NASA Solicitation JSC-CCDev-1

Commercial Crew Development

Thomas Lee Elifritz
Madison, Wisconsin

September 22, 2009

Research and Development Proposal

Synopsis - August 4, 2009
Announcement - August 10, 2009
Proposals Due - September 22, 2009
Space Act Agreements - November 2009
Recovery Act Conclusion- September 30, 2010

Synopsis

NASA's Commercial Crew and Cargo Program is applying Recovery Act funds to stimulate efforts within the private sector to develop and demonstrate human spaceflight capabilities. These efforts are intended to foster entrepreneurial activity leading to job growth in engineering, analysis, design, and research, and to economic growth as capabilities for new markets are created. By developing commercial crew service providers, NASA may be able to reduce the gap in U.S. human spaceflight capability. All ARRA funded activities must comply with its provisions and will conclude no later than September 30, 2010.

The program intends to solicit proposals from all interested U.S. industry participants to mature the design and development of commercial crew spaceflight concepts and associated enabling technologies and capabilities. NASA plans to use its Space Act authority to invest up to $50 million dollars in multiple competitively awarded, funded agreements. This activity is referred to as Commercial Crew Development, or CCDev.

NASA Commercial Crew Development Portal : http://procurement.jsc.nasa.gov/ccdev/

This document : http://webpages.charter.net/tsiolkovsky/Commercial_Crew.pdf

Reference documents : http://webpages.charter.net/tsiolkovsky/

Table of Contents

Executive Summary

Proposals shall include an executive summary describing the prominent and distinguishing features of commercial crew capability maturation plan and company information for the proposed CCDev effort. The summary should confirm eligibility as specified in section 4.2. The executive summary shall stand alone and not directly reference the other sections of the proposal.

The Perfect Storm

America is just not serious about life, earth, space, nature and the sciences. Thirty years of neglect of the sciences has yielded a generation of citizenry ill prepared for the future, while fully engaged in a sociological framework of behavior destructive of that future. Globalization has now propagated these behavioral deficiencies into a worldwide pattern of resource extraction, environmental degradation, deforestation and overpopulation. With seven billion humans on the planet, soon to be nine billion, only the space sciences provides the uniting background of physical reality capable of providing unified solutions to now inarguable social, economic and technological problems facing future generations. Only the space sciences can necessitate and demand excellence of complete cooperation between nations and the individuals, organizations, corporations and governances within, and to encourage the enthusiasm and good will necessary to address critical global issues. America needs to be world leader in recognizing and confronting this difficult situation.

The Acrimonious Debate

For those aware and cognizant of the coming storm, there is no need for more debate. But for those unaware or willingly ignorant of the prospect of an economic and social disaster of this magnitude, the suddenness of the recognition of the nearly irreversible collision of civilization with physical reality, and the sheer magnitude of the failures at every level, has divided the nation and polarized the political discussion. The fact that the solutions to these problems are of a highly technical nature requiring a profound acknowledgement of science further increases a gap of understanding that exists in American culture today.

The Inevitable Result

The results of science denial are easily predictable. Any organization, culture, society, nation or governance that denies science will not survive. The symptoms of the decline and decay which leads to the inevitable bankruptcy and extinction are unusually clear and unmistakable, revealing themselves in every aspect of life, business and administration. Without an institutionally mandated foundation of scientific principles, education begins to deteriorate, research becomes more difficult, problems are not solved, solutions are not developed, economies recede, and as a result, the environment and human health suffer. This has left American society in a position of a health care crisis, energy dependency, climatic instability and financial insolvency with severe national educational deficiencies and a very limited amount of time to research, analyze, develop and implement credible strategies to diagnose, reverse, remediate and solve these outstanding national problems.

The Future

The disregard and neglect of science in America, particularly space sciences as driver of critical scientific and engineering analysis, has risen to level of national security problem. We have rendered ourselves unable to rationally respond to urgent national imperatives due to the lack of critical thinking and reasoning skills of our leaders and representatives, and the unwillingness of our citizens to recognize and acknowledge very clear problems.

If the trends of science denial in the United States of America continue to persist into the coming decades, we face, in order: financial collapse, economic ruin, energy and resource scarcity, a quickly warming and deteriorating climate, increasingly hostile environments and a complete breakdown of social order when our educational system finally collapses. Our workforce and its citizens and the representatives they elect will simply not have the intellectual and technological resources necessary to recognize, acknowledge and solve the complex interrelated scientific problems that unconstrained human behaviors imply.

The immediate cessation of unhealthy behaviors and prompt adoption of the rational and empirical methods of proven mathematical, scientific and engineering modes of thought, is guaranteed to provide timely relief of the immediate symptoms of economic decline, and is eminently capable of providing necessary solutions leading to evolutionary change.

The planet Earth and the space of physical laws and evolutionary history surrounding us places the concepts of survival into the rigorous scientific and technological perspective that they deserve, and renders the problems associated with that reality into stark relief.

The Plan

The plan is to continue to work those problems, which have been around in their present basic form for as long as the space age. Human space flight defines those problems, and the extension of the international human space flight model to the surface of the planet Earth is the surest way to confront our serious economic, environmental, energy, health and education problems, directly addressing the national security dilemmas they create.

Moreover, the fundamental prerequisite for further progress in developing solutions for urgent national priorities and imperatives is the tacit acknowledgement of the sciences and scientific methods as the evolutionary and technological basis of our civilization, at the personal, organizational, local, regional, national, international and educational levels. Thus far average American citizens have been unable or unwilling to take that great leap. They misunderstand the complex nature of interdisciplinary scientific endeavors such as abstract and real scientific exploration and discovery, space travel, and the development and colonization of space, particularly low Earth orbit and the surface of the planet Earth.

Fortunately, there are individuals and organizations willing to make those leaps, and are willing to demonstrate and share that knowledge with anyone who cares to view it. The challenge then is to create attractive and visionary earth, life and space science venues, and then present them in affordable, understandable and convincing forms to the public.

Commercial Crew Capability Maturation Plan

The participant shall present its proposed plan through September 2010 to make significant progress on long lead capabilities, technologies, and commercial crew risk mitigation tasks that could ultimately be used on a commercial crew space transportation system.

Space Science and Technology – Program Management

The author of this recovery act stimulus funds proposal has a long and well documented history of working the problems of human space flight on the surface of the planet Earth. In order to justify the huge expenses of developing our low earth orbit test infrastructure, a clear relevance of orbital flight must be demonstrated as directly applicable to the stated national priorities of energy, environment, economy, education, health care and security. *We already know this to be the case*, but to those Americans who are unable or unwilling to make that connection because of deficiencies in their previous educational experiences, new evidence must be presented in an affordable, understandable and convincing manner. The immediate value and obvious benefits of space science and technology to civilization must be demonstrated and that task is well within the scope of this space act agreement.

Rockets - Science and Engineering

Within days of the Columbia disaster, the author and his collaborators developed a plan to human rate the Delta IV Medium launch vehicle for small capsule transport to the ISS. We assumed the Space Launch Initiative (SLI) propulsion efforts would be continued to the inevitable conclusions of indigenous Russian derived hydrocarbon engine production, channel wall nozzle production for the Space Shuttle Main Engines (SSME), and a new development of cryogenic second generation, Integrated Powerhead Demonstrator (IPD) derived, large, full flow, staged combustion engines, with modern hydrostatic bearings and deep throttling capabilities. Unfortunately, those developments never came to pass.

The situation dramatically deteriorated four years ago in late September of 2005, with the announcement of a blatantly intractable launch vehicle architecture - the Ares I and V. To minimize a loss of time and funds easily predicted by this approach to launch vehicle design, we became much more aggressive in our launcher design and analysis activities. This culminated in the submission of a JSC-COTS-2 proposal for an SSME derived, hydrocarbon booster assisted, stage and half and single stage to orbit (SSTO) launch vehicle architecture, which this author considered to be a definitive result for that time. This was originally intended to be a method of salvaging the Constellation program and was the smallest launch vehicle in our analytical phase space and operational trade space, which turns out to be larger than the largest launch vehicle in our inventory, short of the space shuttle itself. Remarkably, the failure of the CxP Constellation program suddenly presented the space shuttle system itself as the safest, most versatile and least expensive method of solving our space shuttle retirement problem, which is the paradox to solve, because safety and cost were the initial reasons for proposing its retirement to begin with. Thus we are left with an easily preventable loss of time and money, with very few results.

In the subsequent years a remarkable transformation has occurred in commercial space. While the Constellation program blundered to its inevitable critical review and demise, the commercial world was revolutionized by the arrival of the Falcon 1 launch vehicle, the anticipated arrival of the COTS award winner's Taurus II cargo resupply vehicle and the larger human rated Falcon 9 launch vehicle with a new seven person Dragon capsule.

Great advances have been achieved in the commercial suborbital and the private engine development markets, and the Augustine review committee has created a renaissance in commercial space flight concepts and thinking. We leave a critical review of that review to a later paper; suffice it to say that these CCDev proposals will be reviewed thoroughly and will form an integral part of the administration decision making process as their new space policy develops. One cannot overstate the impact of a one metric ton, two stage to orbit launch vehicle, available in 2010 for $10 million dollars, which can be delivered by conventional semi tractor trailer, and launched from nearly anywhere in the world where water recovery is effective, on a clear economic and technological path to reduced costs.

With extension of the manifested space shuttle flights through 2011, the space shuttle retirement problem is effectively solved, and the question now is, again – what next? Again we were caught unprepared for the further descoping of the scale of our launch vehicle size and funding limits, as our traditional phase space consisted of heavy lift. But we are still confident that a superficial examination of recent developments in the commercial space industry will reveal that many of the issues of small to medium class expendable launch vehicles, a class of systems formerly neglected by NASA, are quickly being resolved by their vendors, as these commercial crew proposals will clearly indicate.

We are also confident that contrary to the wishes and desires of the various Augustine committee members, funding levels necessary for any robust heavy lift launch vehicle development and deep space exploration architectures will not be forthcoming and the incremental operational and performance gains of existing launch vehicle architectures, from trusted commercial vendors, will more than adequately evolve into the heavy lift requirements remotely foreseeable in the near future, in a regime of decreasing costs.

Thus absent of any rapid development of mid range hydrogen pintle engines by SpaceX, we stand by our original COTS proposal as the most cost effective and timely manner for the Marshall Space Flight Center to fast track second generation recoverable and reusable heavy lift launch vehicle demonstration into reality, by leveraging existing commercial assets with a well funded technology development program and fixed price procurement. Just to refresh your memories this launch vehicle architecture consists of widely available hydrocarbon boosters assisting SSME powered reusable or recoverable five meter cores, and is contingent upon solving, in rapid order, many outstanding issues of rocket science.

This program of incremental performance and efficiency gains of existing commercial launch vehicles is well outside of the funding profile of this space act agreement award, and thus we will defer to simple purchases of commercial SpaceX Falcon 1e launcher missions in order to facilitate the testing of advanced concepts of core and upper stage recovery and retrofit, rendezvous and reentry profiles and space mission demonstrations.

Space Ports - Engineering Management

The establishment of the small vertical hydrocarbon launch vehicle market now makes our previous work in space port location and development especially relevant, since these vehicles only require a modest amount of open water for range and first stage recovery. Space based imagery has made identification and location of space ports relatively easy.

SLC46 - Cape Canaveral

Great Circle - Bahamas

Lake Michigan - USA

We already share the world's most capable space port - the International Space Station.

Earth Homes - Project Engineering

The International Space Station is not only a commercial space port, it is also a scientific laboratory, and a home for the workforce and research staff residing there. This can serve as a model for modern efficient homes, and the alternative energy systems of the future that must power them, the virtual communication systems of the future that will connect them, and transportation systems of the future that will supply them, if we ever intend to solve many urgent national economic and environmental problems in a rational manner. The value of the ISS primarily resides in the knowledge of thermodynamics and physics required in order to design, fabricate, assemble, launch and operate these facilities, and the experience acquired in the attempt to live and perform quality research aboard them. These skills are directly applicable to terrestrial reproduction of home laboratory analogs and the Earth and the ISS provide a synergistic testing loop for technology development necessary for the successful deployment of a modern equatorial commercial crew system.

The author's initial 1978 facility for commercial crew research and development activities.

Although it is difficult to accurately forecast and predict the direction and applicability of future space science and technology to terrestrial needs, it is worth reviewing NASA's original pre-1980 discussion on the subject, which this author considers most relevant to affordability and sustainability of commercial crew development over the long term and was used as the guiding principle during early tentative steps to implement this program, and then compare that to actual evolutionary developments over the subsequent decades.

From : NASA SP-387, *A Forecast of Space Technology, 1980 – 2000*; January, 1976.

> Study has concentrated primarily on the question of whether or not a completely closed ecological life support system could be maintained in a space environment for an indefinite period. As a matter of fact, the only experimental evidence we have on closed long-life ecological systems is the biosphere itself. In fact, no one has actually put together such a closed system and operated it for any extended period. One could visualize a somewhat heroic set of experiments in which various candidate systems were set up and sealed off, complete with their human populations, and then tested for equilibrium operation. The pacing element is basic biological knowledge itself, not the limitations of space technology. The results of such research would not only have benefit for space habitats, but also benefits on Earth. The knowledge of how to build more efficient farms is clearly valuable.

Energy Science and Technology - Program Development

Commensurate with the necessity of developing life habitats for humanity, are the energy fluxes and gradients necessary to operate them in both an affordable and sustainable manner. Obviously solar energy collection and concentration are the preferred methods of energy conversion on the Earth and in space. The surface of the planet also offers some additional modes, such as wind and hydroelectric power, on both very large and small scales. Another national imperative that is immediately relevant to condensed matter physics, is the program of the laboratory investigation of evolving knowledge in fundamental quantum phenomena, This certainly involves the construction of modern facilities; light sources and spectroscopy laboratories of every description. All require the education and training of scientists and engineers and the development of program and project engineering and management experiences for those individuals, thus exposing them to the broad base of knowledge available in the sciences. Human and unmanned space flight activities are a fundamental component of this endeavor, and the International Space Station and our near earth space represents the ideal testing grounds for the rapid advances that will be expected in the very near future.

(Photos : early small wind generator prototyping and market testing units.)

Rocket Science – Theory

Assuming that America chooses to acknowledge and solve the problems that confront us, scientific methods may be applied to promote reasonable progress in lowering the cost of transportation to and from low earth orbit, and implementing a space faring civilization. The author and his silent collaborators have spent the last four years doing precisely that.

> **Hydrocarbons verses Hydrogen** – Hydrogen cannot compete with kerosene and other hydrocarbons for low earth orbit transportation. For deep space and upper stage applications the increased performance of hydrogen is almost essential.
>
> **Hydrocarbons and Hydrogen** – Only the increased performance of hydrogen allows ground started hydrocarbon assisted core stages to attain single stage to orbit capabilities, eliminating the need for upper stages, and making the recovery, retrofit and reusability of the core stages possible, greatly increasing infrastructure value and reducing costs. Solar powered high impulse ion thrusters may also be substituted for upper stages in certain applications. The availability of space rated hydrogen upper and core stages in orbit also multiplies the intrinsic value of these expensive booster staged, medium lift launch vehicles, significantly reducing cost. Reusability provides further linear reductions of developmental, production and operational costs, while proportionally increasing the customer flight rate value.
>
> **Engine Clustering verses Single Engine** – Engine clustering permits linear force multiplication while simultaneously providing engine out reserves and sequential shutdown for acceleration reductions, at the cost of increased weight, complexity and the potential for failure, while single engines optimize weight and simplicity with the increased risk and potential for loss of mission during aborts and failures. Single engine cores utilizing efficient closed cycle high performance engines also require the addition of roll control engines, but this can actually be an advantage, in that these same roll control engines can double as orbital maneuvering engines for the necessary orbital circularization and synchronization, fuel settling engines, space station reboost engines, reentry retro rockets and terminal landing engines, as well as idlers and sustainers for on-orbit fuel scavenging and long term storage. Small high performance engines of this type can also be used for ascent steering.
>
> **Engine Clustering and Single Engine –** Combining engine clustering and single engine boosters allows much greater flexibility in matching booster performance with payload requirements, and clustering a single high performance engine with clustered pairs of OMS engines provides full redundancy for orbital operations. Eventually full dual fuel operations could be incorporated into a single vehicle.
>
> **Sequential Shutdown verses Deep Throttling** – Sequential shutdown of large engine clusters allows for terminal flight acceleration reduction and elimination of the need for throttling, while permitting nozzle extensions on the center engine for better vacuum efficiency at altitude. Deep throttling eliminates the need for any engine clustering at all, but suffers from efficiency problems during cruise phase.

Steering, Fuel Recovery, OMS, Reboost, Reentry and Landing Engines – Redundant pairs of small sustainer engines have a wide variety of uses on single engine hydrogen core stages in single stage to orbit applications. These engines are well within the talents and abilities of small nascent aerospace companies interested in developing efficient reusable, horizontally launched suborbital systems, and extending their expertise and experience to full orbital operations.

Core and Clustered Stage Expendables – Modern vertically launched medium lift launch vehicles generally scale easiest with clusters of core stages to increase payload. However, single fuel usage across these clustered core stages, whether hydrocarbon or hydrogen, prohibit single stage to orbit performance, demanding rather that the entire cluster be either expended simultaneously, or sequentially.

Core and Upper Stage Recovery and Retrofit – As has been discussed many times previously, every launch vehicle mission to low earth orbit necessarily also delivers a complete core or upper stage to low earth orbit along with its payload. These launch vehicle cores and upper stages can be space rated by design, and contain many of the components necessary for orbital and deep space operations, including fuel and oxidizer storage tanks, attitude control systems, pressurization systems, and in the case of upper stages, reasonably powered restartable engines. Logistically, it makes no sense whatsoever discarding usable hardware after the effort and expense of transporting them to the location where they are needed. The cost of recovering and returning expensive one of a kind reusable engines back to the earth is far less than the cost of replacing them with new engines, and such activities can serve as precursor efforts preceding fully reusable operations.

Core and Upper Stage to Orbit Reusability – Full reusability is the ultimate goal of commercial low earth orbit space flight, but it is worth noting that many current efforts at suborbital flight, including hovering landers, ground launched rocket planes and horizontal flying wings, all provide unique and inexpensive methods of rapid turnaround testing of engines, airframes, sensors and missions, which very shortly are expected to scale up to full orbital space flight capabilities. These systems are complementary to conventional vertically launched heavy lift launch vehicles, and can serve as models, and intrinsic participatory systems, for the incremental development and testing of reusability for core and upper stages.

Booster Stage Recovery – Modern trends to liquid fueled hydrocarbon boosters for medium to heavy lift launch vehicles dictate that their eventual recovery and refurbishment, or at the very least the salvage of their engines and components, proceed at least experimentally and developmentally, for cost reduction reasons. A modest amount of thermal protection plus the installation of parachute systems and water impact and flotation airbags, as well as terminal deceleration rockets, can easily deliver lightweight fuel depleted booster stages to the sea for recovery.

Booster Stage Flyback – Full reusability ultimately enables suborbital test flight and tourist operations concurrent with conventional orbital space flight missions.

Rocket Science – Experiments

The availability of the Falcon 1e in late 2010 presents a remarkable opportunity to jump start the commercial orbital space transportation system market sector, with few caveats. The evolutionary heritage of this vehicle, the Falcon 1, has already flown several times. The engine that powers this vehicle has already undergone several technology and power upgrades, and several more are anticipated, putting it just within the capabilities required for extremely lightweight single person capsule flights to commercial equatorial stations. The capabilities and cost of this vehicle scales linearly up to the Falcon 9, so any concept to be tested on the Falcon 9, can be first tested on the Falcon 1e, much less expensively.

This author intends to leverage the astonishing capabilities of this vehicle to the fullest extent possible, in order to demonstrate the viability of the commercial space transport sector, and to validate our business model for commercial low earth orbit space flight. Five optional $10 million dollar developmental mission toggles are presented, for up to the full amount of $50 million dollars of the commercial crew recovery act funds applied to this space act agreement. Any, all or none of these five components may be selected.

Falcon 1e – The estimated price of a commercial Falcon 1e launch vehicle mission flown from Kwajalein atoll is approximately $10 million US dollars.

Launch Pads – SLC 36 and 46 – The estimated cost of setting up Falcon remote payload processing and launch pad facilities at the Space Launch Complex (SLC) pads 36 and 46 at Cape Canaveral Air Force Station is approximately $10 million.

Distributed Mission and Ground Control – The estimated cost of the software and hardware development for the remote interactive launch and mission control facilities, allowing for training of launch crews and mission specialists, and active educational outreach and public participation in integrated space flight missions, is approximately $10 million dollars. This includes flight simulation capabilities.

Flight Test Vehicle – The estimated cost of the integrated Falcon 1e upper stage and flight test vehicle, which includes an amateur radio internet packet transceiver and associated power supplies and antennas, and a minimal suborbital or low orbit count capsule, reentry system, parachute system, airbag terminal landing system, emergency rescue life raft and personal parachutes, is approximately $10 million.

Test Flight – The challenge of the initial test flight of the Falcon 1e is to retire as much anticipated future mission risk with the least amount of current mission risk, satisfying as many of the goals as are reasonably possible within a single mission. The resulting mission can take on many different forms and will evolve over time, but is severely restricted by payload capabilities of the Falcon 1e launch vehicle. In order to satisfy these payload restrictions, as well as time restrictions implied by recovery act stimulus funds legislation, many compromises will be necessary. Thus I propose a single 50th anniversary (sub) orbital ‘cape to the cays’ capsule flight, using the Falcon 1e upper stage as the primary orbital rendezvous satellite.

Overall Concept and Performance

The participant shall describe its proposed commercial crew space transportation system goals, architecture, capabilities, and concept of operations that require the long lead capabilities, technologies, and commercial crew risk mitigation tasks proposed under its CCDev effort.

Goals – The goal, of course, of any credible commercial space transportation system and its infrastructure, is to sufficiently cover the costs of operations with capital and revenues. Additionally, owners and operators of such a system may have proprietary philosophical and intellectual reasons for engaging in human space flight. I have no problems revealing my motivations; as I have clearly stated, civilization will perish if science and scientific methods are not embraced universally, at every level of human organizational structure. The collapse of civilization would indeed make operation of private human space flight systems difficult, if not impossible. Thus, human space flight, as the world's premier multidisciplinary scientific activity, is absolutely essential for the survival of civilization. The severe social, economic, energy, environmental, health, security and educational problems that plague humanity across the globe clearly demonstrate this fundamental truth, and the prospect of nine billion people all demanding and struggling to achieve a modern standard of living makes the necessity of human space flight absolutely clear.

There is an ulterior motive in writing this paper and submitting this CCDev proposal; NASA's Constellation Program – CxP, as currently envisioned, has no chance of success. The ill-advised Ares I launch vehicle is fraught with technical and budgetary problems. The continued support for this intractable launch vehicle architecture is a perfect example of the problems with our American education system outlined here. The American public, and the congressional representatives they have elected to represent them, simply have no comprehension of their inability to recognize their own incompetence and the problems it has created. Because of their extreme lack of education and experience, they are blind to there own failings, and thus, it falls to those who do have that experience to identify and solve those problems. With regards to Constellation, that is the commercial space sector.

Concepts – Since NASA, and congress that funds them, and the American people who elect them, appear unable to come to grips with the failure of the Constellation program, it thus falls to the nascent commercial space flight sector to confront this tragic situation, and thus far they appear to have done an enviable job of that. In order to achieve the goal of profitable development and operations of a space flight system, smaller really is better. Bigger can come later. Space is an extremely unforgiving environment, and space flight systems development and operation has traditionally been a financial black hole in which large amounts of cash have historically disappeared, never to be seen in this world again.

SpaceX and Orbital Sciences appear poised to break that paradigm, and NASA, congress and the American public are still reluctant to admit their failures and embrace solutions. The best way to invest recovery act funds and stimulate the commercial space industry is to buy and use their products, and the Falcon 1e is an immediate and ideal way to do that. The concept is very simple - investing in American talent ensures the success of America.

Given the magnitude of the failures in American society, finance and politics, congress and the president need to start critically asking themselves where that talent actually lies. Spotting scientific and technical talent is easy, all you have to do is look. It displays itself by demonstration. Like any other government, organization or individual, NASA needs to demonstrate its talents to its stakeholders if it is to continue to expect any lavish funding. NASA still expects funding on the order of $100 billion dollars for human space flight, after failing to recognize the failure of Constellation to meet any of its milestones, and congress insists on funding cargo resupply at only $3.5 billion dollars, and commercial space transportation at only $500 million dollars when they have exercised due diligence in meeting all their milestones, and now commercial crew at a level of only $50 million dollars? This should give all of NASA stakeholders pause for thought, but apparently not.

The concept of responsibility and due diligence even in the face of failure is a uniquely scientific characteristic, one that government, businesses and individuals must embrace, if they expect to survive. Human space flight is not exempt from oversight and criticism, just as businesses are not exempt from failure and bankruptcy, government is not exempt from insolvency and default, species are not exempt from extinction and civilizations are not exempt from collapse. The bottom line is that the means by which these organizations make their living must be affordable and sustainable, if they intend to continue to survive.

Architectures – Human space flight architectures must continually adapt and evolve to changing environments, improving themselves to adjust to the new realities as they arise. The obvious social, economic, environmental and scientific realities that now confront the United States are: limited funds, a polarized electorate, rapidly changing ecosystems, environmental pollution and orbital debris, immediate threats of natural and manmade catastrophes and disasters, and a citizenry hostile to science and apathetic to its benefits.

In order to reverse these trends, some very dramatic demonstrations of the abilities of scientific and engineering accomplishments to confront these problems must be quickly forthcoming, beyond those developments which most people now take for granted, such as computers, networking, flat screen television, cell phones and satellite technologies, *as if these things weren't enough*. The primary barrier preventing human space flight from participating in this process of scientific and technological innovation in the widespread commercial manner as other market sectors, is the cost of low earth orbit transportation. Until commercial space flight demonstrates itself to be both profitable and affordable in markets where costs are decreasing and capabilities are improving, our government will continue to dominate this sector, and the widespread recognition among the public for the potential of space flight to improve their lives, *which it already ha*s, will not materialize. Thus government designed space flight architectures are the primary barrier to progress.

Capabilities – The capabilities of any space launch architecture must be matched to the needs of its customers, or in the case of NASA and the government, its stakeholders. The EELVs are designed primarily for military and government or commercial surveillance applications, but are versatile enough and are of a scale and cost to meet almost any need. Since they are already for all practical purposes commercial vehicles, they may be used in any manner their shareholders deem appropriate, depending on any markets that exist.

Proposed heavy lift vehicles such as the Ares V have such high development costs that their only market is the United States government. Unless there is a clear need for such vehicles, it makes little sense to develop them. They are basically unaffordable to operate, because the launch prices demanded by their development costs make them prohibitive for most potential customers, and their payload capacities far exceed the current demand. Multi-use launch vehicles have evolved into their current configurations over a long time, whereas the only previously known heavy lift launch vehicle, the Saturn V, had a single customer and two uses, launching government employees to the moon, and launching a government space station into orbit. Even as a multi-use launch vehicle it was cancelled. That being said, it is certain that launch vehicles of the future will be larger than launch vehicles of the present - more valuable, capable, versatile, reusable, and less expensive.

At the opposite end of the spectrum, small existing launch vehicles are very nearly to the limit of capabilities necessary to loft extremely lightweight single person capsules with integrated upper stages to privately owned inflatable space habitats in equatorial orbit. The prospect of private low earth orbit space flight completely independent of the ISS but supported and enabled concurrently by high inclination orbit ISS operational experience, is no longer a dream, but is a reality that is suddenly upon us. NASA can be a part of this. Indeed NASA is the enabler of these developments long considered and actively pursued.

Risks – Personally, the invocation of absolute astronaut safety as the guide for human rating liquid fueled launch vehicles is somewhat suspect, given that US citizens routinely and willingly give up their lives for public and military service, and collateral deaths are routinely considered to be acceptable in military action by the United States government. The concept of safety as risk becomes even more tenuous when commercial and private space transportation becomes more routine, and irrelevant when individuals travel alone, particularly when traveling far from Earth, in vehicles they purchase or build themselves.

There are great benefits in proactive preparation as accident prevention, however, and fifty years of space flight has given us a fairly good perspective of what actually works and how creative and innovative planning and design can help minimize the loss of lives. But we acknowledge up front that lives are going to be lost, whether they be lost in the service of nations, citizens, paying customers, or in the pursuit of one's individual goals.

Failure and loss of mission as risk are concepts that should be discussed routinely and at great length, separately from safety and loss of life. Life will never be entirely safe, but failure is a ubiquitous and constant threat to all organizations and their stated missions. The potential for failure must be confronted honestly and thoroughly in order to clearly predict the probability of their occurrence, and to develop the necessary infrastructure to recover from them, the redundancy to continue the mission when they occur, the rescue capabilities needed to save lives after they occur, and the confidence required to reduce their frequency. Honesty is the single most valuable quality of science and its methods. The ability to admit institutional, organizational and individual failure when it occurs is a necessary prerequisite to identifying and solving the problems which caused it to happen, and to redeem and forgive those who may have inadvertently been a part of the problems. Organizations and individuals who learn from their mistakes are our most valuable assets.

Technical and Programmatic Risks

The participant shall describe its approach for identifying and managing technical and programmatic risks. Describe the technical and programmatic risks associated with the CCDev effort within the timeframe of this agreement and include the risk level (low, medium, or high) along with a strategy to mitigate each risk.

The primary risk of any endeavor is thus failure; to deliver what was originally promised, to construct what was designed, to design what was envisioned, to envision the possible, and to understand the problem. Sometimes it's just a failure to get up in the morning and confront the problem and commit to the solutions. In these situations science can provide the confidence there will be solutions; that they can indeed be implemented reliably and repeatably, such that your costumers and stakeholders will find them useful, understand their value, are deeply appreciative of them, and are thus willing to fund then over time.

Scientific methods and engineering best practices are the force multipliers for the talents that all humans are endowed with at birth, which are cultivated by their early educational and life experiences and are contributed to by the organizations with which they interact. When our national educational system fails to nurture the intellectual and physical health of its citizens, that failure propagates through our entire system of governance, commerce and society, and allows an already natural propensity of systems to relax into the state of least energy and maximum entropy, where no useful work will be done. A primary goal of the human space flight program is to provide the knowledge and tools where this trend may be reversed, and energy and resources directed towards the natural human creativity that drives research and innovation forward, where clearly identified problems are solved. The methods of science clearly can be applied to any problems in order to find solutions, even if one of those solutions is to admit failure and move on. So I focus on the methods:

Financial – The risk of losing all one's money with little or nothing to show for it, is the fundamental reason investment capital hasn't flown into the commercial space sector and a primary reason American citizens have displayed a general indifference to space flight. In the former case investors may have underestimated the breadth of the markets and the difficulties in creating the demand for and bringing profitable products to fruition, and in the latter case, the money does not belong to the person signing the checks, the check is left blank, and no oversight of any significance is subsequently applied to those activities.

To solve these problems, the stakeholders need to be capable of understanding intimate details of the program, as well as being in possession of that information, those writing the checks must be aware of what is being purchased and the organization spending the money must be competent enough to deliver the product on time, and within the budget.

The greatest danger is financial collapse due to a lack of openness, honesty and oversight. Had even a minimal effort been expended on initially keeping the original ESAS process within these parameters, we would not be in the position today of four years later having to continuously review, criticize and justify the huge sums of money and years spent on pursuing a project that would have not stood the test of even a superficial critical review.

Engineering – Assuming that any engineering solution has no fatal fundamental flaws easily uncovered by initial strategic and tactical quality assurance oversight activities, then the primary engineering risk involves the level of technological innovation required to address the scientific problems that must be implicitly solved to close a chosen design.

Engineering science, unlike engineering physics, is a relatively new scientific domain. Previously, engineering best practices where developed by the trial and error application of engineering experience, much in the same way doctors develop techniques for surgery. Modern engineering has a rapidly expanding set of information and technology tools, which have put much more emphasis on simulation, greatly reducing its costs and risks. Fundamental engineering problems can now be uncovered much earlier in the design and development process, without the need for extensive hardware fabrication, which is the traditional source of personnel costs associated with most modern engineering endeavors.

Management – Management of the creativity of the individuals who engage in advanced engineering programs and projects, and the information and technology tools they use in their craft, presents perhaps the most challenging risk confronting any large organization. The adoption of open source, closed loop, stakeholder and customer driven feedback and control mechanisms is capable of providing the critical review, guidance and oversight necessary to direct the efforts and final products towards national and regional priorities, and citizen and organizational imperatives and desires, without compromising quality. Scientific methods provide the analytical and quantitative perspectives such that program goals can evolve into what funding reality permits, even if that means that evolutionary changes in the product line must be implemented in order to adapt to changing demands.

Technology – The speed and scale at which technological evolution progresses, implies that yesterday's solutions may no longer be today's solutions, and today's solutions may no longer be tomorrow's solutions. Flexibility must now be inherently designed into the structure of any program, project, product or operational service, in order to ensure that new scientific and technological developments can be incorporated rapidly into products, and to enable those products to adapt to uses for which they were not originally designed. The primary risk is not so much the failure of technology to satisfy stakeholder demand, but rather that projects will be extended far beyond their useful life, stifling development. Choosing methodical technology development over singular overarching goals can help prevent program failures resulting from inappropriate choices of technology applications.

Program – The failure of a program can be the most traumatic of all final results, when the realization sinks in that some predetermined goal was not reached, such as 'failure to summit', or that a goal cannot be reached in a timely manner with the resources available. My personal experiences, from a perspective of science, is that once one is committed to a certain goal or outcome, the time and funding constraints become much less restrictive. A general up front rule of thumb is that one already assumes that any specific endeavor is going to take twice as long as originally anticipated to accomplish, and at twice the cost. Commitment to general hierarchical and philosophical goals, and then moving forward on broad fronts, ensures that commonplace individual and institutional setbacks will not dampen the enthusiasm, fortitude and patience required to eventually meet those goals.

Maturation Plan

The participant shall provide its plan to develop key capabilities and technologies to mitigate commercial crew risks that could ultimately be used to mature the development of their commercial crew space transportation capabilities. This should include a schedule of the CCDev effort, concluding by September 2010. The participant shall describe the elements of its system that are either already operational or commercially available and elements that are under development or to be developed, including an indication of the Technology Readiness Level (TRL) for each of those elements.

The commercial crew space transportation system proposed in NASA **JSC-COTS-2** resides well outside the funding limits proposed even at the maximum possible award, and I've provided reasonable development toggles for the commercial space industry to begin vetting the advanced technologies necessary to commercialize LEO space flight. Since many credible commercial aerospace companies and contractors are competing for an extremely limited pool of funds, and a $50 million dollar one year effort to launch a small test flight from the cape is unnecessary when a very large test flight is forthcoming, the author instead proposes a maximum of one percent of the funds as more appropriate for the kind of strategic planning, quality assurance, and tactical design oversight needed for any subsequent larger technology development efforts to succeed, ultimately leading to commercial procurement of new, fixed price, launch vehicle design and development.

The 1% Solution

Decades of work on space commercialization, earth home design and construction, life support systems, alternative energy and chemical physics, and the referenced list of my short publications and positions papers written in the last two years alone serves as ample demonstration of my abilities to drive innovation, create new markets and produce jobs. My willingness to confront and tackle immensely complex and challenging problems in extremely difficult funding, logistical and physical environments is well documented.
In what follows, I assume that the recovery funds applied to this space act agreement will be provided in five equal payments starting September 30, 2009, which includes an initial payment, which is nonrefundable, and four additional quarterly payments upon successful completion of the project milestones on December 31, March 31 and June 30, and finally ending on September 30, 2010, at which time the full amount of the award must be spent. The author already has invested four years into the effort of working on the Constellation program 'problem', which has brought us to a point where commercial crew development is now a national imperative. This stimulus funds space act agreement presumes then that the author is willing to spend an additional year working the 'problems' of transition to a new direction in human space flight with NASA, making four of the payments retroactive on a yearly basis. The author is willing to take the initial nonrefundable payment as first payment for the next fiscal year, applying the four retroactive payments to entirely new Commercial Crew research. The $500,000 award amount would involve the construction of a modern earth home research facility for the author and his collaborators, whereas the $100,000 level would involve continuing commercial crew research one additional year, by paying off the accumulated debts incurred working on this since September 30, 2005.

Safety and Mission Assurance

The participant shall describe its approach for safety (i.e., test operations, range, ground, flight), reliability, maintainability, supportability, quality, and software assurance. Include a discussion of the proposed approach for assuring the safety and survivability of crew members and passengers.

To ensure then the safety of the public rather than the safety of the private astronauts, and to assure success of the mission rather than the attainment of a goal, we intend to launch from the furthermost eastern portions of the Cape Canaveral Air Force Station and range, necessarily defaulting to Space Florida jurisdiction of space launch complexes 46 and 36.

At the much lesser funding levels associated with extended research and development, the approach is to locate those activities into modern high visibility, high public profile superinsulated zero carbon, earth sheltered home, office and laboratory greenhouse space.

At a minimal funding level the approach is to continue current commercial crew research and development activities for another full year, until funding ends September 30, 2010, or upon early termination of this space act agreement for failure to meet its milestones.

Performance Milestones

The participant shall provide a proposed schedule of performance milestones for the CCDev effort including descriptive title, objective success criteria, rationale, and planned achievement dates (month and year). Milestones should represent the progress of significant technical events in the participant's program. At least one milestone per calendar quarter should be proposed and milestone dates should be scheduled to ensure all invoices (as set forth in Article 5 of Appendix A, Draft Space Act Agreement) are submitted no later than September 30, 2010. The milestones described here shall also be included within the proposed CCDev SAA submitted in Appendix 1 of the proposal with proposed payment amounts listed. Upon selection of a participant, NASA will negotiate specific payment amounts for the identified milestones.

The satisfaction of this space act agreement is presented in three tiers, representing three different negotiable funding levels of full ($50M), 1% ($500,000) or minimal ($100,000).

The full funding level involves five $10 million dollar payments to establish complete SpaceX Falcon 1e integration, launch, operations and mission capabilities at the Space Florida launch pads out on Cape Canaveral Air Force Station at Cape Canaveral, Florida. Additionally, a single Falcon 1e launch vehicle will be purchased, and a single integrated flight test vehicle will be constructed, and a single test flight mission launched and flown.

The one percent funding level involves five $100,000 dollar payments to demonstrate our innovative and essential commercial crew facilities on the surface of the planet Earth, and the minimal funding level involves five $20,000 dollar payments to continue commercial crew research, and then publish the quarterly reports very similar to this CCDev proposal.

Performance Milestone Tables

The Minimal Investment Level

Date	Amount	Milestone
September 30, 2009	$20,000	Submission of JSC-CCDev-1 proposal
December 31, 2009	$20,000	Submission of first quarterly report.
March 31, 2010	$20,000	Submission of second quarterly report.
June 30, 2010	$20,000	Submission of third quarterly report.
September 30, 2010	$20,000	Submission of fourth quarterly report.

The 1% Investment Level

Date	Amount	Milestone
September 30, 2009	$100,000	Submission of this JSC-CCDev-1 proposal.
December 31, 2009	$100,000	Identification and purchase of a facility site.
March 31, 2010	$100,000	Design and subcontract negotiation finished.
June 30, 2010	$100,000	Foundation and shell infrastructure poured.
September 30, 2010	$100,000	Structure backfilling and facility completion.

The Full Investment Level

Date	Amount	Milestone
September 30, 2009	$10,000,000	Purchase of the Falcon 1e launch vehicle.
December 31, 2009	$10,000,000	Launch pad operational readiness.
March 31, 2010	$10,000,000	Ground and mission control operations ready.
June 30, 2010	$10,000,000	Flight test vehicle operational readiness.
September 30, 2010	$10,000,000	Initial test flight mission.

Company Information

This section shall describe the participant's business viability, target markets, governance structure, management team, job creation efforts, financing, key resources, teaming arrangements, and legal compliance related to the CCDev project.

The author is a citizen of the United States of America residing in the State of Wisconsin, and also a published scientist in the life sciences, earth sciences, space sciences and the natural sciences and a research and development specialist in the area of product design.

The only resources the author can legally claim are debt and available natural resources.

Business Viability

The participant shall provide data that demonstrates the participant viability as an ongoing company able to provide the proposed commercial crew space transportation capability once developed.

The commercial crew space transportation system originally described in JSC-COTS-2 was proposed to be developed by Marshall Space Flight Center in Huntsville, Alabama, executed by Johnson Space Center in Houston, Texas and operated by Kennedy Space Center at Cape Canaveral, Florida, with the assistance of the United Space Alliance, in order to solve clear and outstanding problems of modern commercial crew space flight.

The commercial crew space transportation capability described for the full funding level of this announcement is intended to be a method of directing funding to the commercial space transportation companies and their commercial space transportation assets most likely to be able to implement significant advances in commercial crew space transport capabilities before the recovery act funding expires on or before September 30, 2010.

The one percent funding capabilities were designed to demonstrate the applicability and relevance of existing commercial crew space transportation capabilities to the national imperatives of energy, environment, economy, national security, health and education.

The minimal funding effort is an extension of commercial crew space transport research and development activities accomplished over the last four years, for one additional year.

Governance Structure

The participant shall provide information on the decision-making structure that impacts participant's business continuation in future years. For public companies, this will include financial-return expectations. For private companies, this will include the composition of the board of directors as well as an explanation of corporate covenants that impact the decision-making process.

The author of this research and development proposal is a private United States citizen.

Management Team

The participant shall identify its top level management team and key personnel for this effort, including a description of the reporting structure, biographical information, history of relevant experience and business ventures, and professional references for each.

The author of this research development proposal, and precursor proposal JSC-COTS-2, is the principle, director and producer of the supporting documents listed in the references and will remain principle director and executive producer of any subsequent research and development activities, construction projects, media documentation and/or presentations resulting from the successful completion of any resulting NASA space act agreements.

The author's published works of science, position papers, references and brief biography may be viewed at and distributed from the URL: http://webpages.charter.net/tsiolkovsky/.

Jobs Accountability

The participant shall describe an estimate of the number of jobs to be created and/or the number of jobs to be retained and the location of those jobs (by State) during the term of the CCDev SAA as a result of the funding provided under the CCDev SAA.

The author estimates 50 jobs created in the State of Florida for the execution of the full funding proposal for creation and implementation of a commercial space transportation operations company and its necessary infrastructure, at Space Florida launch facilities.

I estimate five jobs created for the one percent funding level proposal for a modern earth home contracting company for commercial crew demonstration in the State of Wisconsin.

The minimal funding level proposal for continuation of commercial crew research and development work by the author will create two job positions in the State of Wisconsin.

Finance

The participant shall provide and discuss its current financial status and financial plan for the CCDev effort (e.g., historical and pro forma income, sources and uses of cash, balance sheets, statements of stockholder's equity). For pro forma income statements and sources and uses of cash, the NASA CCDev funding shall be treated as a source of cash from financing and shall not be treated as revenue, as other income or as a net against research and development expenses.

This proposal is unable to make any financial guarantees due to the scale of the endeavor. The final commercialization and internationalization of human space flight represents the greatest challenge that humanity and civilization has ever undertaken, with the exception of the scientific investigation of quantum and condensed matter physics, and this author is committed to achieving that goal for personal, intellectual and humanitarian reasons.

The participant shall discuss the total amount of funding necessary to execute the financial plan for the CCDev effort and the specific amount requested from NASA. Recognizing the funding allocated to a participant is solely at NASA's discretion, the participant shall establish a prioritized list of activities for funding should the amount offered by NASA be more or less than proposed. Priority of this list is to be based upon the degree to which those activities will accelerate a U.S. commercial crewed space transportation capability. Include an estimate of the costs required to comply with reporting requirements contained in Article 5 of Appendix A, Draft Space Act Agreement.

The total amount requested for this commercial crew research and development effort over the next fiscal year running from September 30, 2009 through September 30, 2010, is $100,000. The cost of the reporting requirements over the next year is also $100,000. An additional one percent extended research and development tier and five - $10 million dollar complementary projects are provided to increase the scope and scale of the effort.

Resources

The participant shall describe key resources such as personnel, facilities and other assets, including intellectual property currently owned or yet to be obtained, that may be used toward the CCDev effort. The use and/or need of government resources as described in Section 4.8 of this Announcement shall be identified in this section of the proposal.

The development of credible and affordable second generation reusable launch vehicles and their associated large propulsion efforts will require the resources of the entire nation. Without direct presidential and congressional interdiction, space flight will not become affordable, and without direct commercial space participation, it will not be sustainable.

Teaming Arrangements

The participant shall describe teaming arrangements including respective roles and contributions to the project. A list of all partners and suppliers shall include name, address, country of incorporation, and contact name and phone number. Provide a brief description of any previous experiences working with these partners and suppliers. If foreign participation is included in the proposal, the participant shall describe the critical elements of the foreign content, an assessment of supplier risks, and any alternatives or mitigation of the identified risks.

The potential contracting base has not changed much since submission of JSC-COTS-2, with the obvious exception of Orbital Sciences and some recent Aerojet discussion about starting up domestic production along with concurrent foreign production of the NK-33.

http://www.spacenews.com/launch/aerojet-looking-restart-production-nk-33-engine.html

This proposal makes no specific claims beyond this space act agreement, with regards to teaming agreements, contracts or guarantees with any of the companies or products listed.

Compliance

*The participant shall describe compliance with eligibility requirements and applicable federal laws, regulations, and policies specified in sections 4.2 and 4.3. Participants that intend to rely on Russian suppliers for their commercial crew space transportation system and intend to service the ISS shall explain how their concept would provide service capability after July 1, 2016, when the relief from the INKSNA prohibition expires***.**

The author is submitting this research and development proposal as a private citizen of the United States of America, and is of the view that living near or on the surface of the Earth is, for all practical purposes, planetary and space colonization. All inhabitants of the planet Earth are valuable participants and crew members in that effort, and all should have the right to participate in at least low Earth orbit space flight. It just isn't that hard, especially if it is restricted to short stays with the appropriate safety features designed in.

At the very least the author would be willing to register limited liability corporations in the State of Wisconsin and the State of Florida, under the public relations trade name : *Launch LLC*, in order to guarantee eligibility and compliance with all requirements, and no recovery act stimulus funds will be invested in or invoiced to foreign owned interests.

[NOTE: As discussed in Section 4.3 of this Announcement, INKSNA currently prohibits payments of NASA funding for goods or services directly related to human spaceflight, other than for work on the ISS.]

Proposed Space Act Agreement

The participant shall provide a proposed CCDev SAA using the Draft Space Act Agreement template included in Appendix A of this Announcement. Any proposed changes to the Draft Space Act Agreement template by the participant shall be highlighted and rationale provided for the proposed change.

See Appendix A.

Optional Appendix B – NASA Solicitation JSC-COTS-2

Addendum – September 22, 2009.

Typos corrected and historical references added.

NASA Reference Documents :

http://ntrs.nasa.gov/archive/nasa/casi.ntrs.nasa.gov/19760010916_1976010916.pdf

http://ntrs.nasa.gov/archive/nasa/casi.ntrs.nasa.gov/19760010917_1976010917.pdf