NASA Goddard Space Flight Center Support for the Planetary Decadal Activities

Michael Amato, et al.

NASA GSFC

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Outline

- GSFC support and commitment
- GSFC Experience and Capabilities: Some relevant information about GSFC
- GSFC planetary missions and instruments
- What capabilities, approaches and other experience can GSFC leverage to complete studies it is asked to do?
- Integrated Design Center (IDC) – IDL and MDL
- Study maturity and GSFC study costing capabilities
- GSFC planetary studies and proposal work
- GSFC HQ and Decadal studies
- Summary
- Contacts/Interfaces for Planetary decadal work







Goddard support for Planetary Decadal work

- GSFC has the science, engineering, management, facilities and experience to provide the highest quality support for Planetary Decadal activities.

- GSFC is committed to accomplishing the studies you identify and working with you and the panels.







GSFC Experience and Capabilities

Why GSFC can be useful for planetary decadal survey activities;

•GSFC has tremendous flight mission experience. 247+ space flight missions.

•GSFC has deep, experienced, capable engineering and management organizations. ~1300+ person engineering directorate covering all disciplines with more engineers in other directorates, and a ~400 person flight project manager organization.

•GSFC has large group of experienced scientists and instrumentalists. The largest group of space scientists in the world.

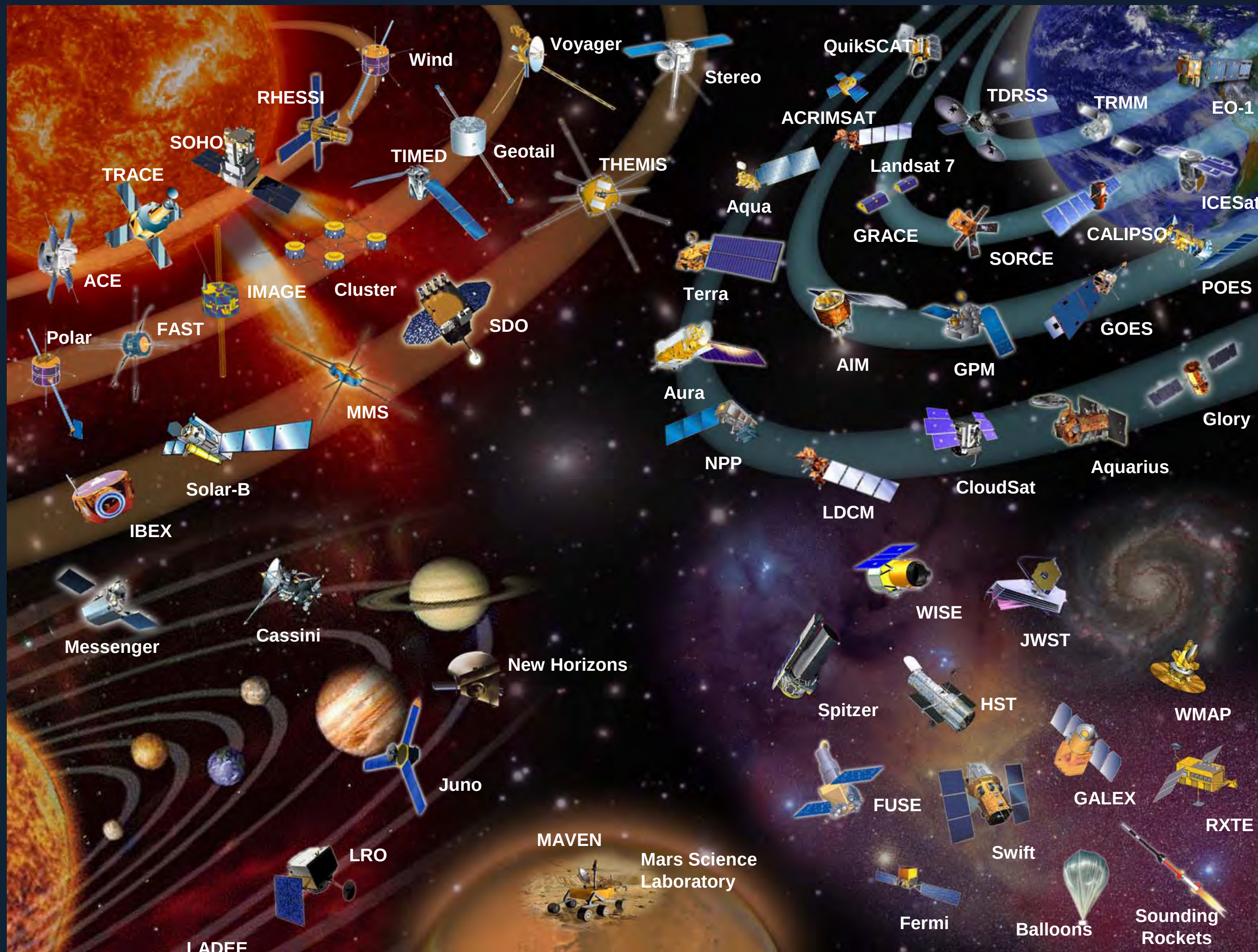
•GSFC has a dedicated planetary and lunar science division (Solar System Exploration Division) with well over 200 scientists and staff.

•GSFC has very broad flight instrument experience and has flown more instruments to planetary targets than any other organization.

•Full end to end capability – initial concept through science analysis and results.

GSFC Experience and Capabilities

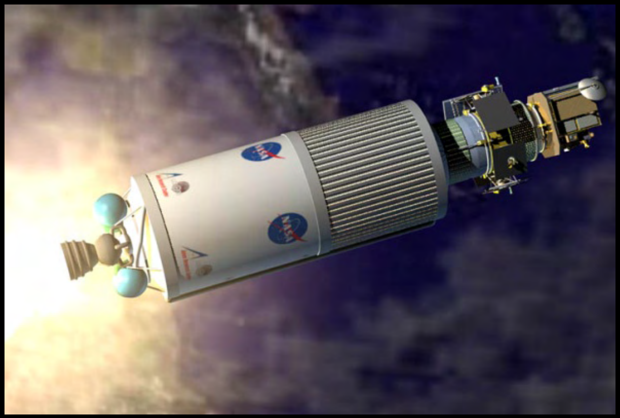
Current and future missions and mission involvement



GSFC and Planetary Missions

- Some of GSFC's Planetary missions involvement
  (green = GSFC managed);
  - Explorer 33 (IMP-D) - 1966
  - Explorer 35 (IMP-E)- 1967
  - Voyager I- 1977
  - Voyager II- 1977
  - Pioneer- Venus- 1978
  - ISEE-C- 1978
  - Galileo- 1989
  - Mars Observer
  - Ulysses- 1990
  - NEAR-Shoemaker-1996
  - Mars Global Surveyor- 1996
  - Cassini-1997
  - Huygens (Cassini) -1997
  - Lunar Prospector- 1998
  - Contour- 2002
  - Messenger-2004
  - LRO- 2009
  - JUNO- 2011
  - Mars Science Lab-2012
  - LADEE
  - MAVEN- 2014

GSFC and Planetary Missions
Lunar Reconnaissance Orbiter (LRO)



LRO & LCROSS on Atlas-Centaur Upper Stage

INSTRUMENT	Key Data Products
CRaTER Cosmic Ray Telescope for the Effects of Radiation — Boston University/MIT 	Lunar and deep space radiation environment and tissue equivalent plastic response to radiation
DLRE Diviner Lunar Radiometer Experiment — UCLA/JPL 	500 m scale maps of surface temperature, albedo, rock abundance, and ice stability
LAMP Lyman Alpha Mapping Project — SWRI 	Maps of frosts and landforms in permanently shadowed regions (PSRs).
LEND Lunar Exploration Neutron Detector — Russian Space Agency 	Maps of hydrogen in upper 1 m of Moon at 10 km scales, neutron albedo
LOLA Lunar Orbiter Laser Altimeter — GSFC 	~25 m scale polar topography at < 10 cm vertical, global topography, surface slopes and roughness
LROC Lunar Reconnaissance Orbiter Camera — ASU/MSSS 	1000's of 50cm/pixel images, and entire Moon at 100m in UV, Visible. Illumination conditions of the poles.
Mini-RF *Technology Demonstration* — DOD/NSWC 	X and S-band radar imaging and interferometry

Mission Objective

The LRO Mission objective is to conduct investigations that are specifically targeted to prepare for and support future human exploration of the Moon. LRO will provide detailed maps of the Moon's topography, surface features, surface environments, radiation environment, and potential resources

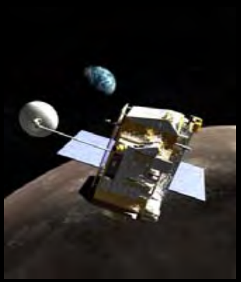
Mission Implementation

LRO is an ESMD mission executed as an in-house GSFC Project with competitively selected instruments. The spacecraft was built at GSFC and the Mission Operations Center is at GSFC.

Mission Description & Status

1 year mission in a 50 km lunar polar orbit. Spacecraft is 3-axis stabilized, nadir pointed 95% of the time to support near continuous observations over the year. Launch was on June 18th, 2009. LRO is in commissioning phase thru late August 2009. After completion of 1 year ESMD mission LRO will conduct a 2 year SMD sponsored science mission.

Mass (wet): 1950 kg
Power: 680 W
Volume: 2.6 x 1.4 x 3.7 m (array stowed)
Launch Vehicle: Atlas V 401



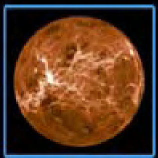
LRO Depicted in Lunar Orbit

LRO in Launch Configuration

LRO Launch

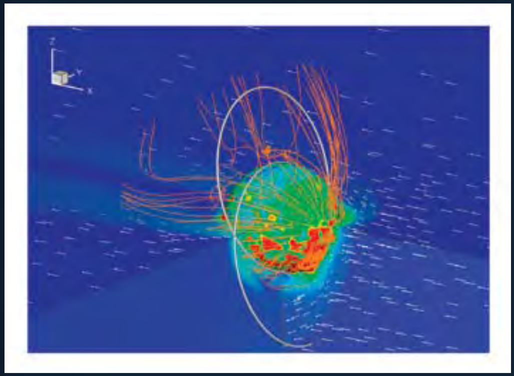






GSFC and Planetary Missions
MAVEN Project Overview

SELECTED 2008



Mission Objectives

- Determine the role that loss of volatiles from the Mars atmosphere to space has played through time, exploring the histories of Mars' atmosphere and climate, liquid water, and planetary habitability
- Determine the current state of the upper atmosphere, ionosphere, and interactions with solar wind
- Determine the current rates of escape of neutrals and ions to space and the processes controlling them
- Determine the ratios of stable isotopes that will tell Mars' history of loss through time

Organizations

- LASP – PI and science team; E/PO; science operations; IUVS and LPW instruments
- GSFC – project management; mission systems engineering; safety and mission assurance; project scientist; NGIMS and MAG instruments
- JPL – Navigation; DSN; Mars Program Office
- SSL – Deputy PI; Particles and Fields Package management; STATIC, SEP, SWIA, and SWEA instruments; LPW probes and booms (CESR provides the sensor for SWEA)
- LM – spacecraft; assembly, test and launch operations; mission operations

Launch

- On an EELV from KSC between 11/18/13 and 12/7/13
- Mars Orbit Insertion on 9/16/14 (for 11/18/13 launch)

Mission Approach

- Obtain detailed measurements of the upper atmosphere, ionosphere, planetary corona, solar wind, solar EUV and SEPs, to define the interactions between the Sun and Mars
- Operate 8 instruments for new science results:

  Particles and Fields Package (6 instruments):

    SWEA - Solar Wind Electron Analyzer
    SWIA - Solar Wind Ion Analyzer
    STATIC - Suprathermal and Thermal Ion Composition
    SEP - Solar Energetic Particle
    LPW - Langmuir Probe and Waves
    MAG - Magnetometer

  IUVS - Imaging Ultraviolet Spectrometer

  NGIMS - Neutral Gas and Ion Mass Spectrometer
- Fly 75°-inclination, 4.5-hour-period, 150-km-periapsis- altitude science orbit
- Perform five 5-day "deep dip" campaigns to altitudes near 125 km during the 1-year mission

Goddard Planetary Instruments

*Includes a some helio-physics and earth science applications

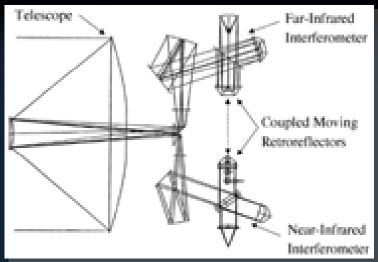
GSFC and Planetary Instruments:

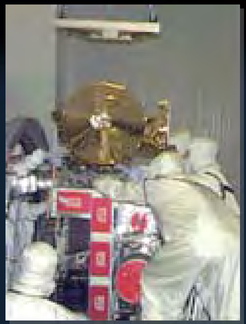






Many in house and mostly in house builds – concept, costing and proposal through delivery and operations

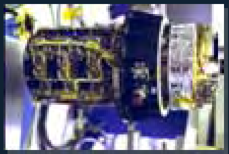




CASSINI- Composite Infrared Spectrometer (CIRS)

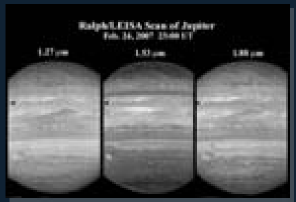
Infrared emissions from atmospheres, rings and surfaces, composition, temperatures and thermal properties.

Cassini-Huygens - Probe/Gas Chromatograph Mass Spectrometer



The probe descended into the depths of Titan's atmosphere for 147 minutes, plus 71 minutes of surface operations,

New Horizons- Linear Etalon Imaging Spectral Array (LEISA)



High spectral, moderate spatial resolution hyper-spectral imager using a wedge filter technology

Messenger- Mercury Laser Altimeter

MLA maps Mercury's landforms and other surface characteristics. tracks the planet's slight, forced libration.

LRO- Lunar Orbiter Laser Altimeter (LOLA)

LOLA pulses an infrared laser to lunar surface with five distinct beams. Analyze science and safety issues for landing sites along with the models and reference system needed to navigate.

Sample Analysis at Mars (SAM) Instrument Suite

Atmosphere or solid sample gas sampling. Individual gases from a complex mixtures. Precise methane and oxygen and carbon isotope ratios in CO_2.

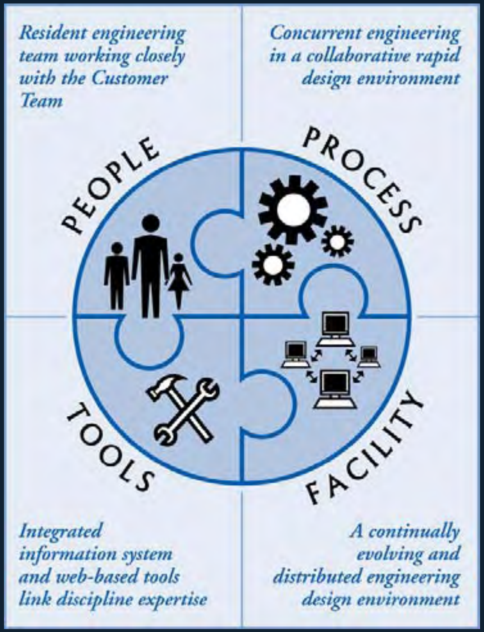
Planetary Instrument Technology and Planning

- Instrument work and technology investments allow us to study future applications in detail, for example;
- Likely Planetary Lidar capabilities 2011-2022 :
  - **LOLA-class multi-beam lidar altimeters for planetary orbiters**
    - At least 3-5 beams with 5 to 50m footprints with 10-30cm (RMSz) vertical precision, with along-track sampling from 10m to 200m laser (PRF-related)
    - Total mass 12-15 kg at 30W with ~ 10 Kbps
  - Multi-beam, analogue waveform altimeters (high PRF, ***LVIS-in-Space*** class)
    - Multiple beams with continuous 25m spots along-track and full analogue waveforms (10cm “bins”) and retrieval of full surface height distribution (SHD) within each footprint
    - 25-30kg at 25-50W with 5-8B shot lifetimes at 100Kbps data rate.
  - Photon-counting swath mapping lidar altimeters
    - Close proximity (1km to 50km) for 1-3m range mapping in a swath
    - Various swath widths with sub-meter ranging
    - Low mass and small lasers and telescopes, in 10kg, 10-20W range at 1 Mbps
  - Gas retrieval “DIAL” Lidars for trace gases, CO_2, H_2O, dust, CH_4, H_2CO, etc.
    - Retrievals at 300m x 3000m scales at 1-10 ppbv for species such as CH_4, H_2CO, etc. (relevant to trace gas mapping and localization)
  - Surface-based dust/water vapor/etc lidars that go beyond the PHX lidar
    - Water vapor, ice, dust, and other species, up-looking lidars for Wx stations etc.
  - Doppler Winds Lidars for Venus, Titan, and possibly Mars

What capabilities, approaches and other experience will GSFC leverage to complete studies it is asked to do?

The Integrated Design Center

- A main component of our study approach is the Integrated Design Center (IDC) and it's Mission Design Lab and Instrument Design Lab (MDL and IDL).
- The IDC Integrates People, Facilities, Tools and Processes.
- Over 470 studies over 12 years of operation, including most of our proposals and numerous decadal studies.
- Approximately 20 planetary missions have been through MDL and many planetary instruments through the IDL in the past few years.
- Dozens of earth science and astrophysics decadal studies of various maturity the past 3 years.
- The IDC and it's engineers and managers will be an integral part of the rapid studies you request.
- Costing is an integral part of IDC and GSFC concept studies in general.



People, Facilities, Tools and Processes - Engineers

Mission Design Lab (MDL)

Lab Lead | MDL Systems Engineer

- Reliability 302
- Structural 540
- Mechanical Systems Engineer 543
- Thermal Engineer 545
- Contamination 546
- Mechanical Designer 547
- Avionics 561
- Radiation Environment 561
- Power Systems Engineer 563
- Communications Engineer 567
- Integration and Test 568
- Flight Software 582

- Ground Systems 588
- Missions Operations 588
- Attitude Control 591/595
- Team Lead 592
- Deputy Team Lead/ Systems Engineer 592
- Launch Vehicle 592
- Mechanical Systems Engineer 592
- Mission Cost 592
- Orbital Debris 592
- Flight Dynamics 595
- Propulsion 597

Instrument Design Lab (IDL)

Lab Lead | IDL Systems Engineer

- Reliability 302
- Structural 540
- Mechanical Systems Engineer 543
- Electro-mechanical Engineer 544
- Cryogenics 545
- Thermal Engineer 545
- Contamination 546
- Mechanical Designer 547
- Electro-optics 551
- Optics 551
- Detectors 553
- Lasers 554

- Microwave Systems 555/567
- Team Lead 556
- Deputy Team Lead/ Systems Engineer 556
- Instrument Systems Engineer 556
- Instrument Cost 556
- Radiation Environment 561
- Avionics/Electronics 564
- Integration and Test 568
- Flight Software 582
- Fine Guidance 591/595
- Orbital Design 592

Experienced, knowledgeable engineers assigned from all required disciplines.

People, Facilities, Tools, Processes

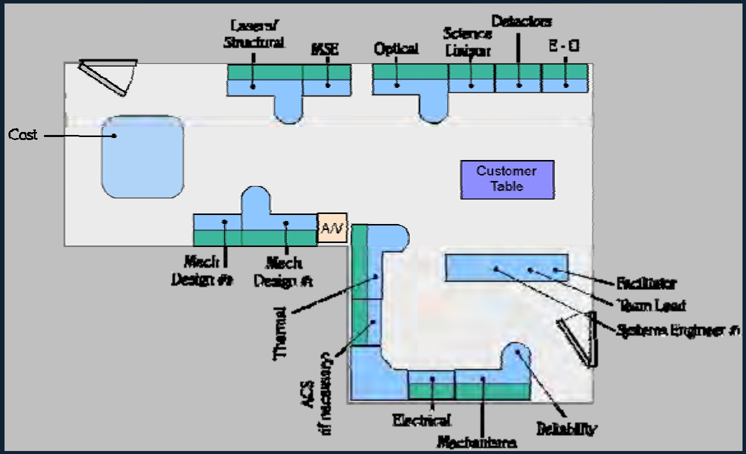
Concurrent, collaborative, systems engineering:

- All required engineering disciplines in the same location at the same time

  DEDICATED for study duration
- Customer team part of design team
- Systems Engineer constantly infuses end-to-end system and mission life-cycle view
- Lab Lead constantly evaluates

  customer needs and product

  consistency and quality



IDL

Rapid, responsive, evolving concept design development:

- One-week engineering schedule requires real-time evaluation and iteration of concept design
- Engineering team constantly responsive to customers' inputs
- Evolving engineer staffing determined by customers' requirements

MDL

The right facilities and tools:

- State-of-the-art engineering workstations, engineering and support software, and information technology to ensure current, consistent, and rapid engineering capabilities
- State-of-the-art audio/visual, communications, and product production capabilities with ability to integrate real-time external customer participation

MDL—Capabilities and Services

Capabilities:

- Complete mission design capabilities include Lunar, planetary orbiters, planetary surface access, LEO, GEO, libration, retrograde, drift away, and deep space orbit and spacecraft design
- Single spacecraft, constellations, formation flying, distributed systems
- Ground system concept development, including services, and products
- Expendable, non-expendable launch accommodations
- Controlled and uncontrolled de-orbit as well as controlled recovery modules, etc.

Services:

- End-to-end mission architecture concept development
- Existing mission/concept architecture evaluations
- Trade studies and evaluation
- Technology, risk, and independent technical assessments
- Requirement refinement and verification
- Mass/power budget allocation
- Cost estimation (grass roots and Price H)

GEMS team in MDL early in proposal process, recent GSFC SMEX AO selection

IDL—Capabilities and Services

Capabilities:

- Instrument families ranging from mass spectrometers, telescopes, cameras, geo–chemistry, lidars, IR/Vis/UV spectrometers, coronographs, etc.
- Instrument spectrum support from microwave through gamma ray
- Planetary orbits, planetary probes, surface access, deep space fly by, LEO, GEO, libration, retrograde, drift away, lunar, deep space, balloon, sounding rockets and UAV instrument design environments
- Non-distributed and/or distributed instrument systems

Services:

- End-to-end instrument architecture concept development
- Existing instrument/concept architecture evaluations
- Trade studies and evaluation
- Technology, risk, and independent technical assessments
- Requirement refinement and verification
- Mass/power budget allocation
- Cost estimation

IDC Products

IDC Discipline Engineers

MDL

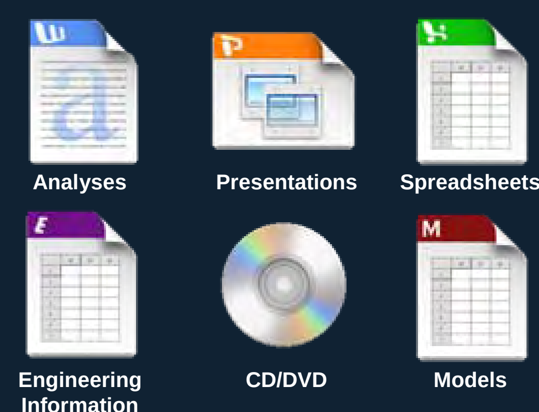
- Mission Systems
- Mission Design/Flight Dynamics
- Avionics/Electronics
- Attitude Control
- Propulsion
- Thermal
- Integration & Test
- Launch Vehicle
- Ground Systems
- Cost Estimating

IDL

- Instrument Systems
- Optical
- Lasers
- Microwave/RF
- Detectors
- Electrical
- Mechanical Configuration
- Thermal
- Flight Software
- Cost Modeling

Each discipline prepares material that addresses

Products



Product Areas

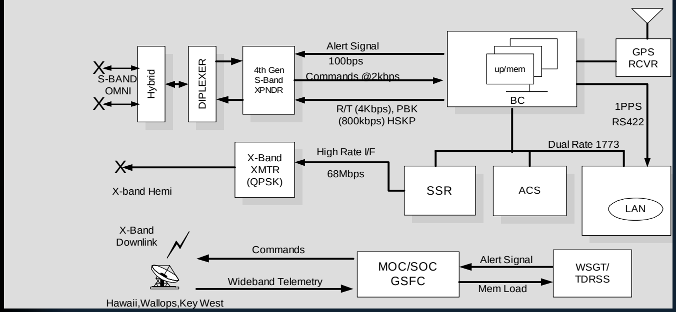
- Requirements
- Baseline Design
- Alternative Designs and Trade Studies
- Functional Diagrams
- Interfaces
- Detailed estimates of
  - Mass
  - Power
  - Data Rate
- Technical Risk Assessment
- Issues and Concerns
- Conclusions and Recommendations
- Models & Background Information
- Parametric and Grass-roots Costs





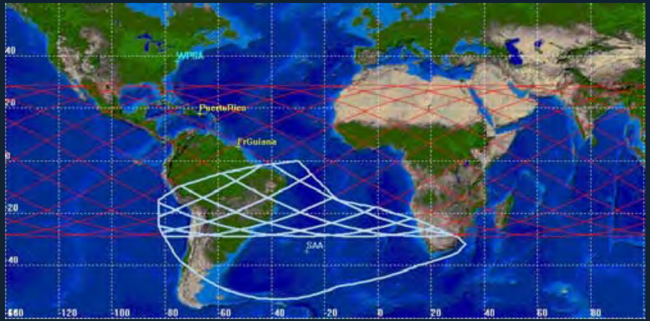


IDC Products - Examples

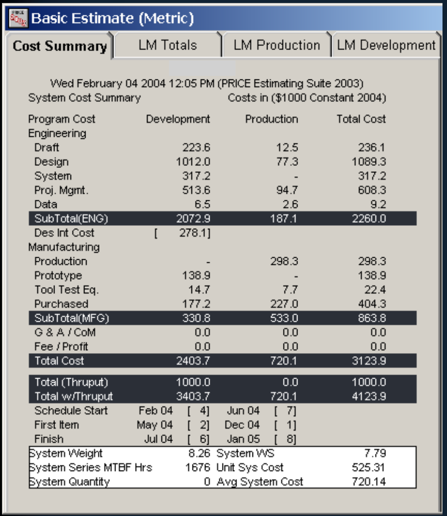


Systems Block Diagrams and Performance Analyses

Launch Systems Accommodations and Performance Analysis



Orbit, Ground Track, FOV, Communications, Ground Systems, Environmental Analyses (show Mars, Enc, or Venus ex.)



Basic Estimate (Metric)

Cost Summary | LM Totals | LM Production | LM Development

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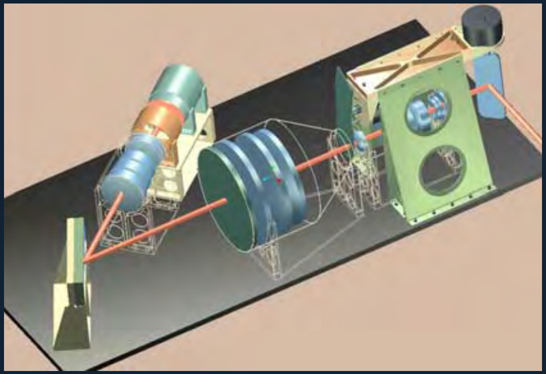
System Cost Summary — Costs in ($1000 Constant 2004)

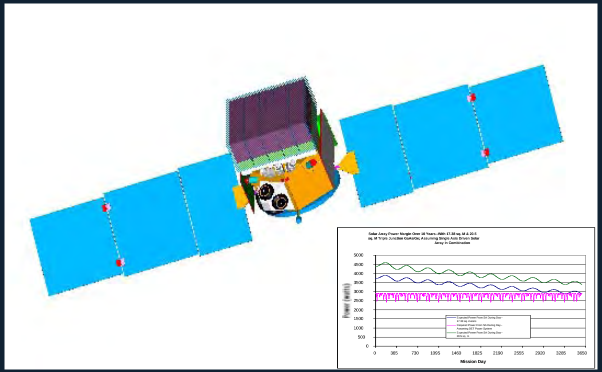
Program Cost	Development	Production	Total Cost
Engineering			
Draft	223.6	12.5	236.1
Design	1012.0	77.3	1089.3
System	317.2	-	317.2
Proj. Mgmt.	513.6	94.7	608.3
Data	6.5	2.6	9.2
SubTotal(ENG)	2072.9	187.1	2260.0
Des Int Cost	[278.1]		
Manufacturing			
Production	-	298.3	298.3
Prototype	138.9	-	138.9
Tool Test Eq.	14.7	7.7	22.4
Purchased	177.2	227.0	404.3
SubTotal(MFG)	330.8	533.0	863.8
G & A / CoM	0.0	0.0	0.0
Fee / Profit	0.0	0.0	0.0
Total Cost	2403.7	720.1	3123.9
Total (Thruput)	1000.0	0.0	1000.0
Total w/Thruput	3403.7	720.1	4123.9
Schedule Start	Feb 04 [4]	Jun 04 [7]	
First Item	May 04 [2]	Dec 04 [1]	
Finish	Jul 04 [6]	Jan 05 [8]	

System Weight	8.26	System WS	7.79
System Series MTBF Hrs	1676	Unit Sys Cost	525.31
System Quantity	0	Avg System Cost	720.14

Cost Modeling



Mechanical Configurations and Thermal Analyses



Spacecraft Systems Block Diagrams and Performance

More on Decadal Study Products

- Advance the concept science implementation, instrument, mission, design, maturity and detail.
- Identify the major science and cost drivers.
- Discuss the major trades that were involved.
- Summarize mission design decisions and parameters
- Summarize any potential technology issues
- Create cost estimates.
- Create the required packages for external cost estimates (parameters, MEL’s, schedules, etc.)







Study Concept Maturity

- GSFC has experience with all maturity levels.
- Large advances in maturity level, detail and cost knowledge require larger studies and more time.
- Table is not linear relative to effort and time, particularly for CML 3-6.

Concept Maturity Levels (CML) definitions

CML	Development Stage	Description
CML 1	Back of the envelope	Defined Objectives and basic approach
CML 2	Initial Feasibility	Top level approach checks out, Mass and cost in right ball park
CML 3	Trade space	Objectives trade space and architecture trade space elaborated and evaluated (cost, risk, performance)
CML 4	Point Design	Subsystem level design study and cost (eg IDC study)
CML 5	Step 1 proposal or just before Phase A	Partnering, heritage, technology, dependencies, risk. Start of Phase A or Step 1 proposal
CML 6	Phase B entry point	Grass roots cost, level 3 requirements and schedule

More time

Source : Adler, Vane

Study Cost Estimating

- GSFC regularly estimates and iterates cost capped planetary and lunar missions for Discovery, Mars Scout, New Frontiers AO, flagship trades, instruments. These include AO step 1 and Phase A (recently Vesper, OSIRIS, MAVEN) and Concept Maturity Levels 1 through 6

- Extensive costing experience includes parametric, analogous and grass roots

- GSFC has experience creating packages with details, Master Equipment Lists (MEL’s), etc. for Aerospace and other independent cost assessments.

- Dedicated parametric cost estimating office

Study Cost Estimating

- Parametric costing office
  - Experienced Price H, SEER, ACEIT personnel.
  - Full parametric estimates on a variety of missions and instruments. In IDC and outside. Top level estimates through very detailed estimates.
  - Over the last 10 years PRICE H and the other tools (SEER, ACEIT) have been used at GSFC to support over 270 studies in the IDC and other efforts at GSFC (recently Phase A/Step 2 MAVEN and GEMS Phase A/step 2, ,etc.).
  - Level of accuracy and detail depends on maturity of concept, and its draft MELs, draft schedules, etc.
  - Parametric results can also be used to compare to grass roots or other estimates.

GSFC and Planetary Studies

- GSFC IDC and related capabilities have examined planetary mission studies in many classes over the past few years:
  - Orbiters (for example Venus, Saturn and Jupiter moons and MAVEN selected 2008 via Mars Scout 2 competition)
  - Landers (with mobility *and in situ* measurements)
  - Aerial vehicles (balloons)
  - Sample returns (asteroids, comets, lunar surface)
  - Small body flybys
  - Active sensing missions (lidars, SAR/sounders)
  - Planetary probes (Venus, Saturn, moons)

- GSFC experience includes NF class, Discovery/Scout class, flagship related studies
  - – PI, PM, major instruments, partial flight systems [roles]

- GSFC also has extensive experience in major instruments:
  - E.g., MSL SAM (Huygens NMS, Galileo NMS) to Lidars (MOLA, MLA, NLR, LOLA, and Europa Lidar), and IR spectrometers, plus Neutron-Gamma Ray spectrometers and Magnetometers

GSFC and Planetary Studies, Some Experience

- MAVEN (Mars Scout selection)
- Enceladus flagship and smaller mission studies
- OSIRIS (Discovery Step 2, Phase A)
- Vesper (Discovery Step 2, Phase A)
- LRO (June launch, in commissioning, operating well)
- LEx (shadowed crater mini lunar lander)
- Ceres radar, etc. orbiter
- Trace gas missions on solar system targets and Mars
- LADEE
- Orion-launched Lunar RF orbiter
- Atmospheric and surface Probe studies
- Europa altimetry and thermal orbiter
- Venus geodynamic missions
- Crustal Mag. Explorer for Mars
- Instrument studies of all types







GSFC and Planetary Studies, Some Recent Experience

Target	Characteristics
Venus (Orbiter)	Elliptical-orbit climate orbiter with instruments for atmos. Chemistry/dynamics
Lunar surface (lander) in polar region	Small polar lander and “hopper” in search for volatiles via NS, EM sounding, cold-finger etc.
Mars (Orbiter)	Integrated climate sensing using lidar and high resolution SAR with emphasis on mass balance
Martian north polar layered terrain (lander)	Landed volatile and imaging explorer into NPLD layers in Chasma Boreale
Lunar surface sample return (Earth return)	Dual Minotaur V launch of 100kg landers, using EKV high-thrust propulsion; return 200g of lunar regolith (lander, Rendezvous-ERV)
Mars (dual orbiters)	Dual satellite study of shallow interior and climate using GRACE approach, plus lidars
Asteroid sample return	Regolith sample return of asteroid, with sampling and recon
Small/primitive body multiple fly bys	Recon. and classification of multiple small body objects

GSFC and Planetary Studies, Some Recent Experience

Target	Characteristics
Venus	Smaller versions of flagship concepts
Mars (circumpolar balloon) atmosphere and surface	Circumpolar balloon with NMS and other instruments (GPR, imaging, NIR Spectrometer)
Europa (Orbiter)	Europa orbiter with lidar, 2-way tracking for gravity and MAG : focus on oceans in 3D via geodetic lidar
Inactive cometary nucleus sample return	Basic core sample return and remote sensing
Comet sample return	Various comet sample return mission and instrument studies
Enceladus orbiter, surface	Medium sized missions, subsets of flagship study versions
Mars trace gas	Circular orbiting lidar for 10 km^2 retrievals of methane etc. at 1-10 ppbv and other trace gas mission approaches.

GSFC and Planetary Studies

- GSFC is particularly suited to study ‘medium sized missions’ (New Frontiers cost, plus or minus 50%), instrument and instrument technology driven issues.

- GSFC is also particularly suited to study areas in its core planetary strengths. These are the missions we worked on recently in studies, proposals, IRADs.
  - Geodetic altimetry of solar system objects (Lidar and other)
  - Quantitative atmospheric and surface chemistry missions
  - Venus missions
  - Asteroid/Comet/Trojan/Centaur/Phobos
  - Small instrument carrier probes
  - ‘Icy Moons’ (Enceladus)
  - Robotic Lunar missions (orbiter, small lander, sample return, etc..)
  - Mars trace gas
  - Difficult Instruments, integrated instrument suites, instrument technology issues

GSFC and Planetary Studies

- GSFC will partner with institutions in those areas where more expertise is needed on studies. This is how some Earth science and astrophysics decadal studies worked also.

- GSFC can help studies where it is not the lead but has an instrument expertise or capability.

GSFC - HQ and Decadal studies

- GSFC has a experience as a trusted source for HQ and Decadal studies
- In the past year GSFC has conducted ~21 Astrophysics mission and instrument studies for Astrophysics Decadal
- In the past three years GSFC has completed dozens of Earth science mission and instrument studies for Earth science Decadal
- These study deliverables often include main science drivers, major trade questions preliminary designs, summary of issues and options, costing.
- GSFC can customize our approach for your needs
- GSFC plans on assigning overall planetary decadal study lead, and lead scientist for you to interface with and form a working relationship with.
  - Individual studies will also have a lead

Summary

- GSFC has the experience and capability to perform Decadal Studies
  - People - deep, experienced and capable science, engineering and project management organizations
  - Experience – Broad space flight experience including 40+ years of planetary experience (recently LRO, LOLA, SAM)
  - Facilities and processes – Goddard has performed many studies involving planetary missions and/or instruments and is very experienced at decadal panels studies in general

- Goddard management is committed to this endeavor and is ready to support you.

GSFC contacts

- Anne Kinney - NASA GSFC
- 301-614-6873,
  - Anne.l.Kinney@nasa.gov

- Michael Amato - NASA GSFC
- 301-286-3914,
  - Michael.Amato@nasa.gov

Backup

Example of Additional Study Products

One Potential Process

- Initial work done by core team with panelists to make sure requirements and goals are clear. Initial questions are worked.
- Initial major trades identified and large or difficult technical issues worked. Pre work for IDC completed.
- IDC run
- Core team analyzes results and trades. Pursues issues, may talk to panel.
- Second IDC run
- Core team summarizes results and iterates remaining issues, iterates internal cost and independent cost package







The Work We Do

Accomplishments in planetary and lunar science

- Goddard won the Mars Atmosphere and Volatile Evolution (MAVEN) mission – NASA's next Mars Scout, in partnership with the Laboratory for Atmospheric and Space Physics at University of Colorado Boulder.
- LRO successfully launched, LOLA operational.
- Sample Analysis at Mars (SAM) instrument suite has been integrated and is thermal vacuum. SAM is a significant element of the Mars Science Laboratory, now slated for 2011 launch.
- Juno mission confirmation August 2008. Goddard will contribute the magnetic field investigation.
- LADEE instrument designs