CARNEGIE
ENDOWMENT FOR
INTERNATIONAL PEACE

Congressional Testimony

CHINA'S OFFENSIVE MISSLE FORCES

Testimony by **James M. Acton**
Senior Associate
Carnegie Endowment for International Peace

Testimony before the U.S.-China Economic and Security Review Commission

April 1, 2015

Mr. Chairman, Commissioners,

It is a genuine honor to testify before you today. I am a theoretical physicist turned policy wonk, who for almost a decade has worked on nuclear deterrence, disarmament, nonproliferation, and nuclear energy. While I do not claim to be a China expert *per se*, I do have expertise in both nuclear deterrence and hypersonic weapons. In 2013, I authored a book-length study on the development of prompt, long-range, conventional strike capabilities, *Silver Bullet?: Asking the Right Questions About Conventional Prompt Global Strike*, and have since published a number of pieces about China's efforts in this area.

Today, I would like to address four issues: (i) the drivers and possible extent of China's nuclear modernization program; (ii) the possibility of changes to China's nuclear doctrine; (iii) the technical status of China's hypersonic boost-glide weapon development program; and (iv) the strategic drivers and implications of China's pursuit of boost-glide technology. The discussion of China's force modernization and nuclear doctrine will help to set the context for understanding the possible drivers of its boost-glide program.

China's Nuclear Forces: Future Build-Up And Trajectory

The People's Liberation Army (PLA) is slowly building up its nuclear forces and this trend seems likely to continue for the time being. Without significant resource investments, however, it cannot continue indefinitely since Beijing possesses only a limited quantity of fissile material, which is required to manufacture nuclear explosives. All unclassified attempts to estimate the size of China's fissile material stockpile by analyzing the capacity and operation of its enrichment plants and plutonium-production reactors have reached the conclusion that China only produced enough material for a nuclear arsenal numbering in the hundreds. It appears that China is currently observing an undeclared moratorium on further production. Admittedly, this moratorium is much more difficult to verify for highly enriched uranium than for plutonium. However, assuming China uses plutonium primaries in its nuclear weapons, which the fall-out from atmospheric testing suggests and is desirable for miniaturization, the moratorium on further plutonium production is enough, by itself, to cap the size of China's arsenal.

China could try to spread its existing fissile material stockpile more thinly by attempting to improve its weapon designs so each warhead uses less material. However, in the absence of renewed nuclear testing, this change would be difficult and would probably involve significant technical risk. Even if it were successful, this approach might allow for, say, a 25 percent increase in arsenal size, but probably not much more. Alternatively, Beijing could decide to manufacture more fissile material. While this eventuality cannot be ruled out, it would probably be detected by U.S. intelligence at an early stage.

The most striking of the changes to China's nuclear forces are qualitative, not quantitative. In particular, the PLA is significantly enhancing their mobility—and hence improving their survivability—by its deployment of new road-mobile missiles, and its development of the *Jin*-class submarine and JL-2 sea-launched ballistic missile. China's submarines may have attracted more attention but the PLA's road-mobile missiles are almost certainly more survivable given the relatively high noise levels associated with China's second-generation nuclear-powered submarines, the expertise of the U.S. Navy in anti-submarine warfare, and the extraordinary difficulty of tracking and destroying mobile targets in a huge country with robust air defenses.

The PLA appears to be genuinely concerned about the long-term survivability of its nuclear forces and these concerns are, in part at least, a motivation for its force modernization. As Jeffrey Lewis has noted, development of the DF-21 medium-range ballistic missile began in the late 1970s, while the decision to procure the DF-31 and DF-41 intercontinental ballistic missiles (ICBMs) was taken in 1985. China's decision to develop more survivable mobile missiles at that time—when its nuclear forces were smaller and much more fragile than they are now—suggests it was motivated by survivability concerns, rather than more offensive purposes.

Three decades later, these concerns remain—although they have evolved. Today, in addition to worrying about the threat of a nuclear first strike by the United States, Chinese military thinkers increasingly express concerns about a conventional first strike. They tend to talk generally about "conventional strategic strike capabilities" or simply "conventional weapons," suggesting their concerns are broader than any one specific weapon system. One important illustration of this concern comes from a classified 2004 PLA textbook, *Science of Second Artillery Campaigns*, which identifies China's "nuclear missile troops and their launch sites" as "the core targets" of an adversary's pre-emptive attacks. It then calls upon the Second Artillery Corps, the PLA's missile branch, to prepare defenses

> against the precision guided weapon attacks launched from the enemy's land (sea) platforms, against weapon attacks delivered from the enemy's aerial platforms, and against the attacks mounted by the enemy's airborne troops, and attacks and harassments carried out by the enemy's special operation forces.

It is clear from the subsequent text that "precision guided weapons" refers to cruise missiles such as the Tomahawk. Most noticeable, however, is the reference to airborne and special operations forces as a threat to China's nuclear weapons. To see such concerns highlighted in what most American experts consider an authoritative Chinese document is striking. Other Chinese authors, especially in recent years, have highlighted concerns about U.S. programs to develop long-range, hypersonic, conventional strike capabilities. Indeed, this concern is specifically highlighted in the 2013 edition of the PLA's unclassified textbook, *Science of Military Strategy*.

Chinese strategists have also expressed serious concerns about current and particularly future U.S. ballistic missile defenses, including the possibility that, in combination with conventional counterforce capabilities, they could allow the United States to disarm China without crossing the nuclear threshold. As I will discuss, China's development of boost-glide technology may be a response to this fear. Its development of multiple independent re-entry vehicle (MIRV) technology may be another response; indeed, the U.S. Department of Defense assessed explicitly in its 2014 report on *Military and Security Developments Involving the People's Republic of China* that this is the case. However, I would not rule out the possibility that MIRV technology may have been developed as a way of reducing the costs of a larger arsenal, or that different constituencies within the Chinese military and government have supported it for different reasons, as was the case in the United States.

Finally, while less discussed, it is also possible that internal considerations—not just external ones—shape Chinese policy in important ways. After all, U.S. and Soviet/Russian nuclear-weapon decisions—particularly over procurement—were not based solely (or perhaps even mostly) on cold-blooded cost-benefit calculations. They were shaped by bureaucratic and political factors. The Kennedy administration, for example, increased defense spending, including the construction of more nuclear weapons, to stimulate the U.S. economy. Meanwhile, according to a detailed study of Soviet nuclear policy based on interviews with senior decision-makers conducted just before and after the collapse of communism, Soviet acquisition policy was largely driven by the defense-industrial sector's use of "its political clout to deliver more weapons than the armed services asked for and even to build new weapon systems that the operational military did not want." While the specific internal factors at play in China may be rather different, I would not assume they are absent.

China's Nuclear Forces: Doctrinal Tensions And Developments

China's no-first-use pledge has been a core feature of its nuclear doctrine since 1964 and remains so today. However, it appears to concern some PLA strategists, especially those who worry about the potential for conventional attacks on China's nuclear forces. The omission of the pledge from China's 2013 defense white paper was, I believe, a reflection of this dissention. To be sure, Beijing quickly restated the pledge when questioned, so I no longer believe that the white paper was intended to signal a change in policy. However, neither do I believe the explanation, offered by Chinese experts and officials, that the white paper was "thematic" rather than "comprehensive," and that the no-first-use pledge was omitted because it was not relevant to the theme (the diversified employment of China's armed forces). After all, in a section closely resembling language in prior defense white papers, the 2013 edition contains a description of how China would alert its nuclear forces in response to a perceived nuclear threat, and retaliate with nuclear weapons to a nuclear strike; the only meaningful difference is the omission of the no-first-use pledge.

I am inclined to judge that this omission hints at an ongoing internal debate within the Chinese military. Indeed, in an op-ed entitled *China Will Not Change its Nuclear Policy*, Maj. Gen. Yao Yunzhu of the PLA Academy of Military Sciences, the organization that produced the white paper, wrote that "speculations on a possible change to the [no-first-use] policy have not been conjured up without reason." She states that internal criticism of no-first-use is fueled by concerns about U.S. strategic conventional strike capabilities and ballistic missile defense.

Given that China's no-first-use pledge has been central to its nuclear doctrine for over 50 years, the barriers to change are surely very high, although they may not be entirely insurmountable. However, more likely than outright renunciation, I believe, are continued attempts by the PLA to de-emphasize no-first-use and perhaps to inculcate ambiguity. Given the PLA's concerns about U.S. conventional capabilities, China would presumably be less likely to renounce or deemphasize no-first-use if its on-going modernization results in increased confidence in the survivability of its nuclear forces. I am, however, not convinced that force survivability is the only relevant consideration. If, for example, the United States can maintain its conventional superiority in the western Pacific, there may be increased pressure within China to reevaluate no-first-use.

A feature of Chinese doctrine that I believe is more likely to change is its policy of de-alerting, that is, of storing warheads separately from delivery systems. The 2013 edition of *Science of Military Strategy* openly raises the possibility of launching on warning of an incoming attack. This strategy would require Chinese nuclear forces to be alerted in a crisis or, perhaps even, on a day-to-day basis. Moreover, two ongoing technical developments also point to the possibility of a change.

First, China appears to be enhancing its strategic early-warning capability. In the last few years, the Pentagon has hinted that China has recently upgraded its land-based early-warning radars, and may be considering further improvements. Moreover, there have also been reports that China is developing a space-based early-warning system. Early warning is, however, of little value with a de-alerted force. After all, states generally seek strategic early-warning capabilities to enable launch on warning.

The second reason to question whether China will continue to field de-alerted forces is its development of the *Jin*-class submarine. To my knowledge, there is no authoritative, unclassified information about whether China intends to de-alert its sea-launched ballistic missiles. From a technical perspective, it is entirely possible to do so (warheads could either be stored on land or in empty launch tubes on the submarine). However, de-alerting would seriously compromise submarine force survivability. There is, therefore, I believe a significant chance that Chinese sea-launched ballistic missiles will be mated with warheads during submarine patrols. Once the PLA Navy has set this precedent, the Second Artillery Corps may face less resistance in doing likewise. Indeed, from a technical perspective, the Second Artillery Corps' increasing use of solid-fueled, road-mobile ballistic missiles, which can reportedly be launched within minutes of an order to do so, would facilitate its adoption of a launch-on-warning posture.

China's Boost-Glide Program: A Technical Assessment

"Hypersonic speeds" are usually defined to mean at least five times the speed of sound. There are three basic approaches to delivering a payload accurately over long ranges at such speeds: terminally guided ballistic missiles, boost-glide weapons, and hypersonic cruise missiles. I will not discuss hypersonic cruise missiles in any depth, but will note that a number of experts, including Mark Stokes and my former Carnegie colleague Lora Saalman, have found considerable evidence that China, like the United States, is conducting extensive research in this area. While I am aware of no evidence that China has flight-tested a scramjet engine—the type of propulsion system that would be required for sustained hypersonic flight—it should come as no surprise if China does so within the next few years.

A boost-glide weapon, like a ballistic missile, 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. How far a re-entry vehicle can glide depends on its initial speed and its aerodynamic performance. In theory, gliders with global ranges could be developed, but no state has successfully flown one anywhere near that distance.

Although terminally guided ballistic missiles and boost-glide weapons have quite different trajectories, they are not fundamentally different technologies; rather, they lie at different ends of the spectrum of maneuvering re-entry vehicles. The more aerodynamic lift that such a re-entry vehicle generates, compared to the drag it encounters, the farther it can glide.

I mention this point because China's boost-glide program may well be an outgrowth of its program to develop terminally guided ballistic missiles (just as American efforts to develop hypersonic gliders can trace their lineage back to U.S. programs to develop terminally guided re-entry vehicles in the 1960s and 1970s). China has developed such missiles, including the DF-21C and DF-21D, for the purpose of delivering conventional warheads. Given the relatively short range of China's glider tests—a point I will return to at greater length—it is possible, though by no means certain, that the glider is essentially a "souped-up" version of an existing type of terminally guided re-entry vehicle (though without access to the design of the glider it is difficult to say much definitively).

In any case, it has been widely reported that, in 2014, China conducted three tests of a hypersonic glider, dubbed WU-14 by the news media, on January 9, August 7, and December 2. (Given what is known about the Department of Defense's naming conventions for foreign space and missile systems, WU-14 probably refers to the booster, although it has now become the de facto name of the glider.)

At least one senior American official has unequivocally and publicly confirmed the U.S. assessment that the January 9 test did involve a hypersonic glider—and, given the range of information sources available to the United States government, I do not doubt that assessment. Because the keep-out zone declared by China for this test was identical to one of the zones declared for the August 7 test, it seems virtually certain that this second test also involved the same glider. I am less certain about the third test. Beijing has acknowledged it tested *something* on December 2 but, contrary to media reporting, it did not explicitly confirm that the something was a hypersonic glider. The U.S. government has also not confirmed the nature of this test. In the absence of additional information, such as the keep-out zones for this test (which I have not been able to obtain), it is not possible to definitively confirm media reports that the December 2 test involved a boost-glide vehicle.

There is no reliable evidence about the outcomes of the first and third tests in open sources, but it is possible to say more about the August 7 test. My analysis of this test was conducted jointly with Jeffrey Lewis and Catherine Dill of the James C. Martin Center for Nonproliferation Studies, and I gratefully acknowledge them.

Ahead of the test, China released two keep-out zones in its own territory, warning pilots of falling debris. These zones enable two conclusions to be drawn.

- The plan for the August 7 test appears to have been to test the glider to a range of 1,750 km. To put this figure in perspective, it is not much longer than the estimated range of the DF-21D. Moreover, it is much shorter than the range of the U.S. Advanced Hypersonic Weapon, a glider which has been successfully tested across 3,800 km and was due to be tested across more than 6,000 km in August 2014 before the test was cut short by a booster failure.
- The flight path for the August 7 test involved almost no cross-range maneuvering. One of the main advantages of gliders is that they are capable of maneuvering perpendicular to their velocity. Indeed, the U.S. test in August 2014 was supposed to involve a cross-range maneuver of hundreds of kilometers. The planned flight path for China's test was, by contrast, almost completely straight.

At the same time as the test, pictures of rocket debris appeared on Chinese social media. There is sufficient information in the photos to geolocate the crash site (which turns out to be a few kilometers from the *Bulong Hu* hot springs resort in the Ordos Desert). Two more conclusions can be drawn from this information.

- First, the booster used in the test was liquid-fueled. The orange cloud around the crash site shown in the photographs is characteristic of the N_2O_4/UDMH liquid rocket propellant used in all *Long March* rockets, which are derived from China's long-range, liquid-fueled missiles.

- Second, the test appears to have been a failure, as the crash site lies outside the declared drop-zones and uncomfortably close to the resort. The large quantity of unburnt fuel left in the rocket stage (or stages) that crashed also suggests a premature termination of the flight.

These observations summarize what we know with at least some confidence about the status of China's boost-glide development program (though perhaps Mandarin speakers can glean additional information from the Chinese literature). Against this background, I offer three cautious conclusions.

First, there is considerable uncertainty about many basic aspects of China's glider. How fast does it travel on re-entry? What is its lift-to-drag ratio? What guidance system does it use? How accurately can it hit a target? Was the technology developed indigenously or is it based on classified foreign sources? In fact, we can't even be certain that China has tested only one glider design.

Many claims about the glider in media reports—such as its speed—are highly questionable. I believe that, in a number of cases, Chinese journalists, who know effectively nothing about the program, simply copy descriptions of U.S. programs. The claims made in these articles then are portrayed in the U.S. press as accurate descriptions of China's program. Let me give an example. An article in *Aviation Week* that described the January 7 test contained a picture of a glider published in a "Chinese academic engineering article." However, as a Google search immediately revealed, this picture was of the U.S. Advanced Hypersonic Weapon, and not an indigenous Chinese glider.

On the question of the origins of China's technology, Lora Saalman has found that the unclassified Chinese literature on hypersonic gliders draws very heavily from the *unclassified* American literature on the same subject. There is little doubt that Chinese scientists pay very close attention to U.S. developments and may even be trying to copy them. However, I have no evidence—one way or the other—as to whether China's program uses classified foreign information acquired by espionage.

Second, the available evidence very tentatively suggests that China's hypersonic glider development program is significantly less advanced than the United States'. The flight plan for the August 7 test was much less ambitious—in terms of both its range and its lack of cross-range maneuvering—than contemporary American tests. Of course, it is important to be very cautious about generalizing on the basis of one test. It is possible that the range of the December 2 test (if it occurred) was longer. Indeed, I cannot say with confidence whether the flight plan for the August 7 test indicates that the glider has a limited capability, or that China has adopted a gradual and cautious pattern of flight-testing. The United States, for example, did not immediately test the AHW to its full potential range, so there is a precedent for an evolutionary approach to flight-testing. Continued observation of the program may shed more light in due course.

Third, regardless of the exact nature of the glider tested last year, 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. It also creates qualitatively new challenges, such as accurate navigation over long ranges. The United States has chosen the Global Positioning System, or GPS, for this purpose. China has started to deploy its own space-based precision navigation and timing system, *Beidou*, which is eventually intended to provide global coverage. Nonetheless, ensuring the reception of navigation data during all stages of the boost-glide flight path presents its own set of technical difficulties. 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.

It is certainly possible, by examining the available data selectively, to paint a picture of Chinese hypersonic boost-glide capabilities that are already advanced and rapidly evolving. Overall, however, the evidence available to the public does not support categorical statements about whether the existing Chinese glider would be an effective weapon, or about the pace at which the program will progress. This is not to say that the more alarmist accounts are necessarily wrong, but it is to argue that there is a significant degree of uncertainty. Some of this uncertainty derives from our lack of knowledge about China's program. However, the uncertainty is not purely epistemic; given the limited number of tests, which probably includes one failure, even the PLA may be unsure of how close it is to a capability that is reliable enough to be deployed.

China's Boost-Glide Program: Strategic Drivers And Implications

There is significant uncertainty about why China is pursuing boost-glide technology. Assuming that China successfully completes the development of such a system and deploys it, a critical issue will be whether the payload is nuclear or conventional. If the PLA's ultimate decision is to integrate a nuclear warhead, it will probably reflect concerns about China's continued ability to penetrate U.S. missile defenses, including potentially more capable future defenses. In this case, the deployment of boost-glide systems would serve to preserve the status quo. By contrast, if the PLA deploys a boost-glide system armed with a conventional warhead, then it may be seeking longer-range conventional strike capabilities including, perhaps, the ability to target the continental United States. In this case, the glider program could signal that the PLA sees a growing role for strategic conventional weapons in its military doctrine. Of course, it is also possible that China could deploy both conventionally armed and nuclear-armed gliders.

That said, it is possible the PLA does not currently have firm ideas about the purpose of a boost-glide system. China has a well-documented history of initiating advanced strategic military programs mainly because it worries about other states' opening up a technology gap, without necessarily being convinced by their ultimate military utility for China. Such technologies, including the neutron bomb, are not always fielded. The deployment of boost-glide weapons, while probable, should, therefore, not be regarded as a given.

Lee Fuell from the National Air and Space Intelligence Center has testified to this committee that his organization assesses that the glider program is associated with China's nuclear forces. Mr. Fuell has access to sources of information that I do not, and I have no particular reason to doubt his assessment. That said, the information I have at my disposal does not enable me to draw a conclusion about any intended payload.

The one piece of evidence that may suggest China's aim is to arm a boost-glide system with a nuclear warhead is its use of a liquid-fueled booster (today, China's liquid-fueled missiles are used exclusively to deliver nuclear weapons). However, there are other possible explanations for this choice of booster. It may have been dictated by the technical requirements of the mission (including the mass of the glider and required injection speed). Alternatively, like the United States, China may simply use decommissioned nuclear missiles for testing hypersonic gliders on cost grounds.

Much has been made about the potential of hypersonic gliders to penetrate U.S. missile defenses, although some nuance is needed to understand the full implications. In broad terms, defenses can be divided into area defenses, which are capable of protecting large swathes of territory, and point defenses, which are capable of protecting particular targets or small clusters of targets. The Ground-Based Mid-Course Defense system deployed in Alaska and California to protect the United States against a North Korean ICBM by intercepting warheads as they pass through outer space is an example of an area defense. Patriot missiles, which are designed to intercept short-range missiles in their terminal phase, are examples of point defenses.

A sports analogy may be helpful. Area defenses are the military equivalent of football's defensive linemen, who try to knock down a pass as soon as it leaves the quarterback's hands to protect the whole of the downfield area. Area defenses require an incoming missile to be intercepted early in flight while it can still reach a large number of potential targets. For technical reasons, gliders are very difficult to track early in flight, and hence would probably be particularly effective at defeating area defenses. As a result, Chinese nuclear-armed intercontinental gliders could help China's military to extend the existing strategic balance into the foreseeable future. More ominously, if those gliders were accurate enough to deliver conventional warheads, they could expose the United States to a qualitatively new threat that would be extremely difficult to defend against.

Point defenses are different. They are the equivalent of a cornerback shadowing a wide receiver downfield. It is much easier for a cornerback to knock down a pass than a defensive lineman, but the cornerback can only protect a very small part of the playing field. Against China, point defenses play an important role in defending U.S. and allied military assets in the western Pacific. Hypersonic gliders would probably be somewhat *less* effective at penetrating these defenses than China's existing ballistic missiles. Although hypersonic gliders re-enter the atmosphere at extremely high speeds, they slow significantly over the course of their trajectory because of air resistance, making them potentially easier to intercept close to a defended target, compared to ballistic missiles. As a result, conventionally armed gliders of regional ranges would probably *not* enhance the threat already faced by U.S. forces and U.S. allies in the western Pacific.

In short, the military threat posed by Chinese gliders, should they be deployed, will depend on their range and payload. While regional gliders and nuclear-armed gliders would reinforce the status quo, conventionally armed intercontinental gliders would create a qualitatively new threat. It will, therefore, be important to monitor the program closely to better discern China's objectives.

* * *

To conclude, let me simply observe that this picture of China's nuclear weapons and emerging missile technologies is a complex one. Some developments—such as the possibility that the PLA may be seeking a conventional, intercontinental boost-glide capability—suggest it may want the ability to change the status quo by force. Other developments—such as its efforts to ensure the survivability of its nuclear forces—suggest it is more intent on preserving the status quo. Such contradictory impulses can and do frequently co-exist within governments. A challenge for U.S. policy, it seems to me, is how to convince Beijing that it will not succeed in any attempt to change the status quo by force *and* that the United States will not seek to do so either.