

Time to Re-think Space Access?

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Abstract

Construction of space vehicles on the surface of the Earth is inhibiting the development of spacecraft and therefore the overall exploration of space.

No one in their right mind would dream of constructing an Aircraft Carrier in the middle of Oklahoma or Kansas and then transporting it to the ocean. The whole idea is illogical and preposterous. Why then do we construct spacecraft on the surface and transport them to orbit before their mission can begin?

This paper will explore the reasons behind the current philosophy and examine the limitations placed on spacecraft design and operation as a result.

Finally, a new regime will be posited, along with an examination of the implications of these proposed changes.

Introduction

The picture conjoured up in the abstract may seem a little ridiculous but it seems to be how we are in fact building spacecraft. Spacecraft built this way are highly constrained in both linear dimensions and mass. Linear dimensions are dictated by the size and shape of the Fairing or in the case of the Space Shuttle by the dimensions of the Shuttle Payload Bay. Launch Vehicle capability effectively limits the mass that may be launched. Table 1 illustrates the mass capabilities of the “big hitter” Launch Vehicles worldwide.

Vehicle	Maximum Payload Mass to LEO (Kg)
Atlas V	20,520
Delta IV H	22,560
Space Shuttle	24,900
Ariane V ECA	17,250
Proton M	21,000
Proton K	19,760

In addition to these limiting factors on spacecraft size there exists a design overhead to make it possible for the payload to survive the launch experience! Launch vehicles also typically present shock and vibration environments to the payloads that have to be considered during the design phase. A typical launch phase consists of about ten minutes of Launch Vehicle thrust and maybe a later boost thrust to the desired trajectory. Therefore, for a spacecraft that is expected to have an operational life of several months to years we are actually spending a lot of money just to allow it to survive for the ten minutes or so it takes to achieve orbit. Back in the early days of spaceflight this was the only way to go but surely we have advanced somewhat since then!

The classic example of a spacecraft inhibited by its launch vehicle is the International Space Station. A large and

complex task made much more difficult by having to assemble the station from a relatively high number of individually complex assemblies requiring many more interfaces than is strictly necessary if assembled in a different manner.

Designing a spacecraft to meet these diverse requirements and to meet the original mission specifications drives up the complexity and cost significantly. It also reduces the overall reliability of the system. If spacecraft development could be decoupled from the requirements of the launch vehicle how would this affect the spacecraft?

Benefits of not Designing for the Launch Vehicle

If spacecraft were to be designed for the mission and did not have to survive launch shock and all the associated hazards introduced by the Launch vehicle then how would the design change?

- Mechanical complexity could be reduced – no longer have to fold antennae or solar panels etc.
- Spacecraft could grow dimensionally and accommodate somewhat larger equipment.

- Mass constraints could be relaxed, and total mass need not be constrained by the launch vehicle.
- Spacecraft will be designed for the loads they will see in space.
- Reduction in complexity should result in higher reliability.

On the other side of the coin, there will probably be a need for larger boost motors to move spacecraft to their destinations and there will probably be a need for more power. Mass properties will change somewhat too.

The net result of such changes will be that only planetary Landers and manned vehicles needing to exit or enter atmospheres will need to be constrained by their respective planetary environments.

The Way Forward

The only reasonable way to accomplish this is by moving the Assembly, Integration and Test (AIT) process into space and having the piece parts delivered appropriately packaged to survive the launch environment.

Typically, such individual component items securely packaged can survive hostile environments more easily than fully assembled spacecraft can.

In order to perform this activity in space we will need to have a functional Space Base or Station. This base will be large enough to handle several large spacecraft at the same time and will have the personnel necessary to perform all aspects of Base Operations and the AIT activity. Accomplishing this will be a major feat in its own right but it will also drive the technologies necessary for long-term human activity in space.

However, there is one aspect of the launch vehicle that needs to be addressed; to wit, the reduction in complexity of the vehicle that can be achieved since it can now be tailored to one particular mission – delivering cargo to the Base. This means that economies of scale may be found in the operation of the launch vehicle. Cargo processing will be simplified because the issue will come down to overall mass and linear dimensions. In addition to these benefits, it will also be possible to realize a relatively intangible benefit in that the cargo carriers and possibly the

entire upper stage and fairings may be stored and recycled in space.

Discussion

To realize this project will call for the establishment of an infrastructure in space that will need a reliable and relatively cheap method of rotating personnel in and out. Much progress has been, and is being made in this area. Sometime in the next few years we are going to see a reusable manned vehicle specifically optimized for manned flight and probably capable of accommodating 10 to 12 people for the ride to orbit and return to Earth.

Economics are probably going to drive this idea – can it ever be cheaper to assemble spacecraft in orbit than on the surface of the Earth? Much of this will depend on the requirements for the spacecraft mission and the capabilities of the launch vehicles. It is probably safe to assume that launch vehicles are not going to get much larger unless there is a definite need. The tendency for the last few years has been for payloads to get more sophisticated as sensors and electronics get smaller. For a given price we try and jam everything we can into the spacecraft simply because it is so expensive. As we push

further out into space and on to the Moon and Mars we are going to need spacecraft that are significantly larger than those we have now. They will almost certainly be assembled in space prior to leaving earth orbit. Large launch vehicles will only be developed when payloads emerge that cannot be accommodated on the current crop of launch vehicles. The development of true Heavy Lift Vehicles will occur at the time the complexity of spacecraft systems assembled from multiple complex components severely impacts the reliability of the overall system.

Space Frontier Operations, Inc. (SFO) has been working on the problems of heavy lift and personnel transfer vehicles for several years and now has designs for a true heavy Lift vehicle as well as a manned vehicle.

Hopefully the development of these vehicles will be driven by commercial rather than government requirements.

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