Prepared Statement of
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Thank you to the Chairman, Vice Chairman, and members of the U.S.-China Economic and Security Review Commission for the opportunity to participate in today's hearing. It is an honor to testify on an issue that is important to U.S. interests in peace and stability in the Asia-Pacific region. The evolving capacity of the Chinese People's Liberation Army (PLA) to use military force presents several challenges for the United States, allies, and friends in the region.

In my presentation this morning, I will address People's Republic of China (PRC) investment into hypersonic and maneuverable re-entry vehicle programs. First, hypersonic flight vehicles can be difficult to define. For the purposes of this discussion, a hypersonic flight vehicle is one that attains a speed of Mach 5 or higher during a significant portion of its flight. Such a system could be a post-boost vehicle launched by ballistic missile that maneuvers and glides during a portion of its re-entry phase. A hypersonic weapon also could be an airbreathing flight vehicle, such as a cruise missile, propelled by a supersonic combustion scramjet (scramjet) engine. The following discussion, focused mostly on the former type of hypersonic system, is keyed to questions provided by the Commission.

What hypersonic weapons are currently being considered or pursued by the PLA? In general, why are these weapons significant?

Authoritative sources indicate the PLA is investing in research and development (R&D) on two categories of hypersonic vehicles: 1) ballistic missiles equipped with increasingly sophisticated re-entry vehicles aerodynamically configured to maneuver and glide in the upper atmosphere before a final descent onto a target; and 2) airbreathing flight vehicles powered by scramjet engines. Both categories are significant primarily due to potential challenges in defending against these systems during their flight. A conventional ballistic missile system is equipped with a payload that re-enters the atmosphere on a predictable ballistic trajectory. A hypersonic glide vehicle is able to maneuver after entering the atmosphere, transition toward a relatively flat glide

path in near space, at an altitude between 20 and 100 kilometers, then dive down toward a target in its final phase of flight.

Authoritative sources suggest preliminary research into maneuvering re-entry vehicle technology in 1991. Engineering R&D on China's first ballistic missile system with a rudimentary post-boost maneuvering capability began no later than 2002 and resulted in initial introduction of the terminally-guided systems shortly thereafter.[1] Re-entry vehicles on subsequent systems, such as the DF-15B, DF-16, and DF-26, likely are structured aerodynamically to permit some maneuvering and glide during the descent phase of flight. Western media has reported seven tests of at least one new hypersonic glide vehicle, dubbed WU-14 or DF-ZF, between 2014 and 2016.[2] It remains unclear whether or not these tests represent a modified variant of an existing system or an entirely new ballistic missile system.

Where is China's hypersonic weapons program currently located within the PLA's defense research and development timeline? Is it best characterized as a single program?

Based on general Central Military Commission (CMC) policy and planning guidance, an end user is responsible for development of operational and technical requirements for hypersonic weapons programs. In the case of land-based ballistic and land attack cruise missiles, the PLA Rocket Force (PLARF) is the end user. The PLARF Equipment Department likely plays a major role in requirements development and oversight of defense industrial R&D. The department's PLARF Equipment Research Academy, established in December 2003, integrates the efforts of more than three dozen labs responsible for long range force planning, technical feasibility studies, concept development, and program validation.

Two large defense industrial enterprises -- the China Aerospace Science and Technology Corporation (CASC) and China Aerospace Science and Industry Corporation (CASIC) -- support the PLARF Equipment Department in the development and production of ballistic and cruise missiles, including hypersonic glide vehicles. Within CASC and CASIC, chief designers, normally housed within general design departments, are responsible for systems engineering. Most relevant are the CASC's First Design Department, CASIC's Fourth Design Department, and possibly CASC's Tactical Weapons Department. These general design departments coordinate the work of research institutes responsible for R&D on sub-systems, such as hypersonic glide vehicles, materials, control systems, warheads, solid rocket motors, and mobile launchers. The most prominent entity probably leading R&D on hypersonic glide vehicle sub-systems may be CASC's Beijing Institute of Near Space Flight Vehicle Systems Engineering (10th Research Institute). The 10th Institute appears to have a close relationship with CASC 14th Research Institute, which traditionally has been responsible for development of re-entry vehicles and warheads. In addition, the CASIC's Third Design Department appears to play a prominent role in R&D on scramjet engines.

The PLA Strategic Support Force (PLASSF) supports R&D through management of missile test facilities in Shanxi's Wuzhai County (Base 25) and Gansu's Jiuquan prefecture (Base 20). These commands support missile testing throughout engineering R&D. After a system is certified and enters the operational inventory, PLASSF bases also support PLARF in live fire training. Hypersonic glide vehicle testing cited in Western media between 2014 and 2016 reportedly has been carried out from Base 25.

What are the primary drivers for China's hypersonic weapons program? What PLA-assessed Western or regional capabilities are these weapons intended to counter/defeat?

The primary driver for PLA investment into hypersonic weapons is to offset shortcomings in the face of a more technologically advanced adversary equipped with missile defenses. Theater missiles, defined as conventional ballistic and land attack cruise missiles with ranges between 500 and 5500 kilometers, create a more permissive environment for PLA Air Force (PLAAF) and Navy operations. In a Taiwan scenario, increasingly accurate conventional ballistic and land attack cruise missiles are optimal means for suppressing air defenses and creating a more permissive environment for subsequent conventional air operations due to their relative immunity to defense systems.

Longer range conventional precision strike systems also could enable political leaders in Beijing to apply effective military measures to enforce territorial claims in the western Pacific Ocean. Theater missiles, including those adapted for the maritime environment, could enable precise targeting of U.S., Japanese, or other naval combatants with limited defenses. An extended range strike capability would allow China to defend its interests in other parts of the world, including assured access to energy resources transiting through the Straits of Malacca and perhaps even the Indian Ocean. Over the longer term, successful development and deployment of intercontinental-range hypersonic glide vehicle could offer the PRC political leadership a flexible deterrent that could achieve strategic and operational effects in a crisis.

What specific capabilities for China's hypersonic weapons do PLA and defense industry weapons developers and scientists discuss in their writings? Can these weapons be produced as envisioned?

First, engineers acknowledge challenges posed by heating of re-entry vehicles that glide for an extended period after descending through the upper atmosphere, or near space. Engineers appear to place a premium on aerodynamic control and thermal protection systems able to resistant extreme heat while maintaining high speeds in near space.

Engineers also highlight the potential of a missile-borne synthetic aperture radar (SAR) package on a hypersonic glide vehicle. Intimately connected to China's air- and space-based SAR programs, the advantages of missile-borne SAR include all-weather capability, high resolution, extended range imaging, and autonomous guidance and/or target acquisition. During flight, a

SAR seeker could penetrate cloud cover to acquire a surface target, and then turn it over to another active or passive seeker in the terminal flight phase.

Obstacles to utilizing SAR for missile navigation and guidance include the high speed of the missile and sudden changes in speed and motion. As a general rule, the SAR sensor should operate while the vehicle is on a linear, constant altitude flight path. As a result, missile-borne SAR presents significant technical challenges. Chinese engineers highlight the need for advanced inertial measurement units to compensate for the motion of the post-boost vehicle. Engineers also have carried out electronic warfare simulations to ensure survivability of on-board SAR systems. In terms of cost, technical commentators have noted that a radar package may be the most expensive aspect of an extended range precision strike program.

In addition to materials and missile-borne SAR, Chinese technical writings outline issues associated with a radiofrequency blackout that happens when a flight vehicle re-enters and glides through near space at hypersonic speeds. In early concept studies, a notional system would glide in the upper atmosphere on a relatively even path to permit on-board sensors to acquire a target. Engineers have cited radiofrequency blackout periods that occur at hypersonic speeds (e.g., above Mach 5) in near space. Chinese media reporting highlights progress in overcoming blackout problems in its manned space program.

What challenges and resource constraints does China face in its research, development, and acquisition efforts for hypersonic weapons? How might China be expected to fill gaps in its ability to innovate? What types of technology acquisitions—either legally or through espionage—is China likely to emphasize? What advantages and/or disadvantages might China have in competing with the United States to develop innovative military technologies in the long term?

The PLA and China's space and missile industry can be expected to continue investment into increasingly sophisticated hypersonic flight vehicles. While maintaining a long-term perspective, force planners and defense industry designers rely on conservative, incremental upgrades to existing missile variants. Although specifics remain unclear, priorities likely include longer range glide vehicles, autonomous target acquisition, and possibly reusable boosters. Backed by national-level civil-military integration policies, engineers may seek access to foreign dual use technologies applicable to a hypersonic program. Technical exchanges between Russian and Chinese engineers also may be relevant. Among China's advantages is the ability to mobilize resources, including an expanding science and technology base, to achieve breakthroughs in basic research and engineering. Organizational innovations, such the establishment of an institute in October 2008 dedicated to R&D of near space flight vehicles, may over time close the gap in hypersonic technologies.

What do PLA doctrine and gray literature, as well as academic and defense industry publications, tell us about how China's hypersonic weapons are intended to be

operationally employed? Are they likely to be armed with nuclear payloads, conventional payloads, or both?

How hypersonic weapons could be employed remain open to question. Over time, existing PLARF missile systems with traditional ballistic trajectories replaced by more advanced variants equipped with advanced post-boost hypersonic glide vehicles. Existing missile systems with some apparent ability to maneuver upon reentry, such as the DF-21 and DF-26, reportedly can deliver nuclear or conventional payloads. However, PLARF launch brigades equipped with these systems appear trained to operate in either a conventional or nuclear environment. During a conflict, nuclear and conventional brigades likely would fall under separate operational command structures. Whether this practice would be retained is unknown.

The DF-26 intermediate range ballistic missile (IRBM) may serve as an illustration. Publicly highlighted during the September 2015 military parade in Beijing, the DF-26 may incorporate an aerodynamically configured maneuvering re-entry vehicle capable of delivering nuclear and conventional payloads out to a range of 3000-4000 kilometers. The first brigade most likely equipped with this system, garrisoned in Henan Province, appears optimized for conventional operations. In April 2016, *PLA Daily* reporting suggested joint training between the PLARF brigade and the PLA Central Theater Command. After "fusing into the theater system," the unit reportedly received direction from Central Theater Command authorities for employment of "dozens" of new missiles in a PLA Navy fire support mission.[3]

What are the operational and strategic implications for the United States, our allies, and our regional partners in the Indo Pacific of China's future employment of hypersonic weapons?

Hypersonic glide vehicles may reduce the effectiveness of mid-course missile defenses and extend the operational range of ballistic missiles. The PLA's growing interdiction capabilities, often referred to as anti-access/area denial (A2/AD), not only could complicate U.S. ability to operate in the Asia-Pacific region, but also give the PLA a decisive edge in securing control over the skies around its periphery should territorial disputes erupt into conflict. Over the long term, conventionally capable ICBMs could allow the PLA to reach targets deep inside continental United States territory without relying on forward bases. The PLA's growing capacity for long range precision strike provides an incentive for neighbors to shore up defenses and develop similar strike capabilities. The most effective and efficient means of defending against theater missiles is neutralizing the missile infrastructure on the ground.

The Commission is mandated to make policy recommendations to Congress based on its hearings and other research. What are your recommendations for Congressional action related to the topic of your testimony?

In addition to missile defense investments, alternative approaches could examine means to moderate PLARF force posture and address underlying security dilemmas through cooperative threat reduction programs. A thorough review and modification of the Intermediate Nuclear Forces (INF) Treaty may be warranted, as well as possible alternative missile control regimes.

ENDNOTES

[1] For discussion on one prominent designer responsible for MARV development, see Cai Meng (蔡萌), (访中国航天科技集团公司一院研究员朱广生), China Awards for Science and Technology (中国科技奖励杂志), 2015(8), pp. 56-61.

[2] See Bill Gertz, "China Successfully Tests Hypersonic Missile," *Washington Free Beacon*, April 27, 2016, at http://freebeacon.com/national-security/china-successfully-tests-hypersonic-missile/. Although speculative, the "ZF" could be short for "re-entry vehicle" in Chinese (***z**airu **f**eixingqi* 再入飞行器). WU-14 is likely a U.S. intelligence community designation for a ballistic missile tested from China's Base 25 near Wuzhai County.

[3] In *PLA Daily* commentary, Xue Jinfeng, probable chief of staff of PLARF Base 54, highlighted the importance of joint operations. See Shi Yijie (时义杰) and Feng Jinyuan (冯金源), "Rocket Force Actively Integrating into Theater System, Exploring Scope of Joint Operations" (火箭军积极融入战区体制 探索联合作战规范), *PLA Daily*, April 1, 2016, at http://news.xinhuanet.com/mil/2016-04/01/c_128856027.htm. For reference to "fusing into the theater system" (融入战区体制), see "Xi Jinping: Military Entering Period of New System, Reforming a Strong Military Capable of Winning" (习近平：军队已进入新体制时间 打赢改革强军攻坚战), CCTV, August 2, 2016, at http://mil.news.sina.com.cn/china/2016-08-02/doc-ifxunyya3005972.shtml. A new brigade in Xinyang, Henan Province (notional true unit designation of 827 Brigade) possibly began training with the DF-26 in 2013, if not earlier.