Why do humans explore space?

Humans pursue space exploration for five basic reasons. The first involves space science.[1]

The purpose of a science-based space program is a better understanding of the universe in which humans live. Understanding how things work enlightens human understanding and contributes to technological innovation.

A US space program focused solely upon science would consume an amount equal about one-third of the 2022 overall National Aeronautics and Space Administration (NASA) budget (about $7.6 billion for science). This is an amount roughly equal to the entire budget of the US National Science Foundation ($8.8 billion in 2022). Such an undertaking would depend substantially upon private and philanthropic donations for its funding.

Prior to the advent of space travel supported by governmental entities, most of the achievements of space scientists were supported by private benefactors. Astronomers and their supporters spent substantial sums between 1820 and 1940 building astronomical observatories on the surface of the Earth.

Space economist Alexander MacDonald estimates that when adjusted for inflation these contributions approached the amounts later spent to dispatch spacecraft to explore the solar system first-hand. Only two of the 38 terrestrial observatories MacDonald studied were funded by public dollars; the remainder relied upon private and philanthropic subscriptions.[2]

The Lick Observatory is one example. Constructed between 1876 and 1887 in central California, the observatory reportedly cost $700,000 in the currency of its day. It was financed by the eccentric James Lick, one of the richest individuals in California. A half century later, the Rockefeller Foundation supported the $6 million Palomar Observatory, proposed in 1928 and constructed further south near San Diego.[3] John Hooker, an amateur scientist, provided start-up funding for the Hooker telescope at the $1.5 million Mount Wilson Observatory above Los Angeles. Edwin Hubble used the telescope to confirm the proposition that the universe consisted of many galaxies, more than just the Milky Way.

To explore the relative burden of privately sponsored observatories compared to government-funded projects, MacDonald examines cases like the NEAR Shoemaker mission, launched in 1996 and funded through NASA.

Arriving at its destination in 2000, the NEAR spacecraft orbited asteroid 433 Eros for a year before landing on the object, providing close-up inspection that no Earth-based

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[1] Roger D. Launius, NASA chief historian and Associate Director for Collections and Curatorial Affairs at the Smithsonian National Air and Space Museum, developed the original five-item rational for why humans explore space upon which this and other frameworks are based. See Roger D. Launius, "Compelling Rationales for Spaceflight? History and the Search for Relevance," in Steven J. Dick and Roger D. Launius, eds. *Critical Issues in the History of Spaceflight*, NASA SP-2006-4702, 2006: 37-70.

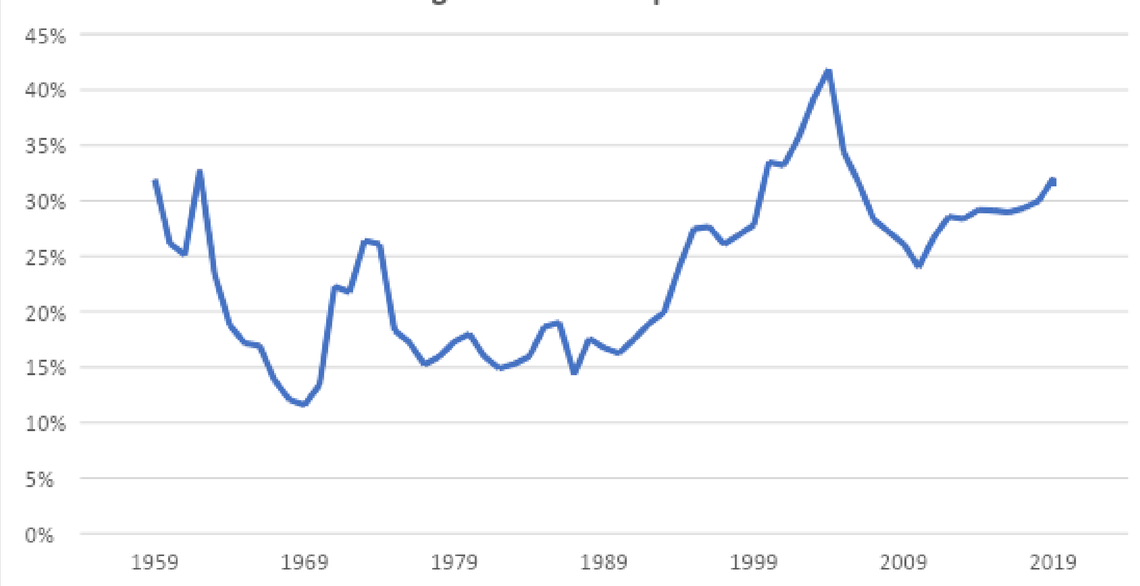
[2] Alexander MacDonald, *The Long Space Age*. Yale University Press, 2017: 14-20.

[3] Library of Congress on line catalog, Film Division, Edison Manufacturing Co., Lick Observatory, Mt. Hamilton, Cal.,\\ 1897 www.loc.gov/item/00694234/ (accessed June 4, 2023); Palomar Observatory, A History of Palomar Observatory, 21 October 2022 <History of Palomar (caltech.edu)> (accessed June 4, 2023).

observatory could reproduce. The mission cost slightly more than $200 million during a period when the US gross domestic product surpassed $8 trillion. Adjusting the NEAR project to the scale of the US gross domestic product in 1928, the Palomar Observatory appears to have cost considerably more than the adjusted NEAR Shoemaker mission.[4] To MacDonald, the observatory movement represents one of the early attempts to significantly involve the private and non-profit sectors in space exploration.

When the US Congress created NASA in 1958, legislators set aside a significant sum of government money to fund what they labeled "scientific investigations in space." Science projects consumed 32 percent of the $53 million Congress provided for outer space activities in that first year (see Table 1).[5] Thereafter, spending on non-military space science benefited from association with NASA's efforts to land Americans on the Moon. The NASA science budget grew from $17 million (fiscal year 1959) to $479 million (FY 1962) and onward to $747 million (FY 1964). It incorporated astronomy, physics, bioscience, Earth science, lunar and planetary missions, meteorological satellites, communication satellite research, sounding rockets, and associated launch vehicles.

Table 1. NASA Budget Devoted to Space Science 1959-2022



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[4] The earliest year in which accurate estimates of the US gross domestic project appear is 1929, when the GDP reached $110 billion. The Near Shoemaker mission cost $212 million (MacDonald estimates $224: p, 19). The US DPR for 1996 – the year of the spacecraft's launch – was $8.07 trillion. [8.07 trillion/110 billion = 73 x 6 million = 440 million.]

[5] National Aeronautics and Space Administration, Research and Development, Estimate of Appropriations, Fiscal Year 1961: 101. NASA annual budget documents, the primary source for budget figures summarized here, are available through the Planetary Society web site. The figures cited generally include the cost of rockets required to dispatch spacecraft from the Earth to their various destinations. Space science figures incorporate investigations of the Earth (generally characterized as space applications) as well as the more commonly cited scientific investigations of phenomena beyond the planet.

By 1970, space science funding had fallen to 13 percent of NASA's overall budget, which was declining sharply in the wake of the concluding lunar missions. Civil science projects received $519 million that year, still a generous sum.

As the direction of the US post-Apollo space effort became apparent (a winged space shuttle and a large orbiting space station), the space science share of the overall civil space budget stabilized at roughly 15 percent. Scientists complained that government officials were sacrificing science projects to make room for human flight. Physicist James Van Allen, designer of the instrument package on the first US Earth orbiting satellite (Explorer 1), prepared a list of foregone and delayed science projects that included missions to Venus, Mars, Jupiter, and comet Halley, two observatories, data reception from three existing spacecraft, and an international effort to study the sun.

Writing in *Scientific American*, Van Allen characterized the shift as the "slaughter of the innocent" and argued that there was little that humans could do in space that could not be done less expensively and more effectively by machines.[6]

By 2006, assembly of the International Space Station was finally underway, and the US was making plans to decommission its expensive space shuttle. Space scientists were launching missions to the outer planets, rovers to Mars, and a succession of large observatories beginning with the Hubble Space Telescope.

NASA's science budget rebounded to $5 billion or roughly 30 percent of the overall NASA appropriation. Future plans included a sample return mission to Mars and a search for evidence of life forms on Jupiter's moon Europa. The finally-launched Webb space telescope returned enhanced images of the universe as it existed at the edge of creation.

Space scientists benefited enormously from advances in computer programming and robotics, while the human space program had remained sluggishly confined to low Earth orbit. In 2022 NASA tested its Artemus return-to-the-Moon objective with a hardware test carried out entirely with robotic technology (no human crew on board). In many ways, the US civil space program provided high returns on the rationale that favored investments in space science as a primary rationale for exploring space.

Dr. Howard McCurdy, August 19, 2023

[6] James A. Van Allen, Space Science, Space Technology and the Space Station," *Scientific American* (January 1986): 37.