Comments on Future U.S. Space Programs
Earth Space Applications Inc.
William C Strobl
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Our nation is at a crossroad that will define our activities in Space for many, many years to come. So lets do it correctly.

The U.S. Human Space Flight Plans Committee's summary report provides our nation with a start. The committee's effort was outstanding, providing unbiased and comprehensive recommendations for future human space flight plans. The report leaned toward a system-of-systems infrastructure approach, building on each step to evolve to the next level and to eventually achieve all the U.S. Space Objectives.

I agree with the comments of Adelbert O. Tischler that we should take the time to put together a total plan of desirable robotic and human space activities. His statement, "Considering what has happened previously, it seems to me shrew to project the scope of what is to be done with new system developments throughout their useful life." also fits an approach of a system-of-systems infrastructure.

In 2003 I gave a presentation on my 53 years "Lessons Lived" in the rocket industry to NASA personnel that included a methodology to analyze and define system requirements for earth orbit, lunar and Mars objectives as shown in Figure 1.

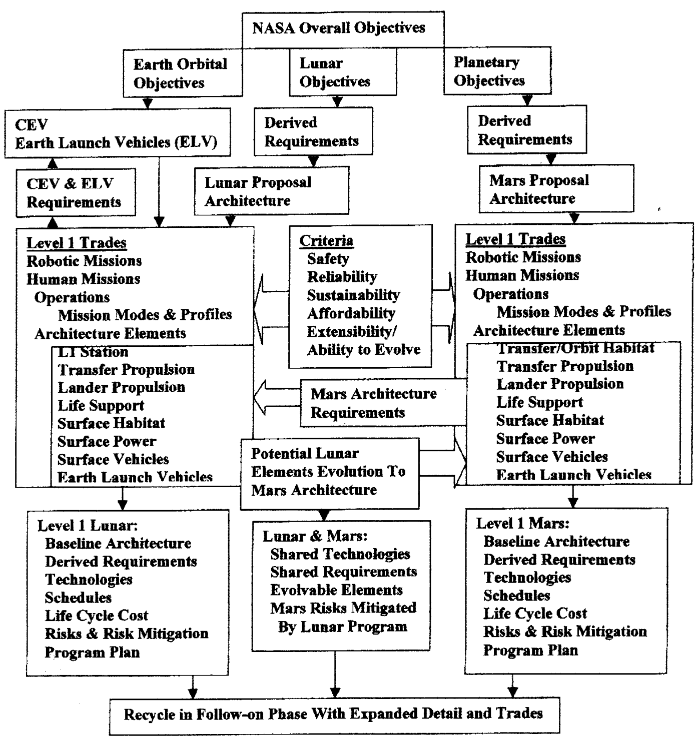

Figure 1 Space Program Architecture Requirements Analysis Flow

The best method to develop an understanding of a system-of-systems infrastructure is to conduct an architecture study including all space exploration areas of interest. Then apply basic system engineering principles to define required elements and system requirements for all elements for a given set objectives.

Conducting an architecture study to include the three areas of space activity of interest will allow development of various architecture strategies with related funding profiles. The projected NASA budget could overlay the funding profiles to determine what was affordable and what areas we could seek partners to join the activities. Thus we could potentially continue with the commitments we have made with our orbiting international space station (ISS) partners. As Adelbert Tischler commented that we would loose our space exploration leadership status if we abandon these relationships. Open the architecture study to include our nations ISS partners.

In 1985 NASA and the Air Force jointly funded and managed four Space Transportation Architecture Studies. The Joint NLS Program Office included representatives from every NASA and Air Force center. The studies were to define potential Architectures that could satisfy the objectives of NASA, Air Force and SDIO. I managed the General Dynamics study. We applied prior General Dynamics developed software to evaluate 615 architectures and 40 vehicle concepts in 6 months. In the same time and detail our competitors evaluated 4 to 5 architectures. The studies yielded a flexible launch system capable of evolving as the requirements change. An interesting fact is that the six-engine Ares V booster is nearly exactly like the six-engine NLS-2 booster shown in figure 2. Additionally, the Ares V RS-68 engine is nearly identical to the NLS-2 engine in design, size, and cost. NLS-1 is the NLS-2 Booster with 2 standard Space Shuttle solid motors also similar to Ares V Heavy Booster.

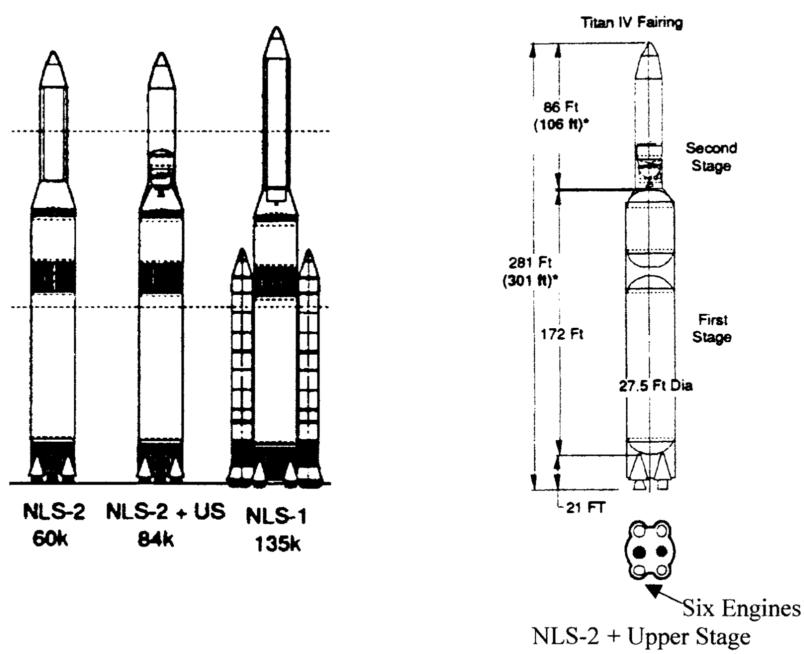

Figure 2 NLS-1 and NLS –2 Concepts

I believe that developing systems-of-systems infrastructure for human flights to earth orbit and the moon before venturing to Mars will lower the cost and mitigate risks for the Mars missions. The recent disclosure of water being discovered on the Moon further validates this approach, and opens new potential solutions. I believe that I can add a few hither to unmentioned reasons based upon the four years that I worked for Krafft Ehricke, (1962-1965) designing and analyzing vehicles to transfer humans to Mars and Venus; the ALS/NLS (1985-1992) experience; and studies and tools completed this year for AFRL/Edwards on in-space use of nuclear electric propulsion.

Vehicles designed in the early 1960’s were planed for launch from low earth orbit and employed 1500 MWt Nerva and a 4,100 MWt Phoebus engines. All vehicle stages were expendable. To minimize risk to the astronauts we assumed a convoy of two vehicles assembled in low earth orbit rather than joining vehicle elements on the way to or at Mars. The Mars mission round trip travel time was 420 days (180 days earth to Mars, 30 day stay at Mars, and 210 days return to earth). A Crew vehicle (Crew of 8) and a cargo vehicle, each vehicle weighed 2 million pounds. At this weight a launcher much larger than the Saturn V would be required, which kicked-off the NOVA studies at MSFC. A major contributor to the weight was the requirement of an initial vehicle thrust to weight of 0.2 to minimize earth departure gravity losses. (I have retained copies of these1960’s era reports that include vehicle, crew quarters, and life support mass properties.)

In around 1988 (early in the ALS/NLS effort) I published a paper updating my 1960’s work. At that time we knew more about the Mars atmosphere and could apply an aero brake for capture in Mars orbit. Reducing the crew size to 4, and use of an aero brake caused each Mars vehicle weight to drop to 1.1 million pounds (a total of 2.2 million pounds for both vehicles). This data set the requirement for the largest ALS/NLS concepts, which were smaller than the NOVA systems concepts of the 1960’s. I have a complete copy of the GD ALS/NLS SDR and access to most of the people that worked for me on that program.

I recently supported Advatech Pacific Inc. for a contracted study with a government agency for the use of nuclear electric propulsion in space. With the help of NASA Glen, we were able to define a few break-through ideas that reduced weight and risks of a nuclear electric propulsion system. On my own, I then applied the knowledge learned in these studies to define a potential lower weight, lower thermal power, and reusable nuclear electric propulsion system for a human Mars mission.

With an earth orbit and lunar infrastructure established, we could launch a human-Mars vehicle from lunar altitude, rather than low Earth orbit. A low Earth orbit altitude launch requires a vehicle with an ignition thrust to weight of 0.2, verses 0.02 (or less) for a lunar altitude launch, a 10 to 1 reduction. The latter would also reduce the earth departure velocity by about 10,500 ft/sec. Now, we can use low thrust nuclear electric propulsion, to reduce the travel time to and from Mars. For example, a version of the Chang-Diaz’s VASIMR engine, applied to the above mission concept, could reduce the travel time from earth to Mars to as little as about 39 days (Aerospace America, July- August 2009 issue, page 38). The Mars orbit-to-surface infrastructure could be patterned after that of the lunar system with a much lower delta-velocity requirement, hence smaller, lighter vehicles.

A lunar-altitude departure to Mars with nuclear electric propulsion could yield:

1. A vehicle weight potentially 1/3 of that launched from a low Earth orbit
2. A 50 to 200 MWt system (100 to 40 day transfer) verses multiple (3 or 4) Nerva derivative (1500MWt to 4000 MWt each at 180 to 210 day transfer) expendable systems
3. A space nuclear propulsion system launched many miles from Earth
4. Reusable vehicles verses expendable vehicles
5. Much smaller Earth to orbit launch vehicles like Ares V family
6. 40 to 100 day potential transfer times Earth to Mars and return
7. Produce propellants, oxygen, and other materials on the moon
8. Lower cost and lower risk for the Human Mars mission after a lunar program.

Recently, working with Advatech Pacific Inc. under contract with AFRL/Edwards we have enhanced the industry leading tools I have been developing over my career. I developed the first working software in 1966 to find viable applications for Atlas and Centaur. I slowly evolved it to also determine the cost effectiveness and risk of introducing new technologies as well as defining system operations. So, in 1985 we were ready to take on the Space Transportation Architecture Study challenge. The tools are now bound in an integrated optimizing architecture, with up to date databases to support their calculations and simultaneously optimize performance, operations, cost and risk. They are user friendly and perform tasks in minutes instead of weeks and months. These tools emulate those applied in the definition and evaluation of the 615 architectures in the early NLS studies.

In summary I believe that NASA (perhaps in cooperation with its international partners) should embark on an architecture study similar to that conducted in 1985 for the NLS program, funding multiple contractors for 6 to 9 months. A Space Plan for a 30 year timeframe must satisfy every sensitivity and be flexile enough to absorb future changes. With the proper tools, people and processes, our nations engineers can define a viable and affordable Space Plan to meet the Space Exploration challenge.

William C. Strobl
Tel. 760-942-2038
Email wcstrobl@roadrunner.com