

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OPTIONS	WITH $120/MIN TDRSS CHARGE	WITHOUT TDRSS CHARGE*
CENTRALIZED	.20	.07
CENTRALIZED WITH BACKUP	.35	.22
DISTRIBUTED WITH DOMSAT DIST	.49	.35
DISTRIBUTED	.41	.28
DISTRIBUTED WITH FO DIST WITH BACKUP	-	-

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

PRELIMINARY OBSERVATIONS

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- OPTION E - C & C TERMINALS AT CE'S, FO COM, DIST PROCESSING
  - LOWEST COST
  - TERMINALS AT CE'S DO NOT INCREASE PASS TIMES OF COVERAGE
  - TIMELINESS CANNOT BE MET WITHOUT INCREASING DATA RATE

- OPTION A TO E - NORTHERN RTS'S, CENTRALIZED PROCESSING
  - 3 NORTHERN STATIONS PROVIDE COMPLETE COVERAGE AND PASS TIMES GREATER THAN 8.5 MIN (12 MIN TYPICAL)
  - SLIGHTLY HIGHER COST (ABOUT 17%)

- OPTION D - DOMSAT COM, DISTRIBUTED PROCESSING
  - ALL SITES GET ALL DATA
  - DRR FUNCTION TOTALLY RELIANT ON DOMSAT'S
  - 67% HIGHER COST THAN OPTION E

- OPTION F - C&C TERMINALS AT CE'S, FO COMS, DIST PROCESSING
  - SAME TIMELINESS DEFICIENCY AS OPTION E
  - C&C TERMINALS AT CE'S ADD NO ADVANTAGE
  - LARGE NUMBER OF HI RATE FO LINKS REQUIRED FOR DATA DISTRIBUTION
  - HIGHEST COST (OVER 2 TIMES OPTION E)

CONCLUSIONS FROM OPTIONS EXAMINED

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- COMPLETED INITIAL EVALUATION OF SIXTEEN ALTERNATIVES
- FO CHEAPER IF ONLY A FEW SITES ARE BEING SUPPORTED
- DEDICATED COMMUNICATION LINKS ARE NOT HIGHLY USED - THEREFORE COST PER BYTE TRANSFERRED IS HIGH
- DOMSAT IN BROADCAST MODE IS DESIRABLE IF ALL SITES NEED ALL DATA
- TDRSS IS CHEAPER IF NO BACKUP SYSTEM IS REQUIRED

CONTINUING ANALYSIS PLANNED

- COMMUNICATION LINKS DRIVEN BY TIMELINESS REQUIREMENT ARE A MAJOR LIFE CYCLE COST DRIVER
- CONTINUED EFFORT NEEDED TO MINIMIZE DATA RATE / NUMBER OF LINKS:
  - EVALUATE RELAXING DATA TIMELINESS FOR SOME DATA TYPES
  - QUANTIFY IMPACT OF CENTRALIZED PROCESSING
  - DETERMINE IMPACT OF LINK RATE BY BER REQUIREMENT
  - VERIFY NUMBER OF SPACECRAFT WHICH REQUIRE SIMULTANEOUS SUPPORT
- FURTHER EXAMINATION OF TDRSS USE
  - CONDUCT LOADING ANALYSIS

C2 - SOC ANALYSIS

R. WOLL

C^2 ASSUMPTIONS

- THE C2 WILL UTILIZE A UNIFIED S-BAND CAPABILITY (I.E. "GSTDN LIKE" TRANSPONDER))
- THE COMMAND UPLINK RATE WILL BE NO GREATER THAN 2 KBPS
- ALL C2 DATA WILL BE CCSDS FORMATTED (NPOESS & EUMETSAT)
- ALL C2 DATA ARE UNCLASSIFIED
- THE SMD - TLM (STORED SOH 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 (SS0C) AND THE ALTERNATE IS FALCON (FBSOC). FOR THE BASELINE, THE FBSOC IS EQUALLY CAPABLE TO THE SSOC, I.E. MANNING, CAPABILITY, OPS CONCEPTS, NEED,

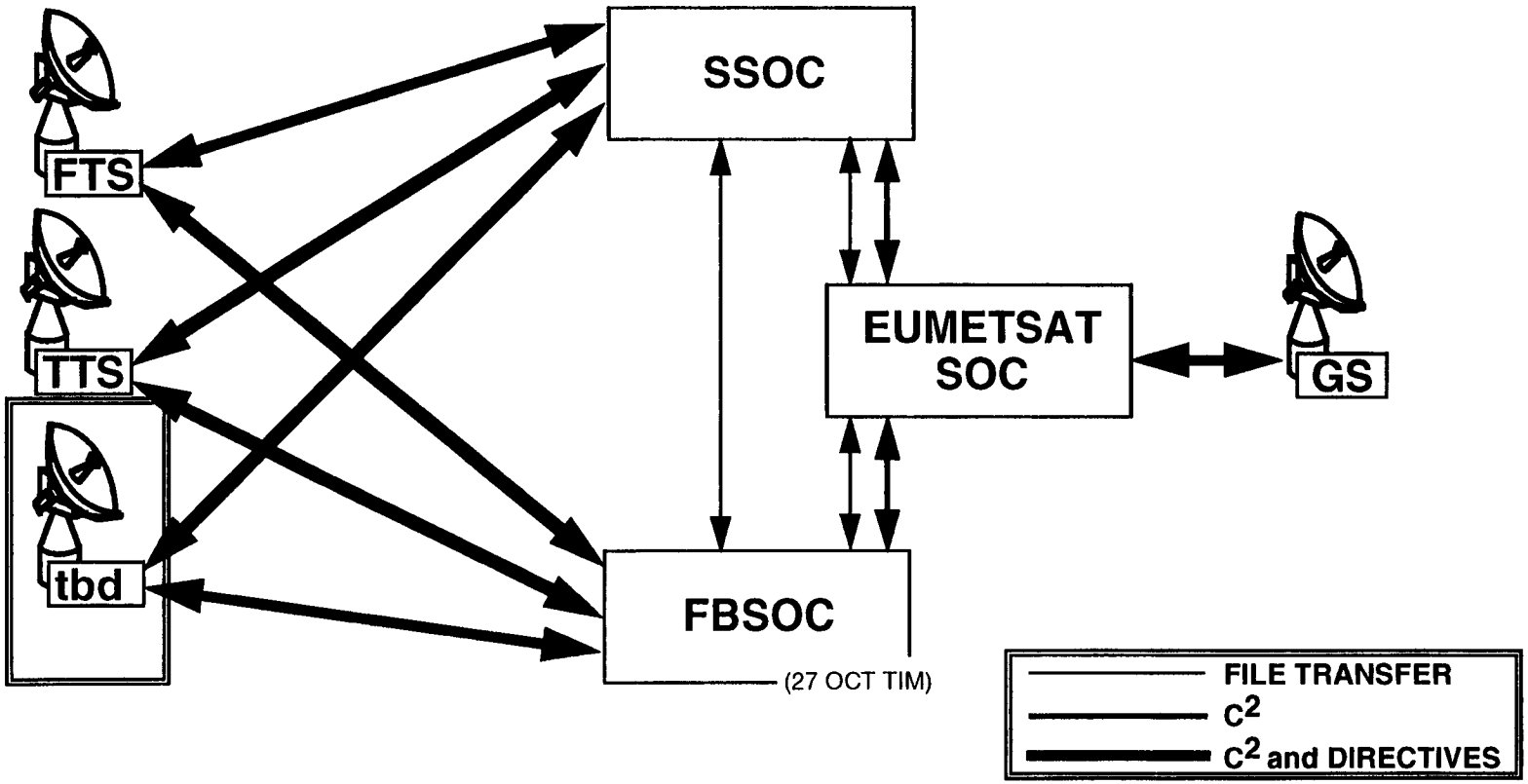
C^2 ASSUMPTIONS (CONT.)

- THE INITIAL C2 SYSTEM WILL BE CAPABLE OF THREE SIMULTANEOUS CONTACTS. THIS WILL ALLOW FOR INITIAL TESTING / DEMONSTRATION
- THE COMMAND ECHOES WILL BE AVAILABLE IN THE SOH TELEMETRY
- THE SPACECRAFT WILL PROVIDE TELEMETRY TIME TAGGING FUNCTION
- THERE ARE NO REQUIREMENTS FOR A GROUND ORBIT DETERMINATION FUNCTION AT THE SSOC / FBSOC. THIS WILL BE EXAMINED DURING TRADE ANALYSIS (I.E. USE 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

C^2 ASSUMPTIONS (CONT.)

- CONTINGENCY OPERATIONS RELATED TO EUMETSAT REQUIREMENTS WILL BE LIMITED TO VEHICLE SAFEING ONLY (MINIMUM VEHICLE KNOWLEDGE REQUIRED)
- 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 SYSTEM

C^2 GROUND ARCHITECTURE



CONVERGENCE EFFORT MODIFICATION

C2 CONFIGURATION

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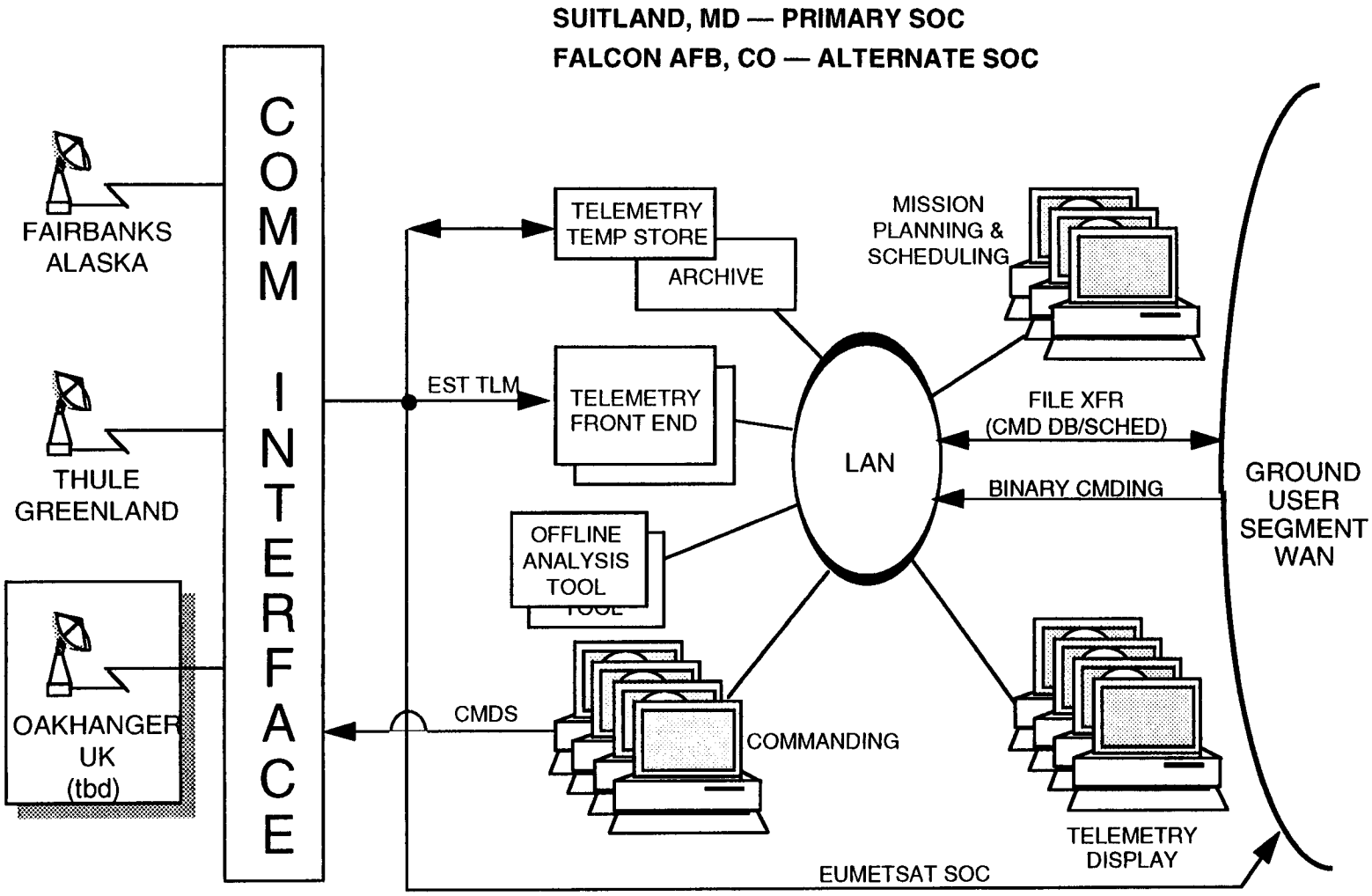

12/5/94
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OPERATIONS CONCEPT KEY CONSIDERATIONS:

- WHAT SHOULD BE ACCOMPLISHED ON THE GROUND VERSUS THE SPACECRAFT (E.G. NAVIGATION, ETC.)?
- WHAT IS THE APPROPRIATE LEVEL OF AUTONOMY?
- DETERMINE EARLY, THE APPROPRIATE NUMBER AND SKILL LEVEL OF THE OPERATIONS .
- MISSION OPERATIONS MUST BE ADDRESSED EARLY IN THE PROGRAM PLANNING.
- DO NOT DEVELOP A SYSTEM AND 'THROW IT OVER THE FENCE' TO THE OPERATOR.
- WHERE POSSIBLE, USE THE SAME HARDWARE, SOFTWARE AND OPERATIONS DURING GROUND TESTING THAT WILL BE USED DURING SPACE OPERATIONS.

OPS CONCEPT KEY CONSIDERATIONS (CONT.):

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- MULTI-TASKING OF THE OPERATORS GUARANTEES THEM THE 'BIG PICTURE' AND OFFERS THEM INCENTIVES.
- ASSURE FLEXIBILITY IN GROUND COVERAGE REQUIREMENTS.
- MINIMIZE THE NUMBER OF COMPLEX MANEUVERS.
- MINIMIZE THE NUMBER AND COMPLEXITY OF MISSION RULES.
- DEVELOP OPERABLE SPACECRAFT WITH MINIMUM INTERACTION BETWEEN SUBSYSTEMS.
- USE AUTOMATED ANALYSIS TOOLS.
- *MAXIMIZE AUTOMATION...*

AUTOMATION:

- WHERE DOES AUTOMATION END AND ARTIFICIAL INTELLIGENCE BEGIN?
- AI ALLOWS ROUTINE OPERATIONS OF MORE COMPLEX SYSTEMS.
- WHAT SHOULD BE AUTOMATED (ROUTINE FUNCTIONS, COMPLETE MISSION SEQUENCES, CONTINGENCY OPERATIONS, ETC.)?
- HOW TO OVER RULE THE AUTOMATED DECISIONS?
- A PRIMARY DRIVER IS THE MANPOWER REDUCTION.
- HOW DO YOU MAINTAIN OPERATOR PROFICIENCY?

AUTOMATION: (CONT.)

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- PUT TOGETHER SYSTEM WITH "SMALL COTS" (WHERE EVERY PIECE IS REPLACEABLE ALLOWING NEW / BETTER COTS INSERTION, WHEN AVAILABLE).
- WHAT ARE THE NECESSARY TECHNOLOGIES?
- HOW WILL THEY BE VALIDATED?
- HOW TO MODEL, DIAGNOSE AND MAINTAIN?
- USE OF LINE ANALYSIS TOOLS

CLOSING THOUGHTS

- WITH LESS PEOPLE, "AI" WILL HAPPEN. FOR SPACECRAFT AUTONOMY, EXPERT SYSTEMS SHOULD BE VALIDATED ON THE GROUND AND THEN MOVED TO THE SATELLITE.

- THERE IS A NEED FOR INCREASED SATELLITE CONTROL AUTONOMY IN BOTH GROUND AND SPACE SEGMENTS.

- FOR NPOESS, GETTING THE OPERATOR INVOLVED WITH THE SPACECRAFT DESIGN IS PARAMOUNT. KNOWING THAT THEY WILL BE RESPONSIBLE DURING THE ON ORBIT OPERATIONS, ASSURES THEIR VESTED INTEREST. THESE INPUTS MUST BE RESPECTED AND ACTED UPON.

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EDR REQUIREMENTS: ASSESSMENTS & IMPACTS

K. HARDY

KEY EDR TOPICS

- EDR REQUIREMENTS AND SENSING TECHNIQUES
  - EO AND MICROWAVE IMAGERY
  - IR AND MICROWAVE PROFILERS
  - CLIMATE MONITORING

THE SCIENCE TEAM

npoess

CLOUDS & AEROSOLS
- K. HUTCHISON
- G. LOGAN
- S. WESTERMAN
- K. HARDY

PROFILERS (IR & μWAVE)
- T. WILHEIT (TX A& M)
- P. ROSENKRANZ (MIT)
- A. HUANG (U. WISC)
- K. HARDY

LAND / OCEAN PARAMETERS
- R. STEWART (TX A & M)
- T. WILHEIT (TX A & M)
- M. DAVIS
- M. ABBOTT (OSU)
- K. HUTCHISON

SPACE & TRACE GASES
- Y. CHIU
- A. ROCHE

THE EDR HERITAGE

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38 EDRs OF THE FIRST DRAFT OF THE CON SYS	MATCHING EDRs OF THE 10/1/94 A-SPEC	EDRs OF 10/1/94 RELATED TO THE 38 EDRs	EDRs OF 10/1/94 UNRELATED TO THE 38 EDRs
1. CLOUD IMAGERY	1. CLOUD IMAGERY (KEY PARAMETER)	40. OPTICAL BCKGNDS	
2. PROCESSED CLOUD DATA	2. CLOUD COVER/LYRS	41. CLOUD BASE HGT	50. CLD ICE, LIQ EQVLNT
	3. CLD TOP TEMP	42. CLD OPT DEPTH	51. CLD ICE WATER PATH
	4. CLD TOP HEIGHT	43. DROPLET SIZE DIST	
	5. CLD TOP PRESS		
3. VERT TEMP PROF	6. VERT TEMP PROF		52. TOT SOLAR IRDNC
			53. TOT SHORTWV RAD
4. VERT MOIST PROF	7. VERT MOIST PROF		54. TOT LONGWV RAD
			55. LONGWAVE RAD
5. GEOSTROPHIC WIND PROFILE	8. TROPOSPHERIC WINDS		56. NET RAD (TOA)
			57. NET SFC SW RAD

CONVERGENCE EFFORT MODIFICATION

THE EDR HERITAGE

38 EDRs OF THE FIRST DRAFT OF THE CONVERGED SYSTEM INCLUDING THE ORIGINAL 22 EDRs OF BLOCK 6	EDRs OF THE A-SPEC DATED 10/1/94 WHICH MATCH EDRs OF THE FIRST DRAFT OF THE CONVERGED SYSTEM	EDRs OF THE A-SPEC DATED 10/1/94 WHICH ARE RELATED TO THE EDRs OF THE FIRST DRAFT OF THE CONVERGED SYSTEM	EDRs OF THE A-SPEC DATED 10/1/94 WHICH ARE UNRELATED TO THE EDRs OF THE FIRST DRAFT OF THE CONVERGED SYSTEM
1. CLOUD IMAGERY	1. CLOUD IMAGERY (KEY PARAMETER)	40. OPTICAL BACKGROUNDS	50. CLOUD ICE, LIQUID EQUIVALENT
2. PROCESSED CLOUD DATA	2. CLOUD COVER / LAYERS	41. CLOUD BASE HEIGHT	51. CLOUD ICE WATER PATH
	3. CLOUD TOP TEMPERATURE	42. CLOUD OPTICAL DEPTH / TRANSMITTANCE	
	4. CLOUD TOP HEIGHT	43. DROPLET SIZE DISTRIBUTION INDEX	52. TOTAL SOLAR IRRADIANCE (FULL SPECTRUM)
	5. CLOUD TOP PRESSURE		53. TOTAL SHORTWAVE RADIATION
3. VERTICAL TEMPERATURE PROFILE	6. VERTICAL TEMPERATURE PROFILE		54. TOTAL LONGWAVE RADIATION (TOP OF ATM)
4. VERTICAL MOISTURE PROFILE	7. VERTICAL MOISTURE PROFILE		55. LONGWAVE RADIATION
5. GEOSTROPHIC WIND PROFILE	8. TROPOSPHERIC WINDS		56. NET RADIATION (TOP OF ATM)
6. PRECIPITATION	9. PRECIPITATION (TYPE, RATE)		57. NET SURFACE SHORTWAVE RADIATION
7. VISIBILITY		44. AEROSOL OPTICAL THICKNESS	
		45. AEROSOL PARTICLE SIZE	58. CH4 COLUMN (METHANE)
		46. SUSPENDED MATTER	59. CO COLUMN (CARBON MONOXIDE)
8. TOTAL WATER CONTENT	10. TOTAL WATER CONTENT		60. CO2 COLUMN (CARBON DIOXIDE)
	11. CLOUD LIQUID WATER		
	12. PRECIPITABLE WATER STABILITY ?		61. OZONE TOTAL COLUMN / PROFILE
9. LAND SURFACE TEMPERATURE	13. LAND SURFACE TEMPERATURE	47. ICE SURFACE TEMPERATURE	
10. SEA SURFACE TEMPERATURE	14. SEA SURFACE TEMPERATURE		
11. SURFACE MOISTURE API	15. SOIL MOISTURE		
12. SNOW AND LANDLOCKED ICE COVER	16. SNOW COVER / DEPTH	48. SNOW WATER EQUIVALENT	
13. SURFACE ALBEDO	17. ALBEDO		
14. VEGETATION INDEX/SURFACE TYPE	18. VEGETATION / SURFACE TYPE		
15. SEA ICE	19. SEA ICE	49. FRESH WATER ICE CONCENTRATIONS	
16. OCEAN SURFACE WIND SPEED	20. SEA SURFACE WINDS		
17. IONOSPHERIC ELECTRON DENSITY PROFILES	21. ELECTRON DENSITY PROFILES / ION SPEC		62. AURORAL IMAGERY
18. IONOSPHERIC ELECTRIC FIELDS, ION DRIFT VELOCITIES	22. ELECTRIC FIELDS		63. AURORAL BOUNDARY
	23. ION DRIFT VELOCITY		64. TOTAL AURORAL ENERGY DEPOSITION
19. PRECIPITATING CHARGED PARTICLES			65. SUPRA-THERMAL / AURORAL PARTICLES
20. GEOMAGNETIC FIELD, MAG-CURRENTS	24. GEOMAGNETIC FIELD,		
21. RADIATION DOSE MEASUREMENTS	25. RADIATION BELT / LOW ENERGY SOLAR		66. IN SITU PLASMA DENSITY
22. NEUTRAL ATMOSPHERIC MEASUREMENTS	26. NEUTRAL DENSITY PROFILES / NEUT ATM SPEC		67. IN SITU PLASMA TEMPERATURE
23. PRESSURE (SURFACE / PROFILE)	27. PRESSURE (SURFACE / PROFILE)		68. IN SITU PLASMA FLUCTUATIONS
24. OCEAN WAVES	28. OCEAN WAVE CHARACTERISTICS		
25. SEA SURFACE TOPOGRAPHY	29. SEA SURFACE HEIGHT / TOPOGRAPHY		69. WAVE SPECTRAL ENERGY
26. BATHYMETRY (DEEP OCEAN AND NEAR SHORE)	30. BATHYMETRY (DEEP OCEAN AND NEAR SHORE)		
27. NEAR SHORE CURRENTS	31. CURRENTS		
28. OCEAN COLOR / CLARITY	32. OCEAN COLOR (CHLOROPHYLL)		
29. SALINITY	33. SALINITY		70. SOLAR GALACTIC COSMIC RAY PARTICLES
30. SOLAR FUV / EUV FLUX	34. SOLAR EXTREME ULTRA VIOLET (EUV) FLUX		71. UPPER ATMOSPHERIC AIRGLOW
31. TURBIDITY	35. TURBIDITY		
32. NET HEAT FLUX	36. NET HEAT FLUX		72. SURFACE WIND STRESS
33. LIGHTNING DETECTION			
34. INTERPLANETARY MAGNETIC FIELD			
35. LITTORAL SEDIMENT TRANSPORT	37. LITTORAL SEDIMENT TRANSPORT		
36. GAMMA RAYS			
37. BIOLUMINESCENCE	38. BIOLUMINESCENCE		
38. IONOSPHERIC SCINTILLATION	39. IONOSPHERIC SCINTILLATION		

AN ASSESSMENT OF ELECTRO-OPTICAL IMAGERY TO ADDRESS NPOESS REQUIREMENTS

EO IMAGERY

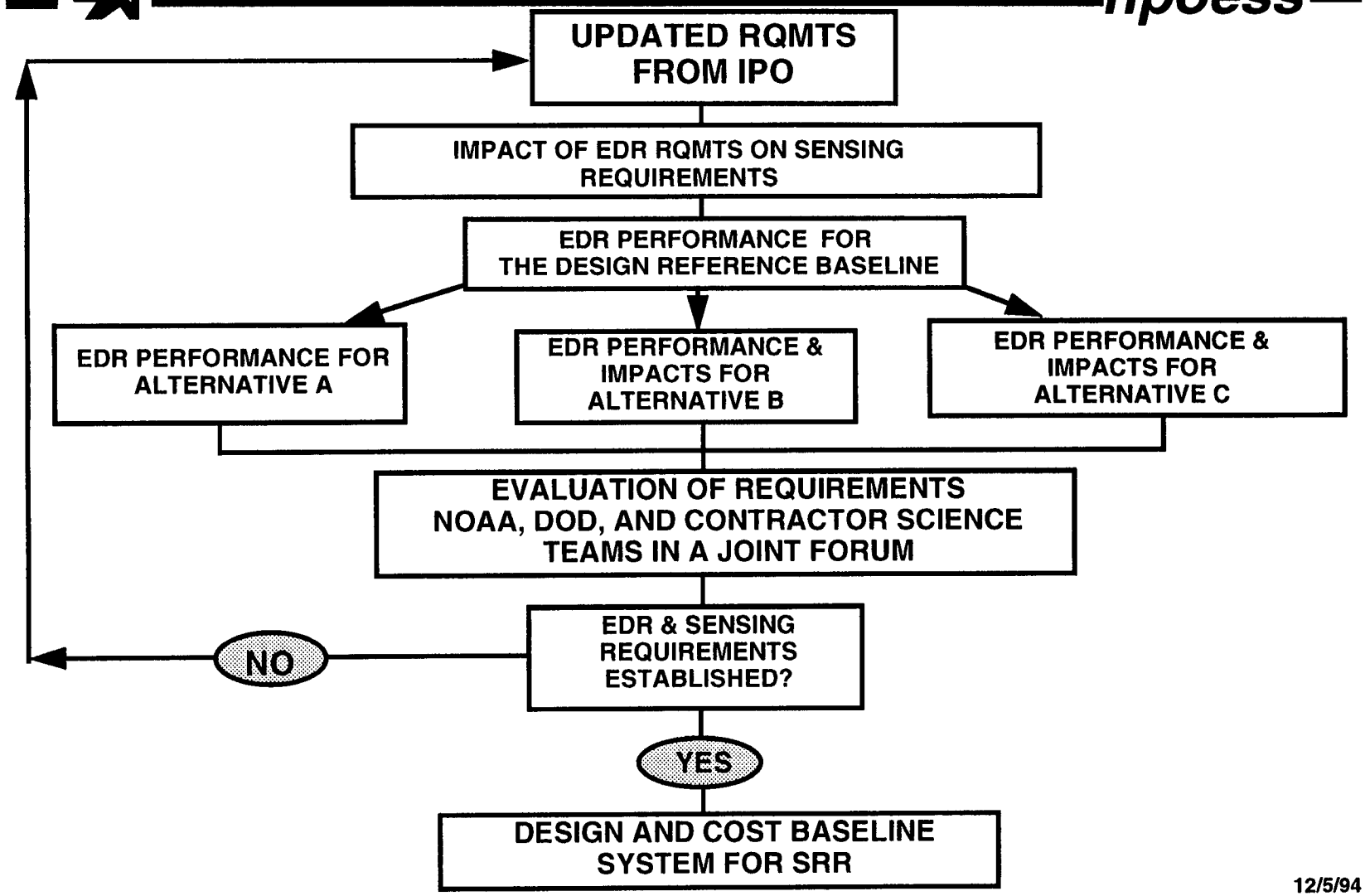
- THE MAJOR EDR CATEGORIES
  - CLOUDS
  - AEROSOLS
  - OCEAN SURFACE PARAMETERS (COLOR, SST)
  - LAND PARAMETERS (SURFACE TYPE, VEGETATION)

- THE LIMITATIONS OF EO IMAGERY FOR SOME EDRs

CONVERGENCE EFFORT MODIFICATION

APPROACH FOR CONVERGENCE OF EDR REQUIREMENTS

npoess



BAND SELECTION PROCESS

- RELIES ON PERFORMANCE OF CURRENT SATELLITE SENSORS
  - AVHRR, OLS, LANDSAT
- COLLECTION OF MULTISPECTRAL DATA WITH THE ER-2
- PAST AND PLANNED OCEAN SENSORS
  - CZCS, SeaWifs, MODIS
- ALGORITHM DEVELOPMENT BY NOAA, NASA, DOD, LOCKHEED, AND THE SCIENTIFIC COMMUNITY
- COLABORATION WITH OTHER SCIENTISTS
  - DR. ROBERT STEWART, DR. MARK ABBOTT

EO SENSOR/WAVELENGTH COMPARISON

(1 OF 4)

npoess

B/L: Indicates one of the 8-channels of the Baseline OASIS

WAVELENGTH nm or µm / SENSOR	402-422 gelb-stoffe	433-453 chloro-phyll	459-479 cloud	483-493 color	500-520 chloro-phyll	526-536 color	546-556 color	545-565 sedi-ments	605-625 cloud B/L	620-670 cloud
CZCS		√			√		√			
SeaWifs	√	√		√	√			√		
MODIS	√	√	√	√		√	√	√		√
AVHRR/3 NOAA K, L, M, & N									580-680	
ALTERNATIVE A / BASELINE									√ / √	
EXAMPLE OF ALTERNATIVE B	7*	5			2		8	1	√	

*Number indicates the priority of the channel added to the baseline

EO SENSOR/WAVELENGTH COMPARISON

(2 OF 4)

npoess

B/L: Indicates one of the 8-channels of the Baseline OASIS

WAVELENGTH nm or μm / SENSOR	662-672 color	673-683 atm corr	743-753 aero-sols	841-876 cloud	860-880 cloud B/L	890-920 water vapor	931-941 water vapor	915-965 water vapor	1.23-1.25 μm cloud	1.35-1.4 cirrus
CZCS	———		700-800							
SeaWifs	———		√		√					
MODIS	√	√	√	√	√	√	√	√	√	√
AVHRR/3 NOAA K, L, M, & N					725-1000					
ALTERNATIVE A / BASELINE					√ / √					
EXAMPLE OF ALTERNATIVE B		6* (660-680)	3		√					4

*Number indicates the priority of the channel added to the baseline

EO SENSOR/WAVELENGTH COMPARISON

(3 OF 4)

npoess

B/L: Indicates one of the 8-channels of the Baseline OASIS

WAVELENGTH nm or μm / SENSOR	1.58-1.64 snow/ ice B/L	2.105-2.155 cloud	3.55-3.93 cirrus SST B/L	3.93-3.99 cloud	3.93-3.99 cloud	4.02-4.08 cloud	4.43-4.50 atm temp	4.48-4.55 atm temp	6.54-6.90 water vapor	7.18-7.48 water vapor
CZCS										
SeaWifs										
AVHRR/3 NOAA K, L, M, & N	√		√							
MODIS	√	√	√	√	√	√	√	√	√	√
ALTERNATIVE A / BASELINE	√ / √		√ / √							
EXAMPLE OF ALTERNATIVE B	√		√							

*Number indicates the priority of the channel added to the baseline

EO SENSOR/WAVELENGTH COMPARISON
(4 OF 4)

npoess

B/L: Indicates one of the 8-channels of the Baseline OASIS

WAVELENGTH nm or μm / SENSOR	8.4-8.7 cirrus SST B/L	9.58-9.88 ozone	10.3-11.3 cloud SST B/L	11.5-12.5 cloud SST B/L	13.19-13.49 cloud	13.49-13.79 cloud	13.79-14.09 cloud	14.09-14.39 cloud	0.4-1.0 clouds aurora B/L
CZCS			—	—					
SeaWifs									
MODIS			√	√					
AVHRR/3 NOAA K, L, M, & N	√	√	√	√	√	√	√	√	
ALTERNATIVE A / BASELINE	√ / √		√ / √	√ / √					/ √
EXAMPLE OF ALTERNATIVE B	√		√	√					√

*Number indicates the priority of the channel added to the baseline

CONVERGENCE EFFORT MODIFICATION

EO SENSOR/WAVELENGTH COMPARISON

npoess

B/L: Indicates one of the 8-channels of the OASIS Baseline

WAVE-LENGTH / SENSOR	402-422 gelb-stoffe	433-453 chloro-phyll	459-479 cloud	483-493 color	500-520 chloro-phyll	526-536 color	546-556 color	545-565 sedi-ments	605-625 clouds B/L	620-670 cloud	662-672 color	673-683 atm corr	743-753 aero-sols	841-876 cloud	860-880 clouds B/L	890-920 water vapor	931-941 water vapor	915-965 water vapor	1.23-1.25 mm cloud	1.35-1.4
CZCS		√			√		√				--------		700-800							
SeaWifs	√	√		√	√			√			--------		√		√					
MODIS	√	√	√	√		√	√	√		√	√	√	√	√	√	√	√	√	√	√
AVHRR/3 NOAA K, L, M, & N									580-680						725-1000					
ALTERNATIVE A / BASELINE									√ / √						√ / √					
EXAMPLE OF ALTERNATIVE B	8 *	5		7	2			1	√			6 (660-680)	3		√					4

WAVE-LENGTH / SENSOR	1.58-1.64 snow/ ice B/L	2.105-2.155 cloud	3.55-3.93 cirrus SST B/L	3.93-3.99 cloud	3.93-3.99 cloud	4.02-4.08 cloud	4.43-4.50 atm temp	4.48-4.55 atm temp	6.54-6.90 water vapor	7.18-7.48 water vapor	8.4-8.7 cirrus SST B/L	9.58-9.88 ozone	10.3-11.3 clouds SST B/L	11.5-12.5 clouds SST B/L	13.19-13.49 cloud	13.49-13.79 cloud	13.79-14.09 cloud	14.09-14.39 cloud	0.4-1.0 clouds aurora B/L	
CZCS													--------							
SeaWifs																				
AVHRR/3 NOAA K, L, M, & N	√		√										√	√						
MODIS	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√		
ALTERNATIVE A / BASELINE	√ / √		√ / √								√ / √		√ / √	√ / √					/ √	
EXAMPLE OF ALTERNATIVE B	√		√								√		√	√					√	

***Number indicates the priority of the channel added to the baseline**

CONVERGENCE EFFORT MODIFICATION

EXAMPLE OF EDR & WAVELENGTH RELATIONSHIP (12-CHANNEL ALTERNATIVE B)

npoess

* EDR CONTAINS A KEY PARAMETER (see Data Requirements)

B/L: Indicates one of the 8-channels of the OASIS Design Reference Baseline

10/1/1994 A-Spec Number				NOMINAL WAVELENGTHS (nanometers or µm)									
	WAVELENGTH & KEY PHENOMENON (nm or µm) / EDR	500-520 chloro-phyll	545-565 sedi-ments	605-625 clouds B/L	743-753 aero-sols	860-880 clouds B/L	1.35-1.4 µm cirrus	1.58-1.64 snow/ ice B/L	3.55-3.93 cirrus SST B/L	10.3-11.3 clouds SST B/L	11.5-12.5 clouds SST B/L	0.4-1.0 clouds aurora B/L	8.4-8.7 cirrus SST B/L
20.3.1	CLOUD IMAGERY*			3	1	3	2	3	3	3	3	3	2
20.3.2	CLOUD COVER/LAYERS			3	1	3	2	3	3	3	3	1	2
20.4.3	SEA ICE*			3		3	2	3	3	3	3	1	2
20.6	SEA SURFACE TEMPERATURE*			2	1	2	2	3	3	3	3		2
20.3.6.1	DROPLET SIZE DISTRIBUTION INDEX			3	2	3	2	2	2				2
20.9.41	TURBIDITY	3	3	2	2	2	1	1		1	1		1
20.3.5.1	CLOUD ICE WATER PATH			3		3	2	3	2				2
	TOTALS	20	23	60	39	59	45	55	44	42	42	15	43

*** If re-stated as Optical Depth, vice thickness, a passive system could be used, and the priority would be higher

Value for the wavelength band: 3 for critical, 2 for important, and 1 for helpful

12/5/94
PSR6

CONVERGENCE EFFORT MODIFICATION

EDR WAVELENGTH RELATIONSHIP FOR 12-CHANNEL ALTERNATIVE B

npoess

* EDR CONTAINS A KEY PARAMETER (see Data Requirements) B/L: Indicates one of the 8-channels of the OMIS/VIRSR Baseline

				NOMINAL WAVELENGTHS (nanometers or µm)									
	WAVELENGTH & KEY PHENOMENON (nm or µm) / EDR		545-565 sedi-ments	605-625 clouds B/L	743-753 aero-sols	860-880 clouds B/L	1.35-1.4 µm cirrus	1.58-1.64 snow/ ice B/L	3.55-3.93 cirrus SST B/L	10.3-11.3 clouds SST B/L	11.5-12.5 clouds SST B/L	0.4-1.0 clouds aurora B/L	8.4-8.7 cirrus SST B/L
20.3.1	CLOUD IMAGERY*			3	1	3	2	3	3	3	3	3	2
20.3.2	CLOUD COVER/LAYERS			3	1	3	2	3	3	3	3	1	2
20.4.3	SEA ICE*			3		3	2	3	3	3	3	1	2
20.6	SEA SURFACE TEMPERATURE*			2	1	2	2	3	3	3	3		2
20.9.17	LAND SURFACE TEMPERATURE			2	1	2	2	3	3	3	3		2
20.3.9	CLOUD TOP TEMPERATURE			2	1	2	2	3	3	3	3		2
20.9.2	ALBEDO	2	2	3	1	3	2	2	2	2	2		2
20.9.3.2	AURORAL IMAGERY											3	
20.9.3.1	AURORAL BOUNDARY											3	
20.9.42	VEGETATION/SURFACE TYPE		2	3	2	3	2	2					
20.3.10	CLOUD TOP HEIGHT			2	1	2	2	3	3	3	3		2
20.9.4		3	3	2	2	2	2	2	1	1	1		1
20.9.1.2	AEROSOL PARTICLE SIZE	1	1	3	3	2	1						2
20.3.6.2	CLOUD OPTICAL DEPTH/TRANSMITTANCE			3	2	3	2	2	2				2
20.9.1.4	SUSPENDED MATTER	1	1	2	2	2	2	2					2
20.3.3	CLOUD BASE HEIGHT			1	1	1	1	1	1				1
20.9.3.3	OPTICAL BACKGROUNDS	2	2	2	1	2	2	2	2	2	2		2
20.4.1	FRESH WATER ICE CONCENTRATIONS			3	1	3	2	3	3	3	3	1	2
20.9.23	OCEAN COLOR (CHLOROPHYLL)	3	3	2	3	2	2	2		2	2		1
20.9.1.3	AEROSOL OPTICAL THICKNESS ***			2	3	2							2
20.9.20	CURRENTS	3	3	2	2	2	2	2		2	2		1
20.3.7	CLOUD TOP PRESSURE			2	2	2	2	3	3	3	3		2
20.9.18	LITTORAL SEDIMENT TRANSPORT	2	3	2	2	2	2	2	2	2	2		2
20.3.4	CLOUD ICE, LIQUID EQUIVALENT			3	2	3	2	3	3	3	3	3	2
20.9.8	BIOLUMINESCENCE												
20.3.6.1	DROPLET SIZE DISTRIBUTION INDEX			3	2	3	2	2	2				2
20.9.41	TURBIDITY	3	3	2	2	2	1	1		1	1		1
20.3.5.1	CLOUD ICE WATER PATH			3		3	2	3	2				2
	TOTALS	20	23	60	39	59	45	55	44	42	42	15	43

*** If re-stated as Optical Depth, vice thickness, a passive system could be used, and the priority would be higher

Value for the wavelength band: 3 for critical, 2 for important, and 1 for helpful

AN EDR PRIORITY ESTIMATE

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- START WITH THE MJCS 154-86 (1 AUG 1986)
  - 43 EDRs PRIORITIZED
- HIGH PRIORITY TO THE 7 KEY EDRs
  - CLD IMAGERY, TEMP PROF, MOIST PROF, SOIL MOISTURE SEA ICE, SEA SFC TEMP, SEA SFC WINDS
- CONSIDERATION OF NOAA OPERATIONAL & NOAA & NASA RESEARCH NEEDS
  - USUALLY HIGHER PRIORITY TO OPERATIONAL REQUIREMENTS
- GUESSES WERE ALSO EFFECTIVE
- INDEPENDENT PRIORITIES PREPARED BY D. PAUL, S. WESTERMAN AND K. HARDY AND MERGED TO A COMMON LIST

CONVERGENCE EFFORT MODIFICATION

ESTIMATE OF EDR RELATIVE VALUE
(1 OF 4)

npoess

10/1/1994 A-Spec Number	EDR (* DENOTES AN EDR WITH A KEY PARAMETER)	KEY PARAMETER	RELATIVE VALUE 70: HIGH 2: LOW	LOCKHEED PI
20.1	ATM VERT MOISTURE PROFILE*	Vert. Samp Interval	70	Hardy
20.3.1	CLOUD IMAGERY*	Refresh 4 Hours	70	Logan
20.2	ATM VERT TEMPERATURE PROFILE*	Vertical Sampling Interval	70	Hardy
20.8.2	TROPOSPHERIC WINDS		50	Hardy
20.8.1	SEA SURFACE WINDS*	Refresh: Global 12 Hours	50	Davis
20.3.2	CLOUD COVER/LAYERS		45	Hutchison
20.4.3	SEA ICE*	Horiz. Res, Concentration	41	Davis
20.6	SEA SURFACE TEMPERATURE*	Refresh 6 hours	40	Hutchison
20.9.39	TOTAL WATER CONTENT		40	Davis

CONVERGENCE EFFORT MODIFICATION

ESTIMATE OF EDR RELATIVE VALUE
(2 OF 4)

npoess

10/1/1994 A-Spec Number	EDR (* DENOTES AN EDR WITH A KEY PARAMETER)	KEY PARAMETER	RELATIVE VALUE 70: HIGH 2: LOW	LOCKHEED PI
20.9.10	ELECTRON DENSITY PROFILES/		40	Chiu
20.9.17	LAND SURFACE TEMPERATURE		30	Hutchison
20.5	OZONE TOTAL COLUMN/PROFILE		25	Roche
20.3.9	CLOUD TOP TEMPERATURE		24	Hutchison
20.9.2	ALBEDO		23	Hutchison
20.7	SOIL MOISTURE*	Refresh: 4 hours	21	Davis
20.9.31	SEA SURFACE HEIGHT/TOPOGRAPHY		22	Davis
20.9.3.2	AURORAL IMAGERY		21	Chiu
20.9.3.1	AURORAL BOUNDARY		20	Chiu

CONVERGENCE EFFORT MODIFICATION

ESTIMATE OF EDR RELATIVE VALUE (3 OF 4)

npoess

10/1/1994 A-Spec Number	EDR (* DENOTES AN EDR WITH A KEY PARAMETER)	KEY PARAMETER	RELATIVE VALUE 70: HIGH 2: LOW	LOCKHEED PI
20.4.10	SNOW COVER/DEPTH		19	Davis
20.9.9	ELECTRIC FIELDS		18	Chiu
20.9.16	IONOSPHERIC SCINTILLATION		17	Chiu
20.9.42	VEGETATION/SURFACE TYPE		16	Davis
20.9.24	OCEAN WAVE CHARACTERISTICS		13	Davis
20.9.15.1	IN-SITU PLASMA DENSITY		12	Chiu
20.9.21	NET HEAT FLUX		12	Hardy
20.3.10	CLOUD TOP HEIGHT		12	Hutchison
20.9.34	SURFACE WIND STRESS		10	Hardy
20.9.13	GEOMAGNETIC FIELD		10	Chiu
20.9.4	BATHYMETRY (DEEP OCEAN & NEAR SHORE)		10	Hardy
20.3.5	CLOUD LIQUID WATER		10	Davis
20.9.22	NEUTRAL DENSITY PROFILES/NEU ATM SPEC		10	Chiu
20.4.9	SNOW WATER EQUIVALENT		8	Davis
20.9.1.2	AEROSOL PARTICLE SIZE		8	Hutchison
20.9.15.2	IN-SITU PLASMA TEMPERATURE		8	Chiu
20.3.6.2	CLOUD OPTICAL DEPTH/TRANSMITTANCE		8	Hutchison
20.9.14	NET RADIATION (TOP OF ATMOSPHERE)		8	Hardy
20.9.1.4	SUSPENDED MATTER		8	Hutchison
20.3.3	CLOUD BASE HEIGHT		8	Hutchison
20.9.3.3	OPTICAL BACKGROUNDS		8	Chiu
20.4.1	FRESH WATER ICE CONCENTRATIONS		7	Davis
20.4.4	ICE SURFACE TEMPERATURE		6	Davis
20.9.23	OCEAN COLOR (CHLOROPHYLL)		6	Hutchison
20.9.1.3	AEROSOL OPTICAL THICKNESS **		6	Hutchison
20.9.28	PRESSURE (SURFACE/PROFILE)		5	Hardy
20.9.5	CH4 COLUMN (METHANE)		5	Roche
20.9.20	CURRENTS		5	Hutchison

** If this is re-stated as OPTICAL DEPTH, it can be done with a passive system, and the priority would be higher

CONVERGENCE EFFORT MODIFICATION

ESTIMATE OF EDR RELATIVE VALUE
(4 OF 4)

npoess

10/1/1994 A-Spec Number	EDR (* DENOTES AN EDR WITH A KEY PARAMETER)	KEY PARAMETER	RELATIVE VALUE 70: HIGH 2: LOW	LOCKHEED PI
20.9.19	LONGWAVE RADIATION		5	Hardy
20.9.7	CO2 COLUMN (CARBON DIOXIDE		5	Roche
20.3.7	CLOUD TOP PRESSURE		5	Hutchison
20.9.6	CO COLUMN (CARBON MONOXIDE)		5	Roche
20.9.18	LITTORAL SEDIMENT TRANSPORT		4	Hutchison
20.9.16.1	IN-SITU PLASMA FLUCTUATIONS		4	Chiu
20.9.26.2	RADIATION BELT/LOW ENERGY SOLAR		4	Chiu
20.9.37	TOAL SHORTWAVE RADIATION		4	Hardy
20.9.36	TOTAL LONGWAVE RADIATION (TOP OF ATM)		4	Hardy
20.9.15.3	ION DRIFT VELOCITY		4	Chiu
20.3.4	CLOUD ICE, LIQUID EQUIVALENT		4	Hutchison
20.9.26.1	SUPRA-THERMAL/AURORAL PARTICLES		3	Chiu
20.9.32	NET SURFACE SHORTWAVE RADIATION		3	Hardy
20.9.26.3	SOLAR/GALACTIC COSMIC RAY PARTICLES		3	Chiu
20.9.27	PRECIPITABLE WATER STABILITY		2	Hardy
20.9.8	BIOLUMINESCENCE		2	Hutchison
20.9.35	TOTAL AURORAL ENERGY DEPOSITION		2	Chiu
20.9.43	WAVE SPECTRAL ENEGERY		2	Davis
20.9.3.4	UPPER ATMOSPHERIC AIRGLOW		2	Chiu
20.3.6.1	DROPLET SIZE DISTRIBUTION INDEX		2	Hutchison
20.9.41	TURBIDITY	OBJECTIVES ONLY	2	Hutchison
20.9.38	TOTAL SOLAR IRRADIANCE (FULL SPECTRUM)		2	Hardy
20.9.30	SALINITY		2	Davis
20.3.5.1	CLOUD ICE WATER PATH		2	Hutchison
20.9.33	SOLAR EXTREME ULTR VIOLET (EUV) FLUX		2	Chiu

REQUIREMENTS ANALYSIS PROCESS

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Supplier "Hows"
Design Alternatives/
Performance Measures

Customer "Rqmts"

1. Vert Profiles
2. Cloud Imagery
3. Ocean Parameters
4. Space Parameters
•

Utility/Relationship Matrix

Measures how well "Rqmts" are met.

Customer Prioritization of "Rqmts" & Customer/ Contractor Interaction

1. Cost
2. Supportability
3. Mission Effectiveness
•

Sensitivity to Design Features
Prioritization of relative importance of changes in design features

Key Tasks

1. **Identify operational and environmental needs**
2. **Identify customer preferences**
3. **Prioritize importance of design features**

EXAMPLE OF RELATIVE VALUE OF EO CHANNELS FOR RETRIEVING AN EDR

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* EDR CONTAINS A KEY PARAMETER (see Data Requirements)

B/L: Indicates one of the 8-channels of the OASIS Design Reference Baseline

RELATIVE WEIGHT	WAVELENGTH & KEY PHENOMENON (nm or µm) / EDR	500-520 chlorophyll	545-565 sediments	605-625 clouds B/L	743-753 aerosols	860-880 clouds B/L	1.35-1.4 µm cirrus	1.58-1.64 snow/ice B/L	3.55-3.93 cirrus SST B/L	10.3-11.3 clouds SST B/L	11.5-12.5 clouds SST B/L	0.4-1.0 clouds aurora B/L	8.4-8.7 cirrus SST B/L
		NOMINAL WAVELENGTHS (nanometers or µm)											
6.52	CLOUD IMAGERY*	0.0	0.0	19.6	6.5	19.6	13.0	19.6	19.6	19.6	19.6	19.6	13.0
4.19	CLOUD COVER/LAYERS	0.0	0.0	12.6	4.2	12.6	8.4	12.6	12.6	12.6	12.6	4.2	8.4
0.19	TURBIDITY	0.6	0.6	0.4	0.4	0.4	0.2	0.2	0.0	0.2	0.2	0.0	0.2
0.19	CLOUD ICE WATER PATH	0.0	0.0	0.6	0.0	0.6	0.4	0.6	0.4	0.0	0.0	0.0	0.4
	TOTAL	14.5	17.8	93.8	42.4	93.0	70.7	96.0	88.1	87.4	87.4	40.8	67.6

Value for the wavelength band: 3 for critical, 2 for important, and 1 for helpful and weighted by the "Relative Weight"

"RELATIVE WEIGHT" IS A VALUE ASSIGNED TO EACH OF THE 72 EDRs THAT INDICATES THE EDR'S RANKING OR WEIGHT NORMALIZED TO 100.

CONVERGENCE EFFORT MODIFICATION

RELATIVE VALUE OF 12 EO CHANNELS FOR RETRIEVING AN EDR (ALTERNATIVE B)

npoess

* EDR CONTAINS A KEY PARAMETER (see Data Requirements) B/L: Indicates one of the 8-channels of the OASIS Design Reference Baseline

RELATIVE WEIGHT	WAVELENGTH & KEY PHENOMENON (nm or µm) / EDR	500-520 chloro-phyll	545-565 sedi-ments	605-625 clouds B/L	743-753 aero-sols	860-880 clouds B/L	1.35-1.4 µm cirrus	1.58-1.64 snow/ice B/L	3.55-3.93 cirrus SST B/L	10.3-11.3 clouds SST B/L	11.5-12.5 clouds SST B/L	0.4-1.0 clouds aurora B/L	8.4-8.7 cirrus SST B/L
				NOMINAL WAVELENGTHS (nanometers or µm)									
6.52	CLOUD IMAGERY*	0	0	19.56	6.52	19.6	13.04	19.56	19.56	19.56	19.56	19.56	13.04
4.19	CLOUD COVER/LAYERS	0	0	12.57	4.19	12.6	8.38	12.57	12.57	12.57	12.57	4.19	8.38
3.82	SEA ICE*	0	0	11.46	0	11.5	7.64	11.46	11.46	11.46	11.46	3.82	7.64
3.72	SEA SURFACE TEMPERATURE*	0	0	7.44	3.72	7.44	7.44	11.16	11.16	11.16	11.16	0	7.44
2.79	LAND SURFACE TEMPERATURE	0	0	5.58	2.79	5.58	5.58	8.37	8.37	8.37	8.37	0	5.58
2.24	CLOUD TOP TEMPERATURE	0	0	4.48	2.24	4.48	4.48	6.72	6.72	6.72	6.72	0	4.48
2.14	ALBEDO	4.28	4.28	6.42	2.14	6.42	4.28	4.28	4.28	4.28	4.28	0	4.28
1.96	AURORAL IMAGERY	0	0	0	0	0	0	0	0	0	0	5.88	0
1.86	AURORAL BOUNDARY	0	0	0	0	0	0	0	0	0	0	5.58	0
1.49	VEGETATION/SURFACE TYPE	0	2.98	4.47	2.98	4.47	2.98	2.98	0	0	0	0	0
1.12	CLOUD TOP HEIGHT	0	0	2.24	1.12	2.24	2.24	3.36	3.36	3.36	3.36	0	2.24
0.93	BATHYMETRY (DEEP OCEAN & NEAR SHORE)	2.79	2.79	1.86	1.86	1.86	1.86	1.86	0.93	0.93	0.93	0	0.93
0.75	AEROSOL PARTICLE SIZE	0.75	0.75	2.25	2.25	1.5	0.75	0	0	0	0	0	1.5
0.75	CLOUD OPTICAL DEPTH/TRANSMITTANCE	0	0	2.25	1.5	2.25	1.5	1.5	1.5	0	0	0	1.5
0.75	SUSPENDED MATTER	0.75	0.75	1.5	1.5	1.5	1.5	1.5	0	0	0	0	1.5
0.75	CLOUD BASE HEIGHT	0	0	0.75	0.75	0.75	0.75	0.75	0.75	0	0	0	0.75
0.75	OPTICAL BACKGROUNDS	1.5	1.5	1.5	0.75	1.5	1.5	1.5	1.5	1.5	1.5	0	1.5
0.65	FRESH WATER ICE CONCENTRATIONS	0	0	1.95	0.65	1.95	1.3	1.95	1.95	1.95	1.95	0.65	1.3
0.56	OCEAN COLOR (CHLOROPHYLL)	1.68	1.68	1.12	1.68	1.12	1.12	1.12	0	1.12	1.12	0	0.56
0.56	AEROSOL OPTICAL THICKNESS ***	0	0	1.12	1.68	1.12	0	0	0	0	0	0	1.12
0.47	CURRENTS	1.41	1.41	0.94	0.94	0.94	0.94	0.94	0	0.94	0.94	0	0.47
0.47	CLOUD TOP PRESSURE	0	0	0.94	0.94	0.94	0.94	1.41	1.41	1.41	1.41	0	0.94
0.37	LITTORAL SEDIMENT TRANSPORT	0.74	1.11	0.74	0.74	0.74	0.74	0.74	0.74	0.74	0.74	0	0.74
0.37	CLOUD ICE, LIQUID EQUIVALENT	0	0	1.11	0.74	1.11	0.74	1.11	1.11	1.11	1.11	1.11	0.74
0.19	BIOLUMINESCENCE	0	0	0	0	0	0	0	0	0	0	0	0
0.19	DROPLET SIZE DISTRIBUTION INDEX	0	0	0.57	0.38	0.57	0.38	0.38	0.38	0	0	0	0.38
0.19	TURBIDITY	0.57	0.57	0.38	0.38	0.38	0.19	0.19	0	0.19	0.19	0	0.19
0.19	CLOUD ICE WATER PATH	0	0	0.57	0	0.57	0.38	0.57	0.38	0	0	0	0.38
	TOTAL	14.47	17.82	93.77	42.44	93	70.65	95.98	88.13	87.37	87.37	40.79	67.58

*** If re-stated as Optical Depth, vice thickness, a passive system could be used, and the priority would be higher

Value for the wavelength band: 3 for critical, 2 for important, and 1 for helpful

"RELATIVE WEIGHT" IS A VALUE ASSIGNED TO EACH OF THE 72 EDRs THAT INDICATES THE EDR'S RANKING OR WEIGHT NORMALIZED TO 100.

CONVERGENCE EFFORT MODIFICATION

RADIANCE FROM SEA SURFACE AND CHLOROPHYLL

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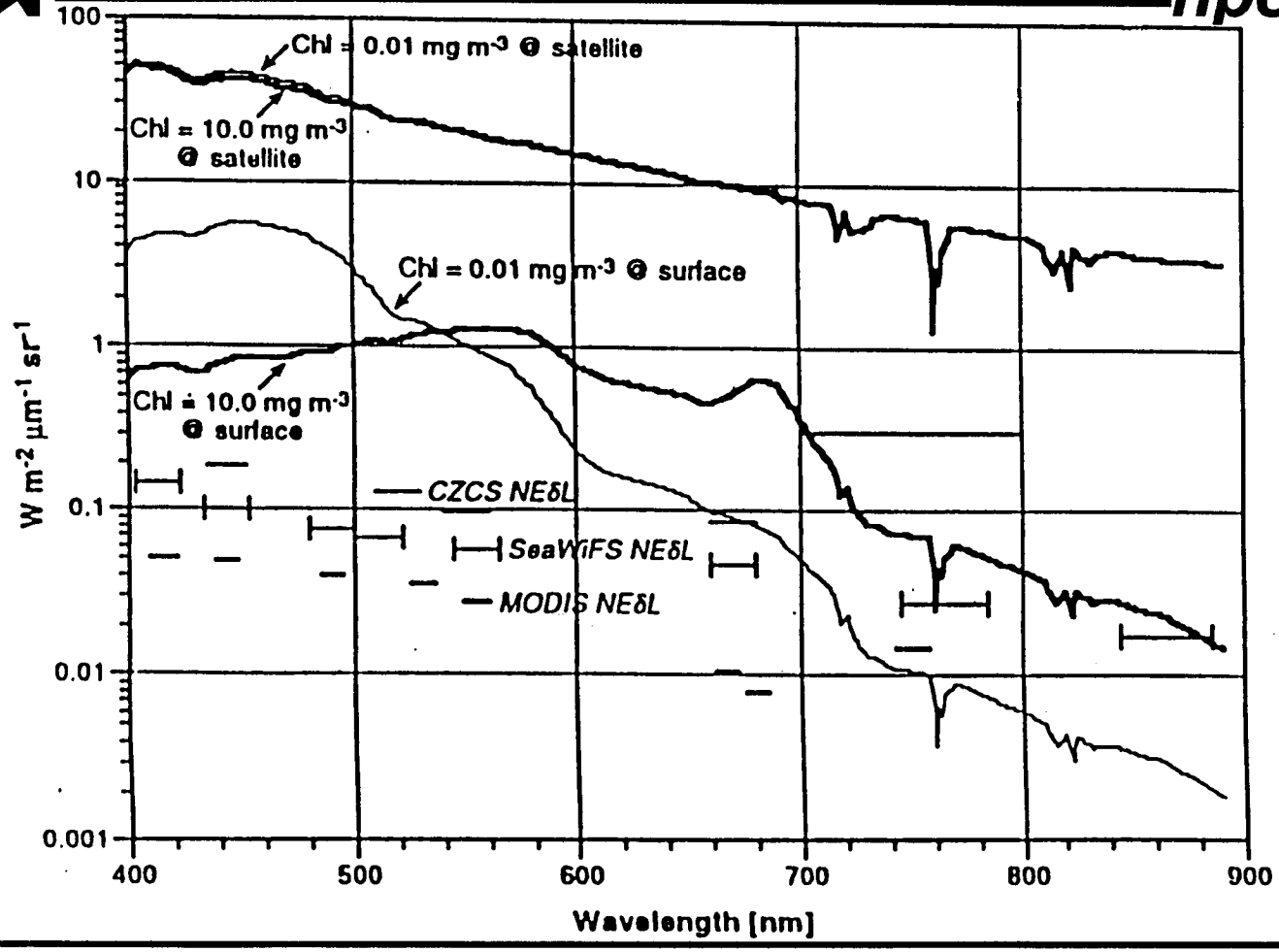

WELL CALIBRATED SENSOR NEEDED FOR OCEAN COLOR, CHLOROPHYLL, AND SEDIMENTS

SAMPLE Of EDRs AND EO SENSORS

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* EDR CONTAINS A KEY PARAMETER (see Data Requirements)					
10/1/94 A-Spec Number	EDR	DESIGN REF BASELINE	ALTERNATIVE B (12 BANDS)	NEW SENSOR	REMARKS
20.9.23	OCEAN COLOR (CHLOROPHYLL)	0	1	SeaWifs/ MODIS	
20.9.1.3	AEROSOL OPTICAL THICKNESS ***	0	1	Lidar	
20.9.20	CURRENTS	0	1		
20.3.7	CLOUD TOP PRESSURE	2	2		
20.9.18	LITTORAL SEDIMENT TRANSPORT	0	1		
20.3.4	CLOUD ICE, LIQUID EQUIVALENT	0	1		
20.9.8	BIOLUMINESCENCE	0	0	Low light level	
*** If re-stated as Optical Depth, a passive system could be used and the priority would be higher.					
Value in the sensor column: 2 - sensor satisfactory , 1 - sensor helpful, and 0 - sensor nearly useless					

EDRs AND EO SENSORS

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* EDR CONTAINS A KEY PARAMETER (see Data Requirements) B/L: Indicates one of the 8-channels of the OASIS Design Reference Baseline

10/1/94 A-Spec Number	EDR	DESIGN REFERENCE BASELINE	ALTERNATIVE B (12 BANDS)	NEW SENSOR	REMARKS
20.3.1	CLOUD IMAGERY*	2	2		
20.3.2	CLOUD COVER/LAYERS	2	2		
20.4.3	SEA ICE*	1	1		combine with µwave
20.6	SEA SURFACE TEMPERATURE*	2	2		Cloud-free only
20.9.17	LAND SURFACE TEMPERATURE	1	2		combine with µwave
20.3.9	CLOUD TOP TEMPERATURE	2	2		
20.9.2	ALBEDO	2	2		
20.9.3.2	AURORAL IMAGERY	1	2		
20.9.3.1	AURORAL BOUNDARY	1	2		
20.9.42	VEGETATION/SURFACE TYPE	1	1		combine with µwave
20.3.10	CLOUD TOP HEIGHT	2	2		
20.9.4	BATHYMETRY (DEEP OCEAN & NR SHORE)	0	1	Lidar	
20.9.1.2	AEROSOL PARTICLE SIZE	0	1	Lidar	
20.3.6.2	CLOUD OPTICAL DEPTH/TRANSMITTANCE	1	1	Lidar	
20.9.1.4	SUSPENDED MATTER	1	1	Lidar	
20.3.3	CLOUD BASE HEIGHT	0	0	Lidar/radar	
20.9.3.3	OPTICAL BACKGROUNDS	1	1	?	
20.4.1	FRESH WATER ICE CONCENTRATIONS	1	1	?	
20.9.23	OCEAN COLOR (CHLOROPHYLL)	0	1	SeaWifs/MODIS	
20.9.1.3	AEROSOL OPTICAL THICKNESS ***	1	1	Lidar	
20.9.20	CURRENTS	0	1		
20.3.7	CLOUD TOP PRESSURE	2	2		
20.9.18	LITTORAL SEDIMENT TRANSPORT	0	1		
20.3.4	CLOUD ICE, LIQUID EQUIVALENT	0	1		
20.9.8	BIOLUMINESCENCE	0	0	Low light level	
20.3.6.1	DROPLET SIZE DISTRIBUTION INDEX	0	1		
20.9.41	TURBIDITY	0	1		
20.3.5.1	CLOUD ICE WATER PATH	0	0		

*** If re-stated as Optical Depth, vice thickness, a passive system could be used, and the priority would be higher.

Value in the sensor column: 2 - sensor satisfactory , 1 - sensor helpful, and 0 - sensor nearly useless

ISSUES FOR EO IMAGERY EDRS

npoess

- 2 KEY EDRs CAN BE RETRIEVED WITH THE EO DESIGN REF BL

  - CLOUD IMAGERY
  - SEA SURFACE TEMPERATURE

- SEA ICE, THE FINAL KEY PARAMETER USING THE EO SENOR, IS A CHALLENGE:

  - ICE CONCENTRATION:
    - - HORIZONTAL SPATIAL RESOLUTION of 600 m WITH ±20 % MEASUREMENT UNCERTAINTY

- THREE OR MORE CHANNELS NEEDED IN THE 400-500 nanometer BAND TO RECOVER INFORMATION ON OCEAN PARAMETERS

ISSUES FOR EO IMAGERY EDRS

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- OTHER STRESSING EDRs USING THE EO BANDS INCLUDE:
  - CLOUD BASE, CLOUD ICE, CLOUD DROPLET SIZE,
  - AEROSOL PARTICLE SIZE,
  - BATHYMETRY, OCEAN CURRENTS, BIOLUMINESCENCE
  - TURBIDITY

CONVERGENCE EFFORT MODIFICATION

AEROSOL MEASUREMENT IMPACTS FROM SATELLITES

npoess

- MINIMUM REQUIREMENTS
  - AEROSOL PARTICLE SIZE - MIN: SFC - 15 KM (13 LEVELS)
  - AEROSOL OPTICAL THICKNESS PROFILE (13 LEVELS)
  - SUSPENDED MATTER
    -- SAND, DUST, ASH, & RADIOACTIVE SMOKE PLUMS

AEROSOL MEASUREMENTS FROM SATELLITES

KEY METHODOLOGIES

- ACTIVE MEASUREMENTS FOR AEROSOL PROFILES
  - HORIZONTAL & VERTICAL RESOLUTIONS REQUIRE SCANNING LIDAR
  - EXISTING MINIMUM MAY BE A COST DRIVER FOR SYSTEM
- USEFUL INFORMATION USING EO IMAGERY AND RADIATIVE TRANSFER MODELING FOR COLUMNAR ATMOSPHERIC PROPERTIES
  - CORRECT FOR PATH DEPENDENT ATMOSPHERIC SCATTERING
  - CORRECT FOR STRATOSPHERIC AEROSOL
  - GENERATE TOTAL AEROSOL OPTICAL DEPTH OR THICKNESS
  - AEROSOL PARTICLE SIZE FOR ATMOSPHERIC COLUMN

AN ASSESSMENT OF MICROWAVE IMAGERY SENSORS TO ADDRESS NPOESS REQUIREMENTS

MICROWAVE IMAGERY SENSOR ASSESSMENT - INTRODUCTION -

OBJECTIVE

ASSESS EXISTING/PLANNED MICROWAVE IMAGERY SENSORS REGARDING ABILITY TO ADDRESS PLANNED EDRs

SENSOR CANDIDATES

- AMSR (ADEOS-2)
- MIMR (EOS SENSOR)
- MISS (DMSP BLOCK-6)
- SSM/I (EXISTING DMSP SPACECRAFT)
- SSMIS (DMSP 5D-3)
- TMI (TRMM MICROWAVE IMAGER)

ASSESSMENT CRITERIA

- ABILITY TO ADDRESS EDRs (i.e. PROPER FREQUENCIES)
- COVERAGE (90% REQUIRED BY NPOESS A-SPEC - OCEAN WIND)

CONVERGENCE EFFORT MODIFICATION

MICROWAVE IMAGERY EDRs
- EDR / FREQUENCY COMPARISON -

npoess

PHYSICAL OBSERVABLE	1.4	6	10	19	22	37	85-91	183
Ocean Wind Speed			Critical	Important	Helpful	Helpful		
Sea Ice - Edge				Critical		Critical	Helpful	
Sea Ice - Concentration				Critical		Critical	Helpful	
Sea Ice - Age		Helpful	Important	Critical		Critical	Important	
Sea Ice - Thickness	Helpful							
Sea Ice - Leads/Polynyas				Critical		Critical	Helpful	
Sea Surface Temperature		Critical	Important	Important	Important	Helpful		
Soil Moisture	Critical	Helpful	Helpful	Helpful			Helpful	
Precipitation (over ocean)			Important	Critical	Helpful	Important		
Precipitation (over land)				Important		Critical	Critical	Important
Snow Cover / Depth		Helpful	Helpful	Critical		Critical	Important	
Surface Type				Important		Important	Important	
Cloud Liquid Water					Important	Critical	Important	
Snow Water Equivalence	Important	Important	Helpful	Important		Important		
Fresh Water Ice Concentration				Critical		Critical	Helpful	
Ice Surface Temperature		Important						
Salinity	Important							

Key: Critical | Important | Helpful

12/5/94
PSR6

CONVERGENCE EFFORT MODIFICATION

MICROWAVE IMAGERY EDRs
- SENSOR / FREQUENCY COMPARISON -

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SENSOR	1.4	6	10	19	22	37	50-60	85-91	150	183
AMSR		■	■	■	■	■		■		
MIMR		■	■	■	■	■		■		
MISS				■	■	■	■	■	■	■
SSM/I				■	■	■		■		
SSMIS				■	■	■	■	■	■	■
TMI			■	■	■	■		■		

Note: MISS and SSMIS have channels that support temperature/moisture profiling

MICROWAVE IMAGERY SENSOR COMPARISON

npoess

PHYSICAL OBSERVABLE (maximum score given in parentheses)	SENSOR OPTION					
	AMSR	MIMR	MISS	SSM/I	SSMIS	TMI
Ocean Wind Speed (7)	7	7	4	4	4	7
Sea Ice - Edge (7)	7	7	7	7	7	7
Sea Ice - Concentration (7)	7	7	7	7	7	7
Sea Ice - Age (11)	11	11	8	8	8	8
Sea Ice - Thickness (1)	0	0	0	0	0	0
Sea Ice - Leads/Polynyas (7)	7	7	7	7	7	7
Sea Surface Temperature (10)	10	10	5	5	5	7
Soil Moisture (7)	4	4	2	2	2	3
Precipitation (over ocean) (8)	8	8	6	6	6	8
Precipitation (over land) (10)	8	8	10	8	10	8
Snow Cover / Depth (10)	10	10	8	8	8	9
Surface Type (6)	6	6	6	6	6	6
Cloud Liquid Water (7)	7	7	7	7	7	7
Snow Water Equivalence (9)	7	7	4	4	4	5
Fresh Water Ice Concentration (7)	7	7	7	7	7	7
Ice Surface Temperature (2)	2	2	0	0	0	0
Salinity (2)	0	0	0	0	0	0
MAX POSSIBLE SCORE: 117	**108**	**108**	**88**	**86**	**88**	**96**
Add 10 GHz to MISS: Score = 100	Score derived by: 3 points for critical frequency, 2 for important, 1 for helpful					

CONVERGENCE EFFORT MODIFICATION

MICROWAVE IMAGERY SENSOR - COVERAGE COMPARISON -

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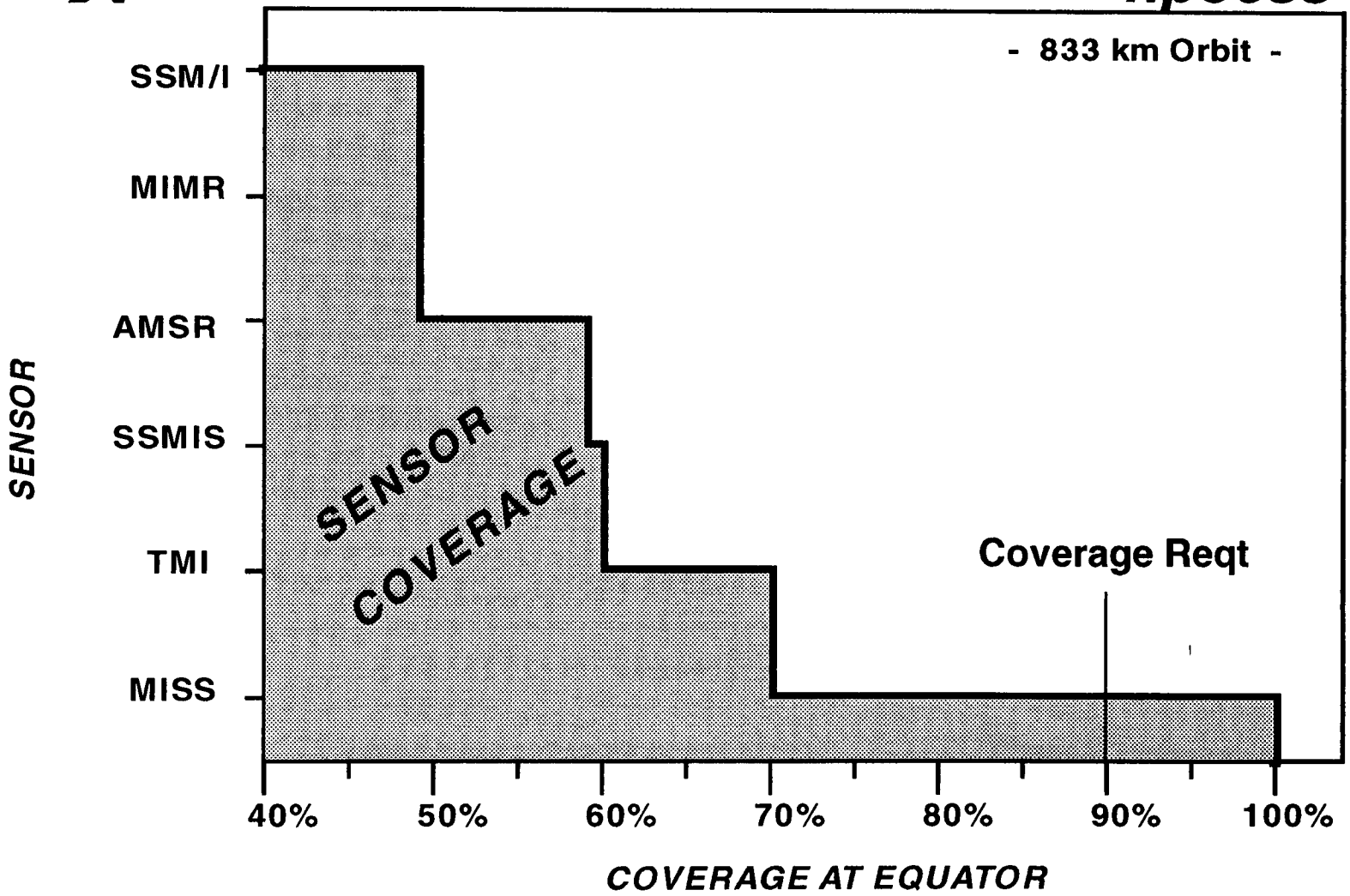

12/5/94
PSR6

CONVERGENCE EFFORT MODIFICATION

MICROWAVE IMAGER
- CONICAL SCANNER SIZING PARAMETRICS -

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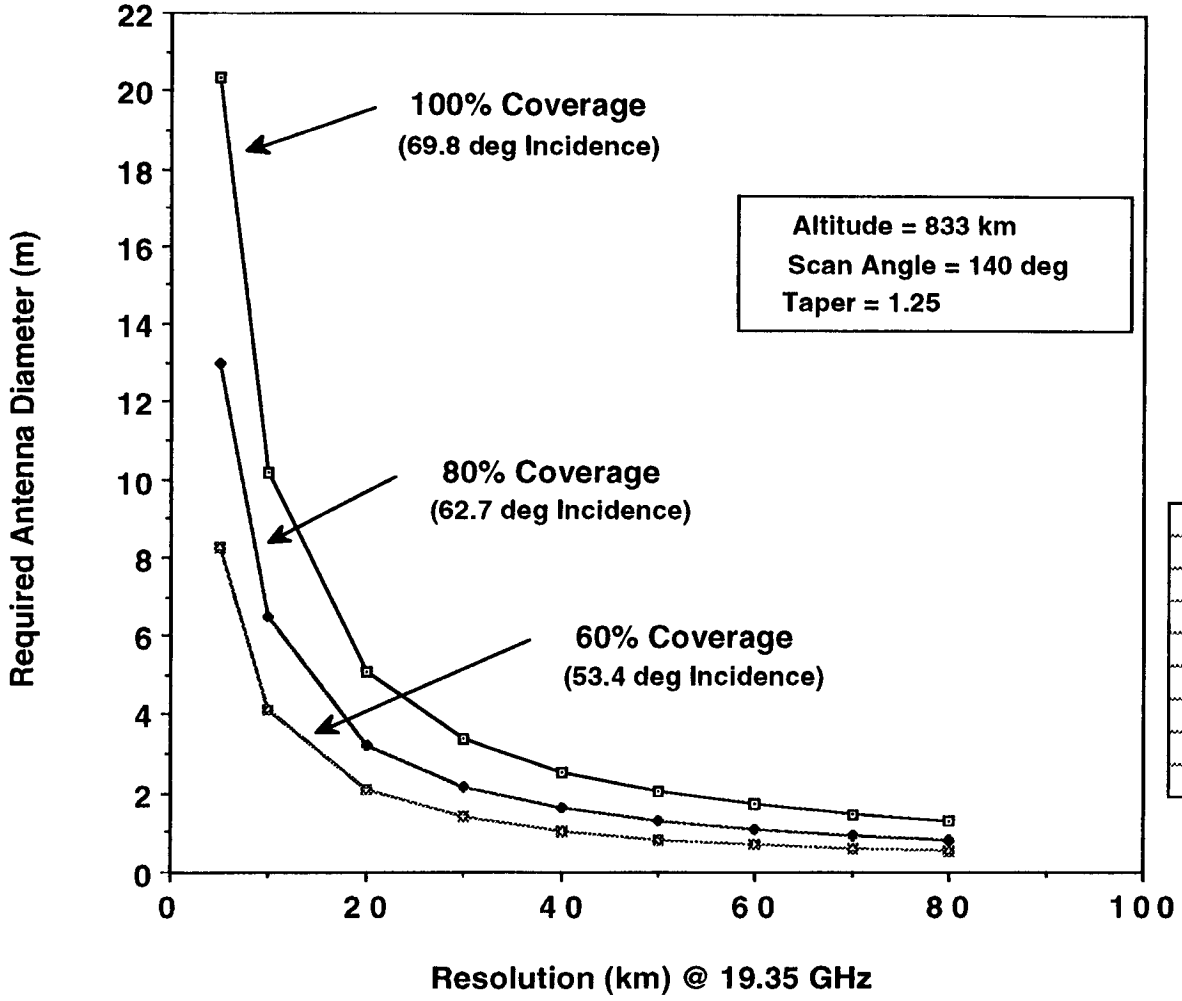

Sensor	Scan Angle (deg)	Ant Diam (m)
AMSR	140	2
MIMR	120	1.6
MISS	140	2.04
SSM/I	102	0.61
SSMIS	144	0.61
TMI	140	0.61

CONVERGENCE EFFORT MODIFICATION

MICROWAVE IMAGERY SENSOR - OPTIONS & CONCLUSIONS -

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- o AMSR & MIMR OFFER GREATEST EDR APPLICABILITY BUT WITH COVERAGE < 60%

- o MISS OFFERS SLIGHTLY DIMINISHED EDR APPLICABILITY BUT WITH COVERAGE = 100%

  REDUCED CAPABILITY FOR FOLLOWING EDRS:

  - OCEAN WIND SPEED
  - SEA ICE AGE
  - SEA SURFACE TEMPERATURE
  - SOIL MOISTURE (no sensor has critical 1.4 GHz frequency)
  - PRECIPITATION (OVER OCEAN)
  - SNOW COVER / DEPTH
  - SNOW WATER EQUIVALENCE
  - ICE SURFACE TEMPERATURE

- o NO SENSOR HAS CAPABILITY FOR SEA ICE THICKNESS AND SALINITY (1.4 GHz)

MISS OFFERS GREATEST BALANCE OF COVERAGE AND EDR APPLICABILITY

CONVERGENCE EFFORT MODIFICATION

ADDRESSING EDR REQUIREMENTS vs MEETING EDR REQUIREMENTS

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- JUST BECAUSE A SENSOR CAN ADDRESS AN EDR DOESN'T MEAN THE SENSOR CAN MEET THE EDR

- FOR EACH EDR, THE FOLLOWING PARAMETERS ARE REQUIRED, ALLOWING AN IDENTIFICATION OF THE DRIVING SENSOR DESIGN REQUIREMENTS

EDR	Horiz Resol	Reqd Channels	Polariz	Chanl Bndwdth	Center Frq Sblty	Reqd NEdT	Reqd Cal Uncer.
Ocean Wind Speed							
Sea Ice - Edge							
Sea Ice - Concentration							
Sea Ice - Age							
Sea Ice - Thickness							
Sea Ice - Leads/Polynyas							
Sea Surface Temperature							
Soil Moisture							
Precipitation (ocean)							
Precipiation (land)							
Snow Cover / Depth							
Surface Type							
Cloud Liquid Water							
Snow Water Equivalence							
Fresh Water Ice Conc.							
Ice Surface Temp							
Salinity							

CONVERGENCE EFFORT MODIFICATION

STATUS: IR & MICROWAVE PROFILES

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- BASED ON SIMULATIONS:
  - AIRS / ITS ACHIEVE TEMP RMS ERRORS NEAR 1 K
  - RELATIVE HUMIDITY RMS ERRORS OF ABOUT 10 %
  - VERTICAL RESOLUTION NEAR 1 KM
- NEED TO SUPPLEMENT IR SOUNDER WITH MICROWAVE SOUNDERS TO OBTAIN ALL-WEATHER DATA
- ADDITIONAL STUDY NEEDED:
  - TO QUANTIFY THE OPTIMUM NUMBER OF CHANNELS
    - FOR PERFORMANCE AND
    - COST

CONVERGENCE EFFORT MODIFICATION

SENSOR CANDIDATES FOR CLIMATE MONITORING

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1. THE ACTIVE CAVITY ARRAY (ACA)
2. THE CLOUDS & EARTH'S RADIANT ENERGY SYSTEM (CERES)
3. THE CONICALLY SCANNING RADIOMETER (CSR)
4. THE EARTH RADIATION BUDGET EXPERIMENT (ERBE)
5. THE NIMBUS 7 BIAXIAL SCANNER

STATUS: CLIMATE MONITORING

npoess

- BASED ON NESDIS REPT NO 58 BY STOWE ET AL
  - CERES COMES CLOSEST FOR:
    - - RADIATION STUDIES
    - - CLIMATE MONITORING

SIGNIFICANT EDR FINDINGS

72 EDRs DIVIDE INTO 3 BROAD CATEGORIES

1. REQUIREMENTS SATISFIED BY DESIGN REFERENCE BASELINE

2. REQUIREMENTS SATISFIED BY TBD RESOLUTION OR FLYING / MODIFYING EXISTING SENSORS

3. MAJOR DEVELOPMENT OR TECHNICAL INNOVATION REQUIRED

CONVERGENCE EFFORT MODIFICATION

ASSESSMENT OF SENSOR COMPLEMENT (1 OF 4)

npoess

10/1/94 A-Spec Number	EDR (*DENOTES AN EDR WITH A KEY PARAMETER)	DESIGN REF BL	ALTER-NATIVE A	ALTER-NATIVE B	ALTER-NATIVE C
20.1	ATM VERT MOISTURE PROFILE*	2	2	2	2
20.3.1	CLOUD IMAGERY*	2	2	2	2
20.2	ATM VERT TEMP PROFILE*	2	2	2	2
20.8.2	TROPOSPHERIC WINDS	2	2	2	2
20.8.1	SEA SURFACE WINDS*	1	1	1	2
20.3.2	CLOUD COVER/LAYERS	2	2	2	2
20.4.3	SEA ICE*	1	1	1	2
20.6	SEA SURFACE TEMPERATURE*	2	2	2	2
20.9.39	TOTAL WATER CONTENT	2	2	2	2

Value in Sensor-complement Column: 2 - Satisfactory; 1 - Helpful; 0 - Nearly useless

ASSESSMENT OF SENSOR COMPLEMENT (2 OF 4)

npoess

10/1/94 A-Spec Number	EDR (*DENOTES AN EDR WITH A KEY PARAMETER)	DESIGN REFERENCE BASELINE	ALTER-NATIVE A	ALTER-NATIVE B	ALTER-NATIVE C
20.9.10	ELECTRON DENSITY PROFILES/	2	2	2	2
20.9.17	LAND SURFACE TEMPERATURE	1	1	1	2
20.5	OZONE TOTAL COLUMN/PROFILE	0	0	2	2
20.3.9	CLOUD TOP TEMPERATURE	2	2	2	2
20.9.2	ALBEDO	2	2	2	2
20.7	SOIL MOISTURE*	1	1	1	2
20.9.31	SEA SURFACE HEIGHT/TOPOGRAPHY	0	0	2	2
20.9.3.2	AURORAL IMAGERY	1	1	2	2
20.9.3.1	AURORAL BOUNDARY	1	1	2	2
Value in Sensor-complement Column: 2 - Satisfactory; 1 - Helpful; 0 - Nearly useless					

ASSESSMENT OF SENSOR COMPLEMENT (3 OF 4)

npoess

10/1/94 A-Spec Number	EDR	DESIGN REFERENCE BASELINE	ALTER-NATIVE A	ALTER-NATIVE B	ALTER-NATIVE C
20.9.25	PRECIPITATION (TYPE, RATE)	1	1	1	2
20.4.10	SNOW COVER/DEPTH	1	1	1	2
20.9.9	ELECTRIC FIELDS	2	0	2	2
20.9.16	IONOSPHERIC SCINTILLATION	0	0	0	1
20.9.42	VEGETATION/SURFACE TYPE	1	1	1	2
20.9.24	OCEAN WAVE CHARACTERISTICS	0	0	2	2
20.9.15.1	IN-SITU PLASMA DENSITY	2	0	2	2
20.9.21	NET HEAT FLUX	1	1	1	2
20.3.10	CLOUD TOP HEIGHT	2	2	2	2
20.9.34	SURFACE WIND STRESS	1	1	1	1
20.9.13	GEOMAGNETIC FIELD	2	0	2	2
20.9.4	BATHYMETRY (DEEP OCEAN & NEAR SHORE)	0	1	1	1
20.3.5	CLOUD LIQUID WATER	1	1	1	2
20.9.22	NEUTRAL DENSITY PROFILES/NEU ATM SPEC	1	0	1	1
20.4.9	SNOW WATER EQUIVALENT	0	0	0	1
20.9.1.2	AEROSOL PARTICLE SIZE	0	0	1	2
20.9.15.2	IN-SITU PLASMA TEMPERATURE	2	0	2	2
20.3.6.2	CLOUD OPTICAL DEPTH/TRANSMITTANCE	1	1	1	2
20.9.14	NET RADIATION (TOP OF ATMOSPHERE)	0	0	2	2
20.9.1.4	SUSPENDED MATTER	1	1	1	2
20.3.3	CLOUD BASE HEIGHT	0	0	0	1
20.9.3.3	OPTICAL BACKGROUNDS	1	1	1	2
20.4.1	FRESH WATER ICE CONCENTRATIONS	1	1	1	2
20.4.4	ICE SURFACE TEMPERATURE	1	1	1	2
20.9.23	OCEAN COLOR (CHLOROPHYLL)	0	0	1	2
20.9.1.3	AEROSOL OPTICAL THICKNES	0	0	1	2
20.9.28	PRESSURE (SURFACE/PROFILE)	0	0	1	2

Value in Sensor-complement Column: 2 - Satisfactory; 1 - Helpful; 0 - Nearly useless

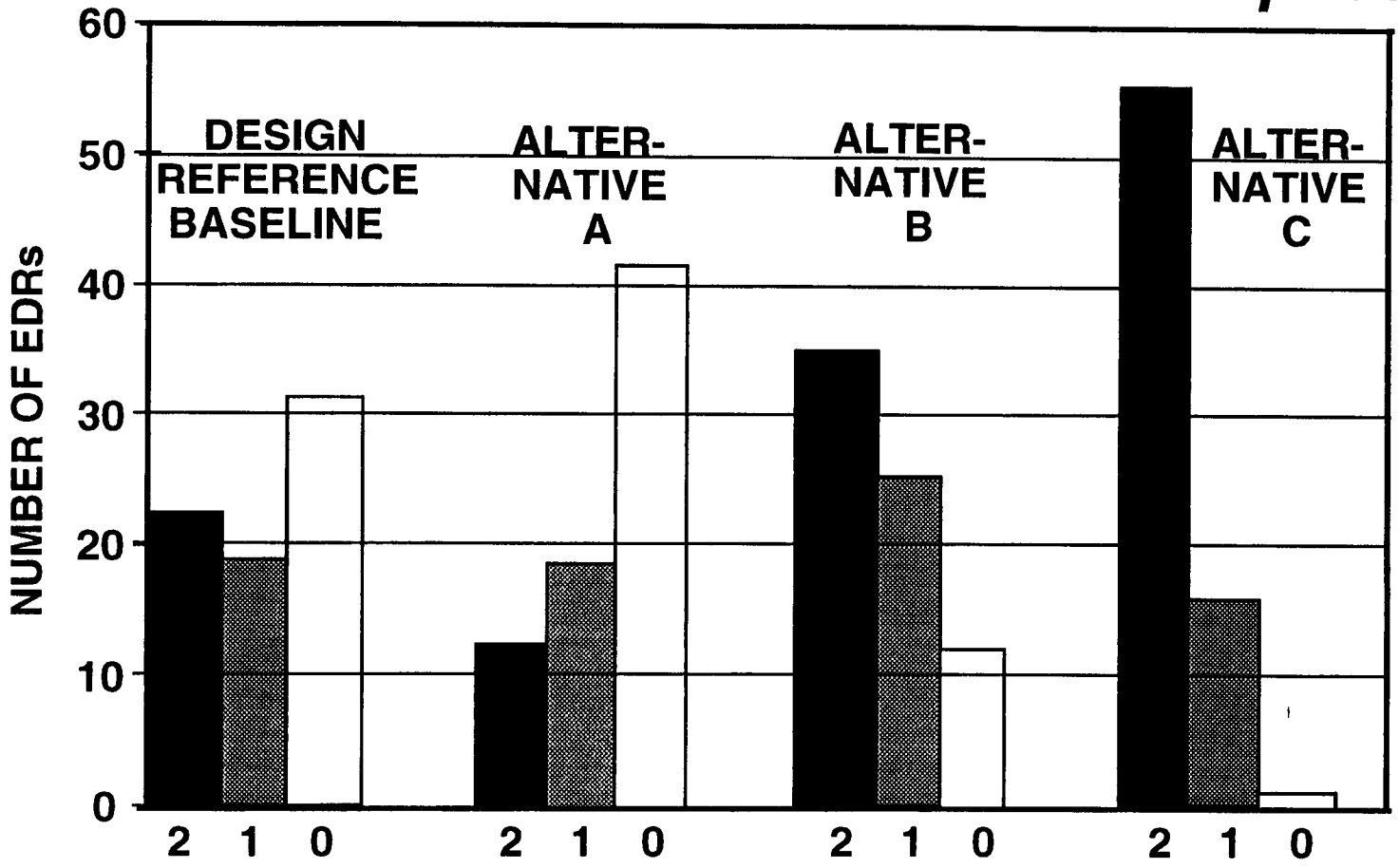
CONVERGENCE EFFORT MODIFICATION

ASSESSMENT OF SENSOR COMPLEMENT (4 OF 4)

npoess

10/1/94 A-Spec Number	EDR	DESIGN REFERENCE BASELINE	ALTER-NATIVE A	ALTER-NATIVE B	ALTER-NATIVE C
20.9.5	CH4 COLUMN (METHANE)	0	0	0	2
20.9.20	CURRENTS	0	0	1	1
20.9.19	LONGWAVE RADIATION	0	0	2	2
20.9.7	CO2 COLUMN (CARBON DIOXIDE	0	0	0	1
20.3.7	CLOUD TOP PRESSURE	2	2	2	2
20.9.6	CO COLUMN (CARBON MONOXIDE)	0	0	0	2
20.9.18	LITTORAL SEDIMENT TRANSPORT	0	0	1	1
20.9.16.1	IN-SITU PLASMA FLUCTUATIONS	2	0	2	2
20.9.26.2	RADIATION BELT/LOW ENERGY SOLAR	2	0	2	2
20.9.37	TOAL SHORTWAVE RADIATION	0	0	2	2
20.9.36	TOTAL LONGWAVE RADIATION (TOP OF ATM)	0	0	2	2
20.9.15.3	ION DRIFT VELOCITY	0	0	0	0
20.3.4	CLOUD ICE, LIQUID EQUIVALENT	0	0	1	2
20.9.26.1	SUPRA-THERMAL/AURORAL PARTICLES	2	0	2	2
20.9.32	NET SURFACE SHORTWAVE RADIATION	0	0	2	2
20.9.26.3	SOLAR/GALACTIC COSMIC RAY PARTICLES	2	0	2	2
20.9.27	PRECIPITABLE WATER STABILITY	1	1	1	2
20.9.8	BIOLUMINESCENCE	0	0	0	1
20.9.35	TOTAL AURORAL ENERGY DEPOSITION	2	0	2	2
20.9.3.4	UPPER ATMOSPHERIC AIRGLOW	2	0	2	2
20.3.6.1	DROPLET SIZE DISTRIBUTION INDEX	0	0	1	1
20.9.41	TURBIDITY	0	0	1	1
20.9.38	TOTAL SOLAR IRRADIANCE (FULL SPECTRUM)	0	0	2	2
20.9.30	SALINITY	0	0	0	1
20.3.5.1	CLOUD ICE WATER PATH	0	0	0	1
20.9.33	SOLAR EXTREME ULTR VIOLET (EUV) FLUX	0	0	0	1
Value in Sensor-complement Column: 2 - Satisfactory; 1 - Helpful; 0 - Nearly useless					

SUMMARY: DRAFT ASSESSMENT



SENSOR COMPLEMENT CAPABILITY
(2 - SATISFACTORY; 1 - HELPFUL; 0 - NEARLY USELESS)

SENSOR SUITE RQTS/IMPACTS

P. CALLARY

CONVERGENCE EFFORT MODIFICATION

REVISED A-SPEC (DRAFT) IMPACTS TO SENSOR SUITES

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- TOTAL NUMBER OF EDRs INCREASED TO 72
- MAJOR IMPACTS FALL INTO FOUR BROAD CATEGORIES
  - REQUIREMENTS WHICH RESULT IN NEW SENSOR TYPES
  - ADDITION OF SPECTRAL BANDS (OR FREQUENCIES) TO EXISTING SUITE
  - INCREASED SENSITIVITY REQUIREMENTS
  - INCREASED MAPPING ACCURACY REQUIREMENTS
- IDENTIFICATION OF ADDITIONAL EO SPECTRAL BANDS AND MICROWAVE FREQUENCIES IS A MAJOR ONGOING TASK
  - GREATEST IMPACT TO EO SENSORS
  - UP TO 8 ADDITIONAL EO SPECTRAL BANDS HAVE BEEN IDENTIFIED

INITIAL IMPACTS ASSESSMENTS

npoess

- INITIAL ASSESSMENTS IN FIVE CATEGORIES
  - REQUIREMENTS MET BY EXISTING REFERENCE BASELINE
  - REQUIREMENTS REQUIRE MOD TO EXISTING BASELIINE
  - REQUIREMENTS REQUIRE TRADE OF BASELINE SENSOR MODIFICATION VS NEW SENSOR
  - REQUIREMENTS REQUIRE NEW SENSOR
  - NO SENSING TECHNIQUE IDENTIFIED TO MEET REQUIREMENTS

- TRADES FOR ACHIEVING NEW REQUIREMENTS
  - SCIENCE TEAM WORKING ON EDR REQUIREMENTS FLOWDOWN
  - SENSOR TRADES WILL CONTINUE AS SENSOR REQUIREMENTS ARE DETERMINED
  - COST/RISK/INTERFACE IMPACTS WILL BE IDENTIFIED

REQUIREMENTS FLOWDOWN FROM EDR TO SENSOR(S)

EDRs ARE OBTAINED BY REMOTELY SENSING PHYSICAL PARAMETERS WHICH DIRECTLY RELATE TO EACH EDR

- REQUIREMENTS CAN OFTEN BE BALANCED AMONG SEVERAL SENSORS

THE "ART" OF SENSOR DESIGN IS TO MEET THE SENSING REQUIREMENTS ... WHILE SIMULTANEOUSLY ACHIEVING THE OPTIMUM DESIGN BALANCE OF LCC, POWER, WEIGHT, RELIABILITY AND ENVELOPE CONSTRAINTS

- CAREFUL SPACE SEGMENT DESIGN CAN BALANCE CONSTRAINTS BETWEEN SEVERAL SENSORS TO REDUCE OVERALL RISK FOR ALTERNATIVE DESIGNS

SENSING AND SENSOR REQUIREMENTS

npoess

- THERE IS A DIFFERENCE BETWEEN SENSING REQUIREMENTS AND SENSOR REQUIREMENTS
  - SENSING REQUIREMENTS DEFINE THE CONDITIONS OF THE PARAMETER(S) TO BE MEASURED
  - SENSOR REQUIREMENTS COMPLETELY DEFINE THE TOOL(S) USED TO MEET THE SENSING REQUIREMENTS
- SENSING REQUIREMENTS ARE A DESIGN SUBSET OF THE COMPLETE SET OF SENSOR(S) REQUIREMENTS
  - MAY OR MAY NOT BE DRIVING REQUIREMENTS
  - OFTEN LCC, WEIGHT, POWER AND ENVELOPE ARE MORE STRESSING REQUIREMENTS

CONVERGENCE EFFORT MODIFICATION

SYSTEM RELATION TO SENSOR REQUIREMENTS

npoess

EDR REQUIREMENTS

↓

REMOTE SENSING REQUIREMENTS

↓

SENSOR REQUIREMENTS

EXAMPLE

20.9.1.4 SUSPENDED MATTER

Detect Aerosols : dust, sand, ash

Goal: dust, sand, ash and sea salt

SENSING TECHNOLOGY: EO IMAGER and/or LIDAR. (Incl. Spectral Bandpasses, Dynamic Range, Resolution, SNR, Accuracy/Precision)

KEY SENSOR PARAMETERS: Spectral Bandpasses, Dynamic Range, Resolution, SNR, Accuracy/Precision, Weight, Power, Envelope, Reliability, Straylight, LCC, etc.

KEY REVISED A-SPEC (DRAFT) IMPACTS TO MISSION SENSORS

- NEW GROUPING OF SENSOR SUITES

IMAGER SUITE
PROFILER SUITE
CLIMATE MONITORING SUITE
SES SUITE

- "DRAFT" REVISED A-SPEC REVIEWED FOR CHANGES TO BASELINE DESIGNS
  - i.e. OMIS/M ISS/SESS IMPACTS PLUS ANY NEW SENSORS REQUIRED
  - ONLY MAJOR IMPACTS WILL BE DISCUSSED

- FINAL VALUES USED FOR "TBD" REQUIREMENTS MIGHT CAUSE ADDITIONS AND/OR DELETIONS TO THIS LIST

CONVERGENCE EFFORT MODIFICATION

A-SPEC REV(DRAFT)
TOP LEVEL EO SENSOR IMPACTS (1 OF 2)

npoess

OMIS/VIRSR

- AS MANY AS 8 ADDITIONAL SPECTRAL BANDS HAVE BEEN IDENTIFIED

- EDR STATES REQUIREMENT FOR 0.65 km CONSTANT RESOLUTION
  - OPEN LMSC QUESTION (A-SPEC COMMENTS DATED 18 OCTOBER, #SYS-21)
    - » IS INTERPOLATION ALLOWED? i.e. DOES MTF APPLY?
    - » VERBAL FEEDBACK INDICATES THAT "CONSTANT" MEANS $\leq$ 0.65 km EVERYWHERE IN THE SCAN

- SEA ICE EDGE UNCERTAINTY WILL REQUIRE FROM 5 -30 m MAPPING CAPABILITY AT EDGE OF SCAN .... NEW DRIVING REQUIREMENT. (DISCUSSION NEEDED ON INTERPRETATION OF THIS REQUIREMENT)

- CLOUD IMAGERY EDR MEASUREMENT ACCURACY HAS BEEN DELETED
  - APPENDIX C MAKES REFERENCE TO CALIBRATION, BUT THIS IS FOR INFORMATION ONLY AND IS NOW "TBD" FOR VISIBLE BANDS

- LOSSY DATA COMPRESSION IS NOW ALLOWED ON ALL SENSOR DATA

CONVERGENCE EFFORT MODIFICATION

A-SPEC REV (DRAFT)
TOP LEVEL EO SENSOR IMPACTS (2 OF 2)

npoess

- IR SOUNDER
  - THE NEED RESULTS FROM REQUIREMENTS

- CLIMATE MONITORING SUITE
  - OZONE, RADIATION BALANCE AND SEA SURFACE SKIN TEMP

- TRANSLATION OF EDRs TO SENSING REQUIREMENTS IS NOW CRITICAL TO PROGRAM SUCCESS
  - SENSOR TRADES NEED PRIORITIZATION OF REQUIREMENTS
  - EDR REQUIREMENTS OFTEN STATED AS UNIT-LESS NUMBERS
    - » OFTEN MINIMUM IS "TBD" AND GOAL IS BLANK
    - » POTENTIAL FOR CONFUSION IS HIGH
  - RATIONAL QUANTIFICATION OF MINIMUM/GOAL REQUIREMENTS

EUMETSAT I/F CONCERN FOR OMIS/VIRSR

- NOT MUCH HAS BEEN SAID ABOUT EUMETSAT INTERFACE
- VIRSR ENVELOPE CONSTRAINTS NOT APPLIED TO OMISVIRSR

KEY PROFILER ALTERNATIVES

npoess

- MICROWAVE SOUNDER REQUIREMENTS DRIVERS
  - GROUND COVERAGE (NOAA AMSU/MHS ~ 80% COVERAGE
  - SENSOR LIFETIME (AMSU/MHS VS NEW SENSORS)
  - SOUNDING REQUIREMENTS (LEVELS vs #CHANNELS)
  - HORIZONTAL RESOLUTION (NADIR vs EDGE OF SCAN)

- IR SOUNDER REQUIREMENTS DRIVERS
  - AIRS 2378 SPECTRAL CHANNELS vs 1000 - 1500 CHANNELS
  - [redacted]
  - RELIABILITY
    - » LIFETIME (AIRS MECH. REFRIGERATOR vs [redacted] PASSIVE RADIATOR)
    - » DEVELOPMENT RISK (AIRS vs NEW SENSOR ... CONSIDERING LIFETIME ISSUES)
  - SIZE, WEIGHT, POWER
  - COST (NRE + RECURRING)
    - » AIRS vs LOW COST [redacted] (OR ITS)

CONVERGENCE EFFORT MODIFICATION

INITIAL SENSOR CANDIDATES FOR PROFILER SUITE

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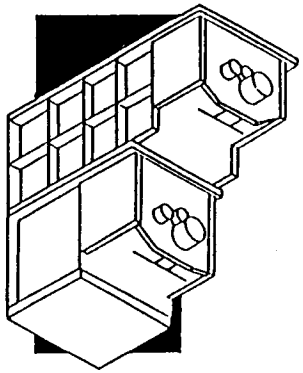
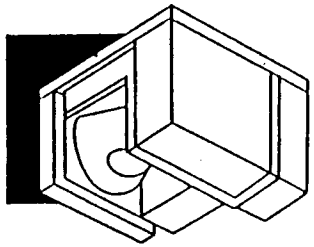
MICROWAVE SOUNDERS

AMSU



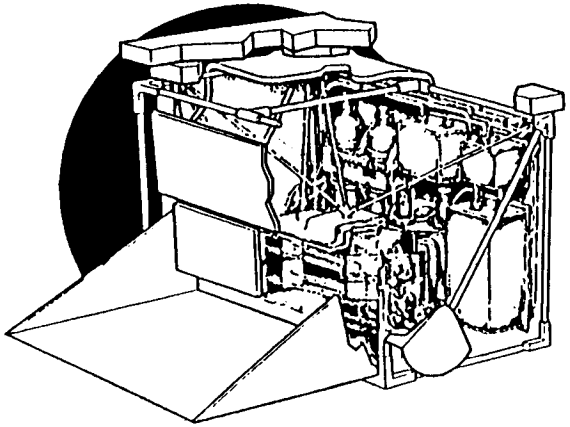
AND

MHS



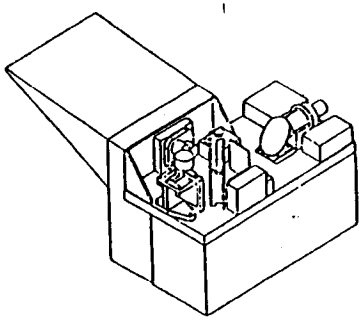
IR SOUNDERS

AIRS



OR

[redacted] vs ITS



MISS IMPACT DUE TO NPOESS A-SPEC

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- o MOISTURE PROFILE: VERTICAL SAMPLING IN 20 mb INCREMENTS REQUIRES MANY ADDITIONAL CHANNELS OR AN IR SOUNDER
- o TEMPERATURE PROFILE: VERTICAL SAMPLING IN 20 mb INCREMENTS REQUIRES MANY ADDITIONAL CHANNELS OR AN IR SOUNDER
- o SEA ICE: ICE CONCENTRATION & AGE ACHIEVABLE ONLY BY MICROWAVE BUT 600 m RESOLUTION REQUIRES ANTENNA DIAMETER UP TO 20 m
- o ICE SURFACE TEMPERATURE: REQUIRES 6 GHz CHANNEL AND 11 m DIAMETER DISH FOR 30 km RESOLUTION
- o SALINITY: REQUIRES FREQUENCY LOWER THAN 1.4 GHz

TBD RESOLUTION FOR SEVERAL EDRs COULD IMPACT SENSOR DESIGN

- o SNOW WATER EQUIVALENCE
- o SNOW COVER/DEPTH
- o SOIL MOISTURE
- o OCEAN WIND SPEED
- o PRECIPITATION
- o SURFACE TYPE

PRELIMINARY ANALYSIS OF SES EDR REQUIREMENTS FROM NPOESS A-SPEC (1)

npoess

EDR #	NAME	COVERAGE	RESOLUTION	MEASUREMENT RANGE
20.9.3 20.9.3.1 20.9.3.2 20.9.3.4	AURORAL & AIRGLOW IMAGERY	• Global = constellation swath	• Goals imply imagery	• Broadband goals implies complex cluster of imagers • UV goals achievable • IR & X-ray require different instrument types
20.9.3.3	OPTICAL BACKGROUND	• Global = constellation swath	• Goals imply imagery in IR with very large cooled sensor	• Simple instrument can achieve some of range • LWIR not feasible unless with moderate complexity
20.9.9	ELECTRIC FIELD	• Global = constellation swath	• Goals achievable	• Goals achievable
20.9.10	ELECTRON DENSITY	• Global	• 10km horizontal resolution achievable only along orbit • Minimum: 200km global away from orbit	• Goals achievable
20.9.13	GEOMAGNETIC FIELD	• Global = constellation swath	• Goals likely achievable	• Goals likely achievable

PRELIMINARY ANALYSIS OF SES EDR REQUIREMENTS FROM NPOESS A-SPEC (2)

npoess

EDR #	NAME	COVERAGE	RESOLUTION	MEASUREMENT RANGE
20.9.15 20.9.15.1 20.9.15.2 20.9.15.3 20.9.16.1	IN-SITU MEASUREMENTS	• Global = constellation orbit	• Goals achievable	• ΔN/N goal requires addition to RPAD
20.9.16	IONOSPHERIC SCINTILLATION	• Global = where measurements can be made of C L	• Sensing depth requires bi-static measurements	• (C L,q) cannot be obtained with uni-static instrument
20.9.22	NEUTRAL DENSITY	• Global = constellation swath	• Goals imply limb scanner	• Goals outside current proven state-of-art except for low altitude in-situ measurements • Measurements at orbit altitude not meaningful
20.9.26 20.9.26.1 20.9.26.2 20.9.26.3 20.9.35	ENERGETIC PARTICLES	• Global = constellation orbit	• Goals achievable	• Most goals achievable • Cosmic ray mass/flux goals imply higher complexity
20.9.33	SOLAR EUV	• Sun disk	• N/A	• Heritage instrument, not proven

EO SENSORS

P. CALLARY

EO SENSORS

- OMIS/VIRSR UPDATE
  - SUMMARY OF SBRC/LMSC 2 NOV TIM
- IR SOUNDER TRADE ALTERNATIVE APPROACH
- SEAWIFs

PAGES 252 THROUGH 283 ARE EXEMPT FROM RELEASE AND ARE REPLACED WITH THIS PAGE.

EO SENSORS SUMMARY

npoess

- SBRC OASIS SENSOR PROGRESS
  - FLEXIBILITY OF DESIGN ... TRADES ARE PARAMOUNT
    - » SPATIAL RESOLUTION vs DATA RATE FLEXIBILITY
    - » [redacted]
- [redacted]
  - [redacted]
  - [redacted]
- [redacted]

LMSC/SBRC TEAM STRIVING FOR MAXIMUM DESIGN FLEXIBILITY DURING THIS PERIOD OF REQUIREMENTS DEVELOPMENT ...TRADES WILL BE ONGOING AS REQUIREMENTS EVOLVE

/13/95
PSR6

DATA COMPRESSION of MULTI-SPECTRAL IMAGERY

SYLVIA SHEN

DATA COMPRESSION MOTIVATION

- GOAL IS TO SEND UNCOMPRESSED DATA TO CENTRAL SITES
  - LOSSLESS DATA COMPRESSION A RATIONAL ALTERNATIVE
  - X-BAND DATA RATE CAPABILITY IS AN ISSUE
    - » LMSC USING A CONSERVATIVE 90 MBPS FOR THE DOWNLINK

- REGIONAL SITES WILL REQUIRE LOSSY DATA COMPRESSION FOR EO SENSORS
  - COMPRESSION RATIOS OF 8 -16 MAY BE REQUIRED
  - QUANTIFICATION OF ERROR IN PROCESS FOR REGIONAL SITES

- RADIOMETRIC ACCURACY REQUIREMENTS AT REGIONAL SITES SHOULD BE DIFFERENT FROM CENTRAL SITES
  - GLOBAL CHANGE RELATED REQUIREMENTS CAN USE CENTRAL SITE DATA
  - REGIONAL SITE REQUIREMENTS HAVE NOT BEEN DEFINED ANY DIFFERENTLY FROM CENTRAL SITES

DATA COMPRESSION IMPACTS

- DATA COMPRESSION IMPACT ON MEASUREMENT ACCURACY
  - MUST BE CONSIDERED AS PART OF THE MEASUREMENT ERROR BUDGET
    - » LOSSLESS WILL CONTRIBUTE ZERO ERROR BY DEFINITION
    - » LOSSY A SMALL CONTRIBUTOR TO PREVIOUS AF ERROR BUDGET AT A COMPRESSION RATIO OF 4
- ON-BOARD STORAGE REQUIREMENTS DRAMATICALLY AFFECTED BY USE OF DATA COMPRESSION

LMSC WILL CONTINUE TO STUDY THE IMPACT OF DATA COMPRESSION

IMAGE COMPRESSION TYPES

npoess

- LOSSLESS COMPRESSION
  - EXACT REPLICA OF ORIGINAL DATA RECONSTRUCTIBLE FROM ENCODED FORM
  - COMPRESSION RATIO DEPENDS ON IMAGE INFORMATION CONTENT (AVERAGE COMPRESSION RATIO ≥ 2 IS TYPICAL)
  - COMPRESSION ALGORITHMS UTILIZED
    - » LEMPEL-ZIV COMPRESSION
    - » MODIFIED HUFFMAN COMPRESSION

- LOSSY COMPRESSION
  - ACHIEVES HIGHER COMPRESSION RATIOS WITH "NEGLIGIBLE" DATA DEGRADATION
  - COMPRESSION ALGORITHMS UTILIZED
    - » DISCRETE COSINE TRANSFORM (DCT) COMPRESSION
    - » WAVELET COMPRESSION

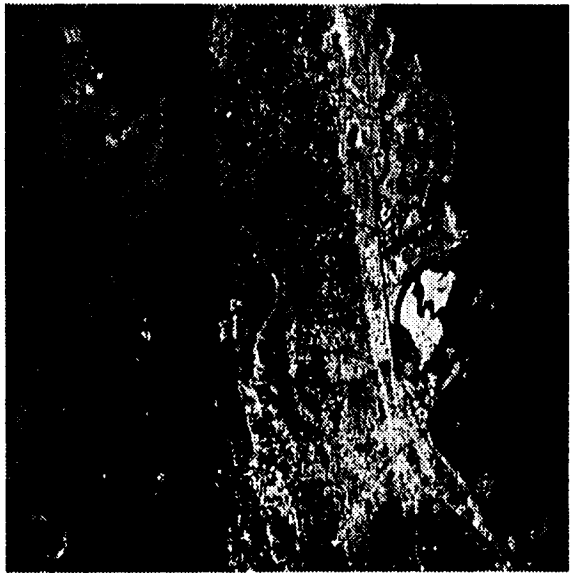
RESULTS PRESENTED FOR TWO TYPICAL TEST IMAGES

TEST IMAGE 1
OMIS/VIRSR_B4
(MODIS_B9, 3.659 - 3.810 um, 512x512 pixels)

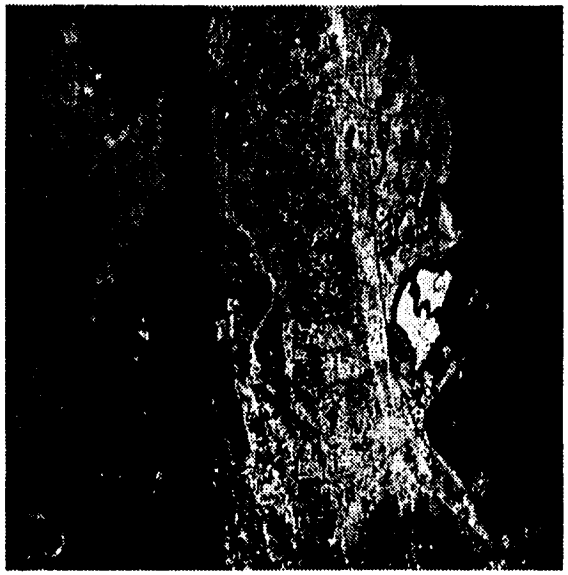
IMAGE STATISTICS
(in digital counts)

OMIS/VIRSR	Wavelength	MODIS	Wavelength	Mean	STD	Range	Entropy
1	0.6 um	3	0.635 - 0.688 um	19.85	14.38	8 to 63	4.43
2	0.9 um	4	0.896 - 0.927 um	25.34	14.65	4 to 63	4.67
3	1.6 um	5	1.595 - 1.652 um	24.36	15.47	4 to 63	5.20
4	3.7 um	9	3.659 - 3.810 um	119.63	7.60	108 to 166	4.58
5	10.0 um	11	10.259 - 10.725 um	191.99	21.81	148 to 255	6.17
6	12.0 um	12	11.799 - 12.246 um	161.94	24.45	120 to 242	6.24
8	8.5 um	10	8.342 - 8.738 um	168.04	23.96	128 to 214	6.08

Discrete Cosine Transform Compression on OMIS/VIRSR_B4

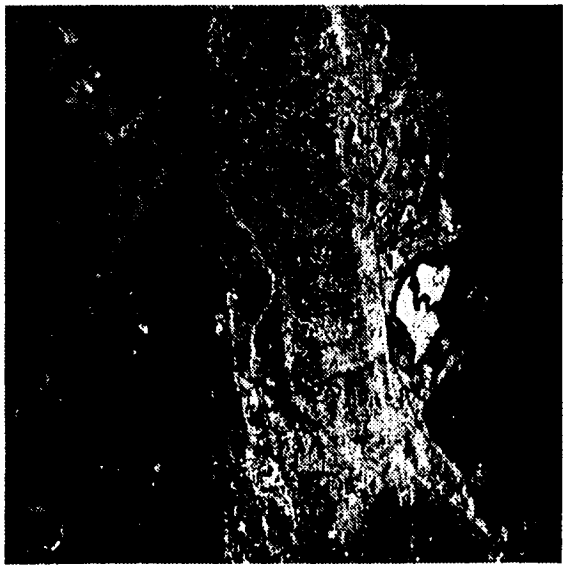


Original Image



Compressed/Reconstructed Image
Compression Ratio 3.62 : 1

Compressed/Reconstructed Image
Compression Ratio 7.84 : 1



Compressed/Reconstructed Image
Compression Ratio 16.23 : 1

CONVENTIONAL PERFORMANCE MEASURES

Individual Band (for Band k)

$$RMSE_k = \sqrt{\frac{1}{MN}\sum_{j=1}^{N}\sum_{i=1}^{M}(x_{ij}^k - y_{ij}^k)^2}$$

$$MAE_k = \max_{i,j}\left|x_{ij}^k - y_{ij}^k\right|$$

$$SNR_k = 10 \cdot \log \frac{\sum_{j=1}^{N}\sum_{i=1}^{M}(x_{ij}^k)^2}{\sum_{j=1}^{N}\sum_{i=1}^{M}(x_{ij}^k - y_{ij}^k)^2}$$

DCT Lossy Compression Performance Measures
(in digital counts, 8 bit data)

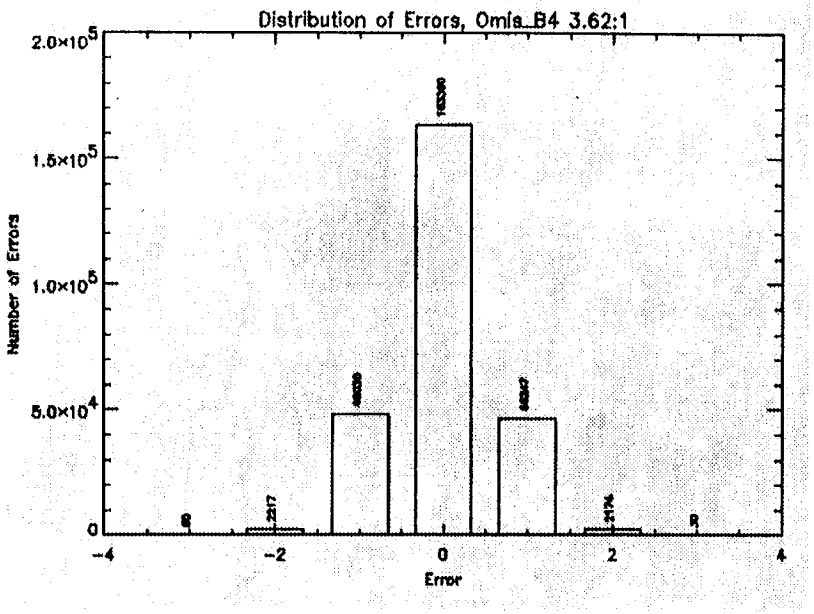
Band	Compression ratio	RMSE	MAE	SNR (dB)
Omis_b1	3.62:1	0.48	2	34.21
	6.24:1	0.67	5	31.21
	8.09:1	0.77	9	30.05
	15.66:1	1.02	15	27.58
Omis_b2	3.82:1	0.63	4	33.37
	5.82:1	0.87	6	30.57
	7.94:1	1.01	8	29.24
	15.86:1	1.40	15	26.39
Omis_b3	3.78:1	0.85	5	30.63
	6.08:1	1.22	9	27.45
	8.15:1	1.42	15	26.17
	16.28:1	1.98	16	23.26
Omis_b4	3.62:1	0.66	3	45.24
	5.55:1	0.91	6	42.38
	7.84:1	1.06	7	41.10
	16.23:1	1.46	13	38.31

RMSE: Root Mean Squared Error
MAE: Maximum Absolute Error
SNR: Signal-to-Noise

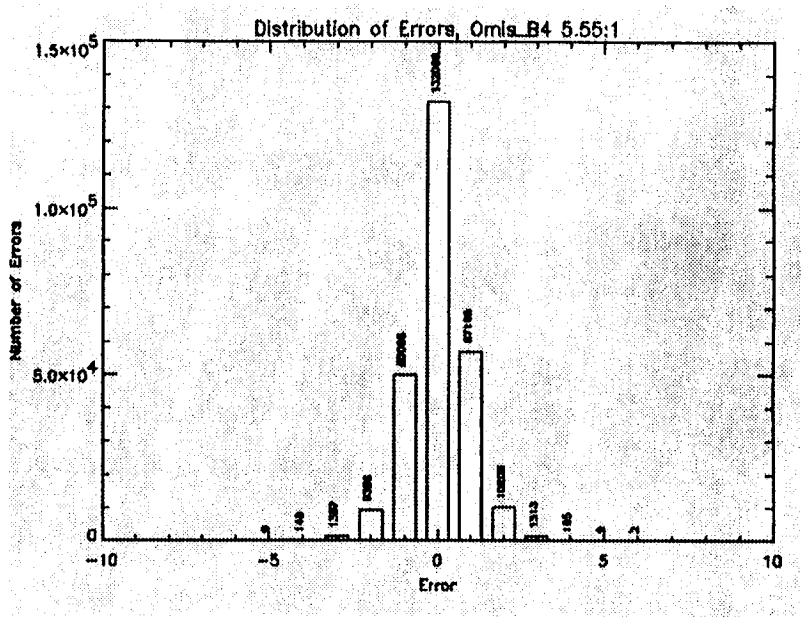
DCT Lossy Compression Performance Measures
(in digital counts, 8 bit data)

Band	Compression ratio	RMSE	MAE	SNR (dB)
Omis_b5	4.07:1	1.48	9	42.33
	5.99:1	1.95	13	39.92
	8.15:1	2.34	17	38.34
	16.08:1	3.23	25	35.55
Omis_b6	4.03:1	1.45	9	41.07
	5.89:1	1.96	14	38.46
	7.99:1	2.39	18	36.71
	16.04:1	3.48	27	33.46
Omis_b8	3.82:1	1.26	8	42.56
	5.90:1	1.77	15	39.65
	7.92:1	2.16	16	37.92
	16.08:1	3.07	27	34.84

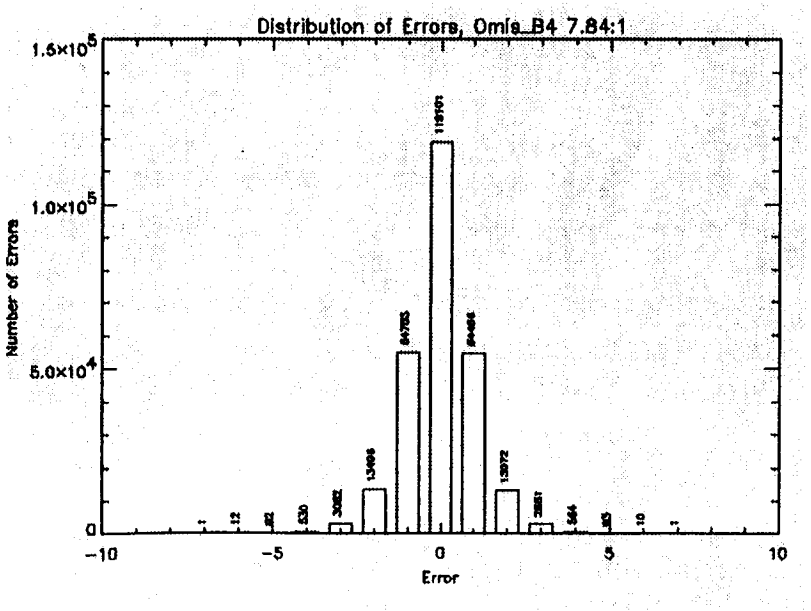
DCT Compression Error Distribution -- OMIS/VIRSR_B4



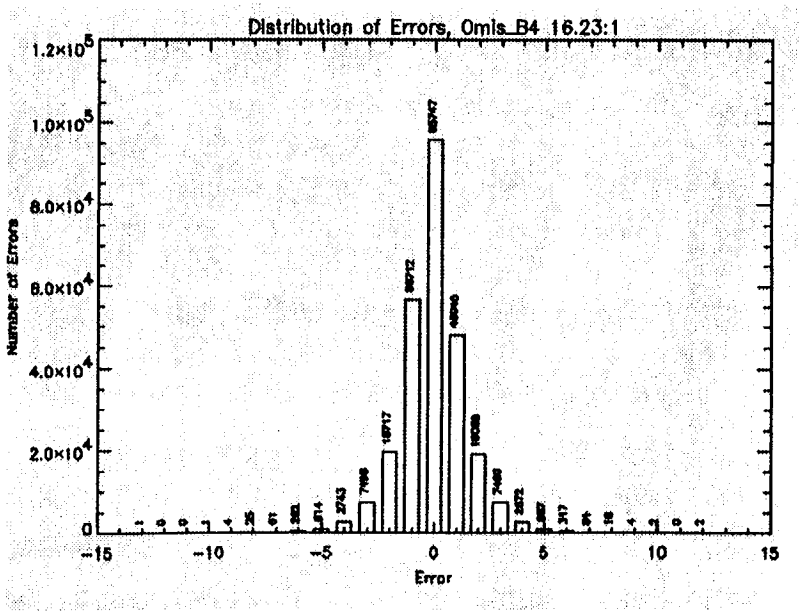
Compression Ratio 3.62 : 1



Compression Ratio 5.55 : 1



Compression Ratio 7.84 : 1



Compression Ratio 16.23 : 1

WAVELET COMPRESSION

WAVELET VS FOURIER TYPE IMAGE COMPRESSION

- PERFORMANCE HIGHLY COMPARABLE TO DCT
- MORE COMPUTATIONALLY EFFICIENT THAN DCT
  - O(N) FOR WAVELET
  - O(n•Log n) for DCT
- MULTI-RESOLUTION CAPABILITY
  - i.e. Preview of Scene at Lower Resolution Can be Provided
- LMSC WILL CONTINUE TO EXAMINE THE BENEFITS OF WAVELET COMPRESSION OVER DCT
  - WILL NOT SIGNIFICANTLY AFFECT ANY COMPRESSION RATIO RESULTS

Wavelet Lossy Compression Performance Measures (in digital counts, 8 bit data)

Band	Compression ratio	RMSE	MAE	SNR (dB)
Omis_b1	4.13:1	0.476	2	34.23
	6.09:1	0.687	4	31.05
	8.04:1	0.840	4	29.30
	16.18:1	1.282	10	25.62
Omis_b2	3.98:1	0.654	3	33.02
	6.14:1	0.973	5	29.57
	8.01:1	1.151	6	28.11
	15.94:1	1.780	12	24.32
Omis_b3	4.07:1	0.886	4	30.26
	6.01:1	1.336	7	26.69
	8.00:1	1.672	9	24.74
	15.98:1	2.510	19	21.21
Omis_b4	4.08:1	0.671	3	45.04
	5.84:1	0.936	4	42.14
	7.88:1	1.179	7	40.14
	16.01:1	1.800	16	36.46

TEST IMAGE 2
MAMS_B10, 3.55 - 3.93 um (high range), 712x712 pixels

IMAGE STATISTICS
(in digital counts)

MAMS	WaveLength	Mean	STD	Range	Entropy
5	0.60 - 0.73 um	36.55	30.27	5 to 215	5.84
8	0.83 - 1.05 um	68.86	41.22	5 to 255	6.94
9	3.55 - 3.93 um (low)	183.00	39.15	67 to 255	6.75
10	3.55 - 3.93 um (high)	158.84	22.93	97 to 255	6.31
11	10.3 - 12.1 um	152.48	44.90	37 to 255	7.12
12	12.5 - 12.8 um	140.05	38.86	44 to 245	6.87

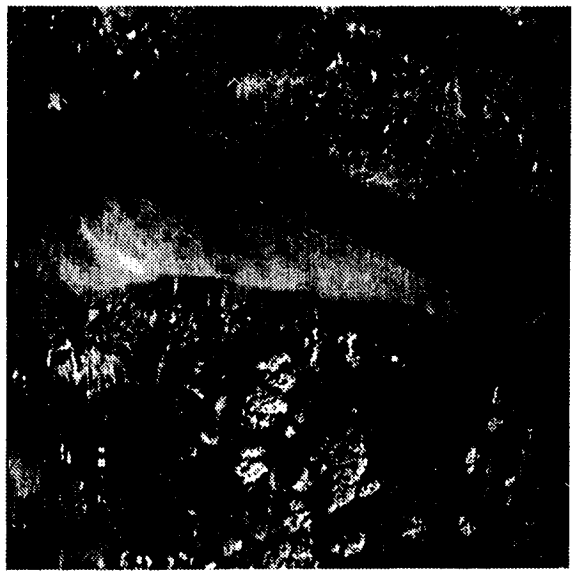
Lossless Compression Performance Measures (8 bit data)

MAMS	Method	Bits/Pixel	Compression Ratio
Channel 5	Lempel-Ziv	3.61	2.22:1
	Modified Huffman	2.41	3.32:1
Channel 8	Lempel-Ziv	5.39	1.48:1
	Modified Huffman	3.47	2.31:1
Channel 9	Lempel-Ziv	5.76	1.39:1
	Modified Huffman	3.86	2.07:1
Channel 10	Lempel-Ziv	4.89	1.64:1
	Modified Huffman	3.29	2.43:1
Channel 11	Lempel-Ziv	5.73	1.40:1
	Modified Huffman	3.61	2.22:1
Channel 12	Lempel-Ziv	5.16	1.55:1
	Modified Huffman	3.32	2.41:1

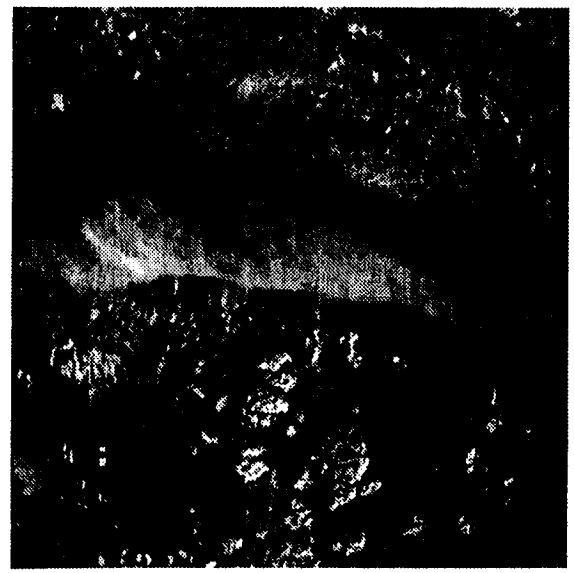
Discrete Cosine Transform Compression on MAMS_B10

Original Image

Compressed/Reconstructed Image
Compression Ratio 4.07 : 1



Compressed/Reconstructed Image
Compression Ratio 8.03 : 1

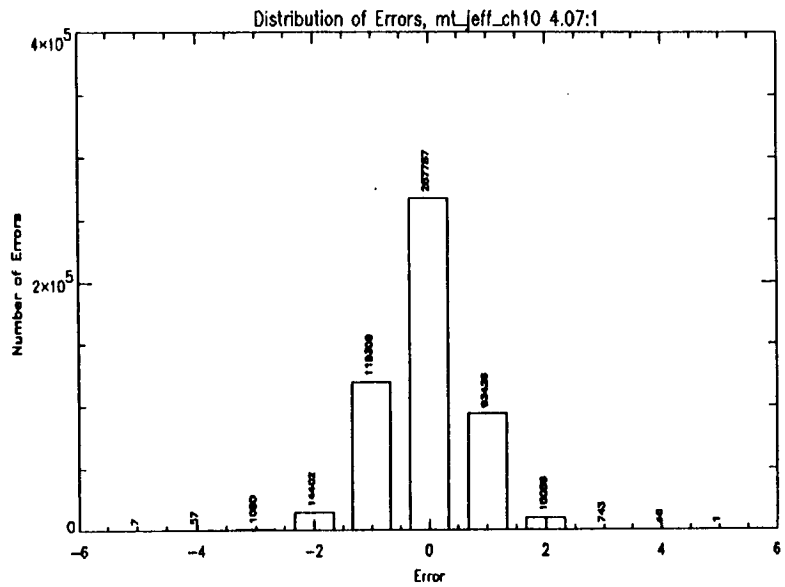


Compressed/Reconstructed Image
Compression Ratio 15.97: 1

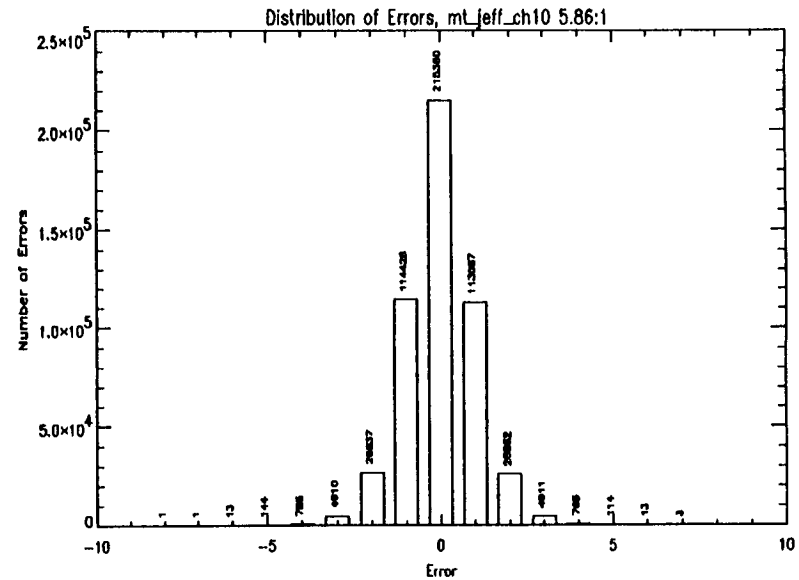
DCT Lossy Compression Performance Measures
(in digital counts, 8 bit data)

MAMS	Compression ratio	RMSE	MAE	SNR (dB)
Channel 5	3.95:1	0.515	3	39.28
	6.16:1	0.735	7	36.20
	7.80:1	0.851	9	34.92
	15.89:1	1.468	17	30.19
Channel 8	3.81:1	0.934	7	38.68
	5.89:1	1.301	10	35.81
	8.09:1	1.703	14	33.46
	16.07:1	2.915	29	28.80
Channel 9	3.91:1	1.146	9	44.26
	5.93:1	1.729	18	40.68
	7.95:1	2.295	21	38.22
	15.99:1	4.469	43	32.44
Channel 10	4.07:1	0.806	5	45.99
	5.86:1	1.048	8	43.70
	8.03:1	1.392	12	41.24
	15.97:1	2.637	19	35.69

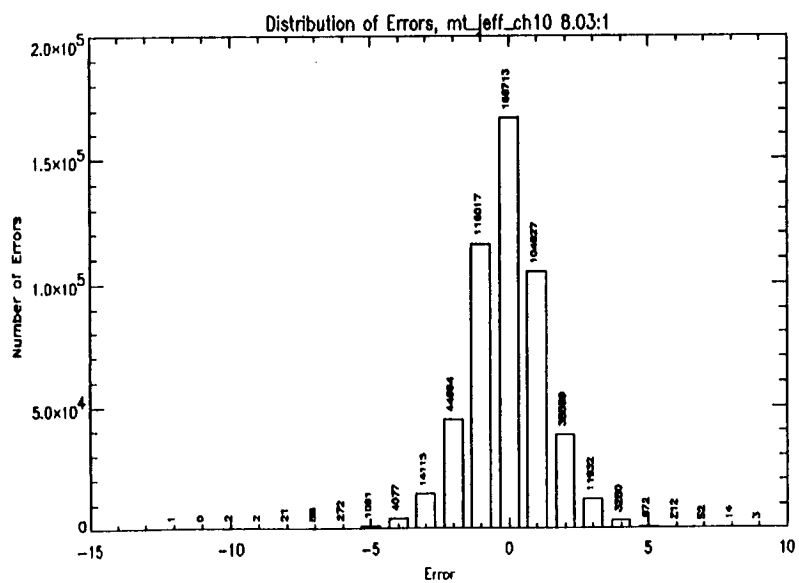
DCT Compression Error Distribution -- MAMS_B10



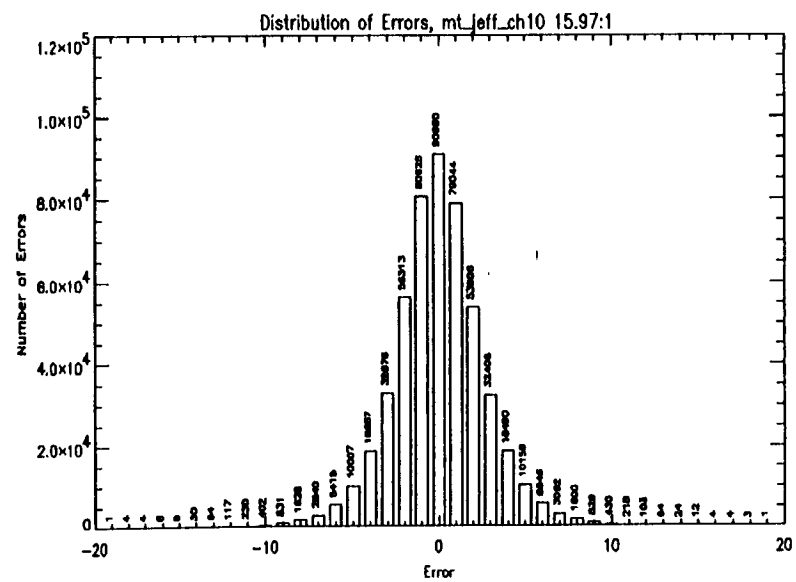
Compression Ratio 4.07 : 1



Compression Ratio 5.86 : 1



Compression Ratio 8.03 : 1



Compression Ratio 15.97 : 1

DATA COMPRESSION SUMMARY

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- LITERALLY LOSSLESS DATA COMPRESSION HAS BEEN ACHIEVED
  - 8 BAND AVERAGE COMPRESSION RATIO ≥ 2
  - VIABLE FOR CONSIDERATION TO THE CENTRAL SITES
- LOSSY DATA COMPRESSION WILL BE NEEDED FOR THE REGIONAL SITES
  - REGIONAL SITE MEASUREMENT ACCURACY REQUIREMENTS NEED TO BE CLEARLY UNDERSTOOD
  - COMPRESSION RATIO REQUIRED IS HIGHLY DEPENDENT ON RESOLVING "TBD" ISSUES IN SPEC .... EXPECT 8< COMPRESION RATIO < 16
  - IR ERRORS INVOLVED ARE < 3% FOR 100% OF THE DATA AT CR=8
  - APPROXIMATELY 35% OF THE DATA HAS ZERO ERROR AT CR=8
- LMSC WILL MAINTAIN OUR GOAL TO SEND UNCOMPRESSED DATA TO THE CENTRAL SITES
  - ACTUAL X-BAND DATA RATE IS AN ISSUE
  - LOSSLESS COMPRESSION IS A VIABLE ALTERNATIVE

MISS UPDATE

M. DAVIS

MISS PRESENTATION OUTLINE

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- o MISS PROGRESS TO DATE
- o MISS CONCEPT EXPLORATION UPDATE
- o F8 TILT EXPERIMENT DATA ANALYSIS
- o SUMMARY

MISS PROGRESS TO DATE

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CONTRACT OBJECTIVES: DEVELOP AFFORDABLE, PRODUCIBLE MISS PRELIMINARY DESIGN ALTERNATIVES THAT MEET USER NEEDS FOR MICROWAVE SOUNDING & IMAGING WHILE MINIMIZING COST & RISK

PRESENTED AT PSR # 1 (FEB '92)

- o REQUIREMENTS AND LIFE CYCLE COST DRIVERS, 3 vs 1 SENSOR TRADE STATUS, PHENOMENOLOGICAL SIMULATIONS OF HIGH INCIDENCE ANGLE RETRIEVAL VIABILITY

PRESENTED AT PSR # 2 (JUL '92)

- o SCANNER SIZING PARAMETRICS, SCAN MODE vs EDR RETRIEVAL PROBABILITIES

PRESENTED AT PSR #3 (JAN '93)

- o RISK ASSESSMENT, EDU OPTIONS, RFI PREPARATION STATUS

PRESENTED AT PSR #4 (JUL '93)

- o GLOBAL CLOUD CLIMATOLOGY IMPACT ON TEMPERATURE PROFILE RETRIEVALS, NORTH SEA TOWER DATA ANALYSIS, RFI EVALUATION

PRESENTED AT PSR #5 (MAY '94)

- o HUGHES PRELIMINARY MISS DESIGN, CONVERGENCE IMPACT, SRR PLANNING, TILT EXPERIMENT DATA ANALYSIS PLANS

HSC PROGRESS

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- o HSC HOSTED TIM ON 4 NOVEMBER 1994
- o TOPICS INCLUDED:
  - END-TO-END ANTENNA/RECEIVER SUBSYSTEM OPTIONS
  - FEEDHORN TRADE STUDY
  - NOISE BUDGETS
  - REQUIREMENTS DEFINITION ISSUES
  - MASS/POWER BUDGETS
  - POINTING AND PIXEL LOCATION BUDGETS
  - DMSP F12 SSM/I ON-ORBIT ANOMALIES
  - UPPER AIR SOUNDING OPTION
- o HSC POSITIONED TO SUPPORT MISS CONCEPT EXPLORATION

EXCELLENT PERFORMANCE PROVIDED IN SEVERAL AREAS:

- *LEVERAGING FLIGHT-PROVEN SENSOR HERITAGE (SSM/I)*
- *LEVERAGING STATE-OF-THE-ART TECHNOLOGY (TMI)*
- *BUTTRESS LMSC SCIENCE TEAM (EDR ANALYSIS SUPPORT)*
- *EDR SENSING ALTERNATIVES (UPPER AIR SOUNDING)*

PAGE 310 IS EXEMPT FROM RELEASE AND IS REPLACED WITH THIS PAGE.

PAGE 311 IS EXEMPT FROM RELEASE AND IS REPLACED WITH THIS PAGE.

PAGE 312 IS EXEMPT FROM RELEASE AND IS REPLACED WITH THIS PAGE.

F8 TILT EXPERIMENT

DATA ANALYSIS ALTERNATIVES

F8 TILT EXPERIMENT / DATA ANALYSIS
- OVERVIEW -

- o OBJECTIVE OF F8 TILT EXPERIMENT (TEX) WAS TO ACQUIRE SSM/I DATA AT HIGH EARTH INCIDENCE ANGLES (EIAs) TO ASSESS INCIDENCE ANGLE IMPACT ON EDR RETRIEVALS

- o TEX CONDUCTED FROM JUNE 25 TO JULY 13, 1993. 3 DAYS AT 69° INCIDENCE, 2 TO 6 DAYS AT EIAs OF 64.5°, 60°, 57° & 53.1°

- o LMSC HAS EXTENSIVELY STUDIED VIABILITY OF HIGH EIA RETRIEVALS

  - FEB '92: PSR#1 INCLUDED EXTENSIVE SIMULATIONS ON HIGH EIA RETRIEVALS
  - AUG '92: PROVIDED COMMENTS ON TEX SOW
  - APR '93: PROVIDED COMMENTS ON SSM/I TEX TEST PLAN
  - JUL '93: PSR#4 ADDRESSED USE OF WETNET TO SUPPORT TEX ANALYSIS AND RESULTS OF NRL TOWER DATA ANALYSIS
  - FEB '94: REVIEWED AEROSPACE TEX DATA ANALYSIS PLAN (12/21/93)
  - MAY '94: PSR#5 INCLUDED SECTION ON LMSC TEX ANALYSIS PLAN
  - JUL '94: HSC MISS TIM#1 INCLUDED DERIVATION OF 97% COVERAGE REQUIREMENT
  - JUL '94: RECEIVED TEX TDRs FROM SPO
  - NOV '94: HSC MISS TIM#2 INCLUDED LMSC PRELIMINARY TEX ANALYSIS

- o DATA ANALYSIS RESULTS NECESSARY PRIOR TO SRR TO DETERMINE VIABILITY OF HIGH EIA RETRIEVALS. EIA AFFECTS SENSOR DESIGN.

CONVERGENCE EFFORT MODIFICATION

AEROSPACE PLAN FOR ANALYSIS OF TILT EXPERIMENT DATA

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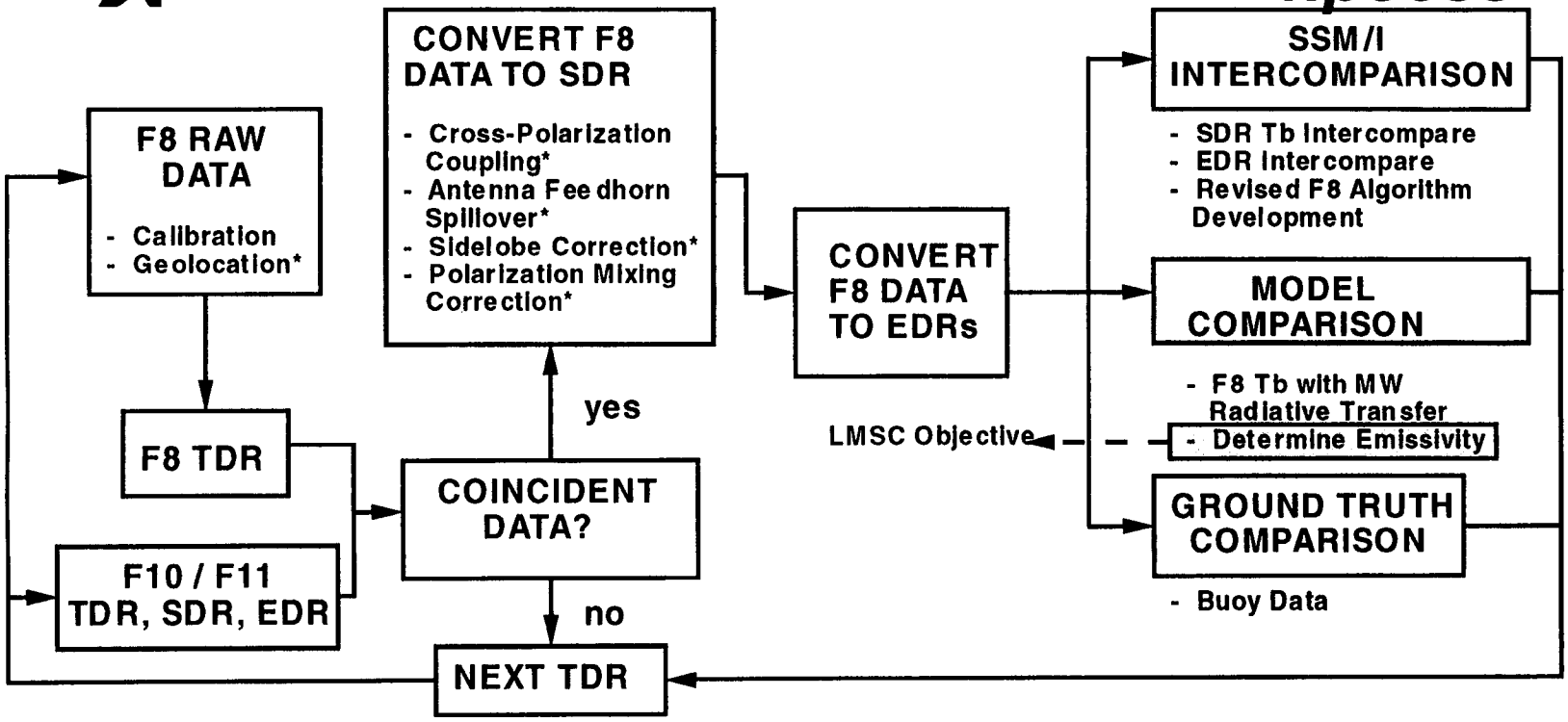

* Items designated with an asterisk require development of appropriate software to account for F8 tilt. The resulting SDR/EDR is a "corrected" F8 data set.

OCEAN WIND SPEED EDR ASSESSED AS PROVIDING EASIEST TEST OF HIGH INCIDENCE ANGLE VIABILITY

EDRs COMPARED

- Ocean Surface Wind Speed
- Total Atmospheric Water Content
- Surface Type
- Surface Moisture / API
- Precipitation
- Sea Ice Concentration
- Snow

SIMPLIFIED GEOMETRY FOR OCEAN SURFACE MICROWAVE EMISSION

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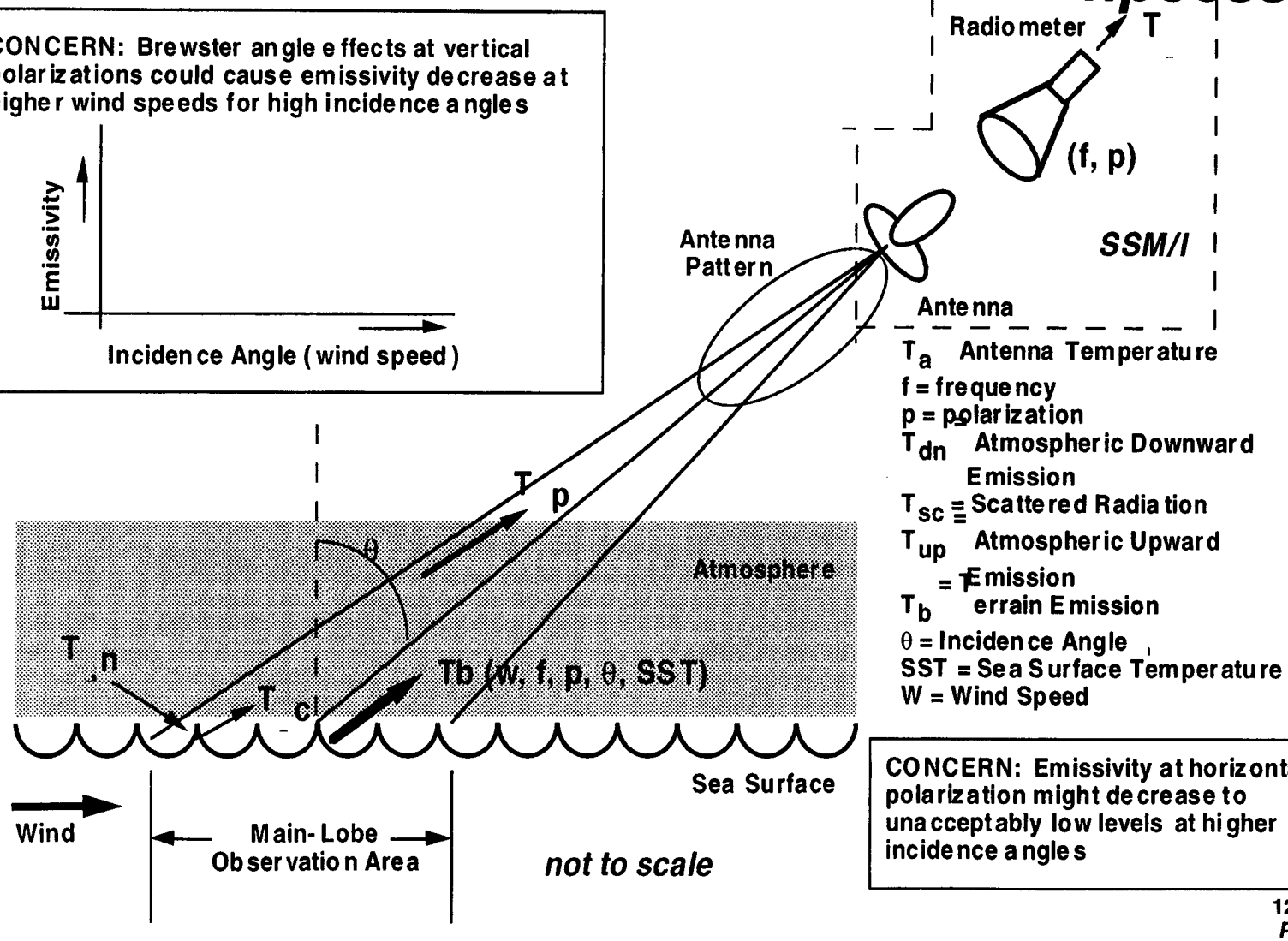
CONCERN: Brewster angle effects at vertical polarizations could cause emissivity decrease at higher wind speeds for high incidence angles



T_a Antenna Temperature
f = frequency
p = polarization
T_{dn} Atmospheric Downward Emission
T_{sc} = Scattered Radiation
T_{up} Atmospheric Upward Emission
T_b = Terrain Emission
θ = Incidence Angle
SST = Sea Surface Temperature
W = Wind Speed

CONCERN: Emissivity at horizontal polarization might decrease to unacceptably low levels at higher incidence angles

LOCKHEED PLAN FOR ANALYSIS OF TILT EXPERIMENT DATA

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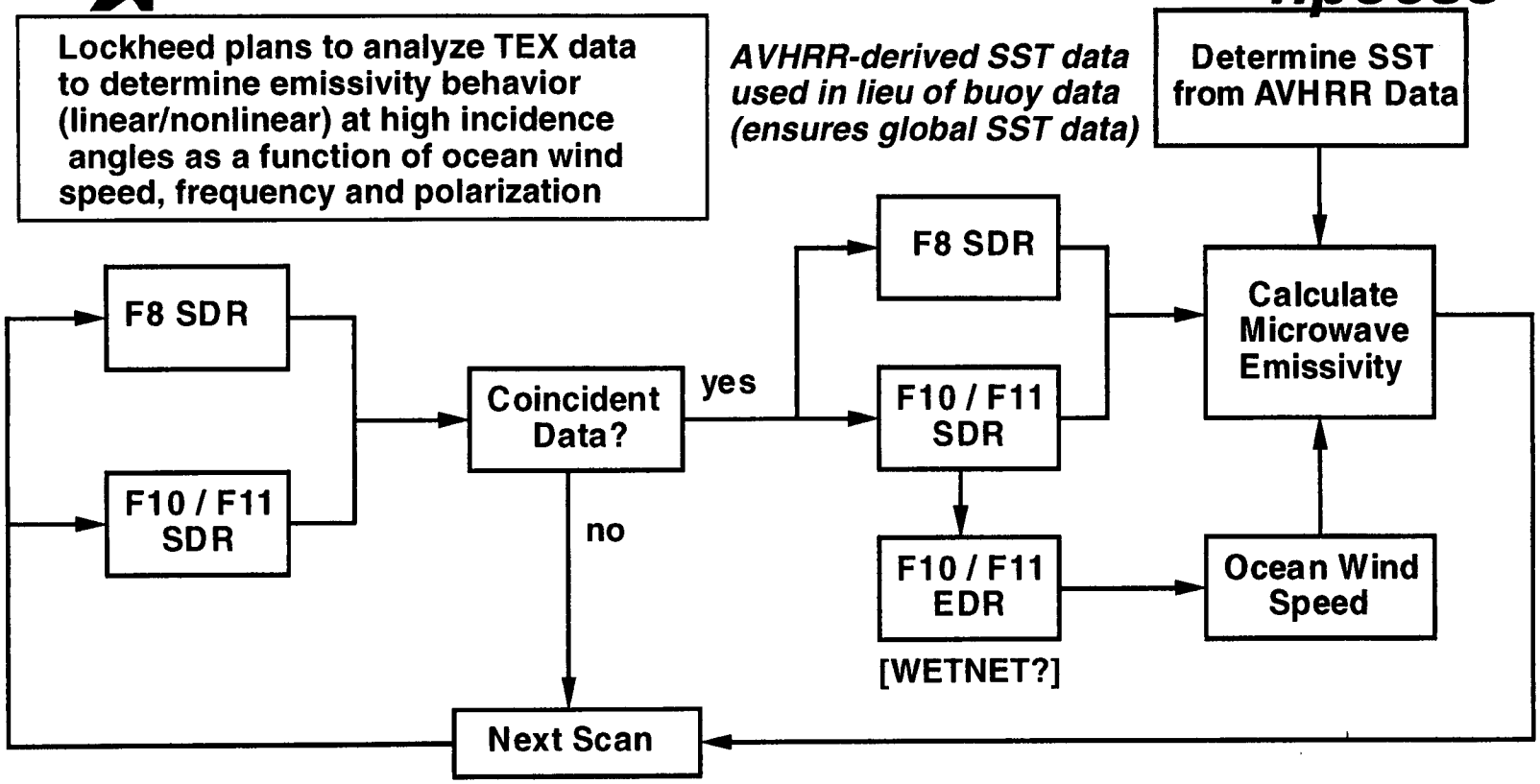
Lockheed plans to analyze TEX data to determine emissivity behavior (linear/nonlinear) at high incidence angles as a function of ocean wind speed, frequency and polarization

AVHRR-derived SST data used in lieu of buoy data (ensures global SST data)



VIABILITY OF HIGH INCIDENCE ANGLE RETRIEVALS IMPACTS SENSOR DESIGN.
EIA → COVERAGE → ANT DIAMETER

Emissivity Calculated By:

ε (tilt) = F8 Tb / SST
ε (non-tilt) = F10 or F11 Tb / SST

CONVERGENCE EFFORT MODIFICATION

LOCKHEED PLAN FOR DEVELOPMENT OF MISS WIND SPEED ALGORITHM

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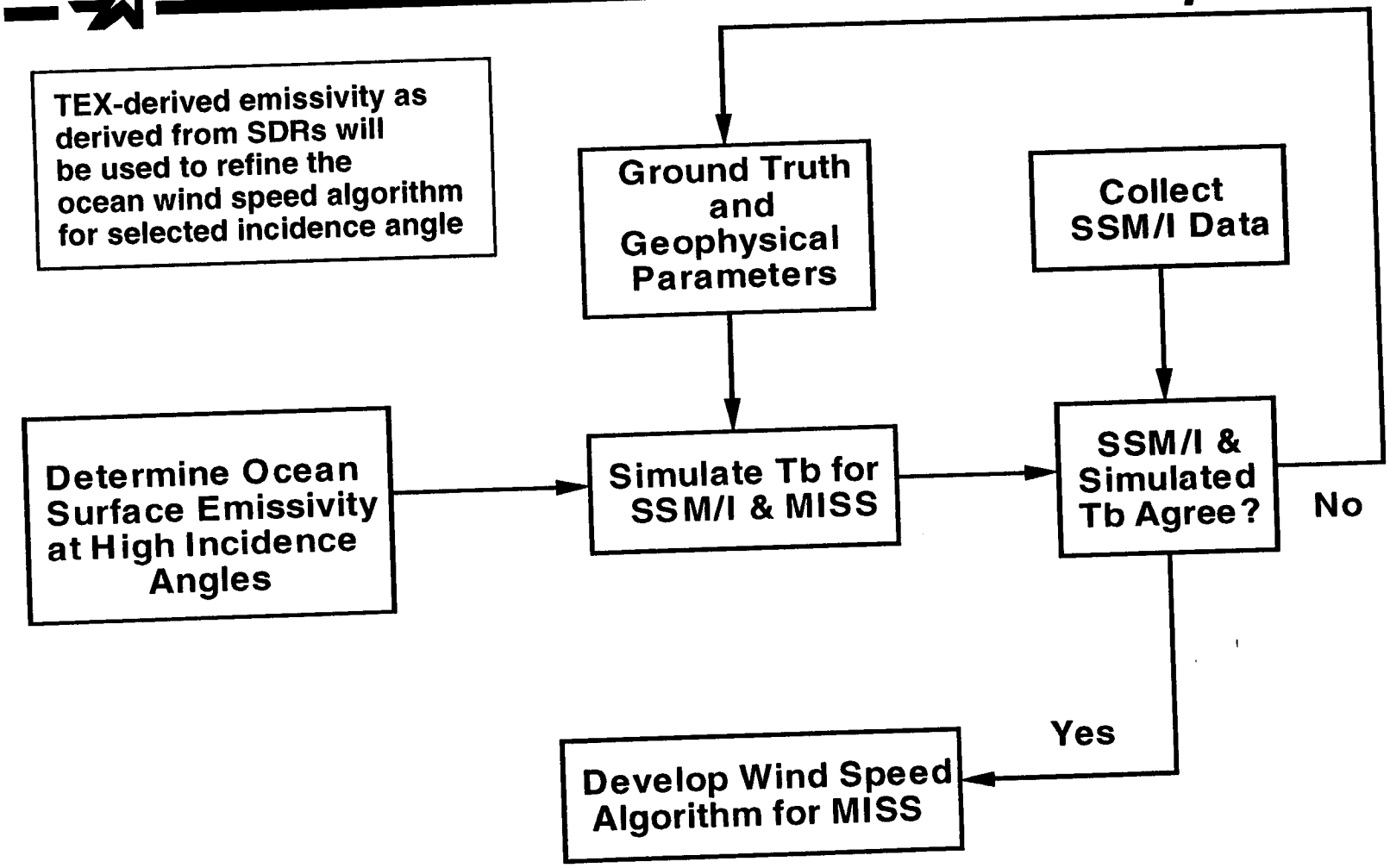

12/5/94
PSR6

CONVERGENCE EFFORT MODIFICATION

SSM/I SDRs ARE DERIVED FROM RDRs & TDRs

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RAW DATA RECORD (RDR)

- o SSM/I A/D Output

→

RDR Processing

- Geolocation
- Absolute Calibration
  - T_{warm}
  - T_{cold}

* IMPACTS T_b UNCERTAINTY

↓

TEMPERATURE DATA RECORD (TDR)

- o Antenna Temperature (T_a)

→

TDR Processing

- Polarization Mixing*
- NEdT*
- Sensor Bias*
- Antenna Pattern Correction Bias*
- Feedhorn Spillover*
- Cross-Polarization Coupling*
- Sidelobe Correction*
- Incidence Angle Variations*

↓

SENSOR DATA RECORD (SDR)

- o Brightness Temperature (T_b)

Aerospace-provided SDRs used for TEX data analysis would provide data set commonality and allow corroboration of results of various analyses

ISSUE: IF SDRs NOT AVAILABLE PRIOR TO SRR, COULD TDRs BE OF ANY USE IN TEX DATA ANALYSIS?

- Necessary to quantify expected errors in conversion from Ta to Tb and assess the resulting emissivity uncertainty & TDR usefulness

Ta TO Tb ERROR QUANTIFICATION FOR 69° INCIDENCE ANGLE

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Antenna Temp Uncertainty (deg K)	19V GHz	19H GHz	22V GHz	37V GHz	37H GHz
Polarization Mixing (single sample, 3 sigma)	1.5	1.5	1.5	1.5	1.5
NEdT (single sample, 3 sigma)	1.26	1.2	2.04	1.02	1.2
Sensor Bias	0.76	0.76	0.76	0.76	0.76
Antenna Pattern Correction (APC) Bias	0.01	0.01	0.01	0.01	0.01
Feedhorn Spill/Cross-Polarization Coupling (single sample, 3 sigma)	6.9	2.76	5.76	5.64	1.95
Sidelobe Contribution (single sample, 3 sigma)	2.43	0.98	1.92	1.04	0.98
dTb/dEIA Bias (incidence angle beamwidth effect)	2.08	0.63	1.59	1.62	0.69
Wind Anisotropy Effects (single sample, 3 sigma)	4.8	5.85	4.8	4.8	5.85
RSS Error (deg K)	9.24	6.89	8.33	7.90	6.61

- o Polarization mixing assumption is worst case (valid for data confined to near-center of scan, assume scan center +/- 200 km [SSM/I scan station 24-40])
- o NEdT based on SSM/I 16 month orbital performance from cal/val report
- o Sensor bias from cal/val report
- o APC bias from cal/val report
- o Feedhorn spillover/cross-polarization coupling assumes 1% uncertainty as worst case citation from cal/val report and uses Tower Data to generate typical 69° incidence antenna/brightness temperature
- o Sidelobe correction scaled from SSM/I proportion to feedhorn spillover/X-pol error
- o dTb/dEIA bias assumes +/- 1 deg incidence angle variation over SSM/I beamwidth at 69° incidence
- o Wind anisotropy effects based on Wentz model and assumed OWS = 7.5 m/s

TDR TO SDR EMISSIVITY UNCERTAINTY

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WINDSPEED	MODELED EMISSIVITY 19V	MODELED EMISSIVITY 19H	COMPUTED Tb 19V	COMPUTED Tb 19H	EMISSIVITY UNCERTAINTY 19V	EMISSIVITY UNCERTAINTY 19H	PERCENT UNCERTAINTY 19V	PERCENT UNCERTAINTY 19H
0 m/s	.80	.32	230	92	.035	.025	4.4	7.8
10 m/s	.76	.25	219	72	.034	.025	4.5	10.0
20 m/s	.74	.20	213	58	.035	.024	4.7	11.9

ASSUMPTIONS

- o Emissivity model used as presented in Aerospace data analysis plan
- o Earth incidence angle = 69°
- o 19.35 GHz, Tsea = 288°K, Salinity = 35 ppt
- o Tsea uncertainty = 1°K (worst-case AVHRR value)
- o Tb modified by error quantification shown on previous page

EMISSIVITY ERROR USING TDRs: < 5% (3 sigma) @ 19.35 V GHz
<12% (3 sigma) @ 19.35 H GHz
(errors at other frequencies expected to be similar)

DATA SET OPTIONS / IMPACTS

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THIS CHART IDENTIFIES THE PRIMARY TILT EXPERIMENT DATA SETS, THE PREFERRED DATA SET, THE ALTERNATE DATA SET AND THE ANALYSIS IMPACT OF USING THE ALTERNATE DATA SET

DATA SET	PREFERRED SOURCE	ALTERNATE SOURCE	IMPACT OF USING ALTERNATE SOURCE
F8 Tilt Data	F8 SDRs	F8 TDRs	Increased emissivity uncertainty (~10% at 19H GHz), unable to quantify at other frequencies (but probably similar), trend analysis possible, detailed analysis requires SDRs
Ocean Wind Speed Data	F10/F11 EDRs	WETNET	WETNET uses F10/F11 EDRs but OWS is binned in 5 m/s increments, OWS EDRs have 1.6 m/s accuracy, OWS valid to 25 m/s
Sea Surface Temperature Data	AVHRR SST	Buoy Data	AVHRR 7-day mean SSTs in possession for TEX time frame, <1K accuracy for AVHRR data, buoy data would be of higher accuracy but not available on global basis

FEASIBILITY OF TDR ANALYSIS

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BASED ON DATA ANALYSIS ALTERNATIVES, DISCUSSIONS WITH DR. TOM WILHEIT, DR. KEN HARDY & DR. RICHARD SAVAGE RESULTED IN CONCLUSION THAT ANALYSIS OF F8 TDRs AT 69° EIA IS WORTHWHILE PENDING PROVISION OF SDRS

GOALS OF TDR ANALYSIS AT 69° EIA:

- ***ASSESSMENT OF EMISSIVITY AND EMISSIVITY TREND AS A FUNCTION OF FREQUENCY, POLARIZATION AND WIND SPEED***
- ***COMPARISON OF EMISSIVITY TRENDS WITH VARIOUS MODELS AS A FUNCTION OF FREQUENCY, POLARIZATION AND WIND SPEED***

TDR ANALYSIS: *DETERMINE IF SENSOR RETRIEVALS ARE VIABLE AT HIGH EIAs, USE TO ESTABLISH SENSOR BASELINE PRIOR TO SRR*

SDR ANALYSIS: *REFINE DATA TO ALLOW HIGH EIA ALGORITHMS TO BE DEVELOPED*

ALTERNATIVE DATA SOURCES
- CONCLUSIONS -

- o OVERALL NEAR-TERM LOCKHEED OBJECTIVE OF TILT EXPERIMENT DATA ANALYSIS IS TO DETERMINE VIABILITY OF HIGH INCIDENCE ANGLE MICROWAVE RETRIEVALS AND ESTABLISH SENSOR BASELINE PRIOR TO SRR
- o UTILIZATION OF TDRs FOR ANALYSIS APPEARS FEASIBLE, WITH EMISSIVITY ERRORS OF <12% (3 sigma) LIKELY
- o ERRORS SMALL ENOUGH TO ALLOW DETERMINATION OF EMISSIVITY BEHAVIORAL TRENDS AT 69° EIA
- o TDR ANALYSIS RESULTS SHOULD BE CORROBORATED AT LATER DATE BY ANALYSIS USING SDR DATA (ALSO USED TO REFINE ALGORITHMS FOR HIGH EIA RETRIEVAL).
- o OCEAN WIND SPEED AND SEA SURFACE TEMPERATURE DATA SOURCE ALTERNATIVES EXIST

LMSC ANALYZING EMISSIVITY BEHAVIORAL TRENDS AT 69° EIA USING F8 TDRs, WETNET OWS & AVHRR SST DATA SETS

WILL FULLY SUPPORT AEROSPACE CO. & SPO IN GENERATION OF SDRs TO FACILITATE DETAILED ANALYSIS

ANALYSIS OF F8 TILT EXPERIMENT TDRs OBTAINED AT 69° EIA

ESTABLISHMENT OF COINCIDENT DATA

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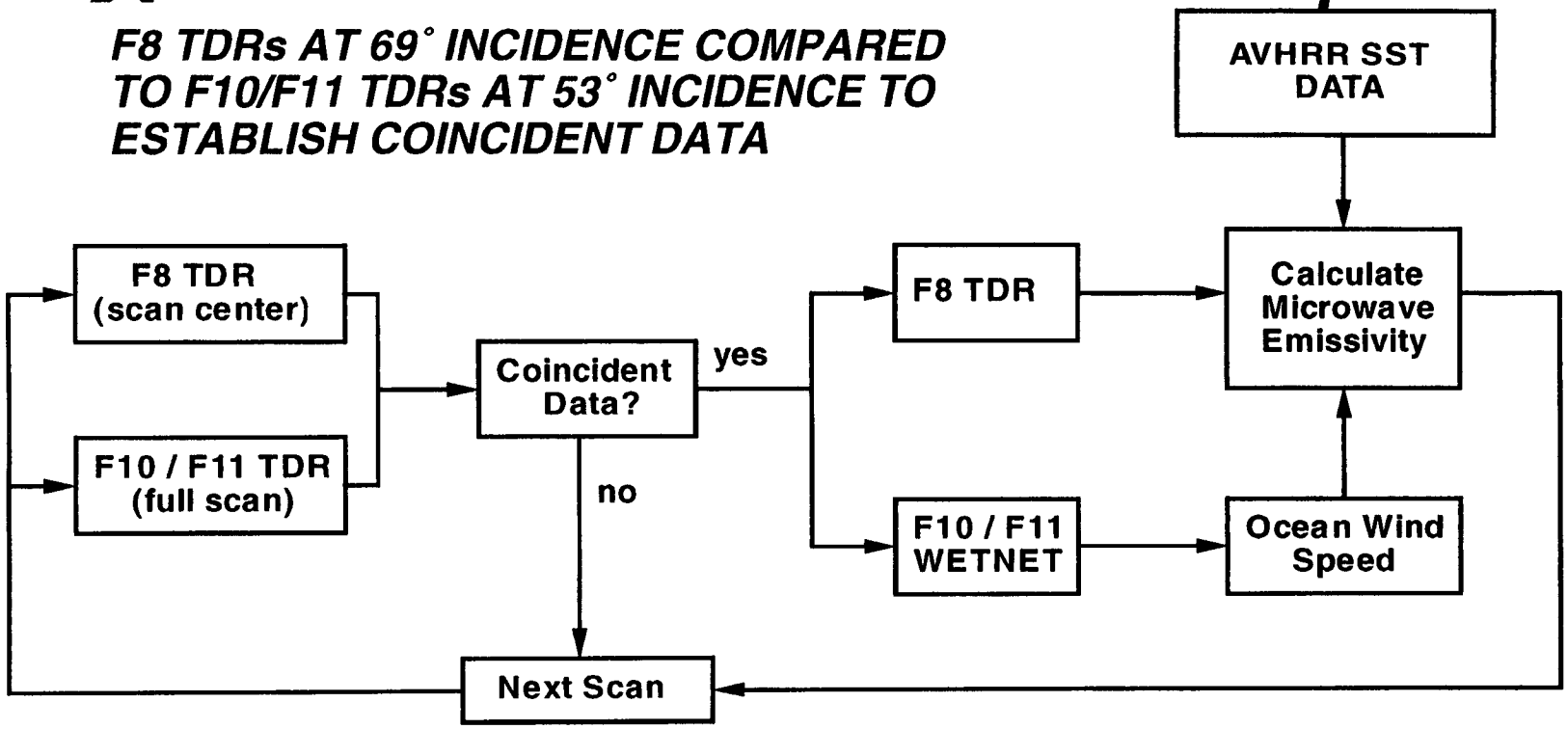
F8 TDRs AT 69° INCIDENCE COMPARED TO F10/F11 TDRs AT 53° INCIDENCE TO ESTABLISH COINCIDENT DATA



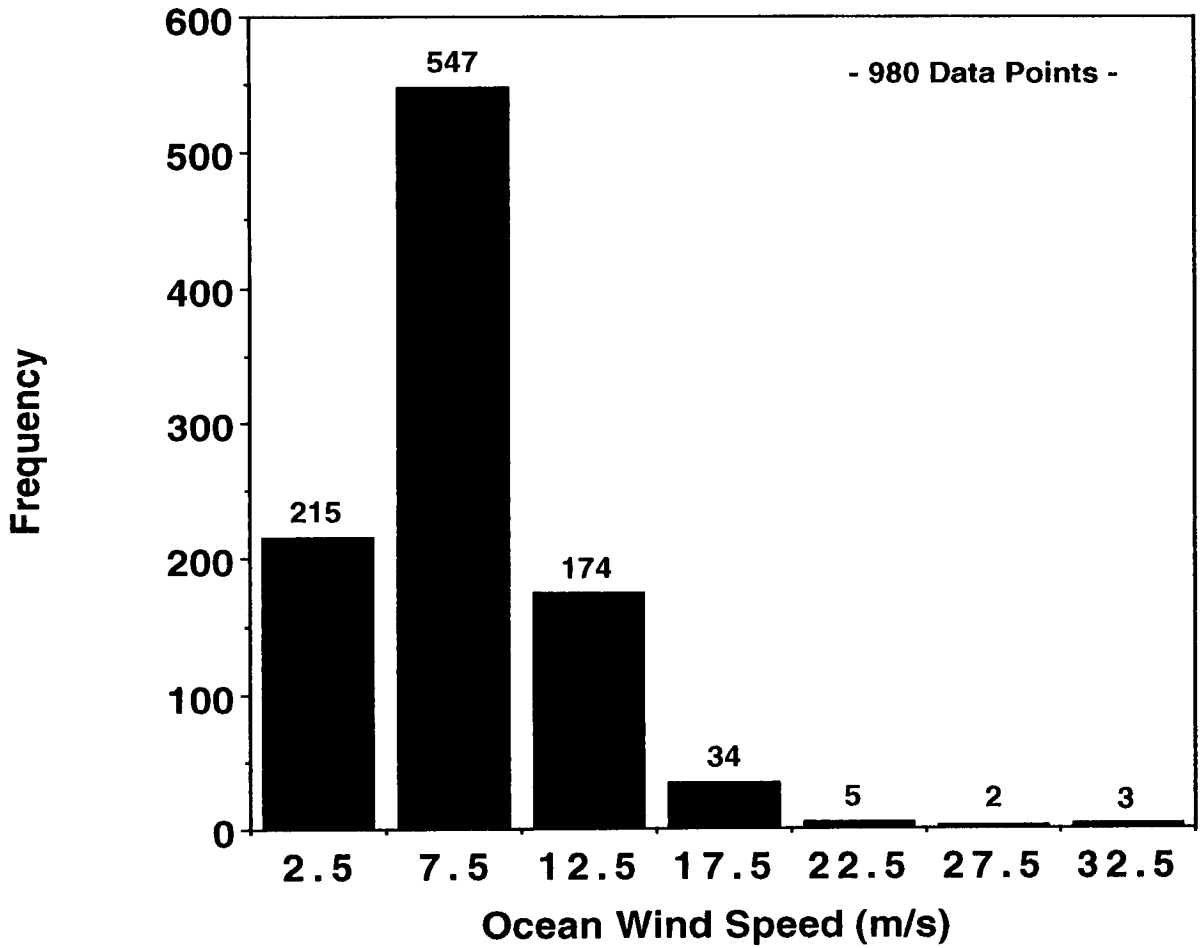
NOTE: COINCIDENCE CRITERIA ESTABLISHED AS 30 km, 30 min & OCEAN SURFACE TYPE. SIMILAR TO CRITERIA USED IN ALTIMETRY GROUND-TRUTHING AND SSM/I OCEAN WIND SPEED CAL/VAL EFFORT

Emissivity Calculated By:

ε = F8 Ta / SST

BINNED ACCORDING TO WETNET OCEAN WIND SPEED

COINCIDENT DATA DISTRIBUTION



EVERY 5th SCAN OF COINCIDENT DATA WAS SELECTED.

PROVIDES A MANAGEABLE DATA SET SIZE WHILE ALLOWING MEANINGFUL ANALYSIS.

69° EIA COINCIDENT DATA SET SAMPLE

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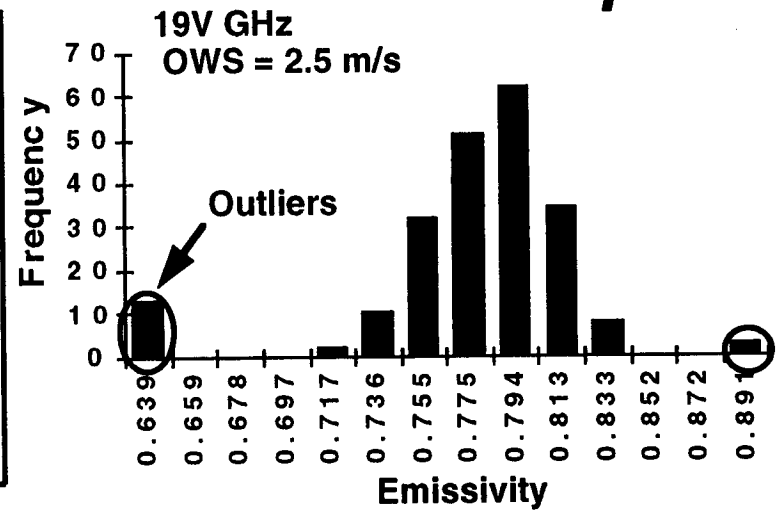
EXAMPLE FOR TILT EXPERIMENT DATA ANALYSIS

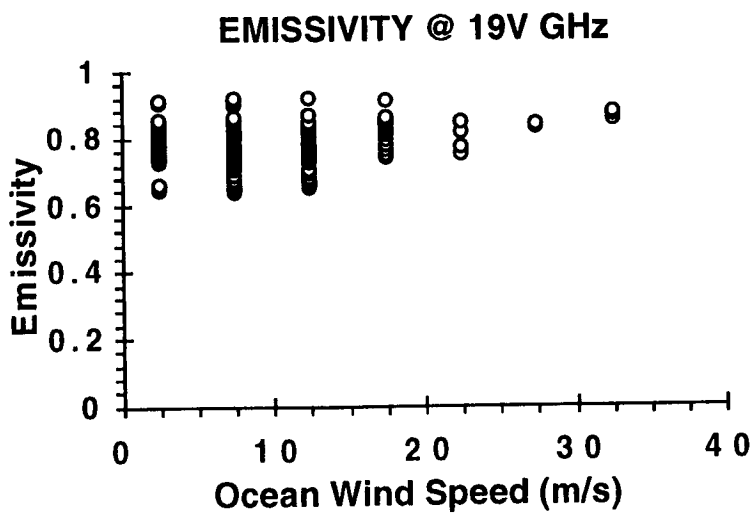
DATE	LAT	LONG	Ta 19V	Ta 19H	Ta 22V	Ta 37V	Ta 37H	COINC	SST	OWS	e 19V	e 19H	e 22V	e 37V	e 37H
179/o31091	-10.2	268.6	234.4	137.9	252.1	247.9	174	F11	298	7.5	0.787	0.463	0.846	0.832	0.584
179/o31091	-11.3	268.3	233.2	136.3	248.9	247.6	175.5	F11	298	7.5	0.783	0.457	0.835	0.831	0.589
179/o31091	-12.4	268.1	231.2	129.9	246.6	245.5	170	F11	298	7.5	0.776	0.436	0.828	0.824	0.570
179/o31091	-13.5	267.8	230.4	124.8	244.6	243.1	159.8	F11	298	7.5	0.773	0.419	0.821	0.816	0.536
179/o31091	-14.6	267.5	231.6	124.5	245.8	244.4	160.8	F11	298	7.5	0.777	0.418	0.825	0.820	0.540
179/o31091	-15.7	267.3	231.5	125.2	247.8	244.6	159	F11	296	7.5	0.782	0.423	0.837	0.826	0.537
179/o31091	-16.8	267	232.5	127.2	247.6	246.7	163.6	F11	296	7.5	0.785	0.430	0.836	0.833	0.553
179/o31091	-17.9	266.7	231.4	123.1	246.1	244.4	157.2	F11	296	7.5	0.782	0.416	0.831	0.826	0.531
179/o31091	-18.9	266.5	230.2	118	244.1	242.9	148.9	F11	296	7.5	0.778	0.399	0.825	0.821	0.503
179/o31091	-20	266.2	231.3	118.3	244.4	244.8	153.5	F11	296	2.5	0.781	0.400	0.826	0.827	0.519
179/o31091	-21.1	265.9	232	115.2	245.6	244.8	147.6	F11	296	2.5	0.784	0.389	0.830	0.827	0.499
179/o31091	-22.2	265.7	236.4	119.2	252.6	249.2	149.7	F11	296	2.5	0.799	0.403	0.853	0.842	0.506
179/o31091	-23.3	265.4	238.8	136.2	255.4	251.5	170.4	F11	294	2.5	0.812	0.463	0.869	0.855	0.580
179/o31091	-24.4	265.1	237.7	149.3	256.2	249.6	183.9	F11	294	2.5	0.809	0.508	0.871	0.849	0.626
179/o31091	-25.5	264.8	235.2	143.5	252.6	248.1	179.5	F11	294	7.5	0.800	0.488	0.859	0.844	0.611
179/o31091	-26.4	264.5	230.9	127.1	246.9	242	154.4	F11	294	7.5	0.785	0.432	0.840	0.823	0.525
179/o31091	-27.7	264.2	227.1	114.4	240.6	239.3	145.5	F11	294	2.5	0.772	0.389	0.818	0.814	0.495
179/o31091	-28.8	263.9	225.7	110.2	238.4	239.5	141.1	F11	294	2.5	0.768	0.375	0.811	0.815	0.480
179/o31091	-29.9	263.6	224.6	109.5	236.7	239.6	148.3	F11	293	2.5	0.767	0.374	0.808	0.818	0.506
179/o31091	-31	263.3	223.5	110.4	235.1	237.6	147.6	F11	292	7.5	0.765	0.378	0.805[1]	0.814	0.505
179/o31091	-32.1	263	223.5	112.6	234.3	236.6	150.2	F11	292	7.5	0.765	0.386	0.802	0.810	0.514
179/o31091	-33.1	262.7	223.5	117.3	235.8	236.6	154.6	F11	292	12.5	0.765	0.402	0.808	0.810	0.529
179/o31091	-34.2	262.4	223.2	120.9	233.8	236.4	158.7	F11	292	12.5	0.764	0.414	0.801	0.810	0.543
179/o31091	-35.3	262	223.1	123.3	235.1	235.7	163.8	F11	290	12.5	0.769	0.425	0.811	0.813	0.565
179/o31091	-36.4	261.7	221.2	123.9	233.9	234.1	159	F11	290	12.5	0.763	0.427	0.807	0.807	0.548
179/o31091	-37.5	261.3	221.6	122.8	233	233.4	157	F11	290	12.5	0.764	0.423	0.803	0.805	0.541
179/o31091	-38.6	261	218.8	118	230.4	234.3	162.2	F11	290	12.5	0.754	0.407	0.794	0.808	0.559
179/o31091	-39.6	260.6	215.7	105.8	226.4	230	139.4	F11	288	12.5	0.749	0.367	0.786	0.799	0.484

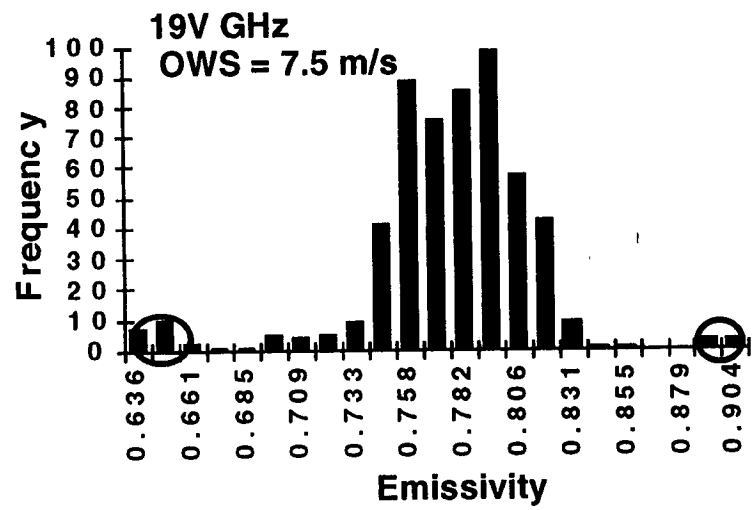
INITIAL EMISSIVITY DATA

npoess

- EMISSIVITY DATA PLOTTED FOR EACH FREQUENCY AS A FUNCTION OF WIND SPEED
- HISTOGRAMS GENERATED PLOTTING FREQUENCY vs EMISSIVITY FOR EACH OCEAN WIND SPEED BIN
- OUTLYING DATA POINTS DETERMINED BY HISTOGRAM ANALYSIS AND STUDIED FURTHER





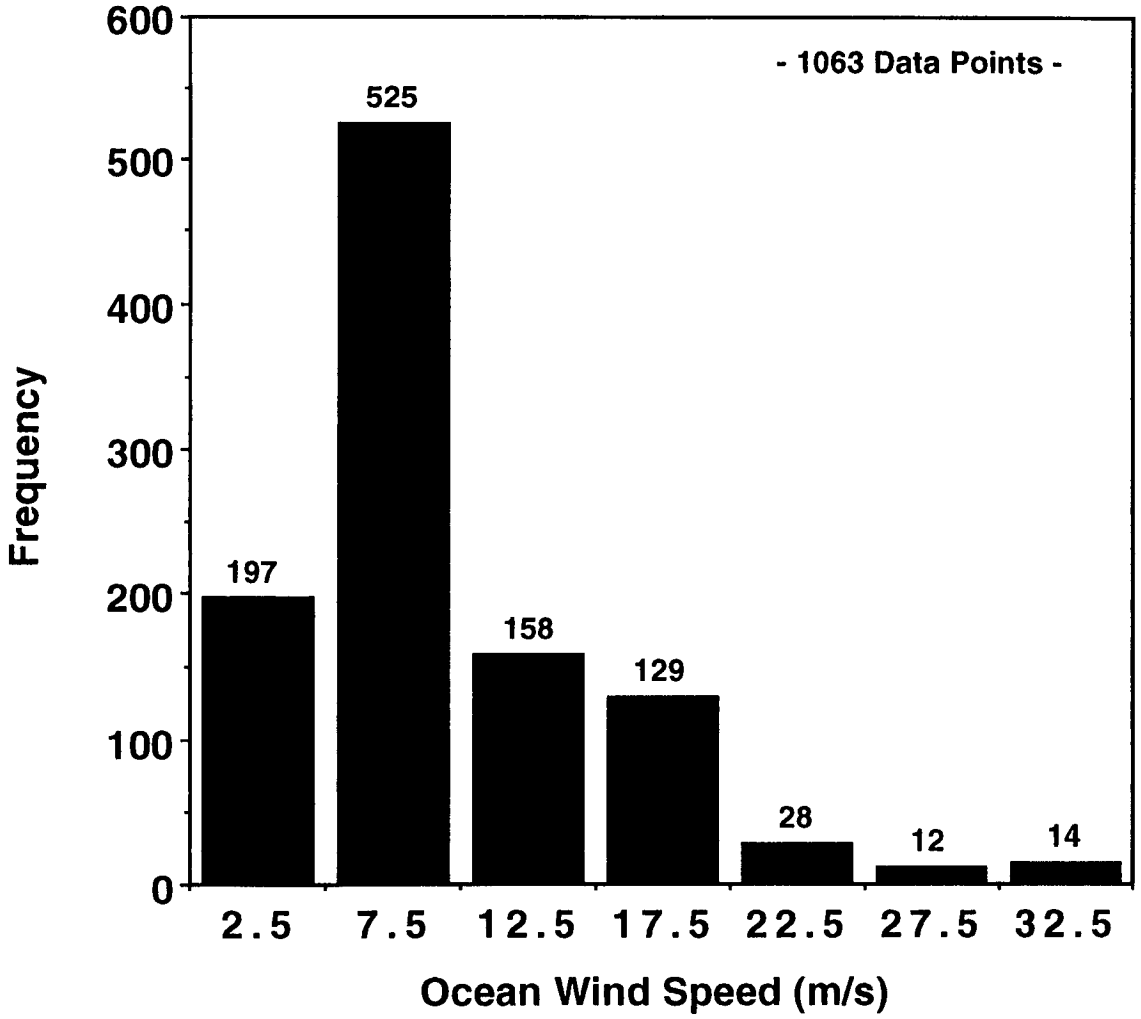


DATA FILTERING

- o OUTLYING DATA POINTS DETERMINED BY HISTOGRAM ANALYSIS
- o 73 DATA POINTS IDENTIFIED AND STUDIED:
  - 48 DATA POINTS DELETED. 6 MINUTES FROM ORBIT 31086 (INITIAL ORBIT OF TILT DATA @ 69° INCIDENCE), 9 MINUTES FROM ORBIT 31127 (INITIAL ORBIT OF 69° INCIDENCE DATA FOLLOWING RETURN FROM 53° INCIDENCE). POINTS SHOWED UNIFORM SHIFT IN EMISSIVITY AT ALL WIND SPEEDS.
  - 6 DATA POINTS DELETED DUE TO COASTAL PROXIMITY. SUSPECT THAT SSM/I SURFACE TYPING ROUTINE WAS NOT REWRITTEN TO ACCOUNT FOR LARGER FOOTPRINT DUE TO HIGHER INCIDENCE ANGLE.
  - 11 DATA POINTS RECLASSIFIED TO A DIFFERENT OCEAN WIND SPEED
  - 8 DATA POINTS RETAINED WITH NO CHANGE
- o DATA POINTS SAMPLED AT EVERY SCAN (OTHER THAN EVERY 5th SCAN) AT WIND SPEEDS OF 17.5 m/s OR GREATER TO INCREASE SIZE OF DATA BASE AT HIGHER WIND SPEEDS.

REVISED COINCIDENT DATA DISTRIBUTION

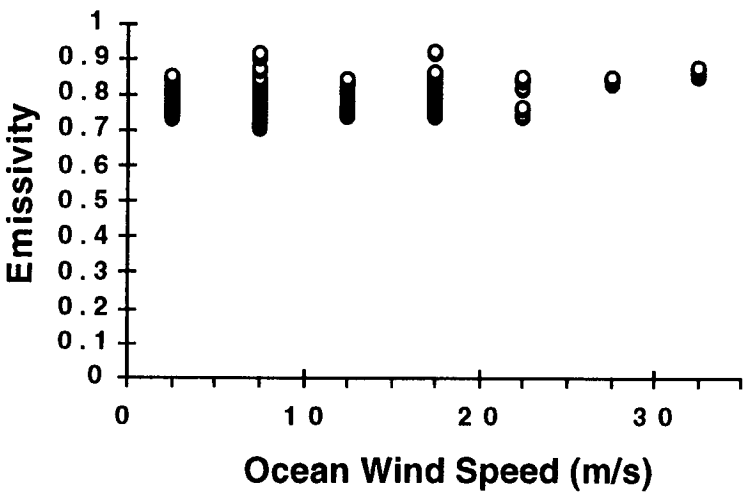
npoess



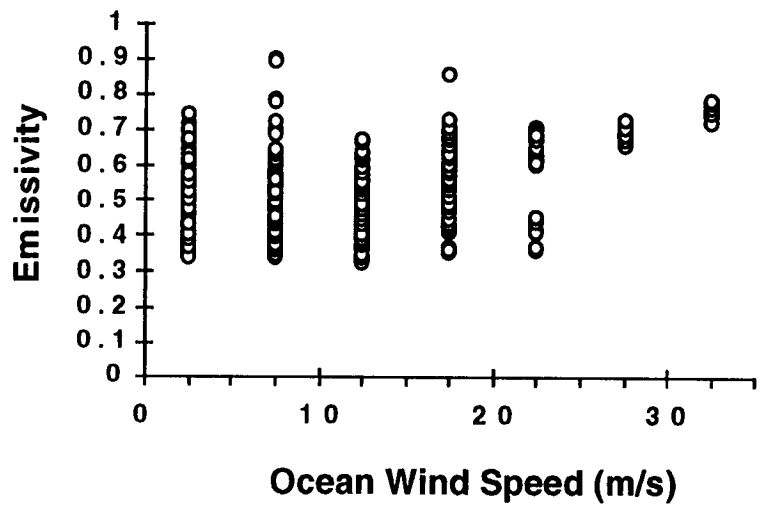
RECTIFICATION OF OUTLYING DATA POINTS AND INCREASED SAMPLING AT HIGHER WIND SPEEDS RESULTED IN AN INCREASE IN DATA BASE SIZE FROM 980 TO 1063 DATA POINTS

EMISSIVITY AT 19 GHz FOR 69° EIA

VERTICAL POLARIZATION

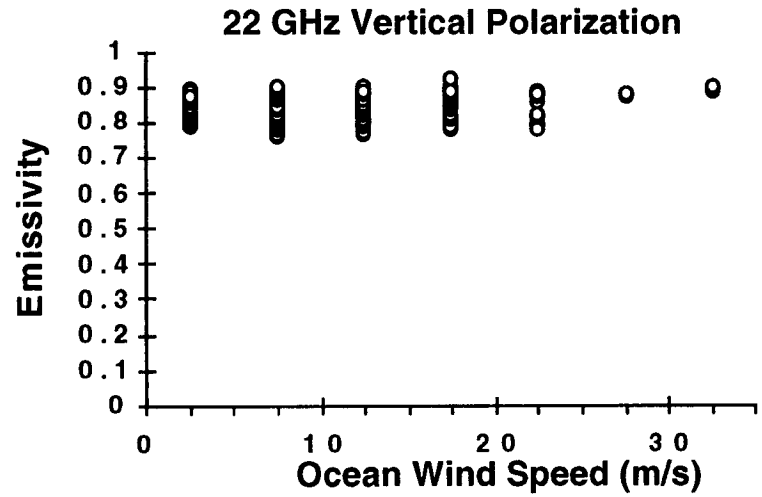


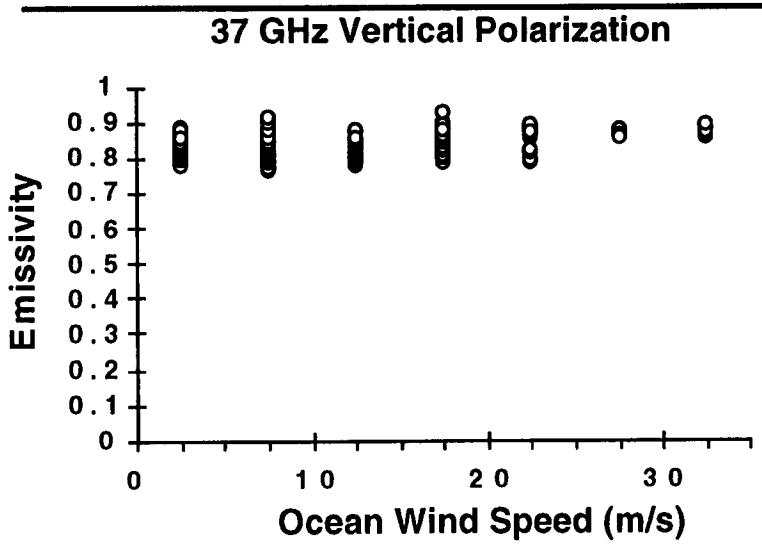
HORIZONTAL POLARIZATION

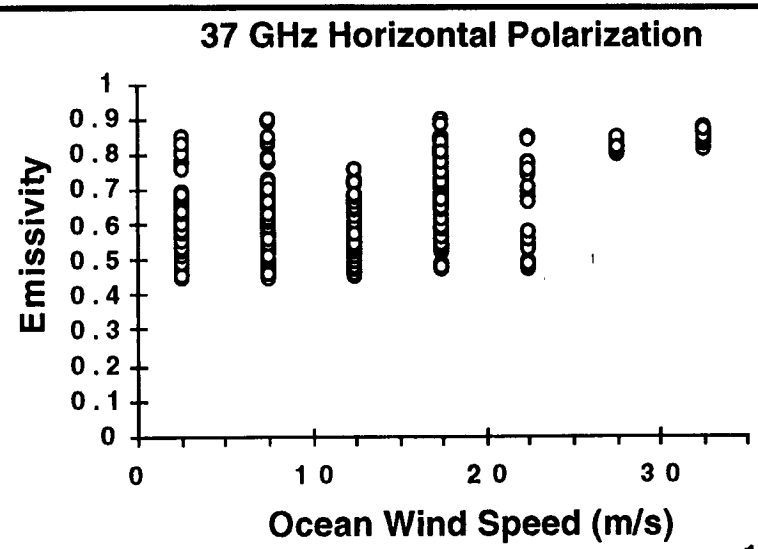


EMISSIVITIES AT 22 & 37 GHz FOR 69° EIA

npoess







EMISSIVITY HISTOGRAMS AT 19V GHz

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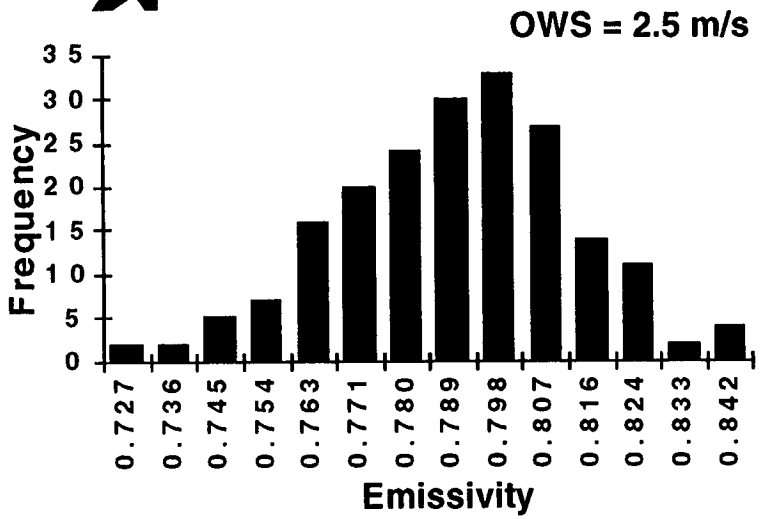

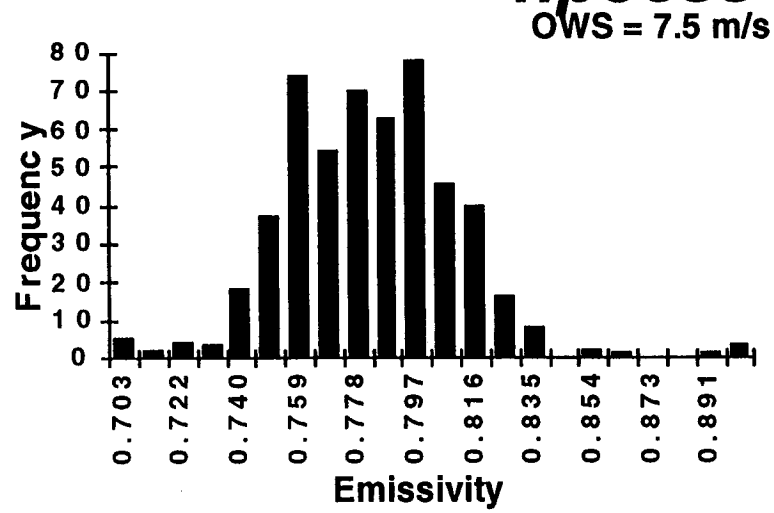

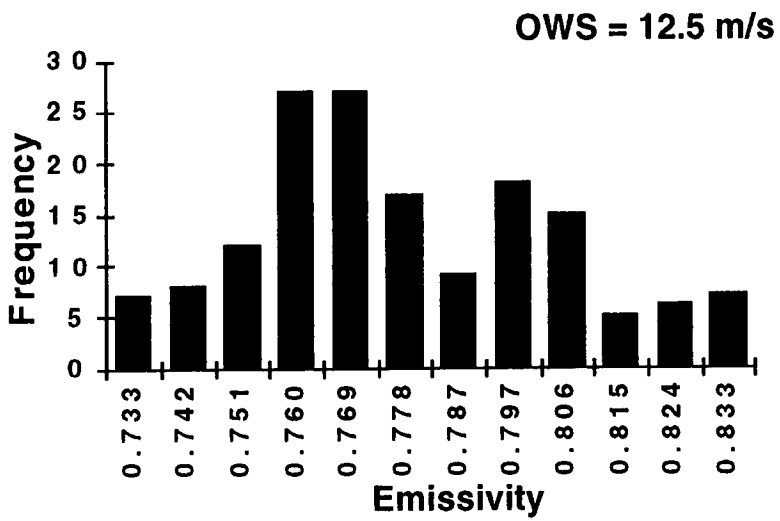

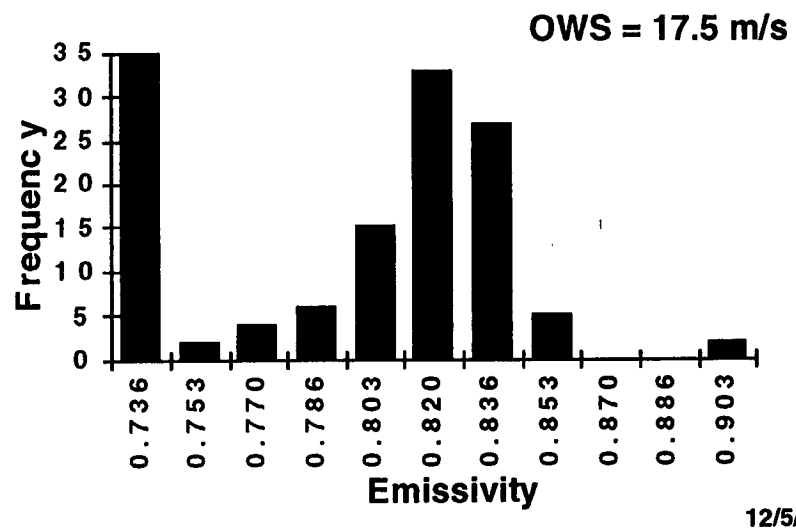

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EMISSIVITY HISTOGRAMS AT 19H GHz

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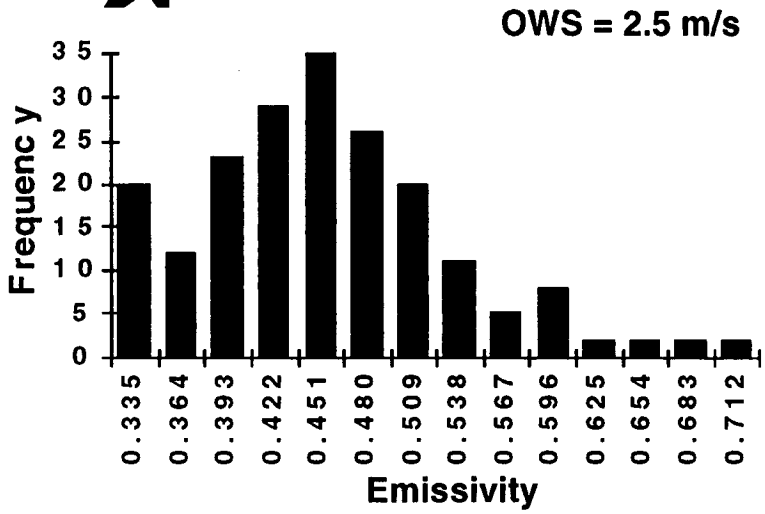
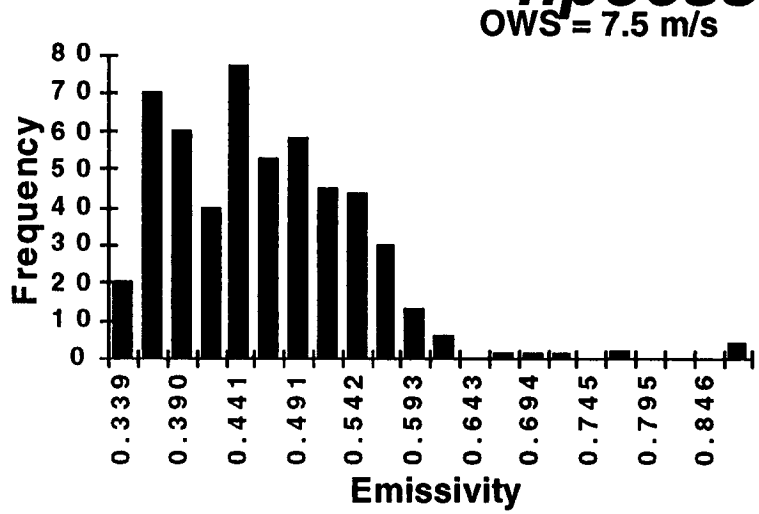
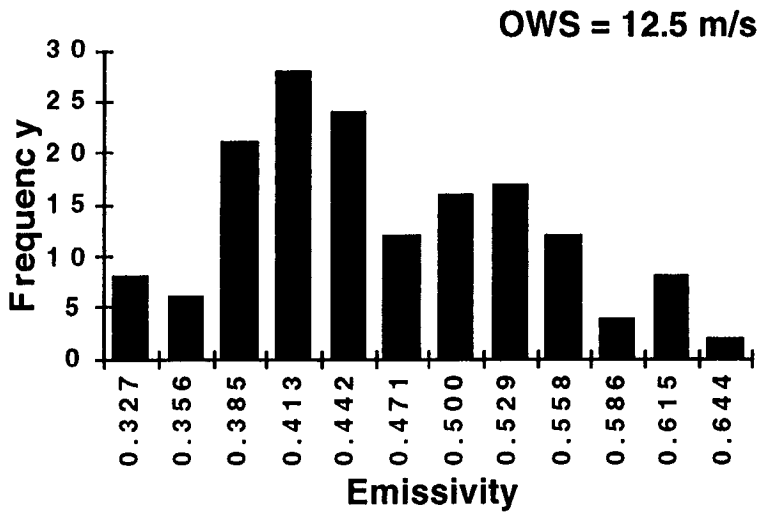
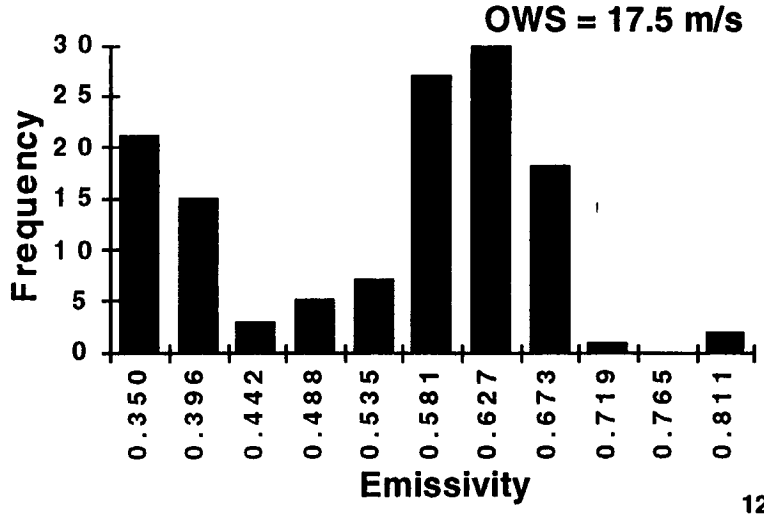


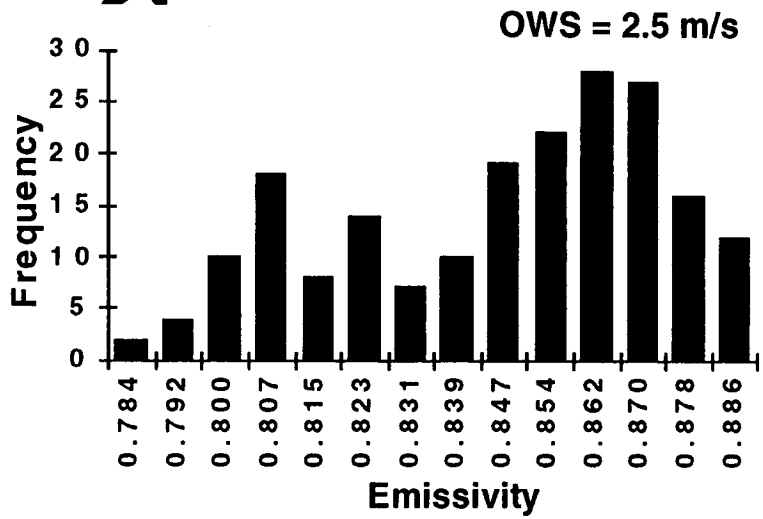


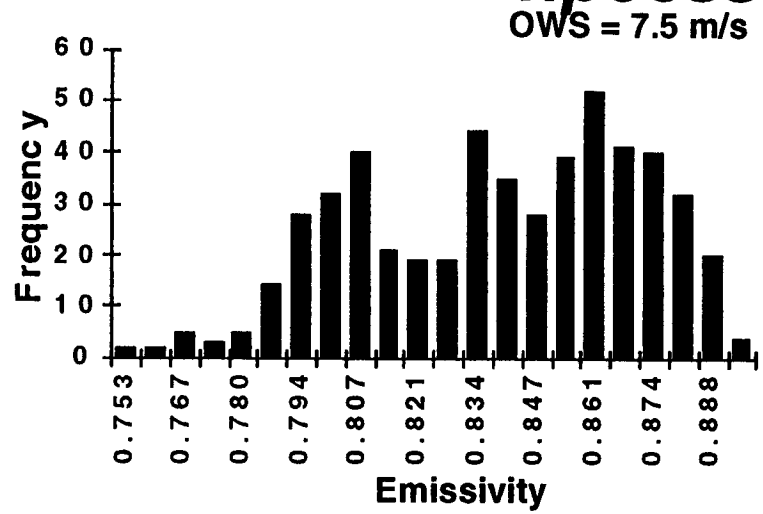


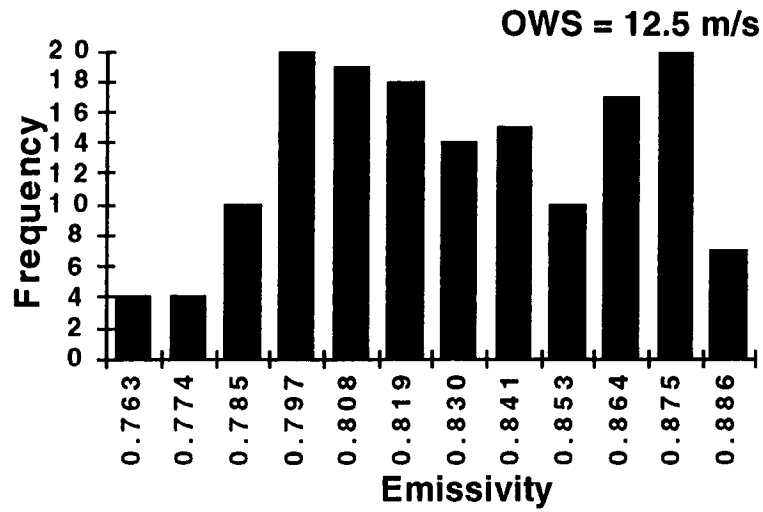


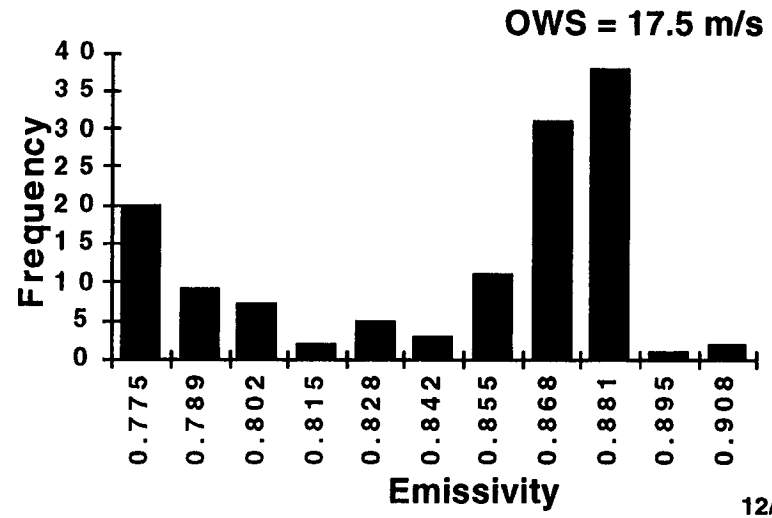
EMISSIVITY HISTOGRAMS AT 22V GHz

npoess









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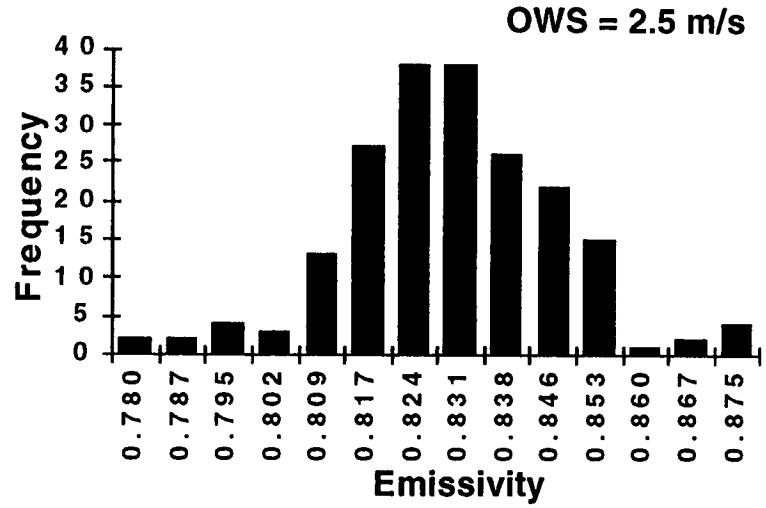
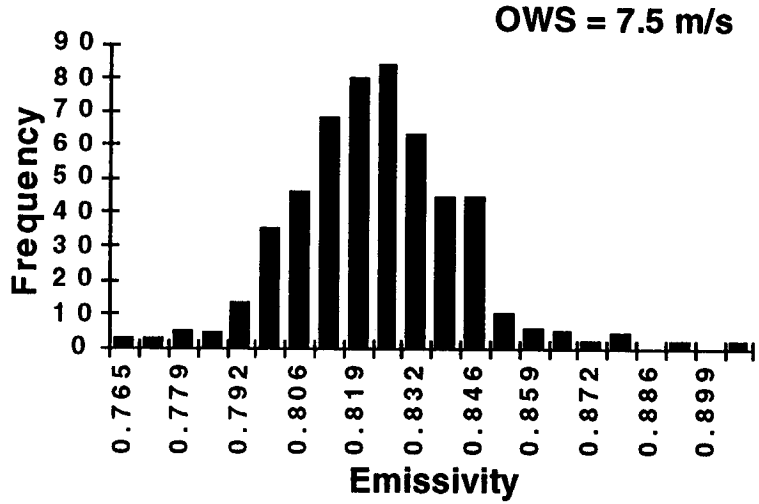
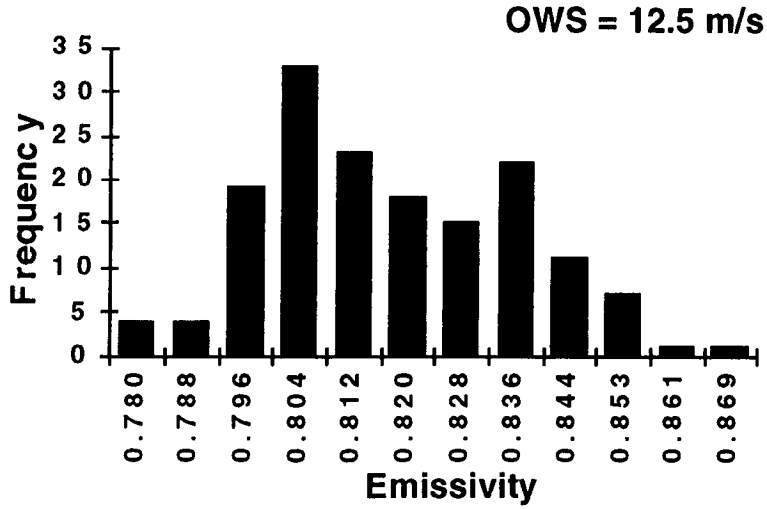
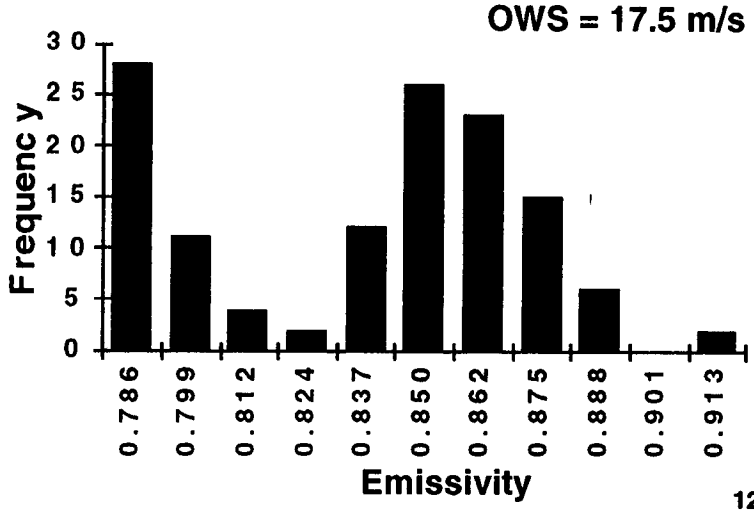
EMISSIVITY HISTOGRAMS AT 37V GHz

npoess









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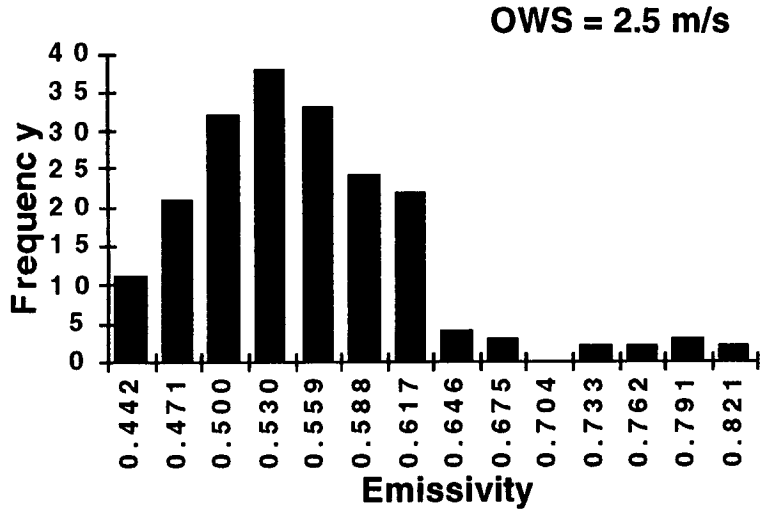
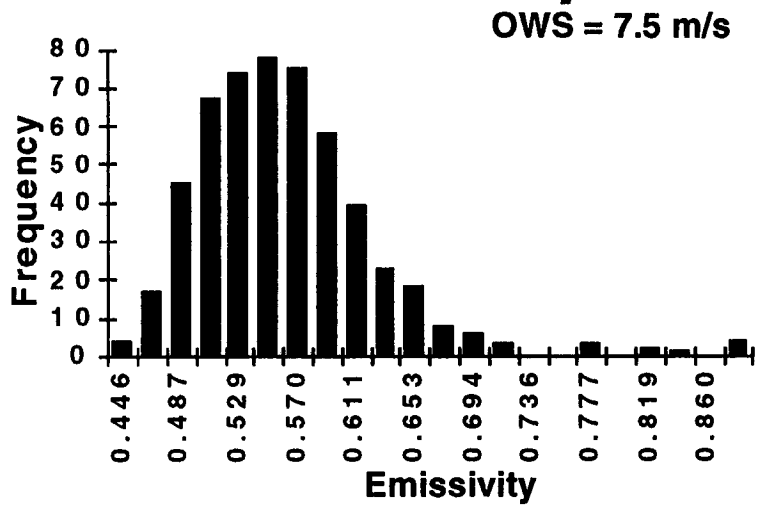
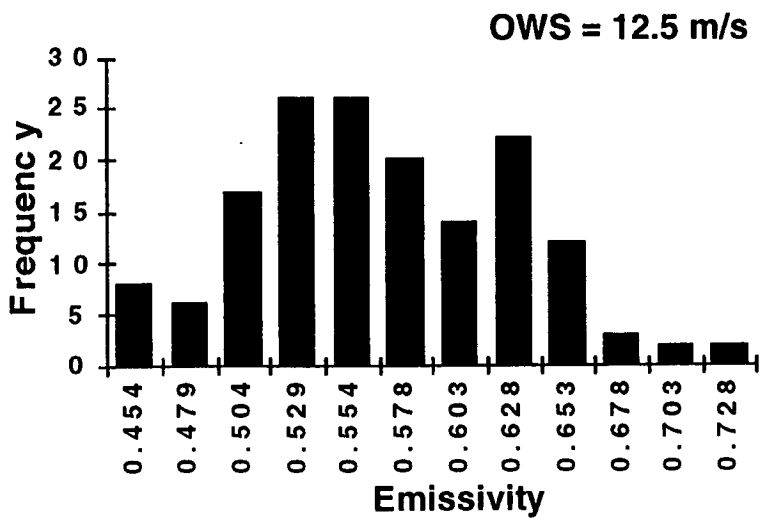
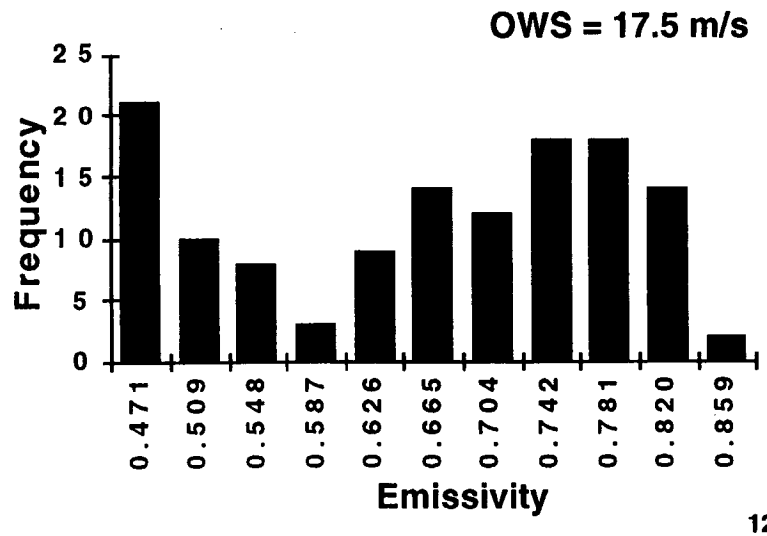
EMISSIVITY HISTOGRAMS AT 37H GHz

npoess









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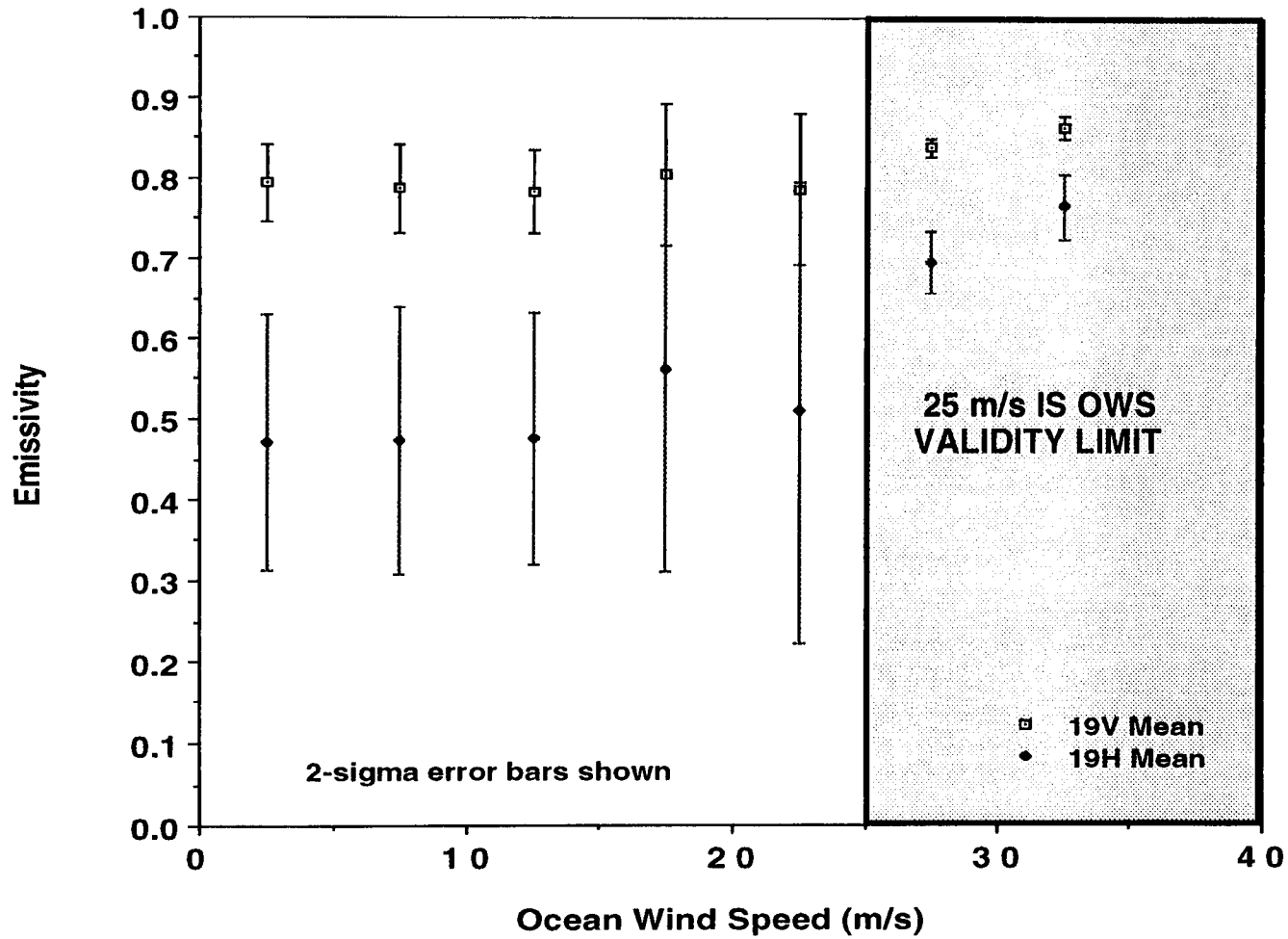
STATISTICAL ANALYSIS

- o STATISTICS DETERMINED FOR EACH FREQUENCY, POLARIZATION AND OCEAN WIND SPEED BIN
- o MEAN EMISSIVITY PLOTTED
- o ERROR BARS DETERMINED (+/- 2 SIGMA)

REMINDER OF OBJECTIVES:

- *DETERMINE EMISSIVITY TRENDS BASED ON F8 TDRs @ 69° EIA*
- *SENSITIVITY VARIATION IN V-POLARIZATION CHANNELS DUE TO BREWSTER ANGLE EFFECTS (NON-LINEAR AT HIGH WIND SPEEDS?)*
- *OCEAN EMISSIVITY FOR H-POLARIZATION*

19 GHz EMISSIVITY @ 69° EIA BASED ON TDR ANALYSIS



CONVERGENCE EFFORT MODIFICATION

22 GHz EMISSIVITY @ 69° EIA BASED ON TDR ANALYSIS

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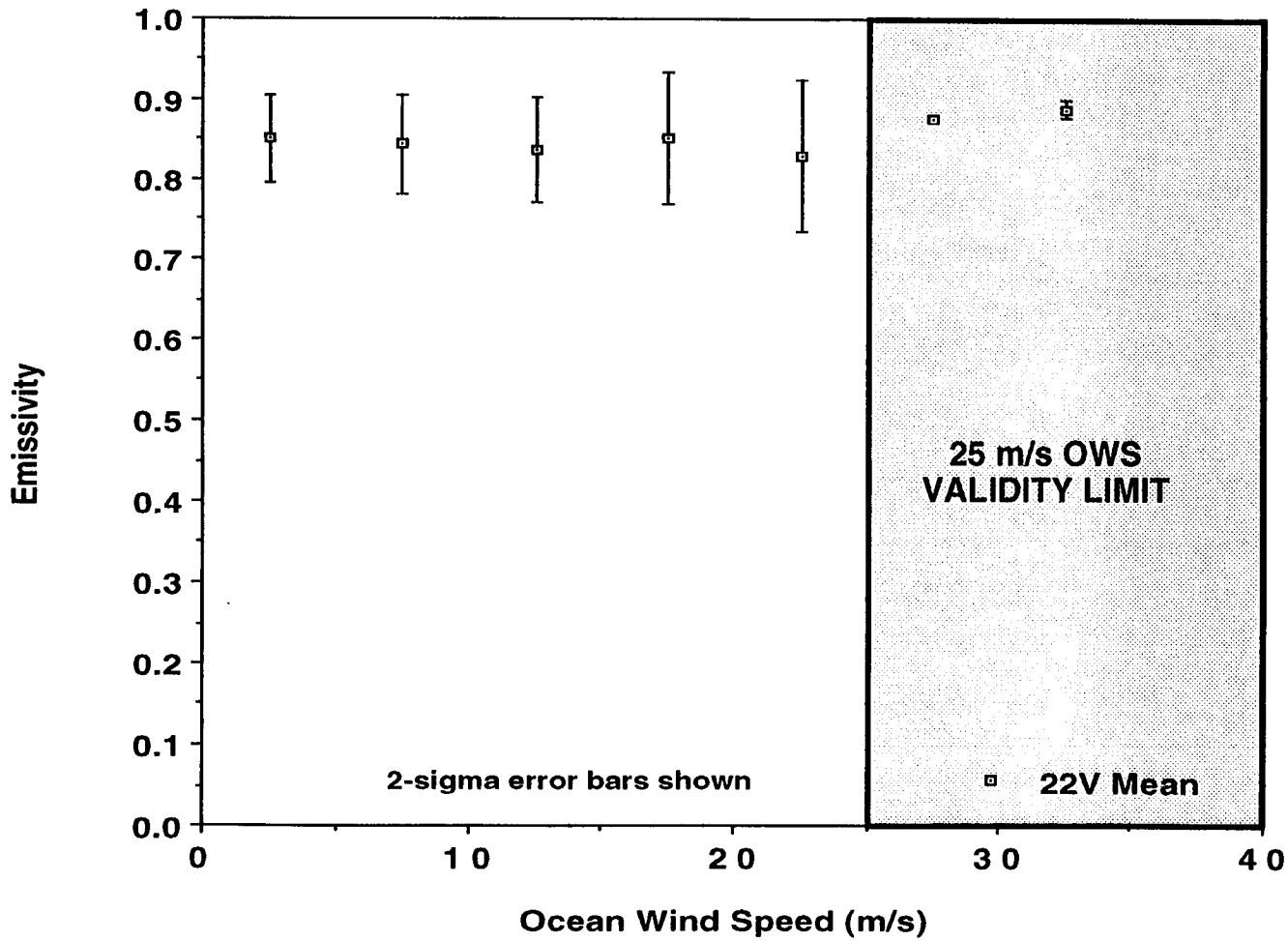
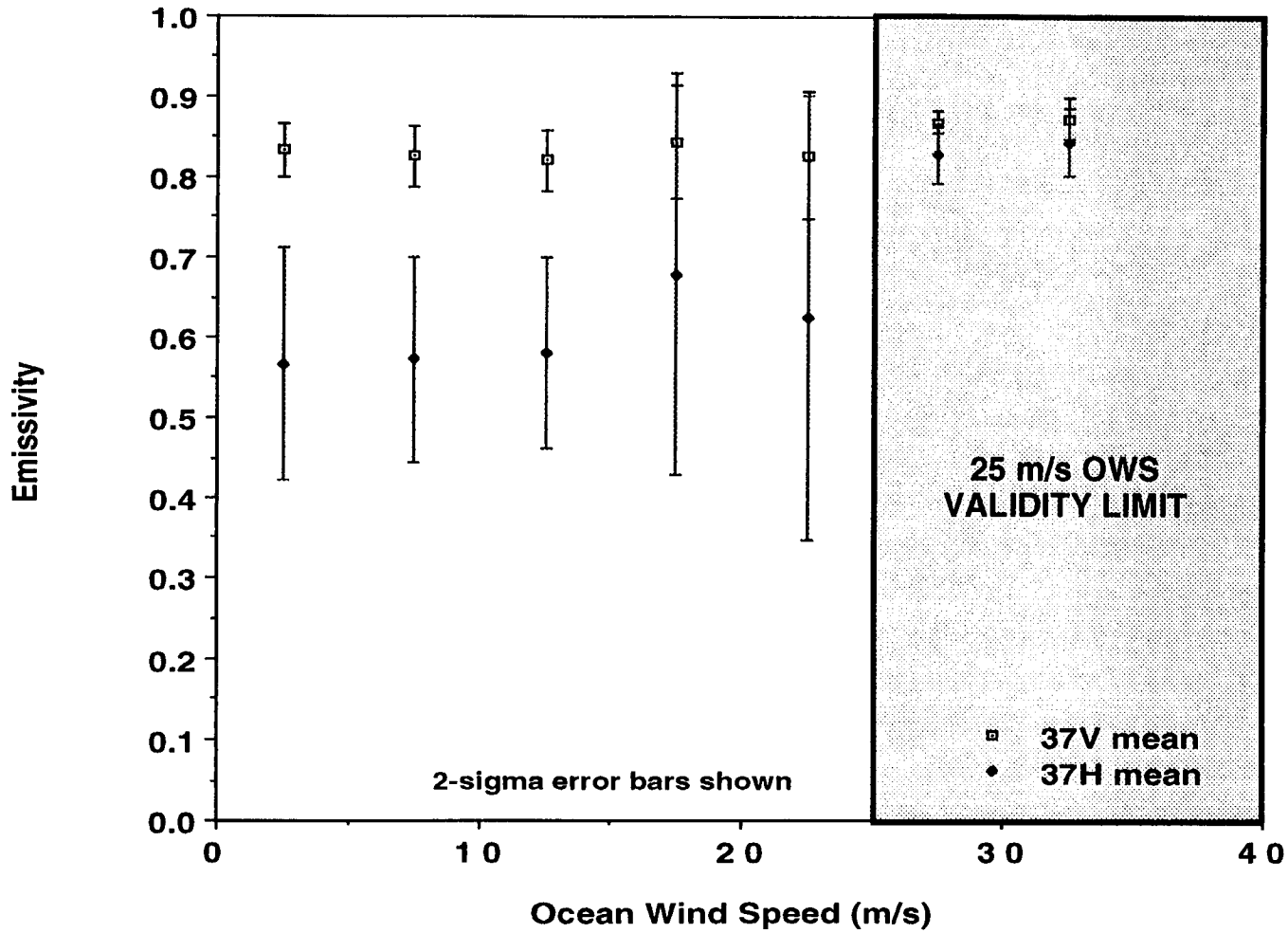


37 GHz EMISSIVITY @ 69° EIA BASED ON TDR ANALYSIS



COMPARISON OF TDR-DERIVED EMISSIVITIES TO VARIOUS EMISSIVITY MODELS

FOUR EMISSIVITY MODELS USED TO COMPARE WITH TDR RESULTS

1) HOLLINGER MODEL

DEVELOPED IN PART FROM EXTRAPOLATIONS OF LIMITED DATA AT EIAs OF 0 TO 70° MADE FROM A SURFACE PLATFORM WITH SMALL SPOT SIZES (0.9m @ NADIR @ 19 GHz)

2) WILHEIT MODEL

DEVELOPED TO SUPPORT SMMR DATA ANALYSIS, LIMITED BY SIMPLISTIC TREATMENT OF SEA FOAM EMISSIVITY AND LACK OF PHYSICAL OPTICS EFFECTS

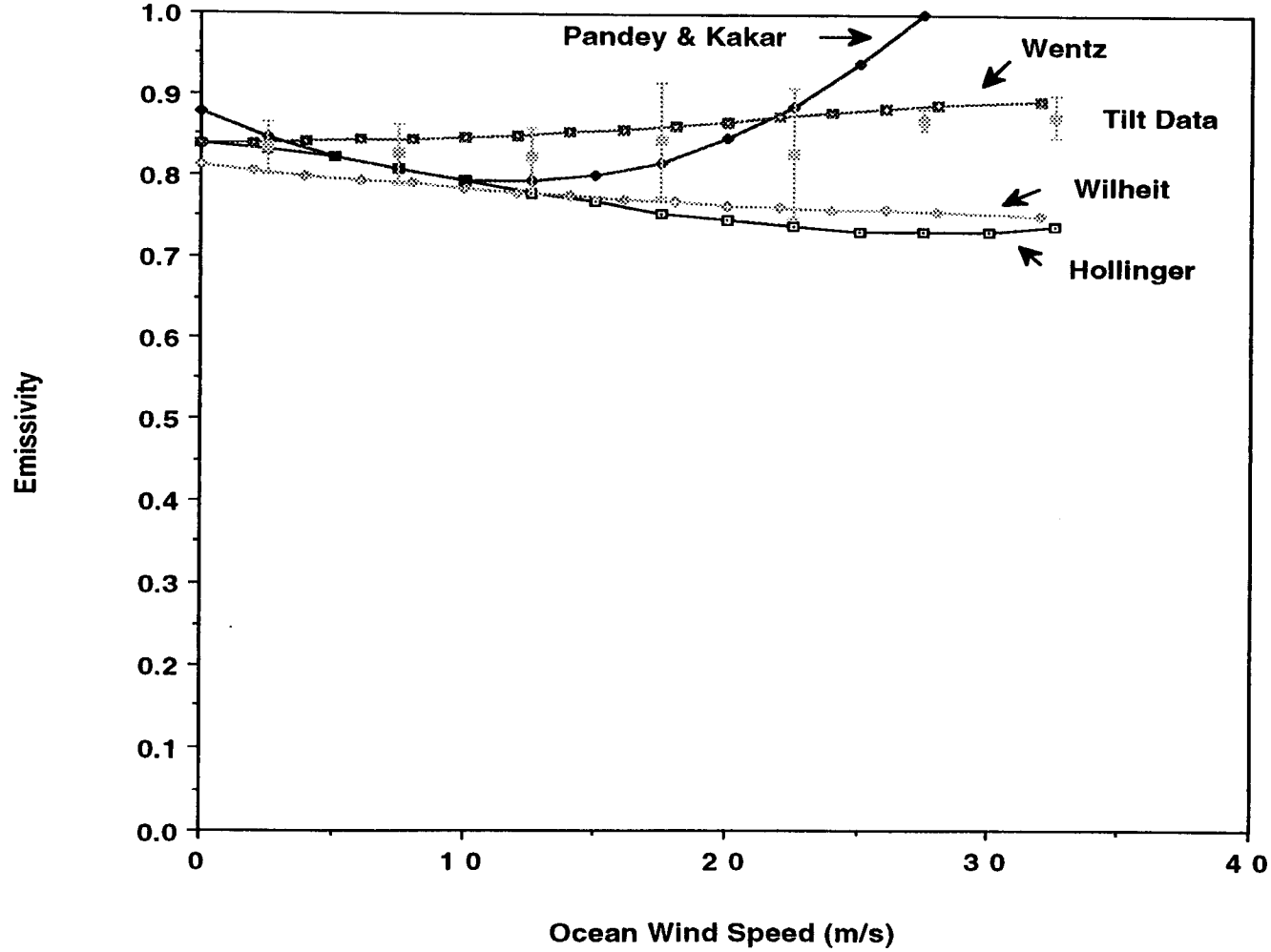
3) WENTZ MODEL

DERIVED USING SMMR DATA, REFINED USING SSM/I DATA, PARTICULARLY VALID FOR EIAs BETWEEN 48 - 54°

4) PANDEY & KAKAR MODEL

TUNED FOR 48.8° EIA USING SMMR DATA, VALID FOR OWS TO 15 - 25 m/s

COMPARISON OF TDR-DERIVED EMISSIVITY TO MODELS AT 69° EIA FOR 37V GHz



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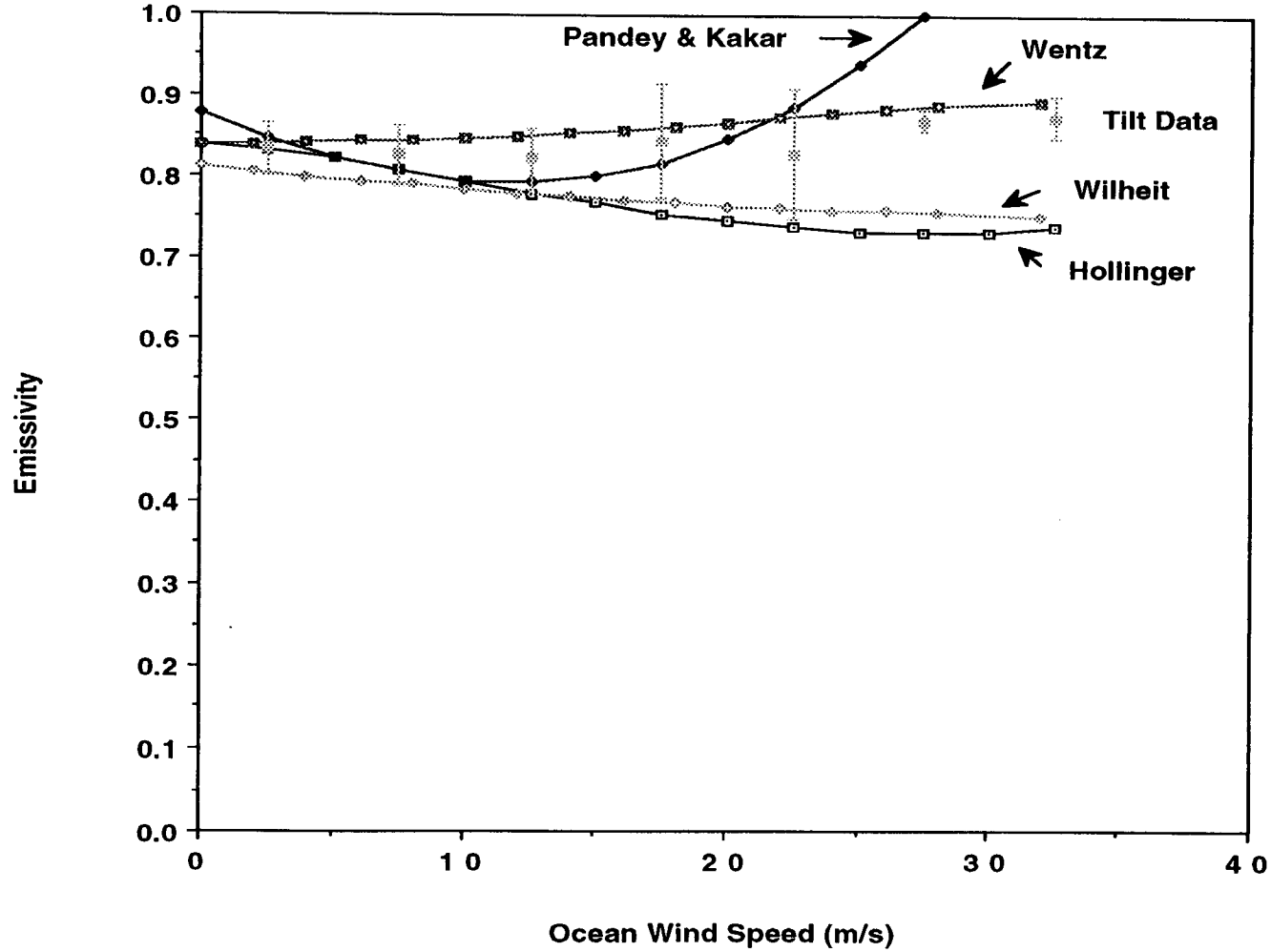

COMPARISON OF TDR-DERIVED EMISSIVITY TO MODELS AT 69° EIA FOR 37H GHz

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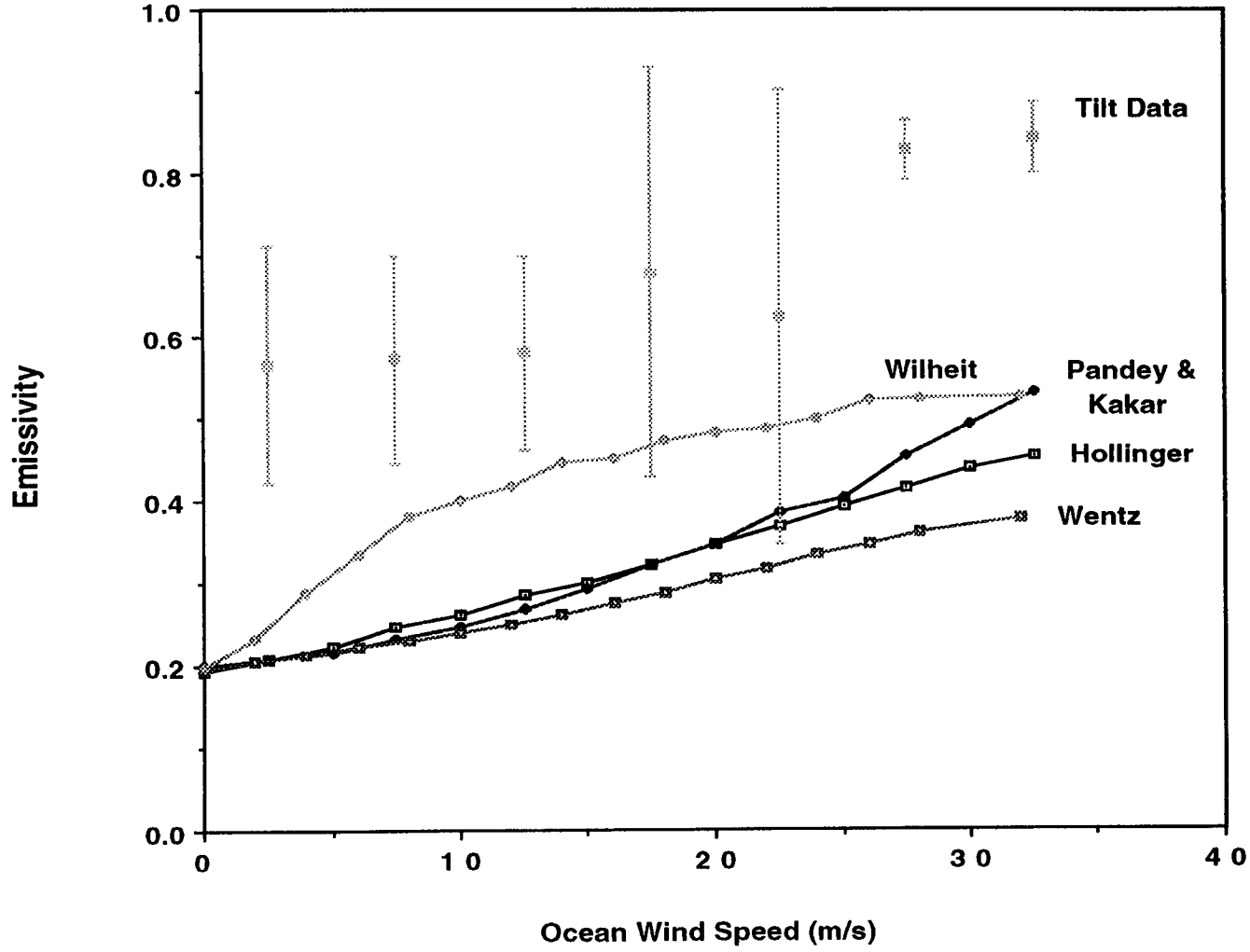

EMISSIVITY BEHAVIOR OBSERVATIONS

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- *V-POLARIZED EMISSIVITIES IN ACCORDANCE WITH MODELS*
- *H-POLARIZED EMISSIVITIES HIGHER THAN PREDICTED BY MODELS, LARGE DISPERSAL IN HORIZONTAL EMISSIVITIES*

POTENTIAL CAUSES

SENSOR

- Receiver Instability*
- Space Reflection
- Other

PHENOMENOLOGICAL

- Atmospheric Up/Downwelling Effects*
- Rain Contaminated Pixels
- Other

* STUDIED TO DATE

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* STUDIED TO DATE

F8 CALIBRATION READINGS AT 69° EIA

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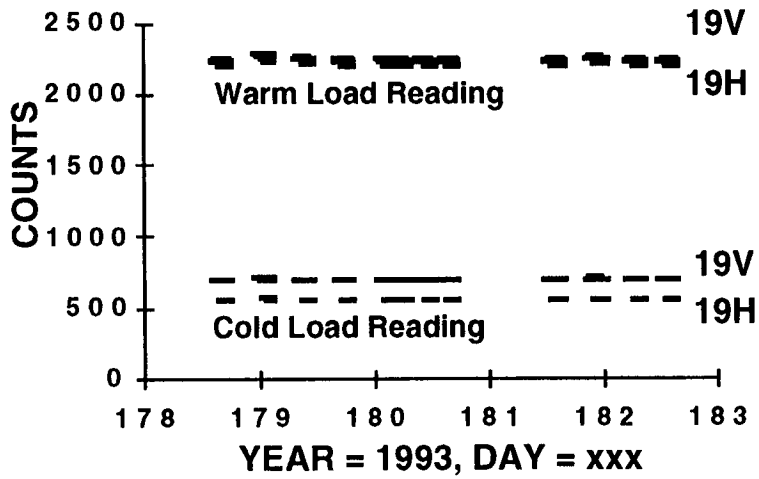
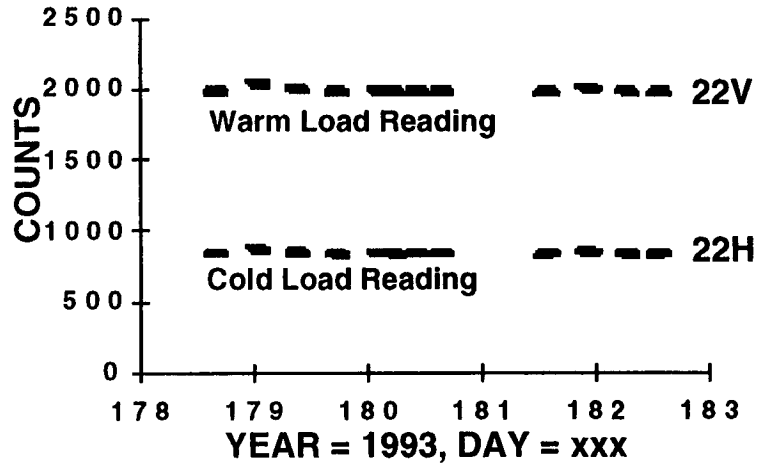
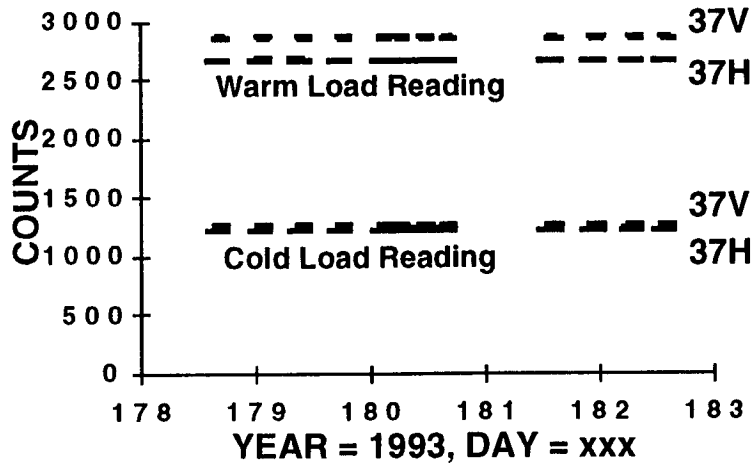




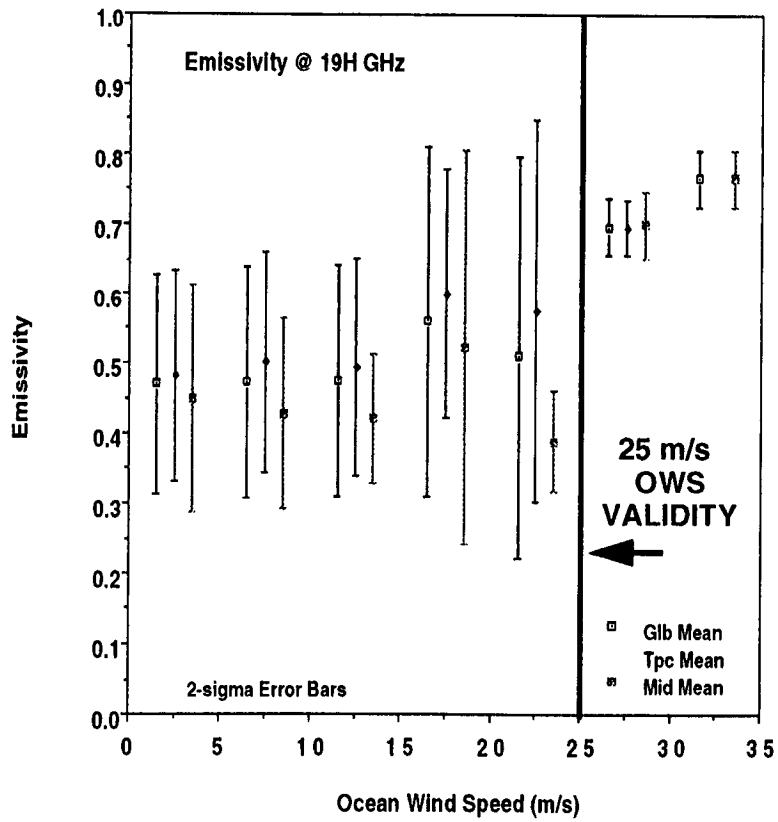


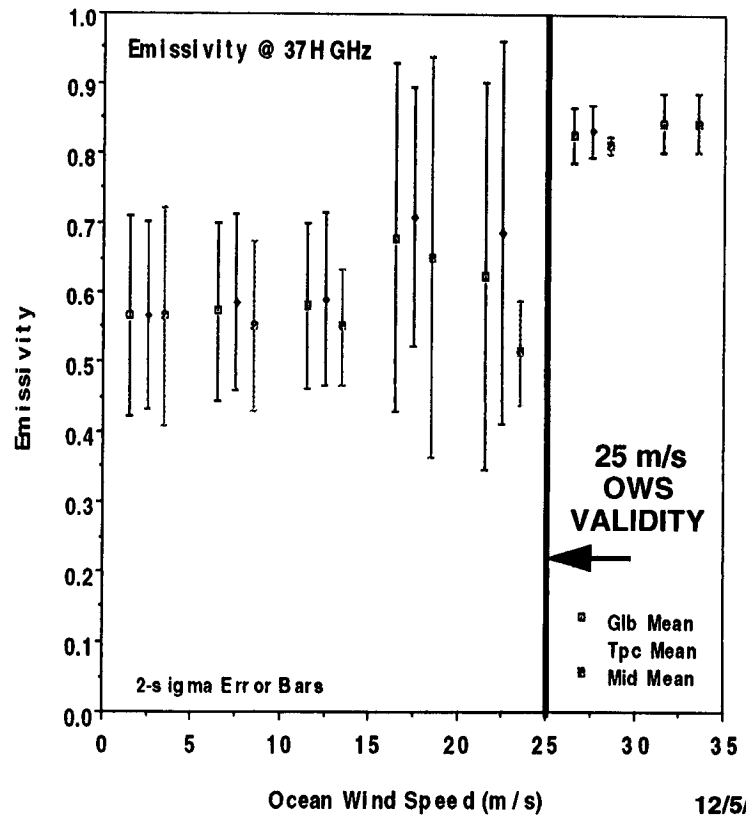
- EXAMINED F8 CALIBRATION STABILITY TO EXPLORE POTENTIAL RECEIVER INSTABILITY AS CAUSE FOR H-POLARIZATION EMISSIVITY DISPERSION
- INTENT IS TO DETERMINE IF F8 CALIBRATION READINGS WERE STABLE DURING TILTED ORBITS

CALIBRATION READINGS CONSTANT OVER TIME FRAME OF INTEREST. NO EVIDENCE OF RECEIVER-INDUCED EMISSIVITY EFFECTS

HORIZONTAL POLARIZATION EMISSIVITY - ATMOSPHERIC UP/DOWNWELLING EFFECTS -

- EMISSIVITY AT HORIZONTAL POLARIZATIONS IS SHOWN FOR AREAL COINCIDENCE BROKEN DOWN BY GLOBAL (GLB), TROPIC (TPC) & MID-LATITUDE (MID) REGIONS
- EMISSIVITY @ 19H LESS THAN EMISSIVITY @ 37H (AS EXPECTED)
- ERROR BARS SLIGHTLY SMALLER FOR MID-LATITUDE REGIONS





EMISSIVITY BEHAVIOR SUMMARY

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VERTICAL POLARIZATION

- TDRs INDICATE LINEAR INCREASE IN EMISSIVITY WITH WIND SPEED
- TDR EMISSIVITIES SIMILAR TO MODELED EMISSIVITIES AT 69° EIA
- TDR-DERIVED EMISSIVITIES SHOW FAIRLY SMALL DISPERSION FOR EACH WIND SPEED BIN

HORIZONTAL POLARIZATION

- HIGH DISPERSION OF TDR-DERIVED EMISSIVITIES FOR OWS < 27.5 m/s
- TDR EMISSIVITIES HIGHER THAN MODELED EMISSIVITES AT 69° EIA
- NO EVIDENCE OF RECEIVER-INDUCED EMISSIVITY EFFECTS
- ATMOSPHERIC UP/DOWNWELLING EFFECTS AS PREDICTED (e @19H < 37H)
- MID-LATITUDE COINCIDENCE REGIONS SHOW SMALLER ERROR BARS
- REQUIRES FURTHER INVESTIGATION (FILTER BY F10/F11 RAIN FLAG?)
- REFINE BY SDR DATA, IF STILL PRESENT, STUDY FREQUENCY SHIFT FROM 23.8H TO 22.235V

TILT EXPERIMENT
- CONCLUSIONS -

- o LOCKHEED HAS ESTABLISHED THE VIABILITY OF TDR-BASED ANALYSES UNTIL SDRs ARE AVAILABLE
- o LMSC HAS COMPLETED PROCESSING OF TDR DATA AT 69° EIA
  - RESULTS ARE VERY ENCOURAGING
  - RETRIEVALS AT 69° EIA APPEAR TO BE VIABLE, SENSOR DESIGN PROCEEDING
  - VERTICAL POLARIZATION DATA SHOW NO EVIDENCE OF BREWSTER ANGLE EFFECTS
- o FURTHER DATA COLLECTION MAY BE MERITED
  - DESIRE FOR INCREASED SAMPLING AT HIGHER WIND SPEEDS
  - GROUND-BASED RADIOMETRY FOR ATMOSPHERIC UP/DOWNWELLING CHARACTERIZATION

SDR ANALYSIS REQUIRED TO PROPERLY REFINE EMISSIVITY EFFECTS AT HIGH INCIDENCE ANGLES

MISS NEAR-TERM ACTIVITIES

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- UPDATE MISS SPECIFICATION BASED ON CONVERGED REQUIREMENTS
- CONTINUE TO ANALYZE MISS RISK & COST
- HUGHES TO PROVIDE CONCEPT EXPLORATION OF ALTERNATIVE MISS CONCEPTS
  - [redacted]
- SUPPORT AEROSPACE IN TILT EXPERIMENT SDR GENERATION AND CONTINUE ANALYSIS

SUMMARY

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- o LMSC MISS TEAM WELL POSITIONED TO ASSESS CONVERGED MICROWAVE EDR REQUIREMENTS
- o HUGHES PERFORMANCE TO DATE IS EXCELLENT
- o REFERENCE MISS DESIGN DEVELOPED TO SUPPORT CONCEPT EXPLORATION STUDIES
- o HAVE DETERMINED VIABILITY OF HIGH INCIDENCE MICROWAVE RETRIEVALS USING F8 TILT EXPERIMENT TDRs TO STUDY EMISSIVITY TREND DATA

SPACE ENVIRONMENTAL SUITE

Y. CHIU

PRESENTATION OUTLINE

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- o SES OBJECTIVES AND KEY ACCOMPLISHMENTS (THIS PERIOD)
- o SUMMARY OF IONOSPHERIC AND NEUTRAL ATMOSPHERE ALGORITHM STATUS
- o PRELIMINARY IMPACT ASSESSMENT OF CONVERGED SES REQUIREMENTS:
  - SES REQUIREMENTS SUMMARY
  - PRELIMINARY SES INSTRUMENTS
  - SES INSTRUMENT ISSUES
- o CONCLUSIONS

SES OBJECTIVES

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CONTRACT OBJECTIVES: DEVELOP AN AFFORDABLE, PRODUCIBLE SES PRELIMINARY DESIGN THAT MEETS USER NEEDS IN A COST-EFFECTIVE MANNER. DEVELOP ALGORITHMS FOR IONSOPHERIC ELECTRON DENSITY PROFILES AND NEUTRAL ATMOSPHERE MEASUREMENTS.

KEY ACCOMPLISHMENTS THIS PERIOD:

- o CONTINUED TO IMPROVE 3-D IONOSPHERIC TOMOGRAPHY AND NEUTRAL UPPER ATMOSPHERE DENSITY ALGORITHMS
- o SUCCESSFULLY CAST THESE ALGORITHM RESULTS IN 3-D SPHERICAL GEOMETRY FOR DISPLAY TO USERS, AS REQUESTED IN LAST TIM
- o REVIEWED SES KEY ISSUES IN NPOESS A-SPEC
- o DETERMINED PRELIMINARY INSTRUMENT CONCEPTS AND METHODOLOGY OF INSTRUMENT SELECTION FOR NPOESS/SES SUITE AS DRIVEN BY A-SPEC

ELECTRON DENSITY PROFILE
- GPS RETRIEVAL GEOMETRY -

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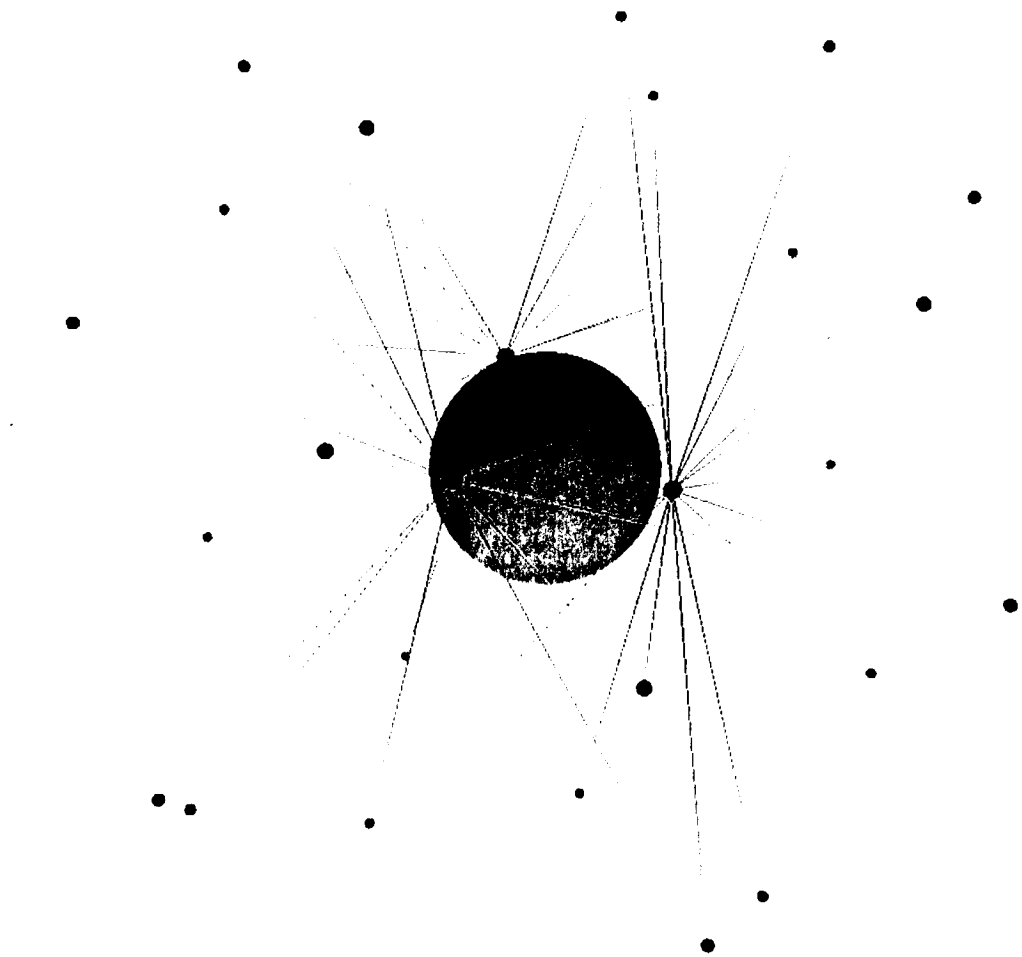

END-TO-END TOMOGRAPHY TEST SCHEMATICS

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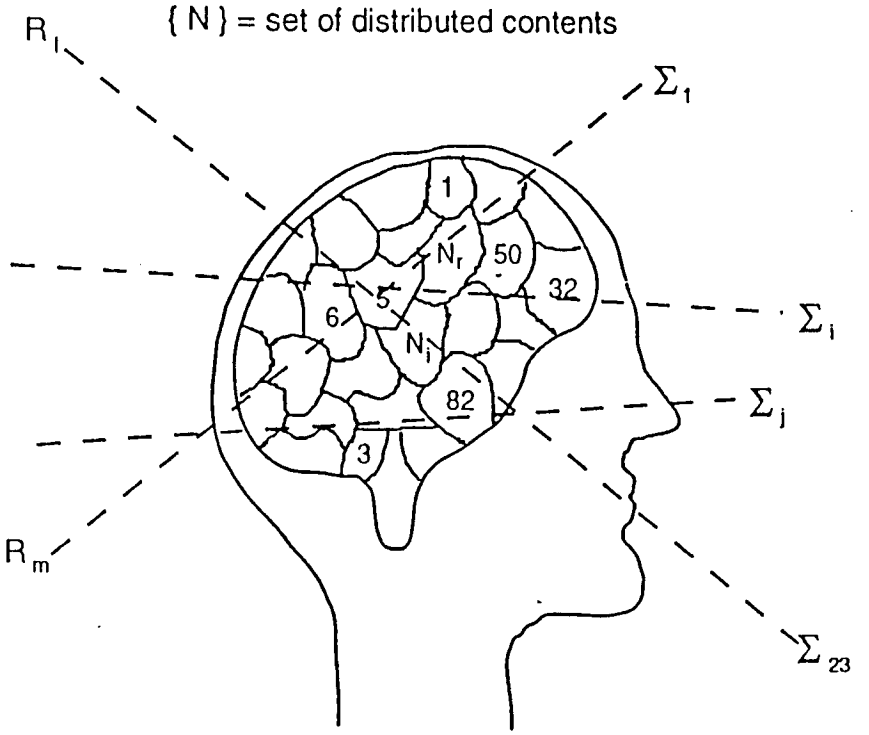


{ R } = set of ray directions

{ Σ } = set of content sums intercepted by { R }

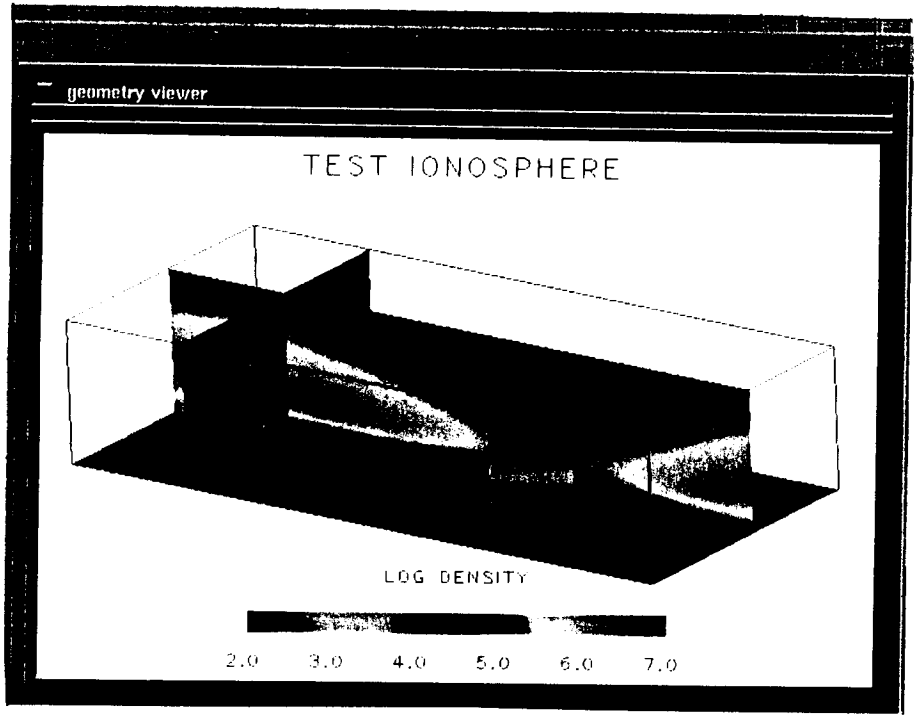
Operational Tomography

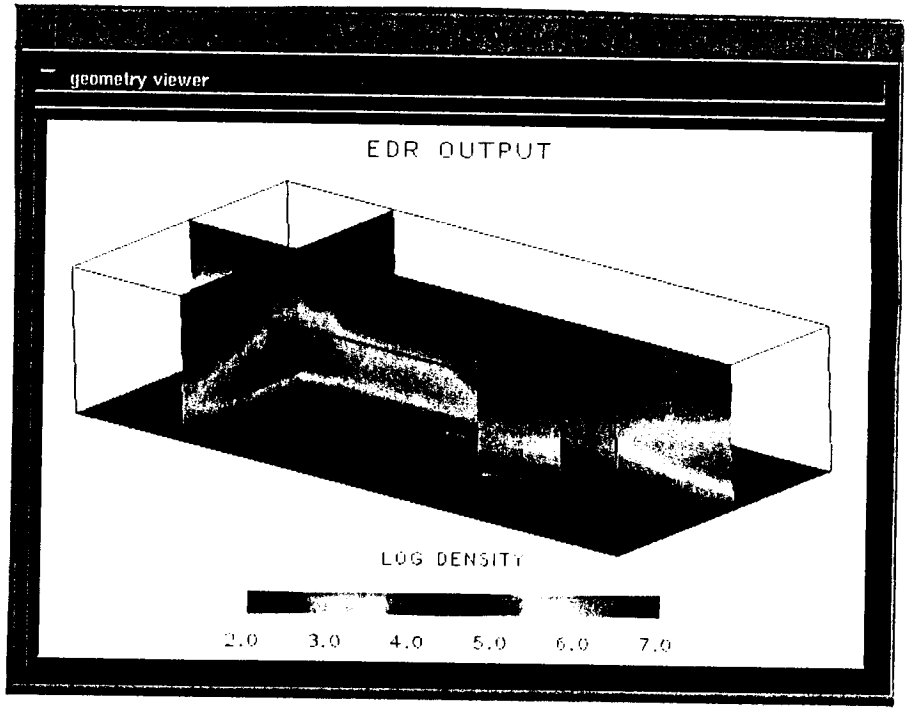
- Obtain { N } from { Σ } and corresponding { R }

Tomography Test

- Initialization
  - Populate { N } with an ionosphere model
  - Exercise real GPS & DMSP/NOAA orbit dynamics to obtain { R }
  - Simulate GPSR measurements { Σ } from { N }
- Excercise tomography algorithm
  - Algorithm is BLIND TO { N }
  - Algorithm given { Σ } & { R }
  - Output : { I }
- Test : Compare { I } with { N }

ELECTRON DENSITY PROFILE
- SAMPLE RETRIEVAL -





ELECTRON DENSITY PROFILE
- SPHERICAL DEPICTION -

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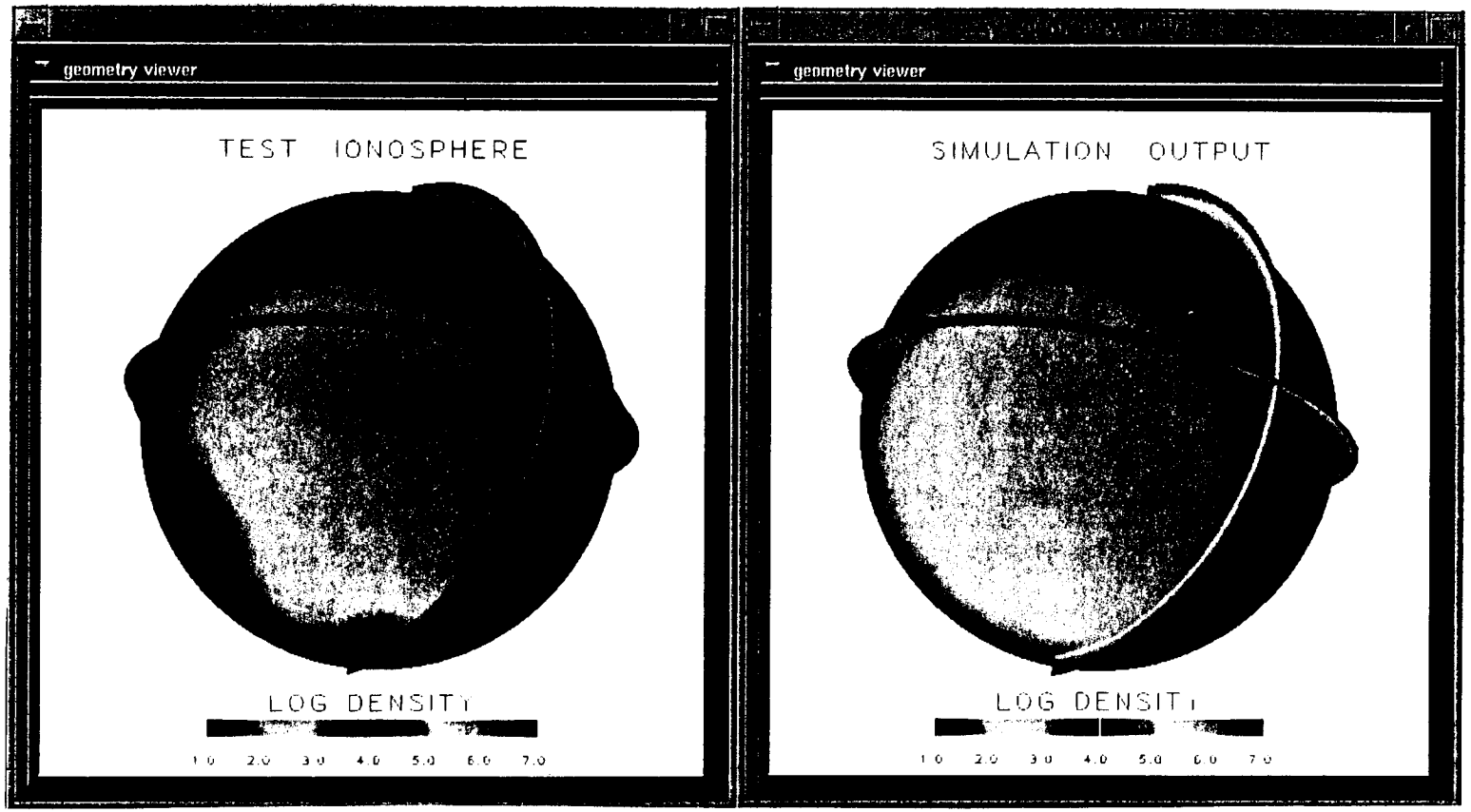

CONVERGENCE EFFORT MODIFICATION

PRELIMINARY ANALYSIS OF SES EDR REQUIREMENTS FROM NPOESS A-SPEC (1)

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EDR #	NAME	COVERAGE	RESOLUTION	MEASUREMENT RANGE
20.9.3 20.9.3.1 20.9.3.2 20.9.3.4	AURORAL & AIRGLOW IMAGERY	• Global = constellation swath	• Goals imply imagery	• Broadband goals implies complex cluster of imagers • UV goals achievable • IR & X-ray require different instrument types
20.9.3.3	OPTICAL BACKGROUND	• Global = constellation swath	• Goals imply imagery in IR with very large cooled sensor	• Simple instrument can achieve some of range • LWIR not feasible unless with moderate complexity
20.9.9	ELECTRIC FIELD	• Global = constellation swath	• Goals achievable	• Goals achievable
20.9.10	ELECTRON DENSITY	• Global	• 10km horizontal resolution achievable only along orbit • Minimum: 200km global away from orbit	• Goals achievable
20.9.13	GEOMAGNETIC FIELD	• Global = constellation swath	• Goals likely achievable	• Goals likely achievable

CONVERGENCE EFFORT MODIFICATION

PRELIMINARY ANALYSIS OF SES EDR REQUIREMENTS FROM NPOESS A-SPEC (2)

npoess

EDR #	NAME	COVERAGE	RESOLUTION	MEASUREMENT RANGE
20.9.15 20.9.15.1 20.9.15.2 20.9.15.3 20.9.16.1	IN-SITU MEASUREMENTS	• Global = constellation orbit	• Goals achievable	• ΔN/N goal requires addition to RPAD
20.9.16	IONOSPHERIC SCINTILLATION	• Global = where measurements can be made of C L	• Sensing depth requires bi-static measurements	• (C L,q) cannot be obtained with uni-static instrument
20.9.22	NEUTRAL DENSITY	• Global = constellation swath	• Goals imply limb scanner	• Goals outside current proven state-of-art except for low altitude in-situ measurements • Measurements at orbit altitude not meaningful
20.9.26 20.9.26.1 20.9.26.2 20.9.26.3 20.9.35	ENERGETIC PARTICLES	• Global = constellation orbit	• Goals achievable	• Most goals achievable • Cosmic ray mass/flux goals imply higher complexity
20.9.33	SOLAR EUV	• Sun disk	• N/A	• Heritage instrument, not proven

CONVERGENCE EFFORT MODIFICATION

NON-PRIORITIZED DEPICTION OF PRELIMINARY SES INSTRUMENTS AND EDRs (1)

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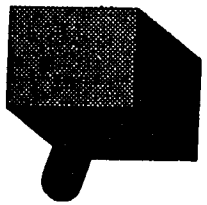
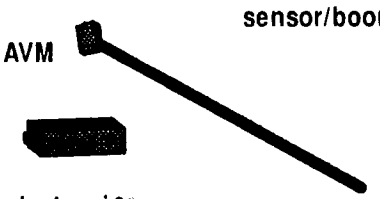
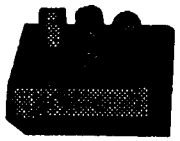
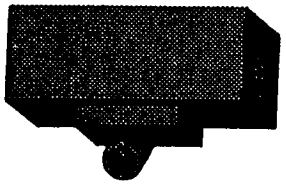
ENVIRONMENT DATA RECORD	SENSOR	COMPONENTS/ HERITAGE	ATTRIBUTES / A-SPEC IMPACTS
AURORAL & AIRGLOW IMAGERY	ABIS 	FUV NADIR IMAGER / DMSP BLOCK 5, HILAT, POLAR BEAR	• FUV REMOTE SENSING OF AURORAL AURORAL EMISSIONS • IR&X-RAY IMPLY HIGHER COMPLEXITY • DESIGN SIMILAR TO NADIS FOR COST REDUCTION
GEOMAGNETIC FIELDS	AVM  sensor/boom electronics	BOOM-MOUNTED VECTOR MAGNETOMETER/ DMSP BLOCK5, MAGSAT	• PROVIDES INFORMATION ABOUT AURORAL CURRENT SYSTEMS TO SUPPORTS ELECTRODYNAMIC MODELING AND AURORAL BOUNDARY IDENTIFICATION • REQUIRES CAREFUL BOOM DESIGN
ENERGETIC PARTICLES, SOLAR PROTONS, GALACTIC COSMIC RAYS	HEPS 	UARS/PEM/NASA	• STATE-OF-ART DESIGN PROVIDES HIGH-ENERGY PARTICLE FLUXES AND SPECTRA • FLUX INTEGRATION TO YIELD TOTAL DOSE
NEUTRAL DENSITY	NADIS 	FUV LIMB-IMAGER DMSP BLOCK 5, ABIS	• FUV REMOTE SENSING OF DAYTIME NEUTRAL ATMOSPHERE EMISSIONS. • DESIGN SIMILAR TO ABIS, BUT SCANS LIMB INSTEAD OF NADIR, FOR COST REDUCTION

CONVERGENCE EFFORT MODIFICATION

NON-PRIORITIZED DEPICTION OF PRELIMINARY SES INSTRUMENTS AND EDRs (2)

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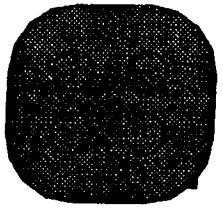
ENVIRONMENT DATA RECORD	SENSOR	COMPONENTS/ HERITAGE	ATTRIBUTES / A-SPEC IMPACTS
IONOSPHERIC ELECTRON DENSITY	GPSR receiver 6 Antennas oscillator	GPS RECEIVER AND ANTENNA / TOPEX	• 3D GLOBAL IONOSPHERIC SPECIFICATION BY TOMOGRAPHY • PERFORMS SIMULTANEOUS GEOLOCATION
IONOSPHERIC ELECTRIC FIELDS & IN-SITU MEASUREMENTS	RPA-D ground plane  Langmuir Probe electronics	RETARDING POTENTIAL ANALYZER AND DRIFTMETER/ DMSP BLOCK 5 AND DYNAMICS EXPLORER	• STATE-OF-ART DESIGN • ADD PLASMA/RF PROBE FOR ION FLUCTUATIONS
ENERGETIC CHARGED PARTICLES	MEPS	HEMISPHERIC ELECTROSTATIC ANALYZER / DMSP BLOCK 5 & CRRES	• STATE-OF-ART DESIGN • SIMULTANEOUS ENERGY & PITCH ANGLE DISCRIMINATION • FLUX INTEGRATION TO YIELD TOTAL ENERGY DEPOSITION

CONVERGENCE EFFORT MODIFICATION

NON-PRIORITIZED DEPICTION OF PRELIMINARY SES INSTRUMENTS AND EDRs (3)

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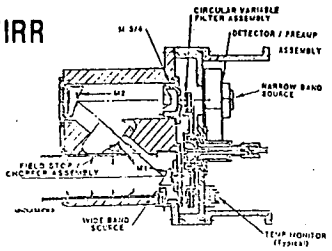
ENVIRONMENT DATA RECORD	SENSOR	COMPONENTS/ HERITAGE	ATTRIBUTES / A-SPEC IMPACTS
OPTICAL BACKGROUND	CVF/IRR 	CIRCULAR VARIABLE FILTER, INFRARED RADIOMETER, MULTIPLE DoD MISSIONS	• COOLING / COOLANT REQUIRED
IONOSPHERIC SCINTILLATIONS	BI-STATIC RADIO BEACON • RECEIVER AT MULTIPLE SURFACE SITES • TRANSMITTER AT NPOES	WIDE-BAND / DNA	• GLOBAL SCINTILLATION PARAMETERS CAN ONLY BE MEASURED BY THIS TECHNIQUE
SOLAR EUV	SOLAR EUV EXPERIMENT (SEE) / NCAR no picture available	TIMED / NASA (NOT YET FLOWN)	• TBD

SES INSTRUMENT ISSUES

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EDR#	NAME	INSTRUMENT	COMPLEX	HERITAGE	non-NPOESS RESOURCES	MULTI USE
20.9.3 20.9.3.1 20.9.3.2 20.9.3.4	Auroral Imagery	ABIS	High	Yes	None	Yes
20.9.3.3 (new)	Optical Background	Cooled IR Radiometer	Medium	Yes	None	No
20.9.9	Electric Field	RPAD (upgrade)	Medium	Yes	None	Yes
20.9.10	Electron Density	GPSR + RPAD + ABIS + NADIS	GPSR = Low	Yes	None	Yes
20.9.13	Geomagnetic Field	VECMAG	Low	Yes	None	No
20.9.15 20.9.15.1 20.9.15.2 20.9.15.3 20.9.16.1	In-Situ Measurements	RPAD (upgrade)	Low	Yes	None	Yes
20.9.16	Scintillation	Multifrequency Radio Beacon	Medium	Yes	Ground Recvrs Reqd	No
20.9.22	Neutral Density	NADIS	High	Yes*	None	Yes
20.9.26 20.9.26.1 20.9.26.2 20.9.26.3 20.9.35	Energetic Particles	HEPS	High	Yes	None	No
20.9.33 (new)	Solar EUV	Whole Disk Imager	Medium	Yes	None	No

* not proven

SHADED BOXES HIGHLIGHT CRITICAL ISSUES

SES CONCLUSIONS

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- *IONOSPHERIC DENSITY & ATMOSPHERIC DENSITY ALGORITHMS, BASED ON 3-D TOMOGRAPHY AND 2-D IMAGING RESPECTIVELY, CONTINUE TO BE IMPROVED:*
  - USER-FRIENDLY SPHERICAL DISPLAY GENERATION ACCOMPLISHED
  - VERIFICATION EXERCISES TO BE COMPLETED NEXT QUARTER.
- *SES INSTRUMENTS SATISFYING NPOESS A-SPEC EDR REQUIREMENTS HAVE BEEN IDENTIFIED*
  - CONCEPT DESIGN EXPLORATION TO BE CONDUCTED OVER NEXT FEW MONTHS

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INTERFACE DATA PROCESSOR SEGMENT UPDATE

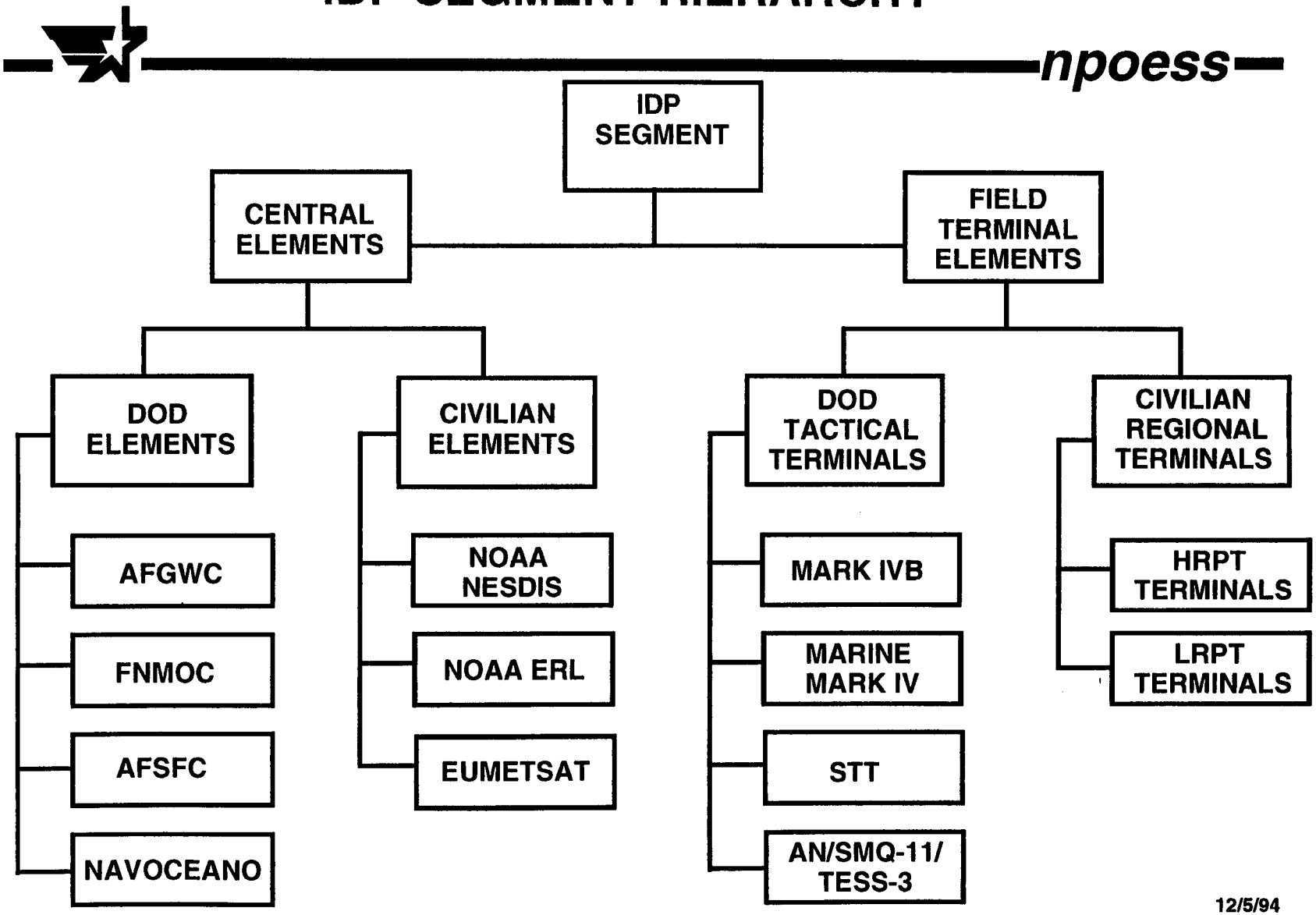
PHILLIP TOPPING

OUTLINE OF INTERFACE DATA PROCESSOR SEGMENT UPDATE

- INTERFACE DATA PROCESSOR SEGMENT OVERVIEW
- OBJECTIVES AND PROGRESS TO DATE
  - UPDATED DESIGN REFERENCE BASELINE PROCESSOR (CPU) AND DISK STORAGE ESTIMATES
  - DEVELOPED IDPS IMPACT ASSESSMENTS FOR ALTERNATIVES B AND C
- IDPS - C^3 INTERFACE OPTIONS AND COSTS UPDATE
- ISSUES AND TASKS

CONVERGENCE EFFORT MODIFICATION

IDP SEGMENT HIERARCHY



OBJECTIVES AND PROGRESS SUMMARY

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- OBJECTIVES (SOW 3.4)
  - DEFINE THE IDP SEGMENT IAW SYSTEM AND SEGMENT SPECS PERFORM TRADE STUDIES AND ANALYSES •••, LCC ANALYSIS••• INCLUDE FEP (DATA PROC. STRATEGIES •••), DBMS (SUPPORT ACCESSIBILITY AND EXPANSION•••)
- PROGRESS TO DATE
  - ARCHITECTURE AND COST BASELINE DEFINED (CARD OCT 92)
  - TECHNOLOGY INSERTION ALTERNATIVES IDENTIFIED (PSR #2) DEC'S ALPHA FAMILY, OTHER RISC CONVEX, HP, IBM
  - INTEGRATED HARDWARE AND SOFTWARE DESIGN (CARD)
  - DEVELOPED DRAFT USER SEGMENT SYSTEM SEGMENT SPEC
  - COMPLETED USER SEGMENT IMPACT FOR NAVY SUITE 3
  - EVALUATED IMPACTS OF CONVERGED SYSTEM ON IDPS SIZING

CONVERGENCE EFFORT MODIFICATION

INTERFACE DATA PROCESSOR SEGMENT CENTRAL ELEMENT REQUIREMENTS

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SITE	SATELLITES	REQUIRED PROCESSING
AFGWC	O1,O2,O3	SDRS, EDRS, &SDC
FNMOC	O1,O2,O3	SDRS, EDRS, &SDC
NAVOCEANO	O1,O2,O3	SDRS, EDRS, &SDC
AFSFC	O1,O2,O3	SDRS, EDRS, &SDC
NOAA NESDIS	O1,O2,O3	SDRS & EDRS
NOAA ERL	O1,O2,O3	SDRS
EUMETSAT*	O1,O2,O3	SDRS & EDRS

* SEPARATE PROCUREMENT

CONVERGENCE EFFORT MODIFICATION

INTERFACE DATA PROCESSOR SEGMENT FIELD TERMINAL ELEMENT REQUIREMENTS

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SITE	SATELLITES	REQUIRED PROCESSING
DOD TERMINALS		
MARK IVB	O1,O2,O3	SDRS, EDRS, &SDC
MARINE MARK IV	O1,O2,O3	SDRS, EDRS, &SDC
AN/SMQ-11/TESS-3	O1,O2,O3	SDRS, EDRS, &SDC
STT	O1,O2,O3	SDRS, EDRS, &SDC
CIVILIAN TERMINALS *		
HRPT	O1,O2,O3	SDRS &EDRS
LRPT	O1,O2,O3	SDRS &EDRS

* SEPARATE PROCUREMENT

CENTRAL ELEMENT PROCESSING DRIVERS

- INCREASED DATA QUANTITY (6 GBITS/ORBIT FOR BASELINE BLOCK 6 SATELLITE VS 42 GBITS/ORBIT FOR NPOESS SATELLITE) AT CENTRAL SITES DUE TO:
  - INCREASED PRECISION (8-10 BIT DATA MODIFIED TO 12 BIT DATA)
  - ADDITIONAL OASIS CHANNEL(S)
  - NUMBER OF EDRS INCREASED FROM 38 TO 72
  - FIVE TO TEN ADDITIONAL/NEW SENSORS
- INCREASED DATA PROCESSING AT CENTRALS DUE TO:
  - INCREASE IN NUMBER OF EDRS (38 TO 72)
  - STRINGENT PROCESSING TIME REQUIREMENT OF "NOT TO EXCEED <u>20 MINUTES</u>"

IDP SEGMENT CENTRAL SITE ARCHITECTURE

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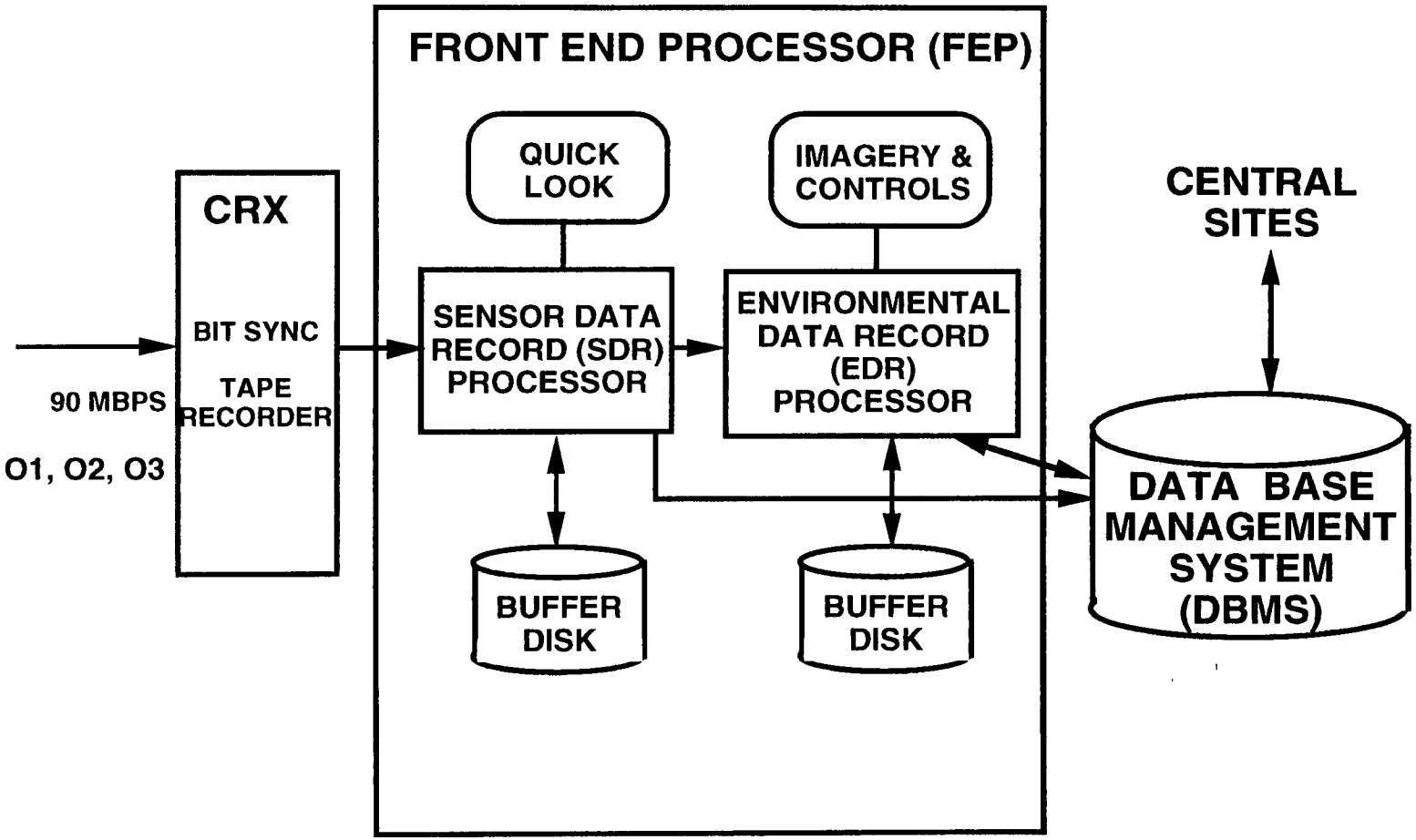

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INTERFACE DATA PROCESSOR SEGMENT IMPACT ASSESSMENT

GREG LOGAN

APPROACH TO ESTIMATING IMPACTS

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- ESTIMATED CPU UTILIZATION AND DISK STORAGE FOR BASELINE AND ALTERNATIVES B AND C
  - USED JUNE SPEC THRESHOLDS FOR DESIGN REFERENCE BASELINE
  - USED OCTOBER SPEC
    - » MINIMUM OR NOMINAL TBD's FROM EDR IMPACTS ANALYSIS (ALTERNATIVE B)
    - » GOALS FOR ALTERNATIVE C (ALL GOALS)
- FOR CPU UTILIZATION
  - TIMED 9 ALGORITHMS FROM AUGUST 1994 DEMONSTRATION ON LARGE SCALE DATA BLOCKS
  - EXTRAPOLATED TO COVER ALL ALGORITHMS
- EDR STORAGE DRIVEN PRIMARILY BY RESOLUTION (HORIZONTAL, VERTICAL)

APPROACH CONTINUED

- CPU ESTIMATES ARE CONSERVATIVE
  - TIMING INCLUDED ALGORITHM MEETING GOALS (E.G. CLOUD / NO CLOUD AT 91%) GIVING BUILT IN MARGIN FOR BASELINE AND ALTERNATIVE B
  - DIFFERENT TEST CASES WERE RUN AND CPU REPORTS FROM SEVERAL INDEPENDENT UNIX UTILITIES WERE COMPARED
  - TIMED CODE REPRESENTS OPERATIONAL ENVIRONMENT BUT CODE WAS NOT OPTIMIZED
  - SUBSEQUENT SIMPLE OPTIMIZATION VIA COMPILER FLAGS SHOWED 50% REDUCTION (> 100 % MARGIN IS IN THE CPU NUMBERS)
- STORAGE ESTIMATES ARE CONSERVATIVE
  - RAW PIXEL COUNTS
  - FULL RESOLUTION EDRS WERE STORED

IDP SEGMENT CENTRAL SITE IMPACTS

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- **ASSUMPTIONS:**
  - PROCESS ALL SDRS/EDRS WITHIN 20 MINUTES OF RECEIPT FROM C3 SEGMENT
- **HARDWARE IMPACTS OF ALTERNATIVE B FROM JUNE 1994 BASELINE**
  - INCREASE PROCESSING POWER APPROXIMATELY 35 %
  - NO CHANGE IN RAM
  - INCREASE MASS STORAGE APPROXIMATELY 2:1
- **SOFTWARE IMPACTS**
  - NEW MODULES TO PROCESS ADDITIONAL SDRS & EDRS

CONVERGENCE EFFORT MODIFICATION

CENTRAL ELEMENT EDR IMPACTS ON DATA VOLUME/PROCESSING

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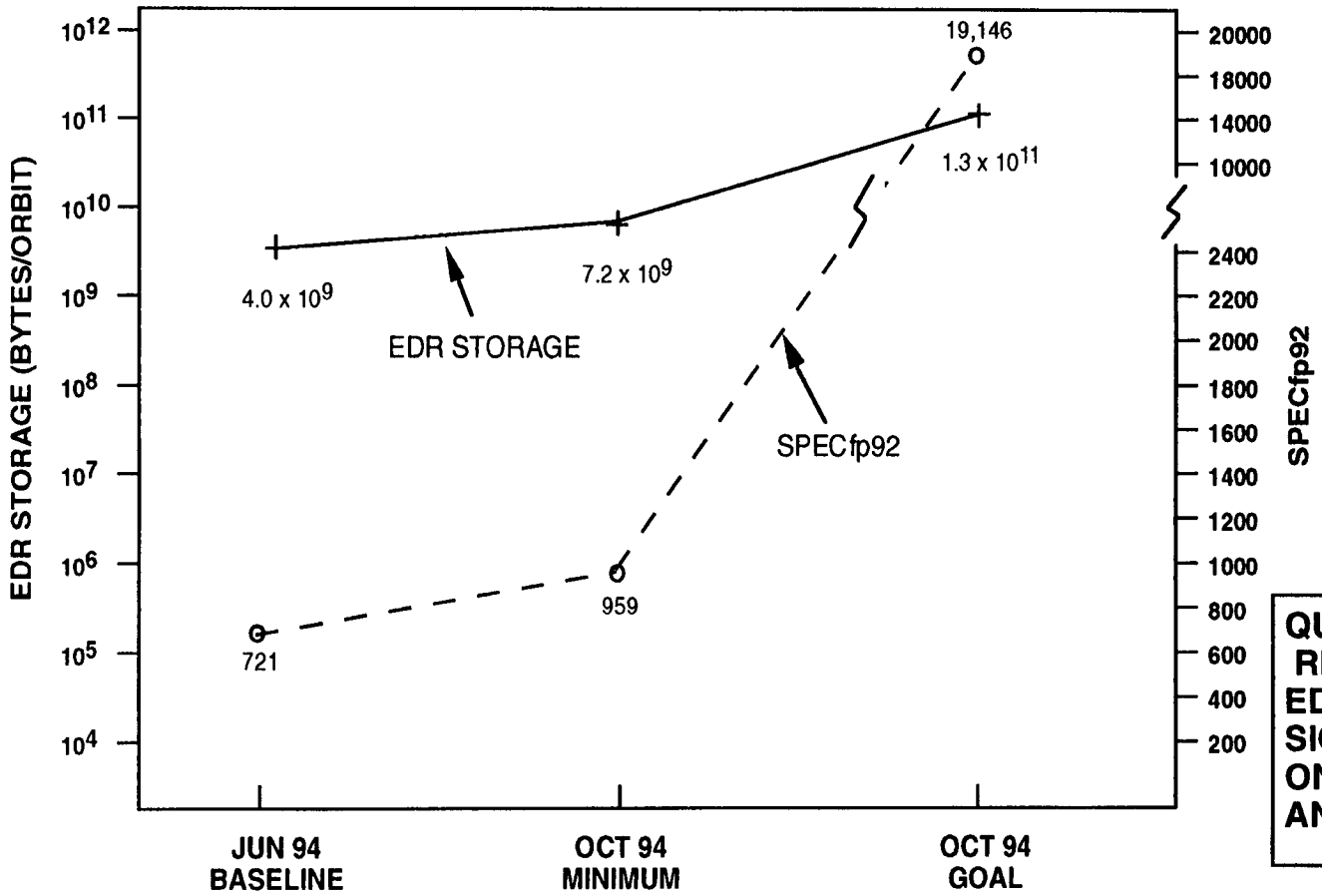


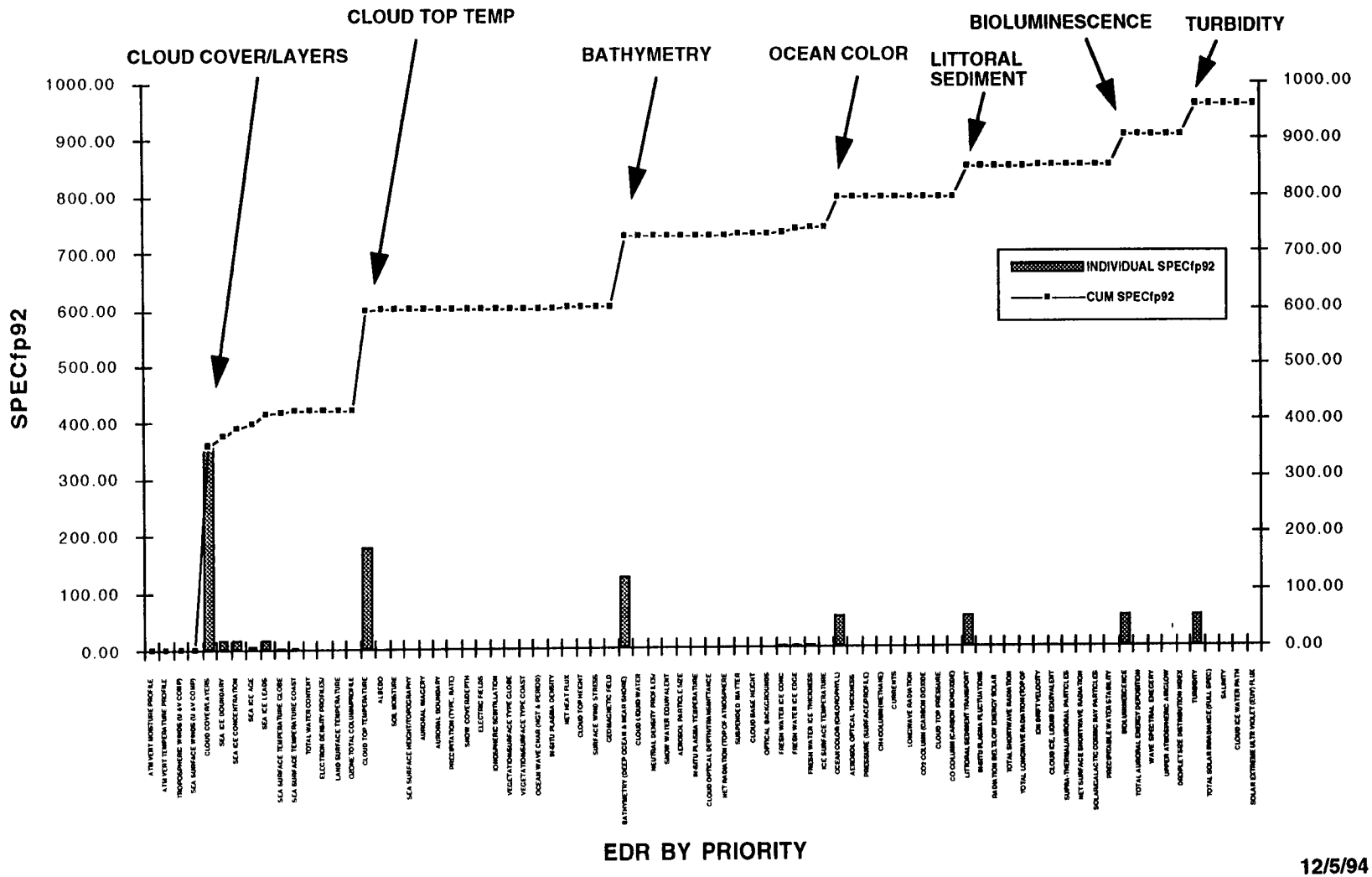
QUANTITY AND RESOLUTION OF EDRS HAVE A SIGNIFICANT IMPACT ON STORAGE AND PROCESSING

Note: 1 200MHz DEC Alpha CPU = 180 SPECfp92

CONVERGENCE EFFORT MODIFICATION

CENTRAL ELEMENT EDR PROCESSING (MIN REQUIREMENTS)

npoess



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CONVERGENCE EFFORT MODIFICATION

CENTRAL ELEMENT EDR PROCESSING BY PRIORITY

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20.1	ATM VERT MOISTURE PROFILE
20.2	ATM VERT TEMPERATURE PROFILE
20.8.2	TROPOSPHERIC WINDS (U &V COMP)
20.8.1	SEA SURFACE WINDS (U &V COMP)
20.3.2	CLOUD COVER/LAYERS
20.4.3	SEA ICE BOUNDARY
20.4.3	SEA ICE CONCENTRATION
20.4.3	SEA ICE AGE
20.4.3	SEA ICE LEADS
20.6	SEA SURFACE TEMPERATURE GLOBE
20.6	SEA SURFACE TEMPERATURE COAST
20.9.39	TOTAL WATER CONTENT
20.9.10	ELECTRON DENSITY PROFILES
20.9.17	LAND SURFACE TEMPERATURE
20.5	OZONE TOTAL COLUMN/PROFILE
20.3.9	CLOUD TOP TEMPERATURE
20.9.2	ALBEDO
20.7	SOIL MOISTURE
20.9.31	SEA SURFACE HEIGHT/TOPOGRAPHY
20.9.3.2	AURORAL IMAGERY
20.9.3.1	AURORAL BOUNDARY
20.9.25	PRECIPITATION (TYPE, RATE)
20.4.10	SNOW COVER/DEPTH
20.9.9	ELECTRIC FIELDS
20.9.16	IONOSPHERIC SCINTILLATION
20.9.42	VEGETATION/SURFACE TYPE GLOBE
20.9.42	VEGETATION/SURFACE TYPE COAST
20.9.24	OCEAN WAVE CHAR (HGT & PERIOD)
20.9.15.1	IN-SITU PLASMA DENSITY
20.9.21	NET HEAT FLUX
20.3.10	CLOUD TOP HEIGHT
20.9.34	SURFACE WIND STRESS
20.9.13	GEOMAGNETIC FIELD
20.9.4	BATHYMETRY (DEEP OCEAN/NEAR SHORE)
20.3.5	CLOUD LIQUID WATER
20.9.22	NEUTRAL DENSITY PROFILES/
20.4.9	SNOW WATER EQUIVALENT
20.9.1.2	AEROSOL PARTICLE SIZE
20.9.15.2	IN-SITU PLASMA TEMPERATURE
20.3.6.2	CLOUD OPTICAL DEPTH/TRANSMITTANCE
20.9.14	NET RADIATION (TOP OF ATMOSPHERE
20.9.1.4	SUSPENDED MATTER
20.3.3	CLOUD BASE HEIGHT
20.9.3.3	OPTICAL BACKGROUNDS
20.4.1	FRESH WATER ICE CONC
20.4.1	FRESH WATER ICE EDGE
20.4.1	FRESH WATER ICE THICKNESS
20.4.4	ICE SURFACE TEMPERATURE
20.9.23	OCEAN COLOR (CHLOROPHYLL)
20.9.1.3	AEROSOL OPTICAL THICKNESS
20.9.28	PRESSURE (SURFACE/PROFILE)
20.9.5	CH4 COLUMN (METHANE)
20.9.20	CURRENTS
20.9.19	LONGWAVE RADIATION
20.9.7	CO2 COLUMN (CARBON DIOXIDE
20.3.7	CLOUD TOP PRESSURE
20.9.6	CO COLUMN (CARBON MONOXIDE)
20.9.18	LITTORAL SEDIMENT TRANSPORT
20.9.16.1	IN-SITU PLASMA FLUCTUATIONS
20.9.26.2	RADIATION BELT/LOW ENERGY SOLAR
20.9.37	TOTAL SHORTWAVE RADIATION
20.9.36	TOTAL LONGWAVE RADIATION (TOP OF
20.9.15.3	ION DRIFT VELOCITY
20.3.4	CLOUD ICE, LIQUID EQUIVALENT
20.9.26.1	SUPRA-THERMAL/AURORAL PARTICLES
20.9.32	NET SURFACE SHORTWAVE RADIATION
20.9.26.3	SOLAR/GALACTIC COSMIC RAY PARTICLES
20.9.27	PRECIPITABLE WATER STABILITY
20.9.8	BIOLUMINESCENCE
20.9.35	TOTAL AURORAL ENERGY DEPOSITION
20.9.43	WAVE SPECTRAL ENERGY
20.9.3.4	UPPER ATMOSPHERIC AIRGLOW
20.3.6.1	DROPLET SIZE DISTRIBUTION INDEX
20.9.41	TURBIDITY
20.9.38	TOTAL SOLAR IRRADIANCE (FULL SPEC)
20.9.30	SALINITY
20.3.5.1	CLOUD ICE WATER PATH
20.9.33	SOLAR EXTREME ULTR VIOLET (EUV) FLUX

CONVERGENCE EFFORT MODIFICATION

CENTRAL ELEMENT EDR STORAGE (MIN REQUIREMENT)

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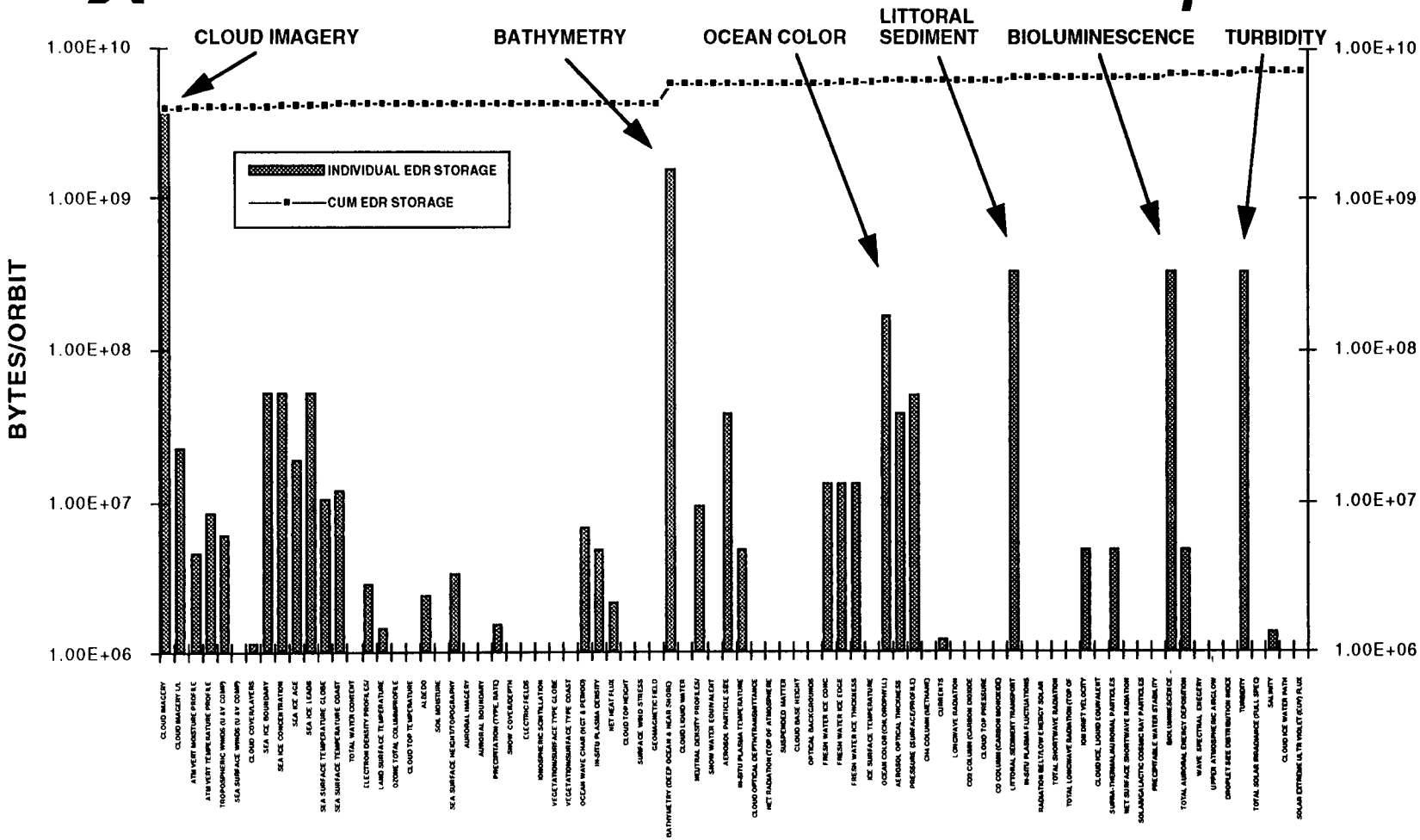

EDR BY PRIORITY

NOTE: DOES NOT INCLUDE SDR STORAGE

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CENTRAL SITE EDR STORAGE BY PRIORITY

20.3.1	CLOUD IMAGERY
20.3.1	CLOUD IMAGERY LL
20.1	ATM VERT MOISTURE PROFILE
20.2	ATM VERT TEMPERATURE PROFILE
20.8.2	TROPOSPHERIC WINDS (U &V COMP)
20.8.1	SEA SURFACE WINDS (U &V COMP)
20.3.2	CLOUD COVER/LAYERS
20.4.3	SEA ICE BOUNDARY
20.4.3	SEA ICE CONCENTRATION
20.4.3	SEA ICE AGE
20.4.3	SEA ICE LEADS
20.6	SEA SURFACE TEMPERATURE GLOBE
20.6	SEA SURFACE TEMPERATURE COAST
20.9.39	TOTAL WATER CONTENT
20.9.10	ELECTRON DENSITY PROFILES
20.9.17	LAND SURFACE TEMPERATURE
20.5	OZONE TOTAL COLUMN/PROFILE
20.3.9	CLOUD TOP TEMPERATURE
20.9.2	ALBEDO
20.7	SOIL MOISTURE
20.9.31	SEA SURFACE HEIGHT/TOPOGRAPHY
20.9.3.2	AURORAL IMAGERY
20.9.3.1	AURORAL BOUNDARY
20.9.25	PRECIPITATION (TYPE, RATE)
20.4.10	SNOW COVER/DEPTH
20.9.9	ELECTRIC FIELDS
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20.9.24	OCEAN WAVE CHAR (HGT & PERIOD)
20.9.15.1	IN-SITU PLASMA DENSITY
20.9.21	NET HEAT FLUX
20.3.10	CLOUD TOP HEIGHT
20.9.34	SURFACE WIND STRESS
20.9.13	GEOMAGNETIC FIELD
20.9.4	BATHYMETRY (DEEP OCEAN/NEAR SHORE)
20.3.5	CLOUD LIQUID WATER
20.9.22	NEUTRAL DENSITY PROFILES/
20.4.9	SNOW WATER EQUIVALENT
20.9.1.2	AEROSOL PARTICLE SIZE
20.9.15.2	IN-SITU PLASMA TEMPERATURE
20.3.6.2	CLOUD OPTICAL DEPTH/TRANSMITTANCE
20.9.14	NET RADIATION (TOP OF ATMOSPHERE
20.9.1.4	SUSPENDED MATTER
20.3.3	CLOUD BASE HEIGHT
20.9.3.3	OPTICAL BACKGROUNDS
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20.9.33	SOLAR EXTREME ULTR VIOLET (EUV) FLUX

FIELD TERMINAL ELEMENT PROCESSING DRIVERS

- INCREASED DATA QUANTITY DUE TO:
  - INCREASED PRECISION (8-10 BIT DATA MODIFIED TO 12 BIT DATA)
  - ADDITIONAL OASIS CHANNEL(S)
  - INCREASED NUMBER OF EDRS
- INCREASED DATA PROCESSING DUE TO:
  - INCREASED NUMBER OF EDRS
  - DECREASE IN PROCESSING TIME (DERIVED REQUIREMENT OF 5 MINUTES FROM END OF PASS CHANGED TO 2 MINUTES)

FIELD TERMINAL ELEMENT EDRS

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JUNE 1994 BASELINE EDRS

CLOUD IMAGERY
CLOUD IMAGERY L/L
SEA SFC TEMP
CLOUD COVER
CLOUD TYPE
CLOUD LAYERS
SUSPENDED MATTER
ALBEDO
VISIBILITY
LAND SFC TEMP
TEMP 16 LVLS
HGT 16 LVLS
TEMP TROPOPAUSE
PRES TROPOPAUSE
MOIST 7 LAYERS
R.H. 6 LVLS
PRECIPITATION
OCEAN SFC WIND SPD
LIQUID WATER CONT
CLOUD WATER CONT
SNOW/LAND ICE COVER
ICE COVER
ICE AGE
ICE EDGE
SFC TYPE
VEG INDEX
SFC MOIST ANTECEDENT

OCT 1994 EDRS

CLOUD IMAGERY
CLOUD IMAGERY LL
ATM VERT MOISTURE PROFILE
ATM VERT TEMPERATURE PROFILE
TROPOSPHERIC WINDS (U &V COMP)
SEA SURFACE WINDS (U &V COMP)
CLOUD COVER/LAYERS
SEA ICE BOUNDARY
SEA ICE CONCENTRATION
SEA ICE AGE
SEA ICE LEADS
SEA SURFACE TEMPERATURE GLOBE
SEA SURFACE TEMPERATURE COAST
TOTAL WATER CONTENT
LAND SURFACE TEMPERATURE
CLOUD TOP TEMPERATURE
ALBEDO
SOIL MOISTURE
SEA SURFACE HEIGHT/TOPOGRAPHY
PRECIPITATION (TYPE, RATE)
SNOW COVER/DEPTH
VEGETATION/SURFACE TYPE GLOBE
VEGETATION/SURFACE TYPE COAST
CLOUD LIQUID WATER
OCEAN WAVE CHAR (HGT & PERIOD)
CLOUD TOP HEIGHT
SURFACE WIND STRESS
BATHYMETRY (DEEP OCEAN & NEAR SHORE)
SNOW WATER EQUIVALENT
AEROSOL PARTICLE SIZE
CLOUD OPTICAL DEPTH/TRANSMITTANCE
SUSPENDED MATTER
CLOUD BASE HEIGHT
OPTICAL BACKGROUNDS
FRESH WATER ICE CONC
FRESH WATER ICE EDGE
FRESH WATER ICE THICKNESS
ICE SURFACE TEMPERATURE
AEROSOL OPTICAL THICKNESS
PRESSURE (SURFACE/PROFILE)
CURRENTS
CLOUD TOP PRESSURE
CLOUD ICE, LIQUID EQUIVALENT
WAVE SPECTRAL ENERGY
TURBIDITY
SALINITY
CLOUD ICE WATER PATH

DOD FIELD TERMINAL ELEMENT IMPACTS

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- **ASSUMPTIONS:**
  - PROCESS OASIS & MISS OR OASIS, AMSU, & MHS SDRS AND EDRS
  - AIRS, SOLAR ENVIRONMENTAL SENSOR, AND CLIMATIC SENSOR DATA NOT PROCESSED
  - ONLY HIGH RESOLUTION (0.65KM) DATA RECEIVED
  - NO MODIFICATION TO ANTENNA
- **HARDWARE IMPACTS FROM JUNE 1994 BASELINE**
  - INCREASE PROCESSING POWER APPROXIMATELY 65 %
  - NO CHANGE IN RAM
  - INCREASE MASS STORAGE APPROXIMATELY 35%
- **SOFTWARE IMPACTS**
  - NEW MODULES TO PROCESS ADDITIONAL SDRS & EDRS

CONVERGENCE EFFORT MODIFICATION

EDR IMPACTS ON DATA VOLUME/PROCESSING FOR FIELD TERMINAL ELEMENT

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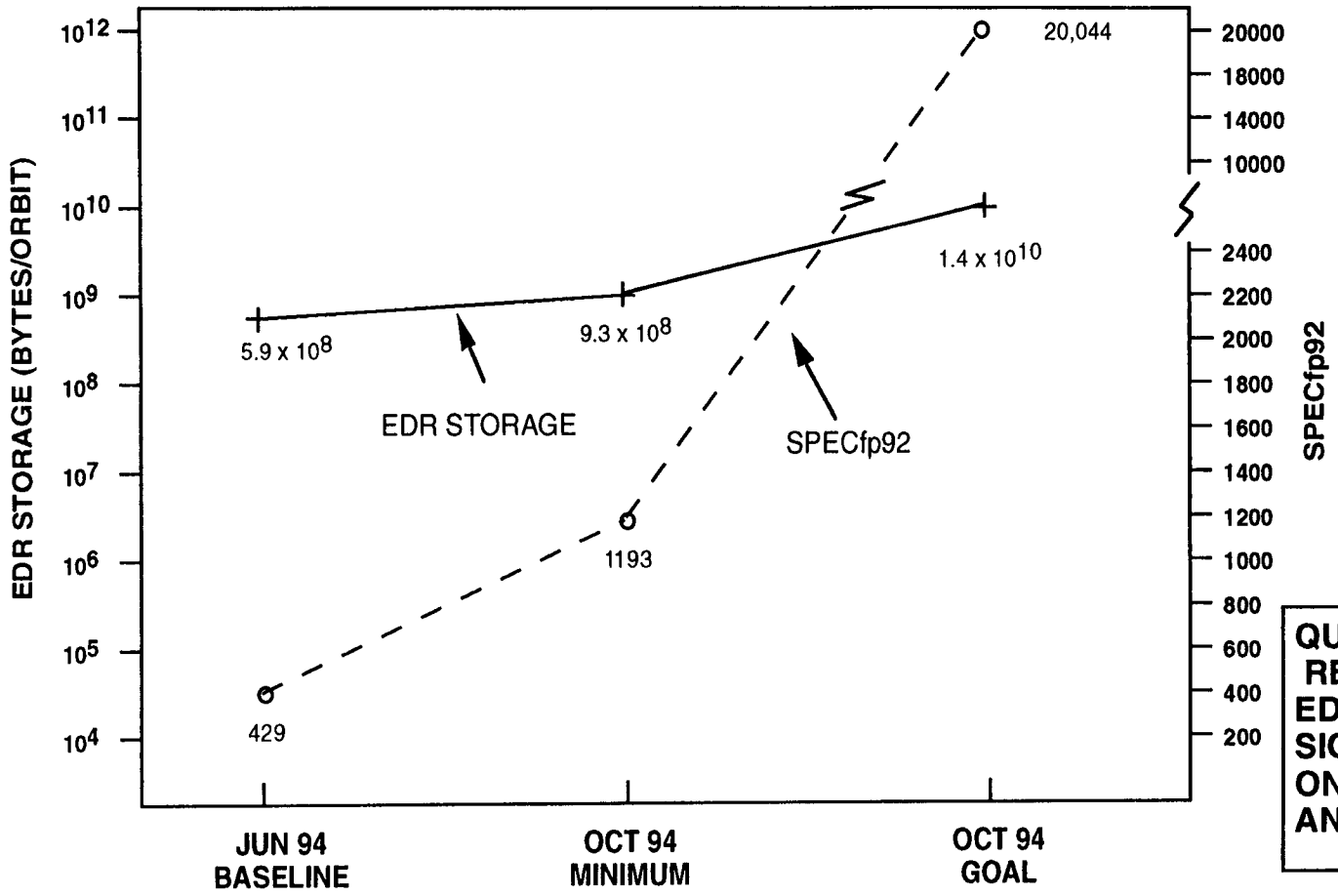

QUANTITY AND RESOLUTION OF EDRS HAVE A SIGNIFICANT IMPACT ON STORAGE AND PROCESSING

Note: 1 200MHz DEC Alpha CPU = 180 SPECfp92

CONVERGENCE EFFORT MODIFICATION

FIELD TERMINAL ELEMENT EDR PROCESSING (MIN REQUIREMENTS)

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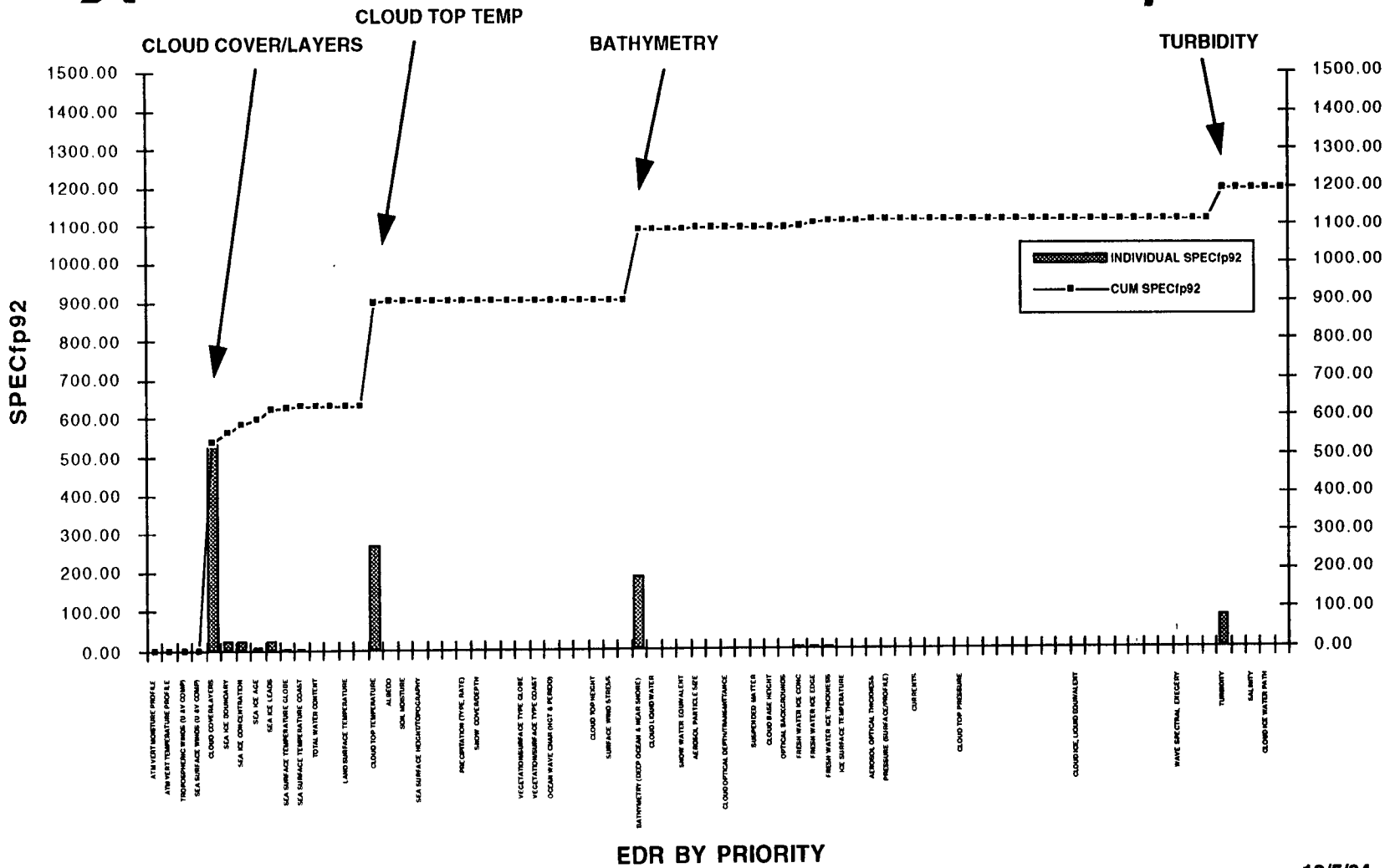

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CONVERGENCE EFFORT MODIFICATION

FIELD TERMINAL ELEMENT EDR PROCESSING (MIN REQUIREMENTS)

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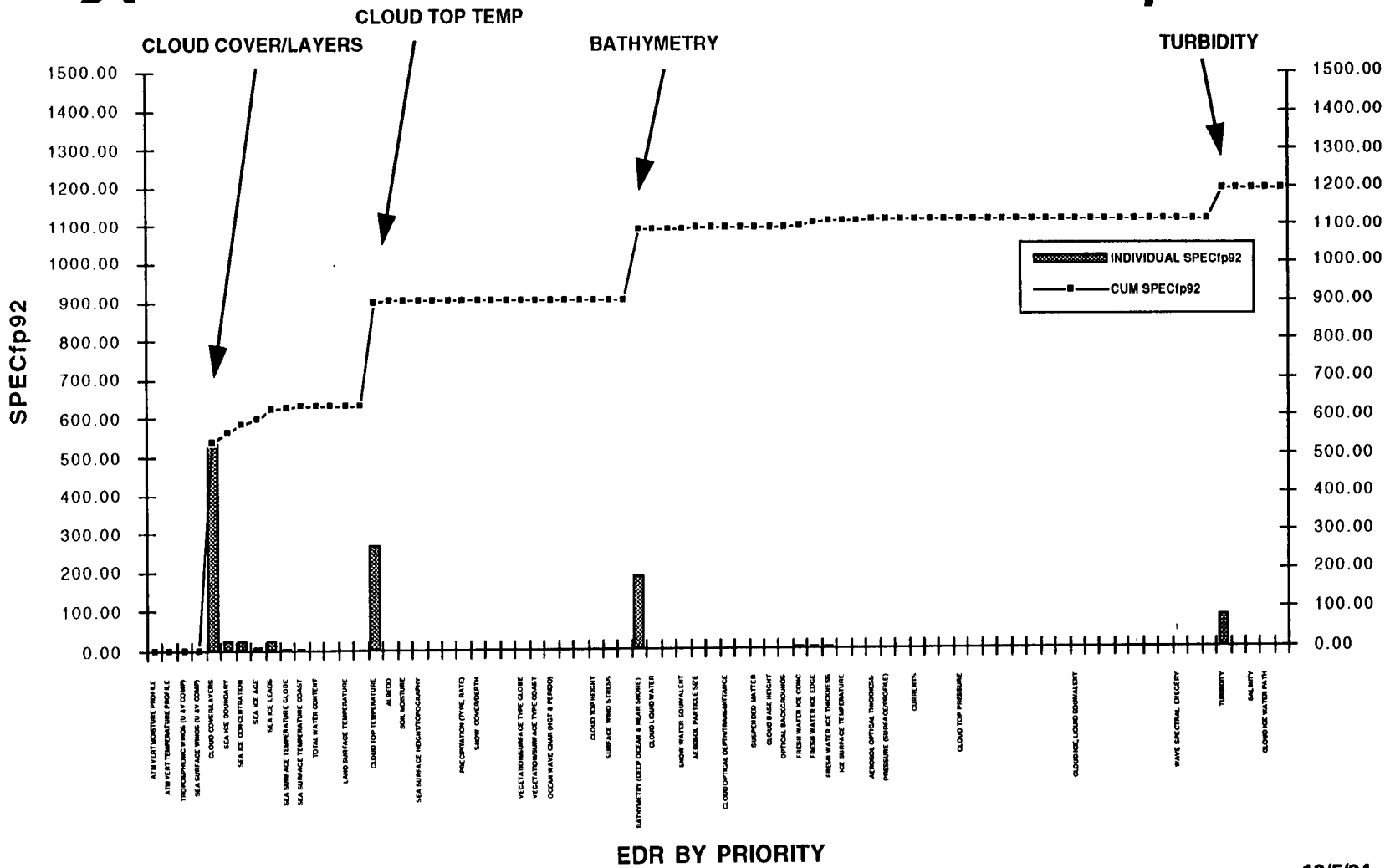

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FIELD TERMINAL EDR PROCESSING BY PRIORITY

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20.9.39	TOTAL WATER CONTENT
20.9.17	LAND SURFACE TEMPERATURE
20.3.9	CLOUD TOP TEMPERATURE
20.9.2	ALBEDO
20.7	SOIL MOISTURE
20.9.31	SEA SURFACE HEIGHT/TOPOGRAPHY
20.9.25	PRECIPITATION (TYPE, RATE)
20.4.10	SNOW COVER/DEPTH
20.9.42	VEGETATION/SURFACE TYPE GLOBE
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20.9.24	OCEAN WAVE CHAR (HGT & PERIOD)
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20.3.5	CLOUD LIQUID WATER
20.4.9	SNOW WATER EQUIVALENT
20.9.1.2	AEROSOL PARTICLE SIZE

20.3.6.2	CLOUD OPTICAL DEPTH/TRANSMITTANCE
20.9.1.4	SUSPENDED MATTER
20.3.3	CLOUD BASE HEIGHT
20.9.3.3	OPTICAL BACKGROUNDS
20.4.1	FRESH WATER ICE CONC
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20.4.1	FRESH WATER ICE THICKNESS
20.4.4	ICE SURFACE TEMPERATURE
20.9.1.3	AEROSOL OPTICAL THICKNESS
20.9.28	PRESSURE (SURFACE/PROFILE)
20.9.20	CURRENTS
20.3.7	CLOUD TOP PRESSURE
20.3.4	CLOUD ICE, LIQUID EQUIVALENT
20.9.43	WAVE SPECTRAL ENERGY
20.9.41	TURBIDITY
20.9.30	SALINITY
20.3.5.1	CLOUD ICE WATER PATH

CONVERGENCE EFFORT MODIFICATION

FIELD TERMINAL EDR PROCESSING BY PRIORITY

npoess

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CONVERGENCE EFFORT MODIFICATION

FIELD TERMINAL EDR STORAGE (MIN REQUIREMENT)

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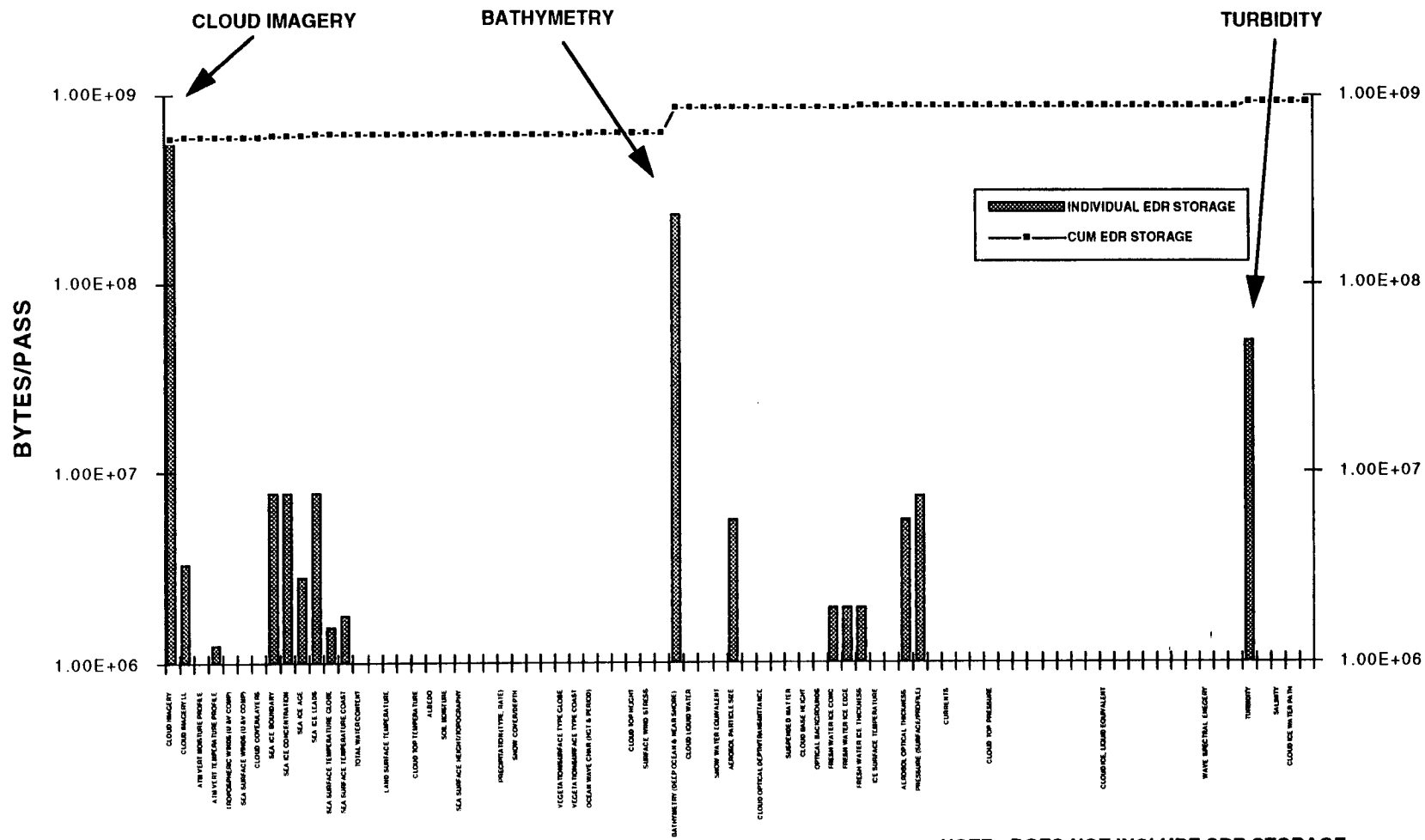

NOTE: DOES NOT INCLUDE SDR STORAGE

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FIELD TERMINAL EDR STORAGE BY PRIORITY

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CONVERGENCE EFFORT MODIFICATION

DOD FIELD TERMINAL ELEMENT IMAGERY EDR STORAGE IMPACT

npoess

	TIROS APT	TIROS HRPT	DMSP RDS	DMSP RTD	NPOESS
BASIC STT	3.5 MB	N/A	5.2 MB	N/A	582 MB
ENHANCED STT	3.5 MB	70 MB	5.2 MB	60 MB	582 MB
MARK IVB	N/A	315 MB	5.2 MB	126 MB	582 MB
TESS(3)	N/A	70 MB	N/A	86 MB	582 MB
MARK IV	N/A	70 MB	N/A	60 MB	582 MB

MASS STORAGE REQUIREMENT PER EACH SATELLITE PASS

MB: MEGABYTES

IDPS TASKS AND ISSUES

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- DEVELOP ALTERNATIVE SETS OF EDRS CENTRAL AND FIELD PROCESSING
  - PROCESSING POWER AND STORAGE IS DEPENDENT ON NUMBER OF EDRS AND COMPRESSION SCHEME
- VARY SDR HORIZONTAL RESOLUTION AS AN INPUT PARAMETER TO EDR ALGORITHMS
  - PROCESSING POWER IS DEPENDENT ON SDR HORIZONTAL RESOLUTION - EXAMPLE: CLOUD ANALYSIS
    - » 16 TIMES MORE POWER IS NEEDED TO PROCESS 0.65 KM CLOUD IMAGERY INTO A CLOUD ANALYSIS VERSUS AN INPUT OF 2.6 KM CLOUD IMAGERY
- DETERMINE IMPACT OF RECEIVING/PROCESSING TWO HOURS OF PREVIOUSLY IMAGED DATA AT REGIONAL TERMINAL ELEMENTS

IDPS TASKS AND ISSUES

npoess

- DEVELOP ALTERNATIVE SETS OF EDRS CENTRAL AND FIELD PROCESSING
  - PROCESSING POWER AND STORAGE IS DEPENDENT ON NUMBER OF EDRS AND COMPRESSION SCHEME
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- DETERMINE IMPACT OF RECEIVING/PROCESSING TWO HOURS OF PREVIOUSLY IMAGED DATA AT REGIONAL TERMINAL ELEMENTS

IDPS COSTS

ASSUMPTIONS

- COSTING INVOLVES OPERATIONS AT SIX SITES (AFGWC, NOAA NESDIS, NAVOCEANO, FNOC, SFC, AND NOAA ERL)
- THREE DIFFERENT PROCESSING OPTIONS
  - PROCESSING AT ALL SITES (EXCEPT NOAA ERL)
  - PROCESSING AT TWO CENTRALS (NOAA NESDIS AND AFGWC) DISTRIBUTED TO OTHERS
  - PROCESSING AT THREE SITES (NOAA NESDIS, AFGWC, AND FNOC) DISTRIBUTED TO OTHERS
- HARDWARE COST PER SITE FOR COMPLETE PROCESSING CAPABILITY ~ $[redacted]K

IDPS COSTS (CONT)

ASSUMPTIONS (CONT)

- HARDWARE COST PER SITE FOR DBMS ONLY ~ $[redacted]K
- MANNING REQUIREMENTS:
  - 2 PER SITE FOR COMPLETE PROCESSING (10 EQUIVALENT MEN PER SITE FOR 7 DAY/WEEK, 24 HR/DAY OPERATIONS)
  - 1 PER SITE FOR DBMS ONLY (5 EQUIVALENT MEN)
- COST PER MAN YEAR ~ $[redacted]K

IDPS COSTS*

OPTION	H/W COST	OPS COST	TOTAL
TWO SITE	$[redacted] M	$[redacted] M	$[redacted] M
THREE SITE	$[redacted] M	$[redacted] M	$[redacted] M
FIVE SITE	$[redacted] M	$[redacted] M	$[redacted] M

* BASED ON 10 YEAR OPERATIONAL LIFETIME

PAGE 399 IS EXEMPT FROM RELEASE AND IS REPLACED WITH THIS PAGE.

S/C REQUIREMENTS IMPACTS (SH 1 OF 3)

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- PAYLOAD MATRIX
  - SATELLITE SENSOR ALLOCATION
  - ESTABLISH WEIGHT, SIZE, POWER, & FOV'S
  - DETERMINES COMMON S/C CONFIGURATION DESIGN PARAMETERS

- MAPPING ACCURACY
  - CROSS SCANNERS (ALL DATA, 3 SIGMA)
    - 2 - 4 KM IS ACHIEVABLE AT EDGE-OF-SCAN (EOS)
    - ≤ 1 KM IS NOT REASONABLE AT (EOS)
    - < 1 KM IS REASONABLE AT NADIR
  - CONICAL SCANNERS (56 DEG, 3 SIGMA)
    - ≤ 10 KM IS ACHIEVABLE
    - < 5 KM IS NOT REASONABLE AT 56 DEG
      (6 KM IS OBTAINABLE AT 45 DEG; e.g., SSMI)

PAYLOAD MATRIX (TBD)

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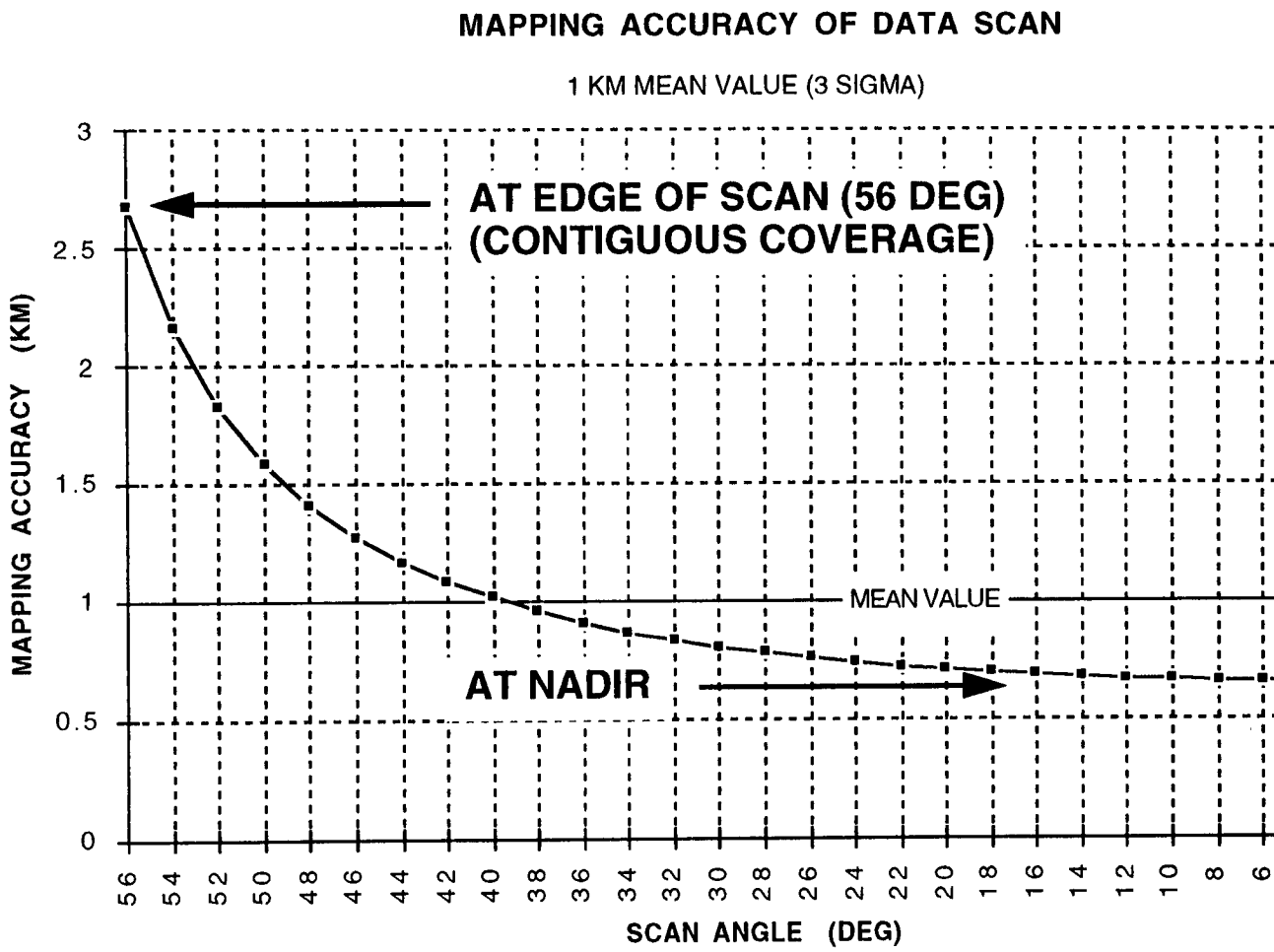
NPOESS PAYLOAD MATRIX						
		SATELLITE			REFERENCE	
SUITE	SENSOR	O1	O2	O3	EOS PM	
IMAGER	OMIS/VIRSR	X	X	X		
	MISS	X		X		
	MIMR		X		X	
	MODIS				X	
PROFILER	AIRS/ITS	X		X	X	
	AMSU-A1	X	X	X	X	
	AMSU-A2		X		X	
	MHS	X	X	X	X	
	IASI		X			
SPACE ENV	SES SENSORS	X	X	X		
CLIMATE	CERES			X	X	
	SBUV			X		
OTHER	TDRSS				X	
	STORE & FORWARD	X		X		
	SURF DATA COLL (ARGOS)	X	X	X		
	SEARCH & RESCUE		X	X		
	MSTRS	X		X		
EUM (Unique)	AATSR		X			
	HIRS/3		X			
	ScaRab		X			
	OMI		X			
	LAUNCH VEHICLE	DELTA II	(EUM)	DELTA II	DELTA II	
	NODAL CROSSING TIME	0530 A	0930 D	1330 A	1330 A	
	A-Ascending, D-Descending					

CONVERGENCE EFFORT MODIFICATION

CROSS SCAN MAPPING ACCURACY



CONICAL SCANNER MAPPING ACCURACY

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PRELIMINARY BUDGET

WORST ANGLE - SCAN POSITION IN VELOCITY VECTOR

MISS MAPPING 3 SIGMA ACCURACY (KM) (RSS)
7.62

ALTITUDE = 833 KM (450 NM)

NADIR ANGLE (DEG) 56.1

SATELLITE (KM) (RSS)
5.8820

PIXEL LOCATION (CO-REGISTRATION) (KM) (RSS)
4.84

(x SENSOR GAIN)	
ALONG SCAN (DEG)	0.12
(Random Only)	
CROSS SCAN (DEG)	0.04

MULTIPLIED BY SENSOR GAIN

BEAM ALIGNMENT ERRORS

EPHEMERIS (KM) (RSS)
0.046

IN-TRACK	0.015
CROSS-TRACK	0.025
ALTITUDE	0.036

SPACECRAFT (KM) (RSS)	YAW	ROLL	PITCH
	0.7190	0.4854	4.8964
GAIN (KM/DEG)	26.59	17.7	91.85
SPACECRAFT (RSS)	0.0270	0.0274	0.0533
(DEG)			
ATT KNOWLEDGE	0.0025	0.0052	0.0041
THERMAL - CTR	0.015	0.015	0.015
THERMAL - WING	0.02	0.02	0.05
JITTER	0.01	0.01	0.01

SENSOR ERROR (KM)	ALONG SCAN	CROSS SCAN	TOTAL SENSOR
	2.65	1.69	3.14
			RSS
GAIN (KM/DEG)	26.32	91.72	
SENSOR (RSS)	0.1007	0.0184	
(DEG)			
ZERO G	0	0.007	
STIFFNESS	0.012	0.017	
MECH SCAN ACCY	0.1	0	

RANDOM ERRORS

S/C REQUIREMENTS IMPACTS (SH 2 OF 3)

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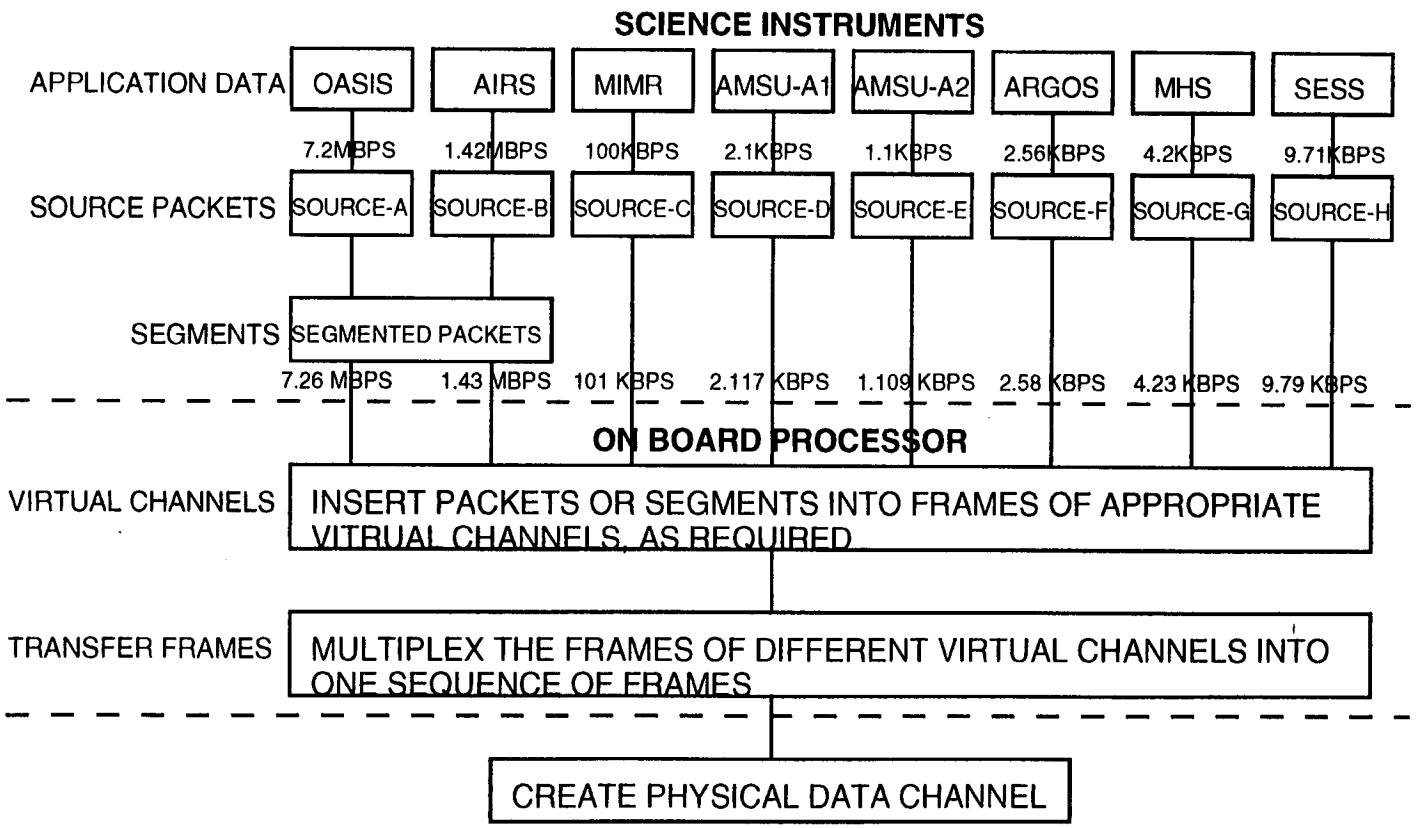
- OBP
  - DATA COMPRESSION
  - TLM FORMAT (CCSDS)
  - BER (DERIVE RQMT ~ 10E-8 END-TO-END, USE R-S CODING)
  - RESERVE / MARGIN (25% AT LAUNCH)
  - GEOREFERENCING OF DATA NOT GEOLOCATION

- SSM
  - NUMBER OF ORBITS (DERIVE RQMT - PROBABLY TWO)
  - TACTICAL WINDOW (ROLLING VS FIXED OR NONE)
  - SIZING = ACTUAL RQMT PLUS MARGIN (TBR) @ EOL

PRELIMINARY CCSDS FORMAT



CCSDS FINDINGS

- **RESULTS**
  - R-S CODING ≈ 12.7%
  - R-S CODING IMPROVES BER BY 7.5 DB OVER UNCODED TRANSMISSION
  - ADDITIONAL PROCESSING SLOC TBD
  - TOTAL OVERHEAD FOR CCSDS PACKETIZED SCIENCE TELEMETRY:
    - R-S CODING 12.7%
    - HEADER 0.8%
    - TOTAL 13.5% (10.1 KB TLM FRAME)

LMSC INDEPENDENT DEVELOPMENT

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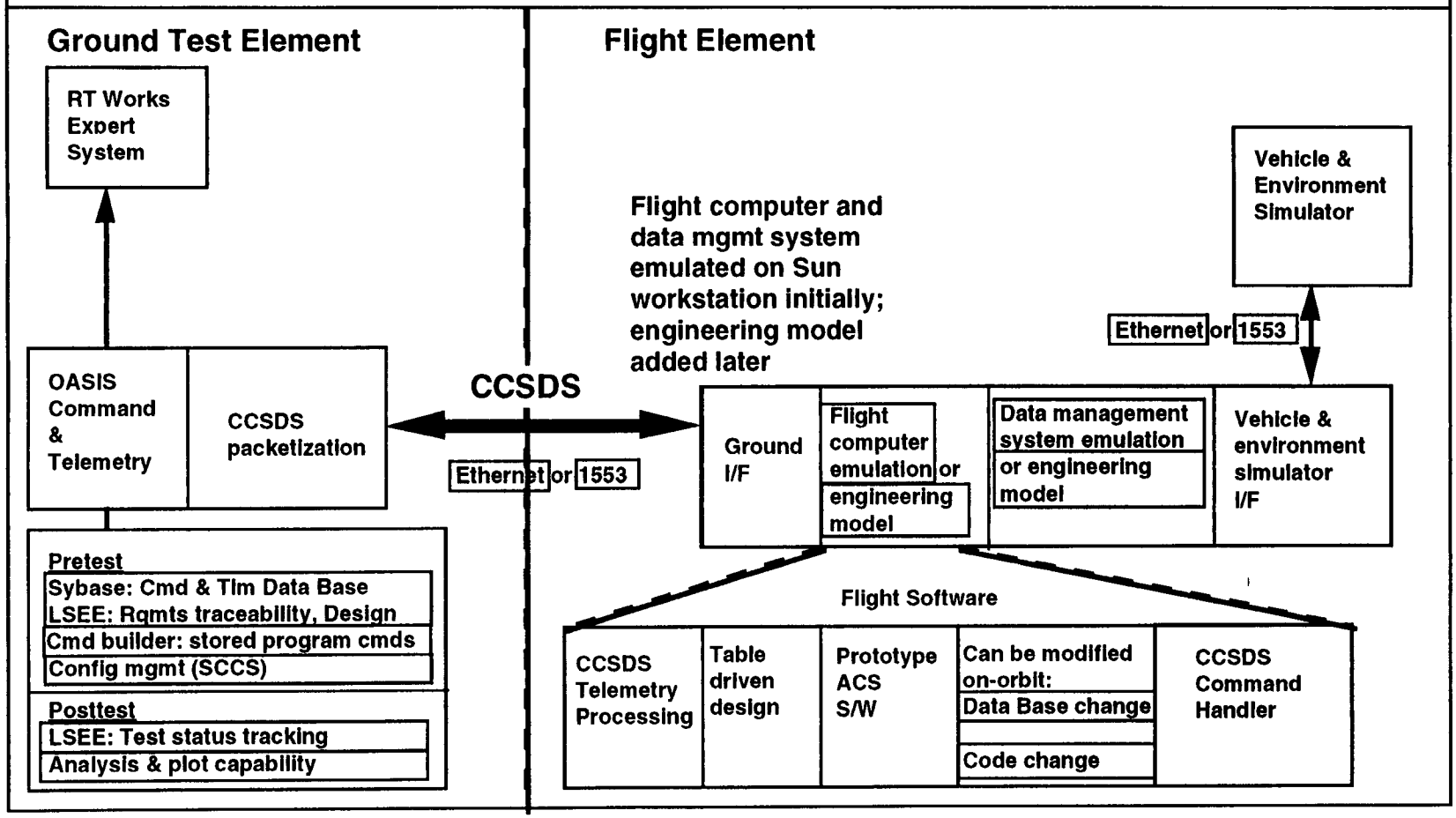
Software Development & Validation Facility (SDFV) Prototype



S/C REQUIREMENTS IMPACTS (SH 3 OF 3)

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- ORBIT
  - LAUNCH TIME: NOMINAL TIMES VS ANYTIME (ALL BETA)
  - MAINTENANCE:
    - NODAL (±10 min), REPEAT GROUND TRACK (RGT), ETC
    - MAINTAIN OPERATIONS; AS FAR AS POSSIBLE
  - DE-ORBIT: OCEAN IMPACT WITH (TBR) PROBABILITY, OR NONE

- TESTING - LAUNCH BASE
  - REDUCE TIMELINE AND COST AT LAUNCH BASE
  - LAUNCH READINESS TEST (CONFIDENCE TEST) TO VERIFY NO SHIPPING DAMAGE. TESTING INCLUDES:
    - BOOSTER I/F TESTS
    - S/C CRITICAL FUNCTIONS AND HEALTH & STATUS
    - END-TO-END COMMUNICATIONS TEST
    - LAUNCH CONFIGURATION VERIFICATION

SPACECRAFT SUMMARY

- **BASIC SPACECRAFT DESIGN**
  - MODULAR DESIGN TO ACCOMMODATE SENSORS FOR ALL CONSTELLATION CONFIGURATIONS
  - COMMON BUS FOR THE CONSTELLATION
  - ACCOMMODATED ~ 30 DIFFERENT PAYLOAD CONFIGURATIONS OVER THE PAST YEAR
  - PAYLOAD PLATFORMS ULTILIZE FLIGHT PROVEN MILSTAR DEPLOYMENT SYSTEM

- **CONFIGURATION DEVELOPMENT PROCESS**
  - CONCURRENT ENGINEERING WITH PHENOMENOLOGY, SENSOR, C3, AND OPERATIONS DESIGN
  - DETERMINE SPACECRAFT ACCOMMODATION SOLUTIONS, IMPACTS, AND RISKS AS CANDIDATE PAYLOAD AND OPERATIONS SOLUTIONS DEVELOP