

NASA's Exploration Architecture



September 2005





A Bold Vision for Space Exploration

- ◆ **Complete the International Space Station**
- ◆ **Safely fly the Space Shuttle until 2010**
- ◆ **Develop and fly the Crew Exploration Vehicle no later than 2012**
- ◆ **Return to the moon no later than 2020**
- ◆ **Extend human presence across the solar system and beyond**
- ◆ **Implement a sustained and affordable human and robotic program**
- ◆ **Develop supporting innovative technologies, knowledge, and infrastructures**
- ◆ **Promote international and commercial participation in exploration**



"It is time for America to take the next steps.

Today I announce a new plan to explore space and extend a human presence across our solar system. We will begin the effort quickly, using existing programs and personnel. We'll make steady progress – one mission, one voyage, one landing at a time"

*President George W. Bush –
January 14, 2004*





Why We Explore

- ◆ **Human curiosity**
 - Stimulates our imagination
 - Excites and inspires creativity and productivity
 - Inspirational

- ◆ **International leadership**
 - Continued roll of global pre-eminence for the US requires pre-eminence in space
 - Strategically important for the US always to 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

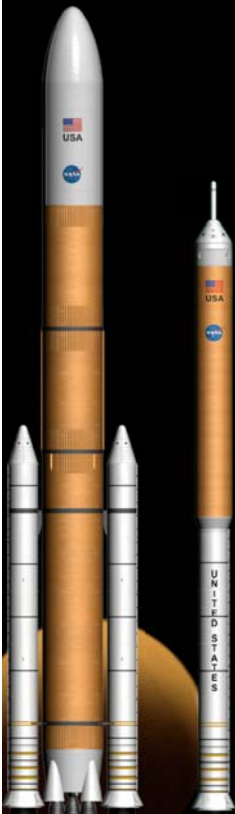


Next Step in Fulfilling Our Destiny As Explorers

A Safe, Accelerated, Affordable and Sustainable Approach



- ◆ **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**





Lunar Surface Activities

- ◆ **Initial demonstration of human exploration beyond Earth orbit**

- □ Learning how to operate away from the Earth



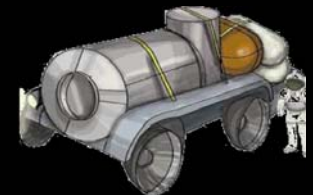
- ◆ **Conduct scientific investigations**

- □ 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**

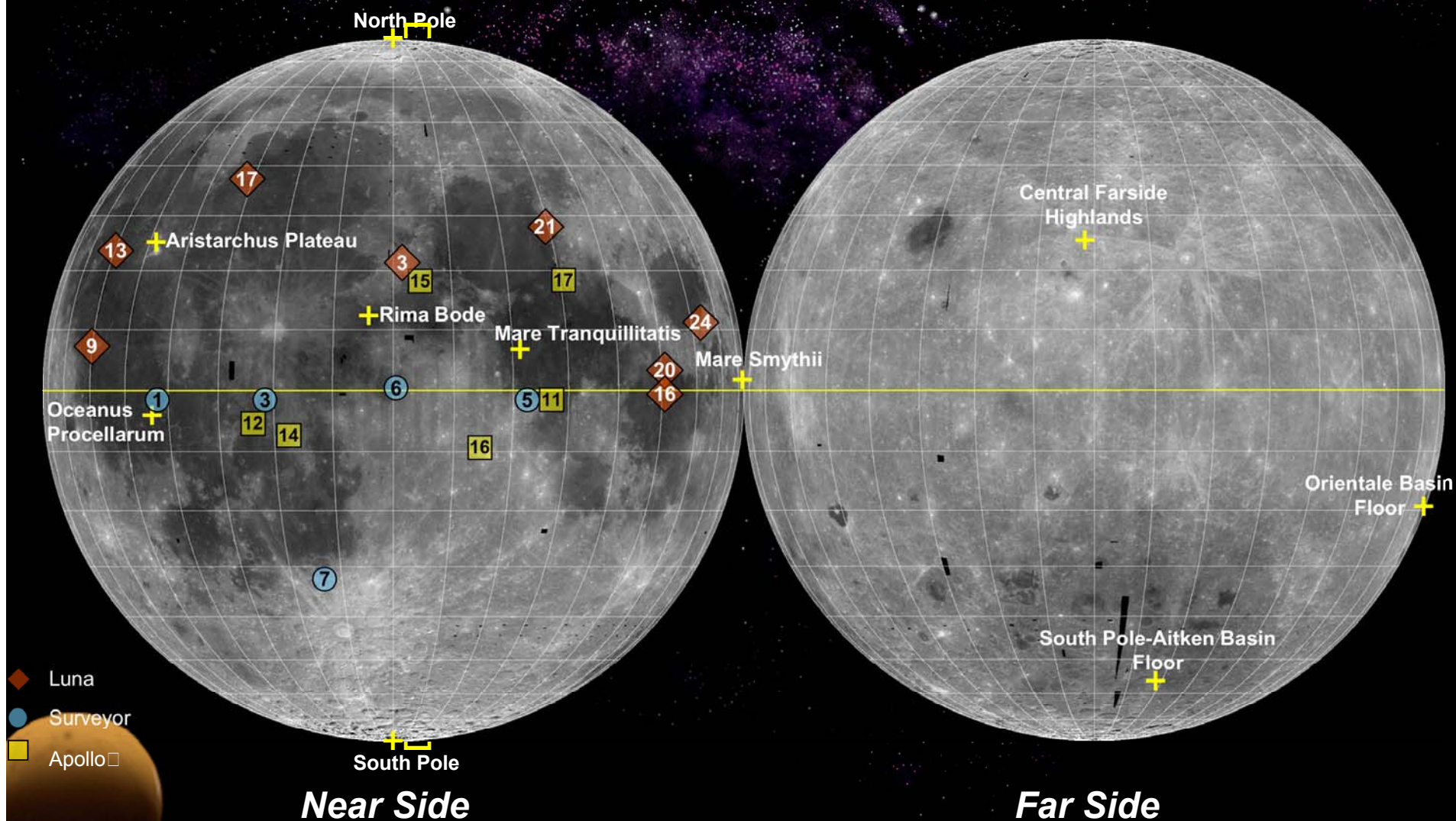
- □ Enable longer term stays

- ◆ **Testing of operational techniques and demonstration of technologies needed for Mars and beyond.....**





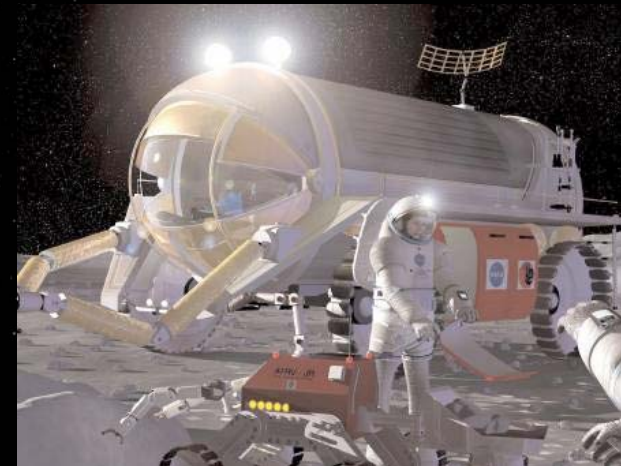
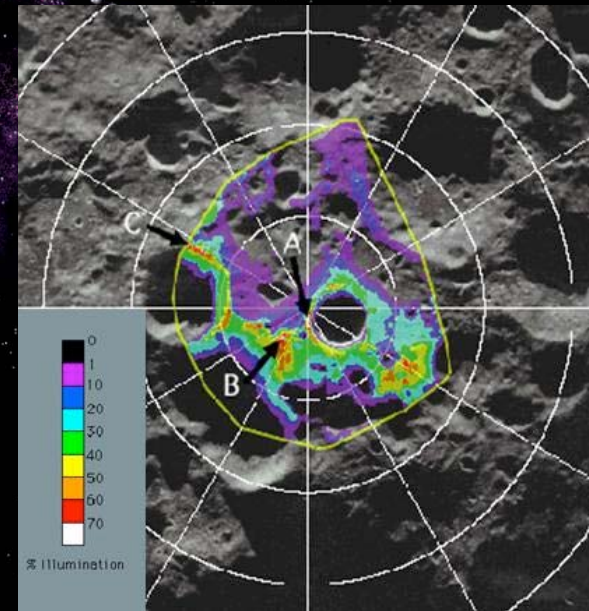
High Priority Lunar Exploration Sites





Possible South Pole Outpost

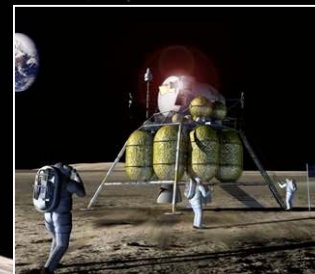
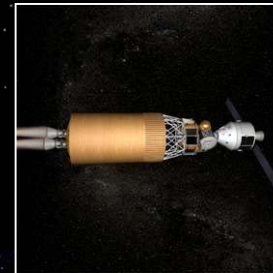
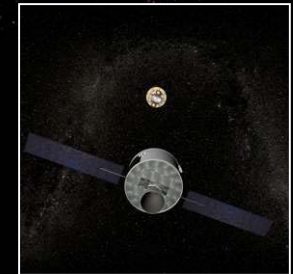
- ◆ The lunar South Pole is a likely candidate for outpost site
- ◆ Elevated quantities of hydrogen, possibly water ice (e.g., Shackleton Crater)
- ◆ Several areas with greater than 80% sunlight and less extreme temperatures
- ◆ Incremental deployment of outpost – one mission at a time
 - Power system
 - Communications/navigation
 - Rovers
 - Habitat and laboratory modules





Lunar "Flight Plan" – Getting to the Moon

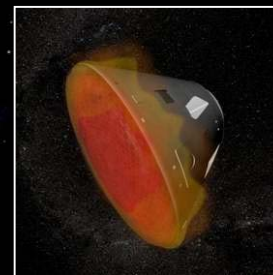
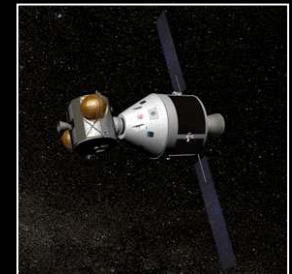
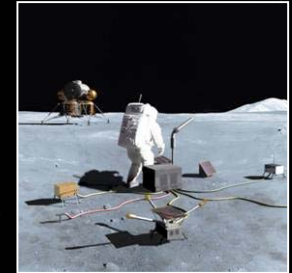
- ◆ Heavy lift launch of the Earth departure stage and lander
- ◆ Launch of the Crew Exploration Vehicle (CEV)
- ◆ CEV docks with Earth departure stage / lander in low Earth orbit
- ◆ Transfer to the moon
- ◆ CEV and lander arrive in low lunar orbit
- ◆ Lunar landing





Lunar "Flight Plan" – Returning to Earth

- ◆ Lunar surface activities
- ◆ Ascent from the surface
- ◆ Ascent stage docks with CEV in low lunar orbit and returns to Earth
- ◆ CEV enters the Earth's atmosphere
- ◆ CEV recovery





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

- ◆ **5.5 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

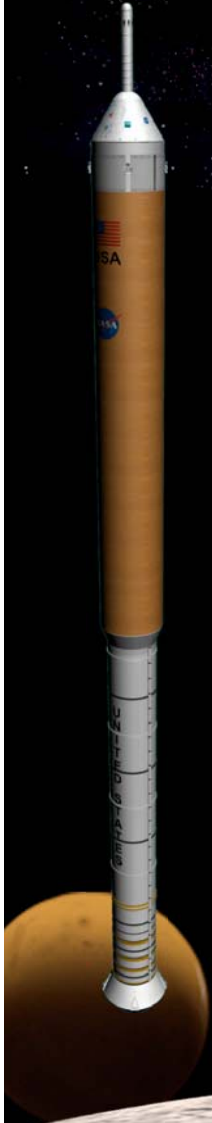
- ◆ **Continue to rely upon the existing U.S. expendable launch vehicle fleet for robotic missions**
- ◆ **For human missions, the safest, most reliable and most affordable launch system will be one derived from the Space Shuttle systems**
 - Capitalizes on human-rated systems and 85% of existing facilities
 - The most straightforward growth path to later exploration super heavy lift needs
- ◆ **100 metric tons+ lift capacity required to minimize on-orbit assembly and complexity – increasing mission success**
 - A clean-sheet-of-paper design is too expensive and risky
 - Super heavy lift derived from EELV increases complexity, increases cost and decreases overall safety/reliability
 - Current Shuttle system already lifts 100 metric tons to orbit on every launch
 - 80 metric tons is the Orbiter





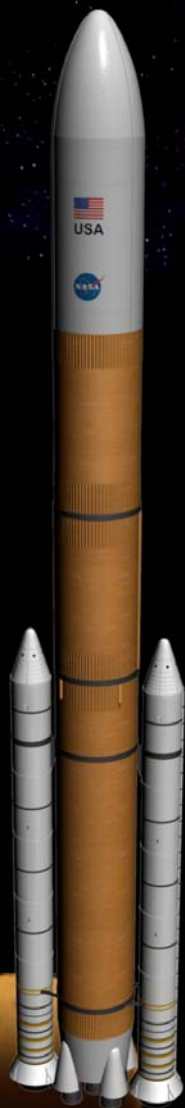
Crew Launch Vehicle

- ◆ **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





Lunar Heavy Cargo Launch Vehicle



- ◆ **5 Segment Shuttle Solid Rocket Boosters**
- ◆ **Liquid oxygen / liquid hydrogen core stage**
 - Heritage from the Shuttle External Tank
 - 5 Space Shuttle Main Engines
- ◆ **Payload capability**
 - 106 metric tons to low Earth orbit
 - 125 Metric tons to low Earth orbit using Earth departure stage
 - 55 metric tons trans lunar injection capability using Earth departure stage
- ◆ **Can be certified for crew if needed**





Earth Departure Stage

- ◆ **Liquid oxygen / liquid hydrogen stage**
 - Heritage from the Shuttle External Tank
 - 2 J-2S engines

- ◆ **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





Potential Commercial Opportunities

- ◆ **Commercial services for space station crew/cargo delivery and return**
- ◆ **Purchase launch / communications services as available**
- ◆ **Innovative programs to encourage entrepreneurs**
- ◆ **Where commercial services meet NASA needs and safety requirements, they will be purchased instead of government assets**





Potential International Opportunities

- ◆ **Continue International Space Station cooperation re-focused on human exploration**
- ◆ **Purchase of additional international partner transportation assets for the Space Station**
- ◆ **Coordination of lunar robotic pre-cursor missions**
- ◆ **Cooperate on variety of lunar surface systems**
 - □ Habitats
 - □ Rovers
 - □ Power and logistics
 - □ Science and in-situ resource utilization equipment
- ◆ **Cooperation on Mars pre-cursor/science missions**
- ◆ **Preparation for joint human Mars missions**

Space Exploration Budget Projections

2 Year Gap in Human Spaceflight

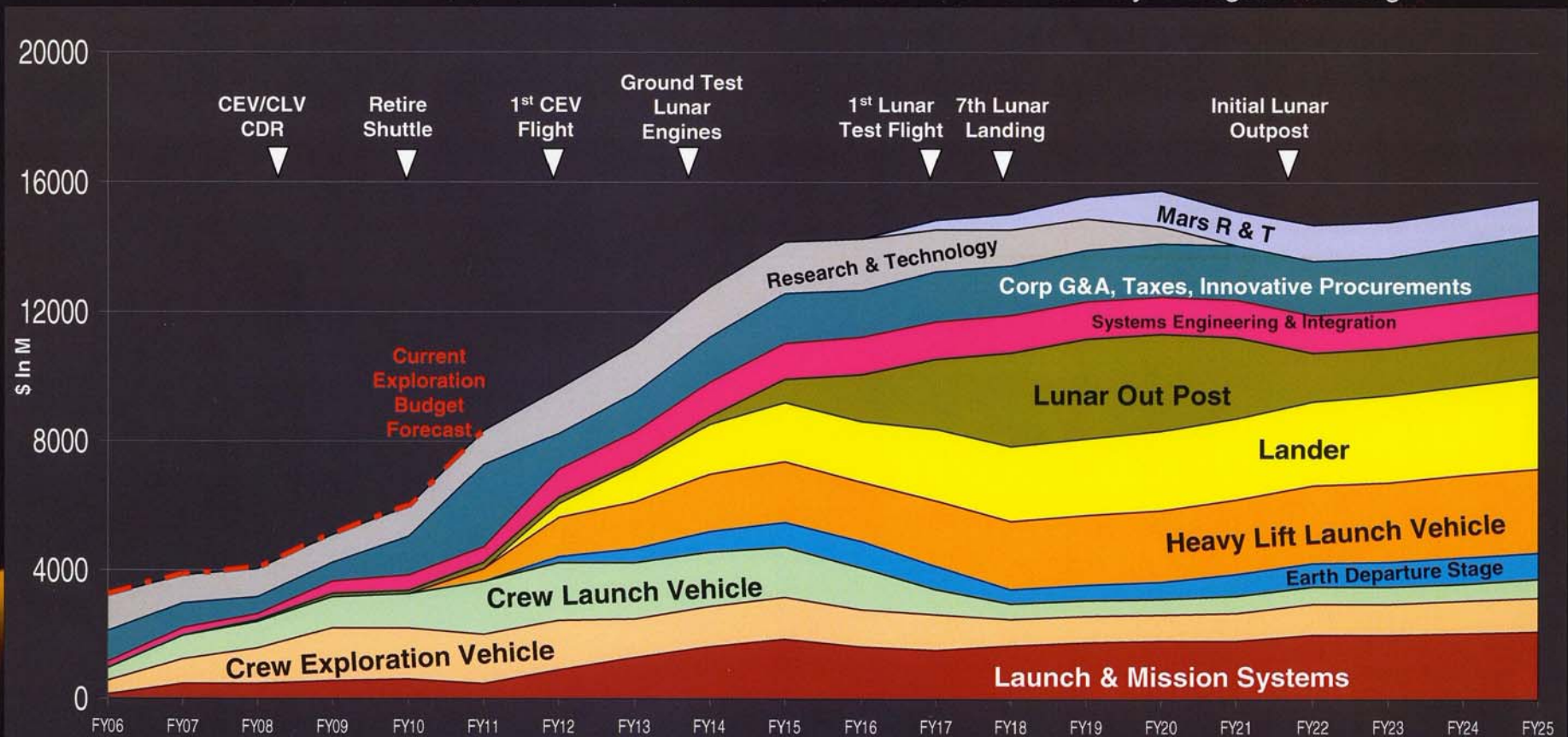


Cost Assumptions

- 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



Our Destiny is to Explore!



- ◆ **The goals of our future space flight program must be worthy of the expense, difficulty and risks which are inherent to it.**
- ◆ **We need to build beyond our current capability to ferry astronauts and cargo to low Earth orbit.**
- ◆ **Our steps should be evolutionary, incremental and cumulative.**
- ◆ **To reach for Mars and beyond we must first reach for the Moon.**

A committed and long term lunar effort is needed, and we need to begin that investment now!



- ◆ *The human imperative to explore and settle new lands will be satisfied, by others if not by us. Humans will explore the Moon, Mars, and beyond. It's simply a matter of which humans, when, what values they will hold, and what languages they will speak, what cultures they will spread. What the United States gains from a robust program of human space exploration is the opportunity to carry the principles and values of western philosophy and culture along on the absolutely inevitable outward migration of humanity into the solar system and, eventually, beyond. These benefits are tangible and consequential. It matters what the United States chooses to do, or not to do, in space.*
- ◆ *It is our nation's privilege and obligation to lead yet another opportunity to explore places beyond our own, and to help shape the destiny of our world for centuries to come. We in our generation are uniquely privileged to be given the challenge of initiating a visionary program of exploration and discovery on behalf of the American people and the world.*

Mike Griffin, AIAA speech, 9/2005 □

*“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



***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.***