

A space exploration strategy that promotes international and commercial participation



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ABSTRACT

NASA has created a plan to implement the Flexible Path strategy, which utilizes a heavy lift launch vehicle to deliver crew and cargo to orbit. In this plan, NASA would develop much of the transportation architecture (launch vehicle, crew capsule, and in-space propulsion), leaving the other in-space elements open to commercial and international partnerships. This paper presents a space exploration strategy that reverses that philosophy, where commercial and international launch vehicles provide launch services. Utilizing a propellant depot to aggregate propellant on orbit, smaller launch vehicles are capable of delivering all of the mass necessary for space exploration. This strategy has benefits to the architecture in terms of cost, schedule, and reliability.

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1. Introduction

In October 2009, after years of pursuing the system architecture to return humans to the Moon presented in the Exploration Systems Architecture Study (ESAS) [1], the U.S. Congress sanctioned a committee to review the path that NASA was taking with human spaceflight [2]. The result from that committee was that the existing strategy was not affordable or sustainable. The committee recommended that NASA pursue a flexible path strategy, where capabilities and technologies are developed as humans explore incrementally more challenging destinations. NASA then developed a plan to implement that strategy which utilized a Heavy Lift Launch Vehicle (HLLV) to deliver crew and cargo to orbit [3]. In-space propulsion and habitation elements would then be used to explore the solar system along the flexible path. NASA would develop much of the transportation architecture (the

HLLV, crew capsule, and in-space propulsion elements), leaving the other in-space elements open to commercial and international partnerships.

This paper presents a space exploration strategy that reverses that philosophy. Commercial and international launch vehicles could provide access to space, while NASA focuses primarily on the in-space elements and technology development. There are many launch vehicle providers around the world that have the ability to launch more than the current market demands [4]. The use of smaller launch vehicles increases the number of launches for a given mission, and requires that the payloads originally delivered on an HLLV be divided into smaller segments. A propellant depot enables propellant to be divided to fit on these launch vehicles and aggregated in orbit, while most flight hardware elements have already been sized to fit on existing launch vehicles [3].

2. Background

The current strategy and implementation for human space exploration was presented by the Review of U.S. Human Spaceflight Plans Committee (also called the

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Nomenclature		P_S	probability of success
n	number of launches	R	launch vehicle reliability

Augustine Commission) [2], the Human Exploration Framework Team (HEFT) [3], and the International Space Exploration Coordination Group (ISECG) [5]. These plans, however, do not fully utilize the available worldwide launch vehicle capacity, which includes both commercial vehicles and those operated by government space agencies.

2.1. Flexible path strategy

In October 2009, the Augustine Commission released its report providing an overview of the state of human spaceflight and recommendations on the future of human spaceflight within NASA. In that report, the committee recommended a flexible path strategy, in which capabilities and technologies are developed over time in order to visit increasingly more challenging destinations. As notionally shown in Fig. 1, these destinations begin with operations in cis-lunar space. Then, as capabilities and technologies are developed and advanced, destinations such as the lunar surface and Near Earth Asteroids (NEAs) would become accessible. Once technically feasible, humans would then be able to travel to destinations within the Martian sphere of influence. The reason for selecting this strategy was to reduce initial cost required to perform meaningful space exploration in the near term that would keep the public interested while NASA continued to build toward more challenging destinations [2].

In September 2011, ISECG identified two pathways through this flexible path, as shown in Fig. 2. Both pathways

begin with exploration of cis-lunar space, utilizing the International Space Station, and emphasizing capability development. Then, two destinations could be pursued thereafter: the Moon or a NEA. The order in which these two destinations are visited is the trade which creates the two alternate options. The first option visits a NEA first, developing long duration, in-space habitation capability. The second option visits the lunar surface first, developing surface access elements as well as the systems required to live on a planetary body. Both of these options lead to building the capability to send humans to Mars (or the Martian moons) after visiting both lunar surface and NEA destinations [5].

One of the principles used in developing these pathways is “International Partnerships,” where the ability to provide early and sustained opportunities for diverse partnerships is emphasized [5]. The elements required to perform these missions existed within the framework planned by NASA in response to the Augustine Commission [2]. Therefore, international and commercial partnerships were limited to a support role outside of the planned NASA framework.

The NASA framework was defined by the Human Exploration Framework Team (HEFT) in a report that was released in 2010. This report established a capability driven framework that develops capabilities and technologies that can be used to explore the various destinations within the flexible path strategy. The systems within this framework, as shown in Fig. 3, are divided into two categories: transportation architecture and destination architecture. The transportation architecture contains

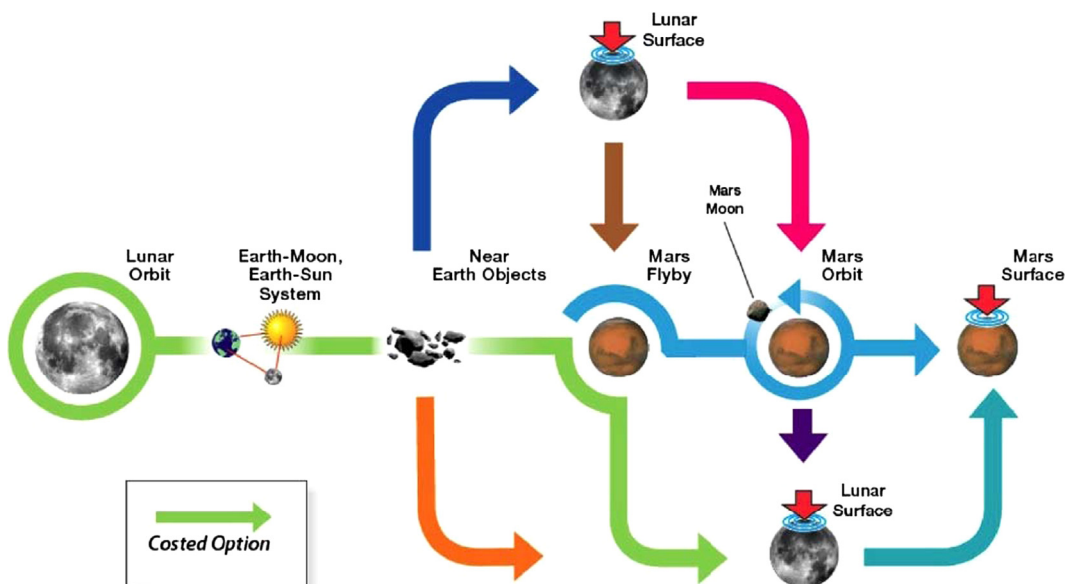


Fig. 1. Flexible path strategy outlined by the Augustine Commission [2].

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