



# **Unaffordable and Unsustainable: NASA's Failing Earth-to-orbit Transportation Strategy**

**A Policy White Paper of the  
Space Frontier Foundation**

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## Executive Summary

Over the past 30 months, NASA has made fundamental errors in its implementation of the Vision for Space Exploration (VSE), errors which can be fixed today but will be fatal if left uncorrected. In particular, NASA has laid out a strategy for Earth-to-orbit transportation that is already showing signs of failure to meet its own stated goals: closing the gap in U.S. human spaceflight, supporting full utilization of the ISS, and enabling affordable and sustainable exploration beyond Earth orbit.

In developing this strategy, NASA has apparently ignored key elements of the White House's Space Exploration Policy and several critical recommendations of the *President's Commission on Implementation of U.S. Space Exploration Policy* ("President's Commission"). Instead of planning its exploration transportation in a way that maximizes economic (and national security) benefit, NASA is working with its incumbent contractors to develop a series of government-designed and owned space exploration transportation systems to service ISS as well as explore the Moon.

For example, many elements of Dr. Griffin's initial plan to "reduce the gap" in U.S. human spaceflight have had to be abandoned, and therefore the gap is likely to be larger than any U.S. politician expects. Worse still, the high cost of operating these systems to service the ISS, compounded with likely cost, schedule, and performance problems in developing the lunar transportation elements, will delay and make unsustainable – and probably unaffordable – the human exploration of the Moon and beyond.

The Foundation proposes a solution that will easily work within NASA's existing budget at funding levels already supported by the White House and Congress. We will explain why this solution:

1. Is our nation's best chance to "minimize the gap" in U.S. human spaceflight,
2. Is consistent with White House space policy and the recommendations of the President's Commission in specific areas where NASA's plans are not, and
3. Will allow Congress to restore funding (and avoid future cuts) to NASA's technology, science and aeronautics programs.

We will show that NASA can expand its timid outreach to America's NewSpace industry (most notably its underfunded Commercial Orbital

Transportation Services (COTS) program) to solve the near-term challenges of minimizing the "gap" and affordably servicing ISS. Furthermore, we will show that turning over low Earth orbit (LEO) space operations to NewSpace is the only way NASA can focus its talents and resources on returning humanity to the Moon and achieve the goals of the VSE in an affordable, sustainable and credible manner. Also, turning LEO over to NewSpace will broaden the U.S. space exploration community, grounded in the traditional American values of free enterprise, entrepreneurship and opportunity that opened our first frontier of the West.

We propose that NASA can and should pay for this by immediately eliminating all work on Block 1 of the Crew Exploration Vehicle (CEV), which is designed for missions to the ISS. Since COTS will become the primary approach to reducing the gap in U.S. human spaceflight, this eliminates the schedule pressure to fly the CEV by 2014. By focusing on CEV Block 2, which is targeted at the Moon and beyond as the President intended, NASA can transfer back the funds it moved from the Science Mission Directorate to pay for rushing the CEV Block 1 and Crew Launch Vehicle (CLV).

Furthermore, as the CEV-to-ISS schedule pressure will be gone, the urgent rush to develop the CLV will be removed. Because CLV has substantially changed since the decision to use the Shuttle SRB option, NASA should reopen its CLV trade study to fairly assess options such as the Atlas V or Delta IV, consistent with White House policy that the VSE should support U.S. national security interests.

Finally, consistent with the recommendation of the President's Commission to decisively transform the relationship between NASA and the private sector, the White House should enforce this by establishing a new policy — after 2010 the U.S. will buy all crew and cargo services with a destination of low Earth orbit (like the International Space Station) from U.S. commercial providers using privately-owned and operated spaceships.

In summary, America is the world's most powerful nation and the world's leader in high-tech innovation because we are better at capitalism, not because we are better at socialism. Using the tools of capitalism is now our nation's best and only chance to have an affordable and sustainable human space exploration program, and the best way to minimize the gap in U.S. human spaceflight and turn the ISS into a successful initial human settlement in Earth orbit.

## Preface

The Space Frontier Foundation (“Foundation”) has strongly and publicly supported America’s Vision for Space Exploration (VSE) since it was unveiled 30 months ago. After all, we have called for NASA to get out of Earth orbit and start exploring again since we were founded nearly two decades ago.<sup>1</sup>

Until now, however, the Foundation has remained largely silent about the details of NASA’s *implementation* of the VSE. Instead, we chose to give our friends inside NASA a chance to succeed, even though many Foundation members wanted us to speak up in opposition. And we specifically praised<sup>2</sup> the appointment of Dr. Mike Griffin as Administrator, hoping his record of innovation in industry signaled an opportunity to “dramatically transform” how NASA conducts its mission.

But we cannot remain silent any longer. Today, we see many of the same patterns of failure that have doomed previous NASA space transportation development efforts being offered as somehow likely to work this time. Indeed, everything about NASA’s implementation of the Vision appears nostalgic, as if retracing the steps of Apollo 45 years later will somehow lead to success today.

For now, we are confident that NASA’s plans for solving the politically vexing “gap” in U.S. human spaceflight between retirement of the Shuttle and the initial operation of a Crew Exploration Vehicle, and then affordably servicing the International Space Station, will fail. The remainder of this White Paper details why, and what policymakers can do to avoid the disastrous consequences of those failures.

## NASA’s Apparent Disregard of White House Policy Puts the VSE at Risk

The White House’s Vision for Space Exploration (VSE) represents this generation’s first rallying call for an expanding human presence in space. The Foundation strongly supports the VSE.<sup>3</sup>

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<sup>1</sup> In fact, the Space Frontier Foundation’s very first project was a Return to the Moon petition drive.

<sup>2</sup> See the March 2005 Foundation press release at <http://www.space-frontier.org/PressReleases/2005/20050312mikegriffin.html>

<sup>3</sup> The VSE is a wonderful step forward. However, in the Space Frontier Foundation’s view, the President missed an opportunity to take additional but critical steps. It is not just about “*exploration*” or

The VSE, as offered by the President two and a half years ago, represents a major change in direction of our nation’s civilian space efforts, including several key reforms the Foundation has advocated for many years. Most importantly, the VSE gives NASA a real exploration mission on the “far frontier” (beyond Earth orbit) and transfers responsibility for the “near frontier” (e.g. low Earth orbit) to the private sector<sup>4</sup>. Perhaps it was for this reason that the White House invited the Foundation to hear the President’s speech at NASA HQ on January 14th, 2004.

In announcing the VSE, the President also established the *President’s Commission on Implementation of U.S. Space Exploration Policy* (“President’s Commission”) and directed it to make recommendations on implementing the VSE. One core recommendation of the President’s Commission was that NASA should “*decisively transform*” its relationship with the private sector, “*most immediately in LEO,*” and that “*NASA’s role must be limited to only those areas where there is irrefutable demonstration that only government can perform the proposed activity.*”

NASA’s planners have apparently ignored or rejected this element of White House exploration policy and explicit direction from the President’s Commission, and therefore will not deliver an “affordable” and “sustainable” exploration program.

The Foundation believes that this divergence from the goal of “economic benefit” is a root cause for why NASA’s plans appear to be in the early stages of a major programmatic failure.

When President Bush announced the VSE<sup>5</sup>, he called for the United States to “*Promote international and*

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“extending human *presence* across the solar system.” It is also about the permanent human settlement of space, the value to human society of a real frontier, developing the material resources of space for the benefit of humanity, protecting human civilization from a cataclysmic disaster, and protecting the Earth’s fragile biosphere.

<sup>4</sup> The Foundation has written extensively on this subject for over a decade, and has repeatedly testified before Congress on the subject. For example, on March 16, 1995, Space Frontier Foundation testified to Congress on the “Near-Frontier, Far Frontier” policy model (see <http://www.space-frontier.org/Policies/manifesto.html>). You can also read the Foundation’s congressional testimony from April 9, 1997 <http://www.space-frontier.org/Policies/alphatown.html>, and October 1, 1998 <http://www.space-frontier.org/Policies/frontieragenda.html>.

<sup>5</sup> [http://www.whitehouse.gov/space/renewed\\_spirit.html](http://www.whitehouse.gov/space/renewed_spirit.html)

commercial participation in exploration to further U.S. scientific, security, and economic interests.” Dr. John Marburger, the President’s Science Advisor, has publicly explained and amplified this White House policy<sup>6</sup>:

*As I see it, questions about the vision boil down to whether we want to incorporate the Solar System in our economic sphere, or not. Our national policy, declared by President Bush and endorsed by Congress last December in the NASA authorization act, affirms that, "The fundamental goal of this vision is to advance U.S. scientific, security, and economic interests through a robust space exploration program."*

Dr. Marburger further clarified what the White House meant by this phrase:

*The wording of this policy phrase is significant. It **subordinates** space exploration to the primary goals of scientific, security, and economic interests. Stated this way, the "fundamental goal" identifies the benefits against which the costs of exploration can be weighed*

Instead, NASA appears to be doing the opposite, and is subordinating scientific, security and economic interests to the programmatic imperatives of NASA’s exploration program. Specifically, NASA has:

- Made serious cuts to the space science program
- Ignored “security interests” by deciding to invest tens-of-billions-of-dollars in two completely new launch vehicles, whose benefit to U.S. national security, if any, has remained unstated. (NASA could have designed some of its architecture around launch vehicles that are also used for national security purposes, which would have reduced their costs for all government users while saving the taxpayer billions in development costs.)
- Made an underfunded and insignificant (less than 1% of the NASA budget) investment in “commercial participation” to support our “economic interests,” providing mere “lip

service” rather than a serious intent to engage the private sector in Earth-to-orbit transportation.

- Decimated the space technology investment portfolio, effectively declaring that NASA is no longer in the technology development business, thereby eliminating all the indirect economic benefits that would have been created by technology transfer

It is important to note that **nothing** in White House policy gives NASA authority or direction to own and operate space vehicles for sending crew and cargo to the International Space Station after retirement of the Space Shuttle. Instead, the White House specifically gave NASA a narrowly defined task (emphasis added) to “**Develop** a new manned exploration vehicle to explore **beyond our orbit** to other worlds.”

It is clear from White House policy that the plan was for NASA to get out of low Earth orbit, where it has been stuck going in circles for 25 years. How can we assert this?

We can do so because the President’s Office of Management and Budget created a new program called “ISS crew and cargo services” to purchase ISS crew and cargo services from the commercial sector, starting in Fiscal Year 2005.

### **Commission on Implementation of the U.S. Space Exploration Policy**

In the immediate aftermath of the *Columbia* disaster, NASA had diminished credibility as the lead agency for the nation’s civil space policy. Furthermore, it was recognized that there was more to civil space than NASA. Therefore, the President did not simply leave implementation of the VSE to NASA, but formed a *Commission on the Implementation of U.S. Space Exploration Policy* to advise the U.S. government on “how” to implement the VSE.

The final report of the President’s Commission was issued on June 4<sup>th</sup>, 2004 and contained the following critical finding (#3, page 19, emphasis added):

*NASA’s relationship to the private sector, its organizational structure, business culture, and management processes must be decisively transformed.*

<sup>6</sup> Speech to 44th Annual Goddard Symposium, March 15, 2006. See <http://www.ostp.gov/html/jhmGoddardSymp03-15-06Release.pdf>

The President's Commission was clear about what NASA's role should be in low Earth orbit (LEO). Recommendation 3-1 (page 19, emphasis added) was:

*The Commission recommends NASA recognize and implement a far larger presence of private industry in space operations with the specific goal of allowing private industry to assume the primary role of providing services to NASA, and most immediately in accessing low-Earth orbit.*

NASA's relationship with the commercial space sector has been disastrous. The need for a new approach to commercial low-Earth orbit transportation was not a minor point of the President's Commission. Their report focused significant attention on this critical need, which was the subject of fully one third of its specific recommendations. They summed up their attitude quite clearly (emphasis added):

*Implementation of the space exploration vision must be built around several core management principles and comprehensively internalized throughout NASA. Most crucial is a significant shift regarding NASA's relations with the private sector.*

The core of the Presidential Commission's recommendation is a clear paradigm shift from NASA as builder and operator, to NASA as customer. (Recommendation 3-1, page 19, emphasis added):

*In NASA decisions, the preferred choice for operational activities must be competitively awarded contracts with private and non-profit organizations and NASA's role must be limited to only those areas where there is irrefutable demonstration that only government can perform the proposed activity.*

It is important to note that NASA has not "irrefutably demonstrated" that only NASA can deliver crew and cargo to ISS. NASA has not even attempted to do so. Therefore, the fact that NASA is planning on spending many billions of taxpayer dollars in the next five years to send the Crew Exploration Vehicle (CEV) to ISS would seem to be a complete rejection of the President's Commission on this point.

The President's Commission used the phrase "private sector" 43 times in its 64-page report, and repeated the central idea of using the private sector in the conclusion (emphasis added):

*We must challenge and rely heavily upon the private sector – major corporations, small business, and entrepreneurs – beyond anything that has ever been attempted in a major government-run program. The government must execute only those activities that are too risky for private sector involvement. The government must change its focus to provide incentives for the commercialization of space, and to create, nurture, and sustain a robust space-based industry.*

The President's Commission stated that there were "Three Imperatives for Success" and private industry is critical to achieving all three. This white paper demonstrates that each of these "imperatives" is increasingly missing from NASA's current plans (Page 15, emphasis added):

*Three imperatives must continuously animate the nation's space exploration journey. It must be: (1) sustainable over several decades; (2) affordable with available resources; and (3) credible in the stewardship of taxpayer dollars.*

One of the clearest indictments of NASA's snubbing of the Commission's report is how the agency is pursuing the simplest of goals – created by pressure from some in Congress — "to reduce the gap" in U.S. human spaceflight.

### **NASA's Implementation of VSE — Exploration Systems Architecture Study**

Handed a "Vision" statement, and provided guidance in the form of recommendations from the President's Commission, NASA undertook the task of implementation in the only way it institutionally knew how – by designing an "architecture" of the various systems it deemed necessary to carry out the VSE, all elements of which would be developed, owned and operated by NASA.

The resulting document was not a laundry list of available resources and private companies ready to step up and build that vision, but yet another

centrally-planned, government-built space program with an entire menu of new vehicles, systems, and technologies, and the awarding of those new “plums” to the various NASA centers, hungry for a new generation of public funding. It has aptly been described as “Apollo on Steroids.” It appears that Dr. Griffin thought the comparison to Apollo was a positive feature, seeming to forget that Apollo was ultimately unaffordable, and politically unsustainable.

In November 2005, NASA released the Final Report (NASA-TM-2005-214062) of its Exploration Systems Architecture Study (ESAS).<sup>7</sup>

This section will explore:

- 1) The initial design approach that Administrator Griffin brought to NASA: using existing Shuttle hardware (except for the Orbiter).
- 2) Dr. Griffin’s selling of this strategy as reducing costs, risk and schedule, and how it would help NASA minimize the gap in U.S. human spaceflight.
- 3) The collapse of this plan within just eight months as Griffin’s design philosophy hits the wall of the NASA bureaucracy that (historically) can only do things in a more costly, more bureaucratic manner that always takes longer than anybody would imagine, and always gravitates towards developing new systems.

A key focus of ESAS was the use of existing proven technology whose purpose, as communicated to Congress, was to “minimize the gap.” As reported by NASA Watch<sup>8</sup> on May 5, 2005, NASA’s Legislative Affairs office sent a memo to Congress that states in the lead-off sentence (emphasis added):

*NASA has initiated the Exploration Systems Architecture Study (ESAS) in an effort to minimize the gap between the final Space Shuttle mission and the maiden flight of an operational Crew Exploration Vehicle (CEV).*

The ESAS approach was not new, and was not surprising, to those who followed Dr. Griffin before

he became NASA Administrator. The previous year, Dr. Griffin was the Co-Chairman of a study by the Planetary Society<sup>9</sup> called “Extending Human Presence Into the Solar System,” which stated in its Executive Summary (page 4):

*We believe these requirements can best be met, at least initially, by means of designs that utilize existing Space Shuttle components (e.g., the SRM and External Tank)*

This Griffin-led study further stated (page 19, emphasis added):

*It allows us to take advantage of the existing Shuttle human space flight assets at the Vehicle Assembly Building (VAB) and Launch Complexes 39A and B that would otherwise become idle upon termination of Shuttle operations. Furthermore, the SRM has proven to be the most reliable launch vehicle in the history of manned space flight, with no failures in 176 flights following the modifications implemented in the aftermath of the Challenger accident.*

Later, when Dr. Griffin came to NASA in Spring 2005, he immediately placed Dr. Doug Stanley, who had worked for Dr. Griffin at Orbital Sciences Corp., in charge of the ESAS study. Dr. Stanley immediately began studying various approaches to returning to the Moon and Mars. The November 2005 ESAS report was the result.

After November 2005, and publication of ESAS, NASA and Griffin continued to use the mantra of “existing technology” to sell the “credibility” and the “affordability” of the program to the White House and Capitol Hill. For example, in a House Science Committee hearing<sup>10</sup> held on November 3, 2005, with Griffin as the only witness, the hearing charter stated (emphasis added):

*NASA is able to state the cost with that confidence level because most of its work in the next five years is dedicated to developing elements of the ESAS, such as the CLV and heavy-lift launch vehicle, based on existing technology.*

<sup>7</sup> [http://www.nasa.gov/mission\\_pages/exploration/news/ESAS\\_report.html](http://www.nasa.gov/mission_pages/exploration/news/ESAS_report.html)

<sup>8</sup> <http://www.spaceref.com/news/viewsr.html?pid=16509>

<sup>9</sup> [http://www.planetary.org/programs/projects/aim\\_for\\_mars/study-report.pdf](http://www.planetary.org/programs/projects/aim_for_mars/study-report.pdf)

<sup>10</sup> <http://www.house.gov/science/hearings/space05/nov3/CHARTER.pdf>

## **NASA Seemingly Refuses to Hand off Responsibility**

As reported earlier, the President's Commission explicitly stated that (emphasis added):

- *NASA's role must be limited to only those areas where there is **irrefutable demonstration** that only government can perform the proposed activity.*
- *The Commission recommends NASA recognize and implement a far larger presence of private industry in space operations with the specific goal of allowing private industry to assume the primary role of providing services to NASA, **and most immediately in accessing low-Earth orbit.***

Compare these statements with page 34 of the NASA ESAS report (emphasis added):

*One of the key requirements to enable a successful human space exploration program is the development and implementation of a **vehicle** capable of transporting and housing crew on **LEO**, lunar, and Mars missions.*

This statement constitutes a complete rejection by NASA of Recommendation 3-1 of the President's Commission. ESAS did not provide any proof or argument that only NASA could do the ISS job, let alone an "irrefutable demonstration." Instead, NASA chose to ignore the President's Commission, and appears to be institutionally committed to continue going around in circles in low Earth orbit.

And indeed, the facts show that NASA is not the only entity that can, or will, fly humans and cargo to the ISS. Until last July, the Russians provided the only human flights to the ISS post-Columbia, and RSC Energia, a Russian company, has funded and flown manned flights both to the Mir space station and the ISS, including two private U.S. citizens. Several other non-U.S. groups are actively designing and building systems for ISS cargo [e.g., Europe's Automated Transfer Vehicle (ATV), and Japan's HII Transfer Vehicle (HTV)].

## **ESAS's Flawed Logic of a Single National Vehicle for Multiple Missions**

The expert agency had now spoken. The ESAS report clearly assumes that a single vehicle is the

path for these multiple missions. This conclusion is not only flawed, but it also demonstrates NASA's amazing ability to forget its own history.

The ESAS logic of designing, building, owning and operating a single vehicle for multiple space missions is identical to NASA's logic in the 1970s that created the national space transportation system, later called the Space Shuttle, which was supposed to serve all national needs (civil, military and commercial.) This logic was used for over a decade to kill off all other competing launch systems in the United States. Furthermore, it created a fragile space transportation infrastructure, with no redundancy or resiliency in the face of failure, as we saw after the losses of both *Challenger* and *Columbia*.

Even after the *Challenger* accident, the NASA bureaucracy fought to keep White House policy from being changed. It was only the aggressive actions of other parts of the U.S. government (DoT, DoC) that prevented NASA from keeping a stranglehold on America's commercial satellite launch industry.

The NASA bureaucracy's intent in this case "appears" to be quite similar — to kill off other competing (commercial) U.S. crew and cargo systems by eliminating the need for their services. The appearance of ill intent is supported by multiple sources inside NASA who have reported that CEV executives and advocates have tried to kill the Commercial Orbital Transportation Services (COTS) program and steal its budget. Administrator Griffin gets credit for making sure this has not happened to date, but it appears that he is (again) letting the bureaucracy get its way.<sup>11</sup>

*Sources close to the (COTS finalists) have told Flight International that the NASA budget proposal for fiscal year 2007 has a major reduction for COTS, which could make the project's targets unobtainable. Speaking at his 30 June Kennedy Space Centre (KSC) press conference for Space Shuttle Discovery's International Space Station logistics mission (STS-121), Griffin said: "If 2010 is not realistic then we'll see where we'll go from there".*

<sup>11</sup> <http://www.flightglobal.com/Articles/2006/07/01/Navigation/177/207552/NASA's+Commercial+Orbital+Transportation+Services+demonstration++target+date+could+be+extended+into.html>

Thus, here are the facts so far:

- NASA has rejected major recommendations from the President's Commission
- NASA has extended its role to "developing, owning and operating a new vehicle" for "low Earth orbit" missions
- NASA's bureaucratic CEV and CLV programs are eating the budgets of every other NASA priority

This white paper recommends a simple solution to the problem these facts represent — the White House and/or Congress should mandate that NASA implement the key recommendations by the President's Commission with respect to the private sector.

**RECOMMENDATION:** The White House and Congress should specify, as a matter of policy and/or law, that NASA cannot develop, build, own or operate a new vehicle for crew or cargo missions to the ISS or to other parts of low Earth orbit. For those missions, NASA must buy a service from U.S. companies.<sup>12</sup>

### **Griffin's Plan Hits NASA Bureaucratic Wall:**

The ESAS "focus on existing technology and proven approaches" was one of the few seemingly positive features about NASA Administrator Griffin's approach to the VSE. However, this approach, which was intended to maintain existing jobs and to simultaneously hold down costs and to fly "Safe, Simple, and Soon", is now gone.

In November 2005, when the ESAS report was published, Griffin was about to hit the bureaucratic wall. Griffin was about to re-learn the "NASA way," which means everything costs more and takes longer than anybody from the outside can rationally explain.

It is surprising that nobody has seriously commented on this, but in the last eight months the NASA

bureaucracy has systematically rejected Griffin's safer, lower-risk, lower-cost approach to design. At every step of the way, the NASA bureaucracy has made changes that were intended to "improve" the design.

To be specific, some of the changes in NASA's Constellation program since ESAS was published include:

### ***1. Crew Launch Vehicle (CLV):***

ESAS recommended that the CLV be designed from the existing off-the-shelf four-segment Space Shuttle Solid Rocket Motor (SRM), and an upperstage that used the existing off-the-shelf Space Shuttle Main Engine (SSME). The ESAS report stated (page 42):

*(The 4-segment Shuttle SRB for CLV) configuration was selected due to its lower cost, higher safety/reliability, and its ability to utilize existing human-rated systems and infrastructure.*

The ESAS report continues (page 492):

*The goal of using the SRB for the CLV is to take advantage of an existing booster with little risk to the manufacturing schedule and cost. Overall, development risk is low with utilization of existing assets and experience. Facilities and hardware risk is low, without significant vendor ramp-up.*

Dr. Scott Horowitz, who was Director of Space Transportation and Exploration for SRB manufacturer ATK Thiokol less than a year ago, called this "Safe, Simple, Soon." Horowitz even set up a website around this mantra<sup>13</sup> before he was hired by Griffin to come to NASA to implement this strategy as Associate Administrator for ESMD. The "Safe, Simple, Soon" argument was explicitly used to eliminate the primary competitors to the "single stick" — minor upgrades of the Defense Department's workhorse Evolved Expendable Launch Vehicles (Atlas V and Delta IV). Not only did the DoD and the White House National Security Council prefer this alternative, but the U.S. Space Transportation Policy took account of this, calling

<sup>12</sup> To clarify the proposed policy, the mission objective is a key discriminator of how the policy applies. NASA would be allowed to launch a Block 2 CEV from Earth to LEO if it is destined for the Moon. The same goes for the return of CEV's from the Moon to Earth.

<sup>13</sup> <http://www.safesimplesoon.com/>

for the White House to make the final decision<sup>14</sup>, since this choice would determine to what extent NASA's plans obeyed the exploration policy's declaration that U.S. exploration efforts should support national security goals (emphasis added):

*The fundamental goal of this vision is to advance U.S. scientific, **security**, and economic interests through a robust space exploration program.*

By January 2006, the NASA bureaucracy had rejected the "Safe, Simple, Soon" approach which was used to kill off the EELV option. Among other things, NASA's bureaucracy chose to change the CLV design to one that used five SRM segments, compared to four segments in the existing Space Shuttle SRM<sup>15</sup>. This was a non-trivial change, as it alters technical characteristics of the CLV.

NASA's own words document that the five-segment SRB option was significantly more costly and risky (ESAS Final Report, page 42):

*... the five-segment (SRB) development added significant near-term cost and risk*

Second, in the hope of reducing operating costs, NASA rejected the use of the existing (but expensive) Space Shuttle Main Engine (SSME), replacing it with an upgraded J2 Apollo-era engine, calling it the J2-X.<sup>16</sup> This change was made despite the fact that a modernized J2 is effectively a brand new engine, with all the cost and risk involved of a new engine (ESAS Final Report, Page 406):

*... the J-2S (is) equivalent to (a) new engine ... due to the length of time that has passed since the J-2 was in production*

Not surprisingly, reports leaking out of NASA suggest that these two changes on the CLV have tripled the development cost from around \$1 Billion to \$3 Billion.<sup>17</sup> Clearly, the CLV is no longer "low cost."

The CLV can no longer claim to be "safe," compared to the Atlas V and Delta IV. In July 2004, Griffin specifically claimed in writing that the CLV was more reliable with a four-segment SRB because the Shuttle SRBs had launched 176 times in a row without failure. But the new design of the CLV has no track record, so it can no longer claim it is "more reliable," which means that the "safe" marketing term is no longer appropriate.

Since the new CLV requires a complete redesign of the SRM segments, and incorporates an upgraded J2 rocket engine that has not been used in a launch for over thirty years<sup>18</sup>, it is also neither "simpler" or "sooner."

So if the CLV is no longer "lower cost," "safer," "simpler," or "sooner," why are we not using an upgraded version of the Atlas V or Delta IV for the CLV instead?

Did NASA use a "bait & switch" tactic to kill off the commercial Atlas V and Delta IV options for CLV? We don't know, but this certainly does appear to be the case. Whatever the case, NASA no longer has a sufficiently good reason to ignore White House policy that we should explore the solar system in a manner that also supports "national security."

**RECOMMENDATION:** NASA should re-open the CLV trade study options, since 1) Much of the original basis for rejecting the Atlas V/Delta IV option is now gone, 2) There is plenty of time to do so if CEV does not go to ISS, and 3) Using the Atlas V or Delta IV for CLV will enhance national security consistent with White House policy.

## 2. Cargo Launch Vehicle (CaLV):

ESAS (and the Griffin-led Planetary Society study before it) recommended a heavy-lift launch vehicle to be similarly designed around maximum use of existing off-the-shelf Shuttle technology. To keep development costs to a minimum, NASA designed the planned heavy-lift Cargo Launch Vehicle (CaLV) around the same tooling that is used for the Shuttle external tank, the existing SSME engines, the use of the existing Shuttle launch pads, and the

<sup>14</sup> See U.S. Space Transportation Policy Fact Sheet 6 January 2005 <http://www.spaceref.com/news/viewstr.html?pid=15010>

<sup>15</sup> <http://www.spaceref.com/news/viewnews.html?id=1087>

<sup>16</sup> <http://www.spaceref.com/news/viewpr.html?pid=20058>

<sup>17</sup> [http://www.nasawatch.com/archives/2006/04/clv\\_cost\\_escala.html](http://www.nasawatch.com/archives/2006/04/clv_cost_escala.html)

<sup>18</sup> [http://en.wikipedia.org/wiki/J-2\\_%28rocket\\_engine%29](http://en.wikipedia.org/wiki/J-2_%28rocket_engine%29)

existing Vehicle Assembly Building (used for both Saturn 5 and the Shuttle).

On May 18, 2005, the NASA bureaucracy officially rejected the use of the existing SSME, choosing to substitute the RS68 engine that is used on the Delta IV to reduce the marginal cost of future CaLV missions.<sup>19</sup> Unfortunately, the RS68 has a much lower specific impulse (ISP), which required NASA to increase the size of the CaLV. To compensate, NASA chose to widen the CaLV from 8.4 to 10 meters in diameter, which requires throwing away the existing tooling used to build the Shuttle external tanks. This change will be significant in terms of development cost.

In summary, the CaLV is now essentially a brand new super-heavy-lift launch vehicle, which has essentially nothing in common with the Shuttle, other than the ASRM segments used to build the SRBs. The CaLV will be an expensive, time-consuming and risky undertaking that has no other use to our nation beyond multi-billion-dollar launches to the Moon or Mars<sup>20</sup>.

Furthermore, the issue of whether or not such a heavy-lift vehicle is the correct strategic path<sup>21</sup> remains unresolved. There are valid arguments on both sides, and this is a hotly debated issue. Fundamentally, the correct answer depends on your objective. If your primary goal is to place humans on the Moon or Mars, as soon as possible in the simplest and lowest risk manner, a super-heavy-lift vehicle is arguably the best answer. However, if your primary objective is to open up the frontier to large numbers of people, or to produce large reductions in launch costs, or to increase competition and create redundant pathways to space, or to create a breakthrough in space commerce for the benefit of humankind, or to settle this new frontier, then logic and history suggests a different choice.

History indicates that regardless of how large a vehicle is designed, payloads ultimately outgrow it. More importantly, such a large vehicle will have

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<sup>19</sup> [http://www.nasa.gov/home/hqnews/2006/may/HQ\\_06226\\_RS-68\\_ENGINE.html](http://www.nasa.gov/home/hqnews/2006/may/HQ_06226_RS-68_ENGINE.html)

<sup>20</sup> CaLV may turn out to be too small for human Mars missions, and those who refuse to consider orbital assembly may demand a larger one for that demanding goal.

<sup>21</sup> For examples of those who oppose the heavy-lift approach, see <http://www.thespacereview.com/article/526/1> and <http://www.thenewatlantis.com/archive/6/simberg.htm>.

high development costs and low flight rates. Although the marginal costs per pound are lower than comparable expendable launch vehicles, it is still extremely expensive. Creating an “architecture” that is dependent on a huge launcher with low flight rates locks us into a system that will have high launch costs into the foreseeable future.

Many U.S. companies have proposed methods of human planetary exploration that don’t require heavy lift, and instead develop and utilize orbital propellant storage and assembly techniques. Some of these methods were being evaluated by NASA in the Concept Exploration and Refinement (CE&R) program, under Sean O’Keefe and Admiral Steidle. Such techniques are the foundation of a truly space-faring nation, and orbital propellant delivery in flexibly sized increments would offer a vital and large market for the further development of private space transportation providers, in a manner similar to the airmail subsidy that spurred the early airline industry.

However, Dr. Griffin came to NASA with his mind already made up on this issue.<sup>22</sup> ESAS essentially ignored the many interesting concepts and analysis developed by the CE&R contractors.

Overall, the major implications of NASA’s plans, and ongoing changes to its plans, include:

- 1) The United States will have a much larger gap in human spaceflight than NASA is willing to admit.
- 2) ESAS will fail at its goal of repeating NASA’s glory days of Apollo by attempting to implement an “Apollo on Steroids” program.

First, repeating Apollo is not a good thing, even if we could. The design choices made in Apollo were based on the need to beat the Soviets to the Moon, and NASA was given an order to “waste anything but time.” But as the president said in his speech, VSE is not a race, but a journey. We should not blindly follow the path of a successful program designed for one set of circumstances, but which was not designed for affordability or sustainability.

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<sup>22</sup> For examples, read Griffin’s lecture on the subject from 2001 at <http://fti.neep.wisc.edu/neep533/FALL2001/lecture29.pdf> and his October 6, 2003 and March 10, 2004 congressional testimony at <http://www.spaceref.com/news/viewstr.html?pid=10683> and <http://www.spaceref.com/news/viewstr.html?pid=12151>.

Second, the amazing and innovative NASA of the Apollo days is long gone. To paraphrase Santayana, since NASA (and our elected leaders) have not learned from history, it is doomed to repeat it. This NASA gave us the Space Shuttle and the Space Station, both significantly over budget and behind schedule, and have yet to meet any major promises made by NASA to U.S. politicians and taxpayers. This NASA gave us the serial fiasco of SLI, OSP, CTV, and CRV, which demonstrated NASA's tendency to spend large amounts of money to keep changing the design, year after year, before canceling the program. This NASA is in the early stages of failing to implement the Vision for Space Exploration in an affordable and sustainable manner, and will fail unless we do something different ... and soon.

### **Stimulating Development of Earth-to-Orbit Transportation and Buying the Service**

The essence of the recommendations by the President's Commission on Earth to Orbit transportation is that NASA should be buying these services commercially. The problem is the services NASA wants are not currently commercially available from a US provider. This creates a choice between either purchasing services from abroad, and/or stimulating the development of the desirable capability domestically.

Stimulating desirable activity from the private sector is a very common goal for Government, and there are a variety of well-established methods. It is important to note that NASA currently has neither the in-house expertise nor the legal authority<sup>23</sup> to make use of some of the standard methods. Congress, on the other hand, has access to the legal authority, and U.S. industry has access to the expertise.

This is a situation where NASA needs to go to Congress and non-traditional U.S. industry with the problem, and ask for a solution rather than providing one based on its "limited" in-house expertise.

In the next section we briefly discuss three of the possible methods. There are several other approaches with a good history of success that we do

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<sup>23</sup> There is a limit on the size of prizes that NASA can offer. NASA needs the approval of Congress to offer the larger prizes that are suitable for stimulating Earth-to-orbit transportation.

not discuss, but which may be applicable to the current situation, including tax credits, tax holidays ("Zero G, Zero Tax") and vouchers (or voucher-like forward purchase commitments.)

### **Three Methods: Demonstrators, Commercial Launch Services and Prizes**

All three proposed approaches to enable commercial services – one of which NASA is pursuing – take advantage of a proven process called "capitalism." America is the most powerful nation on this planet because we are better capitalists, not because we are better at bureaucracy. We lead or dominate almost every high-tech industry on this planet where free enterprise and free trade is allowed to reign. It is time to extend the power of free enterprise capitalism to space.

Demonstration programs involve funding technical approaches to the point where there is confidence that the developer can, when given a firm fixed price contract, actually deliver the required service. That is what NASA's Commercial Orbital Transportation Services (COTS) program is doing.

COTS is actually one of the few things that NASA is doing that is consistent with the VSE's emphasis on "economic benefit" and the recommendations of the President's Commission. That said, while the Foundation praises Dr. Griffin for championing COTS, it is a small tactical add-on to NASA's exploration plan, not the central strategic thrust it should be. The COTS budget of \$500 million over four years is less than 1% of NASA's budget over the same period, and less than 5% of exploration spending. This small investment is hardly commensurate with a mandate to "*decisively transform ... NASA's relationship to the private sector.*" Nor is it sufficient to minimize the gap in U.S. human spaceflight.

At the same time, NASA has acknowledged that it received excellent COTS proposals from U.S. companies.

*"We've been very pleased with the quality of the proposals we've received."* – James Bailey, COTS Agreement Officer<sup>24</sup>

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<sup>24</sup> <http://www.msnbc.msn.com/id/12706352/>

"NASA was extremely pleased in the quality of the proposals received and is expected to announce the final selections later this summer," - NASA spokesman Michael Braukus<sup>25</sup>

Clearly NASA received many quality COTS proposals. Some high-quality proposals did not even make the final round of six COTS competitors. This eliminates the excuse that there were not enough good opportunities to justify a larger COTS investment.

Another under-funded NASA effort that we applaud is Centennial Challenges, a prize program. While we are not among those who believe that prizes are the answer to every problem, stimulating development of reliable, affordable and safe Earth-to-Orbit transportation could greatly benefit from well-crafted and sufficiently funded prizes<sup>26</sup>.

It is NASA's "stated" intention to purchase services commercially from any US provider as soon as they are ready to deliver. However, NASA's huge investment in CEV Block 1 is a significant reason for entrepreneurs and investors to be skeptical that any such purchases will ever happen. The direct funding of a government competitor frightens away potential service providers, professional investors, and therefore reduces the likelihood that the desired commercial services will actually show up. Consistent with this, the Foundation notes that NASA has significantly cut the projected budget for ISS crew and cargo services after 2010<sup>27</sup>, to pay for CEV and CLV.

More to the point, however, NASA could buy commercial services today from U.S. providers. True, no U.S. company has already fully developed and demonstrated the service, but there is every reason to believe they could in response to a commercial-style request for proposals. Private

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<sup>25</sup> <http://www.newscientistspace.com/article/dn9149-space-station-supply-vessel-contenders-revealed.html>

<sup>26</sup> A serious Earth to orbit prize, with passengers as the payload, would be well in excess of \$100M.

<sup>27</sup> Originally, the ISS crew and cargo services budget was projected to grow to nearly \$1 billion per year after the Shuttle retired. In the most recent (FY07) NASA budget proposal, the projected budget for ISS crew and cargo services for was reduced to \$375 million from the nearly billion dollars in previous projections. See "SAE ESMD 2-14" of the NASA FY07 budget proposal, at [http://www.nasa.gov/pdf/142458main\\_FY07\\_budget\\_full.pdf](http://www.nasa.gov/pdf/142458main_FY07_budget_full.pdf)

industry purchases new services like this all the time. Meanwhile, NASA is buying ISS crew and cargo delivery services, but only on a sole source and non-competitive basis from foreign governments, in particular Russia. The fact that NASA is not allowing U.S. industry to compete with foreign governments on a level playing field today does not bode well for allowing COTS or prize winners to sell commercial services to NASA tomorrow.

One of the lessons from private industry, that almost every high-tech investor understands, is a policy called "diversification." It is an almost universal rule of venture capitalists and other sophisticated high-risk investors that you never place all your eggs in one basket, or even two or three baskets. In general, venture capital funds invest in about ten different companies, with the expectation that they will have their share of strikeouts, will hit a few singles, a couple of doubles, and one home run. The problem is that \$500M is barely enough for two under-funded COTS winners, or three very under-funded COTS winners (increasing the chance that all of them will fail).

Let's review Recommendation 3-1 (emphasis added) of the President's Commission:

*The Commission recommends NASA recognize and implement a far larger presence of private industry in space operations with the specific goal of allowing private industry to assume the primary role of providing services to NASA, and most immediately in accessing low-Earth orbit.*

If NASA were seriously following this recommendation, NASA would invest more money in prizes and COTS than it is spending on building a competing vehicle for low Earth orbit missions. If NASA was serious, it would issue a request for commercial service proposals today as a way to assure developers of Earth-to-Orbit launch services that the Agency is really going to buy such services at a price high enough to justify the substantial private investment that is required.

But the exact opposite is true. NASA is spending an order of magnitude more money on sending the CEV to ISS than it is investing in COTS and Centennial Challenges combined. Dr. Griffin claims that he hopes that COTS will work, but that he needs to

fund NASA vehicles to go to ISS as an “insurance policy” against the possibility that COTS doesn’t work. But most insurance policies are a small amount of the value of the thing being insured. NASA’s budget priorities seem to turn the traditional concept of insurance on its head, and demonstrates very little confidence in the private sector on Dr. Griffin’s part. The best “insurance” is to invest in a portfolio of private sector approaches to COTS as previously suggested, consistent with the general practice of venture capital funds.

It is not only unfair, but it also ineffective, for the U.S. Government to demand that private firms and private U.S. investors put their own private investment capital at risk to build a system that must directly compete with a government vehicle (e.g. CEV Block 1) that, in comparison, has a “blank check” of taxpayer money to spend. This is a double problem for those markets, such as ISS cargo delivery, where NASA is the only existing customer<sup>28</sup> in the market.

What message does NASA’s direct funding of a competing government system, at an order of magnitude higher level of funding, send to private investors who have been approached by NewSpace firms about COTS? That NASA is not serious about commercial approaches to exploration. This is not decisive transformation of NASA’s relationship with the private sector.

This white paper recommends a change in NASA’s budgetary priorities to implement a decisive transformation of NASA’s relationship with the private sector.

**RECOMMENDATION:** The U.S. government should immediately transfer several billion dollars from CEV and CLV to pay for an additional round of COTS, for larger prizes, and service purchases.

Why should the U.S. Government do this?

For a very simple reason. Not only is capitalism our nation’s best hope of minimizing the gap in U.S.

<sup>28</sup> By this we mean that NASA is well over 99% of the proven market for ISS cargo delivery that is accessible to potential U.S. ISS cargo delivery suppliers. The European, Japanese, and Russian markets are not accessible.

human spaceflight, but a much larger role for private industry in the VSE is the only hope for a “sustainable” and “affordable” American mission to explore, develop and settle the solar system. The President’s Commission understood this well. NASA apparently does not.

### ***Fixing the “U.S. Human Spaceflight Gap” Problem is Easy***

The development of the CEV is broken into phases, or “blocks”<sup>29</sup> as NASA calls it. Upon examination, the organization of the CEV program makes proposing a solution quite easy.

CEV “Block 1” is the design for a CEV for ISS and Earth orbital missions. CEV Block 1 is the spacecraft that will be developed under the current competition, with contracts expected in September of 2006. CEV Block 1 is also the primary new program that is draining NASA funding over the next 5 years from technology investments, science, aeronautics and now COTS.

The “vehicle” that NASA was explicitly authorized to “develop” by the White House is CEV “Block 2,” not “Block 1.” The Block 2 version of the CEV is explicitly designed for lunar missions. This is the real CEV that the White House intended NASA to “develop” as it will transport humans from Earth to the Moon, which is a much different mission than going to ISS.

Yet, NASA is planning to spend many billions in additional taxpayer dollars to develop both block versions of the CEV. The NASA ESAS Final Report is filled with design conflicts between a CEV that goes to the Moon, and a CEV that must go to ISS (under much schedule pressure).

NASA should be designing a simpler CEV that is solely for missions beyond Earth orbit. Instead, NASA is making decision after decision that increases both the cost and complexity of CEV so the same vehicle meets both the unique requirements of the ISS, as well as the Moon. Every time this happens, the CEV becomes a little less optimal for exploration and less likely to be completed at any cost.

<sup>29</sup> <http://www.astronautix.com/craft/cevcm.htm>

We will provide two examples to illustrate the overall problem — the CEV vs. APAS docking system trade-off, and the NTO/MMH vs. LOX/Methane trade-off.

### **CEV Docking Systems (APAS vs. LIDS):**

The ESAS Final Report clearly states that neither the “Androgynous Peripheral Adaptor System” (APAS) docking system, nor any other existing docking or berthing system works well for beyond Earth orbit exploration vehicles<sup>30</sup>. Instead, the ESAS recommended<sup>31</sup> that CEV use a new docking system called “Low Impact Docking System” (LIDS) that has been in development since the early 1990s.

Unfortunately, this created a problem, which was only a problem because NASA wanted the CEV to go to ISS. There were no LIDS docking ports at ISS. As a result, ESAS recommended that the ISS APAS ports be converted to LIDS to allow the CEV to dock to ISS. From ESAS, pages 308-309:

*...after assessing the inability of the APAS to meet CEV and exploration requirements, it is recommended that the LIDS mechanism be incorporated onto an adapter, enabling near-term CEV/ISS use.*

However, this ESAS recommendation created another problem for a different part of NASA. How do you convert an APAS port to a LIDS port? You take up an APAS-to-LIDS port converter on a Shuttle flight.

Sources in NASA’s ISS program in November of 2005 reported that this solution had major problems. One problem was reportedly the requirement of another Shuttle flight, which costs at least a billion dollars because NASA has to account for the additional fixed costs of the shuttle as you extend the entire Shuttle program life. Another problem was the Shuttle retirement date of 2010, which created huge schedule pressure on finishing the design, development and construction of LIDS.

So it should come as no surprise that the ESAS strategy for converting ISS to use LIDS was cancelled within a few months after the ESAS

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<sup>30</sup> See ESAS Final Report, pages 306-307, [http://www.nasa.gov/mission\\_pages/exploration/news/ESAS\\_report.html](http://www.nasa.gov/mission_pages/exploration/news/ESAS_report.html)

<sup>31</sup> See ESAS Final Report, page 38.

report. Instead, the NASA bureaucracy mandated a different solution — that Block 1 of the CEV use APAS, while Block 2 of CEV will use LIDS. As a result the CEV bidders were told to propose a CEV design that can incorporate two completely different docking systems.

Simple? No way. Low-cost? Not a chance.

If this decision appears complex, the next bureaucratic design change — all in the name of making sure the CEV can go to ISS — makes the docking port issue look minor.

### **CEV Engines (NTO/MMH vs. LOX/Methane):**

One of the key recommendations of the President’s Commission, which all parts of the U.S. Government agree on, is the recommendation on affordability. One of the keys to long-term affordability is the use of *in situ* resources at the Moon, Mars or wherever you go.

The Space Studies Institute<sup>32</sup>, founded by Dr. Gerard O’Neill, was one of the earliest advocates of *in situ* resource utilization (ISRU), showing how the use of lunar materials could provide huge reductions in the cost of cis-lunar activities. The most important lunar *in situ* resource is oxygen<sup>33</sup>. Even the President’s Science Advisor, Dr. John Marburger, has talked<sup>34</sup> about the value of oxygen as a lunar resource, stating:

*The greatest value of the Moon lies neither in science nor in exploration, but in its material ... The production of oxygen in particular, the major component (by mass) of chemical rocket fuel, is potentially an important Lunar industry.*

More recently, the benefits of ISRU was re-introduced to a new generation by Dr. Robert Zubrin of the Mars Society,<sup>35</sup> most particularly in showing how ISRU (via CO2 in particular for early missions,

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<sup>32</sup> <http://www.ssi.org/>

<sup>33</sup> For more information on this subject, we suggest reading the congressional testimony by Foundation advisor Dr. John Lewis at <http://www.house.gov/science/hearings/space04/apr01/lewis.htm>

<sup>34</sup> Speech to 44th Annual Goddard Symposium, March 15, 2006. See <http://www.ostp.gov/html/jhmGoddardSymp03-15-06Release.pdf>

<sup>35</sup> <http://www.marssociety.org/>

for Methane engines) was critical to lowering the cost of humans on Mars. In general, there has been broad and deep agreement within the space community for some time that ISRU is critical to human expansion into the Solar System. So, it was not news when the ESAS study concluded that a LOX/Methane engine was best for the CEV. The ESAS Final Report stated (page 569):

*The LOX/methane system was desirable from a performance perspective and also to eliminate the operability issues related to hypergols and to enable the use of in-situ methane on Mars and oxygen on the Moon and Mars.*

The ESAS conclusion was not really a surprise as Administrator Griffin disclosed the decision to use LOX/Methane when he talked about its advantages in September 20, 2005 in a news conference<sup>36</sup>:

*"The LOX/methane combination offers quite a lot more performance capability than the storables that you were talking about in your question with, we believe, no additional risk. In fact, overall, we think the system will be safer."*

The ESAS team conducted a detailed trade study between LOX/methane and the major existing alternative, which is the hypergolic bi-propellant of Nitrogen Tetroxide (NTO) plus Monomethyl Hydrazine (MMH). ESAS concluded (page 115) that LOX/methane had many significant advantages, and only one downside (which we underline for emphasis).

*LOX/LCH4 is a clean-burning propellant combination. ... LOX/CH4 does offer higher Isp performance compared to state-of-the-art storables (i.e., NTO/MMH), without the volume increase that is common with LOX/LH2 systems, which results in an overall lower vehicle mass as compared to MMH/NTO propulsion systems. A LOX/LCH4 system uses less power, on the order of 1,000 watts less power, than comparable MMH/NTO propulsion systems, thereby significantly reducing the mass of the spacecraft power system(s). ... LOX/CH4 propulsion systems offer significant gains in spacecraft performance, and the risks of developing a LOX/CH4 system*

*appear to be manageable. However, the tight development schedule for the CEV puts the successful development of a LOX/CH4 system for the SM at risk.*

The only reason there is a "tight development schedule for the CEV" is because NASA has decided it needs the CEV at ISS. Even so, ESAS concluded that the schedule risk was manageable, and recommended LOX/Methane be the baseline in all versions of the CEV.

You can guess what happened. In less than two months, on January 11, 2006<sup>37</sup> the NASA bureaucracy eliminated LOX/Methane in the CEV. The reason, as stated in the CEV "Call for Improvements" was (emphasis added):

*NASA desires to streamline CEV development, production and operations to meet a first crewed test flight as close to 2010 as possible, but no later than 2012, without compromising safety.*

So, we are now in a situation where everybody agrees that ISRU is critical to the VSE, and that LOX/Methane is by far the best fuel/oxidizer combination for the CEV, which is supposed to be for human missions beyond Earth orbit.

But, instead, NASA is designing the initial version of the CEV with a sub-optimal fuel/oxidizer engine because NASA has created phony schedule pressure by choosing to send the CEV to ISS.

### Conclusion on CEV:

NASA is currently designing, and preparing to build, two substantially different spacecraft. One for ISS missions, and another for missions beyond Earth orbit. Although CEV Block 1 and CEV Block 2 will have some commonalities, the extra cost of designing, building and testing these two different spacecraft (as opposed to just one that would go directly to the Moon) will be measured in many billions of dollars and many years of additional development time. Only NASA might tell us how many billions extra it will cost the taxpayer to design two different versions. But the leaks<sup>38</sup> coming out of NASA already report a \$10-15 billion increase in program costs for ESAS as a whole. How much of

<sup>37</sup> <http://prod.nais.nasa.gov/cgi-bin/eps/sol.cgi?acqid=117013>

<sup>38</sup> [http://www.nasawatch.com/archives/2006/07/cev\\_cost\\_climbi.html](http://www.nasawatch.com/archives/2006/07/cev_cost_climbi.html)

<sup>36</sup> <http://www.spaceref.com/news/viewsr.html?pid=18122>

this is due to CEV is unknown, but it surely is not zero.

Why is NASA doing this?

It is commonly understood in public choice economic theory<sup>39</sup>, which has resulted in several Nobel Prizes in the last two decades (Buchanan<sup>40</sup>, Stigler<sup>41</sup>) that a public agency, left to its own devices, will bend its funds and mission toward its own self-interested institutional ends.

The “Concise Encyclopedia of Economics” explains why “Public Choice Theory”<sup>42</sup> is directly relevant to this white paper.

*... public choice economists point out that there also is such a thing as "government failure." That is, there are reasons why government intervention does not achieve the desired effect.*

*... In addition to voters and politicians, public choice analyzes the role of bureaucrats in government. Their incentives explain why many regulatory agencies appear to be "captured" by special interests. (The "capture" theory was introduced by the late George Stigler, a Nobel Laureate who did not work mainly in the public choice field.)*

Despite the many good and good-willed people who work at the agency, there is nothing about NASA that exempts it from this iron law. In any event, it is certainly not because the White House or the President’s Commission has directed NASA to do this. In fact, as already described, the President’s Commission clearly stated that NASA should get out of the business of conducting operations in low Earth orbit. In fact, some Members of Congress have recently called on NASA to use the COTS program to eliminate the gap in U.S. spaceflight.<sup>43</sup>

Simultaneously with NASA spending many billions on a spacecraft that is unnecessary and which they have not been directed to build, the agency is “eating

its seed corn” by cutting the five-year budget plans for space science, aeronautics, and advanced space technologies, with potentially devastating effects on future national competitiveness.

The Foundation finds this unacceptable, and recommends in the strongest terms that it be fixed.

**RECOMMENDATION:** The U.S. Government should immediately cancel all plans for, and work on, CEV trips to the ISS. Instead, NASA should refocus its limited resources on development of a CEV that will go to the Moon, consistent with White House policy to “develop vehicles for missions beyond our orbit.”

This means canceling Block 1 of the CEV. The benefits of doing this would be enormous. It would:

1. Help NASA succeed, by focusing NASA on the original streamlined mission that it was given by the White House, which is “beyond our orbit.” A streamlined focus will:
  - a. Simplify the design of the “beyond Earth orbit” CEV (Block 2)
  - b. Clarify what NASA’s ESMD division should be doing (which does not include activities in low Earth orbit)
  - c. Significantly increase the probability that NASA will succeed at putting humans on the Moon by 2020, affordably
2. Free up many billions-of-dollars in funding in the next five years that can be used to:
  - a. Pay for a much larger and aggressive COTS program, which is our best chance to “minimize the gap” in U.S. human spaceflight
  - b. Allow NASA to put billions-of-dollars back into space science and technology
  - c. Allow Congress to put significant funding back into aeronautics
  - d. Eliminate the need for raids by ESMD on the Shuttle and ISS budgets
3. Enforce the recommendation of the President’s Commission that “NASA’s role must be limited

<sup>39</sup> <http://www.econlib.org/library/Enc/PublicChoiceTheory.html>

<sup>40</sup> [http://en.wikipedia.org/wiki/James\\_M.\\_Buchanan](http://en.wikipedia.org/wiki/James_M._Buchanan)

<sup>41</sup> [http://en.wikipedia.org/wiki/George\\_Stigler](http://en.wikipedia.org/wiki/George_Stigler)

<sup>42</sup> <http://www.econlib.org/library/Enc/PublicChoiceTheory.html>

<sup>43</sup> [http://www.space.com/spacenews/archive06/Kbhside\\_052906.html](http://www.space.com/spacenews/archive06/Kbhside_052906.html)

*to only those areas where there is irrefutable demonstration that only government can perform the proposed activity.”*

4. Allow NASA to keep both Shuttle launch pads (39A and 39B) in operation through 2010 for the remaining Shuttle launches. Because of the pressure to “minimize the gap” NASA is planning on starting the conversion of one of the launch pads as early as 2007, which will have significant impacts on Shuttle launches.<sup>44</sup>

The benefits to eliminating the need to change over one of the pads in the next few years includes:

- a. It frees up near-term funds for science, shuttle, station, aeronautics, or COTS
- b. It will remove a schedule constraint to Shuttle launches, thereby possibly accelerating the assembly of ISS and increasing safety
- c. It will allow the availability of an emergency Shuttle launch (called STS-300) for the Hubble Space Telescope (HST) repair mission, even if the HST repair mission is delayed. (Currently, the HST mission is the only remaining Shuttle mission that does not have a safe haven for the crew.)

## Conclusion

Based on the facts, we have sadly concluded that NASA’s implementation of the President’s Vision for Space Exploration is already failing, and bound to get worse. One definition of insanity is doing the same thing over and over again, and expecting different results.

Does anybody expect different results from NASA after the Shuttle and Space Station? It is time for our nation to do something different. It is time for the U.S. government to implement the recommendations of the President’s Commission, and force NASA to “decisively transform” its relationship with the private sector.

A \$500 million investment in COTS as the primary means of delivering crew and cargo to ISS, considering the billions of dollars that NASA plans to spend on CEV Block 1 as an “insurance policy,” and the \$2 Billion in reported cost increases incurred by the CLV, is **not** a decisive transformation, it is business as usual. Expecting this to work is insane.

The Foundation recommends that CEV Block 1, which is focused on ISS, be cancelled immediately.

The Foundation recommends that the CLV be delayed consistent with CEV Block 2 and that the Atlas V & Delta IV be reconsidered because of the national security and taxpayer benefits, and the large jump in the cost estimates of the CLV program.

The Foundation recommends that several billion dollars of the near-term savings be used to create an additional COTS competition, to create larger space transportation prizes, and for service acquisitions.

If there is going to be a Vision for Space Exploration that succeeds at its stated goals, which lasts for a generation, and which continues through a dozen congresses and several more Presidents, then NASA’s implementation needs to be radically revised.

The Houston Chronicle, the hometown newspaper of the NASA Johnson Space Center, clearly understood the fundamental problem when they wrote an editorial on May 30, 2006 (emphasis added):

*NASA should develop a long-range strategy to harness the engine of free enterprise for the exploration of space, with government providing regulatory oversight, while allowing private partners in the pilot's seat. After all, a formula that made the United States the most powerful nation on Earth should work just as well on the moon and beyond.*

America gets it. We are the land of the free, and the most powerful nation on Earth, because of free enterprise. Let us reflect this truth in our space activities. A half a century after taking the dead-end state socialist road of Apollo, let us choose a different path. Let us open the new frontier with those same values that have made our nation so great in the past.

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<sup>44</sup> [http://en.wikipedia.org/wiki/Launch\\_Complex\\_39#LC-39B\\_28Post-Shuttle.29](http://en.wikipedia.org/wiki/Launch_Complex_39#LC-39B_28Post-Shuttle.29)

## APPENDIX: Assuming Nothing Changes, Our Prediction

What will happen if NASA stays the course? It is quite easy to make some specific predictions about the future, when all we are doing is repeating the past. We feel no joy in making these predictions. There is no profit in being right. In fact, it makes us quite sad. But we will say what must be said. As the saying goes “Fool me once, shame on you. Fool me twice, shame on me.”

We are not being sarcastic in making these predictions. We challenge supporters of the current NASA strategy to make a similar set of “specific” predictions, and post them online, so they can be compared to ours as events unfold.

We don’t want to be right. We want to see the permanent human settlement of space in our lifetimes.

Assuming nothing significant changes, we predict:

- NASA will attempt to delay and avoid reporting to the public and Congress on the increasing costs in the Constellation program (CEV, CLV and CaLV). NASA public statements on the Constellation program will be characterized by a distinct lack of cost information.
- In spite of NASA’s best efforts to keep it quiet, there will be a constant trickle of news about mounting costs by the increasing number of blogs with access to NASA information. The Internet empowers and frees, and is the enemy of bureaucracy.
- As NASA’s credibility deteriorates, serious space reporters will increasingly ask NASA executives questions about cost (affordability) and schedule (sustainability)
- The Constellation Program will (continue) to eat the budgets for science, COTS, aeronautics, and other NASA activities
- The CEV will be overweight, and over budget
- To fix the CEV weight problems, the capabilities of the CEV will be reduced, or the size and cost of the LVs (CLV and CaLV) will be significantly increased

- The near-term CEV schedule will slip to the right
- The gap in U.S. human spaceflight will increase. There will be no U.S. government human presence in space in 2014 (unless COTS succeeds, which is possible but unlikely with only two-three under-funded winners.)
- There will be no US government presence on the Moon in 2020
- There will be no US government presence on the Moon in 2025
- There will be no US government presence on the Moon in 2030<sup>45</sup>
- Public support for a civilian space program will continue to decline
- Seeing all this, the next Administration will decide to go in a different direction in 2008
- Twenty years from now the VSE will be little more than a footnote in a history book

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<sup>45</sup> Don’t laugh. We are serious about this prediction. Even if you don’t think this is likely, we believe you will have to admit that it is certainly possible. Remember, this is the NASA that sold the White House and Congress on a huge space station that would be built in “a decade” for \$8 Billion. It is now over 20 years later, the station is only half assembled, it is many times the original cost projection, and it is small shadow of the original station that NASA once promised. A 10+ year delay in our return to the Moon, with huge cost overruns, is an easy prediction to make.