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U.S. strategy of damage limitation vis-à-vis China: long-term programs and effects

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Abstract
A number of U.S. military programs, if successfully developed and deployed, could undermine China's nuclear retaliatory capabilities, thereby enhancing U.S. damage limitation capabilities vis-à-vis China. Meanwhile, China seeks to maintain the credibility of its nuclear retaliatory capabilities and increase the survivability and penetration of its nuclear weapons. These interactions are part of the nuclear competition between the United States and China. This article discusses three cases: the U.S. homeland missile defense system, anti-submarine warfare (ASW) preparations, and the space-based Ground Moving Target Indicator. These programs may serve declaratory purposes in one way or another, but their development has had a negative impact on China's strategic nuclear retaliatory capabilities. Using non-nuclear means that differ technologically from the measures taken by China, these programs have created an asymmetric competition between the two sides. These U.S. programs have endured for several decades, and have continued to introduce new technologies despite occasional interruptions. The main element of development in these programs has been qualitative improvement, while quantitative increases have not always been evident. The development of these U.S. damage limitation capabilities put pressure on China's nuclear retaliatory capabilities. The arms race theories developed during the Cold War are inadequate for fully understanding nuclear competition between the United States and China. We need new theories and wisdom to explore cooperative solutions.

Keywords United States · China · Damage limitation · Missile defense · Anti-submarine warfare · Ground Moving Target Indicator

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1 Introduction

China's nuclear weapons modernization has become a prominent topic in the American strategic community. It is worth noting that Chinese nuclear modernization moves are in part responses to pressure from U.S. damage limitation programs. U.S. damage limitation vis-à-vis China means denying or reducing China's nuclear retaliatory capability. Any gain in U.S. efforts to limit damage is a loss in the effectiveness of China's nuclear deterrent. To protect its strategic nuclear deterrent, China must consider and respond to U.S. damage limitation programs.

The connections between Chinese nuclear modernization and U.S. damage limitation have sometimes been overlooked due to three reasons. The first reason is that the relations between the capabilities and intentions of some U.S. programs are complicated. For a long time, the Soviet Union (Russia) was the primary target in most of the U.S. nuclear and strategic programs but the capabilities of some of these programs may cover China. Some U.S. military programs are originally designed to counter emerging threats from proliferation countries but the capabilities of these programs may also cover China. For example, for a long time, the U.S. government claims that its homeland missile defense system is aimed at proliferation countries (U.S. Department of Defense 2022a, b, 6). The disparity between intention and capacity contributes to the complexity of the discussion.

The second reason is that some of the efforts in Chinese nuclear modernization and U.S.-damage limitation are asymmetric. For example, Chinese development of mobile missiles could increase the survivability of its nuclear weapons and enhance Chinese strategic deterrence, while U.S. development of space-based sensors to detect and locate Chinese mobile missiles could negate Chinese efforts in this regard. This is very different from nuclear competitions between the United States and the Soviet Union, in which the two superpowers pursue similar technical capabilities. It is more difficult to understand the interactive link between asymmetric competitive efforts in the U.S.-Chinese context than the symmetric programs in the U.S.–Soviet context.

The third reason is that it takes very long time, on a scale of decades, for some competitive programs in the United States and in China to be developed. During these long periods, the major focus of these programs is to improve their qualities rather than quantities. For example, the size of the U.S. homeland missile defense system, consisting of 44 to 64 interceptors now (U.S. Department of Defense 2020, 2), has been growing very slowly over the past two decades. Major efforts in the homeland missile defense program have been to improve the technical capabilities of the system. Traditional research on arms races focuses more on exploring and explaining the competitive relationship between the simultaneous numeric growth of military capabilities in rival countries, for example, the U.S.–Soviet arms race on the numbers of strategic nuclear warheads. Traditional arms race theories are not sufficient to explain the long-term nuclear competition between the United States and China (Tertrais 2001).

This paper takes a materialist approach to check the U.S. military programs that could potentially impact on China's nuclear retaliatory capability and would contribute to the U.S.'s damage limitation capability vis-à-vis China. The focus is to analyze the technical implications of these U.S. programs for China's nuclear deterrent, regardless of whether they are declared to have a purpose or not. This approach aims to avoid the endless controversies on the inequality between the capabilities and intensions of these programs.

Asymmetry is a key pattern of U.S.-Chinese competition in the nuclear domain that separates it from the U.S.–Soviet nuclear arms race during the Cold War. In this paper, all discussed cases of U.S. technologies for damage limitation and their effects on Chinese technologies are asymmetric. For example, the United States develops Doppler radars on its satellite to watch Chinese mobile missiles. Space-based radars and land-based mobile missiles are technically very different, but the former has an impact on the survivability of the latter.

The big difference between the numbers of the U.S. and Chinese nuclear weapons is the root of the asymmetrical patterns between U.S.-damage limitation programs and Chinese nuclear modernization programs. According to the FAS data (Kristensen and Korda 2023; Kristensen et al. 2024), the total nuclear warhead inventories of the United States and China are respectively 5244 and 500. In the event that the United States was to strike first, China would have little chance of saturating the incoming warheads. The situation would not change much in the event that either side changes the number of its nuclear warheads by half. Consequently, the survivability of Chinese nuclear weapons are not sensitive to the sizes of the nuclear arsenals in the two countries. China must seek other approaches to increase the survivability of its nuclear weapons, such as hiding some of its nuclear weapons. The U.S. damage limitation capability vis-à-vis China is more sensitive to its intelligence capability than to the number of its nuclear weapons.

The paper analyzes three groups of technical development in the United States that would contribute to the U.S. damage limitation vis-à-vis China: missile defense, anti-submarine warfare, and space-based ground moving target indicator.

2 U.S. ballistic missile defense and creditability of Chinese nuclear deterrence

Toward the end of the 1990s, China began to feel the pressure of a new U.S. effort for a nation-wide ballistic missile defense system, as such a system could be used to counter China's small nuclear retaliatory capability. The official U.S. declaratory position is that the U.S. homeland missile defense system is aimed at proliferation countries rather than China (U.S. Department of Defense 2022a, b, 6). But China's concerns have not been allayed by these statements, because the technical characteristics of the system do not align well with the statements. Below, we discuss the impact of the U.S. missile defense system on China's nuclear retaliation capability from three perspectives: the basic architecture of the U.S. homeland missile defense system, the number of its interceptors, and the kill probability.

2.1 Architecture

Since later 1990s, the core element of the U.S. homeland missile defense has been a ground-based midcourse intercept system. The system consists of (1) an early warning system that detects and locates incoming missile threats; (2) an X-band radar that measures the trajectory of the incoming target and identifies the nature of the target; (3) a command and control center; (4) interceptors that are guided by data from both the radar and its own infrared sensors and kill the targets by hitting them (hit-to-kill) (U.S. Department of Defense 2020).

In the current U.S. homeland missile defense system, the interceptors are deployed primarily in central Alaska and California. This basic architecture allows the system to intercept Intercontinental Ballistic Missiles (ICBMs) from North Korea, which serves as the declaratory argument and justification for the development of U.S. homeland missile defense. Due to the geographic proximity of North Korea and China, such a system could also be used to intercept nuclear retaliatory ICBMs from China.

Some American scientists had proposed alternative missile defense architectures, such as a boost-phase intercept system (Garwin 2005). Such a system might be useful in intercepting missiles from small countries such as North Korea and Iran, but would be ineffective in intercepting missiles from large countries like China and Russia. However, U.S. policymakers refused to accept this proposal and instead opted for the basic architecture of land-based midcourse interception. As long as the U.S. uses the ground-based midcourse homeland missile defense architecture and uses North Korea as the system's hypothetical enemy, the system threatens China's nuclear retaliatory capability, even if the U.S. slightly adjusts the system's geographic parameters. Therefore, when explaining its homeland missile defense system to China, the United States tends to simply state that the system is not aimed at China, rather than explaining why the system's architecture is not aimed at China.

2.2 Number of interceptors

Should China worry about the U.S. homeland missile defense system if the United States deploys a small number of interceptors? The U.S. system currently consists of 44 to 64 interceptors and this number may continue to slowly increase. Assuming that four interceptors are used to counter one incoming warhead, 64 interceptors of the U.S. homeland missile defense system could engage only 16 incoming warheads. The total number of Chinese nuclear weapons is reportedly much larger than 16 (Kristensen et al. 2024), so it does not seem that China has cause to worry about the U.S. system. Unfortunately, the comparison between the total number of Chinese nuclear warheads and the total number of the U.S. homeland defense interceptors does not work. China's concern lies in its retaliatory nuclear capability. After a hypothetical U.S. first nuclear strike, the number of Chinese retaliatory warheads would be significantly smaller than its total number and a U.S. homeland defense system with a small number of interceptors could become a substantial threat to China's nuclear retaliatory capability.

2.3 Kill probability

The issue of kill probability of a missile defense system is very complicated and the description of the issue cannot be as explicit as the issues of the architecture and the number of interceptors. The probability is influenced by numerous factors, with one crucial group being the countermeasures (or penetration aids) adopted by the offensive side.

One widely discussed countermeasure is decoy warhead (Sessler et al. 2000). One incoming missile could carry and release one or a few real warheads plus many decoy warheads. These decoy warheads are light balloons, so they do not add a lot of mass to the offensive side. If the missile defense sensors (fire-control radar and infrared sensors on the interceptors) cannot distinguish decoys from real warheads, the defensive side would have to intercept all targets. This would result in the consumption of interceptors to enhance the probability of successfully penetrating real warheads.

There are several different designs of decoy warheads. One version is to make the appearance of the decoy warheads so similar to the real warheads that they are indistinguishable to radar, making it difficult to identify the real warheads among the targets. In fact, the front of a decoy warhead must be very similar to the front of a real warhead, while their backsides could be very different (Postol 2001, 8). Missile defense radars, which are often located in front of the incoming warheads, can only see the front of the incoming and decoy warheads, not the back of either. Therefore, as long as the fronts of the real warhead and the decoy warhead are similar, the missile defense radar will not be able to distinguish between them.

The decoy warheads of the above design could work if the missile defense system has a single fire-control radar or if all radars are in the same direction of the incoming missile's trajectory. Although the backs of the real warhead and the decoy warhead have different patterns, the backs are usually invisible to missile defense radars in front of them. Therefore, for the purpose of countermeasures against the defense, it would be unnecessary for the backs of the real warhead and the decoy warhead to be the same. The problem is that over the past two decades, U.S. missile defense systems (both homeland and regional) have been expanded around the world, including to China's periphery. The growing number of U.S. missile defense radars deployed around the world allows the defense system to look at incoming warheads from multiple directions.

In 2016, the United States and South Korea declared that they would deploy the THAAD system in South Korea. The radar of the THAAD system is located at a very special position. If the system is used to observe a North Korean missile warhead attacking South Korea, the system's radar sees the front of the North Korean warhead. If the system is used to observe a Chinese warhead in a nuclear retaliation against the United States, the system sees the back of the Chinese warhead. This would allow the THAAD radar to read the radar signatures from the rear of the target. If China adopts the same design as the aforementioned decoy warhead, then the THAAD radar would have the opportunity to distinguish between a real Chinese warhead and a decoy warhead. Of course, as a penetration aide, the back of a decoy warhead could be made to look like the back of a real warhead, but this would involve additional costs for China.

One of the technical difficulties associated with a ground-based midcourse missile defense system is the exchange of data between the fire-control radar and the interceptors. The radar is very accurate in measuring radial distance, making it easier to determine which of two adjacent targets is farther away; the interceptor's infrared sensor is suitable for measuring the target's lateral position, making it easier to determine which of two adjacent targets is more to the left or right. In this case, even if the radar identifies real warhead from decoy warheads, it can only mark the radial position difference between the real and decoy warheads (farther or closer), not the lateral position difference between them. The opposite is true of an interceptor's infrared sensor. If the fire-control radar of a ground-based midcourse missile defense system is located on the same side of a group of targets as the interceptor, it is difficult for the fire-control radar and the interceptors to exchange information about the relative positions of multiple targets.

U.S. homeland missile defense radars were originally deployed along the trajectory of incoming missiles launched from East Asia, as are the interceptors. If China were to launch a nuclear retaliation, the retaliatory warheads are on the same side of the radar and the interceptors, leading to challenges in the exchange of data between them. The United States planned to deploy a new missile defense radar in Hawaii (Judson 2021). This planned radar's line of sight to the Chinese nuclear retaliatory warheads is exactly perpendicular to that of the deployed radars, and is therefore able to avoid the problem of data exchange. There would thus be better coordination between the missile defense radars and the interceptors to improve intercept effectiveness. The Hawaii radar program is not moving forward smoothly (Liang 2023; Sherman 2024), and its follow-up is worth watching.

The U.S. homeland missile defense system would undermine China's nuclear retaliation capability in terms of its architecture and the number of its interceptors. The system may have to contend with a number of technical deficiencies that could initially reduce its kill probability in the U.S.–China context. This has given China more opportunities to maintain the effectiveness of its nuclear retaliation capability. Over the past two decades, the U.S. has increased its investment in its homeland and regional missile defense systems. It has also continued to invest in upgrading their capabilities. One focus has been on deploying more missile defense radars over a wider geographic area, some of which can observe Chinese nuclear retaliatory warheads from a variety of directions, increasing the difficulty and cost of Chinese penetration aids. U.S. missile defense developments have spent an extended period of time exerting pressure on the credibility of China's nuclear retaliation capabilities.

3 U.S. anti-submarine warfare and the survivability of Chinese nuclear submarines

The development of submarine-launched ballistic missiles (SLBMs) is one of the ways in which China can increase the survivability of its nuclear weapons. If China's nuclear submarines are quiet enough, the United States would not be able to detect them and, therefore, would not be able to attack the missiles carried by those submarines in a first nuclear strike. China could thus improve the credibility of its nuclear retaliation capability. The problem is that the U.S. has conducted anti-submarine warfare (ASW) efforts against China for the past couple decades. This long-term U.S. damage limitation program against China puts pressure on the survivability of China's sea-based nuclear force.

In the field of ASW, the U.S. has an advantage on both technical and geographic levels. First, the survivability of a submarine depends on its quietness, and U.S. nuclear submarines have a tremendous advantage over Chinese nuclear submarines. The two generations of Chinese nuclear ballistic missile submarines (Type 092 and Type 094) have large missile compartment "humps" and flood openings, which could result in higher noise levels. A graphic comparing the quietness of Chinese and Russian submarines was included in a report released by the U.S. Office of Naval Intelligence in 2009. It shows that while the Type 094 is quieter than the Type 092, it still produces more noise than the Soviet Delta III ballistic missile submarine (SSBN) and Victor III attack submarine (SSN) from the Cold War era (U.S. Office of Naval Intelligence 2009, 22). If this data is true, the survivability of Chinese nuclear submarines is worrisome.

Second, Chinese submarines entering the oceans must traverse several key chokepoints in the first island chain, which are surrounded by land under the control of the U.S. and its allies, making it easy for the U.S. to deploy sensors to detect submarines and deploy anti-submarine forces. During the Cold War, the U.S. developed the Sound Surveillance System (SOSUS) with passive acoustic technology to detect discrete, narrowband tonals generated by submarines. Previously, Soviet submarines were very noisy, and the detection range of SOSUS could cover the entire ocean. As Soviet submarines became quieter, the range of SOSUS decreased dramatically. Later, the United States began deploying the Fixed Distributed System (FDS) in key chokepoints. The FDS consists of multiple passive sensors in an upward looking array that have limited coverage but can detect even extremely quiet submarines.

There is no doubt that China is working to improve the quiet level of its submarines, which will decrease the likelihood of detecting and tracking Chinese submarines by the U.S. The improved version of the 094 submarine, the 094A, was publicly unveiled during a maritime parade held in the South China Sea in April 2018 (Zhang 2018, 5). China is also developing a third-generation SSBN, Type 096. The level of submarine silence will inevitably improve over time. In early 2023, China reportedly launched a nuclear-powered attack submarine with a pump-jet propulsion system instead of a propeller. The pump-jet propulsion system can effectively reduce submarine noise, which is the first application of this technology on Chinese submarines. The U.S. is concerned that “the era of unchallenged dominance of the U.S. under the seas around China is ending.” (Gale 2023).

As Chinese submarines have become quieter, the United States, mirroring its past efforts against Soviet submarines, has begun to work with allies to build an underwater surveillance network against China (Ball 2015, 51–54). In addition to the fixed SOSUS and FDS arrays, this system includes the Surveillance Towed Array Sensor System, which can be carried by military or civilian vessels and the Transformational Reliable Acoustic Path System (TRAPS), which can be placed on the seafloor in hostile waters and used to monitor submarines passing above them (Brock 2023). In future, when Chinese submarines become quieter, the U.S. will lose the ability to locate Chinese submarines from long distances, but FDS and TRAPS will still be able to detect Chinese submarines that are traversing over the sensors.

The ranges of China’s SLBMs also affect the U.S.–China competition in the ASW domain. China’s first-generation SLBM, the JL-1, has a range of 1,700 km and lacks the capability to strike the continental U.S. (Lewis and Di 1992). The second-generation SLBM, the JL-2, has a reported range of 7,200 km (U.S. Department of Defense 2016, 26). At this range, the JL-2 would not be able to reach the continental U.S. when launched from the Chinese coast, and Chinese SSBNs carrying the JL-2 would have to pass through the first island chain to do so, which would further reduce their survivability. The U.S. Department of Defense reports that the JL-3, a third-generation submarine-launched ballistic missile, has probably already been deployed on the Type 094 nuclear submarine, and that the JL-3 can be launched from waters around China to reach the continental U.S. (U.S. Department of Defense 2023, 55). However, given that the JL-3’s range is only 9,700 km, its reach is still very limited, and launching it from the vicinity of Qingdao would barely be able to strike the northwestern part of the U.S. mainland.

The U.S damage limitation capabilities in the fields of anti-submarine and missile defense are closely related. If the Chinese submarine is noisy, then the best result for the United States is to sink the submarine before it launches its missiles, significantly reducing the pressure on the U.S. missile defense system. With the improvement of Chinese submarine quietness, the United States may not be able to guarantee its anti-submarine capability at all times to hold the Chinese strategic nuclear submarines at risk, but it can still roughly locate the submarine. At this point, the U.S. could deploy warships carrying anti-missile interceptors based on the submarine’s approximate location in preparation for intercepting Chinese SLBMs. Finally, when the Chinese nuclear submarines are quiet enough to break through the first island chain to patrol any water, and the U.S. anti-submarine system is unable to give even an approximate indication of their location, the U.S. homeland missile defense system will be directly confronted with all the submarine-launched missiles.

Since Soviet/Russian strategic nuclear submarines have long since ceased patrolling the southern hemisphere, the current U.S. missile defense system is designed to target incoming missiles from the north, and missile warning radars have been dismantled in the southern part of the United States. If Chinese nuclear submarines were to patrol the South Pacific, it raises a new concern about whether the U.S. builds a missile defense system to counter incoming missiles from the South.

The use of SSNs to trail rival SSBNs is a strategic ASW tactic used by the United States since the Cold War, where SSNs are stationed in the vicinity of rival submarine's home port and follow the SSBN when it leaves the port. The U.S. undersea surveillance network can also be used to locate SSBNs and direct the SSNs to search and establish a trail within a small area. The premise of trailing is that the noise level of the target submarine is higher than that of the trailer, and the trailing distance has to be close enough so that the sonar of the trailer can detect the target submarine, but far enough away that the sonar of the target submarine can't detect the trailer. Close and continuous tracking of a quiet submarine could easily lead to collisions. According to Reuters, although it is unclear if China is deploying fully armed SSBNs to maintain continuous deterrent patrol, the United States and its allies (including Japan, Australia, and the United Kingdom) are ready to step up their efforts to continuously trail Chinese SSBNs (Torode and Lague 2019). The stage set for the US and China to play an underwater "cat and mouse game".

Artificial intelligence technology and its application to unmanned surface vessels (USVs) and unmanned underwater vehicles (UUVs) provide new options for U.S. ASW. The U.S. military has developed a number of unmanned combat platforms that can perform early warning, surveillance, anti-submarine, surface ship strike, and special operations missions. They feature a variety of modes of operation, including remotely controlled, semi-autonomous, and autonomous. Typical projects include the Sea Hunter USV, which has a trimaran sailboat shape and can operate autonomously for 3 months without human intervention, and the large-diameter unmanned underwater vehicle (LDUUV), which can be deployed and recovered from a nuclear submarine, with a self-sustainability requirement of 70 days or more. These U.S. technological upgrades have put new pressures on the survivability of China's submarine-launched missiles.

The United States has been carrying out ASW preparatory activities against China for a long time, with continuous technical upgrades. It is part of a long-term U.S. damage limitation effort against China and is one of the obstacles to China's establishment of a credible nuclear deterrent.

4 U.S. Ground moving target indicators and the survivability of Chinese-mobile ICBMs

The United States could read the photos taken by its space-based infrared and optical sensors to search fix-based Chinese nuclear weapons. However, mobile missiles are entirely different. Even if the United States is able to locate some Chinese mobile missiles, these missiles can be moved to new positions. The U.S. space-based infrared and optical sensors cannot persistently track Chinese mobile ICBMs because these missiles can sometimes be hidden in the dark or shielded by clouds. This is an opportunity for China to increase the survivability of its nuclear weapons through mobility.

China has spent a couple of decades developing and deploying its mobile ICBMs. The United States has spent about the same amount of time trying to build a space-based capability, called the Ground Moving Target Indicator (GMTI), to track mobile targets on the ground. It launched its first space-based GMTI program, the Discoverer II, in 1998 (GlobalSecurity 2011) and recently committed to renewing this effort (Hudson and Trimble 2021). Unlike the space-based infrared and optical sensors, which could be shielded by clouds, a U.S. space-based GMTI system could in principle provide real-time tracking of Chinese mobile missiles, thus reducing their survivability. This is another form of competition between U.S. damage limitation and Chinese nuclear retaliation capability.

A GMTI system consists of elevated Doppler radars that send radar beams to ground targets. The frequency of the radar beams reflected from moving targets with non-zero radial speed changes, while the frequency of radar beams reflected from stationary targets remain the same as original. If the system screens out a radar beam with an unchanged frequency from stationary ground targets, it can highlight moving targets with non-zero radial targets. A radar system operated in this way is called a GMTI or a surface moving target indicator (SMTI).

The Doppler radars operated in GMTI mode can be carried by airplanes and satellites. Airborne GMTI radars are technically more mature but they may have to invade the airspace of rival countries and would potentially need to contend with their air defense. So, space-based GMTI radars are more useful in peacetime and for strategic purposes. This paper only discusses the GMTI that are related to space-based systems.

According to the designs proposed around 2000s, about twenty or so GMTI satellites would be deployed on low earth orbit, for example, at an altitude of 1000 km. Each satellite carries a GMTI radar. The maximum detectable range of a GMTI radar is 2800 km for a moving target with a radar cross-section (RCS) of 10 square meters. Apparently, this requirement is aimed at tracking big vehicles, for example, the Transporter-Erector-Launchers (TELs) that carry mobile missiles. If a GMTI radar detects a moving mobile missile on the ground, it could track the target for more than ten minutes until its hands over the monitoring task to another GMTI radar. A GMTI system in this constellation could cover most of the earth's surface, with the exception of two poles (Li 2007).

The space-based GMTI involves some very challenging technologies, for example, a radar on low earth orbit may need a very large antenna. The United States has not been successful in deploying a space-based GMTI so it has to rely on air-based GMTI to track moving targets on the ground. However, the United States recently explored new ventures to build a space-based system. Some U.S. military and intelligent organizations, including the Space Force, Indo-Pacific Command, Air Force, National Reconnaissance Office, are working on the system. A prototype radar may be launched in around a year (Albon 2023; Hudson and Trimble 2021).

The U.S. space-based GMTI system aims to provide real-time tacking of mobile missiles. If successfully deployed, the Chinese mobile ICBMs would be at risk of exposure to the U.S. GMTI system and their survivability would be threatened.

5 Conclusions

In recent decades, the United States has been working or attempting to work on a number of programs that, whatever their stated purposes, could negatively impact China's nuclear retaliatory capability. They could contribute to the U.S. damage limitation capability vis-a-vis China and put pressure on China. China must protect its nuclear retaliatory capability and respond to these programs. These interactions constitute asymmetric competition between the United States and China in the nuclear field. This paper has discussed three U.S. programs as examples: homeland missile defense, ASW, and space-based ground moving target indicator.

The U.S. homeland missile defense system could be used to intercept Chinese nuclear retaliatory missile warheads. As the United States adds new missile defense radars and integrates them into the homeland system, the system could become more capable of defeating penetration aids. U.S. preparations for ASW could make it easier for the United States to round up China's missile submarines and reduce their survivability. As China's nuclear submarines become quieter, the United States is also taking new steps to improve its ability to track them. The United States has been trying to develop and deploy a space-based GMTI system that could be used to track Chinese mobile ICBMs and it has recently renewed such efforts. If successfully deployed, the system could potentially reduce the survivability of Chinese mobile missiles.

Over the past 2 decades, the United States has made long-term investments in these three areas and others. There have been times when certain projects have gone well and times when they have not. From China's perspective, these programs represent a long-term potential threat to its nuclear retaliatory capabilities. The resulting nuclear competition between China and the United States is characterized by asymmetry: the technologies employed by the two sides are different. China could opt for moderate measures to protect its nuclear retaliation capability, but the United States is exploring new technological means in a number of different areas to suppress China's nuclear retaliation capability. This may force China to adopt more expensive technological means and would be detrimental to both countries.

Arms race theories developed during the Cold War are inadequate for understanding the nature and pattern of nuclear competition between the United States and China. We need new theories and wisdom to explore cooperative solutions for the two countries on this issue. Nuclear competition between the United States and China needs to be mitigated and stabilized through nuclear dialog. Previous discussions have more or less imitated the U.S.–Soviet dialogs, shaping the agenda more from a symmetrical perspective. According to this paper, it is more important to use an asymmetric perspective between China and the U.S. to examine the long-term movements and implications.

In addition to the three areas discussed in this paper, some other new technologies, such as artificial intelligence, some space technologies other than GMTI, and cyber technology, may also be involved in the U.S.–China competition for damage limitation and nuclear retaliation. It is imperative that we also pay attention to these new developments.

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