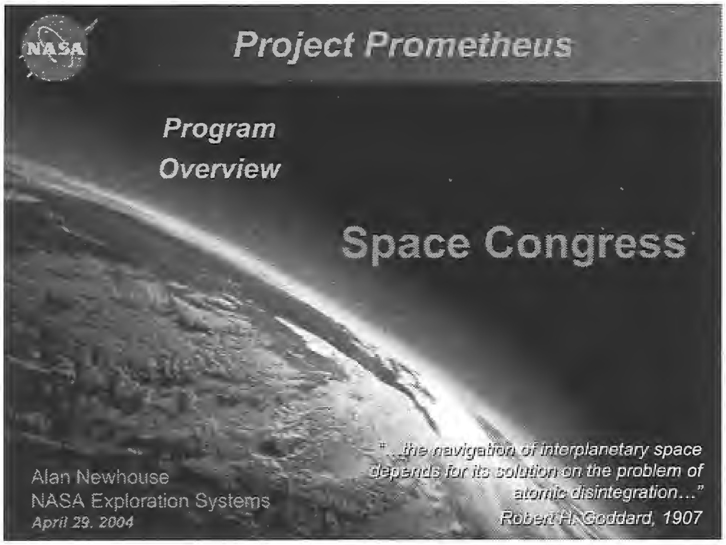
Apr 29th, 8:00 AM

Project Prometheus: Program Overview

Alan Newhouse
Project Prometheus, NASA



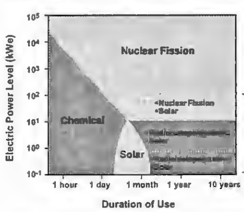
Presentation Overview

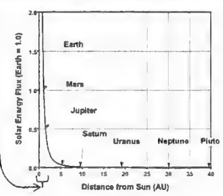
- History

Nuclear Power in Context of Spacecraft Applications

Enabling Aspects of Space Nuclear Power Systems

Nuclear Fission Reactors and Radioisotope Thermoelectric Generators



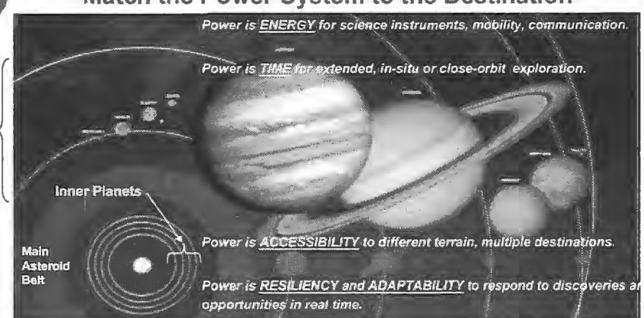


- Operate continuously regardless of orientation or distance from the Sun
  - Locations where solar power density is too low or solar power not readily or continuously available (lunar polar craters, high Martian latitudes)
- Operate for long-durations (years to decades) at power levels from milliwatts to multi-hundred kilowatts
- Operate in harsh environments (radiation, weather, magnetic)
- Provide safe, light-weight, long-lived heat source
- Enabling new methods of space exploration
  – Deliberate trajectories, high-power science, large band-width communications

PROJECT PROMETHEUS

Match the Power System to the Destination

Relative Size of Planets

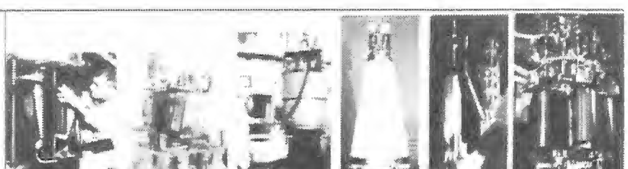


Power and Propulsion Systems	Solar Electric Best Suited to Inner Solar System – Also limited reach to large outer planetary bodies with aerocapture (Jupiter, Saturn, Uranus, Neptune only)	Radioisotope Electric for New Frontiers Class Solar System Missions • 500-1,000 W • <50 kg payload • 5 MT EELV ~ high energy earth departure	Nuclear Fission Electric for Large Flagship Missions to Outer Planets • 10s – 100s kW • >500 kg Payloads • 20MT EELV ~ low energy earth departure

Radioisotope Power Systems for Surface Lander and Fission Reactors for Surface Applicatio

Space-Based Nuclear Reactor Technologies

1960's Space Nuclear Auxiliary Power (SNAP)

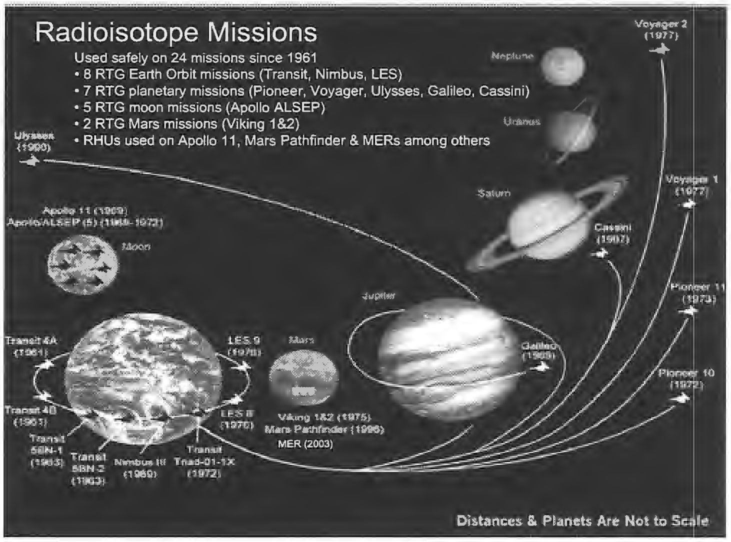


	SNAP Experimental Reactor (SER)	SNAP Developmental Reactor (SDR)	SNAP 8 Experimental Reactor (S8ER)	SNAP 10A Flight System (FS-3)	SNAP 10A Flight System (FS-4)	SNAP 8 Developmental Reactor (S8DR)
Critical	September 1959	April 1961	May 1963	January 1965	April 1965	June 1968
Shutdown	December 1960	December 1962	April 1965	March 1966	May 1965	December 1969
Thermal Power	50 kWt	65 kWt	600 kWt	38 kWt	43 kWt	600 - 1000 kWt
Thermal Energy	225,000 kWt-hr	273,000 kWt-hr	5.1×10^6 kWt-hr	382,944 kWt-hr	41,000 kWt-hr	4.3×10^6 kWt-hr
Electric Power	-	-	-	402 Watts	560 Watts	-
Electric Energy	-	-	-	4028 kW-hr	574 kW-hr	-
Time at Power and Temperature	1800 hr at 1200°F 3500 hr above 900°F	2800 hr at 1200°F 7700 hr above 900°F	1 yr at 1300°F 400 to 600 kWt	10,005 hr (417 days)	1000 hr	7023 hr 1100 - 1300°F

SNAP 10A (FS-4) Launched in 1965

SP-100 Program Overview

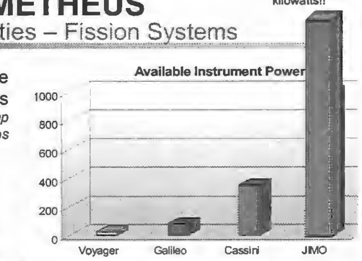
- SP-100 Program initiated in FY83, terminated FY1993
- Three agencies involved, each contributing funding separately
  – NASA and DoD had potential missions
  – DOE had potential technology
- SP-100 technology base was an evolution of SNAP-50/SPUR space reactor programs from late-60's/early-70's

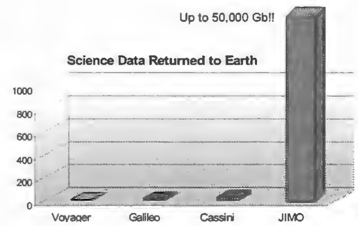


PROJECT PROMETHEUS

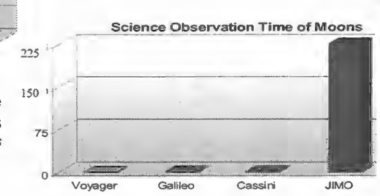
Revolutionary Capabilities – Fission Systems

Amount of **power** available to science instruments
One bedside reading lamp compared to several homes





Amount of science **data** return
1 – 2 floppy disks as compared to >20 CD-ROMs



Time available for science observation of moons
1 to 5 hours compared to 180 days

Pre-Decisional – for discussion purposes only

PROJECT PROMETHEUS

History

- Program initiated in response to identified limitations of current paradigm for Solar System exploration
  - Solar power limits power budgets and can be of limited use in outer planetary system
  - Chemical propulsion can limit maneuverability and destinations
- *Nuclear Systems Initiative* included in President's FY03 Budget and renamed *Project Prometheus* in President's FY04 Budget
- Initial mission studies, detailed technical analysis, and industry surveys completed in 2002 and early 2003. Leading to the establish of the Jupiter Icy Moons Orbiter (JIMO) Mission in early 2003

Pre-Decisional – for discussion purposes only

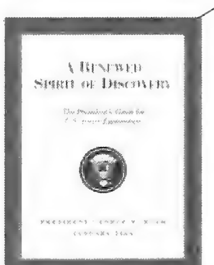
Presentation Overview

Vision for Space Exploration

Pre-Decisional – for discussion purposes only

Vision for Space Exploration

THE FUNDAMENTAL GOAL OF THIS VISION IS TO ADVANCE U.S. SCIENTIFIC, SECURITY, AND ECONOMIC INTEREST THROUGH A ROBUST SPACE EXPLORATION PROGRAM



Implement a sustained and affordable human and robotic program to explore the solar system and beyond

Extend human presence across the solar system, starting with a human return to the Moon by the year 2020, in preparation for human exploration of Mars and other destinations;

Develop the innovative technologies, knowledge, and infrastructures both to explore and to support decisions about the destinations for human exploration; and

Promote international and commercial participation in exploration to further U.S. scientific, security, and economic interests.

Pre-Decisional – for discussion purposes only

PROJECT PROMETHEUS

Vision for Space Exploration, cont'd

Space Exploration Beyond Low-Earth Orbit:

- Conduct robotic exploration across solar system to search for life, understand history of universe, search for resources
- Demonstrate power, propulsion, life support capabilities for long duration, more distant human and robotic missions
- Conduct human expeditions to Mars after acquiring adequate knowledge and capability demonstrations

Pre-Decisional – for discussion purposes only

Presentation Overview

- Program Description

PROJECT PROMETHEUS
Objectives and Benefits

Project Prometheus supports the Vision for Space Exploration by developing safe, reliable, long-lived, rugged power sources, from milli- to multi-kilowatt, using radioisotope and fission reactor power systems, and advanced propulsion systems that would enable more robust and ambitious science exploration not possible with current power and propulsion technologies.

Direct Benefits
- **Radioisotope power systems** enable detailed and extended *in situ* scientific exploration of Solar System locations that cannot be explored in detail using solar or battery power, such as Mars, Europa, Titan, and the Neptune system.
- **Nuclear fission power systems** would enable unprecedented exploration of the solar system by providing the energy necessary to power high capability science instruments and advanced electric propulsion systems, as well as a variety of auxiliary and surface systems in support of future human missions.

Indirect Benefits
- Compelling stimulus to student interest in technical education from the combination of exciting new space exploration and nuclear propulsion development.
- Terrestrial systems, benefit from the development of advanced technologies required for space nuclear power and propulsion.

Project Prometheus builds on NASA and DOE's history of safety in the use of nuclear power for space applications

PROJECT PROMETHEUS
Key Technology Components

Energy Generation
- Fission reactor (10s-100s of kWs)

Conversion to Electricity
- Static: Thermoelectrics, Thermophotovoltaic
- Dynamic: Stirling, Rankine, Brayton

Energy Generation
- Radioisotope (milli to kilowatts)

Electricity Utilization
- Electric Propulsion
- Scientific Instruments
- Communications
- Auxiliary spacecraft/planetary habitat systems*
- In-situ resource utilization

Propulsion
- High-power electric
- Nuclear thermal*

Electricity Utilization
- Scientific instruments
- Communications
- Electric propulsion

Space Exploration Missions

Jupiter Icy Moons Orbiter (JIMO), Mars Science Laboratory (2009), New Frontiers, Scout and others

Future Prometheus Technology - Enabled Missions
– Robotic, Human, and Human/Robotic

Ensuring safety is our paramount objective and all program activities will be conducted in a manner to achieve this goal.

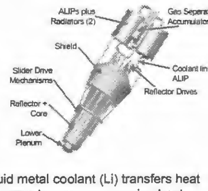
* Analysis of future applications is in initial stages

Presentation Overview

- Technologies

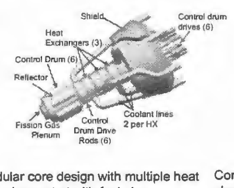
PROJECT PROMETHEUS
Reactor Options Under Evaluation

Liquid Metal Cooled



Liquid metal coolant (Li) transfers heat from core to power conversion heat exchangers
Requires high temperature liquid metal pumps
Requires lithium / helium gas separator
Requires pumped-loop thaw system, potentially with freeze/thaw capability

Heatpipe Cooled



Modular core design with multiple heat pipes integrated with fuel pins
Heat pipes passively transfer heat from core to heat exchangers.
Independent heat exchangers transfer heat from heat pipes to multiple, independent power conversion loops

Direct Gas Cooled

Core includes fuel pins and gas flow channels
Core provides thermal power via single He/Xe pumped gas loop
Hot gas directly feeds single or multiple Brayton power conversion units
Brayton power conversion includes compressor for pumping gas back into core

*** "The JIMO is enabled by Project Prometheus, NASA's program to develop space nuclear power and propulsion technology. The nuclear power and nuclear-electric propulsion technologies that support this mission are also key to enabling other advanced robotic missions and human missions beyond Earth's orbit"

PROJECT PROMETHEUS
Nuclear Fission Reactor Research
*Paper Reactors, Real Reactors**

An academic reactor or reactor plant almost always has the following basic characteristics:

1. The reactor is in the study phase. It is not being built now.
2. It is simple, small, cheap, and light
3. It can be built very quickly
4. It is very flexible in purpose
5. Very little development is required. It will use mostly off-the-shelf components.

On the other hand, a practical reactor plant can be distinguished by the following characteristics:

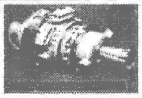
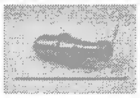
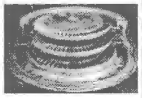
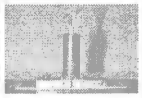
1. It is being built now
2. It is complicated, large, expensive, and heavy
3. It is behind schedule
4. It takes a long time to build because of the engineering development problems.
5. It is requiring an immense amount of development on apparently trivial items.

- The tools of the academic reactor-designer are a piece of paper and a pencil with an eraser. If a mistake is made, it can always be erased and changed.
- If the practical-reactor designer errs, he wears the mistake around his neck; it cannot be erased. Everyone can see it.

*Admiral Hyman Rickover, *The Journal of Reactor Science and Engineering*, June 19

PROJECT PROMETHEUS

Heat-to-Electrical Power Conversion Technologies

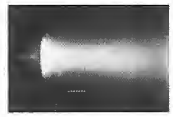
			
Closed Brayton • Heat engine with inert gas in rotating turbo-alternator • High eff. (20-25%) • Relative high maturity, but not flight proven • Engine prototypes built at 2 and 15 kW • Scales well to high power, but large radiator • Well suited for high voltage applications • Turbine Inlet 1150K (superalloys), Temp ratio ~3.0	Free-Piston Stirling • Heat engine with reciprocating piston & linear alternator • High eff. (20-30%) • Relative high maturity, but not flight proven • 55 W Tech Demo Convertor (TDC) currently in flight dev't for 100 W class RPS • Well suited for low to medium power applications • T_{hot} 925K (superalloys), Temp ratio ~2.0	Rankine • Heat engine with two-phase fluid in rotating turbo-alternator • Moderate eff. (10-20%) • Most work completed during 60's SNAP-8 Program (50 kW Mercury Rankine) • K-Rankine scales well to 100's of kW (e.g. SNAP-50, MPRE) • Turbine inlet 650K (organic fluids) to 1400K (Potassium), Temp ratio ~2.0	Thermoelectric • Electrical potential produced by dissimilar materials exposed to temperature diff. • Low eff. (4-7%) • Flown on SNAP-10A (500 W), baselined for SP-100 (100 kW) • SiGe or PbTe unicouples flight proven in RTG at power <300 W • Segmented TE projects 10-15% eff. • T_{hot} 1300K (refr. alloys), T_{cold}~600K
Mature Technology with Growth Potential	High Efficiency & Scales Well to Low Power	Potential for Low Mass, but Materials Issues	Flight Proven with Long Life, but Low Efficiency

Pre-Decisional – for discussion purposes only

PROJECT PROMETHEUS

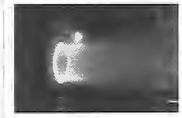
Electric Propulsion Technologies

• Utilizes electric power to ionize propellant and accelerate it to produce thrust



Electrostatic Ion

Isp = 2500 - 15,000 sec
Power = 10W - 30kW
Efficiency = 60 – 80%
Mature at 2.3kW



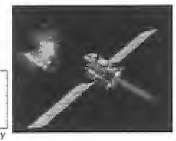
Electrostatic Hall

Isp = 1500 - 3500 sec
Power = 100W - 50kW
Efficiency = 45 – 60%
Mature at 1.5kW

Electro-magnetic MPD, PIT, VASIMR

Isp = 2000 – 10,000 sec
Power = >100kW
Efficiency = 35 – 50%
Immature

Successfully Flew on 1997 Deep Space-1 Mission to Comet Borelly (2.3 kW unit)



Electrostatic – accelerates ions through applied electric field
Electro-magnetic – ions accelerated via combinec electric and magnetic fields

Pre-Decisional – for discussion purposes only

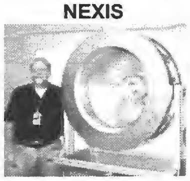
PROJECT PROMETHEUS

Nuclear Electric Propulsion

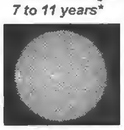
HiPEP & NEXIS Thruster Beam Extraction Testing

NEXIS

~80 cm

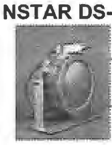


16-25 kW
6500-7500 s Isp
78% Eff.
>5000 Volt Grid
Life: >1600 kg Xe
*7 to 11 years**



February, 2004 - 27 kWe, Isp 8700 s, 78% efficiency, 6500 V, 0.5N thrust

NSTAR DS-1

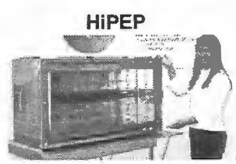


~30 cm

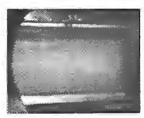
2.5 kW
3100 s Isp
61% Eff.
1200 Volt Grid
Life:125 kg Xe
*1.3 years**

HiPEP

~50 cm



20-50 kW
6000-8000 s Isp
78% Eff.
>5000 Volt Grid
Life: >2000 kg Xe
*7 to 11 years**



February 2004 - 34kWe, Isp 9500 s, 78% efficiency, 7700 V, 0.6N thrust

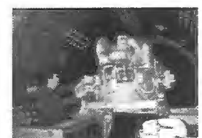
Pre-Decisional – for discussion purposes only

PROJECT PROMETHEUS

Nuclear Electric Propulsion

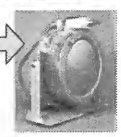
Brayton - NSTAR Demonstration

- Successful Integrated Test Completed Dec 03 at GRC Vacuum Facility #6
  - 2 kW Brayton Power Converter
  - 1100 V-dc Power Mgmt & Distribution
  - 2.3 kW Engr Model NSTAR Ion Thruster
- Fully Representative JIMO-type PMAD/PPU Architecture
  - Brayton Speed and Voltage Control with Parasitic Load Radiator (PLR)
  - 10:1 Transformer-Based Voltage Increase
  - Direct Feed of Rectified Output into Thruster Beam Supply
- Significance of Test
  - Demonstrated End-to-End Electrical Throughput from Brayton Alternator to Ion Thruster in Vacuum
  - Demonstrated High Efficiency AC-to-DC Conversion using Radiation Tolerant Transformer/Rectifier Approach
  - Demonstrated High Speed Load Switching from Ion Thruster to PLR During Thruster Re-Cycles
    - No Adverse Energy Deposition onto Thruster Grids
    - No Harmful Transients on Brayton Rotating Unit
  - Design Techniques are Scalable to JIMO Power Levels



Brayton Power Unit Generates ~2 kW at 100 V-ac, 870 Hz

PMAD Converts AC to High Voltage DC via Transformer/Rectifier



1100 V-dc PMAD Output Fed Direct to Thruster Beam Supply

Pre-Decisional – for discussion purposes only

Presentation Overview

• Jupiter Icy Moons Orbiter

Pre-Decisional – for discussion purposes only

Decadal Survey

- In 2002, the National Academy of Sciences conducted the Solar System Exploration Survey to prioritize technologies and missions
- The Survey identified the following areas in which it believed that technology development is appropriate:
  - *Power*: Advanced RTGs and in-space nuclear fission reactor power source
  - *Propulsion*: Nuclear electric propulsion, advanced ion engines, aerocapture

"The two most-constrained resources in the current generation of planetary spacecraft are *onboard power and propulsion*. Improvements in these two areas will enable the largest leaps forward in capability."

- The Survey identified a Jupiter Geophysical explorer as its top priority flagship mission

"The proposed Jupiter Icy Moons Mission will *more than fulfill our goal of a flagship mission* to further explore the subsurface oceans on Europa while simultaneously applying the new technologies that the Survey advocates as a basis for much of the future program."*

*Dr. Michael J.S. Belton, Ph.D. Chair, Solar System Exploration Survey Committee, National Research Council in testimony given to US Senate Committe on Commerce, Science, & Transportation at a Science, Technology, and Space Hearing: Space Exploration Wednesday, July 30 2003 -

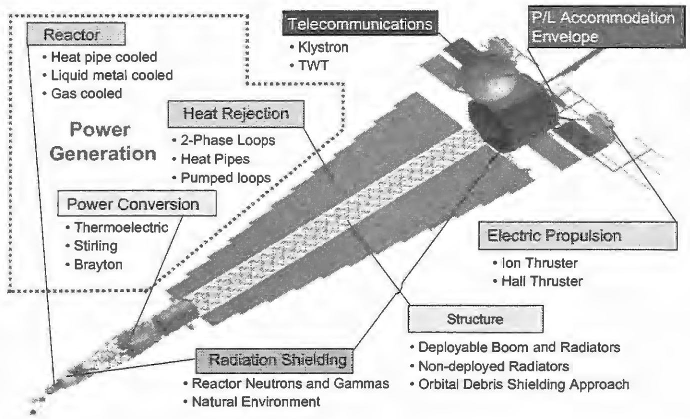
Pre-Decisional – for discussion purposes only

PROJECT PROMETHEUS
Jupiter Icy Moons Orbiter (JIMO)

- **Technology**
  - Develop a nuclear reactor powered spacecraft and show that it can be processed safely, launched safely, and operated safely and reliably in deep space for long-duration deep space exploration
- **Science**
  - Explore the three icy moons of Jupiter – Callisto, Ganymede, and Europa – and return science data that will meet the highest scientific goals as set forth in the Decadal Survey Report of the National Academy of Sciences.
    - The high power and high data rate afforded by nuclear power will enable science data return far beyond current capabilities.
- JIMO would be the first flight mission to use nuclear power and propulsion technologies applicable to future human exploration missions.

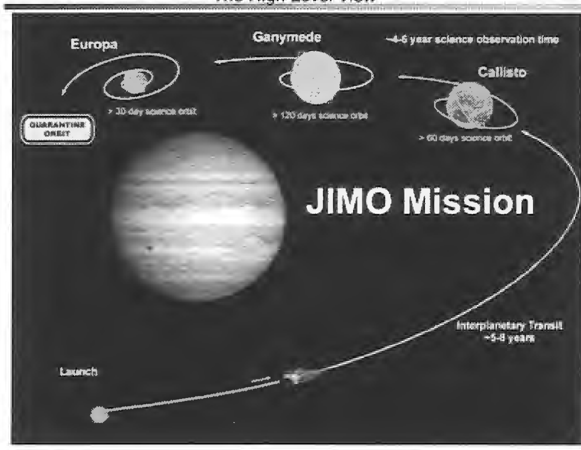
Pre-Decisional – for discussion purposes only

PROJECT PROMETHEUS
Jupiter Icy Moons Orbiter
Representative Technology Options – Conceptual Spacecraft



Pre-Decisional – for discussion purposes only

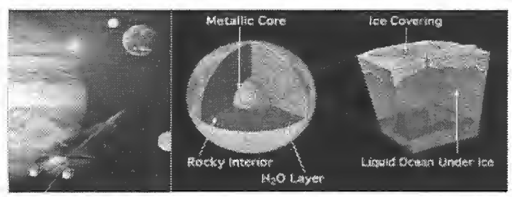
PROJECT PROMETHEUS
Jupiter Icy Moons Orbiter
The High Level View



Pre-Decisional – for discussion purposes only

PROJECT PROMETHEUS
Jupiter Icy Moons Orbiter
Science

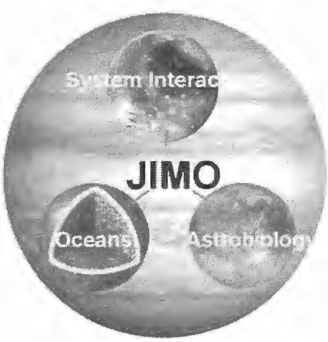
- Europa, Ganymede, and Callisto very likely have global liquid water oceans beneath their icy crusts.
  ...one of the major discoveries in solar system science in the last decade.
- There is spectral evidence for salts and organic materials on their surfaces, and geologic evidence that the Europan ocean may have been in contact with the surface in the geologically recent past (less than about 100 million years).
  ... these bodies are among the most exciting in the solar system for geophysical, geochemical and astrobiological exploration.



Pre-Decisional – for discussion purposes only

PROJECT PROMETHEUS
Jupiter Icy Moons Orbiter
Three Cross-cutting Themes and Investigations

Explore the icy moons of Jupiter and determine their habitability in the context of the Jupiter system



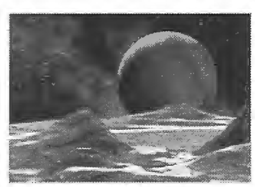
Oceans:
Liquid water, Icy Crustal Structure and Active Internal Processes

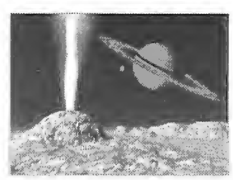
Astrobiology:
Volatiles, Organics and Surface Processes

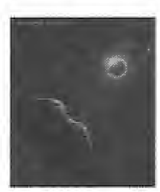
Jovian System Interactions:
Satellite Atmospheres, Surfaces and Interiors

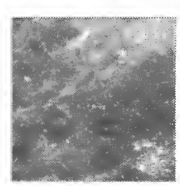
Pre-Decisional – for discussion purposes only

PROJECT PROMETHEUS
Potential Future Destinations


Neptune and its Moons


Saturn and its Moons


Kuiper Belt Region

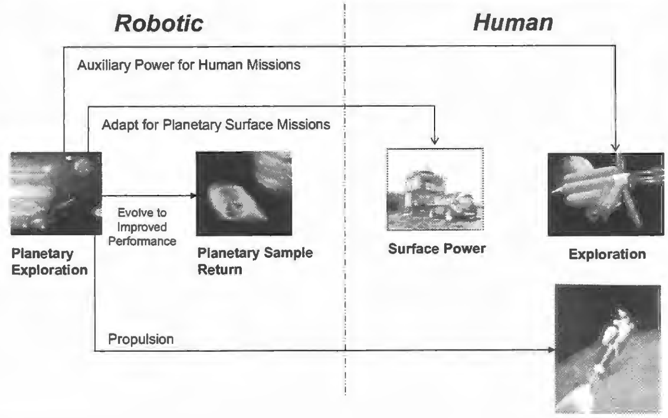

Interstellar Space

Pre-Decisional – for discussion purposes only

Presentation Overview

- History
- Vision for Space Exploration
- Program Description
- Technologies
- Jupiter Icy Moons Orbiter
- **Future Directions**
- Safety
- Communications, Engagement & Outreach

PROJECT PROMETHEUS
Evolution to Advanced Exploration Missions



PROJECT PROMETHEUS
Evolution to Advanced Exploration Missions

- Systems and techniques developed within Project Prometheus for robotic missions will provide:
  - advanced capabilities for scientific exploration,
  - address long term issues for development of nuclear systems,
  - demonstrate operation of fission systems in space
- Human surface exploration activities, mobile or fixed, could also require a new source of power (compact, all-weather, day and night), enabled by JIMO-developed technologies.
  - ample electric power to support a human crew
  - ample electric power to support in-situ resource utilization
- Human exploration transport vehicles could require a new source of power for auxiliary power supply and a new scale of power for propulsion systems.

Early Concept Definition (RFI)

- **Solicitation: Request for Information (RFI):**
  - In support of Projects Constellation and Prometheus requirements development and acquisition strateg
  - Expected response from industry, academia, NASA centers, related commercial enterprises, etc.
- **Deliverables:**
  - Unfunded "White Papers" addressing key areas for further study and risk reduction
- **Purpose:**
  - Identification of areas for future trade studies & risk reduction activities
  - Identification of technical risk areas and cost drivers
  - Assessment of design drivers and other critical architecture considerations
  - Innovative concepts or considerations in key areas such as:

• Sustainability	• Crew size	• Lunar/Mars Commonality
• Affordability	• Payloads	• Power/propulsion Issues
• Reliability & Safety	• In-space repair	• Acquisition Strategy/PM Tools
• Launch Infrastructure	• Maintenance & assembly	• ETC.

May '04	Jun '04	Jul '04
Release	Delivery/ Review	Review Complete

Output to help structure follow-on BAA and RFP

Concept Exploration & Refinement (BAA)

- **Solicitation: Broad Area Announcement (BAA):**
  - In support of Projects Constellation and Prometheus requirements development and acquisition strategy
  - Expected response from industry
  - Multiple Awards/Varying Response Times
- **Deliverables:**
  - Architectural Trade Studies and Risk Reduction Analyses
  - Concepts for Lunar Missions and Architecture
  - Concepts for CEV
  - Methods for incorporating TECHMAT into CEV and Lunar Architecture
  - Recommendations for Streamlining Acquisition
- **Purpose:**
  - Advanced Development of Potential Risk Reduction Concepts
  - Support Systems Integration and CEV contract process
  - Continued pursuit of innovative concepts determined to be feasible/affordable based on Jan RFI results and recommendations

Jun '04	Jul '04	Sep '04	Jan '05	TBD	4th Qtr '05
Release	RFP Response	Award	Initial Contract Deliverable	Other Deliverables	Final Deliverable

Note: Additional BAA Procurement Cycles will further define the System-of Systems operations concepts and perform integrated systems trade studies.

Presentation Overview

- History
- Vision for Space Exploration
- Program Description
- Technologies
- Jupiter Icy Moons Orbiter
- Future Directions
- **Safety**
- Communications, Engagement & Outreach

PROJECT PROMETHEUS
Safety is Paramount

Must be safe to launch

- Space reactor designs minimize potential for inadvertent startup during all potential launch accident scenarios
  - Choice of core materials and geometry
  - Launch with fuel separated from core (Option)
  - In-core neutron absorbers - removed before startup (Option)
- U-235 fuel and other materials pose very small radiological hazard prior to extended operations in space

Must be safe to develop

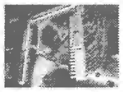
- Maximize use of non-nuclear testing in all phases of development
  - High-performance electric resistance heaters to mimic fission
  - Operation at moderate power densities/temperatures obviates need for nuclear/materials characterization - within existing database
- Emphasize use of existing facilities and mature component technology

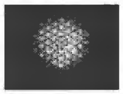
Reduce potential hazard to earth, space or planetary environments

- NASA applications restricted to "outbound" trajectories and use in deep space
- Planetary protection requirements will be developed

Transparent, accessible communications, process responds to public concerns

- Highest commitment to safety required throughout all phases of development, deployment and operation
- Engage the public to assure that safety concerns are addressed





Pre-Decisional – for discussion purposes only

PROJECT PROMETHEUS
Designing for Safety

- NASA has over 30 years' experience in the successful management of radioisotope power systems (RPS)
- Working with DOE, we would apply that safety experience to the design, manufacture, and flight of a fission reactor
  - The reactor would be specifically designed to prevent accidental criticality while still in the Earth environment
  - We are engaging NASA and DOE expertise in continuous safety management and risk assessment
- NASA Will Fully Comply with Environmental and Nuclear Safety Launch Approval Processes Applicable to the Use of Nuclear Power Systems in Outer Space
  - National Environmental Policy Act (NEPA)
    - Purpose: Ensure NASA considers the potential environmental impacts of a proposed mission (or program) and reasonable alternatives
    - Entails: Environmental Assessment or Environmental Impact Statement (EIS), as appropriate
      - EIS provides opportunity for public engagement
  - Presidential Directive/National Security Council Memorandum #25 (PD/NSC-25) (as amended)
    - Purpose: Ensure informed decision-making at the Presidential level before launching a mission with radioisotope power systems or nuclear reactors.
    - Entails: NASA/DOE safety analyses, interagency safety evaluation, and nuclear safety launch approval by Director of OSTP or the President.

Pre-Decisional – for discussion purposes only

Presentation Overview

- Communications, Engagement & Outreach

Pre-Decisional – for discussion purposes only

PROJECT PROMETHEUS
Communicating with Our Customers and Stakeholders

- Goal is to ensure open, honest, pro-active, inclusive, dialogue and communication with the public, media, educators, legislators and others
- Focus on Project Prometheus-specific technological and programmatic goals within the context of NASA scientific and exploration goals
- Provide for proactive, cooperative engagement with a broad range of potential stakeholders including environmental organizations
- Include technology education and outreach programs and materials available to all citizens

Pre-Decisional – for discussion purposes only

PROJECT PROMETHEUS
Conclusion

- Project Prometheus technologies can play a vitally important role in supporting robotic and human exploration of the Solar System
  - Safety is the absolute highest priority; NASA has over 30 years of demonstrated safety record in the launch of radioisotope power systems
  - We can recapture work done for past programs and move forward quickly
- We believe the technologies being developed by Prometheus could enable a new paradigm in human and robotic exploration
  - Project Prometheus is a logical outgrowth of previous technology development programs and will fill an important gap in capability
- The proposed JIMO mission will be the first of a new generation of missions characterized by more maneuverability, flexibility, power and lifetime
- Project Prometheus is also leading the Agency in new approaches to communication, engagement, and outreach
- We can make a great contribution to the fulfillment of the Nation's vision for space exploration
- *It is easy to go nowhere. It requires no energy and has no risk except that of being left behind. To go forward and run ahead is a supreme test. – unknown*

Pre-Decisional – for discussion purposes only