Low-Cost Innovation in the U.S. Space Program: A Brief History

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What do these activities have in common?

Commercial clients on Mt. Everest, delivering the U.S. mail, UNIVAC computer, completing the transcontinental railroad.
All benefited from partnerships that promoted lower costs, advances in technology, and commercial provision.

- Advocates wanted to spend more money on the activity than governments wanted to provide.
- Governments participated but not exclusively (public-private partnerships).
- New approaches and technologies caused costs to fall.
- Prompting commercialization,
- Creating competition,
- Encouraging further innovation and cost reduction.
- Low-cost innovation: it can be and has been done.
- Even in the U.S. space program.
Reducing the cost of space travel: the Holy Grail of space policy

“The resulting economies may bring operating costs down as low as one-tenth of those of present launch vehicles.”

Richard M. Nixon

“Factor of ten.”

James Fletcher

Voyager did it: a factor of three.

• NASA wanted $1 billion for four spacecraft to conduct a Grand Tour of the outer solar system.
• Congress appropriated $360 million for two spacecraft to visit Jupiter and Saturn.
• Officials at the Jet Propulsion Laboratory built two spacecraft that visited four planets.
• Launched in 1977, the Voyager spacecraft are still working.

“Grand Tour” became Voyager.
X-33 / VentureStar team tried.

- NASA proposed a joint venture with Lockheed Martin
  - NASA invested $922 million and Lockheed Martin $357 million in the X-33.
  - Lockheed Martin would raise private funds for VentureStar.
  - NASA, among other organizations, would use VentureStar.

- Innovative technologies
  - Aerospike engine
  - Graphite-epoxy composite fuel tanks
  - Lightweight single stage to orbit

- Cancelled by NASA in 2001
  - Weak market
  - Technological obstacles
  - Growing costs
Spitzer Space Infrared Telescope: factor of five.

- Original estimate: 12,500 pounds, $2.2 billion for design, test, and fabrication
- Actual telescope: 1,650 pounds, $473 million for development
- Launched 2003; still operating in a warm mode.
Applying the Concept to Human Space Flight: A Low-Cost Human Mission to Mars?

• In 1997 planners at the Johnson Space Center proposed a “Mars Direct” plan for sending humans to Mars for about $35 billion over 8 years.

• The original Space Exploration Initiative (Moon/Mars 1989) died when a cost estimate of $500 billion emerged.

The vision of cost innovation prompted a series of even more low-cost missions to Mars.

Bob Zubrin, president of the Mars Society, has proposed that NASA establish a $15 billion dollar prize for the first private organization to land a crew on Mars and return it safely to Earth.*

Buzz Aldrin has endorsed the concept of a “one way” trip to Mars.

Dennis Tito has proposed a privately financed very low cost 501-day “fly around” trip to Mars for 2018.

*Prizes are real. The federal government has established more than 200 prizes, including the $4.5 million DARPA robot car Grand Challenge and the $1.5 million NASA Sample Return Robot Challenge.
Space flight advocates in the private sector are pushing a number of initiatives designed to cut costs and commercialize space travel.

- Burt Rutan and Richard Branson hope to begin suborbital flights “within two years.”
- SpaceX has a contract to resupply the International Space Station. Its founder, Elon Musk hopes to reduce launch costs to $500 per pound.
NASA Experiments with Low-Cost Innovation

- NASA officials conducted the Viking Project (1976) for the equivalent of $3.9 billion (1997) – not a low-cost mission.
- Officials at the NASA Jet Propulsion Laboratory conducted the Pathfinder project for $265 million (1997).
- Then completed the Mars Exploration Rover program *Spirit* and *Opportunity* for $820 million (2004 landings).
Competition helps with cost innovation.

- When NASA proposed a low-cost asteroid rendezvous mission, officials at the Jet Propulsion Laboratory said that they could do it with three spacecraft costing $436 million.

- Officials at the Applied Physics Laboratory offered to build one spacecraft for $110 million.

- JPL lowered its estimate to $150 million but lost the competition.

- Not only did NEAR-Shoemaker orbit Eros for one year, the spacecraft landed on it (not an original mission objective).

- Total mission cost: $221 million.
NASA’s Space Science Explorers Program

TRACE, a small solar observatory built at the Goddard Space Flight Center, cost $35 million.

WISE, a wide-field infrared telescope developed by the Jet Propulsion Laboratory, captured an image of newly forming stars in the Berkeley dust cluster 3,300 light years from Earth. Total mission cost: $300 million.
NASA can do and has done low-cost innovation.

A transformational process: if the space exploration community completes the strategic vision for space exploration, NASA will not resemble the organization that launched that vision in 2004 – no more so than the NASA of 1969 resembled the organization that reached for the Moon in 1961.
What went wrong with “Faster, Better, Cheaper?”

- A simple explanation: NASA executives pushed the edge of the cost envelope too far.
- Approach still alive. NASA will follow the Curiosity Mars rover with a Discovery-class InSight mission in 2016.
How is it done?

• Small project teams
  – In-house or single site design and development
  – Risk taking
  – Cost as a major project objective

• Advances in technology
  – Reprogrammable computers
  – Long-life plutonium power generators
  – Robotics

• Public-private partnerships
  – Competition for awards
  – Mixed sources of funding (government, industry, foundations, private capital, private customers, media, other countries)
Economies of Scale

- The first expedition to the Moon cost $21 billion.
- The next six expeditions cost $4 billion.
- NASA’s shuttle cost estimates were based on airline-type economies of scale.
- Low-cost projects like InSight are based on knowledge and materials gathered from previous lander missions.

Apollo 15 and Phoenix lander.