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**Plan: The United States federal government shall establish human settlements on the Moon. We will clarify.**

**Observation 1 is Inherency:**

The cancellation of the Moon Constellation program has brought U.S. space leadership to a crossroad

Wolf, U.S. House Appropriations commerce, justice, science subcommittee, 10

Frank, SpaceNews, “U.S. House Appropriations Commerce, Justice, Science subcommittee,” 4-25, <http://spacenews.com/commentaries/100425-dont-forsake-leadership-space.html>)

Yet today our country stands at a crossroad in the future of U.S. leadership in space. President Barack Obama’s 2011 budget proposal not only scraps the Constellation program but radically scales back U.S. ambition, access, control and exploration in space. Once we forsake these opportunities, it will be very hard to win them back. As Apollo astronauts Neil Armstrong, Jim Lovell and Gene Cernan noted on the eve of the president’s recent speech at Kennedy Space Center, Fla.: “For The United States, the leading space faring nation for nearly half a century, to be without carriage to low Earth orbit and with no human exploration capability to go beyond Earth orbit for an indeterminate time into the future, destines our nation to become one of second or even third rate stature.” In terms of national security and global leadership, the White House’s budget plan all but abdicates U.S. leadership in exploration and manned spaceflight at a time when other countries, such as China and Russia, are turning to space programs to drive innovation and promote economic growth.

**Advantage 1: Leadership**

**We isolate 3 internal links:**

**First is the geopolitical high ground. Race for space will be played out on the Moon first and soon – winning is key to maintaining the geopolitical high ground**

Schmitt et al 9 (Harrison, geologist, Apollo 17 astronaut, Former Chair NASA Advisory Council, Andy Daga, Lunar surface architecture and technology consultant, and Jeff Plescia, Applied Physics Laboratory, The Johns Hopkins University, 2009, “Geopolitical Context of Lunar Exploration and Settlement,” http://www.lpi.usra.edu/decadal/leag/DecadalGeopolitical.pdf)

Moon, Mars, asteroids, and other space locations have attracted international attention as possible targets of interest for peaceful and geopolitical competition in space. Strategically, however, the race for space dominance will be played out on the Moon first and soon. This competition has long-term implications for the future of liberty on Earth as well as for understanding the history and evolution of the solar system.

If non-democratic regimes, such as China or Russia, dominate exploration and settlement of the Moon, liberty will be at risk. Only the United States and its democratic partners can assure the elimination of this space-related risk to liberty. If we abandon leadership in accessing the resource, science and settlement potential of our nearest neighbor to the any other nation or group of nations, particularly a non-democratic regime, the ability for the United States and its allies to protect themselves and liberty for the world will be at great risk. To others would accrue the benefits – psychological, political, economic and scientific – that the United States harvested as a consequence of Apollo's success 40 years ago. This lesson has not been lost on our intellectual, ideological and economic competitors.

The investment of money and intellectual capital in going back to the Moon, permanently, brings with it, not merely geopolitical high ground and prestige of physically being there, but constitutes a deliberate pathway to economic advancement. We need such an effort to grow our economic and technological base. The dividends paid by a return to the Moon will be seen in growth of our intellectual and technical capability and in outpacing others who do not go or in competing on equal terms with those who do. More will result from our efforts than the obvious advantage that comes from having an Saturn-class heavy lifter. A myriad of discoveries are bound to accompany lunar exploration, including astronomical and physical science, in opening the potential of extraterrestrial resource utilization, in developing new energy resources, and in many other areas. At stake are more than mere spin-offs of technology. At stake is access to transformational discovery.

Growth or stagnation forms the crossroads decision facing our country. Protection of human liberty depends on the affirmative decision to grow. For growth to occur the intellectual system of America must be stressed and problems that appear intractable must be solved. For example, history ties the expansion of democracy to a people's access to energy to drive economic. Comparable transformations await in space.

Commitment to lunar space colonization is key to hard and soft power - ensures both the control of space assets and the fate of space development

Spudis 10 (Paul, Senior Staff Scientist at the Lunar and Planetary Institute, February 9, “The New Space Race,” <http://www.spudislunarresources.com/Opinion_Editorial/NewSpaceRace.pdf>)

In one of his early speeches defending the Apollo program, President John F. Kennedy laid out the reasons that America had to go the Moon. Among the many ideas that he articulated, one stood out. He said, “whatever men shall undertake, free men must fully share.” This was a classic expression of American exceptionalism, that idea that we must explore new frontiers not to establish an empire, but to ensure that our political and economic system prevails, a system that has created the most freedom and the largest amount of new wealth in the hands of the greatest number of people in the history of the world. This is a statement of both soft and hard power projection; by leading the world into space, we guarantee that space does not become the private domain of powers who view humanity as cogs in their ideological machine, rather than as individuals to be valued and protected.

The Vision was created to extend human reach beyond its current limit of low Earth orbit. It made the Moon the first destination because it has the material and energy resources needed to create a true space faring system. Recent data from the Moon show that it is even richer in resource potential than we had thought; both abundant water and near-permanent sunlight is available at selected areas near the poles. We go to the Moon to learn how to extract and use those resources to create a space transportation system that can routinely access all of cislunar space with both machines and people. Such a system is the logical next step in both space security and commerce. This goal for NASA makes the agency relevant to important national interests. A return to the Moon for resource utilization contributes to national security and economic interests as well as scientific ones.

There is indeed a new space race. It is just as important and vital to our country’s future as the original one, if not as widely perceived and appreciated. It consists of a struggle with both hard and soft power. The hard power aspect is to confront the ability of other nations to deny us access to our vital satellite assets of cislunar space. The soft power aspect is a question: how shall society be organized in space? Both issues are equally important and both are addressed by lunar return. Will space be a sanctuary for science and PR stunts or will it be a true frontier with scientists and pilots, but also miners, technicians, entrepreneurs and settlers? The decisions made now will decide the fate of space for generations. The choice is clear; we cannot afford to relinquish our foothold in space and abandon the Vision for Space Exploration.

**Second is ally support. Unilateral abandonment of lunar base plans has shaken our international standing and undermines our allies’ willingness to accept U.S. leadership**

Newton 11 (Elizabeth, Director for Space Policy- U Alabama-Huntsville, with Michael D. Griffin, United States space policy and international partnership, Space Policy 27 n 1)

The president’s request and congressional authorization for continued funding of the ISS’s operations delivers on commitments made to international partners beginning in the mid-1980s when the program was conceived. However, without a successor system to the Shuttle, the USA has abrogated intergovernmental agreements to provide crew and cargo transportation, and crew rescue, as partial compensation for partner investments in the ISS’s infrastructure and operations. Reliance on the Russian Soyuz for limited down-mass cargo transport seriously inhibits the value that can be realized from ISS utilization until a commercial solution is available. In addition, the USA’s unilateral abandonment of the Moon as a near-term destination shakes partners’ political support for their exploration plans, some of which were carefully premised on US intentions, and more than five years of collaborative development of lunar base plans. 3.3. Leadership The USA is a majority funder for many space programs and is a technology leader, two features which have provided sufficient motivation for partners to accept US leadership, even when unfortunately high-handed. It is a stunning failure of political will to lack a successor system to the retiring Space Shuttle, and so the US cedes leadership in human spaceflight with its inability to access the ISS independently, for itself or for its partners, until a new commercial capability has been demonstrated. The USA further relinquishes leadership when abandoning years of work on strategic planning and guidance, the evaluation of alternatives, and orchestration of diverse but important contributions that were manifested in the Global Exploration Strategy. Sudden redirections without consultation are not hallmarks of leadership and will no doubt motivate partners to do more unilateral planning and execution, at least for a while. Finally, leadership in the future is at risk: how can the USA hope to influence outcomes and protect interests-- strategic, commercial, and cultural -- on the Moon if it is not present?

**Bypassing the Moon relinquishes a powerful symbol of U.S. technological superiority and deals a blow to**

**its superpower status**

**Quek 2010** (Tracy, US Correspondent for *Straits Times*, “Skipping the Moon: One Giant Leap Back for U.S.” *The Straits Times*, 3 May,

L/N)

However, some fear bypassing the Moon would mean relinquishing a powerful symbol of US technological superiority, dealing a blow to its superpower status. China, Russia, India and Japan all have, or are committed to building, strong space programmes that include lunar missions. China is the leading contender to become the second country to send a man to the Moon and could do so by 2020. If China lands on the Moon before the US has the chance to go back 'even if it is by choice, this raises questions about where US science and technology stand in relation to China', said Mr Cheng. 'Coming on the heels of things like the financial bubble, it really raises questions about American credibility.' Things will get even more complicated if the US is not active in space at the same time China is making leaps in space exploration. Said Dr Scott Pace, director of George Washington University's Space Policy Institute: 'If the Chinese are part of a partnership with us, that's fine. But if the Chinese are going off by themselves separate from us and we're not also out there, then I think it is a problem.' Experts say they do not expect a similar US-Soviet contest over ideology between Washington and Beijing. The competition will instead be on the business and industrial fronts. Space-related technologies, such as satellites for navigation and communication, are essential to each country's key industries, in cluding banking, media, shipping and airlines

Third is human space flight. Commitment to human spaceflight is a key signal of American leadership

Vergano 10 (Dan, Jan. 29, USA Today, “Has USA hit its final frontier in space; Tight budgets and success of unmanned missions could shackle human exploration,” http://www.usatoday.com/tech/science/space/2010-01-19-space19\_CV\_N.htm)

In June, Obama appointed the Augustine committee to review the human spaceflight program. "Planning for a human spaceflight program should begin with a choice about its goals -- rather than a destination," the Augustine report said, laying out five options for NASA and calling for international colonization of the solar system as an ultimate goal. The first two options keep space agency budgets flat and essentially remove NASA from the astronaut exploration business (aside from trips to the ISS) for decades, which Bolden says isn't going to happen. The others require adding $3 billion to NASA's budget in 2011 and increasing the budget 2.4% every year. These options vary in how long they would keep the ISS operational and what rocket NASA develops as an alternative to launch astronauts beyond Earth orbit. In some options, commercial rockets would carry astronauts to the station. Instead of landing on the moon or Mars, astronaut "flybys" would visit asteroids, the moon and Mars' tiny moons, Phobos and Deimos. A question of reputation In a recent Space Policy journal, Robinson and astronomer Daniel Lester of the University of Texas noted that most scientists view the astronauts as unimportant, their achievements negligible compared with the Hubble space telescope or the Mars rovers. But they and others note that scientific results aren't the big reason for NASA's existence. "The space program was an important source of American soft power in the competition with the Soviet Union during the Cold War. Even today, with more competitors in space, American leadership conveys a sense of competence that attracts others," says international relations expert Joseph Nye Jr. of Harvard. "While it is difficult to put a dollar figure on it, a perception that the U.S. was falling behind in space would damage our reputation." So NASA faces hard choices. Dropping the astronaut program looks impossible, given Bolden's promise. And cutting pure science probes for the cash to build astronaut colonies would be difficult. But something has to give.

Space represents the future - China is using human space flight as a means of accelerating its leadership – it’s imperative that the U.S. not allow human space leadership to slip away

Johnson-Freese, Professor at the Naval War College, 05

(Joan, “Maintaining US Leadership in Human Spaceflight”, May, Space Policy, p. 242)

But the USA must not allow human space leadership to slip away. Human spaceflight requires pushing the envelop in areas of science and engineering—in medical fields and areas of life support systems engineering, for example— that could otherwise potentially be neglected. While direct benefits to the economy or defense from a particular program may not always be identifiable in advance, GPS, once a government program without a clear mission, has certainly demonstrated that we should not be bound by the limits of our imagination. The importance that space provides to building science capabilities generally is not unnoticed elsewhere. China is acutely aware that it has a long way to go toward becoming a science '"power' and it hopes human spaceflight will accelerate its movement up the learning curve. For the USA to maintain its leadership position, it is therefore imperative that it stays active in space as well. It is also important to remember that human spaceflight is part of the US space agenda, but not the entire agenda. We need to maintain a balance to assure continued pre-eminence in all aspects of science and engineering. Finally, space represents the future. It is imperative that the USA, as the world's leader, remains the world's leader into the future.

**U.S. hegemony is key to preventing multiple global nuclear conflicts**

**Kagan, 07** (Robert, Senior Fellow at the Carnegie Endowment for International Peace, “End of Dreams, Return of History,” http://www.realclearpolitics.com/articles/2007/07/end\_of\_dreams\_return\_of\_histor.html)

This is a good thing, and it should continue to be a primary goal of American foreign policy to perpetuate this relatively benign international configuration of power. The unipolar order with the United States as the predominant power is unavoidably riddled with flaws and contradictions. It inspires fears and jealousies. The United States is not immune to error, like all other nations, and because of its size and importance in the international system those errors are magnified and take on greater significance than the errors of less powerful nations. Compared to the ideal Kantian international order, in which all the world's powers would be peace-loving equals, conducting themselves wisely, prudently, and in strict obeisance to international law, the unipolar system is both dangerous and unjust. Compared to any plausible alternative in the real world, however, it is relatively stable and less likely to produce a major war between great powers. It is also comparatively benevolent, from a liberal perspective, for it is more conducive to the principles of economic and political liberalism that Americans and many others value. American predominance does not stand in the way of progress toward a better world, therefore. It stands in the way of regression toward a more dangerous world. The choice is not between an American-dominated order and a world that looks like the European Union. The future international order will be shaped by those who have the power to shape it. The leaders of a post-American world will not meet in Brussels but in Beijing, Moscow, and Washington.

The return of great powers and great games

If the world is marked by the persistence of unipolarity, it is nevertheless also being shaped by the reemergence of competitive national ambitions of the kind that have shaped human affairs from time immemorial. During the Cold War, this historical tendency of great powers to jostle with one another for status and influence as well as for wealth and power was largely suppressed by the two superpowers and their rigid bipolar order. Since the end of the Cold War, the United States has not been powerful enough, and probably could never be powerful enough, to suppress by itself the normal ambitions of nations. This does not mean the world has returned to multipolarity, since none of the large powers is in range of competing with the superpower for global influence. Nevertheless, several large powers are now competing for regional predominance, both with the United States and with each other. National ambition drives China's foreign policy today, and although it is tempered by prudence and the desire to appear as unthreatening as possible to the rest of the world, the Chinese are powerfully motivated to return their nation to what they regard as its traditional position as the preeminent power in East Asia. They do not share a European, postmodern view that power is passé; hence their now two-decades-long military buildup and modernization. Like the Americans, they believe power, including military power, is a good thing to have and that it is better to have more of it than less. Perhaps more significant is the Chinese perception, also shared by Americans, that status and honor, and not just wealth and security, are important for a nation. Japan, meanwhile, which in the past could have been counted as an aspiring postmodern power -- with its pacifist constitution and low defense spending -- now appears embarked on a more traditional national course. Partly this is in reaction to the rising power of China and concerns about North Korea 's nuclear weapons. But it is also driven by Japan's own national ambition to be a leader in East Asia or at least not to play second fiddle or "little brother" to China. China and Japan are now in a competitive quest with each trying to augment its own status and power and to prevent the other 's rise to predominance, and this competition has a military and strategic as well as an economic and political component. Their competition is such that a nation like South Korea, with a long unhappy history as a pawn between the two powers, is once again worrying both about a "greater China" and about the return of Japanese nationalism. As Aaron Friedberg commented, the East Asian future looks more like Europe's past than its present. But it also looks like Asia's past. Russian foreign policy, too, looks more like something from the nineteenth century. It is being driven by a typical, and typically Russian, blend of national resentment and ambition. A postmodern Russia simply seeking integration into the new European order, the Russia of Andrei Kozyrev, would not be troubled by the eastward enlargement of the EU and NATO, would not insist on predominant influence over its "near abroad," and would not use its natural resources as means of gaining geopolitical leverage and enhancing Russia 's international status in an attempt to regain the lost glories of the Soviet empire and Peter the Great. But Russia, like China and Japan, is moved by more traditional great-power considerations, including the pursuit of those valuable if intangible national interests: honor and respect. Although Russian leaders complain about threats to their security from NATO and the United States, the Russian sense of insecurity has more to do with resentment and national identity than with plausible external military threats. 16 Russia's complaint today is not with this or that weapons system. It is the entire post-Cold War settlement of the 1990s that Russia resents and wants to revise. But that does not make insecurity less a factor in Russia 's relations with the world; indeed, it makes finding compromise with the Russians all the more difficult. One could add others to this list of great powers with traditional rather than postmodern aspirations. India 's regional ambitions are more muted, or are focused most intently on Pakistan, but it is clearly engaged in competition with China for dominance in the Indian Ocean and sees itself, correctly, as an emerging great power on the world scene. In the Middle East there is Iran, which mingles religious fervor with a historical sense of superiority and leadership in its region. 17 Its nuclear program is as much about the desire for regional hegemony as about defending Iranian territory from attack by the United States. Even the European Union, in its way, expresses a pan-European national ambition to play a significant role in the world, and it has become the vehicle for channeling German, French, and British ambitions in what Europeans regard as a safe supranational direction. Europeans seek honor and respect, too, but of a postmodern variety. The honor they seek is to occupy the moral high ground in the world, to exercise moral authority, to wield political and economic influence as an antidote to militarism, to be the keeper of the global conscience, and to be recognized and admired by others for playing this role. Islam is not a nation, but many Muslims express a kind of religious nationalism, and the leaders of radical Islam, including al Qaeda, do seek to establish a theocratic nation or confederation of nations that would encompass a wide swath of the Middle East and beyond. Like national movements elsewhere, Islamists have a yearning for respect, including self-respect, and a desire for honor. Their national identity has been molded in defiance against stronger and often oppressive outside powers, and also by memories of ancient superiority over those same powers. China had its "century of humiliation." Islamists have more than a century of humiliation to look back on, a humiliation of which Israel has become the living symbol, which is partly why even Muslims who are neither radical nor fundamentalist proffer their sympathy and even their support to violent extremists who can turn the tables on the dominant liberal West, and particularly on a dominant America which implanted and still feeds the Israeli cancer in their midst. Finally, there is the United States itself. As a matter of national policy stretching back across numerous administrations, Democratic and Republican, liberal and conservative, Americans have insisted on preserving regional predominance in East Asia; the Middle East; the Western Hemisphere; until recently, Europe; and now, increasingly, Central Asia. This was its goal after the Second World War, and since the end of the Cold War, beginning with the first Bush administration and continuing through the Clinton years, the United States did not retract but expanded its influence eastward across Europe and into the Middle East, Central Asia, and the Caucasus. Even as it maintains its position as the predominant global power, it is also engaged in hegemonic competitions in these regions with China in East and Central Asia, with Iran in the Middle East and Central Asia, and with Russia in Eastern Europe, Central Asia, and the Caucasus. The United States, too, is more of a traditional than a postmodern power, and though Americans are loath to acknowledge it, they generally prefer their global place as "No. 1" and are equally loath to relinquish it. Once having entered a region, whether for practical or idealistic reasons, they are remarkably slow to withdraw from it until they believe they have substantially transformed it in their own image. They profess indifference to the world and claim they just want to be left alone even as they seek daily to shape the behavior of billions of people around the globe. The jostling for status and influence among these ambitious nations and would-be nations is a second defining feature of the new post-Cold War international system. Nationalism in all its forms is back, if it ever went away, and so is international competition for power, influence, honor, and status. American predominance prevents these rivalries from intensifying -- its regional as well as its global predominance. Were the United States to diminish its influence in the regions where it is currently the strongest power, the other nations would settle disputes as great and lesser powers have done in the past: sometimes through diplomacy and accommodation but often through confrontation and wars of varying scope, intensity, and destructiveness. One novel aspect of such a multipolar world is that most of these powers would possess nuclear weapons. That could make wars between them less likely, or it could simply make them more catastrophic.

It is easy but also dangerous to underestimate the role the United States plays in providing a measure of stability in the world even as it also disrupts stability. For instance, the United States is the dominant

naval power everywhere, such that other nations cannot compete with it even in their home waters. They either happily or grudgingly allow the United States Navy to be the guarantor of international waterways and trade routes, of international access to markets and raw materials such as oil. Even when the United States engages in a war, it is able to play its role as guardian of the waterways. In a more

genuinely multipolar world, however, it would not. Nations would compete for naval dominance at least in their own regions and possibly beyond. Conflict between nations would involve struggles on the oceans as well as on land. Armed embargos, of the kind used in World War i and other major conflicts, would disrupt trade flows in a way that is now impossible.

Such order as exists in the world rests not merely on the goodwill of peoples but on a foundation provided by American power. Even the European Union, that great geopolitical miracle, owes its founding to American power, for without it the European nations after World War ii would never have felt secure enough to reintegrate Germany. Most Europeans recoil at the thought, but even today Europe 's stability depends on the guarantee, however distant and one hopes unnecessary, that the United States could step in to check any dangerous development on the continent. In a genuinely multipolar world, that would not be possible without renewing the danger of **world war.**

People who believe greater equality among nations would be preferable to the present American predominance often succumb to a basic logical fallacy. They believe the order the world enjoys today exists independently of American power. They imagine that in a world where American power was diminished, the aspects of international order that they like would remain in place. But that 's not the way it works. International order does not rest on ideas and institutions. It is shaped by configurations of power. The international order we know today reflects the distribution of power in the world since World War ii, and especially since the end of the Cold War. A different configuration of power, a multipolar world in which the poles were Russia, China, the United States, India, and Europe, would produce its own kind of order, with different rules and norms reflecting the interests of the powerful states that would have a hand in shaping it. Would that international order be an improvement? Perhaps for Beijing and Moscow it would. But it is doubtful that it would suit the tastes of enlightenment liberals in the United States and Europe.

The current order, of course, is not only far from perfect but also offers no guarantee against major conflict among the world's great powers. Even under the umbrella of unipolarity, regional conflicts involving the large powers may erupt. War could erupt between China and Taiwan and draw in both the United States and Japan. War could erupt between Russia and Georgia, forcing the United States and its European allies to decide whether to intervene or suffer the consequences of a Russian victory. Conflict between India and Pakistan remains possible, as does conflict between Iran and Israel or other Middle Eastern states. These, too, could draw in other great powers, including the United States.

Such conflicts may be unavoidable no matter what policies the United States pursues. But they are more likely to erupt if the United States weakens or withdraws from its positions of regional dominance. This

is especially true in East Asia, where most nations agree that a reliable American power has a stabilizing and pacific effect on the region. That is certainly the view of most of China 's neighbors. But even China, which seeks gradually to supplant the United States as the dominant power in the region, faces the dilemma that an American withdrawal could unleash an ambitious, independent, nationalist Japan.

In Europe, too, the departure of the United States from the scene -- even if it remained the world's most powerful nation -- could be destabilizing. It could tempt Russia to an even more overbearing and potentially forceful approach to unruly nations on its periphery. Although some realist theorists seem to imagine that the disappearance of the Soviet Union put an end to the possibility of confrontation between Russia and the West, and therefore to the need for a permanent American role in Europe, history suggests that conflicts in Europe involving Russia are possible even without Soviet communism. If the United States withdrew from Europe -- if it adopted what some call a strategy of "offshore balancing" -- this could in time increase the likelihood of conflict involving Russia and its near neighbors, which could in turn draw the United States back in under unfavorable circumstances.

It is also optimistic to imagine that a retrenchment of the American position in the Middle East and the assumption of a more passive, "offshore" role would lead to greater stability there. The vital interest the United States has in access to oil and the role it plays in keeping access open to other nations in Europe and Asia make it unlikely that American leaders could or would stand back and hope for the best while the powers in the region battle it out. Nor would a more "even-handed" policy toward Israel, which some see as the magic key to unlocking peace, stability, and comity in the Middle East, obviate the need to come to Israel 's aid if its security became threatened. That commitment, paired with the American commitment to protect strategic oil supplies for most of the world, practically ensures a heavy American military presence in the region, both on the seas and on the ground.

The subtraction of American power from any region would not end conflict but would simply change the equation. In the Middle East, competition for influence among powers both inside and outside the region has raged for at least two centuries. The rise of Islamic fundamentalism doesn't change this. It only adds a new and more threatening dimension to the competition, which neither a sudden end to the conflict between Israel and the Palestinians nor an immediate American withdrawal from Iraq would change. The alternative to American predominance in the region is not balance and peace. It is further competition. The region and the states within it remain relatively weak. A diminution of American influence would not be followed by a diminution of other external influences. One could expect deeper involvement by both China and Russia, if only to secure their interests. 18 And one could also expect the more powerful states of the region, particularly Iran, to expand and fill the vacuum. It is doubtful that any American administration would voluntarily take actions that could shift the balance of power in the Middle East further toward Russia, China, or Iran. The world hasn 't changed that much. An American withdrawal from Iraq will not return things to "normal" or to a new kind of stability in the region. It will produce a new instability, one likely to draw the United States back in again.

The alternative to American regional predominance in the Middle East and elsewhere is not a new regional stability. In an era of burgeoning nationalism, the future is likely to be one of intensified competition among nations and nationalist movements. Difficult as it may be to extend American predominance into the future, no one should imagine that a reduction of American power or a retraction of American influence and global involvement will provide an easier path.

**Advantage 2: Get Off the Rock**

**Numerous credible existential threats to the planet – resource depletion, disease, droughts, famine, climate change, asteroid strikes**

Popular Science 11 (March, “After Earth: Why? Where? How? When?” p. 46, Vol. 278, No. 3)

Earth won't always be fit for occupation. We know that in two billion years or so, an expanding sun will boil away our oceans, leaving our home in the universe uninhabitable-unless, that is, we haven't already been wiped out by the Andromeda galaxy, which is on a multibillion-year collision course with our Milky Way. Moreover, at least a third of the thousand mile-wide asteroids that hurtle across our orbital path will eventually crash into us, at a rate of about one every 300,000 years. Indeed, in 1989 a far smaller asteroid, the impact of which would still have been equivalent in force to 1,000 nuclear bombs, crossed our orbit just six hours after Earth had passed. A recent report by the Lifeboat Foundation, whose hundreds of researchers track a dozen different existential risks to humanity, likens that one in- 300,000 chance of a catastrophic strike to a game of Russian roulette: "If we keep pulling the trigger long enough we'll blow our head off, and there's no guarantee it won't be the next pull." Many of the threats that might lead us to consider off-Earth living arrangements are actually manmade, and not necessarily in the distant future. The amount we consume each year already far outstrips what our planet can sustain, and the World Wildlife Fund estimates that by 2030 we will be consuming two planets' worth of natural resources annually. The Center for Research on the Epidemiology of Disasters, an international humanitarian organization, reports that the onslaught of droughts, earthquakes, epic rains and floods over the past decade is triple the number from the 1980s and nearly 54 times that of 1901, when this data was first collected. Some scenarios have climate change leading to severe water shortages, the submersion of coastal areas, and widespread famine. Additionally, the world could end by way of deadly pathogen, nuclear war or, as the Lifeboat Foundation warns, the "misuse of increasingly powerful technologies." Given the risks humans pose to the planet, we might also someday leave Earth simply to conserve it, with our planet becoming a kind of nature sanctuary that we visit now and again, as we might Yosemite. None of the threats we face are especially far-fetched. Climate change is already a major factor in human affairs, for instance, and our planet has undergone at least one previous mass extinction as a result of asteroid impact. "The dinosaurs died out because they were too stupid to build an adequate spacefaring civilization," says Tihamer Toth-Fejel, a research engineer at the Advanced Information Systems division of defense contractor General Dynamics and one of 85 members of the Lifeboat Foundation's space-settlement board. "So far, the difference between us and them is barely measurable." The Alliance to Rescue Civilization, a project started by New York University chemist Robert Shapiro, contends that the inevitability of any of several cataclysmic events means that we must prepare a copy of our civilization and move it into outer space and out of harm's way-a backup of our cultural achievements and traditions. In 2005, then-NASA administrator Michael Griffin described the aims of the national space program in similar terms. "If we humans want to survive for hundreds of thousands or millions of years, we must ultimately populate other planets," he said. "One day, I don't know when that day is, but there will be more human beings who live off the Earth than on it."

Human survival has been a matter of touch and go – it is foolish to keep our eggs in one basket

CNN 8 (quoting Stepehen Hawking, Oct 9, “Hawking: If we survive the next 200 years, we should be OK”)

CAMBRIDGE, England (CNN) -- Professor Stephen Hawking, one of the world's great scientists, is looking to the stars to save the human race -- but pessimism is overriding his natural optimism. Stephen Hawking, here delivering a lecture in May, spoke recently to CNN about his vision of the future. Hawking, in an exclusive CNN interview, said that if humans can survive the next 200 years and learn to live in space, then our future will be bright. "I believe that the long-term future of the human race must be in space," said Hawking, who is almost completely paralyzed by the illness ALS. "It will be difficult enough to avoid disaster on planet Earth in the next 100 years, let alone next thousand, or million. The human race shouldn't have all its eggs in one basket, or on one planet. Let's hope we can avoid dropping the basket until we have spread the load." Hawking is one of the few scientists known to a wide audience outside academia thanks to his best-selling books, a guest spot on "The Simpsons" and an ability to clearly explain the complexities of theoretical physics. He has 12 honorary degrees, was awarded the CBE in 1982 and since 1979 has been at Cambridge University's Department of Applied Mathematics and Theoretical Physics, where he is Lucasian Professor of Mathematics -- a post once held by Isaac Newton. Speaking at Cambridge's Centre for Mathematical Studies, he said: "I see great dangers for the human race. There have been a number of times in the past when its survival has been a question of touch and go. The Cuban missile crisis in 1963 was one of these. “The frequency of such occasions is likely to increase in the future. We shall need great care and judgment to negotiate them all successfully. "But I'm an optimist. If we can avoid disaster for the next two centuries, our species should be safe, as we spread into space." Twenty years ago, Hawking wrote "A Brief History of Time." Now he is looking forward to a space flight of his own next year. He said: "I don't think the human race has a moral obligation to learn about space, but it would be foolish and short sighted not to do so. It may hold the key to our survival."

**Dispersal of humanity across space is key to reducing existential threats to Earth – other species extinction cases prove**

Sowers, 2 (George, transhumanist, “The Transhumanist Case for Space,” April, <http://www.georgesowers.com/Other_pdf/The_trans_case_for_space.pdf>)

What can we do to maximize our odds of survival, irrespective of what those odds might actually be? Furthermore, as humans or aspiring transhumans, we desire much more than mere survival. We also wish to grow in our capabilities and enjoy not only continued life but an ever increasing abundance of life. In this light the question becomes one of risk management. How can we best avoid any large-scale events that would either threaten our survival or significantly degrade our quality of life or limit our ability to grow our technology? Risk management is a fairly standard technique practiced in the management of many (if not most) large scale engineering projects, especially those involving significant amounts of technological development. It came of age in the era of the massive nuclear power plant projects10 and has become stock and trade in the aerospace and defense industry.11 The logic of risk management is straightforward. A risk is an event that has consequences adverse to the achievement of the project’s goals. It is quantified by two numbers: the probability of the event and the severity of the consequences. Typically, the severity of the consequences is measured in dollars of additional cost or weeks of schedule delay or some technical measurement of the performance of the system. The risk management process consists of several basic steps. First is risk identification, followed by risk assessment and analysis and finally risk handling. Risk identification involves the recognition of possible future adverse events—events with consequences detrimental to the projects goal’s. Risk assessment and analysis is the process of estimating the probability of occurrence and consequences of the identified events. Since uncertainty is a significant element of risk, a key element of risk analysis is bounding the uncertainties on the estimated probabilities and consequences. Finally, risk handling is determining and executing a set of actions to reduce the overall risk level, the point of risk management. By now you may be wondering what all this has to do with transhumanism and space. The transhumanism agenda can certainly be seen as embodying a set of goals, among them being extended life and mental capabilities for individual humans/transhumans. Furthermore, it is clear that there are possible future events that would severely curtail, or prohibit our ability to achieve those goals. Those events - 10 - constitute risks to the transhumanist movement, and risk management techniques can be applied to mitigate them. My claim here will be that the expansion of humanity into space, colonizing other planets and eventually other solar systems, provides substantial mitigation for the most severe risks facing transhumanists and the human species as a whole. What kinds of future events should we be worried about? Nick Bostrom has taken a credible stab at developing a list.12 Although he was ostensibly looking at existential risks—no, not the risk of becoming like Camus, but risks that threaten the existence of the species, risks of extinction—his list is a good starting point for general risks to the transhumanist future. Among the items he mentions are deliberate or accidental misuse of nano-technology, nuclear holocaust, badly programmed superintelligence, genetically engineered biological agents, and asteroid impact. We can think of others that don’t have existential consequences but can cause grave harm to transhuman objectives through derailment and delay. For example, anti-technology sentiment generated by religious or environmentalist groups, economic crisis spurred by energy scarcity or regional conflict or simply the chaotic dynamics of economies, global environmental or climatic catastrophe leading to economic crashes—any of these might severely curtail the technological progress necessary for transhumanist aims. Of course, eventually the earth will be consumed by the death of the sun, an event we should have a few billion years to prepare for. So much for risk identification. You can add your own favorites. Clearly there is no lack of things to worry about. Next comes risk assessment and analysis. In this phase we attempt to estimate the probability of ocurance and severity of consequences for the identified events. For proper risk assessment, the estimates should include not only a point estimate but also confidence intervals, as the range of possibilities is important to the mitigation planning phase. A detailed assessment of these risks is far beyond the scope of this article, but let me make a few general comments. In order to make the probability estimate precise, we need to specify the time horizon, say the next 100 years or the next 1000 years. For example, we could say that the probability of a significant asteroid strike (greater than x tons) to the earth within the next 100 years is y y to 95% confidence. It happens that the probability of an asteroid strike is perhaps the easiest of all to estimate given the - 11 - available astronomical data. The other events are devilishly hard to get credible numbers for, so we would resort to a relative likelihood. The severity of consequences is again very difficult to predict but would generally range from complete extinction through collapse of civilization to a relatively mild economic downturn. Here it is helpful to devise some common system of measurement in order to facilitate comparison of different risks. For example, each risk could be quantified in terms of the resulting time delay to achieving some transhumanist milestone. In this case, extinction would be tantamount to an infinite delay, where an economic crash might delay things only a few years. The third and final phase of risk management is risk handling or risk mitigation. Standard risk management identifies four risk handling techniques: avoidance, control, assumption, and transfer. Risk avoidance means eliminating the event as a possibility. For example, we could avoid the risk of nano-technology disaster by refusing to pursue nano-technology research. I am not advocating that course of action. Risk control consists of taking actions to either reduce the probability of occurrence or reduce the severity of consequences or both. It is what we traditionally think of as risk mitigation. Risk assumption occurs when we resign ourselves to the fact that a particular risk exists and there is not much we can do about it. Risk transfer is shifting the consequences of the event to someone else and is typically used when considering the financial consequences of an event, i.e., who pays for the disaster. The exploration and colonization of space falls into the category of risk control for the risks we have identified above. To see this it is only necessary to recognize that the effects of these risk events are confined to a particular limited spatial locale, namely Earth. Hence, distributing the species across space reduces the consequences of such an event to only that portion of the population resident in that particular spot. This phenomenon is well known in biology. If you look at the wide diversity of biological species, the ones at greatest risk for extinction are those who are geographically isolated. Most of the modern extinctions have come from species indigenous to one or a handful of islands. Species that are wide spread are far more resilient. The reasons are simple. Just one bit of bad luck can wipe out an island species: the introduction of a new predator, a new more virulent disease, a change of climate, the loss of food sources, etc. But if a - 12 - species is geographically diverse, one of these kinds of events will lead to only local extinction.13 The analogy is straightforward: humanity is on an island called earth. As long as we are confined to this one locale, we are vulnerable to various calamities: nuclear war, bio-terrorism, global warming, asteroid impact, invasion by a super intelligent race, or some nano-tech experiment run amok. Once humanity or transhumanity becomes dispersed among the stars we become far less exposed to extinction by our own stupidity or just bad luck.

Now is key - population and resource pressures will undermine colonization plans if we delay

Hender 9 (Matthew, August, University of Adelaide School of Mechanical Engineering, “Colonization: A Permanent Habitat for the Colonization of Mars,”http://digital.library.adelaide.edu.au/dspace/bitstream/2440/61315/3/02chapters1-4.pdf)

It is considered that we should think about it now and plan to be ready to commence colonization in the near future. If the process is left for the distant future it is possible that the resources to perform such a feat will no longer exist, absorbed for the purpose of survival by a swelling population. If the population levels exceed a “critical mass” or resource use continues at unsustainable levels there could conceivably become a time when the opportunity has passed us by. If we wish to open up this frontier we will need to do so whilst resources are available.

Discovery of water catapulted the moon to the most practical colonization destination and a critical launching pad for deep space

**Bryner 09** (Jeanna, senior writer for *Space,* “Water Discovery Fuels Hope to Colonize the Moon” November 13, http://www.space.com/7532-water-discovery-fuels-hope-colonize-moon.html)

Hopes, dreams and practical plans to colonize or otherwise exploit the moon as a source of minerals or a launch pad to the cosmos got a boost today with NASA's announcement of significant water ice at the lunar south pole. The LCROSS probe discovered the equivalent of a dozen 2-gallon buckets of water in the form of ice, in a crater at the lunar south pole. Scientists figure there's more where that came from. "The presence of significant quantities of ice on the lunar surface catapults the moon from an interesting waypoint to a critical launching pad for humanity's exploration of the cosmos," said Peter Diamandis, CEO and chairman of the X Prize Foundation, which is running a $30 million contest for private moon rovers. "We're entering a new era of lunar exploration 'Moon 2.0,' in which an international group of companies and governments will use the ice and other unique resources of the moon to help us expand the sphere of human influence, and to help us monitor and protect the Earth." The water discovery firms up previous detections of the signature of water molecules by three independent spacecraft. But the new finding makes more of a splash in that the detections come from both infrared and ultraviolet measurements, and a lot more of it was detected than scientists had expected. "It is a big 'wow,'" said Jack Burns of the Center for Astrophysics and Space Astronomy at the University of Colorado, Boulder, and director of the Lunar University Network for Astrophysics Research. Set up lunar camp Having that store of water on the moon could be a boon to possible future lunar camps. In addition to a source of drinking water, lunar water ice could be broken into its constituent hydrogen and oxygen atoms, ultimately to be used in rocket fuel. That would mean spacecraft ferrying future colonists to the moon would not have to take fuel for the return trip, or the fuel could be used to launch trips beyond the moon. And water could be used as a shield from cosmic radiation. "We now can say ... that the possibility of living off the land has just gone up a notch," said Peter Schultz, professor of geological sciences at Brown University and a co-investigator on the LCROSS mission, referring to past detections of water on the moon. The new discovery comes just as the Obama administration is deciding whether to continue on with NASA's goal of putting astronauts back on the moon by 2020. Today's news could tip the scales toward another lunar leap. "It's going to boost the interest in the moon, no doubt about it," said with Michael Wargo, chief lunar scientist for Exploration Systems at NASA Headquarters. "It's going to provide additional information that will inform the decision that will inform the future of human space exploration." He added that the new finding will likely be taken into account when that administrative decision is made. "In terms of the clearly most practical destination for the next two to three decades for human exploration it has to be the moon," Burns told SPACE.com.

**Low-cost water-derived propellants from the Moon will quickly transform and invigorate space exploration**

**Stone 2011** (Bill, CEO of Shackleton Energy, interview with Mike Wall, Space.com senior writer, “Mining the Moon's Water: Q & A with

Shackleton Energy's Bill Stone,” January 13, <http://www.space.com/10619-mining-moon-water-bill-stone-110114.html>)

It costs about $10,000/kg [$4,545 per lb] to launch most "business-class" payloads into low- Earth orbit (LEO), except for the space shuttle, which is tremendously more expensive. New breakthroughs in physics and/or economy must be realized to significantly reduce this high cost; however, none appear to be on the horizon. A major issue in making access to space cheaper is that every space mission must carry its own fuel for in-space operations, since in-space refueling does not currently exist. Even if it did, that fuel would have to be lifted and stored on orbit in fuel depots at even higher prices. To avoid this high-cost barrier to real progress, a means to provide cheaper propellants in space has to be developed. We have the answer: water-derived propellants from the moon. Since water is abundantly available on the moon, as corroborated by recent NASA observations, it can be harvested, transported to LEO and converted to liquid oxygen and liquid hydrogen propellants to be sold commercially at much lower prices. Our analysis shows it is about 15 times cheaper to launch any mass from the moon to LEO than from the Earth. Lower-cost propellants in space will transform access to and invigorate operations in space. Importantly, our business model indicates this can be realistically done within the decade. Launch providers will now be able to use smaller, cheaper launch vehicles that do not carry excess fuel. They can now get that extra fuel from our orbiting "gas stations." What is very encouraging is that current space treaties and law permit commercial operations on the moon, so the opportunity is wide open to anyone.

**Lunar in situ resource utilization creates a paradigm shift in launching that overcomes our mass limitations**

**Spudis 2009** (Paul, Lunar Planetary Institute. “Paradigms Lost,” in Air & Space Magazine, October 23, 2009,

http://blogs.airspacemag.com/moon/2009/10/paradigms-lost/)

The paradigm model might also be applied to conducting business in other fields, in particular, the business of spaceflight. Since it arose more than 50 years ago, the paradigm of spaceflight has largely remained unchanged. In short, we conceive a mission (robotic or human), then design, build and launch a spacecraft to conduct that mission. This satellite or spacecraft operates for a time in space—gathering information or providing a service—until it breaks down or becomes obsolete and is abandoned. We then imagine the next mission—going back to the drawing board to design the next spacecraft—a process repeated continuously and a major cost of space exploration. Is a paradigm shift – a “revolution” in space travel possible? One would think that with 50 years of experience under our belts, we would have already exhausted all the possibilities. Indeed, the imminent development of warp drive or “Cavorite” does not seem likely, but then, that’s the nature of truly revolutionary breakthroughs, isn’t it? On the other hand, is there something missing – something that could be done right now using existing knowledge to change the rules of spaceflight and possibly spur additional breakthroughs? As long as we’re chained to the existing spaceflight paradigm, we must continue hauling from Earth everything we need in space. For human missions this includes all the air, water and other consumables needed for life support. The cost to lift all this mass (which includes the weight of a massive amount of fuel needed to escape from Earth’s very deep gravity well) is budget busting. So for “normal” space exploration, costs will never be lower except at the margins and we will always be mass-limited in space. And when you are mass-limited, you are capability-limited as well. Such was the original intent of the Vision for Space Exploration (VSE). The desire for fundamental change in perspective was behind the program’s specific direction to study and experiment with using the material and energy resources of the Moon. From the moment it was announced, the true purpose of a lunar return was misunderstood, both inadvertently and deliberately. Constellation is a rocket program; the VSE is not. No one knows if using space resources is possible but we can find out by pursuing innovative technology. In theory it works. We’ve never attempted high-risk mining on the Moon and it may have significant practical difficulties but potentially, it could become a highly leveraging activity. If we can extract and make rocket propellant on the Moon, we can create a completely reusable, refuelable transportation infrastructure in cislunar space. If we can extract the oxygen and hydrogen, we can live in space. Of course, such an outcome would change and transform the business model of space—something that fascinates and attracts many but repels others and hence, its mixed reception in aerospace circles. This would truly be a revolution, a paradigm shift in the same sense as we understand it from Kuhn’s description of scientific progress; as a vast new expanse is opened to us and we are free to move about the universe, the world changes and things are never the same again. I’ve argued here and elsewhere that there is a method that is already well understood in principle, but its practical application and viability is completely unknown. If we could use what we find in space to create new capabilities, we would change the rules of spaceflight, thereby ushering in a true paradigm shift in space travel.

**Acknowledging the feasibility of known technology ends resource conflicts that will culminate in nuclear war – low space travel costs are key**

**Collins and Autino, 10** (Patrick and Adriano, Life and Environmental Science, Azabu University and Andromeda, Inc., “What the growth of a space tourism industry could contribute to employment, economic growth, environmental protection, education, culture and world peace,” Acta Astronautica 66 (2010) 1553–1562, science direct)

The major source of social friction, including international friction, has surely always been unequal access to resources. People ﬁght to control the valuable resources on and under the land, and in and under the sea. The natural resources of Earth are limited in quantity, and economically accessible resources even more so. As the population grows, and demand grows for a higher material standard of living, industrial activity grows exponentially. The threat of resources becoming scarce has led to the concept of ‘‘Resource Wars’’. Having begun long ago with wars to control the gold and diamonds of Africa and South America, and oil in the Middle East, the current phase is at centre stage of world events today [37]. A particular danger of ‘‘resource wars’’ is that, if the general public can be persuaded to support them, they may become impossible to stop as resources become increasingly scarce. Many commentators have noted the similarity of the language of US and UK government advocates of ‘‘war on terror’’ to the language of the novel ‘‘1984’’ which describes a dystopian future of endless, fraudulent war in which citizens are reduced to slaves.

7.1. Expansion into near-Earth space is the only alternative to endless ‘‘resource wars’’

As an alternative to the ‘‘resource wars’’ already devastating many countries today, opening access to the unlimited resources of near-Earth space could clearly facilitate world peace and security. The US National Security Space Ofﬁce, at the start of its report on the potential of space-based solar power (SSP) published in early 2007, stated: ‘‘Expanding human populations and declining natural resources are potential sources of local and strategic conﬂict in the 21st Century, and many see energy as the foremost threat to national security’’ [38]. The report ended by encouraging urgent research on the feasibility of SSP: ‘‘Considering the timescales that are involved, and the exponential growth of population and resource pressures within that same strategic period, it is imperative that this work for ‘‘drilling up’’ vs. drilling down for energy security begins immediately’’ [38].

Although the use of extra-terrestrial resources on a substantial scale may still be some decades away, it is important to recognise that simply acknowledging its feasibility using known technology is the surest way of ending the threat of resource wars. That is, if it is assumed that the resources available for human use are limited to those on Earth, then it can be argued that resource wars are inescapable [22,37]. If, by contrast, it is assumed that the resources of space are economically accessible, this not only eliminates the need for resource wars, it can also preserve the beneﬁts of civilisation which are being eroded today by ‘‘resource war-mongers’’, most notably the governments of the ‘‘Anglo-Saxon’’ countries and their ‘‘neo-con’’ advisers. It is also worth noting that the $1 trillion that these have already committed to wars in the Middle-East in the 21st century is orders of magnitude more than the public investment needed to aid companies sufﬁciently to start the commercial use of space resources.

Industrial and ﬁnancial groups which proﬁt from monopolistic control of terrestrial supplies of various natural resources, like those which proﬁt from wars, have an economic interest in protecting their proﬁtable situation. However, these groups’ continuing proﬁts are justiﬁed neither by capitalism nor by democracy: they could be preserved only by maintaining the pretence that use of space resources is not feasible, and by preventing the development of low-cost space travel. Once the feasibility of low-cost space travel is understood, ‘‘resource wars’’ are clearly foolish as well as tragic. A visiting extra-terrestrial would be pityingly amused at the foolish antics of homo sapiens using longrange rockets to ﬁght each other over dwindling terrestrial resources—rather than using the same rockets to travel in space and have the use of all the resources they need!

7.2. High return in safety from extra-terrestrial settlement

Investment in low-cost orbital access and other space infrastructure will facilitate the establishment of settlements on the Moon, Mars, asteroids and in man-made space structures. In the ﬁrst phase, development of new regulatory infrastructure in various Earth orbits, including property/usufruct rights, real estate, mortgage ﬁnancing and insurance, trafﬁc management, pilotage, policing and other services will enable the population living in Earth orbits to grow very large. Such activities aimed at making near-Earth space habitable are the logical extension of humans’ historical spread over the surface of the Earth. As trade spreads through near-Earth space, settlements are likely to follow, of which the inhabitants will add to the wealth of different cultures which humans have created in the many different environments in which they live.

Success of such extra-terrestrial settlements will have the additional beneﬁt of reducing the danger of human extinction due to planet-wide or cosmic accidents [27]. These horrors include both man-made disasters such as nuclear war, plagues or growing pollution, and natural disasters such as super-volcanoes or asteroid impact. It is hard to think of any objective that is more important than preserving peace. Weapons developed in recent decades are so destructive, and have such horriﬁc, long-term side-effects that their use should be discouraged as strongly as possible by the international community. Hence, reducing the incentive to use these weapons by rapidly developing the ability to use space-based resources on a large scale is surely equally important [11,16]. The achievement of this depends on low space travel costs which, at the present time, appear to be achievable only through the development of a vigorous space tourism industry.

**Observation 2 is Solvency:**

**Rapid build up of a Moon base is feasible – Moon’s proximity and placement allow for direct communication**

**Schrunk et al. 7** – Faculty Member of the Kepler Space Institute (Dr. David G., author and Founder of the Quality of Laws Institute; Madhu Thangavelu, works with the Department Of Aerospace Engineering & School of Architecture at the University of Southern California, lecturer for a graduate seminar in Extreme Environment Habitat Design as part of the USC School of Architecture, former Conductor of the Space Exploration Architectures Concept and Synthesis Studio in the Department of Aerospace and Mechanical Engineering in the School of Engineering at USC, former Space Projects Director for the Calearth Institute, Advisory Board Member for the Los Angeles Section of the American Institute of Aeronautics and Astronautics; Burton L. Sharpe, participant in mission operations planning and execution of the Gemini, Apollo, and Viking NASA space programs; Dr. Bonnie L. Cooper, from Oceaneering Space Systems in Houston; *The Moon: Resources, Future Development, and Settlement*, 2nd edition, p. xl, p. SpringerLink, MV)

I.2.1 Proximity to Earth The Moon is in orbit around the Earth at an approximate distance of 377,000 km (234,000 miles). This relatively small distance means that existing propulsion systems can be adapted to place the first elements of a permanent base on the Moon. The Earth—Moon separation is small enough (a round trip speed-of-light time of less than three seconds) to permit operators on Earth to direct near-real-time command and control of tele-operated and semi-autonomous robotic devices on the lunar surface. Since the Moon always presents the same face to Earth as the result of "tidal locking”, direct communication links with devices on the lunar surface can be maintained continuously. These advantages, and the use of robotic devices, will allow for a rapid build-up of lunar base facilities as well as world-wide coordination of exploration and development efforts. For follow-on human operations, the proximity of the Moon to the Earth will allow astronauts to return to the Earth in three days in the event of emergencies.

**Moon’s proximity makes it ideal for colonization – permits setting up a functioning lunar installation in advance and retrieving assets at any time**

**Spudis and Lavoie 2010** (Paul, Lunar and Planetary Institute, and Tony Lavoie, NASA Marshall Space Flight Center.

“Mission and Implementation of an Affordable Lunar Return,” December 19,

<http://www.spudislunarresources.com/Papers/Affordable_Lunar_Base.pdf>)

The Moon is the closest planetary object to Earth and it contains the necessary material and energy resources to create new space faring capability. Its proximity to Earth is a key attribute: because round-trip light-time between Earth and Moon is only 3 seconds, we can control robotic machines on the lunar surface from Earth to accomplish a variety of tasks. This relation is crucial; it permits early and significant accomplishment on the Moon prior to human arrival. We use the proximity of the Moon to set up a functioning, productive lunar surface installation before the first human crew arrives. With constant availability of launch window and relatively low Δv requirements, our Moon is the most accessible extraterrestrial body. This accessibility adds significant flexibility to our operational plans, as we can send or retrieve assets to and from the Moon at any time.

**Moon is accessible with existing launch systems for only modest increase in budget**

**Spudis 2005** (Paul, staff at Johns Hopkins Univ. Applied Physics Laboratory. “The Moon: A New Destination in Space for America,” in

*Return to the Moon*, ed. Rick Tumlinson & Erin Medlicott, p. 23)

The Moon is close, accessible with existing systems, and has resources we can use to create a true, economical space-faring infrastructure. The Moon is a scientific and economic treasure trove, reachable with existing systems and infrastructure that can revolutionize our national strategic and economic posture in space. The dark areas new the poles contain significant amounts (at least 10 billion tons) of hydrogen, most probably in the form of water ice. This ice can be mined to support human life on the Moon and in space and to make rocket propellant (liquid hydrogen and oxygen). Moreover, we can return to the Moon using the existing infrastructure of Shuttle-derived launch systems for only a modest increase in the space budget.

# \*\*Leadership Advantage

# Solves Space Assets

**Moon base will create a transcontinental railroad that allows us to access and protect our space assets**

**Spudis and Lavoie 2010** (Paul D. Spudis, Lunar and Planetary Institute, and Tony Lavoie, NASA Marshall Space Flight Center.

“Mission and Implementation of an Affordable Lunar Return,” December 19, http://www.spudislunarresources.com/Papers/Affordable\_Lunar\_Base.pdf)

Establishing a permanent foothold on the Moon opens the space frontier to many parties for many different purposes. By creating a reusable, extensible cislunar space faring system, we build a “transcontinental railroad” in space, connecting two worlds (Earth and Moon), as well as enabling access to all points in between. We will have a system that can access the entire Moon, but more importantly, we will have the capability to routinely access all of our space assets within cislunar space (Spudis, 2010): communications, GPS, weather, remote sensing and strategic monitoring satellites. These satellites will then be in reach to be serviced, maintained and replaced as they age. We have concentrated on the water production attributes of a lunar outpost because the highest leveraging capabilities that are most easily exploited are associated with the availability of propellant. However, there are other possibilities to explore, including the paradigm-shifting culture to eventually design all structural elements needed for lunar activities using lunar resources. These activities will spur new commercial space interest, innovation and investment. This further reduces the Earth logistics train and helps extend human reach deeper into space, along a trajectory that is incremental, methodical, sustainable and within projected budget expectations.

# Winning Moon Race Key to Capitalism

Winning the moon race is key to the societal paradigm that will prevail in space- American loss means free market will never emerge

Spudis 10 – Paul D. Spudis, Senior Staff Scientist at the Lunar and Planetary Institute, February 9, 2010, “The New Space Race,” <http://www.spudislunarresources.com/Opinion_Editorial/NewSpaceRace.pdf>)

The struggle for soft power projection in space has not ended. If space resource extraction and commerce is possible, a significant question emerges – What societal paradigm shall prevail in this new economy? Many New Space advocates assume that free markets and capitalism is the obvious organizing principle of space commerce, but others might not agree. For example, to China, a government-corporatist oligarchy, the benefits of a pluralistic, free market system are not obvious. Moreover, respect for contract law, a fundamental reason why Western capitalism is successful while its implementation in the developing world has had mixed results, does not exist in China. So what shall the organizing principle of society be in the new commerce of space resources: rule of law or authoritarian oligarchy? An American win in this new race for space does not guarantee that free markets will prevail, but an American loss could ensure that free markets would never emerge on this new frontier.

# \*\*Get Off the Rock Advantage

# Resource Wars Solvency

**Solving resource scarcity is key to world peace**

**Garan, 10** – Astronaut (Ron, 3/30/10, Speech published in an article by Nancy Atkinson, “The Importance of Returning to the Moon,” <http://www.universetoday.com/61256/astronaut-explains-why-we-should-return-to-the-moon/>, JMP)

Resources and Other Benefits: Since we live in a world of finite resources and the global population continues to grow, at some point the human race must utilize resources from space **in order to survive**. We are already constrained by our limited resources, and **the decisions we make today will have a profound affect on the future of humanity.** Using resources and energy from space will enable continued growth and the spread of prosperity to the developing world without destroying our planet. Our minimal investment in space exploration (less than 1 percent of the U.S. budget) reaps tremendous intangible benefits in almost every aspect of society, from technology development to high-tech jobs. When we reach the point of sustainable space operations we will be able to transform the world from a place where nations quarrel over scarce resources to one where the basic needs of all people are met and we unite in the common adventure of exploration. The first step is a sustainable permanent human lunar settlement.

# Lunar Water Revolutionizes Space Travel

**Lunar water will allow for the creation of orbital gas stations that will revolutionize space travel**

**Wall 2011** (Mike, Space.com senior writer, “Mining the Moon's Water: Q & A with Shackleton Energy's Bill Stone,” January 13, 2011.

Online at http://www.space.com/10619-mining-moon-water-bill-stone-110114.html. Accessed 4/18/11)

The moon has water, and lots of it. Permanently shadowed craters at both poles have likely been trapping and accumulating water ice for billions of years, recent research has shown. These concentrated stores are a precious resource that could revolutionize space travel, some scientists and entrepreneurs have argued. Lunar ice can be mined, split into its component hydrogen and oxygen and transformed into rocket fuel, which could then be sold to spacecraft from orbiting "gas stations." Such an arrangement could spur a wave of space travel and exploration, the argument goes, since spaceships wouldn't have to lug all the fuel they need from Earth.

**Accessing lunar water is critical to cutting the cord with Earth – resources are so limitless that initial processing won’t even be detectable**

**Stone 2011** (Bill, CEO of Shackleton Energy, interview with Mike Wall, Space.com senior writer, “Mining the Moon's Water: Q & A with

Shackleton Energy's Bill Stone,” January 13, <http://www.space.com/10619-mining-moon-water-bill-stone-110114.html>)

With a global surface area of over 35 million square kilometers [13.5 million square miles], with proven reserves of over a billion tons of water ice, and with the likelihood that initial surface resource processing will be done in relatively small, localized crater areas, it is unlikely that lunar return and resource harvesting will even be detectable to other lunar explorers, scientists or users. To put this in a more practical perspective, the lunar north pole water alone (from LRO radar signature) is enough to launch one shuttle equivalent per day for over 2,300 years. But this is, literally, only the tip of the "iceberg." If the LCROSS data are correct and the ice zone extends as far as the area between each of the poles to a circle at 80 degrees latitude, there is likely to be enough ice on the moon to launch, again at one-per-day, an equivalent shuttle launch for 250 million years. The moon is a large body with lots of room and lots of resources. There is space enough for everybody on the moon for whatever purposes they envision. Lunar water is absolutely critical to opening up the frontier of space. By harvesting it, we begin the process of "cutting the cord" with the Earth and learning how to supply and provision ourselves from the virtually limitless material and energy resources of the solar system. If humanity is to have any future beyond Earth, we must learn how to responsibly extract and make what we need in space from what we find there. The moon is near, accessible and possesses the resources we need to learn these skills.

**Moon regolith contains frozen water that makes it the most valuable real estate in the solar system**

Schrunk Space: beyond 1999 Chemistry & Industry, 20 December 1999 The Moon: resources, future development and colonization David Schrunk, Burton Sharpe, Bonnie Cooper & Madhu Thangavelu)

Data returned by the 1996 Clementine mission indicated that the regolith in the shadows of the lunar poles included a substantial fraction of ice. The subsequent Lunar Prospector mission confirmed this and, even more significantly, suggested the presence of vast seams of ice below the regolith. This ice probably fell in a shower of meteorites, most of which contain some H2O. The permanently shadowed craters of the lunar poles provided ideal deep-frozen storage for this key resource, which Clementine team member Paul Spudis described as 'the most valuable piece of real estate in the solar system'. This book presents a comprehensive overview of the peculiar challenges and opportunities presented by the industrial colonisation of the Moon. It covers a range of topics from power generation Ñ fusion reactors, photovoltaic cells or, most intriguingly, heat engines exploiting the 300K temperature difference between the lunar day and night - to lunar governance, including a less convincing advocacy of an 'engineering discipline of laws'. The pharmaceutical and biotech industries get a relatively brief look-in with the observation that lunar laboratories would be ideal secluded environments for working with biohazardous materials. The authors also note that, once a colony had been well established, the Moon would be an ideal home for the physically disabled and elderly: one-sixth Earth gravity offers greater mobility and less chance of a bad fall. All we need to return to the Moon is the will, and this book is designed to build that will. It is certainly an inspiring read, and would be enjoyed by fans of Stephen Baxter and Kim Stanley Robinson at least as much as by its target audience of students and space industry professionals. The more evangelical passages tend to be somewhat gushing, and the authors show rather too much faith in the willingness of the private sector to commit resources to long-term, high-risk ventures, but their case is persuasive and, perhaps most importantly, visionary. As John F Kennedy declared nearly 40 years ago when he committed the US to the first lunar landing: we do these things not because they are easy, but because they are hard. People have never been willing to remain in one place given the means to travel further afield, and it is, after all, a big universe out there. The question is, if not now, then when?

# Extraction Technology Exists

**Technologies for extracting material from the moon already exist and have been tested**

**Jarvstrat 2**

(Ad Astra, Niklas Jarvstrat has a PhD in the area of Solid Mechanics and Strength of Materials, Master of Science in Applied Physics and Electrical Engineering, is the Associate Professor of Materials technology at University West, and Head of the Department of Technology, “Lunar Colonization: Why, How and When”, Ad Astra, March-April 2002, [http://moon-isru.com/information/AdAstra2002.pdf //](http://moon-isru.com/information/AdAstra2002.pdf%20//))

We are not that lucky on the Moon — although the necessary energy and raw materials exist on the lunar surface, they are not available without significant effort. And, although the very latest in modern technology might be unobtainable luxuries for a budding lunar colony, an industrial production complex will be necessary to replenish raw materials lost to vacuum or diluted beyond usefulness. The technologies needed to extract crucial elements from lunar soil, to maintain an artificial ecosystem exist today and have been tested on a small scale. Technologies for producing goods and equipment needed in daily life are in principle identical with the same processes currently in use on Earth, and would only need minor adaptions.

# \*\*Solvency

# Technology Exists Now

**No need for technological breakthroughs – lunar infrastructure will created by adapting existing technologies**

**Schrunk et al. 7** – Faculty Member of the Kepler Space Institute (Dr. David G., author and Founder of the Quality of Laws Institute; Madhu Thangavelu, works with the Department Of Aerospace Engineering & School of Architecture at the University of Southern California, lecturer for a graduate seminar in Extreme Environment Habitat Design as part of the USC School of Architecture, former Conductor of the Space Exploration Architectures Concept and Synthesis Studio in the Department of Aerospace and Mechanical Engineering in the School of Engineering at USC, former Space Projects Director for the Calearth Institute, Advisory Board Member for the Los Angeles Section of the American Institute of Aeronautics and Astronautics; Burton L. Sharpe, participant in mission operations planning and execution of the Gemini, Apollo, and Viking NASA space programs; Dr. Bonnie L. Cooper, from Oceaneering Space Systems in Houston; *The Moon: Resources, Future Development, and Settlement*, 2nd edition, p. 117, p. SpringerLink, MV)

The global settlement of the Moon will require electric power and communications as well as transportation networks (the lunar utility infrastructure), on and below the lunar surface. Without these elements in place, the exploration of the Moon and other large-scale tasks would be difficult. When in-situ resource utilization capabilities begin producing infrastructure components, such as solar cells, bricks, metal structures, and electric cable, the placement of a permanent global utilities infrastructure on the Moon will commence. Although technological advances and innovation are expected as a by-product of lunar development, virtually all of the infrastructure needs of the Moon can be satisfied by simply adapting existing Earth-based technologies to the lunar environment. There is no need for technological breakthroughs.

**Moon colonization is feasible – resources and technology exists**

**Schrunk et al. 7** – Faculty Member of the Kepler Space Institute (Dr. David G., author and Founder of the Quality of Laws Institute; Madhu Thangavelu, works with the Department Of Aerospace Engineering & School of Architecture at the University of Southern California, lecturer for a graduate seminar in Extreme Environment Habitat Design as part of the USC School of Architecture, former Conductor of the Space Exploration Architectures Concept and Synthesis Studio in the Department of Aerospace and Mechanical Engineering in the School of Engineering at USC, former Space Projects Director for the Calearth Institute, Advisory Board Member for the Los Angeles Section of the American Institute of Aeronautics and Astronautics; Burton L. Sharpe, participant in mission operations planning and execution of the Gemini, Apollo, and Viking NASA space programs; Dr. Bonnie L. Cooper, from Oceaneering Space Systems in Houston; *The Moon: Resources, Future Development, and Settlement*, 2nd edition, pp. 80-81, p. SpringerLink, MV)

As shown in the previous chapters, the Moon has the energy and material resources that are needed to sustain permanent human colonies, and the technology exists to undertake large-scale lunar development projects. The question of whether it is possible to colonize the Moon has been answered — in the affirmative. The first step on the road to a globally-inhabited Moon will be to establish an unmanned robotic outpost. From these, extensive analysis and research (including mining and manu- facturing experiments) will be performed and the first elements of a global utilities infrastructure will become operational. These activities will prepare the way for colonization to follow. The polar regions of the Moon are probably the best locations for initial lunar base activities. Evidence of hydrogen (implying water-ice deposits) was discovered by the Lunar Prospector mission. Due to favorable topography, Earth–Moon–Sun geometries, and access to resources, Mons Malapert in the south polar region is an excellent location for the first lunar base.

# Self-sufficiency

**Generating self-supporting habitation facilities will be easier than doing so on the ISS**

**Schrunk et al. 7** – Faculty Member of the Kepler Space Institute (Dr. David G., author and Founder of the Quality of Laws Institute; Madhu Thangavelu, works with the Department Of Aerospace Engineering & School of Architecture at the University of Southern California, lecturer for a graduate seminar in Extreme Environment Habitat Design as part of the USC School of Architecture, former Conductor of the Space Exploration Architectures Concept and Synthesis Studio in the Department of Aerospace and Mechanical Engineering in the School of Engineering at USC, former Space Projects Director for the Calearth Institute, Advisory Board Member for the Los Angeles Section of the American Institute of Aeronautics and Astronautics; Burton L. Sharpe, participant in mission operations planning and execution of the Gemini, Apollo, and Viking NASA space programs; Dr. Bonnie L. Cooper, from Oceaneering Space Systems in Houston; *The Moon: Resources, Future Development, and Settlement*, 2nd edition, pp. 101-103, p. SpringerLink, MV)

Reliable life-support systems must be developed for permanent human habitation. They need air, food, and water to survive, as well as regenerative waste management systems (see Figure 6.4). Manned space missions such as the International Space Station are partially-closed life-support systems, in which water and oxygen are recycled, but food is periodically supplied from Earth and solid wastes are stored for later removal. However, it will be easier to create self-supporting human habitations on the Moon than in Earth orbit! The reason is that the Moon has local material resources that can be used to support human missions, whereas Earth-orbiting stations are dependent upon re-supply missions from the Earth.2 As noted earlier, the lunar base will also be safer than Earth-orbiting stations because the habitats on the Moon can provide higher levels of protection for the crews from the hazards of space.

As the term implies, ECLSS provides the crew with the basic conditions for life functions and comfort — parameters that directly impact crew survival and produc- tivity, Therefore, a safe and reliable environmental control and life-support system is essential to the successful operation of a crewed lunar base. Two approaches exist in the design of ECLSS to date. They are physio-chemical systems and biological— biospheric systems. 6.4.3 Physico-chemical (non-biological) systems Expendable or regenerative chemicals can be used to recycle air and water. By circulating the effluents through a variety of chemical filters and processes, it is possible to maintain the atmosphere and the water in the proper constitution for life. The operational characteristics of these systems are well understood and routinely employed in spacecraft today. They are dependable, show highly predictable behavior, and are rather easy to operate. However, for permanently-manned lunar bases, the material resources needed to operate such systems must be replenished at considerable expense. While small physico-chemical systems are adequate for short-term missions and activities, more capable regenerative systems will be needed to sustain the operations of a lunar base that supports tens to hundreds of people over long periods of time. 6.4.4 Biological-biospheric systems Biospherics is a newly-evolving discipline that studies and emulates the environmental, ecological, and life-support system of planet Earth. Advances in biospherics show much promise in the development of CLSS that can be applied to long-duration habitats on the Moon, and eventually Mars. By introducing biological systems such as plants and animals into a cycle that resembles an ecological system on Earth, a symbiotic, balanced, and efficient ECLSS can be evolved. Such systems can be designed to regenerate food supplies (something that physico-chemical systems do not do) through complex feedback loops that are being developed and tested now with encouraging results. The result is a system that can imitate the functions of the Earth by regenerating the air, water, and food within the enclosure with only minimal additional input. Such a system is referred to as a sustainable ecological life-support system (SELSS). Current experimental life-support systems show promise but are quite complex in their layout and function, and their performance has not been consistent, However, as experience with these systems increases, so will reliability and case of operations. The long-term goal of the ECLSS community is to produce a fully-closed system that can regenerate all of the water, air, and food without adding anything to the system after startup. This ideal3 system is often referred to as the closed ecological life- support system or CELSS. 6.4.5 Medical care Humans will need medical care on the Moon, and the first crews to return to the Moon will include physicians. The crews that are selected for trips to the Moon will have no pre-existing medical conditions and will be in excellent physical condition. Their health status will be monitored regularly, as in human spaceflight today, by Earth-based medical specialists on a minimum interference basis. However, there is an inevitable element of risk of injuries and other acute medical problems on lunar missions, and plans must be made for emergency medical treatment. The Moon is only three days' travel time from the Earth and a crew member who develops appendicitis or other serious medical conditions can be flown back to Earth for treatment. For less serious conditions (e.g., infections and minor injuries), medical problems will be handled on the Moon by the crew, using limited medical facilities and supplies, As more tools and equipment are delivered to the Moon with each crew, however, an increasingly-sophisticated on-site medical diagnosis and treatment capability will evolve, and it will become possible to treat more serious problems such as burns and broken bones on the Moon without curtailing lunar missions. Telemedicine techniques will also allow Earth-based physicians to assist in medical diagnostic and treatment procedures on the Moon (Figure 6.5).

**Moon has all the resources needed for human civilization – it possesses all the elements found on earth**

**Schrunk et al. 7** – Faculty Member of the Kepler Space Institute (Dr. David G., author and Founder of the Quality of Laws Institute; Madhu Thangavelu, works with the Department Of Aerospace Engineering & School of Architecture at the University of Southern California, lecturer for a graduate seminar in Extreme Environment Habitat Design as part of the USC School of Architecture, former Conductor of the Space Exploration Architectures Concept and Synthesis Studio in the Department of Aerospace and Mechanical Engineering in the School of Engineering at USC, former Space Projects Director for the Calearth Institute, Advisory Board Member for the Los Angeles Section of the American Institute of Aeronautics and Astronautics; Burton L. Sharpe, participant in mission operations planning and execution of the Gemini, Apollo, and Viking NASA space programs; Dr. Bonnie L. Cooper, from Oceaneering Space Systems in Houston; *The Moon: Resources, Future Development, and Settlement*, 2nd edition, pp. 49-50, p. SpringerLink, MV)

3.1 INTRODUCTION The Moon has more than sufficient resources for all phases of lunar development. It also has access to the vacuum of space from the lunar surface, low gravity (as compared with the Earth), and other unique features that will enhance exploration and development projects on and from the Moon. The present chapter reviews the resources that the Moon offers for future exploration and settlement. 3.2 ELEMENTS The cost of transporting payloads from the Earth to the Moon is greater than U.S. $20,000 per kilogram. Lunar activities will be greatly facilitated if the materials that are needed for exploration and settlement are obtained directly from the Moon. The Moon possesses all of the elements that are found on Earth. From these elements a global infrastructure that supports all human activities on the Moon can be constructed. The elemental composition of the Moon is usually described in two categories — major elements and trace elements. In general. a major element is one that constitutes more than 1 percent of the total. Table 3.1 lists the major elements found on the Moon, based on analysis of lunar samples. Trace amounts of other important elements that are present in the regolith are listed in Table 3.2. Many of the lighter elements in Table 3-2 are delivered to the lunar regolith by the solar wind. As previously mentioned, iron, aluminum, and titanium will be used for construction materials, while silicon is used in the production of computer chips, photo- voltaic (solar) cells, fiber-optic cables, mirrors, and lenses. The trace elements will be used to produce fatty acids, amino acids, vitamins, and sugars that are needed for life-support systems,1 as well as plastics. The inert elements such as helium and neon will be used for compressed gas and other applications. The lighter isotope of helium (He-3) is present in greater concentrations on the Moon than on the Earth, and it has significant economic potential as a fuel for future atomic fusion reactors (see Appendix H).

**Moon contains all the raw materials needed for colonization and technology exists to exploit them**

Schrunk, ‘99 (Space: beyond 1999 Chemistry & Industry, 20 December, The Moon: resources, future development and colonization David Schrunk, Burton Sharpe, Bonnie Cooper & Madhu Thangavelu)

If only we'd listened to Gerry Anderson, we'd be living there by now. His Space:1999 television series was based in Moonbase Alpha, the first permanent lunar colony, staffed by a multinational team of scientists and military personnel in space-age fashions. Or, to take a slightly more high-brow example from science fiction, Arthur C Clarke and Stanley Kubrick's 2001: a space odyssey showed industry taking its first steps into space, with Pan-Am flying to orbiting hotels and the mineralogical exploration of the lunar surface. What these visions of the near future assumed was that the impetus of the US Apollo programme would continue past the initial goal of sending a couple of test pilots for a lunar walkabout and round of golf, into serious long-term colonisation and exploitation of the near extraterrestrial environment. What they didn't count on was the collective failure of nerve that saw funding slashed and the grand project abandoned. Once the glory was won, this government-driven project fell to fundamentally political pressures, from a Congress jealous of the billions of dollars sequestered by NASA and from a disillusioned public, who, at a time of social turmoil at home and unpopular military intervention overseas, came to view the space programme as a grotesquely grandiose extension of US foreign policy. But is the time now right to return to the Moon - not, this time, in a politically driven, publicly funded national gala, but in a long-term multilateral industrial venture based on solid commercial and scientific returns? David Schrunk, Burton Sharpe, Bonnie Cooper and Madhu Thangavelu believe it is, and this book is their manifesto. A multidisciplinary team who met by chance at a 1994 conference on lunar exploration, the authors have a vision of the Moon as the ultimate out-of-town science park. Virtually all of the raw materials needed by any lunar colony are already there, they argue. And the technology needed to exploit them is available today. All that appears to be missing is the will. Chemistry and the chemical industry would inevitably play a leading role in the colonisation and exploitation of the moon. Importing materials from Earth is prohibitively expensive, thanks to the $10,000/lb cost of carrying mass away from the home planet's gravitational clutches. But all the elements needed for colonisation are available hidden in the regolith - the rubble of rock fragments and dust that covers the lunar surface. The challenge is the universal challenge of chemistry: how to manipulate those elements into useful molecular forms. The need to live off the land would fuel the development of a uniquely lunar chemical industry. The regolith contains metals, minerals and oxygen, and inert elements such as helium and neon, useful for compressed gas and other applications. And a high concentration of helium-3 promises plentiful fuel for fusion reactors. While few of the organic feedstocks of the terrestrial industry are available on the Moon, trace elements including carbon, nitrogen and hydrogen are constantly delivered by the solar wind. As earlier researchers noted, one cubic metre of regolith contains the chemical equivalent of lunch for two, with plenty of carbon and nitrogen left over. The regolith can therefore provide the building blocks for the fatty acids, amino acids, vitamins, sugars, water and oxygen needed to support life, and for the whole portfolio of polymers and plastics. A series of inorganic reactions can create simple organic molecules such as ethene and formaldehyde, which can then be built into basic foodstuffs and plastics. A small-scale industry encompassing organic chemistry, biochemistry and plastics could be founded in the first stages of colonisation - perhaps with automated production units landed on the surface to ensure a supply of these chemicals for the first human settlers. Water is another basic requirement of any colony, and recent studies indicating the presence of up to six billion tonnes of ice bode well for colonisation plans.

**Moon has a wealth of resources that can be used for construction and operation of a base**

**Schrunk et al. 7** – Faculty Member of the Kepler Space Institute (Dr. David G., author and Founder of the Quality of Laws Institute; Madhu Thangavelu, works with the Department Of Aerospace Engineering & School of Architecture at the University of Southern California, lecturer for a graduate seminar in Extreme Environment Habitat Design as part of the USC School of Architecture, former Conductor of the Space Exploration Architectures Concept and Synthesis Studio in the Department of Aerospace and Mechanical Engineering in the School of Engineering at USC, former Space Projects Director for the Calearth Institute, Advisory Board Member for the Los Angeles Section of the American Institute of Aeronautics and Astronautics; Burton L. Sharpe, participant in mission operations planning and execution of the Gemini, Apollo, and Viking NASA space programs; Dr. Bonnie L. Cooper, from Oceaneering Space Systems in Houston; *The Moon: Resources, Future Development, and Settlement*, 2nd edition, p. xl, p. SpringerLink, MV)

I.2.2 Availability of energy and material resources The Moon, which lacks an atmosphere, receives abundant, energy from the Sun. Sunlight can be converted into electricity with lunar-made solar panels to supply the Moon with all of the power needed for global exploration and development. Sunlight could also be used for operating solar ovens, heat engines, and thermal management systems. The Moon has a wealth of raw materials that can be applied to the construction and operation of lunar bases. The lunar soil (regolith) contains iron, aluminum, calcium, silicon, titanium, and oxygen, as well as trace amounts of lighter elements such as carbon, sulfur, and nitrogen. Increased concentrations of hydrogen, detected by the Lunar Prospector Satellite, suggest the presence of water ice in the polar regions. With due precautions to preserve important geologic information, the lunar regolith will become the feedstock for lunar base industrial processes that manufacture wires, lenses, solar cells, and construction materials.

# Cost Effective

**Recycling equipment makes Moon colonization cost-effective in the long-term**

**Schrunk et al. 7** – Faculty Member of the Kepler Space Institute (Dr. David G., author and Founder of the Quality of Laws Institute; Madhu Thangavelu, works with the Department Of Aerospace Engineering & School of Architecture at the University of Southern California, lecturer for a graduate seminar in Extreme Environment Habitat Design as part of the USC School of Architecture, former Conductor of the Space Exploration Architectures Concept and Synthesis Studio in the Department of Aerospace and Mechanical Engineering in the School of Engineering at USC, former Space Projects Director for the Calearth Institute, Advisory Board Member for the Los Angeles Section of the American Institute of Aeronautics and Astronautics; Burton L. Sharpe, participant in mission operations planning and execution of the Gemini, Apollo, and Viking NASA space programs; Dr. Bonnie L. Cooper, from Oceaneering Space Systems in Houston; *The Moon: Resources, Future Development, and Settlement*, 2nd edition, p. 90, p. SpringerLink, MV)

5.6.8 Growth of the lunar base Over a period of several years, re-supply missions will deliver additional consum- ables, replace or upgrade old equipment, and add new capabilities, until full-scale industrial operations are established. Ideally, all new equipment would be designed with interchangeable parts so that they can eventually be cannibalized for use in other applications. Getting to the Moon costs a lot, but operating things that are already there should cost far less. Once things are there, they do not go away, so recycling and refurbishing the old tools and materials will be an important element in the lunar machine life cycle, The increasing capability and sophistication of industrial activities will enable operators on Earth to direct the construction of lunar pathways and shelters in preparation for the return of humans to the Moon.

# Fast Timeframe

**Moon colonization is affordable and can be accomplished on reasonable time scales**

**Spudis and Lavoie 2010** (Paul, Lunar and Planetary Institute, and Tony Lavoie, NASA Marshall Space Flight Center.

“Mission and Implementation of an Affordable Lunar Return,” December 19, <http://www.spudislunarresources.com/Papers/Affordable_Lunar_Base.pdf>.)

This return to the Moon is affordable and can be accomplished on reasonable time scales. Instead of single missions to exotic destinations, where all hardware is discarded as the mission progresses, we instead focus on the creation of reusable and extensible space systems, flight assets that are permanent and useable for future exploration beyond LEO. In short, we get value for our money. Instead of a fiscal black hole, this extensible space program becomes a generator of innovation and national wealth. It is challenging enough to drive technological innovation yet within reach on a reasonable timescale.

# \*\*Launch Mechanisms

# Soyuz

**Shuttle is not the only option - Soyuz spacecraft can work for the Moon – empirically worked for the Soviets**

**Foust 4** – editor and publisher of The Space Review (8/2/04, Jeff, operator of SpaceToday.net and the Space Politics weblog, The Space Review, “Soyuz to the Moon?” <http://www.thespacereview.com/article/199/1>, MV)

Conventional wisdom over the last several months has been that any human return to the Moon will not—barring an unlikely crash Chinese program—take place for a decade or more. The shuttle, obviously, is not capable of such a mission, and its successor, the Crew Exploration Vehicle (CEV), is not planned to enter service before about 2014, assuming all goes as planned. That would indicate that it will be at least that long, and perhaps longer, before humans again venture beyond low Earth orbit. The shuttle, however, is not the only means of carrying people into orbit; the Soyuz spacecraft has performed that duty for over three decades. The Soyuz today is seen exclusively as a taxi and lifeboat for crews on the International Space Station, but a few see an expanded role for the venerable spacecraft. At a presentation during the Return to the Moon conference in Las Vegas July 17, David Anderman, chief operating officer of Constellation Services International (CSI), offered an innovative approach that could turn the Soyuz from an ISS ferry to a circumlunar spacecraft with potential commercial applications. A Soyuz lunar architecture At first glance it seems unlikely, even preposterous, that a Soyuz spacecraft could be sent to the Moon and back. However, with the right approach, and the right additional hardware, Anderman believes that “every Soyuz launched to the ISS is a potential lunar spacecraft.” The key to this “Lunar Express” approach is addition of a new component, a logistics module, to the Soyuz. In the strawman mission architecture Anderman outlined in his conference presentation, the logistics module and an upper stage are launched into an ISS orbit by a generic launch vehicle. Anderman stressed that the logistics module was not tied to a specific launch vehicle to aid in the flexibility of the mission design; in an animation he showed at the conference the module was launched by a rocket bearing a NASA logo but resembling neither an Atlas nor a Delta. Once the module and upper stage were in orbit, a Soyuz spacecraft that had completed its half-year stay at the ISS would undock from the station and dock with the logistics module. The upper stage attached to the other end of the logistics module then fires, sending the complete spacecraft on a free-return circumlunar trajectory. The upper stage is jettisoned after the translunar injection burn, leaving the Soyuz and logistics module to complete the six-day round-trip mission. Back at Earth, the Soyuz return module separates from the rest of the spacecraft, as normal, and performs a double-dip reentry to handle the higher velocity of returning from the Moon. A similar approach could be used to recycle Progress cargo spacecraft at the end of their ISS missions. Instead of allowing the spacecraft to burn up in the Earth’s atmosphere, they could be docked with a logistics module and upper stage. In this case, instead of sending the spacecraft around the Moon, the Progress spacecraft would be sent to the Earth-Moon L1 point. Several such spacecraft could be docked together there, Anderman suggested, creating a supply depot and perhaps the core of an eventual human base that would be used a staging point for missions to the lunar surface or beyond. The linchpin to both architectures is the logistics module, a spacecraft that doesn’t yet exist. As envisioned by Anderman, the logistics module would be a simple cylindrical module with docking interfaces at either end, one for the Soyuz or Progress and the other for the upper stage. The module would be equipped with a docking radar and communications system designed to work at lunar distances. The module would also carry the food, water, and other supplies needed for a manned circumlunar mission, and provide additional habitation volume. Perhaps most importantly, though, Anderman said, is that the module would carry a new toilet: the toilet currently used on Soyuz missions, located in the orbital module, is designed to support three people for only two to four days. Anderman gave no estimates about how long it would take to develop this module, or at what cost. Given that CSI’s focus to date has been on commercial resupply missions to the ISS, the implication was that the logistics module might be derived from vehicles the company would develop to carry supplies to the station. While sending a Soyuz to the Moon might seem novel, Anderman noted that it had already been done, in a sense. In the late 1960s the Soviet Union sent several stripped-down unmanned Soyuz spacecraft, called Zond, to the Moon in a bid to develop a manned lunar vehicle that could beat the Americans to the Moon. The Zonds, superficially similar to today’s Soyuz but lacking an orbital module, suffered some problems during their flights, including guidance problems, and the program was canceled before any manned missions could fly once the US beat the USSR to the Moon. The Soyuz spacecraft used for Lunar Express missions would have to carry the heavier heat shields developed for the Zond program, incurring a 300-kilogram mass penalty. However, Anderman suggested that this mass could be recouped as more powerful variants of the Soyuz booster enter service in the years to come.

# New Launch Mechanism Will Be Developed

**Technology exists to build a robotic outpost on the Moon – technology to transport humans will be developed in the process**

**Schrunk et al. 7** – Faculty Member of the Kepler Space Institute (Dr. David G., author and Founder of the Quality of Laws Institute; Madhu Thangavelu, works with the Department Of Aerospace Engineering & School of Architecture at the University of Southern California, lecturer for a graduate seminar in Extreme Environment Habitat Design as part of the USC School of Architecture, former Conductor of the Space Exploration Architectures Concept and Synthesis Studio in the Department of Aerospace and Mechanical Engineering in the School of Engineering at USC, former Space Projects Director for the Calearth Institute, Advisory Board Member for the Los Angeles Section of the American Institute of Aeronautics and Astronautics; Burton L. Sharpe, participant in mission operations planning and execution of the Gemini, Apollo, and Viking NASA space programs; Dr. Bonnie L. Cooper, from Oceaneering Space Systems in Houston; *The Moon: Resources, Future Development, and Settlement*, 2nd edition, pp. 80-81, p. SpringerLink, MV)

4.10 LAUNCH VEHICLE CAPABILITY While no system is currently capable 0f placing humans 0n the M00n and returning them safely to the Earth, there are s0me existing launch vehicles that are capable of placing payloads on the Moon, with masses ranging from tens to thousands of kilograms. They give us the capability for placing many of the components of a robotic base on the lunar surface. During the time that it takes to establish a robotic outpost on the Moon, heavy-lift and human-rated rocket systems will be developed that permit permanent human habitation.

# \*\*Location/Habitats

**Moon’s polar regions are ideal for a base – capable of receiving solar power 90% of the year**

**Schrunk et al. 7** – Faculty Member of the Kepler Space Institute (Dr. David G., author and Founder of the Quality of Laws Institute; Madhu Thangavelu, works with the Department Of Aerospace Engineering & School of Architecture at the University of Southern California, lecturer for a graduate seminar in Extreme Environment Habitat Design as part of the USC School of Architecture, former Conductor of the Space Exploration Architectures Concept and Synthesis Studio in the Department of Aerospace and Mechanical Engineering in the School of Engineering at USC, former Space Projects Director for the Calearth Institute, Advisory Board Member for the Los Angeles Section of the American Institute of Aeronautics and Astronautics; Burton L. Sharpe, participant in mission operations planning and execution of the Gemini, Apollo, and Viking NASA space programs; Dr. Bonnie L. Cooper, from Oceaneering Space Systems in Houston; *The Moon: Resources, Future Development, and Settlement*, 2nd edition, p. xxii, p. SpringerLink, MV)

The polar regions of the Moon will likely play a strategic role in the first phases of lunar exploration and development. The summit of Mons Malapert, according to our calculations, always has the Earth and Shackleton Crater (at the lunar south pole) in view for direct and continuous high-bandwidth communications. Moreover, it may receive sunlight for solar power generation for as much as 90 percent of the lunar year. These favorable characteristics will have to be verified by analysis of imaging data from satellites (such as SMART-l and the planned Lunar Reconnaissance Orbiter), and by lander missions that obtain "ground truth” information. If our calculations are confirmed, Mons Malapert would offer great advantages for establishing a permanent foothold on the Moon.

**Lunar lava tubes are ideal for space bases - protects against temperatures, UV radiation, and meteors**

**CNN.com ‘10 (January 1, http://articles.cnn.com/2010-01-01/tech/moon.lava.hole\_1\_lunar-base-lava-flows-lunar-surface)**

Building a home near a moon crater or a lunar sea may sound nice, but moon colonists might have a much better chance of survival if they just lived in a hole. That's the message sent by an international team of scientists who say they've discovered a protected lunar "lava tube" -- a deep, giant hole -- that might be well suited for a moon colony or a lunar base. The vertical hole, in the volcanic Marius Hills region on the moon's near side, is 213 feet wide and is estimated to be more than 260 feet deep, according to findings published in Geophysical Research Letters, a journal of the American Geophysical Union. More important, the scientists say, the hole is protected from the moon's harsh temperatures and meteorite strikes by a thin sheet of lava. That makes the tube a good candidate for further exploration or possible inhabitation, the article says. "Lunar lava tubes are a potentially important location for a future lunar base, whether for local exploration and development, or as an outpost to serve exploration beyond the Moon," writes the team, led by Junichi Haruyama, a senior researcher with the Japanese space agency JAXA. "Any intact lava tube could serve as a shelter from the severe environment of the lunar surface, with its meteorite impacts, high-energy UV radiation and energetic particles, and extreme diurnal temperature variations." Lava tubes have previously been discovered on the moon, but the scientists say the new hole is notable because of its lava shield and because it does not appear to be prone to collapse. Lave tubes exist on Earth and also have been found on Mars. The cylinder-shaped caverns can be carved out by lava flows, volcanic eruptions, seismic activity or ground collapse resulting from meteoroid strikes. The scientists used high-resolution images from a Japanese moon orbiter called SELENE to discover this lunar lava tube. The findings were published November 12, but they grabbed the attention of the public this week. NASA is reportedly working on plans to return to the moon by 2020 and to set up a temporary lunar colony by 2025 as part of the Constellation Program. Funding for the program, however, remains somewhat in question. The American space agency could not be reached for comment.

# \*\*Answers To

# Agriculture Impossible

**No insurmountable barriers to lunar crop growing – experimentation will determine how best to grow food**

**Schrunk et al. 7** – Faculty Member of the Kepler Space Institute (Dr. David G., author and Founder of the Quality of Laws Institute; Madhu Thangavelu, works with the Department Of Aerospace Engineering & School of Architecture at the University of Southern California, lecturer for a graduate seminar in Extreme Environment Habitat Design as part of the USC School of Architecture, former Conductor of the Space Exploration Architectures Concept and Synthesis Studio in the Department of Aerospace and Mechanical Engineering in the School of Engineering at USC, former Space Projects Director for the Calearth Institute, Advisory Board Member for the Los Angeles Section of the American Institute of Aeronautics and Astronautics; Burton L. Sharpe, participant in mission operations planning and execution of the Gemini, Apollo, and Viking NASA space programs; Dr. Bonnie L. Cooper, from Oceaneering Space Systems in Houston; *The Moon: Resources, Future Development, and Settlement*, 2nd edition, pp. 45-46, p. SpringerLink, MV)

The mining and processing of the lunar regolith during the initial unmanned phase of lunar base development will yield quantities of carbon, hydrogen, oxygen, nitrogen, phosphorus, sulfur, and other elements that are essential for life. They will be used to create the nutrients and the atmospheres for the first agricultural habitats, in conjunction with the development of human habitats. It will then be possible to begin agricultural experiments with food crop cuttings and seeds that are delivered from the Earth to the Moon. Pilot development trials of combinations of plants and animals living continuously in controlled ecosystems will become an ongoing investigation. Which species belong together, which are the optional choices, and which must be kept apart? Which sets of lighting, temperature, humidity, atmospheric composition, and air flow produce the best results? Answers to these questions will form the basis for biological aspects of habitat architectures for all subsequent destinations in space. The successful adaptation of food crops to the lunar environment, and the development and integration of technologies for the control of air, water and waste-recycling systems, represent significant engineering challenges. However, no absolute barriers are foreseen. When reliable life-support systems become operational on the Moon, the full-scale migration of people from the Earth to the Moon, and to other sites in the solar system, will be possible. The recycling technologies may also be applicable for air, water, and waste management systems on Earth.

**Agricultural experiments show that lunar agriculture will be sufficient to support colonies**

**Schrunk et al. 7** – Faculty Member of the Kepler Space Institute (Dr. David G., author and Founder of the Quality of Laws Institute; Madhu Thangavelu, works with the Department Of Aerospace Engineering & School of Architecture at the University of Southern California, lecturer for a graduate seminar in Extreme Environment Habitat Design as part of the USC School of Architecture, former Conductor of the Space Exploration Architectures Concept and Synthesis Studio in the Department of Aerospace and Mechanical Engineering in the School of Engineering at USC, former Space Projects Director for the Calearth Institute, Advisory Board Member for the Los Angeles Section of the American Institute of Aeronautics and Astronautics; Burton L. Sharpe, participant in mission operations planning and execution of the Gemini, Apollo, and Viking NASA space programs; Dr. Bonnie L. Cooper, from Oceaneering Space Systems in Houston; *The Moon: Resources, Future Development, and Settlement*, 2nd edition, pp. 389-390, p. SpringerLink, MV)

J.2.3 Food While an oxygen atmosphere and water can be made available for human habitation from existing lunar resources, food is not available in any form on the Moon and will need to be transported from the Earth for initial manned operations. In order to achieve autonomy of lunar settlements, a means for producing food on the Moon will need to be devised. Food production experiments will have a high priority for the hrst human settlements on the Moon. Agricultural experiments on Earth that use lunar regolith simulants have grown a variety of food crops such as wheat, soybeans, potatoes, and lettuce. Experiments with the growth of food crops from "seed to seed" have also been attempted in Earth orbit. When sufficient power and water become available at the first lunar base, seeds of wheat and other food crops will be transported to the Moon and lunar agricultural experiments can begin. Artificial light will be required, because food crops such as wheat cannot adapt to the lunar day/night cycle of 14 Earth days of sunshine and 14 days of darkness.5 The food crops will also need nitrogen, carbon6 (e.g., carbon dioxide), and nutrients such as phosphorus and sulfur — all of which are present in the lunar regolith and can be extracted during the same mining and processing operations that are used to recover oxygen and other elements from lunar ores. All biological sources of food are subject to diseases (viruses, bacteria, fungi). If food crops on the Moon were to be infested with diseases, the result would be potentially catastrophic for the human crews that depend on them. To minimize the threat of crop diseases, a careful disease-screening procedure will need to be developed for all materials that are imported to the Moon. Redundant, biologically-isolated crop-growing regions should also be developed. The lack of an atmosphere on the Moon will make it possible to quarantine a food-growing area that has contracted an infectious disease. Based upon the data that has been gained from experiments that use lunar soil simulants and artificial lighting, there appear to be no significant technological hurdles to the production of wheat7 and a variety of other foods in sufficient volume to support human settlements. After it has been demonstrated that one species of food crop can thrive on the Moon, another species will be introduced and tested for its suitability as a source of food, Over time, many species of crops will be grown on the Moon, to minimize the threat of disease and to provide a wide variety of foods for the human population. After the successful demonstration of plant life cultivation, marine life, including lobsters, and livestock such as chickens and other animals, may also be imported.

# Gravity Problems

**Humans can live a liftime on Moon without significant gravity effects - muscle and bone deterioration will stabilize**

**LRS 2** (2002, Lunar Reclamation Society, an independent organization promoting space expansion, associated with the National Space Society, “15 Questions on Settling the Moon,” <http://www.nsschapters.org/hub/pdf/15Q_LunarSettlement.pdf>, MV)

The Moon’s Gravity is only 1/6 as strong as Earth’s. Won’t that cause health problems? Astronauts staying in orbit many months at a time experience a loss of bone calcium and muscle mass. But that is in “Zero-G”. There is every reason to expect that in the Moon’s 1/6 gravity, any initial deterioration will stabilize at an acceptable level for long term, even lifetime stays. Mass and momentum will be the same as on Earth, so isometric exercises will be more important than lifting, and musculature will be a little different. Children (and flowers!) may grow lithe and tall. Settlers will invent graceful new dances and interesting sports to suit the low gravity.

**Exercise and medication will mitigate the effects of low gravity**

**Legner 4** – former NASA flight surgeon (Klaus, M.D., former flight surgeon at the Austrian Air Force medical care center, former flight surgeon at NASA's Johnson Space Center in Houston, former flight surgeon at NASA's Kennedy Space Center in Florida, former flight surgeon at ESA's European Astronaut Center in Cologne, manages flight safety and security training for Austrian Airlines, “Humans in Space & Space Biology,” pp. 93-94, <http://adsabs.harvard.edu/full/2004UNPSA..15...77L>, MV)

It has long been known that removal of muscle forces and weight from bones, as occurs in bed rest or having a limb in a cast, causes the loss of minerals, which is known as disuse osteoporosis16. Living in the weightlessness environment of space, which represents a form of musculoskeletal disuse, has been found to cause a loss of bone mineral. Early studies of bone mineral changes using X-ray densitometry suggest that large amounts of bone may be lost during relatively brief periods of spaceflight. Measurements from Gemini and Apollo crew members show an average post-flight loss of 3.2% compared with pre-flight baseline values. Data from Skylab, Salyut, and Mir show a loss of 1% of heel bone density per month. The weight bearing bones loose more substance than the non-weight bearing bones do. Flight data from Skylab show a monthly calcium loss for the average of crewmen of about 8 g, or about 25 g for the 84-day flight. This would mean a total calcium loss in 1 year of over 300 g, or approximately 25% of the total body supply. Loss of bone mineral, if allowed to proceed unchecked, could represent a limiting variable for long duration space missions. There is no evidence that the in-flight bone losses are self-limiting, and it is the current assumption that calcium losses occur progressively throughout the flight. The precise mechanisms underlying the loss of bone mineral during spaceflight are still not known. Studies of animals with immobilized limbs indicate that disuse produces a number of time-dependent changes in bone formation and resorption. It may be that a proportionally larger increase in resorption over formation is responsible for the loss of bone mineral mass, at least in immobilized subjects (in response to gravitational unloading). Also not known are the underlying physiologic processes — whether hormonal, neural, electrical or mechanical — that initiate these changes. The major health hazards associated with skeletal changes include signs and symptoms of hypercalcemia17 with rapid bone turnover, the risk of kidney stones from hypercalciuria18, the lengthy recovery of lost bone mass after flight, the possibility of irreversible bone loss, the possible effects of calcification in the soft tissues, and the possible increase in fracture potential. At least two countermeasures, however, are considered to be potentially beneficial. The first countermeasure is exercise. An ideal exercise countermeasure programme represents the best possible compromise among efficacy, equipment size, case of performance, and operational time requirements. 1 to 1.5 hours per day of walking or jogging under a 1g force applied by elastic straps is considered to be adequate to prevent disuse osteoporosis. A pharmacologic countermeasure has also been considered. Ground-based studies have shown that drugs such as diphosphonate can control the loss of calcium in subjects undergoing bed- rest over a period of many weeks. This approach has not been tried during a space mission but may offer a useful means of reducing bone demineralization during the weightless environment of an extended spaceflight.

**Exercise and proper food mitigate the negative effects of spaceflight**

**Lane et al. 7** – Manager of the University Research and Affairs Office at the NASA Johnson Space Center in Houston (Helen Lane, PhD, RD, former director of the Center’s nutritional biochemistry laboratory, former director of the Center’s Biomedical and Research Branch; Vickie Kloeris, MS, Manager of the International Space Station Food System; Michele Perchonok, PhD, Manager of the Space Food Systems Laboratory, Manager of the Shuttle Food System, and Advanced Food Technology Lead at the NASA Johnson Space Center; Sara Zwart, PhD, research scientist in the Nutritional Biochemistry Laboratory at the NASA Johnson Space Center; Scott M. Smith, PhD, Senior Nutritionist and Manager for Nutritional Biochemistry at the NASA Johnson Space Center; May/June 2007, “Food and Nutrition for the Moon Base: What We Have Learned in 45 Years of Spaceflight,” *Nutrition Today*, Volume 42, Number 3, pp. 102-110, p. WilsonWeb, MV)

Musculoskeletal Changes Spaceflight has a significant negative impact on the musculoskeletal system. Losses of muscle volume and strength are routinely reported.8-10 For instance, after only 15 days in flight, astronauts had an 8% loss of hamstring volume, a 6% loss of quadriceps volume, and a loss of more than 10% in the intrinsic lumbar region muscles. Various exercises are used to decrease muscle losses, including resistance exercises.10 Resistance exercise with adequate food intake may prevent loss of muscle function (and bone mass) during spaceflight.11 It is assumed that these levels of exercise will be needed to maintain fitness for long-duration spaceflight.

# No Energy/Night Energy

**Regolith can be made into solar cells that provide enough energy for the moon and earth – an electrical grid will be used for power at night**

**Schrunk et al. 7** – Faculty Member of the Kepler Space Institute (Dr. David G., author and Founder of the Quality of Laws Institute; Madhu Thangavelu, works with the Department Of Aerospace Engineering & School of Architecture at the University of Southern California, lecturer for a graduate seminar in Extreme Environment Habitat Design as part of the USC School of Architecture, former Conductor of the Space Exploration Architectures Concept and Synthesis Studio in the Department of Aerospace and Mechanical Engineering in the School of Engineering at USC, former Space Projects Director for the Calearth Institute, Advisory Board Member for the Los Angeles Section of the American Institute of Aeronautics and Astronautics; Burton L. Sharpe, participant in mission operations planning and execution of the Gemini, Apollo, and Viking NASA space programs; Dr. Bonnie L. Cooper, from Oceaneering Space Systems in Houston; *The Moon: Resources, Future Development, and Settlement*, 2nd edition, p. 52, p. SpringerLink, MV)

Sunlight that reaches the lunar surface is constant, intense, and virtually inexhaustible. It delivers 1.365 kW/m2 t0 the lunar surface when the Sun is directly overhead (orthogonal to the lunar surface). Since photovoltaic (solar) cells that have an energy conversion factor of 20 percent or more can be made on the Moon from lunar regolith materials, all of the electrical power needs of lunar exploration and development projects can be satisfied with solar electric power. A lunar-based power system that is composed of lunar-made solar cells could potentially supply all of the energy that is needed for lunar development and for all of the future energy needs of the Earth (see discussion of a lunar-based solar electric power system in Chapter 10).

Sunlight can be used for agricultural applications on the Moon and it can be concentrated with mirrors to create the high temperatures that are needed for raw material processing and manufacturing. The only problem with sunlight is that it is not available for power generation during the lunar night. However, that problem can be overcome by constructing a solar-powered electric grid around the circumference of the Moon. A circumferentially-placed solar power grid will always be energized, thus providing abundant, constant3 electric energy for all lunar projects (see discussion in Chapter 7).

# Solar Flares/Radiation/Meteorites

**Underground colonies protect against radiation, solar flares, meteorites, and other hazards**

**Schrunk et al. 7** – Faculty Member of the Kepler Space Institute (Dr. David G., author and Founder of the Quality of Laws Institute; Madhu Thangavelu, works with the Department Of Aerospace Engineering & School of Architecture at the University of Southern California, lecturer for a graduate seminar in Extreme Environment Habitat Design as part of the USC School of Architecture, former Conductor of the Space Exploration Architectures Concept and Synthesis Studio in the Department of Aerospace and Mechanical Engineering in the School of Engineering at USC, former Space Projects Director for the Calearth Institute, Advisory Board Member for the Los Angeles Section of the American Institute of Aeronautics and Astronautics; Burton L. Sharpe, participant in mission operations planning and execution of the Gemini, Apollo, and Viking NASA space programs; Dr. Bonnie L. Cooper, from Oceaneering Space Systems in Houston; *The Moon: Resources, Future Development, and Settlement*, 2nd edition, p. xli, p. SpringerLink, MV)

I.2.4 Protection from space hazards The free space environment is hazardous to both biological systems and hardware. Background cosmic radiation levels in free space are ten times greater than the maximum acceptable levels for individuals who work in radiation environments on Earth. In addition, solar flare radiation will be fatal, in a matter of hours to days, to anyone in space who is not protected by adequate shielding. Similarly, cosmic and solar flare radiations degrade electro-mechanical systems. Micrometeorites are a direct threat to humans and equipment, and solar-thermal stress is a significant problem for any structure in space. The solution to these problems is to simply “go underground”. By creating underground compartments on the Moon, humans and equipment can be completely shielded from the hazards of space in Earth-like conditions, and the only serious risk to astronauts will occur during the three-day transit between the Earth and the Moon.

# International Cooperation Needed

Other countries will cooperate with the U.S. – they look to America for leadership in moving forward in space

Aerospace Industries Association, No date given,

(“U.S. Leadership in Space Exploration: Lessons from the International Space Station”, <http://www.aia-aerospace.org/assets/International%20Co-op%20in%20Space%20Exploration%20FINAL.pdf>)

Space partnerships can be an important foreign policy tool. As the U.S. seeks ways to work with rapidly growing developing countries, and newly emerging democracies in the Middle East, space cooperation can be an important tool. As the world’s leading spacefaring nation, other countries look to U.S. leadership in moving forward in space. Additionally, new opportunities for international partnership in human exploration continue to emerge. Fledgling space programs in countries as diverse as India, South Korea and Brazil, are potential targets for international collaborative efforts in human exploration. International cooperation has been the key to successful exploration programs. Throughout its history, the U.S. space exploration program has had its foreign policy impact as one of its primary objectives. This was true from the Cold War race to the moon against the Soviets (which also sought to influence emerging nations in former colonies) to the multination space shuttle program with its Canadian telerobotic arm and the European Space Lab. Since the Apollo moon landings, efforts to proceed with an ambitious U.S. exploration program have foundered and no U.S. human space effort has been initiated and seen through to completion without significant international involvement. NASA leads the development of the international team and works to assure U.S. technical priorities are included in our exploration architecture. International cooperation provides greater program stability. It should be noted that the ISS partnership has continued for nearly twenty five years and is likely to continue through at least the end of this decade. Despite its obvious benefits, there were technical challenges that came with internationalization. Engineers were responsible for integrating all the elements, whether U.S. or foreign-made, and getting them ready for flight. Never-the-less, the ISS has largely been built as envisaged and has not only met its technical objectives; it also has had significant political accomplishments as well. This is exactly the type of commitment and tenacity that a program for human exploration of the solar system will need if it is to be successful. Encouraging international partnerships reaps benefits beyond space exploration. Learning to live and work together in space will invariably improve our ability to live and work together on Earth. Moving forward, it will show the children of the world that our success as a spacefaring civilization is tied to peaceful cooperation with other nations and respecting the agreed upon rules of the road. Exploration will eventually lead us to a destination – but the real benefits will begin while we are on our way. Beyond this new perspective, as with exploration programs to date, technology developed for exploration will have spinoff benefits for life on Earth.

**International cooperation is normal means – a lunar base would inevitably rely on countries like China and India**

**Briggs 03** (Helen, BBC News Online science reporter, BBC News, "Moon colony 'within 20 years'" http://news.bbc.co.uk/2/hi/science/nature/3161695.stm, MM)

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Ion drive. The unmanned Smart-1 craft, which is due to be launched in early September, is flying to the Moon to demonstrate that Europe ahs the technology for future deep space science missions. Its main form of propulsion is an ion engine powered by solar-electrical means rather than conventional chemical fuel. When it arrives at the Moon, after a 15-month voyage, it will search for water-ice in craters and determine the abundance of minerals on the surface. In the process, it will look for landing sites for future lunar exploration such as a sample return mission planned by the US space agency (Nasa) for 2009. "The Moon could be used as a test bed for future human missions," says Sarah Dunkin, a leading British scientist on the Smart-1 project. "To actually live on another world would be quite a test of technology as well as human physiology. We don't know what the long-term effects of living in a low gravity environment would be." Any long term plans to set up a lunar base are bound to rely on international co-operation. They could include India and China, two nations which have recently pledged to send space craft back to the Moon. However, under current policy, the UK would not be included in any manned mission because it does not support human space exploration.

# Moon Dust

**Lunar railroad solve for moon dust – dust can also be collected and used for resources**

**Schrunk et al. 7** – Faculty Member of the Kepler Space Institute (Dr. David G., author and Founder of the Quality of Laws Institute; Madhu Thangavelu, works with the Department Of Aerospace Engineering & School of Architecture at the University of Southern California, lecturer for a graduate seminar in Extreme Environment Habitat Design as part of the USC School of Architecture, former Conductor of the Space Exploration Architectures Concept and Synthesis Studio in the Department of Aerospace and Mechanical Engineering in the School of Engineering at USC, former Space Projects Director for the Calearth Institute, Advisory Board Member for the Los Angeles Section of the American Institute of Aeronautics and Astronautics; Burton L. Sharpe, participant in mission operations planning and execution of the Gemini, Apollo, and Viking NASA space programs; Dr. Bonnie L. Cooper, from Oceaneering Space Systems in Houston; *The Moon: Resources, Future Development, and Settlement*, 2nd edition, pp. 108-109, p. SpringerLink, MV)

Small, unpressurized excursion vehicles will serve the needs of local transportation for crew and cargo (Figure 6.7). The Lunar Excursion Modules (LEMs) used in the Apollo program served this purpose very well. However, these vehicles had limitations in range, safety, and cargo capacity. They also disturb and accumulate the abrasive lunar dust, which is a hazard for both machines and humans (see Appendix J). One solution to the need for effective, safe, and high-speed long-distance transportation on the Moon is a railroad system. The "lunar railroad" will greatly facilitate the exploration, development, and human settlement of the Moon. During the early phases of lunar development, a pathway for the rail system will be surveyed and, after the right of way has been approved by the lunar government (see Chapter 9), the rail bed will be prepared. The lunar regolith that is removed in preparation of the rail bed can be amassed into a berm5 at the side of the railroad to serve as a support for the solar panels and as a sunshield for the rails. The lunar dust that is removed from the rail bed is also a source of solar wind gases and other elements, and it can be processed in-situ by a mobile factory robot.6

Moon dust is not a problem – it can be melted into useful material

Flinn, 6 (January, Edward D., Aerospace America, “Dealing with Moon Dust,” lexis)

As scientists and engineers figure out how to return astronauts to the Moon, set up habitats, and mine lunar soil to produce anything from building materials to rocket fuels, they are scratching their heads over what to do about Moon dust. This troublesome material is everywhere on the Moon's surface. The powdery grit gets into everything, jamming seals and abrading spacesuit fabric. It also readily picks up an electrostatic charge. This characteristic causes it to float or levitate off the lunar surface and stick to faceplates and camera lenses. The fine dust might even be toxic. Household hint Larry Taylor, distinguished professor of planetary sciences at the University of Tennessee, has an idea about what to do with this troublesome dust. He suggests that it can be melted into a useful material. "I am one of those weird people who like to stick things in ordinary kitchen microwave ovens to see what happens," Taylor admitted to several hundred scientists at a recent Lunar Exploration Advisory Group (LEAG) conference at NASA Johnson. At home in Tennessee, his most famous experiment involves a bar of Irish Spring soap, which quickly turns into "an abominable monster" when the microwave's start button is hit. However, the experiment he described at LEAG involved transforming Moon dust: He once put a small pile of lunar soil brought back by Apollo astronauts into a microwave oven. Taylor found that it melted rapidly, within 30 sec, at only 250 W. The reason it melted so quickly has to do with its composition. Lunar regolith, or soil, is produced when micrometeorites plow into lunar rocks and sand at high-impact velocities, melting and creating glass. The glass contains nanometer-scale beads of pure iron -- so-called "nanophase" iron. Those tiny iron beads efficiently concentrate microwave energy, causing the beads to "sinter," or fuse the loose soils into large clumps. This observation has inspired Taylor to imagine all kinds of machinery that could be sent to the Moon and then used to fuse lunar dust into useful solids. "Picture a buggy pulled behind a rover that is outfitted with a set of magnetrons," he suggests. (A magnetron is the heating element in a microwave oven.) "With the right power and microwave frequency, an astronaut could drive along, sintering the soil as he goes, making continuous brick down 0.5 m deep," Taylor points out. He adds that by changing the power settings the astronaut could melt the top inch or two of the soil to make a glass road. "Or say that you want a radio telescope," he continues. "Find a round crater and run a little microwave 'lawnmower' up and down the crater's sides to sinter a smooth surface. Hang an antenna from the middle -- voila, instant Arecibo!" he exclaims, referring to the giant 305-m-diam radio telescope formed from a natural circular valley in Puerto Rico. Technical challenges remain. Sintering Moon dust in a microwave oven on Earth is not the same as doing it on the airless Moon. Researchers still need to work out details of a process for producing strong, uniformly sintered material in the harsh lunar environment. However, the idea has promise. It could result in useful products such as sintered rocket landing pads, roads, bricks for habitats, and radiation shielding, while at the same time providing a means for dust abatement. "The only limit," says Taylor, "is imagination."

# Psychological Problems

**Lunar habitats will be structured to minimize psychological hazards**

**Schrunk et al. 7** – Faculty Member of the Kepler Space Institute (Dr. David G., author and Founder of the Quality of Laws Institute; Madhu Thangavelu, works with the Department Of Aerospace Engineering & School of Architecture at the University of Southern California, lecturer for a graduate seminar in Extreme Environment Habitat Design as part of the USC School of Architecture, former Conductor of the Space Exploration Architectures Concept and Synthesis Studio in the Department of Aerospace and Mechanical Engineering in the School of Engineering at USC, former Space Projects Director for the Calearth Institute, Advisory Board Member for the Los Angeles Section of the American Institute of Aeronautics and Astronautics; Burton L. Sharpe, participant in mission operations planning and execution of the Gemini, Apollo, and Viking NASA space programs; Dr. Bonnie L. Cooper, from Oceaneering Space Systems in Houston; *The Moon: Resources, Future Development, and Settlement*, 2nd edition, pp. 394-395, p. SpringerLink, MV)

To summarize, the first humans on the Moon will be thrust into an environment that has virtually every significant stress factor. They will be required to work in confined, barren, and noisy quarters (most experiments and environmental control systems will operate continuously), yet perform highly-important tasks that relate directly to their survival and to the success of their mission and future missions. The first maimed lunar base will thus present habitat designers with the challenge of minimizing stress, and will, inadvertently, provide psychologists and other investigators with an excellent opportunity to gain further data on the human responses to stress. To minimize the possibility of mission-threatening reactions to stress, screening procedures will be used to select crew members that have a high tolerance for stress. The design of the first lunar base must provide as much privacy as possible, as well as pleasant surroundings for the crew.12 Time must be set aside for recreation, and work assignments from mission control on the Earth must be adjusted so that they conform to the day-to-day performance capabilities and needs of the crew, Psychological monitors will be employed to measure and record behavior, sleep patterns, cognitive ability, and other stress markers. These data will also be used to indicate any deterioration in the performance of the crew so that corrective measures can be taken. Because a significant amount of the stress is related to the limited size of the first manned base, efforts will be made to increase the living and working spaces. The first option for adding living space to the base is to "fly in" additional habitable modules from the Earth and connect them to the base. The second option, which makes the Moon a logical place for the expansion of humankind into space, is to use the existing on-site mining and manufacturing capabilities to create new living spaces. In the same time frame as the first humans establish a base on the Moon, the lunar industrial base will have the capability of producing glass bricks, metal support beams and other construction materials from the lunar regolith. Tele-operated robots will use these materials to create underground structures and connecting tunnels that will have a breathable atmosphere.13 These expanded habitable spaces will become extensions of the original lunar base, and will provide the crew with space for work, scientific experiments, and recreation, away from the confines of the original modular base. By this process, large living spaces, and eventually cities, will be created, and the threat to the psychological health of lunar inhabitants from isolation and confinement will be reduced.

**Human ingenuity will allow people to adjust to the moon and make it home**

**Schrunk et al. 7** – Faculty Member of the Kepler Space Institute (Dr. David G., author and Founder of the Quality of Laws Institute; Madhu Thangavelu, works with the Department Of Aerospace Engineering & School of Architecture at the University of Southern California, lecturer for a graduate seminar in Extreme Environment Habitat Design as part of the USC School of Architecture, former Conductor of the Space Exploration Architectures Concept and Synthesis Studio in the Department of Aerospace and Mechanical Engineering in the School of Engineering at USC, former Space Projects Director for the Calearth Institute, Advisory Board Member for the Los Angeles Section of the American Institute of Aeronautics and Astronautics; Burton L. Sharpe, participant in mission operations planning and execution of the Gemini, Apollo, and Viking NASA space programs; Dr. Bonnie L. Cooper, from Oceaneering Space Systems in Houston; *The Moon: Resources, Future Development, and Settlement*, 2nd edition, pp. 500-503, p. SpringerLink, MV)

T.4 THE MOON FROM A SETTLER’S POINT OF VIEW Magnificent desolation? Yes. Harsh and unforgiving? That too. Alien and hostile? Of course it has always been so from the time our ancestors on the plains of East Africa started pushing ever further into unfamiliar territory: the lush, dense jungles, the hot dry deserts, waters too wide to swim, high mountain ranges, and eventually, the Arctic tundra. Judged by the pool of past experience, each new frontier was hostile, unforgiving, and fraught with mortal dangers . . . until we settled it anyway. Once we learned how to use unfamiliar resources in place of those left behind, once we learned how to cope with those new dangers, as if by "second nature", then the new frontier became as much home as the places we left behind. A person raised in a tropical rain forest, suddenly transported to the north slopes of Alaska, might soon perish, at a loss for how to cope. But the Eskimo never gives it a second thought. How to cope with ice, cold, the Arctic wildlife, the absence of lush plant life have all become second nature. And future Lunans will reach that point as well. Yes, there is sure suffocation outside the airlock. Yes, the Sun shines hot and relentlessly with no relief from clouds for two weeks on end. Yes, the Sun stays "set" for two weeks at a time while surface temperatures plunge. Yes, the moondust insinuates itself everywhere. The litany goes on and on. So? Lunans will learn to take it all in their stride. How to take the right precautions for each of these potential fatal conditions will have become culturallyingrained second nature. The Moon, to Lunans, will become a land of promise. T.4.1 Making themselves at home Even in the first initial human outpost, crew members could bring rock inside the habitat as adornment in itself, or perhaps carve it into an artifact. An early cast-basalt industry, early metal alloys industries, early lunar farming will all supply materials out of which to create things to adorn private and common spaces alike. Learning to do arts and crafts on the Moon may seem useless and irrelevant to some, but it will be the first humble start of learning to make the Moon “home”. And so it has been on every frontier humans have settled. We will also learn to schedule our activities and our recreation in tune with the Moon’s own rhythms. We’ll do the more energy-intensive things during dayspan. the more energy-light, manpower-intensive things saved for nightspan, With no threemonth-long seasons on the Moon, the monthly dayspan-nightspan rhythm will dominate. The pioneers may bring some holidays with them, but will originate other festivities and monthly and annual celebrations. Getting used to lunar gravity will also help pioneers settle in. They will abandon trying to adapt familiar terrestrial sports, which can only be caricatures of the games of Earth. Instead, they will invent new sports that play to the 1/6 gravity and traction, while momentum and impact remain universally standard. Alongside the development of lunar sports will be forms of dance, Can you imagine how ethereal a performance of Swan Lake would be on the Moon? How many loops could an ice-skater do before finally landing on the ice? T.4.2 But they have to live underground, for heaven’s sake! On Earth, our atmosphere serves as a blanket which protects us from the vagaries of cosmic weather, cosmic rays, solar flares, micrometeorite storms. On the Moon, eons of micrometeorite bombardment have pulverized the surface and continue to "garden" it into a blanket of dust and rock bits 3 to 15 meters thick. Tucking our pressurized outpost complex under such a blanket will provide the same protection, along with insulation from the temperature extremes of dayspan and nightspan. Will our outposts look like somewhat orderly mazes of molehills? To some extent, perhaps; but the important thing is that we do not have to live as moles. We have ways to bring the sunshine and the views down under the blanket with us. In the spring of 1985, I had the opportunity to tour a very unique Earth-sheltered home some 32 km northwest of Milwaukee. Unlike other earth-sheltered homes, TerraLux (EarthI.ight) did not have a glass wall southern exposure. Instead, large mirrorfaceted cowls followed the Sun across the sky and poured sunlight inside via mirror-tiled meter-wide tubes that traversed a 2.5»meter-thick soil overburden (Figure T.1). Meanwhile, picture-window-scale periscopic windows provided beautiful views of the Kettle Moraine countryside all around. I had never been in a house so open to the outdoors, so filled with sunlight, as that "underground" one. I at once thought of the lunar pioneers, and how they could make themselves quite cozy amidst their forbidding, unforgiving magnificent desolation. The point is that, yes, the Moon is a place very alien to our everyday experience, but. nonetheless, human ingenuity will find a way to make it "home" (Figure T.2). T.4.3 What about the outdoorsmen amongst us? While Lunans will find plenty to do within their pressurized homes, workplaces, and commons areas, many will miss the pleasures of outdoors life on Earth: fishing, swimming, hunting, boating, flying, hiking, mountain climbing, and caving. The list goes on and on. Yet some of these pleasures we may be able to recreate indoors – fishing in trout streams, for example. We will want an abundant supply of water, and waste water in the process of being purified can provide small waterfalls and fountains, even trout streams for fishing and boating. In large, high-ceiling enclosures, humans may finally be able to fly with artificial wings, as Icarus tried to do. Out on the surface of the Moon, sporting activities will be more of a challenge. Present spacesuits are very cumbersome and clumsy. We must develop suits that give us more freedom of motion, that tire us less easily. Once we do, hiking, motor biking, mountain climbing, and caving (in lava tubes) will become possible. Sporting events, rallies, races, and games will follow. Over the years, we will learn to take the Moon’s conditions for granted, and to "play to them", just as northerners have invented skiing, ice skating, snow boarding, and other winter sports, that people in the tropics would never have imagined (Figure T.3).

# No Colonizers

**Moon colonization will be appealing to the aging population – allows them to enjoy greater levels of mobility**

**Schrunk et al. 7** – Faculty Member of the Kepler Space Institute (Dr. David G., author and Founder of the Quality of Laws Institute; Madhu Thangavelu, works with the Department Of Aerospace Engineering & School of Architecture at the University of Southern California, lecturer for a graduate seminar in Extreme Environment Habitat Design as part of the USC School of Architecture, former Conductor of the Space Exploration Architectures Concept and Synthesis Studio in the Department of Aerospace and Mechanical Engineering in the School of Engineering at USC, former Space Projects Director for the Calearth Institute, Advisory Board Member for the Los Angeles Section of the American Institute of Aeronautics and Astronautics; Burton L. Sharpe, participant in mission operations planning and execution of the Gemini, Apollo, and Viking NASA space programs; Dr. Bonnie L. Cooper, from Oceaneering Space Systems in Houston; *The Moon: Resources, Future Development, and Settlement*, 2nd edition, pp. 136-139, p. SpringerLink, MV)

Advances in nutrition and medical care have led to greater longevity of the population of the Earth, and people now enjoy longer productive and professional lives than was possible in the past. Worldwide living standards have also been steadily increasing in many parts of the world. The aging population has more wealth than ever before in history, and a significant fraction of that wealth is directed to tourism and the treatment of the physical infirmities of aging. In view of these facts, the "Planet Moon Project" will be a magnet for the aging population for several reasons: 1. Participation in lunar development projects will be an exciting task for people of all ages. 2. Lunar development projects will require expertise from a wide range of professions and management that retirees can provide. 3. The Moon offers the ultimate tourism experience. 4. And the lower gravity (1/6G) will allow people with physical limitations to enjoy greater levels of mobility than are possible on Earth. People who have retired from employment on the Earth can extend their productive lives by providing their services on the Moon. They would also be able to enjoy the adventure of living and working on a new world and they could take advantage of the reduced gravity environment that permits greater ease of mobility than is possible on Earth. The common elements among these ideas suggest that it may be worthwhile to create lunar retirement and rehabilitation facilities on the Moon. These facilities promise to be viable economic projects that meet the needs of the older population who will potentially play a vital role in development projects on the space frontier.

# Temperature Variations

**Underground colonies solve drastic temperature variations**

**Schrunk et al. 7** – Faculty Member of the Kepler Space Institute (Dr. David G., author and Founder of the Quality of Laws Institute; Madhu Thangavelu, works with the Department Of Aerospace Engineering & School of Architecture at the University of Southern California, lecturer for a graduate seminar in Extreme Environment Habitat Design as part of the USC School of Architecture, former Conductor of the Space Exploration Architectures Concept and Synthesis Studio in the Department of Aerospace and Mechanical Engineering in the School of Engineering at USC, former Space Projects Director for the Calearth Institute, Advisory Board Member for the Los Angeles Section of the American Institute of Aeronautics and Astronautics; Burton L. Sharpe, participant in mission operations planning and execution of the Gemini, Apollo, and Viking NASA space programs; Dr. Bonnie L. Cooper, from Oceaneering Space Systems in Houston; *The Moon: Resources, Future Development, and Settlement*, 2nd edition, p. 54, p. SpringerLink, MV)

The temperature of the lunar surface at the equator varies between +127°C during the lunar day and —173°C8 during the lunar night and is colder with increasing latitude. This large temperature difference makes it possible to generate power by the operation of heat engines, such as Stirling engines, that convert temperature differences into mechanical energy. In the polar regions, towers whose upper structures are always in sunlight and whose bases are in permanent shadow could thus be used for continuous heat engine operation. On a global scale, pipelines that transport gases around the circumference of the Moon could be used for thermal management (heating or cooling) at desired locations.9 A negative feature of temperature extremes is that, depending upon their composition, structures such as exposed solar power arrays could undergo considerable thermal stress during the transition between lunar night and day. However, at a depth of approximately one meter and below, the temperature is a fairly constant —20°C at the equator. This is advantageous for minimizing thermal stresses. To the greatest possible extent, lunar habitats, structures, equipment, storage facilities, and instruments will be placed below the lunar surface. A simplified representation of the temperature variation on the Moon at the equator is depicted in Figure 3.1.

# \*\*Counterplan Answers

# Privatization

**Government action key to sanctioning utilities and establishing and protecting property rights**

**Schrunk et al. 7** – Faculty Member of the Kepler Space Institute (Dr. David G., author and Founder of the Quality of Laws Institute; Madhu Thangavelu, works with the Department Of Aerospace Engineering & School of Architecture at the University of Southern California, lecturer for a graduate seminar in Extreme Environment Habitat Design as part of the USC School of Architecture, former Conductor of the Space Exploration Architectures Concept and Synthesis Studio in the Department of Aerospace and Mechanical Engineering in the School of Engineering at USC, former Space Projects Director for the Calearth Institute, Advisory Board Member for the Los Angeles Section of the American Institute of Aeronautics and Astronautics; Burton L. Sharpe, participant in mission operations planning and execution of the Gemini, Apollo, and Viking NASA space programs; Dr. Bonnie L. Cooper, from Oceaneering Space Systems in Houston; *The Moon: Resources, Future Development, and Settlement*, 2nd edition, p. 123, p. SpringerLink, MV)

The construction of the electric grid can begin by adding lunar-made solar cell components along illuminated segments of the right of way of the lunar railroad that extends from Mons Malapert to the south pole. A system of governance of the Moon (see Chapter 9) will be required to sanction the construction of the utilities system. The government will also need to establish and guarantee property rights to construction companies and other institutions that utilize regolith materials and build the infrastructure elements along the right of way. Sites of scientific, esthetic, or other interest will be avoided so that they are not disturbed by the construction project.

# Mars

**Moon is the best place for settlement – offers the fastest way to build a rescue base and to return to earth when needed**

Shapiro, ‘07 (Robert, March 19,"Why the Moon? Human survival!" The Space Review, Professor Emeritus and Senior Research Scientist in the Chemistry Department of New York University, <http://www.thespacereview.com/article/832/1>)

Physicist Stephen Hawking, and a number of others, have called for humanity to spread out to distant planets of our Solar System. But there is no need to go so far to protect ourselves. After a few decades—centuries at worst—dust and ash will settle, radioactive materials will decay, and viruses will perish. Earth will once again become the best home for humanity in the Solar System. Return would be easiest if a safe sanctuary were nearby. In the more probable instance that only a limited disaster took place, that nearby sanctuary could also play a valuable role in restoring lost data and cultural materials, and coordinating the recovery. And of course, construction of the rescue base will be much easier if it is only days, rather than months or years, away. We do not have to build the base from scratch, in an environment of emptiness, as we are attempting to do with the space station. A suitable platform has been orbiting our planet ever since its formation. On most clear nights, we need only look up to see it. If I employ the same arithmetic that I use when I insure my home, the cost of the lunar base can easily be justified. My house has not burned down, and the disasters I described may not occur. A host of other benefits, described on the NASA web site, will result from human presence on the Moon. But we do not need to invoke them to provide reasons for our investment.

Moon is ideal test-bed for Mars colonization – presents a similarly hostile environment and opportunity to develop needed technologies

Seedhouse 09 – (Erik, 2009, “Lunar Outpost” Accessed on 7/20/11)

The hostile environment of the Moon, such as the radiation field, reduced gravity, and the ever-prevalent dust, are very similar to the conditions on Mars and therefore offer a suitable test-bed to apply and evaluate technologies designed to deal with such an environment. Also of particular importance for future Mars missions is the testing of M situ resource utilization (ISRU) on the lunar surface, since this process will be med extensively by astronauts during Martian missions. Other scientific objectives that must be met before undertaking manned missions to Mars include the development of autonomous tools and integrated advanced sensing systems such as bio-diagnostics, telemedicine, and environmental monitoring and control. Once again, the lunar surface offers a demanding testing ground for the rigorous evaluation and development of such systems.

**Moon must be out first port – best to test human adaptation and technologies in a location close to home**

**O’Neill 08**, (Ian, Space Producer Space Producer for Discovery News “Building a Moon Base” February 9, <http://www.universetoday.com/12758/building-a-base-on-the-moon-part-2-habitat-concepts/>)

Manned missions to Mars take up a lot of the limelight insofar as colonization efforts are concerned, so it’s about time some focus is aimed at the ongoing and established concepts for colonization of the Moon. We currently have a means of getting there (after all, it is nearly 40 years ago since Apollo 11) and our technology is sufficiently advanced to sustain life in space, the next step is to begin building… In this first installment of “Building a Moon Base”, we look at the immediate issues facing engineers when planning habitats on a lunar landscape. “Building a Moon Base” is based on research by Haym Benaroya and Leonhard Bernold (“[Engineering of lunar bases](http://www.sciencedirect.com/science?_ob=ArticleURL&_udi=B6V1N-4P301RH-1&_user=10&_coverDate=03%2F31%2F2008&_alid=686404075&_rdoc=1&_fmt=summary&_orig=search&_cdi=5679&_sort=d&_docanchor=&view=c&_ct=9&_acct=C000050221&_version=1&_urlVersion=0&_userid=10&md5=aa8dd20470ef0e48fd74103ca914a65e)“) The debate still rages as to whether man should settle on the Moon or Mars first. Mars is often considered to be the ultimate challenge for mankind: to live on a [planet](http://www.universetoday.com/35923/planet/) other than Earth. But looking down on us during cloudless nights is the bright and attainable Moon. From here we can see the details of the lunar landscape with the naked eye, it is so close astronomically when compared with the planets, that many believe that the Moon should be our first port of call before we begin the six month (at best) voyage to the Red Planet. It also helps as we’ve already been there… Opinion has shifted somewhat in recent years from the “Mars Direct” plan (in the mid-1990s) to the “Moon First” idea, and this shift has recently been highlighted by US President George W. Bush when in 2004 he set out plans for re-establishing a presence on the Moon before we can begin planning for Mars. It makes sense; many human physiological issues remain to be identified, plus the technology for colonization can only be tested to its full extent when… well… colonizing. Understanding how the human body will adapt to life in low-G and how new technologies will perform in a location close enough to home will be not only be assuring to lunar colonists and astronauts, it will also be sensible. Exploring space is dangerous enough, minimizing the risk of mission failure will be critical to the future of manned exploration of the [Solar System](http://www.universetoday.com/15908/3d-solar-system/).

**Moon has many relative advantages to Mars – better capital utilization, less fuel required**

**Dinkin 4** – columnist at the Space Review (9/7/04, Dr. Sam, founder of SpaceShot, Inc., space investor, founder of the Space Journalism Prize, currently forming the Space Journalism Association, Ph.D. in economics from the University of Arizona, The Space Review, “Colonize the Moon before Mars,” <http://www.thespacereview.com/article/221/1>, MV)

It will probably take decades of subsidy before a Mars colony could sustain itself. A twenty-year program of $50-billion-a-year subsidies would hit a trillion dollars. This is an affordable sum for a rich planet. It would be an excellent idea to get started if this were the only space colonization option. There is a much better option, however, teasing us as it hangs in the sky. The Moon The Moon has many relative advantages. The first is capital utilization. A Lunar cycler can make hundreds of round trips in the time that a Mars cycler can make. Second, there is much less fuel required to get from the Earth to the Moon than to Mars. Existing technology can be used to get to the Moon (see “Soyuz to the Moon?”, The Space Review, August 2, 2004). A lunar landing mission might cost $120 million for an Ariane 5 booster. If each mission cost another $120 million for the Soyuz, service module and everything else, then that would be $240 million per flight instead of $5 billion per flight. That means that a $50-billion level of commitment from Earth can afford over 400 flights every two years. Of course, that level of commitment could be optimally spent in much better ways. By creating a lunar cycler, a station at L-1, an orbital fuel depot, in situ utilization of lunar oxygen and possibly lunar water, there could be a vibrant community on the Moon. While a single Ariane 5 could not heft as much as a Mars Direct flight, it may still transfer a comparable amount of resources and people as a Mars Direct flight would to Mars. Since life support and consumables are much less onerous for a short trip than a long trip, there is a lower mass requirement for crew transfer flights to the Moon and much less depreciation of capital in transit. Having new heavy lift that would enable Mars Direct would also enable more sensible lunar colonization missions.

**Moon’s closer proximity provides multiple advantages over Mars – allows for rescue missions, just-in-time planning, teleoperation, use of NEO resources**

**Dinkin 4** – columnist at the Space Review (9/7/04, Dr. Sam, founder of SpaceShot, Inc., space investor, founder of the Space Journalism Prize, currently forming the Space Journalism Association, Ph.D. in economics from the University of Arizona, The Space Review, “Colonize the Moon before Mars,” <http://www.thespacereview.com/article/221/1>, MV)

First, on a mission to the Moon, Earth rescue is a decent possibility for certain kinds of failures. On a trip to Mars, this would be out of the question. As NASA is finding out with its shuttle return to flight efforts, having a standby rescue ship and a space station to go to makes failure recovery for many failures feasible without too much increased capability from our existing hardware. Second, the proximity to Earth allows for just-in-time planning. With Earth only a few days away, a regular resupply mission can have last minute changes to its manifest. That means that fewer spares need to be kept on hand to assure the same level of safety as in a Mars mission. Third, the short distance between the Earth and the Moon allow Earth based teleoperation to be a viable alternative to robotics and local human operation. This vastly leverages the capability of capital equipment on the Moon. Fourth, there is valuable information that can be learned in setting up a space colony that will raise the likelihood of success of all future colonization efforts. So if we are colonizing both Mars and the Moon, colonizing the Moon first would help inform the colonization plan of Mars. The reverse would not be as true because Mars colonization would take longer. Finally, resource and energy options are opened up to guard against our energy appetite increasing (as our nuclear appetite isn’t) or carbon appetite decreasing. In addition to lunar resource utilization, creating an option to colonize near Earth asteroids is very interesting and makes many resource extraction strategies feasible even if it would take technology breakthroughs or huge changes in the economy to make them financially viable.

**Moon is preferable to Mars – existing technology can be used, hundreds of trips can be made in the time it takes for a single Mars mission, and costs are significantly less**

Dinkin 4 (Sam, columnist for the Space Review, September 7, “Colonize the Moon before Mars,” <http://www.thespacereview.com/article/221/1>)

The Moon has many relative advantages. The first is capital utilization. A Lunar cycler can make hundreds of round trips in the time that a Mars cycler can make. Second, there is much less fuel required to get from the Earth to the Moon than to Mars. Existing technology can be used to get to the Moon (see “Soyuz to the Moon?”, The Space Review, August 2, 2004). A lunar landing mission might cost $120 million for an Ariane 5 booster. If each mission cost another $120 million for the Soyuz, service module and everything else, then that would be $240 million per flight instead of $5 billion per flight. That means that a $50-billion level of commitment from Earth can afford over 400 flights every two years. Of course, that level of commitment could be optimally spent in much better ways. By creating a lunar cycler, a station at L-1, an orbital fuel depot, in situ utilization of lunar oxygen and possibly lunar water, there could be a vibrant community on the Moon.

While a single Ariane 5 could not heft as much as a Mars Direct flight, it may still transfer a comparable amount of resources and people as a Mars Direct flight would to Mars. Since life support and consumables are much less onerous for a short trip than a long trip, there is a lower mass requirement for crew transfer flights to the Moon and much less depreciation of capital in transit. Having new heavy lift that would enable Mars Direct would also enable more sensible lunar colonization missions.

**Moon is a springboard to Mars – key to engineering and physiological research, radiation protection, helium-3 fusion technology, inexpensive launch capability**

Schmitt et al 9 – (Harrison, geologist, Apollo 17 astronaut, Former Chair NASA Advisory Council, Andy Daga, Lunar surface architecture and technology consultant, and Jeff Plescia, Applied Physics Laboratory, The Johns Hopkins University, 2009, “Geopolitical Context of Lunar Exploration and Settlement,” <http://www.lpi.usra.edu/decadal/leag/DecadalGeopolitical.pdf>)

What, then, should be the focus of national space policy in order to maintain leadership in deep space? Some propose that we concentrate only on Mars. This would be naïve and self-defeating. The country is simply not technically ready to go to Mars at present, and it will be a long time until we are ready to do so. Returning to the Moon, however, provides the fastest path for humans to go to Mars. Without the experience of returning to the Moon, we will not have the engineering or physiological insight for many decades to either fly to Mars or land there. Without lunar water resources, radiation protection for the long voyage to Mars may not be possible. Without the development of lunar helium-3 fusion technology applied to interplanetary propulsion, we may not be able to reduce the transit time to Mars to an acceptable duration. Without lunar operational experience, including learning to operate outside of communications with Earth, we vastly increase the risk of early Martian flights. Without lunar oxygen and water, Earth launch payloads to Mars may be prohibitively large and expensive, not to mention the continued uncertainties about sustainable resources on Mars. Without lunar rocket fuel resources, that is, hydrogen, oxygen and/or methane, we may not be able to land on Mars because of complicating presence of just some atmosphere and not a lot. Indeed, without returning to the Moon, future opportunities of leadership, including a much greater potential for international cooperation in scientific endeavors related to the Moon and beyond, cannot be realized.

**Moon is a key testing ground for dealing with dust and developing in situ resource utilization**

**Science@NASA 5** (3/18/05, Science@NASA, headline news from NASA, “En Route to Mars, The Moon,” <http://science.nasa.gov/science-news/science-at-nasa/2005/18mar_moonfirst/>, MV)

Why the Moon before Mars? "The Moon is a natural first step," explains Philip Metzger, a physicist at NASA Kennedy Space Center. "It's nearby. We can practice living, working and doing science there before taking longer and riskier trips to Mars." The Moon and Mars have a lot in common. The Moon has only one-sixth Earth's gravity; Mars has one-third. The Moon has no atmosphere; the Martian atmosphere is highly rarefied. The Moon can get very cold, as low as -240o C in shadows; Mars varies between -20o and -100o C. Even more important, both planets are covered with silt-fine dust, called "regolith." The Moon's regolith was created by the ceaseless bombardment of micrometeorites, cosmic rays and particles of solar wind breaking down rocks for billions of years. Martian regolith resulted from the impacts of more massive meteorites and even asteroids, plus ages of daily erosion from water and wind. There are places on both worlds where the regolith is 10+ meters deep. Operating mechanical equipment in the presence of so much dust is a formidable challenge. Just last month, Metzger co-chaired a meeting on the topic: "Granular Materials in Lunar and Martian Exploration," held at the Kennedy Space Center. Participants grappled with issues ranging from basic transportation ("What kind of tires does a Mars buggy need?") to mining ("How deep can you dig before the hole collapses?") to dust storms--both natural and artificial ("How much dust will a landing rocket kick up?"). Answering these questions on Earth isn't easy. Moondust and Mars dust is so ... alien. Try this: Run your finger across the screen of your computer. You'll get a little residue of dust clinging to your fingertip. It's soft and fuzzy--that's Earth dust. Lunar dust is different: "It's almost like fragments of glass or coral--odd shapes that are very sharp and interlocking," says Metzger. (View an image of lunar dust.) "Even after short moon walks, Apollo 17 astronauts found dust particles had jammed the shoulder joints of their spacesuits," says Masami Nakagawa, associate professor in the mining engineering department of the Colorado School of Mines. "Moondust penetrated into seals, causing the spacesuits to leak some air pressure." In sunlit areas, adds Nakagawa, fine dust levitated above the Apollo astronauts' knees and even above their heads, because individual particles were electrostatically charged by the Sun's ultraviolet light. Such dust particles, when tracked into the astronauts' habitat where they would become airborne, irritated their eyes and lungs. "It's a potentially serious problem." Dust is also ubiquitous on Mars, although Mars dust is probably not as sharp as moondust. Weathering smooths the edges. Nevertheless, Martian duststorms whip these particles 50 m/s (100+ mph), scouring and wearing every exposed surface. As the rovers Spirit and Opportunity have revealed, Mars dust (like moondust) is probably electrically charged. It clings to solar panels, blocks sunlight and reduces the amount of power that can be generated for a surface mission. For these reasons, NASA is funding Nakagawa's Project Dust, a four-year study dedicated to finding ways of mitigating the effects of dust on robotic and human exploration, ranging from designs of air filters to thin-film coatings that repel dust from spacesuits and machinery. The Moon is also a good testing ground for what mission planners call "in-situ resource utilization" (ISRU)--a.k.a. "living off the land." Astronauts on Mars are going to want to mine certain raw materials locally: oxygen for breathing, water for drinking and rocket fuel (essentially hydrogen and oxygen) for the journey home. "We can try this on the Moon first," says Metzger. Both the Moon and Mars are thought to harbor water frozen in the ground. The evidence for this is indirect. NASA and ESA spacecraft have detected hydrogen--presumably the H in H2O--in Martian soil. Putative icy deposits range from the Martian poles almost to the equator. Lunar ice, on the other hand, is localized near the Moon's north and south poles deep inside craters where the Sun never shines, according to similar data from Lunar Prospector and Clementine, two spacecraft that mapped the Moon in the mid-1990s. If this ice could be excavated, thawed out and broken apart into hydrogen and oxygen ... Voila! Instant supplies. NASA's Lunar Reconnaissance Orbiter, due to launch in 2008, will use modern sensors to search for deposits and pinpoint possible mining sites. "The lunar poles are a cold place, so we've been working with people who specialize in cold places to figure out how to land on the soils and dig into the permafrost to excavate water," Metzger says. Prime among NASA's partners are investigators from the Army Corps of Engineers' Cold Regions Research and Engineering Laboratory (CRREL). Key challenges include ways of landing rockets or building habitats on ice-rich soils without having their heat melt the ground so it collapses under their weight. Testing all this technology on the Moon, which is only 2 or 3 days away from Earth, is going to be much easier than testing it on Mars, six months away. So ... to Mars! But first, the Moon.

# NEO Bases

**Much easier to adapt industrial processes to lunar gravity – NEO bases and orbiting stations threaten human physiology**

**Schrunk et al. 7** – Faculty Member of the Kepler Space Institute (Dr. David G., author and Founder of the Quality of Laws Institute; Madhu Thangavelu, works with the Department Of Aerospace Engineering & School of Architecture at the University of Southern California, lecturer for a graduate seminar in Extreme Environment Habitat Design as part of the USC School of Architecture, former Conductor of the Space Exploration Architectures Concept and Synthesis Studio in the Department of Aerospace and Mechanical Engineering in the School of Engineering at USC, former Space Projects Director for the Calearth Institute, Advisory Board Member for the Los Angeles Section of the American Institute of Aeronautics and Astronautics; Burton L. Sharpe, participant in mission operations planning and execution of the Gemini, Apollo, and Viking NASA space programs; Dr. Bonnie L. Cooper, from Oceaneering Space Systems in Houston; *The Moon: Resources, Future Development, and Settlement*, 2nd edition, pp. xl-xli, p. SpringerLink, MV)

I.2.3 Gravity For the development of the first off-world industrial base, a location that provides gravity is preferred to a location in free space. The world's industrial expertise was developed in Earth’s gravity, and it will be much easier to adapt those same industrial processes to lunar gravity (1/6th that of the Earth) than to the microgravity conditions of Earth orbit or another location in free space. For example, the use of wheeled vehicles to transport goods and the separation of materials by gravity-gradient processes can be modified to be used in lunar conditions. The first lunar settlement activities will be unmanned, but humans will follow soon afterwards because of their ability to solve complex problems and to adapt to unforseen situations. The microgravity conditions of orbiting space stations are known to have adverse effects on human physiology, including cardiac decompensation and loss of bone mass. The long-term physiologic effects of 1/6G are as yet unknown. However, the Moon, whose gravity will permit humans to move about with comparable bipedal posture and locomotion that are used on Earth, will be more Earth-like and "user-friendly” than the microgravity conditions of orbiting space stations or the minimal gravity of near-Earth objects.

# Robotic Mission

**Combination of robotic and staffed missions solves best**

**Schrunk et al. 7** – Faculty Member of the Kepler Space Institute (Dr. David G., author and Founder of the Quality of Laws Institute; Madhu Thangavelu, works with the Department Of Aerospace Engineering & School of Architecture at the University of Southern California, lecturer for a graduate seminar in Extreme Environment Habitat Design as part of the USC School of Architecture, former Conductor of the Space Exploration Architectures Concept and Synthesis Studio in the Department of Aerospace and Mechanical Engineering in the School of Engineering at USC, former Space Projects Director for the Calearth Institute, Advisory Board Member for the Los Angeles Section of the American Institute of Aeronautics and Astronautics; Burton L. Sharpe, participant in mission operations planning and execution of the Gemini, Apollo, and Viking NASA space programs; Dr. Bonnie L. Cooper, from Oceaneering Space Systems in Houston; *The Moon: Resources, Future Development, and Settlement*, 2nd edition, p. 105, p. SpringerLink, MV)

A large robotic/crewed rover, termed the "Nomad Explorer", with a range of several thousand kilometers may also be landed during the early stages of development (Appendix S). Such a vehicle can assist in large-scale construction activities that are foreseen throughout the early development of the Moon. By adding several systems that can assist in base assembly activity, such a rover might be able to carry out development work in remote regions that are the ideal locations for observatories and other scientific facilities (see Appendix S).

One of the myths about space activities is that there are two clearly separate philosophies in the design and architecture of lunar base building systems and their operations: purely robotic and purely crew-operated activities. Nothing could be further from the truth. The most effective methods of exploration and construction operations are designed around a synergistic man-machine architecture. Robots work best under highly-predictable conditions, while humans are able to adapt to an unpredictable or constantly-changing environment. Using a human-robot buddy system, it will be possible to exploit the best attributes of both robots and humans. While it is possible to maximize robotic activity during the initial stages of lunar base and utility infrastructure construction, human crew intervention will likely be required for optimum operations (Figure 6.8).

# \*\*Disad Answers

# Obama Good

Massive bipartisan support for moon colonization

Spudis 10 (Paul, Senior Staff Scientist at the Lunar and Planetary Institute, February 9, 2010, “The New Space Race,” <http://www.spudislunarresources.com/Opinion_Editorial/NewSpaceRace.pdf>)

The Vision for Space Exploration (the Vision, or VSE,) announced by President Bush in January 2004, called for returning the Shuttle to flight after the Columbia accident, completion of the International Space Station, a human return to the Moon and eventually voyages to Mars and other destinations. This proposal was subsequently endorsed by two different Congresses (in 2005 and 2008) under the control of different parties; both authorizations passed with large bipartisan majorities. The preface to the founding VSE document states that the new policy is undertaken to serve national “security, economic and scientific interests.”

Subsequent statements and writings elaborated on the purpose of the VSE. Despite concerted efforts to distort its meaning, the goal of lunar return was not to repeat Apollo but to create a long-term, sustained human presence in space by learning to use the material and energy resources of the Moon. The VSE was to be implemented under existing and anticipated budgetary constraints; the guidance given to NASA for this aspect of the mission was to stretch timetables if money became short. The idea was to create this new system with small, incremental, yet cumulative steps.

Moon is perceived as a source of national prestige and job creation – Congress empirically opposed Obama’s decision to scrap Constellation

Popular Mechanics 10 (March 9, 2010, “What Happens If NASA's Constellation Program Dies?,” http://www.popularmechanics.com/science/space/nasa/4343791)

Reporters at the Orlando Sentinel created a stir today by breaking news—citing anonymous sources—that President Barack Obama's budget will not include any funds for hardware for NASA's human space flight program. They say it axes all spending on the Constellation program: a Bush administration plan that tasked NASA with building a launch vehicle alled the Ares I to deliver supplies and staff to the International Space Station. The plan then called for a larger version of the rocket, Ares V, for longer missions including a return to the Moon.

There will certainly be a fight on Capitol Hill as politicians rush to save jobs, decry the lapse in national prestige and play blame games over who lost the moon. (In truth, both the Bush and Obama administration seem to have underfunded the Constellation plan.) Ares may be salvaged, but the program will not likely get the funds it needs to stay on track unless Congress rebels entirely. The Ares I program has already been hampered by redesigns, delays and cost overruns. (NASA has spent about $8 billion on Constellation hardware so far.) Any partial restoration of funds will only keep the program on life support and sap other NASA efforts

Profitability makes lunar colonization politically feasible

Dinkin 4 (Sam, columnist for the Space Review, September 7, 2004, “Colonize the Moon before Mars,” http://www.thespacereview.com/article/221/1)

Politics

The Moon may become a very exciting destination with a substantial GDP. Being there first means that the high ground is already occupied for any future militarization of the Moon.

It’s possible that colonizing the Moon will help muster the political will to colonize Mars. Earthers will be able to see the colony directly with their own eyes. A convincing existence proof will be there for everyone to see that colonization is feasible and profitable.

A lunar colony is a politically feasible off-Earth gene bank increasing the chances that the species will be immortal. The act of leaving the cradle may be the other addition to our chances for immortality.

Moon colonization would provide hundreds of thousands of jobs – Apollo empirically proves

Anderson 11 (Marc, The Daily Cougar,“Space exploration is our future”, 5-2-11, <http://thedailycougar.com/2011/05/02/space-exploration-is-our-future>)

At its peak, the Apollo program directly and indirectly provided jobs for over 375,000 Americans. This was accomplished using less than 4% of the federal budget. Given the scientific advancements and specialization that has occurred since then, a similar program today would likely employ many more workers, with job openings ranging from construction to physics. This would go a long way in making a dent in the nation’s current unemployment rate, and the open ended nature of the current proposal ensures that it will have a sustained positive impact on the economy. In addition, a program of this size and scale will invariably produce technological innovations that have the potential to transform everyday life. Previous NASA developments have included the invention of the integrated circuit and fuel cells.

# OST

**Lunar base doesn’t violate the OST – countries can establish local governments just not national sovereignty**

**Schrunk et al. 7** – Faculty Member of the Kepler Space Institute (Dr. David G., author and Founder of the Quality of Laws Institute; Madhu Thangavelu, works with the Department Of Aerospace Engineering & School of Architecture at the University of Southern California, lecturer for a graduate seminar in Extreme Environment Habitat Design as part of the USC School of Architecture, former Conductor of the Space Exploration Architectures Concept and Synthesis Studio in the Department of Aerospace and Mechanical Engineering in the School of Engineering at USC, former Space Projects Director for the Calearth Institute, Advisory Board Member for the Los Angeles Section of the American Institute of Aeronautics and Astronautics; Burton L. Sharpe, participant in mission operations planning and execution of the Gemini, Apollo, and Viking NASA space programs; Dr. Bonnie L. Cooper, from Oceaneering Space Systems in Houston; *The Moon: Resources, Future Development, and Settlement*, 2nd edition, p. 160, p. SpringerLink, MV)

Since 1979 governments have extended the rule of law into space through the creation of "space laws"1 for the governments and commercial institutions that conduct business in space. Space law is created by national governments under the aegis of international treaties. It applies, for example, to the liability issues that are raised when a satellite decays from orbit and crashes back to Earth. If a national space agency were to establish a base on the Moon, the body of laws of that base would be provided by that space agency’s government. It might seem logical that the central government of the Moon would also be an extension of one of the existing Earthbased governments. However, the existing outer space treaty agreements prohibit a claim of sovereignty over bodies in space, including the Moon, by existing Earth governments, as expressly stated in Article II of the "Outer Space Treaty of 1967": Article II Outer space, including the Moon and other celestial bodies, is not subject to national appropriation by claim of sovereignty, means of use or occupation, or by any other means. Thus, the Outer Space Treaty of 1967 establishes a limit to the level of government that can be transferred from the Earth to the Moon. **Earth-based governments are permitted to establish municipal, or local, governments for their individual lunar bases** but they are not permitted to become the sovereign, or central, government of the Moon (see Figure 9.1). **The United States, for example, can provide the governance for a lunar base that it has constructed on the Moon**, but it would not be allowed to convert that base and adjacent lunar territory into the fifty-first state of the United States.

# \*\*Add-Ons

# Food Shortages

**Moon colonization solves imminent global food shorages by creating closed-cycle ecological systems**

**Siegfried, 03 –** Program Manager of McDonnell Douglas SEI team with system design that featured common Lunar/ Mars systems (W. H., “Space Colonization—Benefits for the World” <http://www.aiaa.org/participate/uploads/acf628b.pdf>)

SPACE COLONIZATION MUST HAVE LOW-WATER, LOW-PESTICIDE PLANT GROWTH AND WASTE AND WATER PURITY CONTROL

Two of the items listed here represent major concerns of most developed nations and are emerging concerns in developing nations. A technological revolution is needed to address food shortages to allow adequate nutrition for our exploding world population in concert with ever-growing water shortages, and a growing realization that our current pesticide methods are polluting our planet. While previous short-duration human space programs have depended on open-loop life support systems, Space Colonization cannot. Development of a closed-cycle bioregenerative controlled ecological life support system (CELSS) would lead to world benefits. Areas of CELSS development are listed in Table 2. Many long-term (and pressing short-term) world problem solutions can be approached by reaching for the stars. For example, Shimizu Corporation is most interested in bio-regenerative systems as a path toward solution of Tokyo’s waste management problems.

# HIV

**Moon colonization solves HIV through a better understanding of immune systems**

**Siegfried, 03 –** Program Manager of McDonnell Douglas SEI team with system design that featured common Lunar/ Mars systems (W. H., “Space Colonization—Benefits for the World” <http://www.aiaa.org/participate/uploads/acf628b.pdf>)

SPACE COLONIZATION MAY LEAD TO HUMAN PHYSIOLOGY, AGING, AND DISEASE AMELIORATION

Many current human problems are the result of failures of the body’s natural immune system. We can diagnose many of these problems and have made great strides in ameliorating the symptoms, but to date, understanding immune system function and enhancement is seminal. Both United States and Russian long-term space missions have induced similar red blood cell and immune system changes. Hematological and immunological changes observed during, or after, space missions have been quite consistent. Decreases in red cell mass were reported in Gemini, Apollo, Skylab and Soyuz, and Mir programs—probably due to diminished rates of erythrocyte production. Space flight at microgravity levels may produce changes in white blood cell morphology and a compromise of the immune system. Skylab studies indicated a decrease in the number of T lymphocytes and some impairment in their function. Certain United States and Russian findings suggest that space flight induces a transient impairment in immune system function at the cellular level. Space flight offers a clinical laboratory unlike any place on Earth that may lead to an improved understanding of the function of the human immune system. Perhaps cures of aging, HIV, and other immune function-related illnesses can result from a comprehensive approach to Space Colonization.

# Asteroids

**Moon colonization allows for detection and deflection of NEO asteroids – solves extinction**

**Schrunk et al. 7** – Faculty Member of the Kepler Space Institute (Dr. David G., author and Founder of the Quality of Laws Institute; Madhu Thangavelu, works with the Department Of Aerospace Engineering & School of Architecture at the University of Southern California, lecturer for a graduate seminar in Extreme Environment Habitat Design as part of the USC School of Architecture, former Conductor of the Space Exploration Architectures Concept and Synthesis Studio in the Department of Aerospace and Mechanical Engineering in the School of Engineering at USC, former Space Projects Director for the Calearth Institute, Advisory Board Member for the Los Angeles Section of the American Institute of Aeronautics and Astronautics; Burton L. Sharpe, participant in mission operations planning and execution of the Gemini, Apollo, and Viking NASA space programs; Dr. Bonnie L. Cooper, from Oceaneering Space Systems in Houston; *The Moon: Resources, Future Development, and Settlement*, 2nd edition, p. 36, p. SpringerLink, MV)

2.3.3.3 Asteroids, comets, and NEOs Telescopes based on the Moon will be able to provide a comprehensive survey of the asteroid belt between Mars and Jupiter and of "near-Earth objects" (NEOs), which are the asteroids and tailless (or "burned-out”) comets that approach or cross Earth’s orbit. A survey of the asteroids and comets in the Kuiper Belt (which extends from the orbit of Neptune, at 30 AU to 50 AU14 from the Sun and contains tens of thousands of celestial bodies) and the Oort Cloud (which extends from 50 AU to three light years from the Sun) will also be possible. The NEOs are of vital interest for two reasons. First, the collision of a onekilometer diameter or larger NEO (of which there are an estimated two thousand) with the Earth could conceivably destroy all human life here. Therefore, it is imperative that the orbits of all the larger NEOs be known with certainty. If it is determined that the Earth is threatened by the pending collision of an asteroid or comet, measures could then be taken to alter the orbit of the threatening object so that a collision can be avoided. The second reason for the interest in NEOs is that they are composed of valuable resources including metals, hydrocarbons, and water. When mining operations of NEOs become possible in the twenty-first century, the Earth and the Moon, for practieal purposes, will have access to a virtually inexhaustible supply of raw materials (see Chapter 10).

**Moon colonization solves asteroids through platforms for early warning and deflection**

**Siegfried, 03 –** Program Manager of McDonnell Douglas SEI team with system design that featured common Lunar/ Mars systems (W. H., “Space Colonization—Benefits for the World” <http://www.aiaa.org/participate/uploads/acf628b.pdf>)

SPACE COLONIZATION CAN HELP PROTECT EARTH FROM ASTEROID AND METEORITE HAZARDS (NEAR-EARTH-OBJECT IMPACTS)

Over the last decade a large mass of evidence has been accumulated indicating that near-Earth-object (NEO) impact events constitute a real hazard to Earth. Congress held hearings on the phenomenon in 1998, and NASA created a small NEO program. Since 1988, a total (as of 7 August 2002) of some many thousand near-Earth objects (of which about 1,000 are larger that 1 km in diameter) have been catalogued that are potentially hazardous to Earth. New discoveries are accelerating. In just the last few months, a 2-mile-wide crater was discovered in Iraq dating from around 2000 to 3000 B.C. This impact was potentially responsible for the decline of several early civilizations. A similar crater was recently discovered in the North Sea. Major events have occurred twice in the last hundred years in remote areas where an object exploded near the Earth’s surface bur did not impact (such as in Russia). If either of these events had occurred over a populated area the death toll would have been enormous. Our armed forces are concerned that an asteroid strike could be interpreted as a nuclear attack, thus triggering retaliation. What higher goals could Space Colonization have than in helping to prevent the destruction of human life and to ensure the future of civilization? The odds of an object 1 km in diameter impacting Earth in this century range between 1 in 1,500 and 1 in 5,000 depending on the assumptions made. A 1-km-diameter meteoroid impact would create a crater 5 miles wide. The death toll would depend on the impact point. A hit at Ground Zero in New York would kill millions of people and Manhattan Island (and much of the surrounding area) would disappear. The resulting disruption to the Earth’s environment would be immeasurable by today’s standards. A concerted Space Colonization impetus could provide platforms for early warning and could, potentially, aid in deflection of threatening objects. NEO detection and deflection is a goal that furthers international cooperation in space and Space Colonization. Many nations can contribute and the multiple dimensions of the challenge would allow participation in many ways—from telescopes for conducting surveys, to studies of lunar and other planet impacts, to journeys to the comets. The Moon is a natural laboratory for the study of impact events. A lunar colony would facilitate such study and could provide a base for defensive action. Lunar and Mars cyclers could be a part of Space Colonization that would provide survey sites and become bases for mining the NEOs as a resource base for space construction. The infrastructure of Space Colonization would serve a similar purpose to the solar system as did that of the United States Interstate Highway system or the flood control and land reclamation in the American West did for the United States development. In short, it would allow civilization to expand into the high frontier.

# Lunar Mining

Conquering the moon first is key to securing the Helium-3 resources

**Lasker 6** (John Lasker, Freelance Journalist-Major contributor for magazines (eg. Wired & Christian Science Monitor), “Race to the Moon for Nuclear Fuel”, <http://www.wired.com/science/space/news/2006/12/72276?currentPage=all>, 12/15)

"After four-and-half-billion years, there should be large amounts of helium-3 on the moon," said Gerald Kulcinski, a professor who leads the Fusion Technology Institute at the University of Wisconsin at Madison. Last year NASA administrator Mike Griffin named Kulcinski to lead a number of committees reporting to NASA's influential NASA Advisory Council, its preeminent civilian leadership arm. The Council is chaired by Apollo 17 astronaut Harrison Hagan "Jack" Schmitt, a leading proponent of mining the moon for helium 3. Schmitt, who holds the distance record for driving a NASA rover on the moon (22 miles through theTaurus-Littrow valley), is also a former U.S. senator (R-New Mexico). The Council was restructured last year with a new mission: implementing President Bush's "Vision for Space Exploration," which targets Mars as its ultimate destination. Other prominent members of the Council include ex-astronaut Neil Armstrong. Schmitt and Kulcinski are longtime friends and academic partners, and are known as helium-3 fusion's biggest promoters. At the Fusion Technology Institute, Kulcinski's team has produced small-scale helium-3 fusion reactions in the basketball-sized fusion device. The reactor produced one milliwatt of power on a continuous basis. While still theoretical, nuclear fusion is touted as a safer, more sustainable way to generate nuclear energy: Fusion plants produce much less radioactive waste, especially if powered by helium-3. But experts say commercial-sized fusion reactors are at least 50 years away. The isotope is extremely rare on Earth but abundant on the moon. Some experts estimate there a millions of tons in lunar soil -- and that a single Space-Shuttle load would power the entire United States for a year. NASA plans to have a permanent moon base by 2024, but America is not the only nation with plans for a moon base. China, India, the European Space Agency, and at least one Russian corporation, Energia, have visions of building manned lunar bases post-2020. Mining the moon for helium-3 has been discussed widely in space circles and international space conferences. Both China and Russia have stated their nations' interest in helium-3. "We will provide the most reliable report on helium-3 to mankind," Ouyang Ziyuan, the chief scientist of China's lunar program, told a Chinese newspaper. "Whoever first conquers the moon will benefit first."

**Establishing a lunar base is key to Helium-3 – it won’t have a negative effect on the environment**

**Bilder 09**

(Richard B. Bilder is Foley & Lardner-Bascom Professor of Law at the University of Wisconsin-Madison, educated at Williams College and Harvard University Law School, was a Fulbright Scholar at Cambridge University in England, served as an attorney in the Office of the Legal Adviser at the U.S. Department of State. “A Legal Regime for the Mining of Helium-3 on the Moon: U.S. Policy Options”, Fordham International Law Journal, Volume 33: issue 2, <http://ir.lawnet.fordham.edu/cgi/viewcontent.cgi?article=2180&context=ilj&sei-redir=1#search=%22moon%20bases%20before%20mining%22>)

How would lunar He-3 be extracted and transported to Earth?29 Because the solar wind components are weakly bound to the lunar regolith, 0 it should be relatively easy to extract them utilizing reasonable extensions of existing technology. In one proposed scenario, once a lunar base is established, robotic lunar mining vehicles fitted with solar heat collectors would: (1) traverse appropriate areas of the Moon's surface-probably, in particular, the lunar maria, or "seas"-scooping up the loose upper layer of the lunar regolith and sizing it into small particles; (2) utilize solar energy to process and heat the collected regolith to the temperatures necessary to release, separate, and collect in a gaseous state the He-3, along with certain other solar-wind elements embedded in the regolith particles; (3) discharge the spent regolith back to the lunar surface; and (4) return with the collected He-3 and other gaseous byproducts to the lunar base. The collected He-3 gas could then be liquified in the lunar cold and transported to Earth, perhaps in remotely-operated shuttles.3 2 Importantly, this type of mining operation could result in the collection not only of He-3 but also significant amounts of hydrogen, oxygen, nitrogen, carbon dioxide, and water, all potentially very useful-indeed, perhaps indispensable-for the maintenance of a lunar base or further outer space activities such as expeditions to Mars or other planets. 33 Since He-3 is believed to comprise only a small proportion of the lunar regolith, it will probably be necessary to process large amounts of lunar regolith in order to obtain the quantities of He-3 necessary to sustain a large-scale terrestrial He-3-based power program. However, the extraction of He-3 and other solar wind components from the lunar soil seems in itself unlikely to have a significant detrimental impact on the lunar environment because the

**Lunar colonization is prerequisite for mining and development**

**Ad Astra 2k2**

(Niklas Jarvstrat has a PhD in the area of Solid Mechanics and Strength of Materials, Master of Science in Applied Physics and Electrical Engineering, is the Associate Professor of Materials technology at University West, and Head of the Department of Technology, “Lunar Colonization: Why, How and When”, Ad Astra, March-April 2002, pg online @ [http://moon-isru.com/information/AdAstra2002.pdf //](http://moon-isru.com/information/AdAstra2002.pdf%20//) sc)

There are many commercial and scientific reasons for establishing a lunar base. Some examples put forward as potentially profitable are the manufacture of raw materials and structures for use in Earth orbit and deep space, training for deep-space missions, energy generation, tourism and entertainment. Scientific reasons include research concerning biology and low-gravity manufacture, research about the Moon itself and the solar system, and the potential to use telescopes to observe deep space in the radio-shadow of the lunar far side. The main motivation for a lunar colony, however, is purely the human instinct to move on and settle new land. The Moon is the ideal place for the first space colony because the psychological step is smaller than for any other location; you can see it from Earth and there will be solid ground under the colonists’ feet. On the other hand, the psychological step of going from the Moon to other locations in space is much smaller than first leaving the Earth gravity. Thus a lunar colony will become a first bridgehead in the peaceful conquest of space — a stepping stone for the expansion of humanity into space. A lunar colony by definition would consist of a large group of people permanently living on the Moon. And a genuine colony would not need materials or technology from Earth. **All necessary goods should be produced from raw lunar materials in factories on the Moo**n. This self-sufficiency is needed for psychological rather than economic reasons. If you knew you would die if the supply ship did not arrive, you would quickly start thinking about following the next one back to Earth. If, on the other hand, you knew that you would be able to survive by your own work, you would take pride in expanding the colony to make room for your children. Thus, even if all space funding from Earth stops for some reason, once the lunar colony can sustain itself, human nature will ensure that it will also grow.

Control of helium-3 resources are key to avoiding resource wars that culminate in human extinction

**Lasker 10** (John Lasker, Freelance Journalist-Major contributor for magazines (eg. Wired & Christian Science Monitor), "Technoir", <http://www.godlikeproductions.com/forum1/message1363174/pg1>, 4/4)

Back in 1998, representatives from Halliburton and Shell met with officials from NASA to talk, practically in secret. At Los Alamos, NM, no less, home to some of the most radical and exotic US military research ever. They met over the prospects of drilling on Mars and the Moon. From that meeting, Halliburton – the oilfields technology and services corporation once ran by Dick Chaney – came away with the idea of building a drill specifically for our two closest celestial bodies. Why build a drill for the Red Planet and the Harvest Moon? And why “No-bid” Halliburton? Which still has a strong connection to one of its greatest beneficiary's, Dick Chaney, of course. Yes, that US Vice President, the one who tricked the world into thinking the US needed to invade Iraq for Weapons of Mass Destruction. Bruce Gagnon, the space weapons expert who runs The Global Network Against Weapons and Nuclear Power in Space, asks a rhetorical question: “Why do you think Halliburton is building a drill for Mars and the Moon?” To monopolize the untold resources Mars and the Moon might offer? The question nearly answers itself, says Gagnon. “There’s going to be a scramble for the moon by the Chinese, the Russians and the Americans. This is real. There’s going to be a conflict over it,” he says. “Who controls the moon is going to be rich by unimaginable amounts.” Perhaps those cards are in the future for mankind. But certainly mankind has history on its side as a warning. History in the form of an Iraqi insurgency. The Iraq insurgency erupted, in part, over Dick Chaney and his neo-con’s plans to privatize all of Iraq’s industries, including oil, which would be taken over by American oil giants such as Shell and Exxon. And while some may think that thousands of US troops and Iraqi civilians died in vain due to the Iraqi insurgency, perhaps their souls won't allow Chaney’s legacy and his offspring to trick us again. Hopefully on this planet and beyond. This doesn’t mean, however, there won’t be a future when man goes to war on the very surface and within the orbits of Mars and the Moon so to control the resources that can be mined and flown back to Earth. In fact, man has already predicted such a conflict will take place. In 1995, in a New York Times op-ed written by science writer Lawrence Joseph, he asks the question, “Will the Moon become the Persian Gulf of the 21st Century? And if the US does not take action in regards to the Moon, the nation could slip behind in the race for control of the global economy, and our destiny beyond.” Coincidently, late in 2009, a US Air Force recruiting commercial claiming their technology isn't “science fiction”, shows US troops tactically moving across a red and barren landscape that looks too much like Mars. Resource wars will either end when the human race becomes extinct, or rage on forever and ever as humans migrate across the universe. A migration Carl Sagan predicted will undoubtedly occur because of man’s unwaivering desire to survive, he theorized. But Sagan also conceded that our collective stupidity might do us in before we even migrate off the planet. The irony is, it might just be a resource war that ends the human race.

# SPS

**Cost of producing and exporting lunar solar energy is extremely low**

**Schrunk et al. 7** – Faculty Member of the Kepler Space Institute (Dr. David G., author and Founder of the Quality of Laws Institute; Madhu Thangavelu, works with the Department Of Aerospace Engineering & School of Architecture at the University of Southern California, lecturer for a graduate seminar in Extreme Environment Habitat Design as part of the USC School of Architecture, former Conductor of the Space Exploration Architectures Concept and Synthesis Studio in the Department of Aerospace and Mechanical Engineering in the School of Engineering at USC, former Space Projects Director for the Calearth Institute, Advisory Board Member for the Los Angeles Section of the American Institute of Aeronautics and Astronautics; Burton L. Sharpe, participant in mission operations planning and execution of the Gemini, Apollo, and Viking NASA space programs; Dr. Bonnie L. Cooper, from Oceaneering Space Systems in Houston; *The Moon: Resources, Future Development, and Settlement*, 2nd edition, p. 407, p. SpringerLink, MV)

If the energy needs of the Earth in the following decades were to be generated on the Moon by photovoltaic (solar) cells that are constructed from lunar materials, and beamed to Earth by microwave energy, the pollution "cost" of electricity production would be negligible. The dollar cost of producing and exporting solar electric power on the Moon at the 20-terawatt level over an 80-year period has been estimated to be as low as U.S.$0.002/kW-hr (Criswell, 1991), which offers a high profit potential. The combined advantages of virtually-zero pollution, low production costs, and steadily-increasing energy markets on the Earth (as well as on the Moon and other locations in space) will assure the success of lunar electric power companies. Lunar electric power will be popular with consumers, environmentalists, and investors alike.

**Solar cell energy will exceed moon’s needs and supply a major proportion of the Earth’s energy requirements**

**Schrunk et al. 7** – Faculty  Member  of  the  Kepler  Space  Institute (Dr. David G., author  and  Founder  of  the  Quality  of  Laws  Institute; Madhu Thangavelu, works with the Department Of Aerospace Engineering & School of Architecture at the University of Southern California, lecturer for a graduate seminar in Extreme Environment Habitat Design as part of the USC School of Architecture, former Conductor of the Space Exploration Architectures Concept and Synthesis Studio in the Department of Aerospace and Mechanical Engineering in the School of Engineering at USC, former Space Projects Director for the Calearth Institute, Advisory Board Member for the Los Angeles Section of the American Institute of Aeronautics and Astronautics; Burton L. Sharpe, participant in mission operations planning and execution of the Gemini, Apollo, and Viking NASA space programs; Dr. Bonnie L. Cooper, from Oceaneering Space Systems in Houston; *The Moon: Resources, Future Development, and Settlement*, 2nd edition, p. xlvi, p. SpringerLink)

lt is possible to generate terawatts of electric power on the Moon from solar cells that are made from lunar—derived materials. The power levels will meet or exceed all of the needs of the lunar civilization, and excess energy will be available for export to other areas in the solar system, including the Earth. The method for transferring energy from one site to another is to convert the electric energy in the lunar power grid into microwave or laser beams, which are both forms of electromagnetic radiation. The beamed energy is then reconverted into electric energy at the receiving site. As explained in Chapter T', nominal advances in beaming technologies are expected to allow terawatts of microwave energy to be delivered from the Moon to the Earth to supply a major proportion of the future energy needs of the Earth. Lasers convert electric energy into coherent beams of light. The laser beam is able to transmit energy over interplanetary distances at high eff1ciencies.8 The Moon will be an excellent site for the operation of lasers that transmit power to other sites in the solar system. This will make it possible to supply the electric power that is needed for exploration and development projects, such as the exploration of the moons of Jupiter and mining operations on near—Earth objects (NEOs). In addition to the transmission of electric energy, the laser beam can be used as the energy source for solar/laser thermal rockets and for augmenting sunlight propulsion for solar sails on interplanetary missions. Laser—augmented solar sails will be the high—performance interplanetary transports of the twenty—first century; they will be able to carry payloads from the Earth—Moon system to Mars, for example, in less than a month. When the lunar industrial base is able to construct lasers for lower transmission. the high levels of electric power in the lunar electric grid will be made available for extensive exploration programs throughout the solar system.

**Solar power on the Moon would be efficient and effective**

**Schrunk et al. 7** – Faculty Member of the Kepler Space Institute (Dr. David G., author and Founder of the Quality of Laws Institute; Madhu Thangavelu, works with the Department Of Aerospace Engineering & School of Architecture at the University of Southern California, lecturer for a graduate seminar in Extreme Environment Habitat Design as part of the USC School of Architecture, former Conductor of the Space Exploration Architectures Concept and Synthesis Studio in the Department of Aerospace and Mechanical Engineering in the School of Engineering at USC, former Space Projects Director for the Calearth Institute, Advisory Board Member for the Los Angeles Section of the American Institute of Aeronautics and Astronautics; Burton L. Sharpe, participant in mission operations planning and execution of the Gemini, Apollo, and Viking NASA space programs; Dr. Bonnie L. Cooper, from Oceaneering Space Systems in Houston; *The Moon: Resources, Future Development, and Settlement*, 2nd edition, pp. 119-120, p. SpringerLink, MV)

7.2.2 Solar electric power The second option for the production of electric power on the Moon is photovoltaic (solar) cells. The Moon has an abundant supply of energy in the form of sunlight; it is constant,1 unobstructed, and virtually inexhaustible, and it can be converted into electric power by solar cells. Solar cells have been a source of electric power for longduration spacecraft for several decades, and they have been used successfully on the Moon. The first stages of a functioning lunar electric power supply will therefore be established by simply transporting "off-the-shelf" solar arrays from the Earth to the base camp on the Moon. One potential drawback with sunlight as a source of energy is that it is not available during the lunar night.2 Consequently, some form of energy storage device,3 such as batteries or flywheels, will be needed to provide power for nighttime lunar operations. The incorporation of energy storage devices substantially increases the mass, cost, and complexity of solar power systems, and for this reason solar cells have been regarded as less attractive as a primary power source for lunar operations than nuclear reactors. Nevertheless, as noted in Chapter 3, the lunar regolith is an abundant supply of materials that can be used as feedstock for the Moon-based manufacture of solar cells. If a number of Earth-made solar arrays were placed on the lunar surface and connected into an electric power grid, the grid would supply the power required for solar cell fabrication equipment to make solar cells from the lunar regolith. Another possibility is a solar-powered mobile robotic factory that "paves" the lunar surface with additional solar cells (see Appendix A). The lunar-made solar cells would be added to the electric grid, and steadily increasing power levels on the Moon would thus be realized. The combination of inexhaustible sunlight that is unobstructed due to the lack of an atmosphere (and only rarely obstructed by the Earth during an eclipse of the Sun) and the local availability of lunar regolith feedstock for the construction of solar arrays has given rise to a substantial body of literature on the subject of generating electrical power on the Moon.

# SETI

**Moon is an ideal site for scientific activities, including SETI**

**Schrunk et al. 7** – Faculty Member of the Kepler Space Institute (Dr. David G., author and Founder of the Quality of Laws Institute; Madhu Thangavelu, works with the Department Of Aerospace Engineering & School of Architecture at the University of Southern California, lecturer for a graduate seminar in Extreme Environment Habitat Design as part of the USC School of Architecture, former Conductor of the Space Exploration Architectures Concept and Synthesis Studio in the Department of Aerospace and Mechanical Engineering in the School of Engineering at USC, former Space Projects Director for the Calearth Institute, Advisory Board Member for the Los Angeles Section of the American Institute of Aeronautics and Astronautics; Burton L. Sharpe, participant in mission operations planning and execution of the Gemini, Apollo, and Viking NASA space programs; Dr. Bonnie L. Cooper, from Oceaneering Space Systems in Houston; *The Moon: Resources, Future Development, and Settlement*, 2nd edition, pp. xli-xlii, p. SpringerLink, MV)

I.2.5 Science opportunities A lunar base will be a superb platform for scientific activities of, on, and from the Moon. For example, the Moon is a much more stable platform for the operation of space telescopes than Earth orbit or free space, and the lunar regolith can be used to shield instruments from ionizing radiation, micrometeorites, and temperature extremes. Interferometry, the high-precision telescopic technique that yields images of very high resolution in optical and longer wavelengths, can be fully exploited on the Moon. The far side of the Moon is also free from all radio interference from the Earth, and is therefore the ideal site in the solar system for the operation of radio telescopes, including the search for extraterrestrial intelligence (SETI). The Moon will eventually become a coordinated astronomical observatory that will greatly expand humankind’s knowledge of the universe. The Moon is also a treasure trove of information on the geologic history of the solar system, and a global program of geologic exploration of mountains, rilles, maria, and lava tubes will commence with the permanent return of humanity to the Moon.

# Water Scarcity

**Moon colony produces desalination tech and boosts living standards worldwide**

**Schrunk et al. 7** – Faculty Member of the Kepler Space Institute (Dr. David G., author and Founder of the Quality of Laws Institute; Madhu Thangavelu, works with the Department Of Aerospace Engineering & School of Architecture at the University of Southern California, lecturer for a graduate seminar in Extreme Environment Habitat Design as part of the USC School of Architecture, former Conductor of the Space Exploration Architectures Concept and Synthesis Studio in the Department of Aerospace and Mechanical Engineering in the School of Engineering at USC, former Space Projects Director for the Calearth Institute, Advisory Board Member for the Los Angeles Section of the American Institute of Aeronautics and Astronautics; Burton L. Sharpe, participant in mission operations planning and execution of the Gemini, Apollo, and Viking NASA space programs; Dr. Bonnie L. Cooper, from Oceaneering Space Systems in Houston; *The Moon: Resources, Future Development, and Settlement*, 2nd edition, p. xliii, p. SpringerLink, MV)

1.2.8 Earth benefits The construction of the first lunar base will provide business opportunities and jobs for people on the Earth in many diverse fields such as aerospace, robotics, and environmental sciences. In addition to their economic benefits, these efforts will yield advances in virtually every science and engineering discipline, thus directly benefiting the quality of life of people on the Earth. The establishment of a Moon-based solar power system will potentially deliver abundant, low-cost, clean solar power to every region of the Earth, thus improving the living standards of all people, especially those in developing nations. Living standards will also increase with the delivery to Earth of high-value elements and materials that are mined from near-Earth objects. Quality of life standards will benefit from the use of excess electric power from space to clean up pollution, desalinate ocean water, and pump the desalinated potable water to arid regions of the world (discussed in Chapter 10). The delivery of energy and materials to the Earth from space has the promise of dramatically reducing the need for mining operations on Earth and the consumption of fossil fuels (that release greenhouse gases) and nuclear fission fuels.

**Water scarcity threatens extinction**

**NASCA 04** [“Water shortages – only a matter of time,” National Association for Scientific and Cultural Appreciation, http://www.nasca.org.uk/Strange\_relics\_/water/water.html]

Water is one of the prime essentials for life as we know it. The plain fact is - no water, no life! This becomes all the more worrying when we realise that the worlds supply of drinkable water will soon diminish quite rapidly. In fact a recent report commissioned by the United Nations has emphasised that by the year 2025 at least 66% of the worlds population will be without an adequate water supply. As a disaster in the making water shortage ranks in the top category. Without water we are finished, and it is thus imperative that we protect the mechanism through which we derive our supply of this life giving fluid. Unfortunately the exact opposite is the case. We are doing incalculable damage to the planets capacity to generate water and this will have far ranging consequences for the not too distant future. The United Nations has warned that burning of fossil fuels is the prime cause of water shortage. While there may be other reasons such as increased solar activity it is clear that this is a situation over which we can exert a great deal of control. If not then the future will be very bleak indeed! Already the warning signs are there. The last year has seen devastating heatwaves in many parts of the world including the USA where the state of Texas experienced its worst drought on record. Elsewhere in the United States forest fires raged out of control, while other regions of the globe experienced drought conditions that were even more severe. Parts of Iran, Afgahnistan, China and other neighbouring countries experienced their worst droughts on record. These conditions also extended throughout many parts of Africa and it is clear that if circumstances remain unchanged we are facing a disaster of epic proportions. Moreover it will be one for which there is no easy answer. The spectre of a world water shortage evokes a truly frightening scenario. In fact the United Nations warns that disputes over water will become the prime source of conflict in the not too distant future. Where these shortages become ever more acute it could forseeably lead to the brink of nuclear conflict. On a lesser scale water, and the price of it, will acquire an importance somewhat like the current value placed on oil. The difference of course is that while oil is not vital for life, water most certainly is! It seems clear then that in future years countries rich in water will enjoy an importance that perhaps they do not have today. In these circumstances power shifts are inevitable, and this will undoubtedly create its own strife and tension. In the long term the implications do not look encouraging. It is a two edged sword. First the shortage of water, and then the increased stresses this will impose upon an already stressed world of politics. It means that answers need to be found immediately. Answers that will both ameliorate the damage to the environment, and also find new sources of water for future consumption. If not, and the problem is left unresolved there will eventually come the day when we shall find ourselves with a nightmare situation for which there will be no obvious answer.

# Astronomy Study

**Moon is the ideal site for astronomy study**

**Schrunk et al. 7** – Faculty Member of the Kepler Space Institute (Dr. David G., author and Founder of the Quality of Laws Institute; Madhu Thangavelu, works with the Department Of Aerospace Engineering & School of Architecture at the University of Southern California, lecturer for a graduate seminar in Extreme Environment Habitat Design as part of the USC School of Architecture, former Conductor of the Space Exploration Architectures Concept and Synthesis Studio in the Department of Aerospace and Mechanical Engineering in the School of Engineering at USC, former Space Projects Director for the Calearth Institute, Advisory Board Member for the Los Angeles Section of the American Institute of Aeronautics and Astronautics; Burton L. Sharpe, participant in mission operations planning and execution of the Gemini, Apollo, and Viking NASA space programs; Dr. Bonnie L. Cooper, from Oceaneering Space Systems in Houston; *The Moon: Resources, Future Development, and Settlement*, 2nd edition, pp. 28-31, p. SpringerLink, MV)

2.3 ASTRONOMY FROM THE MOON The Moon has many advantages as a location for making astronomical observations and measurements, and it is very likely to become humankind’s principal scientific base for astronomy. For this reason alone, the Moon should be given a high priority for human development. From the time of Galileo until the beginning of the twentieth century, the primary means by which astronomers derived knowledge of the universe was by making telescopic observations of the visible light that was emitted or reflected by objects in space. Significant advances in astronomy were made from these telescopic observations; however, the data that were gathered were incomplete because visible light represents only a small fraction of the electromagnetic spectrum from which the universe may be observed. In the twentieth century, technical advances have allowed astronomers to expand their investigations to include the entire range of the electromagnetic spectrum, thus greatly expanding our knowledge of the universe. The divisions and characteristics of the electromagnetic spectrum from which astronomical observations may be made are listed in Table 2.1. 2.3.2 Astronomy from Earth orbit The most effective method for eliminating the deleterious effects of the atmosphere on astronomical observations is to move telescopes into space. Because technological advances have made access to space possible, telescopes dedicated to the observation of every major segment of the electromagnetic spectrum have been placed in Earth orbit, creating whole new bodies of knowledge about the universe. For example, orbiting observatories such as the IRAS and Compton Gamma Ray telescopes have made extensive observations of the sky in the infrared and gammaray segments of the electromagnetic spectrum, respectively, that would not have been possible by means of Earth-based observatories. The Hubble Space Telescope operates primarily in the visible-light region of the electromagnetic spectrum; it has greater resolving power4 than, and its images far exceed the quality of, Earth-based telescopes. However, Earth orbit is again not the ideal location for an observatory. A telescope in Earth orbit is not a completely stable platform for making observations because it moves through, and is displaced by, the Earth—Moon—Sun gravitational fields. Furthermore, it is subject to other disturbing forces such as sunlight and the tenuous atmosphere of the Earth that extends several hundred miles into space. Although the errant motion of orbiting telescopes can be minimized by devices such as gyroscopes or reaction control jets, the resolving power of Earth-orbiting telescopes is compromised by motions induced from destabilizing and corrective forces. Observations of celestial objects are also disrupted whenever the orbit of the telescope causes the Earth to eclipse the object that is being studied. Telescopes in Earth orbit are difficult to maintain and their useful lifetimes are limited, especially if they use consumable materials such as liquid helium5 for their operations. They are also subjected to damage from micrometeorites, thermal stress (moving in and out of the Earth’s shadow), cosmic rays,6 solar flares, and high-energy photons (X-rays and gamma rays). Finally, it is expensive to transport telescopes into space, and the number of telescopes that are available for making observations from space is consequently far fewer than desired. 2.3.3 Moon-based astronomy The Moon is the ideal site in the solar system for the study of astronomy. It has a very low level of seismic activity, and is thus a much more stable platform for astronomy than either Earth-based or Earth-orbiting observatories. Because there is negligible atmosphere on the Moon, the entire electromagnetic spectrum that arrives through interstellar space is available for observation from the Moon without distortion or attenuation. The regolith of the Moon can be used to shield telescope instrumentation from ' temperature extremes, micrometeorites, and ionizing radiation. Shielding can virtually eliminate thermal stresses7 in telescopes, except for those telescopes that directly view the Sun. X-ray and gamma-ray telescopes, which, by definition, are designed to detect high-energy photons, can be placed several meters below the level of the lunar surface to eliminate the background radiation of space. In this manner, below-ground telescopes will "see” only the primary X-ray and gamma-ray radiation which comes from the small solid angle of the sky that contains the object being observed (Figure 2.1); all other primary and secondary8 ionizing radiation will be attenuated by the Moon.9

# Human Evolution

Colonizing space creates an open environment that fosters human evolution beyond present-day materialism and war-mongering

Collins and Autino 08 (Patrick, econ professor-Azabu University, Japan and a Collaborating Researcher with the Institute for Space & Astronautical Science, and Adriano, President of the Space Renaissance International, “What the Growth of a Space Tourism Industry Could Contribute to Employment, Economic Growth, Environmental Protection, Education, Culture and World Peace, “http://www.spacefuture.com/archive/what\_the\_growth\_of\_a\_space\_tourism\_industry\_could\_contribute\_to\_employment\_economic\_growth\_environmental\_protection\_education\_culture\_and\_world\_peace.shtml)

Healthy societies can revitalise themselves. An interesting explanation of the potential of space travel and its offshoots to revitalise human civilisation is expressed in the idea that "The Earth is not sick: she's pregnant" [35]. Although this idea may seem strange at first sight, it is a surprisingly useful analogy for understanding humans' current predicament. According to the "Pregnant Earth" analogy, the darkening prospect before humanity is due to humans' terrestrial civilisation being "pregnant"—and indeed dangerously overdue—with an extra-terrestrial offspring. Once humans' space civilisation is safely born, the current stresses on the mother civilisation will be cured, and the new life may eventually even surpass it's parent. This idea not only illuminates many aspects of humans' present problems described above, it also provides detailed directions for how to solve these problems, and explains convincingly how successfully aiding this birth will lead to a far better condition than before the pregnancy. A young couple may be happy in each other's company, but their joy is increased by the birth of children and life with them, from which many new possibilities arise. Likewise, the birth of humans' coming extra-terrestrial civilisation will lead to a wide range of activities outside our planet's precious ecosystem. This evolution will solve not just our material problems, by making the vast resources of near-Earth space accessible, but it will also help to cure the emptiness of so-called "modern" commercial culture -- including the "dumbing down" by monopolistic media, the falling educational standards, passification by television, obesity, ever-growing consumption of alcohol, decline in public morality, pornography, narcotics, falling social capital, rising divorce rates, and youths' lack of challenge and lack of "dreams". It will do this by raising humans' sights to the stars, and showing that the door to them is unlocked, and has been for decades—we have only to make a small effort to push it open forever. In addition, re-opening a true geographical frontier, with all its challenges, will in itself be of inestimable value for the cultural growth of modern civilisation. The widespread sense that we live in a closed world which is getting more and more crowded will be replaced by an open-ended, optimistic vision of an unlimited future. Access to the cornucopia of space resources that await humans' exploitation can clearly make a unique contribution to this. To the extent that leaders of major industries are motivated by ambition in business competition, they will welcome this opportunity to extend their activities to new fields in the far wider arena of space. However, to the extent that they are motivated by the attempt to achieve monopolistic control and profits, they may try to hinder development in space, even at the cost of preventing its wide benefits, since this could be more profitable to them. Implementing the "Pregnant Earth" agenda can prevent this cultural regression and start a true world-wide Renaissance, an unprecedented ﬂowering of civilisation of which human culture has been in need ever since the inspiration of the Italian Renaissance was followed by a decline into progressive materialism and war-mongering [35].