NASA Ames Exploration Systems Technology Partnership Day

July 22, 2004

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Director Ames Exploration Systems Office

National Aeronautics and Space Administration

Vision

Our mandate is:

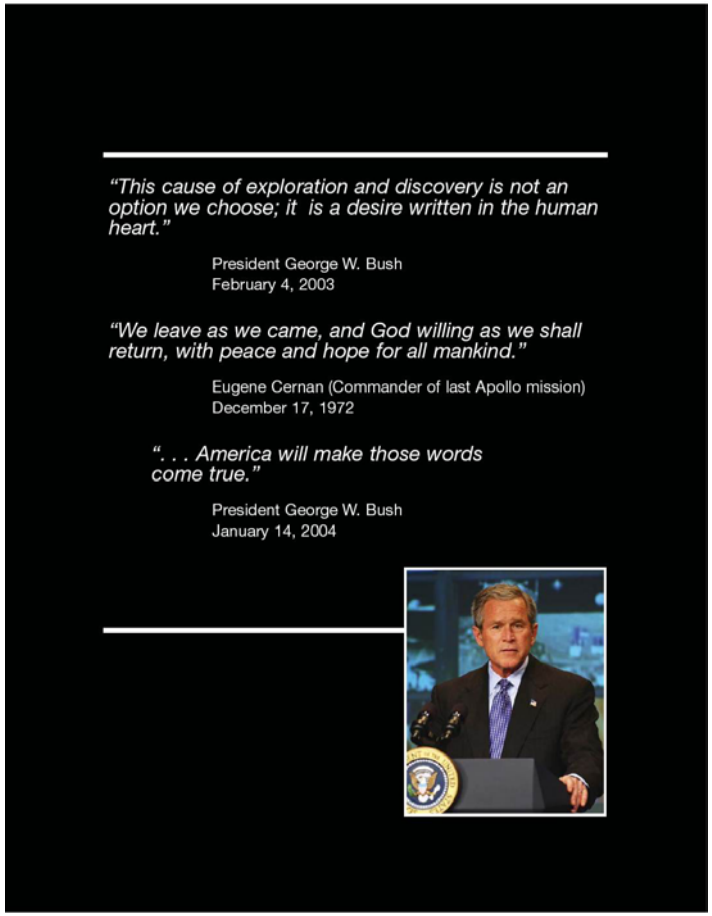
- To improve life here,
- To extend life to there,
- To find life beyond

Mission

- To understand and protect our home planet
- To explore the Universe and search for life
- To inspire the next generation of explorers

…as only NASA can

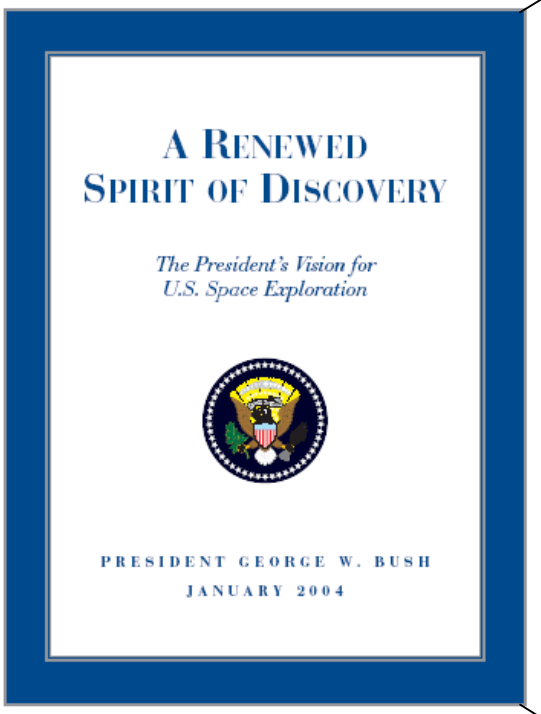
A New Future for U.S. Civil Space Programs



- **On January 14, 2004, President Bush articulated a new Vision for Space Exploration in the 21st Century**
- **This Vision encompasses a broad range of human and robotic missions, including the Moon, Mars and destinations beyond**
- **It establishes clear goals and objectives, but sets equally clear budgetary 'boundaries' by stating firm priorities and tough choices**
- **It also establishes as policy the goals of pursuing commercial and international collaboration in realizing the new vision**

Nation's 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



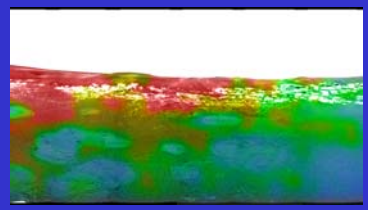
Implement a sustained and affordable human and robotic program to explore the solar system and beyond

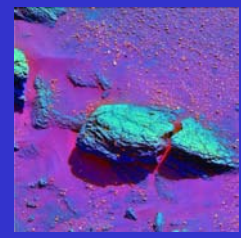
Extend human presence across the solar system, starting with a human return to the Moon by the year 2020, in preparation for human exploration of Mars and other destinations;

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

EXPLORATION "*Science*"





Classical Science

Robotic Precursors, human missions

Flight Demos etc.

Hypothesis driven

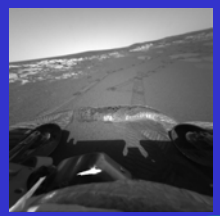
Integrated Exploration

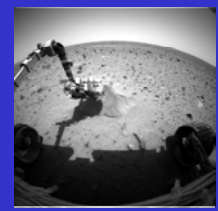
= SCIENCE!

Measurement driven

Engineering Capability Driven

Human on-site Activities



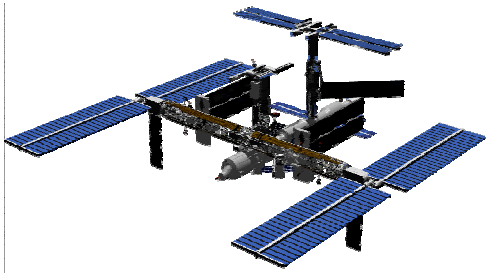


Applied Research

Science Enabling

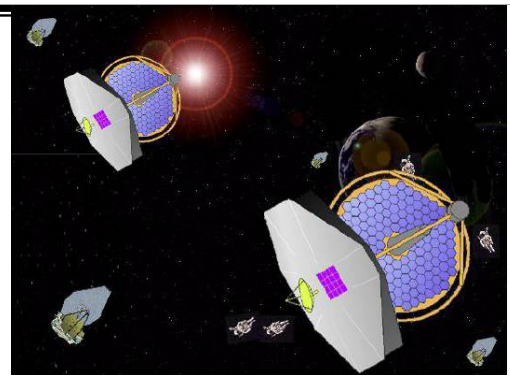
Science Pathways for Human Mars Exploration involve all 3 facets

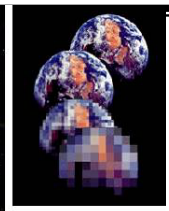
What we may need…



ISS: R&D

?



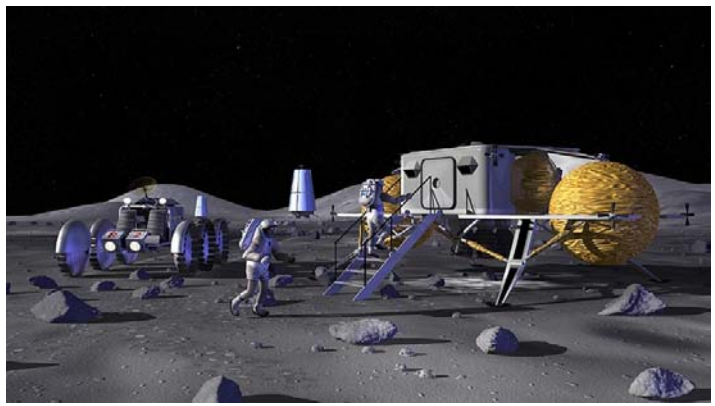


OR:
Earth-viewing
Observatories?

Deep Space Orbits: Universe Viewing

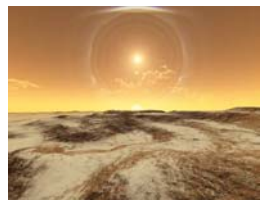
?

Lunar Recon:
Orbit, surface, sample

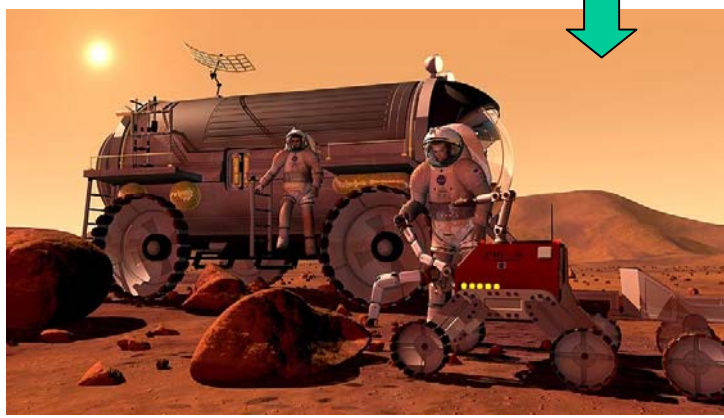


Lunar human presence:
Testbed with science

?

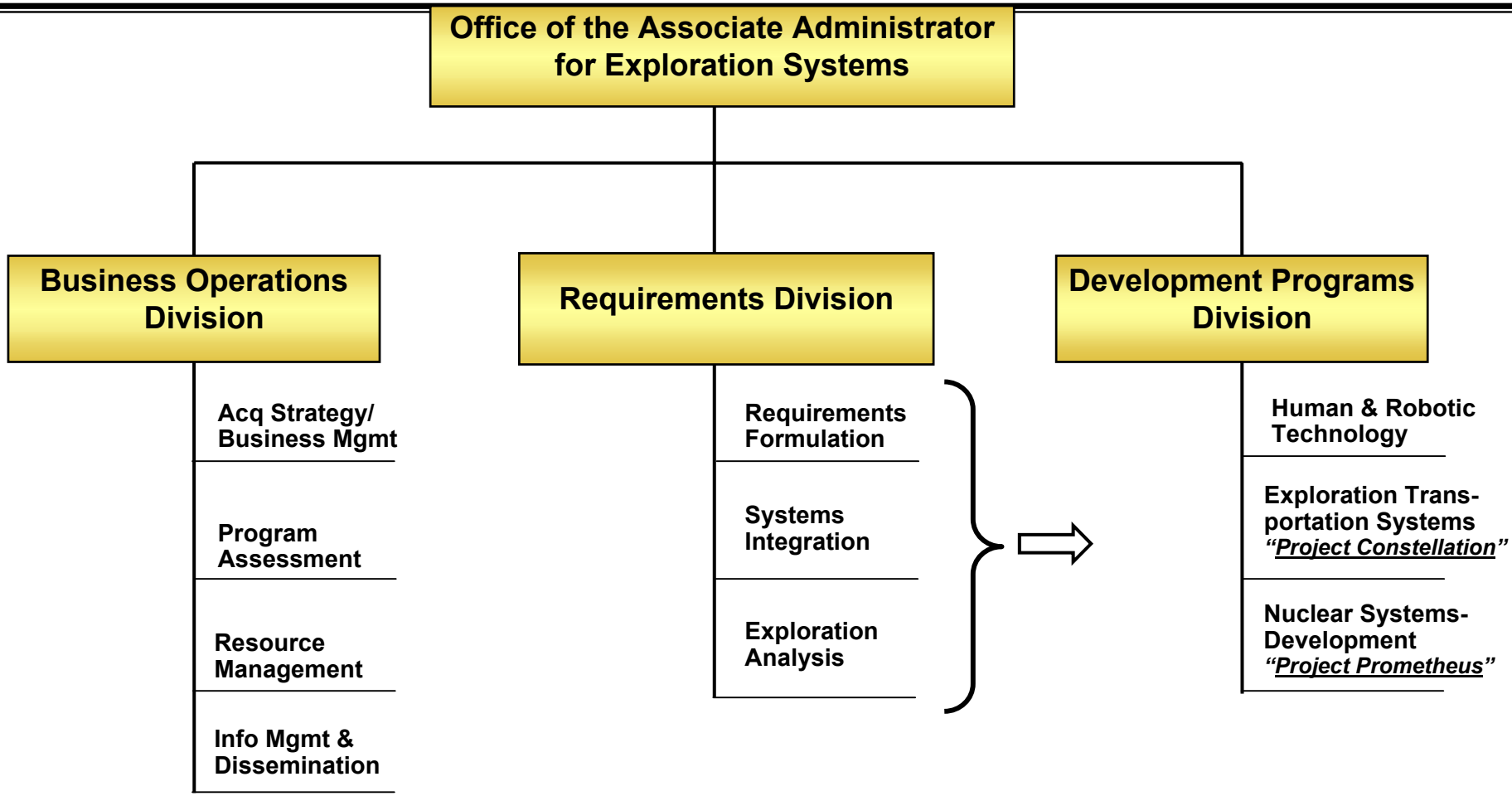


Mars:
Recon +
sampling

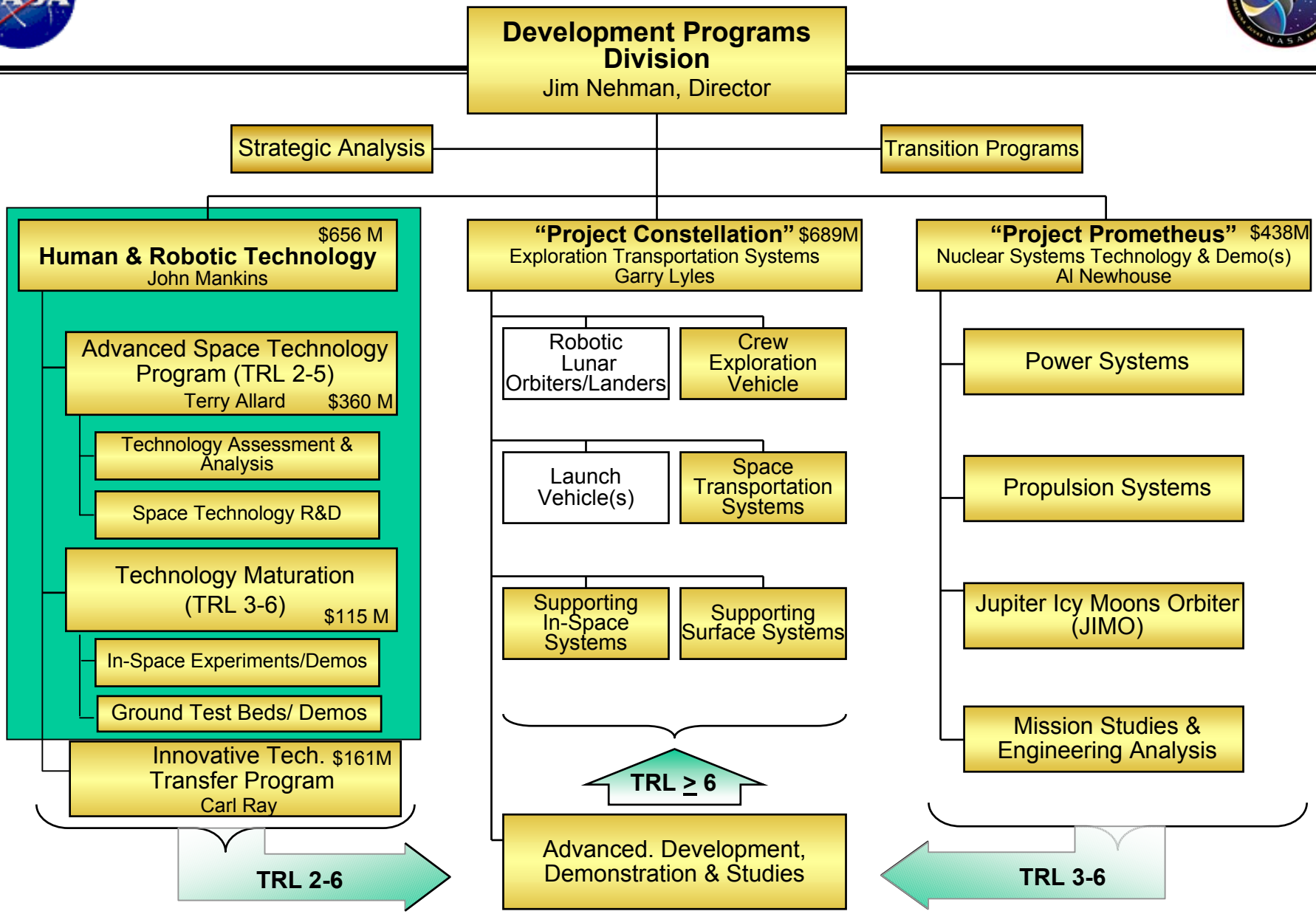


Humans on Mars

Office of Exploration Systems Organization



Development Programs Division



OExS Acquisition Strategy
Constellation as a System-of-Systems

Transit and Launch Systems

Crew Transport

Launch

Crew Support

SYSTEM ENGINEERING

Surface and Orbital Systems

Landing Systems

Comm/Nav

Surface Mobility

Biomedical Countermeasures and Limits

Resource Identification and Characterization

Supporting Research

Long-Duration Habitation

Pre-Positioned Propellants

Surface Power and Resource Utilization

Technology Options

Mars Candidates

Telescope Candidates

Outer Moons Candidates

Commonality/Evolvability For Future Missions

H&RT AST and TM Program

- **Technologies that enable 'system-of-systems' level innovations for Spiral 2 and beyond (e.g., the Human Lunar Return and beyond)**
- **Technologies needed to fill critical subsystem-level 'Capability Gaps' for Spiral 1**
- **High-risk/long-lead technologies that enable new subsystem-level 'capability opportunities' for Spiral 2 and beyond**
- **Technologies of broad common application and value**

Human & Robotic Technology
Advanced Space Technology Program

Human & Robotic Technology Initiative

Innovative Technology Transfer Partnerships Program

Advanced Space Technology Program

Technology Maturation Program

Advanced Studies, Concepts and Tools Program

Advanced Materials & Structural Concepts Program

Communications, Computing, Electronics and Imaging Program

Software, Intelligent Systems & Modeling Program

Power, Propulsion & Chemical Systems Program

Extramural NRA Project # 1

Extramural NRA Project # 2

Extramural NRA Project # n

Intramural "Call" Project #1

Intramural "Call" Project # m

Non-NASA PI
Non-NASA Co-I's Allowed
NASA Co-I's Allowed
Use of NASA Facilities Allowed

NASA PI
NASA Co-I's Allowed
Non-NASA Co-I's Allowed
Use of non-NASA Facilities Allowed

- ***Competitively Selected, with a 1 Year Pilot Project***
- ***3 Year Project ("Gateway" Decision at Year 1)***

Resources

Total Budget: $5-$20M

Should NOT be 'flat'; should follow typical (e.g., log-normal) project funding profile, with variations justified as dictated by specific content

Technology R&D

Goal: Advanced Research of New Technology

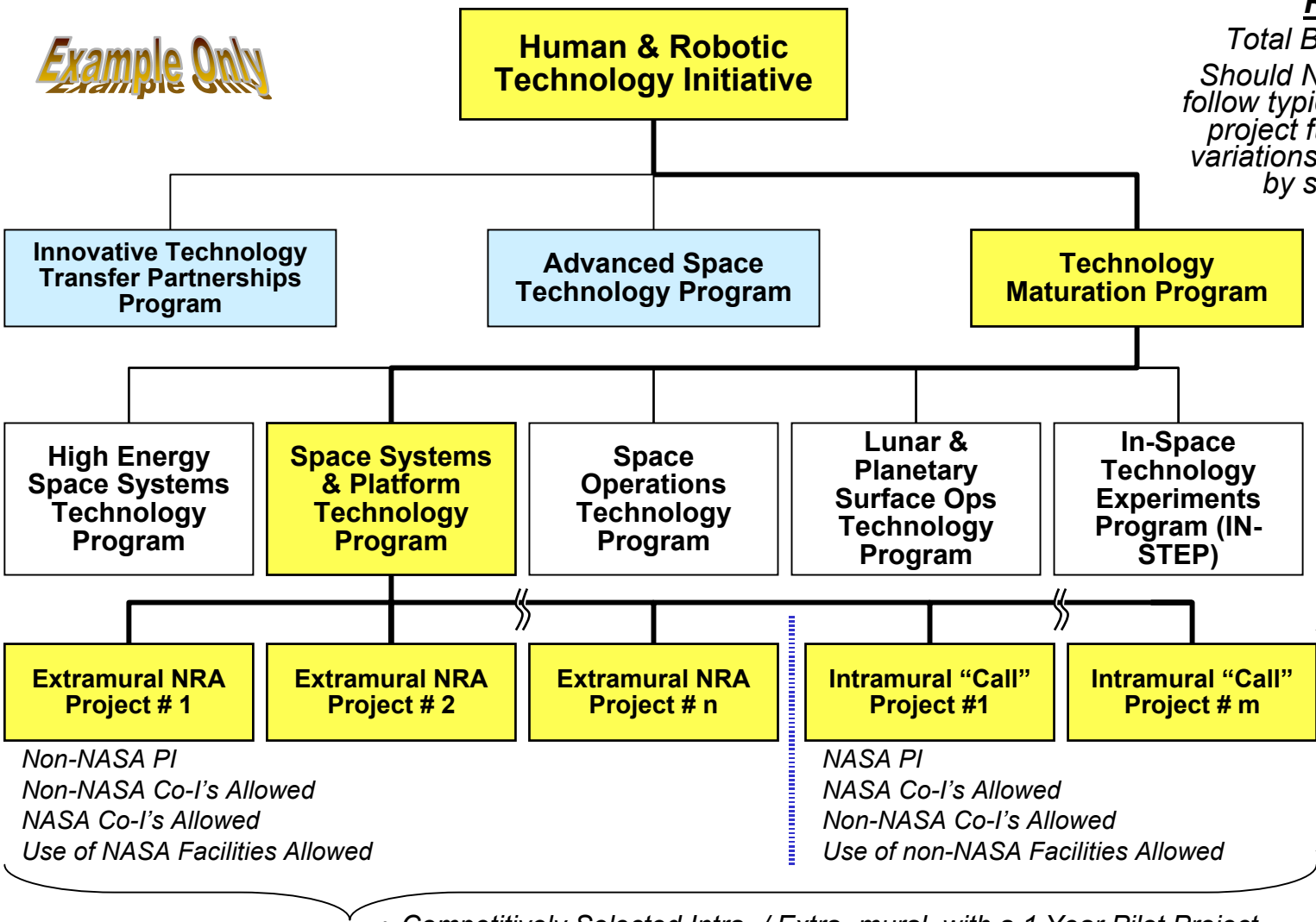
Subsystem Impact:

TRL 2/3 to TRL 4/5
Within 1-2 'Cycle'
3 years, Typical
6+ Years, Max)

System-of-Systems Impact:

TRL 2 to TRL 4/5
Within 2-3 'Cycles'
6 years, Typical
9+ years, Max

Human & Robotic Technology
Technology Maturation Program



Resources

Total Budget: $10-$50M

Should NOT be 'flat'; should follow typical (e.g., log-normal) project funding profile, with variations justified as dictated by specific content

Technology Validation

Goal: Maturation of New Technology

Subsystem Impact:

TRL 5 to TRL 6+

Within 1 'Cycle' 3 years, Typical 6 Years, Max)

System-of-Systems Impact:

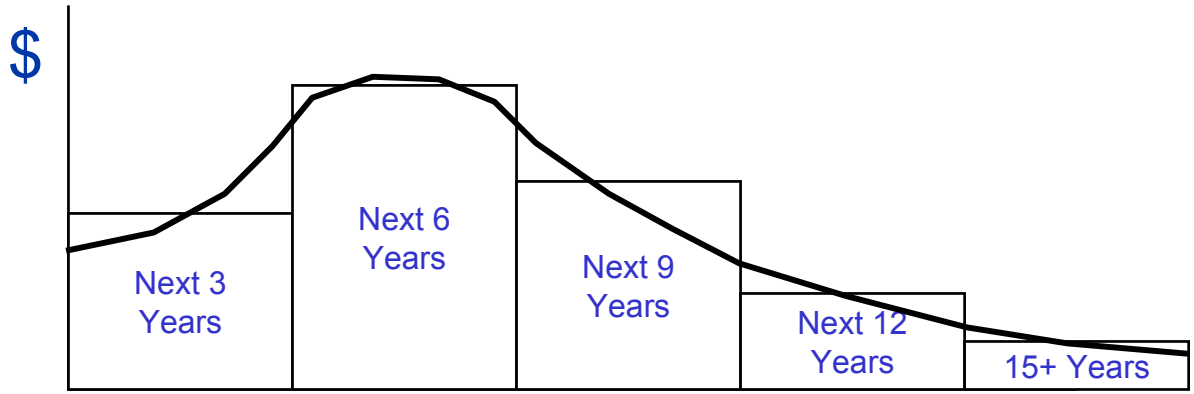
TRL 4 to TRL 6+

Within 2 'Cycles' 6 years, Typical 9 years, Max

- *Competitively Selected Intra- / Extra- mural, with a 1 Year Pilot Project*
- *3 Year Project ("Gateway" Decision at Year 1)*
- *Option for Follow-On (IFF "System-of-Systems" Impact Expected)*

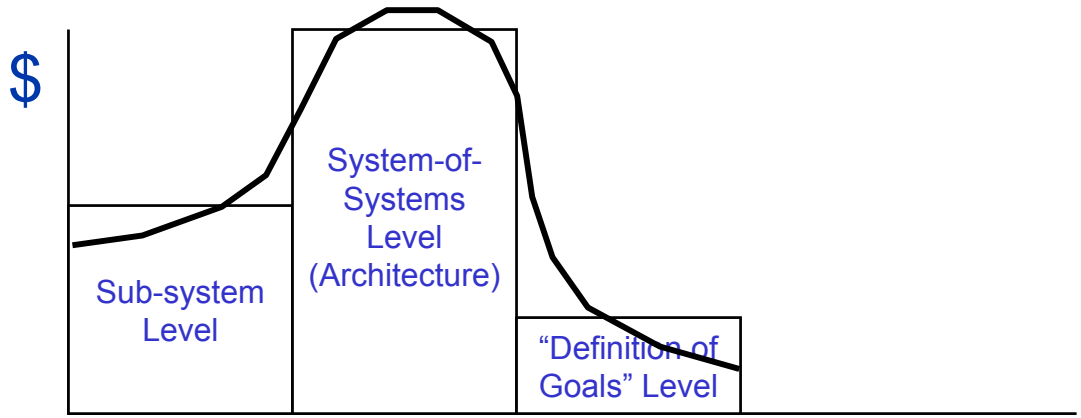
Human & Robotic Technology
Notional Investment "Balance"

H&RT Strategic Focus: TIMEFRAME
(By which Technology Must be Proven)



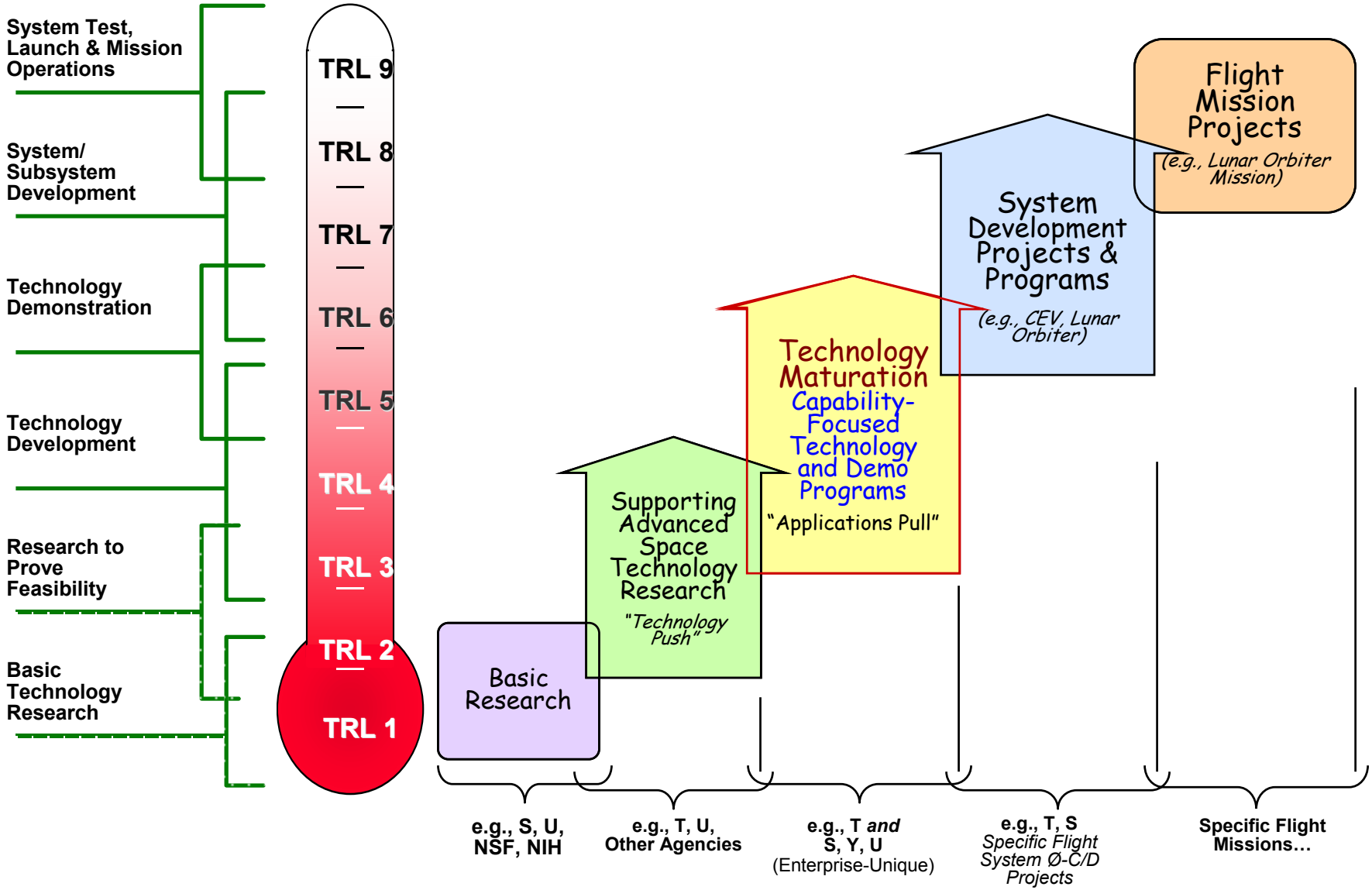
Timeframe
(When Maturity Must be "Proven")

H&RT Strategic Focus: IMPACT
(of the Technology Expected to be Seen in Missions/Systems)



Scale of Impact
(What Influence Will the Technology Have, if "Proven")

Human & Robotic Technology
Strategic Technology/Systems Model



Strategic Technical Challenges (1)

- **Margins and redundancy**
  - in diverse subsystems, systems and systems-of-systems—but particularly those that must execute mission critical operations (such as transportation or life support) with the prospect of significant improvements in robustness in operations, reliability and safety.
- **Reusability**
  - using vehicles and systems during multiple phases of a single mission, and/or over multiple missions instead of 'throwing away' crew transportation, service modules, propulsion stages, and/or excursion systems after only a single mission.
- **Modularity**
  - employing common, redundant components, subsystems and/or systems that can improve reliability and support multiple vehicles, applications and/or destinations—with the potential for significant reductions in cost per kilogram.
- **Autonomy**
  - making vehicles and other systems more intelligent to enable less ground support and infrastructure, including the goal of accelerating application of 'COTS' and COTS-like computing and electronics in space.
- **ASARA" Human Presence in Deep Space**
  - making it possible for humans to operate affordably and effectively in deep space and on lunar/planetary/other surfaces for sustainable periods of operations—while assuring that they are 'as safe as reasonably achievable'.

Strategic Technical Challenges (2)

- **In-Space Assembly**
  - docking vehicles and systems together on orbit instead of launching pre-integrated exploration missions from Earth using very heavy launch vehicles, and including in space maintenance, servicing, reconfiguration, evolution, etc., for exceptionally long-duration deep space operations.
- **Reconfigurability**
  - deploying systems that can be reconfigured following initial deployment, to enable adaptation to new circumstances, evolution at the systems-of 'systems level as new elements are added, or to support high level system options.
- **Robotic Networks**
  - enabling 'networks' of cooperating robotic systems to be deployed that can work cooperatively to prepare landing sites, habitation, and/or resources and to extend the reach of human explorers.
- **Affordable Logistics Pre-positioning**
  - sending spares, equipment, propellants and/or other consumables ahead of planned exploration missions to enable more flexible and efficient mission architectures.

Strategic Technical Challenges (3)

- **Energy-Rich Systems and Missions**
  - including both cost-effective generation of substantial power, as well as the storage, management and transfer of energy and fuels to enable the wide range of other systems-of-systems level challenges identified here).
- **Space Resource Utilization**
  - manufacturing propellants, other consumables and/or spare parts at the destination, rather that transporting all of these from Earth.
- **Data-rich virtual presence**
  - locally & remotely, for both real-time & asynchronous virtual presence to enable effective science and robust operations (including tele-presence and tele-supervision; tele-science; etc.).
- **Access to Surface Targets**
  - that is precise, reliable, repeatable and global for small bodies, the Moon, Mars and other destinations—including both access from orbit and access from other locations on a planetary surface through the use of advanced mobility systems.

BAA Schedule

BAA released postponed approximately one week from previous schedule

Current Schedule

- July 28 Release BAA
- July 29th or Aug 4thIndustry Day
- Aug 11th NOIs due
- Aug 25 response on NOIs
- Sept 22th Final proposals due

Anticipated Content for Notice of Intent (NOI)

- **Required to Propose**
- **Content**
  - **Project Title**
  - **Lead Individual & Co-Lead (s) (limit 3 people)**
  - **Relevant NASA Personnel and Organization**
  - **Lead Organization**
  - **H&RT Program (i.e., AST or TM)**
    - **Primary Element Program (e.g. Advanced Materials and Structures)**
    - **Secondary Element Program (e.g. Advanced Space Platforms and Systems)**
    - **List of deliverables and frequency**
  - **Any Additional Participating NASA Centers and Other Collaborating Institutions, if applicable (non binding).**
  - **Brief Summary which will Serve as the Proposal Abstract**
    - **750 words or less**
    - **Description of technology proposed including goals and objectives**
    - **Description of Technology development/maturation approach including technical challenges**
    - **Impact of proposed technology to future exploration systems**

H&RT Advanced Space Technology (1 of 2)

- **Advanced Materials and Structural Concepts R&D (TRL 3 to 5)**
  - Challenge (Example): The mass of future ambitious Exploration systems will drive in-space propulsion and launch requirements, *however* trimming masses using existing materials reduces margins and reliability
  - Technology Area (Example): novel materials and applications that will reduce the mass *and* increase the strength of diverse space exploration systems tankage, habitats, power systems, etc.

- **Computing, Communications, Electronics & Imaging R&D (TRL 3 to 5)**
  - Challenge (Example): Applications of novel approaches using robotics, autonomous systems, IVHM, etc., will be limited because available on-board computing and data storage can lag a decade or more behind SOA
  - Technology Area (Example): More current generations of robust, fault-tolerant and general purpose flight computers that can enable rapid deployment of novel approaches for successive Spirals

Hand-Out: 21

H&RT Advanced Space Technology (2 of 2)

- **Software, Intelligent Systems and Modeling R&D (TRL 3 to 5)**
  - Challenge (Example): Ground operations costs of future Exploration campaigns lasting years to decades will limit funds available to develop systems for subsequent spirals
  - Technology Area (Example): New generations of robust, fault-tolerant software for intelligent, cooperative space systems that operate largely autonomously from ground control

- **Power, Propulsion and Chemical Systems (TRL 3 to 5)**
  - Challenge (Example): Available storage systems provide relatively low power with substantial penalties in terms of mass, and wasted energy
  - Technology Area (Example): Innovative new batteries and fuel cells could increase available power and total energy for a wide range of systems, including rovers, habitats, space suits and others

Hand-Out: 22

H&RT Technology Maturation (1 of 2)

- **High Energy Space Systems (TRL 4 to 6)**
  - Challenge (Example): The use of expendable space systems imposes a heavy 'per mission' cost penalty (due to hardware) on exploration missions—the larger the systems and more ambitious the mission, the greater the penalty
  - Technology Area (Example): The demonstration of high energy space systems—including advanced power and propulsion—could enable the pre-positioning of fuel and make possible reusable space systems for the human & robotic Moon missions with lower per mission costs

- **Advanced Space Platforms and Systems (TRL 4 to 6)**
  - Challenge (Example): Our ability to deploy future exploration systems-of-systems in remote venues (over years to decades) will be sharply limited if each system employs costly, unique-purpose subsystems and interfaces
  - Technology Area (Example): The validation of intelligent, modular and re-configurable subsystems and systems would enable flexibility and extensibility in space transportation & infrastructures, and surface systems

Hand-Out: 23

H&RT Technology Maturation (2 of 2)

- **In-Space Technology Flight Experiments (TFE)**
  - Challenge (Example): Timely application of new concepts and technologies may depend on early flight validation however flight projects can 'eat' the 'seed corn' for longer term, higher-payoff R&D
  - Technology Area (Example): A focused effort to identify, design, build (where appropriate) and fly novel concepts and technology will accelerate the pace of innovation and application
  - Areas include
    - TFE preliminary design studies
    - TFE accommodations and carriers studies
    - TFE implementation projects

Hand-Out: 25

Contracting Value

AST Element Program	Anticipated Values (per project)
- ASCT Tools and Databases • Phase 1 - 12 mo., Phase 2 – 36 mo.	$4M - $8M
- ASCT Concepts and Studies • Phase 1 - 12 mo., Phase 2 – 12 mo.	$2M - $4M
- Other AST Element Programs • Phase 1 - 12 mo., Phase 2 – 36 mo.	$5M - $15M

TM Element Program	Anticipated Values (per project)
- TFE Definition & Design Studies • Phase 1 - 12 mo., Phase 2 – 12 mo.	$2M - $4M
- TFE Experiment Development Projects • Phase 1 - 12 mo., Phase 2 – 36 mo.	$10M - $20M
- TFE Carrier Definition Studies • Phase 1 - 12 mo., Phase 2 – 12 mo.	$2M - $4M
- Other TM Element Program • Phase 1 - 12 mo., Phase 2 – 36 mo.	$10M - $40M

AST: Advanced Space Technology
TM: Technology Maturation

Hand-Out: 27

Evaluation Process

- **Initial Screening of Notices of Intent to Identify Candidates Eligible to Submit Full Proposals**
- **Detailed Evaluation of Full Proposals**
- **Integration Panel Review Across Areas to Ensure Balanced Portfolio (Best Value to the Government)**
- **Selections**
- **Contracts and Cooperative Agreements Negotiated and Awarded by NASA Centers**

Evaluation Criteria

- Criteria
  - Relevance to NASA H&RT Goals and Objectives
    - Affordability
    - Safety/Reliability
    - Effectiveness
    - Extensibility/Evolvability/Flexibility
    - Development Risk/Schedule Realism
  - Technical Merit
    - Unique or innovative concepts and/or approach
    - Completeness and suitability of proposed SOW
    - Offeror's capabilities and related experience including partnerships and collaboration
    - Key Personnel qualifications and experience
    - Small Business and Small Disadvantaged Business utilization
  - Cost

OExS Extramural Call - Points of Discussion

- In this first round of proposals, the focus is likely to be on those with a 'systems-of-systems' impact, i.e., such a large impact that the entire exploration approach is changed, e.g., the architectural level impact of
- Partnering is encouraged
- NOIs will be reviewed with a binding down select.
- The lead org should have the largest (or equally largest) percentage of funding.
- The PI and the PM need to be from the same organization. Also, the PI/PM should be from the organization that has the largest share of funding.
- Proposal can be submited by any for profit or not-for profit entity except NASA labs and JPL.
- No CVs (or even 2-page bios) for NOI authors are to be included in the extramural proposals.

Overview of Today

Capability Area Presentations: Provide a top level overview of critical Ames capabilities relevant to the Exploration vision.

- Entry Systems Technology
- Nanotechnology
- Autonomous Systems and Robotics
- Crew Assist and Mission Operations
- High-end Computing
- Integrated Systems Health Management
- System Design and Mission Simulation
- Robust Software Systems
- Human Support Technologies
- Advanced Concepts and Analog Mission Campaigns

Poster Sessions: Designed to provide opportunity for more detailed discussions and demos.

One-on-One Discussions: Friday reserved for one-on-one technical discussions as scheduled.

Partners who are Attending

- Univ of California at Santa Cruz
- Carnegie Mellon University
- Institute for Human Machine Cognition.
- Jet Propulsion Lab
- Langley Research Center
- Others