13. Calculus on Missile Defence and Hypersonic Glide

This chapter uses technological advances in the fields of missile defence and hypersonic glide to explore the implications of such platforms for Chinese and Russian nuclear deterrence. Zhao Tong discusses common Chinese and Russian concerns over US missile defence, which is viewed as threatening their respective nuclear deterrents, and the measures both are taking in response. Lora Saalman provides the context for how similar threat perceptions are manifested in China's development of hypersonic glide capabilities. She argues that increased identification with Russia has filtered into Chinese research on hypersonic glide vehicles, such that China may similarly pursue missile defence as the target and nuclear warheads as the payload for its platforms.

13.1. Zhao Tong[1]

Introduction

Russia and China have similar threat perceptions when it comes to the potential impact of US missile defence on their respective nuclear deterrents. While some foreign analysts doubt that the two countries' concerns are genuine, an in-depth examination of the Chinese understanding of US missile defence reveals that a number of factors—including some serious misperceptions—make China deeply wary of these systems. If the similarities between the Chinese and Russian political systems and their decision-making dynamics are taken into account, as well as their deep mistrust of the United States, it is likely that Russian concerns about US missile defence will similar to those of China; and these must be adequately addressed.

Common concerns over missile defence

From a technical perspective, Russia and China evaluate the US missile defence threat based on a variety of basic assumptions. The USA could launch a comprehensive disarming first strike, after which only a small number of their respective nuclear weapons would survive. These could then be neutralized by a layered US missile defence system. Major technological breakthroughs such as the potential US development of the Multiple Kill Vehicle and laser interception technology could further improve the efficacy and efficiency of future US missile defence systems.[2]

[1] Zhao Tong is a Fellow in the Nuclear Policy Programme at the Carnegie-Tsinghua Centre for Global Policy in China.

[2] Vladimir Pyriev and Vladimir Dvorkin have written that the discontinuation of MKV development indicates the extent to which some US programmes continue to receive attention in the Chinese literature even after their demise. Pyriev, V. and Dvorkin, V. (English version, Bubnova, N., ed.), 'The US/NATO programme and strategic stability', Arbatov A. and Dvorkin, V., eds., *Missile Defence: Confrontation and Coop-*

Russia's and China's deep-rooted political mistrust of the USA causes them to embrace worst-case scenarios. This tendency has only grown over time and leads to concerns over the reliability of their respective nuclear second-strike capabilities. These issues are coupled with the geographical dilemma that both Russia and China are located next to North Korea.[3] Any US strategic missile defence system that can intercept North Korean intercontinental ballistic missiles (ICBMs) would also potentially be capable of engaging Russian and Chinese ICBMs launched from North East Asia towards the USA. In addition, US theatre missile defence systems deployed in North East Asia would inevitably affect Chinese and Russian security interests.

Both countries also worry that the USA has been using missile defence cooperation to strengthen its extensive network of alliances. Russia views US deployment of missile defence systems in Romania and Poland as efforts to draw these Eastern European countries closer into the US orbit. From China's vantage point, US installation of Terminal High Altitude Area Defense (THAAD) in South Korea and the export of missile defence systems to Taiwan and Japan have caused major political difficulties for mainland China. Furthermore, US efforts to engage countries such as Australia and India in missile defence cooperation are viewed as a strategy to bring these countries into the US-led security network.

Such shared concerns serve as the foundation for Russia and China to find areas of common interest, mutual support and cooperation. Increasingly, the two countries are cooperating to voice strong opposition to US development of strategic and theatre missile defence systems and their deployment close to Russian and Chinese borders. In June 2016, both countries' presidents issued a joint statement on strengthening global strategic stability and further consolidating their coordination and cooperation against the USA and its allies over missile defence. More substantive cooperation to strengthen their own missile defence capabilities has made rapid progress. The first Russia–China joint missile defence computer simulation exercise took place in 2016 and a second joint exercise has been announced for 2017.

Bilateral cooperation

The room for joint Russian–Chinese cooperation is considerable. Russia has already sold advanced air and missile defence systems to China, such as the S-300, and has signed a contract to sell China the S-400. More information sharing about common missile threats and better coordination of each other's military communication systems is another area for possible cooperation. China is presumably also interested in learning from Russian experiences of developing advanced missile defence countermeasure technologies. In anticipation of increasing tensions with the USA over its missile defence deployment in North East Asia, Chinese experts believe that Russia has long and positive experience of opposing US mis-

eration (Carnegie Moscow Centre: Moscow, 2013), pp. 183–202.

[3] China and Russia are also not far away from Iran, another major target of US missile defence deployment.

sile defence politically on the international stage—and can therefore offer valuable lessons to China.

Despite these convergences, a lack of deep mutual trust remains between Russia and China, which limits the scope and depth of their cooperation. Without being military allies, Chinese experts doubt how far the cooperation can go. Deep cooperation requires full transparency on some of their most sensitive military technologies and a degree of integration of military command and control systems. This is unlikely to occur in the near future. Beyond their borders, both countries have divergent and even competing interests in other parts of the world. Both have developed advanced theatre missile defence systems and are actively marketing them to foreign buyers. In some cases, such as in Turkey, the Russian S-400 and the Chinese HQ-9 systems have become major competitors.

Even more importantly, Russian experts have privately expressed security concerns about China's rapidly growing medium- and intermediate-range missile capabilities. Russia is aware of the fact that much of its own territory is vulnerable to China's large stockpile of ballistic and cruise missiles, which might become a threat should bilateral relations deteriorate. Russia also has different security relations with China's main rivals such as India. Some believe that China's development of mid-course ballistic missile defence technology is at least partially driven by the growing missile threat from India, whereas Russia has been cooperating with India on developing advanced missile capabilities.

In the future, Russia and China will continue to take similar measures to counter the perceived threat from US missile defence. Such measures will have significant security implications not only for these countries, but also for other stakeholders in Asia, Europe and across the globe. Russia and China will continue to strengthen their nuclear capabilities as the most important countermeasure against US missile defence. In this case, China's much smaller nuclear arsenal makes it even more concerned than Russia, forcing China to undertake more dedicated measures to modernize its nuclear programme.

Both countries stress the importance of multiple independently targetable re-entry vehicles (MIRVs) and are working to improve the rapid response capabilities of their nuclear forces. This will have implications for crisis stability. Russian officials have publicly threatened to attack the missile defence assets of the USA and some European countries. Some Chinese experts have made similar threats against THAAD in South Korea. Given that Russian and Chinese analysts tend to downplay the danger of misunderstandings and inadvertent escalation during crises, the risk of miscalculation leading to a regional conflict or war could increase.

Takeaways

A new US president and a new security landscape in Asia make the Russia–China–USA trilateral interaction over missile defence more complex. China has been able to avoid direct confrontation with the USA on the issue, while Russia has waged political battles against missile defence in Europe. However, as the Trump Administration looks to engage with Russia and North Korea's nuclear and missile

capabilities drive the USA, South Korea and Japan to deploy more missile defence systems in North East Asia, the risk of US–Chinese confrontation over missile defence will continue to increase. The 2017 US National Defence Authorization Act mandates the US Department of Defense to develop a layered missile defence system across the globe. Meanwhile, the new US President has surrounded himself with policy advisers deeply committed to missile defence. The future of great power relations is bound to be greatly affected by their decisions on the future of missile defence.

13.2. Lora Saalman[4]

Introduction

Hypersonic glide vehicles are a growing factor in strategic stability calculations.[5] Given their speed, precision and manoeuvrability, these systems are well suited to defeating missile defences.[6] This section takes the current dyadic approach to US–Chinese competition in the field and inserts Russia as a factor that is shaping Chinese views on the subject. Presenting the key takeaways from 872 of 1675 surveyed Chinese-language texts, the author reviews more than a decade of research on hypersonic and boost-glide technologies to reveal growing Chinese interest in Russia. Combining this trend with both countries' shared concerns over US missile defence suggests that it is time to start factoring in how Russia's calculations on its own prompt global strike programme might shape China's decisions on future nuclear and conventional payloads, and the targets and range of its own hypersonic glide vehicle programme.

Strategic intersection

In China, as in Russia, the US prompt global strike programme is discussed as an inherently pre-emptive and destabilizing system. Both countries make the worst-case scenario assumption that the USA will deploy a prompt global strike system that places their arsenals and command and control infrastructures at risk, whether on intercontinental ballistic missiles, air- and submarine-launched hypersonic cruise missiles, or kinetic weapons launched from an orbiting space

[4] Lora Saalman is Director of and a Senior Researcher in the China and Global Security Programme at SIPRI.

[5] For more information see Saalman, L., 'Factoring Russia into the US-Chinese equation on Hypersonic Glide Vehicles', *SIPRI Insights on Peace and Security*, no.1 (Stockholm International Peace Research Institute: Stockholm, Jan. 2017), <https://www.sipri.org/sites/default/files/Factoring-Russia-into-US-Chinese-equation-hypersonic-glide-vehicles.pdf>.

[6] Hypersonic glide vehicles are characterized by speed, precision and manoeuvrability, which can be applied to defeat missile defences. Traditional calculations of strategic stability rely on the ability to undermine an opponent's nuclear deterrent capability and hypersonic glide vehicles are viewed as providing this assurance. On reaching near space, the systems are ejected from their missile boosters to begin their glide phase, during which they can accelerate to upwards of Mach 5 or 6138 kilometres per hour. The glide phase allows them to manoeuvre aerodynamically to evade interception and extends the range of their booster missiles. Unlike conventional re-entry vehicles, which follow a predictable ballistic trajectory, hypersonic glide vehicles are almost impossible to intercept using conventional missile defence tracking systems.

platform. In the light of these concerns, it is not surprising that both China and Russia are exploring similar capabilities to offset or deter decapitation of their arsenals by the USA.

The timing of China's flight test of its DF-ZF (previously designated as the WU-14) in April 2016 further highlights integration as a factor. China's hypersonic glide vehicle test was reportedly a success and occurred just days after Russia carried out its own test. Its proximate timing to that of Russia recalls China's previous flight tests, which often came on the heels of those conducted by the USA. This is more than mere coincidence. A review of more than a decade of Chinese writing on hypersonic and boost-glide technologies reveals growing interest in and research on Russia's hypersonic glide vehicle programme.[7] Combining this trend with both countries' shared concerns over US missile defence suggests that it is time to start factoring in how Russia's calculations on its own prompt global strike programme might shape China's decisions on future nuclear and conventional payloads and targets, as well as the range of its own hypersonic glide vehicle.

Russia and China are not simply linked by China's increased interest in Russia's hypersonic glide developments. China's renaming of its Second Artillery Corps as the People's Liberation Army Rocket Force (PLARF) and the publication of its 2015 Military Strategy White Paper also hint at a growing convergence.[8] The full implications of this name change and restructuring, which seemingly mirror Russia's own Strategic Rocket Force, are unclear but there is an emerging similarity between the two forces. The PLARF commands all three legs of China's nuclear triad and is now thought to be on an equal footing with the People's Liberation Army (PLA), Navy and Air Force.

In addition, while China's 2015 White Paper might not be as specific as Russia's 2015 Military Doctrine, it emphasizes a similar vision of a global revolution in military affairs tied to long-range, precise, smart, stealthy and unmanned weapons in both outer space and cyberspace. It also details how the Second Artillery, now the PLARF, 'seeks to improve nuclear and conventional forces and long-range precision strike capability' and 'is building systems of reconnaissance, early-warning, command and control, as well as medium- and long-range precision strike

[7] Zhang Shaofang, Wu Kunlin and Zhang Hongna are affiliated with the China Haiying Science and Technology Information Institute. 张绍芳 [Zhang, S.], 武坤琳 [Wu, K.] and张洪娜 [Zhang, H.], '俄罗斯助推滑翔高超声速飞行器发展' [Russia's boost-glide hypersonic flight development], 飞航导弹 [*Winged Missile Journal*], no. 3 (Mar. 2016), pp. 20–22; Zhang Lingjun, Qin Daguo and Yuan Yuqing are affiliated with the Department of Graduate Management and Space Command at the Equipment Academy of China. 张令军 [Zhang, L.], 秦大国 [Qin, D.] and袁玉卿 [Yuan, Y.], '基于精确打击体系的卫星系统及其发展探析' [Analysis of satellite systems based on precision strike systems and their evolution], 装备学院学报 [*Journal of Equipment Academy*], no. 6 (June 2015), pp. 58–62; '俄罗斯多管齐下反制美国PGS计划' [Russia's multi-pronged plan to counter US PGS], *Conmilit*, [n.d.], pp. 71–74; and Wang Jinyun and Wei Sujun are affiliated with the 368 Factory of the China Shipbuilding Industry Corporation. 王金云 [Wang, J.] and魏素军 [Wei, S.], '美俄未来高超声速飞航导弹技术发展动向' [Future US and Russian hypersonic manoeuvrable missile technology development], 飞航导弹 [*Winged Missile Journal*], no. 9 (Sep. 2012), pp. 25–29.

[8] State Council Information Office of the People's Republic of China, '"中国的军事战略" 白皮书 (全文)' [China's Military Strategy White Paper (Full version)], 26 May 2015, <http://www.scio.gov.cn/zfbps/gfbps/Document/1435341/1435341.htm>.

capabilities'.[9] Finally, it advocates the development of 'independent new weapons and equipment' and fielding 'a lean and effective nuclear and conventional missile force'.[10]

Thus, Chinese experts from such organizations as the China Airborne Academy in Luoyang and the China School of Aerospace Engineering at the China Institute of Technology already place a high priority on near-space attack systems as the future of warfare.[11] China has also been increasing the manoeuvrability of its hypersonic glide vehicles, conducting simulations that leverage near space and heat reduction to allow for successful re-entry, and researching more powerful engines and better trajectory optimization to expand the range of its hypersonic glide vehicles.[12] While the majority of these papers involve technological mirroring of US advances, a number also highlight the arc of Russia's hypersonic and boost-glide pursuits.[13] Chinese research into aerodynamic properties, manoeuvrability and the G-force effects on the fuselage at high speeds often feature overviews of Russia's programmes, including its Project 4202 which spawned the Yu-70 (102E or 15Yu70) and the more evolved Yu-71 and Yu-74.[14]

As both Russia and China seek to deploy their own version of a hypersonic glide system, they are confronted with many of the same considerations faced by the USA in distinguishing between a conventional and a nuclear payload. Nonethe-

[9] State Council Information Office of the People's Republic of China (note 7).

[10] State Council Information Office of the People's Republic of China (note 7).

[11] Li Yake, Liang Xiaogeng and Guo Zhengyu are affiliated with the China Airborne Academy in Luoyang. 李亚轲 [Li, Y.], 梁晓庚 [Liang, X.] and 郭正玉 [Guo, Z.], '临近空间攻防对抗技术发展研究' [Near space attack-defence confrontation technology], 四川兵工学报 [*Sichuan Ordnance Journal*], no. 5 (May 2013), pp. 24–30; and Chang Jianlong, Zhao Liangyu and Li Keyong are affiliated with the China School of Aerospace Engineering at the China Institute of Technology. 常建龙 [Chang, J.], 赵良玉 [Zhao, L.] and 李克勇 [Li, K.], '临近空间平台与空天飞机在未来战争中的协同作用' [Synergies of the near space platform and space planes in future wars], 飞航导弹 [*Winged Missile Journal*], no. 9 (Sep. 2012), pp. 81–85.

[12] Zhang Xiangyu, Wang Guohong, Zhang Jing and Liu Yuan are affiliated with the Institute for Information Fusion at the Naval Aeronautical and Astronautical University. 张翔宇 [Zhang, X.], 王国宏 [Wang, G.], 张静 [Zhang, J.] and 刘源 [Liu, Y.], '临近空间高超声速助推—滑翔式轨迹目标跟踪' [Tracking hypersonic boost-glide trajectory targets in near space], 宇航学报 [*Journal of Astronautics*], no. 10 (Oct. 2015), pp. 1125–32; 邱翔宇 [Qiu, X.], '再入滑翔式近空间飞行器飞行姿态控制系统研究' [Re-entry-glide near space vehicle flight attitude control systems], Master's Thesis, School of Information and Control, Nanjing University of Information Engineering, May 2013; 李强 [Li, Q.], '高超声速滑翔飞行器再入制导控制技术研究; 孟令赛 [Meng L.], '高速临近空间飞行器跳跃飞行轨迹优化研究' [Optimization of leap trajectory for near space vehicles at hypersonic speed], Master's Thesis, Harbin Institute of Technology, June 2009; and 陈法龙 [Chen, F.] '高超声速滑翔飞行器弹道快速规划研究' [Rapid trajectory planning for hypersonic glide vehicles], Master's Thesis, National University of Defence Technology, Jan. 2012.

[13] Among the systems mentioned by Chinese analysts are the Soviet Union/Russia's 'Eagle' (Ying), 'Hammer' (Tiechui), GosMKB (Raduga or Caihong-D2) and Kholod or GLL-8 (Igla or GLL-VK) programmes. Wu Xuzhong was a graduate student at the China Institute of Technology while writing this thesis: 吴旭忠 [Wu, X.], '滑翔式飞行器再入制导与控制方法研究' [Entry guidance and control algorithm for glide vehicles], China Institute of Technology (Jan. 2015), p. 9. Cao Zhi was a graduate student at the Nanjing University of Aeronautics and Astronautics while writing this thesis: 曹智 [Cao, Z.], '高超声速无人机基于特征模型的机动飞行控制研究' [Manoeuvring and flight control based on the characteristic model for hypersonic UAVs], Master's Thesis, Nanjing University of Aeronautics and Astronautics (Feb. 2012), p. 4.

[14] Zhang Sihu was a graduate student at the Aerospace Research Institute of the Harbin Institute of Technology while writing this thesis: 张四虎 [Zhang, S.], '高超声速飞行器再入热环境分析及弹道优化设计' [Heat environment analysis and trajectory optimization for hypersonic vehicles], Master's Thesis, Harbin Institute of Technology (June 2013), p. 7. An Hao was a graduate student at the Harbin Institute of Technology while writing this thesis: 安昊 [An, H.], '高超声速飞行器建模及控制方法研究' [Modelling control methods for hypersonic vehicles], Harbin Institute of Technology (July 2013), pp. 5–6.

less, Russia's reported testing of its hypersonic glide vehicle on the UR-100N and the potential mounting of it on the heavy liquid-propelled RS-28 ICBM to defeat US ballistic missile defences suggest that it is making its intentions clear.[15] Given the focus on defeating US missile defences, a nuclear payload would be the most likely option. By contrast, China has been hedging on whether its DF-ZF will be conventional or nuclear. Current discussions on mounting hypersonic glide vehicles on the DF-21 medium-range ballistic missile (MRBM) and the DF-26 intermediate-range ballistic missile (IRBM) indicate a regional contingency. This has elicited a profusion of Western analyses of China's use of its systems for anti-access area-denial (A2AD) to complicate US regional intervention in a crisis.[16]

What these studies disregard, however, is that roughly a quarter of the Chinese technical studies on hypersonic glide vehicles remain focused on US missile defences, rather than any A2AD agenda. Some Chinese experts are even beginning to allege that the very existence of A2AD is a fabrication by Western analysts.[17] Roughly half the Chinese studies surveyed on hypersonic glide vehicles and related technologies concentrate on countering or developing longer-range systems, such as space planes. This suggests that the future uses of China's hypersonic glide vehicles will extend well beyond a conventional payload and a regional conflict. The fact that they place a similar focus on Russia's intended use of these systems to defeat US missile defences in response to US withdrawal from the Anti-Ballistic Missile (ABM) Treaty also suggests identification with Russia when confronting this threat.

Thus, when it comes to the question of whether the DF-ZF, or the Yu-71 and the Yu-74, would be used to overcome theatre missile defence (TMD) or national missile defence (NMD), Chinese and Russian analyses have similar perspectives. They do not distinguish between regional and national missile defence.[18] Much as in Russian discussions of US deployment of TMD in Eastern Europe, Chinese debates over TMD in East Asia concentrate on how these systems serve larger US NMD reconnaissance and intercept goals, thereby threatening its strategic deterrent. This has recently come to the forefront of Chinese concerns over the intended stationing by the USA of THAAD in South Korea, in terms of both enhanced radar and intercept capabilities. Moreover, US X-Band radar deployment in Japan has been a concern for a number of years. The fact that both Chinese and Russian

[15] Zhang Shaofang, Wu Kunlin and Zhang Hongna are affiliated with China's Haiying Science and Technology Information Institute. 张绍芳 [Zhang S.], 武坤琳 [Wu K.] and张洪娜 [Zhang H.], '俄罗斯助推滑翔高超声速飞行器发展' [Russia's boost-glide hypersonic flight development], 飞航导弹 [*Winged Missile Journal*], no. 3 (Mar. 2016), pp. 20–22.

[16] Heath, T. and Erickson, A. S., 'Is China pursuing counter-intervention?', *Washington Quarterly* (Fall 2015), pp. 143–56; Gompert, D. C., 'Responding to China's anti-access strategy', US–China Economic and Security Review Commission, Testimony, 24 Jan. 2014, <http://www.uscc.gov/sites/default/files/Gompert_Testimony1.30.14.pdf>; and Heath, T. R., Gunness, K. and Cortez, C. A., *The PLA and China's Rejuvenation* (Rand Corporation: Santa Monica, 2016), pp. 1–61, <https://www.rand.org/content/dam/rand/pubs/research_reports/RR1400/RR1402/RAND_RR1402.pdf>.

[17] Chinese expert on nuclear affairs, conversation with the author, Conference of the Chinese Community of Political Science and International Studies, Tsinghua University, 2016.

[18] Saalman, L., 'The China factor', eds A. Arbatov and V. Dworkin, *Missile Defence: Confrontation and Cooperation* (Carnegie Moscow Centre: Moscow, 2013), pp. 226–52.

developments in prompt high-precision systems are trending towards the targeting of US missile defences and a nuclear payload makes the postural crossover of these countries all the more relevant.

System integration

If China's DF-ZF is intended as a conventional weapon to be used against a non-nuclear target, then the chances of use are likely to increase. This stems from the inherent difference between conventional weapons and nuclear weapons posited by Li Bin, professor and director of the arms control programme at Tsinghua University, who argues that countries do not intend nuclear weapons for actual use, but rather for coercion—or bargaining in the case of the USA.[19] Unlike nuclear weapons, hypersonic glide vehicles are viewed in a much more utilitarian way in Chinese texts. In part, this stems from their current use, which Western analysts assume is to be mounted on medium-range missile systems to thwart US regional intervention.

When it comes to Chinese technical and official analyses, however, China appears to be extending hypersonic glide range and utility from the regional conventional systems to be deployed on DF-21D MRBMs and DF-26 IRBMs, to longer-range nuclear systems that put US missile defences at risk. Given the pre-existing utilitarian concept of these systems as conventional weapons, building hypersonic glide vehicles into China's strategic deterrent creates the potential for them to erode the nuclear taboo, increasing the likelihood of their use even if mounted with nuclear payloads.

The utilitarian posture in China towards hypersonic glide vehicles, which may at some point carry over to nuclear payloads, creates worrying challenges in terms of escalation and overall strategic stability. Exacerbating these challenges is the co-mingling argument made by James Acton at the Carnegie Endowment for International Peace, which posits that a conventional strike against co-located nuclear and conventional command and control centres could trigger a nuclear response.[20] In this case, China's own control architecture poses the greatest challenge.

China's assumed conventional and nuclear co-location deters an adversary from launching an attack. Yet, the likelihood of such facilities being compromised in a conventional conflict remains and could result in rapid escalation. If China's DF-ZF system is launched in response to what has been deemed a 'first-use' attack on a co-mingled facility, there is a chance of nuclear escalation. That is why the

[19] Based on the writing and speeches of Li Bin, Director and Professor at the Arms Control Programme of the Department of International Relations at Tsinghua University and Senior Research Associate at the Carnegie Endowment for International Peace; and Li, B., 'China's potential to contribute to multilateral nuclear disarmament', Arms Control Association, 3 Mar. 2011, <https://www.armscontrol.org/act/2011_03/LiBin#4>.

[20] Acton, J. M., *Silver Bullet? Asking the Right Questions About Conventional Prompt Global Strike* (Carnegie Endowment for International Peace: Washington, DC, 2013), <http://carnegieendowment.org/files/cpgs.pdf>.

impact of Russia's posture on China—as it pertains to its own hypersonic glide vehicles and tactical nuclear weapons—is so critical.

To this end, further exploration of the concept of 'rapid response' (快速反应) should be part and parcel of understanding this postural evolution in China. Although Zhao Tong has noted in previous publications that this term could be associated with launch-on-warning, there are indicators that it could just as easily be referring to prompt global strike capabilities.[21] The concept of 'rapid response' appeared in roughly a quarter of the Chinese texts surveyed for this section. In most cases, it was paired with near space, space-based weapons and prompt global strike capabilities.

As just one example, in China's 2015 Military White Paper, rapid response appears on a list that contains 'strategic warning' (战略预警), 'command and control' (指挥控制), 'missile penetration' (导弹突防) and 'survivability protection' (生存防护).[22] While its inclusion on a list with 'strategic warning' could point towards launch-on-warning, the positioning of 'rapid response' between 'missile penetration' and 'survivability protection'—combined with the importance of early warning in countering prompt global strike—suggest that this reference could also be applied to hypersonic glide vehicles, space planes and the future of strategic stability.

At the military level in China, US space planes such as the X-37B and X-51 are also frequently paired with discussions of 'rapid response' (快速反应) and 'rapid strike' (快速打击).[23] While the latter term correlates with prompt strike systems as a direct translation to Chinese, the postural implication of 'rapid response' is less clear. In Chinese texts, prompt global systems, such as near space aircraft, are viewed as providing platforms for reconnaissance, missile defence, electromagnetic countermeasures, transportation, communication and space weapons.

For example, 'rapid response' appears in Harbin Institute of Technology theses to describe the use of near space aircraft as space weapon platforms and serves as part of a longer list that includes such capabilities as long-range attack, wide-range, high-mobility, precision-strike capabilities or, in other words, the 'fifth dimension' (五位一体) of joint operations.[24]

Chinese technical studies on hypersonic glide vehicles and related technologies emulate what they call US 'rapid response' programmes, such as the Defence Advanced Research Projects Agency (DARPA) Falcon project, with its the common aero vehicle and affordable rapid response missile demonstrator.[25] While the

[21] Zhao, T., 'Strategic warning and China's nuclear posture', *The Diplomat*, 28 May 2015, <http://thediplomat.com/2015/05/strategic-warning-and-chinas-nuclear-posture>.

[22] State Council Information Office of the People's Republic of China (note 7).

[23] Li Li is affiliated with China's National Defence University. 李莉 [Li, L.], 'X-37B: 遮遮掩掩为哪般?' [X-37B: Why so exceedingly secretive?], 解放军报 [*People's Liberation Army Daily*], 3 Jan. 2011, p. 8; 李亚轲 [Li, Y.], 梁晓庚 [Liang, X.] and 郭正玉 [Guo, Z.], '临近空间攻防对抗技术发展研究' [Near space attack-defence confrontation technology], 四川兵工学报 [*Sichuan Ordnance Journal*], no. 5, May 2013, pp. 24–30.

[24] Li Xuefei was a graduate student at the Harbin Institute of Technology when this thesis was written. 李雪飞 [Li, X.], '高超声速飞行器气热弹多场耦合数值模拟' [Hypersonic vehicle: thermoelastic numerical simulation of multi-field coupling], Master's Thesis, Harbin Institute of Technology (June 2011), pp. 9–11.

[25] Chen Yingshuo, Ye Lei and Su Xinxin are affiliated with the China Aerospace Science and Industry Corporation, Third Institute, Department 310. 陈英硕 [Chen, Y.], 叶蕾 [Ye, L.] and 苏鑫鑫 [Su, X.], '国外吸气

USA and other foreign powers such as Russia dominate these Chinese studies, they also focus on China's own ambitions when it comes to hypersonic glide vehicles and related systems.

Beyond papers advocating that China develop more active prompt global systems, a number also detail China's own efforts to obtain 'rapid response' capabilities. These include: (*a*) hypersonic aircraft ground tests and wind tunnel tests by China North Industries Corporation; (*b*) a robust adaptive approach to near space vehicles based on trajectory linearization control at Nanjing University of Aeronautics and Astronautics; and (*c*) designs and simulations using terminal guidance laws, gas thermo-elastic multi-field coupling and thermal protection for reusable hypersonic vehicles at the Harbin Institute of Technology.[26]

If the postural interpretation of the term 'rapid response' is retaliatory and supports 'active defence' (积极防御), a case could be made that it diminishes the chances of pre-emption on the part of China. However, the larger question becomes: to what are these systems responding? If China's hypersonic glide vehicles are to be deployed regionally to serve as A2AD systems mounted on the DF-21D or the DF-26 but with greater delegation of launch authority, this indicates a conventional payload and pre-emptive use.

However, if the goal of China's hypersonic glide systems is more in line with that of Russia and targeted on defeating US missile defences, this suggests a nuclear payload. This latter trend could alter not only how 'rapid response' and 'active defence' are defined, but also how experts interpret China's postural bedrock of no first use. This bedrock is being eroded by the very systems identified in the US Nuclear Posture Review as the USA's deterrent against China and Russia—missile defence and prompt global strike.[27]

Takeaways

Given that hypersonic glide tests conducted by China, Russia and the USA have not yet led to deployment, there is still an opportunity for greater analysis of how these technologies will affect the postural evolution of these three countries. Not

式高超声速飞行器发展现状' [The status of foreign air-breathing hypersonic vehicle development], 飞航导弹 [*Winged Missile*], [n.d.]; Dang Aiguo, Li Xiaojun and Xu Bao are affiliated with the Department of the General Staff Corps of Engineers. 党爱国 [Dang, A.], Li, X. [李晓军] and徐宝 [Xu, B.], '外军快速全球打击能力发展动态' [Developments in foreign military prompt global strike capabilities], 飞航导弹 [*Winged Missile Journal*], no. 7 (July 2012), pp. 51–54.

[26] Tian Jianming, Jing Jianbin and Han Guangqi are affiliated with the Test and Measuring Academy of China North Industries Corporation. 田建明 [Tian, J.], 景建斌 [Jing, J.] and韩广岐 [Han, G.], '高超声速飞行器地面试验方法综述' [Overview of hypersonic aircraft ground test methods], no. 5 (Oct. 2013), pp. 57–60. Xue Yali was a graduate student at the National Defence Science and Technology University when this thesis was written. 薛雅丽 [Xue, Y.], '基于轨迹线性化方法的近空间飞行器鲁棒自适应控制研究' [A robust adaptive approach to near space vehicles based on trajectory linearization control], Doctoral Dissertation, National Defence Science and Technology University Research Institute (June 2010); and 李雪飞 [Li, X.] (note 24), pp. 9–11.

[27] Even the voices reaffirming China's commitment to no first use, such as PLA Major General (Retd) Yao Yunzhu and Tsinghua University's Li Bin, highlight the impact of concerns in China over US missile defence and prompt global strike. Yao, Y., 'China will not change its nuclear policy', *China US Focus*, 22 Apr. 2013, <http://www.chinausfocus.com/peace-security/china-will-not-change-its-no-first-use-policy>; and Li, B., 'Chinese thinking on nuclear weapons', Arms Control Association, 3 Dec. 2015, <https://www.armscontrol.org/ACT/2015_12/Features/Chinese-Thinking-On-Nuclear-Weapons>.

taking the time to assess the potential outcomes of a technology-driven posture could lead to greater strategic instability and arms racing. As part of this process, beyond the US–Chinese paradigm, more emphasis needs to be placed on integrating Russia into analyses of China's hypersonic glide vehicle development. This would provide a more nuanced analysis than the current bilateral calculations, which often simplify nuclear relations.

Chinese and US experts already meet on strategic nuclear issues at the academic and semi-official levels, although prompt global strike is generally a smaller and newer portion of the agenda.[28] Expansion to a trilateral discussion that includes China, Russia and the USA at a more official level would mean moving beyond the idea that China's asymmetrical disadvantage in nuclear warhead numbers precludes its involvement in US–Russian strategic stability talks.[29] As China's advances in hypersonic glide vehicle technology grow and its arsenal size responds to missile defence expansion in the Asia-Pacific region, the excuse of asymmetric disadvantage diminishes and the argument for trilateral engagement grows.

[28] The China Foundation for International and Strategic Studies, the Pacific Forum of the Centre for Strategic and International Studies, the Institute of Applied Physics and Computational Mathematics and the Nuclear Threat Initiative are all active in this sphere.

[29] Some laudable efforts have been made by the Carnegie Endowment for International Peace to stimulate these trilateral exchanges at the Track II level, but these exchanges and studies require greater systematization and frequency. On these dialogues and seminars see Burns, W. et al., 'The future of arms control and strategic stability', Carnegie Endowment for International Peace, 15 Sep. 2016, <http://carnegieendowment.org/2016/09/15/future-of-arms-control-and-strategic-stability-event-5358>; and Saalman, L., 'China–Russia–US strategic stability and missile defence', Carnegie Endowment for International Peace, 31 Jan. 2013, <http://carnegieendowment.org/2013/01/31/china-russia-u.s.-strategic-stability-and-missile-defence-event-3999>.