Launch LLC

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The Tsiolkovsky Group is a private academic study group, initiated in 2005 for the sole purpose of directing the discussion, analysis and study of the low Earth orbit propulsion, launch and life support systems needed to enable the future development, exploration and colonization of space. The group has been meeting informally, weekly and monthly, in order to update and integrate the individual study efforts, and to coordinate group efforts, further enabling the scientific, technical and engineering development of rational, affordable and sustainable launch vehicle architectures.

The initial formation of this study group was in response to the announcement of Constellation, but the organization can trace its roots back to 1985 and the University of Wisconsin at Madison. For a few years in the early 1980s, tentative space shuttle and space commercialization efforts briefly flourished under a set of faulty low Earth orbit launcher cost, flight rate and lift capability assumptions, which were becoming apparent shortly before the Challenger disaster in early 1986.

Remaining illusions of inexpensive and readily available low Earth orbit space transportation evaporated on January 28, 1986, and the concept of innovative launch vehicle architectures and space development and exploration scenarios became the focus of intense and perpetual debate, deviating remarkably from the initial 1970s concepts of O'Neill colonies with reusable launch vehicles and space planes, and focusing almost exclusively on near term off the shelf solutions.

After several decades of research, development and discussion of low Earth orbit launcher and propulsion architectures, the announcement of the Constellation program in September of 2005 promised another additional five year setback for a rational national space transportation policy. This forced a systematic review of the past progress within the study group, and the initiation of more narrowly focused research efforts, again based upon the faulty assumptions of the necessity and possibility of a Constellation program salvage. Work continued for two full years, a year of which involved the unique scenario testing abilities of the 2006 Orbiter Space Flight Simulator. Publication of the study results and its guidance followed in the form of contract and research proposals and scientific research and positions papers for the emerging commercial space sector.

Launch LLC intends to move this guidance directly to the federal contract level, with appropriate monetary compensation at levels commensurate with the sum of their value, and the expenses incurred by their delivery. An arbitrary assessment of $500,000 for a five year period works out to $50,000 per person, for the six month period of the proposed heavy lift trade studies, a level of employee compensation in aerospace studies and engineering that is below current industry rates. Graphic design, programming, managerial and administrative positions are assessed at $25,000. I leave calculation of the value of previously published guidance as an exercise for the investors. A directory of these publications may be found at URL : http://webpages.charter.net/tsiolkovsky/.

Executive Summary - The Genie is Out of the Bottle

With the first flight of the SpaceX Falcon 9 launch vehicle, the genie is clearly out of the bottle with respect to less costly and more routine low Earth orbit space flight - based upon confident engineering design, development, production and operational foundations, and financial security. The question now is what can be learned from watching the birth, development and evolution of successful space launch companies from afar, and how can those lessons be applied in moving forward with a new and more modern heavy lift launch vehicle and space exploration program.

Previous heavy launch vehicle trade studies, optimizing use of existing programmatic hardware and development projects, have already produced a minimally optimized solution of a five meter single SSME powered, ground started, single stage to orbit capable core stage, booster assisted with a pair of parallel (side mounted) hydrocarbon booster stages, any number of which exist. This EELV and Ares upper stage hybrid '**Delta V**' design satisfies congressional insistence on shuttle derived, since it uses SSMEs, and the modern space advocate's insistence on reusability, with a minimum of manned and unmanned beyond Earth orbit space exploration capabilities.

Now is the time to repeat these trade studies in the substantially reduced developmental and operational trade space necessitated by the accelerated time frames and reduced budgets now envisioned for this proposed heavy lift effort. In order to facilitate useful trade studies, without duplicating previous efforts, I have drawn up a preliminary description of a spectrum of LEO launch mass classifications,[1] so that the target architecture may be optimized for size scaling by selecting market niches in the center of the mass sequence unrepresentative of current products. This yields generalized booster staging and recovery mechanisms which may be scaled up into large heavy launch vehicles, and scaled down into minimum launchers capable of reaching orbit.

Successfully competing in today's emerging launch vehicle design and development market essentially reduces to challenging the Falcon 1e, the Taurus II, the Soyuz and the Falcon 9. In order to reduce the costs and complexity of meeting this challenge, one good approach is to attempt to enhance the product spread, rather than duplicating and out competing the products. The top level discrete decision tree of the design hierarchy in this ideal case is extremely sparse, yielding the solution of a three meter, medium light class hydrocarbon launch vehicle core stage, powered by a single NK-33, both singly and clustered three abreast, and finally with seven core stages lofting a single NK-43 upper stage, yielding the anticipated heavy lift launch capabilities. Remarkably, a cluster capable hydrocarbon booster can also directly support the hydrogen core stage previously proposed, with or without exploration capable J-2X upper stage enhancements.

Release of a new administration space policy, stressing international cooperation and diplomacy through global technological infrastructure development and economic trade, justifies this result, and it is the goal of this contract proposal to demonstrate the veracity of this definitive example. This simple design iteration is referred to as the **Orbital Standard Core,** and is contingent upon cooperative hydrocarbon engine coproduction agreements, with proactive Russian collaboration. Orbital Sciences Corporation and Aerojet GenCorp are in ideal positions for these developments. New core stage development, manufacturing and transportation processes and efficiencies allow small and modest core stages to be mass produced by domestic concerns closer to the launch site, significantly improving logistical and scheduling requirements for heavy lift launcher operations.

Concurrent Hydrocarbon Engine Production

We now have two standard stages, a hydrogen core stage and a hydrocarbon booster stage, which can be assembled into a variety of launch vehicle configurations that inhabit several unoccupied niches in the launch vehicle mass classification spectrum. They also respectively use the most advanced and efficient engines in their classes, the space shuttle main engine and the Russian NK-33. When used together they are easily capable of reaching low Earth orbit without the use of upper stages, and also capable of supporting two different fuels in their optional upper stages, kerosene in the case of the NK-43 and hydrogen in the case of the J-2X or other existing engines.

In passing, I note that both the NK-33/43 and the J-2 were developed at great cost and sacrifice for the Russian and American lunar exploration programs, flying in vehicles that were designed without the benefit and availability of modern design tools and practices, without the subsequent decades of space flight experience that has accumulated while pursuing low Earth orbit activities.

Clearly the next order of business is the active testing of these engines, and the accumulation of flight test data, in order to demonstrate the reliability and veracity of their design. Already the large inventory of existing engines, domestically at Aerojet and warehoused in Samara, Russia, greatly advances the cost and schedule for these operations. Orbital Sciences Taurus II puts flight testing of these engines as early as next year, and test firing of the engines has already occurred.

Release of a new national space policy now justifies expanding the scope of these collaborative Russian - American engine reverse engineering goals, and the preservation and enhancement of their metallurgical understanding, their manufacturing capabilities and industrial bases, and the active pursuit of cooperative coproduction agreements that would allow for a eventual reengining of an existing launch vehicle (Soyuz), and active pursuit of new second generation closed cycle hydrocarbon engine and launch vehicle designs, in both Russia and the United States of America. These sorts of cross cultural advanced science and technology programs are precisely the type of activities that support and promote the ideals of human space exploration and development, and it is remarkable these activities are already taking place in the emerging commercial space sector.

Inline and Parallel Sidemount Booster Staging

The proposed standard booster study item consists of a cluster capable, hydrocarbon powered core stage with 335,000 lbf sea level thrust (1500 kN), and a lift off weight of @ 300,000 lbs., midway between the lift capabilities of the Falcon 1e, and the Taurus II which uses twin engines. Such a stage is capable of flying individually with a small capsule and an integrated upper stage. For heavier lift capabilities and deep space exploration applications, such a stage may be paired with the previously proposed five meter SSME powered study unit, as a minimal dual fuel heavy lift launch vehicle. Such a stage does not require any upper stage to reach low Earth orbit, but when paired with an inline upper stage, it is quite capable of ambitious deep space exploration missions, while simultaneously supporting a variety of LEO development, support and resupply activities. The ability to test the booster stages independently from the larger and more complex core stage, within the framework of operational low Earth orbit missions, reduces their overall developmental challenges and costs. The capability to test three abreast stage clustering with a small, lightweight and relatively inexpensive booster stage permits sequential risk retirement.

Parallel and Circular Stage Clustering

The proposed study item may also be parallel clustered three abreast with an NK-43 upper stage, as an EELV equivalent. Extrapolating to much larger launch vehicles, such a stage may also be clustered into a circular arrangement, as a group of seven core stages, with either an NK-43 powered upper stage, or an exploration capable J-2X powered stage, for heavy lift capabilities. The ability to start the development and testing of a single stage within operational situations, greatly reduces cost, schedule and risks of the more ambitious heavy lift stage cluster derivatives.

Highway Stage Transportation

With a booster stage diameter of three meters or less this booster stage is trivially road worthy, with commonly available diesel semi tractor highway transportation, using specialized trailers and methods commonly practiced for transporting wind generator tower segments and blades. This technique alone will substantially reduce overall launcher production and operations costs, especially if vehicles could be launched from dry land with the booster stages fully recoverable.

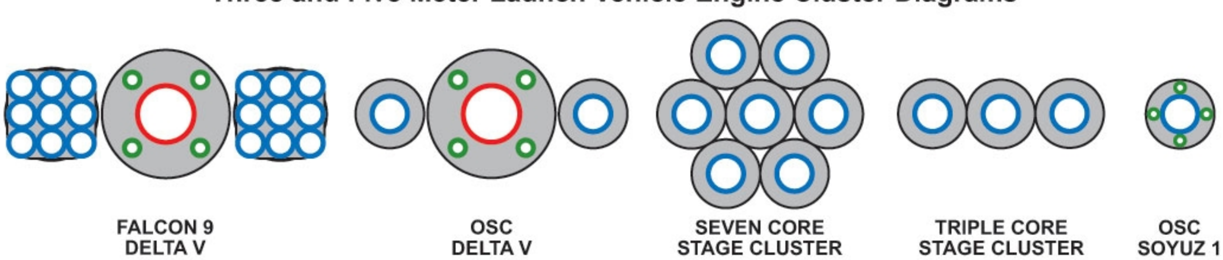
Flyback Booster Recovery

Clean sheet booster design and fabrication processes allow for a booster with critical clustering attachments predesigned and validated for future scaling of the booster into heavier lift designs. Standard booster recovery techniques may be implemented at the single booster level, to reduce development costs within the flight regimes of operational revenue producing orbital missions.

Final Conclusions

We have already eliminated a wide swath of stage configuration phase space from our studies as a result of irreconcilable budget constraints. Through designing for modular stage clustering, we have identified a variety of mass launch capabilities across an entire spectrum of vehicles, that are not in competition with any existing DOD EELV and NASA COTS and CRS commitments. Two prototypical standardized core and booster stages have now been presented, which represent a minimum viable study set for the design, development, test and evaluation (DDT&E) analysis. '**Orbital Standard Cores**' consist of cluster capable five meter core stages, powered by a single space shuttle main engine, and three meter booster stages, powered by a single Aerojet AJ26-58.

Three and Five Meter Launch Vehicle Engine Cluster Diagrams



References

1. The British Scale For Launch Vehicle Mass Classification
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