INFORMATION TO OFFERORS OR QUOTERS
SECTION A - COVER SHEET

1. SOLICITATION NUMBER	2. *(X one)*	
N00173-00-R-JW01		a. SEALED BID
	X	b. NEGOTIATED *(RFP)*
		c. NEGOTIATED *(RFQ)*

INSTRUCTIONS

NOTE THE AFFIRMATIVE ACTION REQUIREMENT OF THE EQUAL OPPORTUNITY CLAUSE WHICH MAY APPLY TO THE CONTRACT RESULTING FROM THIS SOLICITATION.

You are cautioned to note the "Certification of Non-Segregated Facilities" in the solicitation. Failure to agree to the certification will render your reply nonresponsive to the terms of solicitations involving awards of contracts exceeding $25,000 which are not exempt from the provisions of the Equal Opportunity clause.

"Fill-ins" are provided on the face and reverse of Standard Form 18 and Parts I and IV of Standard Form 33, or other solicitation documents and Sections of Table of Contents in this solicitation and should be examined for applicability.

See the provision of this solicitation entitled either "Late Bids, Modifications of Bids or Withdrawal of Bids" or "Late Proposals, Modifications of Proposals and Withdrawals of Proposals."

When submitting your reply, the envelope used must be plainly marked with the Solicitation Number, as shown above and the date and local time set forth for bid opening or receipt of proposals in the solicitation document.

If NO RESPONSE is to be submitted, detach this sheet from the solicitation, complete the information requested on reverse, fold, affix postage, and mail. NO ENVELOPE IS NECESSARY.

Replies must set forth full, accurate, and complete information as required by this solicitation *(including attachments)*. The penalty for making false statements is prescribed in 18 U.S.C. 1001.

3. ISSUING OFFICE *(Complete mailing address, including ZIP Code)*

CONTRACTING OFFICER
NAVAL RESEARCH LABORATORY
ATTN: CODE 3240.JW
WASHINGTON DC 20375-5326

4. ITEMS TO BE PURCHASED *(Brief description)*

X-BAND DOWNLINK COMMUNICATION SERVICES TO SUPPORT THE CORIOLIS SATELLITE PROGRAM

5. PROCUREMENT INFORMATION *(X and complete as applicable)*

X	a. THIS PROCUREMENT IS UNRESTRICTED	
	b. THIS PROCUREMENT IS A ________ % SET-ASIDE FOR ONE OF THE FOLLOWING *(X one). (See Section I of the Table of Contents in this solicitation for details of the set-aside.)*	

	(1) Small Business		(2) Labor Surplus Area Concerns		(3) Combined Small Business/Labor Area Concerns

6. ADDITIONAL INFORMATION

The Naval Research Laboratory Contracting Division issues solicitations and amendments to solicitations electronically via the Internet at the following website: http://heron.nrl.navy.mil/contracts/home.htm.

Any amendments to this solicitation will be posted at that website. Amendments will not be distributed by any other means. It is the responsibility of potential offerors to periodically review the website for amendments to this solicitation.

7. POINT OF CONTACT FOR INFORMATION

a. NAME *(Last, First, Middle Initial)*	b. ADDRESS *(Include Zip Code)*
WALDENFELS, James P.	Naval Research Laboratory
c. TELEPHONE NUMBER *(Include Area Code and Extension) (NO COLLECT CALLS)* (202) 767-3003	4555 Overlook Ave. S.W. Washington DC 20375-5326

8. REASONS FOR NO RESPONSE *(X all that apply)*			
	a. CANNOT COMPLY WITH SPECIFICATIONS		b. CANNOT MEET DELIVERY REQUIREMENT
	c. UNABLE TO IDENTIFY THE ITEM(S)		d. DO NOT REGULARLY MANUFACTURE OR SELL THE TYPE OF ITEMS INVOLVED
	e. OTHER *(Specify)*		

9. MAILING LIST INFORMATION *(X one)*				
	YES		NO	WE DESIRE TO BE RETAINED ON THE MAILING LIST FOR FUTURE PROCUREMENT OF THE TYPE OF TIME(S) INVOLVED.

10. RESPONDING FIRM	
a. COMPANY NAME	b. ADDRESS *(Include Zip Code)*

c. ACTION OFFICER			
(1) Typed or Printed Name *(Last, First, Middle Initial)*	(2) Title	(3) Signature	(4) Date Signed *(YYMMDD)*

DD FORM 1707 REVERSE, MAR 90

FOLD FOLD

FOLD FOLD

FROM

AFFIX
STAMP
HERE

SOLICITATION NUMBER	
N00173-00-R-JW01	
DATE *(YYMMDD)*	LOCAL TIME
000112	4:00 PM

TO CONTRACTING OFFICER
NAVAL RESEARCH LABORATORY
ATTN: CODE 3240.JW
WASHINGTON DC 20375-5326

SOLICITATION/CONTRACT/ORDER FOR COMMERCIAL ITEMS
OFFEROR TO COMPLETE BLOCKS 12, 17, 23, 24, & 30

1. REQUISITION NUMBER: 81-3033-00
PAGE 1 OF 23

2. CONTRACT NO.:
3. AWARD/EFFECTIVE DATE: TBD
4. ORDER NUMBER:
5. SOLICITATION NUMBER: N00173-00-R-JW01
6. SOLICITATION ISSUE DATE: 12/23/99

7. FOR SOLICITATION INFORMATION CALL:
a. NAME: James Waldenfels
b. TELEPHONE NUMBER *(No collect calls)*: (202) 767-3003
8. OFFER DUE DATE/ LOCAL TIME: (Blk.20)

9. ISSUED BY — CODE: N00173
CONTRACTING OFFICER
NAVAL RESEARCH LABORATORY
ATTN: CODE 3230.JW
WASHINGTON DC 20375-5326

10. THIS ACQUISITION IS
☒ UNRESTRICTED
☐ SET ASIDE: % FOR
☐ SMALL BUSINESS
☐ SMALL DISAV. BUSINESS
☐ 8(A)
SIC: 4899
SIZE STANDARD: $11 M

11. DELIVERY FOR FOB DESTINATION UNLESS BLOCK IS MARKED
☐ SEE SCHEDULE

12. DISCOUNT TERMS

☒ 13a. THIS CONTRACT IS A RATED ORDER UNDER DPAS (15 CFR 700)

13b. RATING: D0-C9

14. METHOD OF SOLICITATION
☐ RFQ ☐ IFB ☒ RFP

15. DELIVER TO — CODE:
See Statement of Work.

16. ADMINISTERED BY — CODE:
(Will be filled in upon award of contract.)

17a. CONTRACTOR/ OFFEROR — CODE: — FACILITY CODE:

TELEPHONE NO.

18a. PAYMENT WILL BE MADE BY — CODE:
(Will be filled in upon award of contract.)

☒ 17b. CHECK IF REMITTANCE IS DIFFERENT AND PUT SUCH ADDRESS IN OFFER

18b. SUBMIT INVOICES TO ADDRESS SHOWN IN BLOCK 18a UNLESS BLOCK BELOW IS CHECKED ☒ SEE ADDENDUM

19. ITEM NO.	20. SCHEDULE OF SUPPLIES/SERVICES	21. QUANTITY	22. UNIT	23. UNIT PRICE	24. AMOUNT
	Offers due 4:00 PM Local Time January 12, 2000 See continuation of Blocks 19-24. TOTAL				

(Attach Additional Sheets as Necessary)

25. ACCOUNTING AND APPROPRIATION DATA

26. TOTAL AWARD AMOUNT *(For Govt. Use Only)*

☐ 27a. SOLICITATION INCORPORATES BY REFERENCE FAR 52.212-1, FAR 52.212-4. FAR 52.212-3 AND 52.212-5 ARE ATTACHED. ☐ ARE ☐ ARE NOT ATTACHED
☐ 27b. CONTRACT/PURCHASE ORDER INCORPORATES BY REFERENCE FAR 52.212-4. FAR 52.212-5 IS ATTACHED. ADDENDA ☐ ARE ☐ ARE NOT ATTACHED

☐ 28. CONTRACTOR IS REQUIRED TO SIGN THIS DOCUMENT AND RETURN ______ TO ISSUING OFFICE. CONTRACTOR AGREES TO FURNISH AND DELIVER ALL ITEMS SET FORTH OR OTHERWISE IDENTIFIED ABOVE AND ON ANY ADDITIONAL SHEETS SUBJECT TO THE TERMS AND CONDITIONS SPECIFIED HEREIN.

☐ 29. AWARD OF CONTRACT: REFERENCE ______ OFFER DATED ______. YOUR OFFER ON SOLICITATION (BLOCK 5), INCLUDING ANY ADDITIONS OR CHANGES WHICH ARE SET FORTH

30a. SIGNATURE OF OFFEROR/CONTRACTOR

31a. UNITED STATES OF AMERICA *(SIGNATURE OF CONTRACTING OFFICER)*

30b. NAME AND TITLE OF SIGNER
30c. DATE SIGNED

31b. NAME OF CONTRACTING OFFICER
31c. DATE SIGNED

32a. QUANTITY IN COLUMN 21 HAS BEEN
☐ RECEIVED ☐ INSPECTED ☐ ACCEPTED, AND CONFORMS TO THE CONTRACT, EXCEPT AS NOTED

33. SHIP NUMBER
PARTIAL FINAL

34. VOUCHER NUMBER

35. AMOUNT VERIFIED CORRECT FOR

36. PAYMENT
☐ COMPLETE ☐ PARTIAL ☐ FINAL

37. CHECK NUMBER

32b. SIGNATURE OF AUTHORIZED GOVT. REPRESENTATIVE
32c. DATE

38. S/R ACCOUNT NUMBER
39. S/R VOUCHER NUMBER
40. PAID BY

42a. RECEIVED BY *(Print)*

41a. I CERTIFY THIS ACCOUNT IS CORRECT AND PROPER FOR PAYMENT

41b. SIGNATURE AND TITLE OF CERTIFYING OFFICER
41c. DATE

42b. RECEIVED AT *(Location)*

42c. DATE REC'D *(YY/MM/DD)*
42b. TOTAL CONTAINERS

1. CONTINUATION OF THE SF 1449 - SOLICITATION/CONTRACT/ORDER FOR COMMERCIAL ITEMS

A. Blocks 19 - 24 are completed as follows:

Item No.	Schedule of Supplies/Services	Quantity	Unit	Unit Price	Amount
0001	The Contractor shall complete Phase 1, Design, in accordance with the Statement of Work/Specifications	1**	LO	$	$**
0002	Data in accordance with Exhibit A (DD1423)	1	LO	NSP*	
	*NSP for Item 0002: included in 0001.				
0003	The Contractor shall complete Phase 2, Integration, Testing & Readiness, in accordance with the Statement of Work/Specifications as indicated for Phase 2.	1**	LO	$	$**
0004	Data in accordance with Exhibit B (DD1423)	1	LO	NSP*	
	* NSP for 0004: included in 0003.				

OPTIONAL ITEMS (REMAINING ITEMS)

OPTION 1

Item No.	Schedule of Supplies/Services	Maximum Quantity	Unit	Unit Price	Maximum Amount
0005	The Contractor shall perform Phase 3, Operations services, in accordance with the Statement of Work/Specifications as indicated for Phase 3, First Phase 3 Period.				
0005AA	Low Earth Orbit (LEO) Checkout Support, in accordance with Paragraph 5.3.1.2 of the Statement of Work/Specifications – First Phase 3 Period	1**	LO	NSP	
0005AB	Nominal On-Orbit Data Collection, Archive, and Dissemination, in accordance with Paragraph 5.3.1.3 of the Statement of Work/Specifications – First Phase 3 Period	***	Pass	$***	$***
0005AC	Engineering Support in accordance with Paragraph 5.3.1.4 of the Statement of Work – First Phase 3 Period	1**	LO	NSP	
0006	Data in accordance with Exhibit C (DD 1423 – First Phase 3 Period)	1	LO	NSP*	
	*NSP for 0005AA, 00AC, and 0006: included in 0005AB				

OPTION 2

Item No.	Schedule of Supplies/Services	Maximum Quantity	Unit	Unit Price	Maximum Amount
0007	The Contractor shall perform Phase 3, Operations services, in accordance with the Statement of Work/Specifications as indicated for Phase 3, Second Phase 3 Period.				
0007AA	Nominal On-Orbit Data Collection, Archive, and Dissemination, in accordance with Paragraph 5.3.1.3 of the Statement of Work/Specifications – Second Phase 3 Period	***	Pass	$***	$***
0007AB	Engineering Support in accordance with Paragraph 5.3.1.4 of the Statement of Work – Second Phase 3 Period	1**	LO	NSP	
0008	Data in accordance with Exhibit C (DD 1423) – Second Phase 3 Period	1	LO	NSP*	
	*NSP for 0007AB, and 0008: included in 0007AA				

OPTION 3

Item No.	Schedule of Supplies/Services	Maximum Quantity	Unit	Unit Price	Maximum Amount
0009	The Contractor shall perform Phase 3, Operations services, in accordance with the Statement of Work/Specifications as indicated for Phase 3, Third Phase 3 Period.				
0009AA	Nominal On-Orbit Data Collection, Archive, and Dissemination, in accordance with Paragraph 5.3.1.3 of the Statement of Work/Specifications – Third Phase 3 Period	***	Pass	$***	$***

Item No.	Schedule of Supplies/Services	Maximum Quantity	Unit	Unit Price	Maximum Amount
0009AB	Engineering Support in accordance with Paragraph 5.3.1.4 of the Statement of Work – Third Phase 3 Period	1**	LO	NSP	
0010	Data in accordance with Exhibit C (DD 1423) – Third Phase 3 Period	1	LO	NSP*	
	*NSP for 0009AB and 00010, included in 0009AA				
OPTION 4					
0011	The Contractor shall perform Phase 3, Operations services, in accordance with the Statement of Work/Specifications as indicated for Phase 3, Fourth Phase 3 Period.				
0011AA	Nominal On-Orbit Data Collection, Archive, and Dissemination, in accordance with Paragraph 5.3.1.3 of the Statement of Work/Specifications – Fourth Phase 3 Period	***	Pass	$***	$***
0011AB	Engineering Support in accordance with Paragraph 5.3.1.4 of the Statement of Work – Fourth Phase 3 Period	1**	LO	NSP	
0012	Data in accordance with Exhibit C (DD 1423) – Fourth Phase 3 Period	1	LO	NSP*	
	*NSP for 0011AB and 0012, included in 0011AA				

OPTION 5

Item No.	Schedule of Supplies/Services	Maximum Quantity	Unit	Unit Price	Maximum Amount
0013	The Contractor shall perform Phase 3, Operations services, in accordance with the Statement of Work/Specifications as indicated for Phase 3, Fifth Phase 3 Period.				
0013AA	Nominal On-Orbit Data Collection, Archive, and Dissemination, in accordance with Paragraph 5.3.1.3 of the Statement of Work/Specifications – Fifth Phase 3 Period	***	Pass	$***	$***
0013AB	Engineering Support in accordance with Paragraph 5.3.1.4 of the Statement of Work – Fifth Phase 3 Period	1**	LO	NSP	
0014	Data in accordance with Exhibit C (DD 1423) – Fifth Phase 3 Period	1	LO	NSP*	
	*NSP for 0013AB and 0014, included in 0013AA				

OPTION 6

Item No.	Schedule of Supplies/Services	Maximum Quantity	Unit	Unit Price	Maximum Amount
0015	The Contractor shall perform Phase 3, Operations services, in accordance with the Statement of Work/Specifications as indicated for Phase 3, Sixth Phase 3 Period.				
0015AA	Nominal On-Orbit Data Collection, Archive, and Dissemination, in accordance with Paragraph 5.3.1.3 of the Statement of Work/Specifications – Sixth Phase 3 Period	***	Pass	$***	$***

Item No.	Schedule of Supplies/Services	Maximum Quantity	Unit	Unit Price	Maximum Amount
0015AB	Engineering Support in accordance with Paragraph 5.3.1.4 of the Statement of Work – Sixth Phase 3 Period	1**	LO	NSP	
0016	Data in accordance with Exhibit C (DD 1423) – Sixth Phase 3 Period *NSP for 0015AB and 0016, included in 0015AA	1	LO	NSP*	

OPTION 7

Item No.	Schedule of Supplies/Services	Maximum Quantity	Unit	Unit Price	Maximum Amount
0017	The Contractor shall perform Backup Role Phase 3, Operations services, in accordance with the Statement of Work/Specifications as indicated for Phase 3 for Backup Role Services - First Phase 3 Period.				
0017AA	Low Earth Orbit (LEO) Checkout Support, in accordance with Paragraph 5.3.1.2 of the Statement of Work/Specifications – First Phase 3 Period	1**	LO	NSP	
0017AB	Nominal Backup Role On-Orbit Data Collection, Archive, and Dissemination, in accordance with Paragraphs 5.3.1.3 and 7 for Backup Role Services of the Statement of Work/Specifications – First Phase 3 Period	1,500	Pass	$	$
0017AC	Engineering Support in accordance with Paragraphs 5.3.1.4 and 7 of the Statement of Work – First Phase 3 Period	1**	LO	NSP	

Item No.	Schedule of Supplies/Services	Maximum Quantity	Unit	Unit Price	Maximum Amount
0018	Data in accordance with Exhibit C (DD 1423 – First Phase 3 Period)	1	LO	NSP*	
	*NSP for 0017AA, 0017AC, and 00018, included in 0017AB				
OPTION 8					
0019	The Contractor shall perform Backup Role Phase 3, Operations services, in accordance with the Statement of Work/Specifications as indicated for Phase 3 for Backup Role Services - Second Phase 3 Period.				
0019AA	Nominal Backup Role On-Orbit Data Collection, Archive, and Dissemination, in accordance with Paragraphs 5.3.1.3 and 7 for Backup Role Services of the Statement of Work/Specifications – Second Phase 3 Period	1,500	Pass	$	$
0019AB	Engineering Support in accordance with Paragraphs 5.3.1.4 and 7 of the Statement of Work – Second Phase 3 Period	1**	LO	NSP	
0020	Data in accordance with Exhibit C (DD 1423 – Second Phase 3 Period)	1	LO	NSP*	
	*NSP for 0005AB and 0020, included in 0019AA				

OPTION 9

Item No.	Schedule of Supplies/Services	Maximum Quantity	Unit	Unit Price	Maximum Amount
0021	The Contractor shall perform Backup Role Phase 3, Operations services, in accordance with the Statement of Work/Specifications as indicated for Phase 3 for Backup Role Services - Third Phase 3 Period.				
0021AA	Nominal Backup Role On-Orbit Data Collection, Archive, and Dissemination, in accordance with Paragraphs 5.3.1.3 and 7 for Backup Role Services of the Statement of Work/Specifications – Third Phase 3 Period	1,500	Pass	$	$
0021AB	Engineering Support in accordance with Paragraphs 5.3.1.4 and 7 of the Statement of Work –Third Phase 3 Period	1**	LO	NSP	
0022	Data in accordance with Exhibit C (DD 1423 – Third Phase 3 Period)	1	LO	NSP*	
	*NSP for 0021AB and 0022, included in 0021AA				

OPTION 10

Item No.	Schedule of Supplies/Services	Maximum Quantity	Unit	Unit Price	Maximum Amount
0023	The Contractor shall perform Backup Role Phase 3, Operations services, in accordance with the Statement of Work/Specifications as indicated for Phase 3 for Backup Role Services - Fourth Phase 3 Period.				

Item No.	Schedule of Supplies/Services	Maximum Quantity	Unit	Unit Price	Maximum Amount
0023AA	Nominal Backup Role On-Orbit Data Collection, Archive, and Dissemination, in accordance with Paragraphs 5.3.1.3 and 7 for Backup Role Services of the Statement of Work/Specifications – Fourth Phase 3 Period	1,500	Pass	$	$
0023AB	Engineering Support in accordance with Paragraphs 5.3.1.4 and 7 of the Statement of Work – Fourth Phase 3 Period	1**	LO	NSP	
0024	Data in accordance with Exhibit C (DD 1423 – Fourth Phase 3 Period) *NSP for 0023AB and 0024, included in 0023AA	1	LO	NSP*	
OPTION 11					
0025	The Contractor shall perform Backup Role Phase 3, Operations services, in accordance with the Statement of Work/Specifications as indicated for Phase 3 for Backup Role Services - Fifth Phase 3 Period.				
0025AA	Nominal Backup Role On-Orbit Data Collection, Archive, and Dissemination, in accordance with Paragraphs 5.3.1.3 and 7 for Backup Role Services of the Statement of Work/Specifications – Fifth Phase 3 Period	1,500	Pass	$	$
0025AB	Engineering Support in accordance with Paragraphs 5.3.1.4 and 7 of the Statement of Work – Fifth Phase 3 Period	1**	LO	NSP	

Item No.	Schedule of Supplies/Services	Maximum Quantity	Unit	Unit Price	Maximum Amount
0026	Data in accordance with Exhibit C (DD 1423 – Fifth Phase 3 Period) *NSP for 0025AB and 0026, included in 0025AA	1	LO	NSP*	

OPTION 12

Item No.	Schedule of Supplies/Services	Maximum Quantity	Unit	Unit Price	Maximum Amount
0027	The Contractor shall perform Backup Role Phase 3, Operations services, in accordance with the Statement of Work/Specifications as indicated for Phase 3 for Backup Role Services - Sixth Phase 3 Period.				
0027AA	Nominal Backup Role On-Orbit Data Collection, Archive, and Dissemination, in accordance with Paragraphs 5.3.1.3 and 7 for Backup Role Services of the Statement of Work/Specifications – Sixth Phase 3 Period	1,500	Pass	$	$
0027AB	Engineering Support in accordance with Paragraphs 5.3.1.4 and 7 of the Statement of Work – Sixth Phase 3 Period	1**	LO	NSP	
0028	Data in accordance with Exhibit C (DD 1423 – Sixth Phase 3 Period) *NSP for 0027AB and 0028, included in 0027AA	1	LO	NSP*	

The “maximum amounts” are for amounts depending on the number of passes processed in accordance with Paragraph E, below.

* The extended prices for Phase 3 are maximum prices subject to the adjustment procedure stated in Paragraph E.
**These quantities and amounts (Contract Line Items (CLINs) 0001 – 0004)) are not subject to the adjustment procedure in Paragraph E, below. The quantities and amounts stated are the contractual quantities, not maximums.
***To be entered by offeror based on the number of passes over ground stations proposed, using 14 orbits per day over a period of 365 days; e.g. using 2 stations: 2 stations X 14 orbits X365 days would be 10,220 as the quantity.

2. ADDENDA TO FAR 52.212-4 CONTRACT TERMS AND CONDITIONS--COMMERCIAL ITEMS (MAY 1999)

A. REQUIRED DELIVERY OR PERIOD OF PERFORMANCE

The required delivery is as follows:

ITEM NO.	DELIVERY SCHEDULE FOR COMPLETION OF ACTIVITIES IN PHASES 1 AND 2
0001	8/28/2000
0003	One week prior to launch*

* This date will be on or before 2/15/2002. The nominal launch date is 12/15/2001.
The period of performance shall be as follows:

ITEM NO.	PHASE 3 PERIOD FROM	Through	DESCRIPTION
0005AA	Launch plus about 1 week	Launch plus about 3-4 weeks	Low Earth Orbit checkout support
0005AB	Launch	Launch plus 1 year	First Phase 3 Period
0005AC	Launch	Launch plus 1 year	Engineering Support
0007AA	Launch plus 1 year	Launch plus 2 years	Second Phase 3 Period
0007AB	Launch plus 1 year	Launch plus 2 years	Engineering Support
0009AA	Launch plus 2 years	Launch plus 3 years	*Third Phase 3 Period*
0009AB	Launch plus 2 years	Launch plus 3 years	*Engineering Support*
0011AA	Launch plus 3 years	Launch plus 4 years	*Fourth Phase 3 Period*

0011AB	Launch plus 3 years	Launch plus 4 years	*Engineering Support*
0013AA	Launch plus 4 years	Launch plus 5 years	*Fifth Phase 3 Period*
0013AB	Launch plus 4 years	Launch plus 5 years	*Engineering Support*
0015AA	Launch plus 5 years	Launch plus 6 years	*Sixth Phase 3 Period*
0015AB	Launch plus 5 years	Launch plus 6 years	*Engineering Support*
0017AA	Launch plus about 1 week	Launch plus about 3-4 weeks	*Backup Low Earth Orbit checkout support*
0017AB	Launch	Launch plus 1 year	*Backup First Phase 3 Per.*
0017AC	Launch	Launch plus 1 year	*Backup Engineering Support*
0019AA	Launch plus 1 year	Launch plus 2 years	*Backup Second Phase 3 Per.*
0019AB	Launch plus 1 year	Launch plus 2 years	*Backup Engineering Support*
0021AA	Launch plus 2 years	Launch plus 3 years	*Backup Third Phase 3 Per.*
0021AB	Launch plus 2 years	Launch plus 3 years	*Backup Engineering Support*
0023AA	Launch plus 3 years	Launch plus 4 years	*Backup Fourth Phase 3 Period*
0023AB	Launch plus 3 years	Launch plus 4 years	*Backup Engineering Support*
0025AA	Launch plus 4 years	Launch plus 5 years	*Backup Fifth Phase 3 Per.*
0025AB	Launch plus 4 years	Launch plus 5 years	*Backup Engineering Support*
0027AA	Launch plus 5 years	Launch plus 6 years	*Backup Sixth Phase 3 Per.*
0027AB	Launch plus 5 years	Launch plus 6 years	*Backup Engineering Support*

B. OPTIONS

The Government may require performance of any optional services within the limits and at the rates specified. The Contracting Officer may exercise the option by written notice to the Contractor anytime prior to contract completion.

C. AUTHORIZED GOVERNMENT REPRESENTATIVE

*,Code *,Telephone number *, is hereby designated the Authorized Government Representative for inspection and acceptance purposes.

*(To be filled in at time of award)

D. YEAR 2000 COMPLIANT INFORMATION TECHNOLOGY

This requirement applies to information technology (IT) that processes date-related information. All such IT delivered under this contract shall be Year 2000 compliant as defined at FAR 39.002.

E. The maximum prices for Phase 3 that are stated in the table of prices are based on downlinking, , demodulating, separating, and delivering signals from every satellite pass over a ground station identified in the proposal for this project. The actual price to be paid for each Phase 3 priced subline item of the contract is the product of the unit price and the number of times, in accordance with Government direction, the satellite signal was received and processed in accordance with the Statement of Work. (Fourteen orbits per day are anticipated in the primary provider role, and four per day are anticipated for use in the backup role.) A “pass” is defined as a transit of the satellite within the normal range of one of the Contractor’s ground stations and a successful capture of the signal.

F. Remittance Address: To be entered by offeror.

G. Information to offerors: Options 7 though 12 may be exercised instead of Options 1 through 6. The maximum number of passes under Options 7 through 12 is 1,500 each, a small percentage of the number of passes utilized under the options as the main service provider. It is contemplated that virtually all passes would be utilized under the latter options.

H. The FAR clause entitled Changes-Fixed Price (AUG 1987), Alternate I (APR 1984), is applicable to this contract. It is understood that “time of performance” (Alt. I(a)(2)) includes the launch window.

I. **FAR 252.232-7007 LIMITATION OF GOVERNMENT’S OBLIGATION (AUG 1993)**

(a) Contract line item(s) __**__ through __**__ are incrementally funded. For these item(s), the sum of $__*__ of the total price is presently available for payment and allotted to this contract. An allotment schedule is set forth in paragraph (i) of this clause.

(b) For item(s) identified in paragraph (a) of this clause, the Contractor agrees to perform up to the point at which the total amount payable by the Government, including reimbursement in the event of termination of those item(s) for the Government’s convenience, approximates the total amount currently allotted to the contract. The Contractor will not be obligated to continue work on those item(s) beyond that point. The Government will not be obligated in any event to reimburse the Contractor in excess of the amount allotted to the contract for those item(s) regardless of anything to the contrary in the clause entitled “Termination for Convenience of the

Government."*As used in this clause, the total amount payable by the Government in the event of termination of applicable contract line item(s) for convenience includes costs, profit, and estimated termination settlement costs for those item(s).

(c) Notwithstanding the dates specified in the allotment schedule in paragraph (i) of this clause, the Contractor will notify the Contracting Officer in writing at least ninety days prior to the date when, in the Contractor's best judgment, the work will reach the point at which the total amount payable by the Government, including any cost for termination for convenience, will approximate 85 percent of the total amount then allotted to the contract for performance of the applicable item(s). The notification will state (1) the estimated date when that point will be reached and (2) an estimate of additional funding, if any, needed to continue performance of applicable line items up to the next scheduled date for allotment of funds identified in paragraph (i) of this clause, or to a mutually agreed upon substitute date. The notification will also advise the Contracting Officer of the estimated amount of additional funds that will be required for the timely performance of the item(s) funded pursuant to this clause, for a subsequent period as may be specified in the allotment schedule in paragraph (i) of this clause or otherwise agreed to by the parties. If after such notification additional funds are not allotted by the date identified in the Contractor's notification, or by an agreed substitute date, the Contracting Officer will terminate any item(s) for which additional funds have not been allotted, pursuant to the clause of this contract entitled "Termination for Convenience of the Government."

(d) When additional funds are allotted for continued performance of the contract line item(s) identified in paragraph (a) of this clause, the parties will agree as to the period of contract performance which will be covered by the funds. The provisions of paragraphs (b) through (d) of this clause will apply in like manner to the additional allotted funds and agreed substitute date, and the contract will be modified accordingly.

(e) If, solely by reason of failure of the Government to allot additional funds, by the dates indicated below, in amounts sufficient for timely performance of the contract line item(s) identified in paragraph (a) of this clause, the Contractor incurs additional costs or is delayed in the performance of the work under this contract and if additional funds are allotted, an equitable adjustment will be made in the price or prices (including appropriate target, billing, and ceiling prices where applicable) of the item(s), or in the time of delivery, or both. Failure to agree to any such equitable adjustment hereunder will be a dispute concerning a question of fact within the meaning of the clause entitled "Disputes."

(f) The Government may at any time prior to termination allot additional funds for the performance of the contract line item(s) identified in paragraph (a) of this clause.

(g) The termination provisions of this clause do not limit the rights of the Government under the clause entitled "Default."* The provisions of this clause are limited to the work and allotment of funds for the contract line item(s) set forth in paragraph (a) of this clause. This clause no longer applies once the contract is fully funded except with regard to the rights or obligations of the parties concerning equitable adjustments negotiated under paragraphs (d) and (e) of this clause.

(h) Nothing in this clause affects the right of the Government to terminate this contract pursuant to the clause of this contract entitled "Termination for Convenience of the Government."

(i) The parties contemplate that the Government will allot funds to this contract in accordance with the following schedule:

On execution of contract $**

(month) (day), 192x	$**
(month) (day), 192y	$**
(month) (day), 192z	$**
(etc.)	

*The clause entitled "Termination for Convenience of the Government" means the paragraph entitled "Termination for the Government's Convenience" in Clause 52.212-4, "Contract Terms and Conditions – Commercial Items," in this contract. The clause entitled "Default" means the paragraph entitled "Termination for Cause" in Clause 52.212-4, "Contract Terms and Conditions – Commercial Items," in this contract.

(End of clause)

** To be inserted after negotiation. Offeror shall propose a schedule for Items 0001 through 0004 as well as one or more approaches for funding schedules for Phase 3 items.

3. FAR 52.212-5 CONTRACT TERMS AND CONDITIONS REQUIRED TO IMPLEMENT STATUTES OR EXECUTIVE ORDERS--COMMERCIAL ITEMS (MAY 1999)

(a) The Contractor agrees to comply with the following FAR clauses, which are incorporated in this contract by reference, to implement provisions of law or executive orders applicable to acquisitions of commercial items:

(1) 52.222-3, Convict Labor (E.O.11755); and
(2) 52.233-3, Protest after Award (31 U.S.C 3553).

(b) The Contractor agrees to comply with the FAR clauses in this paragraph (b) which the contracting officer has indicated as being incorporated in this contract by reference to implement provisions of law or executive orders applicable to acquisitions of commercial items or components:

(Contracting Officer shall check as appropriate.)

☒ (1) 52.203-6, Restrictions on Subcontractor Sales to the Government, with Alternate I (41 U.S.C.253g and 10 U.S.C.2402).

☐ (2) 52.219-3, Notice of HUBZone Small Business Set-Aside (Jan 1999)

☒ (3) 52.219-4, Notice of Price Evaluation Preference for HUBZone Small Business Concerns (Jan 1999) (*if the offeror elects to waive the preference, it shall so indicate in its offer*)

☐ (4) (i) 52.219-5, Very Small Business Set-Aside (Pub. L. 103-403, section 304, Small Business Reauthorization and Amendments Act of 1994)

☐ (ii) Alternate I to 52.219-5

☐ iii) Alternate II to 52.219-5

☒ (5) 52.219-8, Utilization of Small Business Concerns (15 U.S.C.637 (d)(2) and (3)).

☒ (6) 52.219-9, Small Business Subcontracting Plan (15 U.S.C.637 (d)(4)).

☐ (7) 52.219-14, Limitations on Subcontracting (15 U.S.C.637(a)(14)).

☐ (8) (i) 52.219-23, Notice of Price Evaluation Adjustment for Small Disadvantaged Business Concerns (Pub. L. 103-355, section 7102, and 10 U.S.C. 2323) (if the offeror elects to waive the adjustment, it shall so indicate in its offer)

☐ (ii) Alternate I of 52.219-23.

☒ (9) 52.219-25, Small Disadvantaged Business Participation Program - Disadvantaged Status and Reporting (Pub L. 103-355, section 7102, and 10 U.S.C. 2323).

☐ (10) 52.219-26, Small Disadvantaged Business Participation Program - Incentive Subcontracting (Pub. L. 103-355, section 7102, and 10 U.S.C. 2323).

☒ (11) 52.222-21, Prohibition of Segregated Facilities (Feb 1999)

☒ (12) 52.222-26, Equal Opportunity (E.O.11246).

☒ (13) 52.222-35, Affirmative Action for Disabled Veterans and Veterans of the Vietnam Era (38 U.S.C.4212).

☒ (14) 52.222-36, Affirmative Action for Workers with Disabilities (29 U.S.C.793).

☒ (15) 52.222-37, Employment Reports on Disabled Veterans and Veterans of the Vietnam Era (38 U.S.C.4212).

☐ (16) 52.225-3, Buy American Act -- Supplies (41 U.S.C.10).

☐ (17) 52.225-9, Buy American Act -- Trade Agreements Act -- Balance of Payments Program (41 U.S.C.10, 19 U.S.C.2501-2582).

☐ (18) [Reserved]

☐ (19) 52.225-18, European Union Sanction for End Products (E.O.12849).

☐ (20) 52.225-19, European Union Sanction for Services (E.O.12849).

☐ (21) (i) 52.225-21, Buy American Act -- North American Free Trade Agreement Implementation Act -- Balance of Payments Program (41 U.S.C 10, Pub.L.103-187).

☐ (ii) Alternate I of 52.225-21.

☒ (22) 52.232-33, Payment by Electronic Funds Transfer -- Central Contractor Registration (31 U.S.C. 3332).

☐ (23) 52.232-34, Payment by Electronic Funds Transfer --Other than Central Contractor Registration (31 U.S.C. 3332).

☐ (24) 52.232-36, Payment by Third Party (31 U.S.C. 3332).

☐ (25) 52.239-1, Privacy or Security Safeguards (5 U.S.C.552a).

☐ (26) 52.247-64, Preference for Privately Owned U.S.-Flag Commercial Vessels (46 U.S.C.1241).

(c) The Contractor agrees to comply with the FAR clauses in this paragraph (c), applicable to commercial services, which the Contracting Officer has indicated as being incorporated in this contract by reference to implement provisions of law or executive orders applicable to acquisitions of commercial items or components:

(Contracting Officer check as appropriate.)

☐ (1) 52.222-41, Service Contract Act of 1965, As Amended (41 U.S.C.351, *et seq*.).

☐ (2) 52.222-42, Statement of Equivalent Rates for Federal Hires (29 U.S.C.206 and 41 U.S.C.351, *et seq*.).

☐ (3) 52.222-43, Fair Labor Standards Act and Service Contract Act -- Price Adjustment (Multiple Year and Option Contracts) (29 U.S.C.206 and 41 U.S.C.351*, et seq*.).

☐ (4) 52.222-44, Fair Labor Standards Act and Service Contract Act - Price Adjustment (29 U.S.C.206 and 41 U.S.C.351, *et seq*.).

☐ (5) 52.222-47, SCA Minimum Wages and Fringe Benefits Applicable to Successor Contract Pursuant to Predecessor Contractor Collective Bargaining Agreement (CBA) (41 U.S.C.351, *et seq*.).

(d) *Comptroller General Examination of Record.* The Contractor agrees to comply with the provisions of this paragraph (d) if this contract was awarded using other than sealed bid, is in excess of the simplified acquisition threshold, and does not contain the clause at 52.215-2, Audit and Records -- Negotiation.

(1) The Comptroller General of the United States, or an authorized representative of the Comptroller General, shall have access to and right to examine any of the Contractor's directly pertinent records involving transactions related to this contract.

(2) The Contractor shall make available at its offices at all reasonable times the records, materials, and other evidence for examination, audit, or reproduction, until 3 years after final payment under this contract or for any shorter period specified in FAR Subpart 4.7, Contractor Records Retention, of the other clauses of this contract. If this contract is completely or partially terminated, the records relating to the work terminated shall be made available for 3 years after any resulting final termination settlement. Records relating to appeals under the disputes clause or to litigation or the settlement of claims arising under or relating to this contract shall be made available until such appeals, litigation, or claims are finally resolved.

(3) As used in this clause, records include books, documents, accounting procedures and practices, and other data, regardless of type and regardless of form. This does not require the Contractor to create or maintain any record that the Contractor does not maintain in the ordinary course of business or pursuant to a provision of law.

(e) Notwithstanding the requirements of the clauses in paragraphs (a), (b), (c) or (d) of this clause, the Contractor is not required to include any FAR clause, other than those listed below (and as may be required by an addenda to this paragraph to establish the reasonableness of prices under Part 15), in a subcontract for commercial items or commercial components --

(1) 52.222-26, Equal Opportunity (E.O.11246);

(2) 52.222-35, Affirmative Action for Special Disabled and Vietnam Era Veterans (38 U.S.C.2012(a));

(3) 52.222-36, Affirmative Action for Workers with Disabilities (29 U.S.C.793); and

(4) 52.247-64, Preference for Privately-Owned U.S.- Flag Commercial Vessels (46 U.S.C.1241) (flow down not required for subcontracts awarded beginning May 1, 1996).

4. 252.212-7001 -- CONTRACT TERMS AND CONDITIONS REQUIRED TO IMPLEMENT STATUTES OR EXECUTIVE ORDERS APPLICABLE TO DEFENSE ACQUISITIONS OF COMMERCIAL ITEMS. (SEP 1999)

(a) The Contractor agrees to comply with the Defense Federal Acquisition Regulation Supplement (DFARS) clause 252.247-7023, Transportation of Supplies by Sea, which is included in this contract by reference to implement 10 U.S.C.2631.

(b) The Contractor agrees to comply with any clause that is checked on the following list of DFARS clauses which, if checked, is included in this contract by reference to implement provisions of law or Executive orders applicable to acquisitions of commercial items or components.

☒ 252.205-7000 Provision of Information to Cooperative Agreement Holders (10 U.S.C.2416).

☐ 252.206-7000 Domestic Source Restriction (10 U.S.C.2304).

☒ 252.219-7003 Small, Small Disadvantaged and Women-Owned Small Business Subcontracting Plan (DOD Contracts) (15 U.S.C.637).

☐	252.225-7001	Buy American Act and Balance of Payment Program (41 U.S.C.10 a-10d, E.O. 10582).
☒	252.225-7007	Buy American Act -Trade Agreements - Balance of Payments Program (41 U.S.C. 10a-10d, 19 U.S.C.2501-2518, and 19 U.S.C. 3301 note).
☒	252.225-7012	Preference for Certain Domestic Commodities.
☐	252.225-7014	Preference for Domestic Specialty Metals (10 U.S.C.2241 note).
☐	252.225-7015	Preference for Domestic Hand or Measuring Tools (10 U.S.C.2241 note).
☐	252.225-7021	Trade Agreements (19 U.S.C. 2501-2518 and 19 U.S.C. 3301 note).
☐	252.225-7027	Restriction on Contingent Fees for Foreign Military Sales (22 U.S.C.2779).
☐	252.225-7028	Exclusionary Policies and Practices of Foreign Governments (22 U.S.C.2755).
☐	252.225-7029	Preference for United States or Canadian Air Circuit Breakers (10 U.S.C.2534(a)(3)).
☐	252.225-7036	Buy American Act -- North American Free Trade Agreement Implementation Act.-- Balance of Payment Program (☐Alternate I) (41 U.S.C. 10a-10d and 19 U.S.C. 3301 note).
☒	252.227-7015	Technical Data -- Commercial Items (10 U.S.C.2320).
☒	252.227-7037	Validation of Restrictive Markings on Technical Data (10 U.S.C.2321).
☒	252.243-7002	Requests for Equitable Adjustment (10 U.S.C. 2410).
☐	252.247-7024	Notification of Transportation of Supplies by Sea (10 U.S.C.2631).

(c) In addition to the clauses listed in paragraph (e) of the Contract Terms and Conditions Required to Implement Statutes or Executive Orders-Commercial Items clause of this contract, the Contractor shall include the terms of the following clause, if applicable, in subcontracts for commercial items or commercial components, awarded at any tier under this contract:

252.225-7014 Preference for Domestic Specialty Metals, Alternate I (10 U.S.C.2241 note).

DFARS:

252.204-7004 Required Central Contractor Registration (MAR 1998)

5. CONTRACT DOCUMENTS, EXHIBITS OR ATTACHMENTS:

1. Contract Data Requirements List, DD 1423

2. Statement of Work/Specifications
3. Accounting and Appropriation Data*
4. SOW Reference Document Attachment-
   Coriolis Mission Concept Plan (MCP)
5. SOW Reference Document Attachment-
   WindSat Experiment Requirements Document (ERD) NCST-D-WS013 Rev. A, dated 28 Jan 99
6. SOW Reference Document Attachment-
   SMEI Experiment Requirements Document Rev. D, dated 9 Jan 99

(To be included at time of award)*

6. FAR 52.212-2 - EVALUATION - COMMERCIAL ITEMS (JAN 1999)

(a) The Government will award a contract resulting from this solicitation to the responsible offeror whose offer conforming to the solicitation will be most advantageous to the Government, price and other factors considered. The following factors shall be used to evaluate offers:

technical, past performance and price. Within the technical factor, the offeror must be able to satisfy the technical specification and to perform the statement of work. The major additional focus is the latency and usefulness of data, which is related to the number, location and capability of ground stations. Demonstrated capability of the contractor's proposed ground systems would provide an extra level of confidence that Coriolis mission objectives can be executed within cost and schedule constraints. Technical and past performance, when combined are more important than price. Past performance is considerably less important than price unless a significant risk is indicated.

(b) Options. The Government will evaluate offers for award purposes by adding the total price for all options to the total price for the basic requirement. The Government may determine that an offer is unacceptable if the option prices are significantly unbalanced. Evaluation of options shall not obligate the Government to exercise the option(s).

(c) A written notice of award or acceptance of an offer, mailed or otherwise furnished to the successful offeror within the time for acceptance specified in the offer, shall result in a binding contract without further action by either party. Before the offer's specified expiration time, the Government may accept an offer (or part of an offer), whether or not there are negotiations after its receipt, unless a written notice of withdrawal is received before award.

7. ADDENDUM TO FAR 52.212-1 INSTRUCTIONS TO OFFERORS- COMMERCIAL ITEMS (NOV 1999)

(b) Submission of offers

Submit two originals and 5 copies of pages 1-11 and 15-16 with appropriate signatures and fill-ins, as well as any other proposal information required by the provisions of the RFP. Submit 7 copies of supporting data. The RFP pages and supporting data may be combined in the same volume. There is no page limit. At a minimum, the technical portion of the proposals should contain the following:

Submit two originals and 8 copies of pages 1-11 and 15-16 with appropriate signatures and fill-ins, as well as any other proposal information required by the provisions of the RFP. Submit 10 copies of supporting data. The RFP pages and supporting data may be combined in the same volume. There is no page limit. At a minimum, the technical portion of the proposals should contain the following:

1. Proposed Coriolis ground system architecture.

2. Description of RSC coordination, scheduling, and replanning process.

3. Earth station architecture block diagrams.

4. Description of method to allow Coriolis program to add emergency supports.

5. A proposed statistical summary report, as suggested in paragraph 5.3.1.4.

6. Specification of the X-Band ground system's nominal bit error rate and how this bit error rate is calculated.

7. Specification of the X-Band ground system's availability and the calculation method.

8. An estimate of the method of meeting the Data Latency requirement.

9. Compatibility Test architecture (X-Band portion), including communications links.

10. Past and present spacecraft programs supported by the vendor, and in what capacity.

11. Archival methodology.

12. Communications link analysis spreadsheet

Regarding Table 1 – Latency Allocation for WindSat Data, Housekeeping Data, Footnote 3: Proposers should provide an estimate of their nominal capabilities, without incurring excessive expense for added capability.

The offeror should propose a method to add emergency supports in the case of a space vehicle emergency under SOW Paragraph 5.3.1.3.

(e) Multiple offers

The primary proposal should be based on the minimum number of ground stations required to satisfy the specifications. Alternate proposals may be submitted based on different number(s) of ground stations.

9. OFFEROR REPRESENTATIONS AND CERTIFICATIONS

Offeror must complete and submit with its proposal, FAR 52.212-3 (JUNE 1999) *Offeror Representations and Certifications--Commercial Items* and DFARS 252.212-7000 *Offeror Representations and Certifications--Commercial Items.,* which are available electronically in full text at : http://heron.nrl.navy.mil/contracts/reps&certs.htm

STATEMENT OF WORK

1.0 PURPOSE

The X-Band downlink communication services to support the Coriolis Satellite Program. These communication services include receipt of downlinked stored data (housekeeping and science) by compatible X-Band ground stations and dissemination of that data to the appropriate subscriber according to the timeliness and quality standards established by the program for the life of the mission.

2.0 BACKGROUND

Coriolis is a 3-year demonstration/validation mission sponsored by the DoD Space Test Program (STP) and the U.S. Navy. The mission may be extended for up to three additional years.As of this date, the mission is scheduled to launch on December 15, 2001 on a Titan II launch vehicle from the Western Test Range at Vandenberg Air Force Base (VAFB). Figure 1 shows the Coriolis Ground Segment Architecture.

The primary payload, WindSat, is a polarimetric microwave radiometer that measures surface wind speed and direction over the global oceans. This mission meets the Navy’s validated but unfilled ocean surface wind observation requirement and provides risk reduction for National Polar-Orbiting Environmental Satellite System (NPOESS) Integrated Program Office (IPO) next-generation weather satellites. A secondary payload, Solar Mass Ejection Imager (SMEI) is a science experiment sponsored by the Air Force Research Lab (AFRL) at Hanscom, AFB in Massachusetts.

The first year of the Coriolis mission is devoted to WindSat and SMEI instrument calibration and validation. During the second and third years, the WindSat payload data will be made available in realtime to operational users. SMEI payload data will be collected and analyzed by AFRL scientists throughout the mission.

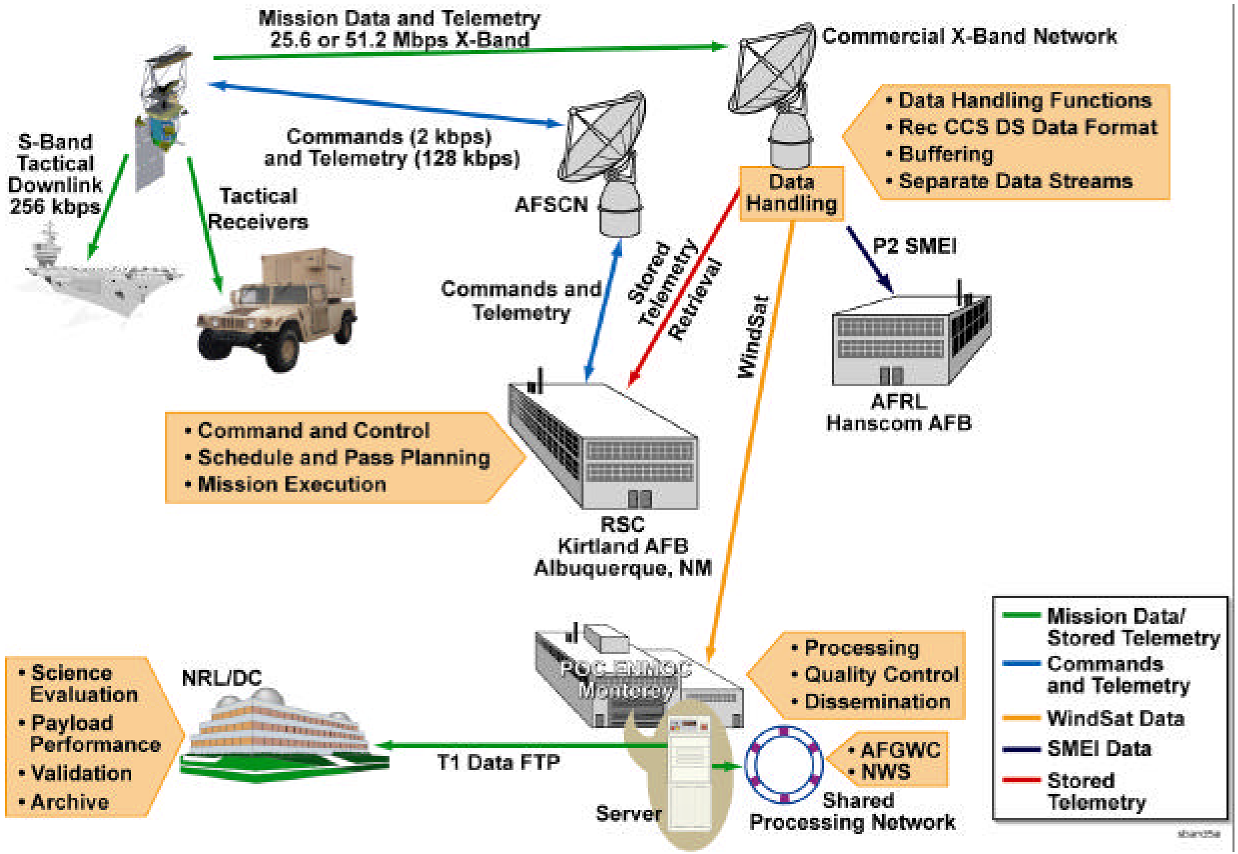

Figure 1. Coriolis Ground Architecture

3.0 SCOPE

After launch, the Coriolis Contractor (hereafter referred to as “Contractor”) shall deliver payload data to the designated data subscribers for a period of three years. The spacecraft design and development process is currently underway and the X-Band service is required to be compatible with this design.

Throughout the entire mission the satellite command and control will be performed by the United States Air Force using the Air Force Satellite Control Network (AFSCN). STP has designated a component, the RDT&E Support Complex (RSC) Kirtland AFB in Albuquerque, New Mexico to coordinate mission operations. An X-Band service provider is required to coordinate downlink schedules with the RSC, receive payload data, and route that data to designated locations (RSC Albuquerque, FNMOC Monterey, NRL Washington, DC, and AFRL Hanscom AFB), in a timely and cost effective manner.

4.0 REFERENCE DOCUMENTS

The following documents are available below as PDF Files in order to aid in proposal preparations:

[1] Coriolis Mission Concept Plan (MCP) (See attachment to RFP.)

[2] WindSat Experiment Requirements Document (ERD) NCST-D-WS013 Rev. A, dated 28 Jan 99 (See attachment to RFP.)

[3] SMEI Experiment Requirements Document Rev. D, dated 9 Jan 99 (See attachment to RFP.)

[4] CCSDS "Blue Book" Recommendations at http://www.ccsds.org

5.0 REQUIREMENTS AND DELIVERABLES

Work related to this contract is divided into three distinct and successive phases:

Phase	Approximate Period
I. Design	Contract Award to Coriolis Ground CDR (Aug 2000)
II. Integration, Testing, and Readiness	Coriolis Ground CDR to Launch (Dec 2001)
III. Operations	Launch to End of Mission (Dec 2004, unless extended by exercise of options)

Throughout the program, the Contractor shall participate in quarterly Mission Operations Working Group (MOWG) meetings and weekly Operations teleconferences, Mission Operations related technical interchange meetings (1/month) and program reviews (2/year) is required.

5.1 CONTRACT PHASE I: DESIGN

The Design phase commences after contract award and includes support for Ground Requirements Definition, ICD development, and Ground Architecture Design. Following contract award, Spectrum Astro will work with the Contractor and will make available all necessary spacecraft design information and packages.

The contractor shall attend the Spacecraft Bus Final Design Status Review (FDSR) at the Spectrum Astro facility in Gilbert, Arizona. The FDSR will be held 8-10 February 2000. At this review, the contractor shall provide an oral presentation of their nominal capabilities as an X-Band service provider.

5.1.1 PHASE I DELIVERABLES

The following paragraphs detail the deliverables that are due during this phase of the contract.

5.1.1.1 MISSION REQUIREMENTS DOCUMENT (MRD)

The Contractor shall provide the MRD, which documents Coriolis X-Band system requirements.

5.1.1.2 PRELIMINARY DESIGN REVIEW (PDR)

The Contractor shall provide a complete PDR documentation package and shall present it at the Contractor's facility. The PDR will identify the preliminary X-Band ground station architecture, interface definitions, data flow, data dissemination, and archival system.

5.1.1.3 CRITICAL DESIGN REVIEW (CDR)

The Contractor shall provide a complete CDR documentation package and present it at the Contractor's facility. The CDR will identify the completed X-Band ground station architecture, interface definitions, data flow, data dissemination, and archival system. In addition, the Contractor shall provide a description of the coordination and scheduling method between the X-Band services and the RSC at Kirtland AFB.

The Contractor shall complete its responsibilities supporting all Interface Control Documents between the Contractor and outside organizations to support signature no later than CDR. These ICDs include:

- S/C to X-Band Provider (Contractor)Interface Control Document
- WindSat POC to X-Band Provider (Contractor) Interface Control Document
- SMEI POC to X-Band Provider (Contractor) Interface Control Document
- SOC to X-Band Provider (Contractor) Interface Control Document

5.2 CONTRACT PHASE II: INTEGRATION AND TEST

The Integration and Test phase is scheduled to begin approximately in September 2000. The Contractor shall implement and test the designs specified in Phase I. In addition, the Contractor shall perform compatibility testing with the spacecraft. During the pre-launch period, the Contractor shall provide X-Band support as needed for launch preparations. Phase II ends with Launch. Upon completion of the rehearsal and compatibility tests, the X-Band service provider shall certify that their portion of the ground system is ready to support on-orbit operations. The Contractor shall coordinate with NRL, Spectrum Astro, and the RSC to meet the testing goals and objectives.

The Contractor shall participate in a maximum of four mission rehearsals. (See 5.2.1.3.) The rehearsals consist of voice and data communications testing, in conjunction with other Coriolis ground system participants. This testing includes integration of the Contractor’s system with the remainder of the ground system. The culmination of this testing is the Dress Rehearsal at approximately one week prior to launch.

The Contractor shall participate in the Factory Compatibility Test (FCT) at NRL/DC or another location in approximately June 2001. The goal of the FCT is to ensure that the Contractor can successfully close the space-ground communications link and to meet the operational concept.

The Launch Base Compatibility Test (LBCT) is similar to the FCT and is conducted with the fully integrated space vehicle at VAFB. The Contractor shall participate in the LBCT at VAFB in approximately November 2001. The goal of the LBCT is to verify and “fine tune” the mission communications links.

In supporting the FCT and LBCT, the Contractor shall coordinate with NRL, Spectrum Astro, and the RSC to meet the test goals and objectives.

5.2.1 DELIVERABLES

The following paragraphs detail the deliverables that are due during this phase of the contract.

5.2.1.1 X-BAND COMPATIBILITY TEST PLAN

The X-Band Compatibility Test Plan describes the method and resources used to complete both the FCT and the LBCT. The purpose of these tests is to ensure that the Contractor provides a ground system that will communicate effectively with the Coriolis spacecraft, WindSat POC, SMEI POC, and the RSC. Compatibility testing, in which the Contractor shall participate, will be conducted under conditions as close as possible to those anticipated for mission support, simulating realistic mission levels. The Contractor shall bring the following “earth station simulator” equipment to NRL that will be used for this test: *

*To be stated in the Offeror’s proposal.

The Contractor shall provide this Test Plan.

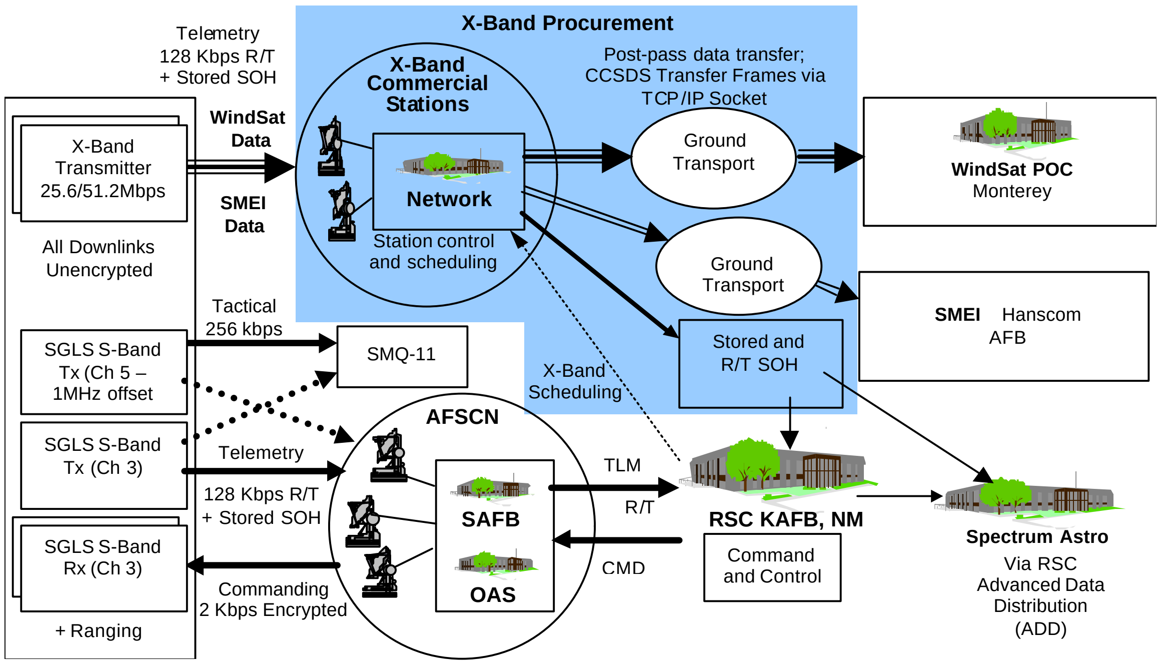

Figure 2. Factory Compatibility Test Flow

5.2.1.2 X-BAND FACTORY COMPATIBILITY TEST REPORT

Ten days after completion of the Factory Compatibility Test, the Contractor shall provide the Test Report. This document shall supply a detailed record of the results and measurements made during the Factory Compatibility Test. At a minimum, the Contractor shall include the following items in the Test Report:

- Measurement of downlink transmitter power output and carrier phase noise
- RF Spectrum Analysis (sidebands, spurious components, modulation)
- Ground receiver threshold measurement
- Telemetry spectrum analysis (sidebands, spurious components, modulation)
- Measurement and/or validation of ground system losses
- Bit error rate measurements

The Contractor shall include measurements and waveform printouts in the Test Report. The Contractor shall also certify RF and telemetry interface design compatibility and establishment of mission support operating parameter ranges.

5.2.1.3 MISSION REHEARSALS

The Contractor shall participate in a maximum of four mission rehearsals. The Government will provide the final schedule for these during Phase II, prior to the Mission Readiness Review. Typically, mission rehearsals are scripted, realtime practices of launch and/or on-orbit operational scenarios, using nominal resources, and are five days in duration. Operational voice and data communications links are usually exercised. A rehearsal review (by conference call or other remote communication) will be held immediately following each rehearsal that summarizes the results and presents lessons learned, with recommendations for any shortcomings.

5.2.1.4 MISSION READINESS REVIEW

About one week prior to launch, the Contractor shall participate in the program's Mission Readiness Review. The Contractor shall present a summary of the results of all pre-launch, rehearsal, and compatibility testing. The Contractor shall include its declaration of its state of readiness for mission support.

5.3 OPTION 1 - PHASE III: OPERATIONS

The Operations phase will commence with launch (approximately December 15, 2001) and end when the mission is completed. During this period, coordination with the RSC for contact scheduling, data retrieval, processing, and data dissemination is required. The minimum number of contacts per day is determined by the data latency requirements as outlined in Table 1.

5.3.1 DELIVERABLES

The following paragraphs detail the deliverables that are due during this phase of the contract.

5.3.1.1 LAUNCH SUPPORT (NO DELIVERABLES)

During the Coriolis mission, the Contractor is tasked to collect WindSat and SMEI mission data. Nominally, neither experiment will begin downlinking their data until approximately one week after launch.

5.3.1.2 LOW EARTH ORBIT (LEO) CHECKOUT SUPPORT

Starting at about one week after launch, the spacecraft bus will spend the subsequent 3-4 weeks exhaustively checking out all the operations of the spacecraft subsystems. Included in this testing is checkout of the X-Band downlink transmitters and associated hardware. The Contractor shall support this checkout through scheduling coordination with the RSC and providing nominal downlink collection, archival, and data dissemination.

5.3.1.3 NOMINAL ON-ORBIT DATA COLLECTION, ARCHIVE, AND DISSEMINATION

With its ground stations, the Contractor shall receive the downlink signal, demodulate, and separate it into the individual virtual channels. The Contractor shall deliver the

CCSDS transfer frames (including both good and bad packets) via TCP/IP socket, or other reliable method, to each POC. This transfer can start after the

has ended, providing the data latency requirement is met. The Contractor shall transfer stored state of health data to both the RSC and Spectrum Astro. This file transfer can be via File Transfer Protocol (FTP) or other reliable method.

The Contractor shall have the capability to record and store the downlink telemetry data for not less than 24 hours after receipt at the ground station, as early in the processing stream as possible, consistent with normal capabilities with no more than minor modification. If a communications link or other failure prevents the WindSat or SMEI POC from receiving the realtime data, the Contractor shall retransmit this stored data to the POC.

Immediately after each ground station support event, the Contractor shall provide the RSC with that support's statistics, including bit error rate, signal-to-noise ratio, and CCSDS packet error rate. (This allows the RSC to quickly assess whether any on-board data needs to be re-sent from the spacecraft.)
The RSC is tasked to calculate, deconflict, and provide a finalized ground station support schedule. The Contractor shall coordinate a scheduling process with the RSC.

The The contractor shall implement its procedure for providing emergency supports as requested during a space vehicle emergency.

5.3.1.4 ENGINEERING SUPPORT

The Contractor shall monitor and report on Ground System performance and quality control during the on-orbit support period. The Contractor shall provide monthly and cumulative summaries of X-Band ground systems statistics, including such things as system availability, number of good packets received, number of bad packets received, and received signal level v. elevation angle.

In the event of a suspected communications link anomaly or underperformance, the Contractor shall support engineering discussion and analysis to troubleshoot the ground station-satellite link. This may include making recommendations of tests to isolate the shortfall, modifications to hardware, software, or operational procedures, or further analysis. (These coordinated activities will be between the Contractor, NRL, RSC, Spectrum Astro, or other Coriolis organizational entities.)

6.0 PROGRESS REPORTS

The Contractor shall provide concise, written monthly progress reports on the technical and budgetary status of each task in progress.

7.0 (OPTION) BACKUP ROLE – SUPPLEMENTARY SERVICE PROVIDER

Under this option the Contractor is a backup service provider instead of the provider as described in Phase 3 exclusive of this paragraph. The Contractor would have performed Phases 1 and 2 prior to this option. For this option, the Contractor shall coordinate with the existing primary provider's infrastructure to transmit WindSat data within the latency requirements, while operating as an auxiliary telemetry service. These supplementary WindSat X-Band services include supplying additional X-band contacts during a space vehicle or payload emergency, or as a routine supplementary service provider. If this option is executed, the spacecraft data destination remains the same (POC at FNMOC).

If, during on-orbit operations, the Coriolis program encounters an anomalous space vehicle or payload situation that requires additional, non-scheduled ground supports, the X-Band provider will be contacted via telephone to request supplementary X-Band ground station supports. Within 90 minutes the X-Band provider shall begin a ground station support, if there is an operational ground station within the space vehicle's downlink field of view.

During nominal on-orbit operations, the Coriolis program may require routine X-Band ground station supports, to supplement the primary support provider. There will be fewer required ground station supports during Phase Three under this paragraph. Nominally, the request to the X-Band provider for these supplementary services shall occur at least 48 hours prior to the start of a particular ground station contact.

"Reaction time" is calculated from the time when the additional contacts are requested until the time when the contact occurs.

8.0 MISSION SPECIFICATIONS

(a) Orbit: 830 km circular, 98.7 degree inclination, Sun Sync, LTAN of 6 PM

(b) Launch: Titan II ELV, nominal date December 15, 2001, from SLC-4W Vandenberg AFB; the launch window for the basic contract is prior to the nominal date through February 13, 2001

(c) The nominal mission life is 3 years total with an additional 1 month for initial checkout. 37 months total.

(d) System level bit error rate: Not greater than 1 bit in 106 bits. The proposal should specify the X-Band ground system's nominal bit error rate and how this bit error rate is calculated.

(e) System level availability: Greater than 95.0%. Availability is the fraction of time during which the ground station service confirms to the specifications provided. It includes both equipment breakdowns and propagation phenomena. The proposal should specify the X-Band ground system's availability and the calculation method.

(f) The Coriolis space vehicle is currently under contract with Spectrum Astro of Gilbert, Arizona, as the Prime Contractor.

(g) The space vehicle has a GPS receiver that will be the primary means of orbit determination used for science purposes.

(h) All ground station scheduling is the responsibility of the RSC, in coordination with the Contractor.

(i) The vehicle will maintain a nadir pointing orientation during normal operations. A safehold mode permits command and control in any spacecraft orientation. There is no requirement to downlink X-Band data in other than nadir pointing orientation.

(j) All spacecraft downlinks are unencrypted and thus there is no ground data decryption requirement.

(k) X-Band Science downlink data rate is 25.6 or 51.2 Mbps, CCSDS compatible, consistent with total daily volume and number of contacts. The rate is selectable by command. The rate to be used will be known prior to the contact since it will have been programmed into the on-board spacecraft command queue.

(l) Total daily data downlink volume will not exceed 28 Gbits. The space vehicle’s data recorder is capable of storing 32 Gbits.

(m) On the X-Band downlink, both WindSat and SMEI will have separate CCSDS Virtual Channels (VC) in the single downlink data stream. There will also be one VC for nominal Stored State of Health (SSOH) data (96 kbps) and one VC for realtime SOH data (32 kbps). There is an additional VC containing diagnostic data that may be transmitted in place of the SSOH. The realtime SOH and the SSOH channels will be disseminated at the request of the SOC.

(n) X-Band data format is OQPSK with Convolutional coding with r=1/2, k=7, G1=1111001, G2=1011011, G1 precedes G2, G2 is inverted at the output. The baseline convolutional coding scheme calls for the I and Q channels to be coded separately. The planned X-Band transmitter is the L3-Com CTX-886. The X-Band frequency request has been submitted for 8075 MHz.

(o) The spacecraft X-Band link was designed using a baseline X-Band G/T of 33 dB/K, a 3 bit Viterbi (8-level soft-decision) decoding scheme and a 2 dB implementation loss. Reed-Solomon Coding will not be used. In order to detect packet errors, a forward error correction word (FECW) (CCSDS 100.0-G-1 page 3-15) will be implemented in the CCSDS frames. This is a 16 bit CRC at the end of the transfer frame.

(p) Data Latency Requirements: Data Latency is defined as the time difference between the Time of Observation (on-board the Space Vehicle) through production of the Environmental Data Record (EDR) at each respective POC. Both WindSat and SMEI have data latency requirements that are not to be exceeded. For the first year of the mission the Data Latency is not to exceed 24 hours for both WindSat and SMEI, including the time required to retransmit data not successfully received due to a failed (>20% packet loss) pass. During years two and three the Data Latency requirement is four hours for WindSat data and six hours for SMEI data for the initial data download. Should data need to be retransmitted due to a failed pass, the latency for this data is 24 hours. Of this requirement, 20 minutes is allocated to the processing of the data at the POC.

(q) In addition to the above, quarterly demonstrations of Integrated Operational Requirements Document (IORD) latency requirements will be conducted as schedule permits. This latency requirement is 1.25 x (orbit period) + 30 minutes.

Table 1. Latency Allocation for WindSat Data

Coriolis Mission Phase	Calibration/Validation Phase	Operational Phase
Time from Launch	Launch to L + 12 mos.	L + 12 mos. to End of Mission
Top Level Latency Requirement Cumulative Time: (Imaging through Processing at the POC)		
WindSat	24 hours1	4 hours2
SMEI	24 hours	6 hours
Realtime (SOH) 32 kbps	Realtime	Realtime
Housekeeping Data (SSOH)	12 hours3	2 hours3
Sub-allocation of Latency Requirement by System Component		
POC Sub-Allocation	30 minutes	30 minutes
AFRL or FNMOC Processing of Payload Data at POC	20 minutes	20 minutes
Transmission of a data packet to POC	10 minutes	10 minutes
Orbit Sub-Allocation		
Max Dump Interval	12 hours (7 Orbits)	204 minutes (2 Orbits)
Contractor Sub-Allocation	11.5 hours	30 minutes
Required Contact Time for Downlink of Stored Data at 51.2 Mbps	6 minutes	2 minutes (depends on station time to lock up on data)
Gnd Station Processing	TBD	TBD
File Transmission Time T1 rate (Start of Frame to Start of Frame)	TBD	TBD

1During the first year of operations there will be quarterly demonstrations of the four hour latency in scripted scenarios as a demonstration of this capability.

2During years two and three there will be quarterly demonstrations of the NPOESS Integrated Operational Requirements Documents (IORD) latency requirement of (1.25 x orbit period) + 30 minutes.

3This is a nominal allocation.

9.0 SCHEDULE MILESTONES

The following is a list of milestones, based on the current launch date of December 15, 2001.

- The Spacecraft Bus Final Design Status Review (FDSR) at the Spectrum Astro facility in Gilbert, Arizona, 8-10 February 2000
- X-Band PDR: 14 June 2000
- X-Band CDR: 28 August 2000
- X-Band ICD's Complete: 28 August 2000
- Factory Compatibility Test at NRL: 25 June 2001
- Launch Base Compatibility Test at VAFB: 19 November 2001
- Launch: 15 December 2001
- LEO Checkout Complete: 14 January 2002
- Calibration/Validation Operations Complete: 13 January 2003
- Nominal Operations Complete: 13 January 2005

MISSION CONCEPT PAPER

FOR

CORIOLIS

9 NOVEMBER 99

Released By

____

Barbara Braun, Capt, USAF
SMC/TEOT
Coriolis Satellite Operations Engineer

1 Introduction

1.1 Purpose

This Mission Concept Paper (MCP) describes TEO's initial concept of operations for the Coriolis Mission. It does not contain mission requirements; the Ground Specifications Document (GSD) contains all mission requirements for the Coriolis program.

1.2 Scope

The MCP covers all operations readiness and on-orbit support provided by TEO and/or performed in TEO facilities. This paper outlines the plans for TEO's Mission Control Team as well as the concept of operations the customer will use when in the Payload Test Center (PTC) and when interacting with TEO.

1.3 References

Coriolis GMRD, Dated 13 May 99

1.4 Mission Overview

1.4.1 Space Vehicle Brief Description

The Coriolis spacecraft bus is being constructed by Spectrum Astro, Inc., in Gilbert, AZ. The satellite has a projected launch mass of 1660 pounds which is slated for an orbit with an altitude of 830 km at 98.7° inclination. The S-band SGLS downlink contains the primary stored and real-time spacecraft and experiment state-of-health (SOH) data. The X-Band downlink also contains stored and real-time spacecraft and experiment SOH data. The SGLS link will be used for TT&C while the X-band link will be used primarily for retrieval of WindSat and SMEI science data. Coriolis contains two experiments, WindSat and SMEI.

WindSat, a passive polarimetric radiometer, is being designed and built by the Naval Research Laboratory (NRL) and will measure ocean surface wind vectors. WindSat is a large experiment (675 pounds, 10 feet tall) incorporating a 6-foot diameter reflector and truss assembly which will spin at approximately 30 rpm. WindSat data will be routed to the WindSat Payload Operations Center (POC) in Monterey, CA. WindSat has an additional S-band tactical downlink to provide real-time science data to Navy SMQ-11 terminals and Air Force and Army Small Tactical Terminals.

Sponsored by the Air Force Research Laboratory (AFRL), the Solar Mass Ejection Imager (SMEI) consists of three camera/baffle assemblies which will image coronal mass ejections from the sun in visible light to forecast geomagnetic disturbances to orbiting satellites. SMEI data will be routed to the SMEI Payload Operations Center (POC) at Hanscom AFB near Boston, MA. This routing is not a TEO responsibility.

1.4.2 Coriolis Mission Brief Description

Coriolis is scheduled to launch on a Titan II rocket from Vandenberg AFB, CA, on 15 Dec 01. The LEO period for Coriolis has been defined as the first 30 days on orbit, with a planned mission duration of 3 years (after 30 days). At the end of LEO, WindSat will enter a Calibration/ Validation phase and SMEI will enter normal operations. The WindSat Cal/Val phase will last approximately one year. After one year WindSat will enter its Operational phase.

The Coriolis spacecraft will require 4-6 AFSCN contacts per day to ensure adequate space vehicle safety coverage. During these contacts, spacecraft (S/C) state-of-health data will be downloaded, and the S/C's schedule of science data dumps will be uploaded. Science data will be dumped via an X-band ground station provider yet to be selected. SMC/TEO will be responsible for scheduling the X-band contacts, loading the X-band downlink times into the S/C schedule, and coordinating with the WindSat POC to ensure data quality and timeliness. Both the WindSat and SMEI experiments will collect data continuously after LEO checkout is complete.

During Cal/Val, the highest priority for WindSat will be to ensure that 100% of the science data is recovered. *[The data recovered may contain bad packets (with bad CRCs) due to the projected bit error rate of the X-band downlink. WindSat wishes to be delivered all packets, good and bad.]* The 4-hour data latency requirement (4 hours is the max time between data measurement and input into the Global Weather Model at the Fleet Numerical Mission Operations Center) will be worked toward depending on the cost of communication lines to the WindSat POC. The tactical downlink and the NPOESS IORD requirements (1.25 times the orbital period plus 30 minutes) will be the lowest priority during Cal/Val, but will be demonstrated quarterly. Therefore, during the Cal/Val phase it is expected that there will be between 2-4 X-band contacts per day (dependent on the X-band provider's coverage and priority assignments).

During the Operational phase, WindSat data will be used by the Fleet Numerical Mission Operations Center (FNMOC) in Monterey, CA to update the Navy Global Weather Model. This phase includes using the tactical downlink to transmit WindSat science data directly to users with SMQ-11s or Small Tactical Terminals. The communication lines between the X-band provider and the WindSat POC will have to be improved to ensure that the 4-hour data latency requirement can be met. In addition, the tactical downlink will be on at all times. The NPOESS IORD requirements will be demonstrated periodically. The 100% data recovery requirement should still hold as a derived requirement from the 4-hour data latency requirement. This will make it necessary to schedule 10-15 Coriolis X-band contacts per day during the operations phase. *[Failed passes may prevent some of the data from being downlinked in time to meet the 4-hour data latency requirement. The data from such passes will be downlinked again during a later pass, but the latency requirement for this data is still TBD. Success or Failure of a contact, which would lead to a requirement for TEO to reschedule a contact, will be based on a percentage of bad packets taken in that contact. The number of bad packets that constitute a failed pass is also TBD.]*

SMEI operational requirements will be enveloped by the WindSat operational requirements. All data latency requirements will follow the WindSat data latency requirements. The chief SMEI concern is 100% data recovery. *[Again, the data recovered may contain bad packets* *(with bad CRCs) due to the projected bit error rate of the X-band downlink. SMEI wishes to be delivered all packets, good and bad.]*

2 Organizational Roles and Responsibilities

2.1 Summary of MCF responsibilities

The Mission Control Force (MCF) will consist of the Mission Control Team (MCT) (described below), a Mission Director Representative (MDR) from SMC/TEL, Technical Advisors (TAs) from both Aerospace Corporation and from Spectrum Astro, and experiment representatives sponsored by NRL for WindSat and AFRL for SMEI.

2.2 MCT Positional Responsibilities

The Mission Control Team (MCT) positions of Satellite Operations Engineer (SOE), Satellite Engineers / Planners (SEs), , Mission Controllers (MCs), Orbit Analysts (OAs), and Data Technicians will be standard roles IAW the generic RSC Operations Concept.

2.3 Other SMC/TEO Support

2.3.1 Deployables

TEO Deployable support will be required for Factory Compatibility testing. Deployables may also be asked to assist in making tapes of spacecraft telemetry during IST (at either Gilbert, AZ or NRL TBD) for use in RSC development-level testing. Vandenberg Tracking Station (VTS) will be used to support Launch Base Compatibility testing.

2.3.2 Mission Engineering Support

TEO will provide standard mission database and MUS development to meet the command and telemetry requirements.

2.3.3 Core Engineering Support

The Engineering, Development, and Sustainment (EDS) contractor will be used to install the mobile T-1 link for the Factory Compatibility Test. Otherwise, no Core development is anticipated for Coriolis. Real-time System Administration support will not be required for any specific mission reason. If the Core is having problems just before or during a significant Coriolis event (such as major rehearsals, compatibility tests, or early orbit operations), special engineering support to Core troubleshooting (such as shift or weekend work) may be needed.

2.3.4 Training Support

TEO will provide standard support for mission qualification training.

The MCF requires training on the spacecraft bus and experiments to be provided by Spectrum Astro, WindSat, and SMEI. This training is required prior to the commencement of the RF Factory Compatibility Test.

2.3.5 Rehearsal Committee Support

The Rehearsal Committee will include representatives of all positions on the MCF.

3 Mission Readiness Activities

3.1 Facilities/Staffing

All pre-mission exercises and rehearsals will use the facilities and staffing appropriate to the mission phase being simulated. Exercises will require all MCT members and RSC resources required for MCT functions (primarily the real-time and planning strings). Rehearsals will also require all MCF members and PTC resources. Compatibility tests will required a fully-staffed MCT with the SOE and any non-TEO members hosted in the PTC. No PTC modifications are planned.

3.2 Mission Operations Working Groups

Coriolis Mission Operations Working Groups (MOWGs) will be chaired by the SOE, who will also produce and distribute minutes. MOWGs are planned approximately every quarter, although the team may decide to hold them more frequently as launch approaches. MOWGs will normally alternate between Kirtland AFB and Gilbert, AZ. The SOE or designee will maintain an action item list which will be discussed as a standing agenda item at each MOWG. Other standing agenda items include: the current readiness schedule, the status of major drivers to the readiness schedule, operations documentation status, and status of customer deliverables such as databases or document inputs. Topics which may change for each MOWG include: requirements clarification, cost/work estimation issues, training plans, and operating procedures.

3.3 Exercises

The standard TEO baseline is three exercises, starting about L-7 months. At least one exercise will include the planning interface with the X-band service provider.

3.4 Rehearsals

Three rehearsals plus one Dress Rehearsal are planned, with Rehearsal #1 scheduled at about L-4 Months (standard TEO baseline). At least one rehearsal and the Dress Rehearsal will also include the X-band service provider, if possible.

3.5 Space Vehicle Integration and Compatibility Testing

TEO will send people to Spectrum Astro and to NRL for design reviews and satellite testing. TEO will provide early input into operational considerations and constraints which may help reduce on-orbit risks. These visits will also help TEO become more familiar with the space vehicle.

TEO Deployables will support Factory Compatibility Testing (FCT). Deployables will perform a site survey, travel to take 2 data recordings, and provide the RF interface for FCT. STEC will also send 1 person to NRL for FCT (7 days). The mobile T-1 will be used for compatibility testing. TEO will lease T-1 communication services to the NRL facility for at least 2 months. Vandenberg Tracking Station (VTS) will be used to support Launch Base Compatibility Testing (LBCT).

The CMO will produce the compatibility test plans and scripts, based on TEO and contractor input.

4 Mission Operations

4.1 Launch and Early Orbit Operations

The LEO period for Coriolis has been defined as the first 30 days on orbit

4.1.1 Facilities (PTC, AFSCN, etc)/Staffing

The SOE and non-MCT members of the MCF will have a designated Payload Test Center (PTC) area with six workstations – five for viewing telemetry, and one for the SOE to view commanding. During LEO, the following positions will be manned 24X7: MDR, TA, SOE, MC, and at least two Satellite Engineers / Planners. OA, Data Tech, and engineering support will only be as needed.

4.1.2 Mission Planning

All spacecraft and experiment initialization passplans and commands will be built and approved before launch. The SEs will perform their standard daily planning using the “24-hour board.” All contact schedules, contact objectives, and passplans are subject to customer approval during LEO. Re-planning within the scheduled contacts may be done up to three hours before a contact. Objectives may be re-arranged within a passplan up to an hour before a scheduled contact. The space vehicle is not expected to require large or extensive command builds prior to each contact. Most commands and command procedures (IMT passplan modules) will be pre-built (essentially static). STEC will develop a command building tool to create command blocks ,command uploads, and to manage the command queues. The GUI (if not the code) for the command builder will be essentially the same as that for MightySat II.1. Hardcopies of the passplans will be archived for the entire duration of LEO.

TEO will work with the IRO to support collision avoidance analysis during orbit raising.

4.1.3 Real-time Operations

During LEO, there will be both an MC and an SE on console in the control room. Passplans will indicate whether the control room personnel must wait for a go-ahead from the PTC or proceed without instruction. The SOE will provide the instruction from the PTC, based on input from the MDR. The MDR is responsible for all real-time decisions about the space vehicle during a contact. The MC and SE will perform real-time limit checking of telemetry values and will execute contingency procedures at the direction of the SOE. Any inputs from Spectrum Astro, WindSat or SMEI will go through the MDR or SOE as coordinated before being executed by the MCT.

4.1.4 Post contact activities

The MC or SE will execute the post-pass-processing procedures, which may include back orbit telemetry limit checking and archiving. STEC must develop processing software to limit-check the stored state-of-health data files dumped from the spacecraft. During LEO, these files will be dumped and processed each contact, and a report of out-of-limit conditions will be provided to the customer. The processed state-of-health data will be available for the customer's use. The details and format of this processed data will be documented in the SOC ICD. It will include data from the Real-time SOH stream as well as data from the SSOH stream. Daily during LEO, a data technician (or system administrator) will copy, label, and store the SOH telemetry flat files in a location allocated to Coriolis for the life of the mission.

GPS data from the stored state-of-health (and PRN track data for the first 5 days on orbit) will be provided to the OAs for processing. OAs will validate their ability to use PRN data for orbit determination, but will not use this method operationally unless both GPS units on the spacecraft fail. Operationally, the OAs will use GPS data from the spacecraft stored state-of-health telemetry to produce their orbit products. *[The requirement to store telemetry files for the life of the mission is currently being revisited.]*

4.1.5 Operations involving the X-band Service Provider

During LEO, checkout of the X-band subsystem and ground operations will be according to initialization procedures TBD. The interface to the X-band service provider will be via a separate PC or Workstation in the control room (TBD). SEs will submit and receive schedules through this interface. MCs will use the interface to monitor contacts, either in real-time or post-pass. Details of TEO requirements and plans w/ respect to X-band services are TBR in the GSD.

4.1.6 Anomaly or Contingency activities

During LEO, the MDR will chair anomaly meetings. The anomaly process will follow standard RSC guidance. Since the MDR, SOE, MC, SE and TAs will be present 24X7 in the PTC, no special resource or staffing arrangements must be made specifically for anomalies.

4.2 Calibration/Validation Phase (1 year from end of LEO)

4.2.1 Facilities /Staffing

The PTC will normally not be manned after LEO. To accomplish mission objectives, Coriolis will require 3 shifts of MCs, 1 shift of OAs, and 2 shifts of SEs. The MDR, SOE, and TAs (TBD) will be available during normal working hours, and will be on call in case of a spacecraft anomaly.

4.2.2 Mission Planning

The RSC will plan 4-6 SGLS contacts per day, and two to four X-band contacts per day. The planning process will be essentially the same as during LEO, except there will be no scheduled SE support on the mid shift. This means no objectives can be added to passplans at night (except for pre-approved contingencies or cases where staff are called in to work an anomaly or special event). Hardcopies of the passplans will be archived for 30 days.

4.2.3 Real-time Operations

Under normal circumstances, only MCs will staff the console during real-time supports. Real-time telemetry will be limit-checked as it comes down from the satellite, and pre-built passplans will be run.

4.2.4 Post contact activities

Post-pass telemetry processing will be accomplished as during LEO, except that the telemetry will only be processed once per day. SOH telemetry files will only be archived as flat files for 30 days.

The OAs will process orbit information using GPS data. Telemetry data will be archived once per week.

4.2.5 Operations involving the X-band Service Provider

TEO will schedule and deconflict X-band contacts via TBD method and will build schedule uploads and/or commands to turn on the X-Band downlink. The X-band station scheduling process will be integrated operationally with the RSC standard scheduling process to ensure that AFSCN station contacts fully support the requirements to downlink the X-Band data. The use of X-Band SOH data and other operations involving the X-Band Service Provider are TBR in the GSD.

4.2.6 Anomaly or Contingency activities

Anomaly or contingency activities will be conducted IAW standard RSC guidance. The MCT will react to predetermined telemetry alarm events identified by Spectrum Astro, WindSat and SMEI. This includes alarm limits. Contact lists will be used. The MCT will not provide subsystem engineering support but will rely on CMO resources.

4.3 WindSat Operational Phase (2 years from end of Cal/Val Phase)

4.3.1 Facilities /Staffing

Same as Cal/Val Phase.

4.3.2 Mission Planning

The planning and deconfliction for X-band will be more time consuming, since there will be up to one contact per orbit (10 -15 contacts per day), but the staffing and the planning processes should be the same as in the Cal/Val Phase.

4.3.3 Real-time Operations

Same as Cal/Val Phase.

4.3.4 Post contact activities

Same as Cal/Cal Phase.

4.3.5 Operations involving the X-band Service Provider

TBR in GSD

4.3.6 Anomaly or Contingency activities

Same as Cal/Val Phase.

4.4 Post Mission Support

TBR in GSD.

NAVAL RESEARCH LABORATORY

NAVAL CENTER FOR SPACE TECHNOLOGY

WindSat
Experiments Requirements Document

NCST-D-WS013A **29 January 1999**

4555 Overlook Avenue, S.W.
Washington, D.C. 20375-5320

RECORD OF CHANGES

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—	21 January 1999	Released per IAW ERN# WS009	M. Mook
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1.0 SCOPE

This document contains payload specific mission and design requirements for the WindSat experiment in the following areas: physical and functional interfaces, spacecraft integration and test, launch systems, and on-orbit flight operations.

2.0 EXPERIMENT OVERVIEW

2.1 Experiment Description. WindSat is a spaceborne polarimetric microwave radiometer system for measuring the ocean surface wind speed and direction. This system is being developed under sponsorship of the U.S. Navy (N6), the National Polar-orbiting Operational Environmental Satellite System (NPOESS), Integrated Program Office (IPO), the U.S. Air Force, and the U.S. Army. WindSat is a risk reduction effort for the microwave imager component of the NPOESS Conical Microwave Imager and Sounder (CMIS).

The objective of this experiment is to demonstrate remote sensing of the ocean surface wind vector (speed and direction) using spaceborne passive microwave polarimetry. Polarimetric radiometry characterizes the polarization properties of the surface emission by measuring the radiometric Stokes vector. An extensive airborne experiment campaign has demonstrated that the microwave emission from the ocean surface varies as not only a function of wind speed, but also the wind direction. Stokes vector measurements from these campaigns have been used to retrieve the ocean surface wind vector. Data collected to date have been from airborne platforms and the range of atmospheric and ocean surface conditions represented by the data are therefore limited when compared to the global environmental conditions that would be observed from a satellite. The next step, essential to conclusively demonstrating that this technique will work from space and is ready to be incorporated into an operational satellite system, is to collect a comprehensive global space-based data set.

The global ocean surface wind vector (speed and direction) is a long-standing Navy operational requirement and has been identified as an essential parameter of the NPOESS. The wind vector provides essential information for short-term weather forecasts and warnings, nowcasting, and climatology and oceanography studies in both the civilian and military sectors. Despite this need for ocean wind velocity, this requirement remains unsatisfied. Operational requirements are enumerated in the "Military Requirements for Defense Environmental Satellites (MJCS 154-86)" and the NPOESS "Integrated Operational Requirements Document (IORD I)." Specifically, the Navy requires wind vector measurements with accuracies of ±2 m/s and ±20° for speed and direction, respectively, over a wind speed range of 3 m/s to 25 m/s. The Oceanographer of the Navy has stated that the ocean surface wind direction is the highest priority unfilled in remote sensing requirement.

The Special Sensor Microwave/Imager (SSM/I), a passive microwave radiometer on the Defense Meteorological Satellite Program (DMSP) satellites, measures the ocean wind speed to within ±2 m/s, satisfying the wind speed requirement. However, these sensors cannot measure the wind direction with a single overpass. To date, only spaceborne scatterometers (a type of radar), like those on SeaSat and ERS-1, have provided global monitoring of the ocean wind vector, but not operationally because of inadequate spatial coverage and technical limitations. Microwave radiometers generally measure more geophysical parameters, weigh less, require less power, and cost less than scatterometer counterparts. Thus, the possibility of wind vector measurements from a passive sensor is an attractive option, offering the potential to extract significantly more information with only minimal increases in cost and complexity over current passive systems. Substantiated by airborne test data, scientific and technological advances have demonstrated that the ocean surface wind vector can be retrieved using a multi-frequency polarimetric microwave radiometer. SSM/I measures vertical (V) and horizontal (H) polarization. Polarimetric radiometer measurements include not only V and H, but also the cross-correlation of V and H.

Made jointly by the Naval Research Laboratory (NRL) and the Jet Propulsion Laboratory (JPL), airborne multi-frequency polarimetric radiometer measurements have shown that the ocean surface brightness temperatures vary with wind direction as well as wind speed, which microwave radiometers measure. Moreover, NRL and National Oceanographic and Atmosphere Administration (NOAA) Office of Research Applications (ORA) used the airborne data to develop retrieval algorithms, which estimate the wind direction with accuracies that satisfy the NPOESS IORD thresholds. This experiment is a spaceborne demonstration of polarimetric microwave radiometry for remote sensing of the ocean surface wind speed and direction. Such a demonstration is necessary for this technology to be included in the NPOESS system.

The WindSat Payload is a multi-frequency polarimetric radiometer nominally operating at 6.8, 10.7, 18.7, 23.8, and 37 GHz. WindSat will cover a 1413 km active swath (based on an altitude of 830 km) using a conically-scanned 1.83 m offset parabolic reflector with multiple feed. The horizontal ground resolution is determined by the size of the antenna and the altitude. Thus, the relatively large WindSat antenna will result in spatial resolutions approximately four times greater than current systems. This high resolution not only improves the utility of the imagery data, but also more importantly, enables passive spaceborne microwave measurements of the ocean surface parameters nearer the littoral regions than currently possible. The 10.7, 18.7 and 37.0 GHz channels are fully polarimetric; that is, they derive all four Stokes parameters by measuring the six principal polarizations. The 6.8 GHz channel is dual polarimetric (vertical and horizontal), because Faraday rotation in the ionosphere would corrupt the Stokes vector measurements at this frequency. The 23.8 GHz channel is also dual polarimetric because the purpose of this channel is to correct for atmospheric water vapor.

2.2 Experiment Objectives. The objectives of the WindSat experiment are to demonstrate the capability of microwave polarimetric radiometry to accurately measure the ocean surface wind speed and direction from space. The WindSat goals for wind speed and direction measurements have been derived from the IORD and are given in Table 2-1.

Table 2-1. Sea Surface Winds (Speed and Direction

Systems Capabilities	WindSat Goals	NPOESS IORD
a. Horizontal Resolution	25 km	20 km
b. Mapping Accuracy	5 km	5 km
c. Measurement Range	3m/s to 25 m/s, 0° to 360°	3 m/s to 25 m/s, 0° to 360°
d. Measurement Precision		
1. Speed	1 m/s	1 m/s
2. Direction	10°	10°
e. Measurement Accuracy		
1. Speed	greater of ±2 m/s or ±20%	greater of ±2 m/s or ±20%
2. Direction	3 m/s to 25 m/s: ±20°	±20°

WindSat must satisfy the wind vector requirements and have no negative impact on the quality of the brightness temperature data from the non-polarimetric channels. This requirement is important because those channels will be used by CMIS to retrieve other environmental data records. A secondary objective of WindSat is to demonstrate the capability to downlink experiment data directly to field users via separate tactical downlink systems.

2.3 Operational Concept. Major influences on the operational concept include:

a. Satellite orbit;

b. Degree of satellite autonomy;

c. Amount of mission data collected in each orbit;

d. Amount of on board storage available for mission data;

e. Accessibility of ground stations for downlink; and

f. Latency requirements for mission data.

WindSat will be designed for a 3 year, Class B/C mission. WindSat is scheduled to launch in December 2001 on a Titan II. A circular, Sun-synchronous, 98.7° orbit with an altitude of 830 km is required.

The WindSat sensor will collect up to 300 kbps of mission data continuously. Mission data will be disseminated in a manner that utilizes the best of existing or proposed infrastructure and is compatible with the data pathways of current and planned passive microwave sensors, like the SSM/I.

The ground segment will allow retrieval of mission data from WindSat and provide processing, dissemination, archival, and conversion of the mission data into environmental data records. Stored mission data along with satellite health and status will be downlinked to the ground segment at prescribed intervals. A satellite operations center (SOC) will be established to perform command and control functions and monitor satellite health and status. A payload operations center (POC) will be established to manage the payload and perform other designated functions.

The WindSat operational concept will support the timely and efficient attainment of mission objectives, as well as involve distinct sequential phases, like post launch checkout, calibration/validation, and quasi-operations. Figure 2-1 illustrates a notional concept of operations of the WindSat mission. Figure 3-1 provides swath geometry.

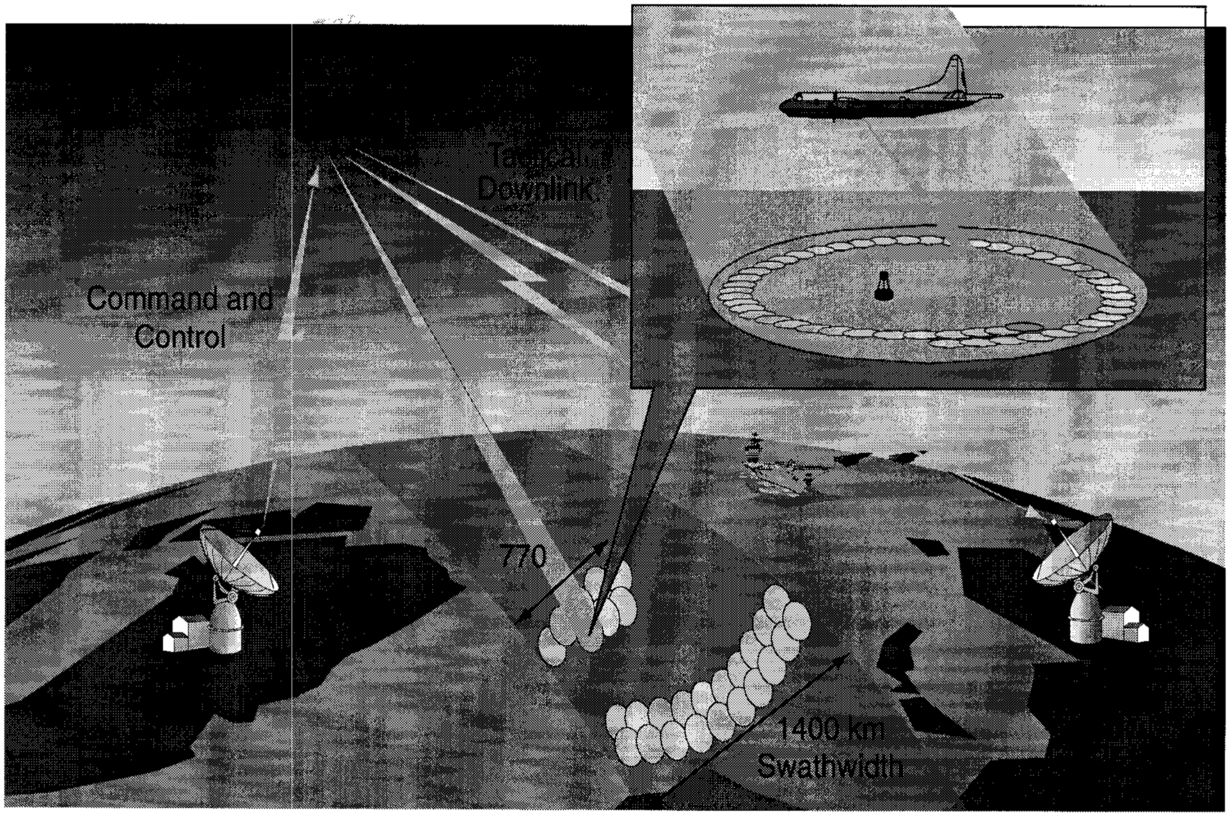


Figure 2-1. WindSat Collecting Radiometric Data

The following is a list of the mission phases:

- *Phase I:* Post Launch Checkout. Following a successful launch and on-orbit acquisition, a series of procedures will be executed over a thirty-day period to assess the health and status of the satellite, and prepare the satellite and sensor for calibration.

- *Phase II:* Cal/Val. Following satisfactory completion of Post Launch Checkout, the WindSat sensor will be calibrated extensively. After calibration, the satellite will begin collecting mission data for developing and validating the algorithms that translate sensor data records (SDR) into environmental data records (EDR). This calibration/validation phase will likely last six months to one year, and involve collection of mission data on a global scale. Teams of scientists will be organized to methodically collect ground truth in support of the calibration/validation effort. In this phase, every effort will be made to collect a complete mission data set, with few or no dropouts. Timeliness of mission data dissemination will be a secondary consideration.

- *Phase III:* Quasi-Operational. After successfully completing the cal/val phase, the mission will be transitioned to a quasi-operational environment. The direct broadcast mode of the tactical downlink will be activated to provide mission data to any unit equipped to receive passive microwave data. This will include regional centers, ships at sea, and Army or Marine tactical units. WindSat will have planned demonstrations of its ability to satisfy NPOESS IORD data latency requirements. Normal satellite command and control will continue. Mission data will still be required through the standard downlink.

2.4 Orbit Requirements.

2.4.1 Standard Orbit Parameters. The WindSat experiment requires a circular, Sun-synchronous, (98.7°) polar-orbit with an altitude of 830-km. The preferred Local Time of Ascending Node (LTAN) is 6 p.m. This orbit is comparable to the DMSP and proposed NPOESS orbits.

2.4.2 Launch Window. The WindSat experiment has no required launch window identified at this time except for the LTAN stated in paragraph 2.4.1 of this document.

2.4.3 Mission Life. WindSat has a desired minimum mission life of 3 years.

2.5 Success Criteria. Success of the WindSat experiment will be measured against the NPOESS IORD requirements specified in Table 2-1. The success of the WindSat experiment will be determined by the following:

- Successful operation of the WindSat radiometer;
- Collection of a set of global ocean surface wind data that comprises a wide range of conditions; and
- Demonstration of the capability of the WindSat data to be used to infer the ocean surface wind speed and direction globally.

It is intended to make the WindSat data available to the Department of Defense (DoD) and Department of Commerce (DoC) user communities for evaluation and operational use, following the successful demonstration of the wind vector retrieval capabilities.

3.0 PHYSICAL DESCRIPTION

The only launch vehicle under consideration for this mission is the Titan II. The mass and dimensions of the payload will be kept within the limits of the vehicle and compatible, solid fuel kick motors, if necessary.

3.1 Engineering Layout. The WindSat ICD WS-IC-0010 shows an isometric view of the WindSat Payload and shows the WindSat Payload in a Titan II fairing envelope. The reflector is approximately 72" across and 61.60" in focal length. The feed horn array is centered on the reflector focal point on the top of the payload canister. The reflector, feeds, and canister all spin together at a constant speed between 26.6 and 32.6 rpm during radiometer operation. A non-spinning, cold sky calibration reflector and blackbody calibration target are mounted above the canister. The feed horns pass below these calibration sources once per revolution. The radiometer system is housed in the canister from front-end electronics to data handling system. Digitized radiometer data is passed across a slip ring to the WindSat Stationary side and from there to the non-spinning spacecraft.

3.1.1 Coordinate Systems and Spin Direction. There are four coordinate systems, each of which is described in paragraphs 3.1.1.1 through 3.1.1.4. The WindSat Payload and WindSat Payload Centroidal Frames are shown in the ICD WS-IC-0010 Isometric Drawing. The WindSat Payload Frame is fixed to the stationary section of the payload. In addition, the calibration source locations are fixed to the WindSat Payload Frame. The Spacecraft Attitude Frame must reference the WindSat Payload Frame during system level alignments. The Payload spin direction is shown in Figure 3-1.

The WindSat Payload Frame must align with the Local Vertical Frame with attitude and alignment errors set equal to zero.

3.1.1.1 Local Vertical Frame. The local vertical frame is defined with its origin at the space vehicle system center of mass and the z-axis along the Zenith. The y-axis is along the orbit normal and the x-axis is defined such that it completes the right hand coordinate system. For a circular orbit, the x-axis is along the velocity vector.

3.1.1.2 WindSat Payload Frame. The WindSat Payload Frame is defined in the ICD WS-IC-0010. The payload frame is defined such that the spin axis is along the z-axis with the origin at the bus/payload mechanical interface and positive out of the payload. The x-axis is along the positive velocity vector. The y-axis is defined so that it completes the right hand coordinate system. These axes are fixed to the non-spinning portion of the payload.

3.1.1.3 WindSat Payload Centroidal Frame. This frame is identical to the WindSat Payload Frame but with the origin at the Payload Center of Mass.

3.1.1.4 Spacecraft Attitude Frame. **TBD** by spacecraft vendor.

3.1.2 Payload Dimensions. Payload dimensions are shown in the ICD.

3.1.3 Mechanical Interfaces. The WindSat Payload requires mounting to the +z (zenith) side of a nadir pointing spacecraft. The mechanical interface between the payload and the spacecraft will be a fixed bolted interface. The spin drive assembly will be contained on the payload side of the interface. See 3.1.3.1 through 3.1.3.3 for more details. The WindSat payload may be mounted by either of the methods described in paragraph 3.1.3.1 and 3.1.3.2.

It is the intent that the WindSat payload will be directly mounted to the spacecraft using simple supports/attachments. This shall be accomplished by aligning major spacecraft axial loadpaths with those of the WindSat payload and without inputting local bending moments into the payload structure due to primary loadpath misalignment. This is imperative for Method 2, as carrying these moments through the payload separation devices is highly undesirable. In cases where this is unavoidable due to geometry constraints, less than 10% of the total local moment should be transmitted to the payload deck, as determined from a coupled FEM of the spacecraft and payload. It is recognized that some minor local bending will be transferred through this joint due to inertia loading of nearby mass items, and/or lateral shear offsets (particularly if flexures are used). This type of bending will be evaluated as designs mature and will be much less critical for the Method 1 interface.

3.1.3.1 Method One. ICD WS-IC-0010 specifies the Mechanical Interface used for Method One. As shown, the payload will be delivered with a four-point attachment to match a **TBR** bolt pattern on the spacecraft. This is a four point, non-separating bolted interface. Additionally, space has been made available for two external star trackers and an IRU package on the -z side of the interface deck.

3.1.3.2 Method Two. ICD WS-IC-0010 specifies the Mechanical Interface used for Method Two. As shown, the payload will be delivered with the structural interface deck, which will include the **TBR** bolt pattern that can be defined to match the **TBR** shape of the top of the spacecraft. Four Points of this interface will contain **TBD** separation devices on the -z side of the interface deck. The envelope of payload components on the spacecraft side (-z) of the interface panel is shown in ICD WS-IC-0010, which includes the momentum wheel, data handling unit (DHU), and other small boxes. Additionally, space has been made available for two external star trackers and an IRU package on the -z side of the interface deck.

3.1.3.3 Payload and Spacecraft Structure. The structural design interface between the payload and the spacecraft will resolve the following:

- Design of deck and/or interface footprint;
- Structural degrees of freedom at the interface;
- Bolt pattern;
- Stiffness range;
- Minimum strength;
- Coefficient of thermal expansion (CTE);
- Alignment stability between bus attitude frame and payload stationary alignment cube;
- Flatness; and
- Electrical grounding.

The structural dimensions of the payload are shown throughout the ICD WS-IC-0010 Drawing. A dynamic, on orbit envelope is shown in the ICD. It is desired that all structural modes of the vehicle (combined payload and spacecraft) while in the deployed configuration will be greater than 5 Hz. The payload and spacecraft will work together to define and verify interface strength and loads, and to support booster coupled loads analyses.

All combined vehicle structural modes, while in the launch configuration, shall be such that minimum stiffness requirements of the launch vehicle are met:

The primary lateral modes will be ≥20 Hz for the payload. The target satellite first bending mode should be in the 7-12 Hz range for the Titan II launch vehicle. This is done to avoid the launch vehicle's first bending modes of 4.5 and 16 Hz. The spacecraft will be designed such that the satellite does not couple directly with launch vehicle primary bending modes.

The primary axial modes will be ≥40 Hz for the payload and ≥50 Hz for the spacecraft, with the goal that the combined vehicle axial modes will be ≥30 Hz.

3.2 Electrical Connections. Electrical connections will be made at a single, fixed interface panel, the location of which will be decided by the payload and spacecraft. These connections will include power, commands, and telemetry. The payload will provide connector sets to the spacecraft.

3.3 Mass Properties. The mass properties for Method One and Method Two WindSat payloads are provided in Coriolis file reference memos entitled "WindSat Method One Analytical Mass Properties" and "WindSat Method Two Analytical Mass Properties," which include all WindSat Payload hardware. Mass, CG, and moments of inertia are provided separately for the spinning, stationary, and total payload sections.

The spinning section CG components, x and y, and the products of inertia, Ixz and Iyz, will be trimmed on-orbit to meet the static and dynamic balance requirements stated in paragraph 1.0 of this document. The stationary mass properties are not trimmed on-orbit.

3.4 Moving Parts. The spinning section of the payload houses four Mass Property Balance Mechanisms in addition to the payload spin assembly and the momentum wheel. These devices allow the placement of a mass along a single axis for each mechanism, and reduce the static and dynamic imbalance of the spinning payload. They will be moved open loop via ground command and will remain fixed otherwise. Rebalance is expected from time to time.

3.5 Mounting and Alignment.

3.5.1 Alignment Requirements. If the bus provides attitude sensors then it must also provide access to an alignment reference (cube) defining the bus attitude frame. The knowledge requirements of Section 10.0 are given with respect to this reference. Note that this applies regardless of where the sensors are physically located.

3.5.2 Mounting. The payload to bus mounting must be such that the inertial attitude knowledge, with respect to the payload stationary deck (alignment cube), has a post-launch bias of less than ±0.02° and varies less than 0.02° 1σ along each axis over the life of the mission. In other words, the combined bus attitude knowledge and bus attitude frame to payload stationary deck alignment errors must be within these limits.

3.6 Field of View Requirements. The boresight of the WindSat Payload main antenna requires an unobstructed field of view of the Earth. The payload is mounted on the Zenith side of the spacecraft resulting in a "keep out" zone, as shown in the ICD WS-IC-0010. The "keep out" envelope is dictated by the calibration source blockage, main beam size, and tilt. Spacecraft structure is permitted in the Nadir centered cone shown. In addition, the spacecraft structure may be permitted to violate the stated "keep out" zone when the calibration sources block the feeds, see Figure 3-1 for clarification. Consequently, it is imperative that the spacecraft and payload teams work together closely during the spacecraft design phase.

The spacecraft will need to identify any components that may interfere with the antenna pattern or reflect energy from the antenna sidelobes into the mainbeam since WindSat is concerned with maintaining very high mainbeam antenna efficiency. Both cases can degrade the antenna beam efficiency. Any possible interferer must be described in terms of temperature, microwave emissivity, and reflectivity.

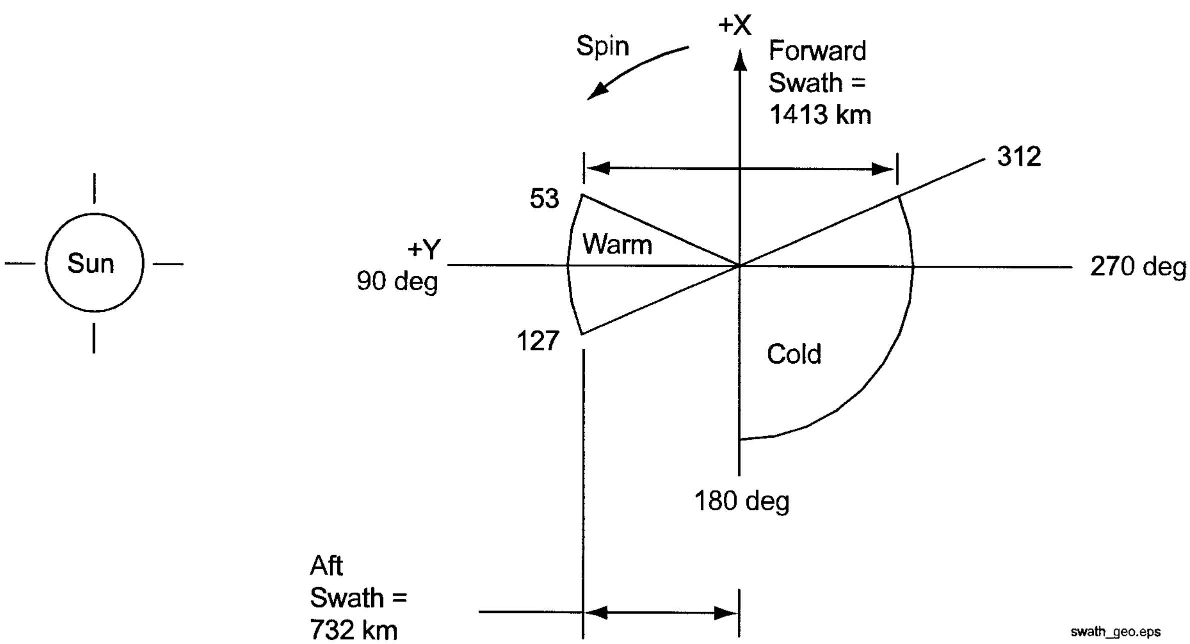


Figure 3-1. Swatch Geometry

3.7 Experiment Models/Simulators. WindSat will create its own finite element model. The model will be provided in Craig-Bampton format to the spacecraft for coupled loads analysis. A NASTRAN model can be provided if desired. Physical and electrical simulators can be fabricated to reduce integration risk with the spacecraft, as long as schedule and funding permits, as follows:

- Mass and CG Simulator;
- Envelope and interface (bolt pattern) Simulator; and
- Power and Data handling Simulator.

NOTE: **TBR** upon negotiation with spacecraft. Simulators may or may not be combined.

3.8 WindSat Payload Spinning Volume. The combined stationary and rotating sections of WindSat require an operating volume, as specified in ICD WS-IC-0010.

4.0 ELECTRICAL INTERFACE REQUIREMENTS:

Figure 4-1 shows a simplified electrical block diagram of the WindSat radiometer payload and its interfaces with the spacecraft bus. WindSat is divided into a rotating canister containing the radiometer antenna and electronics, and a stationary deck which interfaces with the spacecraft bus.

WindSat's Stationary Data Handling Unit (SDHU) incorporates design features supporting the placement of Attitude Determination functions on the WindSat stationary deck. Switched power is provided for two star viewers and data receivers and switched power are provided for an inertial measurement unit. Whether these units are actually located within WindSat, and whether these interfaces are actually used, will be determined by NRL and the spacecraft contractor.

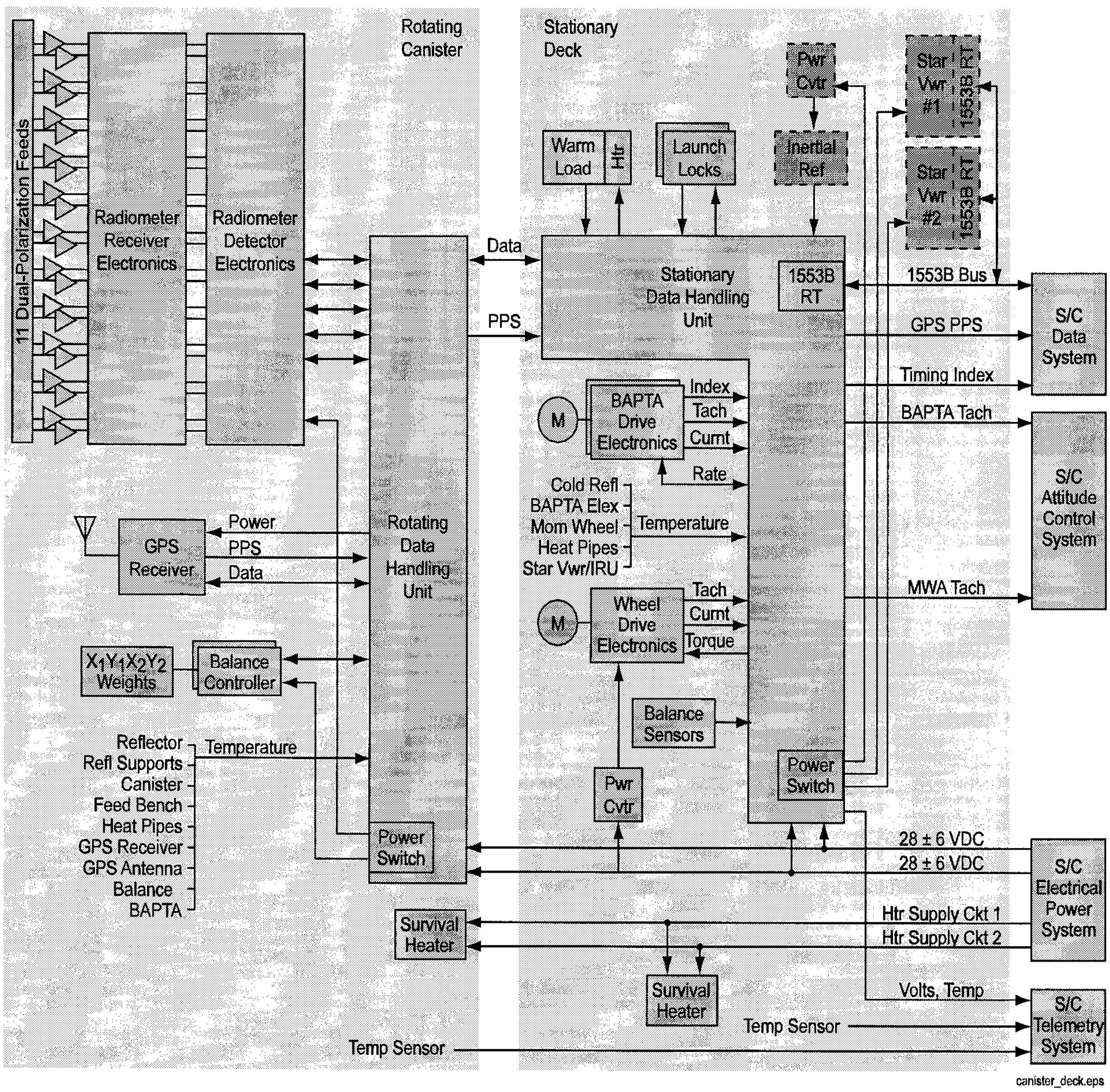


Figure 4-1. WindSat Electrical Block Diagram

4.1 Electrical Power Requirements.

4.1.1 Electrical Power Interface. The spacecraft bus shall supply two sets of four switched power interconnects to the WindSat payload. In each set, two interconnects supply the Payload Electronics and two supply the Survival Heaters. Active power will be supplied through one set of interconnects or the other, but not through both simultaneously. Within WindSat, each redundant interface will be wired in parallel and connected to the respective non-redundant primary power bus.

This provides a redundant interface without specifying that the spacecraft bus need implement a fully redundant electrical power system. The spacecraft bus shall provide power to the WindSat payload through redundant power control relays, wiring, and connectors.

4.1.2 Payload Electronics Power Interface. The two-switched Payload Electronics interconnects supply the WindSat Data Handling Subsystem and the Switched Payload Subsystems, respectively.

Payload Electronics power shall be in the range of 22 to 34 Vdc. WindSat expects to be supplied power from the raw spacecraft battery bus rather than from a spacecraft bus power converter. All WindSat electronic power is supplied through converters incorporating active inrush current limiting. In general, each converter is designed to limit inrush currents to the greater of 1.7 Adc or 120% of steady state power consumption.

4.1.3 Survival Heater Power Interface. Switched electrical power shall be supplied to the WindSat payload Survival Heating subsystem through separate power interfaces. The Survival Heating subsystem includes thermostatic control switches such that the WindSat payload will self-regulate the survival temperature of -20°C. Power shall be applied to the Survival Heaters at all times; when WindSat is fully operating the Survival Heaters will not dissipate any power.

Survival Heaters are composed of simple resistive elements; their peak power consumption varies with supplied voltage. Survival Heaters may be supplied with regulated or unregulated dc voltage and heater resistances will be selected to produce the required dissipation at low supply voltage. If supplied with raw spacecraft battery bus in the range of 22 to 34 Vdc, peak heater dissipation at high line voltage will be approximately 2.4 times that at low line voltage. The total survival heater power requirement at 22 Vdc is 270 watts.

The total Survival Heater power load is divided into two separate interfaces, each carrying approximately half of the total required power. While both interfaces must be energized to ensure that WindSat's survival temperature is maintained, during extremely serious anomalies requiring extensive load-shedding, de-energizing of one circuit will reduce the electrical load without completely removing all survival heating. In this scenario, the survival heater power is 135 watts at 22 Vdc.

4.1.4 Power Consumption. The spacecraft bus electrical power system shall be capable of supplying 427 watts (including 40% WindSat design margin but excluding the survival heater power) to the operating payload regardless of bus voltages. When active, the Survival Heater assembly will consume an average of 270 watts. WindSat operates at 100% duty cycle over the entire orbit and, thus, presents a nominally constant power load at all times. Minor power consumption variations will occur periodically in response to the cycling of thermal regulation heater strips, spin drive motor load variations, etc.

The spacecraft bus power system shall tolerate stepped changes in the power load presented by WindSat, ranging from a low level of 50 watts up to the full load. The WindSat payload will be powered up in a sequence of steps. Initially, closure of WindSat Data Handling power switching relays in the spacecraft bus will activate only the Data Handling Subsystem. After a brief initialization period during which the Data Handling Subsystem ensures that its internal load switching relays are in the off position, power is then applied to the Switched Payload Subsystem power interface. Subsequent commands received over the bi-directional data bus between spacecraft and the WindSat Data Handling Subsystem will cause the WindSat controller to power up other payload components, such as the radiometer receivers, spin drive motor, etc. Thus, the load presented by WindSat to the electrical power system will increase in a series of steps, from quite low levels initially, eventually reaching the full load specified above. This architecture was chosen to reduce the number of switched power interconnects required from the spacecraft bus and to minimize perturbations in the definition of this interface as the WindSat design progresses.

4.1.5 Power EMI/EMC Requirements. Electrical power shall meet the Electromagnetic Interference (EMI)/ Electromagnetic Compatibility (EMC) requirements specified in NCST-D-WS009A - Electromagnetic Compatibility Control Plan, as updated.

The WindSat radiometer payload is quite sensitive and careful attention must be paid to electromagnetic compatibility issues. Since the payload will contain a number of switching power supplies and noise-generating digital subsystems, it is neither necessary nor advantageous that the spacecraft bus provide extremely clean raw power; the bulk of the effort in successfully controlling EMI will fall upon the payload itself. Nevertheless, reasonable and customary EMI/EMC bounds must be placed on the raw power supplied to WindSat.

4.2 Input/Output Signal Interfaces.

4.2.1 Bi-directional Data Interface. The spacecraft bus shall provide a redundant MIL-STD-1553B, Digital Time Division Command/Response Multiplex Data Bus, to the WindSat payload. WindSat will utilize at most three Remote Terminals. The data bus will physically end within the WindSat payload and be properly terminated therein.

The spacecraft bus will transmit two logical data streams to WindSat over the data bus. The two logical data streams are Command Data and Attitude Data. Separate sub-addresses of the WindSat Data Handling System Remote Terminal address will be used to transmit each logical data stream.

The spacecraft bus will issue Commands over the data bus to the WindSat payload. Commands will originate either from ground control stations via the spacecraft bus' uplink receiver, or from command sequences stored within the spacecraft bus' command and telemetry subsystem.

The spacecraft bus will transmit Attitude information to WindSat over the data bus. This data will consist of star viewer data (even if the star viewers are physically located on the WindSat stationary deck) and inertial measurement data if the inertial measurement unit is interfaced directly to the spacecraft bus).

The spacecraft bus will receive over the data bus WindSat radiometer data and WindSat-specific telemetry for subsequent transmission to the ground. WindSat will also transmit other control information to the spacecraft bus requiring decomm of 1553 packets (e.g., GPS data).

The data transmitted by WindSat over the data bus will be divided into three logical data streams. The first and largest data stream contains all WindSat mission data required to process the wind vector results and shall be handled as described later in this document. The second logical data stream provides the complete data stream emanating from the WindSat GPS Receiver. The third logical data stream contains information of interest to the spacecraft and other payloads, such as WindSat status, etc. Each logical data stream will be provided on a separate sub-address of the WindSat Data Handling System Remote Terminal address.

The spacecraft shall provide the Bus Controller function as defined in the standard. The spacecraft may also utilize Remote Terminals for its own purposes, provided that such use does not result in a combined data transfer load exceeding the data bus capacity and result in a loss of WindSat payload data.

Projections of WindSat data rate presently total nearly 200 kbps, representing a substantial portion of the available bandwidth of approximately 700 kbps. WindSat usage of the data bus will not exceed 300 kbps.

In order to minimize the complexity of the interface between the spacecraft bus and the WindSat payload, the bulk of WindSat command and telemetry data will be transported via the 1553 data bus.

4.2.2 Experiment Inputs. No input data other than that carried via the MIL-STD-1553B, Digital Time Division Command/Response Multiplex Data Bus, need be provided from the spacecraft bus to the WindSat payload.

4.2.3 Experiment Outputs. In addition to the radiometer data and telemetry data transmitted via the 1553B data bus, the WindSat payload will provide the spacecraft bus with four separate interface signals as described in the following paragraphs. Each of these four signals will transmit on separate differential RS-422 electrical interfaces as shown in Figure 4-2. The source-terminated configuration is used to minimize adverse effects due to signal reflections while minimizing power dissipation. Cabling will use twisted pair with an overall shield to minimize EMI radiation and susceptibility.

4.2.3.1 GPS Pulse-Per-Second PPS Signal. The one-pulse-per-second signal from the GPS receiver can be used by the spacecraft bus as a precise time interval reference. When associated with the pulse-per-second UTC packet data provided via the 1553B data bus, the spacecraft bus can maintain absolute UTC time and date.

The PPS signal originates in the GPS receiver located in the WindSat rotating canister, is transmitted across the slip rings, and is regenerated in the Stationary Data Handling Unit (SDHU) before transmission to the spacecraft. The pulse is therefore delayed by a small but constant amount relative to the true GPS/UTC epoch. In addition, the process of

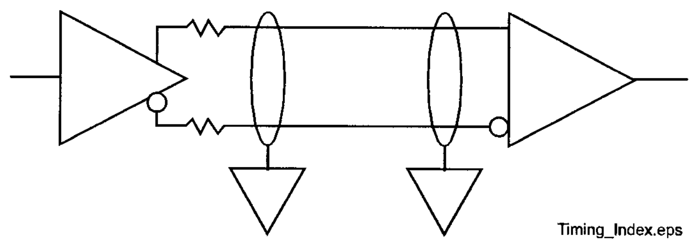


Figure 4-2. RS-422 Interface for PPS, Timing Index, and Tachometer Signal

transmitting and regenerating the PPS signal results in an additional jitter of 1 microsecond peak-to-peak, beyond any jitter and inaccuracy already present in the PPS signal supplied by the GPS receiver itself.

The 1553B UTC packet data will be transmitted at a nominally fixed time offset relative to the one-pulse-per-second signal. This packet will always precede or follow the one-pulse-per-second signal, as determined by the GPS Receiver used in WindSat.

This signal will be active only when the WindSat Data Handling System and the WindSat GPS Receiver is powered up.

4.2.3.2 WindSat Timing Index Mark. The Timing Index mark provides an alternate method of relating the various WindSat measurements to the satellite position, velocity, and attitude in the event of GPS receiver failure. The spacecraft shall either timestamp the leading edge of this pulse with UTC (maintained via the spacecraft uplink and downlink), or modulate the downlink in a manner such that ground-based equipment can timestamp this signal.

The Timing Index pulse will be approximately 1.6 microseconds in width and will occur approximately sixteen times per second. The leading edge time-of-occurrence shall be known to within 1 millisecond of UTC. In addition to timestamping this signal, a means alternate to the GPS receiver position and velocity measurements must be provided for accurately determining satellite ephemeris (such as uplink/downlink ranging tones).

This signal will be active only when the WindSat Data Handling System is powered up.

4.2.3.3 BAPTA Spin Drive Tachometer. The BAPTA Spin Drive Tachometer signal provides knowledge of the spin status independent of the 1553B data bus operation. This signal can be used by the spacecraft bus Attitude Control System to aid in maintaining attitude stability.

This signal will be active only when the WindSat Data Handling System is powered up.

4.2.3.4 Momentum Cancellation Wheel Tachometer. The Momentum Cancellation Wheel Tachometer signal provides knowledge of the momentum wheel status independent of the 1553B data bus operation. This signal can be used by the spacecraft bus Attitude Control System to aid in maintaining attitude stability.

This signal will be active only when the WindSat Data Handling System is powered up.

5.0 COMMAND AND CONTROL

5.1 Command Interface. All WindSat commanding will be provided over the MIL-STD-1553B, *Digital Time Division Command/Response Multiplex Data Bus.* No other command interfaces are required. Release of the rotating canister launch lock mechanism requires that the WindSat controller be powered up and the appropriate 1553B bus command packets be sent.

5.2 Payload Command And Data Handling. When the WindSat payload is operational, all command messages will be provided from the spacecraft bus via the MIL-STD-1553B, *Digital Time Division Command/Response Multiplex Data Bus.*

Operational commands provided by the spacecraft will generally be defined at a high level, such as indicating that the payload should enter its normal operating mode. The WindSat payload contains a controller that will execute this high level command by issuing a number of lower levels commands to WindSat payload subsystems (i.e., powering up the radiometer receivers, setting receiver gain parameters, activating the spin drive motors, etc.). The WindSat payload will provide status packets throughout the execution of a high level command relating the progress of the action.

While most of the commanding between the spacecraft bus and the WindSat payload will occur at a high level, there will also be provisions to supply binary data from the ground to the WindSat payload. Such raw data will used to upload software revisions, command scripts, etc.

6.0 TELEMETRY AND DATA HANDLING

6.1 Telemetry System. The spacecraft bus is required to measure the signals described in the following paragraphs. All other WindSat payload telemetry will be provided via the MIL-STD-1553B, *Digital Time Division Command/Response Multiplex Data Bus.*

6.1.1 Stationary Deck and Rotating Canister Temperature Telemetry. The spacecraft bus will accept two thermistor connections from the WindSat payload. These temperature monitors will be operational even when the WindSat payload is inactive and will be utilized by ground control monitors to detect an out-of-limit condition requiring immediate attention.

6.1.2 Stationary Data Handling Unit Telemetry. The spacecraft bus will measure the secondary regulated supply voltages and one thermistor monitor within the SDHU. This minimal telemetry will be used to determine whether the Data Handling Subsystem has been successfully energized in the event that 1553B data bus transactions cannot be established.

The SDHU operates with five regulated secondary voltages: ±5 Vdc, +12.5 Vdc, and ±15 Vdc. Each output will be supplied to the spacecraft telemetry system through a 4.7 kΩ 1% resistance. The spacecraft may pull these down with an appropriate resistance to scale the voltages as required.

6.2 Attitude And Position Telemetry. The WindSat payload requires precise spacecraft bus attitude, position, and velocity knowledge for determination of key boresight pointing parameters. This information is not required for onboard processing but must be timetagged and transmitted to the ground along with the payload data. Position, velocity, and timing data is measured by the GPS receiver in the WindSat rotating canister and can be made available to the spacecraft bus via the 1553B data bus. The attitude knowledge data must be provided by the spacecraft bus to WindSat over the 1553B data bus and is required continuously while the payload is in operation. Accuracy requirements are provided in Sections 10.2 and 11.2 of this document. This data shall include, at a minimum, the attitude quaternion, inertial rates, and "quality" data. Quaternion updates are required at a minimum 2 Hz update rate and the rate data at a minimum 20 Hz update rate. Raw sensor data may also be desired. The data must be timetagged to UTC with an error of less than 1 millisecond (including uncompensated sensor and filter delay).

The attitude and timetag data delivered by the spacecraft bus will be merged by the WindSat Data Handling Subsystem with the radiometer measurements, GPS position and velocity data, and other telemetry into a composite mission data stream and subsequently transmitted to the spacecraft bus over the 1553B data bus.

6.3 Experiment Data Collection. The WindSat payload will provide a mission data stream containing radiometer measurements, precise attitude measurements, position and velocity data, and other telemetry via the 1553B data bus on a continuous basis. This stream contains realtime data. As the 1553B Bus Controller, the spacecraft must collect data from WindSat in a timely manner to prevent loss of WindSat mission data.

The spacecraft 1553B Bus Controller will collect a realtime WindSat data packet approximately every 2 ms, for an average of 500 packets per second. No more than 127 packets may be collected from WindSat in any span of 150 milliseconds. Collection of packets at a greater instantaneous rate would result in underflow of the WindSat packet buffer.

WindSat will pass data to the spacecraft at a rate not exceeding 300 kbps using the MIL-STD-1553B data bus. WindSat will provide realtime measurement data at a nominally constant rate. The format of 1553B data packets will be defined by NRL and the spacecraft bus contractor.

6.4 Experiment Data Storage And Transfer.

6.4.1 Realtime SMQ-11 Compatible Downlink. The WindSat realtime mission data stream will be transmitted to field users over the SMQ-11 compatible tactical downlink. The WindSat 1553B data stream will embed all necessary framing synchronization words, frame-type header words, error detection words, etc. Other than rate buffering between the bursts of WindSat 1553B packet data, the fixed downlink rate, and synchronization between the downlink bit rate and the 1553B packet collection, no additional processing of the data stream will be required or desired of the spacecraft bus. The format of the data stream will be defined by NRL.

If, however, the spacecraft provides SMQ-11 compatible downlink frame formatting and transports experiment data within that frame, WindSat data packets shall be placed within the frame and fill words shall be transmitted as necessary when insufficient WindSat data exists. WindSat packets transported in this manner shall be distinguishable from other packets so the original WindSat data stream can be recreated and provided to the data processing element.

The SMQ-11 compatible downlink will operate at approximately 256 kbps. The tactical data stream duty cycle must be greater than 90% during quasi-operational mission phase. WindSat data shall be delivered from the payload to the field processing site with a bit error rate not larger than 1×10^{-6}.

6.4.2 Bulk Data Storage and Wideband Downlink. The spacecraft bus shall also store the realtime WindSat mission data in Bulk Data Storage for subsequent transmission over the wideband downlink during ground station contacts. Data shall be stored in a first-in-first-out manner; such that data transmitted at the beginning of a ground station contact will be the oldest WindSat data and will progress toward data that are more recent. After one or more ground station contacts, the bulk storage of WindSat data will eventually be emptied, at which time transmission of realtime data can commence on the S-Band downlink. By this means, continuous, uninterrupted, WindSat measurement data will be provided to the processing center.

The bulk storage size requirements and downlink data rate requirements are driven by the ground system architecture selected and the frequency with which ground station contacts occur. It is the responsibility of the spacecraft bus to get all the WindSat data to the ground using a combination of bulk storage and wideband RF downlinks.

WindSat data shall be delivered from the payload to the ground station with a bit error rate not exceeding 1×10^{-6}.

6.5 Downlink Frequency Selection Criteria. In order to minimize the effects of passive intermodulation products from the communications system on the WindSat payload sensors, it is necessary to carefully select the downlink frequency bands.

Because Coriolis Mission requires three separate downlink carriers (X-Band experiment data, S-Band Tactical, and S-Band Telemetry) and the X-Band carrier frequency is to support at least a 15 Mbps downlink, the X-Band carrier shall meet the following criteria:

$$f_{X\text{-Band}} < 18325\ \text{MHz} - f_{S\text{-Band Tactical}} - f_{S\text{-Band Telemetry}}$$

The S-Band frequencies shall be SGLS compatible, with the additional requirement that the Tactical WindSat Downlink shall use a DMSP allocated carrier frequency. (DMSP frequencies are a subset of the SGLS frequencies.) Therefore, all S-Band frequencies are to be <2245.8 MHz. The nine SGLS frequencies that meet this criteria are shown in Table 6-1.

Table 6-1. SGLS Frequencies

2202.5 MHz	2217.5 MHz	2232.5 MHz
2207.5 MHz (DMSP)	2222.5 MHz (DMSP)	2237.5 MHz (DMSP)
2212.5 MHz	2227.5 MHz	2242.5 MHz

7.0 ENVIRONMENTAL REQUIREMENTS

7.1 Static Load Constraints. The final experiment will be designed to withstand the static or quasi-static loads of launch, as defined below and in the Coriolis file memo, "Titan II Load Factors for Coriolis Preliminary Design Effort". At present, WindSat will be designed to accept launch worst case levels of the Titan II. Local attachment structural sizing of the WindSat payload interface should be based on +7.0/-2 g axial and ±8.2 g lateral load factors applied at the payload CG This is consistent with the Titan II User's Manual for lateral load factor distribution away from the satellite CG (as applied to the S1 Shutdown case for f>12 Hz), and with previous WindSat payload CG acceleration predictions. Specific interface forces may be determined by applying the above condition to the Method One or Method Two payload FEM.

At no time during ground handling should a static load exceeding that expected at launch be placed on the experiment. The interface deck is the only payload structure that is allowed and expected to be a load-carrying member of the spacecraft. Specific points will be provided on the payload truss structure for attachment by a lifting fixture. WindSat will be built so the entire integrated SV can be lifted by these attachment points. WindSat will provide the required lifting fixture. The payload shall not be lifted in any other manner.

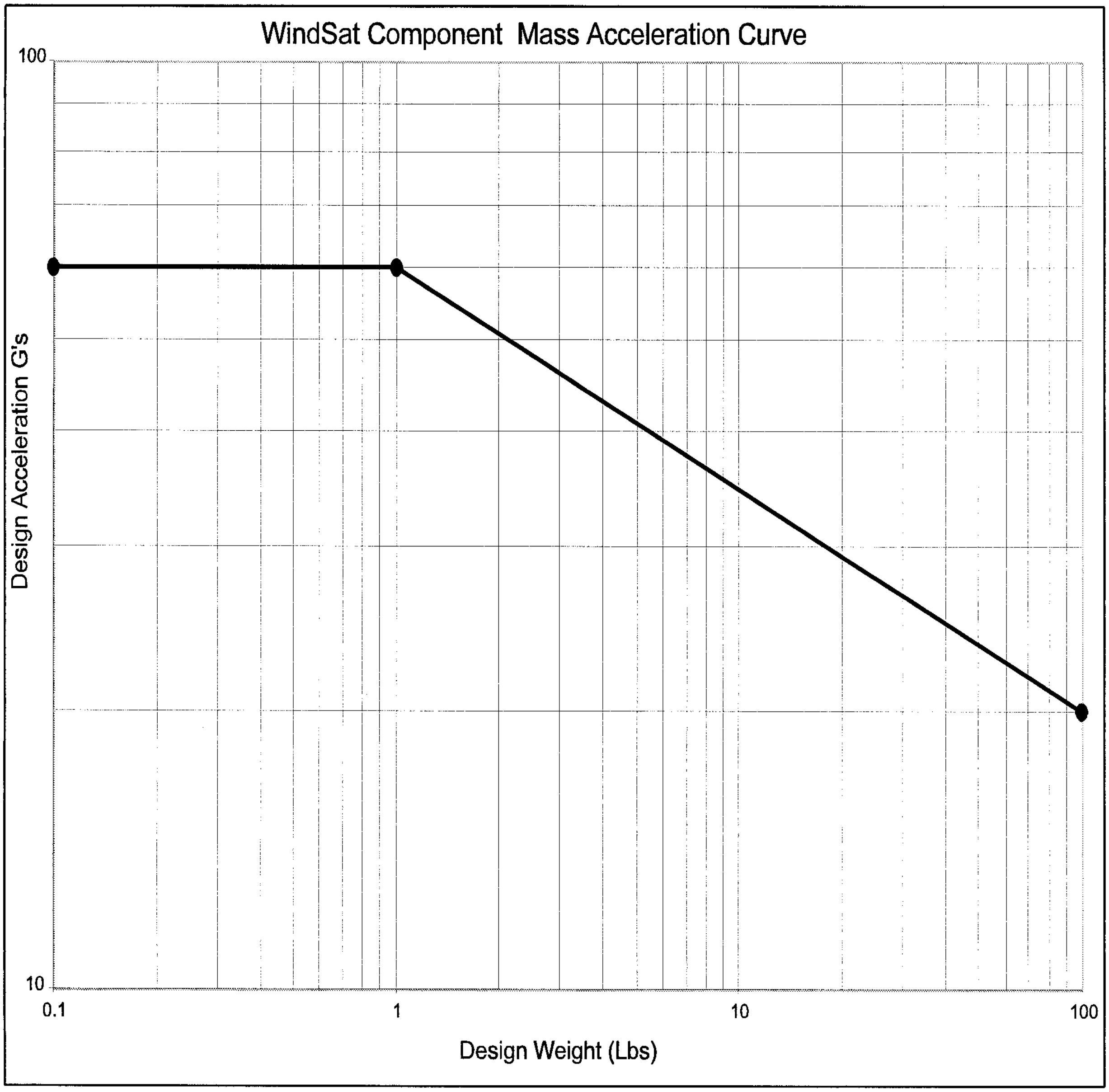
Components will be designed to withstand quasi-static loads, as specified in Figure 7-1.

7.2 Acoustic. The experiment will be designed to withstand the acoustic environments shown in Figure 7-2. This environment is an envelope of Titan II levels.

7.3 Vibration Constraints. The experiment will be designed to withstand exposure to the low frequency random vibration spectrum simultaneously with acoustics. WindSat will be designed to accept launch levels from the Titan II launch vehicle (see Figure 7-3). In addition, WindSat shall be monitored for excess shock or vibration during ground handling and shipping.

7.4 Shock Constraints. WindSat will be designed to accept launch shock levels from the Titan II. WindSat will induce a one time shock environment on the spacecraft which will occur while releasing the launch locks during mission initialization, see Figure 7-4. WindSat will be designed to withstand transmitted shock levels generated from the spacecraft, see Figure 7-4 for reference. The spectra in Figure 7-4 are preliminary estimates and will be updated as the WindSat design evolves.

7.4.1 Canister Launch Lock Release Force. A short duration force and torque will be delivered to the bus upon release of the last two canister launch locks. Figure 7-5 shows a diagram of the forces and how they are introduced. The impulse results from the 0.150 inch pull-down of the rotating payload relative to the stationary deck. This displacement will be split between the stationary deck and the rotating payload according to their stiffness and these stiffness and displacement values are shown in Figure 7-5. The force will act through compression in the BAPTA and will be along the z axis. There will be torques about the x axis and about the y axis immediately after release as tabulated in Figure 7-5. The force and torques will drop to zero when the system damps to its nominal zero gravity state. The effective axial and torsional spring constants of the deployed rotating canister and stationary structure are called out in Figure 7-5. The stationary structure is considered rigidly attached to the Bus. The masses, CG's, and mass moments of inertia of the WindSat components that will move with the rotating payload and those that will move with the bus are also provided in Figure 7-5. A 0.5% damping should be assumed for the diaphragm springs. All of the data



Design Accelerations

Component Wt. (Lbs)	G's
0.1	60
1	60
100	20

Apply in 3 Axes - One Axis at a Time

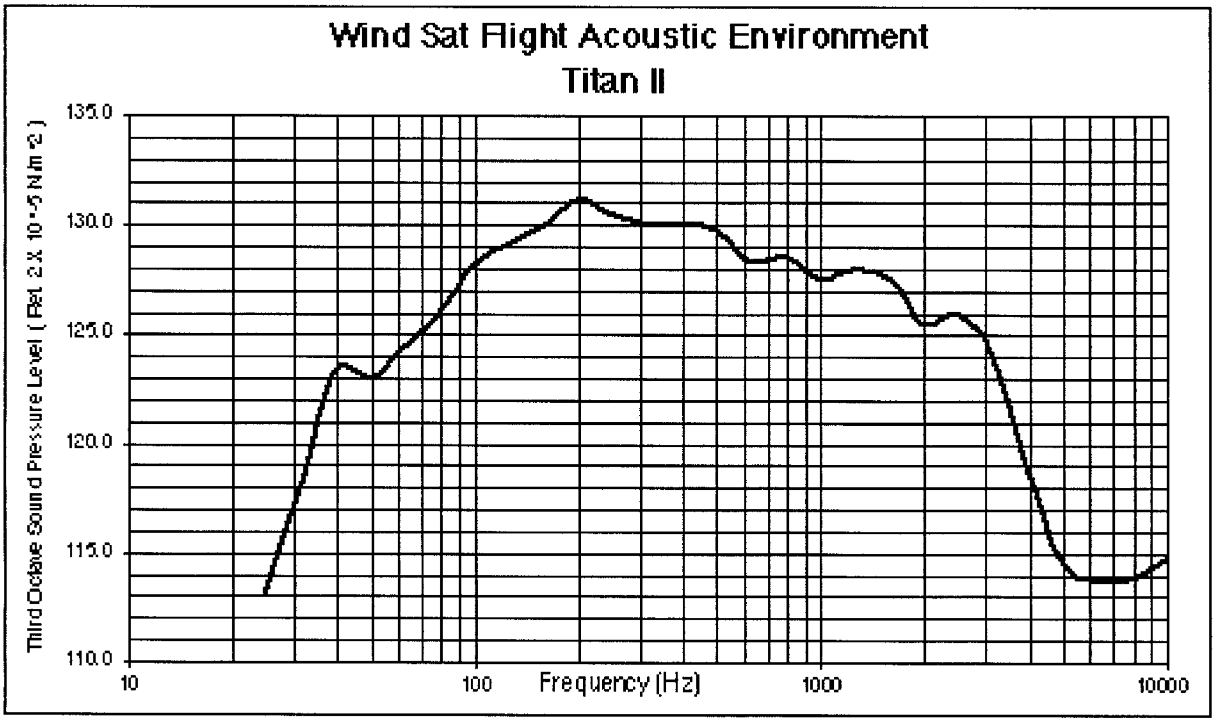
Design Acceleration Philosophy

* These Accelerations Are to Be Used for Design of Components and Their Attachment

- For Designated Components, the Acceleration Level From This Curve May Also Be Used for Random Vibration Test Spectrum Tailoring

Comp_Mass_Acc_Curve.eps

Figure 7-1. Mass Acceleration Curve

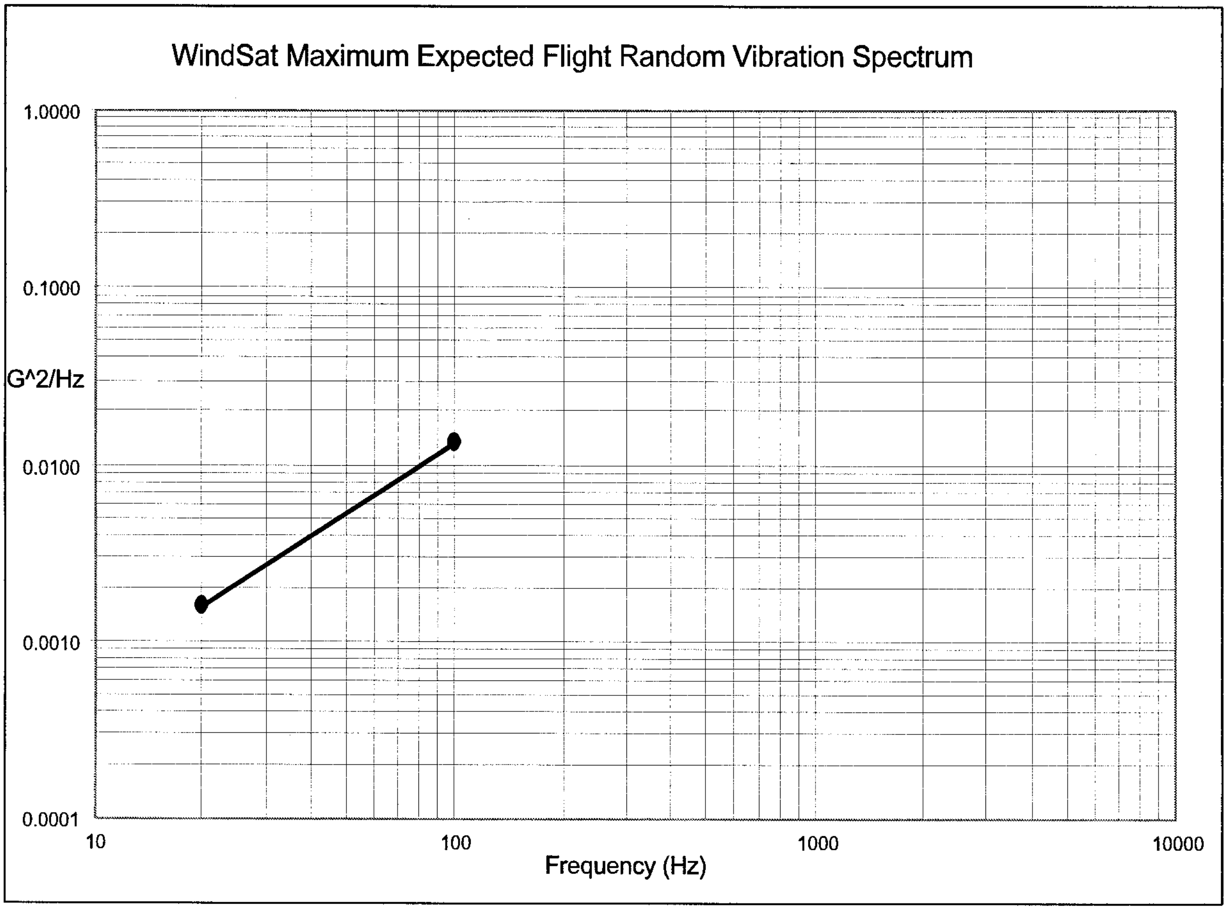


Flight Environment

One Third Octave Frequency (Hz)	SPL (dB)	One Third Octave Frequency (Hz)	SPL (dB)
25	113.0	800	128.5
32	118.0	1000	127.5
40	123.4	1250	128.0
50	123.0	1600	127.5
63	124.5	2000	125.5
80	126.0	2500	126.0
100	128.2	3150	124.0
125	129.1	4000	118.5
160	130.0	5000	114.5
200	131.1	6300	113.7
250	130.5	8000	113.9
315	130.0	10000	114.8
400	130.0		
500	129.8	OA	141.3
630	128.3		

flight_acoustic.eps

Figure 7-2. WindSat Flight Acoustic



Flight Environment

0.8 Grms

Frequency (Hz)	G^2/Hz
20	0.0016
100	0.0135

All 3 Axes

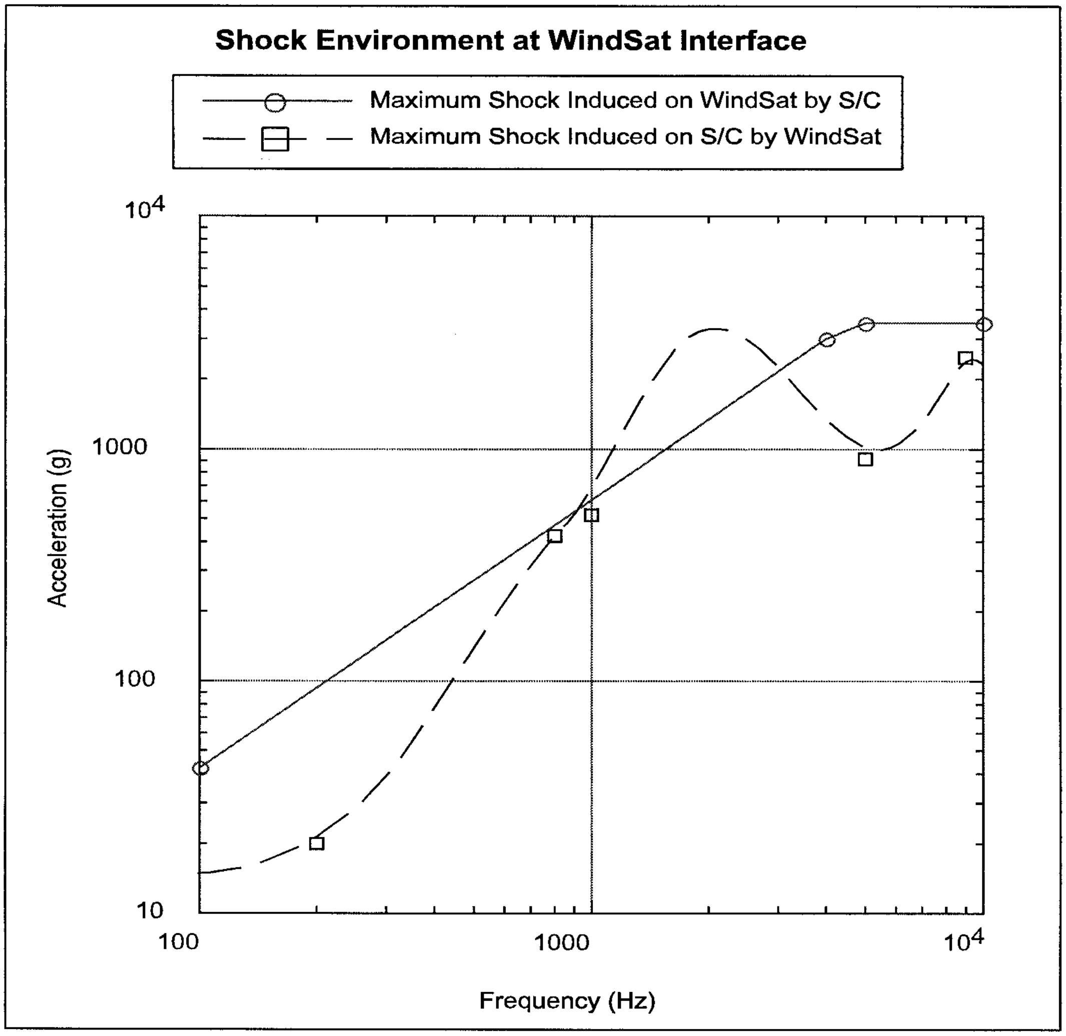
Test Level

	Margin Above Flight Level (dB)	Duration (Minutes)
Engineering Model (Qualification Level)	6	2
Flight (Protoflight Acceptance)	3	2

Note: The Spectrum Will Be Tailored to Keep Primary Structural Responses Below DLL X 1.25 (EM) or DLL (Flight)

LowFQ_RandVib_Spectrum.eps

Figure 7-3. Low Frequency Random Vibration Spectrum



Shock Induced on S/C by WindSat		Shock Induced on WindSat by S/C	
Frequency (HZ)	Accelerations (G)	Frequency (Hz)	Accelerations (G)
100	15	100	42
200	20		
500	111		
800	420		
900	450		
1000	525		
2000	3900		
3000	2081		
4000		4000	3000
5000	911	5000	3500
7000	1040		
9000	2471		
10000	2340	10000	3500

Shock_Constraints.eps

Figure 7-4. Shock Constraints

presented in the figure is preliminary and will be refined as the design and interface definition progresses. Also see Table 7-1.

Table 7-1. Canister Launch Lock Parameters

Parameter	Stowed	Released
Rotating Payload Mass	483 lbm	Same
Rotating Payload CG: CGrp	45.0 in	Same
Rotating Payload Mass Moment of Inertia	496,000 lbm-in^2	Same
WindSat Stationary Mass (Method 1 interface)	192 lbm	Same
CG of WindSat Stationary Mass: CGstat (Method 1 interface)	7.6 in	Same
WindSat Stationary Mass Moment of Inertia (Method 1 interface)	25,225 lbm-in^2	Same
Combined Bus + WindSat Stationary Mass Properties	**TBR** by bus vendor	Same
Axial KRP	5.1E3 lbf/in.	Same
Axial KBUS	7.1E4 lbf/in.	Same
Torsional KRP	1.1E7 in*lbf/rad	Same
Torsional KBUS	6.0E6 in*lbf/rad	Same
∂_{RP}	0.140 in.	0 in.
∂_{BUS}	0.010 in.	0 in.
Torque about X-axis	1200 in*lbf	0 in*lbf
Torque about Y-axis	1061 in*lbf	0 in*lbf
Compressive Force on BAPTA	712 lbf (reference)	0 lbf

7.5 Radiation Constraints. The experimenter shall be notified prior to the use of radiation sources on the spacecraft. WindSat will be designed to operate in the natural radiation environment of the chosen Sun-synchronous orbit. Specific constraints on radiation are still being determined.

7.6 Electromagnetic Compatibility. Please refer to EMI/EMC Plan NCST-D-WS009.

7.6.1 Radiated Emissions from Experiment. Please refer to EMI/EMC Plan NCST-D-WS009.

7.6.2 Conducted Emissions from Experiment. Please refer to EMI/EMC Plan NCST-D-WS009.

7.6.3 Magnetic Fields Generated by Experiment. This information will be provided at a later date.

However, WindSat can be magnetically balanced statically to meet ICD requirements above 1000 pole-cm.

7.6.4 Sensitivity of Experiment to Radiated Emissions. Please refer to EMI/EMC Plan NCST-D-WS009.

7.6.5 Sensitivity of Experiment to Conducted Emissions. Please refer to EMI/EMC Plan NCST-D-WS009.

7.6.6 Sensitivity of Experiment to Magnetic Fields. Please refer to EMI/EMC Plan NCST-D-WS009.

7.7 Atmospheric Pressure Constraints. WindSat will be designed to withstand the normal LV depressurization rates as shown in Figure 7-6.

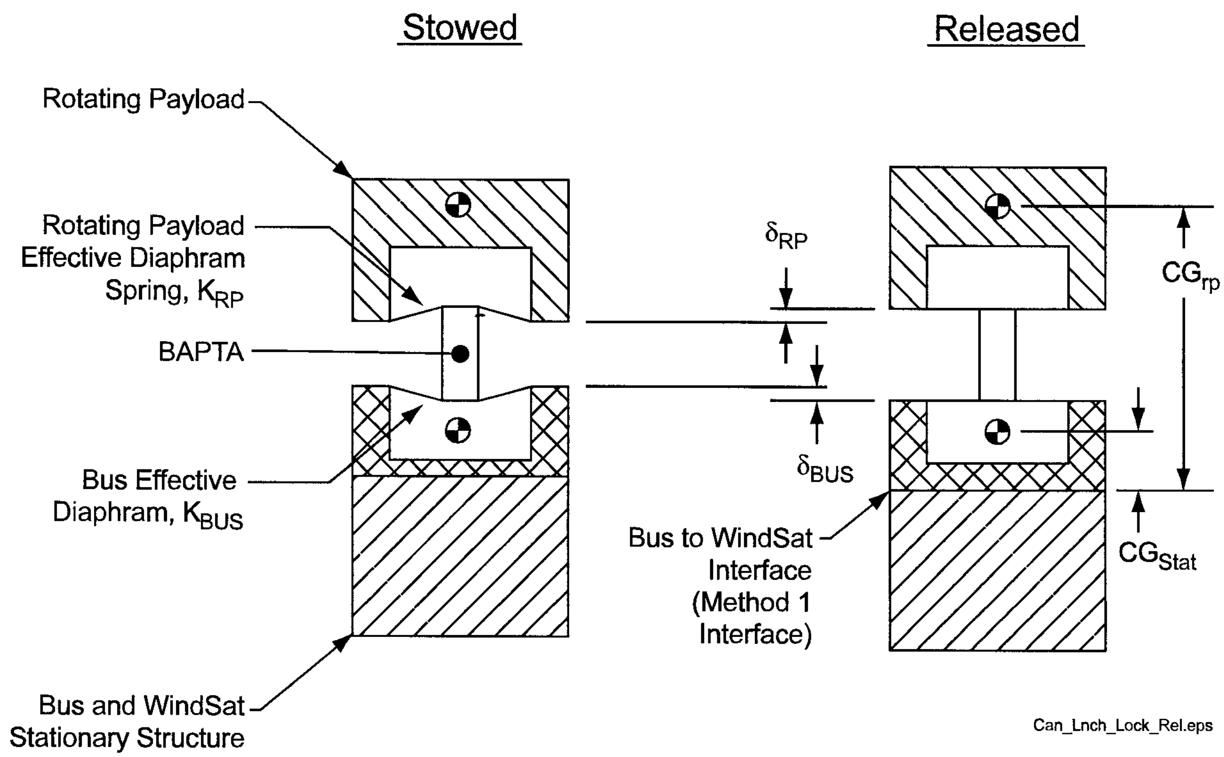


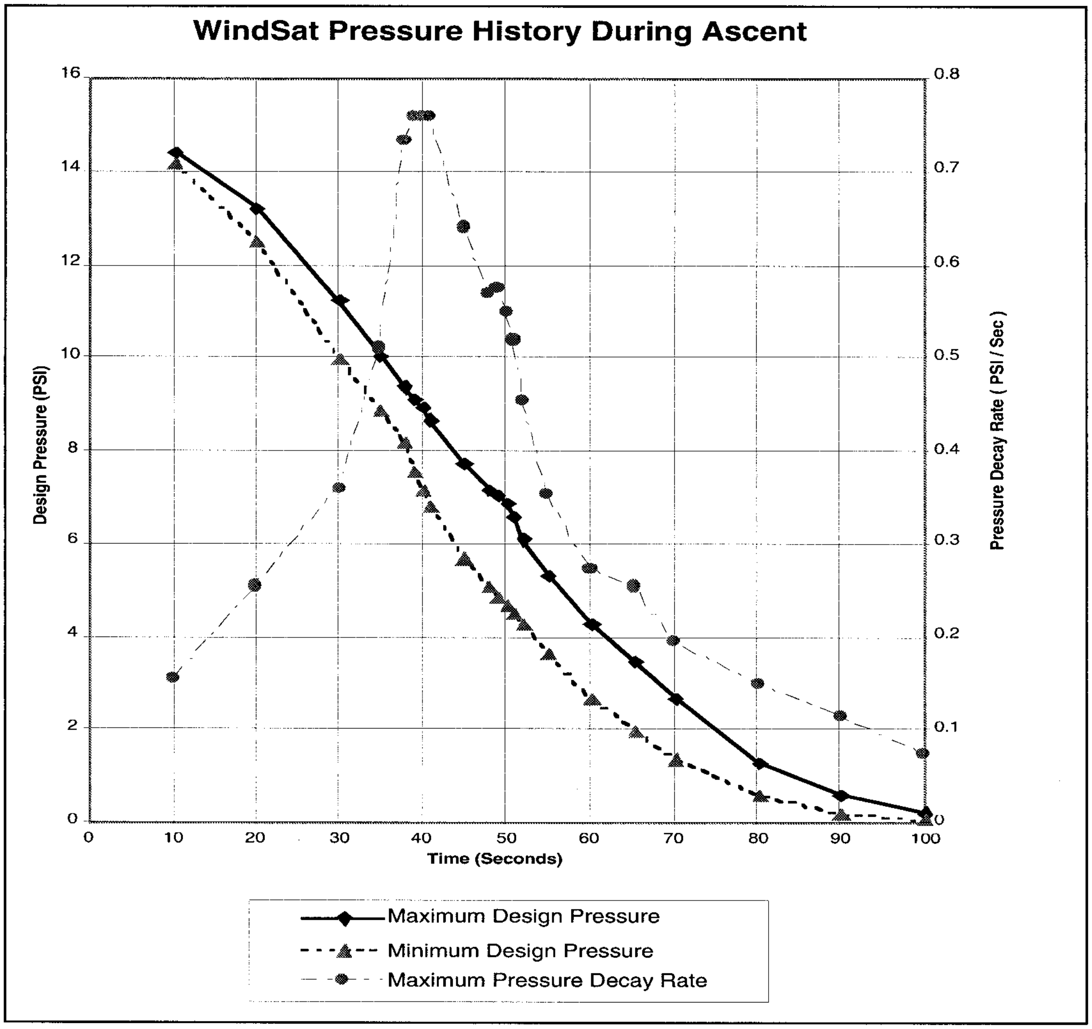
Figure 7-5. Canister Launch Lock Release Force Diagram

7.8 Cleanliness Constraints. At this time, no cleanliness requirements for WindSat have been identified, other than normal flight hardware assembly and integration environments (Class 300,000).

WindSat has no outgassing requirements to impose on the spacecraft at this time. WindSat will be designed to comply with the NASA outgassing specification where performance, schedule, and budget allow.

7.9 Humidity Constraints. WindSat currently has no special humidity requirements, other than being handled, and stored in a normal air-conditioned flight hardware environment.

7.10 On-Orbit Thermal Interface Requirements. Regardless of payload temperature, the spacecraft shall maintain it's interface (conduction and radiation) between 0°C to 40°C when the payload is active (operational) and between -20°C and 60°C when the payload is inactive (non-operational). Conversely, the payload will maintain its interface at the same temperature ranges as stated above, regardless of spacecraft temperature.



	Maximum Design Pressure	Minimum Design Pressure	Maximum Pressure Decay Rate
10	14.45	14.2	0.155
20	13.2	12.5	0.255
30	11.25	10	0.36
35	10.05	8.9	0.51
38	9.4	8.2	0.735
39	9.15	7.6	0.76
40	8.95	7.2	0.76
41	8.7	6.8	0.76
45	7.75	5.7	0.64
48	7.2	5.1	0.57
49	7.05	4.9	0.575
50	6.9	4.7	0.55
51	6.6	4.5	0.52
52	6.1	4.3	0.455
55	5.35	3.65	0.355
60	4.3	2.7	0.273
65	3.5	2	0.255
70	2.7	1.4	0.195
80	1.3	0.6	0.15
90	0.6	0.2	0.115
100	0.25	0.1	0.075

Figure 7-6. WindSat Pressure History during Ascent

7.11 Payload Ground Storage and Ground Test Temperature Limits. All external surfaces of the payload shall be kept within the limits displayed in Table 7-2.

Table 7-2. Payload Ground Limits

Storage/Ground Test	Minimum/ Maximum	Payload Temperature Non-Operative (°C)	Payload Temperature
Storage	Minimum	+10	N/A
	Maximum	+50	N/A
Ground	Minimum	-10	-10
	Maximum	+50	+50

8.0 INTEGRATION AND TEST

8.1 Spacecraft Integration and Test. No radiometer performance or calibration is envisioned during integrated spacecraft-payload testing.

8.1.1 Pre-spacecraft Integration Inspection and Test. The WindSat Payload engineers will perform a post-ship functional test, an alignment test, and inspection prior to integration on the spacecraft.

8.1.2 Post Spacecraft Integration Test Requirements. The WindSat Payload requires a complete; end-to-end Spacecraft/payload integrated test with no unresolved and unacceptable anomalies once it is electrically mated to the spacecraft, prior to any environmental testing.

Alignment measurements relating the WindSat hardware based coordinate system to the spacecraft hardware based coordinate system shall be made before and after system environmental test.

The integrated Spacecraft and Payload testing has the requirement of verifying interfaces and payload functionality, but not payload performance. There shall be a separate ground systems compatibility test.

8.1.3 Ground Support Equipment (GSE) and Facilities. All WindSat electrical checkout equipment, handling fixtures, and containers will be provided by the NRL. Space and Hook Up requirements are provided in Section 4.3.4.1.1 of the Coriolis RFO.

8.1.4 Ground Handling Procedures. Ground handling procedures shall be supplied to the spacecraft contractor **TBR** months before use.

8.2 Space Vehicle Level Environmental Testing.

8.2.1 EMI/EMC and Intermod Testing. Environmental testing of the fully integrated Spacecraft and Payload(s) shall include EMI/EMC tests in accordance with the EMI/EMC Plan NCST-D-WS009.

The EMI/EMC tests shall also include tests designed to detect RF interference due to passive intermods at WindSat frequencies.

8.3 Launch Vehicle (LV) Integration and Test.

8.3.1 LV Integration Site Tests. WindSat has not identified any testing at this time that needs to occur at the launch site, other than the support of the integrated spacecraft post-ship functional tests, alignments (verification only) and launch processing functional tests.

8.3.2 LV Integration Site GSE and Facilities. **TBD**.

8.3.3 Launch Pad Tests. The only launch pad test planned is an aliveness check.

8.3.4 Launch Pad Environment. NOTE: Due to WindSat's sensitivity to RF interference, there may be concern over the launch site radiated environment and special precautions taken to reduce its effects.

8.3.5 Experiment Access. There are currently no requirements for experiment access at the Pad.

8.3.6 Launch Go/No-Go Criteria. **TBD**

8.4 Potentially Hazardous Materials and Equipment.

8.4.1 Pressurized System (Liquid/Gas). N/A.

8.4.2 Ordnance Systems. N/A.

8.4.3 Radiation Sources. N/A.

8.4.4 High Voltage Source Locations. N/A.

8.4.5 Experiment Safety During Integration and Testing. NRL will provide inputs to the spacecraft contractor for Accidental Risk Assessment Report (ARAR)/Safety Data Package.

9.0 ON-ORBIT OPERATIONS REQUIREMENTS

On-orbit operational requirements are derived from those functions and tasks that are necessary to conduct the WindSat mission after successful orbital injection. These include Training, Initial On-Orbit Operations, Routine Operations, and Anomaly Operations. The details will be included in an addendum to the On-Orbit Test Plan, which will be provided at a later date. However, examples of these functions and tasks are listed below. These functions are easily mapped to the Mission Phases (See Section 2.3). The Initial On-Orbit Operations functions apply directly to the Post Launch Checkout Phase. Routine and Anomaly Operations are both relevant to the Calibration/Validation and Proto-Operational Phases. In all phases, the operations shall adhere to the limitations set by the WindSat Operational Constraints (WOC) which will be provided at a later date. Preliminary constraints are given below.

9.1 Operational Constraints. At present, only a few constraints have been identified. These constraints deal with the survival of the payload and with the proper spin-up and de-spin of the WindSat payload. Many of these constraints have already been addressed in other sections of this document. They are repeated here because they impact the on-orbit operations.

9.1.1 Survival Heaters. Power shall be applied to the Survival Heaters within 120 minutes after launch and remain on at all times thereafter. During extremely serious anomalies requiring extensive load-shedding, de-energizing of one heater circuit will reduce the electrical load without completely removing all survival heating.

9.1.2 Shading of Reflector Support Structure . None of the reflector support struts members shall be shaded from Sunlight for periods exceeding 90 minutes. The initial condition prior to start of this prolonged shading shall be any of the nominal operational conditions (at any beta angle and any point in its orbit). For periods of intermittent shading, the duty cycle (shade/Sunlight) shall be <0.6. A period of prolonged shading can not follow a period of intermittent shading. However, a period of intermittent shading can follow a period of prolonged shading. Upon recovery from a prolonged shade to nominal operation, 5 hours of nominal operation shall be achieved prior to experiencing another prolonged shading of the struts.

A more detailed definition of "shading" will be provided during ICD development. However, for the purpose of this document, the term coincides with the Sun located outside the "keep-out" region defined in ICD WS-IC-0010, i.e., the shaded area corresponds to the Sun along the "Nadir" axis ±42.5°.

9.1.3 Payload Start-up. Payload spin-up shall be initiated in view of the Ground Station.

9.1.4 Payload Shut-down. For proper Payload Shutdown, at least 20 minutes notice shall be given to the Payload prior to terminating power to the SDHU. During this 20-minute period, the Payload Controller will de-spin both the rotating side of WindSat and the Momentum Wheel.

9.1.5 Uncommanded Payload Despin. The spacecraft shall be capable of surviving uncommanded or anomalous despin of the WindSat payload.

9.1.6 Nominal Payload Spin-Up and Spin-Down. The spacecraft shall tolerate large yaw motions during payload spin-up and spin-down. If after spin-up or spin down operations, there exists significant yaw offset, the spacecraft shall be capable of reacquiring normal pointing in a timely manner.

9.1.7 Pitch Maneuvers. Pitch maneuvers will be required from time to time to support payload calibration. These maneuvers consist of moving the spacecraft to produce a pitch offset not exceeding ±30°. The slew and offset duration will be tailored to the spacecraft capabilities, but together they will not exceed 1 day.

9.2 Operations Training. Training includes instruction by appropriate WindSat personnel, participation by Operations personnel in selected I&T activities (e.g., WindSat acceptance testing, payload to spacecraft I&T), simulator tests, and other practice and verification Operations exercises to be conducted before launch. The training plan must be developed and managed by an integrated team that includes appropriate members from WindSat, the Spacecraft Contractor, and the Satellite Operations Center (SOC).

9.3 Launch Phase Operations. WindSat will be powered down and locked down during the launch phase. No launch phase operations will be necessary.

9.4 Initial On-Orbit Operations. Before the WindSat Payload can be declared ready for Routine On-Orbit Operations, the payload must be activated and tested for functional readiness. This effort should occur shortly after the spacecraft contractor has completed satellite-specific Initial On-Orbit Testing. The effort must be scheduled by the

SOC scheduling office in cooperation with the WindSat staff. The effort will be a joint effort of the SOC and WindSat personnel.

Specifically the activation process includes a sequenced power up of WindSat components (SDHU, RDHU, & GPS), functional checks, release of WindSat Launch Locks, Spin-up, Radiometer functional checks, and mass property adjustments. The spin-up will be initiated in view of Ground Station operators.

9.5 Routine Operations. Routine Operations are usual WindSat specific operations that are conducted in satisfying the WindSat mission. The operations include the following:

- Planning WindSat specific operations. This is a shared responsibility between the WindSat team and the SOC.
- Scheduling of all WindSat related communications with the spacecraft, except the Tactical Downlink. This is a SOC responsibility.
- Monitoring the payload condition, e.g., temperatures, electrical power consumption, and payload configuration. This is a SOC responsibility. Most monitored items will have go-no go limits assigned for use by the SOC.
- Commanding the payload. This is a SOC responsibility. It requires building command strings and data uploads, verifying command strings before transmission to the spacecraft, insuring commands have been properly transmitted, the commands were properly executed in the spacecraft, and data uploads were passed to the payload.
- Receiving, handling, and passing payload telemetry and data. This is a SOC responsibility. Details of how WindSat mission telemetry and data will be received, handled, and passed to the user are **TBS**. An integrated planning team should be created and charged with developing and managing this effort.

9.5.1 Scheduling. The SOC will publish a satellite operations plan that will cover a 48 hours to 72 hours period of satellite operations. The POC and SOC will coordinate and prioritize events listed in the satellite operations plan. The SOC will interface with supporting organizations to plan satellite contacts and de-conflict the schedule.

9.5.2 Sensor Calibration. Following successful initialization and checkout, the satellite will be prepared for experimental operations. The sensor will undergo a thorough checkout during this time. The receiver dish will be spun up and receivers will be activated and characterized. The sensor will undergo full calibration and be prepared for full operations. Calibration and validation of the WindSat Payload may take as much as one year.

9.5.3 Normal Operations. During the course of normal operations the sensor will be turned on, data will be collected, stored, and downlinked to the ground segment at every opportunity. The SOC will continuously monitor the health and status of the satellite, maintain an archive of health and status conditions, and perform trend analysis of the systems and subsystems. The POC will monitor the quality of the mission sensor data and advise the SOC when data quality is sub-standard, and prescribe corrective actions.

The ground segment will perform pre-processing, post-processing, archival, and dissemination of the data during normal operations. Trends of state of health (SOH) data will also be archived.

9.6 Anomaly Operations. Anomaly Operations are payload specific operations required to treat unexpected conditions of the spacecraft or the payload as specified in 9.6.1 and 9.6.2.

9.6.1 Spacecraft Level Anomaly. A spacecraft-level anomaly is a condition that is not immediately determined to be WindSat specific and is the spacecraft contractor responsibility. The WindSat team should be notified as soon as practical that an anomaly condition exists, how the anomaly affects the payload, and what has been or will be done (e.g., safing the payload) that affects the WindSat performance and mission. The WindSat team will be responsive to the SOC during this period, and will offer all support possible until the anomaly condition is over.

9.6.2 Payload Level Anomaly. Recognition: The standard operating procedure will be to put the payload in a reduced functional mode (that mode is **TBD**), immediately inform the WindSat team of the anomaly condition, and stand by to cooperate with the WindSat team in anomaly investigation.

- *Investigation:* The WindSat team will lead the investigation of the anomaly until the condition is understood.

- *Resolution*: The WindSat team will work with the SOC and the spacecraft contractor to determine how the anomaly condition is to be resolved. The SOC will then conduct the required operations and change Routine SOP as required to adjust to the resolution.

9.7 Operations Support. Several supporting functions and activities must occur in order to fly the satellite and manage the mission data stream. These include pre-flight training and simulation, data processing and distribution, and archival functions.

9.7.1 Pre-Flight Training and Simulation. A comprehensive set of spacecraft operating procedures will be developed that will address all phases of the satellites operation. Flight personnel will undergo extensive pre-flight training in order to become qualified to fly the satellite under normal and anomalous situations. Simulations of normal and abnormal spacecraft situations will occur for training the flight personnel. In addition, thorough end to end testing of the spacecraft and the ground segment components will be performed prior to launch.

9.7.2 Data Processing and Distribution. As the Satellite comes into view of a ground station, the SOC commands the satellite to begin a downlink of stored, interleaved payload data and telemetry. At the ground site the data stream is separated into payload data and telemetry data streams, packetized and forwarded to the appropriate location. Payload data will be sent to the POC for final processing and telemetry is sent to the SOC for analysis and archive. The POC will take packetized payload data stream and apply algorithms to convert raw data records (RDRs) into environmental data records (EDRs).

During the first year of operation (Cal/Val phase), the priority will be to collect 100% of the payload data for scientific analysis. During this phase the latency requirements will be relaxed to minimize cost and maximize efficiency. Objective timeliness/latency (see 9.7.2.1) requirements specified in the IORD will be exercised on a quarterly basis to demonstrate a capability.

During the second and third year of operations, presuming a successful Cal/Val, the priority will be to supply a nearly continuous stream of payload data to a central site for use in numerical weather modeling. In this phase of operations, the data is highly perishable, and thus latency (see 9.7.2.1) becomes a primary consideration. Operational customers have a requirement to receive processed data within 4 hrs of imaging and this drives the latency requirement during this phase.

9.7.2.1 Latency. Latency, as defined by the WindSat program, is the cumulative time it takes for a data record (i.e. Brightness temperature) to be collected, downlinked from the spacecraft, transmitted to the central site, and processed into an EDR. This includes wait times while the record is stored in memory, data buffers and transmit time from location to location. The IORD specifies that timeliness or latency is 1.25 X Orbital period + 30 minutes, where the 30 minutes represents 20 minutes for data processing and 10 minutes for transmission time of a single data record.

9.7.3 Environmental Support. WindSat requires standard weather support services during launch activities. While on orbit, WindSat will require normal space environmental support to aid in the analysis of spacecraft and communication anomalies.

10.0 ORIENTATION AND STABILIZATION

Allocations to the bus to meet the payload pointing knowledge and control requirements are set forth below. Unless otherwise stated, these allocations apply at the mechanical interface to the payload.

10.1 Bus Attitude Control Error. Each bus axis must be controlled with respect to the local vertical coordinate frame. The 1 sigma attitude control errors must be less than ±0.2° in roll and pitch and ±0.5° in yaw. This excludes motion due to payload static and dynamic imbalance of the payload.

See Section 1.0 of this document for control requirements including the static and dynamic imbalance of the payload.

10.2 Bus Attitude Knowledge Error. The 1-sigma attitude knowledge errors must vary less than ±0.02° in each of three orthogonal axes on orbit. One-time launch bias for attitude control knowledge must be less than ±0.02°. See Section 6.2 of this document for attitude telemetry requirements.

10.3 Jitter and Rate Control. The jitter requirements for the payload have been determined with respect to the antenna footprint and the integration period. The allocation to the bus is such that the bus motion must be less than 0.03° over a 1 ms period.

10.4 Payload Angular Momentum. The angular momentum of the spinning portion of the payload will be compensated by a momentum wheel spinning in the opposite direction and located on the stationary deck of the payload. The uncompensated residual angular momentum will be less than 2 N-m-s during normal operations. The bus must meet the requirements set forth in this document in the face of this residual angular momentum. The residual momentum may exceed 2 N-m-s during the initial spin-up period. The attitude requirements do not apply during spin-up and spin-down, however, the spacecraft shall be able to recover and transition to normal pointing after spin-up or spin-down operations.

10.5 Payload Static and Dynamic Imbalance. The payload static and dynamic imbalance are defined with respect to the WindSat Payload Centroidal Frame and will be trimmed on-orbit to less than 0.2 ft-lbm and 1.0 lbm-ft^2, respectively. The bus must maintain attitude control to within ±0.4(for each roll and pitch and ±0.6° for yaw while subjected to this disturbance.

Prior to on-orbit trim, the static and dynamic imbalance will be as large as 1.0 ft-lbm and 10.0 lbm-ft^2. The bus must remain stable in all modes of operation while subjected to this disturbance.

The mass properties (center of mass and inertia) for both the stationary and spinning sections of the payload are provided in reference memos titled "WindSat Method One Analytical Mass Properties" and "WindSat Method Two Analytical Mass Properties".

10.6 Controller-Structure Coupling. The bus system (controller and structural) modes must be such that they do not couple with the payload system modes.

The spacecraft bus provider shall include as a deliverable math models of the bus controller and structure.

11.0 EPHEMERIS DATA

The ephemeris data supports line of sight pointing determination requirements. Ephemeris error allocations are provided below.

11.1 Prediction/Real Time Knowledge. There is no requirement for real time position and velocity knowledge. There is no requirement for predicted knowledge, other than that required by the ground station for signal acquisition and contact scheduling.

11.2 Post Processed Knowledge. Position knowledge of 200 meters is required (along each direction) for the payload data processing. The velocity must be known to better than 30 cm/sec for each axis. While typically provided by payload GPS receiver, the bus must make provisions for this in the event the receiver fails.

11.3 GPS Ephemeris Data. The payload will provide GPS position and rate data to the 1553B bus, updated every 1 sec. The time of the data is determined by the leading edge of a corresponding pulse across the RS-422 interface.

12.0 ORBIT CONTROL

Orbit control will be required only if launch vehicle orbit insertion errors combined with natural orbit variations results in altitude variations greater than ±40 km and/or an inclination error >0.2°.

The orbit insertion errors are expected to contribute no more than a ±20 km altitude error and a 0.1° inclination error.

13.0 SECURITY

All WindSat hardware and data, except those associated with the SMQ/11 tactical downlink, are considered unclassified. The SMQ/11 is considered COMSEC equipment.

14.0 DELIVERABLES

See Table 14-1.

Table 14-1. WindSat Deliverables

Item	Due Date
WindSat Payload	4/1/01
Payload Simulators	**TBR**
Mass Properties Report	**TBR**
Coupled Loads Input	**TBR**
Thermal Model	**TBR**
Drill Templates	**TBR**
Safety Package Input	**TBR**

15.0 NOTES

This section contains the acronyms and abbreviations used within this document.

15.1 Acronyms and Abbreviations.

ACRONYMS	DEFINITION
ARAR	Accident Risk Assessment Report
BAPTA	Bearing and Power Transfer Assembly
BER	Bit Error Rate
°C	Degree(s) Celsius
CDR	Critical Design Review
CG	Center of Gravity
CMIS	Conical Microwave Imager and Sounder
COMSEC	Communication Security
CTE	Coefficient of Thermal Expansion
dc	Direct Current
DDL	Data Downlink
DMSP	Defense Meteorological Satellite Program
DoC	Department of Commerce
DoD	Department of Defense
EELV	Evolved Expendable Launch Vehicle
EDR	Environmental Data Record
EMC	Electromagnetic Compatibility
EMI	Electromagnetic Interference
GHz	Gigahertz
GSE	Ground Support Equipment
H	Horizontal
ICD	Interface Control Document
I/F	Interface
IORD	Integrated Operational Requirements Document
IPO	Integrated Program Office
IRU	Inertial Reference Unit
JPL	Jet Propulsion Laboratory
kbps	Kilobits per Second
kg	kilogram
km	kilometer
lbf	Pounds force
lbm	Pounds mass
LTAN	Local Time of Ascending Node
LV	Launch Vehicle
m	Meters
Mbps	megabits per second
mg	Milligram(s)
m/s	Meters/Seconds
ms	Millisecond
NASA	National Aeronautics and Space Administration
NCST	Naval Center for Space Technology

Nms	Newton Meter Second
NOAA	National Oceanographic and Atmosphere Administration
NPOESS	National Polar-orbiting Operational Environmental Satellite System
NRL	Naval Research Laboratory
OA	Overall Average
ONR	Office of Naval Research
OPNAV	Operational Navy
ORA	Office of Research Applications
PDR	Preliminary Design Review
P/L	Payload
POC	Payload Operations Center
PPS	Pulse Per Second
psi	Pounds per Square Inch
RAAN	Right Ascension of the Ascending Node
rad	Radian
RDHU	Rotating Data Handling Unit
RDR	Raw Data Record
RF	Radio Frequency
RPI	Relay Position Integrator
rpm	Revolutions per Minute
RSD	Remote Sensing Division
S/C	Spacecraft
SDHU	Stationary Data Handling Unit
SDR	Sensor Data Record
SGLS	Space Ground Link System
SMC/TE	Air Force Space & Missile Commands Space Test Program
SOH	State of Health
SOC	Satellite Operations Center
SOP	Standard Operating Procedures
SSM/I	Special Sensor Microwave/Imager
TBD	To Be Determined
TBR	To Be Resolved
TBS	To Be Supplied
UTC	Coordinated Universal Time
V	Vertical
V	Volts
WOC	WindSat Operation Constraints

15.2 Government Documents. The following documents of the exact issue shown form a part of this document to the extent specified herein. In the event of conflict between the documents referenced herein and the contents of this specification, the contents of this specification shall be considered a superseding requirement.

Copies of specifications, standards, drawings, and publications required by Suppliers in connection with specified procurement functions should be obtained from the Contracting Agency or as directed by the Contracting Officer.

15.2.1 Publications.

Number	Title	Cited in Paragraph
MIL-STD-461D	Requirements for the Control of Electromagnetic Interference Emissions and Susceptibility	7.6
MJCS154-86	Military Requirements for Defense Environmental Satellites	2.0
NCST-D-WS009	WindSat Electromagnetic Compatibility Control Plan	4.1.5, 7.6,7.6.4, 7.6.5, 7.6.6
WS-IC-0010	WindSat Payload Envelope ICD	3.1, 3.1.1, 3.1.1.2, 3.1.2, 3.1.3.1, 3.1.3.2, 3.5, 3.7, 7.6.3, 9.1.2
—	Coriolis RFO	8.1.3

15.2.2 Other Publications.

Title	Cited in Paragraph
WindSat Method One Analytical Mass Properties Memo	3.2, 1.0
WindSat Method Two Analytical Mass Properties Memo	3.2, 1.0

EXPERIMENT REQUIREMENTS DOCUMENT

for

The Solar Mass Ejection Imager

Approved by:

Stephen L Keil Jan 12, 1999

Stephen L. Keil Date
Principal Investigator, AFRL/VSBS

Col. Thomas Mead Date
Program Manager, Space Test Program

Approved for public release; distribution is unlimited.

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1. SCOPE

This document contains the specific requirements of the *Solar Mass Ejection Imager (SMEI)*. It provides experiment requirements in the following areas: physical and functional interfaces, spacecraft integration and test, launch systems, and on-orbit flight operations.

2. EXPERIMENT OVERVIEW

2.1. Experiment Description

The purpose of SMEI is a proof-of-concept of ability to predict geomagnetic disturbances for Air Force space operations and to establish the feasibility of tracking interplanetary disturbances from the Sun to the Earth and beyond. The major subsystems of SMEI are an electronic Camera Assembly consisting of three Camera components and a Data Handling Unit (DHU). Each electronic Camera component consists of a baffle, radiator, bright object sensor, strongbox (CCD, mirrors and shutter) and electronics box. The electronic Camera Assembly is used to observe, in visible light, mass ejections from the Sun by sensing sunlight scattered from clouds of solar-produced interplanetary electrons. Predictions of arrival time at Earth of this disturbance can be made up to three days in advance.

2.2. Objectives

Develop and fly an all-sky Camera Assembly capable of measuring solar mass ejections as they propagate through the interplanetary medium. Develop algorithms that use this data to give 1-3 day advanced warning of geomagnetic disturbances that disrupt and destroy DoD operations and assets in space. The experiment will map out approximately 4 pi steradians of space around Earth and towards the Sun and provide predictions of arrival time of mass ejections from the Sun up to three days in advance. Furthermore, the experiment will track the solar ejecta and collect data as the mass leaves the near-Earth environment (passes the Earth) and moves into deep space.

2.3. Operational Concept

The experiment will operate continuously. Data from the electronic Camera Assembly will be digitized within the experiment and delivered to the space vehicle at a constant rate of approximately 56,000 bits per second for recording and periodic downlinking. Shortly after launch (and after outgassing of the spacecraft has dropped to an acceptable level) the SMEI experiment will be activated via an uplinked command from the satellite operations center (SOC).

2.4. Orbit Requirements

2.4.1. Standard Orbit Parameters

Apogee: 1000 km ± 200 km
Perigee: 1000 km ± 200 km
Inclination: Any
Rationale: Low eccentricity orbit preferred for uniform sky scan

2.4.2. Launch Window

If the spacecraft is launched into a sun synchronous orbit, a noon-midnight orbit is preferred. However, even a terminator orbit will be acceptable.

2.4.3. Mission Life

1 year required
3 year goal

2.5. Success Criteria

Minimum acceptable: One year of continuous data
Desired: Greater than 2 years of data, several images of coronal mass ejections traversing interplanetary space.

3. PHYSICAL DESCRIPTION

3.1. Engineering Layouts

The Solar Mass Ejection Imager experiment consists of an electronic Camera Assembly, a DHU and an intra-experiment harness as shown in Figure 1. Not shown in the conceptual drawing are radiators, which attach directly to the strongbox on each one of the three Camera components. Each radiator must be attached as close as possible to its respective strongbox to maximize cooling of each CCD. Also not shown are spacecraft-provided sun shields for protecting the Camera radiators from sunlight, where necessary. The baffle on each Camera component will have an external bright object sensor controlling an internal shutter to prevent direct sunlight from hitting the internal optics. Also, each Camera component will have a spring hinged door covering the external orifice of the baffle which will be opened after the spacecraft has reached the desired orbit and the experiment has been turned on. The baffle doors are not retractable.

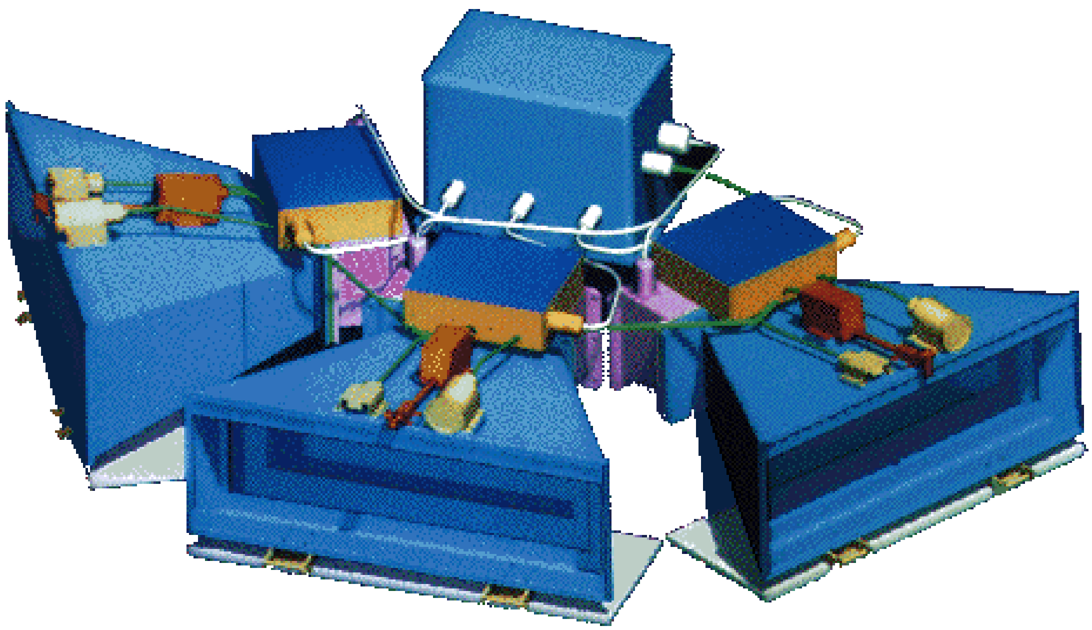

Figure 1
Solar Mass Ejection Imager Conceptual Drawing

3.1.1. Coordinate System

The spacecraft coordinate system is shown in Figure 2. In ddition, each Camera component has its own coordinate system, which is shown in Figure 3.

3.1.2. Dimensions

The DHU dimensions listed below are precise. Dimensions listed below for each Camera component are maximums. Each radiator design (size) will be unique to

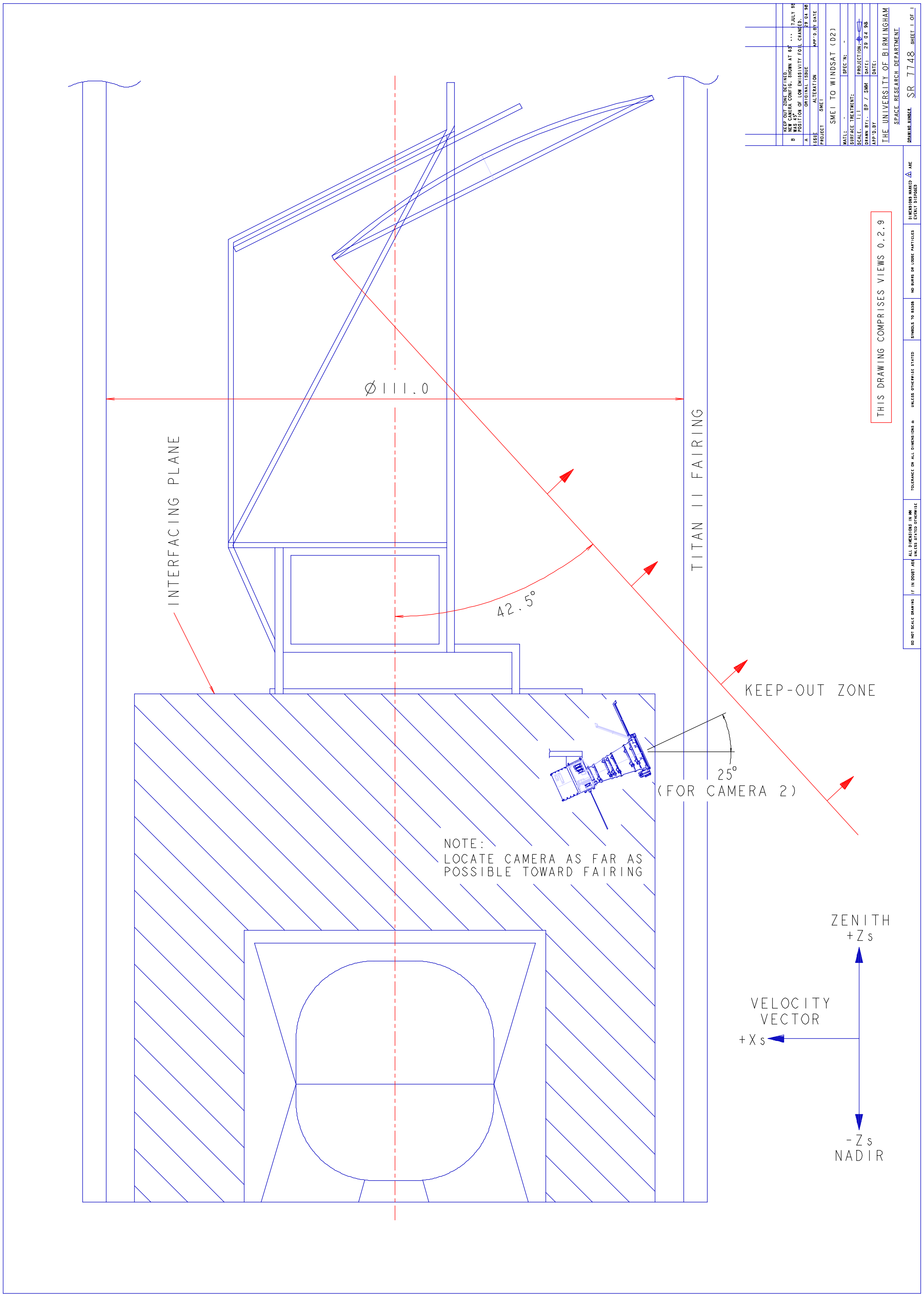

Figure 2
Possible Mounting Location for Camera 2

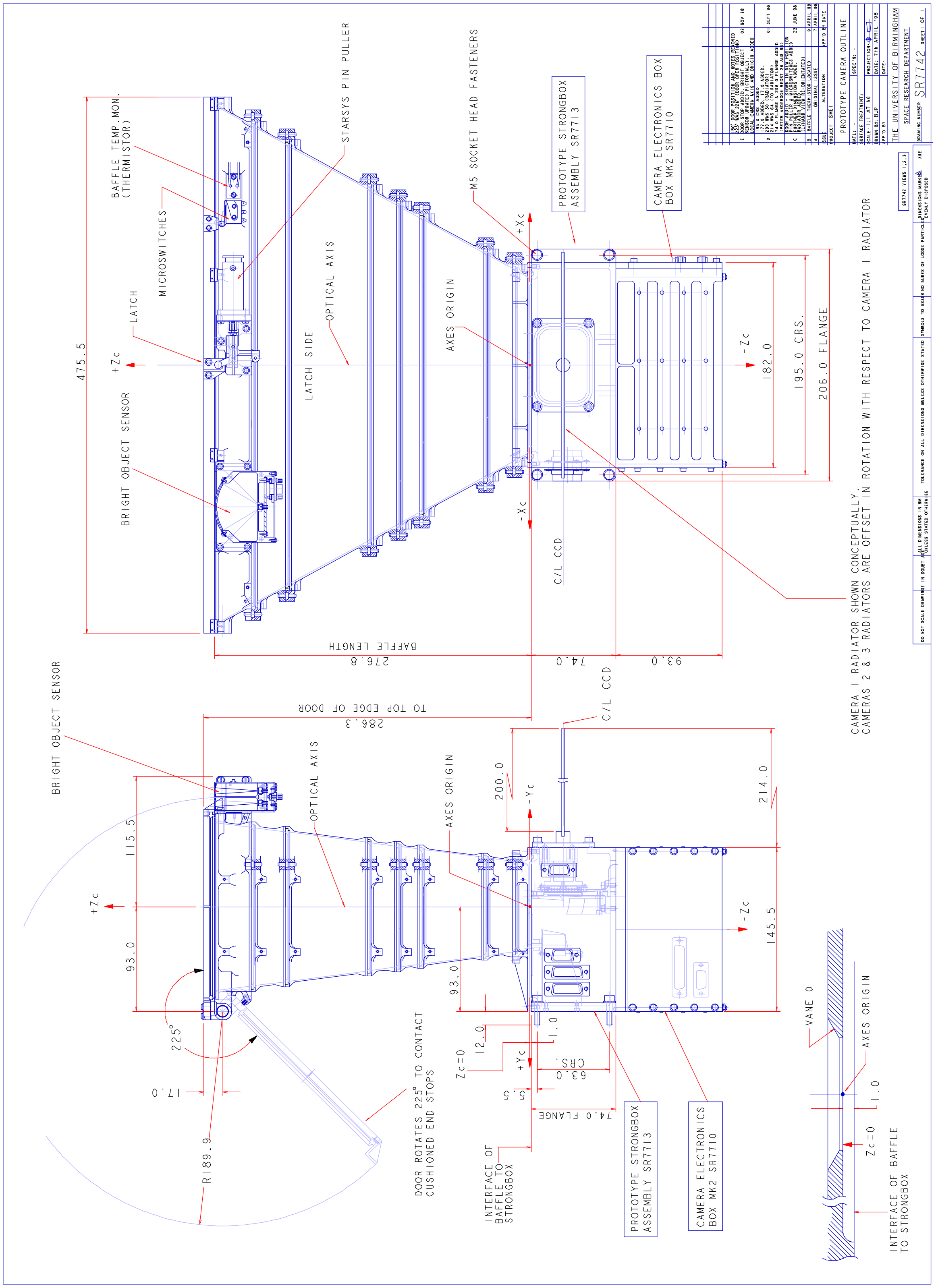

Figure 3
SMEI Camera Component (Typical 3)

the location of each Camera component. The radiator sizes will be determined after the thermal analysis on the Camera components has been completed.

Component:		Dimensions: (D x W x H)
Data Handling Unit		30.0 x 26.1 x 9.36 cm (11.8 x 10.3 x 3.7 in)
Camera 1		50.0 x 50.0 x 25.0 cm (19.7 x 19.7 x 9.8 in)
Camera 2		50.0 x 50.0 x 25.0 cm (19.7 x 19.7 x 9.8 in)
Camera 3		50.0 x 50.0 x 25.0 cm (19.7 x 19.7 x 9.8 in)
Radiator 1	(TBD)	20.0 cm x 20.0 cm (7.9 x 7.9 in)
Radiator 2	(TBD)	20.0 cm x 20.0 cm (7.9 x 7.9 in)
Radiator 3	(TBD)	20.0 cm x 20.0 cm (7.9 x 7.9 in)

3.1.3. Mechanical Interfaces

Several possible arrangements exist for mounting the SMEI Camera Assembly, including the passive radiators, to a spacecraft deck. The baffle opening of each Camera component shall have an unobstructed field of view beyond the exterior surface of the spacecraft. One possible mounting location for Camera 2 with an attached radiator is shown in Figure 2. An outline drawing of a typical SMEI Camera component detailing the mounting features and coordinates (X_C, Y_C and Z_C) is shown in Figure 3. An interface drawing of the SMEI DHU detailing the mounting features is shown in Figure 4. The SMEI equipment shall mounted such that the cable length between the DHU and each Camera component does not exceed two meters. The connector panel on the DHU shall have a minimal clearance of 10 cm, to provide enough space for the EMI connector backshells and the bending radius of the cables.

3.2. Electrical Connections

All electrical interfaces will be made between the spacecraft and the DHU. SMEI shall provide its own intra-experiment harnesses excluding the EMI backshells. The spacecraft contractor shall provide the interface harnesses between the spacecraft bus and the payload (SMEI) as well as the EMI backshells for all intra-experiment harness connectors (standard Cannon D-subminiature). All harnesses shall be properly shielded. In addition, power and signal (data) lines shall be routed in separately shielded cables within each harness. A system level block diagram outlining all of the electrical connections is shown in Figure 5.

SMEI requires redundant power lines on a 15 pin D-subminiature connector, which is shown in Figure 6. The DHU will allow only one set of redundant power lines to be enabled at a time. Switching between the redundant power supplies will be controlled by discrete commands sent via the SOC. Both sets of power lines shall have overcurrent protection at the source of spacecraft power distribution. A block diagram of one of the two redundant processor systems in the DHU is shown in Figure 7.

Physical connection of the telemetry and command interface (MIL-STD-1553B) and the two (redundant) 1 Hz sync signals (provided by the spacecraft) shall be completed via a

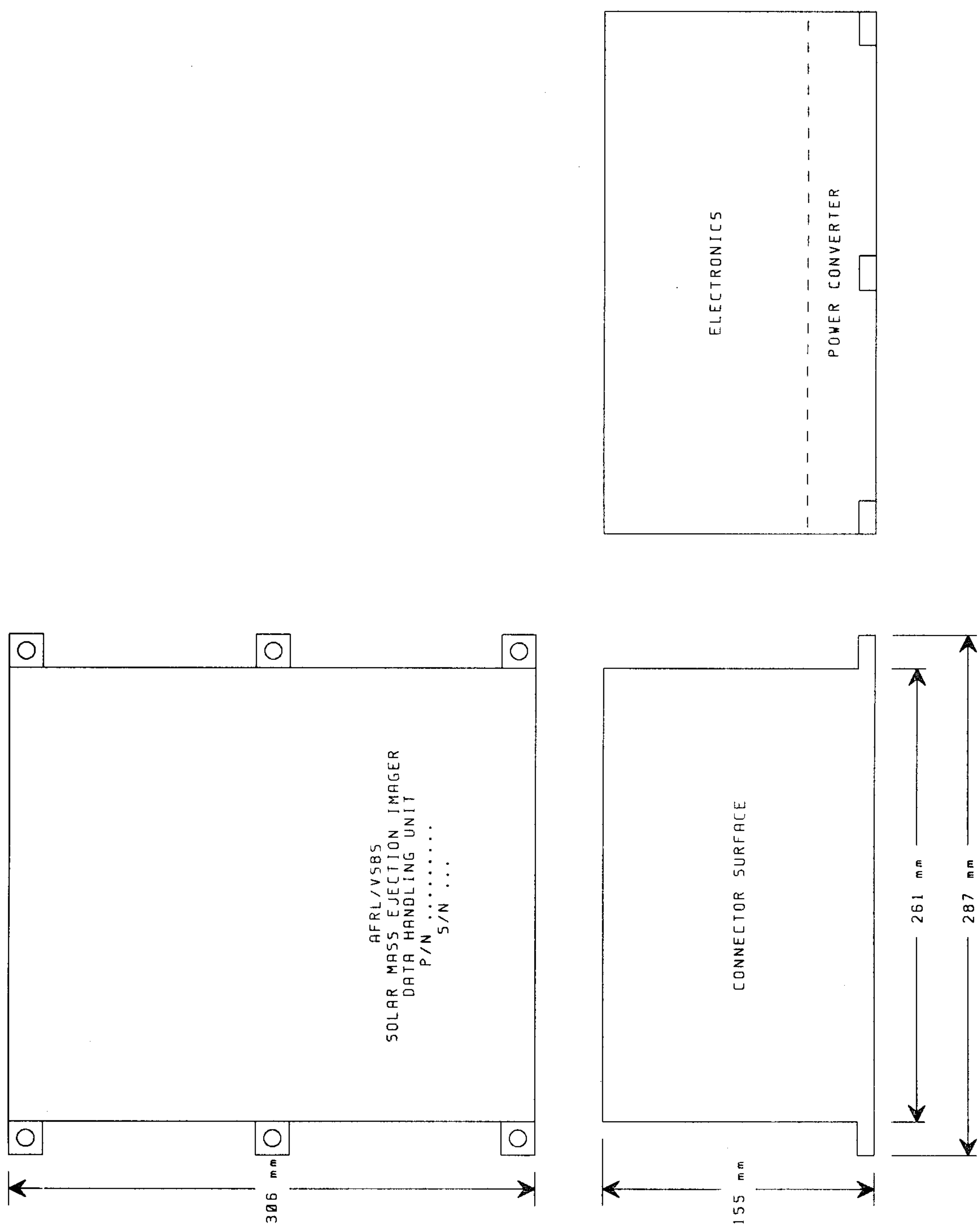

Figure 4
SMEI Data Handling Unit

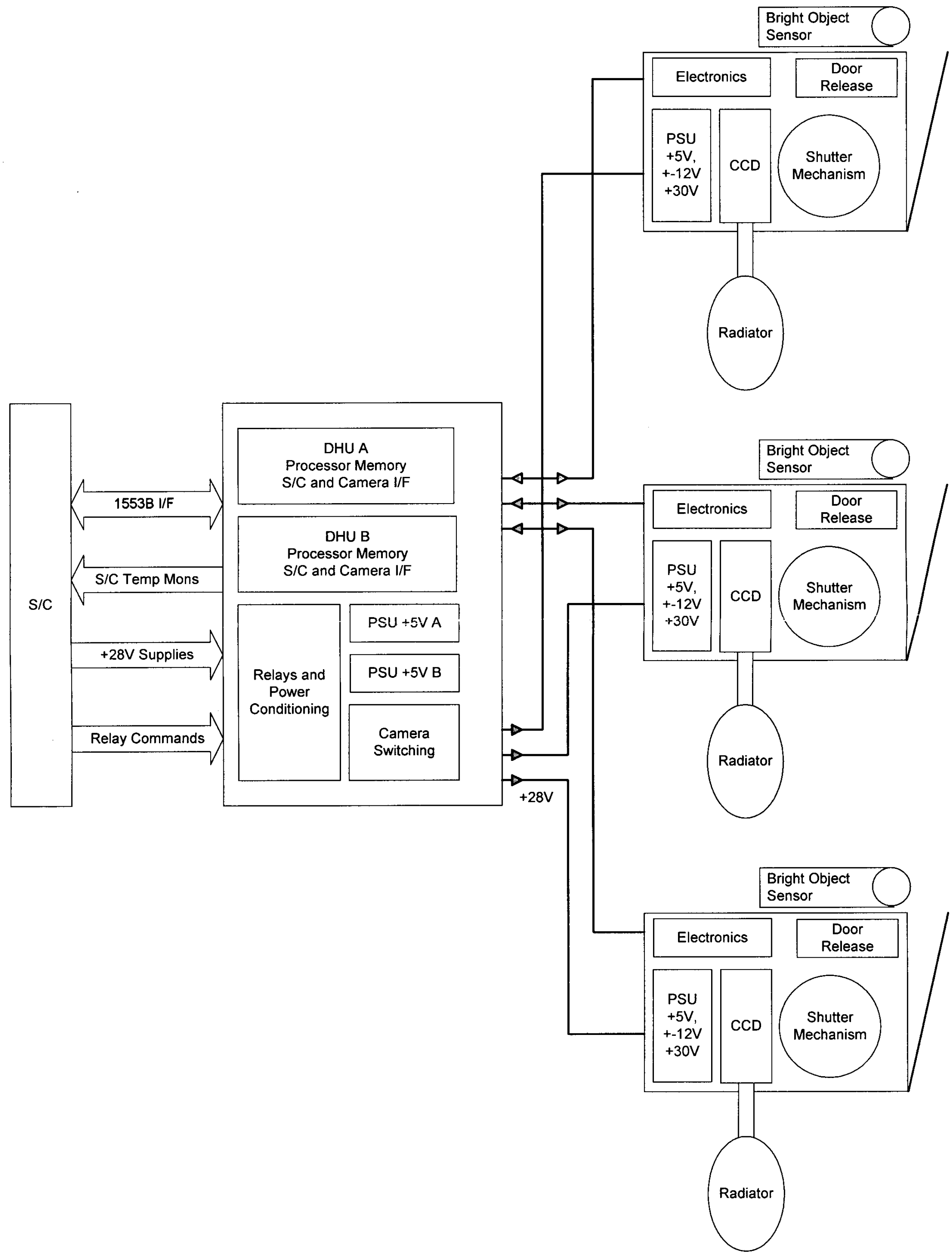

Figure 5
SMEI System Level Block Diagram

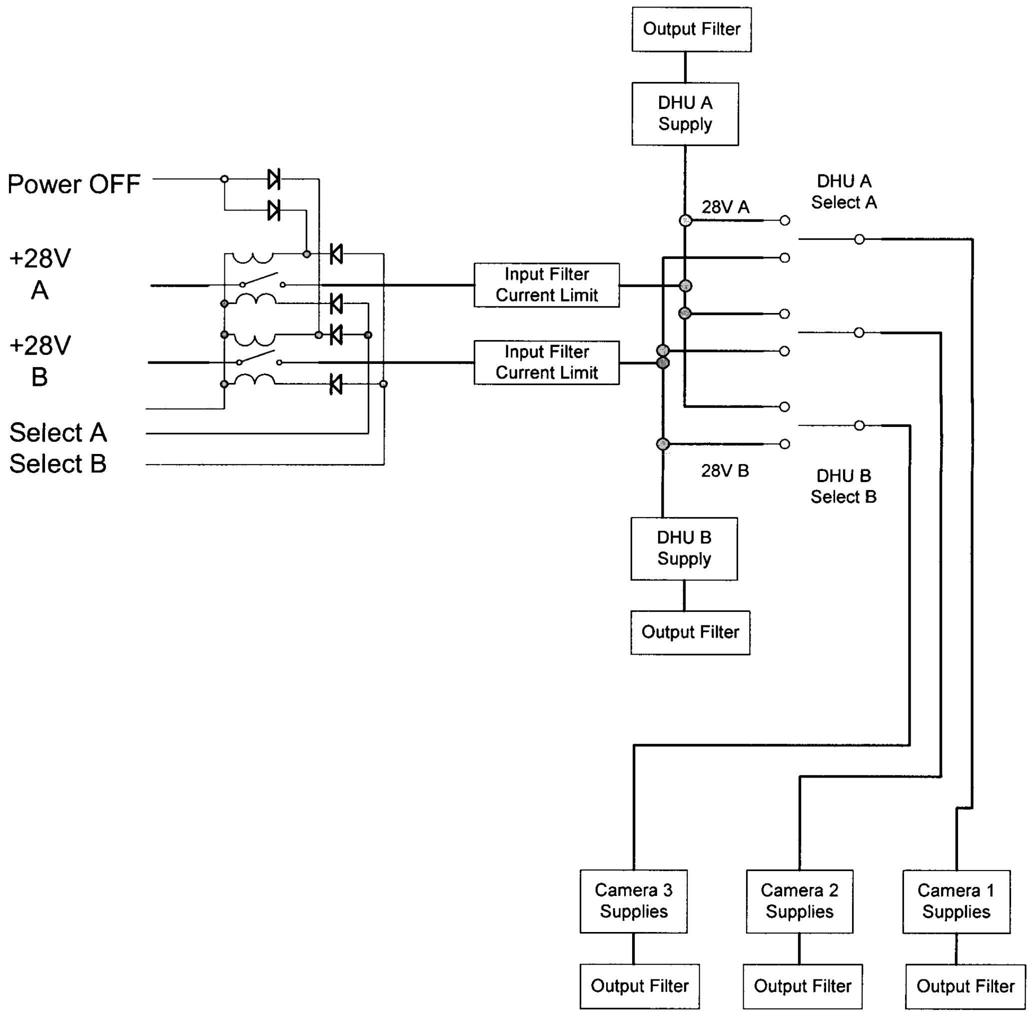

Figure 6
SMEI Data Handling Unit Redundant Power System Block Diagram

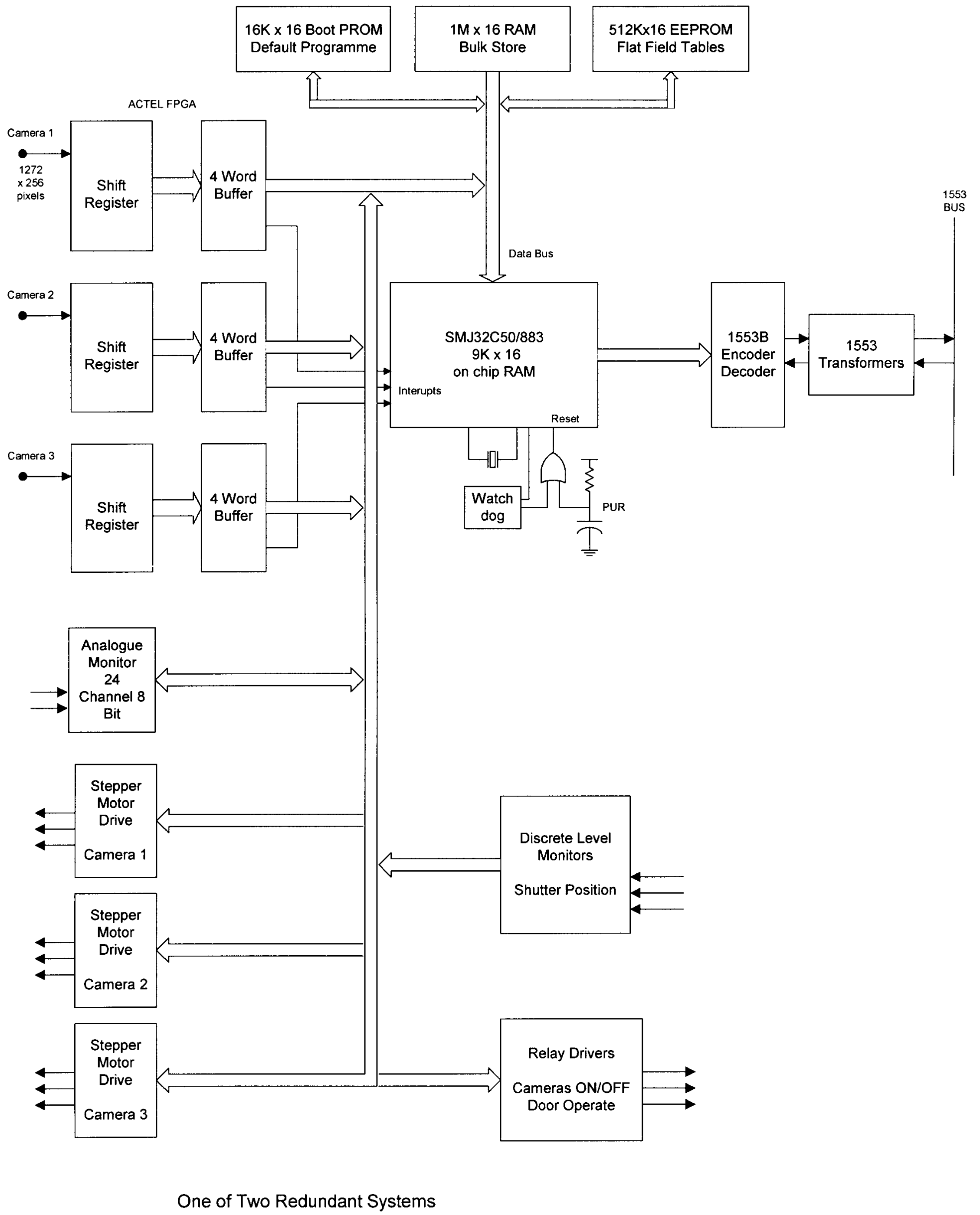

Figure 7
SMEI Data Handling Unit Processor Block Diagram

15 pin D-subminiature connector. The 1553B terminal address will be patched internally on the CPU board prior to delivery; external terminal address adjustments are not feasible. A 9 pin D-subminiature connector shall be provided for receiving three discrete commands as shown in Figure 7. SMEI will not need access to the exterior spacecraft ground support equipment test port.

3.3. Mass Properties

3.3.1. Weight Summary

The total orbital mass of the SMEI experiment will not exceed 35.9 kg (79.2 lbs.). A preliminary weight summary including a contingency (10 %) is as follows:

Item:	Weight:
Data Handling Unit	6.5 kg (14.3 lb.)
Camera 1	8.2 kg (18.1 lb.)
Camera 2	8.2 kg (18.1 lb.)
Camera 3	8.2 kg (18.1 lb.)
Intra-experiment harnesses	1.5 kg (3.3 lb.)
Contingency (10 %)	3.3 kg (7.2 lb.)
Total	35.9 kg (79.2 lb.)

Note: Each Camera component weight includes baffle, bright object sensor, strongbox, radiator, and electronics box. Not included in the experiment weight summary are the sun shields (see Section 3.1) and the spacecraft-provided EMI connector backshells.

3.3.2. Center of Mass

The position of the center of mass (CoM) of the SMEI experiment components will be provided in the Interface Control Document (ICD). The mass properties for the experiment components shall be provided to the spacecraft contractor to support structural testing. In general, the CoM of each Camera component will be approximately 1/3 of the distance from the Electronics Box end of the Camera component to the Baffle Door end in the Zc direction, and approximately centered in the Xc and Yc directions. The CoM of the DHU will be approximately in the center of the package.

3.3.3. Mass Moment of Inertia

Each Camera component is estimated to have the following moments, taken about the origin of the Camera component coordinate system (see Figure 3):

Ix_C 0.155 kg-m^2 (Narrow FOV)
Iy_C 0.180 kg-m^2 (Broad FOV)
Iz_C 0.0574 kg-m^2 (Baffle axis)

3.4. Moving parts

Camera Shutter: (one in each strongbox with each Camera component):

- Range of motion	∅12 cm shutter, rotating in 90° steps, when commanded
- Velocity	2 radian/second maximum
- Momentum	0.03 kg-cm/sec

Baffle Doors:

- Range of motion	0° - 225° (see Figure 3)
- Velocity	180° /sec maximum
- Momentum	16 kg-cm/sec
- Release shock	0.16 kg-m/sec
- Doors, spring hinged	released once per mission

3.5. Mounting and Alignment

The SMEI experiment shall be mounted on a three-axis stabilized, nadir-pointing spacecraft. The experiment must be mounted such that each of the three Camera components will cover a different 60° wide, fan-shaped piece of the zenith-facing hemisphere, as defined by the SMEI experiment pointing requirements (see below), thereby covering as much as possible of the 180° of sky. In addition, each Camera component shall be mounted such that the brightness entering its baffle from any and all spacecraft or experiment appendages does not exceed the levels shown in Figure 8.

Note on interpreting Figure 8: Based on the assumption that the appendages do not reflect specularly (like a mirror), the following approximation can be used to evaluate the impact of a protrusion on SMEI baffle performance. Each protrusion's solid angle in steradians, measured from the position of each SMEI baffle opening, weighted (multiplied) by the protrusion albedo, and then multiplied by 0.32 gives this estimate. The total effect of all protrusions should remain below the limits given in Figure 8. Note that Figure 8 gives a somewhat pessimistic limit of SMEI baffle performance in the region beyond the exclusion zone (see Section 3.6), and, thus, should be used only as a guide in positioning SMEI Cameras.

To aid in reducing the level of light entering the baffle, the spacecraft appendages (which are of concern with respect to the exclusion zone and Figure 8) can be made small, blackened, or otherwise engineered to minimize their brightness.

The most desirable pointing for the Camera Assembly is in the plane that includes the zenith. In this case, the fan-shaped fields of view (FOV) shall be oriented approximately with the baffle wide dimension perpendicular to the plane containing the spacecraft zenith and its velocity vector. In the case of non-zenith viewing the baffles of the experiment must be directed away from the spacecraft velocity vector. It is not necessary to mount the three Camera components in a line, as long as the FOV requirements are met, including the position requirements of Section 3.6. It is desired to have the baffles of the Camera components protrude beyond the exterior surface of the spacecraft by 7 cm to accommodate the doors when opened.

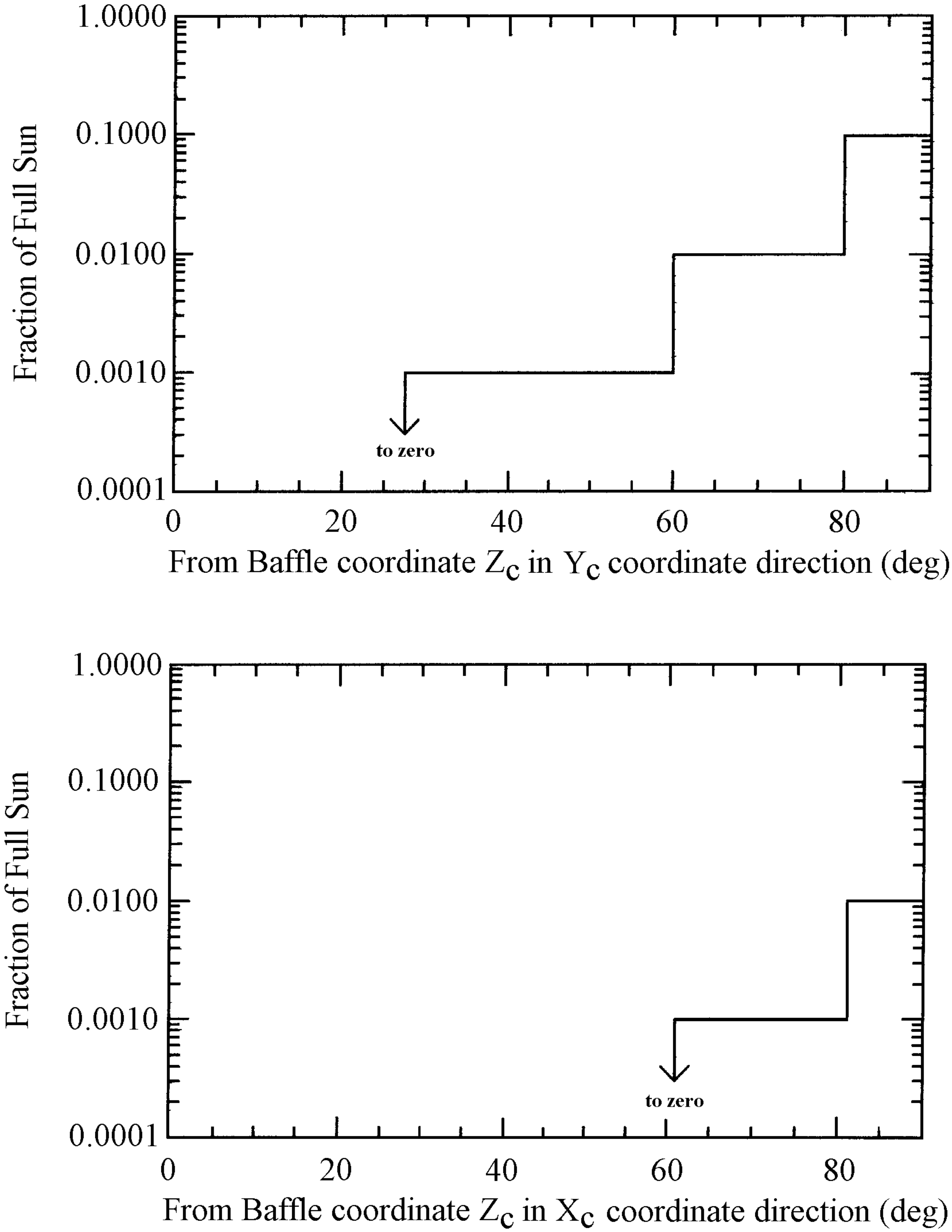

Figure 8
Maximum Allowable Brightness Beyond the SMEI Field Of View

Given the constraints imposed by the WindSat experiment of the Coriolis mission (which requires the spacecraft to be in a sun-synchronous terminator orbit with an evening ascending node), it is anticipated that the best pointing directions for the Camera components are as follows:

Consider the Coriolis spacecraft to be in a perfectly polar orbit at the time of one of the Equinoxes so the Sun lies perfectly in the equatorial plane. Consider further that the spacecraft is over the Earth's North Pole when we define its coordinate-axis directions. Then,

- Define the $+Z_S$ axis as the zenith direction;
- Define the $+X_S$ axis as the spacecraft velocity direction;
- Let the coordinate frame be right handed so that the direction of $+Y_S$ is approximately sunward.

In order to define the Camera Assembly pointing directions and orientations, the individual Camera component coordinate axes (X_C, Y_C and Z_C) are rotated from these initial axes (X_S, Y_S, and Z_S) using Eulerian angular rotations.

EULERIAN ANGLES

Eulerian angles are often used to specify 3-dimensional orientations. The orientation of each of the three Camera components can be specified by giving for each the angles [, ,]. The first two angles specify the baffle Camera component centerline orientation, and the final specifies the polar orientation of the baffle around this centerline. For more description of the Eulerian angles, see:

Classical Mechanics by Herbert Goldstein (Addison-Wesley 1957), §4-4, page 107; or **Mechanics** by Keith R. Symon (Addison-Wesley 1971, 3rd ed.), §11.4, page 451; or probably any other similar book.

The first angle ϕ describes a rotation about the $+Z_S$ axis to define a new $+X_C$ axis about which the second rotation θ will take place. After these, the new $+Z_C$ axis defines the baffle/Camera component centerline. The final angle ψ defines the amount of rotation of the baffle's long dimension ($+X_C$) about the $+Z_C$ axis.

Roughly, Camera 1 views away from the Sun, Camera 2 views slightly above the velocity vector away from the direction of motion, and Camera 3 views towards the Sun. With the following orientations, the three Camera components will cover the sky except for a patch of sky near the Sun that is 20° in radius and a small antisolar patch of a few degrees. In a terminator orbit the sunward-pointing camera (Camera component 3) will at times during the course of a year have the Sun pointing directly into the optics. The Camera component shutter will close during these times to protect the optics. Preliminary values for the Eulerian angles of the three SMEI baffle/Camera components are shown in Table 1. All angles are shown in degrees.

Baffle/Camera No.	ϕ	θ	ψ
1	-28	+79	-13
2	-86	+65	0
3	-144	+68	-5

Table 1

SMEI Camera Component Eulerian Angles

Please note that these proposed pointing directions should be considered subject to slight change until the WindSat experiment and spacecraft bus and orbital parameters are better determined. Three views of the Camera Assembly are shown for reference in Figure 9; the Camera components in these views have been rotated through the Eulerian angles from Table 1.

The DHU shall be located inside the spacecraft structure near the three Camera components, such that intra-experiment harnesses do not exceed 2 meters. The spacecraft is required to be designed to have an equipment arrangement which minimizes contamination of the SMEI Camera Assembly from other experiments and from propulsion systems as set forth in Section 7.7. Each SMEI Camera component will be optically aligned to meet the orientation specifications of Table 1 to within ± 0.5° in each of the three coordinate axis directions. The alignment of each Camera component shall be measured to within ± 0.1° before and after spacecraft vibration testing. Each Camera component will have an alignment cube attached to the top of its baffle near its bright object sensor. The cubes will be mounted on adapter blocks to bring their faces into mutual alignment despite the different orientations of the Camera components.

The spacecraft shall provide a clean, electrically conductive mounting surface, which meets the requirements of MIL-B-5087B, Class R, for each SMEI component. A maximum electrical bonding resistance of 2.5 milliohms (0.0025 ohms) shall be maintained.

3.6. Field of View Requirements

Each of the three SMEI Camera components has a fan-shaped FOV, with 3° x 60° of full-aperture sky-imaging and 5° x 62° of full FOV. The fields of view up to 90° from the pointing direction of the baffles shall be clear and free from scatter, glint, or reflections from spacecraft appendages or other objects, including solar panels according to:

1) No appendage should intrude within an exclusion zone 27.5° from the central axis of the FOV of each Camera component in the narrow baffle dimension (Y_C) and 61° from the central axis of the FOV in the long baffle dimension (X_C).
2) Beyond these angles, appendage integrated visible-light brightness should not exceed the fraction of full Sun levels given in Figure 8. In cases where this requirement cannot be met, the following suggestions may be implemented:
    a) The spacecraft and WindSat appendages may be blackened or otherwise engineered so that they do not glint or otherwise reflect bright sunlight into the SMEI baffle entrance apertures.

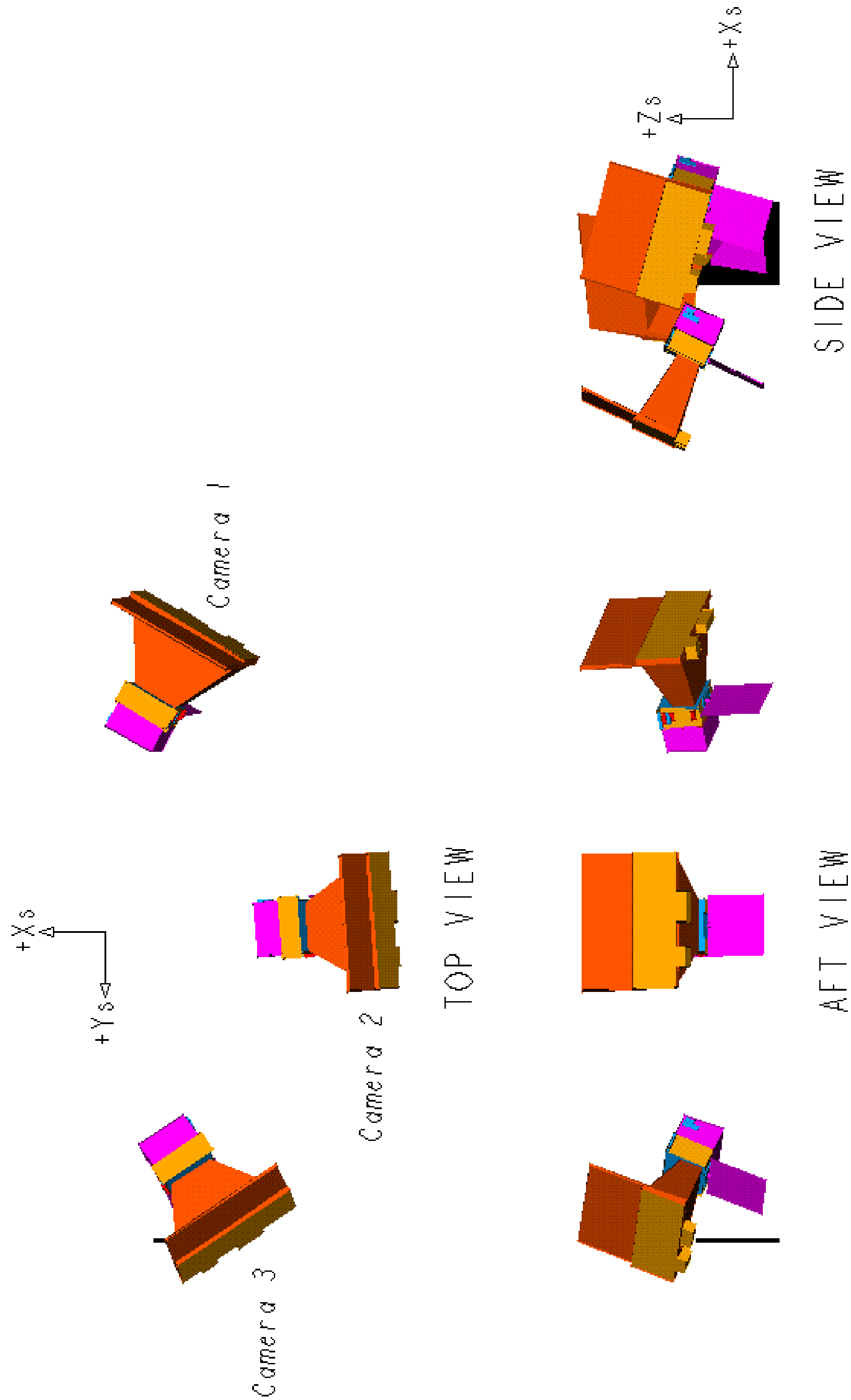

Figure 9
SMEI Camera Assembly

b) The bright spacecraft and WindSat appendages may be covered by a non-reflecting surface on the spacecraft that blocks these appendages and that is less reflecting than the specifications given in Figure 8.

The mounting shall allow the hinged baffle door on any given Camera component to be out of the FOV of the remaining Camera components

3.7. Experiment Models / Simulators

Mass models of the three Camera components and the DHU will be provided to the spacecraft contractor. The mass models will match the physical envelope, mass, and CoM of each of the SMEI components. Electrical simulators will not be provided; however, the DHU engineering model will be made available to the spacecraft contractor for interface compatibility testing.

4.0 ELECTRICAL INTERFACE REQUIREMENTS

4.1. Electrical Power Requirements

4.1.1. Power Supply

The SMEI input power from the spacecraft shall be at a voltage of 28 ± 6 Vdc.

4.1.2. Power Consumption

Maximum: 40 Watts
Nominal: 38 Watts (Orbit Average)
Standby: 8 Watts

The SMEI experiment requires continuous spacecraft power over long periods of time. The exception would be for spacecraft health reasons. Spacecraft power will be used for power converters located in each Camera component and the DHU. Spacecraft power will also be used in each Camera component for the shutter stepper motor, the Peltier CCD cooler (contingent on the results of the thermal analysis) and the baffle door release mechanism. The baffle doors will be opened one at a time with High Output Paraffin (HOP) actuators. Each HOP consumes 5 watts (maximum) of 28 Volt power for 250 seconds and will be opened with a command uplinked to the DHU. In the Standby mode, the microprocessor and memory will be in a low power keep-alive mode, while the Camera components will consume no power. Spacecraft heaters may be required during the Standby mode depending upon the results of the spacecraft thermal analysis.

Component Name	Nominal Power (W)	Peak Power (W)	Average Power (W)
Data Handling Unit	8	10	8
Camera 1	5	5	5
Camera 2	5	5	5
Camera 3	5	5	5
Peltier Coolers	5/Camera	5/Camera	5/Camera
Total	**38**	**40**	**38**

Table 2
Experiment Power Requirements

Experiment Ops Mode	Power (W)	Duration of Ops Time (% of orbit or days)	Frequency of Operations
Standby	8	0 %	Nominally, never used

Experiment Ops Mode	Power (W)	Duration of Ops Time (% of orbit or days)	Frequency of Operations
Science Baseline Mode	38	100 %	Near continuous
Science High Resolution Mode	38	1 day	Approximately once every 120 days
Engineering Mode	38	1 day	Once every 30 to 60 days

Table 3
Experiment Operational Power Requirements

Standby Mode - Operates the DHU only.
Science Baseline Mode - Operates all three Camera components 100 % of the time. CCD pixels are binned (4 x 4) before being passed to the spacecraft.
Science High-Resolution Mode - Operates one Camera component 100 % of the time. The other two Camera components are left powered for thermal reasons. CCD pixels are binned (2 x 2) before being passed to the spacecraft.
Engineering (Flat Field) Mode - Read out every CCD pixel (1 x 1 - no binning) to test chip integrity.

4.2. Input/Output Signal Interfaces

4.2.1. Bi-Directional Interfaces (Command/Telemetry via spacecraft data bus)

MIL-STD-1553B

4.2.2. Experiment Inputs (Discrete and Analog)

Two redundant 1 Hz timing pulses are required having the following characteristics:

Pulse logic -	Positive
High level -	5.0 Vdc nominal 4.5 Vdc minimum 5.5 Vdc maximum
Low level -	0.0 Vdc minimum 0.5 Vdc maximum
Load current -	10 mA nominal 20 mA maximum
Pulse width -	10µS minimum 500 mS maximum
Rise and fall times -	1 µS maximum

Three discrete relay commands are required having the following characteristics:

Pulse logic -	Positive
High level -	28 Vdc nominal 22 Vdc minimum 34 Vdc maximum
Load current -	100 mA maximum
Pulse width -	50 mS minimum 250 mS maximum
Rise and fall times -	Non-critical

4.2.3. Experiment Outputs (Discrete and Analog)

Four spacecraft analog temperature monitors are required for monitoring the temperature of each of the three Cameras and the DHU whether the SMEI experiment is powered on or off. Each of the temperature monitors shall have a minimum range of –50 °C to +60 °C with each having 8-bit resolution.

5. COMMAND AND CONTROL

5.1. Command Interface

MIL-STD-1553B interface, plus three discrete commands.

5.2. Spacecraft Command and Data Handling

The DHU will be activated via an unlinked command to the spacecraft bus from the SOC (see Section 2.3.1.). Commands will be uplinked through the 1553B interface to the DHU to turn on each Camera component, and to initiate the sequence of opening the baffle doors (see Section 4.1.2.). An occasional SMEI mode change command or a block of software upgrades will be uplinked in real time. SMEI does not have a requirement for time-tagged commands. The three discrete commands will be used to switch between redundant power supplies as needed (see Section 3.2.).

5.3. Clock/Time Reference Requirements

The format of time shall be based on the use of the GPS UTC time representation. As a baseline, on-board absolute correlation of the time shall be to within one millisecond. Time representation shall be transmitted over the 1553B interface once per second and shall correspond to the rising edge of the 1 Hz timing pulse, which is required to be supplied redundantly. The redundant timing pulses shall be synchronized to provide a reference to the active 1553B bus.

6. TELEMETRY AND DATA HANDLING

6.1. Telemetry System

MIL-STD-1553B

6.2. Experiment Data Collection & Storage

The SMEI experiment generates 201.6 Mbits/hour (12.6 Mwords/hour) of continuous data after compression, which does not include the sync and parity bits. SMEI does not have a large internal buffer for storing images if the 1553B bus encounters any problems. Data from all modes will be transferred at the rate of 56 kbps to the spacecraft telemetry system in real time. The spacecraft telemetry system is required to store all data between Earth station passes until data can be downlinked. A SMEI data flow chart is shown in Figure 10.

6.3. Experiment Data Transfer

6.3.1. Experiment Data Download Requirements

SMEI data from the Science Modes will be compressed and transferred to the spacecraft for downlinking at the rate of 56 kbps. SMEI will generate 604.8 Mbytes per day (302.4 Mwords/day) after compression on a continuous basis. SMEI does have an internal 1 Mword buffer for storing up to 5-6 consecutive images from one Camera component during the Engineering Mode, which occurs once every 30 to 60 days. While the experiment is in the Engineering Mode, the images will be downlinked until the buffer has been emptied. If a higher spacecraft telemetry rate (up to 500 kbps) is available during the Engineering Mode, SMEI would use whatever is available to expedite downlinking the contents of the buffer. During spacecraft standby operations, DHU housekeeping data from every other orbit is desired. Standby would be defined as the spacecraft having limited power and telemetry resources available.

6.3.2. Data Transfer

Rate: 56 kbps of data after compression; does not include sync and parity bits.
Protocol: MIL-STD-1553B

6.3.3. Data Integrity

Bit error rate must be less than 10^{-6}.

6.4. Spacecraft Data

Spacecraft attitude, position, time, temperature and experiment command history will be required for post-processing. All data shall be updated once per second except for the temperature, which shall be updated at least once every 16 seconds.

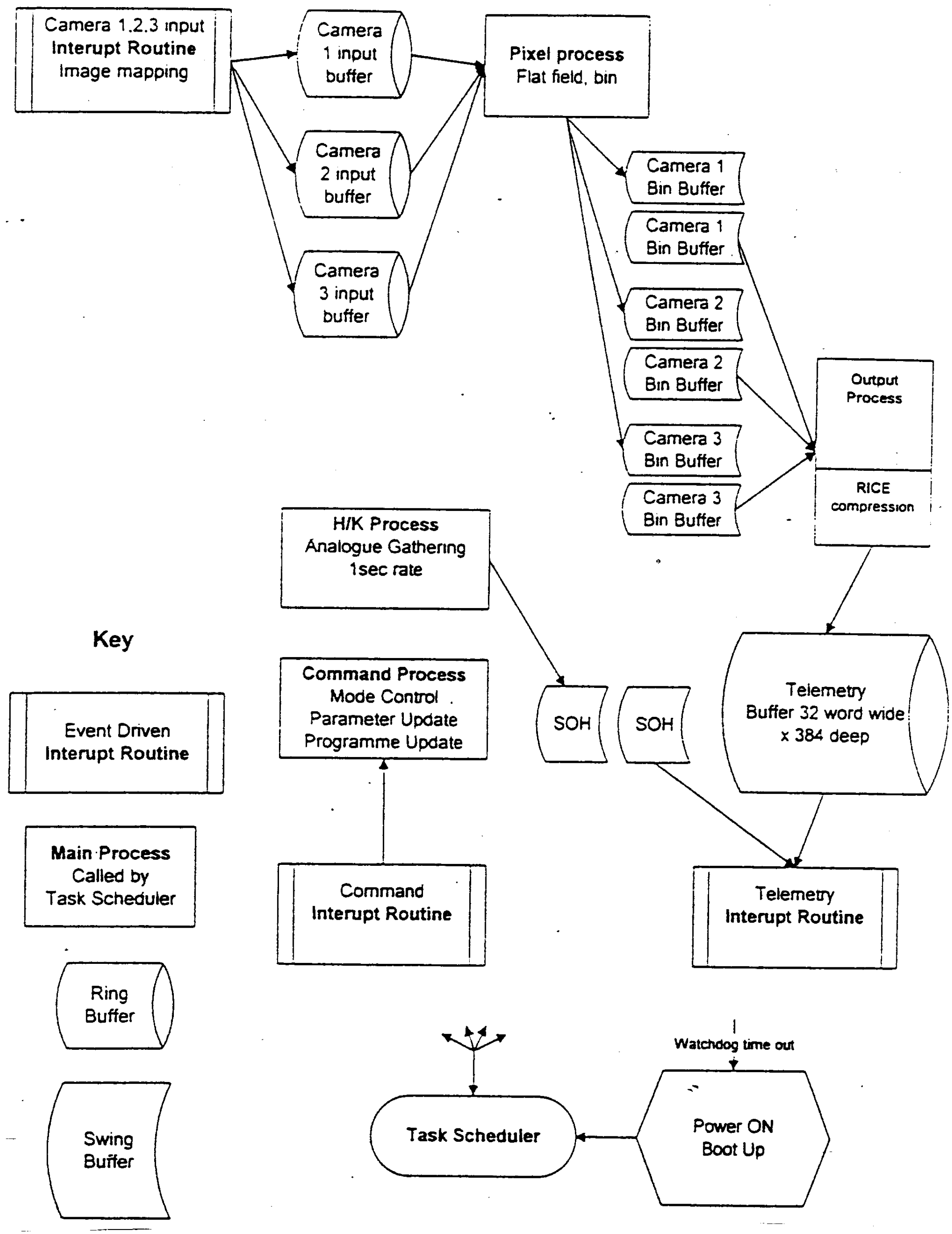

Figure 10
SMEI Data Flow Chart

7. ENVIRONMENTAL REQUIREMENTS

7.1. Static Load Constraints

The experiment will be designed to meet the static load requirements of any launch vehicle, such as, Atlas, Delta, Pegasus, Taurus, Titan II, etc.

7.2. Vibration Constraints

The experiment will be designed to meet the vibration requirements of any launch vehicle, such as, Atlas, Delta, Pegasus, Taurus, Titan II, etc.

The expected vibration exposure at launch is enveloped by the following power spectral densities (PSDs).

For engineering model components:

- Increasing 6 db/Octave from 10 Hz to 15 Hz
- 0.2 g^2/Hz from 15 Hz to 1500 Hz
- Decreasing 6 db/Octave from 1500 Hz to 2000 Hz
- Composite spectrum: 19 g rms
- Duration: 3 minute exposure in each of three axes

For flight components:

- Increasing 6 db/Octave from 10 Hz to 15 Hz
- 0.13 g^2/Hz from 15 Hz to 1500 Hz
- Decreasing 6 db/Octave from 1500 Hz to 2000 Hz
- Composite spectrum: 15 g rms
- Duration: 1 minute exposure in each of three axes

7.3. Shock Constraints

The SMEI design is compatible with all known launch vehicles. The design will withstand at least 50 g positive or negative shock pulse in each of three axes.

7.4. Radiation Constraints

The experiment 's parts shall have a radiation tolerance at the component level of 10 kilorads over a two year mission. The SMEI mechanical design provides shielding of at least 4 mm of aluminum. The experiment will not have any radioactive sources.

7.5. Electromagnetic Compatibility

The experiment shall be designed to be compatible with itself, with its known environment, with the spacecraft, with test equipment and with government furnished equipment. The experiment shall meet the electromagnetic compatibility requirements in accordance with MIL-STD-1541A and MIL-STD-461D.

7.5.1. Radiated Emissions from Experiment

SMEI will be tested in accordance with MIL-STD-461D.

7.5.2. Conducted Emissions from Experiment

SMEI will be tested in accordance with MIL-STD-461D.

7.5.3. Magnetic Fields Generated by Experiment

SMEI will be tested in accordance with MIL-STD-461D.

7.5.4. Sensitivity of Experiment to Radiated Emissions

SMEI will be tested in accordance with MIL-STD-461D.

7.5.5. Sensitivity of Experiment to Conducted Emissions

SMEI will be tested in accordance with MIL-STD-461D.

7.5.6. Sensitivity of Experiment to Magnetic Fields

None

7.6. Atmospheric Pressure Constraints

SMEI will be designed to withstand the launch vehicle depressurization rates.

7.7. Cleanliness Constraints

The spacecraft integration and test area at the spacecraft contractor's facility shall conform to the requirements of a Class 100,000 clean room. During those periods requiring spacecraft location outside of this integration and test area, the three Camera components shall be bagged with an anti-static polyethylene cover and purged with nitrogen.

Transporting the spacecraft to the launch pad shall be done with a shock-mounted container. Temperature, humidity and load information shall be recorded during transport.

The spacecraft and experiments shall be manufactured using materials in accordance with ASTM-E595-84 so the outgassing characteristics are not greater than the following:

0.1 % volatile condensable material (VCM) loss in vacuum
1 % total mass loss (TML) in vacuum

Any component that cannot meet the above requirements shall be encased to prevent contamination of adjacent equipment. Contamination control is required for maintaining a clean environment around the SMEI Camera Assembly which has critical internal components. Contamination on the baffle surfaces, on the aluminum mirrors and on the exposed CCD surfaces would greatly flaw the downlinked visual light images.

The spacecraft shall be designed to have an equipment arrangement, which minimizes contamination of the SMEI Camera Assembly from experiments and from the propulsion system.

7.8. Humidity Constraints

The integration facility shall be maintained with a room temperature of 20° ± 6° C and with a relative humidity of 45 ± 10 %.

7.9. Thermal Interface Requirements

The spacecraft shall provide the necessary controls to maintain the temperature of the thermal reference points within the ranges shown in Table 4 for all orbital conditions. The reference points for SMEI are defined as the DHU, Camera 1, Camera 2 and Camera 3 mounting surfaces. The experiment turn-on sequence may commence when the spacecraft temperature monitors reach -20°C, prior to reaching the minimum operating temperature.

Component Name	**Non-Op Temp Min (deg C)**	**Non-Op Temp Max (deg C)**	**Op Temp Min (deg C)**	**Op Temp Max (deg C)**
Data Handling Unit	- 40	+ 50	- 10	+ 50
Camera 1	- 40	+ 50	- 10	+ 20
Camera 2	- 40	+ 50	- 10	+ 20
Camera 3	- 40	+ 50	- 10	+ 20

Table 4
SMEI Thermal Requirements

The spacecraft shall control thermal gradients on the mounting surfaces of the SMEI experiment to 0.5° C per inch or less. Spacecraft thermal control shall not cause the temperature of SMEI to change at a rate greater than 20° per hour. The spacecraft contractor shall be responsible for applying spacecraft thermal finishes and heaters depending upon the results of the spacecraft thermal analysis. The spacecraft contractor shall also provide 4 temperature monitors (thermistors) mounted on each of the 4 components or adjacent to the components on their respective mounting surfaces.

7.9.1. Thermal Isolation

The SMEI components can be thermally isolated or coupled to the spacecraft, depending upon the results of thermal analysis. The DHU will dissipate up to 10 watts into the mounting surface and each Camera component will dissipate up to 5 watts into the mounting surface at each location. The heat dissipated into the mounting surface is valid in all modes of operation. If thermal analysis dictates the use of Peltier coolers, an additional 5 watts per Camera component will be dissipated into the mounting surface.

7.9.2. Incident Thermal Flux

TBD watts/ft^2

8. INTEGRATION AND TEST

8.1. Spacecraft Integration and Test

8.1.1. Pre Spacecraft Integration Inspection & Test

Prior to delivery, SMEI desires to perform an interface compatibility test between the spacecraft 1553B telemetry system and the DHU engineering model (refer to Section 3.7). At delivery, an incoming Bench Acceptance Test (BAT) will be performed in a Class 100,000 clean room to assure the experiment was not damaged in shipment.

8.1.2. Post Spacecraft Integration Test Requirements

A detailed electrical test, including stimulation of each Camera component with a light source, will be performed on the spacecraft after initial integration.

8.1.3. Ground Support Equipment (GSE) and Facilities

The GSE will consist of a computer and printer. Two additional computers and an additional printer will be used for support purposes, one of the computers requiring continuous access to the internet, with at least two IP addresses. Two desks, two tables, and 115 VAC at 2 kilowatts of power will be required as well as spacecraft telemetry (MIL-STD-1553B downlink data line). Access to a DHU test port is required for monitoring DHU interaction with the 1553B interface during spacecraft integration. It is desired to have telephone, fax, and copier access, as well as storage for shipping containers.

8.1.4. Ground Handling Procedures

Aside from the cleanliness requirements given in Section 7.7. and the spacecraft contractor's handling and contamination control procedures, there are no other special requirements for handling flight components. The optical path in each Camera component is protected from harmful light sources and contamination when the baffle door is closed. Note that particulate matter should be kept at a minimum. The baffle doors are to remain closed at all times except when under test by an experiment representative.

8.2. Launch Vehicle (LV) Integration and Test

8.2.1. LV Integration Site Tests

Perform a functional test of SMEI prior to integration of the spacecraft to the launch vehicle. Access to the DHU test port is not required.

8.2.2. LV Integration Site GSE and Facilities

Access to the downlink data line in the integration area from the launch site is required. Access to the DHU test port is not required. A clean room environment is required for the three Camera components using a container purged with nitrogen or anti-static polyethylene cover purged with nitrogen. Particulate matter should be kept at a minimum. SMEI does not have any "Remove Before Flight" red tag items.

8.2.3. Launch Pad Tests

An aliveness test of SMEI is desired. Access to the DHU test port is not required.

8.2.4. Launch Pad Environment

The spacecraft prelaunch processing area at the launch pad shall have temperature and humidity recorded continuously. An equivalent Class 100,000 clean room environment or better is required.

8.2.5. Experiment Access

None

8.2.6. Launch Go/No-Go Criteria

An unresolved experiment anomaly will be the only SMEI no-go criteria.

8.3. Potentially Hazardous Materials & Equipment

8.3.1. Pressurized Systems (Liquid/Gas)

None

8.3.2. Ordnance Systems

The baffle door on each of the three Camera components will be released sequentially with redundant HOP actuators. Each door has one actuator with redundant power control.

8.3.3. Radiation Sources

SMEI has no radioactive sources.

8.3.4. High Voltage Source Locations

None

8.3.5. Experiment Safety During Integration and Test

No safety hazards exist.

9. ON-ORBIT OPERATIONS REQUIREMENTS

9.1. Launch Phase Requirements

None

9.2. On-Orbit Operations

9.2.1. Initialization

Initial turn-on of the SMEI experiment shall occur two weeks after the spacecraft has reached its final orbit to minimize contaminates reaching the critical optical components in each Camera component. After the spacecraft has enabled the power lines to SMEI, the microprocessor in the DHU will initialize and then will be commanded into the Standby Mode. A command will be uplinked to the DHU to start the process of opening the baffle doors sequentially. After the doors have been opened, the DHU will enable power to each Camera component sequentially. When each Camera component is enabled, the thermal control features will begin cooling the CCD chip to the desired operating temperature of -35° C. SMEI will be turned on in the Science Baseline Mode (default).

9.2.2. Checkout

For the initial checkout of the SMEI experiment, 2 full orbits of downlink data will be needed. During subsequent turn-on checkouts, SMEI will require 1 full orbit of downlink data. During the checkout process, the experiment will be commanded into the Science High Resolution Mode and the Engineering Mode.

9.2.3. Experiment Ops

The CCD chips in the SMEI Camera components will need to stabilize at the desired operating temperature of -35° C to minimize imperfections in the images. Once stabilized, the experiment will operate continuously, generating a 3° x 180° sky image every 4 seconds.

9.3. Experiment Turn-On

Initial turn-on of the SMEI experiment shall occur two weeks after the spacecraft has reached the final orbit as described in Section 9.2. Whether the experiment has been enabled from being turned off or from the Standby mode, the experiment must follow the sequence as noted in Section 9.2. As in the initial turn-on, any subsequent turn-on will place the experiment in the default mode (Science Baseline); if the experiment was in a different mode prior to being turned-off, it is not a requirement to return the experiment to that mode. The latest uplinked revisions to the DHU flight software will be retained in the event of an experiment turn-off, due to the permanent storage capability of the E^2PROM.

9.4. Operations Support

9.4.1. Pre-Flight Training and Simulation

SMEI personnel will be available for pre-flight training as required.

9.4.2. Data Return, Processing, and Distribution

The latency period between the time SMEI data has been transferred to the spacecraft telemetry system and the time it has been made available to AFRL shall be no greater than 24 hours during the first year of operation. In the event that SMEI becomes an operational asset, AFRL will seek necessary funding to support a latency period of 6 hours for the remainder of the mission, in order to utilize SMEI's forecasting capability.

9.4.3. Meteorological Services

Not Required

10. ON-ORBIT ORIENTATION AND STABILIZATION

10.1. Attitude Control

The spacecraft shall be stabilized in three axes with a nadir pointing orientation. The spacecraft's change in orientation with respect to the sky due to nadir pointing is approximately 0.24° during a 4 second exposure and will not be compensated for. The pointing accuracy requirement of the spacecraft shall be within ± 0.2° (1 sigma) for pitch and roll and ± 0.5° (1 sigma) for yaw. The jitter must be held below 0.1°/4 sec (3 sigma).

10.2. Attitude Knowledge

Real time attitude knowledge is not required. Post attitude knowledge to an accuracy of 0.1° (1 sigma) for all axes is required for reconstruction purposes only.

11. EPHEMERA DATA

11.1. Prediction/Real Time Knowledge

Orbital elements may be needed occasionally to plan experiment coordination with other satellite experiments. The desire is to have data processing knowledge for the pointing and orientation of each Camera component to within 0.1° accuracy for each 4 second image exposure.

11.2. Post Processed Knowledge

The space vehicle, in combination with standard SOC resources, shall provide the capability to allow ephemerides to be determined to 5 km post-flight (16,404 feet) for in-track, cross track, and altitude.

12. SCHEDULE

Preliminary Design Review	24-25 Mar 1997
Critical Design Review	Jun 1999 or TBD
Complete Fabrication	Dec 1999 or TBD
Complete Environmental Tests	Jul 2000 or TBD
Complete Calibration	Oct 2000 or TBD
Deliver Experiment	Dec 2000 or TBD
Launch Coriolis Spacecraft	Dec 2001 or TBD

Experiment development and delivery dates are given in the ERD for information only and are not contractually binding dates.

13. SECURITY

Personnel from the University of Birmingham, UK will require access to the spacecraft contractor’s facilities, the launch site facilities, and the SOC.

LIST OF ACRONYMS

AFRL – Air Force Research Laboratory
BAT – Bench Acceptance Test
CCD – Charge Coupled Device
CDR – Critical Design Review
CoM – Center of Mass
DoD – Department of Defense
DHU – Data Handling Unit
ERD – Experiment Requirements Document
FOV – Field of View
GPS – Global Positioning System
GSE – Ground Support Equipment
HOP – High Output Paraffin
ICD – Interface Control Document
LV – Launch Vehicle
PDR – Preliminary Design Review
PSD – Power Spectral Density
SMEI – Solar Mass Ejection Imager
SOC – Satellite Operations Center
TML – Total Mass Loss
UTC – Universal Time Code
VCM – Volatile Condensable Material

REFERENCES

Jackson, B.V., Scientific Background and Design Specifications for a Near-Earth Heliospheric Imager, AFGL-TR-88-0195 (1988)

Jackson, B., R. Gold and R. Altrock, The Solar Mass Ejection Imager, Adv. in Space Res., 11, 377 (1991)

Jackson, B.V., A. Buffington, P.L. Hick, S.W. Kahler and D.F. Webb, A spaceborne near-Earth asteroid detection system, Astronomy and Astrophys. Suppl. Ser., 108, 279 (1994)

Keil, S.L, R.C. Altrock, S.W. Kahler, B.V. Jackson, A. Buffington, P. Hick, G. Simnett, C. Eyles, D.F. Webb, and P. Anderson, The Solar Mass Ejection Imager (SMEI), 1996, SPIE V0l 2804, pg 78

CONTRACT DATA REQUIREMENTS LIST
(2 Da. ms)

Form Approved OMB No. 0704-0188

Public reporting burden for this collection of information is estimated to average 220 hours per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Department of Defense, Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington, VA 22202-4302, and to the Office of Management and Budget, Paperwork Reduction Project (0704-0188), Washington, DC 20503. Please DO NOT RETURN your form to either of these addresses. Send completed form to the Government Issuing Contracting Officer for the Contract/PR No. listed in Block E.

A. CONTRACT LINE ITEM NO.	B. EXHIBIT	C. CATEGORY: TDP ___ TM ___ OTHER ___
0002	A	

D. SYSTEM / ITEM	E. CONTRACT / PR NO.	F. CONTRACTOR
Coriolis X-Band Services	81-3033-00	TO BE DETERMINED

Data Item A001

Field	Value
1. DATA ITEM NO.	A001
2. TITLE OF DATA ITEM	Mission Requirements Document
3. SUBTITLE	MRD
4. AUTHORITY (Data Acquisition Document No.)	
5. CONTRACT REFERENCE	SOW Para 5.1.1.1
6. REQUIRING OFFICE	NRL Code 8133
7. DD 250 REQ	LT
8. APP CODE	A
9. DIST STATEMENT REQUIRED	NA
10. FREQUENCY	ONE/P
11. AS OF DATE	NA
12. DATE OF FIRST SUBMISSION	60 DAC
13. DATE OF SUBSEQUENT SUBMISSION	15 DARC
17. PRICE GROUP	
18. ESTIMATED TOTAL PRICE	

14. DISTRIBUTION

a. ADDRESSEE	b. COPIES Draft	Final Reg	Final Repro
COR	0	3	17
15. TOTAL	0	3	17

16. REMARKS

Block 12: Draft for approval.

Block 13: NRL will provide comments within 15 days.

Data Item A002

Field	Value
1. DATA ITEM NO.	A002
2. TITLE OF DATA ITEM	Preliminary Design Review
3. SUBTITLE	PDR
4. AUTHORITY (Data Acquisition Document No.)	NA
5. CONTRACT REFERENCE	SOW Para 5.1.1.2
6. REQUIRING OFFICE	NRL Code 8133
7. DD 250 REQ	LT
8. APP CODE	NA
9. DIST STATEMENT REQUIRED	NA
10. FREQUENCY	1TIME
11. AS OF DATE	NA
12. DATE OF FIRST SUBMISSION	ASREQ*
13. DATE OF SUBSEQUENT SUBMISSION	NA
17. PRICE GROUP	
18. ESTIMATED TOTAL PRICE	

14. DISTRIBUTION

a. ADDRESSEE	b. COPIES Draft	Final Reg	Final Repro
COR	0	3	17
15. TOTAL	0	3	17

16. REMARKS

*Block 12: As required by COR (approximately 135 DAC)

G. PREPARED BY	H. DATE	I. APPROVED BY	J. DATE
NRL Code 8133	8/12/99		

CONTRACT DATA REQUIREMENTS LIST
(2 Data Items)

Form Approved OMB No. 0704-0188

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A. CONTRACT LINE ITEM NO.: 0002
B. EXHIBIT: A
C. CATEGORY: TDP ____ TM ____ OTHER ____
D. SYSTEM / ITEM: Coriolis X-Band Services
E. CONTRACT / PR NO.: 81-3033-00
F. CONTRACTOR: TO BE DETERMINED

---

1. DATA ITEM NO.: A003
2. TITLE OF DATA ITEM: Critical Design Review
3. SUBTITLE: CDR
4. AUTHORITY (Data Acquisition Document No.): NA
5. CONTRACT REFERENCE: SOW Para 5.1.1.3
6. REQUIRING OFFICE: NRL Code 8133
7. DD 250 REQ: LT
8. APP CODE: NA
9. DIST STATEMENT REQUIRED: NA
10. FREQUENCY: 1TIME
11. AS OF DATE: NA
12. DATE OF FIRST SUBMISSION: ASREQ*
13. DATE OF SUBSEQUENT SUBMISSION: NA
17. PRICE GROUP:
18. ESTIMATED TOTAL PRICE:

14. DISTRIBUTION

a. ADDRESSEE	b. COPIES Draft	Final Reg	Final Repro
COR	0	3	17
15. TOTAL	0	3	17

16. REMARKS

*Block 12: As required by COR (approximately 210 DAC)

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1. DATA ITEM NO.: A004
2. TITLE OF DATA ITEM: Spacecraft to X-Band Provider Interface Control Doc.
3. SUBTITLE: ICD
4. AUTHORITY (Data Acquisition Document No.): NA
5. CONTRACT REFERENCE: SOW Para 5.1.1.3
6. REQUIRING OFFICE: NRL Code 8133
7. DD 250 REQ: LT
8. APP CODE: A
9. DIST STATEMENT REQUIRED: NA
10. FREQUENCY: ONE/P
11. AS OF DATE: NA
12. DATE OF FIRST SUBMISSION: 195 DAC
13. DATE OF SUBSEQUENT SUBMISSION: 15 DARC
17. PRICE GROUP:
18. ESTIMATED TOTAL PRICE:

14. DISTRIBUTION

a. ADDRESSEE	b. COPIES Draft	Final Reg	Final Repro
COR	0	1	9
15. TOTAL	0	1	9

16. REMARKS

Block 12: Draft for approval.

Block 13: NRL will provide comments within 15 days; to be completed by CDR.

G. PREPARED BY: NRL Code 8133
H. DATE: 8/12/99
I. APPROVED BY:
J. DATE:

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1059/183

CONTRACT DATA REQUIREMENTS LIST
(2 Da.   .ms)

Form Approved
OMB No. 0704-0188

A. CONTRACT LINE ITEM NO.	B. EXHIBIT	C. CATEGORY: TDP ___ TM ___ OTHER ___
0002	A	

D. SYSTEM / ITEM	E. CONTRACT / PR NO.	F. CONTRACTOR
Coriolis X-Band Services	81-3033-00	TO BE DETERMINED

1. DATA ITEM NO.	2. TITLE OF DATA ITEM	3. SUBTITLE	17. PRICE GROUP
A005	WindSat POC to X-Band Provider ICD		

4. AUTHORITY (Data Acquisition Document No.)	5. CONTRACT REFERENCE	6. REQUIRING OFFICE	18. ESTIMATED TOTAL PRICE
NA	SOW Para 5.1.1.3	NRL Code 8133	

7. DD 250 REQ	9. DIST STATEMENT REQUIRED	10. FREQUENCY	12. DATE OF FIRST SUBMISSION
LT		ONE/P	195 DAC
8. APP CODE		**11. AS OF DATE**	**13. DATE OF SUBSEQUENT SUBMISSION**
A	NA	NA	15 DARC

16. REMARKS

Block 12: Draft for approval.

Block 13: NRL will provide comments within 15 days; to be completed at CDR.

14. DISTRIBUTION a. ADDRESSEE	b. COPIES Draft	Final Reg	Final Repro
COR	0	1	9
15. TOTAL →	0	1	9

1. DATA ITEM NO.	2. TITLE OF DATA ITEM	3. SUBTITLE	17. PRICE GROUP
A006	SMEI POC to X-Band Provider ICD		

4. AUTHORITY (Data Acquisition Document No.)	5. CONTRACT REFERENCE	6. REQUIRING OFFICE	18. ESTIMATED TOTAL PRICE
NA	SOW Para 5.1.1.3	NRL Code 8133	

7. DD 250 REQ	9. DIST STATEMENT REQUIRED	10. FREQUENCY	12. DATE OF FIRST SUBMISSION
LT		ONE/P	195 DAC
8. APP CODE		**11. AS OF DATE**	**13. DATE OF SUBSEQUENT SUBMISSION**
A	NA	NA	15 DARC

16. REMARKS

Block 12: Draft for approval.

Block 13: NRL to provide comments with 15 days; to be completed by CDR.

14. DISTRIBUTION a. ADDRESSEE	b. COPIES Draft	Final Reg	Final Repro
COR	0	1	9
15. TOTAL →	0	1	9

G. PREPARED BY	H. DATE	I. APPROVED BY	J. DATE
NRL Code 8133	8/12/99		

CONTRACT DATA REQUIREMENTS LIST

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A. CONTRACT LINE ITEM NO.	B. EXHIBIT	C. CATEGORY: TDP ___ TM ___ OTHER ___
0002	A	

D. SYSTEM / ITEM	E. CONTRACT / PR NO.	F. CONTRACTOR
Coriolis X-Band Services	81-3033-00	TO BE DETERMINED

1. DATA ITEM NO.: A007
2. TITLE OF DATA ITEM: SOC to X-Band Provider ICD
3. SUBTITLE:
4. AUTHORITY (Data Acquisition Document No.): NA
5. CONTRACT REFERENCE: SOW Para 5.1.1.3
6. REQUIRING OFFICE: NRL Code 8133
7. DD 250 REQ: LT
8. APP CODE: A
9. DIST STATEMENT REQUIRED: NA
10. FREQUENCY: ONE/P
11. AS OF DATE: NA
12. DATE OF FIRST SUBMISSION: 195 DAC
13. DATE OF SUBSEQUENT SUBMISSION: 15 DARC
17. PRICE GROUP:
18. ESTIMATED TOTAL PRICE:

14. DISTRIBUTION

a. ADDRESSEE	b. COPIES Draft	Final Reg	Final Repro
COR	0	1	9
15. TOTAL →	0	1	9

16. REMARKS

Block 12: Draft for approval.

Block 13: NRL to provide comments within 15 days; to be completed by CDR.

1. DATA ITEM NO.: A008
2. TITLE OF DATA ITEM: Monthly Progress Reports
3. SUBTITLE:
4. AUTHORITY (Data Acquisition Document No.): NA
5. CONTRACT REFERENCE: SOW Para 5.0 and 6.0 (for Phase 1)
6. REQUIRING OFFICE: NRL Code 8133
7. DD 250 REQ: LT
8. APP CODE: NA
9. DIST STATEMENT REQUIRED: NA
10. FREQUENCY: MTHLY
11. AS OF DATE: See Block 16
12. DATE OF FIRST SUBMISSION: End 1st month + 15 days
13. DATE OF SUBSEQUENT SUBMISSION: Block 11 + 15 days
17. PRICE GROUP:
18. ESTIMATED TOTAL PRICE:

14. DISTRIBUTION

a. ADDRESSEE	b. COPIES Draft	Final Reg	Final Repro
COR	0	1	2
15. TOTAL →	0	1	2

16. REMARKS

Re Block 11: end of Contractor's reporting month

Include report of attendance at key meetings and reviews.

G. PREPARED BY	H. DATE	I. APPROVED BY	J. DATE
NRL Code 8133	8/12/99		

CONTRACT DATA REQUIREMENTS LIST
(2 Da ms)

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A. CONTRACT LINE ITEM NO.	B. EXHIBIT	C. CATEGORY: TDP ____ TM ____ OTHER ____
0004	B	

D. SYSTEM / ITEM	E. CONTRACT / PR NO.	F. CONTRACTOR
Coriolis X-Band Services	81-3033-00	TO BE DETERMINED

1. DATA ITEM NO.	2. TITLE OF DATA ITEM	3. SUBTITLE	17. PRICE GROUP
B001	X-Band Compatibility Test Plan		

4. AUTHORITY *(Data Acquisition Document No.)*	5. CONTRACT REFERENCE	6. REQUIRING OFFICE	18. ESTIMATED TOTAL PRICE
NA	SOW Para 5.2.1.1	NRL Code 8133	

7. DD 250 REQ	9. DIST STATEMENT REQUIRED	10. FREQUENCY	12. DATE OF FIRST SUBMISSION
LT		ONE/P	60 DPTT
8. APP CODE		**11. AS OF DATE**	**13. DATE OF SUBSEQUENT SUBMISSION**
A	NA	NA	30 DPTT

16. REMARKS

Re Block 13: NRL will provide comments with 15 days

14. DISTRIBUTION a. ADDRESSEE	b. COPIES Draft	Final Reg	Final Repro
COR	0	1	9
15. TOTAL →	0	1	9

1. DATA ITEM NO.	2. TITLE OF DATA ITEM	3. SUBTITLE	17. PRICE GROUP
B002	X-Band Compatibility Test Report		

4. AUTHORITY *(Data Acquisition Document No.)*	5. CONTRACT REFERENCE	6. REQUIRING OFFICE	18. ESTIMATED TOTAL PRICE
NA	SOW Para 5.2.1.2	NRL Code 8133	

7. DD 250 REQ	9. DIST STATEMENT REQUIRED	10. FREQUENCY	12. DATE OF FIRST SUBMISSION
LT		1TIME	10 DATC
8. APP CODE		**11. AS OF DATE**	**13. DATE OF SUBSEQUENT SUBMISSION**
NA	NA	Test Completion	NA

16. REMARKS

14. DISTRIBUTION a. ADDRESSEE	b. COPIES Draft	Final Reg	Final Repro
COR	0	1	9
15. TOTAL →	0	1	9

G. PREPARED BY	H. DATE	I. APPROVED BY	J. DATE
NRL Code 8133	8/12/99		

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CONTRACT DATA RFQUIREMENTS LIST
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A. CONTRACT LINE ITEM NO.	B. EXHIBIT	C. CATEGORY:
0004	B	TDP ____ TM ____ OTHER ____

D. SYSTEM / ITEM	E. CONTRACT / PR NO.	F. CONTRACTOR
Coriolis X-Band Services	81-3033-00	TO BE DETERMINED

1. DATA ITEM NO.	2. TITLE OF DATA ITEM	3. SUBTITLE	17. PRICE GROUP
B003	Mission Readiness Review		

4. AUTHORITY (Data Acquisition Document No.)	5. CONTRACT REFERENCE	6. REQUIRING OFFICE	18. ESTIMATED TOTAL PRICE
NA	SOW Para 5.2.1.4	NRL Code 8133	

7. DD 250 REQ	9. DIST STATEMENT REQUIRED	10. FREQUENCY	12. DATE OF FIRST SUBMISSION
LT		1TIME	ASREQ*
8. APP CODE		**11. AS OF DATE**	**13. DATE OF SUBSEQUENT SUBMISSION**
NA	NA	NA	NA

16. REMARKS

*Block 12: As required by COR (approximately 1 week prior to launch)

14. DISTRIBUTION a. ADDRESSEE	b. COPIES Draft	Final Reg	Final Repro
COR	0	3	17
15. TOTAL	0	3	17

1. DATA ITEM NO.	2. TITLE OF DATA ITEM	3. SUBTITLE	17. PRICE GROUP
B004	Monthly Progress Reports		

4. AUTHORITY (Data Acquisition Document No.)	5. CONTRACT REFERENCE	6. REQUIRING OFFICE	18. ESTIMATED TOTAL PRICE
NA	SOW Paras 5.2.1.3, & (Ph.2) 5.0 & 6.0	NRL Code 8133	

7. DD 250 REQ	9. DIST STATEMENT REQUIRED	10. FREQUENCY	12. DATE OF FIRST SUBMISSION
LT		MTHLY	End 1st month +15 days
8. APP CODE		**11. AS OF DATE**	**13. DATE OF SUBSEQUENT SUBMISSION**
NA	NA	See Block 16.	Block 11 + 15 days

16. REMARKS

Re Block 11: end of Contractor's reporting month

Include report of attandance at mission rehearsals.

14. DISTRIBUTION a. ADDRESSEE	b. COPIES Draft	Final Reg	Final Repro
COR	0	1	2
15. TOTAL	0	1	2

G. PREPARED BY	H. DATE	I. APPROVED BY	J. DATE
NRL Code 8133	8/12/99		

CONTRACT DATA REQUIREMENTS LIST
(2 Da   ems)

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OMB No. 0704-0188

A. CONTRACT LINE ITEM NO.	B. EXHIBIT	C. CATEGORY: TDP ____ TM ____ OTHER ____
0006	C	

D. SYSTEM / ITEM	E. CONTRACT / PR NO.	F. CONTRACTOR
Coriolis X-Band Services	81-3033-00	TO BE DETERMINED

1. DATA ITEM NO.	2. TITLE OF DATA ITEM	3. SUBTITLE	17. PRICE GROUP
C001	Monthly Progress Reports		

4. AUTHORITY (Data Acquisition Document No.)	5. CONTRACT REFERENCE	6. REQUIRING OFFICE	18. ESTIMATED TOTAL PRICE
NA -	See Block 16.	NRL Code 8133	

7. DD 250 REQ	9. DIST STATEMENT REQUIRED	10. FREQUENCY	12. DATE OF FIRST SUBMISSION
LT	NA	MTHLY	End 1st month +15 days
8. APP CODE		**11. AS OF DATE**	**13. DATE OF SUBSEQUENT SUBMISSION**
NA		See Block 16.	Block 11 + 15 days

14. DISTRIBUTION

a. ADDRESSEE	b. COPIES Draft	Final Reg	Final Repro
COR	0	1	2
15. TOTAL →	0	1	2

16. REMARKS

Re Block 5: SOW paras 5.3.1.2, 5.3.1.3, 5.3.1.4, and 5.0 and 6.0 for Phase 3

Re Block 11: end of Contractor's reporting month

Include summary of results of LEO check out support.

Include summary of results of nominal on-orbit data collection, archive, and dissemination.

Include initial report on ground system performance and quality control during launch. Include report of on orbit engineering support.

//INCLUDE ""COUNT"" OF ______///

1. DATA ITEM NO.	2. TITLE OF DATA ITEM	3. SUBTITLE	17. PRICE GROUP

4. AUTHORITY (Data Acquisition Document No.)	5. CONTRACT REFERENCE	6. REQUIRING OFFICE	18. ESTIMATED TOTAL PRICE

7. DD 250 REQ	9. DIST STATEMENT REQUIRED	10. FREQUENCY	12. DATE OF FIRST SUBMISSION
8. APP CODE		**11. AS OF DATE**	**13. DATE OF SUBSEQUENT SUBMISSION**

14. DISTRIBUTION

a. ADDRESSEE	b. COPIES Draft	Final Reg	Final Repro
15. TOTAL →			

16. REMARKS

G. PREPARED BY	H. DATE	I. APPROVED BY	J. DATE