TSIS-2
25 Year Operational Implementation (2015 – 2040)

TSSI – Total and Spectral Solar Irradiance • CDR – Climate Data Record • TSIS – Total and Spectral Solar Irradiance Sensor • TOMC – TSSI Operational Monitoring Constellation

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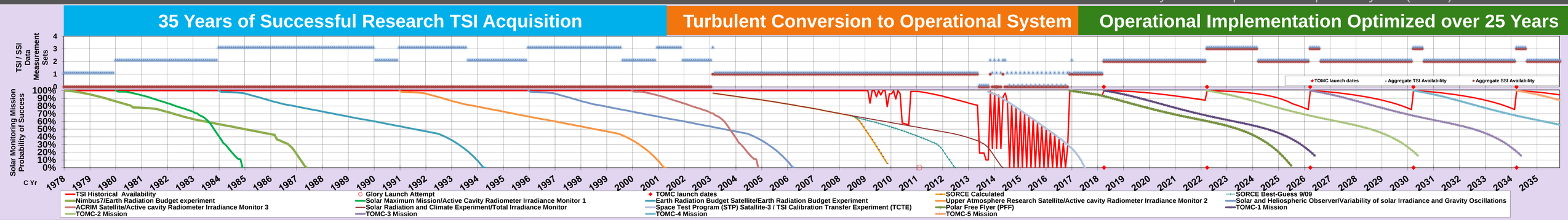
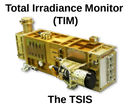


TSIS provides the TSSI Climate Data Record

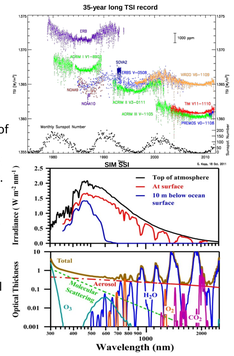
- Solar irradiance variability is the only external forcing of the climate system. Reliable knowledge of solar forcing is crucial to quantifying all climate forcing, including those of natural and anthropogenic origin.
- The Total and Spectral Solar Irradiance Sensor (TSIS) provides two measurements critical for determining natural (solar) influences on Earth climate

The TSIS Total Irradiance Monitor (TIM)



The TSIS Spectral Irradiance Monitor (SIM)

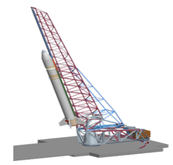
- Total Solar Irradiance (TSI), a continuing 35-year uninterrupted measurement record of incoming solar radiation, is the dominant energy source driving the Earth's climate, and provides the most precise indicator of changes in the Sun's energy output. TSIS/TIM is the newest TSI instrument, benefitting from recently improved ground calibration facilities and has better accuracy and stability than any other TSI instrument
- Spectral Solar Irradiance (SSI) measurements provide the wavelength-dependent variability of solar radiation from which the solar forcing mechanisms can be quantified. The TSIS SIM is the next generation Solar Spectral Irradiance monitor building on the heritage of the SORCE SIM. TSIS SIM is the most accurate and highest precision space-borne SSI radiometer to date. This is possible through utilizing improved NIST spectral calibration facilities that adhere to International (SI)-radiometric standards. It is the only instrument capable of providing long-term solar spectral inputs to advanced chemistry-climate models crucial to quantifying solar influences on Earths climate system.



The TSI data set, with its long and continuous high-precision record, provides the measurement constrains of the total energy available to drive the climate system. The newer SSI measurements provide the details to resolve the underlying mechanisms and terrestrial interactions responsible for driving climate processes. Both are invaluable components for understanding the natural influences on climate, and thus both were selected as part of the TSIS to fulfill the requirements for the Solar Irradiance Climate Data Record.

Keys to Successful Implementation

1) Low Cost Launch



Super Strypi (SPARK) Missile

The solid-fueled Super Strypi launcher is developed by Sandia National Laboratories, the University of Hawaii and Aerojet. The rocket is based on an enlarged version of Sandia's Strypi sounding rocket.

2) LASP-built, very capable but small, low cost, spacecraft bus

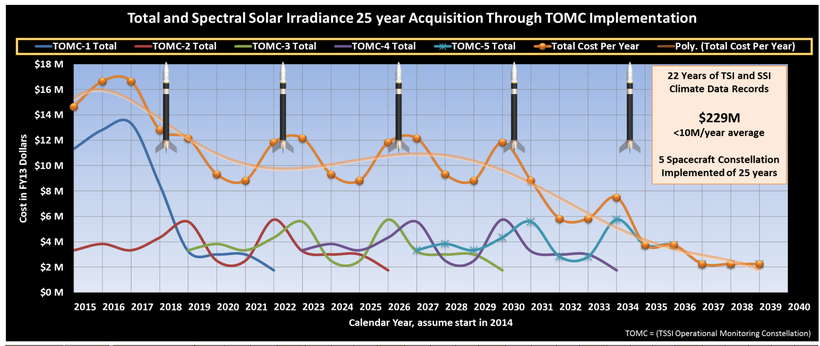
- The LASP Micro (Mighty) Bus (LMB)
- Mature spacecraft architecture tailored to SIM&TIM needs
- Robust design with ample margins results in a high reliability, low cost solution

3) All interfaces managed and integrated within one organization

Spacecraft fully integrated into Operations Environment

- Interface control between hardware, software, test, and verification
- LASP spacecraft design and operations allow for optimization and automation of spacecraft hardware and software to provide a lowest cost approach to autonomous operations and data processing

Implementation Cost and Schedule



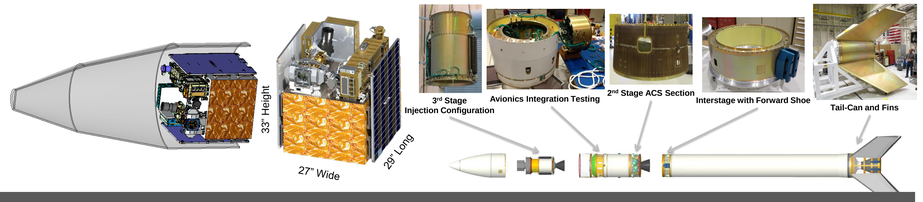
Totals		Phasing	Start up Year	Year	Year	Launch Year	Year	Year	Launch Year	Year	Year	Year	Launch Year	Year	Year	Year	Launch Year	Year	Year	Launch Year	Year	Year	Year	Launch Year	Year	Year	Year	Year
All $ in $M Fy13$			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
		Proposed Year	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039
						TOMC-1																					
NASA Overnight	$ 14.5					1-LRD		2-LRD		TOMC-2																	
											3-LRD			TOMC-3													
															4-LRD			TOMC-4									
																					5-LRD			TOMC-5			
Average/year	$ 9.2																										
Total for 25 yea	$ 229.5	Total/year	$14.7	$16.7	$16.7	$12.8	$12.2	$9.3	$8.8	$11.8	$12.2	$9.3	$8.8	$11.8	$12.2	$9.3	$8.8	$11.8	$8.8	$5.8	$5.8	$7.5	$3.8	$3.8	$2.3	$2.3	$2.3
	$ 6.00	TIM	2.00	2.00	2.00																						
	$ 7.00	SIM	2.33	2.33	2.33																						
	$ 15.50	LMB TIM/SIM	5.00	5.50	5.00																						
	$ 10.00	LAUNCH TOMC	1.00	2.00	3.00	4.00																					
	$ 6.50	OPERATIONS	0.33	0.33	0.33	1.50	1.25	1.00	1.00	0.75																	
	$ 10.00	SCIENCE AND DATA	0.33	0.33	0.33	2.00	2.00	2.00	2.00	1.00																	
	$ 2.00	NASA Overhead (SORCE Numbers)	0.33	0.33	0.33	1.00																					
TOMC-1 Total	$ 57.00																										
	$ 4.50	TIM	0.90	0.90	0.90	0.90	0.90																				
	$ 5.50	SIM	1.10	1.10	1.10	1.10	1.10																				
	$ 5.50	LMB TIM/SIM	1.00	1.50	1.00	1.00	1.00																				
	$ 10.00	LAUNCH TOMC				1.00	2.00	2.00	2.00	3.00																	
	$ 6.00	OPERATIONS					0.25	0.50	0.50	0.75	1.25	1.00	1.00	0.75													
	$ 8.00	SCIENCE AND DATA								1.00	2.00	2.00	2.00	1.00													
	$ 2.65	NASA Overhead (SORCE Numbers)	0.33	0.33	0.33	0.33	0.33																				
TOMC-2 Total	$ 42.15																										
	$ 4.50	TIM					0.90	0.90	0.90	0.90	0.90																
	$ 5.50	SIM					1.10	1.10	1.10	1.10	1.10																
	$ 5.50	LMB TIM/SIM					1.00	1.50	1.00	1.00	1.00																
	$ 10.00	LAUNCH TOMC								1.00	2.00	2.00	2.00	3.00													
	$ 6.00	OPERATIONS									0.25	0.50	0.50	0.75	1.25	1.00	1.00	0.75									
	$ 8.00	SCIENCE AND DATA												1.00	2.00	2.00	2.00	1.00									
	$ 2.65	NASA Overhead (SORCE Numbers)												1.00													
TOMC-3 Total	$ 42.15																										
	$ 4.50	TIM									0.90	0.90	0.90	0.90	0.90												
	$ 5.50	SIM									1.10	1.10	1.10	1.10	1.10												
	$ 5.50	LMB TIM/SIM									1.00	1.50	1.00	1.00	1.00												
	$ 10.00	LAUNCH TOMC												1.00	2.00	2.00	2.00	3.00									
	$ 6.00	OPERATIONS													0.25	0.50	0.50	0.75	1.25	1.00	1.00	0.75					
	$ 8.00	SCIENCE AND DATA																1.00	2.00	2.00	2.00	1.00					
	$ 2.65	NASA Overhead (SORCE Numbers)									0.33	0.33	0.33	0.33	0.33												
TOMC-4 Total	$ 42.15																										
	$ 4.50	TIM													0.90	0.90	0.90	0.90	0.90								
	$ 5.50	SIM													1.10	1.10	1.10	1.10	1.10								
	$ 5.50	LMB TIM/SIM													1.00	1.50	1.00	1.00	1.00								
	$ 10.00	LAUNCH TOMC																1.00	2.00	2.00	2.00	3.00					
	$ 8.00	OPERATIONS																	0.25	0.50	0.50	0.75	1.50	1.50	1.00	1.00	1.00
	$ 8.00	SCIENCE AND DATA																				1.00	2.00	2.00	1.00	1.00	1.00
	$ 4.56	NASA Overhead (SORCE Numbers)													0.33	0.33	0.33	0.33	0.33	0.33	0.33	1.00	0.25	0.25	0.25	0.25	0.25
TOMC-5 Total	$ 46.06																										

Total by Mission	
$M FY13$	Total
TOMC-1 Total	57.00
TOMC-2 Total	42.15
TOMC-3 Total	42.15
TOMC-4 Total	42.15
TOMC-5 Total	46.06
Total Cost	229.51

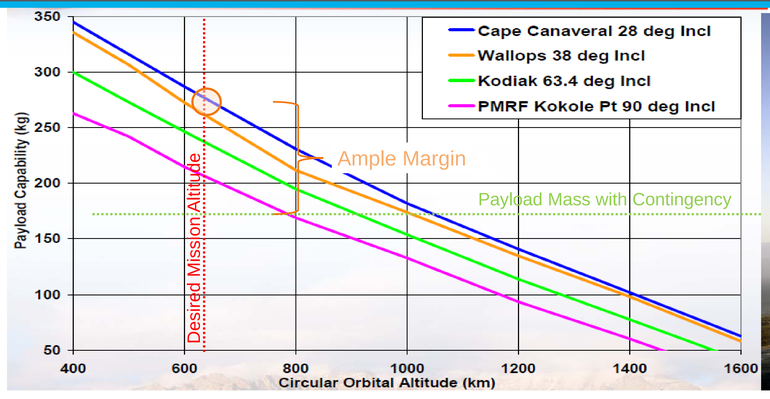
Total by Sub System	
$M FY13$	Total
Space Assets	90.50
Launch Cost	50.00
Operations	32.50
Data Systems	42.00
NASA Oversight	14.51
Total Cost	229.51

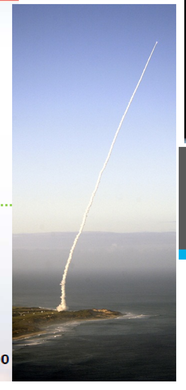
Super Strypi Missile

1) Low Cost Launch ($10M, Vehicle and Launch support)

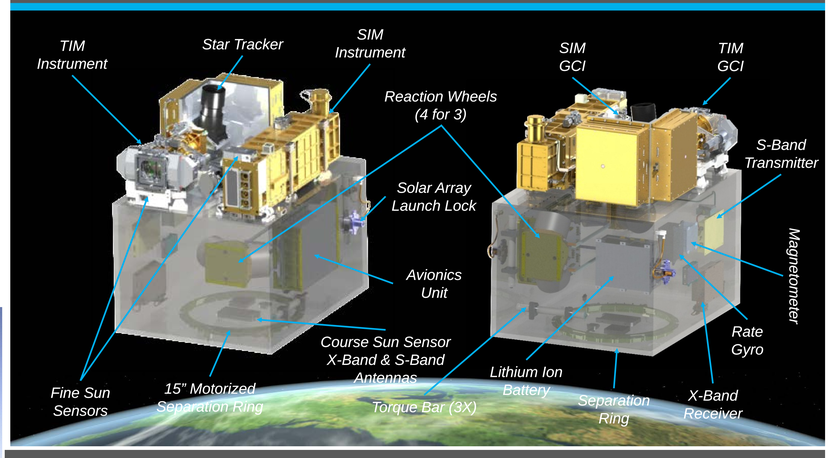


Super Strypi Orbital Launch Performance (ORS-4) Exceeds TOMC Requirements





LASP Micro (Mighty) Bus (LMB)



LMB is a high performance bus delivered for $5.5M/copy

The LMB is fully integrated with the TSIS instruments to produce an optimal system designed for the sounding rocket launch environment. All physical and software interfaces are within one organization (LASP) allowing optimal implementation and lowest possible cost.

Conclusion

- Technology is currently available to produce a low-cost constellation of overlapping space assets launched at an optimal interval for robust and continuous monitoring of TSSI that will fulfill the national interest.
- By managing and optimizing all of the TOMC interfaces (LASP Micro Bus and TSIS instruments, LASP operations and data processing and the Sandia Super Strypi launch vehicle) within LASP's systems engineering organization, and combining with the NASA light-touch management of a PI-mode mission, TOMC will provide the TSSI CDRs for 25 years at less than $10M/year.
- This implementation is ready to go and should start with funding in 2015 to help minimize the risk to the TSSI CDR.