**Subject: The Connection between Human Space flight; Economic Recovery; and Global Climate Change Remediation**

**Public Comments by: George A. Eastman**

## Introduction:

I would like to thank the Committee for this opportunity to submit my comments regarding future human space flight planning for your consideration.

I am a child of the nuclear age, being born in the same week as the first A bomb. I first acquired my interest in all things aviation watching the impressive WWII bombers pass low over our hilltop farm. Later I found that our farm was directly under the primary west coast airway south from Seattle used by these bombers in the early 50's. I missed the early flights of Apollo while serving in Vietnam with the NAVY. Later I was compensated for missing early Apollo flights when NASA helped me celebrate my 24th birthday on July 20 1969 with the Apollo-11 landed on the Moon.

I am an electrical engineer with nearly 40 years of experience designing missile guidance test systems and spacecraft ground support equipment. While at university I collected data on the Space Transportation System architecture evolution for an essay assignment. I watched, with great interest, as the shuttle development GAP evolved, including the inability to save Skylab. I have continued to observe the STS program through initial flight and the subsequent tragic losses (witnessed on the live NASA satellite feed). Now I am nearing retirement, along with the shuttle. During the last decade of my career I have participated in 28 commercial launch campaigns.

The parallels I see in the current plans for Shuttle retirement, compared to my memory of the loss of our Saturn V heavy lift Technology in the early 70's, trouble me greatly. It seems history is repeating itself. I am also disturbed by the ineffective way NASA has performed its primary role in the development of aerospace technology, and science. I fear NASA may be so preoccupied with its current manned space flight crises that it fails to sustain a viable role in identifying, and solving our future challenges, and attracting new engineering talent.

## Some History:

The STS we see now only resembles its early precursor concept as it is landing. The STS concept dates back to the 1920's with Eugen M. Sänger, who later proposed a winged two-stage configuration in 1963. The technology to achieve a fly back first stage, with its inherent safety features, may have been achievable for a small orbiter, but that path was not taken. The fully reusable winged concept, and many other permutations were considered. Ultimately the present configuration evolved when the DOD and commercial payloads were piled on to attract greater development funds. Requirements and configuration creep resulted in an orbiter lacking a safe fly back option, but management clung to their paper safety analysis up to the loss of Challenger[1]. The first flights had in-effective ejection seats[2], to give an illusion of safety (*STS-1 flew manned*).

---

[1] Feynman on STS reliability: "For a successful technology, reality must take precedence over public relations, for nature cannot be fooled."
http://science.ksc.nasa.gov/shuttle/missions/51-l/docs/rogers-commission/Appendix-F.txt

[2] Orbiter ejection seat limitations:
http://sci.tech-archive.net/pdf/Archive/sci.space.history/2006-03/msg00883.pdf

The original orbiter was envisioned as the low orbit transport element of a far-reaching long-term space infrastructure presented in 1969 to President Nixon. This multi-element infrastructure was expected to use our nearly operational nuclear engine technology to power a reusable interplanetary transfer vehicle for Moon and Mars missions. Once launched it would orbit between earth and its mission destinations. The heavy lift capacity needed to get the reusable nuclear stage into orbit was to be based on the fully operational Saturn V technology. After investing nearly 1.4 billion from 1955 to 1972 on nuclear propulsion alone (*then year dollars*), both the heavy lift and interplanetary portions were scrapped. Only the orbiter remained, limiting us to low earth orbit.

The Ares 1 & 5 are following a similar development coarse where they now bare little resemblance, at the critical component level, to the original proposed configuration. The Moon and Mars planning is being cut to save money for a stubborn attempt to save the fundamentally flawed Ares 1. The STS suffered from requirements and configuration creep, justified in the name of development cost. The equivalent requirements and configuration creep being seen with the Constellation architecture is driven by a simplistic safety assessment.

**Ares 1 is pursuing a false dream under schedule pressure, as was done in the 70's with STS**

NASA has deviated significantly from the original VSE interpretation voiced by the 'President's Commission on, Implementation of United States Space Exploration Policy'[3]. The nature of this deviation, and a prediction of the current outcome, was presented in a Space Frontier Foundation[4] white paper in July 2006. The very existence of your committee affirms the predictions made three years ago.

I was pleased to find two members of your committee participated in the 'President's Commission'. General (ret.) Lester L. Lyles served as a member of the commission, while Mr. Augustine is listed as a witness. This first hand participation gives your committee added insight into the original intent of the VSE.

The VSE 'Presidents commission' called for maximum utilization of the current STS heavy lift capability, using commercial vendors to develop the launch system architecture. NASA chose to perform its own study and go its own direction, ignoring most of the mandates of the VSE commission. ESAS adopted a simplistic approach to safety that separates the crew from the payload by launching them on dissimilar launch vehicles. These two designs attempted to utilize STS components in configurations totally outside their optimum envelope, causing neither to achieve target predicted performance margins. As STS components were shed or redesigned we now have two totally new under performing development launchers with no safety history. NASA has taken on the detailed system design task for the Constellation program and is repeating many of the learning curve difficulties previously faced by the US space program in the late 50's.

[3] VSE 'President's Commission' June 2004: www.nasa.gov/pdf/60736main_M2M_report_small.pdf

[4] Frontier Foundation 'Unaffordable and Unsustainable?': http://www.lrt.mw.tum.de/documents/Interessierte/Space_Frontier_Foundation_White%20Paper_25Jul06.pdf

It only takes one overlooked safety issue to torpedo the safety estimates for a new, or even operational system. The Ares 1 configuration results in an operating envelope totally outside any previous launch experience. One extreme aspect is the highest dynamic pressure ever seen, driving many aspects of the launcher design. This excessive pressure, coupled with the inability to gracefully terminate first stage thrust, is the primary limitation on escape system performance[5]. The stress caused by the resulting larger LAS has a negative impact on the Orion capsule design. The classic shuttle derived configurations have a more benign dynamic environment, leading to improved effectiveness of both the escape system, and the Orion, improving their safety margin.

Public attention on the current GAP is only a hiccup in the long-term view. President Nixon selected the perceived low cost path, which had a fundamental safety flaw. Development difficulties with the new configuration created a 70's GAP. In hindsight his choice was very costly in safety, dollars, and capability. If our current effort to deal with this manned space flight GAP does not result in a sustainable, and flexible path to future advances in aerospace, energy sources, and propulsion development, it will poison NASA's ability to achieve viable solutions to key long-term issues, with a cascading impact well beyond NASA. In the long-term, NASA needs to have a rich field of development projects supported with un-interrupted funding. A small percentage of this basic research will advance to enable future systems architectures.

**The first bump in the path: Check The Requirements**

To reach the future NASA must overcome the present GAP. Years have been squandered with failed attempts to fashion a slick Shuttle replacement. Now we have run out of time, and money. You should take this opportunity to revisit the VSE, and the associated 'Presidents Commission' recommendations. Take a fresh look at the primary requirements and contemplate their current viability, along with the associated implementation interpretations. The original VSE commission stressed the value of staying close to the present STS configuration, components, and infrastructure to minimize un-proven new development efforts, and leverage our investment and workforce. NASA chose not to take this path and we now have a costly gap. The ESAS also appears to suffer form over specification, like many of the failed STS replacement programs, and the ISS. Some would argue to blindly stay the course, on paper Ares 1 was the safest concept ever conceived. A parallel can be made: the Titanic was considered unsinkable! Sustainability can be balanced with safety if the separation plain for the crew module is placed well above the payload using a single core vehicle design.

A way past this first hurdle must be found that preserves the NASA budget and future effectiveness. Many options have been conceived, and presented, by a wide range of talent. The committee needs to collect several teams of reasonably unbiased experts, and experienced graybeards with a mix of experience and evaluation methods. Task each team to analyze all proposed options and rank the relative performance of each. At this early stage this approach will not produce absolute rankings, the best evaluation method will only come with hindsight. The resulting multiple viewpoints will provide better relative comparisons than direct comparison of the predictions from each entrant, all developed with differing methods and experience bases.

---

[5] Constellation LAS data:
http://ntrs.nasa.gov/archive/nasa/casi.ntrs.nasa.gov/20080013374_2008012897.pdf

**Recommended Approach: Back to Basics**

NASA must transform itself from an overburdened launch services provider, back to a center for the development and demonstration of advanced ideas in aeronautics, space, and planetary sciences. These advancements must be perceived by the public as beneficial to identifying and helping solve our current world problems, not just narrowly focused on exploration for its wonder alone. LEO operations should be transitioned to COTS launch service providers, while NASA manned efforts transition to exploration.

NASA has taken a wrong turn in its attempt to develop its own detailed design. NASA has not had a cohesive team of rocket designer's sense Dr. Wernher Magnus Maximilian Freiherr von Braun left in 1972. Detailed rocket design talent now resides in the US commercial firms that designed, and operate the current EELV systems. NASA should concentrate on its heavy lift mission requirements and contract out the integration, detailed design, and production of a flexible core launch system. Once the core capability infrastructure is operational, a government facility / commercial operator arrangement should be used to perform the launch services operations. This organization should accept missions from all users, even foreign partners, with the US payloads retaining priority status. This will unload the NASA budget for exploration missions, technology, and science, while increasing the launch rate, experience, safety, and lowering cost.

**The path to the future: Adopt a Sustainable Technology Development Environment**

Many elements of any advanced space exploration system have the potential to address current environmental drawbacks of our society, but they need to be demonstrated to the world in a way that is apparent to the general public. Do not dwell on the past; adopt a long-term plan to develop significantly advanced systems that will enable our path to Mars, and beyond. The current generation, that did not see the steps on the Moon on my birthday in 1969, does not remember the dreams that were shattered when our Apollo-Saturn V capability was scrapped. They are looking for there own new horizons.

Starting with the loss of Saturn V heavy lift, and its associated nuclear supplement[6], NASA has had a history of eating its seed corn (i.e. developed technology). The F-1 engine was the most powerful liquid first stage engine ever developed. A proposal to revive the F-1 for military use[7] failed because F-1 manufacturing capability had been lost. Later successions of Shuttle replacement developments have come, and gone[8], with un-sustained technology development cycles. Many advanced subsystem concepts were abandoned at their prime when these developments were aborted. Now we are on the brink of doing this again with the most efficient engine ever flown, the SSME. A lower cost expendable version of the SSME[9] has been studied, and could be phased into production without impacting schedule. Even more efficient follow on configurations[10] are waiting for a future application. Liquid SRB replacements have also been studied, and could be phased into the new launcher down stream.

6 The Nerva Nuclear Engine program: http://ntrs.nasa.gov/archive/nasa/casi.ntrs.nasa.gov/19910017902_1991017902.pdf

7 1985 Air Force MLV Study, Hughes Jarvis: http://www.astronautix.com/lvs/jarvis.htm

8 Space Daily on Shuttle replacements: http://www.spacedaily.com/news/rlv-03a.html

9 RS-25 expendable SSME: http://ntrs.nasa.gov/archive/nasa/casi.ntrs.nasa.gov/20070002143_2007001281.pdf

10 Integrated Powerhead Demonstrator: http://www.nasa.gov/centers/marshall/pdf/108436main_Integrated_Powerhead_Demonstrator.pdf

Throughout its history of big-ticket project cancellations NASA has systematically raided budget from technology development programs to fund its besieged projects. The more promising canceled tech projects[11] have struggled to find alternate funding, though some have provided sufficient promise to acquire commercial financing. When the large projects have cost overruns the small development projects are shed. When the big projects are canceled, often due to an inability to achieve an integrated architecture, many of the newly developed advancements are abandoned, or continue on in a less productive mode. The current evolution of the Aries-1 has drained funding from many promising development projects previously sponsored by NASA.

NASA must maintain a diverse set of development projects to act as seed for future mission architecture improvements. Interruption of this foundation work will impact development far into the future. In the past, Apollo development was perceived to give society many spin-offs seen in our everyday lives. At this point NASA and its extended concentration on ISS assembly does not provide a public awareness of return on this investment. This lack of early ISS utilization (and active users) was voiced at the June 17th public hearing by Jean-Jacques Dordain (director General, ESA), from Paris. Now that ISS is nearly complete we must ramp up its utilization.

NASA must find a sustainable solution to its current short-term crises or it may lose its long-term ability to contribute to global solutions. Through coordination with other national and international entitles, NASA can help guide the development and demonstrate the advantages of new advancement in aeronautics, propulsion, power, medical, and many other key technologies. Though manned space flight takes us into space, its advancement does not take place in a vacuum, for technological advancement demonstrated in the void finds far wider application on earth.

**A vision of a possible future:**

We may be at a tipping point of much greater impact to the development of mankind than just a concern for closing the GAP in our access to low earth orbit. Our interconnected society may be entering the equivalent of a perfect storm impacting human space flight, the economy, global climate change, and many lesser-interrelated issues. The public perception would put space flight at the bottom of this priority chain. I believe the trajectory to a sustainable solution of these complex issues may turn on societies ability to sponsor an integrated approach to solving these seemingly independent issues. NASA should hold a lofty position in this complex web of technical interaction. The Review Committee should not ignore the subtle connections between these pressing issues when making their recommendations. My visualization of the great challenges before us is reminiscent of the BBC Connections series[12], popularized on PBS in 1979.

**Notional illustration of connected technology development threads:**

1) Advanced Technology development --- provides the seed concepts for future advanced systems and mission architectures.

---

[11] Early example: Dense plasma focus (DPF) fusion reactor, JPL 1993: http://www.lawrencevilleplasmaphysics.com/index.php?pr=Home_Page

[12] BBC Connections, by science historian James Burke: http://en.wikipedia.org/wiki/Connections_(TV_series)

2) Fielding of advanced system and NASA mission architectures --- demonstrate to the public the benefit of the investment in technology, and science.
3) Manned Space flight --- provides a platform for demonstration of advancements in technology and science with wide public awareness.
4) Advanced Nuclear powered (beyond low earth orbit) reusable spacecraft, demonstrated with MOON & MARS missions --- show the public the viability of modernizing our Earth-Bound infrastructure using adaptations of clean space demonstrated generation IV[13], or Thorium cycle[14] Nuclear power systems.
5) Advanced power systems --- provide an economical alternative to our current dependence on coal and oil for base load and transportation infrastructure[15].
6) The seeding of new technology first demonstrated by NASA missions --- provides new jobs with adequate income to offset economic impact of outsourcing our previous industrial base.
7) Adaptation of advanced power infrastructure throughout the world --- provides jobs replacing coal based power plants, and building (carbon neutral) atmospheric $CO_2$ to hydrocarbon conversion plants using diverse advanced energy sources.
8) Shifting base load, and transportation infrastructure to atmospheric derived hydrocarbon fuel or hydrogen --- retires worldwide dependence on an oil economy.

This vision of the future is only one possible path. The available options will become apparent as we proceed with the journey. What we must do is establish the institutional framework to enable the required future developments. This wider perspective assumes NASA would play a leading role in an integrated set of solutions. Many other agencies and international partners would ultimately need to constitute a coordinated effort addressing the non-aerospace aspects of these critical issues. Too much of the current vision seems centered on NASA, giving the public image of an isolationist attitude, even excluding our current international partners form future exploration partnerships.

NASA can serve as a highly visible beacon to the public, helping energize support for the needed advancements required to address these difficult issues. NASA needs to make a fundamental change in its current business-as-usual attitude and leadership or this opportunity for technical leadership will be lost. The challenges I have addressed will not be solved in the short term. Most of the solutions will only develop after significant study and un-interrupted effort. A roadmap with a sequence of intermediate achievable goals is needed. The ESAS provides a roadmap that is limited to a narrow NASA perspective. Though also limited in scope the VSE commission did address some of the issues associated with re-energizing the future role of NASA.

---

[13] Generation IV Nuclear Reactors:
http://www.world-nuclear.org/info/inf77.html

[14] Thorium fuel cycle, IAEA-TECDOC-1450:
http://www-pub.iaea.org/MTCD/publications/PDF/TE_1450_web.pdf

[15] Dr. James E. Hansen on $CO_2$ & Nuclear issues:
http://www.columbia.edu/~jeh1/mailings/20081229_Obama_revised.pdf

**The time has come to Adopt Von Braun's Vision of Space Exploration**

NASA can, and should, build on the legacy of Apollo, but not just the limited architecture previously exercised. The public will respond favorably to an obvious advancement of our frontiers. Well before its time Wernher von Braun laid out his vision for interplanetary exploration. The foundation for his vision was in place with the Saturn V, while Skylab, and Nerva were waiting to fill their future roles. That first attempt to implement his vision was judged too costly to implement. Some would argue the cost of the path taken was greater, but that argument is moot. Though not well funded the advanced propulsion concepts have evolved, and improved nuclear power technology is waiting for implementation. Many of these new emerging technologies can be demonstrated with innovative NASA missions that can attract public support, especially if coupled with their earth based counterparts. The ISS is nearly operational, and stands ready for use as a demonstration platform for our path to the future. The ISS is far from optimum, but it is the best orbital base we have going.

NASA should harvest promising advanced development concepts under its sponsorship only after they exhibit results suitable of engineering assessment. Once the engineering aspects of each new system are quantifiable, compatible systems can be integrated into viable operational demonstration projects with most of the risk retired. This measured approach should break the cycle of failed development projects in the future, and bring back the public trust.

A small demonstration of one promising advanced propulsion system is planned for ISS. VASIMR technology[16] could become a key component of a new vision of future space propulsion. Ask Franklin-Chang Díaz where he could push the ISS in the future with his VASIMR thrusters if powered with an advanced space rated pebble bead thorium fueled TRITON TRImodal nuclear propulsion system? The future even holds promise for fusion power[11] with its roots at NASA.

I believe interplanetary manned space flight will ultimately depend on NASA fostering a more cost efficient commercially operated manned space launch services infrastructure. Limit the development to one flexible core launcher with sufficient heavy lift to enable future missions, and the crew module safely above the propulsion systems and payload. Based on its heritage from the NLS project I favor Direct 3 at this time, but it needs a meticulous verification of its current estimated capabilities. If predicted cost advantages are achieved the present NASA funding levels could support missions and technology development with a connection to earth-bound solutions the public can support. The GAP is an artifact of bad planning. It can be addressed by a mix of Soyuz, existing launchers + Orion, or STS legacy heavy lifter + Orion. There are even some Orion substitutes out there. In the long run we should have assured access to LEO using COTS, EELV, and flexible heavy lift launchers. We will need a new wave of public support to ultimately see Von Braun's vision, and that vision can inspire and lift us all. My wish is that your recommendations will make NASA inspiring and relevant.

Respectfully

George A. Eastman

---

[16] ISS propulsion demonstration:
http://www.spaceref.com/news/viewpr.html?pid=27179