Solar Imaging Radio Array (SIRA)

Electrical Power System (EPS)

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28 August 2003

NanoSat C&DH Driving Requirements

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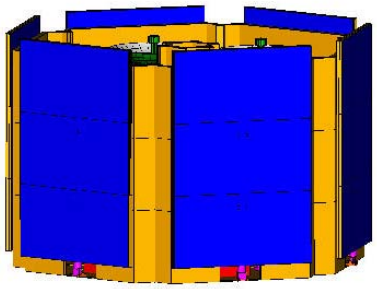
- **Launch Date:** 1 Oct 2009, with 12-16 Spacecrafts
- **Orbit:** Earth-Centered Distant Retrograde Orbit (DRO) at 500,000 Km from Earth 500,000 km radius, 20° orbit inclination relative to the ecliptic
- **Life:** 2 Year requirement

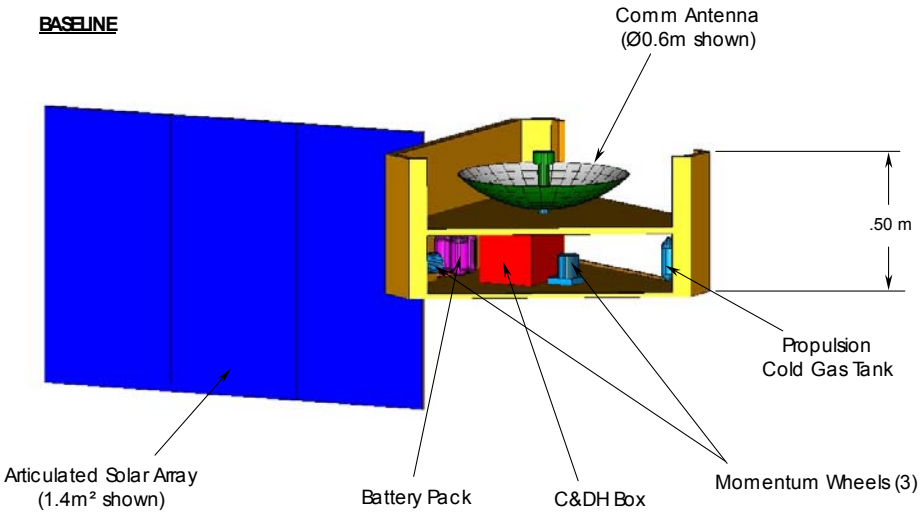
  4 Year goal
- **Solar Array:** Baseline deployed single axis articulated array .5M^2 with cells at 28% efficiency. At 70 Deg C and 20 deg cosine angle loss.
  - Option #1 Body Mounted fixed panel, TJGaAs cells at 28% efficiency. At 105 Deg C.
  - Option #2 Spinner TJGaAs cells at 28% efficiency. At 105 Deg C.
- **Battery:** Single battery with eight cells to make a single

  9 ah battery. Running at about 15.7% DOD.
- **PSE:** MAP like 28Vdc system with FPGA controls. RFI Clean Power System.

The Baseline EPS



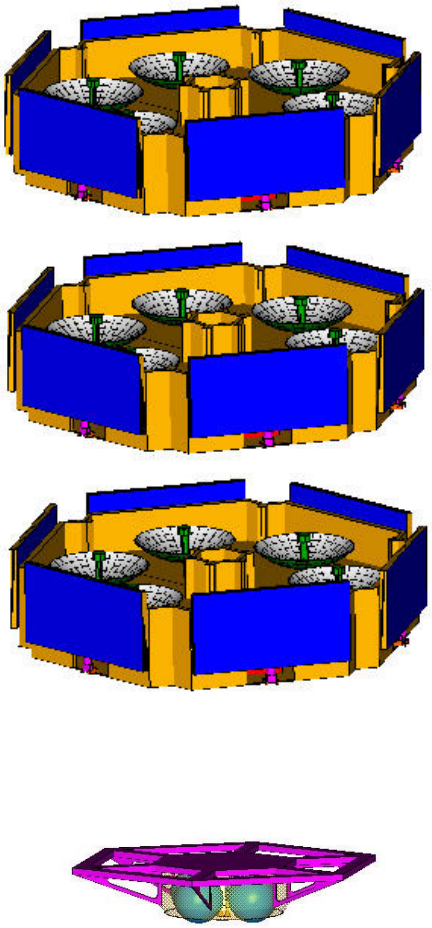
Separation of Fourth Stage

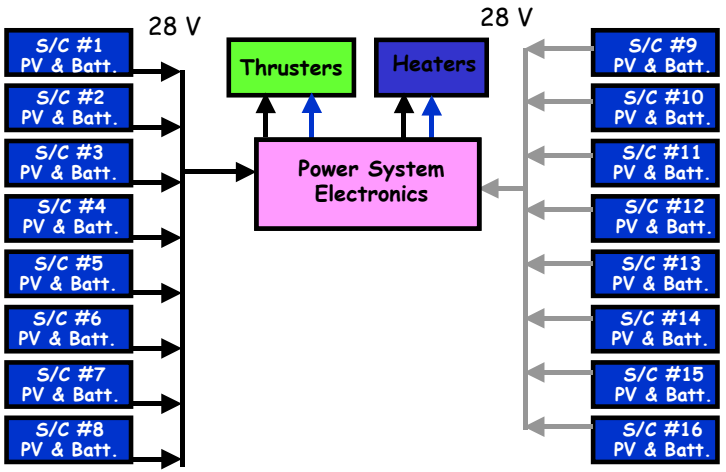


Partial Lunar eclipse of 20% (80% of sun). Spacecraft in full operation (Not Com Mode) will take the batteries to 33% DOD. Spacecraft in Safe Hold Mode will take the batteries to 15% DOD.

Cruse Configuration

Cruse Configuration EPS





Electrical Power System for the Cruse Configuration is based on using “n” number of Spacecraft to provide electrical power.

Load of 10.4 watts thruster card continuous plus 161.0 watts for 15 min thrust will need about 6 spacecraft 9 ah batteries down to 80% DOD. More spacecraft batteries connected the lower this DOD will be. 12 Spacecrafts will bring batteries down to 40% DOD.

Power Box is estimated to be 1kg and cost $100K.

EPS Block Diagram MAP like PSE

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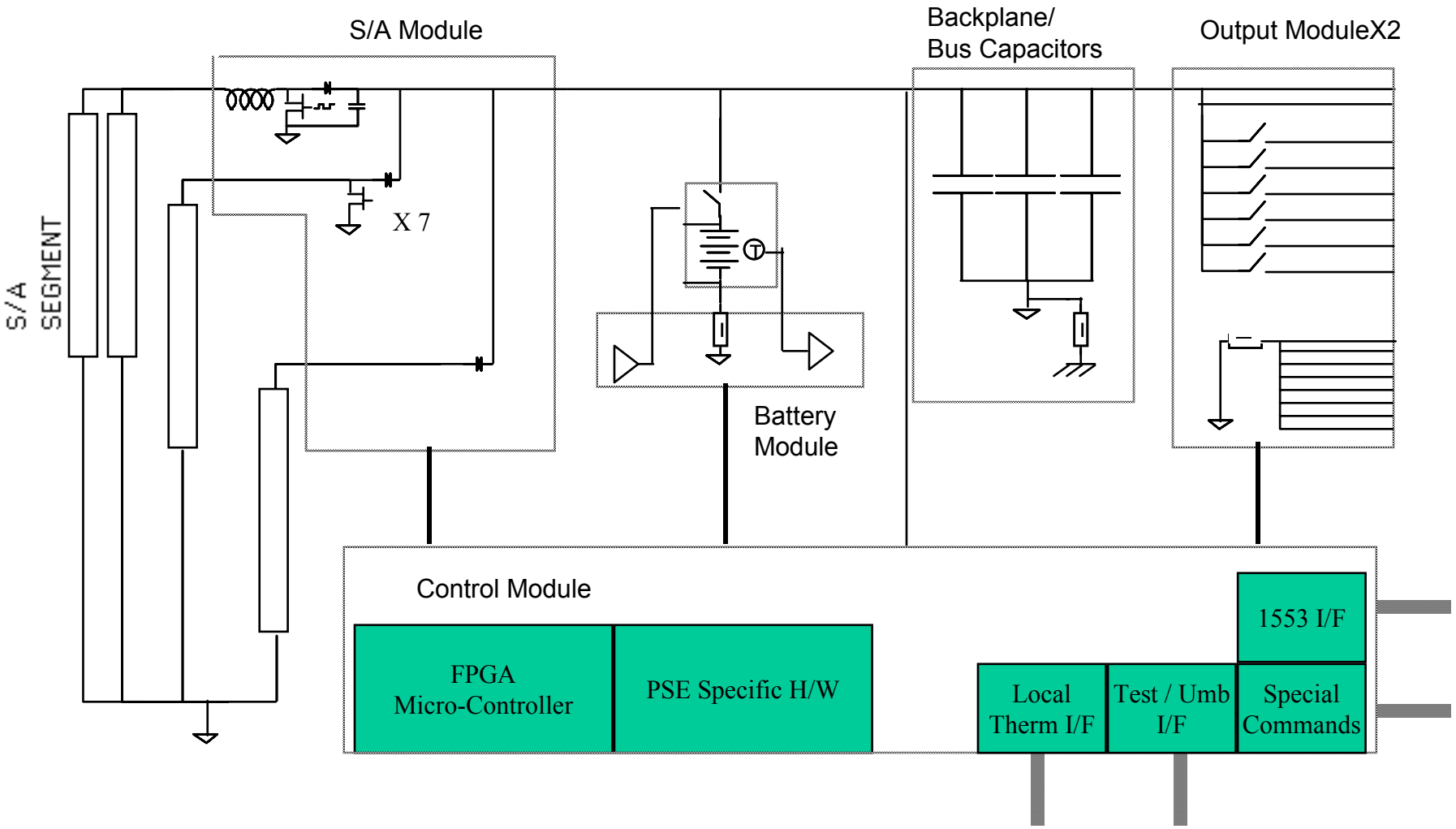
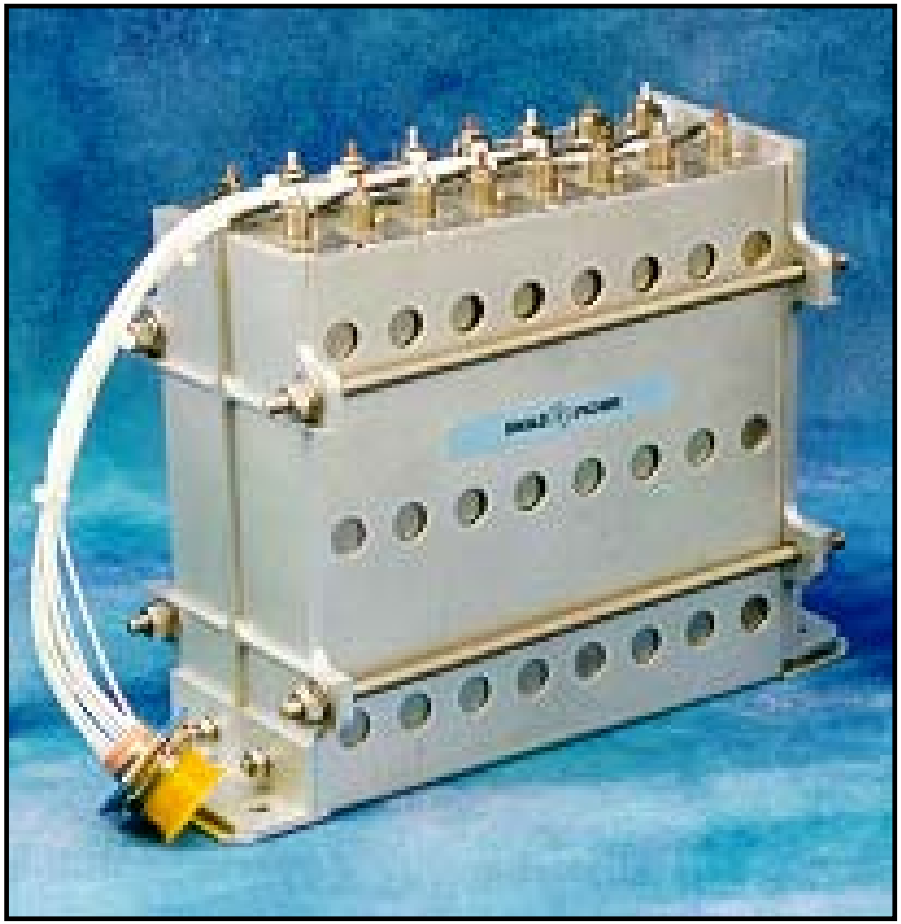


Typical 8 cell Lilon Battery



Baseline Individual Spacecraft Load Analysis

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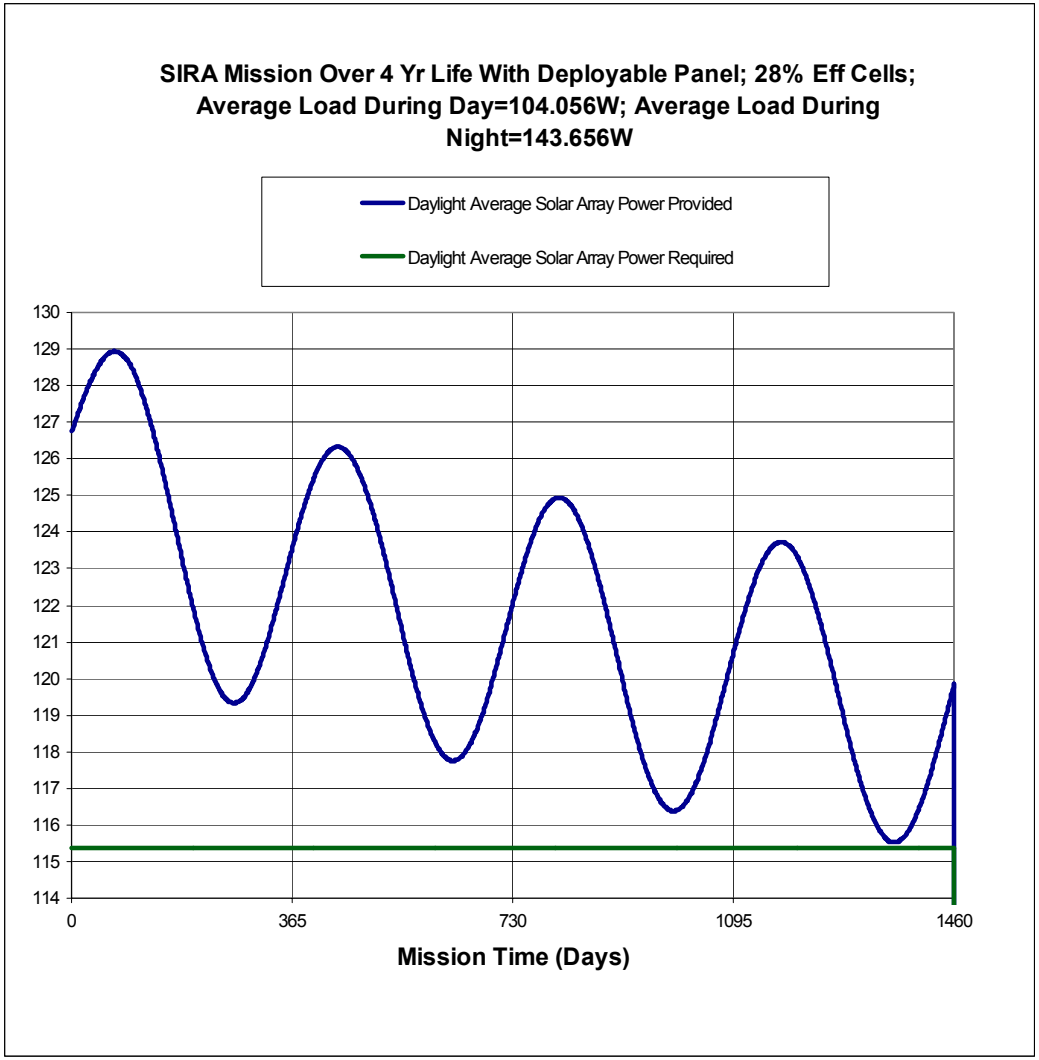
SIRA								
4.0	Mission Life in Years							
				Nominal Mode Day	Communications Mode	Safe Hold		
EPS Load Item Description				Avg. Power Watts	Avg. Power Watts	Power in Watts	Peak Power	Launch Power Requirement
Total Power				**104.1**	**143.7**	**95.8**	**160.4**	**84.7**
Time Period Over Which Averaging Is Done For Each Mode (min.)		Contingency						
	Inst Global Contingency	25						
Instruments with Contingency				**10.0**	**10.0**	**2**	**10.0**	**2.0**
Radio Receiver #1				4.0	4.0	0.8	4.0	0.8
	Contingency	25		1.0	1.0	0.2	1.0	0.2
Radio Receiver #2				4.0	4.0	0.8	4.0	0.8
	Contingency	25		1.0	1.0	0.2	1.0	0.2
Instrument #3				0.0	0.0	0.0	0.0	0.0
	Contingency	25		0.0	0.0	0.0	0.0	0.0
Instrument #4				0.0	0.0	0.0	0.0	0.0
	Contingency	25		0.0	0.0	0.0	0.0	0.0
Instrument #5				0.0	0.0	0.0	0.0	0.0
	Contingency	25		0.0	0.0	0.0	0.0	0.0
Instrument #6				0.0	0.0	0.0	0.0	0.0
	Contingency	25		0.0	0.0	0.0	0.0	0.0
Spacecraft Loads with Contingency				**94.1**	**133.7**	**93.8**	**150.4**	**82.7**
	Spcft Global Contingency	20						
PSE	MAP Like	4.79		4.8	4.8	2.4	7.2	1.0
	Contingency	20		1.0	1.0	0.5	1.4	0.2
Electrical - Harness Losses	BGB			1.0	1.0	0.2	1.500	0.2
	Contingency	20		0.2	0.2	0.0	0.3	0.0
Command & Data Handling	Terry S.			38.0	38.0	38.0	45.0	38.0
	Contingency	20		7.6	7.6	7.6	9.0	7.6
Solid State Data Recorder	N/A			0.0	0.0	0.0	0.0	0.0
	Contingency	20		0.0	0.0	0.0	0.0	0.0
Solar Array Drive Motor	BGB			0.5	0.5	0.1	0.8	0.1
	Contingency	20		0.1	0.1	0.0	0.2	0.0
Solar Array Drive Electronics	BGB			0.5	0.5	0.1	0.8	0.1
	Contingency	20		0.1	0.1	0.0	0.2	0.0
Attitude Control	Jim M.			3.6	3.6	1.0	4.7	3.6
	Contingency	20		0.7	0.7	0.2	0.9	0.7
Com, X Band Transmeter	Ron V.			0.0	32.0	0.0	32.0	0.0
	Contingency	20		0.0	6.4	0.0	6.4	0.0
Com, VHS Crosslink	Ron V.			8.0	9.0	8.0	9.0	8.0
	Contingency	20		1.6	1.8	1.6	1.8	1.6
Com, Reciever	Ron V.			8.0	8.0	1.6	8.0	8.0
	Contingency	20		1.6	1.6	0.3	1.6	1.6
Com UHF Crosslink	Ron V.			9.0	9.0	1.8	9.0	9.0
	Contingency	20		1.8	1.8	0.36	1.8	1.8
Thermal	Dan N.			5.0	5.0	25.0	7.5	1.0
	Contingency	20		1.0	1.0	5.0	1.5	0.2
Propulsion	Mark U.			0.0	0.0	0.0	0.0	0.0
	Contingency	20		0.0	0.0	0.0	0.0	0.0

Baseline Power Curve



EPS Summary, Baseline Each Spacecraft

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	SIRA				Total	Total	
	Dimensions (M)			#	Area or Vol	Mass(Kg)	Cost
Solar Array TJGaAs		1.00	0.47	1	0.467	2.47	$350
Battery LiIon 9	0.14	0.08	0.15	1	0.00	3.22	$1,000
PSE 28Vdc	0.25	0.05	0.46	1	0.01	2.25	$125
Harness spacecraft & solar array				1		0.32	$115
					Total Materials		$1,590

	Man Yr		
Hardware Design/Procurement	3		$360
EPS Integration	1		$120
EPS Launch Site Support	0.5		$60
		Labor Subtotal	$540
		Grand Total 8.3	$2,130

Risk

- **EPS Risk Item: Lilon cell Failure**
- **LIKELIHOOD of Occurrence: Green (Low)- Lilon cell open circuit will affect Com Mode, with loss of battery Com Mode could take longer curtailing science. We also multiple spacecraft, so we have spacecraft redundancy.**
- **What will happen if this risk happens? Com Mode will be affected for that spacecraft.**
- **FALLBACK Plan (What do we do if this risk happens?). Solar array only mode reduce Com Power and relay on multiple spacecraft.**
- **IMPACT (What effect does this fallback plan have?). Less data or use redundant spacecraft.**

EPS Trades

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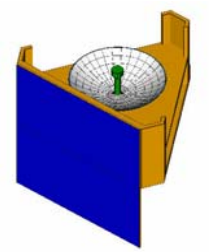
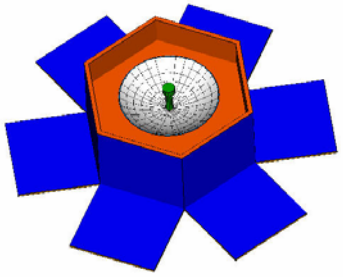
- **Option 1**



SIRA Option # 1		Dimensions (M)		#	Total Area or Vol	Total Mass(Kg)	Cost
Solar Array TJGaAs		1.00	0.54	1	0.542	2.87	$406
Battery LiIon	9	0.14	0.08	0.15	1	0.00	3.22	$1,000
PSE 28Vdc		0.25	0.05	0.46	1	0.01	2.25	$125
Harness spacecraft & solar array					1		0.32	$125
						Total Materials		$1,656
					Man Yr			
Hardware Design/Procurement					3			$360
EPS Integration					1			$120
EPS Launch Site Support					0.5			$60
						Labor Subtotal		$540
						Grand Total	8.7	$2,196

- **Option #2**



SIRA Option #2		Dimensions (M)		#	Total Area or Vol	Total Mass(Kg)	Cost
Solar Array TJGaAs		1.00	3.52	1	3.517	18.61	$2,638
Battery LiIon	9	0.14	0.08	0.15	1	0.00	3.22	$1,000
PSE 28Vdc		0.25	0.05	0.46	1	0.01	2.25	$125
Harness spacecraft & solar array					1		0.32	$125
						Total Materials		$3,888
					Man Yr			
Hardware Design/Procurement					3			$360
EPS Integration					1			$120
EPS Launch Site Support					0.5			$60
						Labor Subtotal		$540
						Grand Total	24.4	$4,428

Executive Summary

- The Baseline configuration provide the lowest EPS mass and cost for the three we looked at.
- The 8Vdc ST-5 Power bus should be looked at in more detail. The lower power bus (8vDC) could be a closer match to the load “real power use” and should save mass by eliminating converters. Also the solar array panel could use larger cells and reduce loss form packing factors. Like wise the battery would be reduced to two cells (however larger amp hour) saving more mass.