

# **Alliance for Marine Remote Sensing Operational Oceanography and Remote Sensing**

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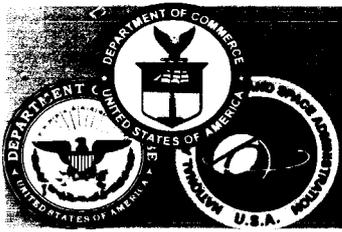
## **Ocean Observer Satellite Study: Instrument and Satellite Constellation Architecture Options**

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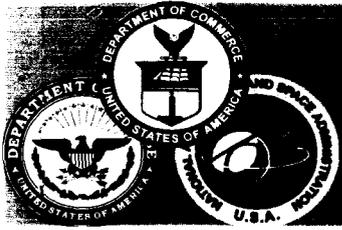


## **Abstract**

During the past two years, operational measurement requirements for the future U.S. operational environmental satellites have been extensively revised. These requirements specify the operational measurements to be made from the National Polar-Orbiting Operational Environmental Satellite System (NPOESS) which is planned for the 2008 to 2018 time period. NPOESS meets the operational needs of the U.S. civilian meteorological, environmental, climatic, and space environmental remote sensing programs, and the Global Military Space and Geophysical Environmental remote sensing programs. This system, however, does not meet all the needs of the user community interested in operational oceanography (particularly in coastal regions) and hazard response.

In the later half of the year 2000, the Integrated Program Office (IPO) initiated the Ocean Observer Study (OOS). The purpose of this study is to: (1) determine what additional ocean (particularly coastal ocean) and hazard observations from space are needed in the 2008 to 2023 time period; (2) turn those needs into requirements; (3) examine instrument and satellite constellation options to meet these requirements, and (4) estimating the costs for building an ocean observation satellite system.

This paper provides: (1) an overview of the set of active and passive instruments identified by the IPO designed to make the ocean measurements including visible and infrared medium and high resolution imagers, radiometers, altimeters, and synthetic aperture radars and (2) the instrument and satellite constellation architecture options studied, and their ability to meet the set of measurement requirements.



# Study Overview

## **Develop an up to Date Requirements Set for Ocean Observing-type Sensor for the Time Frame 2008-2018**

- » Science team composed of Academia, DOC, DOD, DOI, DOT, EPA, FEMA, and NSF generated a User Requirement Document (URD)

## **Identify Candidate Sensors That Can Meet the Requirements in the URD**

- » Altimeter, Scatterometer, SAR, and Hyperspectral imager suite of instruments selected to meet the requirements

## **Develop Candidate System Architectures**

- » Four mission sets, varying in cost and requirements met, were defined and are being studied

## **Identify Key Technologies, Their State of Readiness and Provide Priority for Key Technology Development**

## **Generate Cost Estimates for the Architectures and Sensors**



# Study Assumptions

**OO System Operational Life:** 15 years

**Governing Requirements Document:** Ocean Observing System User Requirements Version 2.0

**Spacecraft Mission Life:** 5 years with a goal of 10 years

**Operational Constellation Hardware Build:** Initial build with 2 successive builds starting on 2 year centers

## **Scatterometer**

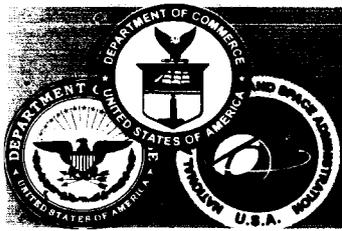
A pre-operational demonstration has been flown to measure Ocean Vector Windes, e.g., Alpha Scatt and that and efficiently packaged scatterometer has flown before 2009

## **“Regular” Altimeter – JASON II Like Nadir Altimeter**

A pre-operational demonstration has been flown to measure Ocean Topography e.g., JASON II, and that a wide swath altimeter has flown before 2009.

## **SAR Spacecraft**

SAR instruments will operate 10 minutes in eclipse and 40 minutes in Sunlight.



# Study Assumptions Con't

## Orbit Knowledge

In addition to the Orbit Knowledge assumed above for the “Regular” Altimeter and the SAR carrying spacecraft, it was also assumed that each spacecraft would have to carry a retroreflector system on-board, and that the NASA laser ranging worldwide network would be utilized as is done with TOPEX to achieve the post processing orbit knowledge requirements.

## TDRS

TDRS was assumed to be an operation system in the 2009 – 2010 time frame since its planned obsolescence date is 2020. During that time TDRS would have Ka-Band capability at 2 Gbps as is planned now. Utilizing TDRS Ka-Band for a maximum of 40 minutes continuous downlinking was acceptable. This was agreed to be a reasonable assumption by the TDRS “people”.

## Data Processing Level Included in Timeliness Requirement

It was assumed that the portion of the of the two (2) hour timeliness requirement included one-half (1/2) hour of processing. It was also assumed that the data was process through Level 1 (L1) and Level 2 (L2). It was further assumed that parallel computers could process the data through these assumed levels.

## Technology Cut-Off Date

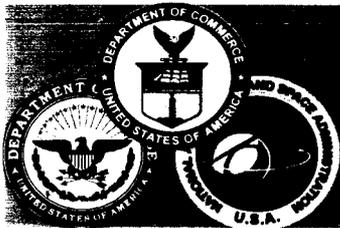
Since the Ocean Observer System would not fly until the 2009 – 2010 time from, it was assumed that various levels of technology would be available at that time that are not be available now. It was assumed that the Technology Cut-Off time would be 2004.











## Mission Constellations Studied

Option	Spacecraft	Orbit Altitude (km)	Orbit Inclination (degrees)	Nodal Crossing (line)	SAR (configuration)	Altimeter (Type)	Scatterometer	Ocean Color
HI 01	s/c 1A & 1B	800	98.6	1:30	Single Sided C&L + ATI + CTI + RPI + Quad Pole		+	+
	s/c 2	1336	66			WSA with DD		

- s/c 1A & s/c 1B needed for Cross Track Interferometry (CTI)  
 - s/c 1B does not have a Scatterometer or Ocean Color Instruments on-board

HI 02	s/c 1	800	98.6	1:30	Single Sided C&L + ATI + RPI + Quad Pole			+
	s/c 2	1336	66			WSA with DD		
	s/c 3	1336	66			DD*		

- Best Orbit for Scatterometer Instrument Coverage

Med 01	s/c 1	800	98.6	1:30	2 Sided C&L + RPI + Quad Pole			+
	s/c 2	1336	66			Regular		
	s/c 3	1336	66			Regular		

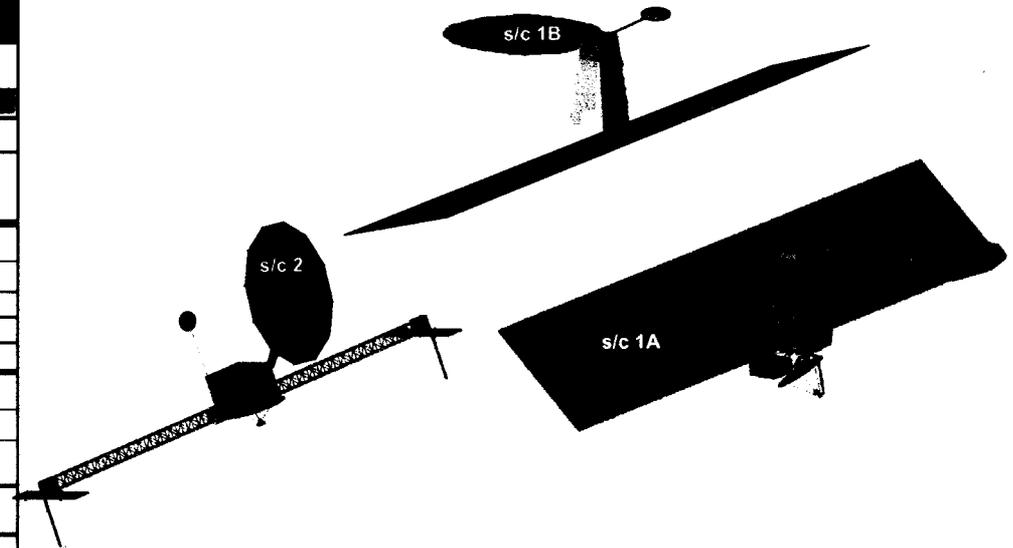
- Best Orbit for Scatterometer Instrument Coverage

Low 01	s/c 1	800	98.6	1:30	Single-Sided C + Quad Pole + RPI			+
	s/c 2	800	108			Regular	+	



# Mission Constellation Configuration – Hi 01

<b>Mission</b>	Duration (yrs.)	15	15	15
	Number of S/C Needed To Meet Mission Duration With a High Probability Of Success - (> 0.65)	3	3	3
<b>Orbit</b>				
	Orbit Type	Sun Sync Cir.	Sun Sync Cir.	Circular
	Altitude (km)	800	800	1336
	Inclination (Degrees)	98.6	98.6	66
	Nodal Crossing Time	1330	1330+	
<b>P/L Instruments</b>				
<b>SAR</b>				
	Single Side C & L Bands + CTI + ATI + RPI + Quad Pole	yes	yes	
	Single Side C & L Bands + ATI + RPI + Quad Pole			
	2 Sided Each Side C& L + Quad Pole + RPI			
	Single Side C Band + Quad Pole + RPI			
<b>Altimeter</b>				
	Wide Swath + JASON II w/Delayed Doppler Processing + Radiometer			yes
	Delayed Doppler + Radiometer			
	JASON II + Radiometer			
<b>Scatterometer</b>				
	Scatt - 1336			
	Scatt - 800	yes		
<b>Ocean Color Imager</b>				
	OCI - 800	yes		



## Spacecrafts

Payload (P/L) Mass (kg)	884	650	115
P/L Mass Contingency (%)	30%	30%	30%
Bus Mass (kg)	1171	1048	289
Bus Mass Contingency (%)	30%	30%	30%
Launch Mass Wet (kg)	2415	2203**	656
Launch Vehicle (L/V) Type	Delta 4250*	Delta 4250*	Delta 2320
L/V Mass to Orbit Capability	6000*	6000*	1400
Launch Mass Margin (kg)	1383*	1383*	744
P/L Peak Power (watts)	6275	6000	360
P/L Peak Data Rate (Mbps)	686.4	605	0.05
Downlink (D/L) Comms Band	Ka-Band	Ka-Band	S-Band
D/L Data Rate	1.7 Gb/s	1.7 Gb/s	350 Kb/s

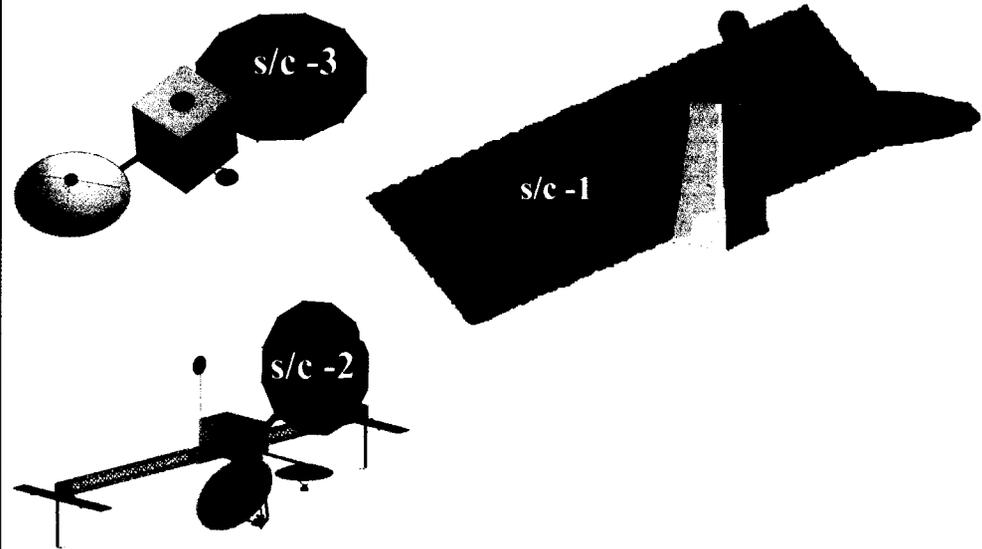
\*\*includes dual adapter

\*dual launch



# Mission Constellation Configuration – Hi 02

<b>Mission</b>	Duration (yrs.)	15	15	15
	Number of S/C Needed To Meet Mission Duration With a High Probability Of Success - (> 0.65)	3	3	3
<b>Orbit</b>				
	Orbit Type	Sun Sync Cir.	Circular	Circular
	Altitude (km)	800	1336	1336
	Inclination (Degrees)	98.6	66	66
	Nodal Crossing Time	13:30		
<b>P/L Instruments</b>				
<b>SAR</b>				
	Single Side C & L Bands + CTI + ATI + RPI + Quad Pole			
	Single Side C & L Bands + ATI + RPI + Quad Pole	yes		
	2 Sided Each Side C& L + Quad Pole + RPI			
	Single Side C Band + Quad Pole + RPI			
<b>Altimeter</b>				
	Wide Swath + JASON II w/Delayed Doppler Processing + Radiometer		yes	
	Delayed Doppler + Radiometer			yes
	JASON II + Radiometer			
<b>Scatterometer</b>				
	Scatt - 1336		yes	
	Scatt - 800			
<b>Ocean Color Imager</b>				
	OCI - 800	yes		



## Spacecrafts

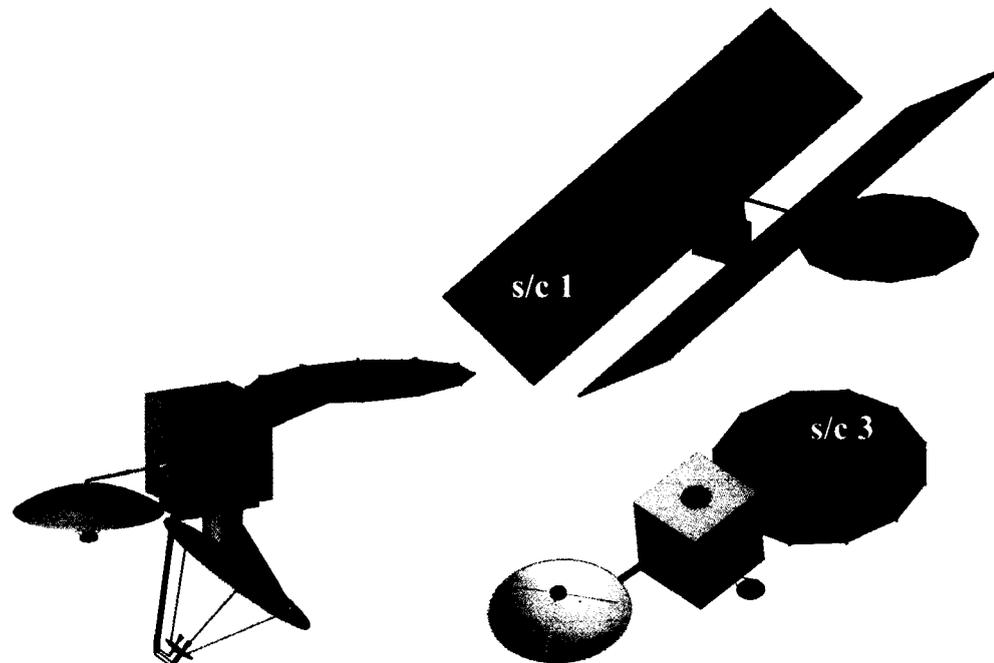
			Data Provided By J. N. Applied Physics Lab
Payload (P/L) Mass (kg)	780	535	35
P/L Mass Contingency (%)	30%	30%	yes
Bus Mass (kg)	1092	371	167
Bus Mass Contingency (%)	30%	30%	yes
Launch Mass Wet (kg)	2207	918	207
Launch Vehicle (LV) Type	Delta 2920-10L	Delta 2320*	Delta 2320*
LV Mass to Orbit Capability	2938	1400	1400
Launch Mass Margin (kg)	731	272	272
P/L Peak Power (watts)	6100	535	50
P/L Peak Data Rate (Mbps)	686.3	0.15	0.020
Downlink (D/L) Comms Band	Ka-Band	S-Band	S-Band
D/L Data Rate	1.7 Gb/s	1 Mb/s	200 Kb/s

\* Dual Launch



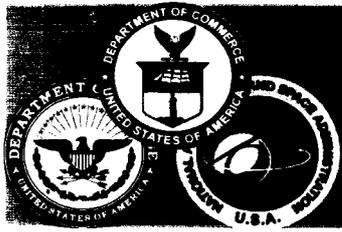
# Mission Constellation Configuration – Med 01

<b>Mission</b>	Duration (yrs.)	15	15	15
	Number of S/C Needed To Meet Mission Duration With a High Probability Of Success - (> 0.65)	3	3	3
<b>Orbit</b>				
	Orbit Type	Sun Sync Cir.	Circular	Circular
	Altitude (km)	800	1336	1336
	Inclination (Degrees)	98.6	66	66
	Nodal Crossing Time	13:30		
<b>P/L Instruments</b>				
	<b>SAR</b>			
	Single Side C & L Bands + CTI + ATI + RFI + Quad Pole			
	Single Side C & L Bands + ATI + RFI + Quad Pole			
	2 Sided Each Side C&L + Quad Pole + RFI	yes		
	Single Side C Band + Quad Pole + RFI			
	<b>Altimeter</b>			
	Wide Swath + JASON II w/Delayed Doppler Processing + Radiometer			
	Delayed Doppler+Radiometer			
	JASON II + Radiometer		yes	yes
	<b>Scatterometer</b>			
	Scatt - 1336		yes	
	Scatt - 800			
	<b>Ocean Color Imager</b>			
	OCI - 800	yes		



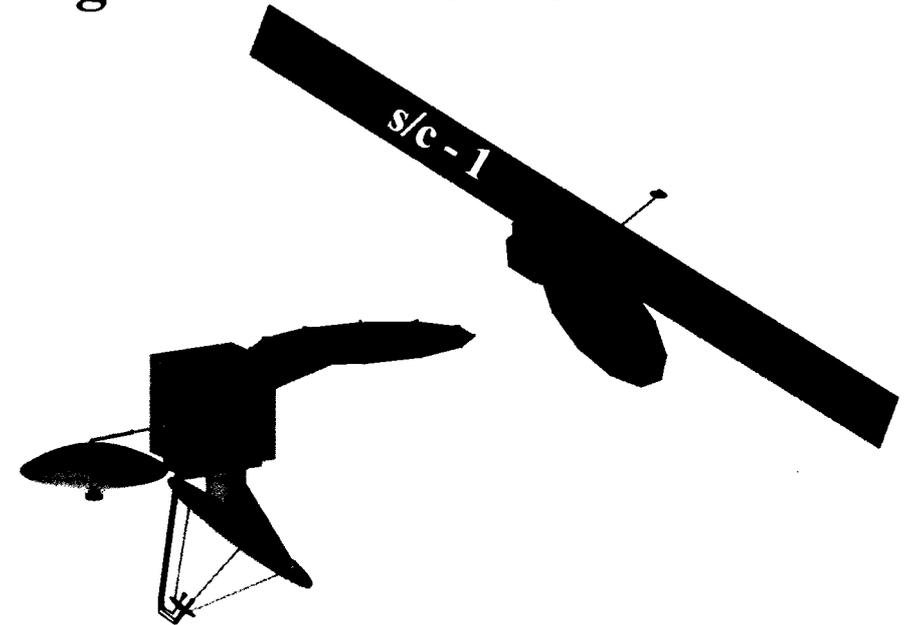
## Spacecrafts

			Only Provided by U.S. Space Programs Ltd.
Payload (P/L) Mass (kg)	1430	253	35
P/L Mass Contingency (%)	30%	30%	yes
Bus Mass (kg)	1740	349	167
Bus Mass Contingency (%)	30%	30%	yes
Launch Mass Wet (kg) - s/c-2	3727	788	
Launch Mass Wet (kg) - s/c-3		207	207
Launch Vehicle (L/V) Type	Atlas 501	Delta 2320*	Delta 2320*
L/V Mass to Orbit Capability	5000	1400	1400
Launch Mass Margin (kg)	1273	525*	525*
P/L Peak Power (watts)	14100	253	50
P/L Peak Data Rate (Mbps)	1291.3	0.15	0.020
Downlink (D/L) Comms Band	↑ Ka-Band	S-Band	S-Band
D/L Data Rate	650 Mb/s	200 kb/s	200 Kb/s



# Mission Constellation Configuration – Low 01

<b>Mission</b>	Duration (yrs.)	15	15
	Number of S/C Needed To Meet Mission Duration With a High Probability Of Success - (> 0.65)	3	3
<b>Orbit</b>	Orbit Type	Sun Sync Cir.	Circular
	Altitude (km)	800	800
	Inclination (Degrees)	98.6	108
	Nodal Crossing Time	13:30	
<b>P/L Instruments</b>			
<b>SAR</b>			
	Single Side C & L Bands + CTI + ATI + RPI + Quad Pole		
	Single Side C & L Bands + ATI + RPI + Quad Pole		
	2 Sided Each Side C & L + Quad Pole + RPI		
	Single Side C Band + Quad Pole + RPI	<b>Yes</b>	
<b>Altimeter</b>			
	Wide Swath + JASON II w/Delayed Doppler Processing + Radiometer		
	Delayed Doppler + Radiometer		
	JASON II + Radiometer		<b>Yes</b>
<b>Scatterometer</b>			
	Scatt - 1336		
	Scatt - 800		<b>Yes</b>
<b>Ocean Color Imager</b>			
	OCI - 800	<b>yes</b>	



Payload (P/L) Mass (kg)	650	176
P/L Mass Contingency (%)	30%	30%
Bus Mass (kg)	888	397
Bus Mass Contingency (%)	30%	30%
Launch Mass Wet (kg)	1829	680
Launch Vehicle (L/V) Type	Delta 2920	Delta 2320
L/V Mass to Orbit Capability	3000	2537
Launch Mass Margin (kg)	1171	1857
P/L Peak Power (watts)	5450	253
P/L Peak Data Rate (Mbps)	526 Mb/s	0.15
Downlink (D/L) Comms Band	Ka-Band	S-Band
D/L Data Rate	1.2 Gb/s	200 kb/s



# Synthetic Aperture Radar

**Instrument Type:** 1 Sided C & L Bands + Quad Pole + CTI + ATI + RPI

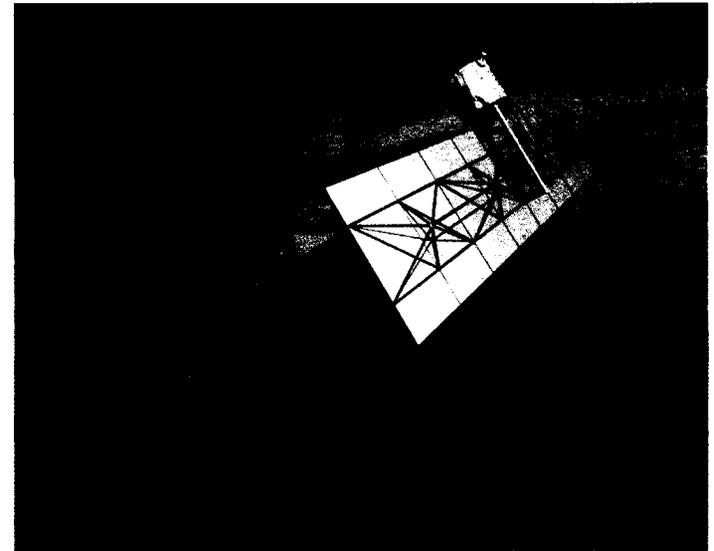
Max Swath Width: 600 km  
Spatial Resolution: <2m-1000m  
Frequency: C - Band - 5.35 GHz  
L - Band - 1.26 GHz  
Antenna Size: 23m x 4.5m  
EDRs Met T/O: 20/14

**Mass:** 500 Kg  
**Peak Power:** 6 KW  
**Peak Data Rate:** 600 Mbps

**Technology Issues:** Inter-spacecraft comms & precision separation measurement

**Configuration Issues:** 2 spacecraft flying in precision formation @ 1km separation

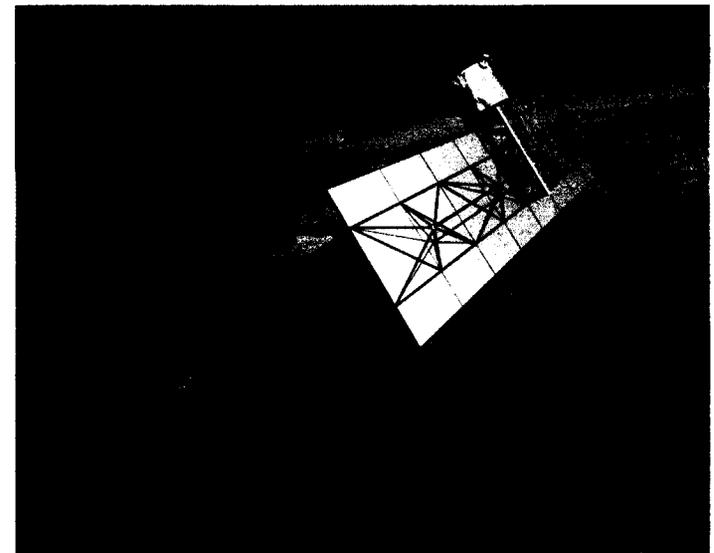
**Areas for further study:** Spacecraft cross-links, tasking strategy, onboard processing





# Synthetic Aperture Radar

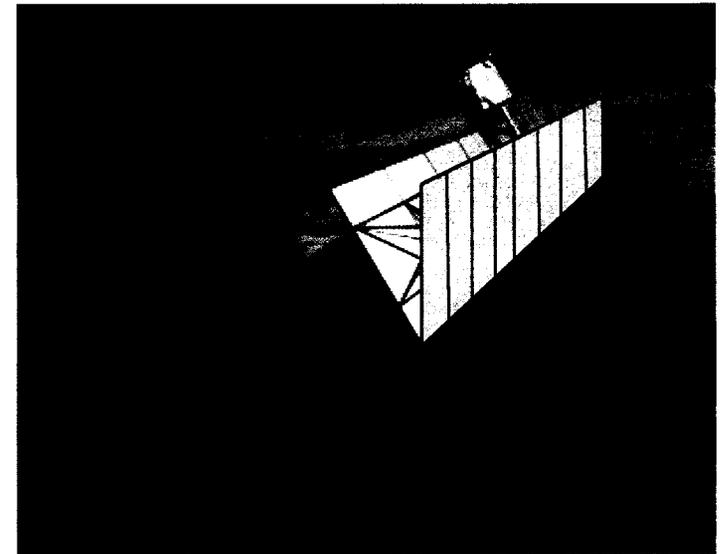
<b>Instrument Type:</b>	<b>1 Sided C &amp; L Bands + Quad Pole + ATI + RPI</b>
Max Swath Width:	600 km
Spatial Resolution:	< 2m-1000m
Frequency:	C - Band - 5.35 GHz L - Band - 1.26 GHz
Antenna Size:	23m x 4.5m
EDRs Met T/O:	20/14
<b>Mass:</b>	<b>500 Kg</b>
<b>Peak Power:</b>	<b>6 KW</b>
<b>Peak Data Rate:</b>	<b>600 Mbps</b>
<b>Technology Issues:</b>	<b>Inter-spacecraft comms &amp; precision separation Measurement</b>
<b>Configuration Issues:</b>	<b>1 spacecraft with a SAR antenna capable of being electronically partitioned into 2 halves with 10m separation for ATI</b>
<b>Areas for further study:</b>	<b>The electronic partitioning of the array to perform ATI</b>





# Synthetic Aperture Radar

<b>Instrument Type:</b>	<b>2 Sided C &amp; L Bands + Quad Pole + RPI</b>
Max Swath Width:	1200km (600km each side)
Spatial Resolution:	< 2m -1000m
Frequency:	C - Band - 5.35 GHz L - Band - 1.26 GHz
Antenna Size:	23m x 1.5m C-band 10.8mx2.9m L-band
EDRs Met T/O:	19/13
<b>Mass:</b>	<b>1000 Kg</b>
<b>Peak Power:</b>	<b>14 KW</b>
<b>Peak Data Rate:</b>	<b>1200 Mbps</b>
Technology Issues:	Commercial technology is available, heritage from SIR-C
Configuration Issues:	2 Large SAR antenna on one spacecraft – stowed & deployed
Areas for further study:	Shared aperture antenna to reduce volume and mass





# Synthetic Aperture Radar

**Instrument Type:** **1 Sided C Band + Quad Pole + RPI**

Swath Width: 10km-600km

Spatial Resolution: < 2m-100m

Frequency: 5.35 GHz

Antenna Size: 23m x 1.5

EDRs Met T/O: 15/11



**Mass:** **400 kg**

**Peak Power:** **5.3 kw**

**Peak Data Rate:** **445 Mbps**

**Technology Issues:** Uses standard commercial technology, inheritance from SIR-C and Radarsat

**Configuration Issues:** Packaging and antenna accommodation are well understood

**Areas for further study:** Reduction of data rate and power is possible



## Low Option 01- C-band, 1-side

Mode of Operation	Hi-Res	Hi-Res Spotlight	Ice Single-pol	Ice Dual-pol	Ice Quad-pol	ScanSAR single-pol	ScanSAR dual-pol	ScanSAR quad-pol
Resolution (m)	<1	5	25	25	25	100	100	100
Ground swath (km)	20	10	100	160-125	145-115	600	600	600
Number of Looks	1	4	4	4	4-3	4-5	4-5	12-36
Field of View from Nadir (angle of incidence, deg)	38-60	15-60	15-40	15-40	15-40	15-50	15-50	15-50
Polarizations	HH or VV	HH	HH or VV	HH, HV or VV, VH	HH, HV, VV, VH	HH or VV	HH, HV or VV, VH	HH, HV, VV, VH
Noise Equiv. $\sigma_0$ (db)	-23	-30	-30	-23	-30	-30	-30	-28
Worst case ambiguity level (db)	-27rng -22az	-27rng -20az	-20rng -21az	-20rng -20az	-20rng -20az	-22rng -20az	-27rng -20az	-20rng -20az
Frequency Range (MHz)	5250-5460	5250-5350	5290-5310	5290-5310	5285-5315	5297.5-5302.5	5297.5-5302.5	5285-5315
Bandwidth (MHz)	210-160	100-30	20.15	20-15	30-22.5	5	5	30
Powered antenna width (m)	1.5	1.5	0.3-0.6	0.3-0.5	0.3-0.5	0.3-1.5	0.3-1.5	0.3-1/5
Powered ant. length (m)	10.8	10.8	10.8	10.8	22.95	10.8	10.8	22.95
PRF (Hz)	1580-1570	1520-1575	1475-1310	1470-1495	1470-1495	1470-1510	1470-1510	1470-1510
Pulse width ( $\mu$ s)	30-60	15-60	95-160	70-50	50-25	20-2	20-2	10-2
RF power, Peak (kW)	4.8	4.8	4.8	4.8	10.2	4.8	4.8	10.2
RF Power Avg (W)	230-455	110-455	675-1010	495-360	755-380	145-15	145-15	150-35
No. channels	1	1	1	2	4	1	2	4
DC Power draw (W)	2270-3070	985-2210	3000-4195	2645-2155	4210-2885	640-1095	1380-930	2600-1635
Data rate (Mbps)	410	55	90-105	250	320-295	30	60	320-265



## Med Option 01 - C-band

Mode of Operation	Hi-Res	Hi-Res Spotlight	Ice Single-pol	Ice Dual-pol	Ice Quad-pol	ScanSAR single-pol	ScanSAR dual-pol	ScanSAR quad-pol
Resolution (m)	<1	5	25	25	25	100	100	100
Ground swath, each side(km)	20	10	100	160-125	145-115	600	600	600
Number of Looks	1	4	4	4	4-3	4-5	4-5	12-36
Field of View from Nadir (angle of incidence, deg)	38-60	15-60	15-40	15-40	15-40	15-50	15-50	15-50
Polarizations	HH or VV	HH	HH or VV	HH, HV or VV, VH	HH, HV, VV, VH	HH or VV	HH, HV or VV, VH	HH, HV, VV, VH
Noise Equiv. $\sigma_0$ (db)	-23	-30	-30	-23	-30	-30	-30	-28
Worst case ambiguity level (db)	-26rng -22az	-26rng -20az	-19rng -21az	-19rng -20az	-19rng -20az	-21rng -20az	-26rng -20az	-19rng -20az
Frequency Range (MHz)	5250-5460	5250-5350	5290-5310	5290-5310	5285-5315	5297.5-5302.5	5297.5-5302.5	5285-5315
Bandwidth (MHz)	210-160	100-30	20.15	20-15	30-22.5	5	5	30
Powered antenna width (m)	1.5	1.5	0.3-0.6	0.3-0.5	0.3-0.5	0.3-1.5	0.3-1.5	0.3-1/5
Powered ant. length (m)	10.8	10.8	10.8	10.8	22.95	10.8	10.8	22.95
PRF (Hz)	1580-1570	1520-1575	1475-1310	1470-1495	1470-1495	1470-1510	1470-1510	1470-1510
Pulse width ( $\mu$ s)	30-60	15-60	95-160	70-50	50-25	20-2	20-2	10-2
RF power, Peak (2-sides) (kW)	9.6	9.6	9.6	9.6	20.4	9.6	9.6	20.4
RF Power Avg (2-sides) (W)	460-910	220-910	1350-2020	990-720	1510-760	190-30	190-30	300-70
No. channels	1	1	1	2	4	1	2	4
Max DC Power draw (2-sides) (W)	6140	14420	8390	5290	8420	2190	2760	5200
Data rate (2-sides) (Mbps)	810	110	210	500	640	60	120	640



# Med Option 01 - L-band

Mode of Operation	Repeat-Pass Interferometry	Quad Polarization	Dual Polarization	ScanSAR	High-Res	Spotlight	Ultra Wide Swath ScanSAR
Ground Resolution (m)	25	25	25	100	a) 5 b) 10	3 to 5	1000
Ground Swath (km)	100	50	50	500	20	15 x 20	900
Field of View (Incidence angles in degrees)	28 to 44	20 to 40	25 to 52	20 to 52	20 to 48	20 to 52	8 to 57
Number of Looks	4	4	4	8	a) 1 b) 4	3	40
Polarization	HH or VV	HH, HV VV, VH	HH & HV or VV & VH	HH & HV or VV & VH	HH or VV	HH or VV	HH or VV
Noise Equivalent Sigma0 (dB)	-31 to -40	-34 to -37	-30 to -37	-32 to -41	-31	-25 to -31	-34 to -42
Worst Case Ambiguity (dB)	-18	-18	-18	-18	-18	-18	-18
Frequency Range (MHz)	1260 to 1280	1260 to 1280	1260 to 1280	1270 to 1280	1217.5 to 1297.5	1217.5 to 1297.5	1277.5 to 1280
Bandwidth (MHz)	20	20	20	10	40 or 80	80	2.5
PRF (Hz)	1500 to 1705	2455 to 3390	1335 to 1490	1095 to 1890	1845 to 1910	1440 to 1525	1110 to 1190
Pulse Width (µsec)	7.5 or 30	7.5	7.5	7.5	15 or 30	15	1
Maximum DC Power Draw (W)	2900	2380	1670	1890	3480	2260	1180
Maximum Data Rate (Mbps)	280	320	280	270	180	260	9.0



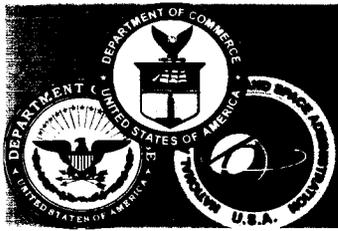
# High Option 01 - C-band

Mode of Operation	Hi-Res	Hi-Res Spotlight	Ice Single-pol	Ice Dual-pol	Ice Quad-pol	ScanSAR single-pol	ScanSAR dual-pol	ScanSAR quad-pol
Resolution (m)	<1	5	25	25	25	100	100	100
Ground swath (km)	20	10	100	160-125	145-115	600	600	600
Number of Looks	1	4	4	4	4-3	4-5	4-5	12-36
Field of View from Nadir (angle of incidence, deg)	38-60	15-60	15-40	15-40	15-40	15-50	15-50	15-50
Polarizations	HH or VV	HH	HH or VV	HH, HV or VV, VH	HH, HV, VV, VH	HH or VV	HH, HV or VV, VH	HH, HV, VV, VH
Noise Equiv. $\sigma_0$ (db)	-23	-30	-30	-23	-30	-30	-30	-28
Worst case ambiguity level (db)	-27rng -22az	-27rng -20az	-20rng -21az	-20rng -20az	-20rng -20az	-22rng -20az	-27rng -20az	-20rng -20az
Frequency Range (MHz)	5250-5460	5250-5350	5290-5310	5290-5310	5285-5315	5297.5-5302.5	5297.5-5302.5	5285-5315
Bandwidth (MHz)	210-160	100-30	20.15	20-15	30-22.5	5	5	30
Powered antenna width (m)	1.5	1.5	0.3-0.6	0.3-0.5	0.3-0.5	0.3-1.5	0.3-1.5	0.3-1/5
Powered ant. length (m)	10.8	10.8	10.8	10.8	22.95	10.8	10.8	22.95
PRF (Hz)	1580-1570	1520-1575	1475-1310	1470-1495	1470-1495	1470-1510	1470-1510	1470-1510
Pulse width ( $\mu$ s)	30-60	15-60	95-160	70-50	50-25	20-2	20-2	10-2
RF power, Peak (kW)	4.8	4.8	4.8	4.8	10.2	4.8	4.8	10.2
RF Power Avg (W)	230-455	110-455	675-1010	495-360	755-380	145-15	145-15	150-35
No. channels	1	1	1	2	4	1	2	4
DC Power draw (W)	2270-3070	985-2210	3000-4195	2645-2155	4210-2885	640-1095	1380-930	2600-1635
Data rate (Mbps)	410	55	90-105	250	320-295	30	60	320-265



## High Option 01 - L-band

Mode of Operation	Repeat-Pass Interferometry	Quad Polarization	Dual Polarization	ScanSAR	High-Res	Spotlight	Ultra Wide Swath ScanSAR
Ground Resolution (m)	25	25	25	100	a) 5 b) 10	3 to 5	1000
Ground Swath (km)	100	50	50	500	20	15 x 20	900
Field of View (Incidence angles in degrees)	28 to 44	20 to 40	25 to 52	20 to 52	20 to 48	20 to 52	8 to 57
Number of Looks	4	4	4	8	a) 1 b) 4	3	40
Polarization	HH or VV	HH, HV VV, VH	HH & HV or VV & VH	HH & HV or VV & VH	HH or VV	HH or VV	HH or VV
Noise Equivalent Sigma0 (dB)	-31 to -40	-34 to -37	-30 to -37	-32 to -41	-31	-25 to -31	-34 to -42
Worst Case Ambiguity (dB)	-19	-19	-19	-19	-19	-19	-19
Frequency Range (MHz)	1260 to 1280	1260 to 1280	1260 to 1280	1270 to 1280	1217.5 to 1297.5	1217.5 to 1297.5	1277.5 to 1280
Bandwidth (MHz)	20	20	20	10	40 or 80	80	2.5
PRF (Hz)	1500 to 1705	2455 to 3390	1335 to 1490	1095 to 1890	1845 to 1910	1440 to 1525	1110 to 1190
Pulse Width (µsec)	7.5 or 30	7.5	7.5	7.5	15 or 30	15	1
Maximum DC Power Draw (W)	1450	1190	835	945	1740	1130	590
Maximum Data Rate (Mbps)	140	160	140	135	140	130	4.5



# Altimeter

## Instrument Type:

## Wide Swath Altimeter

Swath Width:

200 km

Spatial Resolution:

14km x 14km

Frequency:

13.28 GHz &  
13.575 GHz  
5.3 GHz

Antenna Size:

2-2.5mx0.5m  
7m apart

EDRs Met T/O:

2/1

**Mass:**

**80 kg**

**Peak Power:**

**370 watts**

**Peak Data Rate:**

**45 Kbps**

Technology Issues:

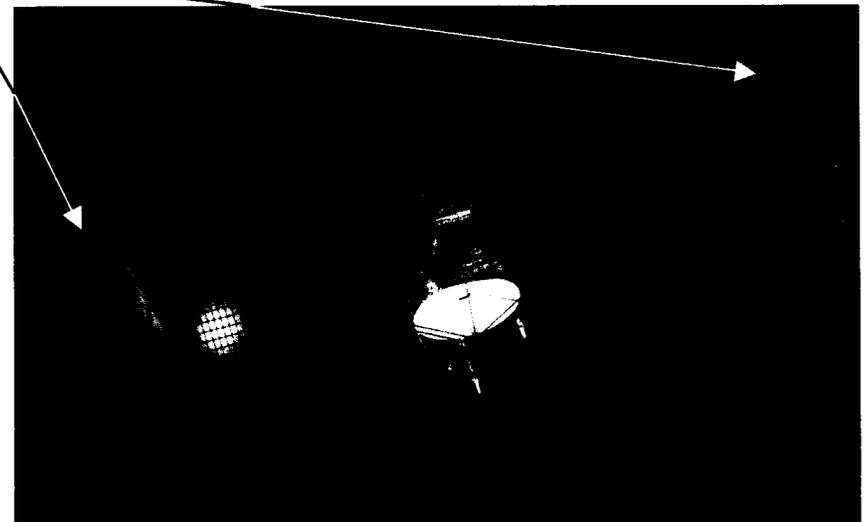
None

Configuration Issues:

7 meter boom deployment and stiffness and antenna panel deployments at both ends of the boom

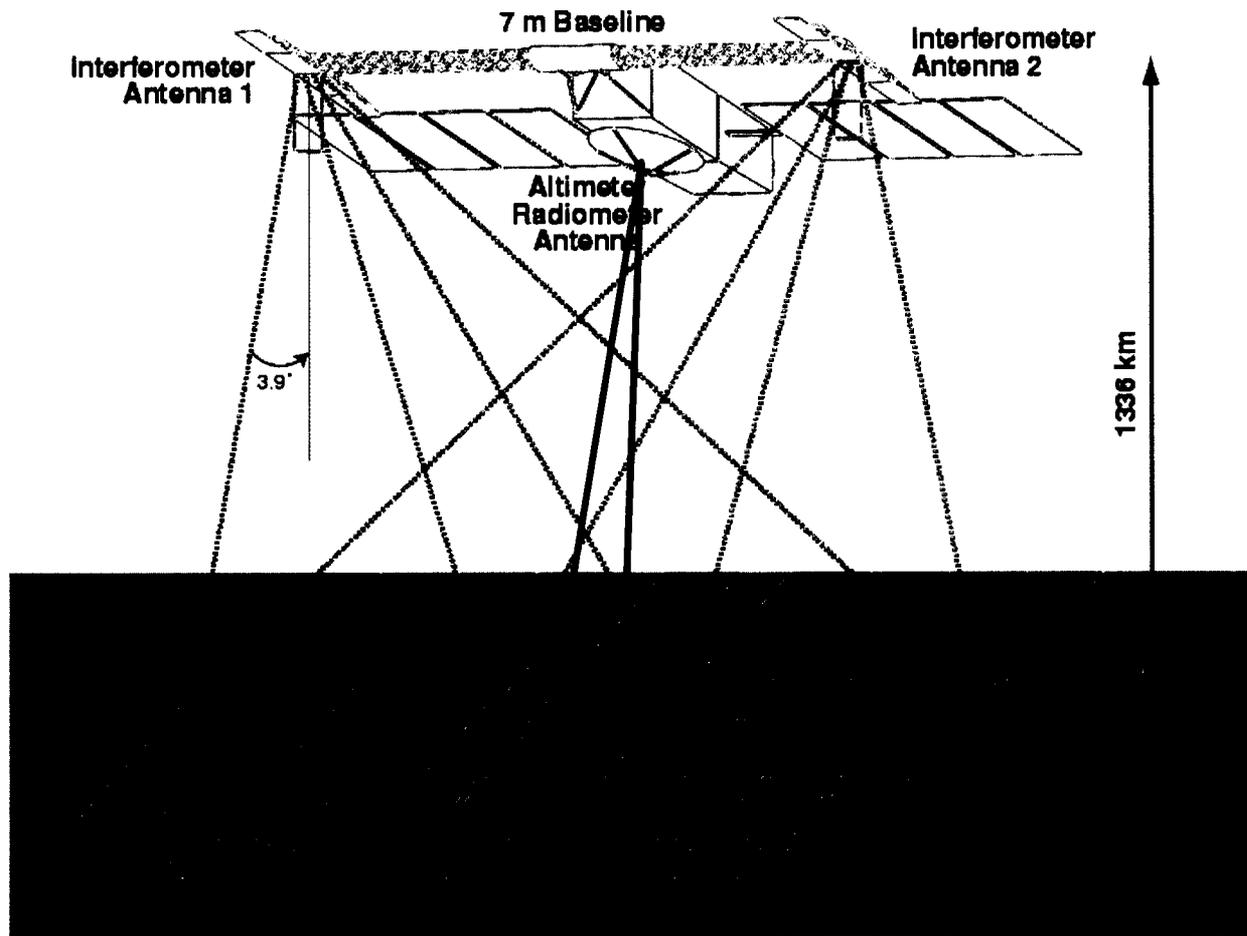
Areas for further study:

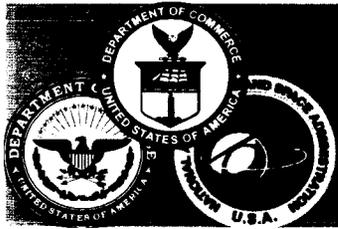
Spacecraft stability requirements



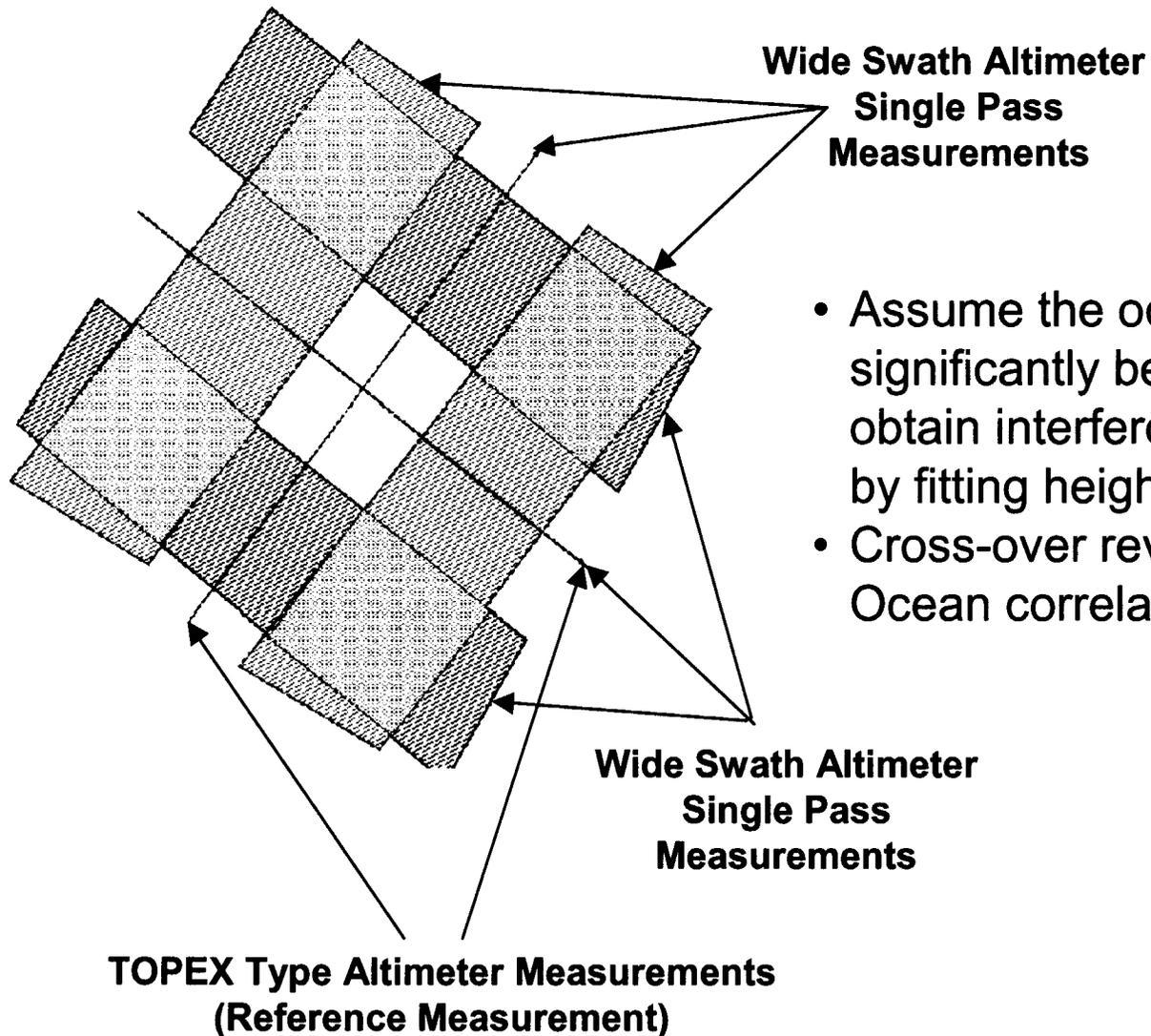


# Wide Swath Altimeter Measurement Concept





## Cross-Over Calibration Concept



- Assume the ocean does not change significantly between crossovers, and obtain interferometer baseline values by fitting height differences.
- Cross-over revisit time < 5 days.  
Ocean correlation time ~ 10 days.



## Altimeter

### Instrument Type:

**“Regular” - JASON II Like Nadir Altimeter**

Swath Width:

3km

Spatial Resolution:

14km along track

Frequency:

13.28 GHz &  
13.575 GHz

Antenna Size:

1.2m

EDRs Met (T/O):

**Mass:**

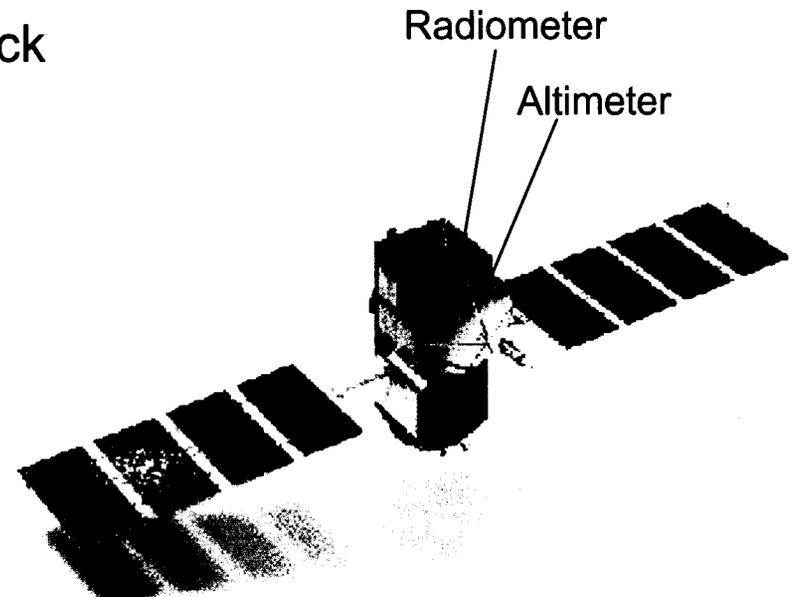
**55 kg**

**Peak Power:**

**78 watts**

**Peak Data Rate:**

**24 Kbps**



Technology Issues:

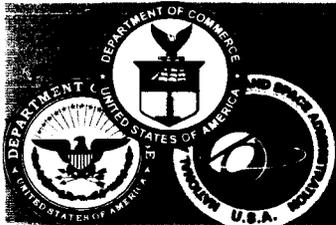
For the JASON II like spacecraft the JASON I altimeter and Radiometer will use a shared aperture.

Configuration Issues:

JASON II like s/c has reduced configuration complexity

Areas for further study:

None – Assumes JASON II flies before the Ocean Observer System



# Altimeter

## Instrument Type:

Swath Width:

Spatial Resolution:

Frequency:

Antenna Size:

EDRs Met T/O:

**Mass:**

**Peak Power:**

**Peak Data Rate:**

Technology Issues:

Configuration Issues:

Areas for further study:

## Delayed Doppler Altimeter

3km

7 km along track

13.28 GHz &  
13.575 GHz

5.3 GHz

1.2m

**35 kg**

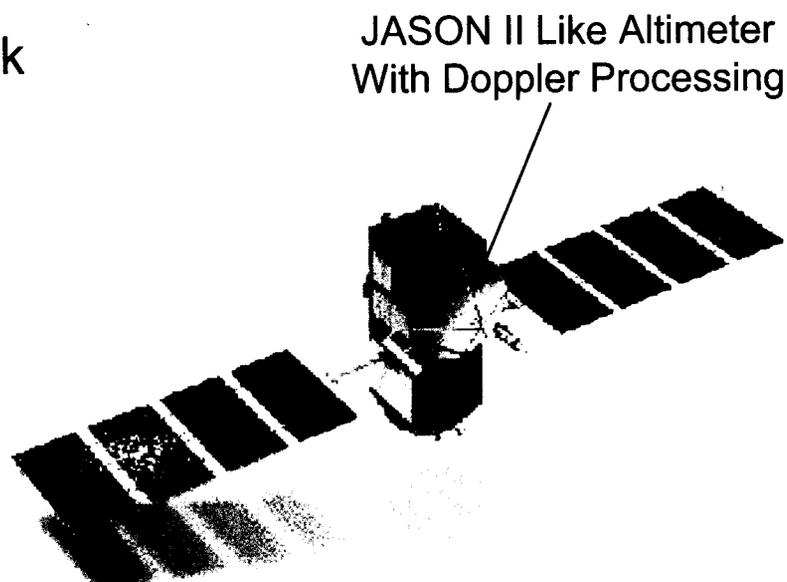
**50 watts**

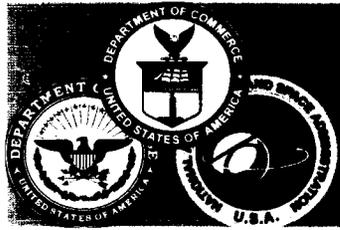
**20 Kbps**

None

None

Doppler Processing Algorithms





# Altimeter

## Instrument Type:

**Cross Track Delayed Doppler Altimeter**

Swath Width:

3km

Spatial Resolution:

7 km along track

Frequency:

13.28 GHz &  
13.575 GHz  
5.3 GHz

Antenna Size:

1.2m

EDRs Met T/O:

**Mass:**

**45 kg**

**Peak Power:**

**150 watts**

**Peak Data Rate:**

**20 Kbps**

Technology Issues:

None

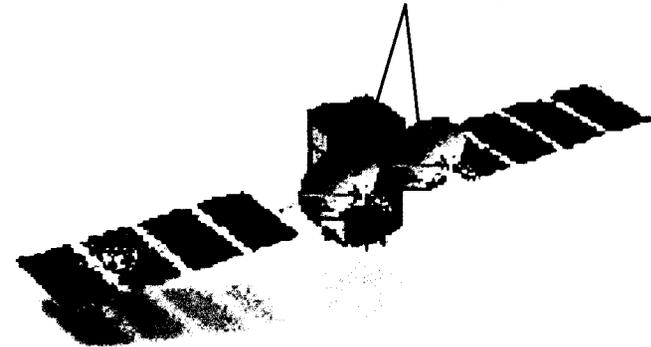
Configuration Issues:

None

Areas for further study:

Doppler Processing Algorithms

Antenna JASON II Like  
Altimeter  
With Cross Track Doppler  
Processing



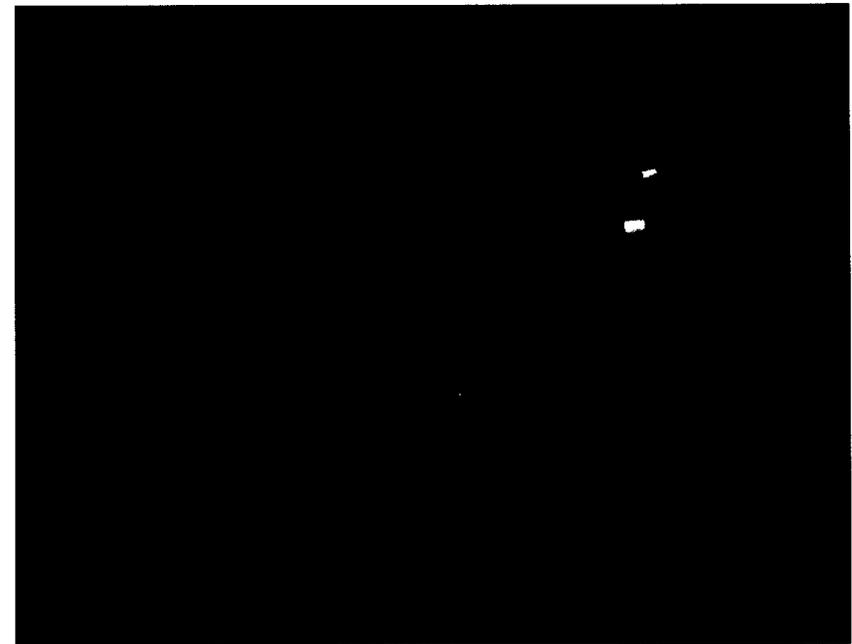


## Scatterometer (800 km orbit)

**Instrument Type:** Conical Scanning Dual Beam Ku-Band Radar

Swath Width: 1600 km  
Spatial Resolution: 20 km  
Frequency: 13.4 GHz  
Channels: 1  
EDRs Satisfied (T/O): 2/0

**Mass:** 100 kg  
**Power:** 200 W  
**Data Rate:** 100 kbps



**Technology Issues:** Ocean Observer scatterometer technologies will be developed, qualified and flown on NASA's AlphaSCAT

**Configuration Issues:** None

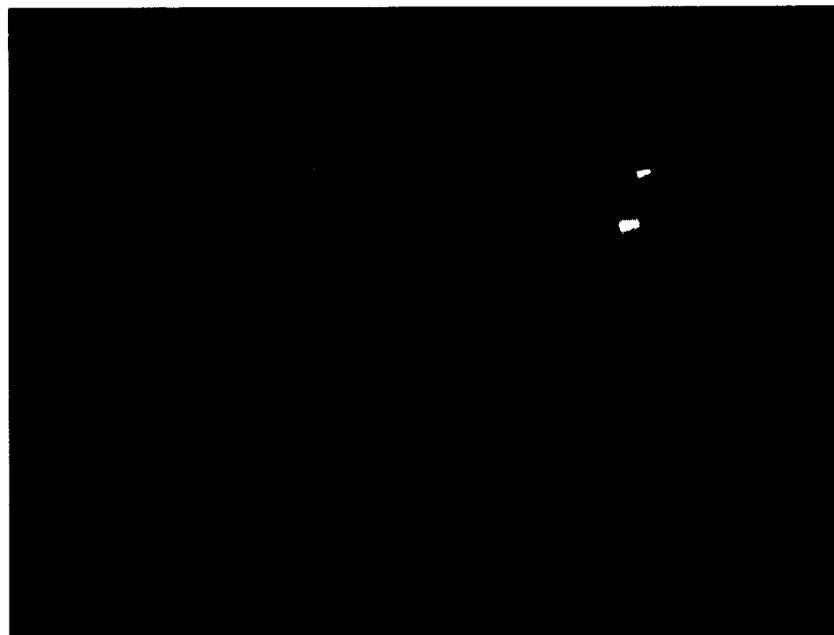
**Areas for further study:** None



## Scatterometer (1336 km orbit)

**Instrument Type:** Conical Scanning Dual Beam Ku-Band Radar

Swath Width: 2600 km  
Spatial Resolution: 20 km  
Frequency: 13.4 GHz  
Channels: 1  
EDRs Satisfied (T/O): 2/0

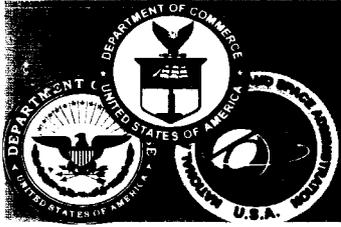


**Mass:** 110 kg  
**Power:** 200 W  
**Data Rate:** 100 kbps

**Technology Issues:** Ocean Observer scatterometer technologies will be developed, qualified and flown on NASA's AlphaSCAT

**Configuration Issues:** None

**Areas for further study:** (1) Antenna design concept  
(2) Dynamic balance performance



# Ocean Color Imager

<b>Instrument Type:</b>	<b>Imaging Spectrometer</b>
Swath Width:	100 km
Spatial Resolution:	0.1 km GSD
Spectral Region:	0.38 – 1.0 micrometer region with 64, 10nm wide bands plus 11 & 12 micrometer bands
Field of View:	Nadir +/- 45 deg.
EDRs Met (T/O):	17/0
<b>Mass:</b>	<b>110 kg</b>
<b>Peak Power:</b>	<b>150 W</b>
<b>Peak Data Rate:</b>	<b>81.3 Mbps</b>
Technology Issues:	QWIP IR Detectors Flight Qualified
Configuration Issues:	None
Areas for further study:	Wider Swath Width & Finer Spatial Resolution