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Motivations for space exploration☆

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ABSTRACT

Possibly the greatest barrier to progress in space exploration is the lack of compelling motivations to justify the necessary investments. *Spaceflight*, a concept that gained currency in the middle of the twentieth century, may not be well adapted to the twenty-first century without significant modification. This article assesses the traditional motivations for space exploration, documented in a Harvard study carried out over two decades ago, in the light of subsequent developments. It then reports on a recent NASA study of justifications for a renewed Moon program, and concludes with the conjecture that the very meaning of human travel in space needs to be redefined.

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A classic challenge for space exploration is the *Fermi paradox*, named after the physicist Enrico Fermi who supposedly discussed it with colleagues over lunch one day in 1950. If life evolves naturally on many planets across the cosmos, why have aliens not colonized or at least visited the Earth? Setting aside popular myths about UFOs, granting Fermi's premise raises the possibility that intelligent species do not develop extensive space travel for the simple reason that they lack sufficient motivations to do so. If every other civilization across the galaxy feels no need to come here, where would we find the motivation to go there?

In the second half of the twentieth century, humanity did summon up the motivation necessary to visit the Moon, send robot probes throughout the solar system, and undertake a wide range of economic, military, and scientific activities in Earth orbit. The question then becomes whether we will find motivations to do more during the twenty-first century.

We can distinguish three kinds of motivations for space exploration and development. First, some goals were valid in the beginning, but are no longer valid, often because the claimed benefit has been fully achieved. Second, we may begin to pursue purposes that were not possible in the beginning, but are becoming possible, some of which remain unrecognized. Finally, some continuing justifications were never valid reasons for promoting spaceflight, but may have been somewhat effective in garnering support under past political conditions. Thus, to understand future motivations for spaceflight, we may wish to begin with an analysis of past justifications, evaluating them in the context of today's changed circumstances and improved knowledge.

1. Classical perspectives on the space program

In January 1986, I happened to be doing observational research at NASA's Jet Propulsion Laboratory, looking at how scientists and members of the press were collaborating to find the right metaphors to communicate to the general public about the encounter of the space probe Voyager II with the planet Uranus. We all watched the launch of the Challenger space shuttle on NASA's direct television feed from Florida, because the networks had stopped carrying these events under the

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assumption they had become routine. The explosion of the Challenger inspired me to carry out a two-phase questionnaire study with students at Harvard University, to chart the distinct goals well-informed people believed might justify a continued space program. In Phase 1 of the study, 1007 student volunteers completed a questionnaire including a number of open-ended questions asking them to express freely any ideas they had about the values served by space exploration. Analysis consisted of extracting the wording of all the distinct utterances, sorting them into categories, and producing a summary statement for each of the 125 resultant groups. In Phase 2, another 894 students rated each of the statements in terms of how good a justification it was, and a form of cluster analysis called *block modeling* was used to derive a smaller number of very general values potentially served by space development (Bainbridge goals).[1]

I will re-examine the results of that two-decade-old study here, in order to assess the current status of each of the main traditional justifications for the space program. This "back to the future" approach will help us extrapolate trends in the declining plausibility of many classic justifications for space exploration. The following paragraphs examine each of 18 broad near-term practical goals for spaceflight, followed by 16 more philosophical or distant goals, each represented by quoting two of the questionnaire statements.

1.1. Earth observation

"Satellites are useful in surveying and mapping the Earth." "Observations from orbit help us find new sources of energy and minerals on the Earth." Earth resources satellites have proven to be of moderate value, and undoubtedly they will continue to be launched over the years. However, this application does not require any further development of space technology; sensor technology may improve, but we already know perfectly well how to get satellites into orbit, how to control them, and how to power their onboard equipment.

1.2. Communications

"Satellites are an important component in navigation systems." "Communication satellites improve television transmissions." The Global Positioning System is one of the breakthrough applications of recent decades, based essentially on communication satellites that transmit time signals, and indeed comsats have long played an important role in radio and TV systems. Again, however, the technology is rather mature, and any further improvements are likely to be in aspects that are incidental to space technology.

1.3. Spin-offs

"Technological spin-offs (advancements developed for the space program, then applied to other fields) improve everyday life." "The space program produces better computers, calculators, and electronics." Spinoffs are not primary justifications for space exploration, but as side benefits they effectively reduce the cost, and they have constantly been cited as among the most valuable results [1–3]. However, it is not clear that spin-offs can be expected from the new US Moon and Mars program, because new technology development is not central to it. Indeed, NASA has cut back research in nanotechnology and robotics to pay for the design and prototyping of launch vehicles that will be "new" in a sense but based on principles developed for the Apollo program four decades ago. Through the 1970s, development of space and missile technology helped drive the development of computers, but that period is now over and computer science progress is stimulated by developments in a myriad of other areas, from bioinformatics to nanoelectronics, and from home information technology to computer vision for cars.

1.4. Exploitation of space conditions

"Some medical problems could be treated more effectively in the weightlessness of space." "In the weightlessness and vacuum of space, we could manufacture new and better alloys, crystals, chemicals, and machine parts." Given how difficult it has proven to launch manned spacecraft to Earth orbit, both in terms of cost and danger, doing medical treatment in Earth orbit simply is not plausible at the present time. After failing at least twice to develop a safe, cheap successor to the shuttle – the National Aerospace Plane and the X-33 [4] – NASA is not planning another attempt to develop a generalized space transportation system for the foreseeable future. Although some promising experiments were done growing crystals in weightlessness, space-based manufacturing could not compete with the vast range of materials innovations being rapidly delivered by nanotechnology [5,6]. Given the existence of a manned space station justified by other purposes, some valuable research may be done with materials in weightlessness. We could conjecture that the same might be true for biomedical research as well, but an as-yet unpublished study I recently conducted on medical spin-offs from the space program suggested that the benefits in this area were small. However, orbital work following current plans would consist of limited research projects most likely having only minor applications on Earth.

[1] The book is available free on my personal website: http://mysite.verizon.net/wsbainbridge/.