Human Space Flight
A New Direction

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Abstract

The NASA Constellation program to the Moon and Mars, consisting of the Ares I and Ares V launch vehicles, Orion spacecraft and Altair lunar lander, has been demonstrated to be ill conceived, technically immature and financially unaffordable, and a full review has been commissioned by the Obama administration, to be headed by Norm Augustine, in order to perform a 90 day study to examine these issues relating to human space flight.

The author has predicted since this program's inception that these issues would render this project intractable, and thus immediately upon the announcement of the Constellation project, embarked upon a two year study of the issues of low earth orbit transportation,[1] publishing the results of this study as a COTS proposal in November of 2007. That COTS proposal outlined a very clear path forward, where the major elements of the Ares I upper stage technology and space shuttle main engine infrastructure and their associated jobs could be salvaged to produce a viable reusable launch vehicle demonstration program, using existing space shuttle and space station assets, in a very short period of time, and at minimal costs. This orbital launch vehicle development and test flight program would be complementary to the presumed alternative commercial space transportation systems that currently exist in the form of two separate evolved expendable launch vehicles (EELVs), and two separate commercial orbital space transportation systems (COTS) which are also currently under development and are fully expected to be applied to this critical problem.

The purpose of this paper is to reiterate the results of the previous study, in a form more easily understandable for the Augustine committee, in order to facilitate a timely decision so that a rational, affordable and sustainable program of human space flight may proceed.

List of Acronyms

IPO – Industry Proposal Outline

USA – United States of America
NASA – National Aeronautics and Space Administration

JSC – Johnson Space Center
KSC – Kennedy Space Center
SLC – Space Launch Complex

STS – Space Transportation System – Space Shuttle
ISS – International Space Station

USA – United Space Alliance
ULA – United Launch Alliance

COTS – Commercial Orbital Transportation System
COSTS – Commercial Orbital Space Transportation System

ELV – Expendable Launch Vehicle
TSTO – Two Stage To Orbit
EELV – Evolved Expendable Launch Vehicle

SSME – Space Shuttle Main Engine
SSTO – Single Stage To Orbit
RLV – Reusable Launch Vehicle

LEO – Low Earth Orbit
OMS - Orbital Maneuvering System
CELLS - Closed Environmental Living and Life Support
ISRU – In-Situ Resource Utilization

VSE – Vision For Space Exploration
ESAS – Exploration Systems Architecture Study

SRB – Solid Rocket Booster
LRB – Liquid Reusable Booster

Current United States Commercial Launch Vehicles

Atlas – The Atlas V Family of Launch Vehicles – United Launch Alliance
Delta – The Delta IV Family of Launch Vehicles – United Launch Alliance
Falcon – The Falcon 9 Family of Launch Vehicles – SpaceX Corporation
Taurus – The Taurus II Family of Launch Vehicles – Orbital Sciences Corporation
DeltaV – The proposed SSME powered reusable launch vehicle demonstration program.

The Unaffordability of Shuttle Derived Heavy Lift Launch Vehicles

My ideal uber monster Frankenstein launch vehicle would be a ten meter lightweight and foam free hydrogen tank, powered by seven space shuttle main engines, augmented with a pair of five segment solid rocket boosters (SRBs), the core flying single stage to orbit (SSTO), with the repressurized tank scavenged for residual fuel and available for retrofit into large Star Trek type interplanetary spacecraft laboratories containing vast hydroponic grow room technologies for sustainable space flight to the far reaches of the solar system. The space shuttle main engines (SSMEs) would simply be removed from the vehicle tail by well equipped and highly skilled space walking station astronauts, placed in a suitable reentry vehicle, and shipped back to the surface of the ocean for refurbishment and reuse.

Fortunately, this dream spaceship is indeed physically possible with the technology and components we have in our possession today, but the costs and timeframes of this large vehicle are such that it would not be available until 2020 and would cost tens of billions of dollars to develop unless a serious effort was begun right now on a much smaller scale.

This same reasoning applies to any other expendable shuttle SRB derivatives - Direct, Shuttle C designs and the Ares V in their wide variety of continually redesigned forms. Expendable shuttle derived SRB powered heavy lift launch vehicles are neither timely nor affordable enough to seriously consider, unless they are flown in a manner producing the greatest possible human space flight value, in the form of the significant advances in reusability, reentry or retrofit experience which dramatically advances the state of the art.

Thus I have recommended that before embarking upon such a large special purpose reusable heavy lift launch vehicle, that the technology first be developed on a smaller scale and in a manner which can directly benefit evolved expendable launch vehicles (EELVs), including both commercial orbital transportation systems (COTS) vehicles. This requires that existing five meter Ares I upper stage core technology be utilized, powered by a single space shuttle main engine, and augmented with reusable liquid fueled boosters instead of expensive and dangerous segmented solid rocket boosters. The necessary roll control would be provided by pairs of hydrogen fueled orbital maneuvering system (OMS) engines using the residual fuel scavenged from the SSTO main core stage.

This simple compromise allows such a reusable test flight demonstration program to be fielded in a much shorter period of time, at greatly reduced costs, with the value of such a program derived from its applicability to EELV and COTS evolution, as well as Ares V.

Therefore the goal I have set is much more modest – to salvage the dozen or so remaining space shuttle main engines (SSMEs) for use in a developmental test flight program, the purpose of which is to develop the necessary technologies to make the interplanetary spacecraft of the future a reality in the shortest period of time, with the greatest value to our existing launch vehicle infrastructure, including programs, vehicles and employment.

My dream vehicle of 2012 is a redesigned Ares I upper stage as ground started core stage, powered by a single SSME, augmented by reusable liquid hydrocarbon boosters (LRBs).

The Unsustainability of Expendable Launch Vehicles

Constellation is the problem at hand on the table for the Augustine Review Committee. I have outlined a method to salvage the booster by specifying a generalized architecture for future dual fuel, liquid propulsion, reusable space flight, using hydrogen core stages flying single stage to orbit, and reusable or recoverable hydrocarbon boosters. One can now begin to consider the existing fleet of our industry and commercial launch vehicles. Considering that any second generation reusable launch vehicle will take some time to develop even with the immediate availability of existing stages and STS / space shuttle main engines, and these same industry and commercial launch vehicle manufacturers and operators are also expected to be the participating contractors for this follow on vehicle, then immediate application of American commercial launch vehicles is clearly indicated.

One can begin immediately testing the concept of the recovery of space rated stages with the upper stages of commercial EELV and COTS vehicles, via the fact that every launch to low Earth orbit (LEO) necessarily delivers an upper stage to your destination, complete with residual fuel and a fully space rated restartable liquid fueled engine. In-situ resource utilization (ISRU) advocates take note, the hardware required for deep space travel is already provided fully mined, refined, fabricated and assembled, and thus immediately available for use, within your existing commercial orbital space transportation system.

The quicker our existing industry and commercial launch vehicle providers can be applied to the problem of human space flight, the sooner NASA can begin to assist those companies in the reusability and second generation propulsion upgrades which will be necessary for evolving expendable launch vehicles to return to a path of decreasing costs. Also in the future at the appropriate time, the general architecture will be able to scale into the heavy payload capacities that may be required in the area of human space flight.

Many outstanding issues of conventional modern rocket science remain yet to be solved. Materials sciences must be applied to the creative second generation anti-icing, deicing and ground insulation systems required to reduce boiloff rates and core stage atmospheric heating, also doubling as the space rated thermal, micrometeorite and debris protection. Repressurization systems capable of withstanding the higher acceleration profiles of the hydrogen SSTO core stages are required, which can function in association with the fuel settling, scavenging and orbital retrofit operations necessary to recover the large amounts of orbital payload mass, which will ultimately be incorporated via orbital assembly into large commercial and equatorial space ports, interplanetary vehicles and observatories.[2]

This strategic plan thus lain out, one should mention other areas of critical investment. There are competing architectures for future human space flight – horizontal multistage flying wings and rocket planes, among others, which in the immediate future promise a fertile environment for rigorous and routine experimental and commercial space flight, and which ultimately are expected to attain capabilities of delivering humans and light cargo to low Earth orbit. These developments, immature at present, are ultimately seen as complementary to routine liquid fueled, vertically launched heavy cargo delivery, and thus it is crucial that strategic long term investment in these concepts proceed swiftly.

The Misconception of the Moon and Mars as Immediate Destinations

Space flight is exceedingly dangerous, and unless a robust pyramidal framework of rescue infrastructure is emplaced beforehand, the chances of crew rescue in a catastrophic failure from even the moon is quite honestly negligible. The United States does not even possess the most rudimentary indigenous crew rescue capabilities for the International Space Station (ISS). Thus it is clear that we are woefully unprepared for the rigors set forth by the Vision for Space Exploration (VSE), and it appears our immediate problem is ISS crew and cargo, with particular regard to space station crew delivery and rescue.

In my previous proposal I set forth a promising method of crew rescue and cargo return which can be immediately implemented on existing EELVs and COTS vehicles, and built into any second generation reusable vehicle – the nosecone aeroshield reentry vehicle. The general premise is that the nosecone aeroshield of a conventional launch vehicle is of the aerodynamic shape necessary for unguided ballistic reentry and open ocean flotation, can be carried along with its enclosed payload or capsule on every low Earth orbit cargo flight, and most likely could be easily reused. The minimal orbital maneuvering control could be unidirectional and redundant, and the rendezvous and docking could be handled at the space station by robotic arm. In this scenario the space station itself functions as the manned orbital shuttle, with the cargo nosecones handling all the rescue and cargo return. This frees up presumed lightweight conventional lifeboat capsules that will then be flown across the entire spectrum of EELVs and COTS vehicles whether they be reusable or not.

For every $10 billion dollar luxury space plane, and every ten - $1 billion dollar luxury capsules visiting a $100 billion dollar luxury space hotel, you'll want ten – $100 million dollar human rated reentry lifeboats and a hundred - $10 million dollar minimal cargo return nosecones, which can then double as crew escape vehicles and lifeboat capsules.

With the combination of existing infrastructure, international partners and participants, multiple international, industry and commercial launch vehicles, and with the robust and sustainable NASA funded second generation EELV and COTS propulsion developments manifesting itself as a reusable test flight program with the goal of orbital stage recovery, retrofit and reusability, and space station construction with cargo return and crew rescue capabilities, humanity will thus have truly become the first space faring species on Earth.

It thus falls to humanity to work together in space in order to secure and protect the Earth. Only then should we contemplate our goals and destinations in our thus assured presence. Multiple destinations immediately present themselves - easily accessible with abundant hardware associated with upper and core stages of modern liquid fueled launch vehicles, yet do not involve the risky and expensive development of landing humans on surfaces of planets and moons within deep gravity wells, with little to offer in the way of resources. All of these destinations require development of the capabilities of pyramidal rescue for multiyear unsupplied sustainable space flight with closed ecological life support systems. All these methods and techniques may be safely developed and tested in low Earth orbit with the International Space Station and launch vehicles that we already have in place, and with the second generation reusable launch vehicle development we can now afford.

The Immediate Goal of U.S. Human Space Flight Planning

The immediate goal of the Augustine review committee on human space flight is to assess the best means by which humanity, by actions of the United States government, can become a full participatory space faring civilization, within our budget constraints.

Clearly innovative and creative methods must be applied in order to meet the budgetary and financial restrictions thus imposed, and I have outlined some very clear methods by which order of magnitude improvements in human and cargo space flight productivity and efficiency may be achieved, using workforce we currently employ, and infrastructure we currently possess, with extensive industry utilization using existent commercial assets.

I have indicated how the sunk costs and assets of the current Constellation program may be recovered, retained and applied to a much more affordable and sustainable approach to human space flight and space station utilization, which is directly relevant and applicable to all future human aspirations and destinations in deep space, whenever they may occur.

I have described some critical areas of basic research in rocket science which must be performed in order to preengineer and space rate large insulated and thermally protected cryogenic core fuel tanks, manage excessive boil off and tank frictional heating, enabling adaptive collection, recirculation and repressurization of the boiloff products during the rapidly increasing acceleration profiles encountered in high performance space flight, such that launch vehicle mass may be recovered and reused as basic space infrastructure.

These fundamental problems of rocket science are now self evident because of rapidly escalating and proliferating collisional orbital debris distributions of expendable stages, and are a necessary prerequisite for order of magnitude decreases in future launch costs. Many of these problems must be solved at the university level by material scientists not easily accessible to those traditional aerospace industry and commercial launch vehicle manufacturers and operators who will directly benefit from these advances in techniques, an endeavor for which our primary national scientific funding agencies are well suited.

Given the severe economic, social and financial problems now faced by the people of all nations on this planet, the imperative of civilization as a collective space faring society has never been clearer, and the necessary conditions for achieving that goal are upon us. Any new direction in human space flight must embrace affordability and sustainability by design, for durability, recovery, retrofit and reusability, as demanded by economic reality.

References

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