Resurrecting the US Space Program by Focusing on New Advanced Technology for Human Presence and Profit

By Paul J. Werbos and Edward D. McCullough

"Who needs humans in space?"
"Who needs humans on Earth?"
Humans, that's us.

Recommendations
For the last 10 to 20 years, civilian space policy has been driven by questions such as: "What should our next ten-year grand challenge be? Should we put flags and footprints on the moon again, this time leaving behind a few structures? Or should we try to get to Mars in ten years, perhaps by flybys or one-way trips? What about building a new big expendable rocket like the Saturn V, but more impressive and more expensive?"

We agree with those commentators[1] who say that there is an urgent need to restructure the entire mission. The United States needs to focus on more meaningful longer term goals, and to restructure the enterprise to achieve longer term goals more efficiently. In particular:

- We do not take a fixed position on what the NASA budget should be. In a decade of budget pressures and sequestration, we now see many activities at NASA that could be cut back without major loss to the nation as a whole, but we would prefer those changes to be made that would justify including NASA in the list of truly cutting-edge, innovative R&D agencies for which a 7% annual growth in real dollars would be appropriate, considering the impact of advanced R&D on productivity and economic growth.

- Instead of a 10-year core focus on moon, asteroids, cis-lunar space, or Mars, we recommend shifting the core focus to a longer term tangible goal: economic sustainability of permanent human settlement and expansion in space. This should be instituted as the permanent core mission of NASA until such time as it is fully achieved. Shorter term subgoals should be pursued in a more adaptive way, only as part of a rational strategy to reach the larger goal.

- At the present time, the most promising and urgent subgoals to reach that goal are the development of reusable launch vehicles which would reduce the unit cost of getting to low Earth orbit (LEO) to $500/kg or less,[2] and the development of space solar power (SSP) at a cost of

[1] Eric Sterner, ed., *America's Space Futures* (Raleigh, NC: Marshall Institute, 2013).
[2] IEEE USA, *Low Cost Access to Space*, www.ieeeusa.org/policy/positions/SpaceAccess0214.pdf.

10¢ per kwh of electricity delivered to the earth,[3] conditional on such launch costs.

- To transition to this new approach, NASA should immediately restructure the Space Launch System program to take more time to do it right, and to use it as a platform for saving and enhancing reentry technologies developed for both the space shuttle and earlier military programs such as TAV and RASV.

- We support the new trends towards competitive, market-based activities in space, which will be crucial to economic sustainability and independence in the long term. Market economics says very clearly that the proper role of the government is to support activities that are too risky or too far in the future for industry to handle on its own; therefore, throughout NASA, we recommend a radical shift away from low-risk, proven technology to the development of the most advanced technology, to aim for the long-term goal of doing things right.

- We also recommend reinvigorating the important noncore, leverage activities of NASA, in order to take advantage of capabilities unique to NASA to address exciting new opportunities in areas such as global Internet education, environmental and military defense, new directions in physics, and imaging the universe.

Guiding Principles: The Basis for the Recommendations

Decades ago, the historian Oswald Spengler[4] described how civilizations on a path to collapse often go through periods of nostalgia, when people try to relive their collective childhood in a way that blocks them from facing up to new challenges and seals their doom. There is reason to worry that the US space program is falling into that same kind of trap, due in part to the power of groups hoping to revive public excitement through ever more boring reruns of the Apollo program, aimed at planting flags and footprints on the moon or Mars for their own sake. But is this really what would excite the new generation the most, in any case? The Star Trek generation and the Neil de Grasse generation understand that space has great potential, but are wisely skeptical on the whole about the present directions at NASA. This position paper calls for a radical change in priorities, to focus more directly on the larger goal of economically sustainable human settlement of space, and to revive the true original spirit of Apollo.

The original Apollo program was a fantastic success, and we can learn a lot from its lessons. The period of Apollo coincided with the fastest growth in overall productivity in the US economy in the twentieth century, related to the great slate of high-risk advanced technology R&D that NASA initiated under President Kennedy. Kennedy said: "We go to the moon, not because it is easy, but because it is hard." The current

[3] Paul Werbos, "Reviewing Space Solar Power Policy, *Ad Astra* 26, no. 2 (2013), www.nss.org/adastra/volume26/ssppolicy.html; John C. Mankins, *The Case for Space Solar Power* (Houston: Virginia Edition, 2014).

[4] Oswald Spengler, *The Decline of the West* (Oxford: Oxford University Press, 1991).

emphasis on proven technology, old pathways, and things that are less demanding on the skills of the workforce reverses the one aspect of Apollo that we really need to revive. Above all, we need to go back to dedicating a larger portion of the NASA budget to more aggressive, high-risk, advanced technology, and building the infrastructure – both human and material – necessary to improve productivity in space enough to achieve economic sustainability and independence. This will be more difficult now than it would have been ten years ago, because of retirements and changes in corporate culture,[5] but there is a serious possibility of success, if we apply enough determination and foresight. If it is not done, risk is avoided by guaranteeing failure. The same applies to the two important subgoals of reducing access costs to LEO to $500/kg or less, and of deploying SSP to supply electricity to Earth at 10¢ per kwh – subgoals that could have an immense impact on the feasibility of the larger goal.

Many critics of space have asked: "Who needs humans in space at all?" Others have sometimes asked: "Who needs humans on Earth either?" Our support for human growth on Earth and in space is based on the fact that we *are* humans, and care about humans for their own sake, as a fundamental value. Certainly there are great risks in trying to improve productivity, markets, and infrastructure in space enough to create a growing human economy there[6] – but there are also risks of human extinction on the Earth itself. The challenge is to create a strategy to maximize the probability that we achieve the core goal here, facing up to all the many uncertainties, and regularly asking ourselves how to adapt that strategy, focusing on the larger goals themselves. This position paper gives a sketch of such a strategy.

The hopes for human economic development in space, and for larger benefits to Earth, do not rest on NASA alone. The DoD, other nations and the commercial private sector all have crucial roles to play, which are part of any optimal strategy for NASA. None of these other space programs are enough, on their present course, to bring us to the human settlement of space, without additional, catalytic efforts through NASA and Congress. New directions for collaboration and enhancing the activities of those partners is a crucial opportunity in making the hope of success ever more real.

Market economics says clearly that the government can have a proper role in this kind of venture, which some call "the moral equivalent of war." Success in the human settlement of space will require investment in technologies too high-risk, too long-term in payoff, and with benefits too hard to limit to just one company for normal market mechanisms. Government investment is justified only if it focuses on those aspects of what is needed, and on general-use infrastructure, and it continues to try to download as much as possible to the commercial market sector. A strong system of universities and small businesses, making use of high-quality, apolitical, competitive review systems, is also crucial, to enable success in this kind of high-risk R&D, and it also

[5] William S. Bainbridge, ed. *Leadership in Science and Technology: A Reference Handbook* (Thousand Oaks, CA: Sage, 2011).
[6] Walt W. Rostow, *The Stages of Economic Growth: A Non-Communist Manifesto* (Cambridge: Cambridge University Press, 1990).

needs some reinvigoration at this time in the United States.[7] When government spending tilts towards large, low-risk jobs programs, it strongly violates the basic principles of free market economics.

Proposed New Structure and Operation of NASA

High productivity in any organization (or research project) depends critically on having a very clear and ambitious long-term target, not only to focus effort within the organization, but also to inspire people and to overcome the petty distractions that can cause stagnation in any aspect of human life.

For NASA, we propose that there should be a core focus on achieving the target suggested above: to achieve technology, new markets, infrastructure, and life support for humans in space (whether NASA or non-NASA) great enough to initiate self-sustaining human presence and growth in space – a "tradeoff economy"[8] for humans in space. How to do that is an optimization problem – how to maximize the probability that humans someday do get to that point, and how to minimize the time between now and then. The mathematics of this kind of optimization should have absolute priority over the myopic kinds of bean counting that have often led to grossly suboptimal policies and policy analysis reports in the past. For example, the cost per pound of getting to LEO is one crucial metric of progress towards these goals, but the requirement is for costs that are low enough ($500/kg or less) under conditions of multiple launches, after the initial R&D is complete; the selection between options for the space shuttle, at the start of that program, put heavy emphasis on short-term variables. It is conceivable that we would already be at $500/kg-LEO today, supporting a much larger volume of activities in space at a lower cost, if we had selected the original, more aggressive proposal from Mueller of NASA, which better reflected the spirit of the Apollo era.[9]

In order to do justice to this optimization problem in real time, year after year, there should be greater use of an open, analytic process of revisiting the "decision trees"[10] involved in achieving the core long-term goal subject to budget constraints, decision trees that will change every year if we develop new technology and new knowledge as fast as we should. A well-constructed process should naturally reflect concepts like technology readiness levels, like "build a little and test a little," and like the value of buying information.[11] Not only strategic plans, but also actual budgets, at the highest level, should be continuously adapted in accord with the shifting needs of the larger goal of human settlement of space, and other values to society. Key information should also

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[7] Norman R. Augustine, *Rising Above the Gathering Storm: Energizing and Employing America for a Brighter Economic Future* (Washington, DC: National Academy of Sciences, National Academy of Engineering, and Institute of Medicine, 1997).
[8] Rostow, *Stages of Economic Growth*.
[9] George E. Mueller, "The New Future for Manned Spacecraft Developments (Manned Spacecraft Developments, Considering Apollo Applications Program, Space Station Establishment, Space Shuttle Operations and Payload Cost)," *Astronautics and Aeronautics* 7 (1969): 24-32.
[10] Howard Raiffa, *Decision Analysis: Introductory Lectures on Choices Under Uncertainty* (Reading, MA: Addison-Wesley, 1968); Frank Lewis and Derong Liu, eds. *Reinforcement Learning and Approximate Dynamic Programming for Feedback Control,* Vol. 17 (Hoboken, NJ: John Wiley & Sons, 2013).
[11] Raiffa, *Decision Analysis*.

be digitized in an organized fashion, as it is developed, with a kind of succession plan, so that we never face the risk of technology loss that we face today.

Given constraints on resources, the goal of not losing technology that may be crucial in the future is perhaps the most urgent task now before us. There are many, many cases of this concern; for example, as of 2009, only one full-scale test article had ever passed the stringent requirements of the unique test lab at Wright Patterson for a structure able to survive all the shocks of repeated re-entry; that test article, developed under RASV and classified programs, has since been lost, and the engineers who knew how to build it have retired. Active thermal protection systems using slush hydrogen are an article of faith in some communities, but even on paper, they never met the weight requirements for use in a re-entry vehicle, when they were actively pursued as part of the National Aerospace Plane program.

Having a strong core mission/target is essential, but there is also a compelling need for NASA to support other activities that leverage its capabilities. Studies of defense spending[12] have shown how gross inefficiencies and gaps can arise when policy is carved up into separate organizations or stovepipes that focus only on their core mission to the exclusion of all else. Therefore, we propose that all NASA funding decisions be based on a kind of cost-benefit analysis (accounting for uncertainties[13]), where benefit is the sum of two benefits:

1. (CORE MERIT) impact on the core mission, the accomplishment of a takeoff economy for humans in space; and

2. (BROADER IMPACT) the extra benefit to other important national goals that results from leveraging the use of unique NASA capabilities developed as a benefit of the core mission.

These are the two foundations of the NASA we would like to see. The remainder of this paper describes the new opportunities in these two areas in more detail.

Strategy for Achieving the Core Mission

To achieve a takeoff economy for humans in space, NASA should support activities aimed at building the four pillars upon which our hopes here rest:

1. NEW MARKETS from space to earth, large enough and tricky enough to create multiplier effects beyond what the existing applications in space provide. Energy from space is now the most promising hope for a very large new market, addressing core economic needs both on earth and in space, thanks to recent advances in power beaming technology and new design approaches.[14] Space tourism has also generated much excitement and interest in the private sector worthy of

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[12] Charles J. Hitch, *Economics of Defense in the Nuclear Age* (Ann Arbor: University of Michigan Press, 1967).
[13] Raiffa, *Decision Analysis*; Lewis and Liu, *Reinforcement Learning*.
[14] Mankins, *The Case for Space Solar Power*; Werbos, "Reviewing Space Solar Power Policy."

support, especially as it calls for support to achieve lower travel tickets and support for forms of tourism that are actually independent, productive activities. We also need to be vigilant in looking for new opportunities with substantial economic potential, such as geoengineering, or higher levels of communication capabilities to bring better Internet capabilities to the poorest people on earth. Whatever the risks in these markets, we need to do the best we can to open up the full potential of the new markets, through both changed regulation and technology development. That is a top priority. There is also a need for NASA to work with other partners to help to smooth the transition of the new technologies to the commercial sectors.[15]

2 ADVANCED TECHNOLOGY will also be crucial to making space activities sustainable, affordable, and profitable on a larger scale. Most urgent is the development of new technology to allow reusable access to space at minimum marginal cost, no more than $500/kg-LEO, designed with foresight, looking ahead to the hope of large launch volumes to serve new markets.[16] DARPA's XS-1 project is a unique shining light in this space, but earlier projects at the height of the cold war (like Science Dawn, RASV, and TAV) developed low-cost technology that is still essential to the possibilities before us. XS-1 does not currently have enough funding to fill this crucial gap. We do not actually take a position on who develops this technology – new space, old space, or governments. Rather, we will try to provide encouragement and support to any player ready to do the serious advanced technology work. In addition to access to space, better technology for transportation beyond LEO is also essential, as are other elements of crucial economic infrastructure to improve cost-effectiveness of all efforts in space, even to the end of the solar system and beyond. Among the most important options in this area would be:

   a restructuring and extension of the Space Launch System program (without reducing spending per year) to move as soon as possible and as completely as possible away from government-developed expendable rockets to at least partially reusable concepts, such as shuttle-derived vehicles, using passive hot structures to withstand re-entry; or

   b a reusable booster to be a companion to the X37B, in a joint NASA-DoD effort organized like NASP, but based on rocket technologies ready for full-scale development and testing here and now.[17] Air-breathing, hypersonic technologies offer real hope of even lower costs in the future, but the long-term success of such efforts will be

[15] See, for example, www.nss.org/legislative/positions/tarrifs.html.
[16] IEEE USA, *Low Cost Access to Space*.
[17] Ibid.

strongly endangered if we do not begin full-scale development and testing now of technologies that will also be needed for such air breathers.

3 NONTERRESTRIAL materials are another basic pillar of humanity's hope for self-sustaining economic growth in space. This will take more time than the initial development of new markets, but it is an essential requirement that we must meet sooner or later. We have no interest in putting flags and footprints on the moon for their own sake – but we do have an interest in rational steps as part of a strategy to get real economic value from the moon and from the asteroids, and eventually Mars. There is also major potential for public excitement and support for subgoals in this area.[18] The economic history of Earth tells us that the best strategy is to develop not just one source of materials, but all of them, starting with what is easiest to get to, and planning to transition the key decisions about priorities into market systems as soon as they become able to take over. It is important that our decision trees account for a variety of materials and production technologies,[19] and that key capabilities not be lost. There should be a new push for cross-disciplinary research, cutting across lunar chemical engineering, manufacturing, and propulsion, and accounting for the new findings from the LCROSS satellite, to try to develop new, higher performance options in this sector.

4 HUMAN ABILITY to live and work in space at an affordable cost, in the long term, is the fourth and final fundamental pillar of human settlement, and another basic commitment. To make this real, we agree, at a minimum, that human presence in space should remain continuous and permanent, initially through the International Space Station, but also through larger, expanded systems in the future, without any retreat. All-robotic assembly of large structures in space is possible in principle, but optimal management of such systems is far in the future,[20] and it poses several risks of global instability including possibilities for "Terminator modes." It is better and more realistic to focus on the use of teleautonomy,[21] as in the robotic mining operations pioneered by Baiden, based on cooperative networks of humans and robots with humans firmly in charge. We should improve automation

[18] Gerard K. O'Neill, *The High Frontier: Human Colonies in Space* (New York: William Morrow and Company, 1977).
[19] See Planetary and Terrestrial Mining Sciences Symposium (PTMSS), www.deltion.ca/ptmss/Home.php. See also www.isruinfo.com/, www.lpi.usra.edu/leag/LER-Version-1-3-2013.pdf, and www.planetaryresources.com/ .
[20] Paul Werbos, "From ADP to the Brain: Foundations, Roadmap, Challenges and Research Priorities," in *2014 International Joint Conference on Neural Networks (IJCNN)* (New York: IEEE, 2014), 107-111. arxiv.org/abs/1404.0554.
[21] Greg Baiden, "Telerobotic Lunar Habitat Construction and Mining." Paper given at the 2008 International Symposium of Artificial Intelligence, Robotics and Automation in Space, Hollywood, CA.

and efficiency in an incremental way by making use of new technology for vector intelligence.[22]

Important New Noncore Opportunities Leveraging Core NASA Capabilities

Among the most important new broader benefits possible from NASA and from its partnerships are:

1. Better understanding and imaging of the Earth, measuring new variables and improving predictions, so as to achieve better early warning and prediction for the worst-case possibilities for changes in the global environment. Perhaps the most serious worst case possibility is the risk that emissions of H_2S gas from the oceans could reach levels fatal to humans, and cause fatal destruction of the stratospheric ozone layer, as they have done five to ten times in the previous history of the earth.[23] Warning and better prediction are important, because it is equally possible that we will somehow escape, and that a major tipping point will occur 40 years in the future as the oxygen levels in the deep far south of the Pacific Ocean will reach zero, at present rates of change. Monitoring oxygen levels and nutrition levels which drive the growth of H_2S-producing microbes, at depth in the ocean, will require expansion in the partnerships with NOAA, the Navy, and the European Space Agency.

2. Combining low-cost launch and massive new communications satellites, and related work, reaching out to provide K-12 education by Internet to the "other three billion" (O3B), in public-private partnerships. Efforts to reach the O3B are already a major priority for several major Internet companies, but with larger new satellites using higher levels of solar power, and new educational materials, this effort could move faster. There is an opportunity here to leapfrog education (and female education) in the poorest parts of the world; those variables, in turn, are crucial to stability and economic growth in those areas, essential to US national security.

3. Technological breakthroughs in imaging of objects in space (asteroids, sun, astrophysics) using new quantum and/or constellation technologies to improve resolution massively and to create other new capabilities.[24] If we can actually see planets in other solar systems with

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[22] Werbos, "From ADP to the Brain."

[23] Peter Douglas Ward, *Under a Green Sky: Global Warming, the Mass Extinctions of the Past, and What They Can Tell Us About Our Future* (New York: Harper Perennial, 2008). Available in Kindle format from Amazon.com; Lee R. Kump, Alexander Pavlov, and Michael A. Arthur, "Massive Release of Hydrogen Sulfide to the Surface Ocean and Atmosphere During Intervals of Oceanic Anoxia," *Geology* 33 (2005): 397-400.

[24] David C. Hyland, Jon Winkeller, Robert Mosher, Anif Momin, Gerardo Iglesias, Quentin Donnellan, Jerry Stanley, et al. "A conceptual design for an exoplanet imager," in *Optical Engineering + Applications*, (Bellingham, WA: International Society for Optics and Photonics, 2007), 66930K; Jianbin Liu, Yu Zhou, and Fuli Li, "Changing Two-Photon Correlation into Anticorrelation by Superposing Thermal and Laser

enough resolution to see the chemical traces of life in earth-sized planets, the cultural benefits will be enormous, and we will develop a better understanding of the future possibilities for humans in the galaxy, which are currently extremely hard to guess in a rational way.[25] There is also some hope that new forms of quantum ghost imaging, using three entangled photons instead of just two, might allow imaging without a sensor on the detector channel, and thus allow some form of predictive imaging for distant objects.[26]

4 Space-based missile defense … where a factor of 10 reduction in $/kg-LEO equates to having ten times as much mass in orbit for the same launch cost. The need for better, more complete defense against missiles has become greater and greater, as events in North Korea and in the Middle East remind us, but at present launch costs it is not really feasible. At $500/kg-LEO, the game changes. As Ronald Reagan once asserted, the greatest security for developed nations may occur if there is sharing of this technology with Russia, and also with emerging powers willing to cooperate on behalf of humanity as a whole, under balanced arrangements. There have been cases where US efforts to avoid technology loss to China have actually resulted in superiority of the Chinese technology as the US players suffer, such as the vector intelligence technology used in hit-to-kill applications.[27]

5 Advanced physics experiments in space, exploiting either the unique observation platform or the safety benefit of doing some things off the surface of the Earth. For example, there may be ways to extend the classic B factory experiments related to the Lisa experiment in space, to help us understand better how nuclear forces really work, or experiments to test and extend the new work of Alfred Leitenstorfer of Konstanz, who has measured field fluctuations in free space at a level of 10 MW per cubic meter. It is possible that a better working understanding of strong nuclear forces may suggest experiments with possible energy release high enough that it is safer to do the work in Earth orbit at the early stages, when we do not yet really know how things will work out. Because of the high cost of pumping lasers for the National Inertial Fusion facility at Livermore, it would make sense to

Light," www.paper.edu.cn/en_releasepaper/downPaper/201401-713.html (see also Ruifeng Liu and Fuli Li, "Effects of Photon Bunching on Ghost Imagining and Interference," paper presented at the Princeton-TAMU Workshop on Classical-Quantum Interface, Princeton University, Princeton, NJ, May 2015; Dmitry V. Strekalov, Baris I. Erkmen, and Nan Yu, "Ghost Imaging of Space Objects," *Journal of Physics: Conference Series* 414, no. 1 (2013): 012037, iopscience.iop.org/1742-6596/414/1/012037/pdf/1742-6596_414_1_012037.pdf.

[25] David Brin, *Existence* (New York: Macmillan, 2012).

[26] Paul Werbos, "Analog Quantum Computing and the Need for Time-Symmetric Physics," *Quantum Information Processing*, submitted 2015, extension of a paper published at SPIE/DSS 2015.

[27] Lewis and Liu, *Reinforcement Learning*; Werbos, "From ADP to the Brain."

experiment with lightweight, optically pumped lasers instead, using lightweight mirrors to focus light on lasers used for fusion experiments.

6 Developing geoengineering capabilities, such as low-cost mirrors, which are strongly advocated by Abdul Kalam,[28] the popular past president of India, as another option for energy from space. If we reduce the cost of bringing these mirrors into earth orbit, there is at least some hope that we could use them to reflect enough light away from the Antarctic to stop the ongoing melting, which has already injected fresh water and ice into the waters near the Antarctic, interrupting the thermohaline currents that previously replenished the oxygen in the deep waters of the Pacific Ocean.

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About the Authors:

Paul Werbos has had major program responsibilities in the U.S. Government, scientific and engineering research organizations, and the National Science Foundation (NSF) since his graduation from Harvard University with a PhD in 1974. His NSF responsibilities, beginning in 1988, have been in Domestic Nuclear Detection, Energy, Power, Adaptive Systems, Robotics, and Science-Engineering and Society. His broad background in science, technology, and engineering has propelled him into a leading professional role as a Fellow in IEEE and an award winner within the International Neural Network Society (INNS). His research and writings have made important contributions to energy, to learning, to sustainability and to study of the Universe and Space.

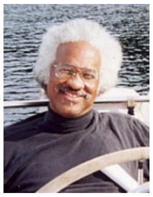
Edward D. McCullough is a retired principal scientist at Boeing and a former member of the NSS Board of Directors. He received his professional training in nuclear engineering through the US Navy and Bettis and Knowles Atomic Power Laboratories (gaining his Certification for Nuclear Engineering at Pearl Harbor Naval Shipyard in 1975).

He focused on concept development, experimental chemistry, and advanced technology at Rockwell Space Systems Advanced Engineering and at the Boeing divisions of Phantom Works and Integrated Defense Systems. He has researched innovative methods to reduce the development time of technologies and systems from

[28] See www.nss.org/news/releases/Kalam_Address_ISDC2013.pdf.

10 to 20 years down to five years. He has experienced successes in chemistry and chemical engineering for extraterrestrial processing and photonics for vehicle management systems, and integrated vehicle health management and communications. He has led efforts for biologically inspired multi parallax geometric situational awareness for advanced autonomous mobility and space manufacturing. He has developed several patents, including patents for an angular sensing system; a method for enhancing digestion reaction rates of chemical systems; and a system for mechanically stabilizing a bed of particulate media.

He is Chair Emeritus of the AIAA Space Colonization Technical Committee, a member of the Board of Trustees for the University Space Research Association, a member of the Science Council for Research Institute for Advanced Computer Science, and a charter member of the AIAA Space Exploration Program Committee. He previously served on the NRC Committee to Review NASA's Exploration Technology Development Programs, and the Planning Committee for the Workshop on Research Enabled by the Lunar Environment.



Editors' Notes: This paper advocates a return to first principles for NASA, focusing on what one might call applied blue-sky research, however much that might sound like an oxymoron. It recalls the pioneer spirit that built America, and it also echoes a comment from *Star Trek*'s Captain Kirk in 1968: "Gentlemen, risk is our business."[29] It is also thoroughly forward-looking, in that it encourages NASA to do what only it can do, and to leave things that others can do as well or better to other organizations. It is a welcome addition to the *Journal of Space Philosophy*. ***Bob Krone and Gordon Arthur.***

[29] "Return to Tomorrow," an episode of *Star Trek*, created by Gene Roddenberry (Paramount Pictures, 1968).