Massachusetts Space Grant Consortium

Distinguished Lecturer Series

NASA Administrator
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NASA’s Exploration Architecture

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Why We Explore

♦ Human curiosity
  • Stimulates our imagination
  • Excites and inspires creativity and productivity
  • Inspirational

♦ International leadership
  • Continued role of global preeminence for the US requires preeminence in space
  • Strategically important that the US always be able to claim the leading role as we explore space.

♦ Scientific discovery and intellectual stimulation
  • Unique opportunity for new scientific observations and discovery

♦ Commercial stimulus
  • Pushing the frontier stimulates technological pay backs
The Moon - the 1st Step to Mars and Beyond….

♦ Gaining significant experience in operating away from Earth’s environment
  • Space will no longer be a destination visited briefly and tentatively
  • “Living off the land”
  • Human support systems

♦ Developing technologies needed for opening the space frontier
  • Crew and cargo launch vehicles (125 metric ton class)
  • Earth ascent/entry system – Crew Exploration Vehicle
  • Mars ascent and descent propulsion systems (liquid oxygen / liquid methane)

♦ Conduct fundamental science
  • Astronomy, physics, astrobiology, historical geology, exobiology

Next Step in Fulfilling Our Destiny As Explorers
Meet all U.S. human spaceflight goals

Significant advancement over Apollo
- Double the number of crew to lunar surface
- Four times number of lunar surface crew-hours
- Global lunar surface access with anytime return to the Earth
- Enables a permanent human presence while preparing for Mars and beyond
- Can make use of lunar resources
- Significantly safer and more reliable

Minimum of two lunar missions per year

Provides a 125 metric ton launch vehicle for lunar and later Mars missions and beyond

Higher ascent crew safety than the Space Shuttle
- 1 in 2,000 for the Crew Launch Vehicle
- 1 in 220 for the Space Shuttle

U.S. system capable of servicing the International Space Station

Orderly transition of the Space Shuttle workforce

Requirements-driven technology program

Annual “go-as-you-pay” budget planning
Lunar Surface Activities

- Initial demonstration of human exploration beyond Earth orbit
  - Learning how to operate away from the Earth

- Conduct scientific investigations
  - Use the moon as a natural laboratory
    - Planetary formation/differentiation, impact cratering, volcanism
  - Understand the integrated effects of gravity, radiation, and the planetary environment on the human body

- Conduct in-situ resource utilization (ISRU) demonstrations
  - Learning to “live off the land”
  - Excavation, transportation and processing of lunar resources

- Begin to establish an outpost - one mission at a time
  - Enable longer term stays

- Testing of operational techniques and demonstration of technologies needed for Mars and beyond…..
High Priority Lunar Exploration Sites

- Aristarchus Plateau
- Oceanus Procellarum
- Mare Tranquillitatis
- Rima Bode
- Mare Smythii
- Central Farside Highlands
- Orientale Basin Floor
- South Pole-Aitken Basin Floor
- North Pole
- South Pole
- Near Side
- Far Side

Luna
Surveyor
Apollo
Crew Exploration Vehicle

♦ A blunt body capsule is the safest, most affordable and fastest approach
  • Separate Crew Module and Service Module configuration
  • Vehicle designed for lunar missions with 4 crew
    – Can accommodate up to 6 crew for Mars and Space Station missions
  • System also has the potential to deliver pressurized and unpressurized cargo to the Space Station if needed

♦ 5.0 meter diameter capsule scaled from Apollo
  • Significant increase in volume
  • Reduced development time and risk
  • Reduced reentry loads, increased landing stability, and better crew visibility
Servicing the International Space Station

- NASA will invite industry to offer commercial crew and cargo delivery service to and from the Station.

- The CEV will be designed for lunar missions but, if needed, can service the International Space Station.

- The CEV will be able to transport crew to and from the Station and stay for 6 months.
Launch Systems

♦ Rely on the EELV fleet for scientific and International Space Station cargo missions in the 5-20 metric ton range to the maximum extent possible.
  • New, commercially-developed launch capabilities will be allowed to compete.

♦ The safest, most reliable, and most affordable way to meet exploration launch requirements is a 25 metric ton system derived from the current Shuttle solid rocket booster and liquid propulsion system.
  • Capitalizes on human-rated systems and 85% of existing facilities.
  • The most straightforward growth path to later exploration super heavy launch.
  • Ensures national capability to produce solid propellant fuel at current levels.

♦ 125 metric ton lift capacity required to minimize on-orbit assembly and complexity – increasing mission success
  • A clean-sheet-of-paper design incurs high expense and risk.
  • EELV-based designs require development of two core stages plus boosters - increasing cost and decreasing safety/reliability.
  • Current Shuttle lifts 100 metric tons to orbit on every launch.
    – 20 metric tons is payload/cargo; remainder is Shuttle Orbiter.
    – Evolution to exploration heavy lift is straightforward.
Crew Launch Vehicle

♦ Serves as the long term crew launch capability for the U.S.

♦ 4 Segment Shuttle Solid Rocket Booster

♦ New liquid oxygen / liquid hydrogen upperstage
  • 1 Space Shuttle Main Engine

♦ Payload capability
  • 25 metric tons to low Earth orbit
  • Growth to 32 metric tons with a 5th solid segment
Earth Departure Stage

- Liquid oxygen / liquid hydrogen stage
  - Heritage from the Shuttle External Tank
  - J-2S engines (or equivalent)

- Stage ignites suborbitally and delivers the lander to low-Earth orbit
  - Can also be used as an upper stage for low-Earth orbit missions

- The CEV later docks with this system and the Earth departure stage performs a trans-lunar injection burn

- The Earth departure stage is then discarded
Lunar Lander and Ascent Stage

- 4 crew to and from the surface
  - Seven days on the surface
  - Lunar outpost crew rotation
- Global access capability
- Anytime return to Earth
- Capability to land 21 metric tons of dedicated cargo
- Airlock for surface activities
- Descent stage:
  - Liquid oxygen / liquid hydrogen propulsion
- Ascent stage:
  - Liquid oxygen / liquid methane propulsion
Space Exploration Budget Projections
2 Year Gap in Human Spaceflight

Cost Assumptions
- NASA Traditional Procurement Approach
- No Savings From Commercial, Fixed Price Services
- No Credit for International Partner Contributions
- No Integrated Budget Benefits From Shuttle/ISS
- 20% Reserves Applied For 65% Cost Confidence
- 3.1% Inflation On Costs Estimates, 2.5% On Budget

Way Forward
- Seek Management-To-Cost Acquisition Approaches
- Engage Commercial Space Industry
- Explore Options With International Partners
- Encourage Entrepreneurial Activity
- Set Clear Program and Budget Priorities
- Annual “Go As You Pay” Budget Planning
The United States must lead the expansion of the space frontier to continue to maintain our world leadership role, and for the security of the nation.

Great nations do great and ambitious things. We must continue to be great.

“We leave as we came, and God willing, as we shall return, with peace and hope for all mankind.”

— Eugene Cernan, Commander of the last Apollo mission