ICON
Ionospheric Connection Explorer

Mission PI Perspective

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The Ionospheric Connection Explorer

ICON : NASA Explorer Mission Programatics

Mission Summary	
Cost	$173.7 M (RY)
Launch vehicle	Pegasus XL RTS - Kwajalein
Spacecraft	LEOStar-2, 3-axis stabilized, no consumables
Launch	June 2017
Orbit	575 km circular, 27° inclination
Ground segment	Berkeley Ground Station, WGS, Santiago
Mission & Science Ops	24 months Phase E Operated from UCB

ICON is a loosely coupled program managed as a Category 2 project per NPR7120.5E

The mission class is Class C per NPR 8705.4

After Mission PDR the project was directed to add a second IVM and plan for a June 2017 launch

- That rephase was completed in August of 2014 w/SRB Review

ICON Pre-Integration Mass/Power

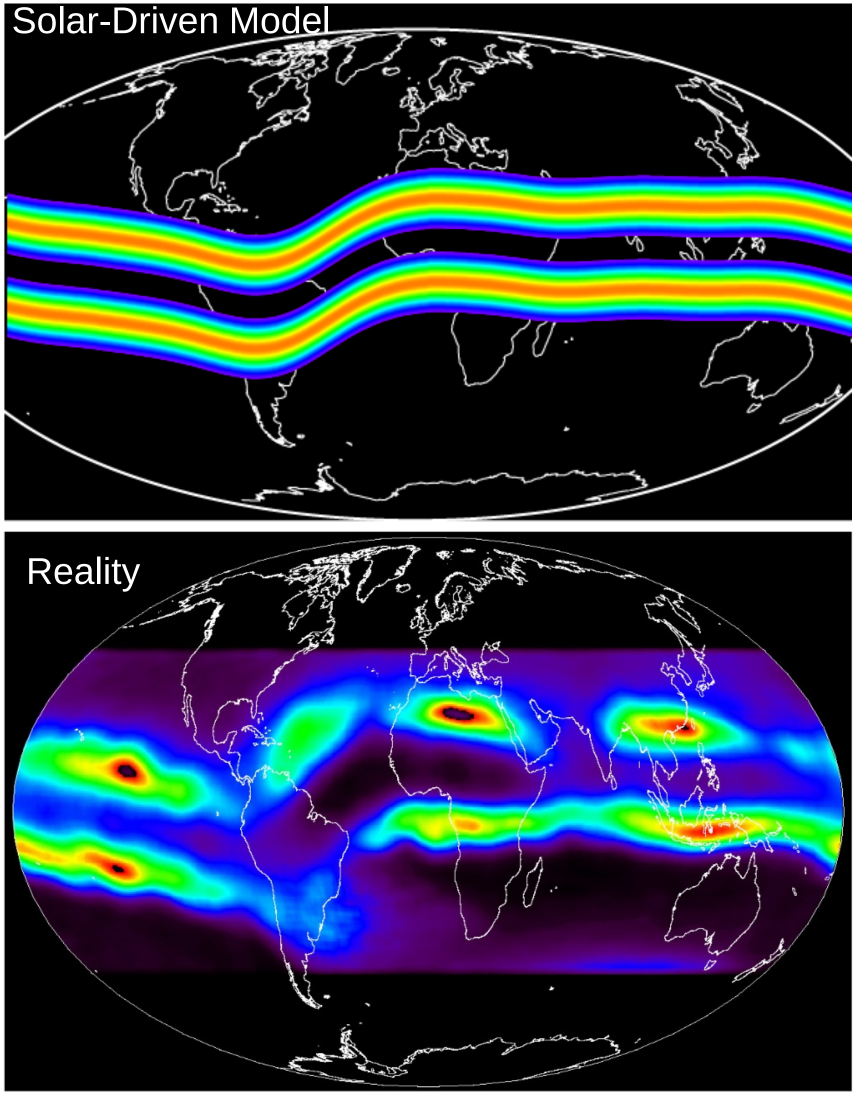
Subsystem	CBE Mass (kg)	Cont. (%)	MEV Mass (kg)
	2015 - October		
01 Mechanical	43.95	2.6%	45.08
02 Thermal	5.83	8.6%	6.33
03 EPS	31.87	1.4%	32.32
04 C&DH	9.36	1.2%	9.47
05 Comm	3.59	1.4%	3.64
06 ADCS	45.72	1.1%	46.22
07 Harness	17.00	6.1%	18.04
Spacecraft Mass	**157.32**	**2.4%**	**161.10**
01 ICP	5.95	7.8%	6.41
02 MIGHTI	46.42	5.2%	48.85
03 FUV	33.08	1.0%	33.43
04 EUV	6.65	1.0%	6.71
05 IVM A&B	8.50	10.0%	9.35
06 PIP Structure	17.36	1.4%	17.59
07 Thermal	2.44	13.3%	2.76
08 Harness	3.69	15.0%	4.24
Payload	**124.09**	**4.2%**	**129.35**
Observatory Mass	**281.41**	**3.2%**	**290.44**
Est. LV Capability (w/ SoftRide)			343.00
Mass Margin			**18.1%**

Scenario:	β=0°	β=+50°
System / Subsystem	**Power (W)**	**Power (W)**
ACS	67.9	67.7
EPS	9.4	9.4
C&DH	46.4	46.4
RF Comm	7.6	7.6
S/C Thermal	20.0	26.5
Spacecraft Power	**151.4**	**157.6**
Payload	104.2	84.1
Observatory Power	**255.6**	**241.7**
Losses	17.5	19.3
Observatory Power on Sun	**273.1**	**261.0**
Battery Recharge Average Power	167.0	115.7
Total S/C Power Required on Sun	440.1	376.7
EOL Solar Array Average Power	718.8	407.7
Solar Array Power Margin	**63%**	**8%**
Minimum Battery Voltage	**31.1V**	**31.4V**

The ionosphere is structured and variable in ways that we cannot account for…

- Since the year 2000, there have been a number of discoveries showing the usual suspects (changes in solar wind and radiance) are insufficient to explain the ionospheric variability.
- It has been shown, for instance, that the ionosphere has large zonal variations in density, that vary temporal scales from months to days.
- There is apparently another influence that is large and controlling.

We now believe that the lower atmosphere is the source of much of this variability.



TIMED-GUVI, England *et al.* (2009)

ICON's Science Objectives require measurements of both drivers and responses

The Ionospheric Dynamo, driven by the neutral atmosphere, governs the motion of the plasma:

- We need to measure the **drivers**:

Neutral winds that carry the energy and momentum that drives the dynamo.

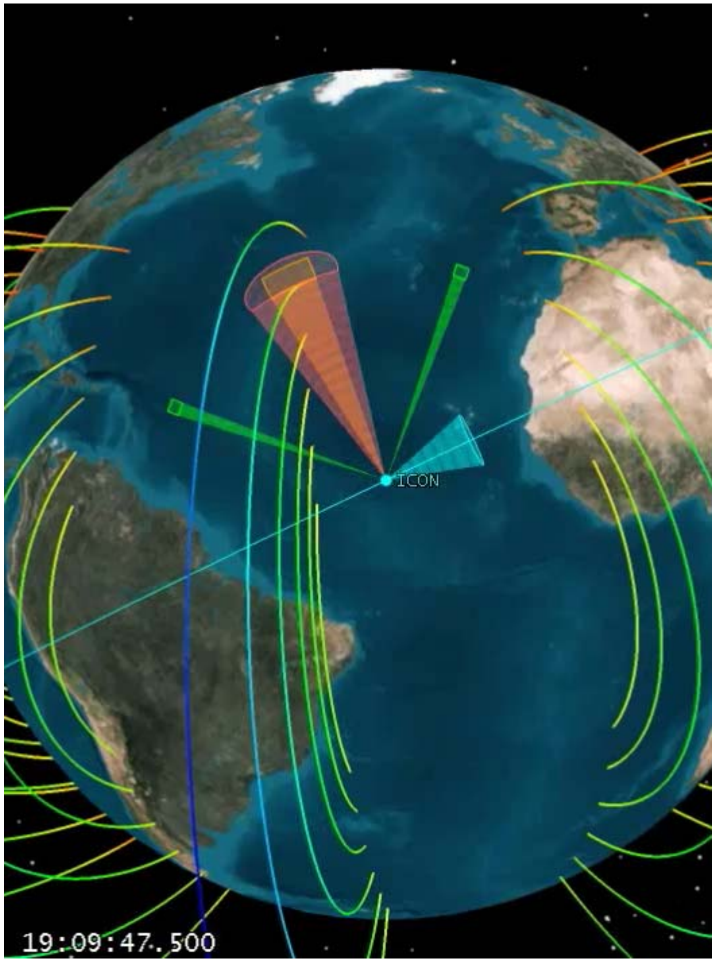
Composition of the atmosphere that controls the chemical production and loss rates of plasma.

Temperature of the atmosphere that reveals the atmospheric waves entering space from below.

- With the **reponses**:

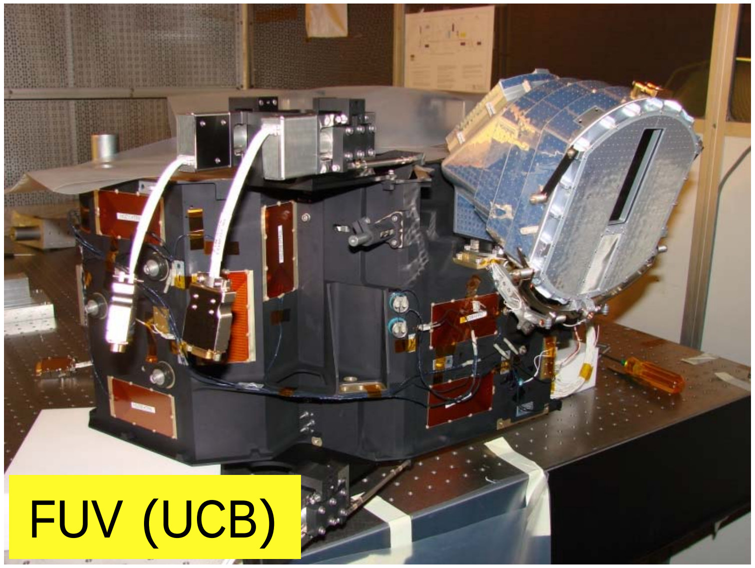
The electric field and **the plasma velocity distribution**, which are directly related.

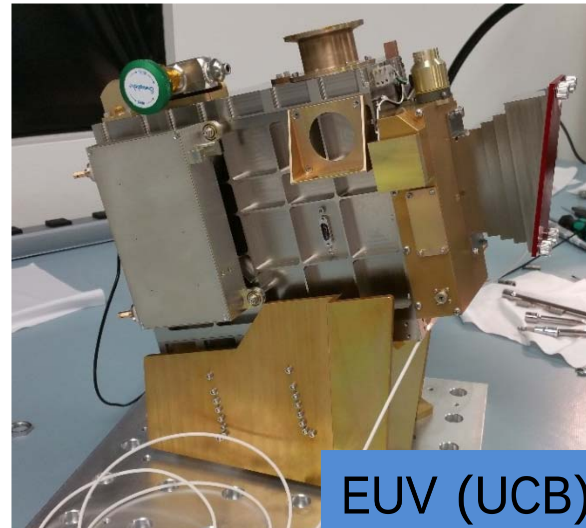
Plasma density of the ionosphere, the combined result of solar production and plasma motion.

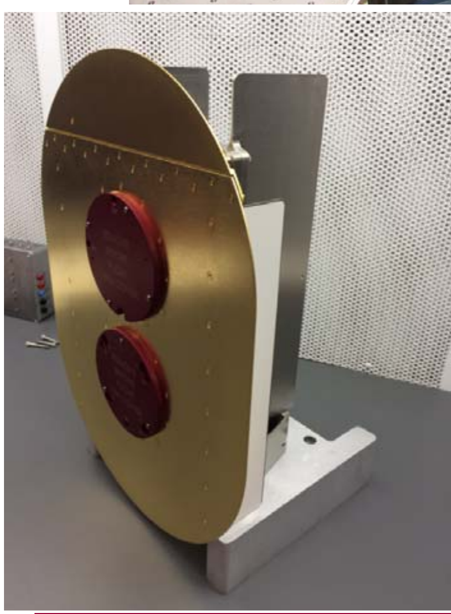


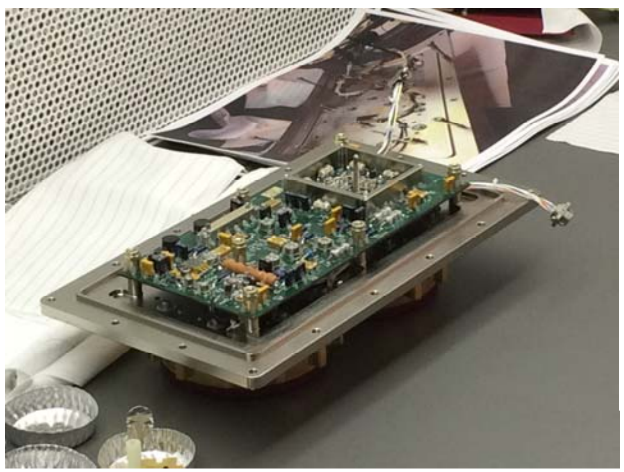
All baseline measurements being made. No science descopes exercised

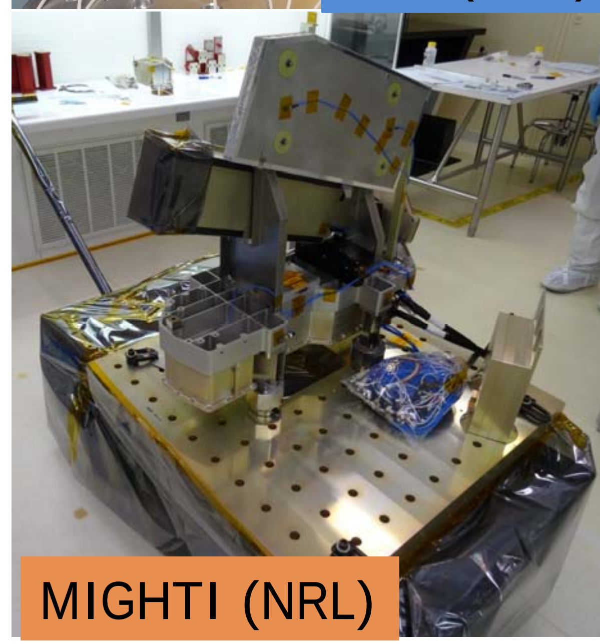
ICON carries a set of instruments to make all the necessary measurements.


FUV (UCB)

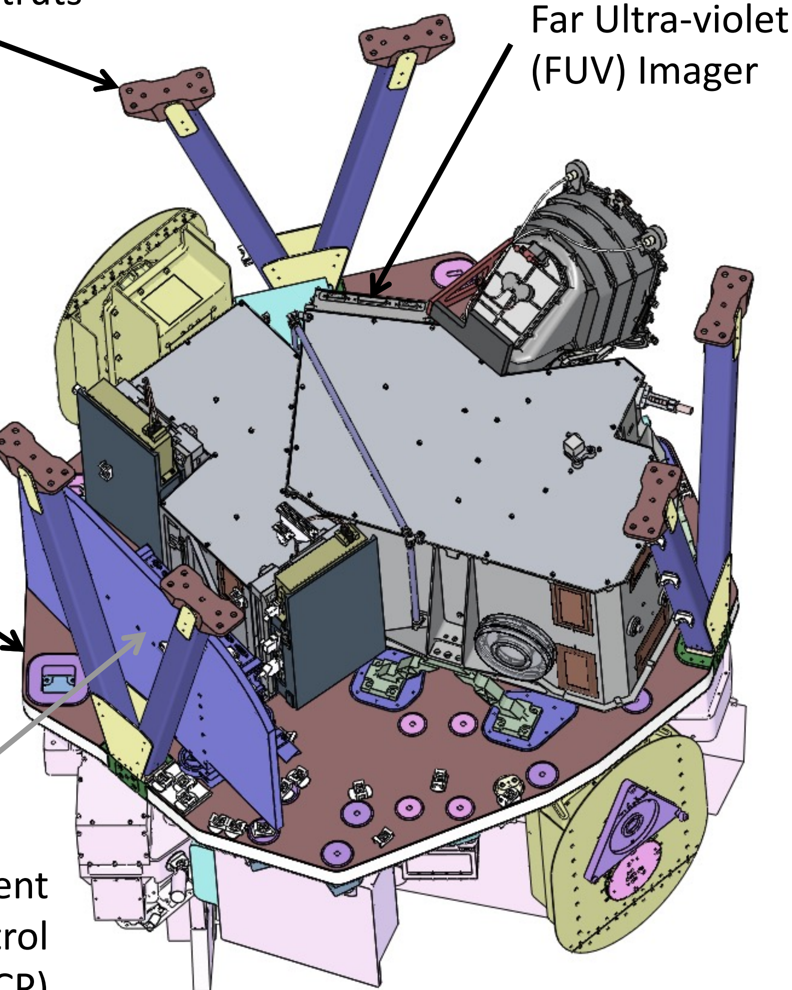

EUV (UCB)

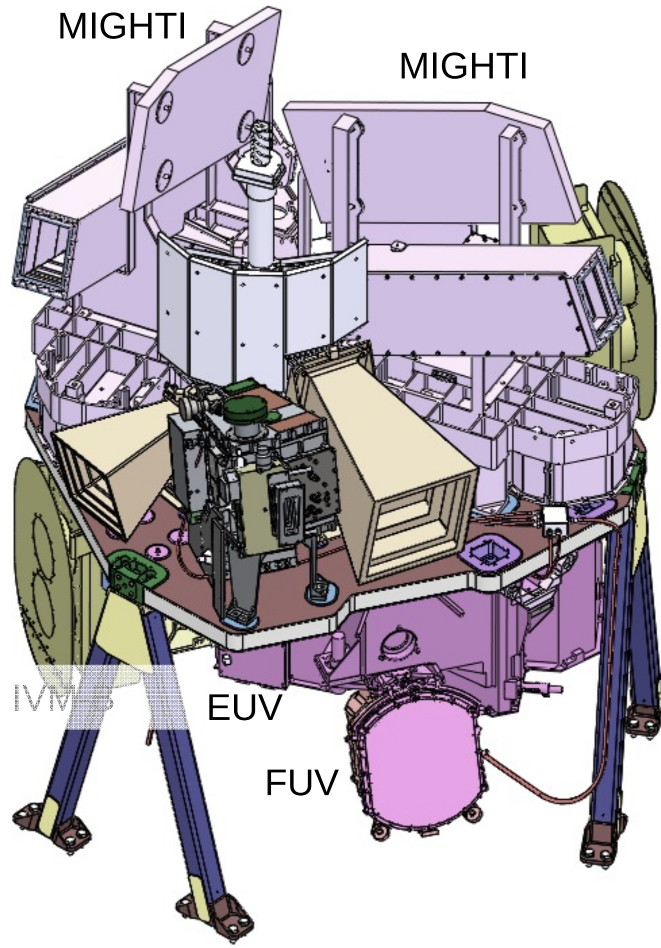



IVM (UTD)

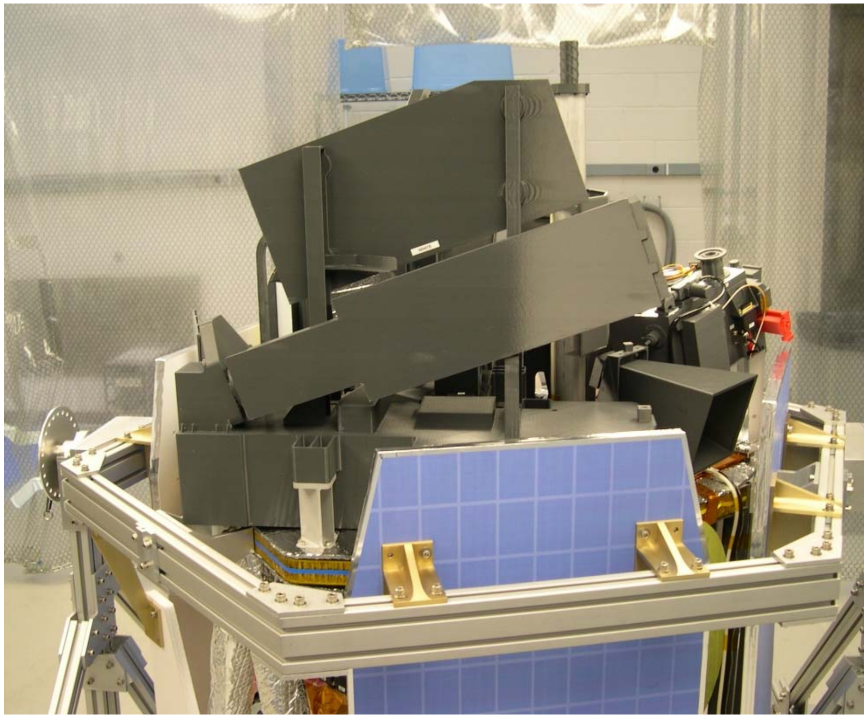

MIGHTI (NRL)

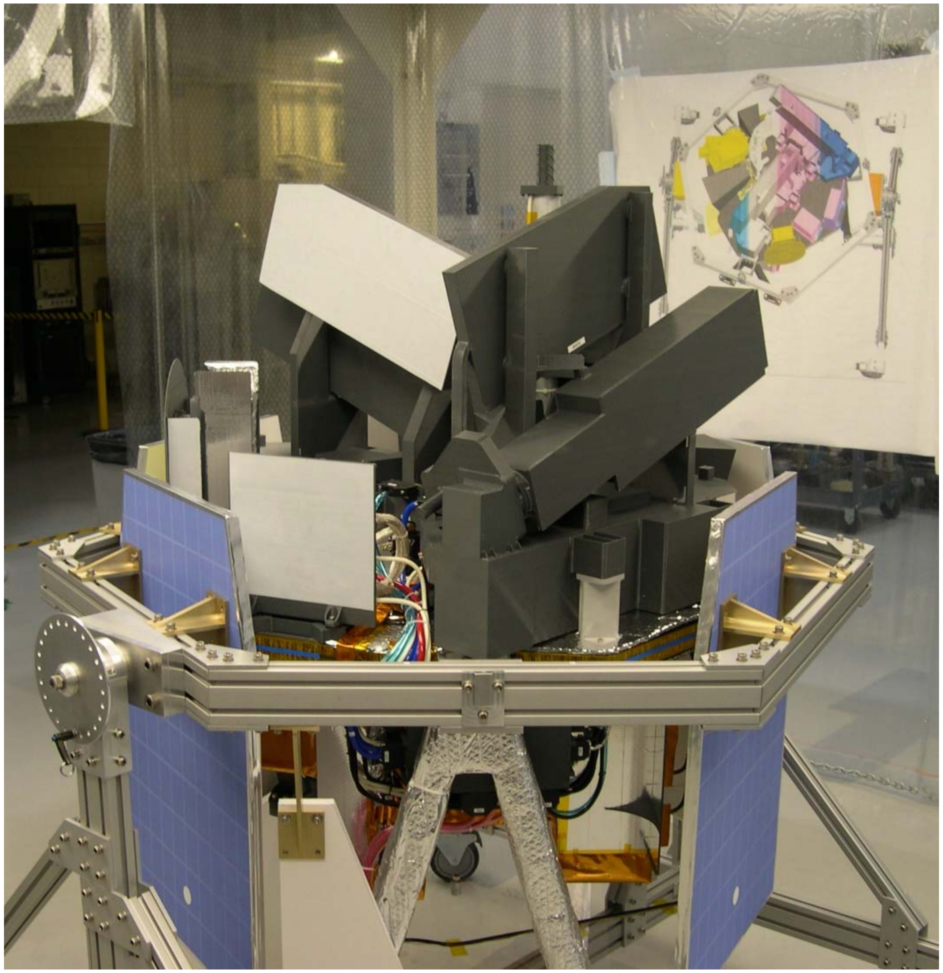
Payload integrated completely before delivery to spacecraft





Payload Mockup @ Space Dynamics Lab





High fidelity mockup of payload allowed for detailed planning of instrument integration.

Addition of solar arrays allows assessment of any issues with late flow calibration and instrument access.

- You will repeatedly revisit your science requirements and the PI ultimately is called to explain every change
  - It is important enough to hold significant margins that the PI controls
    1. In the development of the Program Level Requirements, and Requirements Agreement, strive to maintain margins between the Program (Level 1) and the Project (Level 2) science requirements. Level 2 should not be a pass-through of the Program Requirements to the mission elements.
    2. Payload (Level 3) and Instrument (Level 4) requirements will be developed and reviewed after selection, and the systems engineering effort will expose performance hits that will put pressure on Project requirements. Only with margin to the Program requirements can the mission proceed.
    3. Strategy for achieving this can be agreed upon with mission (GSFC) and program (SMD) scientists. Your strategy will be discussed at length with your Standing Review Board.

    Recommendation: Upon selection, expand your Science Traceability Matrix to a Project Document (ICON: Science Rationale and Traceability Document) that explains the approach and defends the requirements in the PLRA. Model for this was AIM (PI James Russell).

- You have the responsibility to build and deliver the science mission you proposed to SMD.
  - NASA can be very helpful but:
    1. Should there be discussions needed regarding scope; be prepared to stake out your position and stick to it for as long as it takes. The easiest solution is always to tap your reserves; a very precious resource. This should be your last course of action!
    2. You manage, your NASA center provides oversight. Oversight can be very useful; take advantage of it where you can. Recognize, however, that you will need to manage the oversight as well to control cost and schedule.
    3. Even while “pushing back”, it is vitally important to maintain a collegial, respectful, and open relationship with your NASA center and your SRB. Threats to this can come up on either side. Addressing them as early as possible will make your life easier.
    4. Your Mission Assurance Requirements document, MAR, can have significant cost implications (e.g. EEE parts). Be sure your project personnel understand the implications of each and every clause. It is much easier to negotiate in advance than it is to write waivers later.

Other Lessons

- Your PM defends your science budget from cost and schedule threats. For the PI to be able to trust the PM's choices and discretion implicitly is a great value to the mission.
- Earned Value Management can be done, and it can be done right. In either case, it will incur significant financial burdens to your project.
- Optional Enhancements are unlikely to be picked up without strong Program level support. This specifically goes to Student Experiments or Science Enhancements. You will have to fight to actually implement anything presented as optional.