PACE 2012

Communications

14 – 18 May 2012

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Overview

- **X-Band for Science and S-Band for Telemetry & Command**
- **Data multiplexed & stored, transmitted in a single data stream at 105 Mbps via X-Band to following candidate sites**
  - Svalbard, Alaska, Wallops, Santiago and Dongara
  - McMurdo can potentially provide much coverage, however it is a single link site with less reliability and currently has broadband communications link back to the US less than 12 hours a day.
- **1 contact each orbit required**
- **S-Band to NEN for Telemetry & Command**
  - Command at 2 kbps
  - Telemetry at 8 kbps to 4 Mbps
- **GPS for orbit determination** (with a possible backup via **2-way Doppler**)
- **S-Band thru TDRSS for launch, critical events, and emergency situations**
  - Command at 1 kbps
  - Telemetry at 5 kbps

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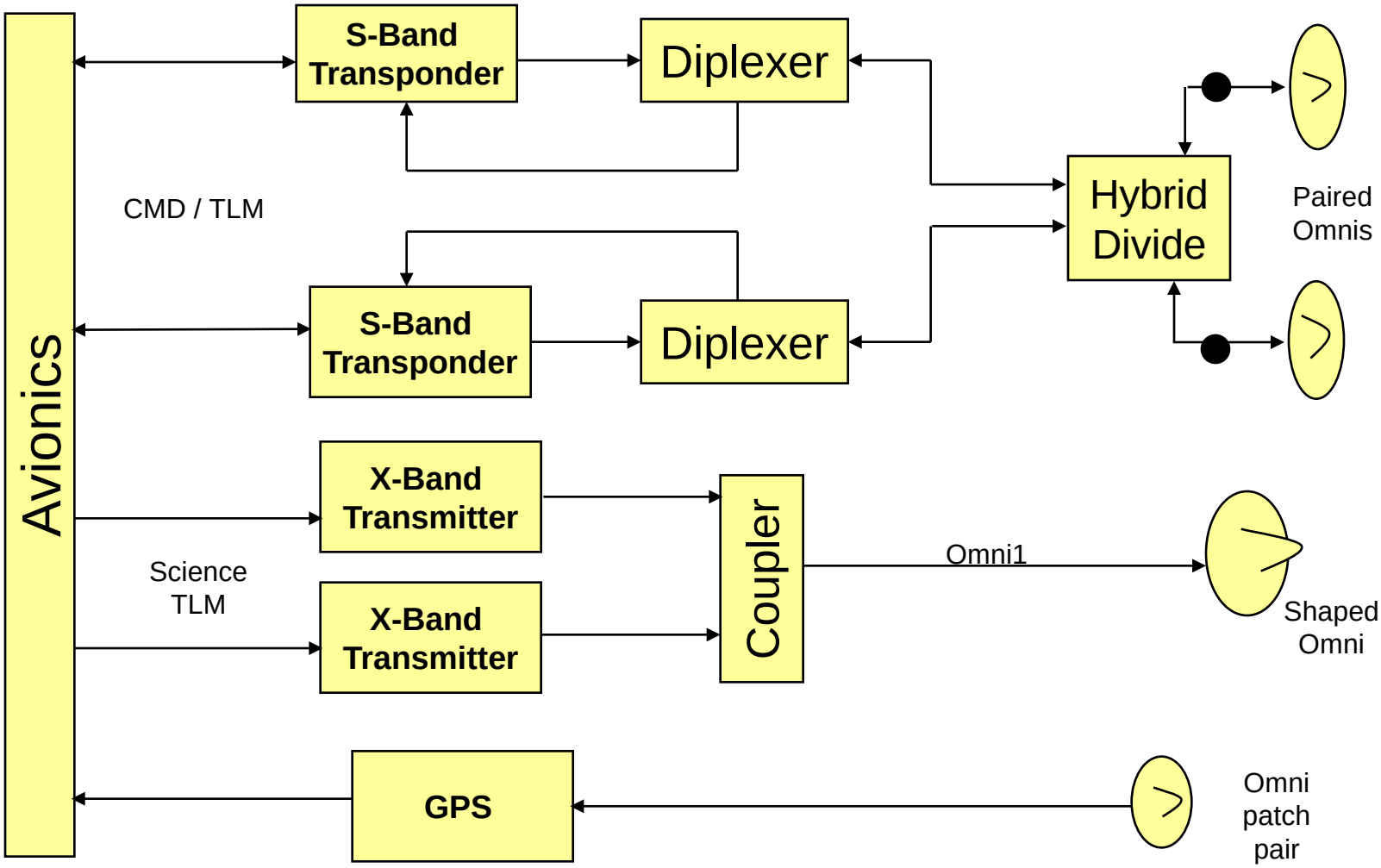
Functional Configuration



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Functional Configuration

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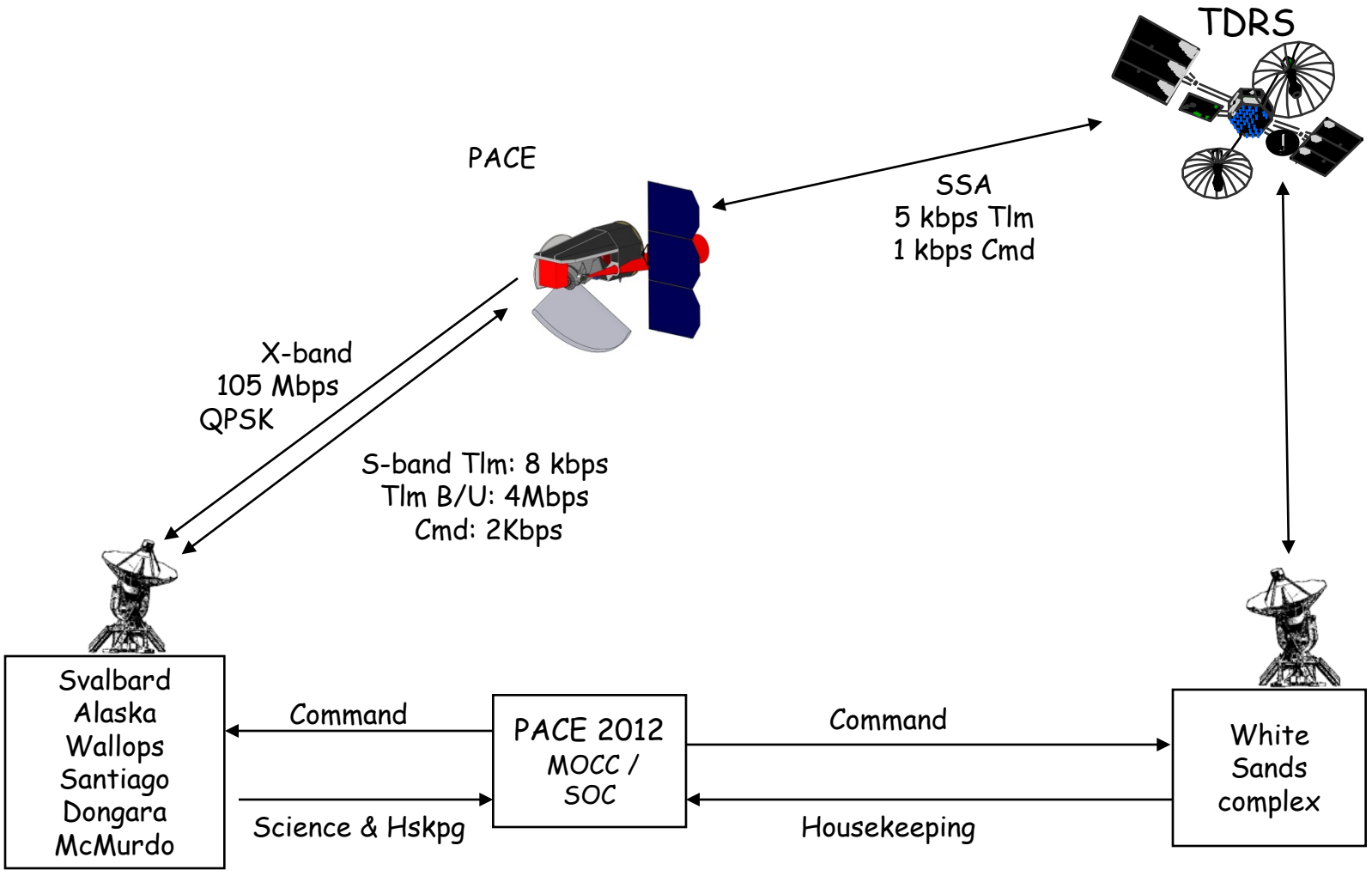

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Science Objectives

PACE Science Context

- **PACE science objective include observations of**
  - The **broad open ocean**,
  - Atmosphere **cloud** observations,
  - Coastal **estuaries**.
  - (Sun-synchronous polar orbit, provides high illumination daylight observations)

- **Success of PACE science relies on:**
  - **O**cean **C**olor **E**xperiment (**OCE**) and Polarimeter measurement requirements that exceed those of heritage sensors particularly in terms of spectral range and resolution;
  - A rigorous calibration/validation program; vicarious *(in situ)* calibration
  - Repeated data reprocessing of the mission data.

- **Science Operations Center/ Science Data Center**

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Driving Requirements & Assumptions

- **Launch: 2019 October**
- **Mission Life: 3 year minimum, 5 desired** (size consumables for this)
- **Nominal Orbit:**
  - **700 km circular** (period: 98.8 minutes; maximum nadir angle: ~ 63°)
  - **98.2 degree inclination**
  - **Sun sync** (noon optimal equatorial crossing. +/- 1 hour)
- **Nadir pointing (Spacecraft +/- 20 deg)**
- **Orbit determination GPS**
- **Latency - Science data: 180**
- **Telemetry: BER = 10^{-5}** (10^{-8} most of the time)
- **Mission Class: C**
- **> 90 Gbit storage capacity** (~ 2 orbits with 30% data margin & CCSDS overhead)

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Data Volume

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Data Acquisition - Broadcast Option			Data Storage - Baseline				Data Downlink - Baseline	
Data Source or type	Average Raw Data (compressed) Rate (kbps)	Average Raw Data Acquisition Period (minutes)	Total Data Volume Per Orbit Before Margin (Gbits)	Data Rate Margin or Contin - gency (%)	Data Volume Per Orbit with Data Rate Margin & CCSDS (Gbits)	Data Volume Two Orbits with Data Rate Margin (Gbits)	Downlink Data Rate (Mbps)	Trans— mission Time for Two Orbit Data (minutes)
OCE-2 Science + H/K	10,000	47	28.2	30%	37.43	74.9	105	14.5
Polarimeter Science + H/K	2,200	47	6.2	30%	8.23	16.5		
Spacecraft H/K Data	4	99	0.024	30%	0.03	0.1		
Total	**12,204**		**34.5**		**45.70**	**91.4**		

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Selected Configuration & Rationale

- **Recommend: X-band via Shaped Omni**
  - Single shaped Omni on nadir pointing axis assures a gain of >0 dBi at all look angles to the ground stations, and eliminates any blockage problems with the nadir looking instruments
  - Maximum angle from nadir to a ground station at 4° elevation is ~64 deg off boresite, or ~ 62.5° for 10°
  - Gain at maximum range is > 4 dBi (less toward nadir – "doughnut" shape)
  - Recommended: Shaped to maximize gain at ~50 degrees off bore site
- **Dual X-band transmitters**
  - Data transmitted at 105 Mbps
  - QPSK modulation
  - LDPC rate 7/8 encoding
  - 6 watts RF power
- **CCSDS overhead : 2%**
- **Housekeeping downlink: 8 kbps**
- **Volume per orbit : 46 Gbits**

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Selected Configuration & Rationale

- **X-band data playback at 105 Mbps**
- **7.3 minutes downlink time to dump each orbit** (~8.3 min pass)
- **15 contacts each day**
- **Ground stations at Svalbard, Alaska, Santiago, Dongara, & Wallops**
  - McMurdo available for any gaps or missed dumps
- **Rain attenuation effect for 99% of time included in Near Earth Network (NEN) ground station signal margins**

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Selected Configuration & Rationale

- **S-Band for T&C**
  - Use S-Band Transponders (2)
  - 5 watts RF
  - Dual omnis (Crossed dipoles)
    - –3 dBi for 90% spherical coverage
    - +3 dB toward ground when nadir pointing
  - 8 kbps telemetry
  - 2 kbps command
  - Selective redundancy
  - 4 Mbps is available
    - Data must not be encoded in order to fit into allowed bandwidth
- **Allows TDRSS compatibility in GN mode**
- **Launch phase support and critical event coverage**
- **On-orbit backup & contingency recovery**
- **TDRSS launch and contingency support**
  - SSA @ 1 kbps command
  - SSA @ 5 kbps housekeeping telemetry

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PACE 2012 Ground Station Geometric View

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PACE 2012 700 km I = 98.2°

Station	Number Passes in 14 days*	Total Access Duration for 14 days (min)	Passes per Day > 5 minutes > 10° elev.	Average Pass Duration (min)	Maximum Pass Duration (min)	Average Duration per Day (min)
Svalbard	147	1292.3	10.5	8.8	9.7	92.3
Alaska	101	818.1	7.2	8.1	9.7	58.4
McMurdo*	144	1270.8	10.3	8.8	9.7	90.8
Wallops	46	374.0	3.3	8.1	9.6	26.7
Santiago	44	354.1	3.1	8.1	9.5	25.3
Dongara	40	326.7	2.9	8.2	9.5	23.3

Note: The approximate orbital period should be ~98.8 minutes.
* Note: McMurdo may be limited to ½ a day when TDRS relay is available so science data can be retransmitted to the SOC

Roughly 8 minutes per orbit, or 120 min/day desired

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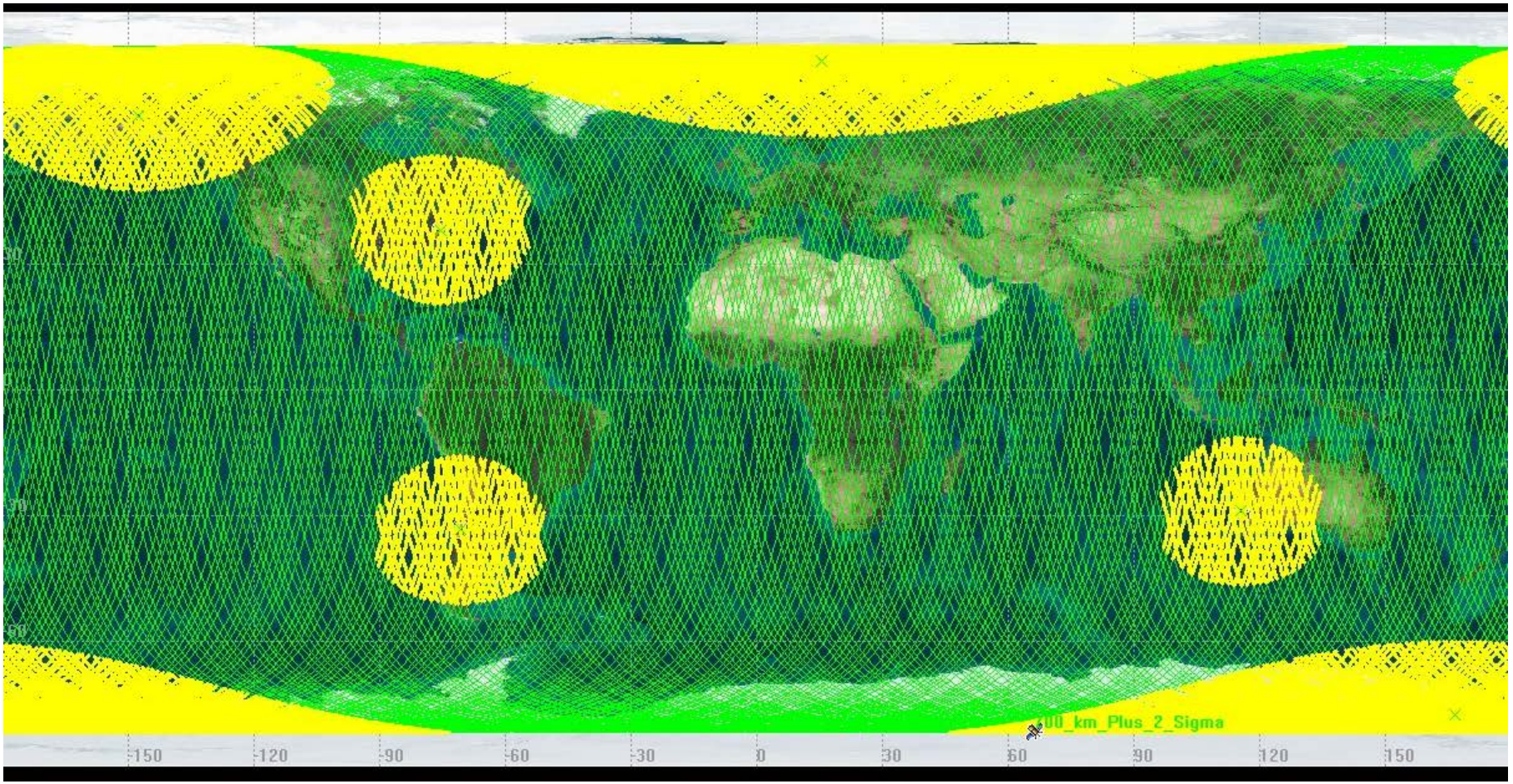
Ground Station Coverage



Ground coverage for Svalbard, Alaska, Wallops, Santiago, McMurdo and Dongara 10° mask for satellite at 700 km orbit with 98 degree inclination

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Link Margin Summary

Link	Data Rate	Margin (dB)	Comment
X-band Downlink	105 Mbps	6.1	99% rain availability Science plus s/c Tlm
S-band Downlink	8 kbps	32.1	Omni to 11.3 meter s/c Tlm
	4 Mbps	5.1	backup science plus Tlm, not for normal use
S-band Uplink	2 kbps	37.8	11.3 m Omni , Command
TDRSS SSA Return	5 kbps	1.1	Omni to TDRSS, s/c Telemetry
TDRSS SSA Forward	1 kbps	0.6	TDRSS to Omni, Command

Note: Ground station calculations include effect of rain attenuation.
Link margins should be better that this result 99% of the time.

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Component Power/Mass Summary

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Component	Quan-tity	Peak Power (watts)	Average Power (watts)	Safefold Power (watts)	Unit Mass (kg)	Total Mass (kg)
X-Band Shaped Omni	1	------	------	------	1	1
X-Band Transmitters	2	70	2	0.1	4	8
S-band Omni (pair)	1	-----	-----	-----	1.5	1.5
S-band Transponder	2	41	18.5	16	3	6
Diplexer	2	-----	-----	-----	0.25	0.5
Hybrid	1	-----	-----	-----	0.2	0.2
GPS & Antenna pair	1	1.6	1.6	1.6	1.5	1.5
Miscellaneous	1	-----	-----	-----	3.7	3.7
Total		112.6	22.1	17.7		22.4

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Direct Broadcast Option

- **Broadcast science data directly to the ground continuously when in daylight, except when downlinking stored science data**
  - This would require ~47 minutes of transmission while over sunlit portions of the earth
- **The raw data rate is 12.2 Mbps** (with overhead and 30% contingency, **16.2 Mbps**)
- **Use same X-band system as used for science downloads**
- **Since some antennas will be in more rainy areas an additional 3 dB should be maintained in the link**

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Broadcast Option

- **If the spacecraft broadcasts 12.2 Mbps to a 2.4 meter antenna, in order to obtain a 3 dB margin one of the following would have to be done:**
  - The ground stations would have to incorporate LDPC demods. Costs TBD
    or
  - 20 watt Power amplifiers would have to be added to the spacecraft at a cost of $2 M for two, a peak power increase of 15 watts to the spacecraft, and an increase in mass of 2 Kg
    or
  - Since the data rate of science dumps is 105 Mbps, convolutional encoding rate 1/2 could be used for science dumps and direct broadcast to obtain a 3 dB margin in science dumps and at the 2.4 meter antennas

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Future Considerations - Issues

- **For this study we assumed 105 Mbps due to CFDP** (CCSDS File Delivery Protocol) **processing limitations in avionics and software in this configuration** (even though SDO & JWST have achieved higher data rates)**.**
  - What if we find we can process 150 or 300 Mbps (we can downlink this if the proper frequencies and bandwidths can be worked with the GSFC Spectrum Manager)? We could reduce the number of passes if the data latency requirement could be relaxed.

- **Choose an X-band "Earth Science" Frequency so that it doesn't extend into DSN spectrum**
  - If it does, then have to work with DSN so no interference.

- **Need to work with the spectrum manager to see if they can broadcast continuously in daylight.**
  - Broadcast bandwidth for 12 Mbps raw data transmission,

- **Consider the feasibility of using LDPC 7/8 for Broadcast mode.**

- **If S/C Pitch option were to be implemented, Pitch angles vary +/- 20° during X-band transmissions and this could affect the gain of the shaped Omni antenna toward the NEN (or Broadcast) stations.**

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Acronyms

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AGO	Santiago, Chile NEN ground station
BER	Bit Error Rate
B/U	Backup
OCE	Ocean Color Experiment
CLASS	Communications Link Analysis and Simulation System
CCSDS	Consultative Committee for Space Data Systems
CFDP	CCSDS File Delivery Protocol
Cmd	Command
dBi	deci Bell relative to isotropic
DSN	Deep Space Network
FTE	Full Time Equivalent
GN	Ground Network (now known as NEN) - ground stations
GPS	Global Positioning System
LDPC	Low-Density Parity-Check (linear error correcting code)
LEO	Low Earth Orbit
MOCC	Mission Operations Control Center
NEN	Near Earth Network , NASA GSFC
PA	Power Amplifier
QPSK	Quadrature Phase Shift Keying
RF	Radio Frequency
SSA	S-band Single Access (in Space Network (SN))
TDRS(S)	Tracking and Data Relay Satellite (System)
Tlm	Telemetry
TT&C	Telemetry, Tracking, and Command
TWTA	Traveling Wave Tube Amplifier
sync	Synchronous (i.e. Sun synch).
WPS	Wallops, VA NEN ground station

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Back-Up

X-Band (Shaped Omni) to Wallops

S-Band Omni pair to 11.3 M

11.3 M to S-Band Omni pair

Broadcast option

TDRSS SSA Return link

TDRSS SSA Forward link

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X-Band Downlink (105 Mbps)

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*** DOWNLINK MARGIN CALCULATION ***
GSFC C.L.A.S.S. ANALYSIS #1 DATE & TIME: 5/16/12 13:22:42 PERFORMED BY: R.VENTO LINKID: PA1202

FREQUENCY: 8200.0 MHz RANGE: 2155.3 km POLARIZATION: RHCP

MODULATION: QPSK TOTAL INFORMATION RATE: 105,000 kbps
CODING: RATE 7/8 LDPC BER: 1.00E-05
SINGLE DATA SOURCE WITH ALTERNATE BITS No PA

PARAMETER	VALUE	REMARKS
01. USER SPACECRAFT TRANSMITTER POWER - dBW	7.78	NOTE A; 6.00 WATTS
02. USER SPACECRAFT PASSIVE LOSS - dB	2.00	NOTE A
03. USER SPACECRAFT ANTENNA GAIN - dBi	4.00	NOTE A
04. USER SPACECRAFT POINTING LOSS - dB	0.00	NOTE A
05. USER SPACECRAFT EIRP - dBWi	9.78	1-24
06. GS DIVERSITY COMBINER LOSS - dB	0.50	NOTE A
07. FREE SPACE LOSS - dB	177.39	NOTE B; ALT: 700.0 KM EL: 10.00 DEG
08. ATMOSPHERIC LOSS - dB	0.27	NOTE B
09. RAIN ATTENUATION - dB	0.53	NOTE B; ITU MODEL; EXC: 1.00% ITU RRATE .01%: 47.70 MM/HR RHGT: 3.63 KM
10. SCINTILLATION/MULTIPATH LOSS - dB	0.61	NOTE B; ITU MODEL; EXC: 1.00% GS DIAM: 11.30 M, EFF: 55.00%
11. CLOUD ATTENUATION - dB	0.44	NOTE B; ITU MODEL; EXC: 1.00%
12. TOTAL PROPAGATION EFFECTS - dB	1.42	NOTE B; ITU MODEL
13. CLEAR SKY G/T - dB/DEGREES-K	35.00	NOTE A; SYS TEMP: 200.00 K
14. SYSTEM NOISE INCREASE DUE TO ATMOSPHERICS - dB	0.64	NOTE B
15. GROUND STATION G/T - dB/DEGREES-K	34.36	13-14
16. BOLTZMANN'S CONSTANT - dBW/(Hz*K)	-228.60	CONSTANT
17. RECEIVED CARRIER TO NOISE DENSITY - dB-Hz	93.42	5-6-7-1216
18. MODULATION LOSS - dB	0.00	NOTE A
19. TOT INFORMATION RATE - (105000.0 kbps) - dB-bps	80.21	NOTE A
20. DIFFERENTIAL ENCODING/DECODING LOSS - dB	0.00	NOTE A
21. USER CONSTRAINT LOSS - dB	0.00	NOTE C
22. RECEIVED Eb/No - dB	13.21	17-18-19-20-21
23. IMPLEMENTATION LOSS - dB	3.00	NOTE A
24. REQUIRED Eb/No AT RATE 7/8 LDPC DECODER - dB	4.10	NOTE A; BER = 1.00E-05
25. REQUIRED PERFORMANCE MARGIN - dB	0.00	NOTE A
26. MARGIN - dB	**6.11**	22-23-24-25

NOTE A: PARAMETER FROM USER INPUT - SUBJECT TO CHANGE
NOTE B: FROM CLASS ANALYSIS IF COMPUTED
NOTE C: PARAMETER NOT CONSIDERED IN THIS ANALYSIS

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S-Band OMNI at 4 Mbps (Downlink)

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*** DOWNLINK MARGIN CALCULATION***
GSFC C.L.A.S.S. ANALYSIS #1 DATE & TIME: 4/28/ 9 14:29:30 PERFORMED BY: RON VENTO
LINKID: PACE

FREQUENCY: 2250.0 MHz RANGE: 1804.5 km

MODULATION: QPSK

I CHANNEL		Q CHANNEL	
DATA RATE:	2000.000 kbps	DATA RATE:	2000.000 kbps
CODING:	UNCODED	CODING:	UNCODED
BER:	1.00E-05	BER:	1.00E-05

PARAMETER	VALUE	REMARKS
01. USER SPACECRAFT TRANSMITTER POWER - dBW	6.99	NOTE A; 5.0 WATTS
02. USER SPACECRAFT PASSIVE LOSS - dB	5.00	NOTE A
03. USER SPACECRAFT ANTENNA GAIN - dBi	-3.00	NOTE A
04. USER SPACECRAFT POINTING LOSS - dB	0.00	NOTE A
05. USER SPACECRAFT EIRP - dBWi	-1.01	1 - 2 + 3 - 4
06. POLARIZATION LOSS - dB	0.30	NOTE A
07. FREE SPACE LOSS - dB	164.61	NOTE B; ALT: 400.0 KM, EL: 5.0 DEG
08. ATMOSPHERIC LOSS - dB	0.43	NOTE B
09. RAIN ATTENUATION - dB	0.00	NOTE A
10. MULTIPATH LOSS - dB	0.00	NOTE A
11. GROUND STATION G/T - dB/DEGREES-K	23.00	NOTE A
12. BOLTZMANN'S CONSTANT - dBW/(Hz*K)	-228.60	CONSTANT
13. RECEIVED CARRIER TO NOISE DENSITY - dB/Hz	85.25	5 - 6 - 7 - 8 - 9 - 10 + 11 - 12

	I CHANNEL	Q CHANNEL	
14. I-Q CHANNEL POWER SPLIT LOSS - dB	3.01	3.01	NOTE B; 1.00 TO 1.00
15. MODULATION LOSS - dB	0.00	0.00	NOTE A
16. DATA RATE - dB-bps	63.01	63.01	NOTE A
17. DIFFERENTIAL ENCODING/DECODING LOSS - dB	0.00	0.00	NOTE A
18. USER CONSTRAINT LOSS - dB	0.00	0.00	NOTE A
19. RECEIVED Eb/No - dB	19.23	19.23	13 - 14 - 15 - 16 - 17 - 18
20. IMPLEMENTATION LOSS - dB	3.00	3.00	NOTE A
21. REQUIRED Eb/No - dB	9.60	9.60	I: NOTE B; Q: NOTE B
22. REQUIRED PERFORMANCE MARGIN - dB	0.00	0.00	NOTE A
23. MARGIN - dB	6.63	6.63	19 - 20 - 21 - 22

NOTE A: PARAMETER VALUE FROM USER PROJECT - SUBJECT TO CHANGE
NOTE B: FROM CLASS ANALYSIS IF COMPUTED

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S-Band OMNI (Uplink)

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TABLE A-1 UPLINK DATE & TIME: 04/28/09 14:41:26
PACE
FREQUENCY - 2070.000 MHZ
GROUND ANTENNA - 11.3 - 11.3 AT ALASKA
POWER - 0.2000 K WATTS

PARAMETERS	UNITS	VALUES (MAX RNG: 1804.52 KM 5.0 EL)	VALUES (MIN RNG: 400.00 KM 90.0 EL)	ESTIMATED TOLERANCES DB FAV	ESTIMATED TOLERANCES DB ADV
EFFECTIVE RADIATED POWER	DBM	96.0	96.0	1.0	-1.0
FREE SPACE DISPERSION LOSS	DB	-163.9	-150.8	0.0	0.0
ATMOSPHERIC LOSS	DB	-0.5	0.0	0.0	0.0
POLARIZATION LOSS	DB	-3.0	-3.0	0.0	0.0
SPACECRAFT ANTENNA GAIN	DBI	-3.0	-3.0	0.0	0.0
SPACECRAFT PASSIVE LOSS	DB	-5.0	-5.0	0.5	-0.5
MAXIMUM TOTAL RECEIVED POWER	DBM	-79.4	-65.8	1.1	-1.1
SPACECRAFT ANTENNA NULL DEPTH	DB	0.0	0.0	0.0	0.0
MINIMUM TOTAL RECEIVED POWER	DBM	-79.4	-65.8	1.1	-1.1
SYSTEM NOISE DENSITY	DBM/HZ	-170.8	-170.8	0.0	0.0
IF NOISE BANDWIDTH(3000.000 KHZ)	DB-HZ	64.8	64.8	0.0	0.0
IF NOISE POWER	DBM	-106.0	-106.0	0.0	0.0
IF SNR (MIN)	DB	26.6	40.2	1.1	-1.1
CARRIER CHANNEL					
CARRIER/TOTAL POWER	DB	-2.9	-2.9	0.3	-0.3
RECEIVED CARRIER POWER	DBM	-82.3	-68.7	1.2	-1.2
CARRIER LOOP NOISE BW(800. HZ)	DB-HZ	29.0	29.0	0.0	0.0
NOISE POWER	DBM	-141.8	-141.8	0.0	0.0
CARRIER/NOISE	DB	59.5	73.1	1.2	-1.2
REQUIRED CARRIER/NOISE	DB	15.0	15.0	0.0	0.0
AVAILABLE CARRIER MARGIN	DB	44.5	58.1	1.2	-1.2
REQUIRED PERFORMANCE MARGIN	DB	3.0	3.0	0.0	0.0
NET MARGIN	DB	41.5	55.1	1.2	-1.2
COMMAND CHANNEL (PCM/PSK/PM)					
COMMAND/TOTAL POWER(MI=1.10 RAD)	DB	-3.5	-3.5	0.3	-0.3
RECEIVED COMMAND POWER	DBM	-82.9	-69.3	1.2	-1.2
PREDETECTION (PSK) NOISE BW(32.000 KHZ)	DB-HZ	45.1	45.1	0.0	0.0
PREDETECTION (PSK) NOISE POWER	DB	-125.7	-125.7	0.0	0.0
PREDETECTION (PSK) SNR	DB	42.8	56.4	1.2	-1.2
COMMAND DATA RATE (2.000KBPS)	DB-BPS	33.0	33.0	0.0	0.0
AVAILABLE ENERGY PER BIT/NOISE DENSITY	DB	54.9	68.5	1.2	-1.2
DECODER DEGRADATION	DB	-2.0	-2.0	0.0	0.0
REQUIRED ENERGY PER BIT/NOISE DENSITY (BER=E-5)	DB	10.5	10.5	0.0	0.0
AVAILABLE COMMAND MARGIN	DB	42.4	56.0	1.2	-1.2
REQUIRED PERFORMANCE MARGIN	DB	3.0	3.0	0.0	0.0
NET MARGIN	DB	39.4	53.0	1.2	-1.2

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One Broadcast option
10 watt PA with No Coding

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*** DOWNLINK MARGIN CALCULATION ***
GSFC C.L.A.S.S. ANALYSIS #1 DATE & TIME: 5/16/12 13:12:58 PERFORMED BY: R.VENTO LINKID: PA1202

FREQUENCY: 8200.0 MHz RANGE: 2155.3 km POLARIZATION: RHCP

MODULATION: QPSK TOTAL INFORMATION RATE: 12200.000 kbps
CODING: UNCODED BER: 1.00E-05
SINGLE DATA SOURCE WITH ALTERNATE BITS 95% availability

PARAMETER	VALUE	REMARKS
01. USER SPACECRAFT TRANSMITTER POWER - dBW	10.00	NOTE A; 10.00 WATTS
02. USER SPACECRAFT PASSIVE LOSS - dB	2.00	NOTE A
03. USER SPACECRAFT ANTENNA GAIN - dBi	4.00	NOTE A
04. USER SPACECRAFT POINTING LOSS - dB	0.00	NOTE A
05. USER SPACECRAFT EIRP - dBWi	12.00	1-24
06. GS DIVERSITY COMBINER LOSS - dB	0.50	NOTE A
07. FREE SPACE LOSS - dB	177.39	NOTE B; ALT: 700.0 KM EL: 10.00 DEG
08. ATMOSPHERIC LOSS - dB	0.27	NOTE B
09. RAIN ATTENUATION - dB	0.15	NOTE B; ITU MODEL; EXC: 5.00% ITU RRATE .01%: 47.70 MM/HR RHGT: 3.63 KM
10. SCINTILLATION/MULTIPATH LOSS - dB	0.47	NOTE B; ITU MODEL; EXC: 5.00% GS DIAM: 2.40 M, EFF: 55.00%
11. CLOUD ATTENUATION - dB	0.28	NOTE B; ITU MODEL; EXC: 5.00%
12. TOTAL PROPAGATION EFFECTS - dB	0.91	NOTE B; ITU MODEL
13. CLEAR SKY G/T - dB/DEGREES-K	22.50	NOTE A; SYS TEMP: 200.00 K
14. SYSTEM NOISE INCREASE DUE TO ATMOSPHERICS - dB	0.20	NOTE B
15. GROUND STATION G/T - dB/DEGREES-K	22.30	13-14
16. BOLTZMANN'S CONSTANT - dBW/(Hz*K)	-228.60	CONSTANT
17. RECEIVED CARRIER TO NOISE DENSITY - dB-Hz	84.09	5-6-7-1216
18. MODULATION LOSS - dB	0.00	NOTE A
19. TOT INFORMATION RATE - (12200.0 kbps) - dB-bps	70.86	NOTE A
20. DIFFERENTIAL ENCODING/DECODING LOSS - dB	0.00	NOTE A
21. USER CONSTRAINT LOSS - dB	0.00	NOTE C
22. RECEIVED Eb/No - dB	13.23	17-18-19-20-21
23. IMPLEMENTATION LOSS - dB	3.00	NOTE A
24. REQUIRED Eb/No - dB	9.60	NOTE B; BER = 1.00E-05
25. REQUIRED PERFORMANCE MARGIN - dB	0.00	NOTE A
26. MARGIN - dB	0.63	22-23-24-25

NOTE A: PARAMETER FROM USER INPUT - SUBJECT TO CHANGE
NOTE B: FROM CLASS ANALYSIS IF COMPUTED
NOTE C: PARAMETER NOT CONSIDERED IN THIS ANALYSIS

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TDRSS SSA Return link

Mission Design Laboratory

*** RETURN LINK CALCULATION -- NETWORK SYSTEMS ENGINEER ANALYSIS ***
GSFC C.L.A.S.S. ANALYSIS #0 DATE & TIME: 09/15/08 13:33:41 PERFORMED BY: RON VENTO
USERID: PACE LINKID: SSAR RELAY SYS.: TDRS-Spare TO WSGTU

TYPE OF TRACKING: PROGRAM TRACK FIELD OF VIEW: PEFOV

SERVICE:	FREQUENCY:	DATA GROUP/MODE:	POLAR:	RANGE CASE:	ALTITUDE:	ELEVATION:	RANGE:
SSA	2250.0 MHz	DG-2 MODE-2A	RCP	MAXIMUM	400 Km	1.5 Deg	44384.5 Km

I CHANNEL	Q CHANNEL
DATA RATE = 2.500 KBPS	DATA RATE = 2.500 KBPS
MOD TYPE = QPSK	MOD TYPE = QPSK
SYMBL FMT = NRZ-L	SYMBL FMT = NRZ-L
RATE 1/2 CODED	RATE 1/2 CODED

	SPACE-SPACE LINK			NOTES
1	USER TRANSMIT POWER, dBW	7.00		User Provided Data
2	PASSIVE LOSS, dB	5.00		User Provided Data
3	USER ANTENNA GAIN, dBi	-3.00		User Provided Data
4	POINTING LOSS, dB	0.00		User Provided Data
5	USER EIRP, dBW	-1.00		(1)-(2)+(3)-(4)
6	SPACE LOSS, dB	192.43		CLASS Analysis
7	ATMOSPHERIC LOSS, dB	0.00		Not Considered
8	MULTIPATH LOSS, dB	0.00		Not Considered
9	POLARIZATION LOSS, dB	0.10		User Provided Data
10	SSL RAIN ATTENUATION, dB	0.00		User Provided Data
11	Prec AT INPUT TO TDRS, dBW	-193.53		(5)-(6)-(7)-(8)-(9)-(10)
12	TDRS G/T, dB/K	10.50		CLASS Analysis
13	C/N0 AT TDRS, dB-Hz	45.57		(11)+(12)-K
14	BANDWIDTH, dB-Hz	71.94		CLASS Database
15	C/N AT TDRS, dB	-26.37		(13)-(14)
	SPACE-GROUND LINK			
16	TDRS EIRP, dBW	39.90		CLASS Database
17	PATH LOSS, dB	207.22		CLASS Analysis
18	ATMOSPHERIC LOSS, dB	0.25		CLASS Analysis
19	POLARIZATION LOSS, dB	0.03		CLASS Database
20	RAIN ATTENUATION, dB	6.00		User Provided Reference Value
21	Prec AT GROUND, dBW	-173.60		(16)-(17)-(18)-(19)-(20)
22	GROUND G/T, dB/K	41.00		CLASS Database
23	TDRS Dwnlnk C/N0 (Thermal), dB-Hz	96.00		(21)+(22)-K
24	IM DEGRADATION, dB	1.38		CLASS Analysis
25	TDRS Downlink C/N0 (TOTAL), dB-Hz	94.62		(23)-(24)
26	BANDWIDTH, dB-Hz	71.94		CLASS Database
27	TDRS Downlink C/N (TOTAL), dB	22.68		(25)-(26)
	GROUND TERMINAL			
28	C/N AT GROUND, dB	-26.40		(15) || (27)
29	BANDWIDTH, dB-Hz	71.94		CLASS Database
30	C/N0 AT GROUND, dB-Hz	45.54		(28)+(29)

		I-Ch	Q-Ch	
31	CHANNEL POWER SPLIT, dB	-3.01	-3.01	User Provided Data
32	CHANNEL C/N0 AT GROUND, dB-Hz	42.53	42.53	(30)+(31)
33	BIT RATE, dB-BPS	33.98	33.98	User Provided Data
34	EB/N0 INTO DEMODULATOR, dB	8.55	8.55	(32)-(33)
35	DYNAMICS LOSS, dB	0.00	0.00	Not Considered
36	USER CONSTRAINT LOSS, dB	0.02	0.02	CLASS Analysis
37	RFI LOSS, dB	0.70	0.70	CLASS Analysis
38	IMPLEMENTATION LOSS, dB	2.50	2.50	CLASS Database
39	NET EB/N0, dB	5.33	5.33	(34)-(35)-(36)-(37)-(38)
40	THEORETICAL REQ EB/N0, dB	4.20	4.20	BER=1E-5
41	MARGIN, dB	1.13	1.13	(39)-(40)

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TDRSS SSA Forward link

Mission Design Laboratory

*** FORWARD LINK CALCULATION -- NETWORK SYSTEMS ENGINEER ANALYSIS ***

GSFC C.L.A.S.S. ANALYSIS #1 DATE & TIME: 09/15/08 13:43:23 PERFORMED BY: RON VENTO
USERID: PACE LINKID: SSAF RELAY SAT.: TDRS-Spare

TYPE OF TRACKING: PROGRAM TRACK FIELD OF VIEW: PEFOV

SERVICE:	FREQUENCY:	DATA RATE:	POLAR:	RANGE CASE:	ALTITUDE:	ELEVATION:	RANGE:
SSA	2070.0 MHz	1.000 Kbps	RCP	MAXIMUM	400.0 Km	1.5 Deg	44331.2 Km

--COHERENT LINK

PARAMETER	VALUE	TOLERANCE	REMARKS
1. RELAY NETWORK EIRP-DBW	46.30	-	STDN 101.2
2. FREE SPACE LOSS-DB	191.70	-	NOTE B
3. POLARIZATION LOSS-DB	0.10	0.01	NOTE A
4. USER ANTENNA GAIN-DB	-3.00	0.20	NOTE A
5. USER ANTENNA POINTING LOSS-DB	0.00	0.00	NOTE A
6. USER PASSIVE LOSS-DB	5.00	0.10	NOTE A
7. USER RECEIVED POWER-DB	-153.50	-	SUM 1 THRU 6
8. ATMOSPHERIC LOSS-DB	*	*	NOTE B
9. RAIN ATTENUATION-DB	0.00	-	NOTE A
10. RFI LOSS-DB	*	-	NOTE B
11. DYNAMICS LOSS-DB	*	*	NOTE B
12. USER EFFECTIVE RECEIVED POWER-DBW	-153.50	-	SUM 7 THRU 11
13. USER NOISE SENSITIVITY-DBW/HZ	-200.80	0.30	NOTE A
14. USER RECEIVED-P/N0-DB-HZ	47.30	-	12 MINUS 13
15. CARRIER/TOTAL POWER RATIO-DB(MI=1.10 RAD)	-2.86	-	NOTE A
16. USER REQUIRED ACQUISITION-P/N0-DB-HZ	39.50	3.00	NOTE A
17. USER ACQUISITION MARGIN-DB	4.95	-	14 16
		-3.61	SUM (NOTE C)
		-3.02	RSS
18. COMMAND/TOTAL POWER RATIO-DB	-3.53	-	NOTE A
19. USER TRANSPONDER LOSS-DB	2.40	1.00	NOTE A
20. RECEIVED COMMAND-P/N0-DB	41.37	-	SUM 14,18,19
21. COMMAND DATA RATE-DB-HZ	30.00	-	NOTE A
22. USER RECEIVED EB/N0-DB	11.37	-	20 MINUS 21
23. USER REQUIRED EB/N0-DB	10.80	1.00	NOTE A
24. EFFECTIVE USER COMMAND MARGIN-DB	0.57	-	22 MINUS 23
		-2.61	SUM (NOTE C)
		-1.46	RSS

NOTE A: PARAMETER VALUE FROM USER PROJECT - SUBJECT TO CHANGE
NOTE B: FROM CLASS ANALYSIS IF COMPUTED
NOTE C: SUM=-ABS(SUM(ABS. VALUES OF TOLERANCES))

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