DMSP / POES CONVERGED PAYLOAD ACCOMODATION STUDY PHASE III

TIM #3

Prepared for:

USAF/AFMC/CIB
SPACE & MISSILE SYSTEMS CENTER
LOS ANGELES, CALIFORNIA

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

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TIM #3 AGENDA - 11 FEBRUARY 1994

February 11, 1994 Sunnyvale, Ca

TIME	TOPIC	PRESENTER
0800-0815	INTRO/AGENDA	M. WHITTEN
0815-0845	S/C CONFIGURATIONS & DEBOOST	J. CLAPP
0845-0945	OMIS/VIRSR RQMTS COMPARISON	P. CALLARY
0945-1005	OMIS DATA COMPRESSION EFFECTS	P. CALLARY
1005-1015	BREAK	
1015-1100	MISS IMPACTS USING DISCRETE SOUNDERS	M. DAVIS
1100-1145	DRR & OPERATIONS CONCEPTS	R. NELSON
1145-1245	LUNCH	
1245-1330	TDRSS XLINK / X-BAND TERMINALS	T. PARSONS
1330-1415	ALTITUDE IMPACTS	J. HARRISON
1415-1430	SUMMARY	M. WHITTEN

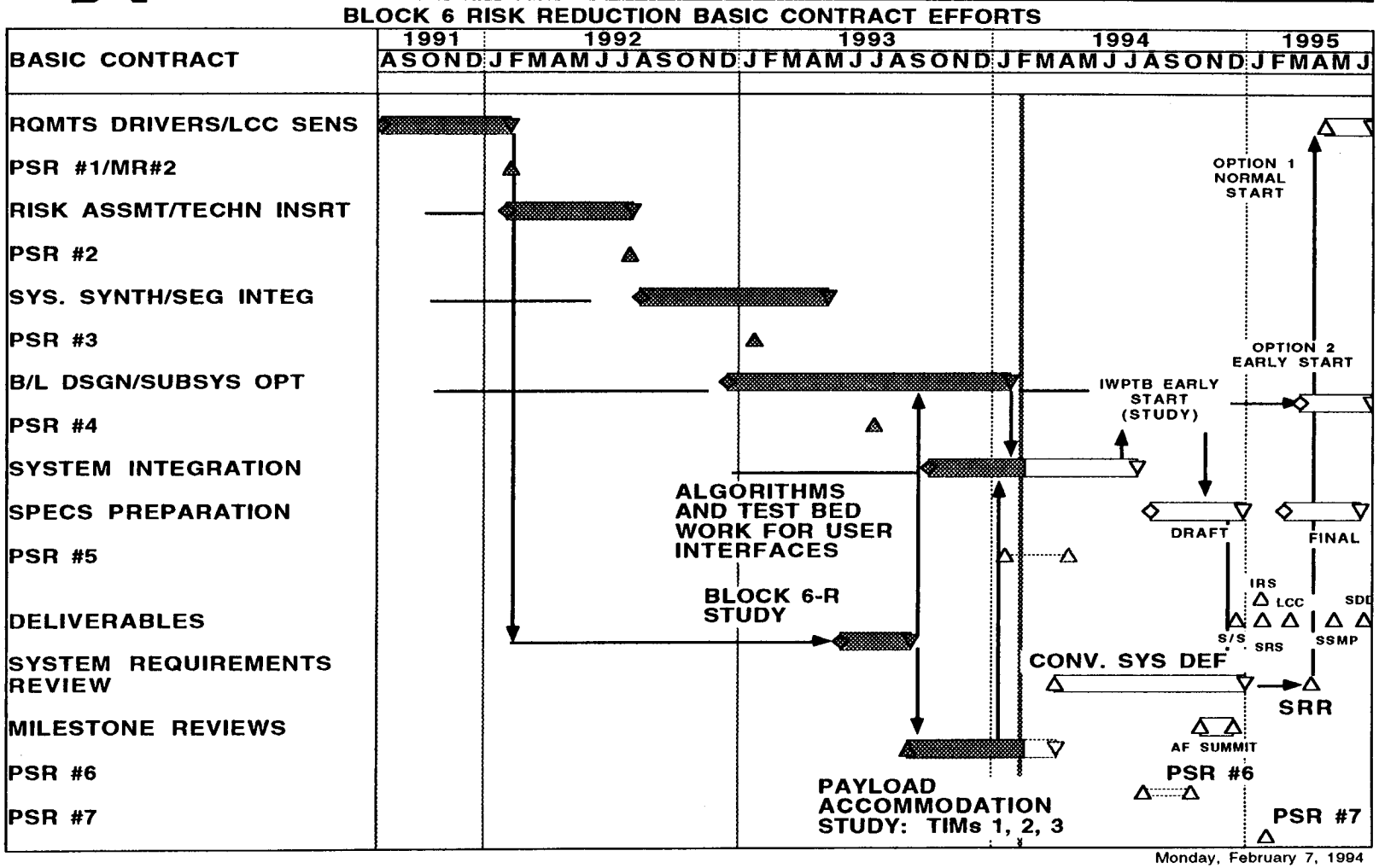
CONVERGENCE TECHNICAL INTERCHANGE

OVERALL OBJECTIVE: ***ANALYZE ALTERNATIVE CONVERGED DMSP/POES/EOS COMMON PAYLOAD OPTIONS***

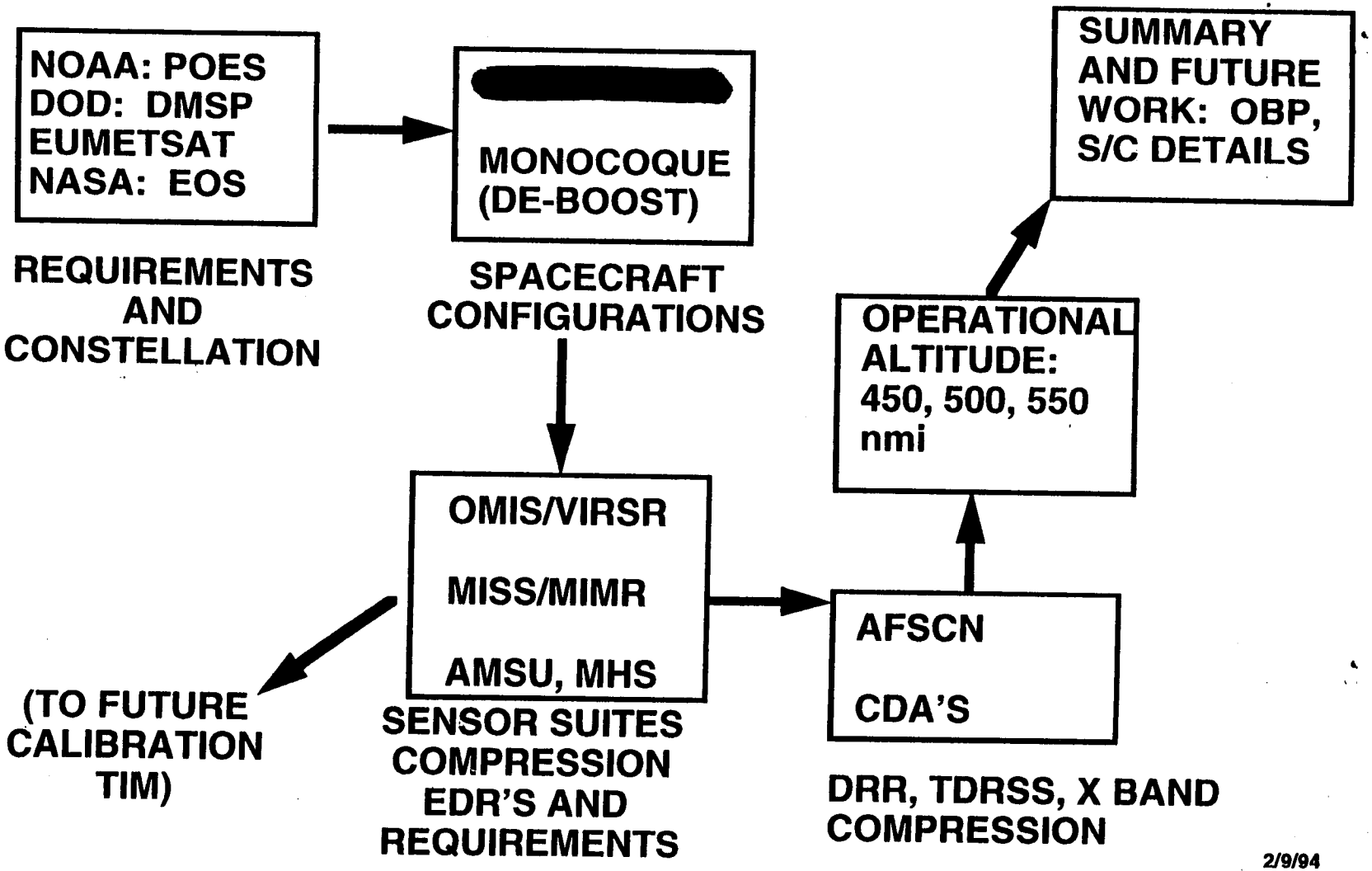
OUTPUT: ***SUPPORT TO AF AND GOVERNMENT WORK IN REFINING ALTERNATIVE OPTIONS FOR DMSP/POES INTEGRATION STEERING COMMITTEE***

CHALLENGE: SEVEN "QUALITY TIME" TIMS IN ONE DAY

CONVERGED SYSTEM SRR IN MARCH 1995



BRIEFING ROADMAP FOR CONVERGENCE



AF-06 STUDY ASSUMPTIONS (1 OF 2)

- OMIS/VIRSR - DEVELOP ONE SENSOR
- DATA COMPRESSION
  - 'ZERO NOISE' MEANS RMS ERROR = 0
- ALTITUDE IMPACTS
  - DMSP/NOAA TYPE AT 833 KM (& OTHER ALTITUDE COMBINATIONS)
  - 'PM' ORBIT AT 705 KM (MODIS DESIGN ALTITUDE)
- SPACECRAFT DEBOOST
  - CONTROLLED ONE-ORBIT, DESIGNATED BROAD OCEAN AREA IMPACT (WORST CASE)
- TDRSS CROSSLINK FOR THE PM SATELLITE (WITH MODIS)
  - PROVIDE AN X-BAND DOWNLINK BACKUP
- MISS / SOUNDERS
  - USED BLOCK 6 FOR MICROWAVE SOUNDER REQUIREMENTS
  - TEMPERATURE & MOISTURE PROFILE RETRIEVAL CAPABILITIES OF THE AMSU-A AND MHS, RESPECTIVELY. USED INPUT FROM ROSENKRANZ & WILHEIT

AF-06 STUDY ASSUMPTIONS (2 OF 2)

- DATA ROUTING & RETRIEVAL
  - EUMETSAT
    - COMMAND & CONTROL LOCATION - TBD
    - NO STORE AND FORWARD
  - PM SATELLITE (D4)
    - NO STORE AND FORWARD
    - NO REAL TIME DOWNLINK'S
  - DATA FORMATS (CCSDS & NON-CCSDS) - RECOMMEND STUDY
  - SDC VS ARGOS. BOTH SYSTEMS ON SAME CONSTELLATION - TBD
  - HRPT/LRPT DOWNLINKS
    - ASSUME AN INTERFACE RQMT (NOT A DESIGN SOLUTION)
- PAYLOAD CONFIGURATIONS - NARROWED TO A', D', & G
  - USE "D" FOR AF06 TIM
-

CONVERGED REQUIREMENTS

- NEW USER
- NEW REQUIREMENTS
- NEW REQUIREMENTS UNDERSTANDING NEEDED

GLOBAL CHANGE vs OPERATIONAL METEOROLOGY

CONFIGURATION SUMMARY AND DEBOOST IMPACT

- J. CLAPP

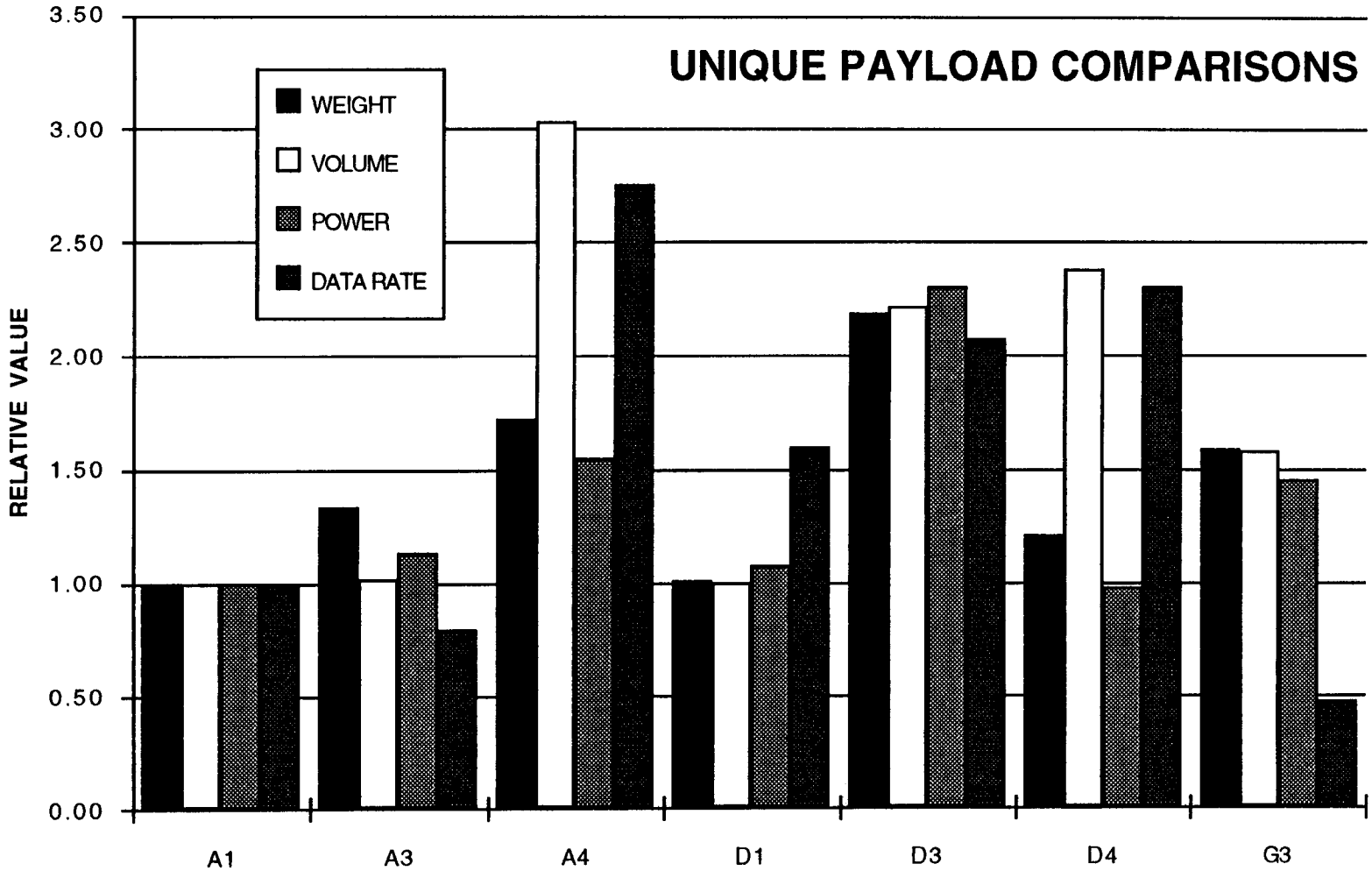
CONFIGURATION SUMMARY AND DEBOOST IMPACT

- <u>CONVERGENCE CONSTELLATIONS</u> (DELTA BOOSTER)
  - NARROWED TO A, D, & G (WAS A', D', & G)
  - AF-06 TIM - FEATURES CONSTELLATION "D"
- <u>SATELLITE CONFIGURATIONS</u>
  - D1 (DMSP), D2 (EUM), D3 (NOAA), & D4 (EOS)
- <u>COMMON BUS SOLUTIONS</u>
  - [redacted]
  - [redacted] SINGLE SENSOR PLATFORMS
- <u>DEBOOST</u>
  - SIGNIFICANT IMPACT ON PROPELLANT STORAGE CAPABILITY (ALMOST 6X)

PAYLOAD CONFIGURATION MATRIX

CONFIGURATION	A1	A2	A3	A4	A2'	D1	D2'	D3	D4	G1	G2	G3	G4	G2'
SENSOR					EUM		EUM							EUM
OMIS-DMSP B/L	X	X								X	X			
OMIS-8 / VIRSR						X	X	X						
AVHRR/3														
VIRSR			X		X							X		X
MODIS				X					X				X	
MISS	X	X				X		X	X	X	X		X	
MIMR					X		X							X
CERES				X					X				X	
AMSU-A1			X	X	X		X	X				X		X
AMSU-A2					X		X							X
MHS (S&E)			X	X	X		X	X				X		X
ITS			X											
AIRS				X				X				X		
IRTS														
SBUV(S&E)			X					X				X		
TOMS														
SESS	X	X	X		X	X	X	X		X	X			
SEM												X		X
TDRSS				X					X				X	
S & R			X		X		X	X				X		X
ARGOS			X		X		X	X				X		X
MSTRS	X	X				X		X		X	X			
SDC	X	X				X				X	X			
IASI					X		X							X
LAUNCH VEHICLE	D 0530	D 0930	D 1330	D PM	AM	D 0530	0930	D 1330	D PM	D 0530	D 0930	D 1330	D PM	AM

CONFIGURATION COMPARISON CHART



CONFIGURATION COMPARISON VALUES

CONFIGURATION	A1	A3	A4	D1	D3	D4	G1	G3
SENSOR								
OMIS-DMSP B/L	X						X	
OMIS/8				X	X			
AVHRR/3								
VIRSR		X						X
MODIS			X			X		
MISS	X			X	X	X	X	
MIMR								
CERES			X			X		
AMSU-A1		X	X		X			X
AMSU-A2								
MHS (S&E)		X	X		X			X
ITS		X						
AIRS			X		X			X
IRTS								
SBUV(S&E)		X			X			X
TOMS								
SESS	X	X		X	X		X	
SEM								X
S & R		X			X			X
ARGOS		X			X			X
MSTRS	X			X	X		X	
SDC	X			X			X	
WEIGHT (KG)	350	466	603	351	763	423	350	553
VOLUME (CM)	1.32	1.34	4.00	1.32	2.92	3.13	1.32	2.08
POWER (W)	476	540	735	511	1095	465	476	692
DATA RATE (Mbps)	2.85	2.26	7.85	4.55	5.89	6.55	2.85	1.34

PAYLOAD MATRIX - D1

INSTRUMENT	V	S	N	Volume	Footprint	Wt	Power	Attitude		FOV	Notes
SPECS	MM	MM	MM	Cubic m	Sq meters	Kg *	Watts	Know(deg)	Kbps	deg	* Wt incl conting & antennas
OMIS-Optics/8	1321	635	610	0.5117	0.838835	89	230	0.03	4500	±55.7 xtrk	w/o sunshade
OMIS-Elect'r'x	760	410	200	0.0623	0.3116	32	0	0	0	0	
OMIS-Ps	300	200	200	0.012	0.06	11	0	0	0	0	
MISS	510	510	510	0.5327	0.2601	100	175	0.05	37.3	±70az,+56el	& 2 M Dish (.4 CuM)
SESS:											
AVM	164	141	52	0.0012	0.023124	10	1	N/A	0.24	in-situ	w/o Sensor Boom *
ABIS-UV	250	560	330	0.0462	0.14	8	7	0.1	3	±50 xtrk	
RPA	230	250	250	0.0144	0.0575	11	11	0.1	2	±60,vel vect	w/o grd plane *
GPS-Rcvr	250	225	120	0.0068	0.05625	4	6	0.3	2	omni	w/o antennas *
GPS-Process	170	100	70	0.0012	0.017	3	6	0	0	0	
DOS	203	140	312	0.0089	0.02842	6	6	N/A	0.27	omni	
NADIS	467	300	330	0.0462	0.1401	8	7	0.1	1	earth limb	
MEPS	222	146	152	0.0049	0.032412	4	5	0.1	1.2	8x128,zenith	
SDC-Rcvr (2)	254	254	228	0.0294	0.129032	22	15	N/A	1	0	
SDC-Xmtr (2)	178	178	64	0.0041	0.063368	5	2	0	0	0	
SDC-Proc/Intrgtr	406	254	228	0.0235	0.103124	27	20	0	0	0	
SDC-Ant	80	80	950	0.0061	0.0064	6	0	0	0	omni	
MSTRS-RCVR	76	127	102	0.001	0.009652	0	0	0	0	0	
	127	178	127	0.0029	0.022606	5	20	N/A	0	0	
MSTRS-SENSOR	152	152	152	0.0035	0.023104	0	0	0	0	0	
Totals				1.319	2.323	351	511		4548		

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PAYLOAD MATRIX - D3

INSTRUMENT	V	S	N	Volume	Footprint	Wt	Power	Attitude		FOV	Notes
SPECS	MM	MM	MM	Cubic m	Sq meters	Kg *	Watts	Know(deg)	Kbps	deg	* Wt incl conting & antennas
OMIS-Optics/8	1321	635	610	0.5117	0.838835	89	230	0.03	4500	±55.7 xtrk	w/o sunshade
OMIS-Elect'r'x	760	410	200	0.0623	0.3116	32	0	0	0	0	
OMIS-Ps	300	200	200	0.012	0.06	11	0	0	0	0	
MISS	510	510	510	0.5327	0.2601	100	175	0.05	37.3	±70az,+56el	& 2 M Dish (.4 CuM)
AMSU-A1	731	337	605	0.149	0.246347	50	90	0.1	2.1	+50,-90 xtrk	
MHS-Sen & Electr	774	990	560	0.4291	0.76626	65	90	0.1	4.2	+50,-90 xtrk	
AIRS	1397	775	762	0.825	1.082675	165	265	0.2	1330	±55 xtrk	
SBUV-Sensor	370	325	610	0.0734	0.12025	50	25	0	0.38	±6 nadir	
SBUV-Elect	245	341	365	0.0305	0.083545	0	0	0	0	0	
SESS:											
AVM	164	141	52	0.0012	0.023124	10	1	N/A	0.24	in-situ	w/o Sensor Boom *
ABIS-UV	250	560	330	0.0462	0.14	8	7	0.1	3	±50 xtrk	
RPA	230	250	250	0.0144	0.0575	11	11	0.1	2	±60,vel vect	w/o grd plane *
GPS-Rcvr	250	225	120	0.0068	0.05625	4	6	0.3	2	omni	w/o antennas *
GPS-Process	170	100	70	0.0012	0.017	3	6	0	0	0	
DOS	203	140	312	0.0089	0.02842	6	6	N/A	0.27	omni	
NADIS	467	300	330	0.0462	0.1401	8	7	0.1	1	earth limb	
MEPS	222	146	152	0.0049	0.032412	4	5	0.1	1.2	8x128,zenith	
S&R-RPU(2)	195	365	280	0.0199	0.071175	31.2	22.8	0	0	0	
S&R-SPU	195	310	280	0.0169	0.06045	14.4	6	0	0	0	
S&R-Rcvr	458	458	152	0.0319	0.209764	15.2	21	0	0	omni	w/o antennas *
S&R-Xmit	350	370	115	0.0149	0.1295	15.2	39	0	0	omni	w/o antennas *
ARGOS-RPU	195	365	280	0.0199	0.071175	16.8	25.2	0	2.56	omni	w/o antennas *
ARGOS-SPU(2)	195	310	280	0.0339	0.1209	31.2	7.2	0	0	0	
ARGOS-DCSR	195	310	280	0.0169	0.06045	18	30	0	0	0	
MSTRS-RCVR	76	127	102	0.001	0.009652	0	0	0	0	0	
	127	178	127	0.0029	0.022606	5	20	N/A	0	0	
MSTRS-SENSOR	152	152	152	0.0035	0.023104	0	0	0	0	0	
Totals				2.917	5.043	763	1095		5886.3		

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PAYLOAD MATRIX - D4

INSTRUMENT	V	S	N	Volume	Footprint	Wt	Power	Attitude		FOV	Notes
SPECS	MM	MM	MM	Cubic m	Sq meters	Kg *	Watts	Know(deg)	Kbps	deg	* Wt incl conting & antennas
MODIS	1121	1740	1213	2.366	1.95054	278	240	0.03	6500	±58 xtrk	Data Rate 11M sun
MISS	510	510	510	0.5327	0.2601	100	175	0.05	37.3	±70az,+56el	& 2 M Dish (.4 CuM)
CERES	590	570	700	0.2354	0.3363	45	50	0.03	10	±84 cone, +Z	0
Totals				3.134	2.547	423	465		6547.3		

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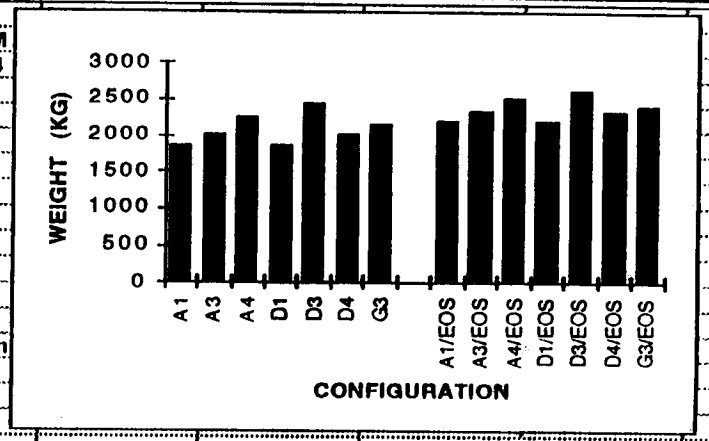
LOCKHEED EOS DEVELOPMENTS

DIRECT BENEFIT TO CONVERGED PROGRAM

- [redacted] BUS EQUIPMENT MODULE
  - CONVERGENCE COMMON BUS [redacted]
- [redacted] SENSOR INTERFACE MODULE (OPTICAL BENCH)
  - USE FOR CONVERGENCE [redacted]
- TDRSS HIGH GAIN ANTENNA WITH KU-BAND SYSTEM
  - CONVERGENCE ALTERNATE DOWNLINK
- WIDE BAND DATA LINK FORMATTOR
- LARGE SOLID STATE MEMORY
  - CONVERGENCE APPROX SAME SIZE
- FLEXIBLE SOLAR ARRAY WITH GaAs CELLS
  - CONVERGENCE APPROX SAME SIZE

SATELLITE WEIGHT SUMMARY

SUBSYSTEM	WEIGHT(Kg) [redacted] Al	WEIGHT(Kg) [redacted] Gr/Ep	EOS PM A4, D4
STRUCTURES	500	652	
ELECTRICAL	576	674	
ATTITUDE DETERM & CTR	107	132	
CMD, TLM, DH	162	215	
PROPULSION	13	31	
THERMAL	73	101	
TOTAL DRY WEIGHT	1431	1805	
PROPELLANT (DMSP B/L)	45	55	55
			Addition
TOTAL S/C BUS	1476	1860	
	[redacted]	[redacted]	

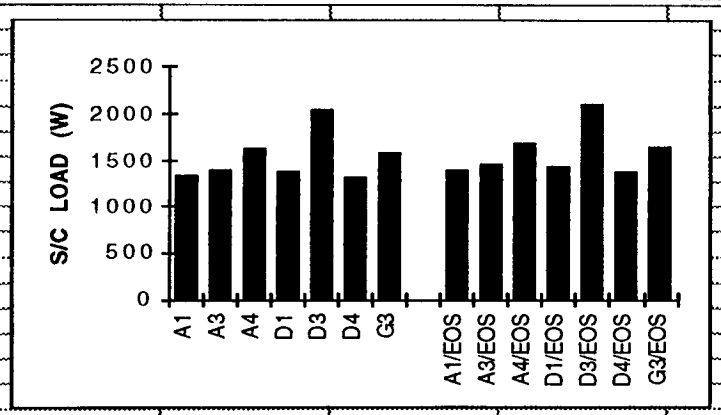


SENSOR COMPLEMENT	Kg	GROWTH(kg) B/L +25% CONV +0%	S/C DELTA Kg (38%) SSM+35Kg	TOTAL SATELLITE (KG) Prop +55 "4"	(LBS)	LAUNCH CAPABILITY 833KM, SUN SYNCH, 85% DELTA 7920 KG/LBS	PERCENT OF MAX
DMSP BASELINE	350	88	0	1914	4219	2700/6000	60
NOAA B/L	523	131	101	2230	4918	2700/6000	70
CONFIGURATION							
A1	350	0	35	1861	4104	2700/6000	59
A3	466	0	79	2021	4456	2700/6000	64
A4	603	0	131	2265	4995	2700/6000	71
D1	351	0	35	1862	4107	2700/6000	59
D3	763	0	192	2431	5360	2700/6000	77
D4	423	0	63	2017	4447	2700/6000	64
G3	553	0	112	2141	4721	2700/6000	67
A1/EOS	350	0	384	2210	4873	2700/6000	70
A3/EOS	466	0	384	2326	5129	2700/6000	73
A4/EOS	603	0	384	2518	5552	2700/6000	79
D1/EOS	351	0	384	2211	4875	2700/6000	70
D3/EOS	763	0	384	2623	5784	2700/6000	83
D4/EOS	423	0	384	2338	5155	2700/6000	74
G3/EOS	553	0	384	2413	5321	2700/6000	76

2/9/94
TIM 3

SATELLITE POWER SUMMARY

SUBSYSTEM	POWER (W) DMSP	POWER (W) EOS
STRUCTURES		51
ELECTRICAL	56	120
ATTITUDE DETERM & CTR	213	198
CMD, TLM, DH	298	373
PROPULSION	3	33
THERMAL	195	73
SUB-TOTAL	765	
SURVIVABILITY	18	
TOTAL S/C BUS	783	848



SENSOR COMPLEMENT	W	GROWTH (W) B/L +25% CONV +0%	S/C DELTA W (15%) Comm +75	TOTAL SATELLITE LOAD W	Solar Array (BOL) W	SA WT-Diff KG (44w/kg)	BATTERY* A-H Total DOD<35%	BATTERY Wt Diff (KG) 1=50 KG*
DMSP BASELINE	476	119	0	1378	3315	0	92	0 *
NOAA B/L	567	142	89	1580	3803	11.1	105	0 *
CONFIGURATION								
A1	476	0	75	1334	3209	-2.4	89	0 *
A3	540	0	85	1408	3386	1.6	94	0 *
A4	735	0	114	1632	3927	13.9	109	0 *
D1	511	0	80	1374	3306	-0.2	92	0 *
D3	1095	0	168	2046	4925	36.6	136	0 *
D4	465	0	73	1321	3178	-3.1	88	0 *
G3	692	0	107	1582	3808	11.2	105	0 *
A1/EOS	476	0	140	1399	3366	1.2	93	0 *
A3/EOS	540	0	150	1473	3543	5.2	98	0 *
A4/EOS	735	0	179	1697	4083	17.5	113	0 *
D1/EOS	511	0	145	1439	3463	3.4	96	0 *
D3/EOS	1095	0	233	2111	5081	40.1	141	0 *
D4/EOS	465	0	138	1386	3335	0.5	92	0 *
G3/EOS	692	0	172	1647	3964	14.8	110	0 *

* ADD BATTERY IF A-H >189

DEBOOST ASSUMPTION (WORST CASE)

- ORBIT TERMINATION INTO A SPECIFIC LOCATION (OCEAN)
  - ONE ORBIT DEBOOST
  - DEBOOST NEGATIVE DELTA VELOCITY & PROPELLANT
    - ORBIT ALTITUDE OF 833 KM
    - MASS OF ~ 2700 KG (RANGE 2000 TO 2700)
    - DELTA V ~ 230 M/S
    - PROPELLANT (HYDRAZINE) ~ 295 KG (650 LBS)
  - OPERATIONAL MISSION PROPELLANT ~ 60 KG
  - TOTAL PROPELLANT (HYDRAZINE) ~ 355 KG (782 LBS)

DEBOOST IMPACTS

- BUS CONFIGURATIONS
  - [redacted] 140 OR 1100 LB TANK - USE LARGER TANK.
    - RELOCATE TDRSS DEPLOYABLE ANTENNA
  - [redacted] ~ 500 LB TANK (WITH REPRESSURIZATION)
    - SUPPLEMENTARY TANK
    - SPACE PROBLEM
- SATELLITE WEIGHT MARGIN
  - ADDITIONAL 295 KG REDUCES BOOSTER MARGIN BY APPROX 9%
  - FOR D3/EOS, THE %OF MAX INCREASES FROM 83% TO 92%; THEREFORE, THE MARGIN REDUCES FROM 17% TO 8%.
- OPTIONS
  - NATIONAL POLICY REVIEW
    - NO DE-ORBIT (OVER 100 YRS EXPECTED LIFE)
    - NON-CONTROLLED DE-ORBIT
    - CONTROLLED DE-ORBIT

SUMMARY

- PAYLOAD CONFIGURATION COMBINATIONS BECOMING MORE DEFINED
- ALLOWS MORE EFFORT TO REDUCE RISK FOR PAYLOAD ACCOMMODATIONS
- GROWTH CAPABILITY IS NEAR ZERO ON SOME CONFIGURATIONS
- NAVY ACCOMMODATIONS STILL CONSIDERED
- DEBOOST CAPABILITY WOULD BE A CHALLENGE
- FUTURE WORK
  - SURVIVABILITY REQUIREMENT FOR OTHER SENSORS
  - MORE DETAIL SPACECRAFT DESIGN DEFINITION

[redacted] PROVIDE THE MOST PAYLOAD ACCOMMODATION

CONVERGED SYSTEM

OMIS IMPACTS

- P. CALLARY

TASK B

- SHOW HOW OMIS PERFORMANCE CHARACTERISTICS HAVE BEEN DERIVED FROM EDR REQUIREMENTS
- COMPARE OMIS/VIRSR AF-05 CONFIGURATION WITH SPECIFIED VIRSR REQUIREMENTS
  - SNR
  - NEΔT
  - CALIBRATION

KEY NOTES

- OMIS AND OMIS/VIRSR REQUIREMENTS
  - SPECIFIED AT THE EDR LEVEL
  - DRIVEN BY TERMINATOR REQUIREMENTS AT END OF SCAN (WORST CASE CONDITION)
- VIRSR REQUIREMENTS
  - SPECIFIED AT SENSOR LEVEL
  - DRIVEN BY NADIR REQUIREMENTS

SUMMARY OF KEY OMIS EDR REQUIREMENTS DESIGN DRIVERS

REQUIREMENT	(REQ ID)
• CONSTANT GROUND RESOLUTION	(SYS1080)
• IR RADIOMETRIC ACCURACY	(SYS01130)
• LOW LIGHT LEVEL (LLL) CHANNEL	(SYS1040, SYS1060, SS000880)

FROM EDR 20.1.1 CLOUD IMAGERY

CONSTANT GROUND RESOLUTION

REQUIREMENT

HORIZONTAL SPATIAL RESOLUTION CONSTANT TO ±25% (0% GOAL)

IMPACT

- REDUCED DETECTOR IFOV AT EDGE OF SCAN
  - REDUCES ENERGY INCIDENT ON DETECTOR (IFOV & RANGE)
  - REQUIRES INCREASE IN APERTURE SIZE OR IN THE NUMBER OF DETECTOR ELEMENTS AND ASSOCIATED ELECTRONICS
- SPECIFICATION BASED ON EXTREME TERMINATOR PERFORMANCE NOT NOMINAL NADIR PERFORMANCE

RESULT → ***SUPPORT OF TACTICAL AND OPERATION AL REQUIREMENTS***

IR MEASUREMENT ACCURACY

REQUIREMENT

	DMSP EDR SPEC TO LMSC	LMSC/ITT OMIS SPEC
MWIR NEDT	1.0 K @ 255K	0.85 K @ 255K
LWIR NEDT	1.0 K @ 190	0.90 K @ 180K
LWIR NEDT		0.30K @ 270K

IMPACT

- ACCURACY INCLUDES BIAS AND PRECISION ERROR
- CALIBRATION NECESSARY AT THREE TEMPERATURES
  - COLD SPACE LOOK
  - LOW TEMPERATURE CALIBRATION POINT REQUIRED ON GROUND ... FLIGHT REQUIREMENT TBD
  - SPACECRAFT AMBIENT TEMPERATURE

RESULT → ***DMSP BLOCK-6 PROGRAM TO DETERMINE ACCURACY NEEDED IN TERMINATOR REGION***

LOW LIGHT LEVEL (LLL) CHANNEL

REQUIREMENT

RADIOMETRIC SENSITIVITY	OPERATE AT $\leq 10^{-9}$ W/cm^2-Sr
SPATIAL RESOLUTION	3.25 km $\pm$ 25% (Goal of 0.65 km $\pm$ 25%)
STRAY LIGHT REJECTION	OPERATE WITH TERMINATOR IN FOV
DYNAMIC RANGE	$\leq 10^{-9}$ to 7×10^{-5} W/cm^2-Sr

IMPACT

TRADE OF SEPARATE LLL PUSHBROOM INSTRUMENT VERSUS BAND 7 INTEGRATED INTO THE OMIS

SEPARATE PUSHBROOM: PROVIDES HIGHER SNR AT $< 10^{-9}$ W/cm^2-Sr CAN THEREFORE PROVIDE RESOLUTION BETTER THAN 3.25 km

INTEGRATED BAND 7: LOWER LCC, EASIER COREGISTRATION OF ALL 7 BANDS, SMALLER SIZE AND WEIGHT

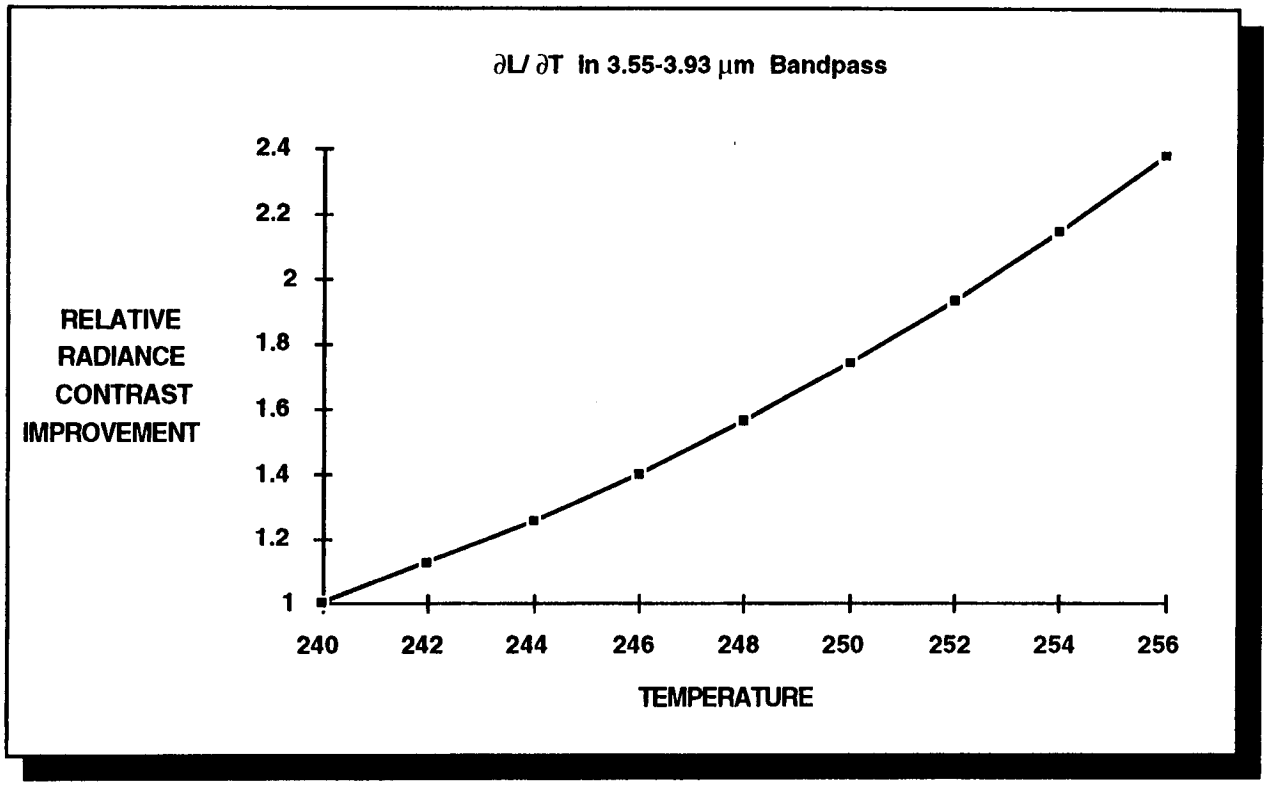
RESULT → *RESOLVING TRANSITION POINT FROM DAYTIME TO NIGHTTIME IS KEY*

INSTRUMENT REQUIREMENTS FLOWDOWN PROCESS

- LOW END OF DYNAMIC RANGE REQUIREMENTS USED TO SIZE INSTRUMENT APERTURE, PLUS
  - ALLOCATION OF EDR BUDGET TO OMIS
  - IFOV SIZE CONSTRAINTS AT END OF SCAN
  - RANGE TO PROJECTED IFOV AT END OF SCAN
  - SNR IMPLIED BY ACCURACY REQUIREMENTS

- EDR REQUIREMENTS FLOWDOWN RESULTED IN INITIAL OMIS ALLOCATIONS
  - RESULTED IN 8" APERTURE AND FPA LAYOUT
  - FPA MATERIALS AND SENSITIVITY REQUIREMENTS
  - SNR AND NEΔT PERFORMANCE CALCULATIONS

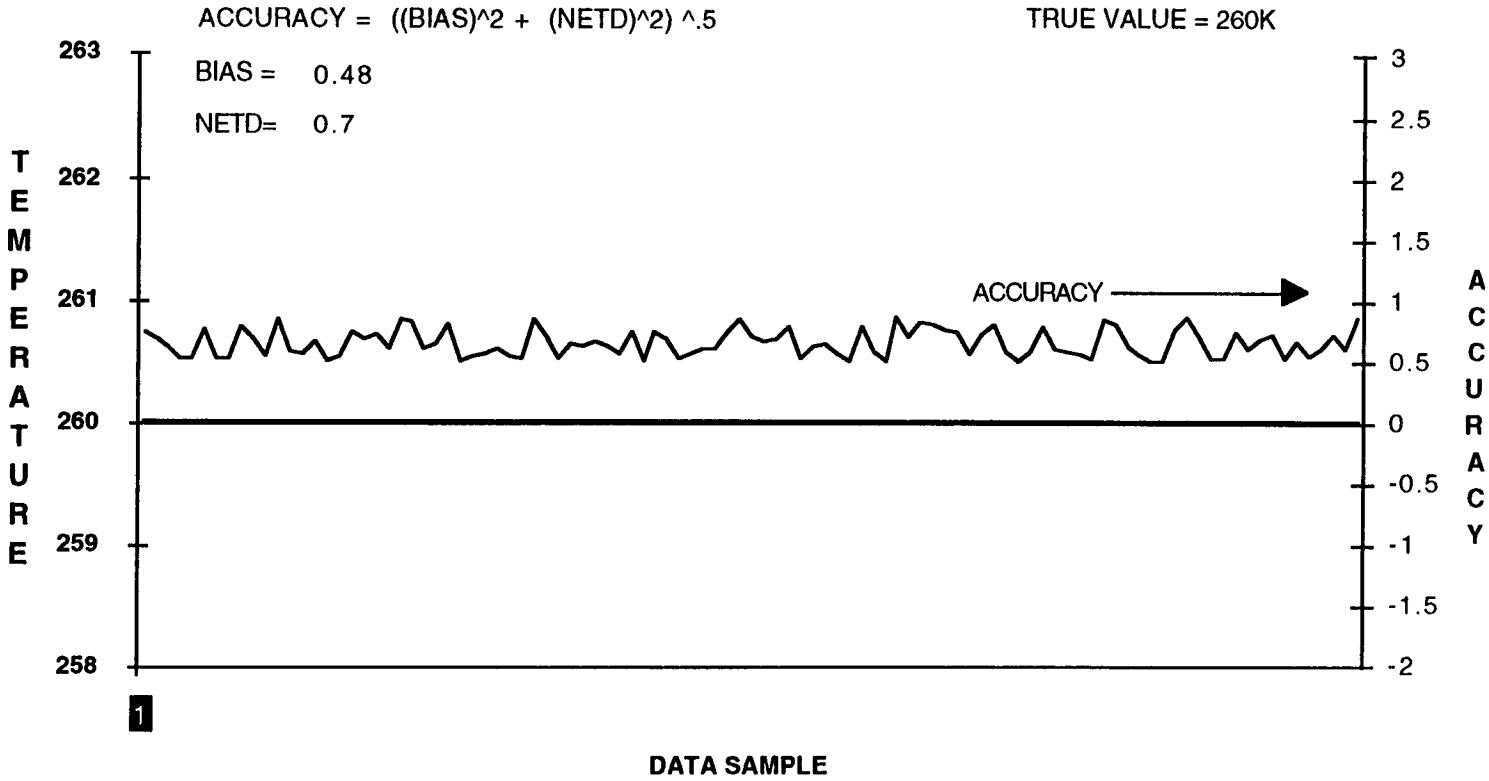
CHANGE IN MWIR RADIANCE CONTRAST WITH BLACKBODY TEMPERATURE



NOTE THE NEDT IMPROVES DRAMATICALLY WITH SPECIFIED BLACKBODY TEMPERATURE

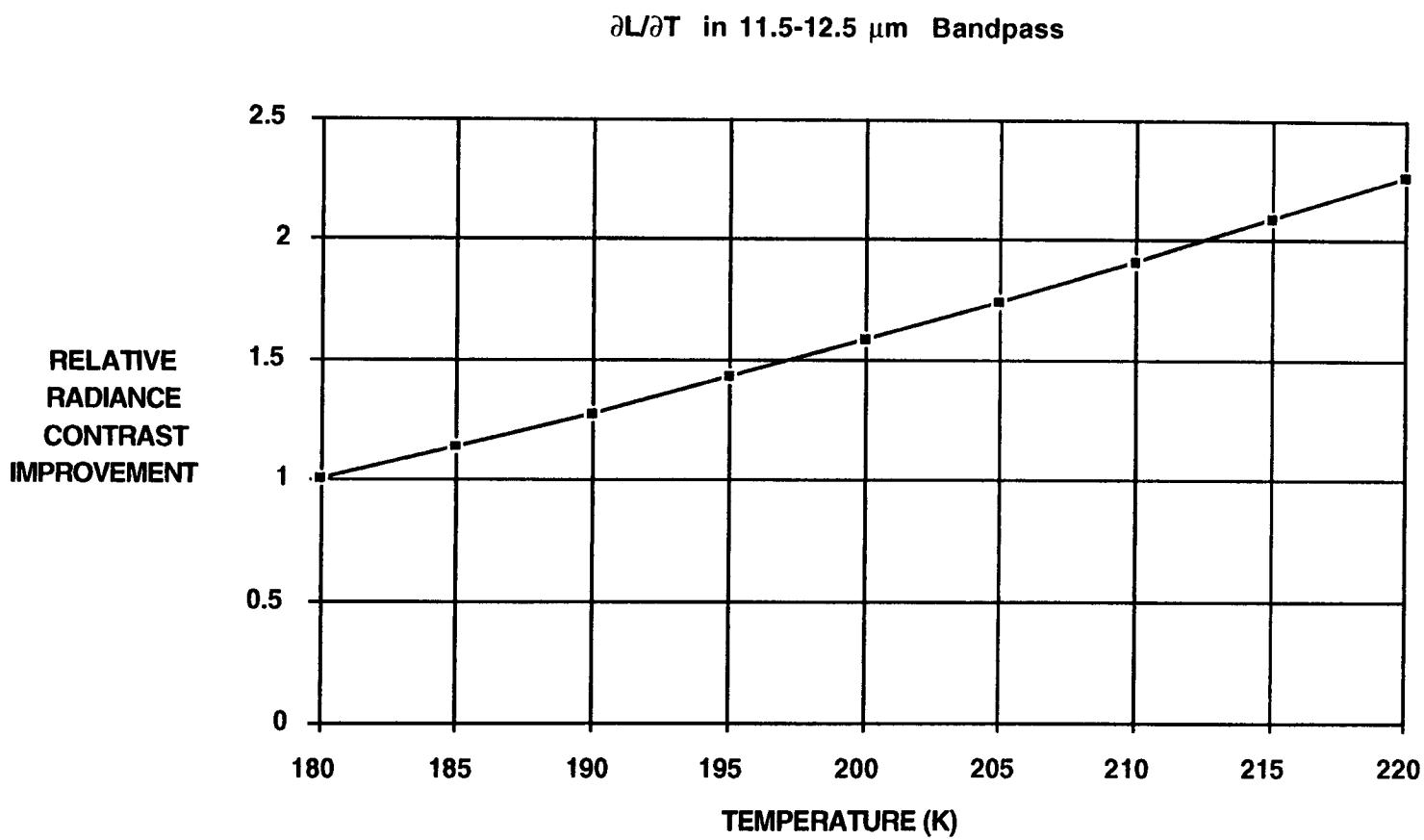
- **BETTER THAN A FACTOR OF 2 FROM 240 K TO 256K**

EXAMPLE OF AN 0.85K MWIR ACCURACY ERROR BUDGET



NOTE: BIAS AND NEΔT CAN BE ALLOCATED IN ANY MANNER WHICH SUPPORTS THE 0.85K ACCURACY. CURRENTLY 0.3K AND .79K RESPECTIVELY

BAND 6 RADIANCE CONTRAST vs TEMPERATURE



EXAMPLE CALCULATION BAND 6 SNR AND MARGIN

- DETAILS OF THE SNR AND MARGIN FOR ALL OMIS BANDS
  - BASIC CALCULATIONS PRESENTED AT OMIS ITT TIM#2 (16 JANUARY 92) WITH UPDATES AS NECESSARY AT LATER TIMS
- EXAMPLE FROM BAND 6 FOLLOWS
- RESULTING BASELINE PERFORMANCE AND MARGIN FOLLOWS EXAMPLE

OMIS LWIR NEΔT CALCULATIONS

DESCRIPTION: THE PHOTO CONDUCTIVE, NE ΔT IS CALCULATED USING THE FORMULA,

$$NE\Delta T = \frac{\alpha_d \sqrt{A_d \Delta f}}{\tau A_o \Omega D^* dL/dT \; \Delta\lambda}$$

THE DETECTOR D^* IS TYPICALLY EXTRAPOLATED FROM THE PERFORMANCE HISTORY OF SIMILAR DEVICES.

OMIS LWIR NEΔT CALCULATIONS
12μm BAND

CENTER WAVELENGTH	12.0μm
SPECTRAL BANDWIDTH	1.0μm
SCENE TEMPERATURE	180K
BACKGROUND TEMPERATURE	288K
BACKGROUND CONE ANGLE	19°
SYSTEM TRANSMITTANCE	.313
COLD FILTER TRANSMITTANCE	.89
AREA, OPTICAL APERTURE	282 cm^2
IFOV	130 μr X 460 μr
AREA, DETECTOR	5.56E-05 cm^2
dL/dT @ (12.0μm, 180 K)	2.273E-06 $W/cm^2 \cdot Sr \cdot K \cdot \mu m$
DETECTOR D^*	1.8E+11 cm $\sqrt{Hz}/W$
1/f DEGRADATION FACTOR α_d	1.55

$$NE\Delta T = .55K$$

OMIS RADIOMETRIC REQUIREMENTS AND BASELINE PERFORMANCE

BAND	ABSOLUTE ACCURACY REQUIREMENT (1-sigma)	PRECISION (1-sigma) NADIR	PRECISION (1-sigma) END-OF-SCAN	ABS. ACCURACY (1-sigma) NADIR	ABS. ACCURACY (1-sigma) END-OF-SCAN	MARGIN END-OF-SCAN
1	7%	67	47	2.2%*	2.7%*	2.6:1
2	7%	75	53	2.1%*	2.5%*	2.8:1
3	10%	20	14	5.3%*	7.3%*	1.4:1
7	17%	13.3	9.4	8.2%***	11.1%***	1.5:1
4	0.85K @ 260K	0.35	0.50	0.42**	0.55**	1.5:1
5	0.3 K @ 270K	0.06	0.09	0.10**	0.12**	2.5:1
	0.9 K @ 180K	0.33	0.46	0.55**	0.63**	1.4:1
6	0.3 K @ 270 K	0.11	0.15	0.13**	0.17**	1.7:1
	0.9 K @ 180K	0.45	0.64	0.56**	0.72**	1.3:1

* CALIBRATION ERROR (1 sigma) = 1.7%

** CALIBRATION ERROR (3 sigma) =0.2K @ 288K

*** CALIBRATION ERROR (1 sigma) = 3.3%

^^ REQUIREMENT AT 240K UNDER DISCUSSION WITH SPO ...CHANGE TO 255-260K EXPECTED

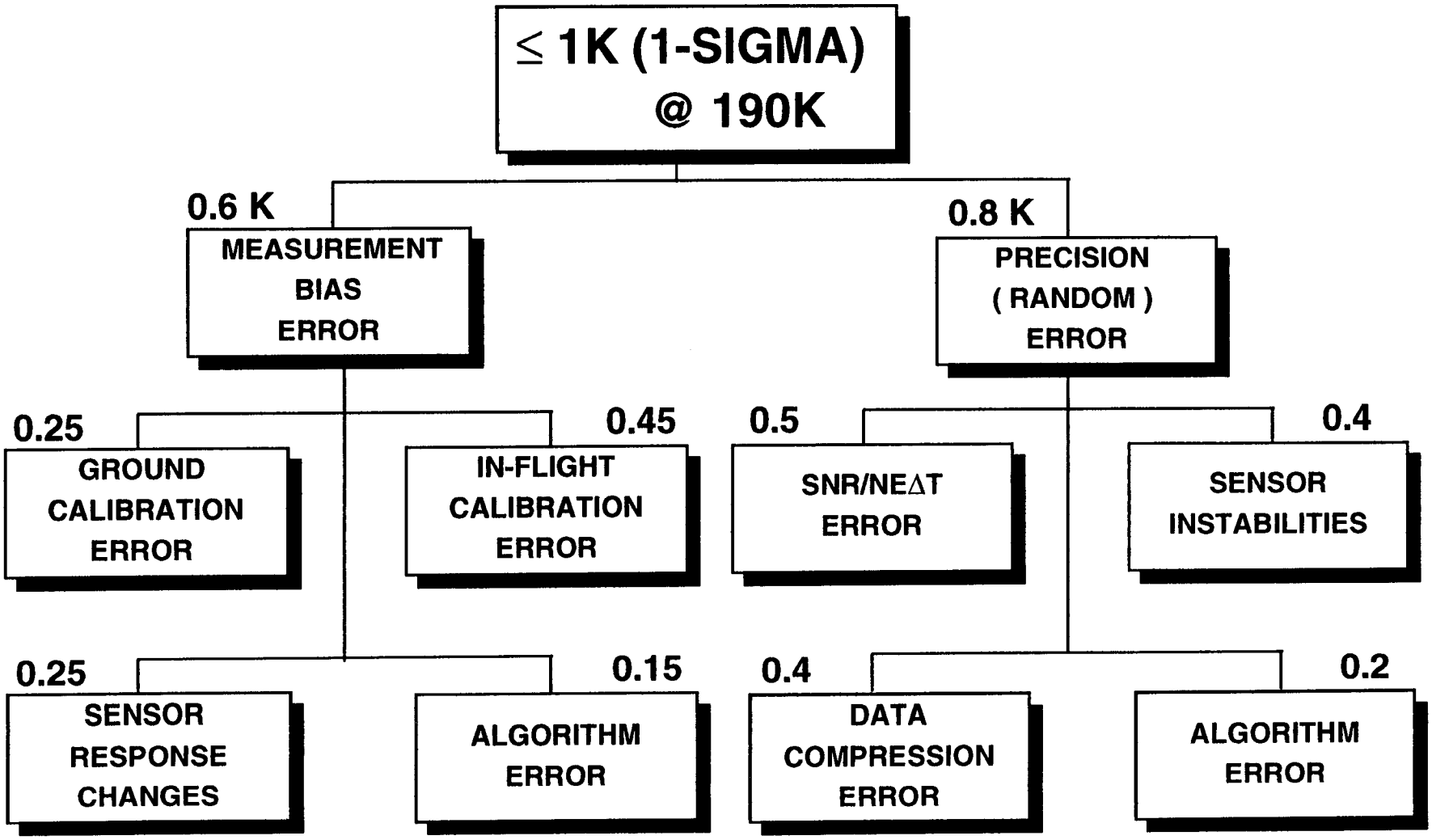
2/9/94
TIM 3

BLOCK 6 SPECIFICATION TERMINOLOGY FOR MEASUREMENT ACCURACY

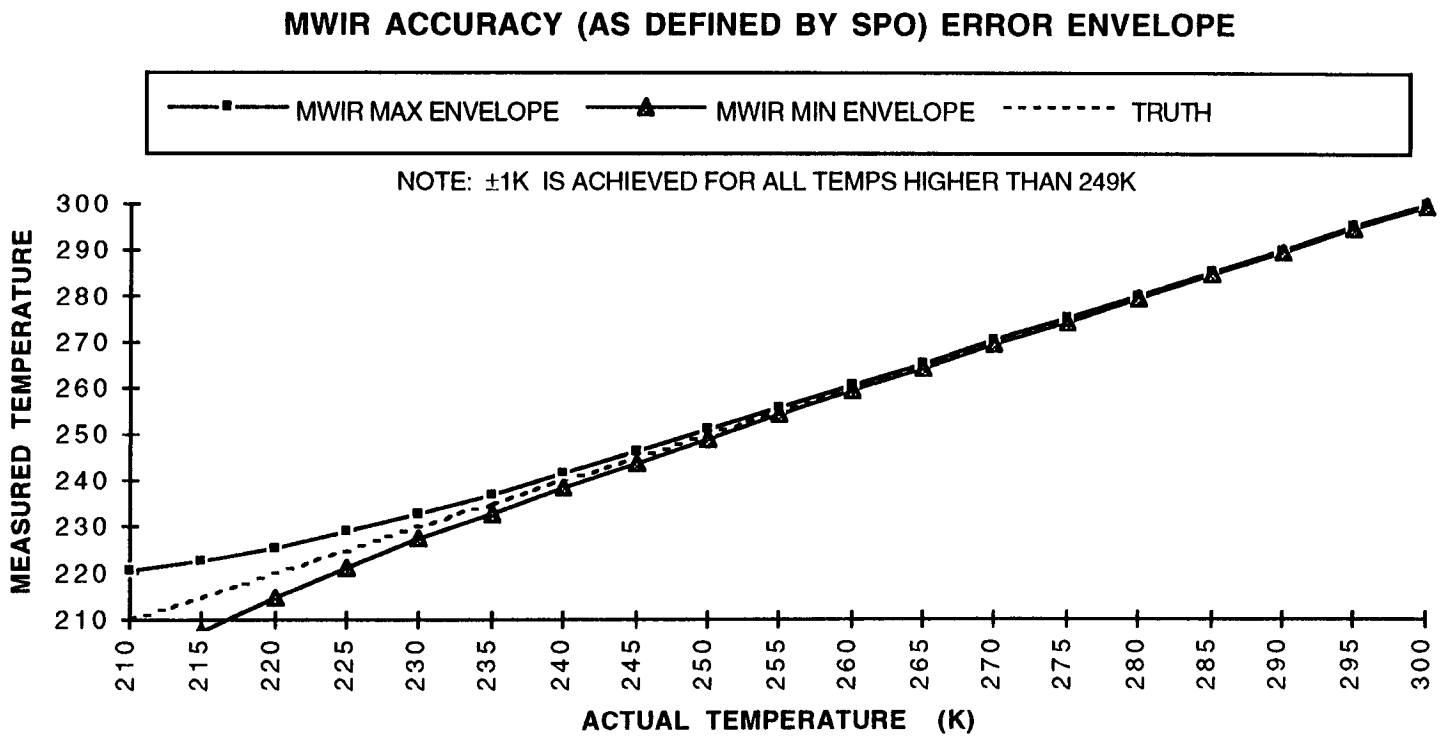
- MEASUREMENT ACCURACY DEFINED IN EDR 20.1.1 IS IN TERMS OF
  - RADIOMETRIC BIAS ERROR
    - > OFTEN CONSIDERED THE "RADIOMETRIC ACCURACY" TERM ON SOME PROGRAMS
  - PRECISION ERROR
    - > RANDOM TERM ... E.G. INCLUDES NEΔT WITH THIS TERM
- CONFUSION CAN ARISE SINCE NOAA APPEARS TO REFER TO RADIOMETRIC ACCURACY AND PRECISION
  - AT SENSOR LEVEL, NOT EDR LEVEL
  - TERMS IN A BLOCK 6 ERROR BUDGET ... NOT THE WHOLE BUDGET
  - 1-SIGMA VERSUS 3-SIGMA NEEDS TO BE UNDERSTOOD

BLOCK 6 SPECIFIES THE ACCURACY AT THE *EDR LEVEL* NOT AT THE SENSOR LEVEL !!!

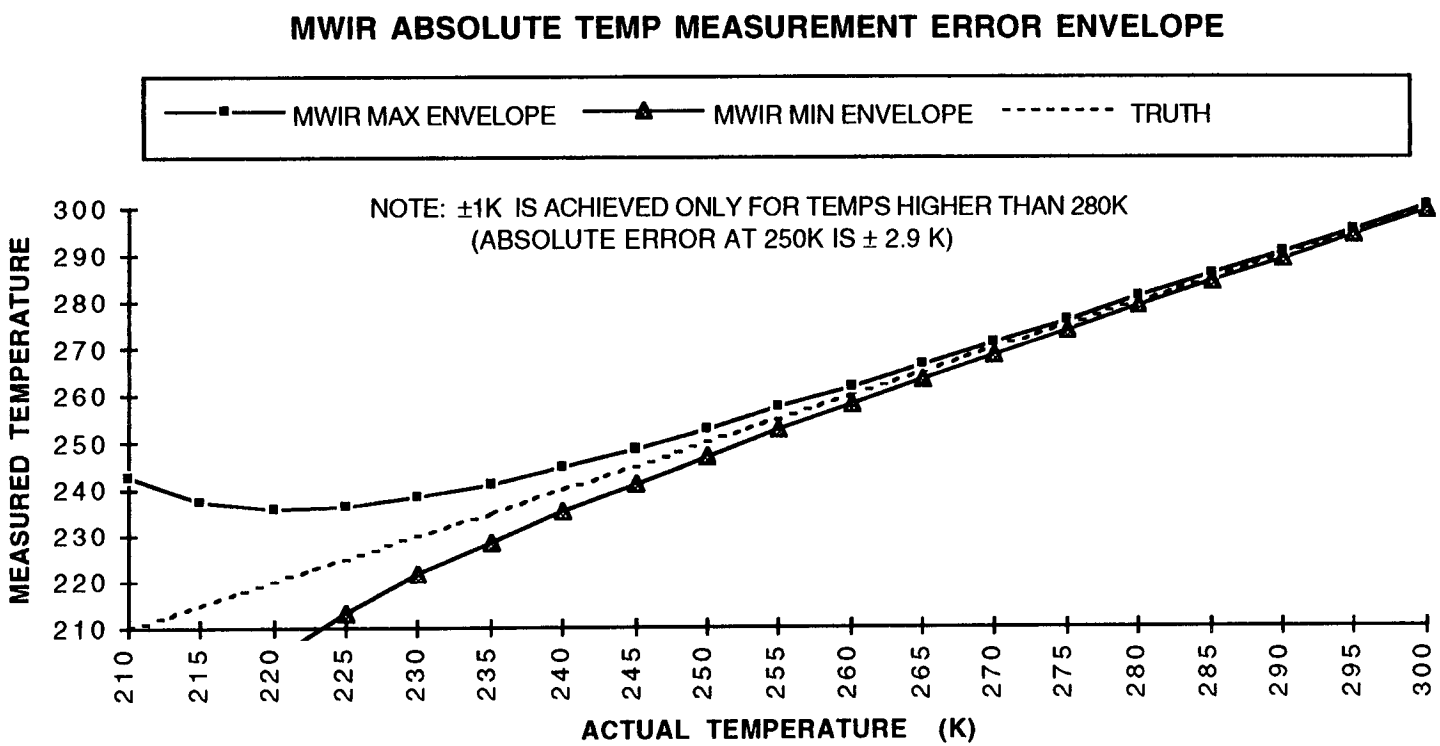
EXAMPLE ERROR BUDGET COMPONENTS FOR EDR MEASUREMENT ACCURACY IN THE LWIR



BLOCK 6 MWIR MEASUREMENT ACCURACY VS TEMP (1-SIGMA BASED)



ABSOLUTE MWIR MEASUREMENT ACCURACY VS TEMP (3-SIGMA BASED)



POTENTIAL VISIBLE BAND CALIBRATION ACCURACY POINTS OF CONFUSION

Comparison of OMIS, OMIS/VIRSR and VIRSR Visible Calibration Specification Requirments (In-Orbit)

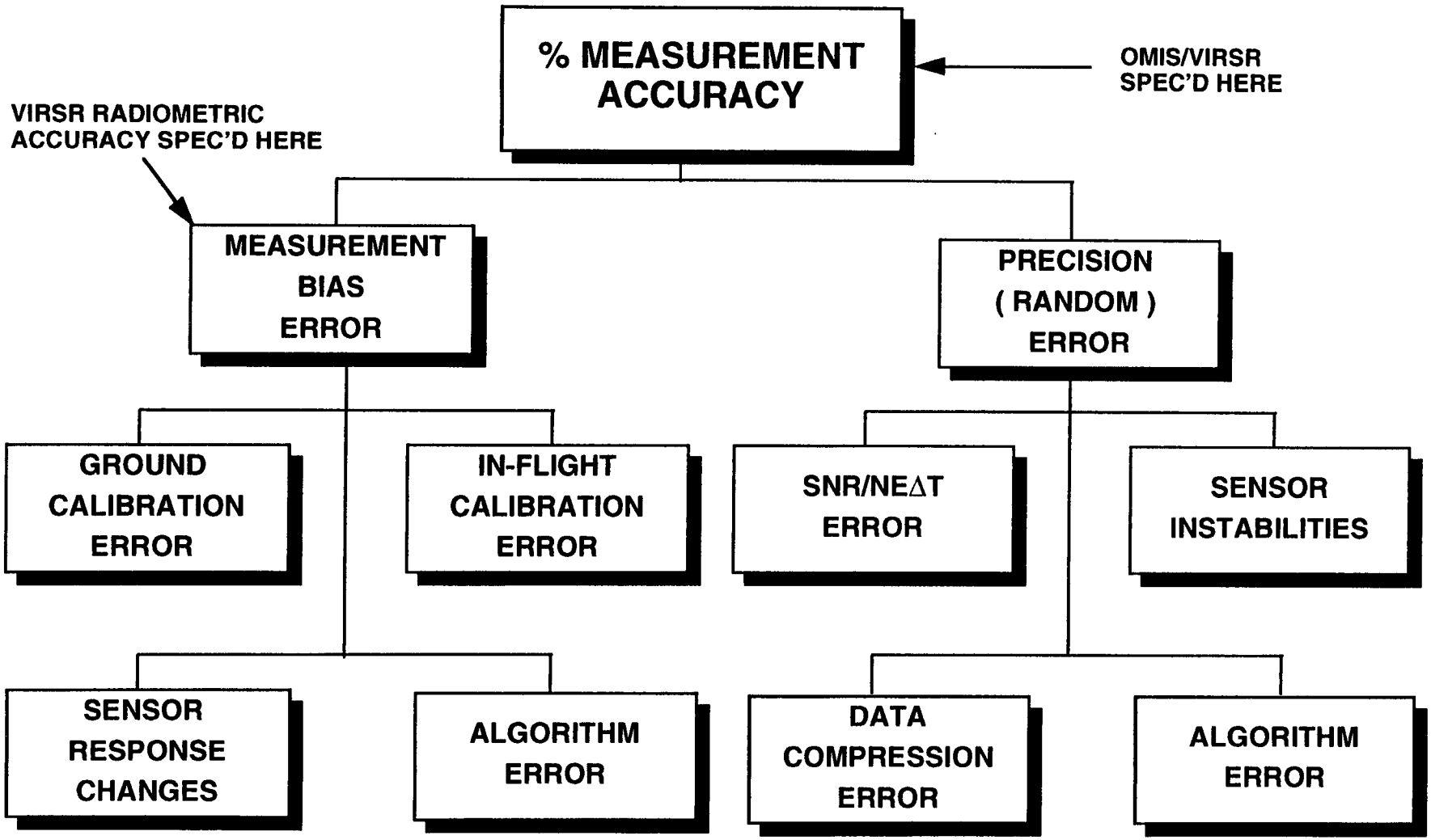
BAND	EDR LEVEL OMIS *	EDR LEVEL OMIS/VIRSR *	VIRSR LEVEL VIRSR **
1	7% (1-sig) @ 0.25% albedo	3% (1-sig) @ 0.25% albedo (Goal of 2%)	1.7% (1-sig) @ 100% albedo
2	7% (1-sig) @ 0.25% albedo	3% (1-sig) @ 0.25% albedo (Goal of 2%)	1.7% (1-sig) @ 100% albedo

* Includes RSS of ACCURACY AND PRECISION (REPEATABILITY) Error

** Includes only ACCURACY ERROR, REPEATABILITY IS 2%; RSS would be 2.6%
(NOTE: EXAMPLE, ACTUAL REPEATABILITY IS NOT KNOWN BY LMSC)

NOTE: AN OMIS/VIRSR SPEC OF 2.6% AT 100% ALBEDO IS COMPARABLE TO THE VIRSR SPECIFICATION, THE 3% AT 0.25% ALBEDO IS SIGNIFICANTLY MORE STRESSING

VISIBLE EDR ERROR BUDGET EXAMPLE



COMPARISON OF BASELINE TO COMMON OMIS CALIBRATION REQMNTS

	BASELINE OMIS	EQUIVALENT COMMON OMIS REQUIREMENTS		
BAND	ABSOLUTE ACCURACY REQUIREMENT (1-sigma)	PRECISION (1-sigma) END-OF-SCAN	CALIBRATION (1-sigma) END-OF-SCAN	ABS. ACCURACY (1-sigma) END-OF-SCAN
1	7%	SNR =10	3%	10.4% *
2	7%	SNR =10	3%	10.4% **
3	10%	SNR =10.5	3%	10.0%
7	17%	SNR =6	3.3%	17 % ***
4	0.85K @ 260K 1.0 K @ 240K	NEΔT =0.27K	1K @ 273 K	1K @ 273 K
5	0.3 K @ 270K 0.9 K @ 180K	NEΔT =0.09 K	1K @ 273 K	1K @ 273 K
6	0.3 K @ 270 K 0.9 K @ 180K	NEΔT =0.15K	1K @ 273 K	1K @273 K

* WITH A FACTOR OF 10X SIGNAL REDUCTION
** WITH A FACTOR OF 15.9X SIGNAL REDUCTION
*** WITH A FACTOR OF 4X SIGNAL INCREASE

COMPARISON OF OMIS/VIRSR TO VIRSR REQUIREMENTS

- OMIS/VIRSR VISIBLE SNR COMPARABLE TO VIRSR
  - VIRSR IS 20:1 @ 0.5% ALBEDO
  - OMIS IS 10:1 @ 0.25% ALBEDO
  - HOWEVER, AT THE EDGE OF SCAN OMIS/VIRSR HAS A SIGNIFICANTLY SMALLER IFOV 0.81 km vs >6.5 km
    - > MUST FACTOR THIS INTO SENSITIVITY COMPARISONS
    - > SAME APPLIES TO NADIR BUT IS NOT AS EXTREME

- OMIS/VIRSR NEΔT REQUIREMENTS ARE NOT EXPLICITLY STATED IN AF-05 ... LMSC SHOWED THE VALUES (PREVIOUS CHART)
  - OMIS/VIRSR SPECIFIED AT END-OF-SCAN ... VIRSR IFOV GROWS AT END OF SCAN TO MAINTAIN THE NEΔT
  - POTENTIAL FOR APPLES AND ORANGES WHEN COMPARING THE NEΔTs

- CALIBRATION LEVELS ARE SIGNIFICANTLY DIFFERENT AS INDICATED ON PREVIOUS CHART

TO DATE: OMIS/VIRSR REQUIRMENTS HAVE BEEN MORE STRESSING THAN VIRSR REQUIREMENTS SINCE THEY APPLY TO END OF SCAN WITH A MUCH SMALLER IFOV COMPARED TO VIRSR

TASK C

- EXAMINE DATA COMPRESSION EFFECTS ON PROCESSING RADIOMETRIC DATA FOR 8, 10, 12 BIT QUANTIZED DATA FOR THE OMIS/VIRSR
- DETERMINE IF ZERO NOISE CAN BE ACHIEVED FOLLOWING 2X2 OR 3X3 PIXEL SMOOTHING

NOTE: QUESTION WAS RAISED TO DEFINE "ZERO NOISE"
NO RESPONSE RECEIVED IN TIME FOR TIM

ZERO NOISE INTERPRETED BY LMSC TO MEAN THAT THE ROOT MEAN SQUARE ERROR (RMSE) = 0

DATA COMPRESSION PERFORMANCE MEASURES

- **ROOT MEAN SQUARE ERROR (RMSE)**

$$\mathrm{RMSE} = \left(\frac{1}{N^2} \sum_{i=1}^{N} \sum_{j=1}^{N} (g(i,j) - r(i,j))^2 \right)^{1/2}$$

- **SIGNAL-TO-NOISE RATION (SNR)**

$$\mathrm{SNR} = \left\{ \frac{\sum_{i=1}^{N} \sum_{j=1}^{N} g(i,j)^2}{\sum_{i=1}^{N} \sum_{j=1}^{N} (g(i,j) - r(i,j))^2} \right\}^{1/2}$$

LOSSLESS DATA COMPRESSION (8-BIT)

- CENTRAL PIXEL GIVEN BY EIGHT BIT REPRESENTATION
- ADJACENT PIXELS GIVEN BY DIFFERENCE FROM CENTRAL PIXEL

+110 +100

+010 10101010

- DUE TO HIGH CORRELATION BETWEEN ADJACENT PIXELS, LESS THAN EIGHT BITS ARE REQUIRED TO REPRESENT

METHOD PERMITS RECONSTRUCTION OF ORIGINAL SCENE WITH RMSE = 0 AND DATA COMPRESSION RATIOS OF ~2:1 FOR 2X2 "SMOOTHING" TECHNIQUES

3X3 "SMOOTHING" ALGORITHMS ARE NOT CURRENTLY IN USE AT LMSC REGARDLESS OF THE COMPRESSION RATIO

CONSTRAINED-LOSS DATA COMPRESSION

- ADJACENT PIXELS AVERAGED TO BECOME ONE PIXEL

243	241	240		
239	242	240	=	241
240	241	243		

- HIGHER DEGREE OF COMPRESSION THAN LOSSLESS, BUT CAN NOT RECONSTRUCT ORIGINAL SCENE WITHOUT ERROR

- ROOT MEAN SQUARE ERROR (RMSE) GIVEN BY:

$$RMSE = \{[1/N^2]\sum_{i=1}^{N}\sum_{j=1}^{N}(g(i,j) - r(i,j))^2\}^{1/2}$$

8-BIT INPUT IMAGE CONSTRAINED LOSS COMPRESSION

RMSE

COMPRESSION RATIO	BAND 1	BAND 2	BAND 4
2	0.274	0.342	0.151
4	1.409	1.532	1.146
8	2.404	2.547	2.149

SNR

COMPRESSION RATIO	BAND 1	BAND 2	BAND 4
2	133.4	116.1	749.9
4	26.0	26.0	98.9
8	15.3	15.7	53.1

10-BIT INPUT IMAGE CONSTRAINED LOSS COMPRESSION

RMSE

COMPRESSION RATIO	BAND 1	BAND 2	BAND 3	BAND 4	BAND 5
2	1.2	1.3	4.2	0.9	0.9
4	4.5	4.8	12.4	3.9	4.0

SNR

COMPRESSION RATIO	BAND 1	BAND 2	BAND 3	BAND 4	BAND 5
2	120.2	118.9	141.3	501.2	543.3
4	32.4	33.1	48.4	116.1	121.6

12-BIT INPUT IMAGE CONSTRAINED LOSS COMPRESSION

- ALGORITHMS NOT RUN FOR OMIS 12-BIT CASE
- PREVIOUS RESULTS OF ID STUDIES INDICATE ESSENTIALLY THE SAME OR SMALLER RMSE COMPARED TO 10-BIT DATA
- NO REASON TO EXPECT A PROBLEM AT 12 BITS

EXAMPLE OF RADIOMETRIC CONVERSION COUNTS TO RADIANCE UNITS

- LWIR DYNAMIC RANGE OF 180 -340K USING 10-BITS
  - 160K/1024 = 0.16K/COUNT
- PREVIOUS 10-BIT ERRORS FOR HIGH SNR (WORST CASE) WERE IN THE RANGE OF 4.5 COUNTS FOR 4:1 COMPRESSION RATIOS
  - WORST CASE OF 0.72K OF RANDOM ERROR
  - EXPECT <0.4 K AT LOWER SNRs

NOTE: FOR DATA COMPRESSION THE RMSE IN "COUNTS" IS DEPENDENT ON THE SIGNAL LEVEL, i.e.

- ADJACENT PIXELS OF HIGH SNR SCENES HAVE A LARGER NUMERIC DIFFERENCE .... BUT A SMALLER RATIO OF ERROR
- SCENES WITH LOWER SIGNAL LEVEL WILL HAVE NUMERICALLY SMALLER RMSE ... BUT ABOUT THE SAME OR WORSE RATIO OF ERROR TO ADJACENT PIXELS

SYSTEM CONSIDERATIONS OF THE USE OF DATA COMPRESSION

- DATA COLLECTED AT FINER RESOLUTION THAN REQUIRED FOR SOME EDRs HAS THE POTENTIAL TO HAVE EFFECTIVE COMPRESSION ERROR REDUCED
  - IMAGERY EDR A DRIVER FOR 0.65 km CONSTANT RESOLUTION
  - NOAA DATA COLLECTED AT > 6 km AT EDGE OF SCAN

- GROUND PROCESSING OF DATA AFTER DECOMPRESSION
  - COMBINING DATA INTO COARSER RESOLUTION CELLS WOULD REDUCE DATA COMPRESSION ERROR BY SQRT(#SAMPLES)
  - CONSTRAIN FINAL DATA PRODUCT RESOLUTION TO BE NO WORSE THAN CURRENT SYSTEM

- EXAMPLE USING PREVIOUS PAGE
  - AT EDGE OF SCAN APPROXIMATELY 10 X 3 SAMPLES INSIDE A 7 X 2.3 km FOOTPRINT
  - PREVIOUS RMSE FROM COMPRESSION WOULD DROP BY 5.5x
    - > IN MOST CASES THE EFFECTIVE RMSE < 1 COUNT FOR EITHER 8 OR 10 BIT COMPRESSION
  - FOR NADIR 2X2 SAMPLES (1.3X1.3 KM) WOULD GIVE 2X IMPROVEMENT ... EFFECTIVE RMSE= 2.25 COUNTS OR 0.35K

DATA COMPRESSION SUMMARY

- LOSSLESS DATA COMPRESSION AT ~2:1 COMPRESSION RATIOS HAS BEEN DEMONSTRATED WITH RMSE = 0

- CONSTRAINED LOSS COMPRESSION HAS BEEN CONSIDERED
  - 4:1 COMPRESSION RATIOS APPEAR REASONABLE AND CONSISTENT WITH INITIAL EDR ERROR BUDGETS
  - AT LMSC [redacted] COMPRESSION RATIOS HAVE BEEN DEMONSTRATED WITH NO VISUAL DEGRADATION ... RADIOMETRIC DEGRADATION DATA NOT AVAILABLE FOR THIS TIM

- DATA COMPRESSION <u>MUST BE CONSIDERED AT THE EDR LEVEL</u> ... NOT JUST AT THE SENSOR LEVEL.

- CONTINUE WORKING TO SHOW COMPRESSION RATIOS $\geq$ 4:1 ARE FEASIBLE FOR RADIOMETRIC DATA

MISS IMPACTS USING DISCRETE SOUNDERS (AMSU-A & MHS)

- M. DAVIS

MICROWAVE TASK OBJECTIVE AND SOUNDING REQUIREMENTS

OBJECTIVE IS TO EXAMINE IMPACTS TO DMSP COVERAGE AND EDR PERFORMANCE REQUIREMENTS AND DETERMINE PHYSICAL IMPACTS OF REPLACING MISS SOUNDING CAPABILITY WITH AMSU-A & MHS

DMSP-6 SOUNDING REQUIREMENTS

> 89% COVERAGE FOR ADJACENT SWATHS (100% COVERAGE GOAL)

VERTICAL TEMPERATURE PROFILE

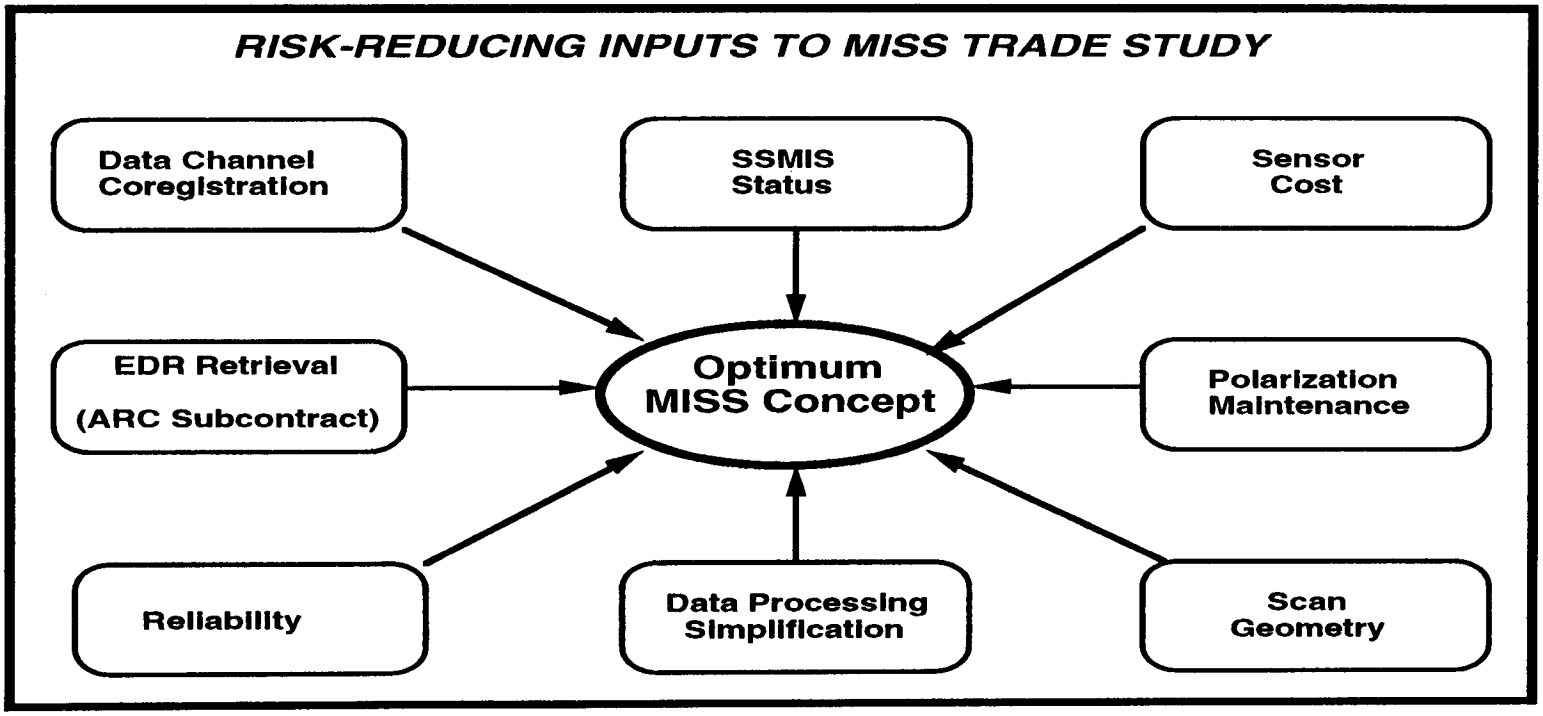
- 50 km SPOT SIZE AND SAMPLING INTERVAL
- RETRIEVE AT LEVELS OF 1000, 850, 700, 500, 400, 300, 250, 200, 150, 100, 70, 50, 30, 20, 10, 7, 5, 2, 1, 0.4, 0.2, 0.1, AND 0.03 mb
- 1°K BIAS REQUIREMENT
- RMS ACCURACIES: 5K @ 1000 mb, 3K @ 850 mb, 2K @ 700 to 10 mb, 5K @ 5 to 0.2 mb, 7K (goal) @ 0.1 to 0.03 mb, 5K temperature of tropopause

VERTICAL MOISTURE PROFILES

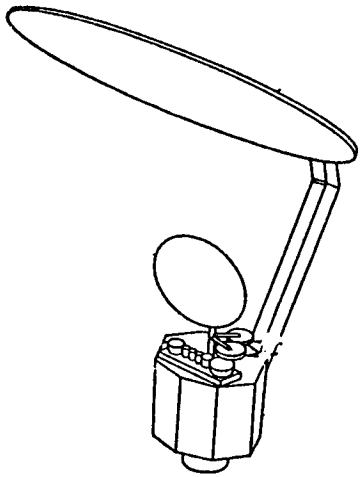
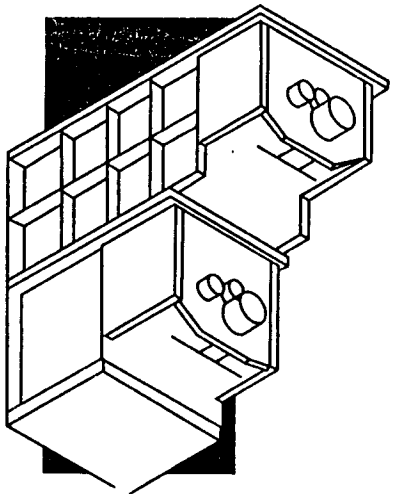
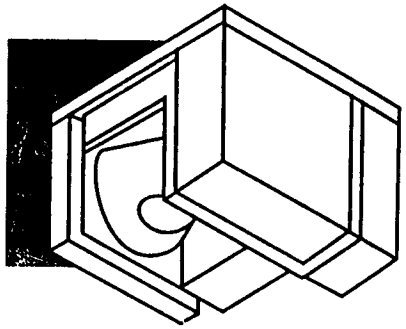
- 50 km SPOT SIZE AND SAMPLING INTERVAL
- RETRIEVE RELATIVE / SPECIFIC HUMIDITY AT 1000, 850, 700, 500, 400 and 300 mb
- RETRIEVE TOTAL WATER VAPOR MASS IN LAYERS BETWEEN ABOVE LEVELS
- NOT REQUIRED IN / BELOW CLOUDS WITH LIQUID WATER CONTENT > 0.15 kg/m2
- 20% MEASUREMENT ACCURACY OVER OCEAN, 35% OVER LAND

MICROWAVE IMAGER / SOUNDER SUITE (MISS) CONFIGURATION TRADE STUDY

- OPTIMUM MISS HAS BEEN STUDIED SINCE 1990
- MISS CONCEPTS UNDER CONSIDERATION INCLUDE:
  - INTEGRATED CONICALLY-SCANNED SENSOR (CURRENT BASELINE)
  - CONICALLY SCANNED SENSOR FOR IMAGERY, NADIR SCANNING SENSOR(S) FOR TEMPERATURE / MOISTURE SOUNDING



6 MISS / AMSU-A / MHS OVERVIEW

SENSOR	Microwave Imager Sounder Suite (MISS)	Advanced Microwave Sounding Unit - A (AMSU-A)	Microwave Humidity Sounder (MHS)
			
Sensor Type	Conical (80 in reflector)	Nadir (two 5.9 in reflectors) (one 12 in reflector)	Nadir (one 9 in reflector)
Coverage	100 % (70° incidence)	81% (56 deg incidence at scan edge)	81% (56 deg incidence at scan edge)
Sounding Function	Temperature and Moisture	Temperature	Moisture
Sounding Depth	Temp: 0 to 70 km Moisture: 0 to 10 km	0 to 47 km	0 to 10 km
Sounding Footprint	50 km	50 km nadir 86 x 172 km edge of scan	15 km nadir 26 x 52 km edge of scan

MICROWAVE TEMPERATURE SOUNDERS

THE DMSP-6 MISS OFFERS TEMPERATURE SOUNDING TO 73 km ALTITUDE AT 50 km RESOLUTION WITH CONTIGUOUS COVERAGE ON SUCCESSIVE ORBITS

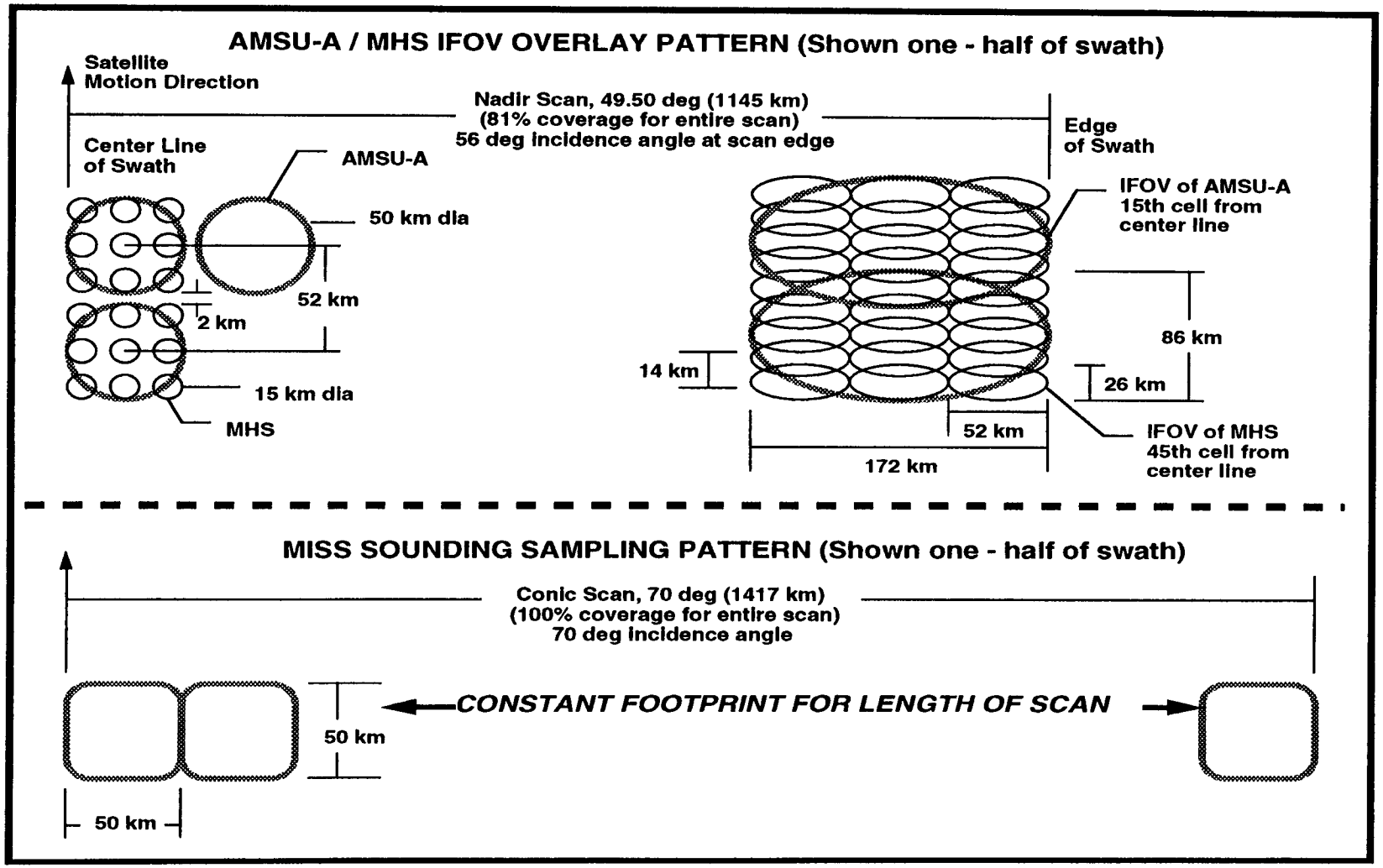
SENSOR	SSM/T	MSU	AMSU-A	SSMIS	MISS
PROGRAM	DMSP 5D-2	NOAA E-J	NOAA K-M EOS am/pm	DMSP 5D-3	DMSP-6 Converge
SENSOR TYPE	Nadir	Nadir	Nadir	Conical	Conical
# SOUNDING CHANNELS	7	4	15	18	20
ALTITUDES SOUNDED	< 30 km	< 21km	< 47 km	< 73 km	< 73 km
FOOTPRINT	186 km @ nadir	109 km @ nadir	50 km @ nadir	38 - 75 km	50 km
SWATH	1257 km	1988 km	2290 km	1707 km	2834 km
COVERAGE	44%	70%	81%	60%	100%

MICROWAVE MOISTURE SOUNDERS

THE DMSP-6 MISS OFFERS MOISTURE SOUNDING AT 50 km RESOLUTION WITH CONTIGUOUS COVERAGE ON SUCCESSIVE ORBITS

SENSOR	SSM/T2	MHS	SSMIS	MISS
PROGRAM	DMSP 5D-2	NOAA K-M EOS am/pm	DMSP 5D-3	DMSP-6 Converge
SENSOR TYPE	Nadir	Nadir	Conical	Conical
# SOUNDING CHANNELS	6	5	5	5
ALTITUDES SOUNDED	< 6 km	< 6 km	< 9 km	< 9 km
FOOTPRINT	46.5 km @ nadir	15 km @ nadir	38 km	50 km
SWATH	1596 km	2290 km	1707 km	2834 km
COVERAGE	56%	81%	60%	100%

AMSU-A, MHS & MISS SOUNDING FOOTPRINT COMPARISON @ 833 km ALTITUDE



CHANNEL CHARACTERISTICS OF MISS, AMSU-A & MHS

Center Frequency of Channel (GHz)	# of MISS Passbands	# of AMSU-A Passbands	# of MHS Passbands	Center Frequency of Channel (GHz)	# of MISS Passbands	# of AMSU-A Passbands	# of MHS Passbands
19.35	2	0	0	f7+ (+0.105), f9+ (-0.105)	2	0	0
23.8	1	1 (AMSU-A2)	0	f7+ (-0.056, +0.048), f9+ (+/-0.048)	4	0	0
31.4	0	1 (AMSU-A2)	0	f7+ (+/-0.022), f9+ (+/- 0.022)	4	0	0
37	2	0	0	f7+ (+/-0.010), f9+ (+/-0.010)	4	0	0
50.3	0	1	0	f7+ (-0.0045), f9+ (+0.0045)	2	0	0
51.76	1	0	0	f7+ (-0.0021), f9+ (-0.0021)	2	0	0
52.8	1	1	0	f7+ (+/-0.001)	2	0	0
f25- (+/- 0.115)	2	2	0	f7+, f9+	2	0	0
54.5	1	1	0	f7+ (+0.001), f9+ (+0.001)	2	0	0
54.94	1	1	0	f7+ (+0.0021), f9+ (+0.0021)	2	0	0
55.5	1	1	0	f7+ (+0.0032), f9+ (+0.0032)	2	0	0
56.02	2	0	0	89	0	1	0
f10	0	1	0	89 +/- 0.9	0	0	2
f10 (+/-0.217)	0	2	0	91.65	2	0	0
f10 (+/-0.3222 +/- 0.048)	0	4	0	150 +/- 0.9	1	0	2
f10 (+/-0.3222 +/- 0.022)	0	4	0	170	1	0	0
f10 (+/-0.3222 +/- 0.010)	0	4	0	183.31 +/- 1.00	0	0	2
f10 (+/-0.3222 +/- 0.0045)	0	4	0	183.31 +/- 3.00	2	0	2
60.793	1	0	0	183.31 +/- 7.00	2	0	2

CHANNEL DETAILS:

f25- (53.596 GHz)

f10 (57.290344 GHz)

f7+ (60.43478 GHz - delta 0)

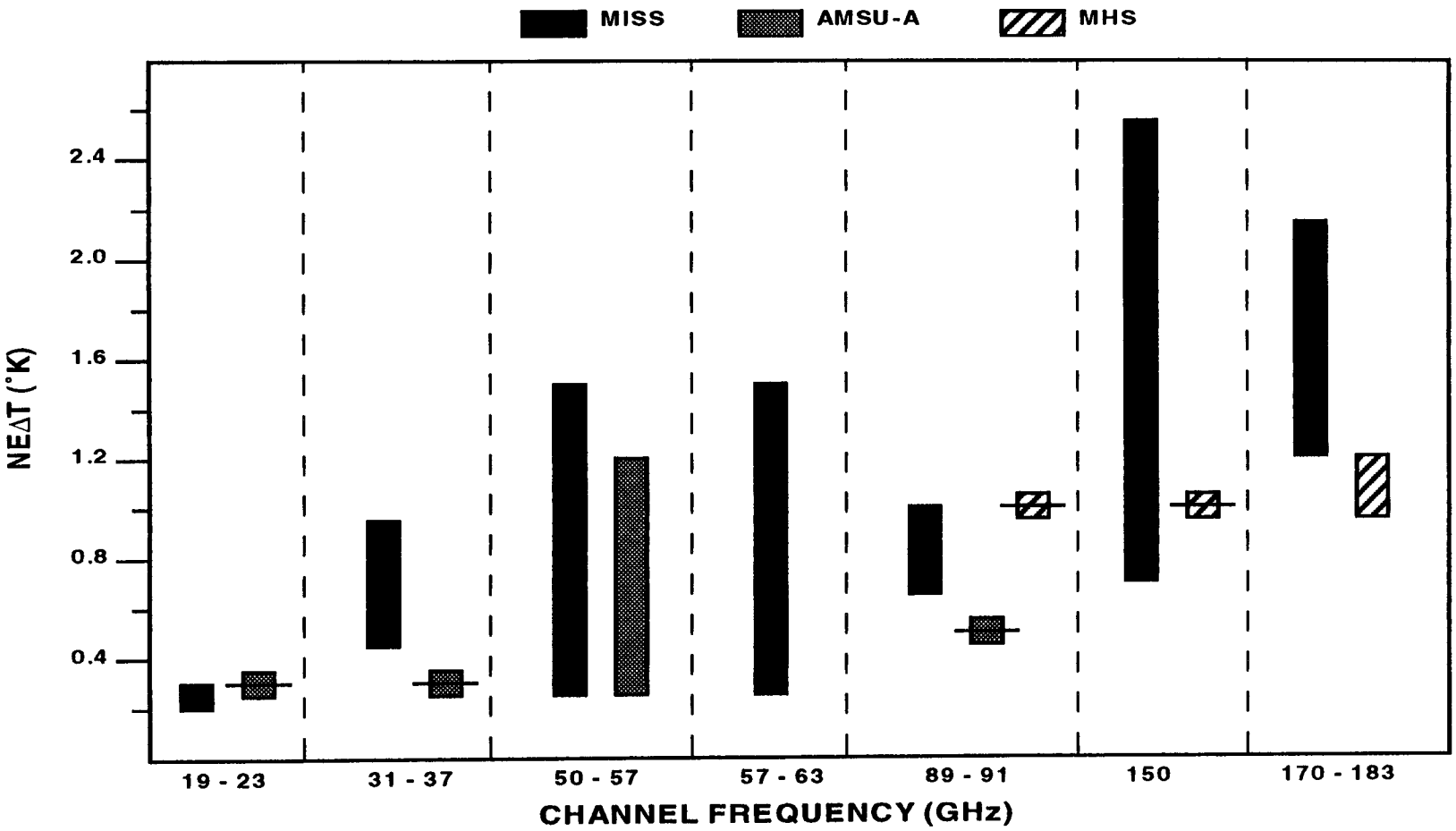
f9+ (61.15056 GHz - delta 0)

delta 0 = doppler shift at center of scan

MISS SOUNDING
- CHANNEL SELECTION RATIONALE -

- o WEIGHTING FUNCTIONS SHIFT UPWARDS AS INCIDENCE ANGLES INCREASED
- o 51.76 GHz CHANNEL ADDED TO FILL GAP THAT OPENS BELOW 52.8 GHz AT HIGH INCIDENCE ANGLES
- o MISS STRATOSPHERE CHANNELS MOVED TO 7+ AND 9+ LINES (SAME LINES AS MESOSPHERE CHANNELS). ONLY ONE HIGH-STABILITY OSCILLATOR REQUIRED, (SIMPLIFIES DESIGN, ENHANCES DESIGN LIFE). SINCE LINES ARE STRONGER, STRATOSPHERE WEIGHTING FUNCTIONS MOVE UP IN ATMOSPHERE, 56.020 GHz CHANNEL ADDED TO FILL RESULTING GAP.
- o 170 GHz CHANNEL REPLACES 183+/-1 GHz CHANNEL AS INCREASED INCIDENCE ANGLE SHIFTS WEIGHTING FUNCTION UPWARDS

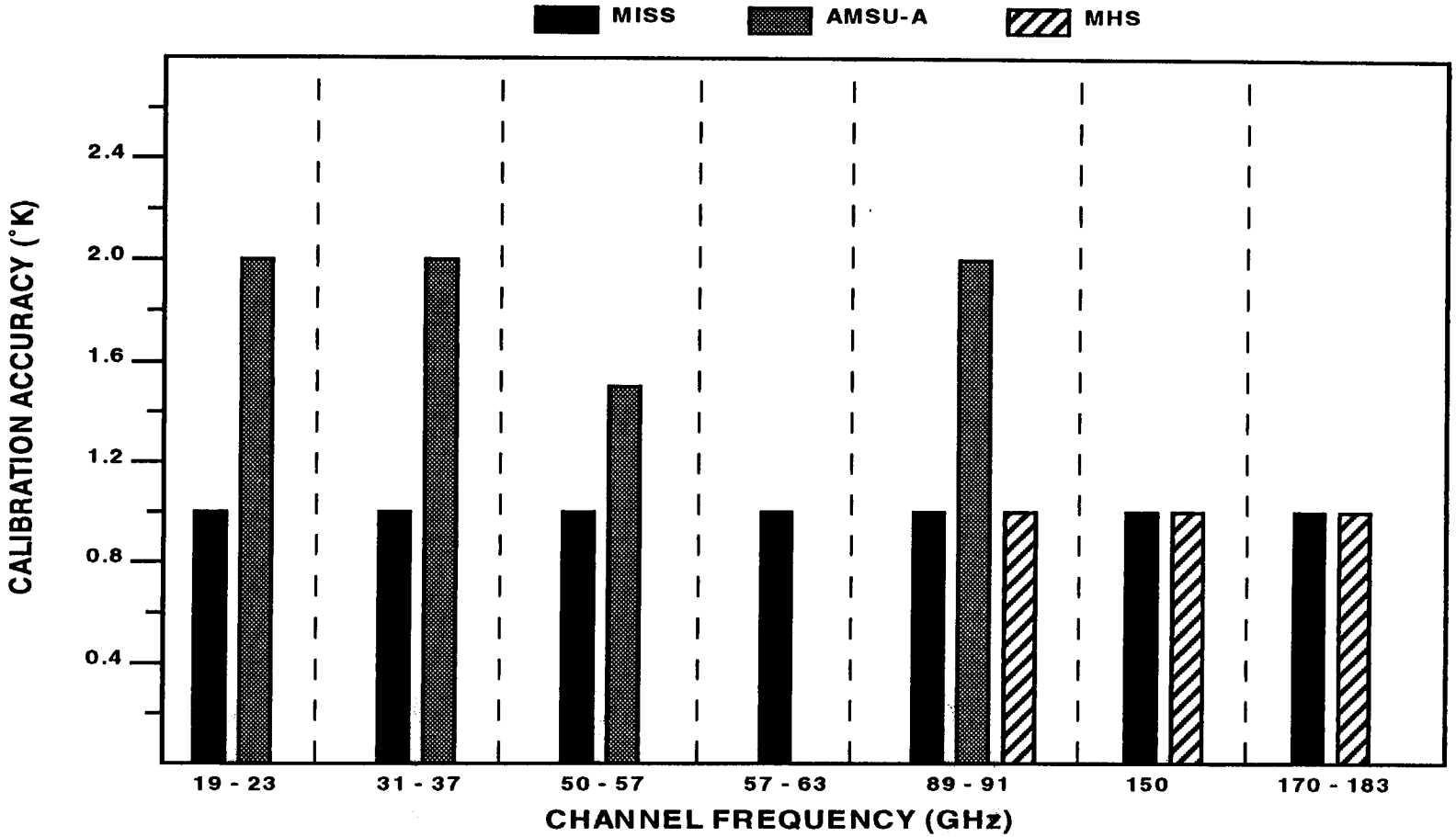
NEΔT VALUES FOR MISS, AMSU-A & MHS



NOTE: MISS values represent a performance range based on receiver design, AMSU and MHS characteristics based on instrument specifications

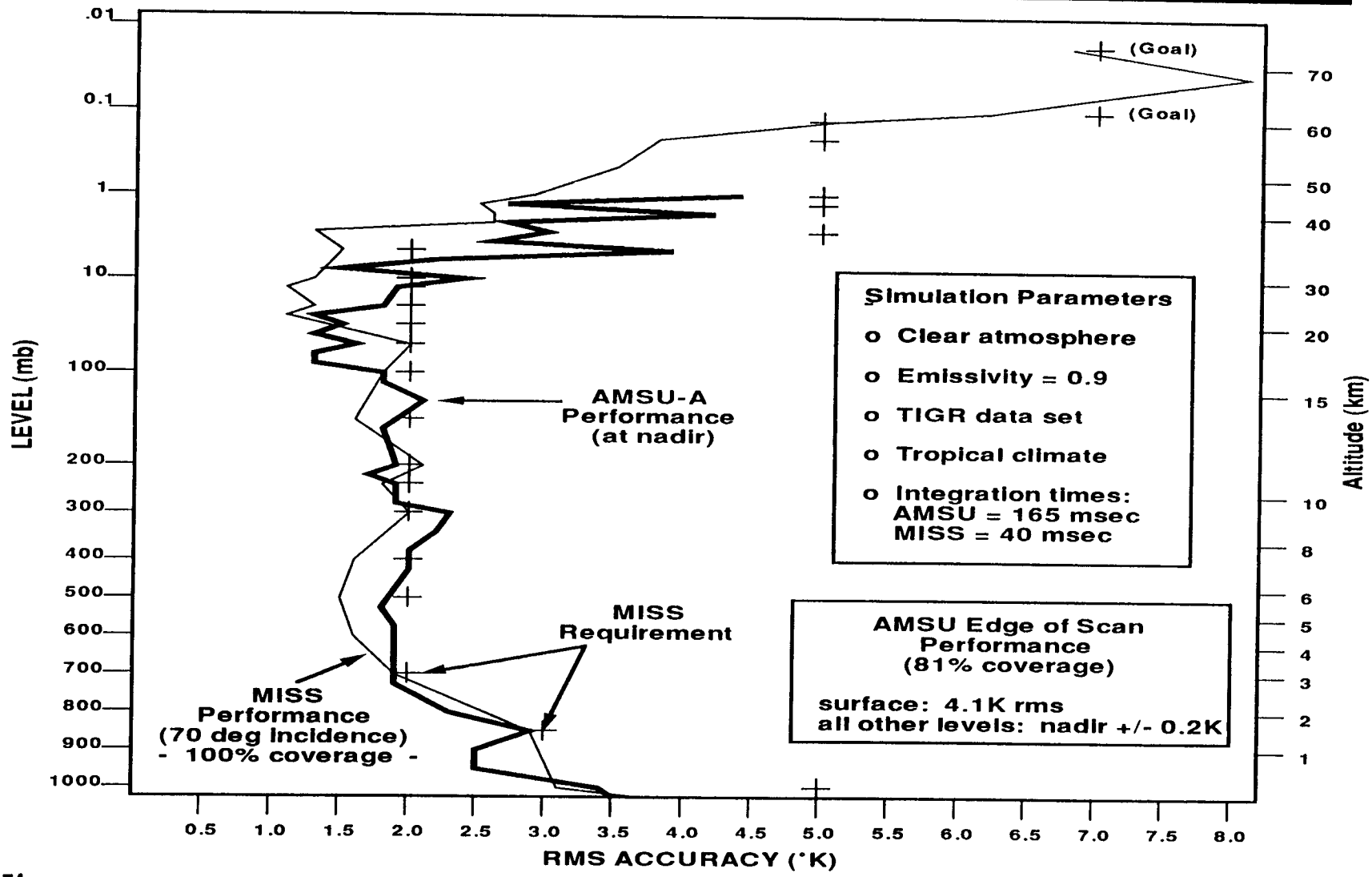
2/9/94
TIM 3

MICROWAVE SENSOR CALIBRATION ACCURACIES



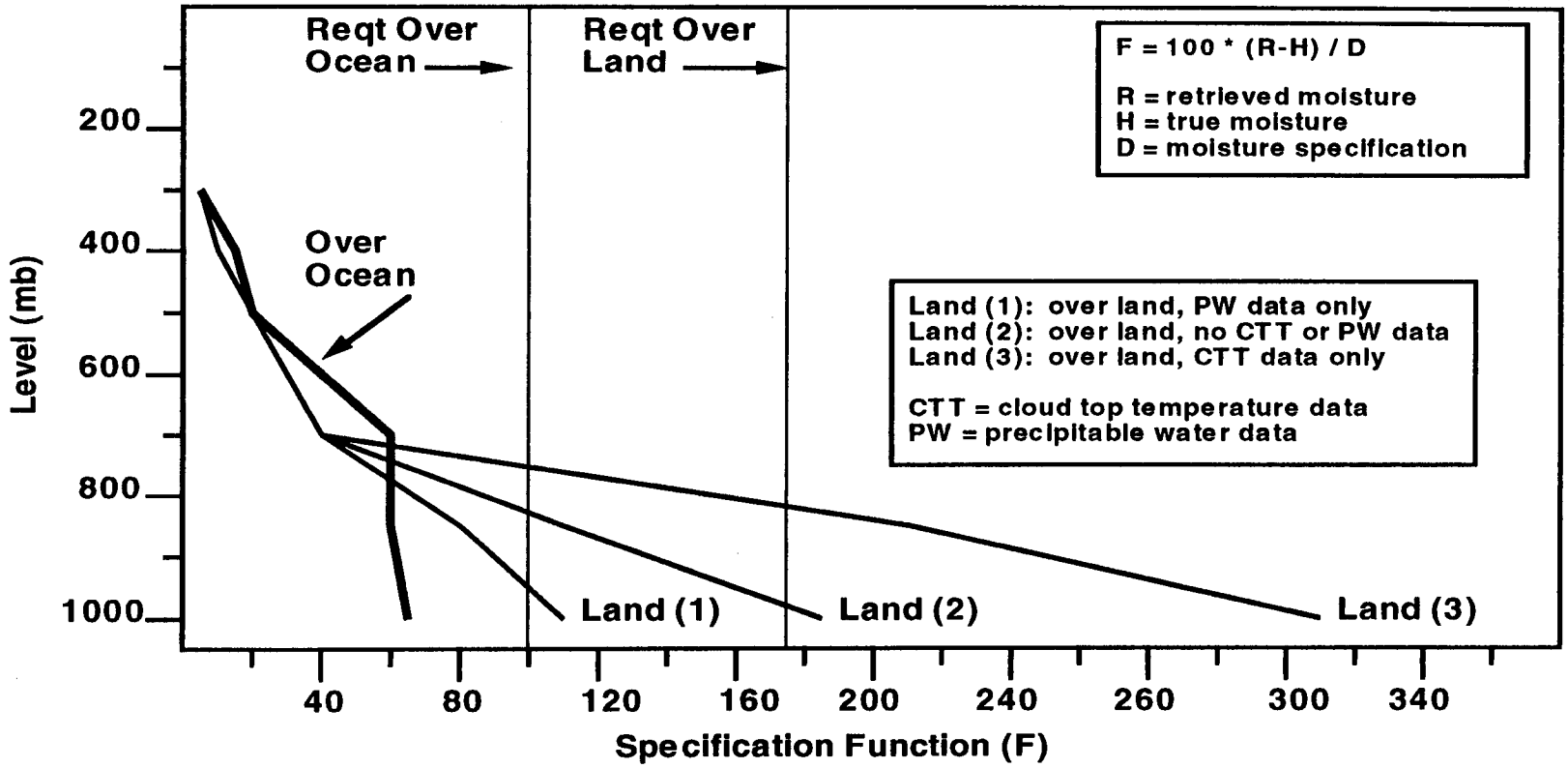
NOTE: Calibration accuracies based on instrument specifications

6 MISS / AMSU TEMPERATURE PROFILE RETRIEVAL COMPARISON



MISS MOISTURE PROFILE RETRIEVAL PERFORMANCE

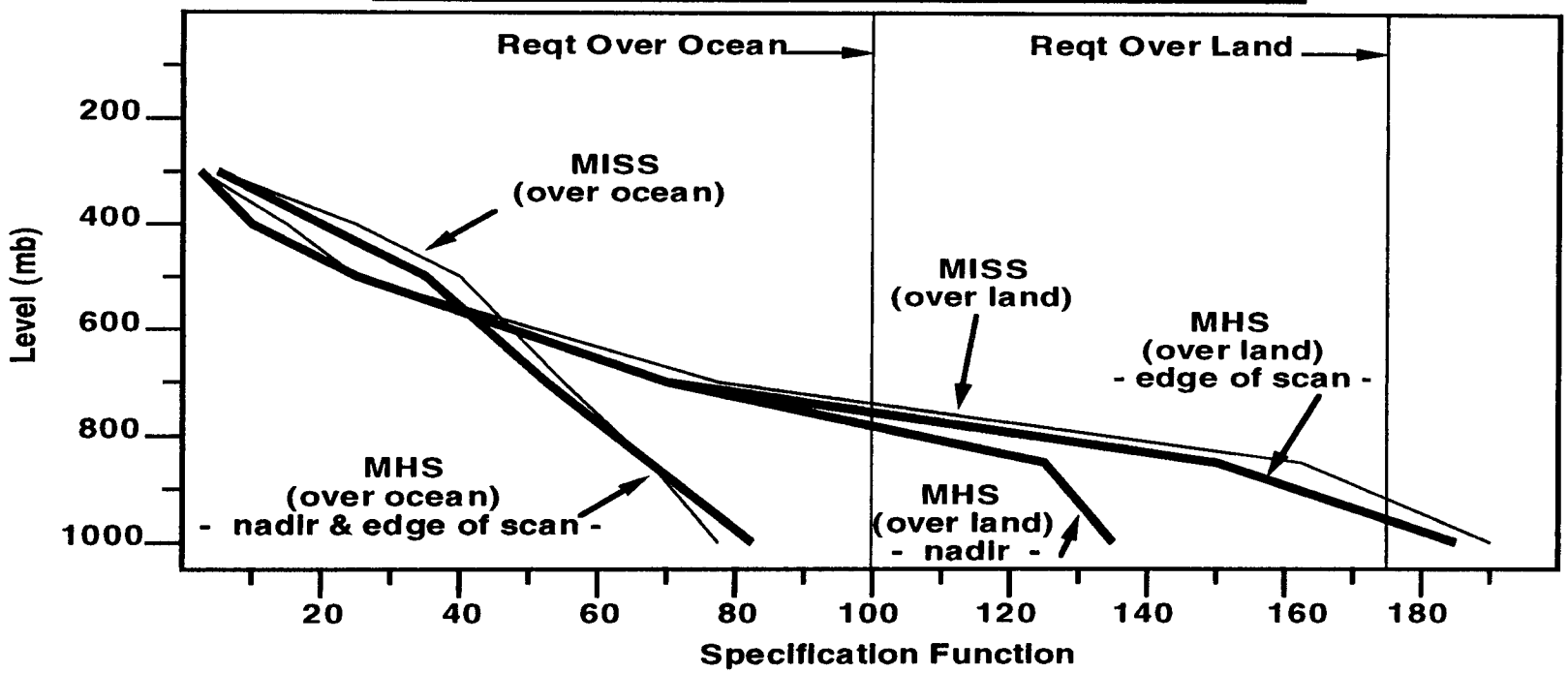
MISS moisture profile retrieval simulations indicate that performance specification can be met over ocean even with large temperature profile errors. Performance specification over land can be met for large temperature profile errors by utilization of precipitable water data



ASSUMPTIONS: 5°K temperature error, dry RAOB set, conical scan
70° incidence angle (100% coverage)

MISS / MHS MOISTURE PROFILE RETRIEVAL CAPABILITY COMPARISON

Simulations use cloudy radiosonde data set normalized to 15 mg/cm^{-2} cloud liquid water content



NOTE:
- MHS edge of scan = 81% coverage
- MISS data for 70 deg incidence (100% coverage)
- Assumes no temperature profile error
- No cloud top temp or precipitable water data
- With PW data, MHS performance improvement similar to MISS performance improvement

COMPARISON OF MISS / AMSU / MHS PHYSICAL CHARACTERISTICS

SENSOR	MISS	AMSU-A1	AMSU-A2	MHS	AMI**
SIZE (in)	80.3 x 20*	29 x 13 x 24	25 x 30 x 27	30 x 39 x 14	80.3 x 20*
REFLECTOR SIZE (in)	80.3	5.9	12	9	80.3
WEIGHT (lb)	227	132	110	146	209
POWER (w)	111	88	37	85	87
DATA RATE (bps)	38696	2100	1100	4200	16460
DESIGN LIFE (yrs)	7	3	3	3	7

NOTES:
* Conical scanner, first dimension is reflector diameter, second dimension is drum diameter, assume cube-shaped d
** AMI is similar to the MISS except that the temperature sounding channels are not present, moisture sounding channels are present to conform to DMSP-6 cloud imagery requirement

MISS / AMSU / MHS COST COMPARISON

	RELATIVE COST (1986 $)	
SENSOR	Non-Recurring Costs	Recurring Costs
MISS	7.0	26.4
AMSU-A1	1.4	25.0
AMSU-A2	1.0	20.1
MHS	2.6	21.4
AMI	2.1	17.1

Note: Recurring costs are for total of 5 flight units

MISS / AMSU / MHS COMPARISON - SUMMARY AND CONCLUSIONS -

- o AMSU-A DOES NOT MEET SEVERAL DMSP-6 TEMPERATURE SOUNDING REQUIREMENTS:
  - ONLY PROVIDES 81% COVERAGE (89% REQUIRED, 100% GOAL)
  - LACKS MESOSPHERE SOUNDING CAPABILITIES
  - 50 km RESOLUTION MET ONLY NEAR NADIR (DEGRADES TO 172 km AT SCAN EDGE)
- o MHS MEETS MOST DMSP-6 MOISTURE SOUNDING REQUIREMENTS
  - ONLY PROVIDES 81% COVERAGE (89% REQUIRED, 100% GOAL)
- o SIMULATIONS HAVE SHOWN THAT AMSU / MHS / MISS SOUNDING PERFORMANCE IS SIMILAR
- o MISS HAS 7 YEAR DESIGN LIFE, AMSU-A AND MHS HAVE 3 YEAR DESIGN LIFE
- o SIGNIFICANT COST INCREASE INCURRED BY REPLACING MISS SOUNDING CAPABILITY WITH AMSU-A AND MHS

AMSU - A & MHS USER REQUIREMENTS INSIGHT IS NEEDED TO COMPARE MISS / AMSU / MHS CAPABILITY. NOAA TIM IS SUGGESTED TO ADDRESS THIS ISSUE.

LOW COST DRR CONCEPT TRADE

(Configuration D)

C3 SEGMENT ANALYSIS & REQUIREMENTS DEFINITION

- R. NELSON

DMSP / NOAA CONVERGED C3 ANALYSIS

DRY CONCEPT DEVELOPMENT

- DERIVED CONFIGURATION - D - C3 REQUIREMENTS
- ASSESSED REQUIREMENTS IMPACTS ON AF06 BASELINE DRY ELEMENT

AF06 DRR TRADE & OPTIMIZATION

- ESSENTIAL FOR DEFINITION OF CONVERGED C3 SEGMENT
- AN OPTIMIZED C3 REDUCES LCC

  - IDENTIFIED LOWEST COST DRR
  - COMPLETE KTA ANALYSIS FACTORS DRR SOLUTIONS

- KEY INPUTS FOR OPERATIONS CONCEPT DEVELOPMENT

DMSP / POES CONVERGED REQUIREMENTS

PARAMETER	REQUIREMENT
Orbit Type	Circular Sun-Synchronous
Orbit Altitude	450 nmi (833 km)
Orbit Inclination	98.7 deg
Orbit Period	101.6 min
Nodal Crossing Time	0530, 0930, 1330 (2)
Satellite Operations Center	SUITLAND, MD. with FALCON AFB backup
Data Routing & Retrieval (DRR) Element	AFSCN - Thule, Hawaii, New Hampshire, Vandenberg AFB, Oakhanger (Modified AFSCN - Thule, New Hampshire, Fairbanks, Oakhanger)
Failures	No single point failures or failure propagation.
Safemode	Place vehicle in a comm, power, and thermal protective attitude
Growth Margin	TBD
Autonomy	60 days
Survivability	System Threat Assessment Report (STAR)

DMSP / POES CONVERGED DATA LINKS

PARAMETER	CONVERGED C3 REQUIREMENTS
DOMSAT LINK BETWEEN	Suitland, Md. with Falcon AFB backup & AFSCN (Thule, Hawaii, New Hampshire, Vandenberg Oakhanger)
RF LINKS	
• Command Uplink	1792 MHz / 1.0 Kbps
• Stored Mission Data	3 - 100 MHz X-band links - 90 Mbps (Encrypted)
• Beacon	SGLS
• Real Time Downlink (LRPT)	137 - 138 MHz / 72 Kbps (Encryption Capable)
• Real Time Downlink (HRPT)	S-band / 3.5 Mbps (Encryption Capable)
• Large Tactical Terminal	S-band / 1.024 Mbps
• Small Tactical Terminal	UHF / 88 Kbps(Encrypted)
• SDC (DCS) Uplink	TBD / 400 Bps. (1 Kbps in SMD)
• SAR Links	Uplink (121.5, 243, & 406 / 0.4 Mbps) Downlink (1544.5 MHz / 2.4 Mbps)

CONVERGED C3 DERIVED REQUIREMENTS

PARAMETER	REQUIREMENT	DERIVED REQUIREMENT
Configuration	On Board Sensor Data Rate by configuration	On Board Sensor Data Rate with 15% overhead
D1	4.55 mbps	5.2 mbps
D2 (EUMETSAT)	4.58 mbps	5.3 mbps
D3	5.89 mbps	6.8 mbps
D4 (EOS)	6.55 mbps	7.5 mbps
Mission Data Storage	Data for 2 orbits	82.6 Gb (91.8 with D4)
Mission Data Offload	Data for 1 orbit	
D1	27.7 Gb	31.8 Gb
D2	27.9 Gb	32.1 Gb
D3	35.9 Gb	41.3 Gb
D4	39.9 Gb	45.9 Gb
SMD Downlink	X-Band	7.455 GHz (TBR)
Data Rate (8.5 min contact without gaps))	Data for 1 orbit	90 mbps
Downlink Sites	5 RTS	TTS, HTS, NTS, VTS, OTS (TBR)
Timeliness	Data products in 120 min avg.	Central EDR processing <19 min.
Data Format	CCSDS and Non-CCSDS	TBD

CONVERGED C3 ELEMENT FUNCTIONS

COMMAND, CONTROL, & COMMUNICATION SEGMENT C3

REMOTE TRACKING SYSTEM (RTS / CDA)

- Tracking
- Range / Timing
- **Acquisition**
- Ephemeris Generation (via GPS)

DATA ROUTING & RETRIEVAL (DRR)

- **Mission Data Routing**
  - **Stored**
  - **Realtime**
- **Equip. Status & Telemetry**
- **Commands & Stored Program Upload**

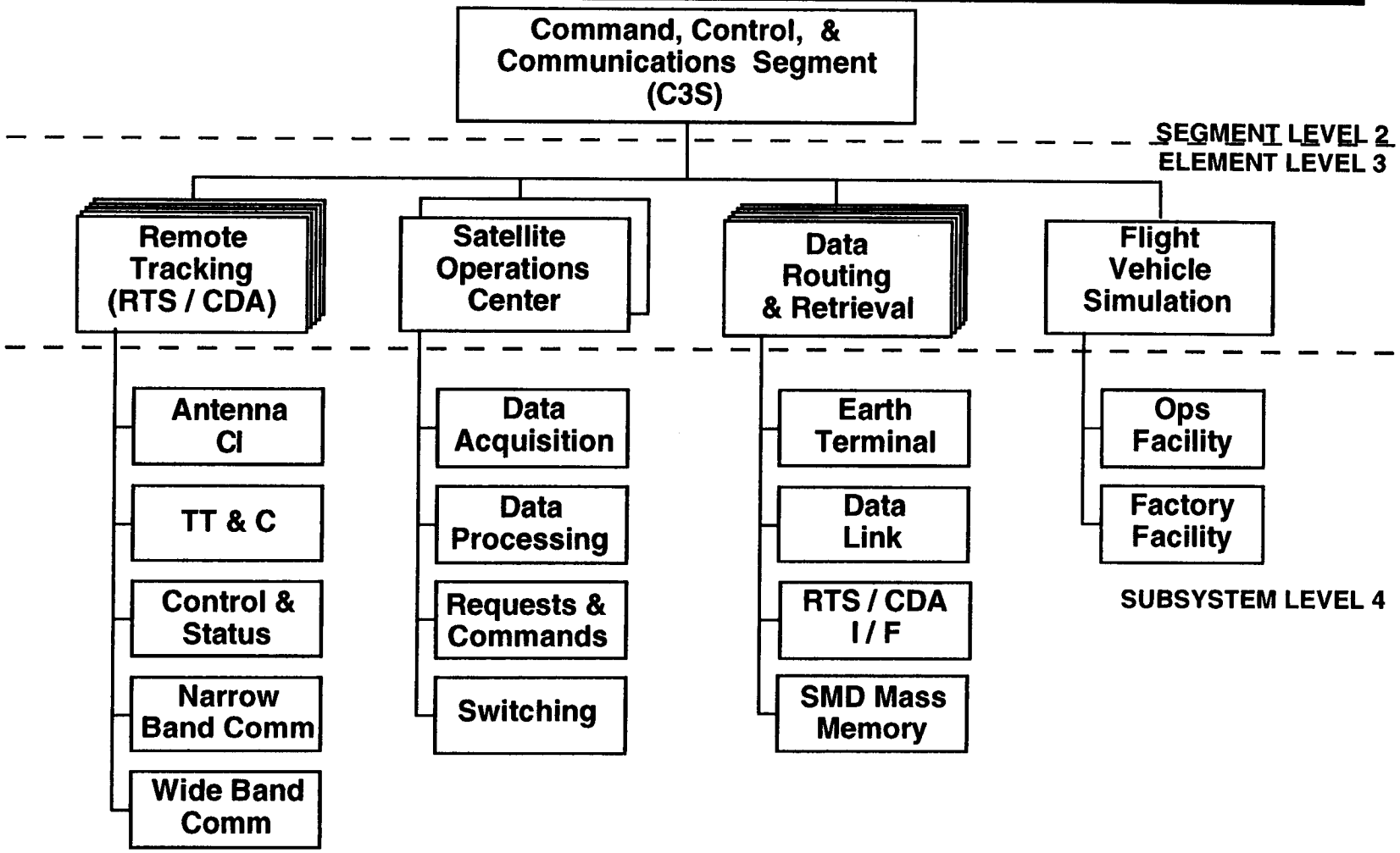
SATELLITE OPERATIONS CENTER (SOC)

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

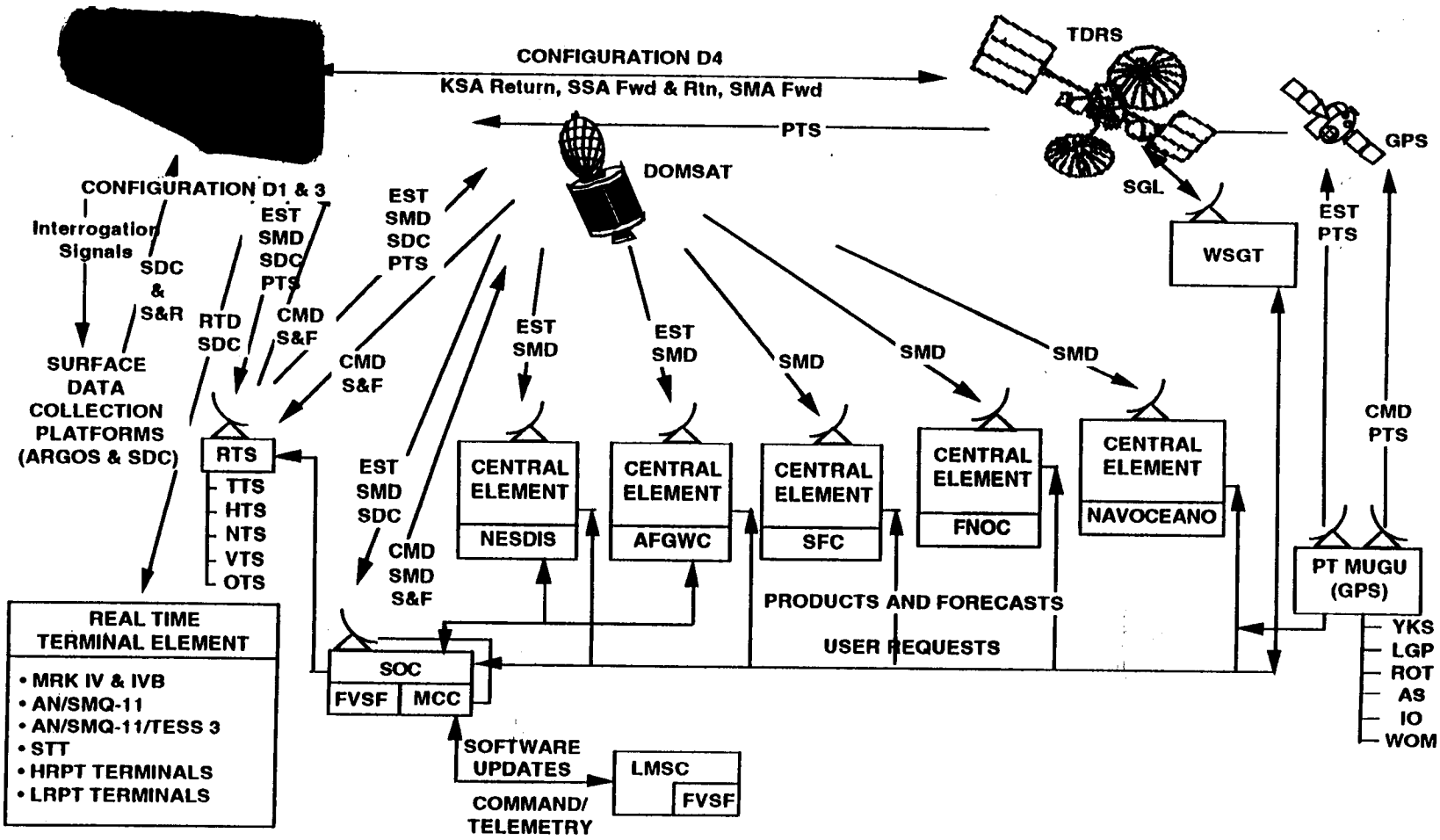
FLIGHT VEHICLE SIMULATION FACILITY (FVSF)

- S/C Enviro. Simulation
- Uplink/Downlink I/F Validation
- Flight Load Package Validation

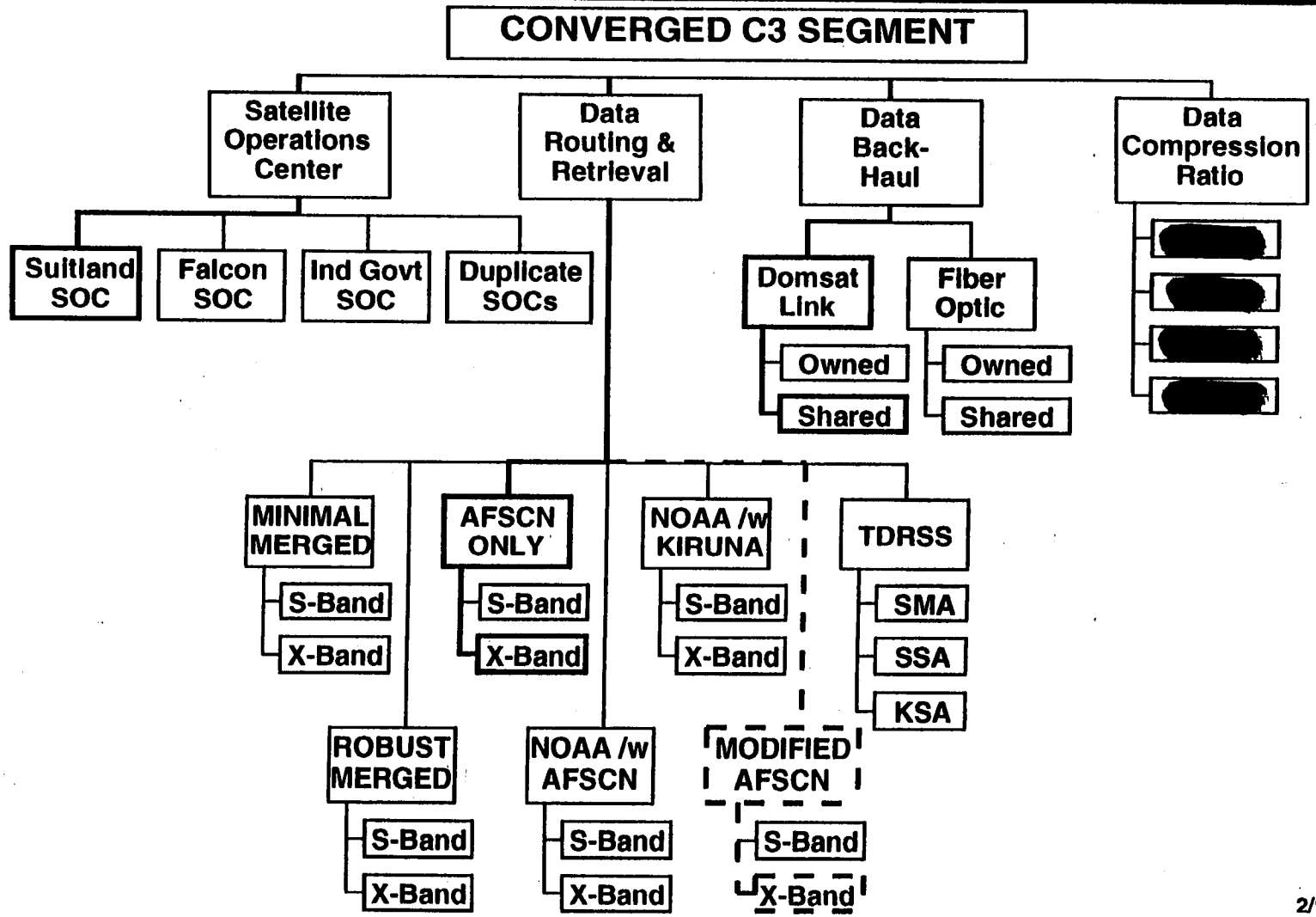
CONVERGED C3 SEGMENT HIERARCHY



CONVERGED SYSTEM CONCEPT



CONVERGED C3 TRADE TREE



DMSP / NOAA CONVERGED DRR ALTERNATIVES

OPTIONS	1	2	3*	4**	5	6***	7
Description / RTS /CDA Location	Minimal Merged System	Robust Merged System	AFSCN Only	NOAA w/ AFSCN Backup	NOAA w/ Foreign Backup	Converged GEO Crosslink	Modified AFSCN Option
Thule	X	X	X	X			X
New Hampshire			X				X
Hawaii			X				
Oakhanger			X				X
Vandenberg or Falcon			X				
Fairbanks	X	X		X	X		X
Wallops Island				X	X		
Kiruna or Tromsoe		X			X		

ANALYSIS ASSUMPTIONS

- Timeliness requirement for all data is 120 min. avg. to central sites
- CDA sites previously upgraded for EOS IOC
- DRR element sized to receive 3 SMD links simultaneously
- 3 - 100 MHz X-Band channels for S / C SMD links
- DRR backup for EUMETSAT & EOS (D2 & D4)

DRR TRADE FACTOR SCORING DEFINITIONS

DECISION CRITERIA	CRITERIA DEFINITIONS		
	SIGNIFICANT IMPACT (1-4)	MODERATE IMPACT (5-7)	LOW IMPACT (8-10)
Hardware cost	Replace equipment	Upgrade existing hardware	Existing or planned upgrade
S / C TT&C - C&DH	Change baseline	Baseline adequate	Baseline exceeds capability
Timeliness	Exceeds 120 min.avg.	Meets 120 min. avg.	<120 min. avg.
Coverage	< 8 min without gaps	8 min without gaps	>8 min without gaps
O & M cost	>$60 M	>$30 M	<$30 M
Interface complexity	Multiple interfaces	Duplicate interfaces	No dual capability required
Availability	No support guarantee	No backup support	No conflicts
5D & NOAA transition	Full dual capability	Reduced dual capability	Single capability
Security	International sites	Civil sites	DoD sites
No. of DOMSAT links	>2	2	1
Schedule impact	Multiple critical paths	Upgrade non-govt facilities	Low risk to schedule

DRR TRADE RESULTS

Boxes Failed "must" criteria

Parameter	Weight	Minimal System	Robust System	AFSCN	NOAA w/ AFSCN Backup	NOAA /w Foreign Backup	TDRSS Crosslink	MODIFIED AFSCN
Hardware cost	8	64	64	8	64	80	72	40
S / C TT&C - C&DH	5	20	45	35	20	40	50	45
Timeliness	9	9	45	81	9	45	90	72
Coverage	10	10	90	60	10	80	100	90
O & M cost	8	64	48	24	56	56	72	40
Interface complexity	4	24	24	12	24	36	36	20
Availability	9	45	54	72	72	72	0	81
Data loading 3 S/C	6	60	60	60	60	60	60	60
5D & NOAA transition	6	30	30	42	18	42	60	30
Foreign stations	6	60	18	60	60	24	60	60
Security	6	48	30	60	42	30	60	60
No. of DOMSAT links	8	56	56	40	56	56	80	32
Schedule impact	5	40	35	30	40	35	40	35
TOTAL		530	599	584	531	656	780	665

DRR DATA ROUTING EQUIPMENT LIST (1 of 2)

ITEM NAME OR MODEL NUMBER	MAKE or BUY	TTS	NTS	VTS	HTS	OTS	TOTAL
ANTENNA SUBSYSTEM							
ANTENNA DISH	B	1	1	1	1	1	5
DUPLEX FEED AND CONE	B	1	1	1	1	1	5
RECEIVER ANTENNA FEED & CONE	B	1	1	1	1	1	5
ANTENNA DRIVE	B	1	1	1	1	1	5
SERVO CONTROL	B	1	1	1	1	1	5
ANTENNA CONTROL UNIT	B	1	1	1	1	1	5
ANTENNA /TRANSMITTER I / F	B	1	1	1	1	1	5
ANTENNA /RECEIVER I / F	B	1	1	1	1	1	5
PEDESTAL/PLATFORM	B	1	1	1	1	1	5
TRANSMISSION SUBSYSTEM							
HIGH GAIN AMPLIFIER	B	1	1	1	1	1	
FREQUENCY UP CONVERTER	B	1	1	1	1	1	
POWER COMBINER	B	1	1	1	1	1	
MODULATOR	B	1	1	1	1	1	

OAKhanger does not have DMSAT cap

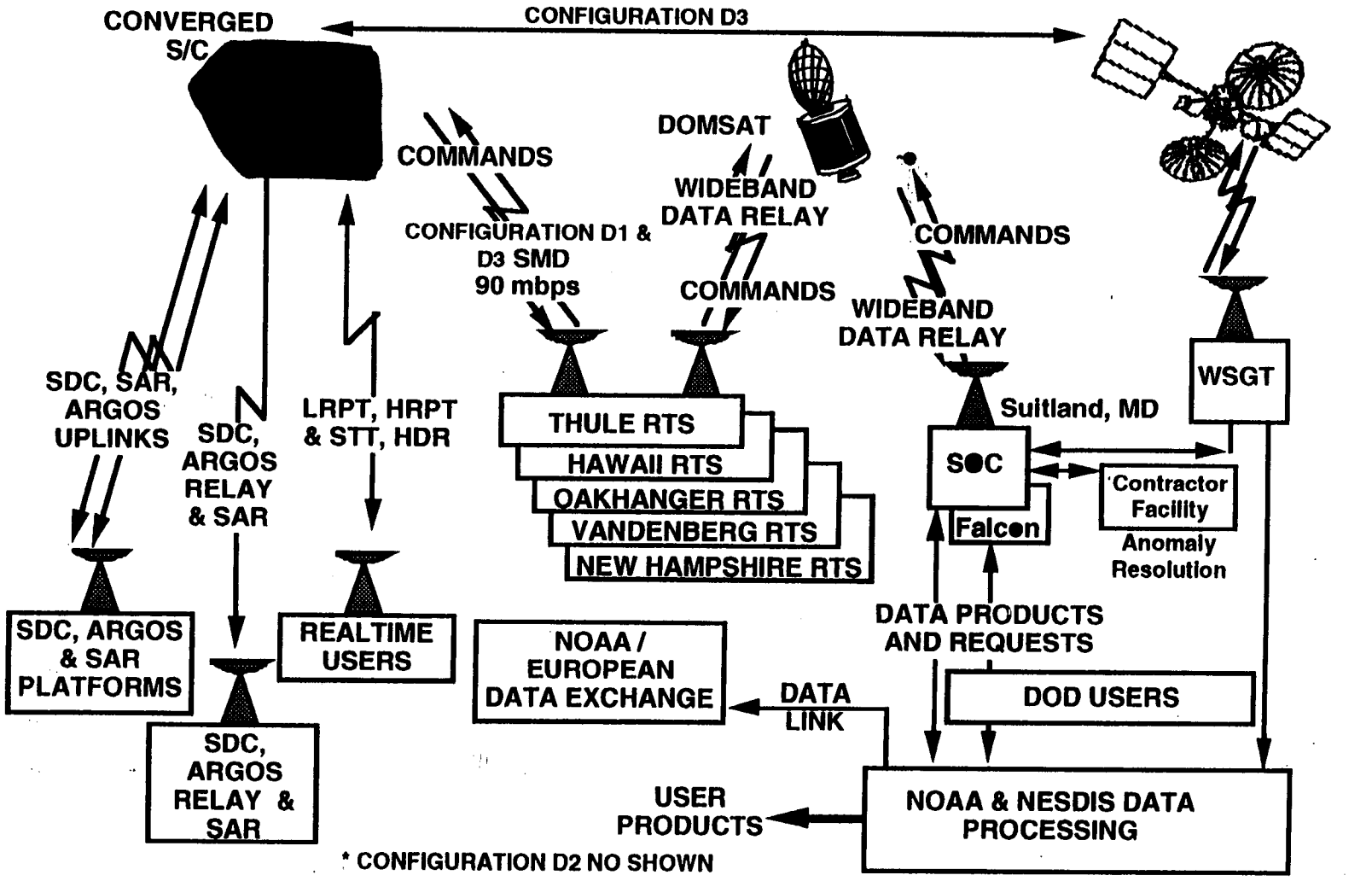
Shading: must be added

DRR DATA ROUTING EQUIPMENT LIST (2 of 2)

ITEM NAME OR MODEL NUMBER	MAKE or BUY	TTS	NTS	VTS	HTS	OTS	TOTAL
TRANSMISSION SUBSYS (COND'T)							
MASS MEMORY UNIT	B	1	1	1	1	1	5
ENCRYPTOR	B	1	1	1	1	1	5
RECEIVER SUBSYSTEM							
FREQUENCY DOWN CONVERTER	B	1	1	1	1	1	5
LOW NOISE AMPLIFIER	B	1	1	1	1	1	5
TRACKING RECEIVER	B	1	1	1	1	1	5
TRACKING PRE-AMP	B	1	1	1	1	1	5
TRACKING DOWN CONVERTER	B	1	1	1	1	1	5
POSITION TRANSDUCERS	B	1	1	1	1	1	5
POSITION READOUT	B	1	1	1	1	1	5
POWER DIVIDER	B	1	1	1	1	1	5
DOMSAT LEASE							
TRANSPONDER CHANNEL	L	1	1	1	1	2	6

OPERATIONS ISSUES

CONVERGED DATA ROUTING CONCEPT



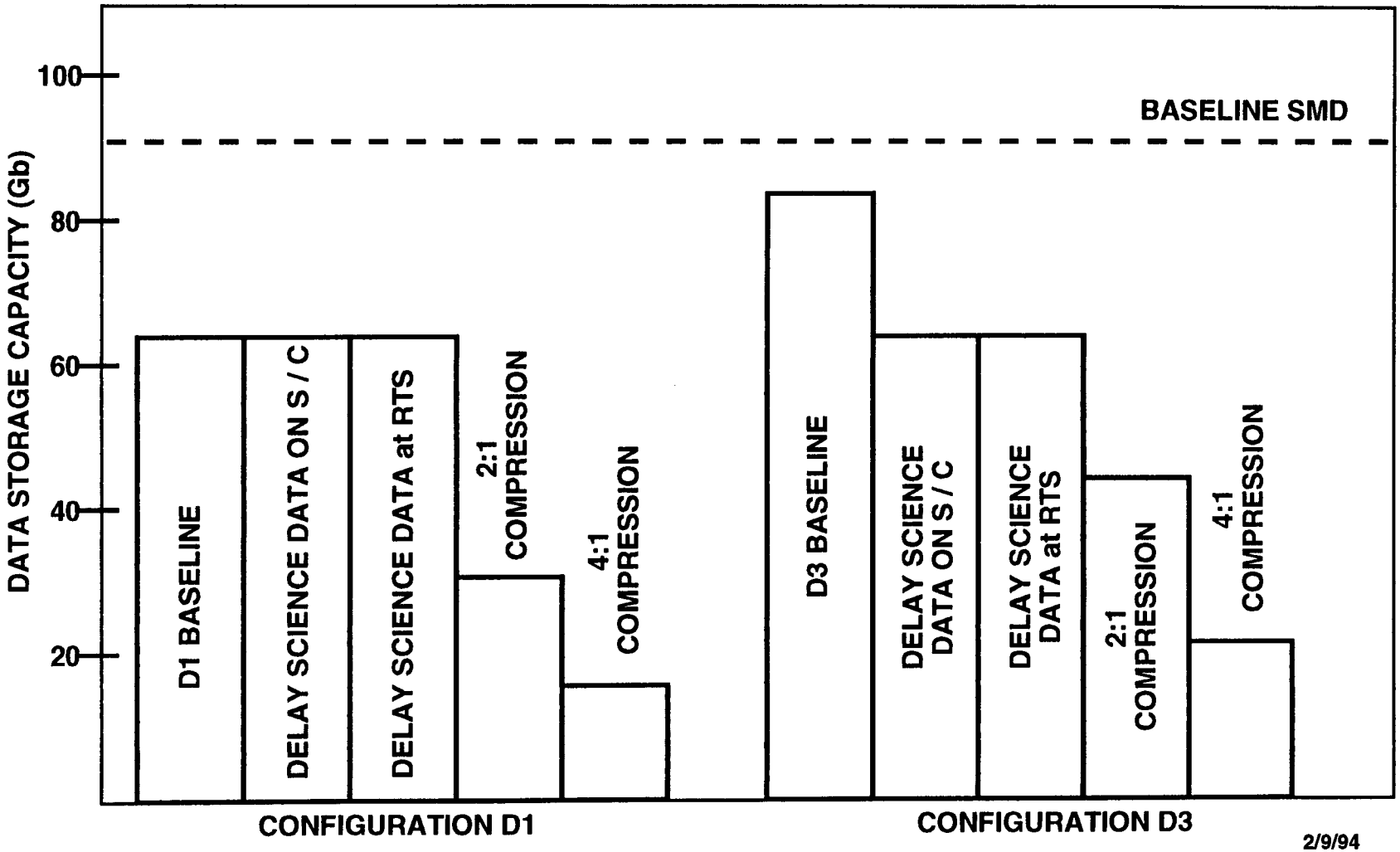
* CONFIGURATION D2 NO SHOWN

DATA DELIVERY ALTERNATIVES

ALTERNATIVE 1 DELAYED SCIENCE DATA TRANSMISSION from S/C	Reduces SMD data rate, Lowers minimum contact time. Schedule downlink for 1 orbit of operational data followed by science data at next RTS / CDA, potentially cuts delivery time to Central Sites 2 - 3 minutes
ALTERNATIVE 2 DELAYED SCIENCE DATA TRANSMISSION from RTS SITES (Archiving of data at RTS)	Using available DOMSAT link bandwidth timeliness savings is less than 2 min. Requires recording of SMD data (Archive). Does provides for RDR storage backup.
ALTERNATIVE 3 DATA COMPRESSION	
2:1 (Lossless data) Compression On board 2:1 Compression at RTS	50% Reduction: • SMD Data Rate • DOMSAT b/w 4 - 5 min reduction in data delivery to Central sites
4:1 (Near lossless) Compression On board 4:1 Compression at RTS	75% Reduction: • SMD Data Rate • DOMSAT b/w 4 - 5 min reduction in data delivery to Central sites

CONFIGURATION D1:	Data rate 4.55 mbps Total data 27.7 Gb
CONFIGURATION D3:	Full data rate 5.89 mbps, operational data rate 4.55 mbps, science data rate 1.34 mbps Total data 35.8 Gb, operational data 27.7 Gb, science 8.2 Gb

ALTERNATIVE DATA DELIVERY IMPACTS



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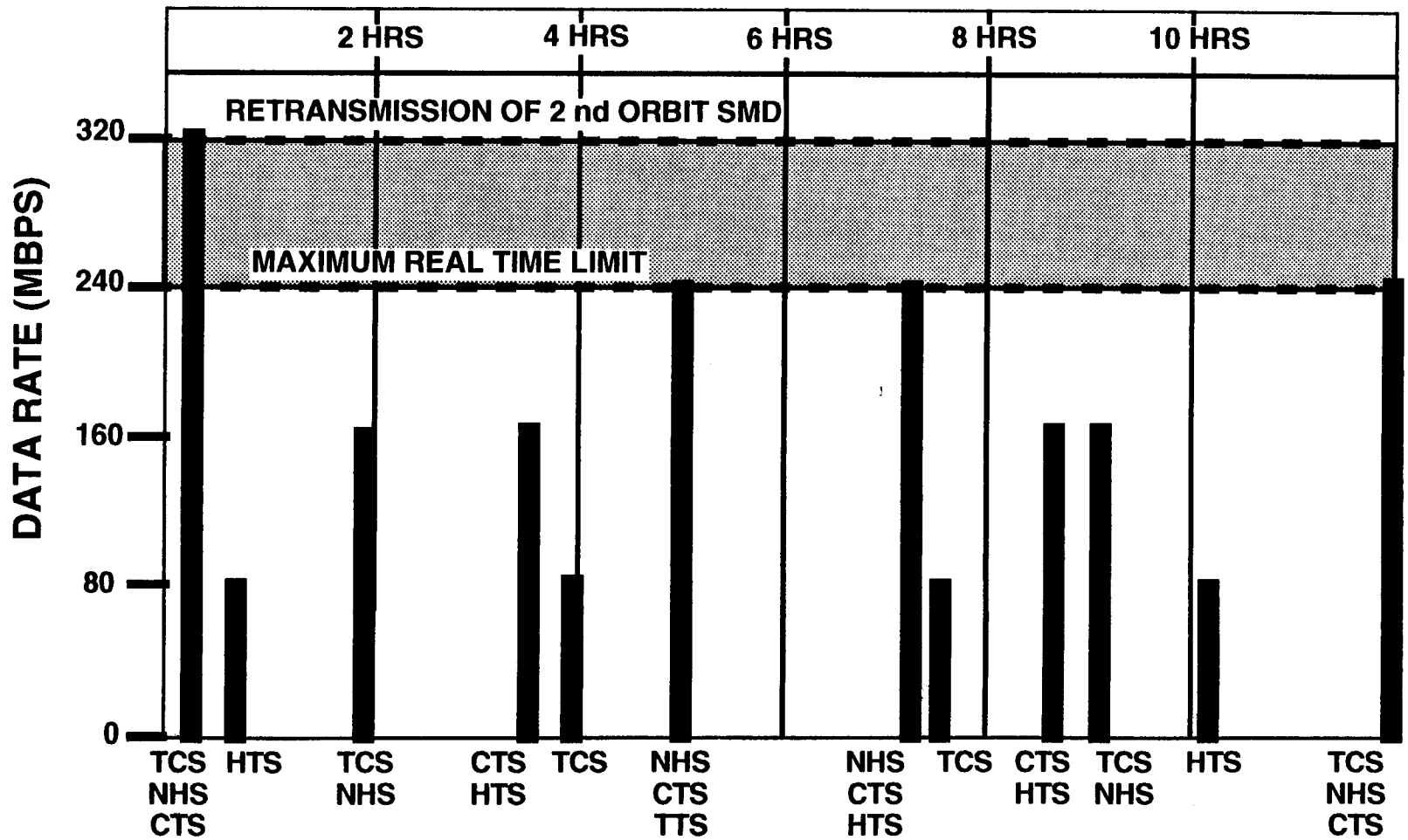
TOTAL RTS DATA LOADING PROFILE

(12 HR SAMPLE)



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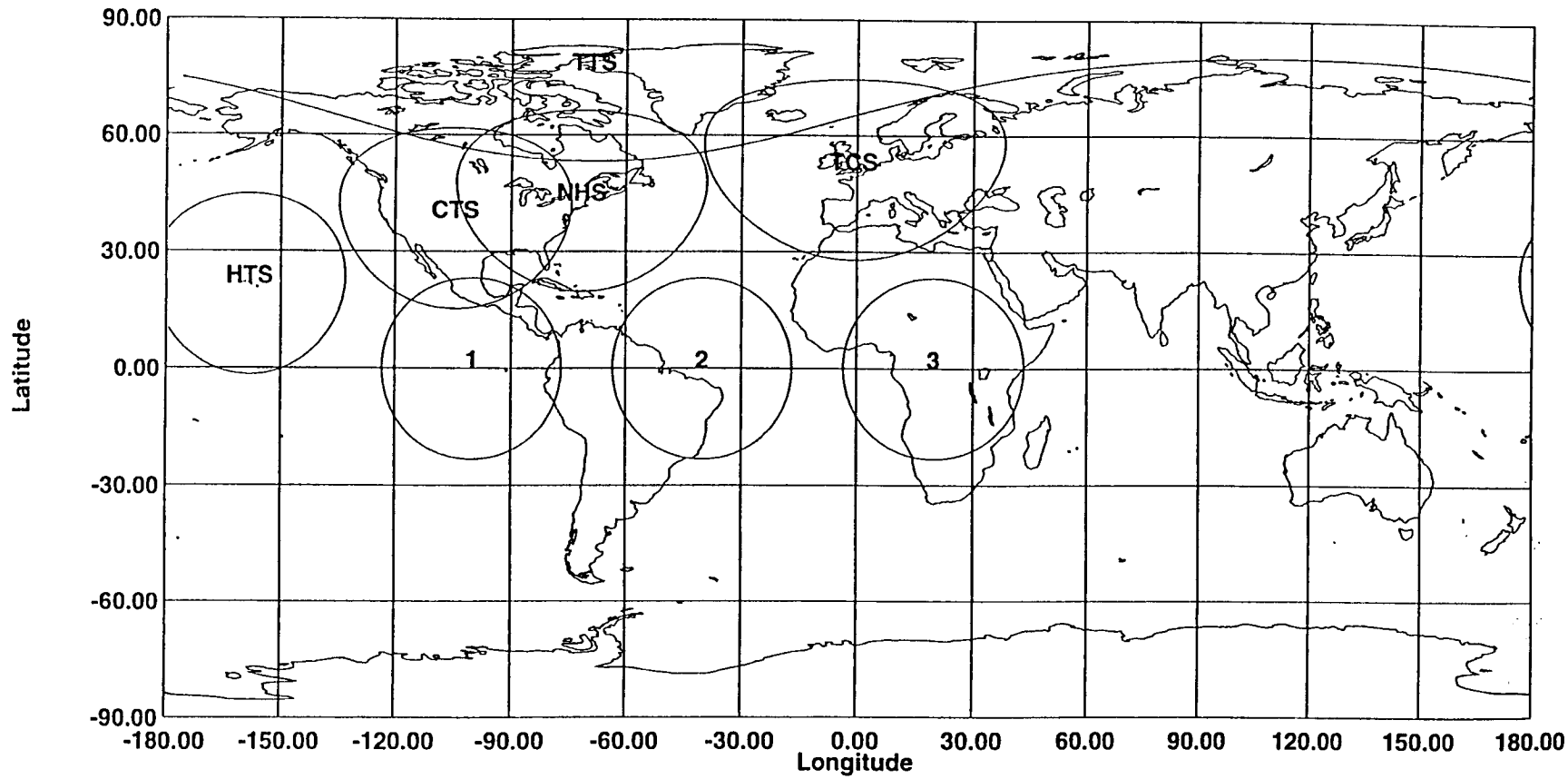
RTS SIMULTANEOUS VIEW OF S / C

Cylindrical Equidistant Projection



DRR ANALYSIS SUMMARY

DRR TRADE RESULTS

- LOWEST COST DRR ALTERNATIVE IDENTIFIED - NOAA CDA STATIONS at FAIRBANKS, WALLOPS & KIRUNA
- TDRSS OPTION PROVIDES GREATEST BENEFITS - GUARANTIED 20 MN / ORBIT ISSUE CRITICAL
- MODIFIED AFSCN PROVIDE ALTERNATIVE APPROACH

ALTERNATIVE DATA DELIVERY RESULTS

- ON BOARD DATA COMPRESSION PROVIDES POTENTIAL REDUCTION IN SMD DATA RATE, MINIMUM CONTACT TIME, & DATA DELIVERY TIME
- TRANSMISSION DELAY OF SCIENCE DATA FROM S / C PROVIDES SMALL BENEFIT
- COMPRESSION, DELAY TRANSMISSION OF SCIENCE DATA & ARCHIVING DATA AT RTS / CDA HAS NEGLIGIBLE BENEFIT TO SYSTEM.

some sights have 20Mb capabilities

TDRSS XLINK / X-BAND TERMINALS

- T. PARSONS

TDRSS TASK OUTLINE

- INTRODUCTION
- TDRSS CROSSLINK REQUIREMENTS
  - MISSION PAYLOAD DATA REQUIREMENTS
    - ON-BOARD STORAGE
    - STORED DATA RATES
- CROSSLINK PACKAGE DESCRIPTION / CHARACTERISTICS
  - REQUIRED EIRP
  - BLOCK DIAGRAM
  - WEIGHT/POWER
- CONFIGURATION DRAWINGS (D3, D4)
- CROSSLINK COST IMPACTS

TDRSS CROSSLINK IMPACTS STUDY TASK

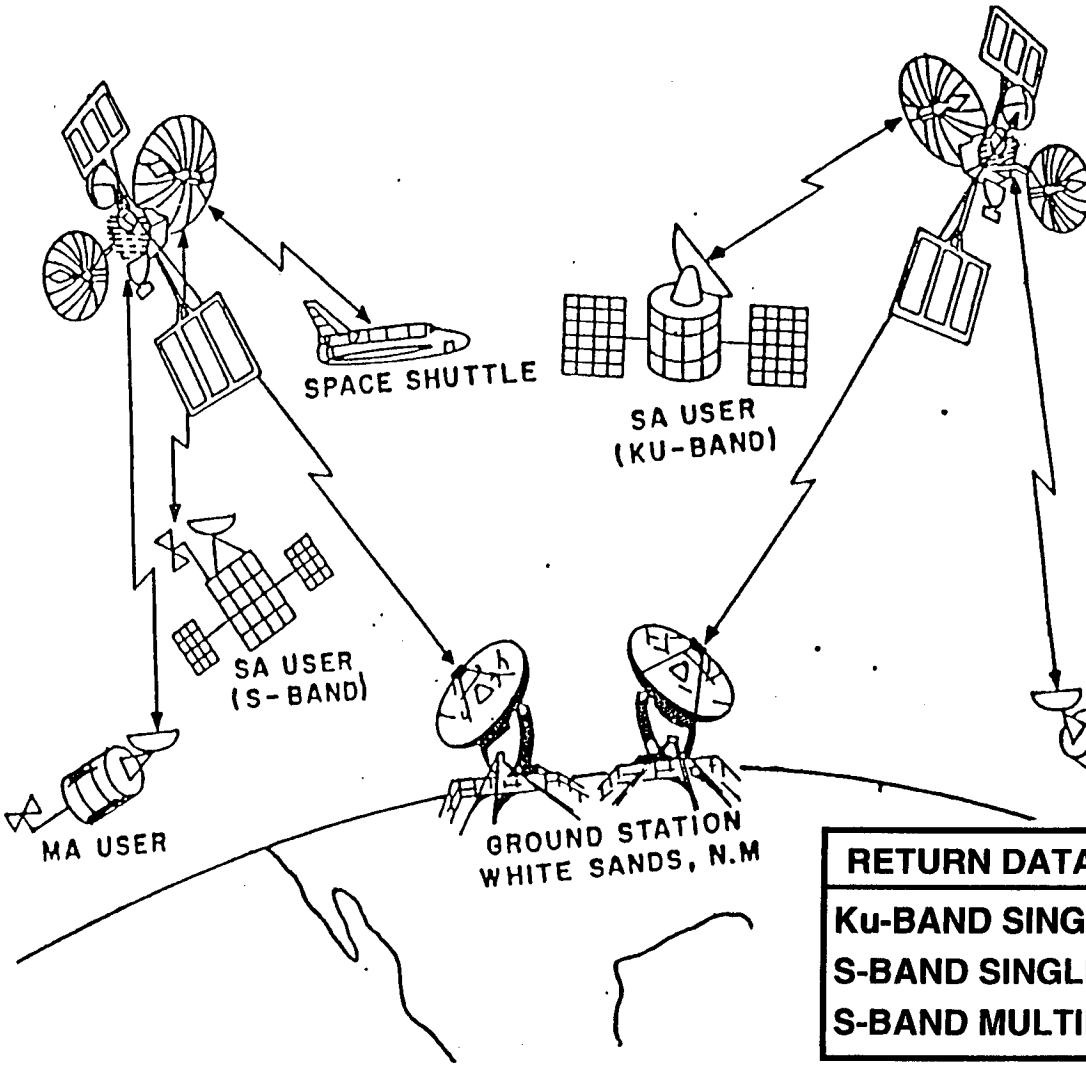
- DETERMINE THE IMPACTS ON ALTERNATIVE A4, D4 & G4 BUSES TO ADD A TDRSS CROSSLINK
- EXAMINE THE IMPACTS OF UTILIZING THE TDRSS CROSSLINK ON THE D3 BUS FOR ALL DATA

TDRSS CROSSLINK SIZING ASSUMPTIONS & CONFIGURATION OBJECTIVES

- ASSUMPTIONS
  - MAXIMUM ACCESS TIME FOR TDRSS IS 20 MIN/ORBIT
  - TWO SATELLITE TDRSS CONSTELLATION
    - TDRS E @ 41° WEST LONG, TDRS W @ 171° WEST LONG
    - FUTURE CONSTELLATION TO INCLUDE UP TO 4 SATELLITES; 2 EAST, & 2 WEST
  - ZONE OF EXCLUSION STILL EXIST
  - TDRSS USER COSTS ARE STABLE
- OBJECTIVES
  - IF POSSIBLE, USE AN EXISTING Ku-BAND SINGLE ACCESS PACKAGE DESIGN & HARDWARE
  - FOR INITIAL ANALYSIS SIZE KSA LINK FOR AN AVERAGE ACCESS TIME WITH TDRSS OF 10 AND 20 MINUTES PER ORBIT

DMSP/NOAA CONVERGENCE STUDY

TRACKING & DATA RELAY SATELLITE SYSTEM



RETURN DATA LINK	DATA RATE	#LINKS 2 SATS
Ku-BAND SINGLE ACCESS	<300 MBPS	4
S-BAND SINGLE ACCESS	< 6 MBPS	4
S-BAND MULTIPLE ACCESS	< 50 KBPS	20

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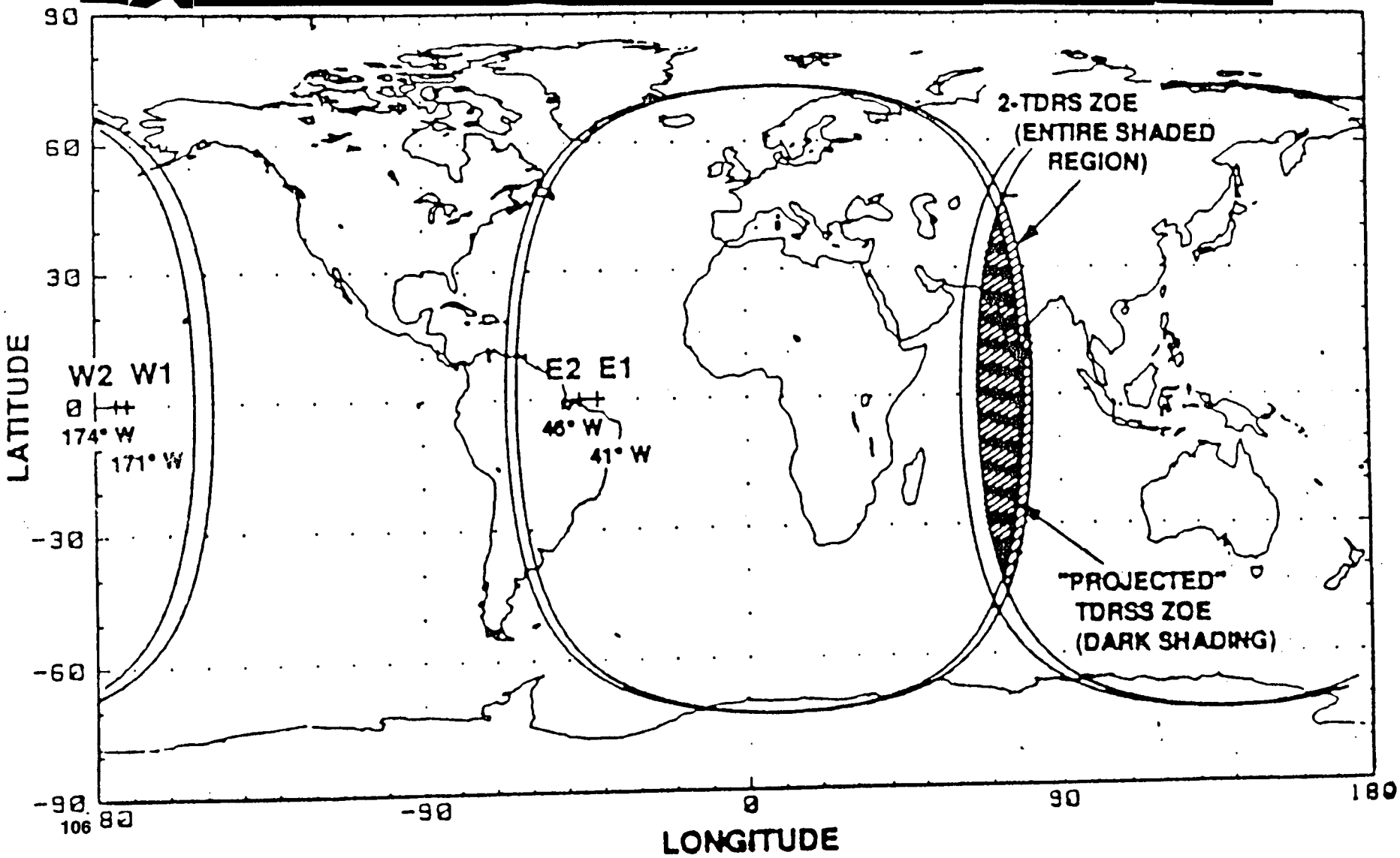
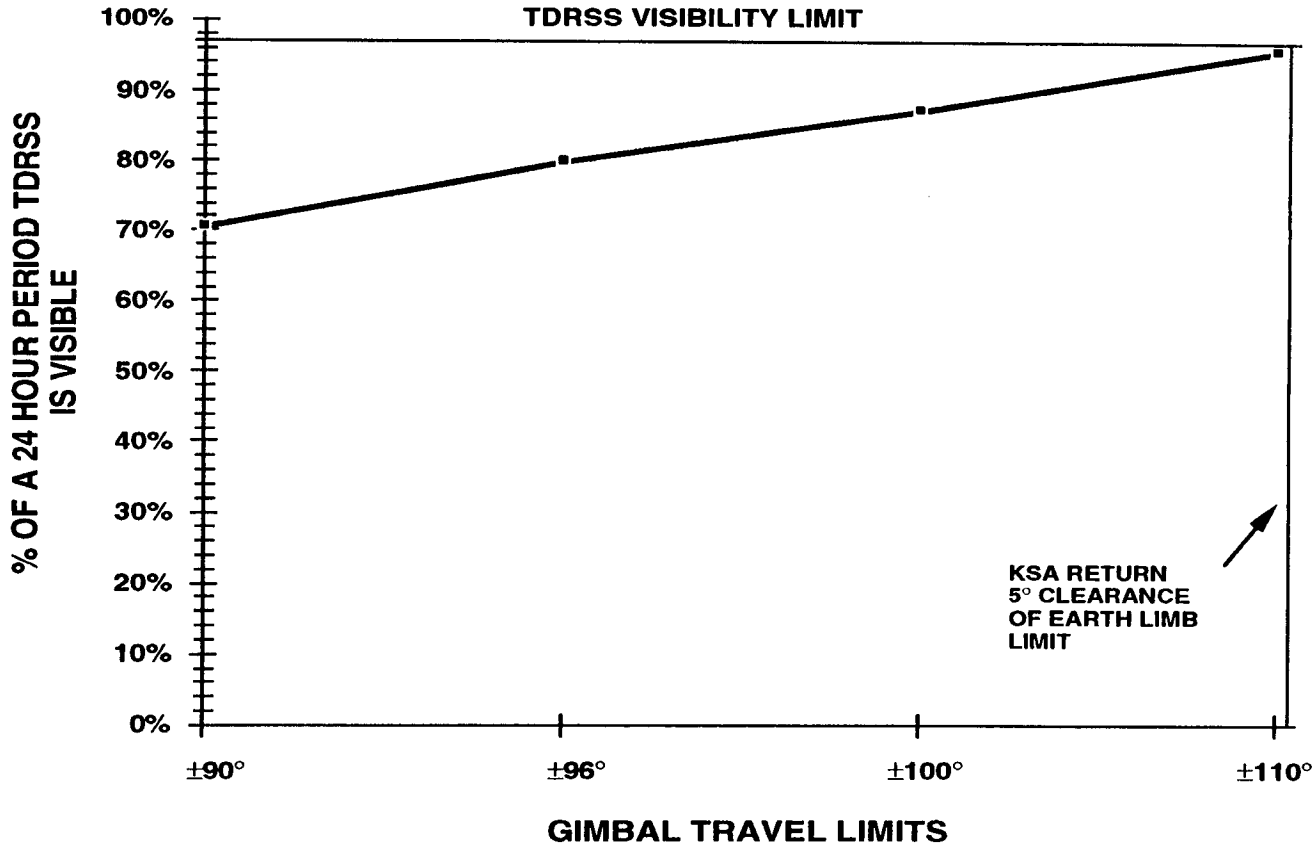
TIM 3

ZONE OF EXCLUSION



DMSP/NOAA CONVERGENCE STUDY

TDRSS VISIBILITY AS A FUNCTION OF GIMBAL TRAVEL LIMITS



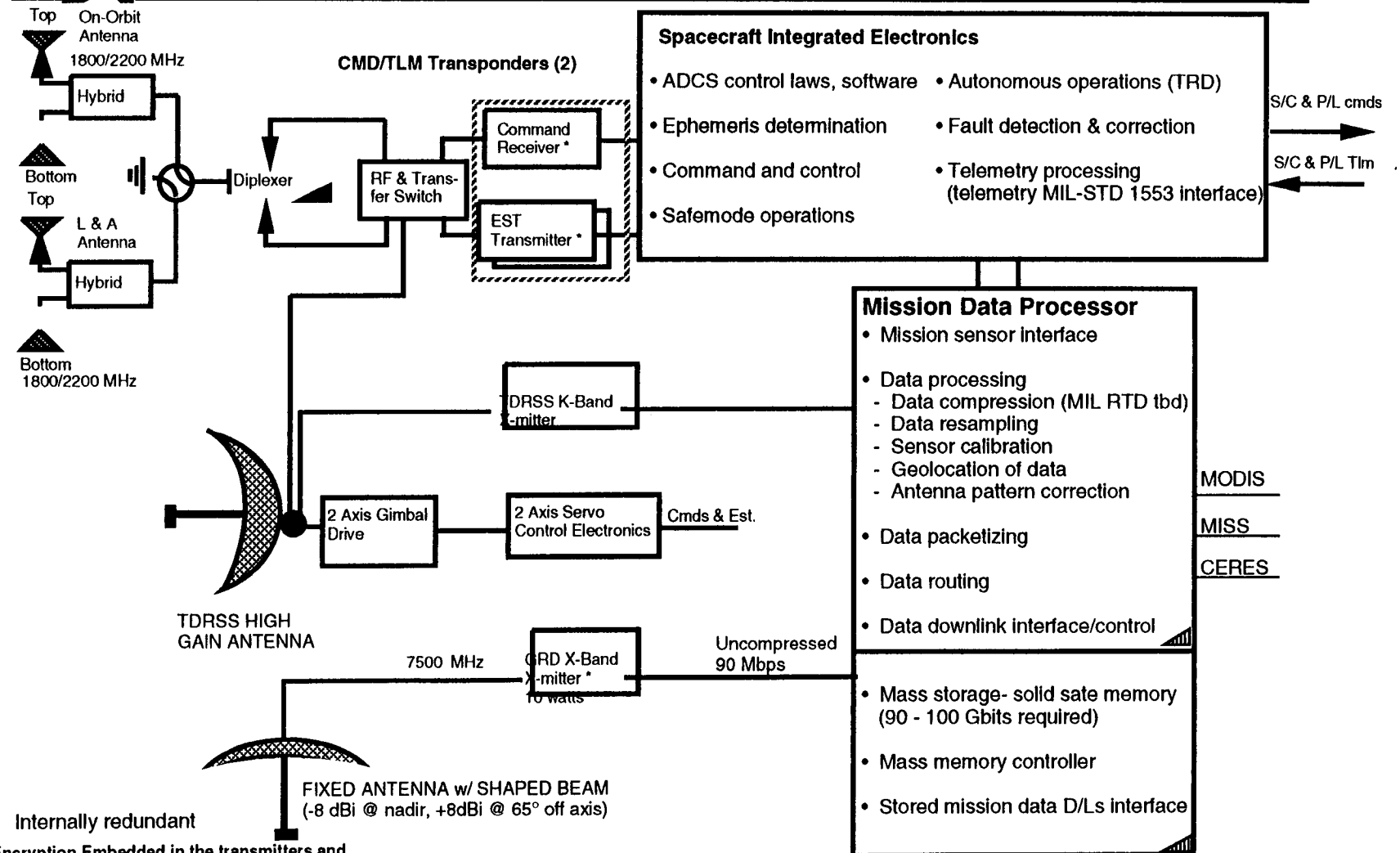
PLOT EXCLUDES SPACECRAFT OBSTRUCTIONS

COMMUNICATION LINK REQUIREMENT COMPARISON

COMMUNICATION LINK REQUIREMENTS	SPACECRAFT CONFIGURATION				
	DMSP BLOCK 6	NOAA O,P,Q	D1&2	D3	D4,A4, G4
SGLS/STDN CMD U/L OMNI	X	X	X	X	X
LRPT		X	X	X	
HRPT		X	X	X	
MILITARY LDR	X		X	X	
MILITARY HDR	X		X	X	
MILITARY S & F REAL-TIME	X		X	X	
X-BAND STORED DATA		X	X	X	X
S-BAND STORED DATA	X				
SDC/ ARGOS U/L	X	X	X	X	
SEARCH & RESCUE U&D/L		X	X	X	
TDRSS KU BAND RETURN				x	X
TDRSS S-BAND				x	X

DMSP/NOAA CONVERGENCE STUDY

D4 OBP & CCT SUBSYSTEMS WITH A TDRSS CROSSLINK



Internally redundant

* Encryption Embedded in the transmitters and receivers

**Mass storage could be packaged separately

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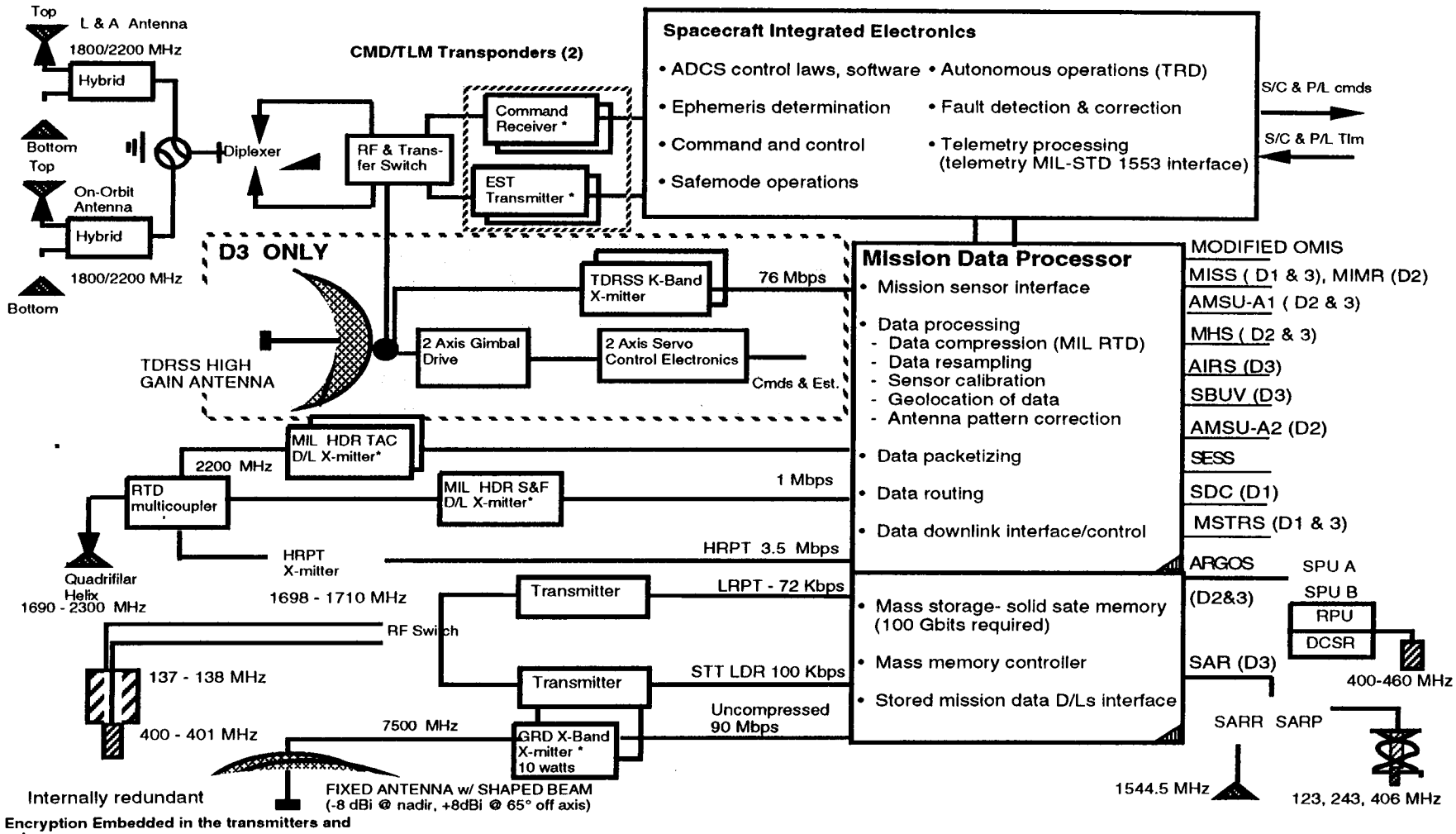
PAGE 110 IS EXEMPT FROM RELEASE AND IS REPLACED WITH THIS PAGE.

DMSP/NOAA CONVERGENCE STUDY

OBP & CCT SUBSYSTEMS FOR ALL CONFIGUATIONS EXCLUDING MODIS



* Encryption Embedded in the transmitters and receivers

** Mass storage could be packaged separately

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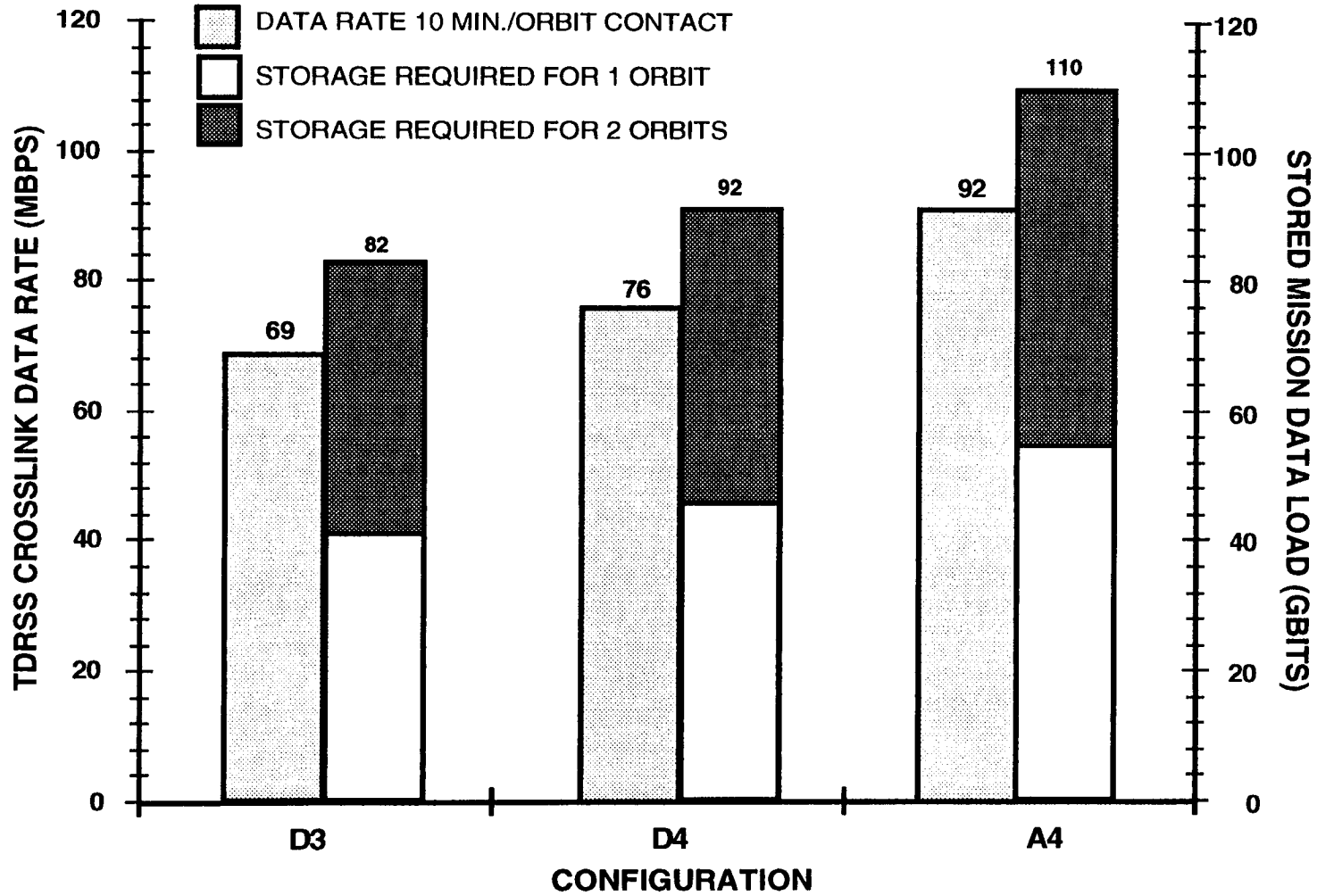
DMSP/NOAA CONVERGENCE STUDY

D3, A4, D4 & G4 TDRSS CROSSLINK DATA RATE REQUIREMENTS REQUIREMENTS



* EXCLUDES STORE & FORWARD STORAGE REQUIREMENTS FOR CONFIGURATION D3

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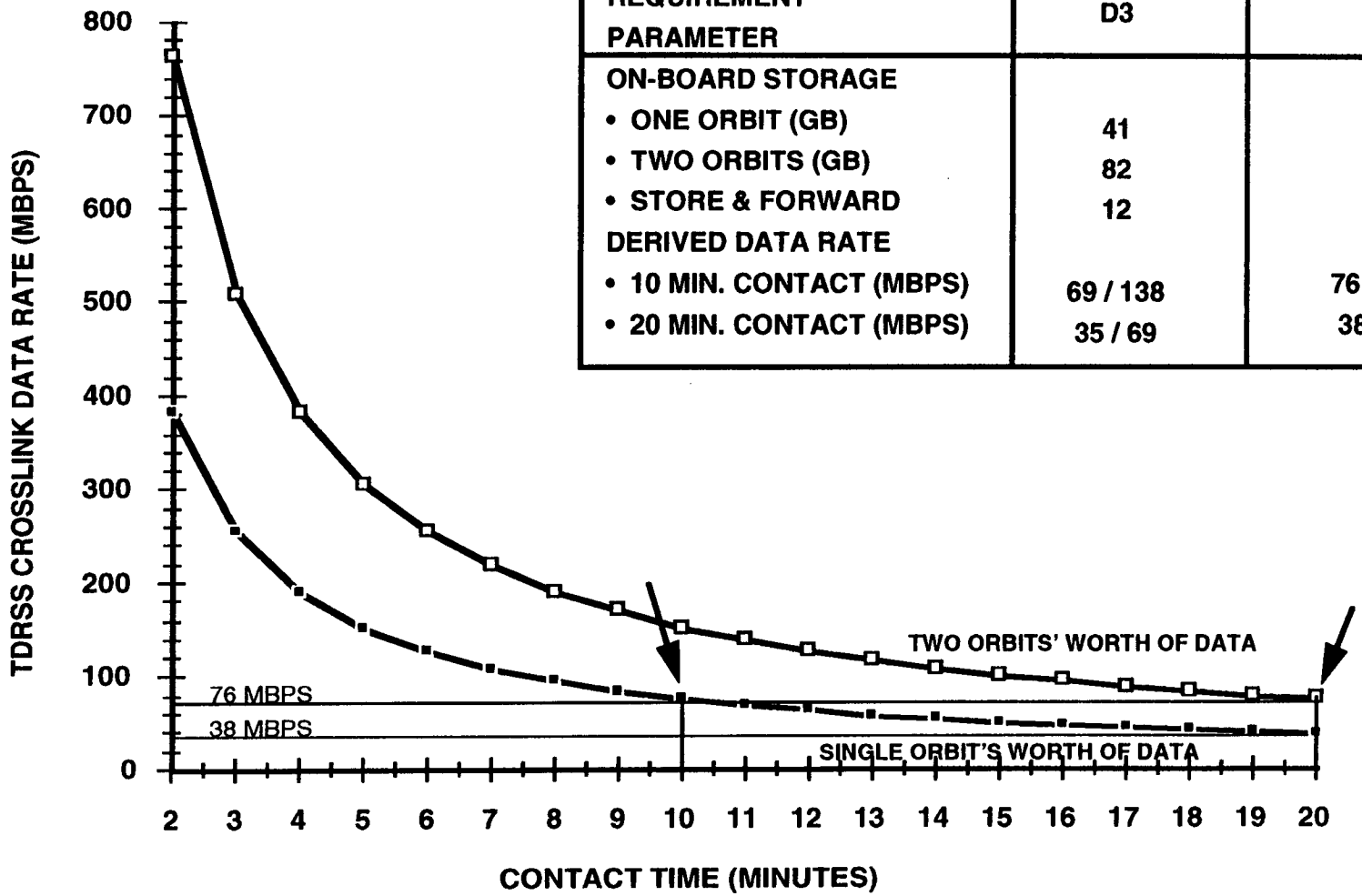
DMSP/NOAA CONVERGENCE STUDY

TDRSS CROSSLINK DATA RATES VS CONTACT TIME

REQUIREMENT PARAMETER	D3	D4
ON-BOARD STORAGE		
• ONE ORBIT (GB)	41	46
• TWO ORBITS (GB)	82	92
• STORE & FORWARD	12	
DERIVED DATA RATE		
• 10 MIN. CONTACT (MBPS)	69 / 138	76 / 152
• 20 MIN. CONTACT (MBPS)	35 / 69	38 / 76



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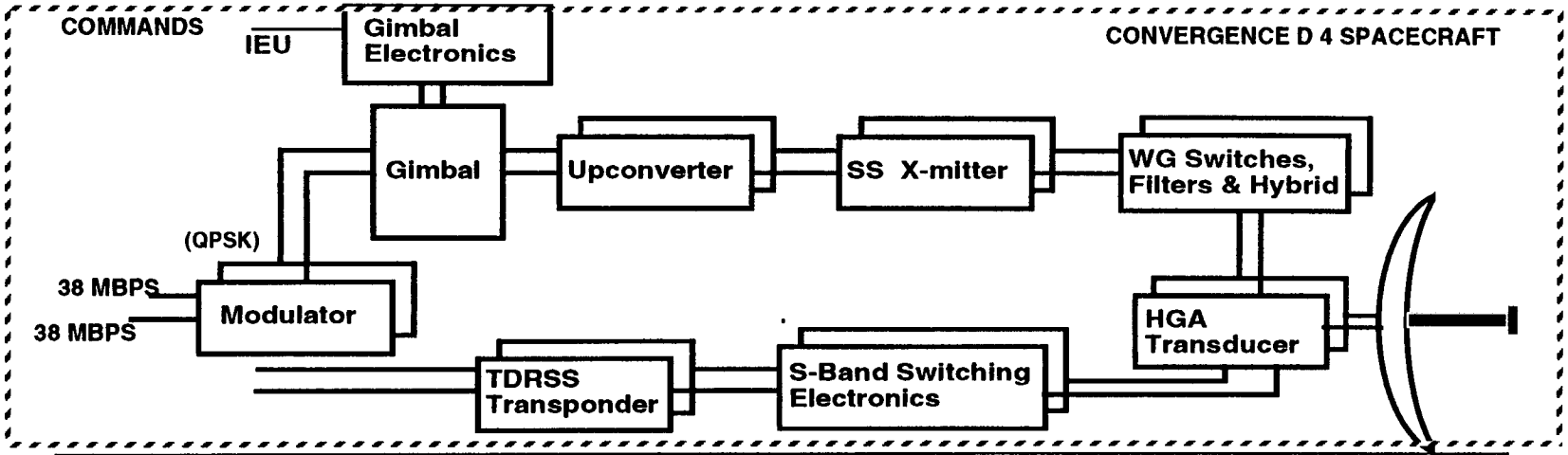
DMSP/NOAA CONVERGENCE STUDY

TDRSS LINK BUDGETS FOR DATA RATES OF 76 AND 38 MBPS (D4)

LINK MARGIN CALCULATION				LINK MARGIN CALCULATION			
FOR TDRSS CROSSLINK				FOR TDRSS CROSSLINK			
10 minute access		(watts)		20 minute access		(watts)	
TRANS POWER (dBm)		18	42.55	TRANS POWER (dBm)		9	39.54
LINE LOSSES			-1.60	LINE LOSSES			-1.60
ANTENNA GAIN	1.45 m dia.		44.40	ANTENNA GAIN			44.40
SPACECRAFT EIRP			85.35	SPACECRAFT EIRP			82.34
PATH LOSS	44595 KM		-209.00	PATH LOSS	44595 KM		-209.00
POINTING LOSS (DB)			-2.50	POINTING LOSS (DB)			-2.50
IMPLEMENTATION LOSS			-2.00	IMPLEMENTATION LOSS			-2.00
CONVOLUTION 1/2 RATE LOSS			- 3	CONVOLUTION 1/2 RATE LOSS			- 3
RECEIVED Pr/No (DB - HZ)			-131.15	RECEIVED Pr/No (DB - HZ)			-134.16
Pwr Rqd @ TDRSS		-243		Pwr Rqd @ TDRSS		-243	
with 1/2 RATE CODING				with 1/2 RATE CODING			
DATA RATE IN dB		78.81	76 MBPS	DATA RATE IN dB		75.80	38 MBPS
in dB		-164.19		in dB		-167.20	
in dBm			-134.19	in dBm			-137.20
MARGIN (dB)			3.04	MARGIN (dB)			3.04

DMSP/NOAA CONVERGENCE STUDY

CONVERGED SPACECRAFT TDRSS CROSSLINK CONFIGURATION



COMPONENT	QUANTITY	WEIGHT (KG)	SIZE, CM	AVE. UNIT PWR (WATTS)	FLIGHT HERITAGE
KU - BAND MODULATOR	2	6.1	30 x 18 x 13	4	E
HGA SYSTEM					
- UPCONVERTERS	2	4	20 x 12 x 20	4	E
- SS TRANSMITTER (12w)	2	4	30 x 25 x 10	6 8	E
- ANTENNA REFLECTOR	1	6.8	1.45m dia.		M
- WAVEGUIDE SWITCH	4	0.2	5 x 5 x 9		E
- BANDPASS FILTER	2	0.2	10 x 2.4 x 2.2		E
- 3dB HYBRID	2	0.3	3.5 dia. x 7.7		E
- ORTHO MODE TRANSDUCER	2	0.2	3.5 dia. x 5		E
- FEEDHORN	2	0.4	5.8 dia. x 6.3		E
- WAVEGUIDE	2	0.5	46 long		E
GIMBAL ASSEMBLY	2	6.8	20 x 12 x 20	39.00	E
HGA DEPLOYMENT MECH.	1	21.1	15 x 20 x 254		M
TDRSS TRANSPONDER (STDN)	2	4.5	15 x 18 x 20	5 7	E
S-BAND SWITCH NETWORK	1.00	5.00	30 x 20 x 12		E
	TOTAL	87.7 KG	ON-ORBIT AVE. POWER BASED ON 20% DUTY CYCLE	36 WATTS	

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TDRSS CROSSLINK USER EQUIPMENT COST ESTIMATE

1986 FISCAL YEAR DOLLARS (MILLIONS)

TDRSS Ku & S -BAND CROSSLINKS*
KU-BAND CROSSLINK

	NR	REC
ANTENNA SUBSYSTEM	0.2	2.6
S-BAND SUBSYSTEM	0.7	2.6
Ku-BAND SUBSYSTEM	1.0	3.5
MAST & DEPLOYMENT SUBSYSTEM	1.0	0.7
DESIGN, ASSEMBLY & INTEGRATION **	1.9	1.0
TOTAL	$4.8 (NRE)	$10.4 (PER VEHICLE)

* BASED ON ESTIMATES FROM TWO VENDORS FOR OTHER PROGRAMS
** INTEGRATION INCLUDES INTEGRATION WITH SPACE VEHICLE

SUMMARY

- BOTH THE [redacted] AND [redacted] BUS CONFIGURATIONS CAN ACCOMMODATE THE TDRSS CROSSLINK PACKAGE
- TDRSS PACKAGE ADDS 88 kg (193lbs) TO THE SATELLITE WEIGHT
- POWER LOAD IS ABOUT THE SAME AS THE X-BAND D/L
- OTHER SATELLITES BEING CONFIGURED WITH TDRSS CROSSLINKS HAVE PAID FOR THE HARDWARE DEVELOPMENT
  - SOLID STATE AMPLIFIERS
  - GIMBAL CONTROLS AND DRIVE MECHANISMS
- WE RECOMMEND AN X-BAND D/L AS BACKUP FOR STORED MISSION DATA RELAY
- TDRSS IMPACTS (i.e., EMI, DYNAMICS) ON CONFIGURATION D3 REQUIRE FURTHER STUDY

X-BAND TERMINALS AT AFSCN SITES

- DEVELOP A PRELIMINARY CONCEPT AND COST ESTIMATE FOR X-BAND TERMINALS AT THE FIVE AFSCN SITES
  - POGO (THULE), HULA (HAWAII), BOSS (NEW HAMPSHIRE), LION (OAKHANGER), AND COOK (VANDENBURG)

→ PLAN TO BRIEF

- IDENTIFY THE CONVERGED SYSTEM REQUIREMENTS AND TERMINAL CONFIGURATION ALTENATIVES
- REVIEW CURRENT RTS CONFIGURATIONS
  - IDENTIFY NECESSARY EQUIPMENT MODIFICATIONS
  - PROVIDE PRELIMINARY COST ESTIMATE

→ PLAN TO DEFER

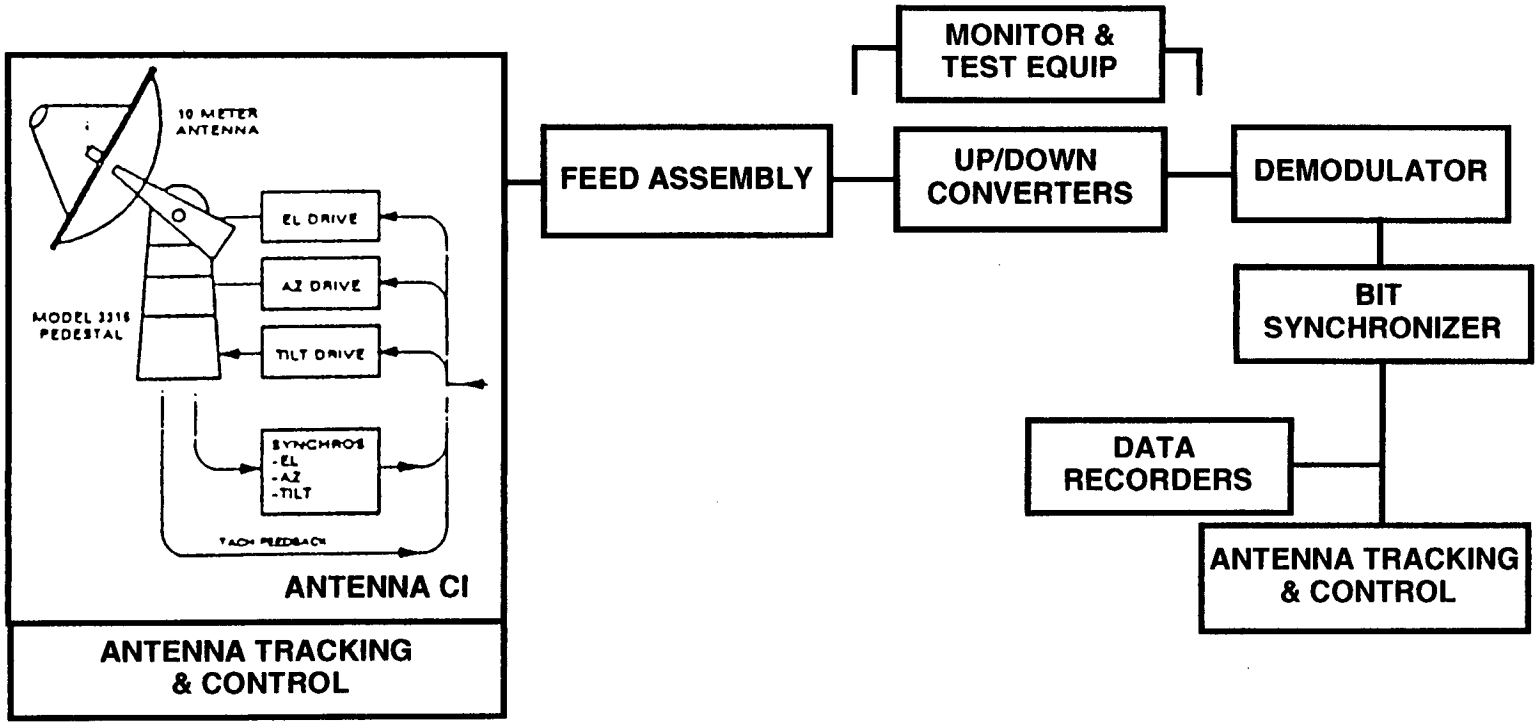
- EQUIPMENT COSTS ARE VERY MUCH DEPENDENT ON REQUIREMENTS (I.E, RELIABILITY, SAFETY, DICTATED PHYSICAL CONFIGURATION, NUCLEAR, ect.)

X-BAND TERMINAL REQUIREMENT

PARAMETER	REQUIREMENT
OPERATING FREQUENCY	7.455 GHZ
DATA RATES	60 - 150 MBPS
MODULATION	QPSK/SQPSK
SYSTEM G/T	31 dB/K
TERMINAL CONTRIBUTION TO BER	$<10^{-7}$ (TBR)
ANTENNA	
TRAVEL LIMITS	360° ELEVATION 360° AZIMUTH
SLEW RATES	5°/SEC ELEVATION 15°/SEC AZIMUTH
DATA STORAGE	30 GBYTES
S-BAND CAPABILITY	OPTIONAL

DMSP/NOAA CONVERGENCE STUDY

X-BAND TERMINAL SYSTEM BLOCK DIAGRAM



- X-BAND TERMINALS ARE AVAILABLE THROUGH MULTIPLE VENDORS
- TERMINAL COSTS RANGE FROM $20 - 25 MILLION DEPENDING ON USER NEEDS

- NOT AFSCN reqts
- Availability

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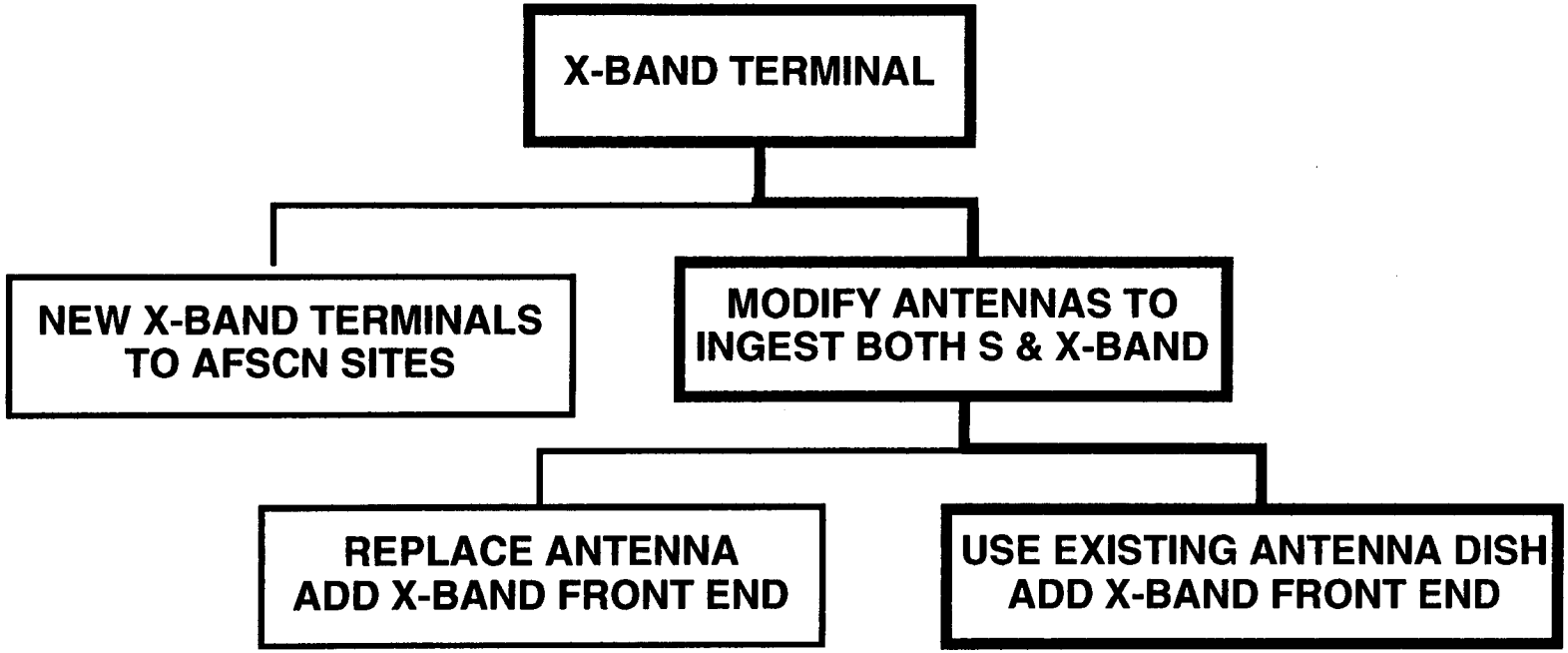
X-BAND TERMINAL OPTIONS



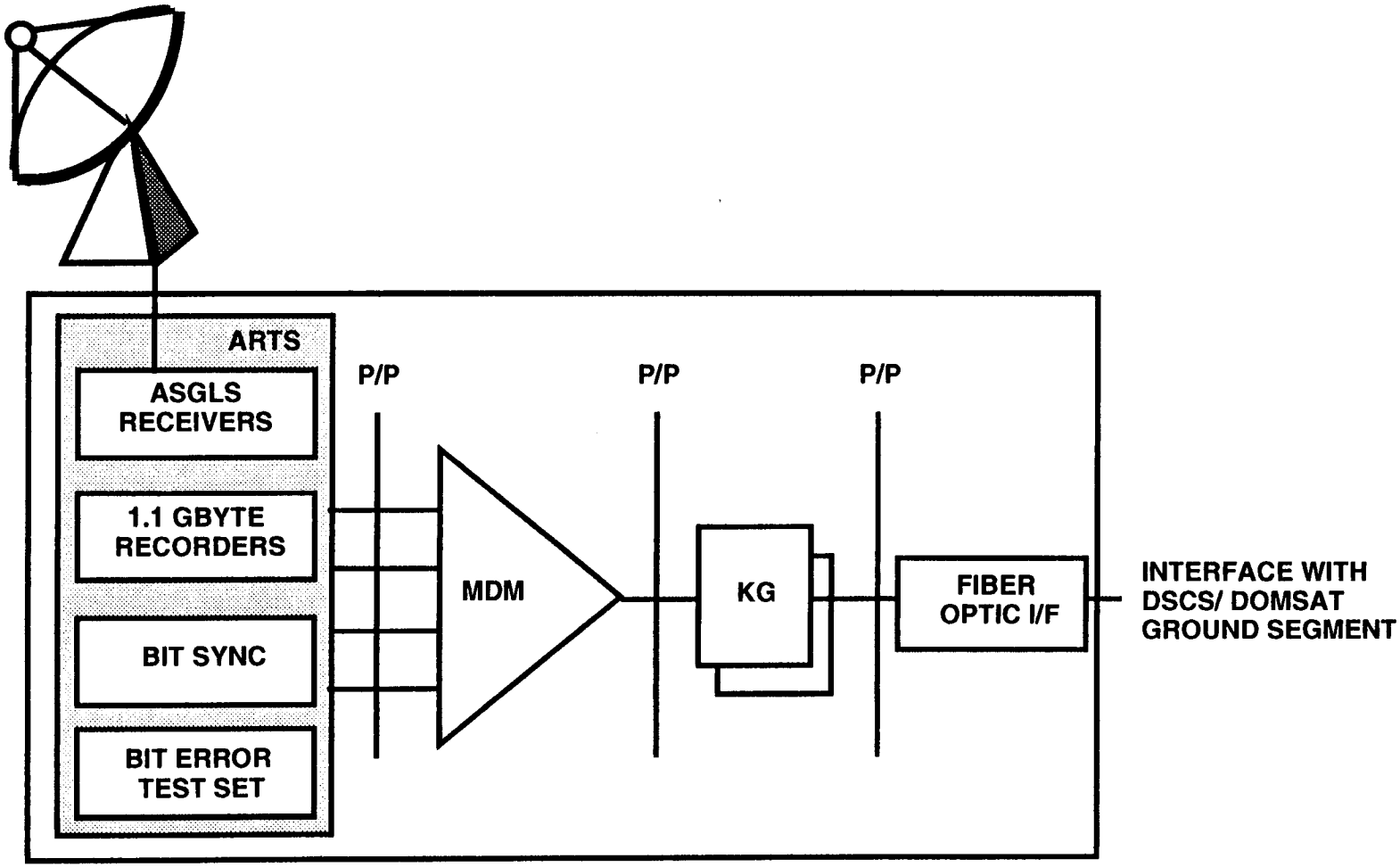
DMSP/NOAA CONVERGENCE STUDY

REMOTE TRACKING STATION EQUIPMENT CONFIGURATIONS

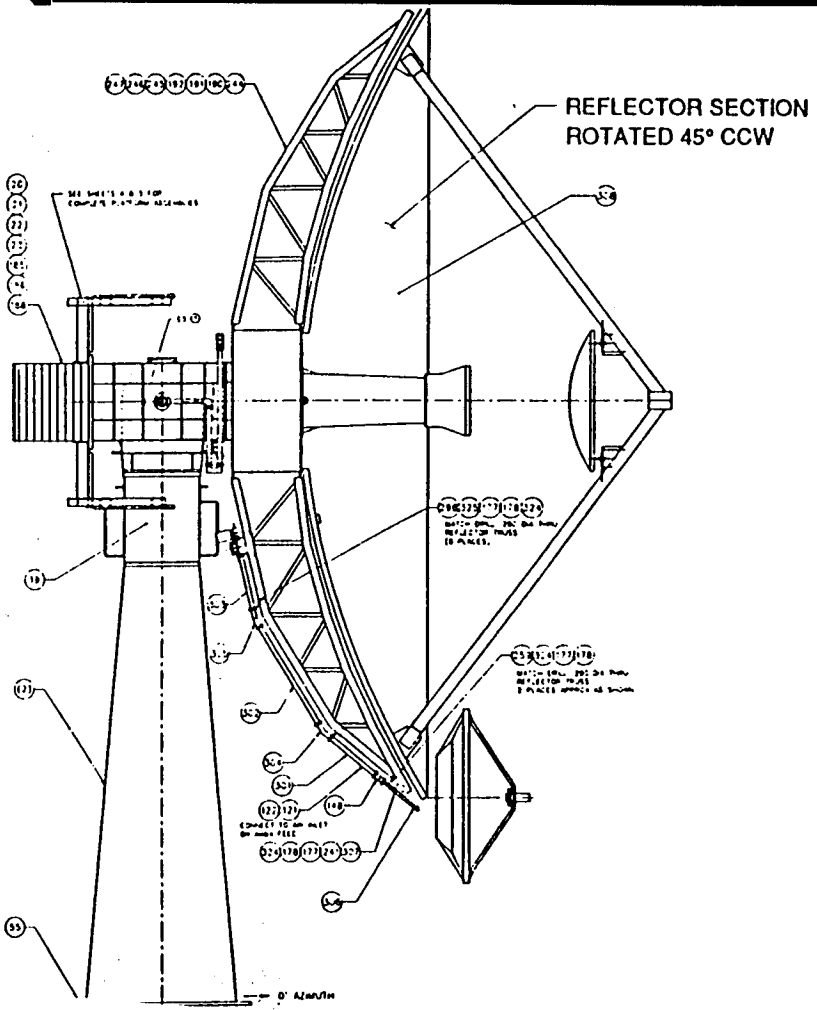
	TCS		TTS			NHS		VTS		HTS	
	A	B	A	B	C	A	B	A	B	A	B
60 FT TT&C (MPF)								X		X	
60 FT TT&C (W&T)	X										
60 FT TT&C						X					
46 FT TT&C				X			X		X		X
33 FT ARTS		X			X						
23 FT TT&C			X								
10 M T&T								X			
10 M DLT			X			X					

DMSP/NOAA CONVERGENCE STUDY

REMOTE TRACKING STATION TT&C CONFIGURATION



ARTS 10 METER ANTENNA CONFIGURATION



ANTENNA CI INCLUDES

- REFLECTOR
- √ SUBREFLECTOR
- √ FEED ASSEMBLY
- AMBA ANTENNA
- PEDASTAL
- RADOME
- ANCILLARY EQUIP

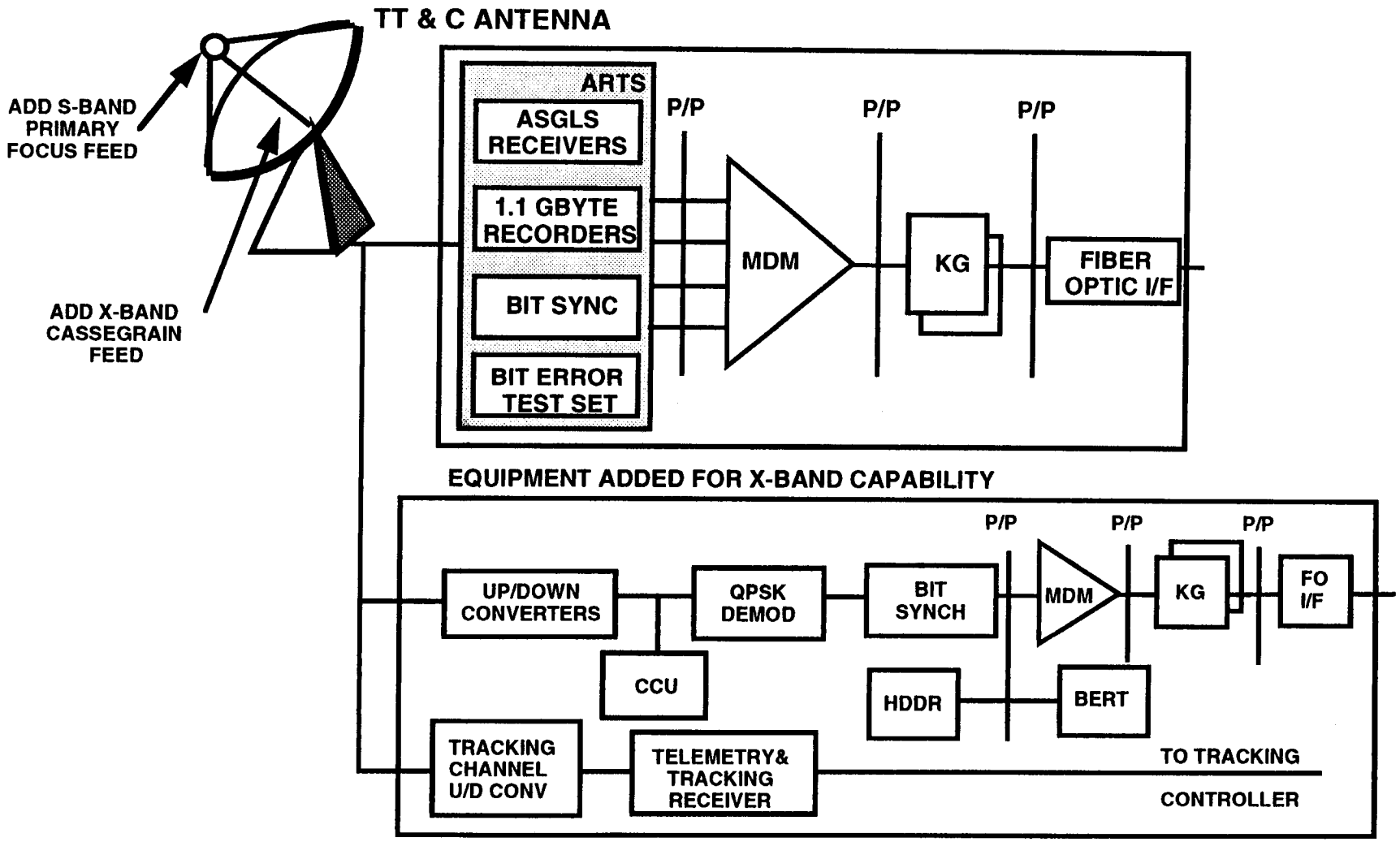
√ EQUIPMENT IMPACTED BY ADDING AN X-BAND RECEIVE CAPABILITY

RTS ANTENNA CAPABILITIES TO SUPPORT X-BAND OPERATIONS

- ALL TT&C AND ARTS ANTENNAS OPERATE AT S-BAND
- 33 FT ARTS ANTENNAS AT THULE AND OAKHANGER INSTALLED AS PART OF THE ARTS ACQUISITION
  - ANTENNA REFLECTOR CAN BE ADAPTED TO SUPPORT SUPPORTFUTURE Ku-BAND OPERATIONS
- 46 FT AND 60 FT ANTENNAS OPERATED AT THE REMAINING SITES
  - 60 FT REFLECTOR SURFACE ACCURACIES OF 0.060" rms, CAN SUPPORT FREQUENCIES UP TO 10 GHZ
  - 46 FT REFLECTORS SURFACE ACCURACIES OF 0.030" rms, CAPABLE OF SUPPORTING FREQUENCIES UP TO 20 GHZ
- THE 10 METER DLT IS A WIDE BAND DATA RELAY TO CSTC THROUGH THE M2P1 SATELLITE
  - OPERATING FREQUENCY RANGE UNAVAILABLE
  - SATELLITE TRACKING CAPABILITY ALSO UNAVAILABLE

DMSP/NOAA CONVERGENCE STUDY

X-BAND MODIFICATION IMPACTS TO EXISTING TT&C CONFIGURATION



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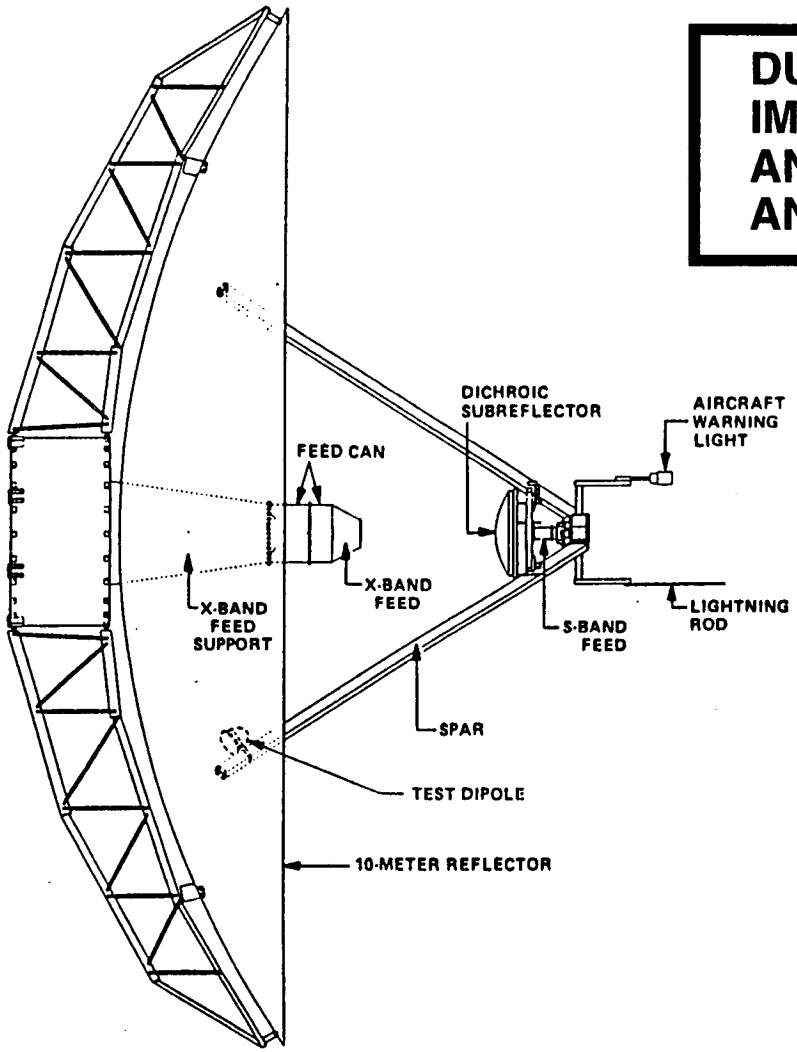
DMSP/NOAA CONVERGENCE STUDY

MODIFICATIONS FOR DUAL S-BAND AND X-BAND CAPABILITIES

DUAL FREQUENCY CAPABILITIES IMPLEMENTED USING TWO FEEDS AN S-BAND PRIMARY FOCUS FEED AND AN X-BAND CASSEGRAIN FEED



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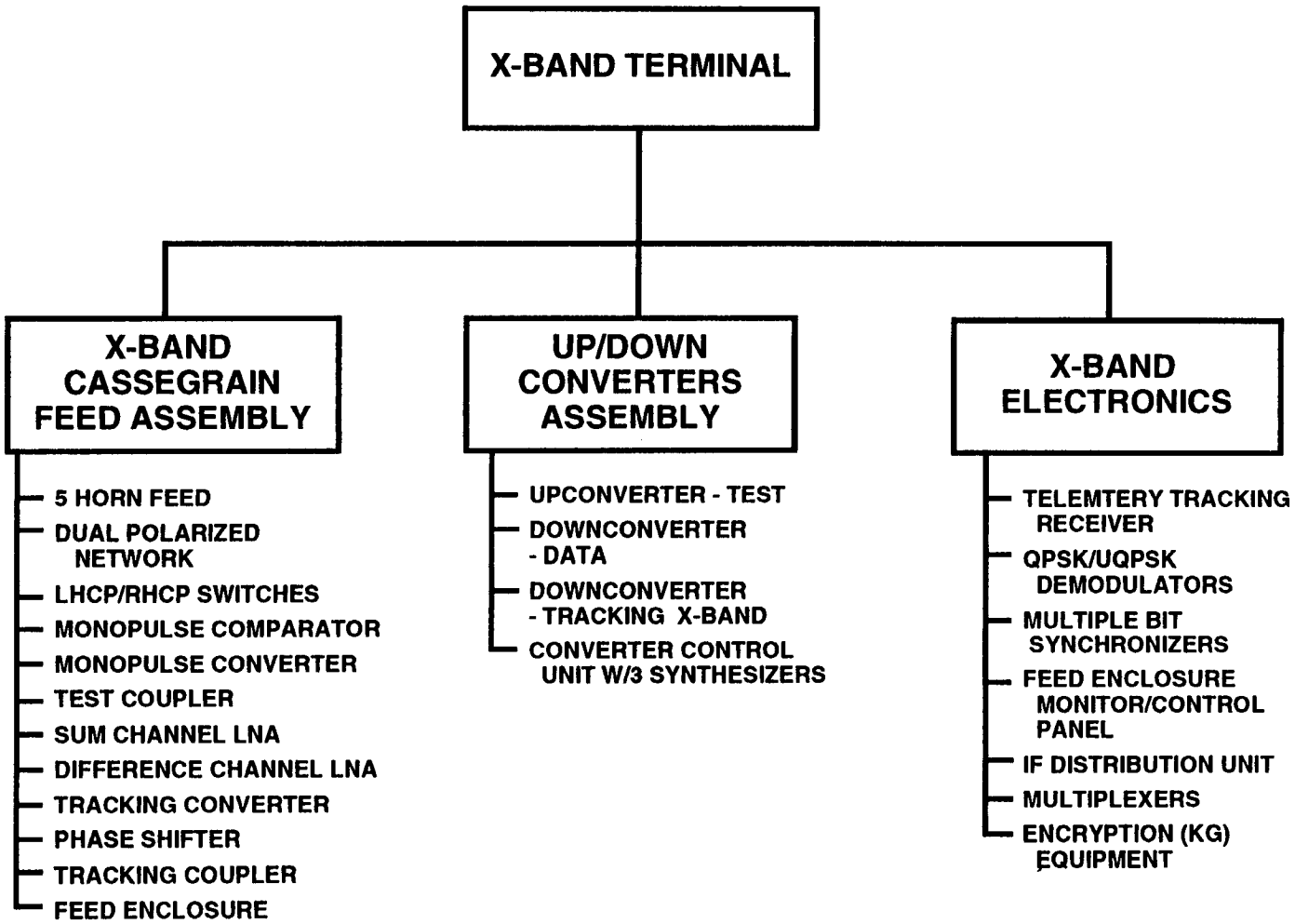
X-BAND EQUIPMENT IMPACTS



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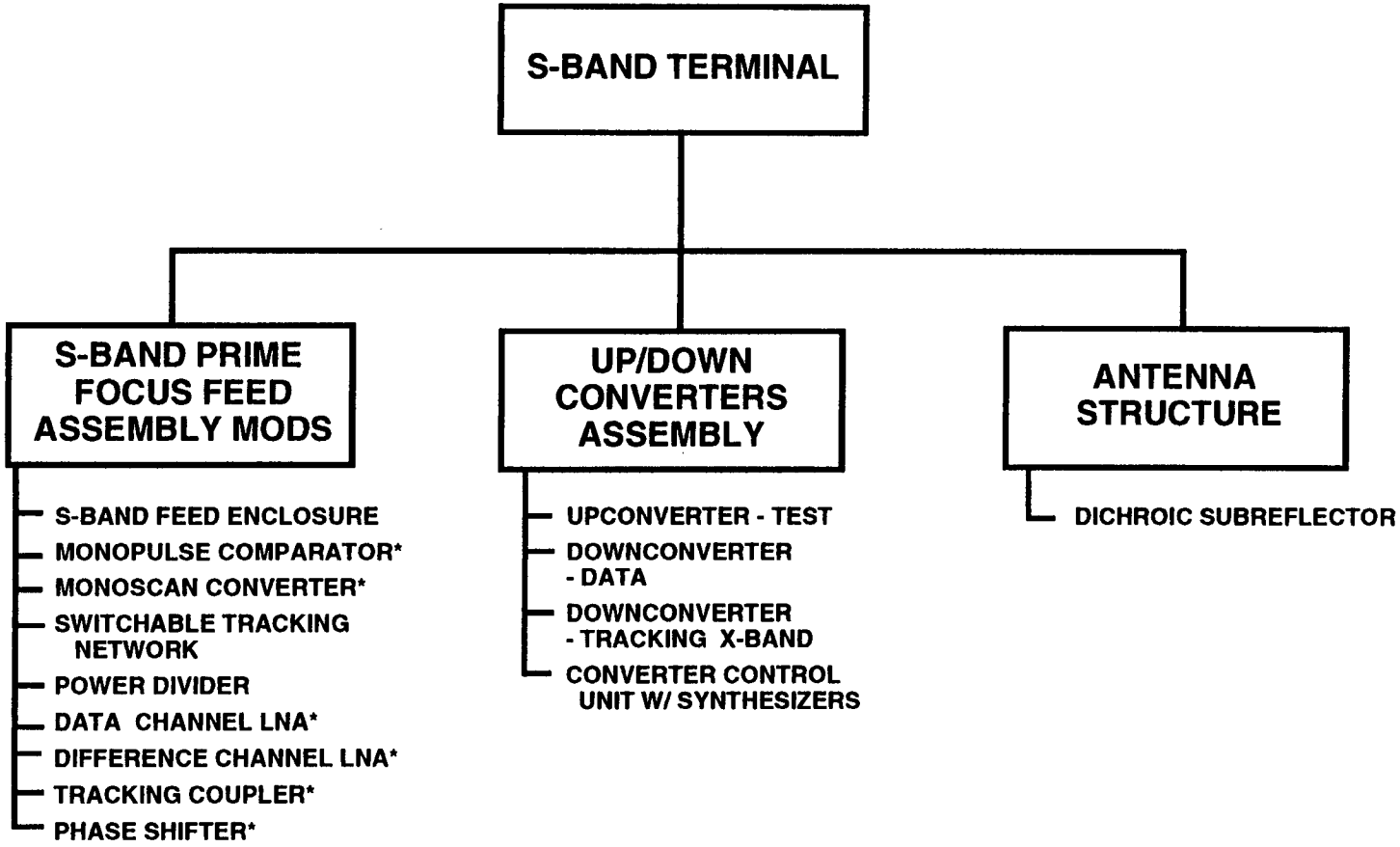
S-BAND EQUIPMENT IMPACTS



* IDENTIFIES EQUIPMENT THAT MAY NOT BE REQUIRED

DMSP/NOAA CONVERGENCE STUDY

X-BAND LINK BUDGET FOR CONFIGURATION D

X-BAND LINK MARGIN			AT NADIR	AT 5° ABOVE HORIZON
TRANSMITTER POWER (WATTS)		12	10.8 dB	10.8 dB
LINE LOSSES			-1.4 dB	-1.4 dB
SHAPED ANTENNA GAIN			-7.0 dBI	6.5 dB
SPACECRAFT EIRP			2.4 dB	15.9 dB
PATH LOSS			-168.3	-179.0
FADING AND RAIN LOSS	99% avail.		0.0	-3.0
POLARIZATION LOSSES			-0.1	-0.2
ATMOSPHERIC LOSS (DB)			-0.2	-0.5
Boltzman's Constant			-228.6	-228.6
			62.4 dB	61.8 dB
GROUND STATION SYSTEM G/T (DB/K)			31.0 dB/K	31.0 dB/K
RECEIVED Pr/No (DB - HZ)			93.4 dB-Hz	92.8 dB-Hz
DATA RATE (MBPS)		90	79.5 dB	79.5 dB
DATA POWER/TOTAL POWER			-3.0 dB	-3.0 dB
RECEIVED Eb/No			10.8 dB	10.2 dB
REQUIRED Eb/No 1/2 CC VD/HD K=7			3.5	3.5 dB
IMPLEMENTATION LOSS			3.0	3.0 dB
MARGIN (DB)			**4.3 dB**	**3.7 dB**

SUMMARY

- X-BAND TERMINALS CAPABLE OF SUPPORTING THE CONVERGED REQUIREMENTS ARE AVAILABLE
- MODIFYING THE EXISTING RTS TERMINALS TO RECEIVE BOTH S AND X BAND MAY BE A LOWER COST ALTERNATIVE
- WE HIGHLY RECOMMEND FURTHER STUDY OF THE OPTION TO ADD X-BAND TERMINALS AT RTS TO
  - DEVLOP AN UNDERSTANDING OF IMPACTS AND COST
- ROM COSTS FOR X-BAND TERMINAL AVAILABLE SOON

SYSTEM IMPACTS AT 833 KM

- J. HARRISON

ALTITUDE IMPACTS INVESTIGATED

- <u>TASK</u>

  - DETERMINE SYSTEM IMPACTS OF BASELINING CONVERGED SYSTEM ALTITUDE AT 833 KM
  - FOCUS ON:
    - * MISS REFRESH VS EARTH INCIDENCE ANGLE (EIA)
    - * CONTACT/DATA LOADING ANALYSES FOR STORED DATA

- MISS REFRESH PERFORMANCE VS EIA COMPARISON

  * 2 SENSORS PER "A" CONSTELLATION (0530, 0930) ($\Delta\Omega$=60 DEG)
  * 2 SENSORS PER "D" CONSTELLATION (0530, 1330) ($\Delta\Omega$=120 DEG)
  * 3 SENSORS PER CONSTELLATION (0530, 0930, 1330)

- CONTACT/DATA LOADING ANALYSES FOR STORED DATA

  * COMPARISON OF OTHER NETWORKS WITH BASELINE
  * DATA RATE CHANGE WITH CONTACT TIME

CONVERGED CONSTELLATION DATA REFRESH ANALYSIS

- OBJECTIVE

  * DETERMINE HOW MISS DATA REFRESH PERFORMANCE VARIES WITH EARTH INCIDENCE ANGLE OVER RANGE OF ALTITUDE
    - ALTITUDE RANGE (450-550 NMI)
    - % CONTIGUOUS COVERAGE RANGE (100%-80%)

- APPROACH

  * PERFORMED DATA REFRESH ANALYSIS OVER COMBINATIONS OF ALTITUDE AND % CONTIGUOUS COVERAGE
    - ALTITUDE RANGE (450-550 NMI)
    - % CONTIGUOUS COVERAGE RANGE (100%-80%)
    - PHASING ANGLE RANGE (0-355 DEG)
  * IDENTIFIED CORRESPONDING EIA FOR CONICAL SCAN MISS (140 DEG SCAN ANGLE)

CONVERGED CONSTELLATION REFRESH ANALYSIS (CONT'D)

- RESULTS

  * CONSTELLATION "D" BEST AT 100% COVERAGE

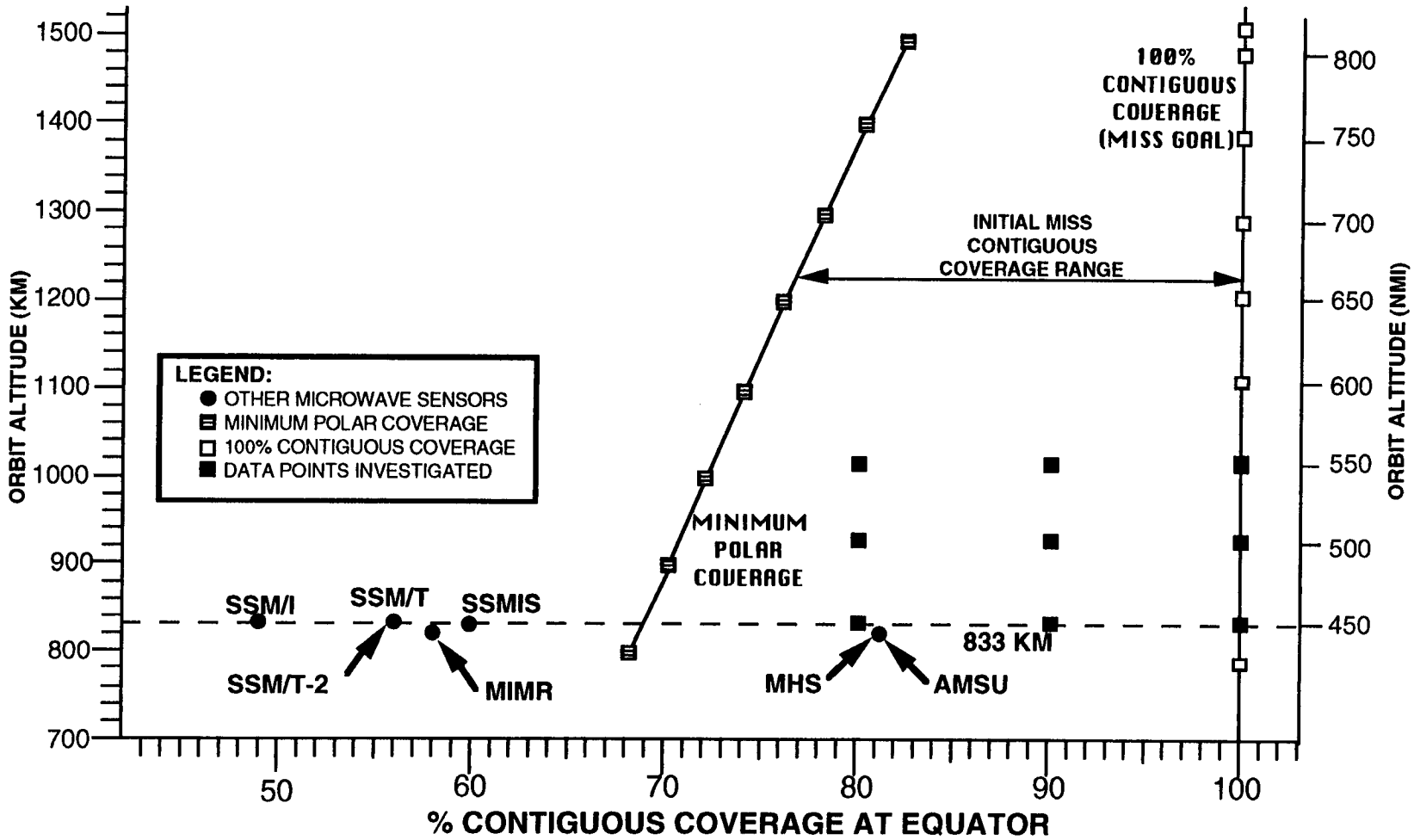
  * CONSTELLATION "A" BEST AT < 100% COVERAGE

  * EIA LOWEST AT HIGHEST ALTITUDE AND LOWEST % CONTIGUOUS COVERAGE

  * MAX DATA REFRESH PERFORMANCE BEST AT 450 NMI ALTITUDE

  * TW0-SATELLITE AVERAGE REFRESH PERFORMANCE ≤ 6 HR REQUIREMENT AT ≥ 90% CONTIGUOUS COVERAGE (INDEPENDENT OF ALTITUDE)

MISS DATA REFRESH VS EIA ANALYSIS DATA POINTS



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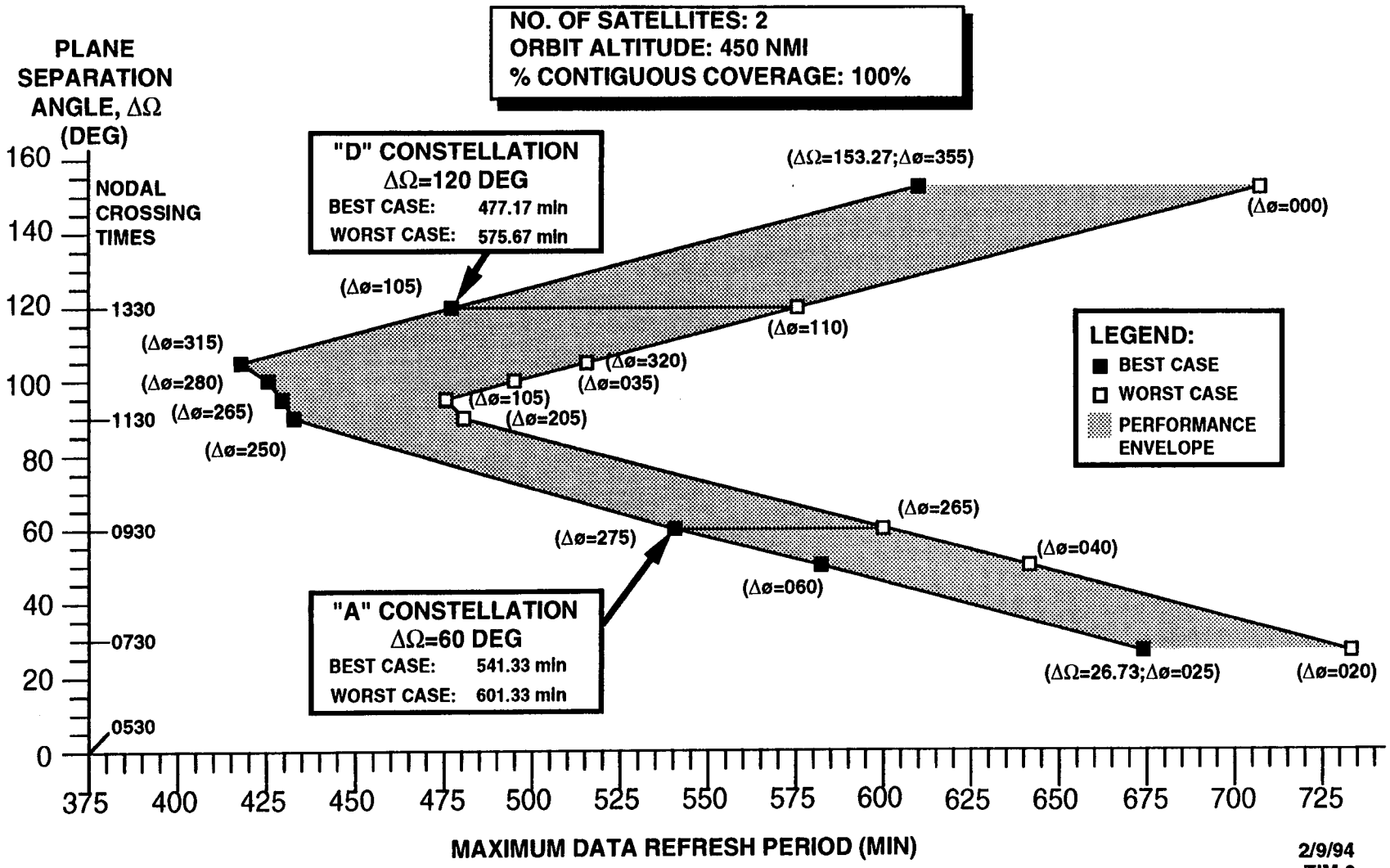
DATA REFRESH PERFORMANCE (TWO-SATELLITE CONSTELLATION)



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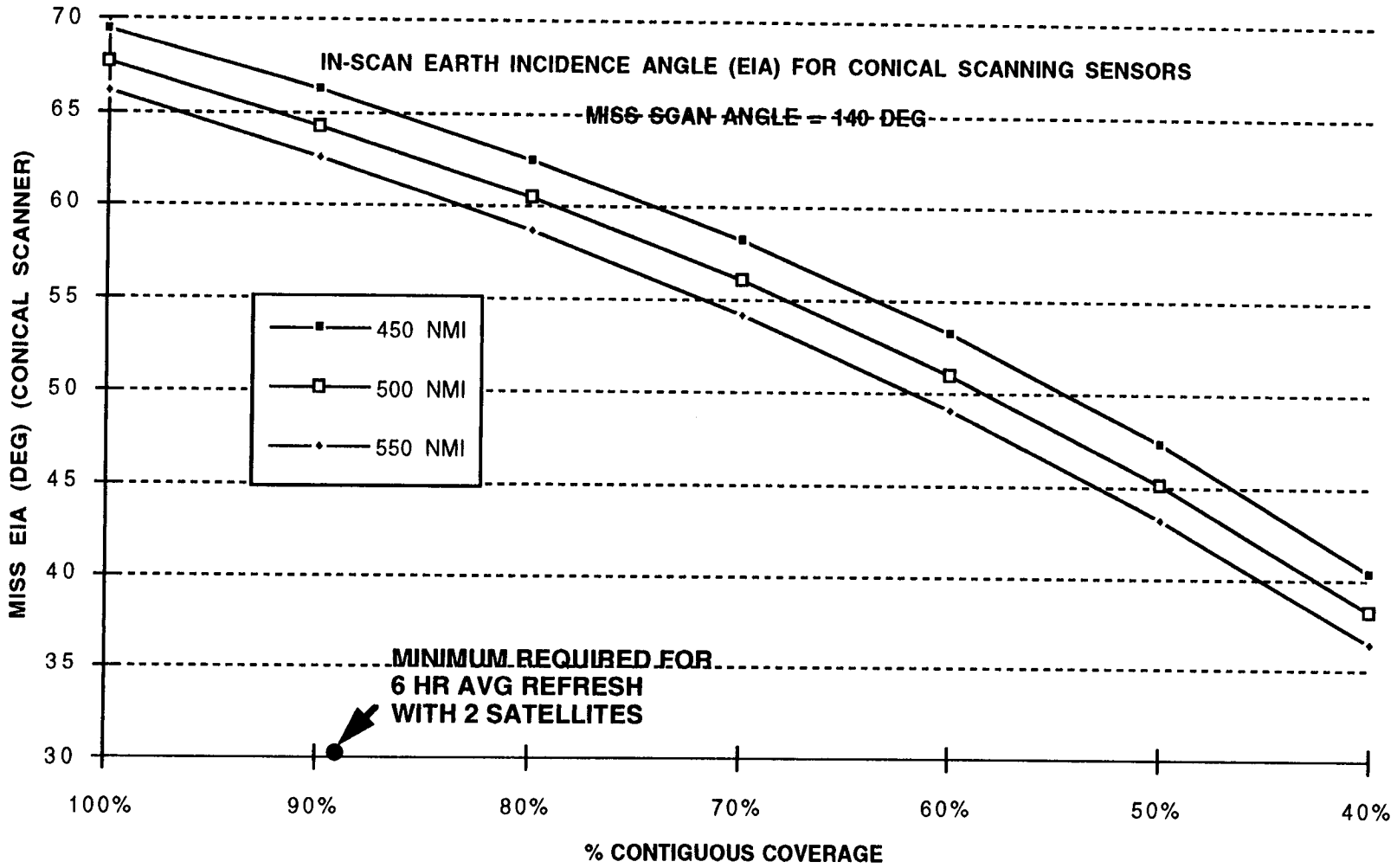
DMSP/NOAA CONVERGENCE STUDY

CHANGE IN EIA WITH ALTITUDE AND COVERAGE (CONICAL SCAN)



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"A" CONSTELLATION REFRESH ANALYSIS

ANALYSIS PARAMETERS

CIRCULAR ORBIT ALTITUDES = 450, 500, 550 NMI

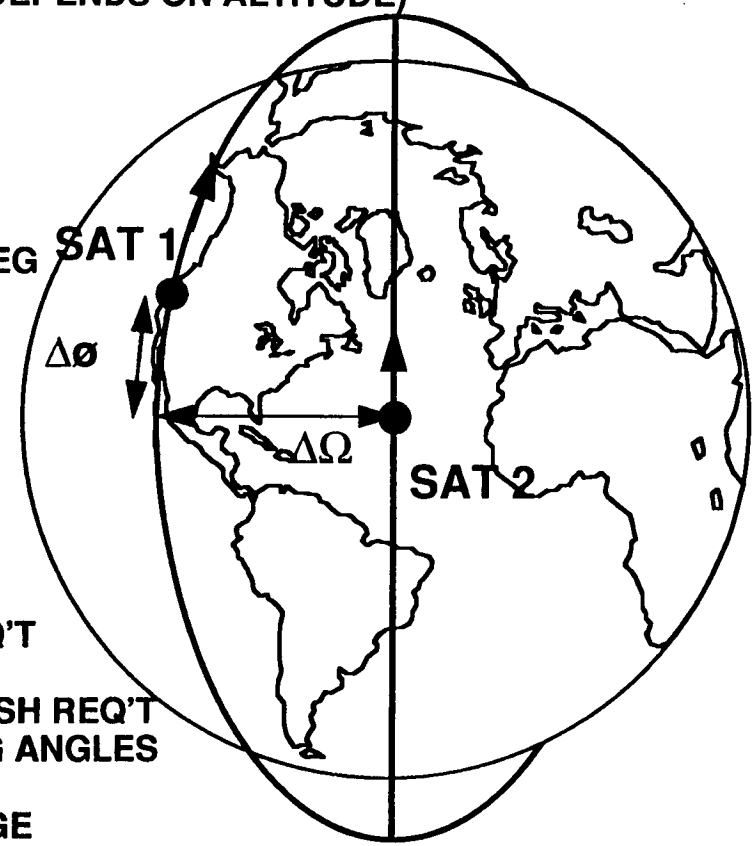
SUN-SYNCHRONOUS INCLINATION = VARIABLE (DEPENDS ON ALTITUDE)

% CONTIGUOUS COVERAGE RANGE = 100%-80%

NODAL CROSSING TIMES: $\Omega 1$=0530; $\Omega 2$=0930

DELTA ASCENDING NODES ($\Delta\Omega$) = 60 Deg

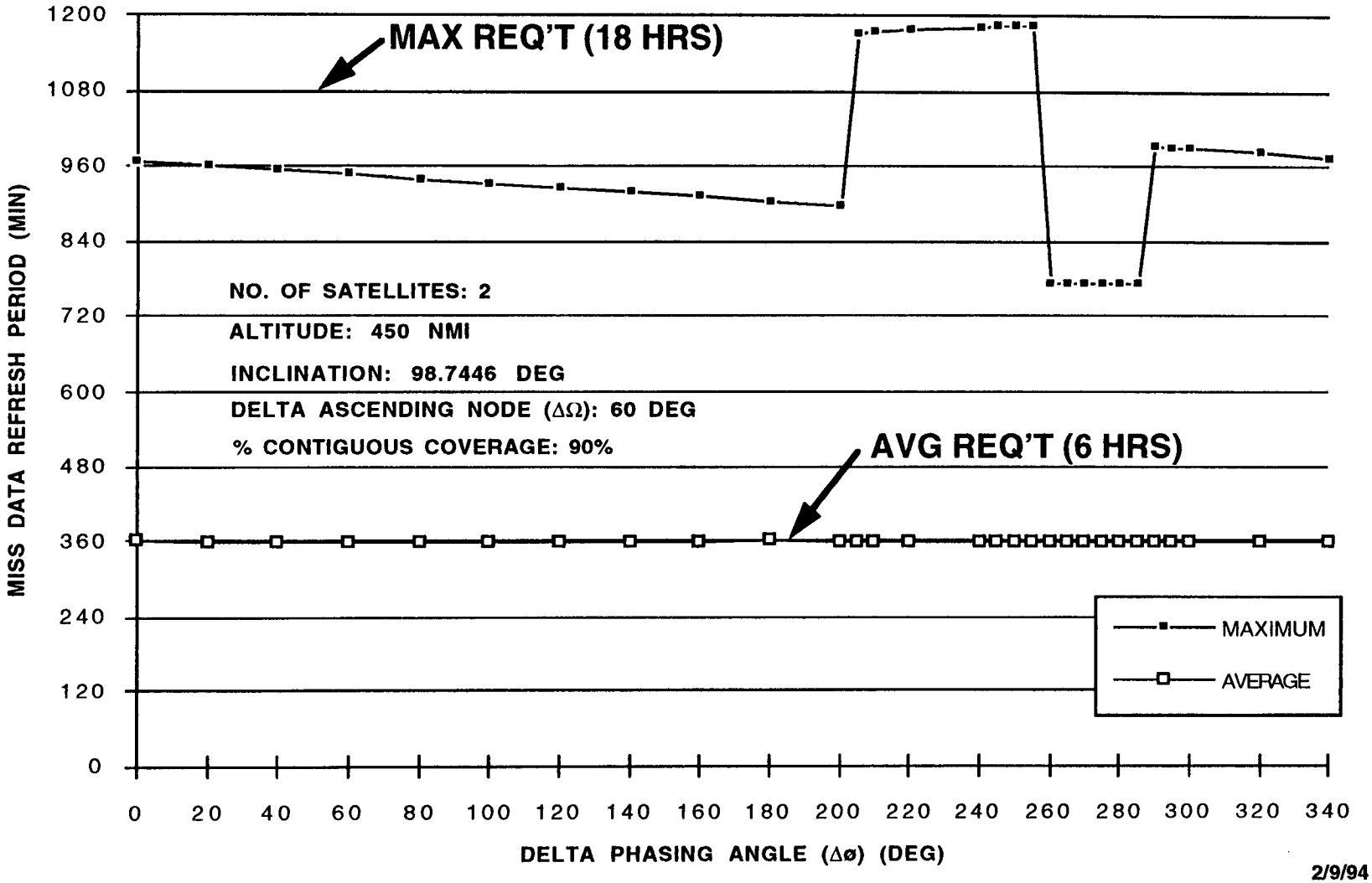
DELTA PHASING ANGLE ($\Delta\phi$):
$\Delta\phi$ = VARIABLE OVER RANGE FROM 0-355 DEG



ANALYSIS CONCLUSIONS

- ALL ALTITUDES MEET OR EXCEED 6 HR AVG REFRESH REQ'T FOR 90%+ COVERAGE
- 100% COVERAGE EXCEEDS MAX REFRESH REQ'T
- > 100% CASES MET OR EXCEEDED MAX REFRESH REQ'T OVER SLIGHTLY REDUCED RANGE OF PHASING ANGLES
- 550 NMI HAD SMALLEST PHASING ANGLE RANGE MEETING MAX REFRESH REQ'T

DATA REFRESH PERFORMANCE OVER PHASING ANGLE RANGE



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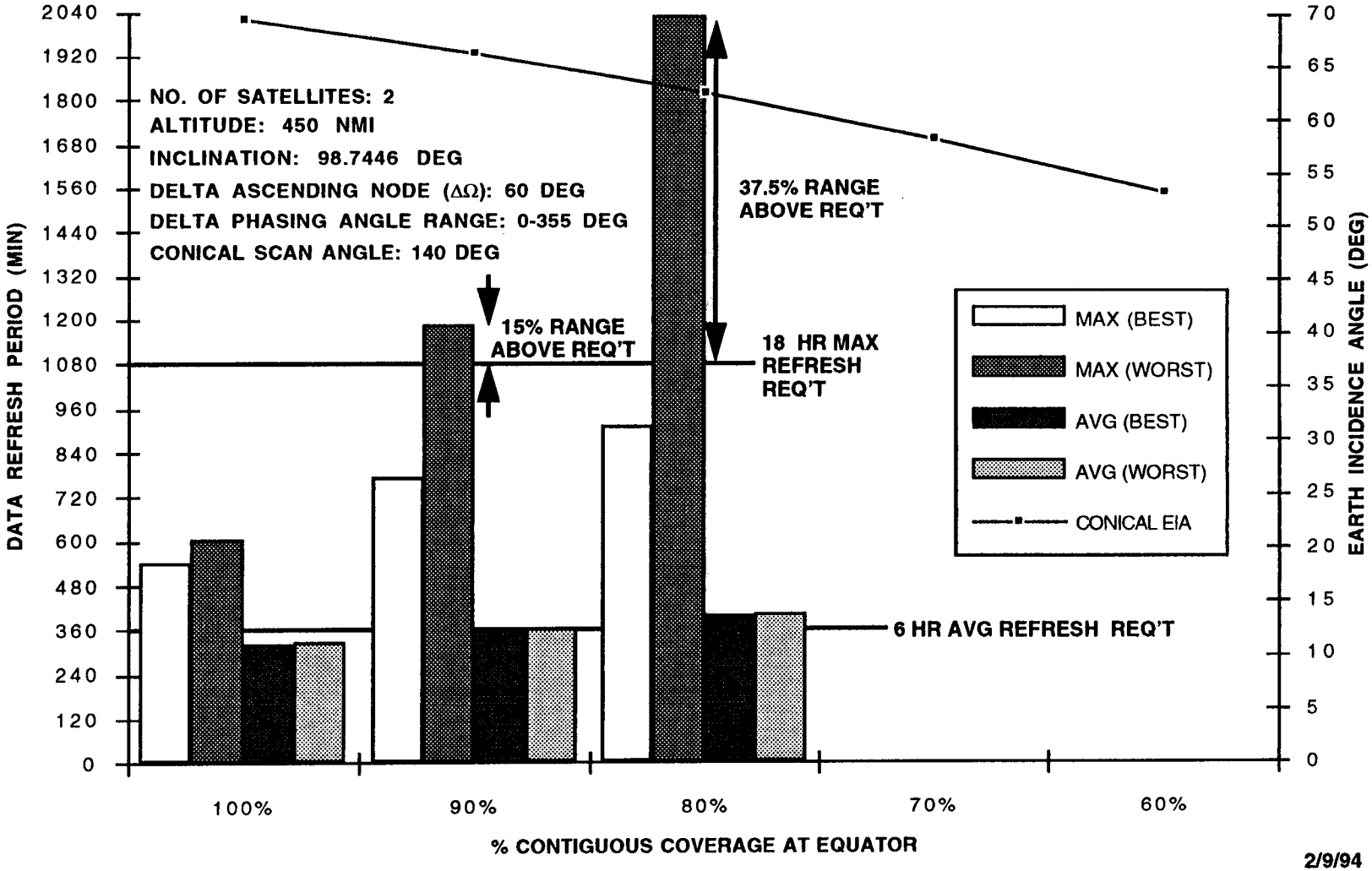
DMSP/NOAA CONVERGENCE STUDY

MISS DATA REFRESH VS EIA (CONSTELLATION "A" AT 450 NMI)



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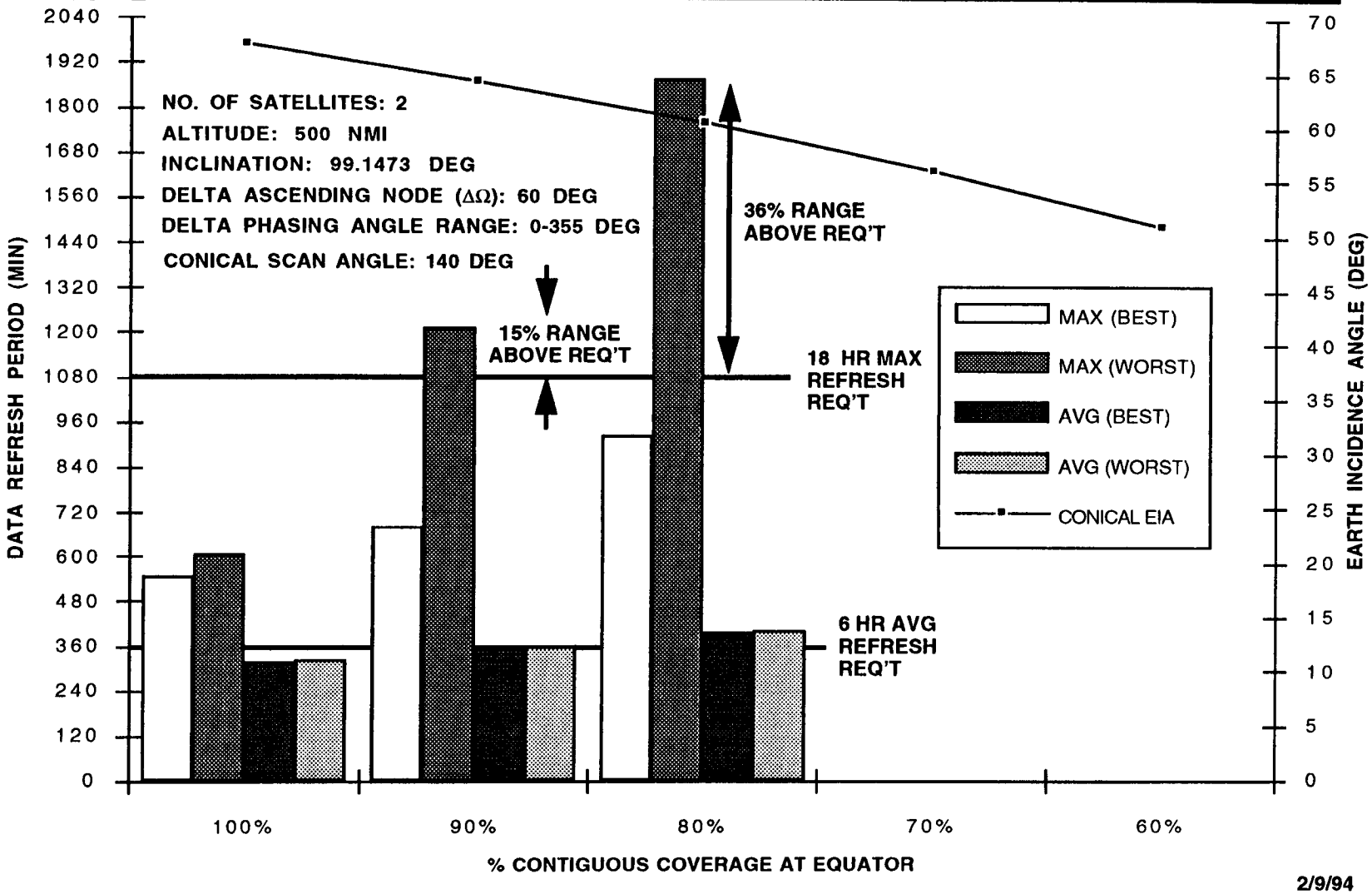
DMSP/NOAA CONVERGENCE STUDY

MISS DATA REFRESH VS EIA (CONSTELLATION "A" AT 500 NMI)



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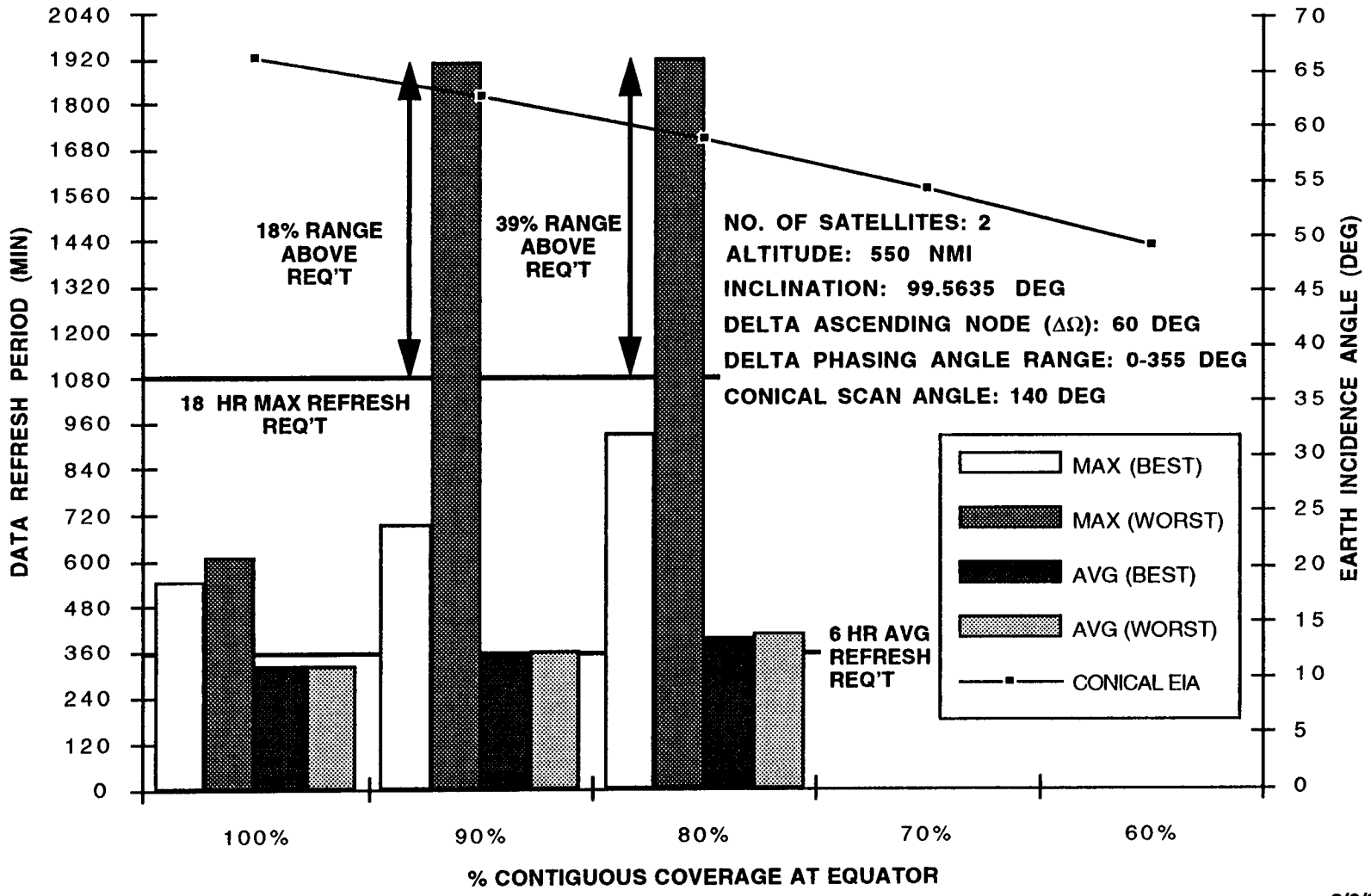
DMSP/NOAA CONVERGENCE STUDY

MISS DATA REFRESH VS EIA (CONSTELLATION "A" AT 550 NMI)



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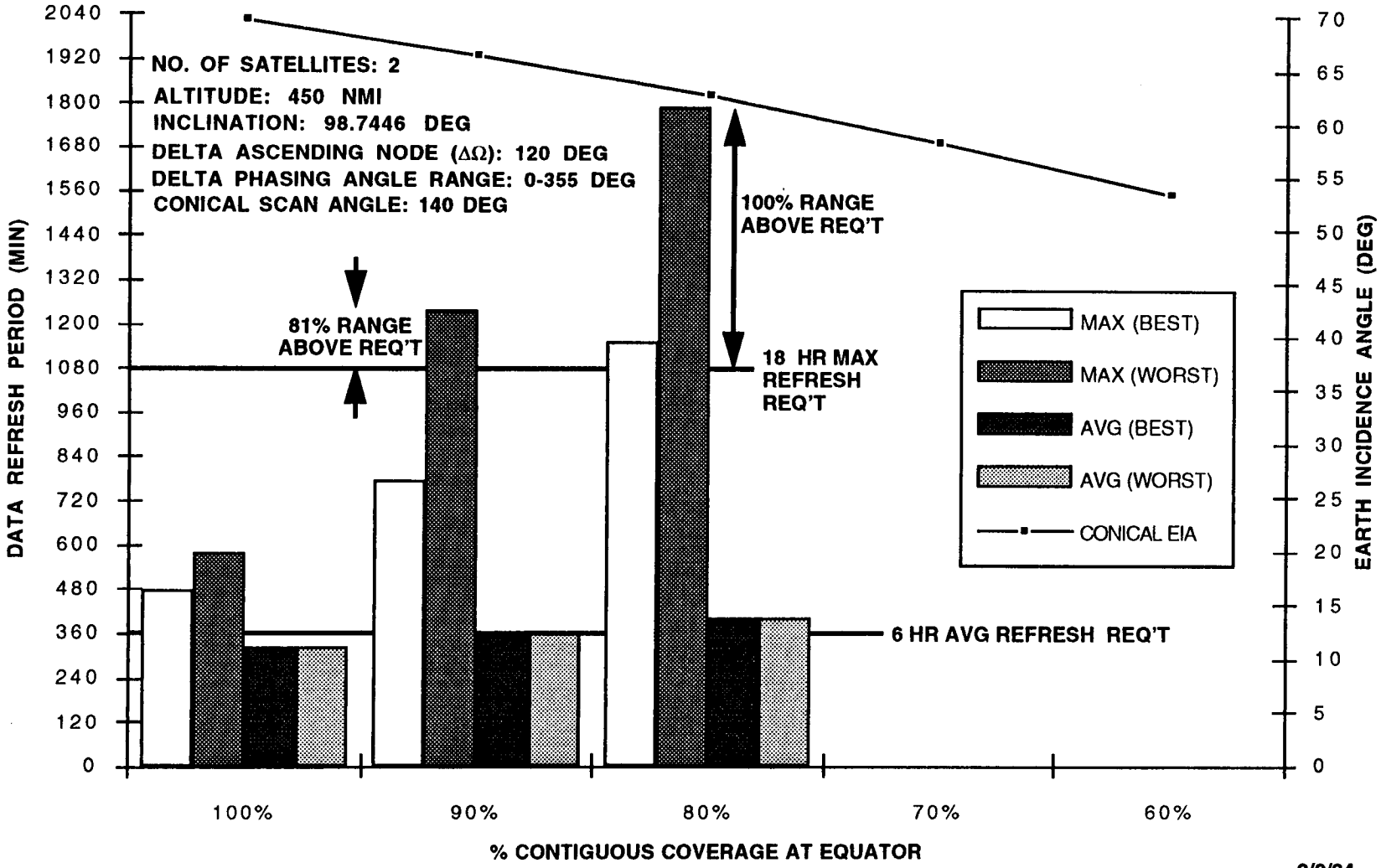
DMSP/NOAA CONVERGENCE STUDY

MISS DATA REFRESH VS EIA (CONSTELLATION "D" AT 450 NMI)



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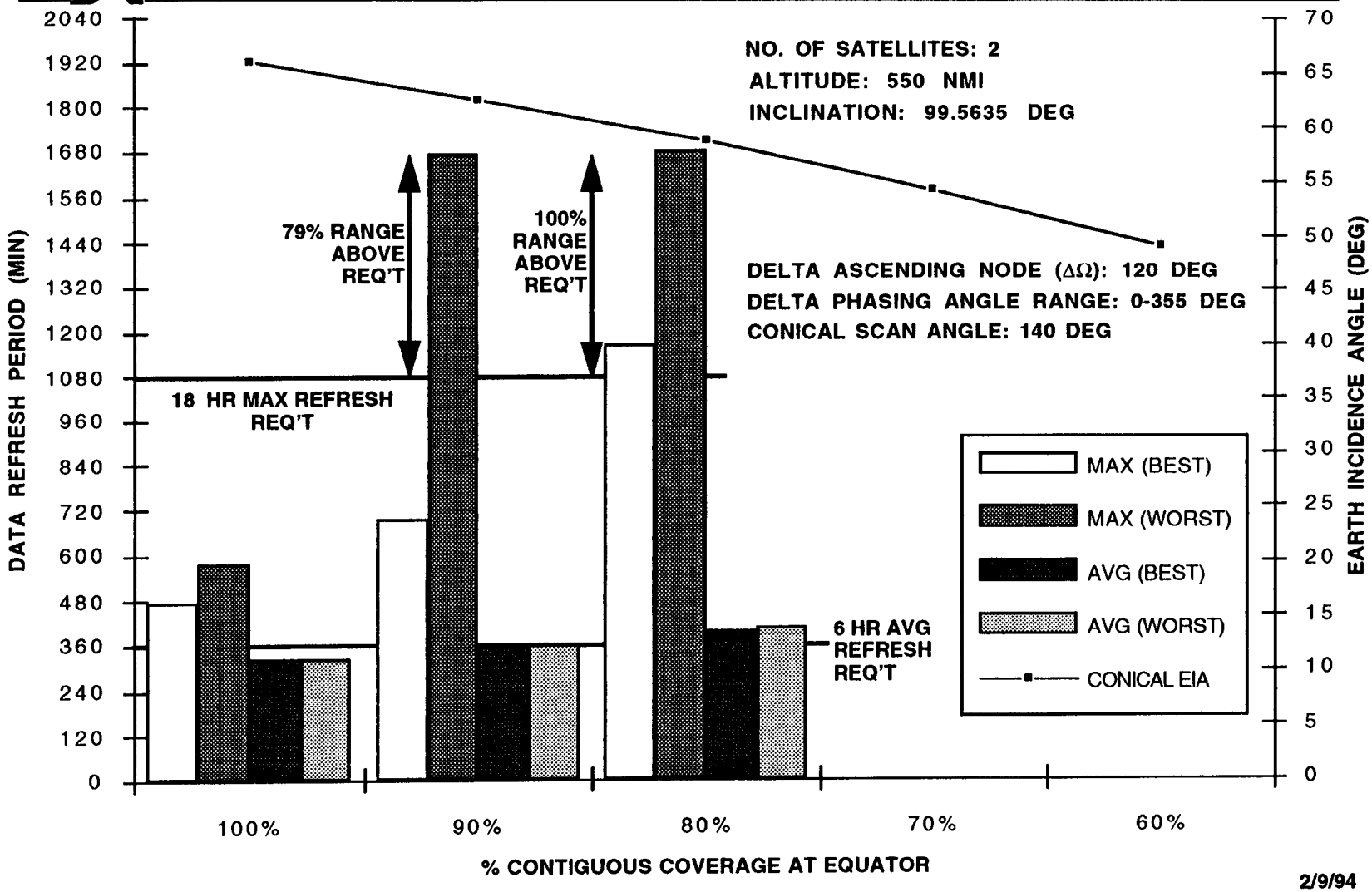
DMSP/NOAA CONVERGENCE STUDY

MISS DATA REFRESH VS EIA (CONSTELLATION "D" AT 550 NMI)



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"D" CONSTELLATION REFRESH ANALYSIS

ANALYSIS PARAMETERS

CIRCULAR ORBIT ALTITUDES = D1 @ 833, 1019 KM; D3 @ 824, 833, 1019 KM

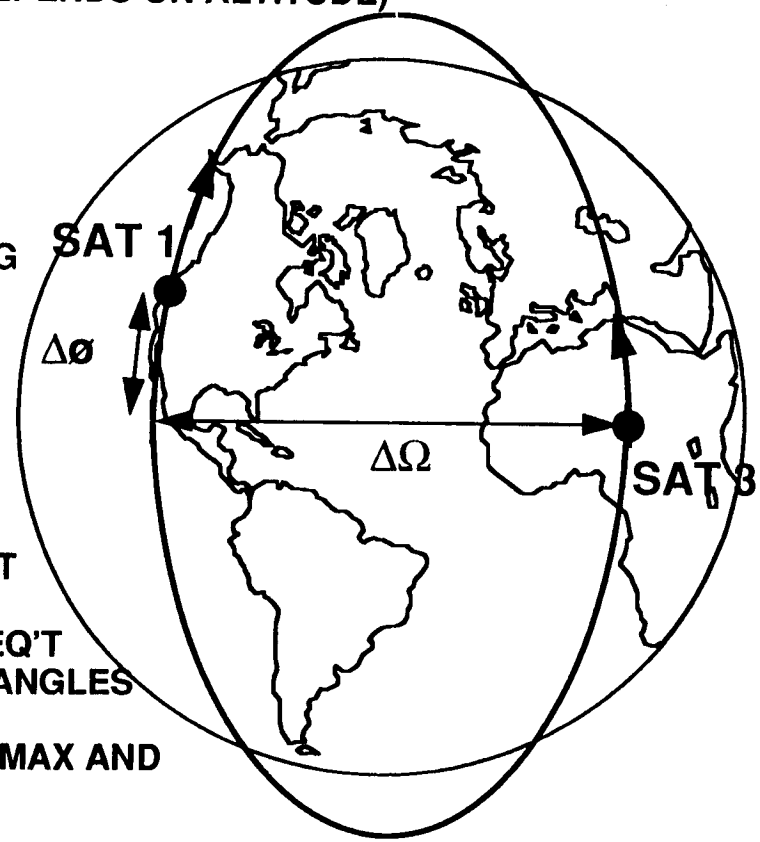
SUN-SYNCHRONOUS INCLINATION = VARIABLE (DEPENDS ON ALTITUDE)

% CONTIGUOUS COVERAGE RANGE = 100%-80%

NODAL CROSSING TIMES: $\Omega 1$=0530; $\Omega 2$=1330

DELTA ASCENDING NODES ($\Delta\Omega$) = 120 Deg

DELTA PHASING ANGLE ($\Delta\phi$):
$\Delta\phi$ = VARIABLE OVER RANGE FROM 0-355 DEG



ANALYSIS CONCLUSIONS

- ALL ALTITUDES MEET OR EXCEED 6 HR AVG REFRESH REQ'T FOR 90%+ COVERAGE
- 100% COVERAGE EXCEEDS MAX REFRESH REQ'T
- 90% CASES MEET OR EXCEED MAX REFRESH REQ'T OVER GREATLY REDUCED RANGE OF PHASING ANGLES
- 80% CASES WERE NON-COMPLIANT WITH BOTH MAX AND AVG REFRESH REQ'TS
- PLACING SAT1 AT 1019 KM AND SAT3 AT 824 KM DEGRADES PERFORMANCE

MISS REFRESH VS EIA ANALYSIS RESULTS ("A" CONSTELLATION)

ALTITUDE	100%	90%	80%
550 NMI	MAX: 547.3-609.0 MIN AVG: 320.2-322.6 MIN EIA: 66.1 DEG	MAX: 694.0-1912.3 MIN AVG: 354.5-359.0 MIN EIA: 62.6 DEG	MAX: 931.3-1924.7 MIN AVG: 396.1-405.5 MIN EIA: 58.7 DEG
500 NMI	MAX: 545.0-605.0 MIN AVG: 319.5-321.8 MIN EIA: 67.7 DEG	MAX: 682.3-1212.0 MIN AVG: 353.4-356.5 MIN EIA: 64.3 DEG	MAX: 922.3-1878.7 MIN AVG: 395.7-403.0 MIN EIA: 60.5 DEG
450 NMI	MAX: 541.3-601.3 MIN AVG: 322.4-324.4 MIN EIA: 69.4 DEG	MAX: 771.3-1185.3 MIN AVG: 356.5-359.4 MIN EIA: 66.2 DEG	MAX: 913.7-2030.7 MIN AVG: 398.3-401.5 MIN EIA: 62.5 DEG

% CONTIGUOUS COVERAGE

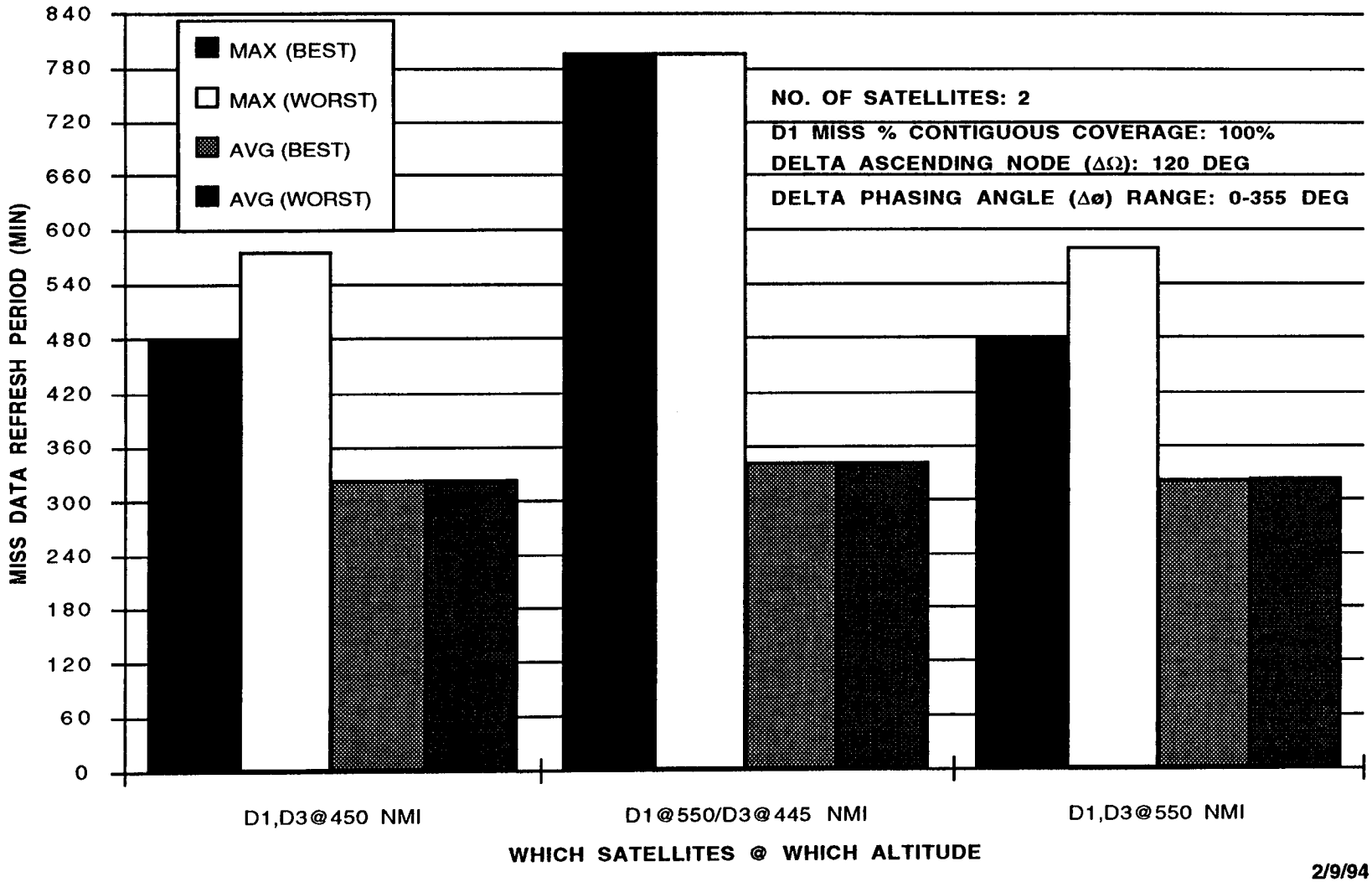
MISS REFRESH VS EIA ANALYSIS RESULTS ("D" CONSTELLATION)

ALTITUDE	100%	90%	80%
550 NMI	MAX: 477.3-578.7 MIN AVG: 320.5-322.8 MIN EIA: 66.1 DEG	MAX: 694.7-1672.0 MIN AVG: 354.9-359.2 MIN EIA: 62.6 DEG	MAX: 1166.7-1684.7 MIN AVG: 395.9-405.9 MIN EIA: 58.7 DEG
550/ 445 NMI	MAX: 794.7-796.0 MIN AVG: 341.0-341.4 MIN EIA@ 550: 66.1 DEG EIA@ 445: 63.0 DEG		
450 NMI	MAX: 477.2-575.7 MIN AVG: 322.2-322.5 MIN EIA: 69.4 DEG	MAX: 771.3-1233.3 MIN AVG: 356.6-359.7 MIN EIA: 66.2 DEG	MAX: 1150.7-1792.0 MIN AVG: 399.7-403.0 MIN EIA: 62.5 DEG

% CONTIGUOUS COVERAGE

DMSP/NOAA CONVERGENCE STUDY

CONSTELLATION "D" MISS DATA REFRESH (D1 AT 550 NMI/D3 AT 445 NMI)



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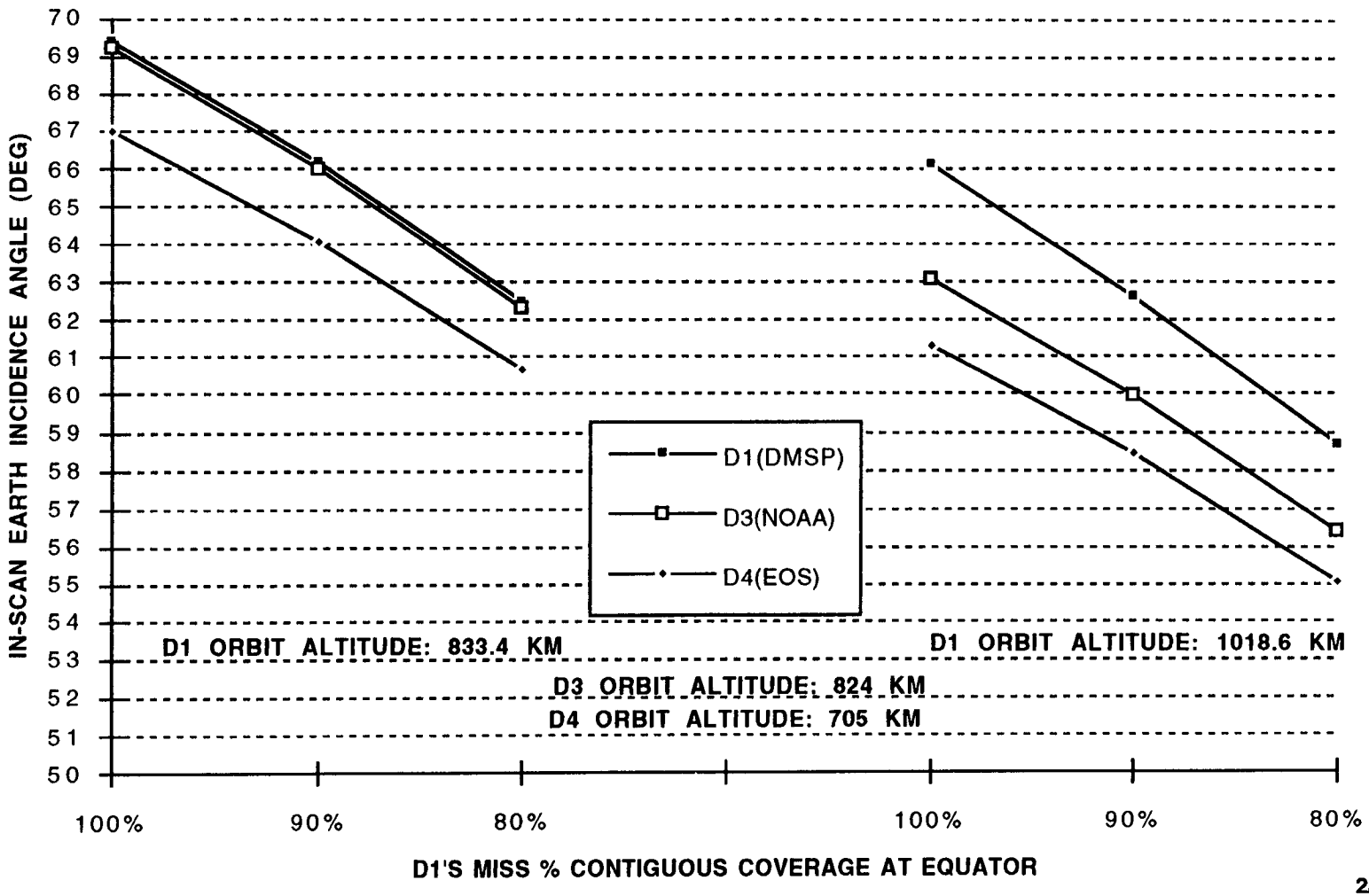
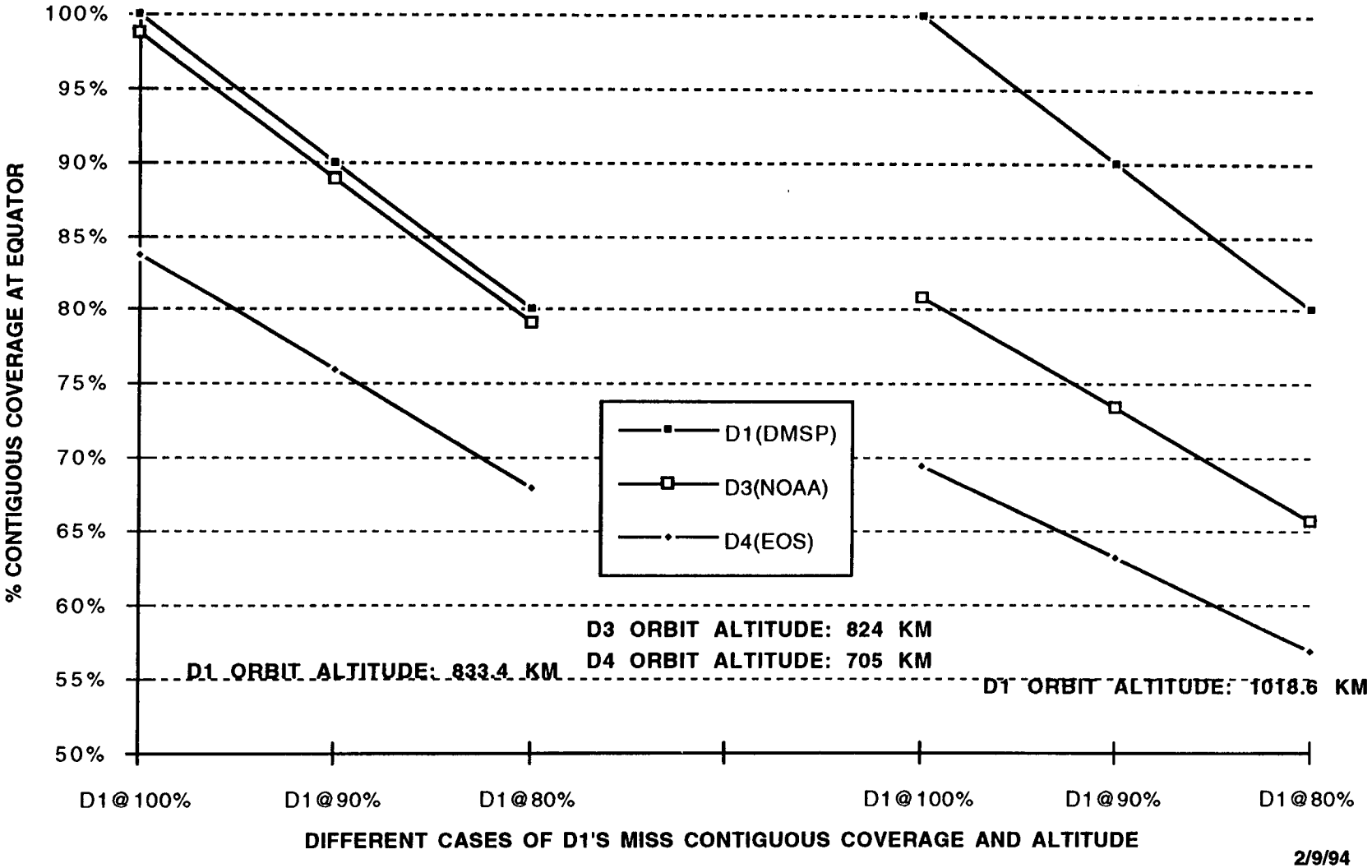
"D" CONSTELLATION RANGE OF EARTH INCIDENCE ANGLES



"D" CONSTELLATION RANGE OF % CONTIGUOUS COVERAGE



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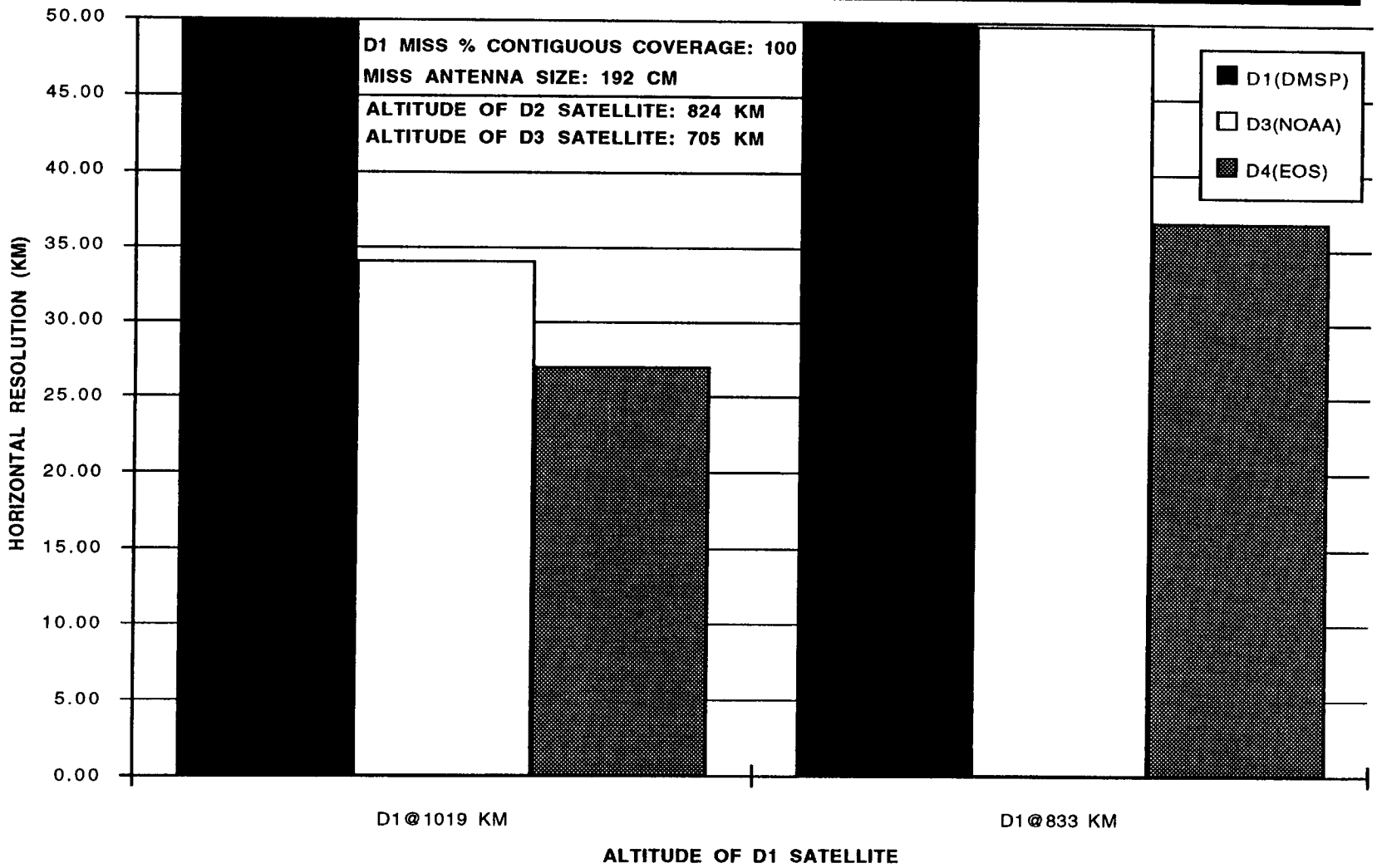
DMSP/NOAA CONVERGENCE STUDY

"D" CONSTELLATION RANGE FOR HORIZONTAL RESOLUTION



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THREE-SATELLITE CONSTELLATION REFRESH ANALYSIS

CIRCULAR ORBIT ALTITUDES = 450, 500, 550 NMI

SUN-SYNCHRONOUS INCLINATION = VARIABLE (DEPENDS ON ALTITUDE)

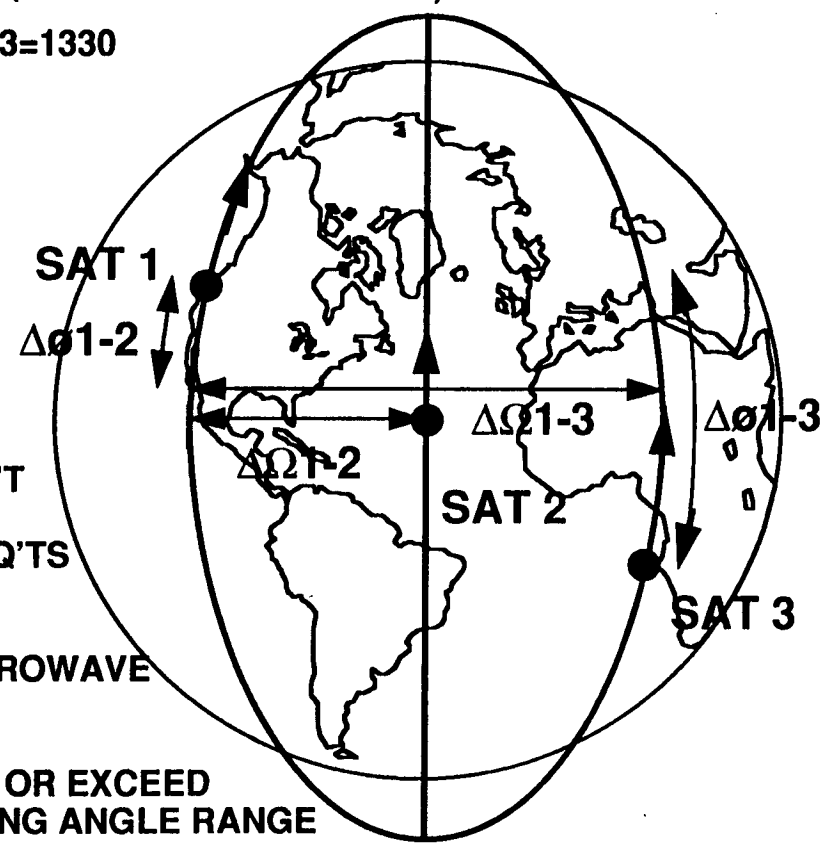
NODAL CROSSING TIMES: $\Omega 1$=0530, $\Omega 2$=0930, $\Omega 3$=1330

DELTA ASCENDING NODES ($\Delta\Omega$):

- $\Delta\Omega 1\text{-}2$ = 60 Deg
- $\Delta\Omega 1\text{-}3$ = 120 Deg

DELTA PHASING ANGLE ($\Delta ø$):

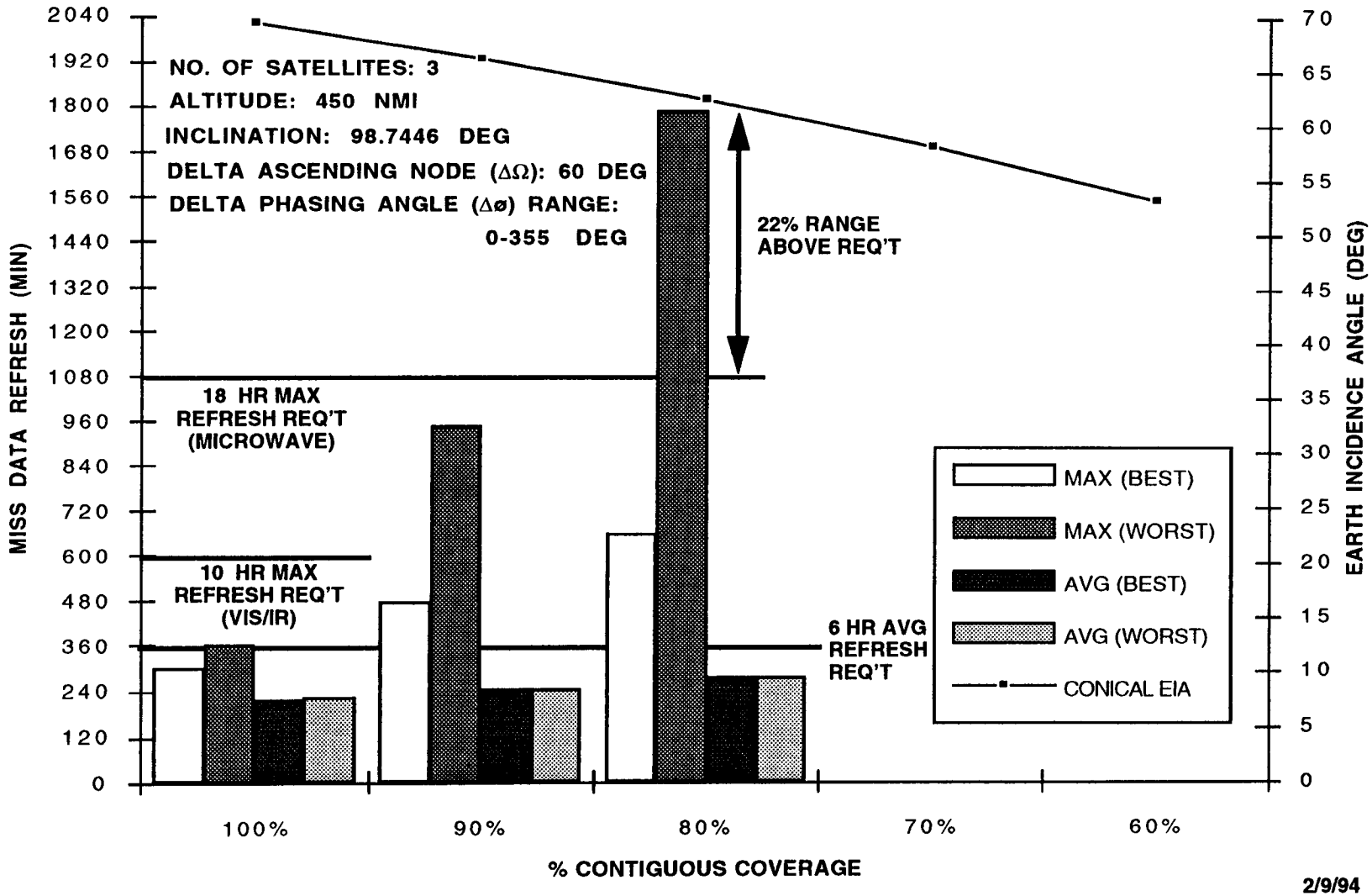
- $\Delta ø 1\text{-}2$ = VARIABLE OVER RANGE FROM 0-355 Deg
- $\Delta ø 1\text{-}3 = 2 \times \Delta ø 1\text{-}2$



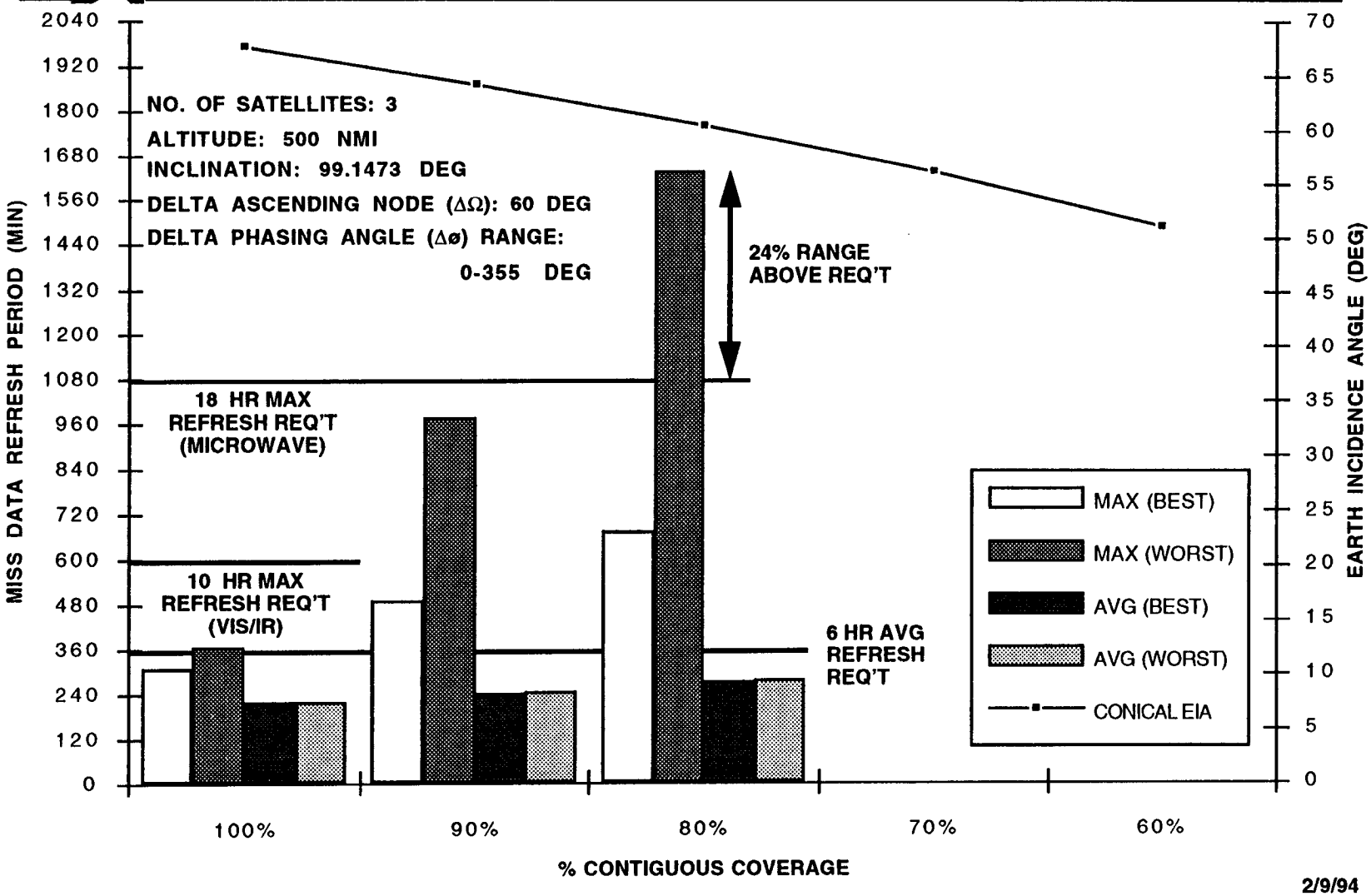
<u>ANALYSIS CONCLUSIONS</u>

- ALL CASES EXCEED 6 HR AVG REFRESH REQ'T
- ALL 100% CASES EXCEED MAX REFRESH REQ'TS FOR BOTH VIS/IR AND MICROWAVE EDR'S
- 90% CASES AT 450 AND 500 NMI EXCEED MICROWAVE MAX REQ'T
- 90% CASE AT 550 AND ALL 80% CASES MEET OR EXCEED MAX REQ'T OVER SLIGHTLY REDUCED PHASING ANGLE RANGE

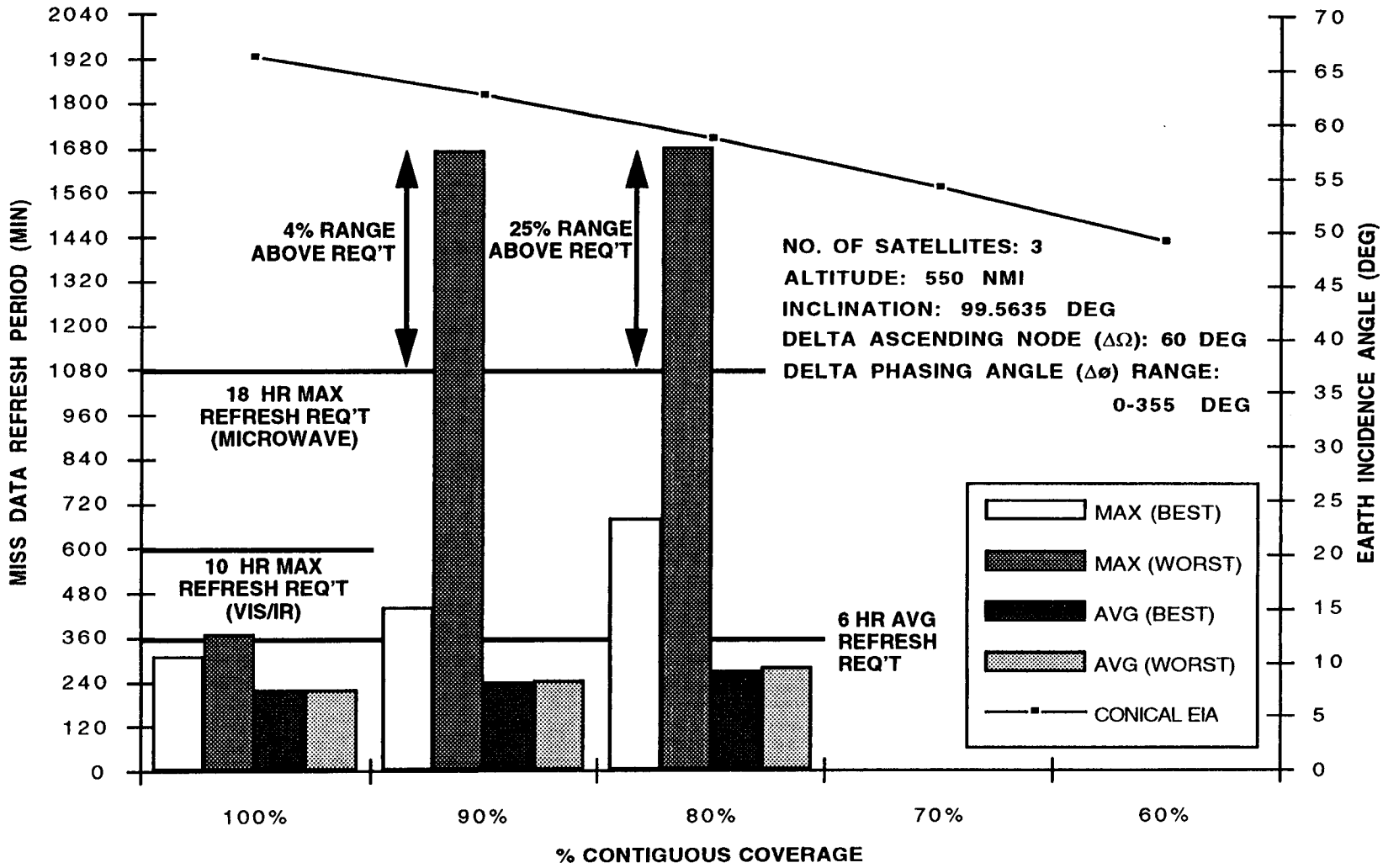
MISS DATA REFRESH VS EIA (3 SATELLITES AT 450 NMI)



MISS DATA REFRESH VS EIA (3 SATELLITES AT 500 NMI)



MISS DATA REFRESH VS EIA (3 SATELLITES AT 550 NMI)



DATA REFRESH VS EIA ANALYSIS RESULTS (3-SATELLITE CONSTELLATION)

ALTITUDE	100%	90%	80%
550 NMI	MAX: 309.7-369.0 MIN AVG: 216.6-218.6 MIN EIA: 66.1 DEG	MAX: 441.0-1671.7 MIN AVG: 240.5-243.8 MIN EIA: 62.6 DEG	MAX: 678.0-1684.0 MIN AVG: 270.0-277.7 MIN EIA: 58.7 DEG
500 NMI	MAX: 305.0-365.0 MIN AVG: 216.1-218.1 MIN EIA: 67.7 DEG	MAX: 486.3-972.7 MIN AVG: 240.2-242.9 MIN EIA: 64.3 DEG	MAX: 669.7-1637.7 MIN AVG: 270.0-274.9 MIN EIA: 60.5 DEG
450 NMI	MAX: 302.5-360.8 MIN AVG: 217.6-219.6 MIN EIA: 69.4 DEG	MAX: 478.7-944.3 MIN AVG: 242.4-244.7 MIN EIA: 66.2 DEG	MAX: 661.0-1789.7 MIN AVG: 271.9-274.6 MIN EIA: 62.5 DEG

% CONTIGUOUS COVERAGE

MISS DATA REFRESH ANALYSIS SUMMARY

- CONCLUSIONS

  - TWO-SATELLITE CONSTELLATIONS

    * "D" CONSTELLATION PROVIDES IMPROVED MAX REFRESH PERFORMANCE AT 100% COVERAGE
    * "A" CONSTELLATION ALLOWS MORE DESIGN AND OPERATIONAL FLEXIBILITY FOR < 100% COVERAGE
    * BEST PERFORMANCE WHEN ALL MISS'S FLOWN AT SAME ALTITUDE
    * NO ADVANTAGE BETWEEN "A" AND "D" FOR AVG REFRESH PERFORMANCE

  - THREE-SATELLITE CONSTELLATION

    * PROVIDES IMPROVED PERFORMANCE IN MAX AND AVG REFRESH PERFORMANCE
    * LOSES ADVANTAGE WHEN TWO SATELLITES SHARE SAME NODAL CROSSING TIME

CONTACT TIME VERSUS DATA LOADING ANALYSIS

- PURPOSE
  - * DETERMINE MAXIMUM ALLOWABLE CONTACT TIMES
  - * DETERMINE MINIMUM STORED DOWNLINK DATA RATE PER NETWORK
- APPROACH
  - * IDENTIFIED GROUND STATION NETWORK CANDIDATES
    - - SIMILAR TO BASELINE
    - - IMPROVEMENT OVER BASELINE
  - * GENERATED GENERALIZED VIEWBAR DIAGRAMS USING ICAP
  - * INCREASED GROUND STATION CONTACT TIMES UNTIL HOLES IN COVERAGE WERE PRESENT
    - - NO-BLIND-REV AND ONE-BLIND-REV CONDITIONS
    - - 450 NMI AND 550 NMI ALTITUDES
- RESULTS
  - * ADDING GUAM TO BASELINE PROVIDED BEST RESULTS
  - * ADDING FAIRBANKS IMPROVES RESULTS AND REDUCES NO. OF STATIONS
  - * UTILITY OF ADDING STATIONS DECREASES WITH INCREASE IN TOTAL NO. OF STATIONS

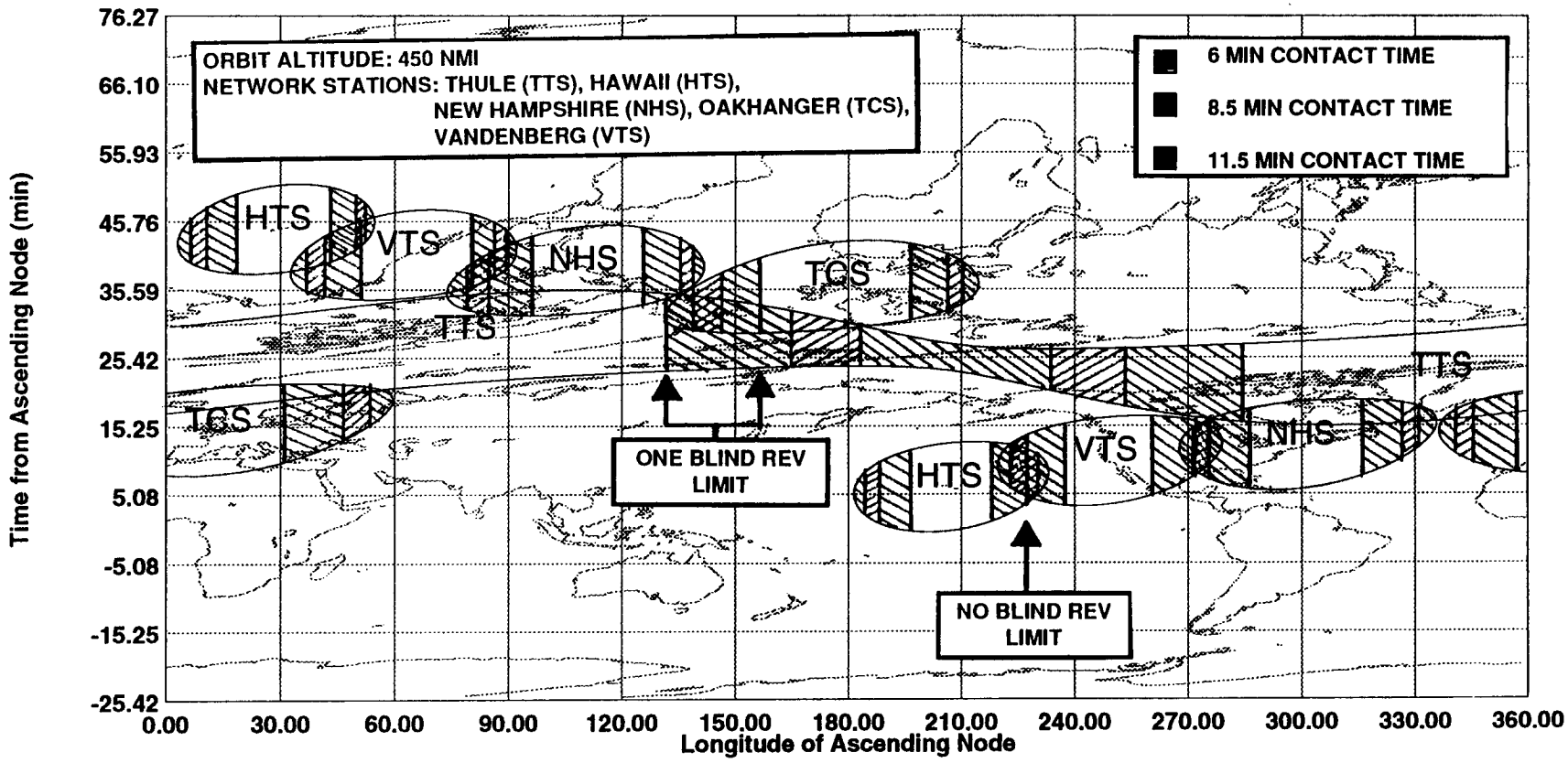
CONVERGED GROUND STATION NETWORK ALTERNATIVES

SOURCE CATEGORY	CONVERGED NETWORK CANDIDATES	NO. OF GROUND STATIONS 1	2	3	4	5	6	7
AFSCN	T-H-N-O-V *	THULE	HAWAII	NEW HAMPSHIRE	OAKHANGER	VANDENBERG		
AFSCN	T-H-N-O-V-G	THULE	HAWAII	NEW HAMPSHIRE	OAKHANGER	VANDENBERG	GUAM	
MIX	T-F-N-O	THULE	FAIRBANKS	NEW HAMPSHIRE	OAKHANGER			
MIX	T-F-N-O-G	THULE	FAIRBANKS	NEW HAMPSHIRE	OAKHANGER	GUAM		
MIX	T-F-N-O-G-H	THULE	FAIRBANKS	NEW HAMPSHIRE	OAKHANGER	GUAM	HAWAII	
MIX	T-F-N-O-G-H-C	THULE	FAIRBANKS	NEW HAMPSHIRE	OAKHANGER	GUAM	HAWAII	COLORADO

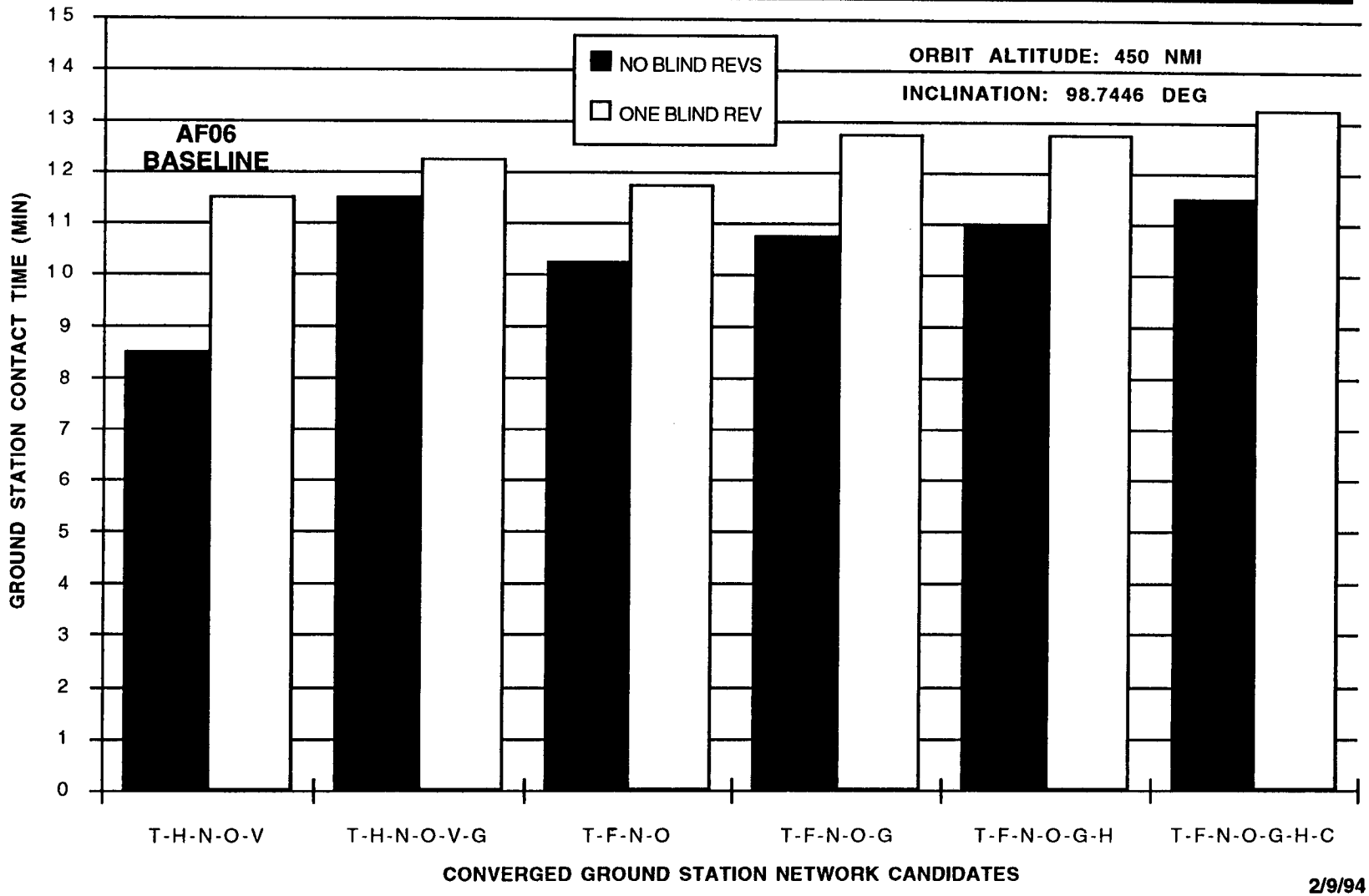
* AF06 BASELINE NETWORK

BASELINE NETWORK COVERAGE

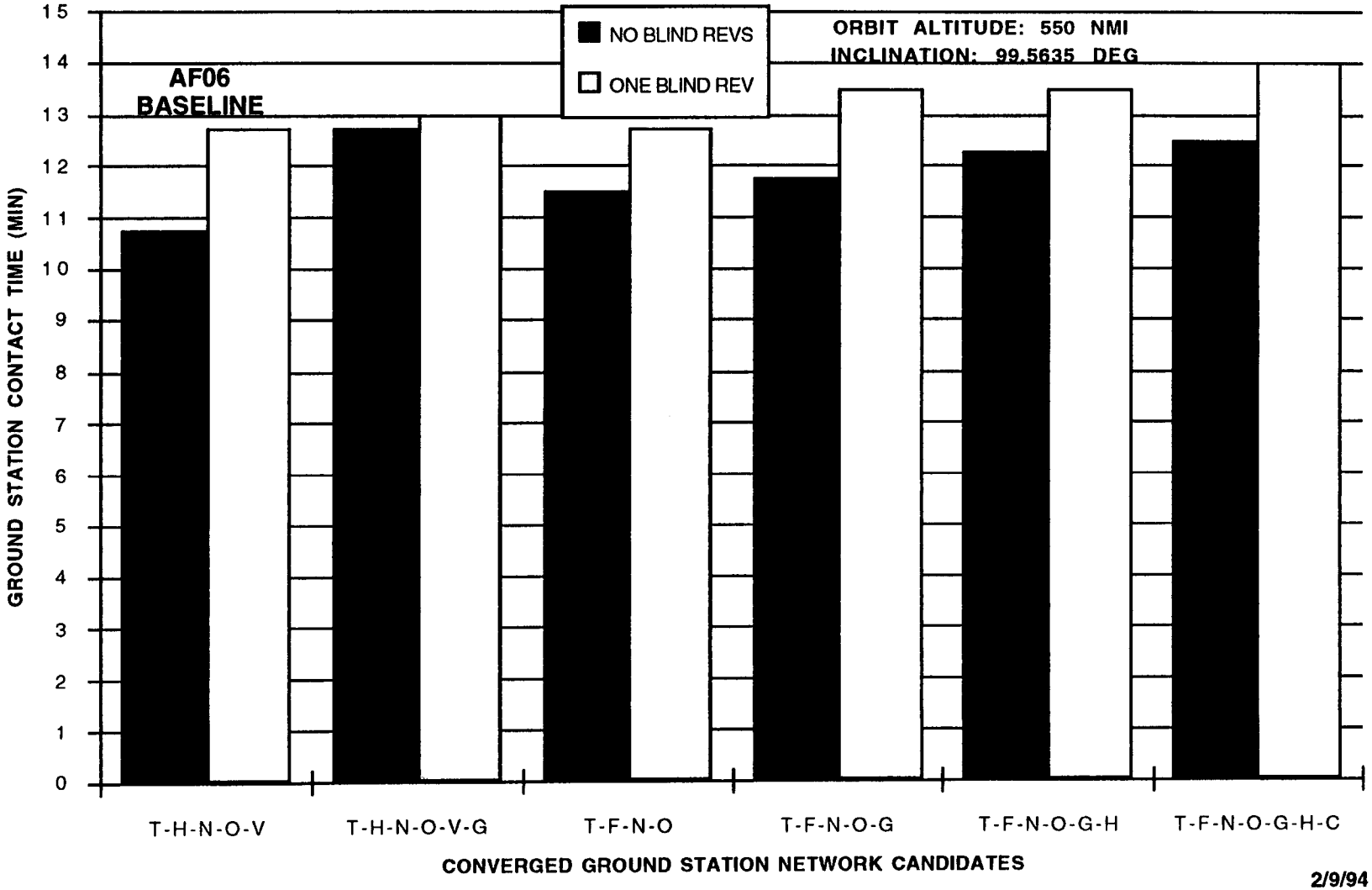
Generalized Viewbar Contours



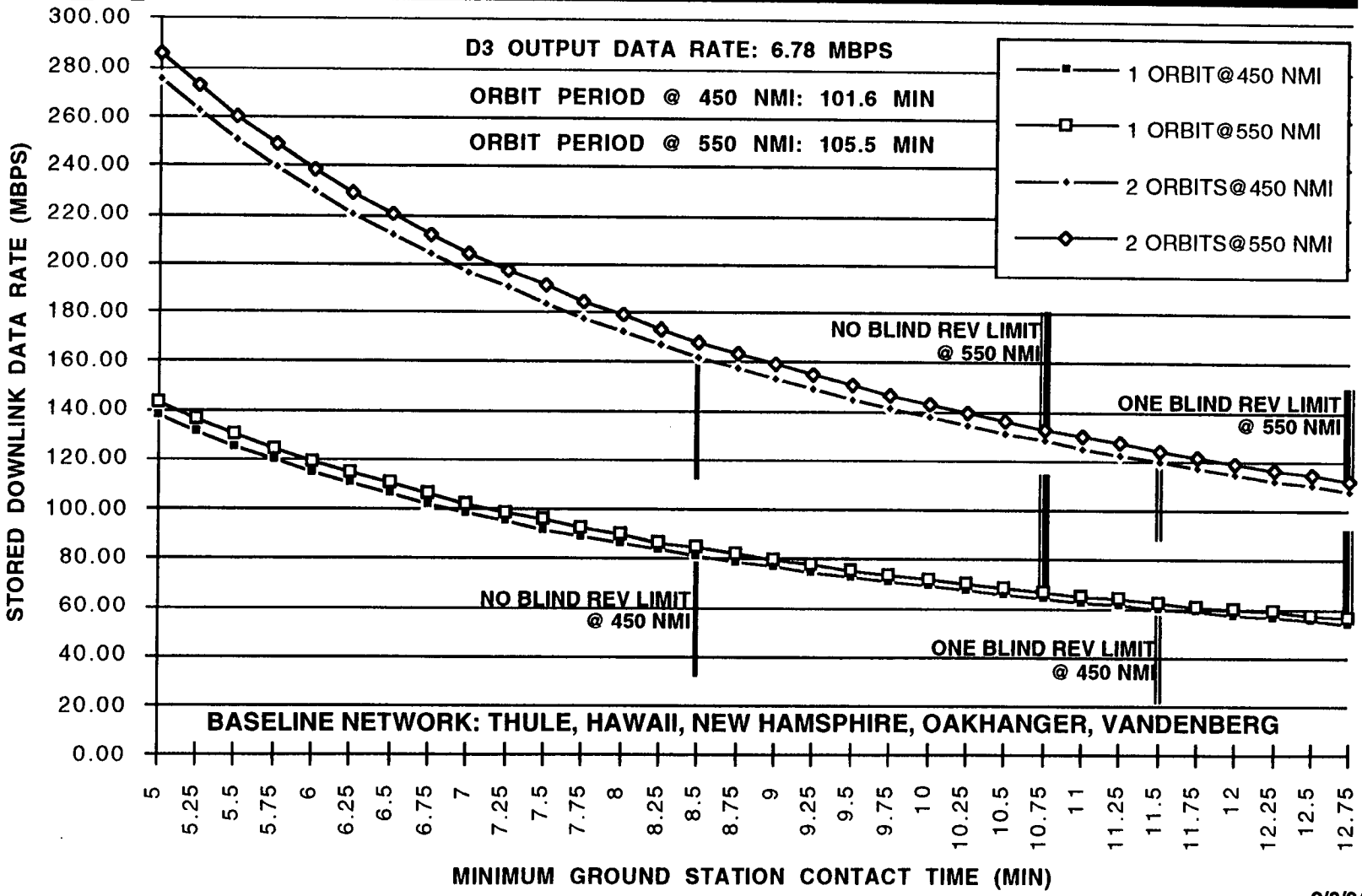
COMPARISON OF MAXIMUM ALLOWABLE CONTACT TIMES (450 NMI)



COMPARISON OF MAXIMUM ALLOWABLE CONTACT TIMES (550 NMI)



ALTITUDE IMPACT ON DATA RATE REQUIREMENTS



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ALTITUDE IMPACT ON DATA RATE VS CONTACT TIME SUMMARY

- CONCLUSIONS
  - AFSCN BASELINE PERFORMANCE IMPROVED BY ADDING FAIRBANKS CDA
  - THULE-FAIRBANKS-NEW HAMPSHIRE-OAKHANGER NETWORK PROVIDED IMPROVED PERFORMANCE WITH FEWEST NUMBER OF STATIONS
  - 550 NMI PROVIDES MORE ROBUST C3 CAPABILITIES
    - LONGER CONTACT TIMES
    - MORE FREQUENT CONTACT OPPORTUNITIES

OVERALL ANALYSIS SUMMARY

- FLY ALL SATELLITES AS CLOSE TO SAME ALTITUDE AS POSSIBLE
- ADDING FAIRBANKS CDA PROVIDES COST-EFFECTIVE C3 IMPROVEMENTS
- EXISTING BANDWIDTHS COMPATIBLE WITH CONTACT TIMES AND DOWNLINK DATA RATES
- FURTHER STUDY RECOMMENDED
  - USER SEGMENT IMPACTS DUE TO DATA LOAD
    - * PROCESS ALL INCOMING DATA OR PARTIAL DATA
    - * SDR VS EDR PROCESSING
    - * INDEPENDENT OR SHARED PROCESSING

ANALYSIS TO DATE CONFIRMS TECHNICAL FEASIBILITY

SYSTEM STUDIES

1) DEVELOPMENT OF A REQUIREMENTS AND EDR-BASED, CONVERGED AND DE-CONFLICTED OPERATIONAL REQUIREMENTS DOCUMENT (ORD). INCLUDE ***DATA UTILIZATION DOCUMENT*** SHOWING ULTIMATE USE OF EDRS IN OPERATIONAL SYSTEMS.

2) PREPARATION OF AN OPERATIONAL CONCEPT DOCUMENT AND AN EVALUATION OF THE CANDIDATE CONSTELLATION(S) AGAINST THAT CONOPS

3) PREPARATION OF A "TRANSITION ISSUES" PAPER SEPARATE FROM THE CONOPS, DOCUMENTING KEY ISSUES THAT NEED RESOLUTION AND A TIMELINE FOR THEIR SOLUTION.

4) DATA LOADING AND DATA COMPRESSION
   - -TIMELINESS IMPACTS
   - -EDR ACCURACY IMPACTS

5) C3 SEGMENT ALTERNATIVES AND COST EFFECTIVE OPTIONS FOR DATA ROUTING AND RETRIEVAL

SYSTEM STUDIES CONT'D

6) LIFE CYCLE COST ESTIMATION FOR SELECTED CONSTELLATIONS (A PRIME, D PRIME)

7) PROGRAMMATIC RISK ASSESSMENT AND MITIGATION PLAN, INCLUDE TECHNOLOGY TRANSITION PLANNING

8) COMMON SPACECRAFT DESIGN OPTIMIZATION FOR "A PRIME, D PRIME"

9) USER SEGMENT DEMONSTRATIONS FOR ADVANCED TECHNOLOGY IMPLEMENTATIONS

10) PRELIMINARY, CONVERGED SYSTEM SPECIFICATION DEVELOPMENT BASED ON JOINT ORD

11) IMPACT OF VARIATIONS IN ALTITUDE ON SENSORS AND MISSION ACCOMPLISHMENT

12) RELIABILITY, AVAILABILITY, NUMBERS OF S/C REQ'D

13) DEVELOP KEY I/F DOCUMENTS FOR S/C, PAYLOAD, C3, AND LAUNCH

14) DOCUMENT IMPACTS OF CONVERGED SYSTEM ON DOC USERS

15) INVESTIGATE IMPACTS OF DIFFERENT DOD AND DOC DATA STREAMS

SENSOR ISSUES

- O OMIS: SENSOR SUB-CONTRACT MANAGEMENT APPROACH
  - CONSTANT RESOLUTION VS VARIABLE RESOLUTION
  - COST OF TWO SENSORS VS ONE SENSOR
  - ABSOLUTE CALIBRATION VS RELATIVE CALIBRATION
  - TRADE-OFF SENSOR VS ALGORITHM PERFORMANCE
- O MISS: SENSOR SUB-CONTRACT MANAGEMENT APPROACH
  - COMPARE MISS WITH AMSU PLUS MHS FOR SOUNDING
  - COVERAGE REQUIREMENTS VERSUS NUMBER OF S/C
  - EARTH INCIDENCE ANGLE VERSUS PERFORMANCE
  - OPTIMUM SOUNDER (AIRS VS ITS)

SENSOR ISSUES CONT'D

O SESS:

COMPARISON OF NOAA AND DMSP SESS REQUIREMENTS

COMPARE DMSP SENSOR PERFORMANCE/COST FOR MEETING NOAA REQUIREMENTS

FOR ALL DEVELOPMENTAL OR CONVERGED SENSORS:

- MMD AND LIFETIME
- ALTITUDE VARIATION
- CONTRACT STATUS--DEGREE OF DVLPMNT
- SENSOR COST
- DATA FORMATS IMPACT ON S/C DATA BUS

OBP TRADES AND ANALYSES

- O OBJECTIVE TO REDUCE OBP AND DOWNLINK RISK
  - -GREATER THAN 2X MORE DATA ON CONVERGED SYSTEM
  - - TWO ADDITIONAL DOWNLINKS AND 3X MORE PROCESSING
- O DEFINE NEW OBP REQUIREMENTS
  - OMIS/VIRSR, MISS AND SESS DATA TO CCSDS PACKETS
  - COMPRESS OMIS/VIRSR DATA BEFORE PACKETIZATION
  - OUTPUT ALL DOWNLINK DATA IN CCSDS
- O RE-DEFINE SOFTWARE SIZING ESTIMATES
- O EVALUATE HARDWARE VENDOR'S 32 BIT PROCESSORS

CONCLUSION

- O LOOK FORWARD TO THE SRR REPLAN
- O USE THE RESULTS OF THIS TIM TO PLAN FOR
  - CALIBRATION TIM
  - AF-07 TASKS
- O PSR STILL PLANNED FOR APRIL 94