



# Critiquing Rationales in Space Policy Proposals: Developing a Methodology for Evaluating Space Policy

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A U.S. President is once again reevaluating American space policy. The direction the Obama Administration will take with respect to its current program, Constellation, is unclear. Many options lay before President Obama, and several groups have once again put forth a new set of proposals for the reorganization of NASA. This paper evaluates two policy proposals that call for the reorganization of American space policy. These are: *Maximizing NASA's Potential in Flight and on the Ground: Recommendations for the Next Administration* by Abbey, et al, and *Sustainable Space Exploration and Space Development: A Unified Strategic Vision* by Hsu and Cox. We adopt a three-test methodology for evaluating these space policy proposals using the model of reasoning, the model of society, and the model of policy-making. We suggest several necessary components that should be required for any national space program and explore whether they are sufficient to carry out government and commercial space efforts. These include: financial and technical capabilities, political and public support, legal requirements (both national and international), and the ability to conduct independent or cooperative missions. We also discuss the preliminary findings of the Augustine Panel and review NASA's current program -- Constellation. Finally, we give our own thoughts in summary of these considerations.

*"That's one small step for (a) man, one giant leap for Mankind..."*

-- Neil Armstrong, *Apollo 11* astronaut and first human to walk on the surface of the Moon on July 20<sup>th</sup>, 1969.

*"The Earth is a much too small and fragile basket for the human race to keep all its eggs in."*

-- Robert Heinlein.

## I. Introduction

THE National Aeronautics and Space Act of 1958 was the first public promulgation of American Space Policy.\* Since 1958, American space policy has suffered from a host of ailments including lack of consistent political vision, severe funding fluctuations, varied definitions of American space policy and disaggregate policy-making. While the exuberance following the Moon landings between 1969 and 1972 filled Americans and the world with ideas and possibilities for humans in outer space, in reality American visions of exploration and dominance in outer space faded away due to political and funding realignments. As a result, popular notions of hotels in space, regular habitation of the Moon, and missions to Mars never materialized. Today, the confluence and increasing degree of private and public ventures in outer space have created many policy proposals calling for a range of missions, *inter alia*, establishing Moon bases, going to Mars, and Earth-focused missions. Yet, space is utilized to a greater extent than at any other time in human history: NASA and various other space agencies still send humans into space, but are confined to low Earth orbit; commercial space ventures march toward maturity; and State participation and space agencies proliferate, diminishing the market power NASA once held. However, private spaceflight ventures have yet to be fully birthed. Given how complicated and involved space policy has become, we argue that policy choices

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\* National Aeronautics and Space Act of 1958 (henceforth Space Act), Pub. L. No. 85-568, 72 Stat. 426, enacted July 29, 1958 (as amended), available at [http://www.nasa.gov/offices/ogc/about/space\\_act1.html](http://www.nasa.gov/offices/ogc/about/space_act1.html) (accessed August 17, 2009).

based upon a comprehensive set of elements and objectives is important to assessing the direction America should take in developing outer space.

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### **A. The Three Models and Other Considerations**

Our analysis is based upon three tests. The first test is based upon the model of reasoning. The model of reasoning has five defined steps and each step is meant to flesh out the arguments of each policy proposal and rank them based upon the defined objectives of the policy (if they can be identified). The second test is based upon the model of society. The model of society is defined as an array of political arrangements, namely between the market and the political community. The third test is based upon the model of policy-making. The model of policy-making relates back to the first and second tests by looking at the process of implementing a particular policy proposal. How does a policy define the problem and how does a particular policy proposal attain its goals? Goal and problem definitions are major components to deciding whether a particular policy is worth pursuing, i.e., makes sense *vis-à-vis* capabilities and other necessary components given a policy's program.

We also consider several necessary components that should be required for any national space program and explore whether they are sufficient to carry out government or commercial space efforts. These include: financial and technical capabilities, political and public support, legal requirements (both national and international), and the ability to conduct independent or cooperative missions. We also discuss the preliminary findings of the Augustine Panel in consideration of our results and review NASA's current program -- Constellation. And, finally, we give our own thoughts in summary of these considerations.

### **B. American Space Policy at the Crossroads**

American space policy is at a crossroads, faced with uncertainty and a multitude of directions. On one hand, this paper is meant to inform the general public of the hard choices that must be faced in order to have a transition from a space-capable society to a truly space-faring society that sees the beginning of regular human habitation of the Moon and eventually of other locations in the Solar System.<sup>§</sup> On the other hand, we hope our methodology serves as a template for use in policy evaluation among space policy-makers. We believe it is necessary to fully account for all aspects of a policy and its ability to provide the sufficient elements and objectives to achieve stated goals. Moreover, we must be keenly aware of the *difference* between NASA policy and space policy, in general. Too often are the goals of NASA and American space policy confused for one another. NASA as an institution is not defined by many aspects of the commercial space industry. Rather, it serves as an exemplar of American ingenuity, innovation, and leadership in outer space. NASA is the source of human spaceflight, and space science and technology, and is America's agency for and in outer space. However, American space policy is a branch of American foreign and domestic policies that includes a larger set of objectives and priorities for and in outer space. This distinction is important to understand what NASA policy has been and where NASA policy is going. If NASA is to have any

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<sup>†</sup> Abbey, George, Lane, Neal, and Muratore, John (Abbey, et al.), *Maximizing NASA's Potential in Flight and on the Ground: Recommendations for the Next Administration*, January 14, 2009, Baker Institute for Public Policy Website, pp. 19-33, available at <http://www.bakerinstitute.org/publications/BIPP-pub-transitionrecommendations-012009-web.pdf> (accessed August 17, 2009).

<sup>‡</sup> Hsu, Feng, and Cox, Ken, *Sustainable Space Exploration and Space Development: A Unified Strategic Vision*, March 29, 2009, Aerospace Technology Working Group Website, available at [http://www.atwg.org/public/UnifiedSpaceVision Approved V 2.1.1 March29.pdf](http://www.atwg.org/public/UnifiedSpaceVision%20Approved%20V%202.1.1%20March29.pdf) (accessed August 17, 2009).

<sup>§</sup> Sociologist Jim Pass made the distinction between space-capable societies and space faring societies in *Inaugural Essay: The Definition and Relevance of Astrosociology in the Twenty-First Century (Part 2: Relevance of Astrosociology as a New Subfield of Sociology)*, Proceedings of the California Sociological Association Conference (Riverside, 2004), pp. 14-15, available at <http://astrosociology.org/vlibrary.html> (accessed August 17, 2009).

future role in American space leadership and human spaceflight, it must adapt, be reformed, or transformed to suit the specific needs of the American government against a backdrop of foreign and commercial space ventures.

If the Apollo program has taught space policy experts anything, it is that we cannot take for granted the enormity of the task ahead in developing outer space for sustained human presence. And, that visions of space as proselytized by past heroes such as Werner von Braun, Arthur C. Clarke, and others are necessary, but not sufficient to maintain goals for or in outer space within a reasonable time frame. We must be vigilant and keep in focus the important aspects that outer space can offer American society.

## II. In the Beginning, There Was NASA....

It is well regarded among space historians that the Soviet launch of *Sputnik I* and *II* were catalysts for the creation of an American national space agency (McDougall 1997).<sup>2</sup> NASA was created out of a complex set of goals set against national security objectives.<sup>\*\*</sup> Moreover, political rhetoric and the election of President Kennedy helped define NASA's goals as milestones in a "race" to beat the Soviets into outer space. As a consequence, the "space race" defined how American space policy would be understood among the general public and limited the policy choices NASA could undertake (Kay 2005).<sup>3</sup> In the end, NASA and American space "priorities" won the "race" to the Moon, but at a cost to future space policy initiatives.

NASA initially sought to develop American space capabilities at a fiscally responsible and relative slow pace despite the hidden national security agenda of the Eisenhower Administration (McDougall).<sup>4</sup> President Eisenhower and his advisors were concerned about protecting America, keeping costs from spiraling out of control, and not putting America on a course toward "fanciful adventures" in outer space without clear objectives or goals (McDougall).<sup>5</sup> However, during the 1950s, events out of Eisenhower's control sought to influence the American public. Werner von Braun's *Collier's* articles, Walt Disney's "Man is Space" series, and popular science fiction, in general, ignited Americans' imaginations toward what was possible in the near future. The public spectacle surrounding the Mercury, Gemini and Apollo astronauts influenced a generation of scientists, social scientists, and artists, *inter alios*, to enter a career in space related fields, despite the social and political turmoil that pervaded America throughout the 1960s. But despite the enthusiasm that convinced so many Americans that humans would conquer outer space in short order, political decisions were well under way as early as 1965 to reduce the funding of American space initiatives (Kay 2005).<sup>6</sup> By the 1970s outer space no longer was the place so many thought it would become. The bold American human spaceflight initiatives of the Kennedy-Johnson years gave way to, *inter alia*, cost controls, inconsistent policy decisions from successive presidents, lack of long-term vision, and a lack of definition for NASA policy goals.

### A. The National Aeronautics and Space Act of 1958

Since July 1958, NASA has been America's space agency. Its mission was to make the United States a space power and serve as a foreign policy tool during the Cold War. To that end, the Space Act was devised with broad abilities, but limited in scope.

The Space Act embodies a host of policy proclamations, regulations, and directions for the National Aeronautics and Space Administration, but distinguishes between civil and military spheres for outer space operations. In 1958, NASA was directed to

- (1) plan, direct, and conduct aeronautical and space activities;
- (2) arrange for participation by the scientific community in planning scientific measurements and observations to be made through use of aeronautical and space vehicles, and conduct or arrange for the conduct of such measurements and observations; and
- (3) provide for the widest practicable and appropriate dissemination of information concerning its activities and results thereof.<sup>††</sup>

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<sup>\*\*</sup> Compare *National Security Council Memorandum 5520* (NSC 5520, May 20, 1955), the first statement of national policy for outer space that laid out the rationale for the American reconnaissance satellite program via the establishment of the freedom of overflight, with the *Introduction of Outer Space*. The latter, authored by President Dwight Eisenhower's Science Advisory Committee, laid out the rationale for an American space program (March 26, 1958). *NSC 5520 Memorandum* available at <http://www.thespacereview.com/archive/995b.pdf>, (accessed August 17, 2009). *Introduction to Outer Space* available at <http://www.fas.org/spp/guide/usa/intro1958.html> (accessed August 17, 2009).

<sup>††</sup> Space Act §203(a)(1-3) (1958) (un-amended).

The Space Act was further amended in 1984 with two additional provisions to the Functions of the Administration:

- (4) seek and encourage, to the maximum extent possible, the fullest commercial use of space; and
- (5) encourage and provide for Federal Government use of commercially provided space services and hardware, consistent with the requirements of the Federal Government.<sup>‡‡</sup>

These additional provisions were incorporated to promote commercial, i.e., private, space development in the United States. Additionally, the Space Act's Declaration of Policy and Purpose was changed to include a new clause to section 102 stating

- (c) The Congress declares that the general welfare of the United States requires that the National Aeronautics and Space Administration [] seek and encourage, to the maximum possible extent, the fullest commercial use of space.<sup>§§</sup>

Other missions include: coordinating aeronautical and space activities with intra- and inter-governmental agencies; prize authority; property management; and establishing upper atmosphere research and policy.<sup>\*\*\*</sup> Hence, NASA must balance two missions: developing and maintaining civilian space capabilities and promotion of commercial space activities.

## B. NASA “Reforms”

The institution that is NASA has come a long way since its inception in 1958. NASA started out conservative in nature under Administrator T. Keith Glennan, but soon expanded in budget and ambition under Administrator James Webb (McDougall).<sup>7</sup> It has been suggested that NASA's decline started when Webb left NASA (Kay 2005).<sup>8</sup> Other scholars have noted that NASA's decline began in the mid-1960s when Congress, and President Johnson to some degree, kept slashing NASA's budget in the wake of the Great Society Initiatives and the weight of the Vietnam War (Dallek 1997).<sup>9</sup> Nevertheless, NASA has been reformed and has had its mission reshaped several times since the Apollo Moon landings. These reforms have reshaped NASA's image and space policy, giving the impression that American space policy is adrift. Below we briefly discuss some of the reforms NASA has endured.

After Apollo, NASA struggled to find a new mission. It has been described by several scholars that a “malaise” permeated the U.S. space program during the 1970s (Kay 2005; Hoff 1997).<sup>10, 11</sup> Political changes in the 1980s brought on a new group of policymakers who were determined to move space policy in a completely new direction, which included the commercialization of space. U.S. space policy changes lasted throughout the 1990s. In each instance, space policy that NASA had to implement required redefinition of goals and priorities, and reorganization that affected NASA's mission, structure, and budget. It also included increased competition with and buying of services from the private space industry.

Beginning under the Nixon Presidency, NASA was placed on some preliminary cost justification and control measures. Starting in 1995, NASA began implementing a Full Cost Accounting methodology.<sup>†††</sup> In FY 2004, NASA was legislative mandated to account for budgeting and recording cost using Full Cost Accounting for all programs and projects.<sup>†††</sup> Full Cost Accounting was further streamlined in FY 2007 with the implementation of fixed rate overhead cost among all NASA field centers.<sup>§§§</sup> Full Cost Accounting has reined in some programs and canceled others, and has rebalanced the allocation of responsibilities between the NASA field centers and the Mission Directorates. These changes have reshaped how NASA goes about picking and developing projects relative to the 1960s and 1970s.

Reagan's Presidency helped redefine American space policy with the opening up of commercial space markets. In 1984, the U.S. Congress redefined NASA's mission by encouraging private development of space, in particular civilian launch vehicle development.<sup>\*\*\*\*</sup> The development of commercial launch vehicles was accelerated by the *Challenger* disaster and the announcement of President Reagan's 1988 commercial launch vehicle policy. After the

<sup>‡‡</sup> Space Act §203(a)(4-5) (1984) (as amended).

<sup>§§</sup> Space Act §102(c) (1984) (as amended).

<sup>\*\*\*</sup> Space Act §101, et seq. (2007).

<sup>†††</sup> *NASA Full Cost Initiative*, NASA Headquarters Website, available at <http://www.hq.nasa.gov/fullcost/> (accessed August 17, 2009).

<sup>†††</sup> National Aeronautics and Space Administration Authorization Act of 2005, Pub. L. No. 109-155 (2005), U.S. Governmental Printing Office Website, available at [http://frwebgate.access.gpo.gov/cgi-bin/getdoc.cgi?dbname=109\\_cong\\_public\\_laws&docid=f:publ155.109.pdf](http://frwebgate.access.gpo.gov/cgi-bin/getdoc.cgi?dbname=109_cong_public_laws&docid=f:publ155.109.pdf) (accessed August 17, 2009).

<sup>§§§</sup> *2008 NASA Cost Estimation Handbook*, “Full Cost Accounting”, NASA Website, available at [http://ceh.nasa.gov/ceh\\_2008/volume\\_3/2\\_1\\_full\\_cost\\_accounting.htm](http://ceh.nasa.gov/ceh_2008/volume_3/2_1_full_cost_accounting.htm) (accessed August 17, 2009).

<sup>\*\*\*\*</sup> National Aeronautics and Space Administration Authorization Act, 1985, Pub. L. No. 98-361, 98 Stat. 422 (1984).

*Challenger* disaster, NASA discontinued the use of the Space Shuttle as a subsidized launch vehicle for private U.S. satellites. Consequently, the U.S. launch market had new need for alternative launch options. Moreover, Reagan's 1988 commercial space policy was premised on the idea that private enterprise should play a larger role in Space and that the private sector's inclusion would be beneficial to the American economy. Reagan encouraged private sector participation in space through favorable government policies toward commercial launch ventures.<sup>††††</sup> Reagan changed NASA space policy by mandating the procurement of private launch vehicles. As a result, the U.S. government encouraged the development of private U.S. launch vehicles independent of NASA and the U.S. military.

Since the 1990s, NASA has been the commercial space industry's biggest buyer of goods and services. Further reforms caused NASA to be in competition with many sectors of the commercial space industry. In 1998, the U.S. Congress passed the Commercial Space Act (CSA), which directed NASA to use private launch firms to send cargo and satellites into orbit.<sup>††††</sup> Again, in 2004, the U.S. Congress passed the Commercial Space Launch Act (CSLA).<sup>§§§§</sup> The CSLA created a regulatory regime which oversees the commercial space launch industry and consolidated the regulations from the FAA, NASA, and other executive agencies (Hearsey 2008).<sup>12</sup> Moreover, the CSLA officially recognized private human spaceflight as a distinct industry (Hearsey).<sup>13</sup> The purpose of the legislation was to further encourage private development of space. The aerospace industry has moved to take advantage of changes to U.S. law, including several entrepreneurs who have taken advantage of the deregulation of the launch vehicle industry to fund private research and development (R&D) projects and create privately owned and operated launch vehicles, space habitats, and spaceports (Hearsey).<sup>14</sup> This dramatic shift in space policy from public to the private space endeavors is indicative of the split between NASA and American space policy.

NASA is again at the crossroads of Presidential space policy. President Obama awaits the options that will be given to him at the end of August 2009 by Norman Augustine's Panel, a Federal Advisory Committee that is reviewing the US human space flight program options.<sup>\*\*\*\*\*</sup> Once again, NASA might be reformed and put on a new path. Nonetheless, the status quo program remains Constellation.

### C. NASA's Limitations

Since the end of Apollo, NASA has drifted away from coherent space policy. NASA's focus *du jour* or lack of focus has allowed NASA space policy to be complicated and diffuse, lacking any strict or sensible vision from president to president. There are several reasons for this. First, NASA is limited by political, budgetary, institutional, and technological constraints. There is also tension between its individual programmatic and organizational goals. The demand of successive political agendas, economic shifts, technical evolution, ideological changes, *inter alia*, shapes how NASA's goals and objectives are met. It has been noted by W.D. Kay that while "most of the criticism of the U.S. space policy has been directed at individual programs, such as Project Apollo, the Space Shuttle, or the International Space Station," it is important to understand how NASA goes about choosing a "solution" (Kay 2005, pg. 19).<sup>15</sup> The problem Kay identifies is that NASA finds "solutions" through NASA's goals, which are defined externally. NASA is not the shaper of policy: its mandates can only come from the Congress or the President.

Second, American space policy under President Eisenhower began with a cold war definition (McDougall 1997).<sup>16</sup> Even as President Kennedy formulated his space policy he was faced with two external crises in 1961: The Bay of Pigs failure and the Gagarin spaceflight. As a consequence, Kennedy sought out a space policy that could be accomplished in a time frame sufficient to meet a major goal before the Soviets could meet the similar challenge, and distract attention away from past Administration failures. The result was the call for landing a man on the Moon by the end of 1969.<sup>†††††</sup> The success of Apollo was heralded by many, but the program's success had no mechanism for continuing on. After 1969, space policy was still dependent on the Cold War definition of space, but the goal of extending America's human spaceflight program beyond the Moon ended with President Nixon's rejection of the Space Council's recommendations in 1971 (Hoff 1997).<sup>17</sup> Moreover, political shifts between the U.S. and the Soviet Union, and within the U.S. caused America's Cold War definition of space to slip away toward a new definition of

<sup>††††</sup> See The White House Office of the Press Secretary, *The President's Space Policy and Commercial Space Initiative to Begin the Next Century - Fact Sheet* (February 11, 1988).

<sup>††††</sup> Commercial Space Act (CSA), Pub. L. No. 105-303 (1998).

<sup>§§§§</sup> Commercial Space Launch Amendments Act (CSLA), Pub. L. No. 108-492, 49 USC §70101, 118 Stat. 3974 (2004).

<sup>\*\*\*\*\*</sup> The 10-member panel includes: Norm Augustine, Wanda Austin, Bohdan Bejmuk, Leroy Chiao, Christopher Chyba, Edward Crawley, Jeffrey Greason, Charles Kennel, Lester Lyles, and Sally Ride.

<sup>†††††</sup> See *President John Kennedy's Moon Speech at Rice University*, September 12, 1962, Johnson Space Center Website, available at <http://er.jsc.nasa.gov/seh/ricetalk.htm> (accessed August 17, 2009).

space. With the inauguration of President Ronald Reagan in 1981, American space policy sought to be more inclusive of private enterprise. What ended up happening is that NASA policy and American space policy started to move away from each other.

Third, Presidential leadership has not guided NASA's policy goals and objectives to meet the visions laid out by successive presidents since President Kennedy. NASA and Presidential scholars have noted that presidential leadership of space policy has been something of a myth (Launius and McCurdy 1997).<sup>18</sup> The complexity of issues related to space is affected by actors in tandem or in competition with presidential leadership. A president can shape policy but very rarely leads. This is due to several factors: presidents tend to only see the short-term political benefits rather than any long-term vision that would be required for a sufficient national space program; there is no incentive for a future president to implement the vision of their predecessor(s); Congress has a leading role in how money is dispensed, therefore has had a disproportionate influence on space policy; Congress tends to kill large non-military projects from time to time if they are not politically identifiable with jobs, job creation, district wealth creation or are of unjustifiably high cost; and outside social and economic shocks tend to affect funding, leadership, and/or technology development. Presidents, more times than not, must build a consensus to make their vision of space a reality. To understand why some reforms were implemented, we must draw our attention away from both presidential politics and NASA's internal struggles, as NASA has been most profoundly affected by the wider social, economic, and political forces that create the changes in the policy environment within which NASA operates. This explains, in large part, why NASA's long-term strategic goals never get implemented.

Fourth, the ability of NASA administrators to influence budgets ended with James Webb (Kay 1995).<sup>19</sup> Since the 1970s, NASA administrators have fought with presidential budget directors (Kay 2005; Hoff 1997).<sup>20, 21</sup> Only recently has Congress mandated strict cost controls in NASA budgets (Full Cost Accounting). Furthermore, no NASA administrator has had the same clout with Congress or a President as James Webb, nor has any administrator after Webb had a similar mandate (Kay 2005).<sup>22</sup> Additionally, Congress, while having the authority to see policy through, has no unifying champion of space policy. In general, it is difficult for any particular member of the House or Senate to get his/her colleagues to follow along on most pieces of legislation with 535 members representing 435 districts and 50 states. Consequently, NASA must compete for its share of the pie with many other programs in the federal budget. Congress consistently changes NASA budgets from year to year, sometimes without changing the mandates of the programs being funded.

Fifth, the managerial culture within NASA and among the field centers have been repeatedly criticized for, *inter alia*, excessive risk-taking, lack of problem delegation, and improper program management (McCurdy 1994).<sup>23, \*\*\*\*</sup> Lack of centralized authority from NASA headquarters has caused problems, but so has mission pressures on field centers that are at times in competition with each other for funding and personnel. Additionally, the distance between NASA centers has led to program failures, which in turn has caused programs to go over-budget, to be scrapped and/or produced failed missions.<sup>\*\*\*\*\*</sup> These are serious administrative issues that NASA continues to try to mitigate.

Sixth, some space historians, policy analysts, and political scientists have noted that the creation of the Space Transportation System (aka Space Shuttle) was one of NASA's biggest space policy failures (Logsdon 1986).<sup>24</sup> The Space Shuttle has been called an aging or experimental reusable launch vehicle that is so augmented from its original design and mission that it financially drains NASA resources away from other projects. It is true that the Space Shuttle is expensive to operate and maintain. However, it has been pointed out that the Space Shuttle has serviced America's human spaceflight needs for almost thirty years, shown off American spaceflight prestige, and has served as a flexible platform for scientific activities (Launius 2006).<sup>25</sup> Regardless, President Reagan's decision in 1986 to prohibit commercial payloads on the Space Shuttle helped provide incentive for private launch vehicle development (Kay 2005).<sup>26</sup> This has limited the Space Shuttle's usability.

Seventh, the lack of infrastructure development in outer space has limited NASA space policy options. Further infrastructure will be required for humans to conduct any activities in space. The International Space Station (ISS) is

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\*\*\*\* See e.g. the conclusions related to NASA management in the *Report of the Presidential Commission on the Space Shuttle Challenger Accident*, June 6, 1986, NASA History Office Website, available at <http://history.nasa.gov/rogersrep/511cover.htm> (accessed August 17, 2009). See also the *Columbia Accident Investigation Board Report*, August 26, 2003, NASA Website, available at <http://caib.nasa.gov/> (accessed August 17, 2009).

\*\*\*\*\* Consider that the failure of the Mars Climate Orbiter was caused by improper conversion of units in the software that could have been corrected by diligent program management. The total cost of the orbiter and the lander was \$327.6 million (not including the Deep Space 2 craft). See *Mars Climate Orbiter Facts Sheet*, Jet Propulsion Laboratory Website, available at <http://mars.jpl.nasa.gov/msp98/orbiter/fact.html> (accessed August 17, 2009).

the first step, but the controversy surrounding its design and mission has caused a great deal of pessimism among some space policy experts at the expense of long-term strategic vision (Neal 2007).<sup>27</sup> We do not necessarily argue that the ISS design was the most optimal, but we do agree that the rationale for life support systems and research facilities in outer space are required elements toward outer space development for long-term human habitation. Knowledge gained from using the ISS will enable policy-makers to have a better understanding of long-term biological effects in outer space. The technology and expenditures needed to develop a Moon base or a mission to Mars has yet to materialize from the private or public sectors.

These limitations have framed NASA as a lost and, at times, dysfunctional agency. However, while some criticism has been warranted, in particular, with respect to NASA management, by and large NASA policy has provided America with a working national space agency providing missions that have helped accumulate a substantial amount of knowledge about outer space and the universe. In many respects, NASA policy has raised America's profile in space, rather than lowered it. NASA is still America's space agency.

#### D. Vision for Space Exploration: Constellation Program

On January 14, 2004, President George W. Bush announced the Vision for Space Exploration (VSE). The NASA Authorization Act of 2005 born out of the VSE mandated that

“The [NASA] Administrator shall establish a program to develop a sustained human presence on the Moon, including a robust precursor program to promote exploration, science, commerce, and U.S. preeminence in space, and as a stepping stone to future exploration of Mars and other destinations. The Administrator is further authorized to develop and conduct appropriate international collaborations in pursuit of these goals.”<sup>\*\*\*\*\*</sup>

As codified, the Constellation Program seeks to:

- Complete the International Space Station and retire the Space Shuttle by 2010;
- Develop the Orion spacecraft by 2008 and put Orion into service by 2014;
- Develop shuttle-derived launch vehicles, such as the Ares I rocket;
- Put the U.S. back on course toward crewed missions to the Moon by 2020;
- Go to Mars sometime after 2020;
- Extend human presence across the Solar System;
- Develop supporting innovative technologies, knowledge and infrastructure; and
- Promote international and commercial participation.<sup>†††††</sup>

Additionally, the VSE calls for the continued development of robotic missions to the Moon and Mars in advance of crewed missions.

The Constellation Program operates under six strategic themes. These include:

- Use the Moon to prepare for future human and robotic missions to Mars and other destinations;
- Pursue scientific activities to address fundamental questions about the Solar System, the universe, and our place in them;
- Expand sustained human presence to the Moon to enable eventual settlement;
- Expand Earth's economic sphere to encompass the Moon and pursue lunar activities with direct benefits to life on Earth;
- Strengthen existing and create new global partnerships; and
- Engage, inspire, and educate the public.<sup>†††††</sup>

While the current goal is to return astronauts to the Moon, it does not call for the initial settlement of the Moon. Nevertheless, the Constellation Program does highlight the continual need for a NASA human spaceflight program.

However, the Constellation Program is behind schedule and underfunded.<sup>§§§§§</sup> Insufficient funding to meet program goals has been a boon to NASA's human spaceflight program since Apollo. Moreover, exogenous forces

\*\*\*\*\* NASA Authorization Act of 2005, §101 (b)(1), Pub. L. No. 109-155, U.S. Government Printing Office, available at [http://frwebgate.access.gpo.gov/cgi-bin/getdoc.cgi?dbname=109\\_cong\\_public\\_laws&docid=f:publ155.109.pdf](http://frwebgate.access.gpo.gov/cgi-bin/getdoc.cgi?dbname=109_cong_public_laws&docid=f:publ155.109.pdf) (accessed August 17, 2009).

††††† The White House, *President George W. Bush Announces New Vision for Space Exploration Program*, January 14, 2004, NASA History Office Website, available at <http://history.nasa.gov/Bush%20SEP.htm> (accessed August 17, 2009).

††††† Connelly, John, *Constellation Program Overview*, Constellation Program Office, October 2006, available at [http://www.nasa.gov/pdf/163092main\\_constellation\\_program\\_overview.pdf](http://www.nasa.gov/pdf/163092main_constellation_program_overview.pdf) (accessed August 17, 2009).

continue to limit how NASA plans future missions. It should not be a surprise if the goals of Constellation are never met. The Augustine Panel's Report on Human Spaceflight options should help President Obama frame NASA's spaceflight policy, but unless President Obama provides leadership for and funding to NASA's human spaceflight program, it could be decades before Americans will be back on the Moon, let alone set foot on Mars.

### III. Methodology

The success of public policy is largely dependent upon whether a given policy is rational and reasonable in light of available resources and societal conditions. To capture these aspects, we have developed a methodology that consists of three tests in which to frame space policy proposals. Below we discuss how these three policy tests work.

Our data set consisted of two proposals authored by Abbey et al. and Hsu and Cox. We evaluated each one with respect to three tests and compared them against a baseline of optimal elements we defined as necessary for the development of outer space through sustained human and non-human spaceflight capabilities. These elements are:

- Financial and technical capabilities;
- Political and public support;
- Legal requirements (both national and international); and
- The ability to conduct independent or cooperative missions.

We used this baseline to evaluate each proposal in the first and third tests, the model of reasoning and the model of policy-making, respectively. We distinguished between elements of human spaceflight capabilities and non-human spaceflight capabilities; however, there is generally overlap between both sets of capabilities. Human spaceflight capabilities are those elements that enable the secure and proper function of space missions for continual human habitation in outer space. These include: infrastructure, such as closed life support systems and enabling technologies; launch vehicles and support crew; navigation systems, such as satellites and tracking stations; and mission specific technologies, *inter alia*, scientific instruments, materials processing and mining equipment, and transportation vehicles. Non-human spaceflight capabilities include, *inter alia*, robots and probes, satellites, ground tracking stations, launch vehicles, scientific instruments, and support crew to enable such capabilities.

#### A. The Model of Reasoning

The model of reasoning test was the first step in our analysis of the space policy proposals below and had five defined steps (Stone 2002, p. 8):

- 1) Identify objectives.
- 2) Identify alternative courses of action for achieving objectives.
- 3) Predict the possible consequences of each alternative.
- 4) Evaluate the possible consequences for each alternative.
- 5) Select the alternative that maximizes the attainment of the objectives.<sup>28</sup>

Each step was designed to examine in detail a particular space policy proposal. The first step in the test was to identify the objectives of a proposal. This was a straightforward task that required only identifying those objectives explicitly stated within a given proposal. Did space policy proposers discuss a designated course of action (COA) to implement each objective? It is one thing to advise policymakers to undertake objectives; it is another to show them how to get from A to Z. If one or more of a space policy proposal's objectives did not identify COAs "stepping to" objectives, or if the COAs were not congruent with the stated objectives, then we were able to evaluate the reasonableness of achieving those objectives in the absence of COAs or of appropriate COAs. Next, we evaluated a proposal with respect to its having enunciated alternative COAs for reaching its objectives. As with proposers' preferred COAs, alternative COAs may not be congruent with a proposal's stated objectives. Herein, when proposers did not identify alternative COAs, we made that effort ourselves with an eye toward congruency with their stated objectives.

Once we identified and defined a proposal's objectives and its preferred and alternative COAs, we turned to predicting the possible consequences for each COA. Predicting the possible consequences of COAs gave us a sense of how well the proposal met its stated objectives.

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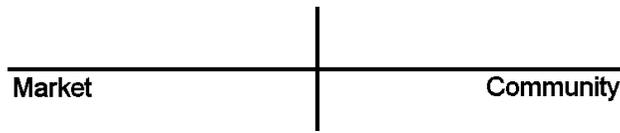
\*\*\*\*\* NASA Internal Presentation: CxMPR, Orion Project Office, July 2, 2008, internal NASA presentation published on Spaceref.com Website, available at <http://images.spaceref.com/news/2008/cxp.charts.pdf> (accessed August 17, 2009).

The evaluation of the possible consequences of each alternative was important to understand how well a proposal compared to the baseline for human and non-human spaceflight capabilities. It also helped us to compare similar proposals. Lastly, the COAs that maximized the attainment of a space policy proposal’s stated objectives were chosen and compared against the baseline for human and non-human spaceflight capabilities.

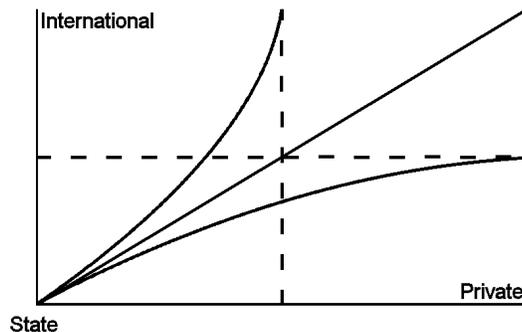
### B. The Model of Society

The model of society test took into account the tendency a society (i.e., a nation-state) displays in implementing policies. This test can map where a particular proposal falls between market and political community parameters (Figure 1). In making this test, we distinguished between whose interests were being served by a particular policy proposal. Did a policy proposal advance a market model, whereby the purpose was to maximize individual stakeholders’ interests (i.e., persons with interests in the policy), or other private stakeholders’ interests (i.e., private firms)? Or did the policy proposal advance the political community model, whereby the purpose was to maximize the interests of the public (i.e., the population within a society) or, to some degree, the international community? This is important to note because many policy proposals aim to advance free-market objectives while also rationalizing the need for international cooperation; moreover, the belief that space can help unite society.

As seen in Figure 2, nation-states are limited by how they balance international cooperation with private participation with respect to policy implementation. A nation-state’s interests are bounded relative to private participation and international cooperation. There may be limits to which nation-states will use private industry and bi- or multi-lateral agreements in the pursuit of policy. That balance can be determined at any given time should we wish to add quantitative rigor to our tests (more on this later). Suffice to say for now that if a proposed policy tended toward favoring private participation, then we can say the policy tends toward the market model. On the other hand, if the policy tended toward international cooperation, then the policy would tend toward the political community model.



**Figure 1. The market – political community continuum**



**Figure 2. Limitations of the market – political community continuum (not to scale)**

Herein, we have taken each proposal and evaluated it against where it maps along the market-political community continuum. How we relatively determined where the Abbey, et al. and Hsu and Cox proposals mapped on that continuum was through a process represented by Table 1, below.

Stakeholders	Stakeholder Interests Served by Proposal	Private + Public Stakeholders’ Interests
Private Stakeholders A1		
Private Stakeholders An		
Public Stakeholders B1		
Public Stakeholders Bn		

**Table 1. A schema for recording private and public stakeholders, their interests, and how each category of stakeholder stands in relation to the other.**

A well-written policy should enunciate private and public stakeholders. Private stakeholders are defined as non-governmental entities, e.g. private-individuals, private-advocacy groups, etc. Public stakeholders are defined as governmental entities, e.g. legislators, government agencies, etc. However, whether or not enunciated, we have identified as many stakeholders as we could find implicit in the proposals in order to find the places on the market-political community continuum of the efforts authored by Abbey, et al. and Hsu and Cox.

### C. The Model of Policy-Making

The model of policy-making relied on the first and second tests *via* an examination of how a policy proposal defined its objectives and how it intended to attain those objectives. Definition of objectives and the COAs to meet those objectives are major components for the decision-making process. The model of policy-making considered whether a policy is worth pursuing, i.e., makes sense *vis-à-vis* the baseline elements we discussed above. We analyzed the baseline elements against each policy proposal and commented on the advantages and disadvantages of implementing each baseline element derived from the first and second model tests. See Table 2, below.

Baseline Elements	The Proposal's COAs	Advantages/Disadvantages
Financial capabilities		
Technical capabilities		
Political and public support		
Legal requirements (national and international)		
Ability to conduct independent or cooperative missions		

**Table 2. A schema for comparing objectives and COAs against the elements of the baseline**

The results of our tests using the three models over the two policy proposals follow. We present our findings for Abbey, et al. first and then for Hsu and Cox. First, we apply the model of reasoning test. Next, we apply the model of society test. Lastly, we apply the model of policy-making test. Each test is meant to flesh out each policy proposals objectives and arguments, as well as point out any limitations each objective might have including the effects an objective might have on different stakeholders.

## IV. Results: Examining the Space Policy Proposals

As outlined in the Methodology section above, any policy can be investigated through the following actions (Stone 2002, p. 8):

- 1) Identify objectives.
- 2) Identify alternative courses of action for achieving objectives.
- 3) Predict the possible consequences of each alternative.
- 4) Evaluate the possible consequences for each alternative.
- 5) Select the alternative that maximizes the attainment of the objectives.<sup>29</sup>

We further incorporated the model of society and the model of policy-making tests to flesh out the arguments, goals, and objectives of the proposals of Abbey, et al. and Hsu and Cox. Below are the results of our analysis.

### A. Abbey, et al. – The Model of Reasoning

On January 20, 2009, George Abbey, Neal Lane, and John Muratore (Abbey, et al.) of the James A. Baker Institute for Public Policy at Rice University published as part of the Institute's "Recommendations to the President" five space policy proposals.\*\*\*\*\* Their paper is titled *Maximizing NASA's Potential In Flight and on the Ground: Recommendations for the Next Administration*. We have examined in detail Abbey, et al.'s recommendations through the application of the three tests by which public policies can be evaluated: 1) the model of reasoning, the model of society, and the model of policy-making.

\*\*\*\*\* Supra Abbey, et al. (2009).

We found that the overall objective in Abbey, et al.'s proposal was to steer NASA in the direction of being more relevant to terrestrial needs, in this case, energy and environmental needs. Besides stating their own preferred COAs, Abbey et al. did not discuss any alternative COAs to meet their objectives. What is more, the proposal authors were short on detail for their own preferred COAs concerning:

- Restructuring the human space initiative (by canceling Ares I);
- The Moon and Mars (putting these goals of human spaceflight on hold indefinitely);
- Orion (scaling it back for LEO use only);
- The Space Shuttle (continue to fly it through 2015);
- Energy and environment (divert NASA's effort to these issues);
- Robotic space science (invigorate NASA's effort); and
- Aeronautical research (invigorate NASA's effort).<sup>+++++</sup>

In Tables 3a – 3g, items 1.1.1, 1.2.1, 1.3.1, 1.4.1, 2.1.1, 2.2.1, 3.1, and 4.1 (in bold font) are Abbey, et al.'s preferred COAs. In every other item in the far left column, they are alternative COAs that we have broached.

A. Identify objectives. B. Identify COAs and alternative COAs for achieving objectives.	C. Predict the possible consequences of each alternative.	D. Evaluate the possible consequences for each alternative.	E. Select the alternative that maximizes the attainment of the objectives.
<b>I. Restructure the Human Space Initiative</b>			
<b>1.1. Ares I.</b>			
<b>1.1.1. Cancel Ares I.</b>	Affordable, requires upgrade and man-rating of existing LV <sup>+++++</sup> , new launch site infrastructure to support manned operations.	Inefficient utilization of existing GSE, but new GSE <sup>#####</sup> is probably cheaper than staying with Ares I.	Cancel Ares I.
1.1.2 Status quo. No cancellation of Ares I.	Possibly not affordable, incurs full Ares I development costs, which may escalate further.	Pressure to cancel Ares I may continue, and ultimately succeed.	

**Table 3a. Concerning restructuring the human space initiative**

A. Identify objectives. B. Identify COAs and alternative COAs for achieving objectives.	C. Predict the possible consequences of each alternative.	D. Evaluate the possible consequences for each alternative.	E. Select the alternative that maximizes the attainment of the objectives.
<b>1.2. Moon and Mars</b>			
<b>1.2.1. Defer lunar and Mars missions indefinitely.</b>	Affordable, but leaves Orion without "out of LEO" missions.	Orion might be canceled in favor of COTS. LEO is boring, might lead to lower overall support for NASA.	
1.2.2. Status quo. Human missions to the Moon and Mars	Not affordable.	Entire Constellation program might be canceled.	
1.2.3. Delay lunar and Mars program.	Affordable, retains Orion "out of LEO" missions.	Justifies Orion development independent of COTS, but at slower pace.	
1.2.4. Cancel lunar landings in favor of lunar and Mars orbital and asteroid missions.	Affordable, retains Orion "out of LEO" missions.	Justifies Orion development independent of COTS, preserves lunar missions in 2020s and Mars missions in 2030s.	Cancel lunar landings in favor of lunar and Mars orbital and asteroid missions.
1.2.5. Cancel lunar landings in favor of Mars landings.	Not affordable.	Entire Constellation program might be canceled.	

**Table 3b. Concerning the Moon and Mars**

<sup>+++++</sup> Ibid. Abbey, et al. (2009).

<sup>+++++</sup> Launch vehicle

<sup>#####</sup> Ground support equipment

A. Identify objectives. B. Identify COAs and alternative COAs for achieving objectives.	C. Predict the possible consequences of each alternative.	D. Evaluate the possible consequences for each alternative.	E. Select the alternative that maximizes the attainment of the objectives.
1.3. Orion			
<b>1.3.1. Redirect Orion to support ISS.</b>	Orion is now optimized for “out of LEO,” LEO efficiency requires redesign.	Orion might be canceled in favor of COTS.	
1.3.2. Status quo. Build Orion and launch on Ares I.	Requires “out of LEO” justification.		
1.3.3. Defer Orion to “out of LEO” missions, push COTS.	High risk. Kistler example. ***** COTS would be first privately-developed manned system.	COTS delay would extend U.S. manned flight gap. With two systems operational, Orion can pinch-hit during COTS stand-down due to catastrophic failure.	Defer Orion to “out of LEO” missions, push COTS.

**Table 3c. Concerning Orion**

A. Identify objectives. B. Identify alternative courses of action for achieving objectives.	C. Predict the possible consequences of each alternative.	D. Evaluate the possible consequences for each alternative.	E. Select the alternative that maximizes the attainment of the objectives.
1.4. Space Shuttle			
<b>1.4.1. Keep the space shuttle flying until 2015.</b>	Low risk, maintains workforce, narrows U.S. manned flight gap.	Probable Constellation stretch-out, extending an expensive, dead-end system drains funds for developing less expensive, more advanced systems.	Keep the space shuttle flying until 2015.
1.4.2. Status quo. Terminate shuttle program in 2010 or 2011.	Reduction in workforce, must accept 5 to 8-year U.S. manned flight gap, rely on foreign systems.	Possible conflict with foreign policy objectives.	

**Table 3d. Concerning the space shuttle**

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\*\*\*\*\* The Kistler example refers to Rocketplane and Kistler, private companies that merged to take on a Commercial Orbital Transportation Services (COTS) contract with NASA to build a reusable launch system to take spacecraft into Earth orbit. After missing a succession of financial milestones, NASA terminated the contract. This one example alone points up the danger of expecting “rocket science” from business models that derive from the virtual reality community. While Rocketplane and Kistler were started by “rocket scientists,” all too often the financing for such ventures in today’s world follows the computer industry’s model. As we have said before, “There is no Moore’s Law for rocketry.”

A. Identify objectives. B. Identify COAs and alternative COAs for achieving objectives.	C. Predict the possible consequences of each alternative.	D. Evaluate the possible consequences for each alternative.	E. Select the alternative that maximizes the attainment of the objectives.
2. Energy and the Environment			
2.1. Short Term Payoffs			
<b>2.1.1. Deliver short-term (within four years) payoffs in energy and the environment, especially climate change.</b>	Requires changes in National Air and Space Act, diverts NASA from focus on space.	Pits NASA against DOE and EPA, precipitates bureaucratic turf wars.	
2.1.2. Status quo. Energy and environmental innovations are not a major NASA responsibility.	DOE and EPA remain responsible for energy and the environment.	Avoids bureaucratic turf wars.	Status quo.
2.2. Long Term Payoffs			
<b>2.2.1. Deliver longer-term payoffs (within four to eight years) for energy and the environment.</b>	Requires changes in National Air and Space Act, diverts NASA from focus on space.	Pits NASA against DOE and EPA, precipitates bureaucratic turf wars.	
2.2.2. Status quo. Energy and environmental innovations are not a major NASA responsibility.	DOE and EPA remain responsible for energy and the environment.	Avoids bureaucratic turf wars.	Status quo.

**Table 3e. Concerning energy and the environment**

A. Identify objectives. B. Identify COAs and alternative COAs for achieving objectives.	C. Predict the possible consequences of each alternative.	D. Evaluate the possible consequences for each alternative.	E. Select the alternative that maximizes the attainment of the objectives.
3. Robotic Space Science			
<b>3.1. Ensure an ongoing and effective robotic space science program.</b>	More emphasis on and funding of robotic space science projects.	Realistically, probably at the expense of manned space projects, but given disparity in budgets, probably small impact.	Ensure an ongoing and effective robotic space science program.
3.2. Status quo. Current reduced level of funding to fund Shuttle and Constellation.	Maintain current level of emphasis on and funding of robotic space science projects.	No impact on manned space projects.	

**Table 3f. Concerning robotic space science**

A. Identify objectives. B. Identify COAs and alternative COAs for achieving objectives.	C. Predict the possible consequences of each alternative.	D. Evaluate the possible consequences for each alternative.	E. Select the alternative that maximizes the attainment of the objectives.
4. Aeronautical Research			
<b>4.1. Implement a reinvigorated and effective aeronautical research program.</b>	More emphasis on and funding of aeronautical research, recapture technical lead, market share of U.S. manufacturers.	Realistically, probably at the expense of manned space projects, but given disparity in budgets, probably small impact.	Implement a reinvigorated and effective aeronautical research program.
4.2. Status quo. Maintain at current levels.	Maintain current level of emphasis on and funding of aeronautical research.	No impact on manned space projects.	

**Table 3g. Concerning aeronautical research**

## **B. Abbey, et al. – The Model of Society**

In making our assessment of stakeholders, private and public, implicit in the Abbey, et al. proposal, we have strictly predicated our appraisal on only the proposers' preferred COAs – not from the alternative COAs that we proposed above in our model of reasoning examination.

### **1. Restructuring the Human Space Initiative (Canceling Ares I)**

Should Ares I be canceled and the Delta IV and Atlas V upgrades made to accommodate the Orion spacecraft, the immediate stakeholders are Boeing and Lockheed-Martin, their labor forces, and the communities in which they and their labor forces reside. We agree with this COA because Ares I was a questionable concept from the start. Other credible commentators besides Abbey, et al. have noted this.<sup>††††††††</sup> The Ares I payload capacity is not much more than the Delta IV and Atlas V. It will cost a lot less to make the Delta and Atlas upgrades than it will to complete the Ares I system. The key problem is in the addition of a segment to the Ares I's solid rocket boosters (SRBs). The Space Shuttle's SRBs have four segments. The Ares I first stage has five segments. The addition of that segment to the SRB on the Ares I has proven to be costlier than earlier estimates. The addition of the segment created attendant technical problems leading to massive vibration over the structure of the launch system that endangers the human crew. There are concerns that the Ares I is not man-ratable.

Likely the U.S. Government will save money by canceling Ares I and upgrading the Delta IV and the Atlas V. And, Ares I's cancellation will incentivize private industry to provide a manned launch services market necessary to the upgrade of the Delta IV and the Atlas V.

### **2. The Moon and Mars**

The relevance of NASA lies in the vanguard of what its mission has been since it was transformed from the National Advisory Committee for Aeronautics (NACA). There are no stakeholders, public and private, in this COA, unless it would be less than 1% of the annual national budget that would be diverted from NASA to other programs and agencies.

### **3. Orion**

If Orion were redirected to support only the International Space Station, it would require a modification for "LEO only," since it is optimized for out of LEO operations. As an example among many, the heat shield could be pared down to handle a re-entry from LEO rather than the higher re-entry velocities from the Moon and deep space. Private stakeholders in the "LEO only" modifications would be those companies and their labor forces that built Orion and that would go on to modify it, and the communities that support those companies and labor forces.

A "LEO only" Orion would be cheaper to operate because all the systems needed for deep space can be downsized. The public stakeholder is the U.S. Government since it will not have to spend so much on a lunar/deep space capable Orion.

### **4. The Space Shuttle**

While extending a dead-end system presents some risk and drains public funds from the development of a new system (Constellation), it maintains private labor forces (i.e., Lockheed-Martin's and Boeing's United Space Alliance) and public labor forces. Keeping the Shuttle flying narrows the U.S. manned flight gap between the Space Shuttle being mothballed and the Orion coming on line. There are geopolitical ramifications to this gap. Our foreign policy national interests are held hostage by our dependence on other space capable countries (Russia and China), but whose national interests may conflict with ours.

### **5. Energy and Environment**

It is not clear what private stakeholders would be better off with a NASA mission focused on energy and the environment at the expense of human spaceflight. What more can NASA do that it is not doing already, or those other agencies, like the Department of Energy (DOE) and the National Oceanic and Atmospheric Administration (NOAA) are not already doing? NASA energy and environment projects that are an extension of their satellite and ISS missions are not likely to create tens of thousands of new jobs. For example, NASA weather satellite tracking

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<sup>††††††††</sup> See Young, John, *Topic: Ares I won't work*, Collectspace.com Website, June 2007, available at <http://www.collectspace.com/ubb/Forum39/HTML/000114.html> (accessed August 17, 2009). See also Aldrin, Buzz, and Nolan, David, *Buzz Aldrin to NASA: U.S. Space Policy Is on the Wrong Track*, August 2009, Popular Mechanics Website, available at [http://www.popularmechanics.com/science/air\\_space/4322647.html](http://www.popularmechanics.com/science/air_space/4322647.html) (accessed August 17, 2009).

stations only employ handfuls of people in host communities. The public stakeholder in a NASA mission that is inward looking is the U.S. Government. It would save billions of dollars in manned missions never flown.

## 6. Robotic Space Science

Abbey, et al. propose an effective ongoing robotic space science program. While such a program will likely be at the expense of the human spaceflight budget, its impact will likely be minimal. Robotic systems cannot do everything that humans need from space exploration, but they are certainly necessary partners to human systems. Private and public stakeholders will likely be maintained at nearly current levels and among the same cast of characters. This could change if nanotechnology verged with robotics to create medical or certain industrial applications. Such a “marriage” would create an overarching industry with various specialties like the computer industry that employs millions of people worldwide.

## 7. Aeronautical Research

The aviation industry is among the largest in the world that touches billions of lives daily. If reinvigorated aeronautical budgets for NASA mean being not much different from those that it has had during its organizational lifetime, and if NASA can help solve for the challenges of running aircraft on the decline side of oil, then its aeronautical research is the biggest bang for the buck. Private stakeholders might multiply as NASA aeronautical innovations are built into new aircraft and overhaul existing ones. Among the public stakeholders are those U.S. Government entities that rely on aviation, like the military services.

Stakeholders	Stakeholder Interests Served by Proposal	Private Stakeholders’ Interests
Private – Canceling Ares I	Lockheed-Martin, Boeing, their labor forces, their host communities; private launch services companies.	Canceling Ares I
Private – The Moon and Mars	None	
Private – Orion	Private companies that built the Orion, their labor forces, their host communities.	Orion
Private – The Space Shuttle	Private companies, like United Space Alliance, and their labor forces; their host communities.	The Space Shuttle
Private – Energy and Environment	Minimal as conceptualized.	
Private – Robotic and Space Science	Minimal change	
Private – Aeronautical Research	Boeing, Lockheed-Martin, Northrop-Grumman, et al., their labor forces, and host communities.	Aeronautical Research

**Table 4a. Private stakeholders and their interests served by Abbey, et al.**

Stakeholders	Stakeholder Interests Served by Proposal	Public Stakeholders’ Interests
Public – Canceling Areas I	U.S. Government	Canceling Ares I
Public – The Moon and Mars	None	
Public – Orion	U.S. Government	Orion
Public – The Space Shuttle	U.S. Government	The Space Shuttle
Public – Energy and Environment	U.S. Government	Energy and Environment
Public – Robotic Space Science	Minimal Change	
Public –Aeronautical Research	U.S. Government	Aeronautical Research

**Table 4b. Public stakeholders and their interests served by Abbey, et al.**

The model of society test, as we have qualitatively conceptualized it thus far, shows an overlap in public and private stakeholder interests in terms of what NASA can do in the realms of: canceling Ares I, using Orion in LEO, keeping the Space Shuttle flying, and aeronautical research. If we were to try and estimate where the Abbey, et al. policy falls on the market-political community continuum as depicted in Figure 1, there might be some trend toward the political community end, with the U.S. Government’s interest in putting “beyond LEO” manned spaceflight on indefinite hold. If we were to quantify this model, we might expect some changes in this profile (more on this later). What is more, historical events could make a difference. If private and international interests affect the profile of a nation-state’s policies (as conceptualized in Figure 2), then, in the case of the American manned space endeavor, the United States could find its space policy profile being radically altered as more nation-states find their way into space and as American private interests clamor for the federal government to respond.

**C. Abbey, et al. – The Model of Policy-Making**

Definition of objectives and the COAs to meet those objectives are major components for the decision-making process. The model of policy-making relied on the first and second tests after having learned through conducting how a policy proposal defined its objectives and how it intended to attain those objectives (its COAs). Is the policy worth pursuing (i.e., makes sense *vis-à-vis* the baseline elements we discussed above)? Here again, we plug in Abbey, et al.’s preferred COAs and do not include in this test the alternative COAs at which we ourselves arrived (as seen in Tables 3a – 3g). These include:

- Restructuring the human space initiative (by canceling Ares I);
- The Moon and Mars (putting these goals of human spaceflight on hold indefinitely);
- Orion (scaling it back for LEO use only);
- The Space Shuttle (continue to fly it through 2015);
- Energy and environment (divert NASA’s effort to these issues);
- Robotic space science (invigorate NASA’s effort); and
- Aeronautical research (invigorate NASA’s effort).††††††††

The results of this test let us break out the implications for implementation by deciphering which preferred Abbey, et al.’s COAs were pragmatic (and therefore easier to implement) and which were problematic (and therefore harder to implement). Let us take each COA by turn.

There does not seem to be much foreseeable resistance or disadvantages to the scrapping Ares I COA (Table 5a). Because Delta IV and Atlas V upgrades can likely be made in order to fly the Orion payload, it might make sense to scrap Ares I.

Baseline elements framed as questions	Restructuring the human space initiative (by canceling Ares I)	Advantages/Disadvantages
Is the objective/COA financially feasible?	Yes.	End problematic cash flow issues with the launch system; opportunities will be stimulated in the upgrade of the Delta IV and the Atlas V.
Is the objective/COA technically feasible?	Yes.	Boeing and Lockheed will have to work the technical problems to upgrade the Delta IV and the Atlas V, respectively.
Will the objective/COA have political and public support?	Yes. There may be resistance among some private and public (Congressional) stakeholders who may be advantaged by the go-ahead of the Ares I. But, this will not likely amount to much if the Delta IV and the Atlas V can be upgraded.	Scrapping the problematic launch system may actually win more political and public support.
Will the objective/COA meet legal requirements (national and international)?	Yes, based on the earlier parameters of the Delta IV and the Atlas V.	No disadvantages.
Will the COA permit the end objective to conduct independent or cooperative missions?	Yes.	No disadvantages.

**Table 5a. Scrapping Ares I as held against the metric of baseline questions**

†††††††† *Supra* Hsu, Feng, and Cox, Ken (2009).

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Putting human spaceflight to the Moon and Mars on indefinite hold is problematic (Table 5b). Yes, putting humans in space is costly. But, for NASA to concede this part of its organizational mission is to invite two categories of predations: 1) “give an inch, take a mile” inroads on the NASA budget and 2) questions about the *raison d’être* of NASA. The sweeping disadvantage of taking the Moon and Mars off the table, as mentioned above and elsewhere, is that it subtracts a whole evolutionary train of science and technology from the human knowledge base – science and technology relating to extremity of environment. This sophistication of know-how is necessary to turn around and apply to the mitigation of the effects of climate change and related issues. Not to mature that evolutionary train “beyond LEO” is not to have it when it is needed for Earth-side extremity.

Baseline elements framed as questions	Putting human spaceflight to the Moon and Mars on indefinite hold	Advantages/Disadvantages
Is the objective/COA financially feasible?	Yes.	Does not require a large sustainable multi-year budget. But, would invite “give and inch, take a mile” predations on the NASA budget.
Is the objective/COA technically feasible?	Yes.	Will not lead to scientific and technological developments that can be turned around and applied to mitigate the effects of climate change and other planetary-sized challenges of energy and environment on Earth.
Will the objective/COA have political and public support?	No. There will be great resistance among pro-space private and public “audiences.” When a wider array of audiences is made aware of the downside of not sending humans to the Moon and Mars, they will resist, too.	May have the effect of further dispiriting an American public. Putting the Moon and Mars on indefinite hold erodes NASA’s organizational mission, inviting questions about its <i>raison d’être</i> .
Will the objective/COA meet legal requirements (national and international)?	Yes.	No disadvantages.
Will the COA permit the end objective to conduct independent or cooperative missions?	Yes, on smaller scale human and unmanned missions, and where in time, we find ourselves partnering with a lower-grade array of partners.	Pursuing this COA will increasingly weaken the U.S.’s ranking in the world system of societies and will set it on a trajectory to the semi-periphery and outside the scope of various rising alliances among Europe, Russia, China, India, and others.

**Table 5b. Putting human spaceflight to the Moon and Mars on hold indefinitely held against the metric of baseline questions**

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Scaling back Orion for LEO use only makes sense if 1) the Space Shuttle absolutely must be retired and 2) if the Moon and Mars are taken off the table (Table 5c). But, putting human missions to the Moon and Mars on indefinite hold is not pragmatic in a seminal and overarching way, as we discussed above. And, as we will discuss below, the Space Shuttle has wrongfully been tarred “an aging system” and should not be retired prematurely. In addition to other downturns, “Orion for LEO only” reduces our ability to cooperate with other nations in space.

Baseline elements framed as questions	Scaling back Orion for LEO use only	Advantages/Disadvantages
Is the objective/COA financially feasible?	Yes.	Saves money on designing and implementing the additional materiel and systems needed for “beyond LEO” flight; with downmoding, spacecraft may be ready sooner to help fill the gap between Space Shuttle retirement and Orion coming on line.
Is the objective/COA technically feasible?	Yes.	Some stakeholders, such as private companies that can design “beyond LEO” systems will be cut out of benefiting from the implementation of the “fully loaded” spacecraft.
Will the objective/COA have political and public support?	No. There will be great resistance among pro-space private and public “audiences.” When a wider array of audiences is made aware of the downside of not having a spacecraft to get to the Moon and Mars, they will resist, too.	May have the effect of further dispiriting an American public.
Will the objective/COA meet legal requirements (national and international)?	Yes.	No disadvantages.
Will the COA permit the end objective to conduct independent or cooperative missions?	Yes, but on a smaller scale than otherwise would be possible even with the Space Shuttle.	It is a “math problem.” The Orion can hold up to six crewmates. The Space Shuttle can hold a maximum of 10 crewmates. That fact delimits the numbers of foreign astronauts who can fly any one American space mission on LEO in Orion.

**Table 5c. Scaling back Orion for LEO use only as held against the metric of baseline questions**

Abbey, et al. are being pragmatic in calling for a COA that keeps the Space Shuttle flying, and in fact the Shuttle can keep it flying beyond 2015 (Table 5d). The gap between Space Shuttle retirement and bringing Orion online is artificial. If the Space Shuttle fleet were retired today, the U.S. Government would put in mothballs a relatively young fleet. Each spacecraft was designed for 100 missions, whose operating life could conceivably be extended longer. None of the Shuttles have flown 100 flights. *Atlantis* just made its 30<sup>th</sup> flight, *Discovery* has 36 missions on it, and *Endeavour* has made only 22 flights. These spacecraft have been refitted with new systems, i.e., new avionics. The *Challenger* and *Columbia* disasters were entirely preventable as the after-actions on those accidents have revealed. However, when the latter was lost, the news media began to tout “an aging Shuttle fleet.” Newscasters are notoriously bad aerospace engineers. The U.S. Government is being railroaded into retiring a perfectly good orbital transport system by a perception created by the infotainment industry. In actual fact, the Space Shuttle fleet could keep flying right up till whenever we have a “good to go” Orion spacecraft and a new man-rated launch system.

The pragmatism in prematurely retiring the shuttle fleet is to be found by following the money trail. Premature retirement would mean a savings of just under half a billion dollars per Shuttle launch held against reliance on bumming rides from the Russians up to the space station, which runs around 20 million dollars or so per astronaut flown on a Soyuz spacecraft. The final decision is all in according to what we Americans want to save – money or the other things of value that make us a nation and that add to our ranking in the world system of societies.

Baseline elements framed as questions	Continue to fly the Space Shuttle through 2015	Advantages/Disadvantages
Is the objective/COA financially feasible?	Yes.	It helps fill the gap between Space Shuttle retirement and Orion coming on line, decreasing our dependence on Russian and even Chinese spacecraft to get to the Space Station.
Is the objective/COA technically feasible?	Yes.	Stakeholders, such as companies that support the Space Shuttle will continue to benefit from it continuing to be used for American spaceflight.
Will the objective/COA have political and public support?	Yes.	That the U.S. can get its astronauts on orbit on its own will help bolster the spirits of the American public.
Will the objective/COA meet legal requirements (national and international)?	Yes.	No disadvantages.
Will the COA permit the end objective to conduct independent or cooperative missions?	Yes.	No disadvantages.

**Table 5d. Continuing to fly the Space Shuttle through 2015 as held against the metric of baseline questions**

There are a lot of open holes in the COA of diverting NASA's effort to energy and environmental issues (Table 5e). For example: Abbey, et al. appear not to have made an analysis concerning how NASA can make these efforts better than other agencies invested with energy and environmental missions, nor has there been an analysis to explain how NASA is technically equipped to address these issues better than those agencies. Legal questions may emerge among federal agencies in relation to NASA "not staying in its lane." Interagency squabbling might break out that would drain away the effectiveness of all the agencies involved. At the very least, the Space Act might have to be amended again. The COA, if advocated before Congress and among federal executives, will invite questions about NASA's *raison d'être*.

Baseline elements framed as questions	Divert NASA's effort to energy and environmental issues	Advantages/Disadvantages
Is the objective/COA financially feasible?	To the extent that Abbey, et al. imply, this answer is unknown.	There has been no cost analysis to explain how NASA can make these efforts better than other agencies invested with energy and environmental missions.
Is the objective/COA technically feasible?	To the extent that Abbey, et al. imply, this answer is unknown.	There has been no analysis to explain how NASA is technically equipped to make these efforts better than other agencies invested with energy and environmental missions.
Will the objective/COA have political and public support?	Yes and no. Yes, because private and public audiences can understand energy and environmental problems as they become more noticeable in daily life. And, they will seek solutions from any agency that says it has a plan. No, because private and public audiences favoring human and robotic exploration of the solar system will not support it because this diversion will kill the quintessential NASA mission.	A substantial number of Congressional members and federal executives will question NASA's ability to make these efforts better than other agencies that already make these efforts. And, that will invite questions about NASA's <i>raison d'être</i> .
Will the objective/COA meet legal requirements (national and international)?	Perhaps not. There may be some legal tussling on the national scene if NASA goes "outside of its lane."	Legal squabbles could drain the effectiveness of NASA and other agencies that are involved.
Will the COA permit the end objective to conduct independent or cooperative missions?	To the extent that Abbey, et al. imply, this answer is unclear.	Lack of data to make an assessment.

**Table 5e. Diversion to energy and environmental issues as held against the metric of baseline questions**

Invigorating NASA’s robotic space science effort seems imminently pragmatic and there are no disadvantages as of yet in ramping up this pursuit (Table 5f). However, using robots should be weighed against the appropriateness of human spaceflight for certain types of missions. No doubt robots can reap great rewards, but they are limited in their ability to conduct various mission types and are only designed for limited usage.

Baseline elements framed as questions	Invigorate NASA’s robotic space science effort	Advantages/Disadvantages
Is the objective/COA financially feasible?	Yes.	Seems imminently practical extrapolating from current robotic efforts.
Is the objective/COA technically feasible?	Yes.	No disadvantages.
Will the objective/COA have political and public support?	Yes.	No disadvantages.
Will the objective/COA meet legal requirements (national and international)?	This will probably not become an issue until robotics edges into ethical concerns, like nanobots that can be injected into the human body for various purposes.	No disadvantages as yet.
Will the COA permit the end objective to conduct independent or cooperative missions?	Yes.	No disadvantages.

**Table 5f. Invigoration of NASA’s robotic space science effort as held against the metric of baseline questions**

Aeronautical research is an older part of the core NASA mission that has been made new again with the decline side of oil (Table 5g). It is not only an imminently pragmatic COA to follow, but also part of a greater energy and environmental effort for cleaner and more efficient engines and fuselage design. It would make sense for NASA to continue to lead the charge on aeronautical research.

Baseline elements framed as questions	Invigorate NASA’s aeronautical research	Advantages/Disadvantages
Is the objective/COA financially feasible?	Yes.	Seems imminently practical extrapolating from current aeronautical research efforts.
Is the objective/COA technically feasible?	Yes.	No disadvantages.
Will the objective/COA have political and public support?	Yes, very much so because private and public audiences are in favor of aviation safety measures of all types and are concerned about the survival of the airlines on the decline side of oil.	No disadvantages.
Will the objective/COA meet legal requirements (national and international)?	Yes.	No disadvantages as yet.
Will the COA permit the end objective to conduct independent or cooperative missions?	Yes.	No disadvantages.

**Table 5g. Invigoration of NASA’s aeronautical research as held against the metric of baseline questions**

The model of policy-making has been used above to integrate the various issues related to policy development in an attempt to create a broader picture of the implications of the Abbey, et al. policy proposal. We have attempted to account for the implications of all the objectives noted by Abbey, et al. Additionally, we have pointed out the societal implications of the various objectives noted above. Below is a summary of our findings.

**D. Abbey, et al. -- Summary of Results from All the Tests**

We have examined in detail Abbey et al.’s recommendations through the application of the three tests by which public policies can be evaluated: 1) the model of reasoning, the model of society, and the model of policy-making. The model of reasoning was useful to us in defining Abbey, et al.’s objectives and COAs, in understanding their overall rationale, as well as to examine some of our own COAs. The model of society demonstrated a solid overlap

in public and private stakeholder interests for canceling Ares I, using Orion in LEO, keeping the Space Shuttle flying, and NASA invigorating its aeronautical research efforts. The model of policy-making showed: the pragmatism of 1) scrapping Ares I; 2) keeping the Space Shuttle flying; 3) invigorating NASA's efforts in robotic space science; and 4) invigorating NASA's aeronautical research. On the other hand, the model of policy-making exposed the weaknesses in: 1) putting Moon and Mars human goals on indefinite hold; 2) scaling back Orion for LEO only; and 3) diverting NASA's effort to energy and environmental issues.

### E. Hsu and Cox – the Model of Reasoning

In February 2009, Feng Hsu and Ken Cox of the Aerospace Technology Working Group announced a space policy proposal meant to put into perspective NASA's prior shortcomings.<sup>§§§§§§§§</sup> Their white paper criticized NASA for not "successfully address[ing] the issues of affordability and sustainability in space exploration, and affordability and profitability in space commerce development."<sup>\*\*\*\*\*</sup> They are further critical of President George W. Bush's Vision for Space Exploration.

We found that the overall objective in the Hsu and Cox proposal was to set up a U.S. Department of Space with a number of priorities, chief among which was setting up a space transportation infrastructure within the Earth-Moon system. They referred to these objectives and the attendant COAs as a Unified Space Vision (USV). Besides stating their own preferred COAs, Hsu and Cox did not discuss any alternative COAs to meet their objective. What is more, the proposal authors were short on detail for their own preferred COAs that involved:

- Establishing a Department of Space with a litany of priorities;
- Setting a space transportation infrastructure within the Earth-Moon system (highest priority);
- Focusing the most on the development of re-usable launch vehicles (RLVs);
- Developing and establishing an international fuel depot and orbital staging/service space station in LEO;
- Promoting/supporting the establishment and construction of spaceport infrastructure in strategic locations within the U.S. and around the world;
- Develop enabling space infrastructure and observation and tracking capabilities for planetary defense; and
- Investing in space-based solar power (SBSP) research and development.<sup>†††††††††</sup>

We investigated their policy proposal through the following actions (Stone 2002, p. 8):

- 1) Identify objectives.
- 2) Identify alternative courses of action for achieving objectives.
- 3) Predict the possible consequences of each alternative.
- 4) Evaluate the possible consequences for each alternative.
- 5) Select the alternative that maximizes the attainment of the objectives.<sup>30</sup>

In Tables 6a – 6g, items 1.1, 2.1, 3.1, 4.1, 5.1, 6.1, and 7.1 (in bold font) are Hsu's and Cox's preferred COAs. In every other item in the far left column, they are alternative COAs that we have broached.

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<sup>§§§§§§§§</sup> Ibid. Hsu, Feng, and Cox, Ken (2009).

<sup>\*\*\*\*\*</sup> Ibid. Hsu, Feng, and Cox, Ken (2009, p. 2).

<sup>†††††††††</sup> Ibid. Hsu, Feng, and Cox, Ken.

A. Identify objectives. B. Identify alternative courses of action for achieving objectives.	C. Predict the possible consequences of each alternative.	D. Evaluate the possible consequences for each alternative.	E. Select the alternative that maximizes the attainment of the objectives.
1. New Government Agency			
<b>1.1 Establish Department of Space to foster the economic development in the Earth-Moon system.</b>	Free NASA to focus on deep space exploration, but proposers' conceptualized new agency is limited in scope.	NASA's deep space exploration program historically has been productive, but small, and might increase.	
1.2. Status quo. There is currently no Department of Space.	NASA's focus remains divided between near-Earth development and deep space exploration.	Not necessarily a problem, there are many examples of multipurpose agencies.	
1.3. Establish Department of Innovation.	Solves technical problems across a broad spectrum.	Would not focus on space development, but not a problem if NASA does.	Establish Department of Innovation.

**Table 6a. Concerning a U.S. Department of Space**

A. Identify objectives. B. Identify alternative courses of action for achieving objectives.	C. Predict the possible consequences of each alternative.	D. Evaluate the possible consequences for each alternative.	E. Select the alternative that maximizes the attainment of the objectives.
2. Earth-Moon Transportation Infrastructure			
<b>2.1 Set the goal of space transportation infrastructure development within the Earth-Moon system as the highest priority.</b>	Economic importance of Moon is unproven, as is commercial market for heavy-lift LV; conservatives will oppose space "industrial policy."	In short term, technocracy might develop capabilities faster; however, we can try techno-economy first, but it would probably take longer and ultimately be more sustainable. Technocracy could be switched on if techno-economy fails to perform.	Set the goal of space transportation infrastructure development within the Earth-moon system as the highest priority.
2.2. Status quo. The programs and policies now in place to develop the Constellation system.	Relies on technocracy, which is dependent on perceived national interest.	Might not be perceived to be in the national interest.	

**Table 6b. Concerning an Earth-Moon Transportation Infrastructure**

A. Identify objectives. B. Identify alternative courses of action for achieving objectives.	C. Predict the possible consequences of each alternative.	D. Evaluate the possible consequences for each alternative.	E. Select the alternative that maximizes the attainment of the objectives.
<b>3. Launch Vehicle and Manned Spacecraft Systems</b>			
<b>3.1 Focus heavily on the development of RLVs, such as crew and cargo transport and launch vehicle systems with top-level requirements of low-cost, low system complexity, and aircraft-like reliability, maintainability and operability.</b>	Advances development of space economy, but commercial enterprise has no track record with manned spacecraft, or with developing launch vehicles from scratch. High risk.	Becomes the preferred choice if Space Shuttle operations continue in the interim.	Focus heavily on the development of RLVs, such as crew and cargo transport and launch vehicle systems with top-level requirements of low-cost, low system complexity, and aircraft-like reliability, maintainability and operability.
3.2. Status quo. The programs and policies now in place to develop the Constellation system.	Technocracy has track record with manned spacecraft, and with developing launch vehicles from scratch, but solutions may not be economically optimized. Low risk.		

**Table 6c. Concerning Reusable Launch Vehicles (RLVs)**

A. Identify objectives. B. Identify alternative courses of action for achieving objectives.	C. Predict the possible consequences of each alternative.	D. Evaluate the possible consequences for each alternative.	E. Select the alternative that maximizes the attainment of the objectives.
<b>4. Fuel Depot and Orbital Staging Base</b>			
<b>4.1. Develop and establish an international fuel depot and orbital staging or service point (station) in the LEO environment that supports and services commercial space-transportation traffic needs or capabilities, such as space tourist flights, lunar and earth orbital transfers, and commercial satellite services.</b>	Might not be cost-effective vs. alternatives TBD.	Insufficient information for evaluation.	No recommendation requires further study.

**Table 6d. Concerning a fuel depot and orbital staging station**

A. Identify objectives. B. Identify alternative courses of action for achieving objectives.	C. Predict the possible consequences of each alternative.	D. Evaluate the possible consequences for each alternative.	E. Select the alternative that maximizes the attainment of the objectives.
5. Global Spaceport Infrastructure			
<b>5.1. Promote and support the establishment and construction of spaceport infrastructure in several strategic locations within the U.S. and around the globe, which will be utilized to meet the emerging demand of increased commercial launch and space-transport economic activities.</b>	Will not succeed without a business case.	Promotion and support is probably low-cost to the government.	5.1. Promote and support the establishment and construction of spaceport infrastructure development in several strategic locations within the U.S. and around the globe, which will be utilized to meet the emerging demand of increased commercial launch and space-transport economic activities.
5.2. Status quo.	Commercial carriers have fewer options to access space.	Little or no impact until commercial need becomes evident.	

**Table 6e. Concerning a global spaceport infrastructure**

A. Identify objectives. B. Identify alternative courses of action for achieving objectives.	C. Predict the possible consequences of each alternative.	D. Evaluate the possible consequences for each alternative.	E. Select the alternative that maximizes the attainment of the objectives.
6. Enabling Space Infrastructure			
<b>6.1. Develop enabling space infrastructure and observation and tracking capabilities for planetary defense.</b>	High expense, low probability of need, not the sole responsibility of the U.S.	International suspicion of U.S. military motives.	
6.2. Status quo.	Earth remains defenseless.	Potential for devastating impact.	
6.3. Establish International Space Agency for planetary defense, <i>inter alia</i> .	Shared responsibility and expense to defend against low probability, high consequence event.	No international suspicion of U.S. military motives.	Establish International Space Agency for planetary defense, <i>inter alia</i> .

**Table 6f. Concerning the development of enabling space infrastructure**

A. Identify objectives. B. Identify alternative courses of action for achieving objectives.	C. Predict the possible consequences of each alternative.	D. Evaluate the possible consequences for each alternative.	E. Select the alternative that maximizes the attainment of the objectives.
Space-based Solar Power			
<b>7.1 Invest in space-based solar power (SBSP) research and development.</b>	May accelerate development of space-based solar power.	Might not be cost-effective vs. Earth-based alternatives.	
7.2. Status quo.	Slower development of space-based solar power.	Longer and deeper fossil fuel dependence, or development of Earth-based alternatives.	

**Table 6g. Concerning investment in space-based solar power (SBSP)**

## **F. Hsu and Cox – The Model of Society**

In making our assessment of stakeholders, private and public, implicit in the Hsu and Cox proposal, we have strictly predicated our appraisal on only the proposers' preferred COAs – not from the alternative COAs that we proposed above in our model of reasoning examination.

### **1. Establishing a Department of Space with a Litany of Priorities**

It would be formidable getting the legislation that would carve out a whole new federal department that focuses on deep space development (i.e., construction, at least as far afield as the Moon), that would be separate from NASA (whose mandates would be aeronautics research and space exploration). There would be minimal U.S. Government interest in this in consideration of other issues: wars on two fronts, the condition of American health care, the United States' crumbling infrastructure of roads, bridges, etc., and the problem of America's competitiveness in the world, to give a few examples. Selling a Department of Space as such on Capitol Hill would be viewed as "pie in the sky." Members of Congress with aerospace industries in their districts would be in favor of it because they and their constituents have the most to gain. But, they are just a few in Congress.

Private individuals and firms invested in the vision and the professed mission of solar system development would benefit the most. However, most of the private firms that attend commercial space conferences and that tout commercial space interests beyond near-Earth space are small and possessive of more vision than actual assets and abilities to do anything off the Earth. Lockheed-Martin, Boeing, and other large aerospace-related companies would certainly bid on any projects that might result from a Department of Space and might support a planned department if they could be convinced large capital projects would materialize from it.

### **2. Setting a Space Transportation Infrastructure within the Earth-Moon System (Highest Priority)**

The large aerospace companies like Lockheed-Martin and Boeing, their labor forces, and the communities that host them would show great stakeholder interest. What is proposed is a large capital project, so perhaps foreign private firms would be allowed to bid. And, of course, their labor forces, and the communities that host them would benefit as well. But, something needs to be brought up at this juncture. Even if we could launch and maneuver a large amount of technology and materiel into space – stepping from the Earth to the Moon – the type of astronauts, cosmonauts, and taikonauts that form the world's space flyer corps cannot be expected to do this construction work or all of it. First of all, there are not enough of them, and most of them are far too valuable as scientists and engineers to demote them to "hardhats in space." Something like a large force of "hard hat" astronauts would have to be trained to do construction work in space. And, such people would come with a host of difficulties. They would have trouble getting security clearances, which is a problem that keeps many would-be civilian military contractors out of the American war zones. Presumably, some of their work would be of a national or global security nature. They could not all be expected to have perfect teeth, as the Chinese space program requires. The list goes on and on concerning how they would be different than existing space flyers. Such an astronaut corps is a completely different breed of cat. But, if a truly large amount of technology and materiel were required to serve the space between the Earth and the Moon, these are the people that will be needed.

There would be minimal U.S. Government interest. Even if the U.S. put a permanent base on the Moon, such an infrastructure would not be a priority.

### **3. Focusing the most on the Development of Re-usable Launch Vehicles (RLVs)**

To put all the technology, materiel, and hard hats in space to assemble large capital infrastructure between the Earth and the Moon will require RLVs. There would be a great deal of interest among large aerospace companies throughout the world vying to build these vehicles. The companies that would win bids, their labor forces, and their host communities would benefit. There would be a good deal of U.S. Government interest, particularly within the Department of Defense, because RLVs can be used for lofting other projects.

### **4. Developing and Establishing an International Fuel Depot and Orbital Staging/Service Space Station in LEO**

The same sort of companies as mentioned above, their labor forces, and their host communities would benefit from constructing this particular infrastructure in LEO. Again, the "hard hat" astronaut corps would have to be deployed. There would be minimal U.S. Government interest unless a permanent base on the Moon and substantial industries on LEO were to be established.

## **5. Promoting/Supporting the Establishment and Construction of Spaceport Infrastructure in Strategic Locations within the U.S. and around the World**

Worldwide, private companies would build the spaceports; and their labor forces and their host communities would benefit. The federal government has shown interest in designating some facilities in the U.S. as spaceports, but there has been little interest in putting launch facilities on foreign soil. This attitude could change, however, if a new technology, like a space plane, were to be developed and put to application. But, likely, these sorts of spaceports would be owned and managed much as airports are throughout the world. In the United States, ownership and management usually falls to cities and counties. Sometimes they are privately owned by large aerospace companies.

## **6. Develop Enabling Space Infrastructure and Observation and Tracking Capabilities for Planetary Defense**

Worldwide, private companies, in collaboration with military and security sectors, would help build the planetary defense infrastructure and capabilities. Their labor forces and their host communities would benefit. We would have put this item at the top of the priority list for a Department of Space. Substantial impacts and near-impacts from near-Earth objects is a very real threat. Just because one has not devastated an area of the Earth since the Tunguska atmospheric bounce does not mean one will not strike again soon. Not having the Earth struck by a large asteroid or comet would certainly benefit the population of the entire Earth. There is minimal U.S. Government interest in this area. While some federal funding has been spent on tracking Near-Earth Objects and discussing mitigation strategies, it will probably take a near-miss or the “blood priority” of a strike on U.S. soil to ramp up serious spending.

## **7. Investing in Space-based Solar Power (SBSP) Research and Development**

Upon investment and appropriate research and development, worldwide, the large private aerospace and power companies would help build the SBSP arrays and stations; their labor forces and their host communities would benefit. Billions of users would benefit from electricity generated through SBSP. Energy-starvation and the conversion of personal transportation to electricity guarantees something like a heavier U.S. Government interest sooner, rather than later.

The model of society test, as we have qualitatively conceptualized it thus far, shows an overlap in public and private stakeholder interests in terms of RLVs and space-based solar power. Clearly, before private interests can act, where there would be expected a great deal of stakeholdership, government needs to lead the way. But, the U.S. Government is not going to lead the way on the total package of the Hsu and Cox proposal. If we were to estimate where the Hsu and Cox policy falls on the market-political community continuum as depicted in Figure 1, there would be a distinct trend toward the market end.

As with the Abbey, et al. proposal, if we were to quantify this model, we might expect some changes in this profile. More on this later. And, as mentioned before, historical events could make a difference. If private and international interests affect the profile of a nation-state’s policies (as conceptualized in Figure 2), then, in the case of the American manned space endeavor, the United States could find its space policy profile being radically altered as more nation-states find their way into space and as American private interests clamor for the federal government to respond.

Stakeholders	Stakeholder Interests Served by Proposal	Private Stakeholders' Interests
Private – Establishing a Department of Space	Private individuals and firms invested in the vision/mission of solar system development would benefit the most. However, most of the private firms on the books that tout a commercial space interest beyond near-Earth space are small and possessive of more vision than actual assets and abilities to do anything off the Earth. Lockheed-Martin, Boeing, and other large aerospace-related companies would bid on any projects that might result from a Department of Space. If projects would emerge (such as those below), these companies' labor forces and host communities would benefit.	Minimal weight among private stakeholders
Private – Establishing a space transportation infrastructure within the Earth-Moon system (highest priority)	Not only the large aerospace companies mentioned above would benefit; their labor forces, and the communities that host them would, too. But also, perhaps foreign private firms would be allowed to bid. And, of course, their labor forces, and the communities that host them would benefit as well. An astronaut corps that would more resemble “hardhats in space” would have to be convened for this work.	Space transportation infrastructure between the Earth and Moon
Private – Focusing the most on the development of reusable launch vehicles (RLVs)	Worldwide: the large private aerospace companies would build the RLVs; their labor forces and their host communities would benefit.	RLVs
Private – Developing and establishing an international fuel depot and orbital staging/service space station in LEO	Worldwide: the private companies that would build this infrastructure, their labor forces, and their host communities would benefit. An astronaut corps that would more resemble “hardhats in space” would have to be convened for this work.	International fuel depot and orbital staging/service space station on LEO
Private – Promoting/supporting the establishment and construction of spaceport infrastructure in strategic locations within the U.S. and around the world	Worldwide: private companies would build the spaceports; and their labor forces and their host communities would benefit.	Spaceport infrastructures throughout the world
Private – Developing enabling space infrastructure and observation and tracking capabilities for planetary defense	Worldwide: the private companies would help build the planetary defense infrastructure and capabilities; their labor forces, their host communities would benefit. Not being struck by a large asteroid or comet would certainly benefit the population of the Earth.	Planetary defense infrastructure and capabilities
Private – Investing in space-based solar power (SBSP) research and development	Worldwide: upon investment and appropriate research and development, the large private aerospace companies would help build the SBSP arrays and stations; their labor forces and their host communities would benefit. Billions of users would benefit from SBSP.	Space-based solar power

**Table 7a. Private stakeholders and their interests served by Hsu and Cox**

Stakeholders	Stakeholder Interests Served by Proposal	Public Stakeholders' Interests
Public – Establishing a Department of Space	Minimal U.S. Government interest. Members of Congress with aerospace industries in their districts would have the most to gain.	Minimal weight among public stakeholders
Public – Establishing a space transportation infrastructure within the Earth-Moon system (highest priority)	Minimal U.S. Government interest. Even if the U.S. put a permanent base on the Moon, such an infrastructure would not be a priority.	
Public – Focusing the most on the development of re-usable launch vehicles (RLVs)	U.S. Government interest because RLVs can be used for lofting other projects.	RLVs
Public – Developing and establishing an international fuel depot and orbital staging/service space station in LEO	Minimal U.S. Government interest unless a permanent base on the Moon and substantial industries on LEO were to be established.	
Public – Promoting/supporting the establishment and construction of spaceport infrastructure in strategic locations within the U.S. and around the world	The federal government has shown interest in designating some facilities in the U.S. as spaceports, but there has been little interest in putting launch facilities on foreign soil.	
Public – Developing enabling space infrastructure and observation and tracking capabilities for planetary defense	Minimal U.S. Government interest. While some federal funding has been spent on tracking Near-Earth Objects and discussing mitigation strategies, it will probably take a near-miss or the “blood priority” of a strike on U.S. soil to ramp up serious spending.	
Public – Investing in space-based solar power (SBSP) research and development	Energy-starvation and the conversion of personal transportation to electricity guarantees something like a heavier U.S. Government interest sooner, rather than later.	Space-based solar power

### 7b. Public stakeholders and their interests served by Hsu and Cox

#### G. Hsu and Cox – The Model of Policy-Making

As said before, the model of policy-making relied on the first and second tests by having learned through conducting them how a policy proposal defined its objectives and how it intended to attain those objectives (its COAs). Definition of objectives and the COAs to meet those objectives are major components for the decision-making process. Is the policy worth pursuing (i.e., makes sense *vis-à-vis* the baseline elements we discussed above)? Here again, we plug in Hsu’s and Cox’s preferred COAs and do not include in this test the alternative COAs at which we ourselves arrived (as seen in Tables 6a – 6g). These include:

- Establishing a Department of Space with a litany of priorities;
- Setting a space transportation infrastructure within the Earth-Moon system (highest priority);
- Focusing the most on the development of re-usable launch vehicles (RLVs);
- Developing and establishing an international fuel depot and orbital staging/service space station in LEO;
- Promoting/supporting the establishment and construction of spaceport infrastructure in strategic locations within the U.S. and around the world;
- Develop enabling space infrastructure and observation and tracking capabilities for planetary defense;
- and
- Investing in space-based solar power (SBSP) research and development.††††††††

The results of this test let us break out the implications for implementation by deciphering which preferred of Hsu’s and Cox’s COAs were pragmatic (and therefore easier to implement) and which were problematic (and therefore harder to implement). Let us take each COA by turn.

†††††††† Supra Hsu, Feng, and Cox, Ken (2009).

A major drawback of this proposal is that it calls for a great deal of large capital projects dependent upon new technologies to be enacted under a banner that will be viewed as “pie in the sky” (Table 8a). The projects will require a good deal of funding, as well as international cooperation. Could the U.S. depend on other space capable nations to reciprocate and cooperate with their own “Departments of Space” on the technological goals?

Baseline elements framed as questions	Establishing a Department of Space	Advantages/Disadvantages
Is the objective/COA financially feasible?	No	Quite likely money could be found to set up the department. Finding the money for the large capital projects that the department would kick off would be greatly problematic.
Is the objective/COA technically feasible?	Overall, no	Some technologies are ready to go; others have to be developed.
Will the objective/COA have political and public support?	Yes and no. There would be a good deal of support from among the pro-space public, but the political enemies of pro-space would point out the flaws in this COA and would counteract its being adopted.	It calls for a lot of large capital projects under a banner that will be labeled “pie in the sky.”
Will the objective/COA meet legal requirements (national and international)?	Unknown	There would likely to be squabbling over what is NASA’s “lane” and what is the new department’s “lane.”
Will the COA permit the end objective to conduct independent or cooperative missions?	Yes	This and related COAs seems to have an international cooperation requirement built into it.

**Table 8a. Establishing a Department of Space held against the metric of baseline questions**

The Hsu and Cox space transportation infrastructure seems to have the cart before the horse, putting the end state first, whereas it is a COA best plied at the terminus of other steps in space between the Earth and the Moon (Table 8b). Where are the initial productive infrastructures on the Moon? Otherwise, this infrastructure is simply a “highway to nowhere.” Moreover, to build any of the large-scale capital projects that they name in their proposal will require a “hard hat” astronaut corps that no national space agency currently recruits and trains, not to mention the infrastructure to accommodate them while they are on the job in space.

Baseline elements framed as questions	Establishing a space transportation infrastructure within the Earth-Moon system (highest priority)	Advantages/Disadvantages
Is the objective/COA financially feasible?	No, not from the U.S. Government alone. This type of project will take sustained, multi-year funding from multiple revenue streams.	It like building an infrastructure on a “highway to nowhere.” What is on the Moon?
Is the objective/COA technically feasible?	Overall, no.	Some technologies are ready to go; others have to be developed.
Will the objective/COA have political and public support?	Yes and no. There would be a good deal of support from among the pro-space public, but the political enemies of pro-space would point out the flaws in this COA and would counteract its being adopted.	Advantage: Would need the creation of a “hard hat” astronaut corps.  Disadvantage: A bit “cart before the horse” in nature. The Hsu and Cox “highest priority” seems more like an end state of other steps.
Will the objective/COA meet legal requirements (national and international)?	Yes.	No disadvantages.
Will the COA permit the end objective to conduct independent or cooperative missions?	Yes	No disadvantages.

**Table 8b. Establishment of a space transportation infrastructure within the Earth-Moon system held against the metric of baseline questions**

The advantages of developing RLVs outweigh any disadvantages. There is an evolution of technology leading up to RLV development (Table 8c). The production of RLVs could help facilitate innovation and lower the cost to LEO.

Baseline elements framed as questions	Development of re-usable launch vehicles (RLVs)	Advantages/Disadvantages
Is the objective/COA financially feasible?	Yes	Advantages: RLVs have multiple uses/users and will likely be a cost-effective technology.
Is the objective/COA technically feasible?	Yes	There is an evolution of technology leading up to RLV development.
Will the objective/COA have political and public support?	Yes, among pro-space advocates and among those who can be convinced of the RLVs’ cost-effectiveness.	Those stakeholders currently profiting from non-RLVs may be resistant at first, but might be expected to re-tool to profit from production of RLVs.
Will the objective/COA meet legal requirements (national and international)?	Yes.	No disadvantages.
Will the COA permit the end objective to conduct independent or cooperative missions?	Yes.	No disadvantages.

**Table 8c. Development of RLVs held against the metric of baseline questions**

Hsu and Cox are not clear what purpose this fuel depot/station in LEO would be serving (Table 8d). It sounds like it is the *initium* at the head of the Earth-Moon transportation infrastructure where on-surface lunar facilities are at its terminus. However, as with the Earth-Moon transportation infrastructure, they do not explain why all these facilities would be needed. Supposing the need would be eventually to exploit space-based energy sources, to include helium-3 mining on the Moon, the RLV spacecraft serving those purposes would have to be co-developed with these facilities. Otherwise, the cautionary tale of the Space Shuttle and Space Station *Freedom* of uncoupled co-components would repeat in history.

Baseline elements framed as questions	An international fuel depot and orbital staging/service space station in LEO	Advantages/Disadvantages
Is the objective/COA financially feasible?	Yes, but this project is a number of ways more complex than the ISS and will need sustained multi-year, multiple revenue streams in order to not overrun costs and not to be downmoded. Costs would have to include matching RLVs as a co-developed article.	In the proposal's scheme of things, this project would be like the <i>initium</i> at the head of the Earth-Moon transportation infrastructure where on-surface lunar facilities are at its terminus. The danger is if the RLVs that would make use of this facility would get uncoupled from the depot/station – as in the case of the Space Shuttle and Space Station <i>Freedom</i> .
Is the objective/COA technically feasible?	Yes and no.	Much of the technology needed has been “test-driven” by several generations of space stations, but many more technologies will have to be developed.
Will the objective/COA have political and public support?	Yes, among pro-space advocates and among those who can be convinced of the necessity, or eventual necessity, of the project.	It is not clear what necessity this project is meeting.
Will the objective/COA meet legal requirements (national and international)?	Yes.	No disadvantages.
Will the COA permit the end objective to conduct independent or cooperative missions?	Yes.	No disadvantages.

**Table 8d. An international fuel depot and orbital staging/service space station in LEO as held against the metric of baseline questions**

Much on the necessity of spaceports the proposers would locate around the world is unclear (Table 8e). Certainly, if there were high launching and re-entry traffic, more spaceports would have to be constructed to accommodate specific types of spacecraft. The construction of spaceports in areas of the world that are poorer than others could bring an influx of opportunity and wealth for those locations. Further upsides are that spaceport technology is probably readily available without much further development, they can probably be operated like international airports, and the body of air and space international law is sufficient to cover the placement of a set of cooperating spaceports around the world.

Baseline elements framed as questions	Spaceport infrastructure in strategic locations within the U.S. and around the world	Advantages/Disadvantages
Is the objective/COA financially feasible?	Yes, but would require multi-year funding and multiple revenue streams.	Unclear. Beyond current launch sites, creation of more implies that the proposers expect a heavy outflow and influx of space traffic.
Is the objective/COA technically feasible?	Yes, some new technologies would likely have to be spun up.	No disadvantages.
Will the objective/COA have political and public support?	This is unclear. Certainly, some countries and their peoples would especially welcome spaceports on their soil if it meant opportunities for jobs and wealth creation.	Unclear
Will the objective/COA meet legal requirements (national and international)?	International law on air and space are likely sufficient to cover an international array of spaceports.	Unclear
Will the COA permit the end objective to conduct independent or cooperative missions?	Yes	Advantage: Could be operated on the international airport paradigm.

**Table 8e. Spaceport infrastructure in strategic locations within the U.S. and around the world as held against the metric of baseline questions**

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Having a planetary defense system to ward off would-be impactors is more pragmatic than many people are prepared to believe (Table 8f). In the absence of “blood priority,” i.e., being able to enumerate the dead killed at a problematic intersection in order to get a traffic light installed, convincing politicians and many members of the public of the necessity of a planetary defense system reads like so much science fiction. When and if people are convinced that they need a defense system against impactors, then international negotiations can proceed, which will not be without their sticking points. By definition, the system is a weapon of mass destruction that is prohibited by the Outer Space Treaty, for instance.

Baseline elements framed as questions	Planetary defense	Advantages/Disadvantages
Is the objective/COA financially feasible?	Unknown, much funding for the annual budget of this project probably dwells within the world’s defense departments and similar organizations.	Of the proposers’ conceptualizations, this is one of the necessary applications of aerospace technology.
Is the objective/COA technically feasible?	Yes, but other technologies need to be developed.	No disadvantages.
Will the objective/COA have political and public support?	Yes, once politicians and the public understand the danger the Earth is in from impactors. But, even so, it will be a tough “sell.” On something like this, “blood priority” events have to be within recent memory.	No disadvantages.
Will the objective/COA meet legal requirements (national and international)?	This will require some negotiations to hash out a planetary defense treaty, the origins of which might be found within existing international law. However, some “stickler” examples, to the contrary, are problematic. By definition, a planetary defense system is a weapon of mass destruction, which is prohibited by the Outer Space Treaty.	Per se, international dialogue and negotiation is beneficial.
Will the COA permit the end objective to conduct independent or cooperative missions?	Yes.	No disadvantages.

**Table 8f. A planetary defense system as held against the metric of baseline questions**

The space-based solar power issue is the second of two of the proposers’ pragmatic COAs (Table 8g). This will likely be the main rationale for putting a wide array of space transportation infrastructure between the Earth and the Moon. Generally, individuals who live in urban areas have an understanding of the effects a power outage can have on daily routines. Freightling “hard hat” astronauts, materiel, and technologies aloft to keep the power on is not such a quantum leap, but could be expensive. In some parts of the world, there is no regular electrical power. Still individuals and nations seek to acquire electrical generators, nuclear power plants, and/or traditional electricity grids. As personal transportation systems come to rely more on electrical power on the decline side of oil, and as global population increases, the need for electrical power will intensify. However, the practicality of develop such infrastructure may also run into allocative problems and legal limitations. These issues would need to be mitigated as the technology matures, including labor practices and standards for construction and maintenance crews.

Baseline elements framed as questions	Space-based solar power (SBSP)	Advantages/Disadvantages
Is the objective/COA financially feasible?	Yes, but only with sustained multi-year, multiple streams of revenue.	Advantage: Can provide electrical power on the decline side of oil as increasingly more personal transport systems depend on electricity.  This is another of the proposers' practical COAs.
Is the objective/COA technically feasible?	Yes, but other technologies will have to be innovated.	No disadvantages.
Will the objective/COA have political and public support?	Yes, but many politicians and members of the public will need to be convinced that there are no safety and health hazards on the ground and that the systems deployed in space are necessary.	No disadvantages.
Will the objective/COA meet legal requirements (national and international)?	Some national and international laws concerning power production and grids will have to be updated.	No disadvantages.
Will the COA permit the end objective to conduct independent or cooperative missions?	Yes.	No disadvantages.

**Table 8g. Space-based solar power (SBSP) as held against the metric of baseline questions**

The model of policy-making has been used above to integrate the various issues related to policy development in an attempt to create a broader picture of the implications of the Hsu and Cox. policy proposal. We have attempted to account for the implications of all the objectives noted by Hsu and Cox. Additionally, we have pointed out the societal implications of the various objectives noted above. Below is a summary of our findings.

#### **H. Hsu and Cox -- Summary of Results From All the Tests**

We have examined in detail Hsu's and Cox's recommendations through the application of the three tests by which public policies can be evaluated: 1) the model of reasoning, the model of society, and the model of policy-making. The model of reasoning was useful to us in defining Hsu's and Cox's objectives and COAs, in understanding their overall rationale, as well as examining some of our own COAs. The model of society demonstrated a solid overlap in public and private stakeholder interests for RLVs and space-based solar power. Clearly, before private stakeholders can act, government needs to lead the way. But, the U.S. Government is not going to lead the way on the total package of the Hsu and Cox proposal. In making our assessments, phrases like "highway to nowhere," "cart before the horse," and "pie in the sky" kept occurring to us as we looked at the proposal through the lenses of society and various private and public stakeholders. The model of policy-making showed the pragmatism of 1) RLVs, 2) planetary defense, and 3) space-based solar power. It also demonstrated the weaknesses in advocating outright for 1) a Department of Space, 2) a space transportation infrastructure between the Earth and the Moon, 3) an international fuel depot and orbital staging/service space station, and 4) an Earthside spaceport infrastructure.

### **V. Discussion**

Below we discuss the preliminary findings of the Augustine Panel on U.S. Human Spaceflight plans. Additionally, we discuss some of the issues that were brought up by Abbey, et al. and Hsu and Feng in their space policy proposals. Finally, we give our own thoughts on the way forward for NASA given the limitations NASA faces, as noted above, as well as the various space related issue areas that do or might affect NASA as noted in our analysis thus far.

#### **A. Review of U.S. Space Flight Plans Committee: Augustine Panel Preliminary Findings**

The Augustine Panel is a Federal Advisory Committee authorized under 5 U.S.C. App. (as amended). Unlike the Abbey, et al. and Hsu and Cox proposals, the Augustine Panel report will not be a list of recommendations for

President Obama. §§§§§§§§ Instead, the Augustine Panel will present the President with several options, i.e., directions, for America's human spaceflight program. These options have been narrowed down from over 3,000 considered by the Panel. On August 6, 2009, it was reported that the Panel had decided upon three options that currently fit into NASA's exploration budget. These included the following:

**NASA Baseline Plan:** Stretch out the schedule for NASA's current Constellation program goals to build and fly Orion and the Ares rockets within the budget available, retire the shuttle fleet in 2011, and end United States involvement in the 16-country International Space Station in 2015. Rely on international partners for crew and cargo transport until Orion and U.S. commercial flights are available.

**Space Station Focused:** Retire the shuttle fleet in 2011, but extend space station operation [sic] through 2020. Rely on international partners for crew and cargo transport until Orion and Ares I rockets, or commercial flight, are available.

**Dash Out of Low Earth Orbit:** This option retains the shuttle fleet's 2011 retirement and the 2015 deadline for U.S. involvement in the space station, but eliminates the Ares I rocket entirely in order to focus on the heavy-lift Ares V rocket, which could then be used to launch Orion flights to lunar orbit, near-Earth asteroids or even planetary flybys. International partners would provide crew and cargo transport until the larger Ares V comes online. §§§§§§§§

Four additional options were considered by the Panel; unfortunately, they exceed the exploration budget currently set by Congress. These included:

**More Directly Shuttle Derived System:** This scenario calls for flying the space shuttle through 2015 and eventually replacing it with a system that more heavily draws on the shuttle hardware, like its external tank and twin solid rocket boosters. A potential Side-Mount Shuttle, which would use the tank and boosters to launch a cargo pod or crew capsule instead of a reusable orbiter, is one such plan. The shuttle would fly beyond 2011 at a rate of up to two flights a year and the space station would fly until 2020. Eventually, commercial crew launch services are envisioned.

**Deep Space:** This option would retire the shuttle fleet in 2011 and extend space station operations through 2020. It suggests developing U.S. crew launch capability as a backup to services provided by international partners and commercial interests. The focus would be building a heavy-lift vehicle capability of launching astronauts on lunar orbital missions, near-Earth asteroid missions, and planetary flybys.

**Lunar Global:** The shuttle replacement plans for this scenario are similar to those for the Deep Space option, but the fleet would still retire in 2011 with the space station continuing through 2020. Instead of setting up a short-duration outpost on the Moon, however, the aim would be for extended stays for more exploration.

**Mars Direct:** The final option under the committee's eye largely skips the Moon and focuses on the sending astronauts directly to Mars. Like others, it includes retiring the shuttle fleet by 2011 and extending the space station through 2020. International partners and commercial companies would provide crew launch services while NASA develops a fleet of Ares V rockets to launch crew and cargo to Mars. The plan would only send humans to the Moon or near-Earth asteroids in order to test hardware for the Mars mission. ††††††††††

On August 12, 2009, the Panel met in Washington, DC and decided to drop several options from their preliminary choices. The following scenarios only fit into NASA's current projected budget. The Panel refined their list of options down to four general scenarios: 1) stay with Constellation; 2) extend ISS operations; 3) extend Shuttle operations; and 4) three flexible deep-space-exploration options with Shuttle retired in 2011 and ISS in 2020. †††††††††† The first scenario calls for: the continuation of the Constellation Program, which will continue

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§§§§§§§§ *Charter of Review of Human Space Flight Plans Committee*, NASA Website, available at <http://www.nasa.gov/offices/hsf/about/charter.html> (accessed August 17, 2009).

\*\*\*\*\* Malik, Tariq, *Presidential Panel Narrows Options for NASA's Future*, Space.com Website, August 5, 2009, available at <http://www.space.com/news/090805-human-spaceflight-options.html> (accessed August 17, 2009).

†††††††††† Ibid. Malik, Tariq (2009).

†††††††††† Matthews, Mark, and Block, Robert, *Space flight panel can't fit lunar mission into NASA budget*, Physorg.com Website, August 16, 2009, available at <http://www.physorg.com/news169653263.html> (accessed August 17, 2009).

development of the Ares I and V rockets to send astronauts and equipment into space; the retirement of the Shuttle in 2010-11 and ISS in 2015; first Moon orbit to occur sometime after 2028. The second scenario calls for: the retirement of the Shuttle in 2011 and the ISS in 2020; the use of commercial rockets instead of the Ares I; the first orbit of the Moon in 2028. The third scenario calls for: the retirement of the Shuttle in 2015 and the ISS in 2020, with commercial rockets transporting the crew to and from the ISS after 2015; the development of Ares V “lite” or a new “heavy-lift” rocket derived from existing Shuttle technologies for future lunar orbit and scouting missions in early 2020s. The fourth scenario consists of three separate missions:

1. Build Shuttle technology derived rockets; develop orbiting fuel depots; commence first Moon orbit by 2023; orbit first asteroids by 2027; orbit Mars by 2029; land on Moon by 2030.
2. Build commercial heavy-lift rockets; develop fuel depots; orbit Moon by 2024; orbit asteroids by 2026; orbit Mars in 2029; land on Moon in 2029.
3. Use commercial rockets to finish building ISS; build Ares V “lite”; orbit Moon in 2025; orbit asteroids in 2030; orbit Mars in 2034; land on Moon in 2025.

Each scenario has different estimated costs. The cost of the first scenario is estimated at \$99 billion through 2020 or \$205 billion through 2030. The second scenario is estimated at around \$101 billion through 2020 or \$204 billion through 2030. There is no cost data available for the third scenario. The fourth scenario will cost: first mission \$123 billion through 2020 or \$266 billion through 2030; second mission \$123 billion through 2020 or \$256 billion through 2030; and third mission \$126 billion through 2020 or \$272 billion through 2030.\*\*\*\*\*

The Augustine Panel has more work to do and may augment the four scenarios above in their final report. However, from these preliminary data, we can see that the Mars Direct option is out. It is also clear that the timetable currently used for the Constellation Program is untenable under NASA’s current budget. Furthermore, unless NASA funding is significantly increased, the pace of the U.S. spaceflight program will be stunted.

## B. The Future Relevance of NASA

It remains to be seen whether NASA will still be relevant in the future. Missions to either the Moon or Mars are not just a matter of political will, but monetary commitments. No government or private entity can currently afford such major capital expenditures due to various financial, political and technological limitations. Using the rationale and conclusions drawn from Apollo are insufficient to account for or mitigate risks of space missions based upon any perceived political reward. We do not doubt the importance of politics in space policy; however, the technology and systems management skills that will be needed are extremely important for the success of any venture in outer space. We are currently at a point in history where our ambitions are greater than our resources and “know-how”. To begin with, the development of sufficient life support systems, mining equipment and processing facilities are not yet available. It is not entirely clear what procedures would be needed to combat the effects of erosion and system failure due to the highly aggressive dust that coats the surface of the Moon. Nor have sufficient regulations been considered for anyone but highly trained and motivated astronauts to be able to do any work on the lunar surface. Moreover, the variable costs associated with maintaining a Moon base will be exceedingly high given our experiences with the ISS, knowledge of leak rates in closed life support systems, and understanding of the materials needed for survival away from Earth. Additionally, the physiological and psychological toll that working on the Moon, Mars or in deep space could possibly have on personnel over prolonged periods is not well understood. Even so, the challenges of a mission to Mars would be orders of magnitude greater than what can be accounted for on the Moon. More research needs to be done to account for these shortcomings, especially in terms of long-term strategic vision. Either more money needs to be injected into NASA programs, or NASA goals need to be streamlined to meet budgets set by Congress.

Deferring Moon and Mars missions indefinitely will kill NASA and American space policy will be relegated to the dustbin of history. There are a great many other consequences as well. Time-slipping these missions further into the future has already done a great deal of damage. For those of us who study technology evolution, over three decades’ worth of stalling on this end of the timeline has translated into many more decades, if not centuries, of technology slowdown and stagnation downrange for the United States and for the world. This is currently having dire ramifications for American innovation. As the need for alternative energy sources mount and climate change and its effects become more extreme, we will find ourselves without the technologies to mitigate these challenges because we do not have the *level* of technology that we would have had, had we stayed our course cutting our teeth on the most extreme of human challenges – humans living and working on the Moon and Mars.

We see where Abbey et al. are headed with their proposal: make NASA relevant to the problems of American innovation, to the need for alternative energy systems, and to the concern for climate change. But, their COA on the

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\*\*\*\*\* Ibid. Matthews, Mark, and Block, Robert (2009).

point of the Moon and Mars will destroy NASA and make the United States a technological backwater. We have connected the dots between sustained human space endeavor, climate change and energy challenges, and some other factors in earlier statements (Dudley-Flores and Gangale 2007, Dudley-Flores 2008).<sup>31, 32</sup> The steps that took men to the Moon created the current level of globalization that, while creating problems, created great leaps in science and technology that have improved the lives of billions and have introduced countless others to a higher bar in the standard of living, life chances, and expectations of social investment. As with any human advancement, it is at once a sword and a plowshare.

Moreover, taking humans out of the picture for the Moon and Mars may have the effect of “taking the stars out of the flag” for Americans who have seen a string of events play out since 9/11 which have led to two wearisome wars. Our national honor, our *esprit de corps* as Americans, our can-do attitudes, and our dreams are on the line. The pursuit of the Moon and Mars has the power to renovate the American soul, just as much as that pursuit will put the quantum leap into American innovation. If this level of innovation is not made, the U.S.’s ranking in the world system of societies will set our country on a trajectory to the semi-periphery of the world system of societies and outside the scope of various rising alliances among Europe, Russia, China, and India – alliances that will do “big science” and enact “great policy” that will ensure their places at the core of the global system.

Human spaceflight, especially in increasing distances away from the Earth, is enormously costly and requires guaranteed, multi-year revenue. Yet, it is the one of the few human activities that has proven to be of monumental worth to the American people and to the world. We are not speaking of the “flags and footprints” of the Moon missions that won the Space Race or even of the first photographs from the Moon of the Earth, but of the combinatorial effects of the technologies that stepped to the Apollo program and the legacy of Apollo that made the world at once smaller and greater than what it once was. If the Apollo program of the 1960s and 1970s can have such a far-reaching impact as it had, what impact might an “Apollo program” with today’s current technology have on an Earth becoming more extreme? Abbey et al. see part of the solution for NASA’s relevancy, but that piece alone will deal NASA a death blow. Energy and environment missions must be conjoined at various interfaces with sustained human missions on Earth orbit and to the Moon and Mars. Such an “Apollo program” must include other global partners. As we have previously written (Dudley-Flores 2008),<sup>33</sup> one of the diagnostic factors of those societies that will emerge as core in the renegotiating world order will be those nation-states that are willing to partner with other space capable nation-states.

The focus on robotic missions has also de-emphasized NASA’s human spaceflight program. While the robotic missions to Mars and probes to other bodies in the Solar System are indeed an important aspect of NASA space policy, human spaceflight is paramount to developing outer space for scientific and commercial ventures. We can only learn so much and do so many things with robots. Sending robots in place of humans is absurd in the long run unless human society agrees to stay put on Earth. However, it is doubtful that such sentiment does exist, or will exist in the future. In that light, the robotic exploration of the Solar System is best understood as either precursory or augmentative to human exploration.

The current debate regarding the inward focus of space infrastructure such as satellites to monitor the Earth is insufficient with respect to meeting the goals of increasing space capabilities. Earth monitoring is an important space objective, however it is doubtful that increased monitoring will reap greater future benefits relative to developing infrastructure for human habitation beyond Earth. There is no reason to suggest that infrastructure for human habitation could not also include Earth monitoring capabilities. The current debate regarding climate change should be fully compatible with developing human spaceflight capabilities. Moreover, technological development of long-term life support systems will enable more efficient, cleaner and less-costly forms of human infrastructure and assets to be utilized on Earth.

NASA’s ability to monitor can also be useful in terms of resource management and utilization. We cannot imagine the construction of a worldwide power grid (the hypergrid) without the space agency’s input. That being said, it is human space endeavors at increasing distances from the Earth that will create the know-how and the various technologies that will combine to reach the level of sophistication needed to adapt to climate change and all its effects. As we discussed above, that means not only staying true to the vanguard of NASA’s overall mission, but also imbuing it with greater vigor. Eventually, the energy demands of the increasing billions of people on Earth will need space-based energy systems. Getting those systems up and running means getting “out there.”

### C. The Way Forward

The authors believe that NASA’s relevance depends upon NASA leaders and space policy makers understanding that issues of space exploration are a key subset of the overarching concern for American innovation. We believe that both the Abbey, et al. and the Hsu and Cox proposals are attempting to grope their way according to this theme.

There is currently a great deal of interest in American innovation as a means to stimulate the economy. President Barack Obama has placed innovation center stage. \*\*\*\*\*

It is yet unclear to us if this keen interest in innovation is understood beyond some sense that the American economy needs to be stimulated. Much more is at stake that begs the attention of innovators. The United States needs to make the investments to stay competitive in the world economy as increasingly more societies quantum leap toward advanced industrialization. At the same time, alternative energy systems are needed that will power a world system of societies that are predominantly running according to an advanced industrial modality. Among those alternative energy systems are space-based energy systems. Those systems will always be viewed as not cost effective or out-of-reach if the steps that “step to” the maturity of the industries are not made. The maturity of those industries requires permanent human beachheads in space.

Certainly, monitoring global warming/climate change is important. Abbey, et al. discuss this as a COA for NASA. But, being able to field mitigations is better than merely watching disaster unfold. The maturity of the mitigations will never occur without permanent human presence in space. Encountering the extremity of environment out there, will teach us what we need to know to face the Earth becoming more extreme.

Abbey, et al. want to see NASA invest itself heavily in issues of energy and environment. And, certainly, NASA has much to offer in terms of short- and long-term payoffs in terms of monitoring climate change. Several satellite missions current and pending, as well as some of the ISS workload, are already devoted to that effort. †††††††††† That NASA scientists can “see” the effects of global warming invests a note of legitimacy to a phenomenon that many Americans think is something they can believe in or not or that they can vote on at the ballot box. The capacity for monitoring is an important convergence of “big science and great policy.”

Abbey, et al. also propose a reinvigorated and effective aeronautical research program. A continuing concern for the aviation industry is safety. Converging with Abbey, et al.’s concern for energy is the problem of how to run airlines on declining stocks of petroleum. We see where NASA might play a leading role in facing this challenge, from the engineering of jet engines with higher compression ratios that can be retrofitted on existing airframes to the development of bio-fuels that can power aircraft.

It will not be enough to mandate NASA with a set of goals – or even beyond that. We think that Hsu and Cox were onto something by conceptualizing a Department of Space. But what is needed is not a Department of Space, but a super-agency to invigorate American innovation, just as national security was reinvigorated by the reorganization of agencies and departments into the Department of Homeland Security. A Department of Innovation could contain NASA, portions of the Department of Agriculture, of the Department of the Interior, of the Department of Transportation, of the Department of Commerce, the Department of Energy, the Environmental Protection Agency, the National Oceanic and Atmospheric Administration, the postsecondary part of the Department of Education, and NASA. This super-agency could be managed by a cabinet level appointee.

## V. Conclusion

A proposal might be deficient in a number of ways, i.e., not fully explaining the objectives, the rationale behind the objectives, the courses of actions, etc. In this investigation, we have pointed out various deficiencies in the two proposals. What both proposals are attempting to tout is this: NASA should lead American innovation. We agree with this stance: NASA should be synonymous with “big science and great policy.” However, we do not agree that diverting NASA’s efforts to issues of energy and the environment a la Abbey, et al. (beyond what it is already doing) is the way forward. Such a diversion would destroy NASA. NASA should remain focused on human spaceflight initiatives. The technologies that are developed in those endeavors can set in motion the technological evolution necessary to adapt to an Earth made more extreme by climate change, due to the decline of oil, and a number of other factors. However, we understand what Abbey, et al. are trying to promote. They are trying to make NASA relevant to energy and environmental concerns. This avenue should be trod without sacrificing NASA’s

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\*\*\*\*\* See e.g. Jackson, David, and Reed, Jason, *Obama: Innovation More Important than Ever*, USA Today Website, August 5, 2009, available at <http://content.usatoday.com/communities/theoval/post/2009/08/68496216/1> (accessed August 17, 2009); Britt, Robert Roy, *Obama: Key to Future is Innovation*, Live Science Website, August 1, 2009, available at <http://www.livescience.com/technology/090801-obama-innovation.html> (accessed August 17, 2009); and King, Cecelia, *Obama Creates Team to Create “Innovation Agenda”*, Washington Post Website, November 25, 2008, available at [http://voices.washingtonpost.com/posttech/2008/11/obama\\_names\\_team\\_to\\_create\\_inn.html](http://voices.washingtonpost.com/posttech/2008/11/obama_names_team_to_create_inn.html) (accessed August 17, 2009).

†††††††††† See *Global Climate Change: NASA’s Eyes on the Earth*, NASA Website, available at <http://climate.nasa.gov/NasaRole/> (accessed August 17, 2009).

“beyond LEO” goals. We similarly understand what Hsu and Cox are trying to promote. They understand that the space enterprise has to be bigger than NASA. We do not think that can be accomplished with a Department of Space. But, it has a chance under the banner of innovation. When innovation and space are practically synonymous, the rest will follow. Innovation has the ear of a wider community of publics than that of a generic sense of space.

Our methods herein for rating space policy proposals have been qualitative. However, we strive for quantitative rigor. Our future research on this score will be pitched toward that endeavor. Some conceptualizations we are entertaining include measurement of maximization of attainment of policy objectives and policy implementation scores based upon numbers and weight of opportunities and constraints.

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