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Prompt Global Strike: American and Foreign Developments

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Chairman Rogers, Ranking Member Cooper, Members of the Committee,

It is a genuine honor to testify before you today. Thank you for the opportunity. I hope I can be of help to this committee on this issue both today and in the future.

I am a senior associate and co-director of the Nuclear Policy Program at the Carnegie Endowment for International Peace. I hold a Ph.D. in theoretical physics and, for the last four years, have been studying the development of hypersonic conventional weapons in the United States, China, and Russia from both a technical and policy perspective. While I would like to focus my testimony on the U.S. Conventional Prompt Global Strike (CPGS) program, I would be very pleased to answer questions about Chinese and Russian developments too.

Let me emphasize from the start that I am genuinely undecided about whether the United States should acquire CPGS weapons. The capability would unquestionably convey potential benefits, but it would also carry potential risks. Today, in my opinion, the relative magnitudes of those benefits and risks are unclear.

The difficulty of reaching a definitive conclusion about whether to acquire CPGS weapons stems, in part, from technological immaturity; the underlying technology is extremely challenging and further research and development—including flight testing—is required prior to any procurement decision. However, it also stems from what I believe are flaws in the Department of Defense's approach to CPGS development.

Most importantly, the Pentagon has no official policy that sets out the specific military missions for which CPGS weapons might be acquired. Until it does so, there can be no yardstick against which to judge their likely effectiveness. The trade-offs associated with acquiring other weapons for the same purposes also cannot be properly assessed. To compound matters further, the Department of Defense appears to have failed to properly consider the enabling capabilities needed to ensure the effectiveness of CPGS weapons as well as the full range of escalation risks.

Not only do these flaws make it impossible, at this time, to reach a conclusion about the ultimate desirability of CPGS weapons, but they also create a real risk that the United States will develop weapons that

(i) are not optimized, from a military perspective, for the missions for which they might be employed;
(ii) are not the most cost-effective way of prosecuting those missions; and
(iii) exacerbate escalation risks with Russia and China unnecessarily.

A brief history of CPGS development

For more than a decade, the United States has explored various technologies for long-range, high-precision, hypersonic strike, including terminally guided ballistic missiles and hypersonic cruise missiles (the latter being funded separately from the CPGS program). Today, the CPGS program is focused on "boost-glide" weapons. Like a ballistic missile, a boost-glide weapon is launched by a large rocket. However, rather than arcing high above the atmosphere, a hypersonic glider is launched on a flatter trajectory that either re-enters the atmosphere quickly—or does not leave it at all—before gliding unpowered to its target.

Initial efforts to develop boost-glide weapons focused on a global-range system, known as the Hypersonic Technology Vehicle-2 (HTV-2). Following two unsuccessful flight tests, in 2009 and 2010, work on this system was suspended in favor of the Advanced Hypersonic Weapon (AHW). The AHW is still in the research and development phase; no acquisition decision has yet been taken. If deployed, the AHW could be based on land or at sea (or perhaps both). According to a 2008 report by the U.S. National Academy of Sciences, the AHW could travel a maximum distance of about 5,000 miles. To my knowledge, this is the only unclassified and authoritative statement about the weapon's range and I do not know whether it is still accurate. Nonetheless, it appears that the AHW might perhaps best be described as a non-global Conventional Prompt Global Strike weapon.

The AHW has been tested twice. A November 2011 test, over a range of about 2,400 miles, appears to represent the first successful flight by any nation of a hypersonic glider over any distance longer than a few hundred miles. A second test, in August 2014, failed because of a booster problem. The Department of Defense's most recent budget request indicates that two more AHW tests, described as "Navy Flight Experiments," are planned in FY 2017 and FY 2019. In my opinion, any acquisition decision should be preceded by sufficient flight testing to demonstrate the system's reliability at its maximum planned range. Such testing should also demonstrate the weapon's ability to maneuver in flight and strike a target with sufficient accuracy for a non-nuclear warhead to be military effective.

The Department of Defense has not identified the specific military missions for which CPGS weapons might be acquired.

The Department of Defense has no policy identifying the specific missions for which CPGS weapons might be acquired. The program's purpose is often stated to be the development of high-precision conventional weapons capable of reaching targets anywhere on earth within an hour. Not only is this mantra an increasingly poor description of the technology actually being developed—the AHW lacks a global range, as do most of the other concepts that have been considered—but it also does not speak to the specific missions for which CPGS weapons might be employed.

Based on official documents and statements by senior officials, it appears that four missions for CPGS weapons have been or are being considered:

- **Counter-nuclear strikes**: denying a new proliferator—generally identified as North Korea or, perhaps in the future, a nuclear-armed Iran—the ability to employ its nuclear arsenal. (There is very little evidence of official U.S. interest in acquiring CPGS capabilities for counter-nuclear strikes against Russia or China.)
- **Countering anti-satellite capabilities**: destroying or disabling an adversary's anti-satellite capabilities, particularly China's.
- **Defense suppression**: countering China's and other states' anti-access/area-denial capabilities that threaten U.S. freedom of movement into and within combat zones.
- **Counterterrorism**: killing high-value terrorists and disrupting terrorist operations.

Each of these missions imposes quite different weapon requirements—a point that tends to be lost in abstract discussions of striking targets anywhere on the globe within an hour. These requirements differ according to a number of factors:

- The need (or otherwise) for **promptness**—a short time between the decision to use a weapon and its reaching the target

- The need (or otherwise) for **tactical surprise**—ensuring that an adversary has too little warning of an incoming strike to take effective countermeasures
- The required **range** of the weapon
- The type and effectiveness of **defenses** that are present
- The **target's characteristics**, including whether it is mobile or buried

To attack Chinese anti-satellite capabilities preemptively, for example, CPGS weapons would have to be able to penetrate robust defenses and could need ranges of at least a few thousand kilometers and potentially much more, depending on their basing mode. Tactical surprise would be critical to mission success. Promptness, however, would probably not be essential because the conflict would almost certainly have been preceded by a prolonged crisis lasting days if not weeks, making it essentially irrelevant whether weapons took one hour or ten hours to reach their targets. By contrast, if North Korea used nuclear weapons and the United States sought to prevent further attacks, promptness could be critical, but the distances involved would generally be shorter and the defenses much weaker than in the case of attacks on China.

The risks and benefits of different CPGS technologies and of non-prompt alternatives can only be evaluated with reference to specific missions.

All of the different potential CPGS technologies and their non-prompt alternatives have strengths and weaknesses; none is the "best" in any absolute sense. The trade-offs between them can only be evaluated in the context of specific scenarios.

To give but one concrete example, the Department of Defense has explored hypersonic weapons with ranges varying from global (in the case of HTV-2) to hundreds of miles (for some hypersonic cruise missiles). Intuitively, longer ranges may appear more desirable, and indeed, they offer a number of genuine advantages including reducing or eliminating the need to deploy forces forward in advance of a conflict. In some circumstances, however, weapons with longer ranges can become more susceptible to adversary countermeasures. There is a growing body of evidence, for example, that China is developing early-warning satellites that could detect a boost-glide weapon shortly after launch. Such satellites could provide about 30 minutes of warning of an attack originating from the continental United States—potentially enough time for Beijing to take countermeasures (it could, for example, use anti-satellite weapons before they were attacked). By contrast, weapons launched from places closer to China would provide it with less warning. To ensure funds are spent efficiently, it is well worth understanding the trade-offs associated with longer ranges—and indeed, with all the other characteristics of CPGS weapons—as early as possible in the research and development process and, certainly, in advance of any acquisition decision.

A scenario-based approach to CPGS development would also permit non-prompt alternatives to CPGS weapons to be properly considered. No non-prompt weapon system offers all of the desirable attributes of CPGS weapons; however, there is also no potential mission for CPGS weapons that utilizes all of these attributes simultaneously. As a result, it is possible that non-prompt weapons could offer a more cost-effective way than CPGS weapons of prosecuting certain missions. Stealth is the principal competitor to speed in many circumstances. Stealthy weapons may be able to penetrate advanced defenses and evade early-warning systems. For missions requiring promptness, forward basing may be able to compensate for slower weapon speeds and can be a viable approach when strategic warning of a conflict is likely.

To be clear, I do not claim to know which potential CPGS technology is the most promising; nor do I claim to know whether non-prompt weapons offer a more cost-effective alternative to CPGS weapons in any of the scenarios for which CPGS weapons might be acquired. I am, however, concerned by the lack of any evidence that the Department of Defense is evaluating the trade-offs. Indeed, I do not see how it can reasonably do so, unless it adopts a scenario-based approach to CPGS development.

Enabling capabilities are critical to the effectiveness of CPGS weapons, but appear to have been neglected.

Without the right enabling capabilities—command and control; intelligence, surveillance, and reconnaissance; and battle damage assessment—CPGS weapons could prove unusable. So far these support systems appear to have received insufficient attention.

Current deficiencies are clearly illustrated by the difficulty of destroying mobile targets, such as road-mobile missiles. All of the potential missions for CPGS weapons could present this challenge. Locating and tracking mobile targets is very difficult, as the United States learned during the 1991 Gulf War, when it failed to achieve a single confirmed kill of an Iraqi Scud launcher in almost 1,500 sorties.

Today, the most plausible means of detecting and tracking mobile targets would be through manned and unmanned surveillance aircraft operating from within or close to the theater of operations. Using these assets to provide targeting data for CPGS weapons would, however, make little sense. If the battlespace permitted the use of aircraft for surveillance, then it would be more effective and cheaper to outfit those same aircraft with strike weapons and use them for offensive operations than to develop a CPGS capability.

Acquiring CPGS weapons to attack mobile targets would make military sense only if the United States also developed a reliable means of remotely locating and tracking these targets. Plans for such a capability—notably, a globe-spanning network of satellite-based radars—have repeatedly been canceled, and to my knowledge, no program is currently in the works. Given that this capability would probably cost an order of magnitude more than the CPGS weapons themselves, deficiencies in current enabling capabilities merit immediate attention.

Probably more worrying than specific gaps in enabling capabilities are apparent organizational deficiencies within the Department of Defense that may cause this issue to receive insufficient attention. A 2008 report by the Government Accountability Office expressed concern that major Department of Defense studies did not analyze what enabling capabilities would be required but instead simply "assumed that certain needed improvements…would be available when any future [weapon] system is fielded." Remarkably, the GAO reported that, in one of these studies—the Prompt Global Strike Analysis of Alternatives—enabling capabilities were not considered because, among other reasons, "the study staff lacks the special access clearances required to obtain information on all [Department of Defense] efforts for improving enabling capabilities." If such deficiencies still persist—as I believe they do—they severely threaten the viability of any future CPGS weapon system.

The full range of escalation risks associated with CPGS weapons has not been considered. Debate about the international ramifications of CPGS weapons—indeed, debate about the program as a whole—has been dominated by a single issue since 2006, when President George W. Bush's administration first announced plans to replace the nuclear warheads on some Trident II D5 ballistic missiles with conventional weapons. These plans sparked concern in Congress that a state observing the launch of a CPGS weapon—Russia in particular—might incorrectly identify it as a nuclear weapon and launch a response in kind.

Although plans for the so-called Conventional Trident Modification have been dropped, warhead ambiguity still dominates the discussion about the escalation risks of CPGS weapons. Indeed, the Department of Defense focused the CPGS program on boost-glide weapons largely because it saw them as a way of mitigating warhead ambiguity. It argues that conventional boost-glide weapons can be distinguished by their non-ballistic trajectories from nuclear-armed ballistic missiles. This argument is, however, not entirely persuasive. While the launch of a boost-glide weapon would be detectable by early-warning satellites, it would generally fly at too low an altitude to be monitored by early-warning radars thereafter. As a result, a state observing—or, rather, trying to observe—a boost-glide weapon would not see an object flying in a non-ballistic trajectory; it would see the launch of a weapon that would quickly disappear from view. The extent to which warhead ambiguity would be mitigated by an unobservable characteristic is, to say the least, an open question.

The risk of warhead ambiguity should not be ignored, especially if the United States acquired CPGS weapons to conduct strikes on China or, much less likely, on Russia. However, the focus on warhead ambiguity has been unhelpful by obscuring other risks.

For example, highly maneuverable CPGS weapons with unpredictable trajectories could create a different form of ambiguity—destination ambiguity, which is uncertainty on the part of an observing state about whether it was the target of a CPGS attack. CPGS attacks against North Korea, for example, could potentially lead Russia or China to conclude that they were under attack, risking inadvertent escalation. (The risk would be even greater if the observing state also misidentified the CPGS weapon as nuclear armed.)

Ambiguity could arise about the nature of the intended target as well. For example, China's nuclear-armed missiles and conventional anti-ship ballistic missiles are reported to share a single command-and-control system. Because some components of this system are buried, hypersonic weapons may provide the only non-nuclear means to attack them. There is a real risk, however, that Beijing could interpret such strikes as an attempt to deny China control of its nuclear arsenal even if their actual goal was to protect American aircraft carriers from Chinese conventional weapons. Such target ambiguity, arising from attacks on "entangled" assets, could be highly escalatory.

Crisis instability is also a real risk; an adversary's fears that CPGS weapons could destroy its strategic weapons could lead the adversary to employ those weapons preemptively. "Strategic" does not just mean nuclear. In a conflict with the United States, for instance, Beijing would want to protect its anti-access/area-denial capabilities. It could do so by destroying or disabling the GPS satellites on which CPGS weapons would, in all probability, rely for navigation. Fearing this, the United States would have an incentive to destroy Chinese anti-satellite capabilities with CPGS weapons early in a conflict. This threat would, in turn, give China an incentive to attack the GPS constellation preemptively to disable CPGS weapons. The result could be rapid escalation that both sides might rather avoid.

Mitigating these escalation risks is complex and, as always, trade-offs are involved. Maneuverable boost-glide weapons may, for example, help reduce warhead ambiguity but at the cost of simultaneously exacerbating destination ambiguity. It would be helpful to understand these trade-offs as early as possible in the CPGS development process.

Finally, it is worth observing that escalation is something of a double-edged sword. While CPGS weapons might undermine the prospects for escalation management in a conflict, they might simultaneously enhance deterrence. Specifically, the very possibility of rapid, unpredictable escalation might have the beneficial consequence of raising the perceived costs of war and making a potential adversary less likely to transgress the interests of the United States or its allies.

Conclusion: A course correction for the CPGS program

I will not even try to offer any definitive conclusion about whether the United States ought to acquire CPGS weapons; as I said at the start of my testimony, I am genuinely undecided. However, I do believe that a course correction is required if the program is to live up to its full potential and, perhaps even more importantly, if Congress is to be able to assess the scale of that potential.

To date, the CPGS program has focused too narrowly on technology development; there has been an apparent failure to give proper attention to the role of CPGS weapons—and potential alternatives—in national strategy. To this end, I would like to conclude by offering some suggestions for how the Department of Defense might improve its process for developing CPGS weapons.

- The Department of Defense could produce an unclassified policy statement on the specific missions for which CPGS weapons might be acquired.

- The Department of Defense could conduct classified studies into the implications of possible adversary countermeasures over the next two or three decades for CPGS weapons, including a comparison of the effect of such countermeasures on non-prompt alternatives.

- The Department of Defense could conduct a comparative study of CPGS weapons and non-prompt alternatives in terms of their ability to hold mobile targets, and hard and deeply buried targets at risk; their relative unit cost; and their capability to successfully prosecute each of the missions for which the Department is considering acquiring CPGS weapons.

- The Department of Defense could conduct a comprehensive and dedicated examination of gaps in enabling capabilities; and develop plans, with cost estimates, to fill these gaps.

- The Department of Defense could produce an unclassified report on (i) the escalation risks of CPGS weapons, including but not limited to warhead ambiguity; and (ii) possible ways of mitigating them, including cooperative approaches.

Appendix: A summary of Russian and Chinese boost-glide development programs

There is very strong evidence that both China and Russia are engaged in research and development into boost-glide weapons.

It has been widely reported that, since January 2014, China has conducted six tests of a hypersonic boost-glide weapon prototype, reportedly called DF-DZ and dubbed WU-14 by the Department of Defense. At least one senior American official has unequivocally and publicly confirmed the U.S. assessment that the first test did involve a hypersonic glider. Chinese blogs have also published the "keep-out zones" for some of the tests (states sometimes declare such zones in advance of missile test to warn pilots of falling debris). These zones also provide strong and direct evidence of the testing of a glider (with the caveat that I have only been able to find independent confirmation of the accuracy of the zones for just one test).

There is real uncertainty about how advanced China's program to develop a hypersonic glider is and how fast it is progressing. On balance, however, the keep-out zones tend to suggest that China's program is significantly less advanced than the United States'. They imply that Chinese tests have covered ranges of less than about 1,250 miles (by contrast the AHW has successfully flown over a distance of about 2,400 miles). In addition, all but one of China's tests appear to have involved virtually straight flight paths with no cross-range maneuvering. In one test, the glider may have maneuvered towards the end of its flight—although the evidence is difficult to interpret. Moreover, it is also important to note that keep-out zones imply the plan for a test; they do not provide evidence as to whether the test was successful. Photos of the debris from the test on August 7, 2014 that appeared on Chinese social media provide reasonably persuasive evidence that this test failed. To my knowledge, there is no publicly available evidence to indicate whether the other tests were successes or failures.

The National Air and Space Intelligence Center has publicly assessed that China's glider program is associated with the country's nuclear forces. While I have no particular reason to doubt this assessment, the information I have at my disposal does not enable me to draw a conclusion about any intended payload: it may indeed be nuclear, but I would also not rule out the possibilities that it is conventional or that China intends to deploy both nuclear and conventional variants. It is also possible that no decision about payload has yet been taken (especially if Beijing has not actually decided whether to deploy boost-glide weapons).

China is likely to face significant difficulties in developing gliders with very long ranges (i.e. a few thousand kilometers or more). The development of such gliders severely exacerbates the engineering challenges associated with shorter-range systems, such as managing the heat that is generated through atmospheric friction. Given sufficient time and resources, China should be able to overcome this challenge, just as the United States seems to have done, as well as the many other obstacles it would face. However, the development of long-range gliders is unlikely to be quick or painless; it is certainly not a case of just putting a glider never tested at long ranges, and perhaps not designed for long-range flight, on top of a more powerful booster.

Russian interest in boost-glide weapons dates back to at least the 1980s, when Moscow became concerned that its existing nuclear-armed re-entry vehicles might not be able to penetrate the highly effective defense systems foreseen by President Ronald Reagan's Strategic Defense Initiative program (popularly known as "Star Wars"). These efforts were revitalized in the 1990s and then again in the 2000s, apparently for similar purposes. Their current incarnation is reportedly known as Project 4202. The most detailed and credible description of this program comes from Pavel Podvig, a respected observer of Russia's strategic forces. He assesses that Russia has conducted three or four hypersonic glider tests since 2011, of which at least two were failures. The range of Russia's glider is not known (although it appears to be substantially longer than China's).

While Russia has not openly acknowledged Project 4202, a series of senior Russian officials have, since 2012, made statements that indicate an interest in developing boost-glide weapons and have strongly hinted that such efforts are already underway (although none has said so unambiguously). Russia's primary goal is almost certainly still to ensure that it can continue to deliver nuclear warheads through U.S. missile defenses. It may also seek to develop conventional boost-glide weapons. Converting a glider designed to deliver nuclear warheads into one capable of delivering conventional warheads would, however, be a major undertaking since the accuracy requirements for a conventionally armed missile are significantly more demanding.