## 1

#### Strong commercial space catalyzes tech innovation – progress at the margins and spinoff tech change global information networks

Joshua **Hampson 2017**, Security Studies Fellow at the Niskanen Center, 1-25-2017, “The Future of Space Commercialization”, Niskanen Center, https://republicans-science.house.gov/sites/republicans.science.house.gov/files/documents/TheFutureofSpaceCommercializationFinal.pdf

Innovation is generally hard to predict; some new technologies seem to come out of nowhere and others only take off when paired with a new application. It is difficult to predict the future, but **it is reasonable to expect that a growing space economy would open opportunities for technological and organizational innovation**. In terms of technology, **the difficult environment of outer space helps incentivize progress along the margins.** Because each object launched into orbit costs a significant amount of money—at the moment between $27,000 and $43,000 per pound, though that will likely drop in the future —each 19 reduction in payload size saves money or means more can be launched. At the same time, the ability to fit more capability into a smaller satellite opens outer space to actors that previously were priced out of the market. This is one of the reasons why small, affordable satellites are increasingly pursued by companies or organizations that cannot afford to launch larger traditional satellites. These small 20 satellites also provide non-traditional launchers, such as engineering students or prototypers, the opportunity to learn about satellite production and test new technologies before working on a full-sized satellite. **That expansion of developers, experimenters, and testers cannot but help increase innovation opportunities**. **Technological developments from outer space have been applied to terrestrial life since the earliest days of space exploration**. The National Aeronautics and Space Administration (NASA) maintains a website that lists technologies that have spun off from such research projects**. Lightweight** 21 **nanotubes**, useful in protecting astronauts during space exploration, **are now being tested for applications in emergency response gear and electrical insulation**. The need for certainty about the resiliency of materials used in space led to the development of an analytics tool useful across a range of industries. Temper foam, the material used in memory-foam pillows, was developed for NASA for seat covers. **As more companies pursue their own space goals, more innovations will likely come from the commercial sector. Outer space is not just a catalyst for technological development.** Satellite constellations and their unique line-of-sight vantage point **can provide new perspectives to old industries**. Deploying satellites into low-Earth orbit, as Facebook wants to do, can connect large, previously-unreached swathes of 22 humanity to the Internet. **Remote sensing technology could change how whole industries operate, such as crop monitoring, herd management, crisis response, and land evaluation, among others**. 23 While satellites cannot provide all essential information for some of these industries, they can fill in some useful gaps and work as part of a wider system of tools. **Space infrastructure, in helping to change how people connect and perceive Earth, could help spark innovations on the ground as well. These innovations, changes to global networks, and new opportunities could lead to wider economic growth.**

#### Short innovation cycles mean every contract counts

John J. **Klein 19**, Senior Fellow and Strategist at Falcon Research Inc. and adjunct professor at the George Washington University Space Policy Institute, 1-15-2019, "Rethinking Requirements and Risk in the New Space Age," Center for a New American Security, https://www.cnas.org/publications/reports/rethinking-requirements-and-risk-in-the-new-space-age

Unfortunately, these variances in models between the MDAP’s lengthy development cycle and the commercial space sector’s 18-month innovation cycle are a result of stark differences in thinking about requirements and risk. Requirements and risk for MDAPs commonly focus on ensuring critical mission capabilities at a given cost. In contrast, the commercial space sector tends to focus more on providing innovation quickly using economies of scale. The commercial sector understands that time dynamically shapes decisions related to requirements and risk **because of the relatively short innovation cycle**. **In a highly competitive space sector with tight profit margins, those unable to innovate quickly will likely be out of business soon**. Alternatively, space systems with mission assurance requirements – where failures are detrimental to national security and military operations – often drive DoD’s timelines. Program managers of critical national security space systems commonly require additional time to test and verify that satellites can perform missions with a very low probability of failure.

#### Tech innovation solves every existential threat – cumulative extinction events outweigh the aff

Dylan **Matthews 18**. Co-founder of Vox, citing Nick Beckstead @ Rutgers University. 10-26-2018. "How to help people millions of years from now." Vox. https://www.vox.com/future-perfect/2018/10/26/18023366/far-future-effective-altruism-existential-risk-doing-good

If you care about improving human lives, you should overwhelmingly care about those quadrillions of lives rather than the comparatively small number of people alive today. The 7.6 billion people now living, after all, amount to less than 0.003 percent of the population that will live in the **future**. It’s reasonable to suggest that those **quadrillions** of future people have, accordingly, **hundreds of thousands of times** more moral weight than those of us living here **today** do. That’s the basic argument behind Nick Beckstead’s 2013 Rutgers philosophy dissertation, “On the overwhelming importance of shaping the far future.” It’s a glorious mindfuck of a thesis, not least because Beckstead shows very convincingly that this is a conclusion any plausible moral view would reach. It’s not just something that weird utilitarians have to deal with. And Beckstead, to his considerable credit, walks the walk on this. He works at the Open Philanthropy Project on grants relating to the far future and runs a charitable fund for donors who want to prioritize the far future. And arguments from him and others have turned “long-termism” into a very vibrant, important strand of the effective altruism community. But what does prioritizing the far future even mean? The most **literal** thing it could mean is preventing human **extinction**, to ensure that the species persists as long as possible. For the long-term-focused effective altruists I know, that typically means identifying concrete threats to humanity’s continued existence — like unfriendly artificial intelligence, or a pandemic, or global warming/out of control geoengineering — and engaging in activities to prevent that specific eventuality. But in a set of slides he made in 2013, Beckstead makes a compelling case that while that’s certainly **part** of what caring about the far future entails, approaches that address **specific threats** to humanity (which he calls “**targeted**” approaches to the far future) have to **complement** “**broad**” approaches, where instead of trying to **predict** what’s going to kill us all, you just **generally try to keep civilization running as best it can**, so that it is, as a whole, well-equipped to deal with **potential** extinction events in the **future**, not just in 2030 or 2040 but in 3500 or 95000 or even 37 million. In other words, caring about the far future **doesn’t mean just paying attention to low-probability risks of total annihilation**; it also means **acting on pressing needs now**. For example: We’re going to be **better prepared** to prevent extinction from **AI** or a **supervirus** or **global warming** if society as a whole makes **a lot of scientific progress**. And a significant bottleneck there is that the vast majority of humanity doesn’t get high-enough-quality education to engage in scientific research, if they want to, which reduces the odds that we have enough trained scientists to come up with the breakthroughs we need as a civilization to survive and thrive. So maybe one of the **best thing**s we can do for the **far future** is to improve school systems — here and now — to harness the group economist Raj Chetty calls “lost Einsteins” (**potential innovators** who are thwarted by poverty and inequality in rich countries) and, more importantly, the hundreds of millions of kids in developing countries dealing with even worse education systems than those in depressed communities in the rich world. What if living ethically for the far future means living ethically now? Beckstead mentions some other broad, or very broad, ideas (these are all his descriptions): Help make computers faster so that people everywhere can work more efficiently Change intellectual property law so that technological innovation can happen more quickly Advocate for open borders so that people from poorly governed countries can move to better-governed countries and be more productive Meta-research: improve **incentives** and **norms** in **academic work** to better advance human knowledge Improve education Advocate for political party X to make future people have values more like political party X ”If you look at these areas (economic growth and technological progress, access to information, individual capability, social coordination, motives) a lot of everyday good works contribute,” Beckstead writes. “An implication of this is that a lot of everyday good works are good from a broad perspective, even though hardly anyone thinks explicitly in terms of far future standards.” Look at those examples again: It’s just a list of what normal altruistically motivated people, not effective altruism folks, generally do. Charities in the US love talking about the lost opportunities for innovation that poverty creates. Lots of smart people who want to make a difference become scientists, or try to work as teachers or on improving education policy, and lord knows there are plenty of people who become political party operatives out of a conviction that the moral consequences of the party’s platform are good. All of which is to say: Maybe effective altruists aren’t that special, or at least maybe we don’t have access to that many specific and weird conclusions about how best to help the world. If the far future is what matters, and generally trying to make the world work better is among the best ways to help the far future, then effective altruism just becomes plain ol’ do-goodery.\*

## 2

#### Bipartisan anti-china momentum ensures COMPETES passes now and maintains tech leadership, but its narrow

Sayers & Kanapathy 2/15 [ Eric Sayers, a senior vice president at Beacon Global Strategies, and Ivan, a vice president at Beacon Global Strategies, both guest contributors for Foreign Policy magazine “America is Showering China with New Restrctions” https://foreignpolicy.com/2022/02/15/us-china-economic-financial-decoupling-controls-restrictions-sanctions/]

In recent years, Washington’s China policies have expanded rapidly into technology sectors such as telecommunications, semiconductors, data security, and financial services. Growing bipartisan concern about Beijing’s actions and intentions have fueled these developments, with little difference between the Trump and Biden administrations or between the White House and Congress.

The result has been a flurry of new restrictions—including on exports, imports, direct investment, and financial securities—that are fundamentally reshaping the U.S.-China economic relationship. Cross-border business travel between the United States and China, essentially halted for the past two years due to the COVID-19 pandemic, is unlikely to fully rebound because of increased caution and suspicion on both sides of the Pacific.

At the same time as this more defensive approach to economic and technology competition with China has taken root, Congress has also gone on the offensive by moving to appropriate new funding to areas deemed critical to maintaining U.S. competitive advantages in technology, manufacturing, and defense. The current depth and breadth of these approaches were hard to imagine just a few years ago. The corporate sector, besides facing increased government action with respect to doing business with China, must also contend with shifting public opinion and increased investor scrutiny—for example, on human rights issues along companies’ supply lines in China. Looking ahead, 2022 promises a continuation of these trends, which will have far-reaching impacts across multiple business sectors.

In just the last three years, Washington has enacted a raft of policy changes and regulation related to economic competition with China. In early 2018, the Trump administration applied and expanded tariffs on Chinese goods in response to Beijing’s unfair practices, including industrial subsidies, forced technology transfer, and state-sponsored intellectual property theft. Leveraging new laws passed in 2018, Washington expanded the use of export controls in defense technology, imposed stricter vetting of foreign investments in strategic U.S. industries, and restricted the procurement of equipment and services from five Chinese information technology companies, the most prominent of which was Huawei.

The pace and scope of Washington’s policymaking have accelerated in ways not previously considered possible.

In addition, U.S. border agencies shifted their sights from primarily countering terrorists to screening for nontraditional intelligence collectors—for example, journalists, researchers, and businesspeople, who are frequently used by Beijing to gather information—as well as counterfeit goods and goods produced with forced labor. Using presidential emergency powers, the Trump administration also created regimes to remove untrusted contractors from U.S. IT infrastructure projects and block Americans from investing in companies that work with the Chinese military.

To Beijing’s consternation, the Biden administration has signaled its general agreement with all these approaches—and even expanded the investment ban to include Chinese surveillance technology companies. While close U.S. allies in Europe and Asia have been reluctant to impose a similarly broad sweep of policies, the Biden administration has achieved significant rhetorical alignment on defining the challenges posed by Beijing. Under pressure from the Trump administration, several U.S. allies turned away from Huawei, blocked inbound Chinese technology investments, and held up the shipment of critical semiconductor manufacturing equipment to China. However, Europe has yet to follow the United States in imposing real costs on China for its ongoing human rights violations, even though this is a declared point of convergence between the United States and the European Union.

For its part, Congress has passed a slew of China-related bills. Among other actions, legislators have reformed inbound investment screening, forced the delisting of Chinese stocks that do not comply with U.S. accounting practices, expanded requirements for the U.S. Defense Department to list Chinese companies assisting the People’s Liberation Army, strengthened sanctions authorities in response to atrocities in Xinjiang and repression in Hong Kong, presumed that all goods produced in Xinjiang are made with forced labor (and thus banned as imports), and prohibited the federal purchase of Chinese telecommunications equipment.

While Washington mainly focused on defensive measures in recent years, Congress began in 2020 to balance its approach with a more offensive agenda. Efforts to invest in semiconductor manufacturing, accelerate the adoption of 5G telecommunications capabilities, and reorganize the National Science Foundation to focus on increasing U.S competitiveness were all added to the Senate’s U.S. Innovation and Competition Act. The House of Representatives, in turn, recently passed a similar bill—the America COMPETES Act of 2022—so the prospects for final passage of a bipartisan competitiveness bill sometime this spring look strong.

This flurry of activity raises the question of what comes next. Looming issues such as rising inflation, possible new variants of COVID-19, and Russian aggression toward Ukraine could take Washington’s attention away from China policy, at least temporarily. At the same time, there is a strong bipartisan consensus—between the White House and Congress—on China. In particular, there are five policy areas where further action appears imminent this year.

#### Space policy causes immense partisan backlash that wrecks the delicate balance

Dreier 16 [Casey Dreier, Chief Advocate & Senior Space Policy Adviser for The Planetary Society, April 13, 2016. “Does Presidential Intervention Undermine Consensus for NASA?” https://www.planetary.org/blogs/casey-dreier/2016/0413-does-a-strong-president-help-or-hurt-consensus-on-NASA.html]

To see how this happens, I recommend reading the book “[Beyond Ideology](http://smile.amazon.com/Beyond-Ideology-Politics-Principles-Partisanship/dp/0226470768/ref=smi_www_rco2_go_smi_g2243582042?_encoding=UTF8&*Version*=1&*entries*=0&ie=UTF8)” by Frances Lee. The author’s larger premise is that issues having no intrinsic relation to stated party ideology have become increasingly polarized in recent years. This is a function of the two party nature of our political system. If your party coalition wins, the other one loses. It’s [It is] zero-sum. Your party can win in one of two ways: you can make a better pitch to voters by demonstrating the superiority of your agenda; or you can undermine and stymie the agenda of the opposition party, making them unpopular with voters, and pick up the seats that they lose. Since you’re the only other political party, you gain in either scenario. I’m not sure if you’ve noticed, but the “undermine and stymie” approach has been popular for quite some time now in the U.S. Congress. Given this situation, the President and their policies naturally become the symbolic target of the opposition party. Anything promoted by the President effectively induces opposition by association. Lee demonstrates the magnitude of this induced polarization on various types of issues. For highly polarized issues like the role of government in the economy, or social issues, the impact is minimal—the opposition has already been clearly defined and generally falls into clearly defined ideologies of the Republican and Democratic parties. But for issues that do not fit readily into a predefined political ideology—like space—the induced polarization by the President can be significant. In fact, Lee showed that space, science, and technology issues incur the greatest increase in partisanship based on their inclusion in the Presidential agenda. One need only look to at the responses by political operatives of the opposing party to the strong human spaceflight proposals by [Barack Obama in 2010](http://www.shelby.senate.gov/public/index.cfm/mobile/newsreleases?ID=25F3AD2E-802A-23AD-4960-F512B9E205D2), [George W. Bush in 2004](http://www.nbcnews.com/id/3950099/ns/technology_and_science-space/t/bush-sets-new-course-moon-beyond/#.Vw3UMRMrKHo), and [George H.W. Bush in 1989](http://www.nytimes.com/1989/07/21/us/president-calls-for-mars-mission-and-a-moon-base.html) to see this reflected in recent history. This isn’t to say that Presidents can’t have a significant impact on the space program. Clearly they can. But the broad consensus needed for stability after their departure from office may be undermined by the very priority they gave it during their tenure. It what amounts to a mixed blessing for NASA, the U.S. space program does have an unusually strong bipartisan group of politicians who support the program due to NASA centers in a variety of states throughout the union. Berger notes this throughout his article, and it does, in a way, act as force that is resistant to change for good and bad. This mitigates somewhat the pure polarization seen on other science and technology issues. But for a Journey to Mars—a major effort that would, at best, require stability and significant funding over many Presidential administrations—that may not be enough. Perhaps the solution is for the next President to maintain a light touch on space. Maybe they should speak softly through the budget process, and avoid the Kennedyesque speeches and declarations to Congress that induce the types of partisanship we so dearly need to avoid.

#### Chinese tech leadership causes nuke war

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Rather, we should think more broadly about how new technology might affect global politics, and, for this, it is helpful to turn to scholarly international relations theory. The dominant theory of the causes of war in the academy is the “bargaining model of war.” This theory identifies rapid shifts in the balance of power as a primary cause of conflict.

International politics often presents states with conflicts that they can settle through peaceful bargaining, but when bargaining breaks down, war results. Shifts in the balance of power are problematic because they undermine effective bargaining. After all, why agree to a deal today if your bargaining position will be stronger tomorrow? And, a clear understanding of the military balance of power can contribute to peace. (Why start a war you are likely to lose?) But shifts in the balance of power muddy understandings of which states have the advantage.

You may see where this is going. New technologies threaten to create potentially destabilizing shifts in the balance of power.

For decades, stability in Europe and Asia has been supported by US military power. In recent years, however, the balance of power in Asia has begun to shift, as China has increased its military capabilities. Already, Beijing has become more assertive in the region, claiming contested territory in the South China Sea. And the results of Russia’s military modernization have been on full display in its ongoing intervention in Ukraine.

Moreover, China may have the lead over the United States in emerging technologies that could be decisive for the future of military acquisitions and warfare, including 3D printing, hypersonic missiles, quantum computing, 5G wireless connectivity, and artificial intelligence (AI). And Russian President Vladimir Putin is building new unmanned vehicles while ominously declaring, “Whoever leads in AI will rule the world.”

If China or Russia are able to incorporate new technologies into their militaries before the United States, then this could lead to the kind of rapid shift in the balance of power that often causes war.

If Beijing believes emerging technologies provide it with a newfound, local military advantage over the United States, for example, it may be more willing than previously to initiate conflict over Taiwan. And if Putin thinks new tech has strengthened his hand, he may be more tempted to launch a Ukraine-style invasion of a NATO member.

Either scenario could bring these nuclear powers into direct conflict with the United States, and once nuclear armed states are at war, there is an inherent risk of nuclear conflict through limited nuclear war strategies, nuclear brinkmanship, or simple accident or inadvertent escalation.

This framing of the problem leads to a different set of policy implications. The concern is not simply technologies that threaten to undermine nuclear second-strike capabilities directly, but, rather, any technologies that can result in a meaningful shift in the broader balance of power. And the solution is not to preserve second-strike capabilities, but to preserve prevailing power balances more broadly.

## 3

#### We will concede lunar dust makes moon basing impossible:

#### Chinese will achieve moon dominance now – that causes space control, PGS, democratic backsliding, and Taiwan invasion

Fisher 15 Testimony of Richard D. Fisher Jr. before the U.S.-China Economic and Security Review Commission, Hearing on China Space and Counter-Space Issues; Senior Fellow on Asian Military Affairs at the International Assessment and Strategy Center. ; President of Pacific Strategies, Inc. “China’s Military Ambitions in Space and America’s Response” 2/18/15 http://www.uscc.gov/sites/default/files/Fisher\_Testimony\_2.18.15.pdf

Introduction Mr. Chairman, distinguished members of the United States-China Economic Security Review Commission, it is a privilege to present testimony concerning China’s strategic and military ambitions in outer space. While China pursues a growing commercial, deep space and space science agenda, the foundation of its space program remains the pursuit of military advantage for the People’s Liberation Army (PLA). China’s space endeavors are subordinate to the PLA. While the PLA does not offer public briefings or budget information about its space combat programs, there is a considerable body of “secondary” literature presumably based on strategy or doctrine, which has long appeared to justify the development of a PLA capability to wage war in space. Occasionally, however, statements by top officials appear. According to Chinese press reports on 5 December 2012, newly elevated Chinese Communist Party (CCP) Secretary General Xi Jinping gave a speech to a Second Artillery (SA) audience. Almost nothing of the content of that speech was reported, until the late 2014 surfacing of a journal article by SA veteran General Sun Mingfu. In that speech, General Sun said that “President Xi made clear the need ‘to enhance the build-up of ground-based anti-satellite combat force to ensure the timely formation of combat capability’, and to “accelerate the development of strategic anti-missile capability.” This article quickly disappeared off of its hosting web page and a famous Chinese military-technical blog “KKTT” that gave it prominence soon disappeared as well. On 14 April 2014, Xi was reported to have given a speech before a PLA Air Force (PLAAF) audience in which he called for an “integrated air and space capability.” This phrase was also used by former PLAAF commander General Xu Qiliang during the 2009 PLAAF 60th anniversary, and by military academic commentators which listed space weapons the PLA should acquire. Perhaps Xi Jinping also gave the PLAAF specific space warfare preparation guidance. While there has been some discussion in the PLA of a new service or a “Space Force,” today it appears that current services of the PLA are being encouraged to develop individual space combat capabilities. Based on an accumulation of data, it is possible to conclude that the PLA’s apparent goal is to exercise denial and then dominance in Low Earth Orbit (LEO) and then to extend control into the Earth-Moon system. Since the early 1990s China has developed four, possibly five, attack capable space-combat systems. China may be the only country developing such variety of space weapons to include: ground-based and air-launched counter-space weapons; unmanned space combat and Earth-attack platforms; and dual-use manned platforms. It is also important to consider that the PLA’s projection into space is an integral part of China’s development of military capabilities to dominate the Asia-Pacific region, and then to project power globally into the 2020s and 2030s. The PLA requires increasing space control in order to 1 assure that space-based Information Surveillance Reconnaissance (ISR) systems can provide targeting and other and support for missile, air, naval and ground forces, future intercontinental Prompt Global Strike (PSG) forces, and for the forces of client/partner states. Sustaining superiority in LEO, in turn, will require control of the “High Ground,” or the Moon and Deep Space. The Chinese Communist Party (CCP) leadership’s intertwined pursuit of global military power and dominant space power has three main motivations: 1) to help sustain the power position of the CCP; 2) to aid the CCP’s pursuit of economic-political dominance in key regions to best assure resource/commercial access; and, 3) to eventually displace the United States from its position of global leadership. Space power will also be used to support new Chinese-led or promoted anti-U.S./anti-democratic coalitions as it will be used to crush democratic threats to its rule, beginning with the democracy on Taiwan. As with the former Soviet Union, China’s pursuit of regional and then global military power is not rooted in an existential threat, but in the CCP’s fears for its power position. This requires a CCP-led “rejuvenation” of China, entailing mobilization for greater power, ever more control over its own people, and then increasing control over others. Another result is China’s choice to be hostile to Western rules or concepts that may constrain China’s power. This justifies an essential Chinese rejection of American or Western conceptions of transparency and restraint, or verifiable weapons control in space which might constrain its power. This mirrors the CCP/PLA’s repeated refusal of U.S. requests to consider real nuclear weapons transparency and control, transparency over its nuclear and missile exports, and --from many of its neighbors and Washington -- fair settlement of territorial disputes which threaten war. The latter, especially in the South China Sea, is instructive. As it has gained military power in the South China Sea, China has sought to change the strategic environment and dictate new rules to increase its security at the expense of others. Once it gains commanding strength and position in space, will China do the same? For the United States, cooperation with China in space may yield some benefits, but it likely will have little impact on the direction and severity of terrestrial conflicts which will dominate relations with China. One can see the value of meeting with Chinese space officials, especially higher CCP and PLA leaders, to advance concerns over their actions in space and to promote transparency. But at this juncture, before China has achieved levels of “space dominance”, it is crucial to link any real cooperation with China to its behavior in space and elsewhere which threatens U.S. security. Furthermore, allowing China increasing access to U.S. space technology, space corporations, or government institutions at this time presents two risks. First it could encourage China to advance an illusion of cooperation with the U.S. and the West while differences on Earth become sharper. This could become useful for Beijing to deflect criticism on other issues, or even to obtain leverage over U.S. options and actions. Second, as has been proven repeatedly, China will exploit any new access for espionage gains to strengthen its own space and military sectors. 2 China’s increasing space power, however, like its growing economic and political power, cannot be “contained.” Russia appears ready to greatly expand space and military cooperation with China as part of a larger strategic alignment, while the European Space Agency is edging toward greater cooperation with China. These attractions may only increase if China has the only LEO manned space station in the mid-2020s. Already a top commercial space service and technology provider, China will use its gathering space diplomacy tools to aid its pursuit of economic, political and military influence in critical regions like Africa and Latin America. The challenge for the United States is to maintain the means to compete with China in space both in military and non-military endeavors. China’s potential for developing new space combat systems means the U.S. must be able to rapidly develop appropriate deterrent capabilities. There should also be a more developed U.S. capability to rapidly repopulate satellite systems taken down by PLA attacks, and there should be more terrestrial or airborne systems to compensate for lost navigation, communication and surveillance satellites. In addition, as the PLA moves substantially out to deep space, the Moon, or to the Lagrangian Points, it will be necessary for the U.S. to consider a compensating presence that is affordable, attractive to a coalition of democracies, and helps to deter China from seeking strategic advantage. Strategic priorities would suggest that a presence on or near the Moon is of greater importance than going to Mars. A multinational government-private presence on the Moon is one option, as is the likely less expensive option of a far cis-lunar presence to further develop manned deep space capabilities. As was the case with the former Soviet Union, relative peace on Earth or in space will not truly be possible until China evolves beyond its Leninist dictatorship. In its final years, the Soviet Union was on the cusp of deploying multiple space combat systems despite years of U.S.-Soviet space diplomacy. Real space cooperation between Russia the West became possible only after the fall of the Soviet Union, and may again become threatened by Russia’s slide into authoritarian aggression. Substantive cooperation with China in space offers no assurance that China will change its threatening behaviors on Earth or in space, but does create opportunities for China to exploit U.S. and Western space technology to gain potential military advantages. The following will address questions posed by the U.S.-China Economic and Security Review Commission. But first, it is necessary to reflect on the relationship between China’s pursuit of space power and its military buildup for regional dominance and global projection. Space Power and China’s Military Expansion During the 1950s and 1960s, Mao Zedong sought to quickly exploit generous assistance from the Soviet Union, and the insights of U.S.-trained engineers like Qian Xuesen, to complete the early nuclear missiles to deter feared U.S. and Soviet nuclear strikes. His 651 Program succeeded in launching the Dong Fang Hong-1 satellite in 1970, while also aiding the development of larger missiles. But Mao’s efforts to build broader space power, such as the 640 Program to build strategic missile defenses, and his early 741 Program manned space ship, faltered largely due to his destructive politics. Mao, nevertheless, realized that China required the technology and 3 prestige of space in order to increase its ability to compete with Moscow and Washington on the global stage. Fears for political survival and ambitions for global leadership remain the basis for China’s current surge for global military power and space power. The greatest impetus for the most recent phase of PLA modernization and buildup was the shock of the 1989 Tiananmen rebellion -- the only time the Party’s power position was actually threatened by popular, though unorganized, reformist and democratic demands. In addition to ruthlessly crushing any potential for democratic dissent, the transitioning CCP leadership of Deng Xiaoping to Jiang Zemin decided to begin the broad military and space modernization and buildup we see today. At first focused on coercing Taiwan and then securing control over disputed territories, the early 1990s saw the start of many PLA programs increasing its Anti-Access/Area Denial (A2AD) capability targeted on the “First Island Chain.” These include the Chengdu Aircraft Corporation’s 4th generation J-10 fighter and its J-20 5th generation fighter, and the large Xian Aircraft Corporation Y-20 heavy jet transport. China’s aircraft carrier ambitions predate Tiananmen but second generation nuclear attack and ballistic submarine programs received greater emphasis. This period also saw the beginnings of the PLA’s first “reconnaissance strike complex” of terminally guided medium-range missiles, and the ability to target them with high resolution surveillance, navigation and communication satellites. In addition, the PLA started developing its second anti-ballistic missile (ABM) system along with a new anti-satellite (ASAT) system, tested successfully on 11 January 2007. The early 1990s also saw the beginning of China’s second manned space program, code named the 921 Program. With substantial inputs from Russian space companies the 921-1 or Shenzhou spaceship made its first unmanned flight in 1999. While the PLA’s General Armaments Department (GAD) took control of the manned space program in 1998, we did not learn of this until former CCP Chairman Jiang Zemin congratulated former GAD Director and then Defense Minister Cao Gangchuan as “chief director of the manned space program” after the April 2002 landing of Shenzhou-3. The dual-use nature of China’s manned space program was starkly demonstrated by the first manned Shenzhou-5 mission in 2005, when Astronaut Yang Liwei shared his ship with two optical surveillance cameras. A little over a year later in December 2004, the current phase of PLA modernization and space development was signaled by the “New Historic Missions” enunciated by Chairman Hu Jintao, in which the PLA started preparing to defend the CCP’s global interest, in addition to its regional ambitions. Over the following decade, better combat systems for regional dominance emerged, with new aircraft carriers, amphibious projection ships, and new large airborne projection transports designed to enable the PLA to defend more distant CCP interests. Since the late 1990s, space systems have played an increasing role in the PLA’s “Informationalization” strategy, providing commanders with higher resolution optical and radar satellite surveillance, new space electronic intelligence tools, space-based data relay and new infrared-multispectral early warning satellites. Space information systems give PLA platforms global navigation and communication capabilities, as they help to target increasing numbers of precision-guided missiles and bombs. These capabilities are essential to the fulfillment of 4 Chinese objectives which include the “recovery” of Taiwan, consolidating military control over disputed regions in the East and South China Seas, and undermining and eclipsing American-led alliance relationships in Asia. China’s space ISR power will also be used to help military allies and clients. Having helped North Korea, Iran and Pakistan to become current or imminent nuclear missile powers, it makes sense that China would directly or indirectly assist their future space ISR requirements. In a scene that could be repeated elsewhere, today China is pushing to help rearm Argentina, which has already agreed to lease a critical space tracking and control facility to China. A Chinese armed Argentina with access to Chinese space ISR may be able to better threaten war to take the Falkland Islands. Even if Britain settles for a negotiated transfer, China will gain regional prestige for having “defeated” a Western power, further reducing U.S. influence in Latin America. By the 2020s and the 2030s, the PLA’s development of space projection and combat capabilities could become the leading element of the next phase of PLA modernization. Networks of larger more capable/survivable surveillance satellites, combined with networks of smaller more survivable satellites, will provide more secure navigation, communication, and targeting for larger numbers of power projection platforms such as nuclear powered aircraft carriers, large amphibious projection ships, very large military transport aircraft, and a next generation of export weapon systems. These could include a new generation of “Prompt Global Strike” systems, enabled by high data rate optical data-relay satellites. These could be joined by more ground-based or air-launched ASAT systems, new LEO-based laser or kinetic armed space combat platforms, and Space-to-Earth combat platforms. China’s political-diplomatic and military space power will be increased by the completion of a dual-use manned space station in the early 2020s and perhaps new small and large reusable dualuse unmanned and manned space planes. If the ISS winds down in the early 2020s it is increasingly apparent that Russia may seek significant space cooperation with China, replacing its space relationship with Washington. By the early 2030s, the new date for the completion of its 100-ton-plus payload heavy SLV, China may be taking its first steps on the Moon and building toward permanent bases by the 2050s or 2060s. China’s push for the Moon is prompted by a quest for prestige and to control areas that may yield potential economic/resource benefits. The PLA can also be expected to seek military benefits from its Moon presence. Should China’s emerging space and terrestrial power increasingly constrain U.S. power, then Europe and India may be tempted to increasingly “bandwagon” with China, especially in space. Question 1: Provide a net assessment of U.S. and Chinese space capabilities in a 2015 conflict scenario. How does this assessment change, if at all, for a 2030 scenario? While it is possible to better assess near term Chinese military-space capabilities due to an accumulation of Western and Chinese disclosures, assessing potential capabilities in the next fifteen years requires making estimates that could over- or under-estimate Chinese capabilities. As the PLA does not reveal its military-space intentions in public documents it is necessary to consider a body of “grey” data that offers indications of potential capability intent. This estimate 5 projects from current indicators but does not review potential major technology breakthroughs that might accelerate development projections. 2015 Conflict Scenario: The main difference in assessments of U.S. and Chinese military space capabilities in the near-term is that China has a gathering “active” space combat potential and is beginning to build “passive” mil-space capabilities, whereas it is not possible to determine whether the U.S.is developing the former, though it is interested in the latter. The U.S. is credited with over 500 military and civil satellites. While China has about 120 satellites, about 75 are used exclusively or largely by the PLA, and the PLA has access to more of China’s “civil” communication satellites. In 2015 China may be capable of strikes against scores of U.S. satellites in LEO, Geostationary Earth Orbits (GEO, 35,000km), or Medium Earth Orbits (MEO, 2,000-35,000km). In 2015 the U.S. may only be capable of limited retaliation against Chinese satellites in LEO, and would be stressed to repopulate critical U.S. satellite networks. Space ISR: By 2015 the PLA’s surveillance satellite network could comprise about 40 optical surveillance satellites, 10 radar satellites, 8 possible early warning satellites, and about 21 electronic intelligence (ELINT) counter-naval satellites. In addition there may be 4 weather satellites that assist global missile targeting. All of these use LEO polar orbits so they are more vulnerable to ground or air-launched ASATs. However, there are indications that the PLA may be developing much larger surveillance satellites, with the potential they may be placed in much higher orbits. By 2015 the PLA may have four to five dedicated communication satellites in GEO, and 16 to 20 navigation satellites in GEO or MEO. The Beidou/Compass navigation satellite system has a secondary global communication capability at a text-message level. In addition the PLA will control three TianLan data-relay satellites in GEO, intended primarily to support tracking and command of manned platforms, but could also support global military operations. Earth-based global tracking and control networks crucial to maintaining China’s space architecture include four large Yuan Wang tracking and control ships. In China there are eight tracking and control facilities and it has or will gain access to facilities in Argentina, Chile, French Guiana, Kenya, Namibia and Pakistan. In September 2013 and November 2014 China launched its Kuaizhou, a China Aerospace Science and Industry Corporation (CASIC) solid-fueled mobile SLV based on the DF-21 medium range ballistic missile (MRBM) or a larger intermediate range ballistic missile (IRBM). The model of a potential export version of this missile was displayed at the November 2014 Zhuhai Airshow. Also revealed were six new microsatellites for surveillance and communication missions for this SLV. This could be the beginning of China’s “Operationally Responsive Space” initiative to be able to repopulate satellite networks. The China Aerospace Science and Technology Corporation’s (CASC) liquid fueled small Long March-6 SLV may also be slated for this mission. Since the mid-1990s China has also invested heavily in micro and nanosatellites, detailing development work mainly to Chinese aerospace universities including the Harbin Institute of Technology, Tsinghua University, Nanjing University of Aeronautics and Aerospace, and the National University of Defense Technology. China has the capability today to rapidly develop 6 constellations of micro and nanosats that can be used to replace attacked satellites, or to succeed them with more secure but distributed satellite networks. A recent Chinese report notes that the Province of Jilin plans to loft China’s first “civil” network of four imaging microsatellites. In contrast, the more varied U.S. surveillance satellite network makes extensive use of larger systems placed in higher orbit systems in order to reduce their vulnerability. But this is now changing as the PLA develops ASATs able to attack higher orbits. Attempts to build a larger number of smaller surveillance satellites like the SBIRS series faltered due to complexity and expense. As a consequence, the U.S. has shown greater interest in even less expensive and smaller satellites like the U.S. Air Force’s TacSat or Operationally Responsive Space-1 (ORS-1). Ground Based Lasers: On 28 September 2006, the U.S. publication Defense News first reported that China had fired a “high power laser at a U.S. spy satellite” as a “test of the Chinese ability to blind the spacecraft.” While U.S. officials tried to downplay the test, China’s intent to military “blind” enemy satellites was confirmed in the December 2013 issue of Chinese Optics in an article “Development of Space Based Laser Weapons” written by three engineers from the Changchun Institute of Optics, Fine Mechanics and Physics. They stated, “In 2005, we have successfully conducted a satellite blinding experiment using a 50-100 KW capacity mounted laser gun in Xinjiang province. The target was a low orbit satellite with a tilt distance of 600 km. Over the following eight years it is likely that China has improved its ground-based ASAT lasers. In 1997 the U.S. Mid-Infrared Advanced Chemical Laser (MIRCL) demonstrated its ability to “dazzle” a LEO satellite but the U.S. is not known to have developed ground-based lasers capable of conducting ASAT missions. As far as is known publicly, the U.S. Air Force YAL-1 chemical airborne laser was not tested against LEO targets during its 2007 to 2011 testing program. Ground-Launched ASAT: The PLA’s combined ASAT and ABM program that gained momentum in the early 1990s has resulted in at least two known ground-launched ASAT systems. Derived from the CASIC KT-1 mobile solid/liquid fuel SLV, the SC-19 ASAT began a test program in 2005 that resulted in its first successful destruction of a FY-1C weather satellite at 864km in January 2007. Subsequent SC-19 tests on 11 January 2010 and 23 July 2014 were judged as ASAT tests even though they destroyed lower altitude missiles. It is possible that the PLA may now have an inventory of scores of SC-19 ASAT/ABM missiles. On 13 May 2013, China tested its larger DN-2 ASAT. Chinese sources claim it reached an altitude of 10,000km, while U.S. sources noted it nearly reached GEO. It is possible that both the SC-19 and DN-2 have been put into production although this cannot be confirmed. The DN-2 could be based on a version of the CASC DF-31 ICBM or the CASIC Kuaizhou mobile SLV. Mobility for the SC-19 and DN-2 means it can be moved to multiple locations to facilitate surprise ASAT strikes. On 20 February 2008, a U.S. Navy modified SM-3 surface-to-air missile destroyed a decaying U.S. reconnaissance satellite at an altitude of 247km. Believed to have been a counterdemonstration for China, the U.S. is not known to have put into production a ground launched 7 ASAT. The SM-3 or U.S. Army THAAD could form the basis for a LEO ASAT but no such program has been reported. Air Launched ASAT: The April 2009 issue of the journal of the Shenyang Aircraft Design and Research Institute, or 601 Institute, contained an article titled, “The Technologies of the Fighter Platform Launching Trajectory Missile Attack Satellite.” This article concludes that it is “feasible and reasonable” that an aircraft be used to attack a satellite “in the present stage.” This suggests that SAC has already adapted, or may be in the process of adapting its J-11 fighter, a clone of the Russian Sukhoi Su-27, to perform ASAT missions to attack LEO satellites. An ASAT-capable J-11 fighter would offer greater tactical flexibility and could be concealed at numerous PLA Air Force airbases. While there are no open reports of a Chinese airborne ASAT test, it is conceivable that China has developed such a system over the last six years. The Reagan Administration in 1988 cancelled the ASM-135, the second U.S. air-launched ASAT program, due to cost, technical and Congressional opposition challenges. It was tested successfully once against a satellite target in September 1985. In 2015 the Defense Advanced Research Program Agency (DARPA) reportedly will start testing its Airborne Launch Assist Space Access (ALASA) F-15 fighter-launched small SLV, which could form the basis for an airlaunched ASAT. Co-Orbital Interceptors: China apparently has developed satellites capable of co-orbital interceptions of other satellites for benign or hostile missions. On 19 July 2013, China launched three satellites, two of which, the Shiyan-7 (SY-7, Experiment-7) and Chuangxin-3 (CX-3), interacted with the Shijian-7 (SJ-7, Practice-7) launched in 2005. The SY-7 is believed to have manipulator arm that could perform maintenance or intelligence missions, or attack missions which disable without creating a debris cloud. While classified as an “experimental” system, this satellite could also be developed into a more capable co-orbital close-up surveillance or interceptor platform. In late 2010 or early 2011, China is believed to have conducted a sub orbital test of its Shenlong small space plane, a technology test bed which could also be developed into a multi-mission dual use platform similar to the U.S. Boeing X-37B small space plane. A Russian source confirmed to this analyst that the Shenlong was tested, but there is no open reporting that an operational version has been produced. Larger manned and unmanned Chinese space planes are very likely under development. U.S. experience with co-orbital inspection capabilities may extend to the Prowler satellite launched in 1990, and more recently to two XXS and two MITx satellites launched in the last decade. However, it is not known publicly whether these have been developed into operational system; most likely not. The U.S. Air Force has also built three 5-ton Boeing X-37A/B small reusable space planes which are capable of deploying micro or nanosatellites, or carrying passive or active military payloads. They have conducted three lengthy but classified missions. While small, the X-37B would be vulnerable to ground-based PLA interception systems. Dual Use Manned Platforms: While the U.S. never launched a manned military space platform, the Soviets lofted military Salyut small space stations in the 1970s, and in the late 8 1980s tried to launch an unmanned space combat platform and were considering turning their Mir space station into a base for space bombers. Perhaps influenced by this Soviet example, China could be planning for a range of military uses for its manned space platforms. The September 2008 Shenzhou 7 mission, remembered most for China’s first manned spacewalk, also saw its launching of a micro-satellite shortly before passing about 45km from the International Space Station. As far as can be determined, China provided no warning of its intention. Also, despite the potential for an accident which may have threatened the lives of two Russian and one U.S. astronaut onboard, there has been no public response to this incident from U.S. or Russian officials. Was this an early Chinese attempt to simulate space docking, or was it a simulated co-orbital attack against the ISS? Does this incident, and the previous use of the Shenzhou to carry military payloads, mean that China’s manned space platforms will be equipped to perform “active” military missions? If the PLA could equip the Shenzhou orbital module to launch the BX-1 micosatellite, could it also modify the orbital module to carry intercept sensors and kinetic kill vehicles (KKVs)? The larger Tiangong has payload bays which have used Earth observation cameras. Might China consider modifying Tiangong to be perform ASAT or orbital Earth bombing missions? U.S. programs to develop manned military-mission space platforms like the Dyna Soar space plane and the Manned Orbiting Laboratory (MOL) were cancelled by the end of the 1960s in favor of unmanned satellites for military-space missions. While both the Soviet Union and China feared that the U.S. Space Shuttle would be modified for combat missions, there is no open reporting this was done. However, the Shuttle was used on numerous occasions to deploy military payloads but was retired in July 2011. The U.S. National Air and Space Administration’s (NASA) Boeing Orion manned capsule made its first unmanned test on 5 December 2014 but may not make a manned test until 2021. The private SpaceX Corporation Dragon manned capsule may not fly until 2017 or 2018. There is no reported consideration that either may be modified for active military missions 2030 Conflict Scenarios: China’s Potential Capabilities Provided the CCP survives to expand its power, by 2030 China will require increasing space power in order to support its expanding global projection forces on Earth, and because military competition in space will have become more intense, largely due to China’s continued development of space combat capabilities. It is likely that an expansion in the number of space combat programs by individual services will have prompted the PLA to create a unique “Space Force.” While China’s first manned forays to the Moon may not occur until soon after 2030, plans will have advanced significantly toward the creation of a permanent Moon Base by 2050 or sooner. A proliferation of its space combat systems around the Earth will push China to seek increasing advantage, setting the stage for its strategic-military development of the Moon. As mentioned earlier, absent a fundamental change in the character of the CCP or its evolution in a pluralistic direction, China is unlikely to accept negotiated limits on its expanding space power. Furthermore, Russia, provided its authoritarian anti-Western character increases, may have to seek a far more deeper military relationship with China, assuming Beijing’s hunger for Russian resources can be satisfied short of taking its territory. 9 Space technology may become Russia strong suit in its military relationship with China, provided it can sustain Chinese funds to insure its space sector remains competitive. Since early in the last decade Russia has been considering its post-ISS future in space, considering alternate space station designs, Moon and initial Mars missions, manned architectures and next generation spaceships, perhaps to include nuclear propulsion. While China’s preference may be to develop its national space capabilities, as it has done repeatedly regarding weapons technology it could begin broad space technology cooperation with Russia to accelerate next generation capabilities. China’s Future Close-to-Earth Mil-Space Capabilities If current trends discernable today continue, it is likely that China will have multiple options to distribute its critical satellite service requirements to larger and deeper space platforms as well as to clouds of micro and nanosats. As it does so, it should be expected that China will develop means to both attack and defend its evolving satellite networks. Large satellites may include 5-ton and 10-ton systems able to reside in deeper space which may active and passive defenses. Chinese academic engineering literature shows some familiarity with large membrane space mirrors, for example as used by the U.S. Defense Advanced Research Projects Agency’s (DARPA) Membrane Optical Imager for Realtime Exploitation (MOIRE). Membrane mirrors can be expected to enable large deep space surveillance satellites, as envisioned by MOIRE, or to make micro and nano-surveillance satellites even more powerful. Future Chinese micro and nanosats might be able to “cleave” or double or quadruple in the event of an attack. A previously mentioned Chinese report notes that the Province of Jilin plans to have a constellation of 137 small satellites by 2030, noting this may enable a revisit time of 10 minutes. The PLA or “civil” authorities in China could be hosting scores of satellite “cloud” constellations by 2030. The potential for China to develop counters to small satellites should also be considered. Already, China is testing and considering other novel concepts for capturing/disabling small UAVs with airborne nets. Conceivably, large nets could be used to coorbitally intercept small satellite clouds. A potential Chinese leap-frog technology advance was briefed at the 2014 International Astronautical Congress (IAC) in Toronto attended by this analyst. A Chinese engineer briefed a paper proposing that China’s next generation data relay satellites use optical or laser data links, which could phenomenally increase data transfer rates. The major technological obstacle was to develop an optical/laser data transfer to Earth receivers that could overcome atmospheric distortion. If successful, such data transfer rates could go far to enable an intimate level streaming tactical imagery of targets for very distant hypersonic Prompt Global Strike systems, space bombing platforms, perhaps in multiple simultaneous combat theaters. The kicker: the engineer noted this satellite could begin development to construction in 2016 or 2021. China may be the only country investing in this capability. Occasional statements from Chinese military academics and academic engineering articles point to China’s interest in developing a range of future space combat capabilities. Asian military sources told this analyst in 2008 that an initial PLA ABM system could emerge in the early 10 2020s. This might happen even sooner. Chinese-developed ABM/ASAT capable missiles may become smaller and deployable on aircraft, ship and submarine platforms. In a December 2013 journal article, engineers from the Changchun Institute of Optics, Fine Mechanics and Physics, a leading Chinese laser weapon research body, proposed it would be possible by the mid-2020s for China to loft a 5-ton laser-armed space combat platform. A key enabling technology would be large membrane mirrors. It should be considered that by the mid-2030s might China be able to halve the size of possible laser space combat platforms so as to launch more in a single SLV. At the 2006 IAC in Valencia, engineers from the China Academy of Launch Vehicle Technology (CALT) briefed a paper on two reusable space plane concepts under consideration: a 130-ton or so manned space plane for LEO operations, and a 100-ton unmanned suborbital space plane for launching payloads on an expendable second stage. Both concepts, which could appear in the early 2020s, apparently are dependent on using the first stage of the Long March-5 heavylift SLV slated to begin testing in 2015 or 2016. The manned space plane concept carries most of its weight in fuel as a “second stage” to reach orbit. However, more reserve fuel may enable greater capability for maneuver than U.S. or Soviet space shuttle concepts, which could increase its military utility. Chinese military academics and academic engineering articles have addressed the idea of using platforms in LEO to bomb targets on Earth. This could be done with a relatively simple platform derived from the Tiangong, a manned or unmanned space plane, or a hypersonic cross air vehicle (CAV), for which there may be some interest as seen in Chinese academic engineering literature. It also has to be considered that China’s interest in manned space combat platforms may extend to its future space stations. The first 120-plus ton space station that may be completed by 2023 is based on the replaceable module concept developed in the 1970s by the Russian Energia Company. There is some reason to conclude that under the guise of goodwill, Russia was unwise enough to allow a significant Chinese espionage exercise within its space companies in the late 1990s and that Energia’s space station technology may have fallen victim. The first Chinese space station may have two experimental modules, one of which will have large imaging systems pointed out to space and at the Earth—which could be dual-use. If needed, such modules could be replaced with others equipped for combat, more capable military surveillance or command-control needed to compensate for the loss of Earth control facilities. At the 2014 IAC in Toronto, a Chinese academic told an audience that China was likely planning a larger second generation space station. Given that the first may have a life span of 10 years, the second may be ready by the early 2030s. Before the 2020s it can be expected that the PLA will also make real progress in creating “Near Space” capabilities that can compensate for the loss of LEO assets. Large UAVs or stratospheric airships capable of performing radar, optical, communication and navigation satellite functions could emerge soon. A next more capable generation of these systems may emerge in the mid-tolate 2020s. 11 Potential Deep Space Ambitions As it controls the rest of China’s space program, the PLA also controls China’s Moon program. As it has done throughout its space program, the PLA can be expected to seek dual use benefits from China’s presence on the Moon. Over a decade ago, Chinese Moon program leader Dr. Ouyang Ziyuan, highlighted the Moons military value and the need for China to be able to secure vital resources, perhaps Helium-3 to power future fusion energy reactors. Writing on 31 January 2015 on the website of the CCP Central Committee’s journal Quishi (Seeking Truth), the Chairman and CCP Party Secretary of the China Aerospace Science and Technology Corporation (CASC), Lei Fanpei, stressed that "We will adhere to the path of developing military-civil integration in our coming demonstration of deep space exploration, manned moon landing, heavy launch vehicle and other major programs, and are of major significance both to the nation's longterm development and to the task of building the nation into a strong space power." This is a strong indicator that the PLA will use its Moon and Deep Space program for military gain. While some Western analysts may scoff at the idea of the Moon having military value, perhaps PLA planners have decided otherwise. While from the perspective of current technology it may be better to invest in ISR and military capabilities closer to Earth that can dominate LEO and GEO, perhaps as ISR assets move well beyond MEO it may then become useful to have Moon capabilities to find or interfere with such assets. Early in the Change unmanned Moon probe program there was mention that the stationary Moon lander might include an experimental payload using a laser to measure distance to the Earth. While recent reporting on the December 2013 Change-3 Moon landing mission has not included mention of a laser package, at the 2014 IAC a Chinese space company official did mention that it could be included in a future landing mission. A low-power laser on the Moon could become militarily useful were it able to vibrate and thus interfere with the very thin membrane mirror of a potential MOIRE like surveillance satellite. What if, in about 100 years, breakthroughs in space propulsion make it possible to reach Mars in weeks, versus months or years? Should the Earth’s economy come to be dominated increasingly by access to resources on Mars, then the Moon and the Langrangian Points become the nearest “parking garages” to support that commerce. So from a very long term perspective it may be attractive to the PLA to secure a dominant position on the Moon in order to have the option to secure access to other potentially strategic positions in the Earth-Moon system. Question 2: Given China’s emerging counter-space capabilities, which defensive or offensive capabilities should the United States prioritize to maintain its strategic advantage in space? Assess the implications, if any, for U.S. defense budget requirements in these areas. The degree to which China, with possible Russian help, obtains “space control” will most likely be determined by the degree to which the United States rises to defend access to space by the democracies and deters attacks by China and Russia. From the perspective of the 2015 policy balance in Washington, this will require a fundamental political shift to emphasize a commitment to sustaining a broad rebuilding of U.S. power to include space power

#### Emerging moon development is inevitable and causes accidental and intentional artifact destruction – heritage sites would be destroyed inevitably by public actors – OST allows it and overriding current OST policies would deck scientific research and space stability

Pace & Hertzfeld 13 [Dr. Henry R. Hertzfeld is a Research Professor of Space Policy and International Affairs in the Space Policy Institute at the Elliott School of International Affairs. Scott Norman Pace currently serves as the Executive Secretary of the National Space Council. Pace was formerly the Director of the Space Policy Institute at the Elliott School of International Affairs at George Washington University, where he was also a Professor of the Practice of International Affairs. “International Cooperation on Human Lunar Heritage.” <https://cpb-us-e1.wpmucdn.com/blogs.gwu.edu/dist/7/314/files/2018/10/Hertzfeld-and-Pace-International-Cooperation-on-Human-Lunar-Heritage-t984sx.pdf>]

The U.S. Apollo Space Program was a premier technological accomplishment of the 20th century. Preserving the six historic landing sites of the manned Apollo missions, as well as the mementos and equipment still on the Moon from those and other U.S. (e.g., Ranger and Surveyor) and Soviet Union (e.g., Luna) missions is important. Some of the instruments on the lunar surface are still active, monitored, and provide valuable scientific information. But recent government and private-sector plans to explore and potentially use lunar resources for commercial activity raise questions about the use of the Moon and potential accidental or purposeful threats to the historic sites and scientific equipment there. Although some steps to protect these sites have been proposed, we suggest a better way, drawing on international, not U.S. unilateral, recognition for the sites.

Less than 2 years before the fi rst footsteps on the lunar surface on 20 July 1969 (see the image) , the United Nations Outer Space Treaty (OST) was drafted, ratifi ed, and came into force ( 1). Article II of the OST reinforced and formalized the international standard that outer space, the Moon, and other celestial bodies would not be subject to claims of sovereignty from any nation by any means, including appropriation. The OST prohibits ownership of territory or its appropriation by any state party to the treaty, which includes the United States, Russia, and 126 other nations. It does not prohibit the use of the Moon and its resources. In fact, the treaty emphasizes the importance of freedom of access to space for any nation and the importance of international cooperation in space exploration. These principles of the space treaties have enabled gains in science and technology and have contributed to international stability in space.

#### The link alone turns case – Chinese control causes massive state mining that zeroes the case

Dezan Shira & Associates 19, pan-Asia, multi-disciplinary professional services firm, publishes China Briefing, citing; Bao Weimin, Director of the Science and Technology Commission of the China Aerospace Science and Technology Corporation; 11/8/19, “China Proposes Establishing Moon-Based Special Economic Zone,” https://www.china-briefing.com/news/china-proposes-establishing-moon-based-special-economic-zone/

Real intent may be to usher in lunar ownership claims.

Bao Weimin, a Director of the Science and Technology Commission of the China Aerospace Science and Technology Corporation (CASC) has been reported in Chinese and Russian state media as suggesting that China would benefit from establishing an “Earth-Moon Special Economic Zone”.

Bao said that Beijing is considering creating the first Earth-Moon economic zone by 2050. According to him, China is planning to invest in studies on how much it would cost for the idea to come to fruition, as well as for the deployment of a transportation system linking Earth and its natural satellite.

The CASC is the main contractor for China’s national space program, while the project could bring in around US$10 trillion for China, the state-linked Science and Technology Daily newspaper reported.

With an earth-moon economic zone, China aims to ensure that it has the ability and the first presence right to establish the rules of behavior for who has access and who can benefit. This also has long term implications for US-China, China-Russia, and China-India relations as well – all have moon-based exploration projects currently underway.

Bao said that the field has huge economic potential and thus the country should study reliable, low-cost aerospace transport systems between the Earth and Moon.

The basic technology is set to be finished by 2030, while the key transport technology is expected to be created by 2040. By the middle of the century, China could successfully establish the space economic zone, according to Bao.

China has been rapidly developing its space sector and studying the Moon in recent years. In July, private company i-Space (also known as Beijing Interstellar Glory Space Technology) launched a carrier rocket in the first successful orbital mission by the Chinese commercial space industry. Last year, China launched its Chang’e 4 probe, successfully landing its lunar rover on the far side of the Moon on January 3 this year.

China has already started investing in Space-Based Solar Power (SBSP) – a technology that it plans to use to power a lunar base. The SBSP’s deployment will take place in stages, with the first satellite scheduled for deployment in low-Earth orbit by 2025 and the GEO-based SBSP to be deployed by 2050.

Other important steps on Beijing’s way to establishing an Earth-Moon economic zone would be a study on the feasibility of 3D printing and lunar manufacturing by 2035 as well as a manned lunar mission, which is scheduled to take place by 2036.

China is also currently planning new lunar probe launches, as well as the deployment of satellites that will ensure a communication bridge between the Earth and Moon.

Dezan Shira & Associates’ Chris Devonshire-Ellis comments: “While the proposal sounds fun, there is a very serious component to this: ‘Who owns the Moon?’ According to the United Nations Outer Space Treaty, signed by every space-faring country, no nation can claim sovereignty over Earth’s lunar satellite. 102 countries have entered the 1967 accord; China joined in 1983. I suspect that Bao’s intent is to lay grounds for Beijing to start to erode the existing treaty and to begin the process of permitting ownership of lunar sites in future.”

#### Chinese revisionism collapses hegemony, causes global prolif, and ensures Taiwan war

Kapila 19 [Dr Subhash Kapila is a graduate of the Royal British Army Staff College, with a Masters in Defence Science (Madras University) and a PhD in Strategic Studies (Allahabad University) Combines a rich experience of Army (Brigadier) and diplomatic assignments in major countries."United States’ Potent Existential Crisis: The China Threat – Analysis." <https://www.eurasiareview.com/18012019-united-states-potent-existential-crisis-the-china-threat-analysis/>]

The ‘China Threat ‘emerging in 2018 in comprehensive and diverse manifestations poses an existential crisis challenging not only the continuance of United States as the global unipolar Superpower but also targeted with intended consequences of prompting the United States to retreat into isolation within its continental confines.

The United States has long ignored the China Threat to the detriment of United States own national security but also to the security of US Allies and strategic partners. The acid test of a nations’ strategic greatness lies not only in checkmating a threat in existence to its national security but also being vigilant to a ‘Threat in the Making’, as I would put it. The United States is guilty of the latter in relation to China.

China has reached this stage of posing a potent existential challenge to the United States mainly due to United States own acts of strategic omission and commission. United States misreading of China’s long range intentions has not only facilitated the emergence of a China Threat to United States but also United States permissive attitudes on China facilitated to create two ‘rogue nuclear weapons state’ of Pakistan and North Korea as its proxy cats-paws against US Allies and strategic partners.

China is unlikely to succeed in achieving ‘strategic equivalence’ that it seeks with the United States in the foreseeable future nor are the Major Powers of the world, including Japan and India, likely to accede ‘American Exceptionalism’ to China despite its burgeoning military power. This for the simple reason that I have been stressing in my writings for two decades and that is China has no Natural Allies like the United States.

For detailed analysis on the subject, kindly read my Book, “China-India Military Confrontation: 21st Century Perspectives” (2015) Chapter 13 ‘China’s Giant Leap for Superpower Status in 21st Century: Geopolitical Implications’.

However, China will in the 21st Century with great persistence, and unmindful of the prevailing reality, that China is besieged today from both within and without, China will continue to challenge United States global predominance and specifically Indo Pacific predominance with greater potency.

The United States has belatedly woken upto the reality that what they attempted to market globally for decades that China can be co-opted as a responsible stakeholder in global security and stability was a mirage. Long years of United States ‘China Hedging Strategy’ and ‘Risk Aversion Strategy’ made China only more recalcitrant and fed Chinese misperceptions that United States global power is on the decline.

United States policy formulations of this decade of a ‘Strategic Pivot to Asia Pacific’ and the recent emphasis on Indo Pacific Security Blueprint are seemingly belated but welcome steps to checkmate China’s unrestrained flexing of its military muscle as evident in the South China Sea.

Chinese President Xi Jinping’s call on Chinese Armed Forces to prepare for an all- out war are not defensive calls by a besieged nation but like Hitlerian Germany, these are offensive calls of a revisionist power. Annexation of Taiwan by use of military force seems to be China’s aim today. This has a larger aim of challenging United States resolve and determination to maintain its Superpower status. China has placed the United States on the horns of a strategic dilemma where the United States will be damned if it does not militarily intervene to defend Taiwan and if it does so it risks a full-fledged war with China. China is gambling on the United States shying away from the latter option.

Right from the turnover of the 19th Century till today no major power, not even Nazi Germany, has dared to challenge the United States predominance, geopolitically and strategically, as China is now engaged in doing so. Even at the height of the Cold War 1945-91 when the United States and the Former Soviet Union were involved in a bitter ideological struggle one did not witness the unfolding of the type of China’s ‘Grand Strategy Blueprint’ decades in the making and operationalising, to initially unravel United States security architecture in Asia Pacific, and graduated now to a more vividly clear reality in 2019 that China is on the avowed path of emerging as the ‘sole challenger ‘of United States predominance and exceptionalism. That China could geopolitically and strategically engage in the execution of such a blueprint unchallenged arose fundamentally from United States flawed policy decisions spread over many US Administrations. Such flawed US policy decisions sprung from misconceived American readings of China’s long range strategic intentions and short-term American geopolitical expediency subjugating and distorting United States strategic vision of the ‘China Threat’ to United States national security. The United States ‘original sin’ in relation to the latent China Threat to US national security can be placed on shoulders of US President Truman who ignored General MacArthur’s dire warnings on China and petulantly dismissed General MacArthur from the command of UN Forces in Korea. If Japan today after decades since 1945 continues as the United States most enduring and steadfast Ally, it has a lot to do with General MacArthur’s visionary zeal. The second most serious sin in relation to flawed US policy decisions was inflicted by US President Richard Nixon in 1972 egged by his Sinophiles Secretary of States Henry Kissinger. To spite the Former USSR the United States in 1972 endowed an unwarranted international legitimacy on China despite its disruptive credentials and thereafter followed as to what could be termed as a China Appeasement policy. The third sin was committed at the turn of the Millennium when US President Bush in his messianic zeal to tame President Saddam’s Iraq left untended both Afghanistan and more significantly Asia Pacific security. China made full use of the decade ending 2010 for its exponential military power expansion and with emphasis on a well-calibrated buildup of Chinese naval power for ‘naval operations in distant seas’.

China’s latest strategic-economic enterprises of One Belt One Road and Maritime Silk Route are nothing but an attempt to control maritime chokepoints along the global commons to United States disadvantage and as strategic pressure points against regional peer competitors

## Case

#### Their ev says dry deserts and high mountains solve neutrinos and lack of accessibility and infrastructure means moon isn’t feasible – Harker reads yellow

1AC Crawford 12, I. A., et al. "Back to the Moon: The scientific rationale for resuming lunar surface exploration." Planetary and Space Science 74.1 (2012): 3-14. (Department of Earth and Planetary Sciences, Birkbeck College)//Elmer

A natural area to use the Moon as a platform for performing scientific experiments is astronomy (for summaries see, e.g., Burns et al., 1990; Livio, 2006; Crawford and Zarnecki, 2008; Jester and Falcke, 2009). Almost the entire electromagnetic spectrum is currently being used to study the universe from radio to high-energy gamma ray emission. Different frequencies typically relate to different physical processes, and consequently the universe looks markedly different in optical, infrared, or radio wavelengths. Hence, during the last century modern telescopes have diversified and evolved enormously, fundamentally changing our view of the universe and our place therein. Due to their ever increasing sensitivity, which allows one to peer deeper and deeper into the earliest phases of the cosmos, the requirements for telescope sites have become more and more extreme: one simply needs the best possible observing conditions. The most important factors here are light pollution (at the relevant frequencies) and distortions due to the atmosphere. Light pollution is generally caused by any form of civilization, thereby pushing observatories to more and more remote locations. Detrimental effects of the atmosphere include: • temporary effects such as clouds and water vapour, which temporarily absorb and disturb optical or high-frequency radio radiation, • turbulence in the ionosphere or troposphere, which distorts radio or optical wave fronts, thereby severely degrading the image quality, • air glow, which can overpower sensitive infrared observations, • total absorption of radiation, e.g., of very low-frequency radio, infrared, X-ray, and gamma-ray radiation. The best – and in many cases only – remedy is to observe from dry deserts, high mountains, or from space. Two of the most remote, but also most exquisite, astronomical sites on Earth are the Atacama desert and Antarctica. The former currently hosts some of the world’s largest telescopes, including ESO’s 8m-class Very Large Telescopes (VLT), the ALMA sub-mm-wave radio telescope, and in the future probably also the ~40 m diameter European Extremely Large Telescope (E-ELT; see http:// www.eso.org). A century after its initial exploration, Antarctica now also hosts a number of somewhat smaller telescopes (e.g., the South Pole Telescope, Carlstrom et al., 2011) as well as the giant IceCube detector. IceCube is the world’s largest neutrino observatory, using the ice itself as detector material (e.g., Abbasi et al., 2011). The Moon would be a logical next step in the quest for the most suitable sites to be used for astronomy. An important secondary important factor in selecting a site, however, is the available infrastructure: How accessible is the site for people and material? How does one obtain power and how good is the data connection? Already for Antarctica this poses serious constraints, and it took a long time until this continent became useful for scientific exploitation. It is needless to say that the Moon is even more difficult to reach. Hence, like Antarctica, any significant exploitation of the Moon requires a developed infrastructure – something that would likely become available only in conjunction with human exploration of the Moon. Even then one has to assess how unique and useful the Moon is for astronomy in the first place. After all, the International Space Station (ISS), while having a well-developed infrastructure available, is not used for telescopes; its small, relatively unstable platform in low Earth orbit (LEO) is simply too poor a telescope site to be competitive. Hence, the vast majority of space-based telescopes have been associated with free-flying satellites. Of course, some of these satellites, most notably the Hubble Space Telescope (HST), benefited from the heavy lift capabilities of the Space Shuttle and the servicing possibilities the human space flight program offered (NRC, 2005). Indeed, it is interesting to note that the one human-serviced space telescope, HST, is in fact the most productive of all astronomy space missions even many years after its launch (see Tables 4 and 6 in Trimble and Ceja, 2008; HST produced 1063 papers in the time frame 2001-2003, compared to 724 for Chandra, the next most productive). So, the question to ask is: Which type of telescopes would uniquely benefit from a lunar surface location? This question has been addressed in a couple of workshops and scientific roadmaps in recent years (Falcke et al., 2006; Livio, 2006; NRC, 2007; Crawford and Zarnecki, 2008; Worms et al., 2009). In the following section we try to synthesize these findings. 4.2 Which astronomy? There is a wide consensus that a low-frequency radio telescope (i.e. a radio telescope operating at frequencies below 30-100 MHz) would be the highest priority (e.g., Jester and Falcke, 2009; Burns et al., 2009). Radio waves at these frequencies are seriously distorted by the Earth’s ionosphere and completely absorbed or reflected at frequencies below 10-30 MHz. Hence, the low-frequency universe is the last uncharted part of the electromagnetic spectrum, and a lunar infrastructure would greatly benefit its exploration. Of particular relevance for science here is the investigation of the “dark ages” of the universe. This is the epoch several hundred million years after the big bang, but before the formation of the first stars and black holes, when the cosmos was mainly filled with dark matter and neutral hydrogen. This epoch contains still pristine information of the state of the big bang and can essentially only be observed through radio emission from atomic hydrogen red-shifted to several tens of MHz. The best location to study this treasure trove of cosmology (Loeb and Zaldariaga 2004) would indeed be on the lunar far-side.

### AT Climate

#### Warming doesn’t trigger extinction

* peer-reviewed journal shows IPCC exaggeration
* history proves resilience
* no extinction- warming under Paris goals
* rock breaking strategy could offset warming

IBD 18 [Investors Business Daily, Citing Study from Peer reviewed journal by Lewis and Curry, “Here's One Global Warming Study Nobody Wants You To See”, 4/25/18, https://www.investors.com/politics/editorials/global-warming-computer-models-co2-emissions/]

Settled Science: A new study published in a peer-reviewed journal finds that climate models exaggerate the global warming from CO2 emissions by as much as 45%. If these findings hold true, it's huge news. No wonder the mainstream press is ignoring it.

In the study, authors Nic Lewis and Judith Curry looked at actual temperature records and compared them with climate change computer models. What they found is that the planet has shown itself to be far less sensitive to increases in CO2 than the climate models say. As a result, they say, the planet will warm less than the models predict, even if we continue pumping CO2 into the atmosphere.

As Lewis explains: "Our results imply that, for any future emissions scenario, future warming is likely to be substantially lower than the central computer model-simulated level projected by the (United Nations Intergovernmental Panel on Climate Change), and highly unlikely to exceed that level.

How much lower? Lewis and Curry say that their findings show temperature increases will be 30%-45% lower than the climate models say. If they are right, then there's little to worry about, even if we don't drastically reduce CO2 emissions.

The planet will warm from human activity, but not nearly enough to cause the sort of end-of-the-world calamities we keep hearing about. In fact, the resulting warming would be below the target set at the Paris agreement.

### AT Prolif

#### No prolif or it takes forever

* Prolif cascades are empirically denied
* Reputational damage and economic costs disincentivize it – cons outweigh pros
* Takes 17 years to proliferate on average – hardware, knowledge, and industrial base

Kahl 13 [Colin H. Kahl, Senior Fellow at the Center for a New American Security and an associate professor in the Security Studies Program at Georgetown University’s Edmund A. Walsh School of Foreign Service, citing Jacques Hymans, USC Associate Professor of IR. If Iran Builds the Bomb, Will Saudi Arabia Be Next? Feb 19, 2013. <http://www.cnas.org/files/documents/publications/CNAS_AtomicKingdom_Kahl.pdf>]

I I I . LESSONS FRO M HISTOR Y Concerns over “regional proliferation chains,” “falling nuclear dominos” and “nuclear tipping points” are nothing new; indeed, reactive proliferation fears date back to the dawn of the nuclear age.14 Warnings of an inevitable deluge of proliferation were commonplace from the 1950s to the 1970s, resurfaced during the discussion of “rogue states” in the 1990s and became even more ominous after 9/11.15 In 2004, for example, Mitchell Reiss warned that “in ways both fast and slow, we may very soon be approaching a nuclear ‘tipping point,’ where many countries may decide to acquire nuclear arsenals on short notice, thereby triggering a proliferation epidemic.” Given the presumed fragility of the nuclear nonproliferation regime and the ready supply of nuclear expertise, technology and material, Reiss argued, “a single new entrant into the nuclear club could catalyze similar responses by others in the region, with the Middle East and Northeast Asia the most likely candidates.”16 Nevertheless, predictions of inevitable proliferation cascades have historically proven false (see The Proliferation Cascade Myth text box). In the six decades since atomic weapons were first developed, nuclear restraint has proven far more common than nuclear proliferation, and cases of reactive proliferation have been exceedingly rare. Moreover, most countries that have started down the nuclear path have found the road more difficult than imagined, both technologically and bureaucratically, leading the majority of nuclear-weapons aspirants to reverse course. Thus, despite frequent warnings of an unstoppable “nuclear express,”17 William Potter and Gaukhar Mukhatzhanova astutely note that the “train to date has been slow to pick up steam, has made fewer stops than anticipated, and usually has arrived much later than expected.”18 None of this means that additional proliferation in response to Iran’s nuclear ambitions is inconceivable, but the empirical record does suggest that regional chain reactions are not inevitable. Instead, only certain countries are candidates for reactive proliferation. Determining the risk that any given country in the Middle East will proliferate in response to Iranian nuclearization requires an assessment of the incentives and disincentives for acquiring a nuclear deterrent, the technical and bureaucratic constraints and the available strategic alternatives. Incentives and Disincentives to Proliferate Security considerations, status and reputational concerns and the prospect of sanctions combine to shape the incentives and disincentives for states to pursue nuclear weapons. Analysts predicting proliferation cascades tend to emphasize the incentives for reactive proliferation while ignoring or downplaying the disincentives. Yet, as it turns out, instances of nuclear proliferation (including reactive proliferation) have been so rare because going down this road often risks insecurity, reputational damage and economic costs that outweigh the potential benefits.19 Security and regime survival are especially important motivations driving state decisions to proliferate. All else being equal, if a state’s leadership believes that a nuclear deterrent is required to address an acute security challenge, proliferation is more likely.20 Countries in conflict-prone neighborhoods facing an “enduring rival”– especially countries with inferior conventional military capabilities vis-à-vis their opponents or those that face an adversary that possesses or is seeking nuclear weapons – may be particularly prone to seeking a nuclear deterrent to avert aggression.21 A recent quantitative study by Philipp Bleek, for example, found that security threats, as measured by the frequency and intensity of conventional militarized disputes, were highly correlated with decisions to launch nuclear weapons programs and eventually acquire the bomb.22 The Proliferation Cascade Myth Despite repeated warnings since the dawn of the nuclear age of an inevitable deluge of nuclear proliferation, such fears have thus far proven largely unfounded. Historically, nuclear restraint is the rule, not the exception – and the degree of restraint has actually increased over time. In the first two decades of the nuclear age, five nuclear-weapons states emerged: the United States (1945), the Soviet Union (1949), the United Kingdom (1952), France (1960) and China (1964). However, in the nearly 50 years since China developed nuclear weapons, only four additional countries have entered (and remained in) the nuclear club: Israel (allegedly in 1967), India (“peaceful” nuclear test in 1974, acquisition in late-1980s, test in 1998), Pakistan (acquisition in late-1980s, test in 1998) and North Korea (test in 2006).23 This significant slowdown in the pace of proliferation occurred despite the widespread dissemination of nuclear know-how and the fact that the number of states with the technical and industrial capability to pursue nuclear weapons programs has significantly increased over time.24 Moreover, in the past 20 years, several states have either given up their nuclear weapons (South Africa and the Soviet successor states Belarus, Kazakhstan and Ukraine) or ended their highly developed nuclear weapons programs (e.g., Argentina, Brazil and Libya).25 Indeed, by one estimate, 37 countries have pursued nuclear programs with possible weaponsrelated dimensions since 1945, yet the overwhelming number chose to abandon these activities before they produced a bomb. Over time, the number of nuclear reversals has grown while the number of states initiating programs with possible military dimensions has markedly declined.26 Furthermore – especially since the Nuclear Non-Proliferation Treaty (NPT) went into force in 1970 – reactive proliferation has been exceedingly rare. The NPT has near-universal membership among the community of nations; only India, Israel, Pakistan and North Korea currently stand outside the treaty. Yet the actual and suspected acquisition of nuclear weapons by these outliers has not triggered widespread reactive proliferation in their respective neighborhoods. Pakistan followed India into the nuclear club, and the two have engaged in a vigorous arms race, but Pakistani nuclearization did not spark additional South Asian states to acquire nuclear weapons. Similarly, the North Korean bomb did not lead South Korea, Japan or other regional states to follow suit.27 In the Middle East, no country has successfully built a nuclear weapon in the four decades since Israel allegedly built its first nuclear weapons. Egypt took initial steps toward nuclearization in the 1950s and then expanded these efforts in the late 1960s and 1970s in response to Israel’s presumed capabilities. However, Cairo then ratified the NPT in 1981 and abandoned its program.28 Libya, Iraq and Iran all pursued nuclear weapons capabilities, but only Iran’s program persists and none of these states initiated their efforts primarily as a defensive response to Israel’s presumed arsenal.29 Sometime in the 2000s, Syria also appears to have initiated nuclear activities with possible military dimensions, including construction of a covert nuclear reactor near al-Kibar, likely enabled by North Korean assistance.30 (An Israeli airstrike destroyed the facility in 2007.31) The motivations for Syria’s activities remain murky, but the nearly 40-year lag between Israel’s alleged development of the bomb and Syria’s actions suggests that reactive proliferation was not the most likely cause. Finally, even countries that start on the nuclear path have found it very difficult, and exceedingly time consuming, to reach the end. Of the 10 countries that launched nuclear weapons projects after 1970, only three (Pakistan, North Korea and South Africa) succeeded; one (Iran) remains in progress, and the rest failed or were reversed.32 The successful projects have also generally needed much more time than expected to finish. According to Jacques Hymans, the average time required to complete a nuclear weapons program has increased from seven years prior to 1970 to about 17 years after 1970, even as the hardware, knowledge and industrial base required for proliferation has expanded