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Chapter 2

"Sputnik-like" Events: Responding to Technological Surprise

Ron Lehman

Sputnik in a Nutshell

National security costs imposed by technological surprise can be immense. Take the case of "Sputnik I," the first man-made satellite. Launched by the Soviet Union on October 4, 1957, Sputnik—primarily a technology demonstration—humiliated a superpower, catalyzed mankind's greatest national-security technology competition, encouraged risky geostrategic behavior, and transformed the world in ways that still shape our future.

Few technological surprises match the impact of Sputnik, and like Sputnik, few are totally unexpected. Their consequences, however, are often not those anticipated. Exploiting lessons learned from the "Sputnik Crisis" to plan and prepare for future technological surprise can reduce danger, mitigate damage, and even promote technological progress and strategic gains.[1] Relearning these lessons is urgent, given current international dynamics involving Russia, China, Iran, North Korea and others.

Sputnik is an existence proof that revolutionary strategic consequences can result from catalytic events. Sputnik shocked the world because an uneven response made the U.S. appear ineffectual when confronted with a rising Soviet Union. Awkward attempts to mitigate the damaging effects of Sputnik—denigrating the Soviet accomplishment after welcoming it and then failing to match it—only reinforced the view that the U.S. was outclassed. As public fear of the military implications of Sputnik grew, invoking the specter of "Massive Retaliation" to suggest that no technological advance by any adversary

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[1] The most detailed of several recent histories of the "Sputnik Crisis" is Yanek Mieczkowski, *Eisenhower's Sputnik Moment: The Race for Space and World Prestige* (Ithaca: Cornell University Press, 2013). See below the *Appendix: Readings on the History of Sputnik* for other interesting accounts and perspectives.

could ever be significant enough to alter the military balance only made the U.S. look uncompetitive and perhaps even desperately at risk.

Subsequent U.S. successes, including some coinciding with Soviet failures, were unable to quickly undo the image of Soviet superiority built up at the beginning of the "space race." Moscow sustained its public affairs momentum by continuing to exploit Sputnik-style spectaculars, often preempting planned U.S. events or "bookending" U.S. milestones with immediate, newsworthy launches of its own.

As the superiority of the longer-term U.S. space program became apparent to the technologically savvy, the U.S. still found itself behind the public-opinion power curve. However, twelve years later, the momentum shifted decisively when the U.S. manned lunar landings on the moon contrasted so vividly with the numerous failures in the troubled Soviet unmanned lunar robot program.

The steps necessary to undo the damage caused by the original Sputnik Crisis were costly. They were also insufficient to discourage dangerous adventures by the U.S.S.R. in Berlin, Cuba, and elsewhere. Still, the American technological hyper-response to Sputnik ultimately transformed the Western democracies and their economies such that their successes highlighted Soviet failings, eventually accelerating the internal collapse of the Soviet Union.

Public perceptions about American technological superiority may again be changing direction. After decades of U.S.-Russian space cooperation, debate with respect to comparative U.S.-Russian prowess in space has returned. With the retirement of its space shuttles in 2011, the U.S. temporarily de-emphasized manned spacecraft. Russian Soyuz rockets currently transport all astronauts—including American—to the International Space Station. While the U.S. explores privatization of space launch,[2] Russia continues to be the major manned space-launch player. Some believe that U.S. dependence on Russian rocket motors even for important unmanned launches today, in the context of the Russo-Ukrainian crisis, exposes a mini-Sputnik-like embarrassment about a U.S. lack of capacity.

Dramatic demonstrations by Russia and China of anti-satellite (ASAT) and military cyber-capabilities have underscored concerns about national security threats to U.S. operations both in space and on earth. Russia and China are exploring cooperation in space bilaterally[3] and as an incentive for cooperation within the BRICS group.[4] In the years ahead, China may surpass Russia in producing technological surprises in space and in other domains that have significant geostrategic impact. Continuous testing of ever more capable missiles by

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[2] "Commercial Resupply Services Overview," *NASA*, accessed November 1, 2016, https://www.nasa.gov/mission_pages/station/structure/launch/overview.html.

[3] "China offers electronics for Russian rocket engines," *Space Daily*, April 20, 2016, http://www.spacedaily.com/reports/China_offers_electronics_for_Russian_rocket_engines_999.html

[4] A first meeting of the Space Agencies of Brazil, Russia, India, China, and South Africa (BRICS) was held this year; see "China wants to buy Russian rocket engines as BRICS boosts space cooperation," *RT*, November 1, 2016, https://www.rt.com/news/364921-rocket-space-china-russia/.

North Korea, which has nuclear weapons, and by Iran, which has a latent nuclear program, expands the pool of potential purveyors of surprise.

Sputnik demonstrated that rapid technological change, compounded by political turmoil, could produce major national security surprises. Sputnik-like events remain likely because potential adversaries see leverage in exploiting the global advance and spread of technology. In many regions and scenarios, numerous technologies short of the cutting edge also provide asymmetrical responses to Western capabilities. Future technological surprises will differ from Sputnik and may never match its impact. Indeed, the near-term aftermath of Sputnik would not have been so disadvantageous to the West if the developing crisis had been handled well.

Predicting and preventing Sputnik-like events is difficult, but careful preparation can mitigate their impact, reverse momentum, and prove productive over time. To exploit opportunities and avoid dangers, the U.S. should plan and program recognizing that:

- Some surprise is inevitable.
- The national security impact of technological surprise can be great.
- Valuable "lessons learned" exist.
- Sound strategy and ongoing preparation can help the U.S. anticipate, mitigate, and respond to surprise.
- Timely exploitation of peer-level technical competence is essential.
- Taking on the risk inherent in cutting-edge S&T programs can give the U.S. the insight and options necessary to reduce the national security consequences of surprise.
- Preventing an embarrassing or dangerous "fait accompli" requires that agile planning, talent, tools, infrastructure, and organizations be in place.
- To minimize damage in the face of strategic surprise, a healthy habit of competitive innovation and exploration of diverse options must be established.

In short, maintaining a timely ability to anticipate, innovate, and act in fields of science and technology that others may exploit is essential to managing technological surprises such as Sputnik-like events. The sixtieth anniversary of Sputnik I in 2017 can energize efforts to revisit the impact of technological surprise and lessons learned. Given the rise of technological near-peers such as Russia and China and antagonistic states such as Iran and North Korea that have technological means and psychological motivations to demonstrate their prowess vis-à-vis "The West," the failure to prepare for technological surprise could be dangerous and costly.

The Sputnik Crisis—Existence Proof and Case Study

The premier existence proof of the potential for dramatic effects from a singular event was the 1957 launch by the Soviet Union of Sputnik I, the first space satellite of human origin. Experts anticipated the launch. It demonstrated no immediate military utility. Nevertheless, Sputnik I had a profound and immediate strategic impact. The reasons for the heightened global surprise and uneven American response are clear.

First, the U.S. was expected to be first and best, but was not. The U.S. had already announced a planned launch of its own satellite during the upcoming International Geophysical Year. Indeed, the U.S. was so certain that the U.S. Navy Vanguard rocket would work that Washington had already ordered an Army competitor to stop work. The U.S. began a self-confident public drumroll, building expectation of peerless U.S. leadership. Despite Moscow's announcement that the Soviet Union would attempt to launch its own satellite, the U.S. did not prepare the public or opinion leaders for the prospect that the United States might not be first. Nor did the U.S. government anticipate that the American public would see being second as a sign of grave danger.

Second, the initial U.S. response was inarticulate and ineffective in the face of America's highly visible superiorities in rocket throw-weight and payload size. Although Soviet General Secretary Nikita Khrushchev's comment that "The United States now sleeps under a Soviet moon" was hyperbole, the American attempt to dismiss the successful Soviet launch of an "artificial moon" as merely well-understood celestial mechanics and the simplest of rocket science was widely perceived as "sour grapes." Quickly the story was viewed in geostrategic and political terms, with U.S. Senate Majority Leader Lyndon Johnson calling for a congressional investigation of the implications of Sputnik.

A second successful Soviet launch a month later with the live dog "Laika" on board (November 3, 1957), even before the first U.S. launch attempt, built a news storyline that contrasted accelerating Soviet success with U.S. inertia. On December 6, 1957, when the first American attempt to launch a satellite with the Navy's Vanguard I blew up on the launch pad, press coverage switched from a theme of the United States moving to regain the lead to a theme of America falling further behind.

On January 31, 1958, four months after Sputnik I and almost two months after the first failed Vanguard attempt, the first U.S. satellite, Explorer I, was finally launched through a reactivated Army/Jet Propulsion Laboratory program. Earlier, that program had been put aside, in part because it was a military program and included former German rocket scientists. The rapid Explorer I response was made possible only because the Army had independently decided to keep its own space launch options open.[5]

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[5] For a detailed history of the Army efforts and the controversial role of German scientists, see Paul Dickson, *Sputnik: The Shock of the Century* (New York: Walker Publishing Company, 2001), especially Chapter Three, "Vengeance Rocket."

The quick success of the reconstituted Explorer I program had only a limited impact on the public. In contrast with the 1,121-pound Sputnik II, launched in November 1957, the thirty-one-pound Explorer I seemed small. Soviet General Secretary Khrushchev pounced on the even smaller Vanguard I, calling the three-pound payload a "grapefruit satellite." This comparison shaped the public image of the emerging Sputnik Crisis.

Both the United States and the Soviet Union followed with successes and failures, but the early failure rates were different. A Soviet satellite launch failure on February 3, 1958, four days after the U.S. launched its first Explorer I, was followed two days later by the second Vanguard failure, again undermining American talking points asserting that the U.S. was regaining the lead. Between December 6, 1957, and September 18, 1959, eight of eleven U.S. Navy/Navy Research Laboratory attempts to launch satellites on Vanguard failed, continuously and vividly undercutting U.S. prestige. The contrast between self-confident Soviet achievements and nervous American failures was amplified by the new social media of the time, television, which instantly and vividly portrayed Soviet space boosters on launch platforms ascending juxtaposed with U.S. boosters exploding.

Successes for the United States, such as Explorer I's discovery of the Van Allen radiation belts, were drowned out by the overwhelming perception that the U.S.S.R. was ascendant. Vice President Richard Nixon, in his 1959 Moscow "Kitchen Debate" with First Secretary Khrushchev, emphasized the high standard of living that everyday Americans obtained from the peaceful application of technology, but at home, as the U.S. elections approached, the debate focused on Soviet technological prowess, the "missile gap," and American decline. The economic recession and the Asian flu pandemic of 1957/'58 that had killed some 69,800 Americans[6] provided a domestic backdrop that reinforced pessimism.

Dismissing possible new Soviet nuclear threats as insignificant given the existing nuclear capabilities of the United States was seen as "spin control" and political damage limitation at best. Worse, invoking our nuclear deterrent and asserting that it was already sufficient to negate any new developments only invited questions about U.S. leadership and competence. Such reassurances only amplified the perceived danger, raised questions about the credibility of U.S. commitments to provide allies with an American nuclear umbrella, and encouraged debates over "How many nuclear weapons are enough?", the increasing risk of surprise nuclear attack, and "Does the U.S. government know what it's doing?"

Third, Sputnik was seen as a harbinger of a military revolution. Both domestic and international press rushed to extrapolate the Sputnik Crisis into a "missile gap" more frightening than the earlier "bomber gap." Intercontinental missiles were seen as making the U.S.S.R. the true, modern global power. The prospect of shorter-range Soviet missiles as well as intercontinental ballistic missiles (ICBMs) undermined allies' confidence in the U.S.

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[6] "Asian flu of 1957," *Encyclopedia Britannica,* accessed October 14, 2016, https://www.britannica.com/event/Asian-flu-of-1957.

and built pressure for American regional deployments to avoid the "decoupling" effects of emerging local Soviet nuclear advantages.

The specter of the "weaponization of space" moved quickly to the United Nations, ultimately leading to the Outer Space Treaty. Concern about crisis stability led to the 1958 international "Surprise Attack Conference." The potential for satellite communications and spy satellites was seen as further enabling global military reach. Defenses against missiles joined air and civil defense as hot topics. Lack of confidence in both U.S. intelligence and counter-intelligence became widespread, with renewed concerns about "atomic spies" and the "Red Scare." In government, interest in controlling technology through export controls expanded.

Although President Eisenhower hoped that Sputnik would lead to Moscow's acceptance of the legality of future reconnaissance-satellite overflight of sovereign Soviet territory, in the near term, U-2 flights over the central U.S.S.R to monitor missile fields became more urgent. This led to the 1960 Soviet shoot-down of Francis Gary Powers and the collapse of a U.S.–U.S.S.R. Summit to deal with Berlin. Fear of advancing Soviet intercontinental nuclear capability increased pressure for the 1958 Nuclear Test Moratorium.

Fourth, the global shadow of the Sputnik Crisis led to geopolitical interpretations adverse to the United States. Western media declared the Soviet Union to be leading in a "space race," prompting a flurry of competing stories underscoring indications of the decline of the American-led West. Moscow exploited the contrast between Soviet technological successes and American failures to pronounce the superiority of the Soviet economic system. A number of countries, such as Ghana,[7] strengthened their ties to Moscow, although none went so far as Cuba. Others distanced themselves from the West in general and from capitalism in particular. In 1961, the Non-Aligned Movement (NAM) was created. Led by Yugoslavia, India, Indonesia, Ghana, and Egypt, this diverse group of nations quickly included most newly independent countries, but also included Cuba and the People's Republic of China.

Many political parties in the West, as in the developing world, cited Sputnik as a demonstration that command economies, central planning, and state-ownership were the wave of the future politically, economically, and technologically. This complicated closer ties among market economies and created sharper divisions within Western democracies. Policies of NATO members toward the Soviet Union diverged as each government dealt with domestic political polarization between Left and Right, leading to mass peace movements, but also mobilizing nationalists. France moved decisively in its own direction, making the decision to acquire nuclear weapons and ultimately withdrawing from NATO's integrated military command.

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[7] See for example Alessandro Iandolo, "The Rise and Fall of the 'Soviet Model of Development' in West Africa, 1957–64," *Cold War History* 12, no. 4 (2012): 683–704, accessed 28 Feb 2017, http://www.tandfonline.com/doi/citedby/10.1080/14682745.2011.649255.

Fear of a missile gap became a central issue in the 1960 presidential election, shaping public perceptions of U.S. vulnerability and driving public policy analysis and priorities. Belief in a missile gap may have helped determine the outcome of the election. The debate had an impact overseas as well. NATO insecurities led to flirtation with the concept of a Multilateral Force (MLF) and ultimately the elaboration of the declared nuclear doctrine of "flexible response" in an effort to reassure allies and discourage more states from seeking nuclear weapons. U.S. flight test failures involving an air-launched ballistic missile (ALBM) being developed with the United Kingdom led to the 1961–62 "Skybolt Crisis." Efforts to repair the U.S.-U.K. "special relationship" after the Skybolt debacle resulted in the Nassau Agreement to share Polaris Submarine Launched Ballistic Missiles (SLBMs) with the UK.

A more self-confident Soviet Union increased its adventurism. Moscow's perception that geostrategic trends were going its way perhaps made more likely the Berlin Crisis of 1961 that led to the Berlin Wall, the 1961 Soviet breakout from the Nuclear Test Moratorium, and the 1962 Cuban missile crisis. Insurgencies and regimes such as Fidel Castro's Cuba looked increasingly to Moscow for support. Demonstrations of Soviet technical prowess in one area made more credible reports of Soviet advances in other areas: for example, corroborating reports of a massive, high-tech Soviet biological weapons program that caused the United States to worry about a "bug gap." Ironically, in the Soviet Union, the success of Sputnik contrasted with weaknesses in microbiology resulting from Stalin's purges and the remnants of Lysenkoism. As a result, a major qualitative modernization of the large Soviet biological weapons program actually followed several years after Sputnik.[8]

Building on Sputnik-derived technology, Yuri Gagarin's orbiting of the earth on April 12, 1961 dramatically boosted the idea of Soviet technical superiority once again. Subsequent U.S. suborbital flights contrasted poorly. The one-two punch of Sputnik I and II and momentum resulting from Moscow's "bookending" of the first U.S. manned space launches with the orbital flights of Yuri Gagarin and Gherman Titov shaped the new Kennedy Administration's views on Berlin, Vietnam, and Cuba, leading both to the largest nuclear buildup in history and to the decision to put a man on the moon. Fear of missiles, amplified by the very public Sputnik experience and the missile gap debate, shaped how the Cuban missile crisis was perceived and handled.

Fifth, and finally, the U.S. response that ultimately proved necessary to counter the adverse impact of the Sputnik surprise was larger, more urgent, and more far reaching than anyone had anticipated at the beginning of the Sputnik crisis. Just 18 days after the second Sputnik launch, President Eisenhower upgraded the Scientific Advisory Committee in the Office of Defense Mobilization to be the Presidential Science Advisory Committee and moved it to the White House. DOD created the Advanced Research Project Agency (now DARPA) a few months after Sputnik, accelerating innovation for military and ultimately civilian applications. The National Defense Education Act (NDEA) was enacted, funding the greatest

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[8] See for example, Milton Leitenberg and Raymond A. Zilinskas with Jens H. Kuhn, *The Soviet Biological Weapons Program: A History* (Harvard University Press: Cambridge, Massachusetts, 2012).

increase in STEM expertise in American history and providing much of the national-security related talent in the U.S. over the next four decades.

The North American Air Defense Command, activated one month before Sputnik to deal with the bomber threat, was re-oriented to deal also with the anticipated missile threat. Ballistic Missile Early Warning System (BMEWS) radars were deployed over the next few years. The National Aeronautics and Space Administration (NASA) was created to replace the National Committee on Aeronautics (NACA) ten months after Sputnik. The National Science Foundation budget was increased by 271% in one year on the way to an increase of 964% in eight years.[9]

Three months after Sputnik I, one month after the U.S. Navy Vanguard I "Kaputnik" failure, and one month before the U.S. Explorer I success, the Pentagon decided to accelerate the Polaris SSBN submarine program. The decision exploited a fundamentally new warhead technology developed at Lawrence Livermore National Laboratory that would permit smaller solid-rocket-motor SLBMs. The new solid-rocket-motor SLBMs, in turn, permitted adding a quickly designed, 16-tube missile section to an SSN attack sub already under construction by cutting the existing submarine in two.[10]

Thus, U.S. ballistic missile submarines went on patrol in two years rather than in the seven or more years that would be required with a new submarine design even with existing Cold War urgency (i.e., in 1960 rather than in 1965). To put this in perspective, consider that comparable programs today may be twenty years or more. In just the ten years following Sputnik, the U.S. nuclear weapons stockpile grew from 5,543 in 1957 to 31,255 in 1967 (compared to today's pre-Sputnik level of 4,018).[11] Immediately after the launch of Sputnik, DOD turned to the Program Analysis and Review Technique (PERT) to manage and accelerate complex research and development programs such as Polaris, where uncertain requirements and timelines exist.[12] Notably, a missile-defense development program including both sensors and interceptors was expanded and accelerated. Most memorable, however, was President Kennedy's widely publicized commitment to send a man to the moon and back, renewing an emphasis on big science that had declined after the Manhattan Project.

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[9] See National Science Foundation, *NSF Requests and Appropriations By Account: FY1951–FY2017*, accessed February 28, 2017, https://dellweb.bfa.nsf.gov/NSFRqstApropHist/NSFRequestsandAppropriationsHistory.pdf,

[10] See for example, Graham Spinardi, *From Polaris to Trident: The Development of U.S. Fleet Ballistic Missile Technology* (New York: Cambridge University Press, 2008) and George J. Refuto, *Evolution of the U.S. Sea-Based Nuclear Missile Deterrent: Warfighting Capabilities* (Xlibris Press, 2011).

[11] U.S. Department of Defense, "Stockpile Numbers: End of Fiscal Years 962–2015," 2015, accessed October 14,2016, http://open.defense.gov/Portals/23/Documents/frddwg/2015_Tables_UNCLASS.pdf, and see Office of the Vice President, "Remarks by the Vice President on Nuclear Security," Washington, D.C., January 11, 2017, accessed February 28, 2017, https://obamawhitehouse.archives.gov/the-press-office/2017/01/12/remarks-vice-president-nuclear-security.

[12] See the classic Harvey M. Sapolski, *The Polaris System Development: Bureaucratic and Programmatic Success in Government* (Cambridge, MA: Harvard University Press, 1972), accessed February 28, 2017, http://www.hup.harvard.edu/catalog.php?isbn=9780674432703.

Surprise and Security: "The Frog in the Pot" Versus Sputnik

In the rapid political, economic, social, and technological change of the 21st Century, the United States needs strategies and capabilities to respond effectively to technology challenges through which other actors may:

- catch up with us on paths we are taking,
- pass us even on our own preferred paths,
- advance on paths we do not favor,
- accelerate along new paths we did not foresee, or
- exploit older, even abandoned paths as asymmetric responses.

The widespread availability of latent, dual-use technology portfolios, the proliferation of scientific talent, and the growth of centers of excellence around the world provide many alternative paths and reduce lead times for exploitation of technology. This global S&T dynamism increases the chances of surprise. Even if most technological challenges are associated with recognized trends and closely watched developments, some challenges do result from unexpected circumstances or events that suddenly surprise us. Such risks, however, are reduced when we have adequate and timely responses.

Most S&T challenges are obvious, although some may be hidden in plain sight. Few are completely concealed. Not all result in surprise, and most surprises are matched, countered, co-opted, or exploited before they become a national security danger. More often a rising tide lifts all boats, as technological competition makes advanced capabilities available more broadly.

Even equal access to technology, however, can have asymmetric effects, sometimes favoring smaller, more agile actors. Such highly focused innovators may be less transparent, less risk averse, and more persistent. Moreover, they may have the opportunity to pick the time, location, and scenario in which to mount precise challenges against technology leaders whose larger size; broader vision; risk aversion; and complex budget, management, and decision processes may slow responses.

In some cases, surprise may emerge slowly and openly. Consider the proverbial "frog in the pot" psychology wherein we find ourselves unprepared because we do not perceive any individual event to be action-forcing until it's too late to do anything about it. Our sensitivity threshold is too high to trigger a response before the situation becomes dire. With each small step taken against our interests we do not perceive the ultimate consequences of the many steps to come.

In other cases, a specific galvanizing act or event does occur. If the impact is very large and persistent, we might say it was a "Sputnik-like event." Such singular technological developments that have sudden, significant geopolitical and/or military consequences are rare, but they can be especially challenging to national security. This paper focuses on the potential for Sputnik-like events rather than on threats that accumulate and reveal themselves gradually. The lessons learned, however, apply more widely to technological challenges, surprise or no surprise.

To avoid the fate of the frog in the pot, Sputnik-like events require the accumulation of STEM[13] talent, ample resources, and sustained programs over time. The central features of Sputnik-like events are sudden awareness of immediate or inevitable risks of large magnitude combined with unavailable, inadequate, or inappropriate response options. In seismic terms, the frog in the pot produces many tremors and occasional large quakes, but Sputnik produced "The Big One." In either case, the ultimate consequences can be great.

Potential Sputnik-like events could involve peer, non-peer, and even non-state actors. Today, transformation takes place in weapons themselves and in delivery platforms, basing, connectivity or control, situational awareness, support technology, research empowering technology, technical demonstrations, industrial technology, or the life and behavioral sciences. Technologies exploited might have applications to weapons of mass destruction (WMD),[14] kinetic weapons, cyber operations, space warfare, multi-mission and poly-capable military or civilian delivery platforms, space launch vehicles, conventional or exotic explosives, unconventional/covert operations, counter-space capabilities, Electromagnetic Pulse (EMP), other weapons effects, warhead packaging, CBRNE (Chemical, Biological, Radiological, Nuclear, and High Yield Explosive) materials production, communications, sensors, battlefield awareness, force integration, stealth or counter-stealth, advanced submarines, anti-submarine warfare (ASW), air and missile defenses, and directed energy weapons.

The technologies themselves might include lasers, optics, information technology, artificial intelligence, robotics, unmanned vehicles, precision navigation, advanced manufacturing, HPC-aided design, simulations and surrogate operational testing, miniaturization, new and engineered materials, advanced armor, synthetic chemistry, nanotechnology, genetic engineering and other biotechnology, human performance enhancement, planetary or moon exploits, geo-engineering, tunneling and other target hardening, camouflage and deception, encryption, non-lethal weapons, new scientific principles, counterfeiting and other technology-enabled economic or societal warfare, etc.

Thus, the symbol of a Sputnik-like event may be a prototype, a technical demonstration, an enabling technology, or even a basic science experiment. It could be some combination of these. Sputnik itself was flown on the prototype of an ICBM, the R-7 "Semyorka," which had a spotty early test record, prompting the substitution of the hastily assembled, lightweight payload that became Sputnik I for a much heavier satellite that became Sputnik III.

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[13] Science, Technology, Engineering, Mathematics.

[14] Weapons of Mass Destruction, sometimes expanded to WMDD or Weapons of Mass Destruction and Disruption.

Ironically, the R-7 quickly proved to be a poor ICBM, but, as the technology matured over the decades, the R-7 became the basis for one of the most successful and frequently used families of large space-launch vehicles. Likewise, the Sputnik I satellite itself did little more than demonstrate celestial mechanics, although scientists were able to add some science value by tracking and listening to its simple broadcast.

The significance of the R-7 and Sputnik I was less what they did, or how well they did it, than what they portended. The driver for a Sputnik-like event is the geostrategic context as much as the technology. Sputnik-like events can differ in type and magnitude due to factors such as:

- the implications for our interests and values,
- the centrality of the technology involved,
- the weight of circumstances or the context,
- the achievements of others,
- the exploitation by the successful actor,
- the clarity of public discussion despite complex, proprietary, and even classified information,
- the capacity for meaningful, timely, and sustained response,
- the perceived magnitude of our failure,
- the impact on third parties internationally, and
- the domestic audience that becomes aware, i.e., experts, officials, publics.

No consensus exists establishing a threshold for declaring an event "Sputnik-like," and analysts disagree as to what events are legitimate examples. A spectrum of candidates to be Sputnik-like shocks includes the 9/11 attacks; the "Shock and Awe" of stealth and precision in Desert Storm; the Manning/Snowden/NSA downloads; "Stuxnet" and other cyber activities such as the hacking of the Democratic National Committee; the Three Mile Island, Chernobyl, and/or Fukushima nuclear reactor accidents; radioactive fallout contamination such as the "Castle Bravo" contamination from an atmospheric nuclear test; nuclear missile or bomber accidents; the sinking of nuclear submarines; new nuclear weapons tests (atmospheric or underground); the technological escalation of improvised explosive devices (IED); WMD terrorism such as that of Aum Shinrikyo; or even the disappearance of Malaysian Airliner MH370.

All have had international security impact. Nuclear weapons use would be a major tipping point, but thus far chemical weapons use, the accidental sinking of nuclear powered submarines, and the post-9/11 anthrax attacks have had less of a Sputnik-like effect than many had anticipated. Perhaps decryption by a future quantum computer of highly encrypted nuclear weapons data, acquired but unreadable in the past, would be Sputnik-like. Again, the context is as important as the event.

Contrasting success with failure was a major feature of the original Sputnik dynamics and contributed to its instant and escalating consequences. Had Soviet success been followed by a corresponding U.S. record of success, President Eisenhower's letters to Soviet Premier Bulganin and First Secretary Khrushchev of 1957–58 proposing cooperation on the peaceful uses of space might have enabled the joint U.S.–U.S.S.R. space program to begin many years earlier. Instead, his proposals were rejected in a climate of Soviet triumphalism, including Moscow's demand that U.S. forward-based nuclear systems be removed from Turkey as a precondition.

The Soviet Union proved initially unenthusiastic even in the multilateral negotiations in the United Nations that led to the Outer Space Treaty of 1967. Discussions began after John Glenn's orbital flight, but a concrete cooperative space program did not begin until the Soviet-manned lunar program experienced major setbacks while the U.S. Apollo program successfully put men on the moon.

Some technological surprises with major strategic consequences are driven by a sudden failure rather than success. Three Mile Island for the United States, Chernobyl for the Soviet Union, and Fukushima for Japan all involved domestic failures that had important international impact. Chernobyl was a major catalyst for the collapse of the Soviet Union. Some would not consider such predominantly self-induced negative technological catastrophes as Sputnik-like no matter what the strategic effect. Still, Moscow's silence, then obfuscation concerning the massive radioactive releases from the nuclear reactor accident at Chernobyl—located in Ukraine near Belarus and contaminating parts of Western Europe, especially in Scandinavia—raised doubts about the legitimacy and viability of the Soviet Union compared to the Western model.

What can cause a Sputnik-like event changes with circumstances over time. The threshold to produce a psychological impact has risen markedly. Consider the example of space-launch capability. In 2010, Japan completed a seven-year round-trip to a distant asteroid, gathering samples and successfully returning them to earth. Ten countries, the European Union, and even private companies have now launched their own satellites on their own boosters. This includes India, Israel, Iran, and North Korea. India has launched an orbiter to Mars; China has placed the "Jade Rabbit" rover on the moon; and SpaceX Corporation has put a 7000-pound commercial satellite into geosynchronous orbit. None of these activities has yet produced a dramatic public effect like that in the original Sputnik crisis, but all signal important trends with both positive and negative strategic implications.

Terra Bella,[15] the commercial miniature satellite constellation project formerly known as "Skybox," aims toward providing global, real-time one-meter photographic resolution

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[15] "Terra Bella," *Planet*, accessed December 4, 2017, https://www.planet.com/terrabella/.

to customers around the world. Terra Bella, recently sold by Google to Planet,[16] builds on the "CubeSat" format that has permitted smaller countries, industry, and nonprofit organizations to have their own satellites in space. Private launch services are supplementing traditional space-launch vehicles for this purpose. Today, private individuals can already obtain essentially free access to satellite imagery that once only superpowers could obtain and then only after those powers invested billions of dollars. What was once inconceivable is now routine. Numerous state and non-state actors may soon have the means to exploit space activities in surprising ways.

Sputnik-like events require more than a spectacular technological accomplishment. They must take place in an international security context involving competitors willing to exploit the event for strategic gain, both political and military. Immediately after the launch of Sputnik I, Moscow was slow to comment on what it had achieved. The excitement of Western audiences, however, sparked the multi-decade implementation by the Soviet Union of a strategy aimed at contrasting Soviet technical prowess with images of American "Me too!" efforts to catch up. Moscow sustained its public affairs momentum by continuing to exploit Sputnik-style spectaculars, notably politically symbolic "firsts" such as the first animal, man, and woman in space, the first spacewalk, the first probe to reach the moon, the first moon rover, etc.

The original U.S. space technology program had some qualitative advantages over Soviet technology. Much of this was too subtle, however, to manifest itself in the battle for public opinion. Subsequent U.S. successes, even in the face of Soviet failures, were unable to quickly undo the image of Soviet superiority built up at the beginning of the space race. The momentum shifted decisively, however, after 1969, when U.S.-manned lunar landings on the moon contrasted so vividly with the numerous failures in the troubled Soviet unmanned lunar robot program. Indeed, Luna 15 crashed on the moon while Apollo 11 was still on the moon's surface. Apollo was meant to be a "counter-Sputnik," and it was. It was meant to rebalance, and it did. Much of the positive symbolism of Apollo, however, was drowned out by the consequences of the war in Vietnam.

The space race did not end with Apollo, but its context changed. In the period since the breakup of the Soviet Union, widespread dependence on the Russian Federation to put men and objects in space has been a major source of Russian pride. During the recent Russo–Ukrainian crisis, however, reacting to Western sanctions in April 2014, the Deputy Prime Minister of the Russian Federation, Dmitry Rogozin, tweeted the message, "After analyzing the sanctions against our space industry, I suggest to the U.S.A. to bring their astronauts to the International Space Station using a trampoline."[17] Immediately, a sub-committee

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[16] Alex Knapp, "Google Is Selling Its Satellite Business Terra Bella to Satellite Startup Planet," *Forbes,* accessed February 28, 2017, https://www.forbes.com/sites/alexknapp/2017/02/07/google-is-selling-its-satellite-business-terra-bella-to-satellite-startup-planet/#35612b946231.

[17] "Trampoline to Space? Russian Official Tells NASA to Take a Flying Leap," *NBC News*, accessed November 4, 2016, http://www.nbcnews.com/storyline/ukraine-crisis/trampoline-space-russian-official-tells-nasa-take-flying-leap-n92616.

of the U.S. House Armed Services Committee added money to the defense budget for development of an American-sourced rocket motor to replace Russian motors now used by United Launch Alliance (ULA) for its Atlas V rocket. Orbital Sciences Corporation also uses Russian-designed motors for its Antares rocket.

In response, Elon Musk, founder of SpaceX, which provides American-built rockets for NASA, tweeted "Sounds like this might be a good time to unveil the new Dragon Mk 2 spaceship that @SpaceX has been working on w @NASA. No trampoline needed."[18] Musk had earlier announced a suit against the Defense Department for sole-sourcing military launches to the ULA team of Boeing and Lockheed Martin. The geopolitics of space competition remain active today.

Future Sputnik-like events need not involve space. Nevertheless, the growing dependence of the United States and its allies and friends on extremely valuable but fragile space-based assets still makes that domain a prime candidate for surprise. The surprise, however, may or may not involve traditional access and use of space. Candidates for national security surprise in space include cyber operations, direct-ascent or directed-energy anti-satellite weapons (ASATS), anti-space nuclear and other weapons effects, and even manned operations. Sputnik-like events in space may be enabled by technologies not normally associated with that domain.

Scenario-Based Assessments of Possible Sputnik-like Consequences

The 1957 Sputnik surprise impacted nearly all aspects of national security. A future Sputnik-like event, however, will likely differ from the historic Sputnik crisis in terms of the technology involved, the path it takes, how quickly it plays out, and its significance. Analysis of alternative scenarios, taking into account both new technological developments and a range of actors and dynamics, greatly assists simulation, evaluation, planning, and training related to policy, strategy, RDT&E, procurements, and operations.

The time factor is also important. The Sputnik crisis is remembered primarily for U.S. mistakes. Nevertheless, early U.S. responses to Sputnik included successes as well as failures, and the cumulative response over time was an overwhelming success. Reduction of harm early on could have been achieved given Soviet problems and the existence of countervailing U.S. achievements. Some would argue, however, that the early embarrassments to Washington actually resulted in a larger and more successful response over time, strategic as well as technological.

To improve the ability to anticipate, mitigate, and respond quickly to possible Sputnik-like events, challenging scenarios should be developed and analyzed. For example, useful scenarios could assess whether a plausible surprise might:

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[18] Ken Kremer, "SpaceX CEO Elon Musk to unveil manned Dragon 'space taxi' on May 29," *Phys*, May 28, 2014, accessed November 4, 2016, http://phys.org/news/2014-05-spacex-ceo-elon-musk-unveil.html.

1) Alter peer relationships adversely by creating the reality or perception of U.S. weakness, for example demonstrating military capabilities beyond those of the United States.
2) Provide incentives for Russia, China, or others to form adversarial alliances aimed at the U.S. and its allies.
3) Undermine confidence in U.S. extended deterrence, perhaps by presenting scenarios in which the U.S. might not have credible responses or is seen as "decoupled from the region."
4) Permit an adversary to implement a "fait accompli" attack on the U.S., an ally, its own soil, or perhaps disputed territory.
5) Provide competitors or adversaries with a more credible ability to act decisively at lower levels of the escalatory ladder or along an "escalatory lattice" of multi-domain[19] technologies (e.g., cyber, electromagnetic, etc.) with precise attacks, low collateral damage, tailored effects, or even non-kinetic kill to negate the U.S. nuclear umbrella or conventional force projection.
6) Project an aura of geographical isolation of U.S. strategic forces from the allies overseas they are meant to reassure.
7) Encourage potential adversaries to offer special security guarantees to countries of concern, such as North Korea, Iran, etc.
8) Incentivize closer relationships between an adversary and nations for whose loyalty we compete, even if only to encourage U.S. allies and friends to play both sides against each other.
9) Create unintended acquiescence in support of an adversary's achievement while inspiring campaigns to freeze, block, or ban any comparable U.S. response.
10) Encourage alternative, independent military power centers that may be destabilizing globally or in regions.
11) Focus blame on the U.S. rather than the actual initiators for having inspired new military capabilities.
12) Undermine U.S. exploitation of dual-use technology, especially if the impression is created that the new technologies are in tension with major international instruments and objectives such as the biological weapons convention (BWC), chemical weapons convention (CWC), Landmine convention, Treaty on the Nonproliferation of Nuclear Weapons (NPT), Comprehensive Nuclear-Test-Ban Treaty (CTBT), Fissile Material Cut-Off Treaty (FMCT), etc.
13) Inspire civilian exploitation by others who seek latent military capabilities.

What Is to Be Done? Learning from Sputnik and the Space Race

Successfully addressing the consequences of Sputnik-like events and other, less dramatic technological surprises requires effective strategies, capabilities, and actions in the face of

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[19] "Multi-domain" has largely replaced "cross-domain" in Defense Department references to the interaction of these different military technologies.

uncertainty. This means success depends on America's ability to anticipate, innovate, and deliver diverse responses. Clear recognition of circumstances, prediction of events, and prevention of adverse developments, however, are problematic. Thus, realistic scenarios that introduce uncertainty should be elaborated to guide formulation of strategies for prevention and response. Furthermore, poor timing and performance, often made more likely by dynamic and morphing scenarios, can negate otherwise prescient strategies and amplify surprise. Such uncertainties are too often not reflected in planning assumptions.

Even with perfect prediction, developments clearly anticipated in planning can get lost in the noise or momentum of implementation of the plan. Surprise should be seen as a process in which adverse consequences are multiplied when uncertainty and inattention undermine capabilities for timely response. In the case of technological surprise, the products of research and development may be clear long before the significance for national security is clear. Even when national security concerns emerge, overburdened decision-makers often see unrealized techno-military possibilities as "improbable," "over the horizon," or even "inconceivable," until after a concrete, dramatic demonstration. Even then, a response might not be supported until the broader political community recognizes the consequences.

Compartmentalization, "stovepiping," and failure to see multi-disciplinary synergism and multi-mission applications increase the risk of surprise. Preexisting STEM competence and sustained capabilities are vital, but interdisciplinary knowledge of interacting technological, economic, or strategic factors is also essential. Likewise, diverse, cross-cultural experts provide different insights into potential developments.

Such cross-discipline brainstorming tends to reduce surprise. More general understanding of the sources of surprise provides a framework for anticipation including difficulties in:

- detecting change,
- identifying possibilities,
- calculating probabilities,
- evaluating trends,
- clarifying consequences,
- anticipating reactions,
- predicting counter-reactions,
- computing complex dynamics, and
- compensating for emergent behavior.

Prior planning and preparation are the keys to timely and effective mitigation even in the face of surprise, not because the plans will be perfect, but because the skills necessary for managing surprise will be honed. Lessons learned from past events such as Sputnik can help. For example, mitigation of the consequences of Sputnik-like events generally requires early demonstration of similar or superior knowledge and capability.

With advanced warning and mature capability, one could preempt with a demonstration of one's own equivalent or better capability. This may help defuse negative reaction to the action of the other. Unfortunately, acting first may also place any perceived responsibility for undesired implications of the action on the U.S. rather than on the party being preempted. "Who is to blame" is a classic element when political or policy debates are about an arms race.

The ability to announce in advance someone else's activity tends to reduce the shock effect when the event occurs. Leaks and false denials, however, can create a drumroll effect that magnifies the adversary's event when it ultimately occurs. Immediate identification of an event and clear explanation based on technical competence tends to be reassuring to allies and publics. Interventions to prevent surprise may be more likely to succeed if private communications are opened before the event and if public statements are made with the confidence of sound information and technical competence.

Acknowledging the self-evident significance of a surprise and then placing it in proper context increases credibility. On the other hand, erroneous statements and assumptions create initial damage that is difficult to reverse. Presentation of a combination of other new or similar capabilities by the U.S. may also reassure. Making available to allies quickly the benefits of any positive, peaceful applications helps reassure, but decisions to deny friends access to technology demonstrated by others may have the opposite effect. Developing tools to balance advantages and disadvantages helps greatly. For example, having some concept about how to exploit, manage, or control the spread of a breakthrough technology may turn the focus toward a work plan rather than an inquisition.

Counter-responses can be similar or asymmetric, immediate or longer term, and qualitative or quantitative. Also, different approaches to countering technological surprise may have different benefits and costs over time. The timeliness and appropriateness of the response may provide more psychological leverage than does the ultimate magnitude of the response. Would the launch of Sputnik have had the effect it had if Washington had emphasized in public in advance that both the United States and the Soviet Union were about to launch satellites and if that statement had been soon followed by a successful American launch?

Readiness for surprise requires the development of options, which in turn requires a relevant technical infrastructure and knowledge base with the agility to respond. This requires practice. "Pay me now" versus "pay me later" trade-offs are inherent in the key questions: What should we prepare for? What are the risks? How ready should we be? What are the costs? How much is enough? Ongoing programs may provide more timely responses than restarts or new starts, but only if they provide a foundation for the needed technical competence and capability.

Conclusions

The 60th anniversary of Sputnik I on October 4, 2017 can be a catalyst to review lessons from the Sputnik crisis. In the context of a Sputnik-like event, success in minimizing the magnitude of surprise, mitigating the downsides of surprise, maximizing possible benefits of change, and managing the process of creative technological advance and obsolescence successfully is more likely when we:

- recognize that surprise is inevitable, and that punctuated, bold "Firsts" carry great weight;
- consider that incremental improvements may have less immediate international or public impact even if their long-term strategic contributions can be large;
- demonstrate the capability and competence to respond credibly to surprise and change;
- understand that appearance of a sudden threat may generate opportunities, resources, and the will to act that might have been lacking without the event;
- explore cutting-edge, albeit risky, S&T in addition to maintaining diverse, multi-disciplinary R&D to gauge possibilities that you or others may wish to explore and provide a foundation for alternative options to match or leapfrog in-kind or asymmetrically;
- prepare to articulate and demonstrate mastery of the subject, initially and over time;
- speak with the confidence that comes from being candid and truthful; and
- understand cultural and political diversity in order to see how different audiences at home and abroad, especially friends and allies, may react and address their individual concerns in a way that is consistent with the message to others.

In short, technological surprise can have severe international security impact. To respond effectively, an energetic base of talent and technology is needed to anticipate, innovate, and deliver options in a timely manner. Creating a healthy habit of promoting and assessing innovation that includes high-risk/high-potential S&T enhances the capability to be competitive in the face of surprise.

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