Nonproliferation and the Search for Stability:
The Impact of New Technologies

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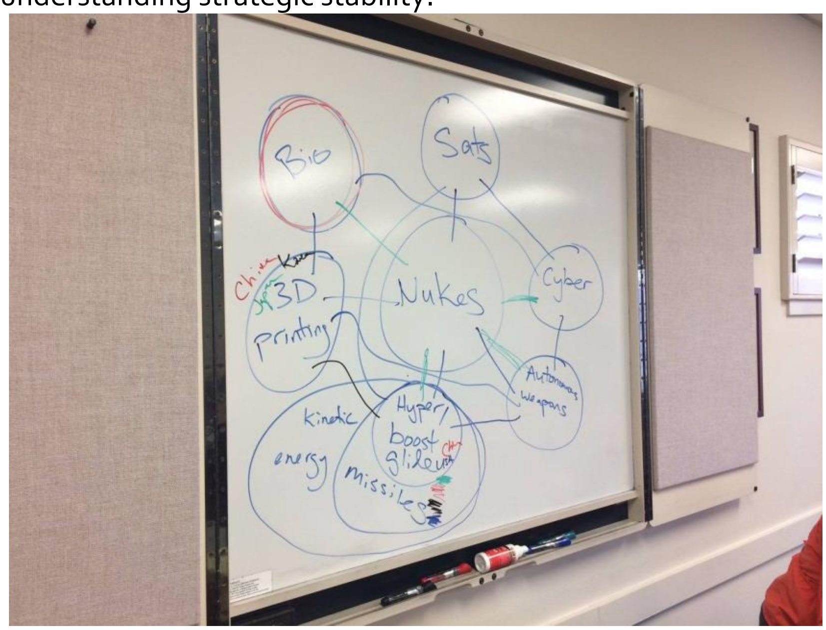
Contemporary discourse on strategic stability in Northeast Asia tends to emphasize the politics that underpin or jeopardize stable relations. During the Cold War the discussion focused specifically on the deterrence relationship between the United States and the Soviet Union based on nuclear weapons possession. Now, extraordinary technological advancements have expanded the role of non-nuclear, yet strategic weapons systems.

Additionally, in the Asia Pacific region there are multiple countries that influence strategic dynamics and drive the development of strategic technology; formal alliance relationships between the US and Japan and the Republic of Korea further complicate strategic dynamics. Do new technologies with strategic implications—seven in particular: satellites, additive manufacturing, biotech, hypersonic glide, long-range strike vehicles, autonomous weapons, and cyber infrastructure—bolster or undermine stability in East Asia?

This combination of capability and intent also involves a discussion of what non-nuclear deterrence might look like and what role it might play. There appear to be two mechanisms by which technological developments affect strategic stability: one through affecting the balance of strategic and tactical capabilities, and another by aiding in the proliferation of certain capabilities (or in some cases the proliferation of the technology itself). In addition to effects on stability, one question that arises is whether these developments and their interactions on capabilities and proliferation may enhance or diminish (or both) the role of nuclear weapons in deterrence and understanding strategic stability.



This image illustrates the linkages between nuclear weapons and new technologies, and their complex, networked effects on strategic stability. Image: Hanham/Dill Group Work

I) Additive Manufacturing

Additive manufacturing—commonly referred to as 3D printing—may pose a new dilemma for strategic stability, from both a capability and proliferation perspective. In terms of capability, additive manufacturing allows for the production of a whole range of items in a more efficient and cost effective manner. As opposed to traditional subtractive manufacturing techniques, additive manufacturing streamlines the production process, reducing the need for materials and human involvement.

Although additive manufacturing changes the manufacturing landscape across the board, there are particular implications for strategic weapons capabilities, especially in the nuclear and missile sphere.[1] Additive manufacturing may reduce the barriers to the production of some sensitive dual-use goods. For example, if a group or a state has access to a 3D printer, a digital build file for an item, and the base powder (metallic or ceramic), in theory no additional tacit knowledge of machining processes is needed. Tacit knowledge of subtractive manufacturing processes—for example, in operating 5-axis milling machines—has remained a barrier to some missile and nuclear programs in a manner that additive manufacturing may not prove to be.

With regards to strategic capabilities, additive manufacturing may enhance a country's ability to develop and produce both new and existing weapons systems. Large-scale defense manufacturing may become cheaper, not only for countries with large existing strategic weapons programs, but also for smaller countries with more limited resources. This has the potential to shift regional power dynamics, especially in East Asia.

The acquisition of a 3D printer, digital build files, and base powders may decrease barriers to proliferation. For example, rather than shipping sensitive dual-use items around the world, a proliferator could send a digital build file to a country with an additive manufacturing capability. In the worst-case scenario, there are no physical items or tacit knowledge to control. Additive manufacturing is still developing, and it remains unclear how many sensitive items are producible through additive manufacturing processes, but the technology does require scrutiny as it continues to evolve.

Since additive manufacturing impacts both capabilities and proliferation pathways, it has the potential to be mainly destabilizing: the technology can facilitate increases in the size, variety, and technical sophistication of strategic weapons systems.

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[1] For an excellent discussion of the impact of additive manufacturing on nuclear proliferation, see Matthew Kroenig and Tristan Volpe, "3-D Printing the Bomb? The Nuclear Nonproliferation Challenge," *The Washington Quarterly*, Fall 2015, available at: https://twq.elliott.gwu.edu/sites/twq.elliott.gwu.edu/files/downloads/TWQ_Fall2015_Kroenig-Volpe.pdf.

II) Satellites

The US' first spy satellite –the Corona—made its first successful flight in August 1960. At the start of the Cold War, only the United States and the Soviet Union possessed the technical capability to peer down upon each other's territories and make intelligence determinations. In the years following the close of the Cold War, commercial satellite imagery exploded onto the scene. Though expensive and with low resolution by today's standards, other countries, companies, and individuals were able to order up images for the first time. Today, not only optical information, but data from non-visible wavelengths, Synthetic Aperture Radar (SAR), and Lidar are available commercially—and at greater abundance and lower prices than ever before. These newly available technologies mean that for better or worse transparency has never been greater.

Satellites have always been entwined with strategic stability. Even from the days of Corona, satellites were used to track submarines, bombers, and launchers. While they continue the same missions today, more countries are getting into the game. Today, there are 1,381 satellites operated by 53 countries and the EU orbiting the Earth.[2] Of those, only a quarter have military or a military-hybrid mission.[3] While the US still operates the most satellites by far, Asia is striving to close the gap. China alone now operates 177 satellites with tasking that spans military, commercial, and research purposes and Beijing continues to invest and accelerate programs to launch more.[4]

Satellite remote sensing is revealing more than ever before too. It was once unthinkable that a private citizen could track a submarine. SAR data—though still expensive—can detect the wake of a moving submarine. It can also detect the infinitesimal changes in the surface of the earth after an underground nuclear test, and even shallow tunnels or the insides of some buildings. Constellations of smaller cheaper satellites mean that commercial companies are offering more frequent revisit rates than military constellations. In fact, the US government remains the single largest purchaser of commercial satellite imagery.

This greater reliance on satellites for both remote sensing and communication has changed the strategic calculations of a growing number of countries inside and outside of Asia. Satellites can play an important role in treaty verification at low numbers, and even drive up the cost of keeping an illicit program secret. However, the US has felt particularly vulnerable to China's anti-satellite (ASAT) program due to its strong reliance on satellites for communications and reconnaissance.

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[2] "UCS Satellite Database," Union of Concerned Scientists, last updated: 1 January 2016, available at: http://www.ucsusa.org/nuclear-weapons/space-weapons/satellite-database#.Vyc0fPkrKUk.

[3] *Ibid.*

[4] *Ibid.*

An analysis by Dr. Gregory Kulacki, of the Union of Concerned Scientists, of China's space strategy through a close reading of the Chinese military textbook, *The Science of Second Artillery Operations*, downplays Beijing's interest in exploiting the United States' dependence on satellites and characterizes China's own satellite program as nascent but rapidly growing. Further, Kulacki argues that China's own growing reliance on satellite technology is a stabilizing influence between the two powers.[5] However since the publication of *The Science of Second Artillery Operations*, China has conducted several kinetic-kill tests, including one in May 2013 which reached the previously "safe" range of high-altitude geostationary orbit, where many US military satellites reside.[6]

III) Autonomous Weapons

Autonomous weapons encompass a range of technological advances. Rather than think of autonomy in discrete weapons systems, when considering strategic stability, it may be more useful to consider different degrees of autonomy that may be possible in weapons with technical advancements. No consistent and agreed definition of autonomous weapons exists.[7]

For the purposes of this workshop, autonomy in weapons systems can be conceptualized as different degrees of machine control over a specific function. Similarly, autonomy can exist in different modalities: in the air as unmanned aerial vehicles (sometimes carrying and capable of firing weapons); in the sea as unmanned submersibles; and, on land. In all of these modalities it is important to note that the unmanned vehicles are not always weaponized. In many—perhaps most—cases the vehicles are used for reconnaissance and support operations. But it is also possible to deploy sophisticated weapons systems from unmanned vehicles, whether in the air, at sea, or on land.

Autonomous technologies are not inherently destabilizing, but weaponized systems certainly introduce uncertainty if there is not a clear understanding of the automated mechanism by which weapons are used. Conversely, autonomous vehicles could serve verification roles in conflicts or in binding treaties, increasing transparency and stability in some circumstances.

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[5] Gregory Kulacki, "An Authoritative Source on China's Military Space Strategy," Union of Concerned Scientists, March 2014, available at: http://www.ucsusa.org/sites/default/files/legacy/assets/documents/nwgs/China-s-Military-Space-Strategy.pdf.

[6] Brian Weeden and Xiao He, "U.S.-China Strategic Relations in Space," in Travis Tanner and Wang Dong, eds., *U.S.-China Relations in Strategic Domains*, The National Bureau of Asian Research, NBR Special Report #57, April 2016, available at: http://www.nbr.org/publications/specialreport/pdf/Free/06192016/SR57_US-China_April2016.pdf.

[7] Michael C. Horowitz and Paul Scharre, "An Introduction to Autonomy in Weapons Systems," Center for a New American Security, February 2015, available at: http://www.cnas.org/sites/default/files/publications-pdf/Ethical%20Autonomy%20Working%20Paper_021015_v02.pdf.

In Northeast Asia in particular, the DPRK is developing an autonomous vehicle program that has the potential to be quite destabilizing.[8] Uncertainty surrounding the level of human control and what weapons the drones may be carrying might result in a scenario on the Korean Peninsula in which a neighbor takes a small retaliatory action that escalates into a more sustained conflict. As North Korea does with ballistic missile technology, Pyongyang could seek to proliferate drone technology for currency, which could have destabilizing effects in Northeast Asia and beyond the region.

A few of North Korea's drones on display in Pyongyang. Image: KCTV.

Autonomous technologies impact stability dynamics in two main ways: one, as reconnaissance and support vehicles; two, as weapons systems. Although increases in transparency from reconnaissance can help inform realistic assessments of adversaries' capabilities and bolster stability, in some cases the loss of ambiguity may degrade stability between countries (increased satellite coverage may lead to similar effects, for example with early warning systems). Autonomous weapons rather than reconnaissance platforms may be destabilizing as an asymmetric capability, especially if rules of engagement for such systems are not clearly defined and understood by adversaries.

IV) Biotechnology

New advancements in biotechnology are making biological weapons more accessible to both state and non-state actors. Technologies like the clustered, regularly interspaced, short palindromic repeats (CRISPR)/Cas9 system allow both scientists and hobbyists to edit genes in

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[8] For a review of North Korea's drone program, see Joseph Bermudez, "North Korea Drones On: Redux," *38North*, 19 January 2016, available at: http://38north.org/2016/01/jbermudez011916/.

order to do research—even in the comfort of their own homes. For $75 USD you can buy a kit to make glow-in-the dark bacteria, for $5,000 you can build your own organism.[9] The science, particularly now that gene-editing has reached the human genome, has enormous potential for medicine or—alternatively—biological weapons.

In December 2015, scientists from the US, UK, China, and Germany met to discuss ethics behind human genome editing. Their statement[10] was a bland call for more attention to the ethical dilemmas involved in gene editing—in part—because China has already been editing the DNA of human embryos.[11] The US government will not fund research on human embryos, though privately funded research is possible. Other countries have chosen to ban the research outright.

While much of the concern around gene editing lies in a fear of a Vonnegutian future wherein bacteria with a dangerous trait are accidentally released into the world, there is another dangerous scenario: the intentional development of biological weapons. Though still in the future, US intelligence agencies are starting to prepare for a world where the barriers to editing the genes of existing biological weapons agents are dropping. Agents could be made more potent, hardier for delivery, or even perhaps more effective against a specific ethnic population. Another fear is that new biological weapons agents could be developed. American and South Korean intelligence agencies believe that North Korea has an active biological weapons capability. Its biotechnology infrastructure could easily incorporate gene-editing capabilities.

In February 2016, James Clapper, Director of National Intelligence in the US, added genome editing to a list of six WMD and proliferation threats in his statement for the record on the "Worldwide Threat Assessment of the US Intelligence Community."[12] In addition to the ethical quandaries, he called attention to the proliferation concerns. The dual-use technology is so cheap, easy to transmit, and so useful to medical research that effective export controls are hard to enforce.

The 2010 Nuclear Posture Review greatly diminished the role of nuclear weapons in responding to non-nuclear threats with a glaring exception: "it reserved the right to employ

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[9] See: "DIY CRISPR Kits. Learn Modern Science by Doing," Ingiegogo, available at: https://www.indiegogo.com/projects/diy-crispr-kits-learn-modern-science-by-doing#/.

[10] See: "In Human Gene Editing: International Summit Statement," The National Academies of Science, Engineering, Medicine, 3 December 2015, available at: http://www8.nationalacademies.org/onpinews/newsitem.aspx?RecordID=12032015a.

[11] Puping Liang, Yanwen Xu, Xiya Zhang, et al., "CRISPR/Cas9-mediated Gene Editing in Human Tripronuclear Zygotes," *Protein & Cell*, May 2015, Volume 6, Issue 5, available at: http://link.springer.com/article/10.1007%2Fs13238-015-0153-5.

[12] James Clapper, "Statement for the Record: Worldwide Threat Assessment of the US Intelligence Community," Senate Armed Services Committee, 9 February 2016, available at: https://www.dni.gov/files/documents/SASC_Unclassified_2016_ATA_SFR_FINAL.pdf.

nuclear weapons to deter CBW attack on the United States and its allies and partners."[13] Biological weapons may not be as "immediate" as nuclear weapons, but their quick and easy proliferation with the possibility of nuclear retribution make them an unequivocally destabilizing force.

V) Hypersonic Vehicles

Hypersonic vehicles is an umbrella term that encompasses different types of weapons systems. This section focuses on a long-range strike system that has a hypersonic glide vehicle. Both the United States and China are developing conventional long-range strike systems capable of flying at Mach 5 speeds.[14]

While also developing its own long-range strike capabilities and hypersonic vehicles, the US Department of Defense has pointed to China's development of the same technologies as potentially destabilizing, both to Sino-US relations and to regional stability dynamics in East Asia.[15] Simultaneous deployment of long-range conventional strike systems and nuclear weapons could complicate nuclear deterrence dynamics in the region.

These systems are not yet deployed in any country. Consequently, no real threat of proliferation exists because of the technological complexity of the systems and because of the range. When deployed, these systems may pose a threat to other deployed strategic forces, such as nuclear systems. Additionally, long-range strike systems also may further complicate already complicated dynamics surrounding missile defense deployments. With hypersonic vehicles, it may become harder to distinguish between nuclear and conventional strikes.

Hypersonic long-range strike capabilities are destabilizing, especially if nuclear and conventional deployments are co-mingled without clear command and control systems for each. Additionally, these systems may affect a country's ability to retaliate with nuclear weapons, potentially undermining established deterrent relationships and introducing instability into regional dynamics.

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[13] "Nuclear Posture Review Report," US Department of Defense, April 2010, available at: http://www.defense.gov/Portals/1/features/defenseReviews/NPR/2010_Nuclear_Posture_Review_Report.pdf.

[14] See: Joshua H. Pollack, "Boost-glide Weapons and US-China Strategic Stability," *Nonproliferation Review,* 22:2, 155-164; James Martin Center for Nonproliferation Studies, "*Hyper-glide Delivery Systems and the Implications for Strategic Stability and Arms Reductions*," April 2015, available at: http://calhoun.nps.edu/bitstream/handle/10945/45558/Hyperglide%20Final%20Report.pdf?sequence=4.

[15] See U.S. Department of Defense, "Annual Report to Congress: Military and Security Developments Involving the People's Republic of China 2015," available at: http://www.defense.gov/Portals/1/Documents/pubs/2015_China_Military_Power_Report.pdf.

VI) Cyber

As the world becomes more dependent on information technology, so does its susceptibility to potential disruption or attack by state or non-state actors. In 2010, cyberspace was mentioned exactly once in the US Nuclear Posture Review. Today, it is seen as inextricably linked to strategic security. Because cyber touches nearly every corner of increasingly advanced weaponry it can be seen as both a failsafe against human error and a dangerous vulnerability open to exploitation.

In retirement, Gen. James Cartwright, former Vice Chairman of the Joint Chiefs of Staff and Commander of US Strategic Command, has made strong arguments to end the US' "launch on warning" strategy because of cyber vulnerabilities.[16] He cautioned, "You've either been hacked and [are] not admitting it, or you're being hacked and don't know it."[17] James Clapper listed China and North Korea as two of four "Leading Threat Actors" in his 2016 Worldwide Threat Assessment. He drew particular attention to China's success in cyber espionage against the US government and private companies. In addition, Clapper noted North Korea's attack on Sony in 2014 and the assertion by South Korean officials that the North had successfully hacked a power plant and compromised its data.[18]

China's national security law, issued in July 2015, emphasized the need to "build an assurance system to protect network and information security, promote the defense capability, [and] safeguard sovereignty, security, and development benefits for the country in cyberspace."[19] However, cyber has a deeper and more ideological meaning to Chinese. As with nuclear technology, a cyber advantage is seen as an extension of the US' hegemonic thinking, and attacks on China's lack of internet freedom and privacy are seen as a pretext to undermine the regime and meddle in internal Chinese affairs.[20]

Though the US-China relationship continues to be tense, the two parties have found some shared interests in the cyber domain. In 2014, cybersecurity company Mandiant published an

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[16] See: James E. Cartwright and Vladimir Dvorkin, "How to Avert Nuclear War," *The New York Times*, 19 April 2015, available at: http://www.nytimes.com/2015/04/20/opinion/how-to-avert-a-nuclear-war.html?_r=1.

[17] Joe Cirincione, "What Happens when Our Nuclear Arsenal is Hacked?" *San Francisco Chronicle*, June 17, 2015, available at: http://www.sfchronicle.com/opinion/openforum/article/What-happens-when-our-nuclear-arsenal-is-hacked-6333739.php.

[18] James Clapper, "Statement for the Record: Worldwide Threat Assessment of the US Intelligence Community," Senate Armed Services Committee, 9 February 2016, available at: https://www.dni.gov/files/documents/SASC_Unclassified_2016_ATA_SFR_FINAL.pdf.

[19] PRC National People's Congress, "中华人民共和国国家安全法全文发布 共7章84条," 1 July 2015, available at: http://www.chinadaily.com.cn/hqcj/zgjj/2015-07-01/content_13912103.html.

[20] Adam Segal and Tang Lan, "Reducing and Managing U.S.-China Conflict in Cyberspace," in Travis Tanner and Wang Dong, eds., *U.S.-China Relations in Strategic Domains*, The National Bureau of Asian Research, NBR Special Report #57, April 2016, available at: http://www.nbr.org/publications/specialreport/pdf/Free/06192016/SR57_US-China_April2016.pdf.

eye-opening dossier on Unit 61398, a shadowy part of the People's Liberation Army (PLA), which it tied to attacks on hundreds of companies deemed strategic for China's economy.[21] Rather than allowing the relationship to deteriorate further, the US and China agreed to several basic principles of cooperation, including collaborative efforts to battle cybercrime and establishing a ministerial-level dialogue on cyber issues.[22] However, these cooperative activities are few and far between in Asia and cyber remains a largely destabilizing force.

Conclusion

Strategic stability dynamics are changing with the rise of new technologies. These technologies affect the capabilities of existing weapons systems, as well as the asymmetrical capabilities in Northeast Asia. New strategic capabilities may reduce or complicate the role of nuclear weapons in the region. Though US allies are wedded to nuclear weapons as part of extended deterrence, with technological changes in conventional capabilities, nuclear weapons may have less utility. The chart below summarizes the situation.

Technology	Stabilizing	Destabilizing
Satellites	X	X
Additive Manufacturing	X[23]	X
Biotechnology		X
Hypersonic Vehicle		X
Autonomous Weapons		X
Cyber	X	X

These six technologies affect stability mainly through two mechanisms: strategic balance and proliferation. Each of these technologies differs in the degree to which they affect stability, proliferation, or both; the technologies also differ in the degree to which they are already operational. For example, for satellites and cyber, the effects are already manifest. For

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[21] Mandiant, "APT1: Exposing One of China's Cyber Espionage Units," available at: http://intelreport.mandiant.com/Mandiant_APT1_Report.pdf .

[22] U.S. White House, "Fact Sheet: President Xi Jinping's State Visit to the United States," 25 September 2015, available at: https://www.whitehouse.gov/the-press-office/2015/09/25/fact-sheet-president-xi-jinpings-state-visit-united-states.

[23] If numerical parity in strategic weapons systems leads to stability, then additive manufacturing could have a leveling effect.

hypersonic vehicles, one of the least developed and proven technologies, the effects are still hypothetical.

How to limit any negative impacts of these technologies on strategic stability, whether through effects on capabilities or proliferation? Four of these technologies—additive manufacturing, biotechnology, satellites, and cyber are dual-use, which may necessitate controls on these technologies but also may hamper effective controls. In the realm of space security, binding treaties have not yet been possible, and instead states have opted to practice responsible use through codes of conduct. In the biotechnology sphere, the Biological and Toxin Weapons Convention has been in force since 1975, but it is widely seen as ineffective because of the lack of a verification regime. However, a drive towards informal mechanisms seems to be occurring. Establishing principles of responsible use while the emerging technologies are still inchoate could limit downwind effects on strategic stability, once the technologies mature.

In addition to limiting negative impacts on strategic stability through control mechanisms, early discussions on how these technologies interact with nuclear deterrence also may help to maintain stability. If some of these technologies may replace nuclear weapons as a strategic deterrent, then maintaining stability during this transition will be paramount. If some of these technologies are used tactically, then the effect on strategic thresholds still needs to be understood. If some of these technologies fundamentally change the mechanisms by which strategic planners understand deterrence now (e.g., satellites changing warning procedures, or cyber threats against nuclear weapons infrastructure), then countries with nuclear weapons should have open dialogues on how to mitigate the destabilizing effects resulting from technological change.

New technologies—such as additive manufacturing, satellites, autonomous weapons, biotechnology, hypersonic vehicles, and cyber—have some stabilizing but predominantly destabilizing effects. Furthermore, the rapid technological development of these new systems precipitates a complication in the effort to stem the proliferation of weapons of mass destruction, especially from North Korea. The complex interactions between these new technologies and nuclear weapons perhaps necessitate a shift in how states conceptualize strategic stability moving forward.