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

Chinese Advances in Unmanned Systems and the Military Applications of Artificial Intelligence—the PLA's Trajectory towards Unmanned, "Intelligentized" Warfare

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Introduction:

The Chinese People's Liberation Army (PLA) is actively advancing its unmanned weapons systems, while capitalizing upon the military applications of artificial intelligence, in order to enhance its war-fighting capabilities. To date, the PLA has incorporated a range of unmanned aerial vehicles (UAVs) into its force structure,[1] while also starting to experiment with and, to a limited extent field, unmanned underwater vehicles (UUVs), unmanned ground vehicles (UGVs), and unmanned surface vehicles (USVs). The Chinese defense industry has likewise made significant progress in its research and development of a range of cutting-edge unmanned systems, including those with supersonic, stealth, and swarming capabilities, but appears to face continued challenges in UAV engines, data links, and sensors. Concurrently, rapid Chinese advances in artificial intelligence will contribute to the PLA's ambitions to progress beyond informatization (信息化) towards "intelligentization" (智能化) in its force development.

The PLA's sophisticated unmanned weapons systems will increase its anti-access/area-denial (A2/AD) capabilities, while its progress in multiple military applications of artificial intelligence could enable a disruptive operational advantage. In the immediate future, the probable missions for the PLA's unmanned weapons systems will include intelligence, surveillance, and reconnaissance (ISR); integrated reconnaissance and strike; information operations, especially electronic warfare; data relay, including communications relay and guidance for missiles engaged in over-the-horizon (OTH) targeting; and military operations other than war, such as counterterrorism and border defense. In addition, recent breakthroughs in swarm intelligence (集群智能) could enable "swarm warfare" (集群战) for asymmetric assaults against major U.S. weapons platforms, such as aircraft carriers. The PLA has also intensified its efforts to capitalize upon the military applications of artificial intelligence. Looking forward, PLA strategists

[1] This testimony relies upon an extensive review of open sources, a methodology that necessarily must take into account a degree of uncertainty about the unknown veracity and the likely limitations of the available information. Since this testimony does not attempt to be comprehensive, see also prior analyses of Chinese unmanned systems, including: Michael S. Chase, Kristen A. Gunness, Lyle J. Morris, Samuel K. Berkowitz, and Benjamin S. Purser III, "Emerging Trends in China's Development of Unmanned Systems," RAND Corporation, 2015. Ian Easton and L.C. Russell Hsiao, "The Chinese People's Liberation Army's Unmanned Aerial Vehicle Project: Organizational Capacities and Operational Capabilities," Project 2049 Institute, March 11, 2013. Kimberly Hsu, Craig Murray, and Jeremy Cook, "China's Military Unmanned Aerial Vehicle Industry," U.S. –China Economic and Security Review Commission, June 13, 2013.

recognize and intend to capitalize upon a trend towards "unmanned, intangible, silent warfare" ("无人, 无形, 无声"战争) that is increasingly "intelligencized" (智能化).[2]

The PLA's Current Unmanned Weapons Systems:

The PLA has incorporated a range of UAVs into its force structure throughout all four services, the PLA Army, Navy, Air Force, and Rocket Force (former Second Artillery Force); in addition, the Strategic Support Force (战略支援部队) and the CMC Joint Staff Department (联合参谋部) likely operate at least limited number of UAVs.[3] Although a high proportion of the UAVs in service with the PLA are smaller, tactical models, the PLA Air Force (PLAAF) and PLA Navy (PLAN) have also started to introduce more advanced, multi-mission UAVs. Certain of the PLA's UAVs appear to be strikingly similar to comparable U.S. models, which in some cases may reflect mimicry or commercial cyber espionage.[4] To a limited extent, the PLA Army is also starting to experiment with UGVs, and the PLA Navy has fielded and prioritized advances in UUVs, while exploring options for USVs.

Unmanned Aerial Vehicles

PLA Army:

The PLA Army (PLAA) has established multiple UAV battalions (无人机营) and a variety of lower-level organizations with UAV within all five theater commands (战区), often subordinate to group armies (集团军). The majority of these UAVs appear to be smaller models, such as the ASN-207, produced by the Xi'an ASN Technology Group, which are typically used for battlefield reconnaissance, communications relay, and electronic warfare.[5] There are also unmanned helicopters, such as the Z-3, produced by the GSD 60th Research Institute, in service.[6] In addition, certain PLA ground forces have been provided with a smaller, hand -held and -launched variant, the CH-802.[7]

PLA Navy:

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[2] Academy of Military Science Military Strategy Research Department [军事科学院军事战略研究部], *The Science of Military Strategy* [战略学], Military Science Press [军事科学出版社], 2013, 97-98.

[3] Please note that this is not intended to be a comprehensive overview of all of the UAVs that the PLA operates but rather a review of representative models.

[4] For prior accounts of Chinese intellectual property theft targeted at drone technology, see, for instance: Edward Wong, "Hacking U.S. Secrets, China Pushes for Drones," *New York Times*, September 20, 2013, http://www.nytimes.com/2013/09/21/world/asia/hacking-us-secrets-china-pushes-for-drones.html?_r=0&pagewanted=all.

[5] ASN, which is the 365th Research Institute of the Northwest Polytechnical University of Xi'an, has delivered thousands of UAVs to the PLA. The models believed to be currently in service with the PLA include the ASN-206, the ASN-207, the ASN-209, and the ASN-215. (See: Xi'an ASN Technology Group website, "About ASN," http://www.asngroup.com.cn/english/About.asp?id=8.)

[6] "Z-3 Unmanned Helicopter Experiences Much Industry Audience" [Z-3型无人直升机备受行业观众], Sina, July 10, 2010, http://slide.mil.news.sina.com.cn/slide_8_3006_4286.html#p=1

[7] "Sergeant Wang Wei Intensely Studied Unmanned Reconnaissance Aerial Vehicles, Became the "Authority"" [上士王伟潜心钻研无人侦察机 成了"大拿"] *China Military Online*, April 23, 2016, http://www.81.cn/jwgz/2016-04/23/content_7019518.htm.

The PLAN has a limited number of sophisticated reconnaissance UAVs, the low-observable medium-altitude long-endurance (MALE) BZK-005, designed by the Beihang University's UAV Institute and the Harbin Aircraft Industry Group. To date, the BZK-005, which reportedly has the ability to remain airborne for up to 40 hours, has already been used for surveillance in the East China Sea and South China Sea.[8] In addition, the PLAN has fielded a medium-altitude, medium-endurance (MAME) UAV, the ASN-209 ("Silver Eagle," 银鹰), which has been used for communications relay and electromagnetic confrontation.[9]

PLA Air Force:

The PLAAF has fielded the GJ-1 (*Gongji*-1, 攻击－1,) variant of the Pterodactyl (or *Yilong*, 翼龙),[10] a medium-altitude long-endurance (MALE) UAV developed by the Chengdu Aircraft Design Institute. The GJ-1, which is roughly analogous to the U.S. Predator, is capable of carrying multiple forms of precision weapons.[11] Its primary missions include reconnaissance and surveillance; anti-radiation interference and attack, through jamming an adversary's air defense radars, fire control radars, and early warning systems; and tactical targeted killings, including in potential counterterrorism or "stability protection" operations.[12, 13] To date, the GJ-1 has been primarily used for its integrated reconnaissance and strike capabilities. The PLAAF has also, seemingly more recently, introduced the BZK-005 into service for reconnaissance purposes.[14]

PLA Rocket Force:

The PLA Rocket Force (PLARF, the former PLA Second Artillery Force) appears to have fielded a number of UAVs across various units. For instance, the PLARF's Base 52 in Anhui Province, which could cover the East China Sea and Taiwan, and also Base 53 in Yunnan Province, which can cover multiple potential targets, including locations in India and Southeast Asia, may have

[8] For instance, according to Japanese media, the BZK-005 entered Japan's ADIZ in the East China Sea and was intercepted by Japanese fighter jets in 2013. In May 2016, *Fox News* reported that China had deployed a BZK-005 UAV to Woody Island, based on satellite imagery.

[9] "The Chinese Navy Fielded the Silver Eagle UAV, Which Can Be Used for Long-Distance Communication" [中国海军列装银鹰无人机 可用于远程通信], July 18, 2011.

[10] The GJ-2, a more advanced version of the GJ-1, has reportedly also been developed, but there are no indications that it has yet been deployed.

[11] "Attack-1 UAV Fills the Chinese Air Force's Integrated Reconnaissance and Strike Gap" [攻击-1 无人机填补中国空军察打一体无人机空白], *Xinhua*, November 14, 2014, http://news.xinhuanet.com/mil/2014-11/13/c_1113239224.htm

[12] "'Pterodactyl' UAV, the Backstabbing Killer in Counterterrorism Operations" ["翼龙"无人机，反恐行动中的"暗箭杀手"], *China Youth Daily*, December 18, 2015, http://kj.81.cn/content/2015-12/18/content_6821963.htm

[13] Experts: "Yilong" UAV is at an International First Class Level" [专家："翼龙"无人机处于国际一流水平], November 14, 2012, http://www.chinanews.com/mil/2012/11-14/4329485.shtml

[14] "The New Treasure Chest Has Secrets Inside, a Great Power Air Force Is Just This Way" [新胸标里有秘密, 大国空军就是这个范儿！], *China Military Online*, May 27, 2016

deployed UAVs to subordinate missile brigades.[15] The PLARF seems to focus upon the use of UAVs for primarily artillery spotting and battle damage assessment, and it may also employ UAVs to provide over-the-horizon guidance for advanced missiles,[16] such as the DF-21D.[17]

PLA Strategic Support Force:

The PLA's new Strategic Support Force (SSF) will probably field UAVs in support of its electronic warfare mission. For instance, the SSF has likely incorporated into its force structure the former General Staff Department's (GSD) Fourth Department (4PLA, 总参四部), the Electronic Countermeasures and Radar Department.[18] 4PLA has previously acquired UAVs and presumably would focus on the employment of UAVs in support of its electronic warfare mission.[19] The former GSD Informatization Department (总参信息化部), which has since been reorganized into the JSD Information and Communications Bureau (联参信息通信局), also leveraged UAVs for reconnaissance.[20] However, it is unknown at this point whether its UAVs remained with the Information and Communications Bureau or could have been transferred to the SSF.

CMC Joint Staff Department:

The Joint Staff Department (JSD, 联合参谋部) has likely retained some of the UAVs that were formerly under the aegis of the GSD, which may include the BZK-005,[21] yet the status of particular units cannot yet be confirmed. For instance, the 55th Research Institute (第五十五研究

[15] Ian Easton and Russell Hsiao, "The Chinese People's Liberation Army's Unmanned Aerial Vehicle Project: Organizational Capacities and Operational Capabilities," Project 2049, March 11, 2013, https://project2049.net/documents/uav_easton_hsiao.pdf

[16] The available publications on the topic include: Liang Yong [梁勇] and Zhou Shaolei [周绍磊], "UAV Over-the-Horizon Guidance Methods" [无人机超视距引导方法], *Missile and Aerospace Delivery Technologies* [导弹与航天运载技术], 2010. The authors are affiliated with the Naval Aeronautical Engineering Institute's Control Engineering Department.

[17] There have been online rumors and reports in Russian media, repeated in Chinese media, that the Xiang Long (Soar Dragon) UAV might be used to guide the DF-21D. See, for instance: "Russian Media Claimed the "Soar Dragon" UAV Could Guide the DF21D Anti-ship Ballistic Missile" [俄媒称"翔龙"无人机可引导 DF21D 反舰弹道导弹本], UAV Network, July 5, 2011, http://www.81uav.cn/uav-news/201107/05/904.html

[18] John Costello, "The Strategic Support Force: Update and Overview," *China Brief*, December 21, 2016, https://jamestown.org/program/strategic-support-force-update-overview/.

[19] "Six-Rotary Winged Unmanned Aerial Vehicle Public Bidding Announcement [六旋翼无人机公开招投标公告], All-Military Weapons Equipment Purchasing Information Network [全军武器装备采购信息网], December 11, 2015, http://www.weain.mil.cn/cggg/zbgg/512788.html.

[20] Mark Stokes and Ian Easton, "The Chinese People's Liberation Army General Staff Department: Evolving Organization and Missions," in Kevin Pollpeter and Kenneth Allen, "PLA as Organization 2.0," Defense Group Inc., 2015.

[21] For instance, in 2009, the GSD established a UAV team (无人机方队) that was described as multi-modal, multi-range, and multi-purpose (多机型, 多航程, 多用途), seemingly incorporating a variety of variants of tactical UAVs. However, which GSD department was responsible for this team was not specified at the time. "UAV Team Primarily Composed Of Units from the General Staff Department" [无人机方队由总参谋部所属部队为主组成], *Xinhua*, October 1, 2009, http://news.xinhuanet.com/mil/2013-06/21/c_124888195_2.htm.

所), which previously supported the Tactical Reconnaissance Bureau (战术侦察局) of the former GSD Intelligence Department (总参谋部情报部), also known as the Second Department (2PLA), seemingly operated at least one UAV regiment or brigade located near Beijing, which may have remained under the aegis of this research institute.[22] There is initial evidence available that 55th Research Institute itself, which also supported the leadership of the former GSD Intelligence Department in the formulation of specific technical and operational requirements for UAVs, is indeed subordinate to the JSD, where it may continue to coordinate with its Intelligence Bureau (联合参谋情报局), the successor to the Intelligence Department.[23]

Unmanned Underwater Vehicles

There are likely several versions of the *Zhishui* (智水) unmanned underwater vehicle (UUV), produced by Harbin Engineering University, in service with the PLAN.[24] Although multiple research institutes are engaged in research and development more advanced systems, there are not yet indications that PLAN has acquired or fielded additional UUVs.

Unmanned Ground Vehicles:

The PLA Army (PLAA) has experimented with and may start to field unmanned ground vehicles (UGVs).[25] As of the fall of 2015, the PLAA engaged in an initial test of a small UGV.[26] This technology is seen as likely to replace soldiers, whether partially or completely, in reconnaissance and surveillance, firepower attacks, and also logistics assurance and support. In the fall of 2016, the PLA Army Equipment Department organized a competition, "Leaping Over Dangerous and Difficult [Roads] 2016" ("跨越险阻 2016"), which tested the ability of unmanned ground systems to engage in tasks such as battlefield reconnaissance.[27] In the future, UGVs may carry out missions including surveillance and reconnaissance, firepower strikes, and logistics assurance and support.[28] Given apparent progress in research and development, the PLAA might progressively employ a greater number of these systems.[29]

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[22] Mark Stokes and Ian Easton, "The Chinese People's Liberation Army General Staff Department: Evolving Organization and Missions," in Kevin Pollpeter and Kenneth Allen, "PLA as Organization 2.0," Defense Group Inc., 2015.

[23] "C/C++ Language Source Code Vulnerability Testing" and Three Other National Standards Successfully Passed the Assessment [《C/C++语言源代码漏洞测试规范》等三项国家标准顺利通过评审], *Evaluation Center* [评测中心], November 23, 2016, http://www.zhsstc.org.cn/xwzx/article_18340.html.

[24] See, for instance: "Zhishui," *Naval Drones*, http://www.navaldrones.com/Zhishui.html.

[25] "Our Military's Unmanned Ground Combat Systems Approach Application" [我军地面无人作战系统走向实用化], China Military Online, October 29, 2015, http://zz.81.cn/content/2015-10/29/content_6745735_2.htm

[26] Ibid.

[27] "Leaping Over Dangerous and Difficult [Roads] 2016" Unmanned Ground System Challenge Completed" ["跨越险阻 2016"地面无人系统挑战赛落幕], China Military Online, October 18, 2016, http://www.mod.gov.cn/power/2016-10/18/content_4748815_3.htm

[28] Ibid.

[29] For instance, the Weapons Unmanned Ground Vehicle R&D Center (兵器地面无人平台研发中心), established in 2014, is engaged in the development of UAVs for multiple military, security, and commercial uses. See: "Weapons Unmanned Ground Platform R&D Center Established" [兵器地面无人平台研发中心成立], *Science and*

Research and Development of Unmanned Weapons Systems:

The former General Staff Department (GSD) and General Armaments Department (GAD) were the PLA's primary authorities for the formulation of UAV requirements and policies; their respective successor organizations, the CMC Joint Staff Department (JSD) and Equipment Development Department (装备发展部) have likely taken on these functions since the PLA's organizational reforms.[30] At this point, the processes through which the PLA directs the development and decides upon the acquisition of unmanned systems remain relatively opaque. The JSD, EDD, and each service's equipment departments appear to establish requirements for systems based on their intended employment. The relevant expert groups, which often involve academics and researchers from the defense industry, appear to undertake an advisory role on issues involving the research and development of unmanned systems. For instance, the former General Armaments Department UAV Expert Group (总装无人机专家组) may have been recently reconstituted as the CMC Equipment Development Department UAV Experts Group (军委装备发展部无人机专家组).[31, 32] At the CMC level, there is reportedly an Intelligent Unmanned Systems and Systems of Systems Science and Technology Domain Expert Group (军委智能无人系统及体系科学技术领域专家组) which may reflect a redoubled focus on "intelligent" unmanned systems.[33]

China's national science and technology plans have enabled consistent funding for the underlying research and development. Since the early 2000s, funding for the basic and applied research relevant to the development of unmanned systems has been directed through the former National High-Technology Research and Development Plan (国家高技术研究发展计划) or "863 Plan" and the former National Key Basic Research and Development Plan (国家重点基础研究发展计划) or "973 Plan."[34] Recently, the Thirteenth Five-Year Plan included a focus on military robotics.[35] Increasingly, a profit incentive may also motivate civilian and military UAV

Technology Daily, June 28, 2014, http://digitalpaper.stdaily.com/http_www.kjrb.com/kjrb/html/2014-06/28/content_267309.htm?div=-1.

[30] Since the reorganization, these authorities would probably shift to the new Joint Staff Department and Equipment Development Department respectively. See: Kenneth Allen, Dennis Blasko, and John Corbett, "The PLA's New Organizational Structure: What is Known, Unknown and Speculation (Part 1)," *China Brief*, February 4, 2016.

[31] "Beijing UAS Engineering Center" [北京无人机系统工程中心], Beijing Institute of Technology November 2, 2016, http://job.nwpu.edu.cn/jobInfoView.do;jsessionid=A487B6337D2A9128D6E056A345A5054D?id=8120

[32] The members included experts from the China Aerospace Science and Technology Corporation's (CASC) Ninth Research Institute's Beijing Aerospace UAV Systems Engineering Research Institute (北京航天无人机系统工程研究所).

[33] "CMC Intelligent Unmanned Systems and Systems of Systems Science and Technology Domain Specialist Group" [军委智能无人系统及体系科学技术领域专家组], October 10, 2016, http://www.wenziyuan.com/p/mqybvsvy.html.

[34] There were also "experts' groups" (专家组) on specific research topics were associated with each of these plans, including the 863 Plan Robotics Subject Experts Group (863 计划机器人主题专家组).

[35] "One Hundred Major Projects of the Thirteenth Five-Year Plan Reflecting China's National Strategy" ["十三五"体现中国国家战略的百大工程项目], *Xinhua*, March 5, 2016, http://news.xinhuanet.com/politics/2016lh/2016-03/05/c_1118240939.htm.

manufacturers, since Chinese UAVs have been exported to multiple militaries worldwide, and the magnitude of the demand is increasing.[36]

Given the relative opacity of the process, it is difficult to estimate the current status of unmanned systems that might be fielded by the PLA in the years to come. Often, only limited and often dubious information is available regarding the status of these systems and their capabilities. It is difficult to anticipate which of these systems the PLA will choose to acquire and field.[37] Since there is competition in the design process, the PLA often has the opportunity to exercise discretion about which systems to acquire. In addition, there may also be (and likely are) multiple unmanned systems under development about which no information is available in the open source. Nonetheless, this initial review of notable unmanned systems known to be under development attempts to evaluate emerging trends.

Advanced Unmanned Aerial Vehicles:

The Chinese defense industry is engaged in the development of a range of high-altitude long-endurance UAVs that variously have stealth or anti-stealth, supersonic, and precision strike capabilities. Major Chinese defense conglomerates have often taken advantage of their existing expertise in aviation or missile technology to develop sophisticated UAVs. Since the mid-2000s, the development of a number of these models has been revealed, often at forums such as the Zhuhai Airshow. Their testing has seemingly continued from the late 2000s through the present, but the timeline for this process varies. The major models of note include, but are not limited, to the following:

- The *Yilong* (Pterodactyl, 翼龙) is a multi-mission, high-altitude long-endurance (HALE) that has entered service with the PLAAF and been exported to multiple foreign militaries.[38] The *Yilong* has primarily been used for an integrated reconnaissance and precision strike mission but also possesses electronic warfare capabilities. According to Li Yidong (李屹东), chief designer for this series of UAVs, the initial model underwent development from 2005 onward and completed its first flight in 2007.[39] It was first exported in 2011 and had entered service the PLAAF by 2014.[40,] At the 2016 Zhuhai Airshow, the second generation of this series, the *Yilong*-2 systems was introduced, which is larger in size, capable of faster

[36] See, for instance: Vishkakha Sonawane, "China Exporting Military Drones Worth Millions of Dollars," *International Business Times*, April 21, 2016, http://www.ibtimes.com/china-exporting-military-drones-worth-millions-dollars-2357211.

[37] For example, various models of the *Caihong* ("Rainbow," 彩虹), developed by the Chinese Aerospace Science and Technology Corporation's China Academy of Aerospace Dynamics, has been exported to and utilized by multiple foreign militaries, but there is no evidence that it has yet been acquired by any service of the PLA.

[38] See, for instance: Richard Bitzinger, "China Is Suddenly a Leading Exporter of Armed Drones," *World Politics Review*, January 18, 2016, http://www.worldpoliticsreview.com/articles/17692/china-is-suddenly-a-leading-exporter-of-armed-drones

[39] Experts: "Yilong" UAV is at an International First Class Level" [专家："翼龙"无人机处于国际一流水平], November 14, 2012, http://www.chinanews.com/mil/2012/11-14/4329485.shtml

[40] For a more detailed case study, see also: Andrew Erickson, Hanlu Lu, Kathryn Bryan, and Samuel Septembre, "Research, Development, and Acquisition in China's Aviation Industry: The J-10 Fighter and Pterodactyl UAV," SITC Research Briefs, January 2014, http://escholarship.org/uc/item/0m36465p

speeds, and with greater maximum weight, roughly analogous to the U.S. Reaper.[41] Like the *Yilong*-1 (GJ-1), it may also enter service with the PLAAF.[42]

- The *Xianglong* ("Soar Dragon," 翔龙) is a HALE UAV, designed by the Chengdu Aircraft Design and Research Institute and produced by the Guizhou Aviation Aircraft Corporation. The *Xianglong* was initially revealed in 2006 at the Zhuhai Airshow.[43] In 2011, a prototype of it was photographed at an airfield in Chengdu, and its first successful flight reportedly occured in 2013.[44] As of the summer of 2016, photos online appeared to indicate that the *Xianglong* had entered production.[45] By late 2016, there were reports in state media that the Xianglong was undergoing final testing and could soon enter service with the PLA.[46] The *Xianglong* could be used for missions including electronic warfare and long-range reconnaissance, including perhaps to track and monitor U.S. aircraft carriers.[47] There has also been speculation that the *Xianglong* could be used as a carrier-based platform to provide early warning and electronic warfare capabilities, given recent photos that seemed to show it in close proximity to China's aircraft carrier.[48] Potentially, it could also be employed to enable over-the-horizon targeting for long-range missiles.
- The *Tianyi* ("Sky Wing," 天翼) is a series of semi-stealthy M/HALE UAVs, developed by the Chengdu Aircraft Design and Research Institute, with reconnaissance and precision strike, as well as electronic warfare, capabilities.[49] The *Tianyi* reportedly engaged in initial testing around 2008. Its export version, known as the *Yunying* ("Cloud Shadow," 云影), was

[41] "Deciphering the World Class Pterodactyl UAV" [解码世界一流的"翼龙"无人机], *Xinhua*, December 9, 2016, http://news.xinhuanet.com/mrdx/2016-12/09/c_135892371.htm

[42] The *Caihong*-5 appears to be a comparable and perhaps competing model, but this series has not, to date, entered service with the PLA, despite the frequency of its export.

[43] Zhuhai Airshow's High-Altitude Unmanned Reconnaissance Vehicle, the Soaring Dragon [珠海航展的高空无人侦察机翔龙], Sina, November 2, 2006, http://jczs.news.sina.com.cn/p/2006-11-02/1234409245.html

[44] "AVIC Chengdu Aircraft Design and Research InstituteSuspected Soar Dragon UAV's First Flight Successful" [中航成都所疑似"翔龙"无人机首飞成功], China Broadcast Network, January 24, 2013http://military.cntv.cn/2013/01/24/ARTI1358990934232852.shtml

[45] Andrew Tate, "China's Xianglong HALE UAV to enter service shortly, says report," IHS Jane's Defence Weekly, December 21, 2016, http://www.janes.com/article/66431/china-s-xianglong-hale-uav-to-enter-service-shortly-says-report

[46] "New drone to beef up PLA aerial skills," *China Daily*, December 7, 2016, http://www.china.org.cn/china/2016-12/07/content_39866858.htm

[47] Ibid.

[48] "China Soar Dragon UAV with the Domestic Catapult-Type Aircraft Carrier, Could Act As an Early Warning Aircraft" [中国翔龙无人机或上国产弹射型航母 充当舰载预警机], Sina Military, February 13, 2017, http://mil.news.sina.com.cn/jssd/2017-02-13/doc-ifyameqr7469492.shtml

[49] There is also a mini-UAV version of this series, the Tianyi-6, that could be released from an aircraft. Kelvin Wong, "Airshow China 2016: AVIC unveils SW-6 air-deployable mini UAV," HIS Jane's, November 4, 2016, http://www.janes.com/article/65202/airshow-china-2016-avic-unveils-sw-6-air-deployable-mini-uav

revealed at the Zhuhai Airshow in the fall of 2016.[50] This system could also be used against enemy air defense systems.[51]

- The *Lijian* ("Sharp Sword," 利剑) could become the PLA's first stealth HALE UAV and also has the capability to carry precision strike weapons.[52] The *Lijian*, produced by the Hongdu Aircraft Industry Group, with involvement from the Shenyang Aircraft Design Institute, was first flight tested in 2013.[53] Although limited information about its status has emerged since, there were indications that *Lijian* achieved breakthroughs in its development as of mid-2016.[54]

- The *Shendiao* ("Divine Eagle," 神雕) is a twin-fuselage HALE UAV with long-range surveillance and strike capabilities, as well as high-performance anti-stealth radars, that could advance the PLA's A2/AD capabilities, including through enabling the interception of stealthy U.S. systems.[55, 56] According to online sources, the *Shen Diao* has been under development by the Shenyang Aircraft Design Institute since 2012, and its first flight seemingly occurred in early 2015.[57, 58]

- The *Anjian* ("Dark Sword," 暗剑), a supersonic stealth UAV, is also believed to be under development by the Shenyang Aircraft Design Institute, where its chief designer is believed to be Liu Zhimin (刘志敏).[59] The *An Jian* was revealed through the display of a model at a 2007 air show.[60] However, there is no credible information available about its current status.

Given this apparent progress, certain of these advanced UAVs appear to be on track to enter service with the PLA within the next several years. These systems will increase the PLA's C4ISR

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[50] "Cloud Shadow UAV Revealed at the China Airshow" ["云影"无人机亮相中国航展], AVIC, January 13, 2017, http://cac.avic.com/web/a/xinwen/tupianxinwen/2017/0113/178.html

[51] Zhuhai Reveals Three "Flagships" of China's UAVs [珠海展示中国无人机三款新"旗舰"], *Observer* [观察], November 10, 2016, http://www.guancha.cn/military-affairs/2016_11_10_380101_s.shtml.

[52] Office of the Secretary of Defense, "Military and Security Developments Involving the People's Republic of China 2015," April 7, 2015.

[53] "Hongdu Lijian stealth UAV maiden flight," November 21, 2013, http://alert5.com/2013/11/21/photo-hongdu-lijian-stealth-uav-maiden-flight/.

[54] Its chief designer is believed to be Zhang Zijun (张子军), whose accomplishments are profiled in this piece: "Pursuing Dreams of a Blue Sky, Letting Dreams Fly [逐梦蓝天 放飞梦想], China Aviation News [中国航空报], May 24, 2016, http://wap.eastday.com/node2/node3/n403/u1ai615301_t71.html

[55] Bill Gertz, "China Unveils New Long-Range Drone," *Free Beacon*, May 29, 2015, http://freebeacon.com/national-security/china-unveils-new-long-range-drone/.

[56] Richard D. Fisher Jr., "Images emerge of new Chinese twin-fuselage HALE UAV concept," *Jane's*, May 28, 2015, http://www.janes.com/article/51759/images-emerge-of-new-chinese-twin-fuselage-hale-uav-concept.

[57] "Unmanned Aerial Vehicles," *Sino Defense*, https://sinodefence.com/chinese-military-aircraft/unmanned-aerial-vehicles/#ASN.

[58] Jeffrey Lin and P.W. Singer, "Divine Eagle, China's Enormous Stealth Hunting Drone, Takes Shape," Eastern Arsenal, May 28, 2015, http://www.popsci.com/divine-eagle-chinas-enormous-stealth-hunting-drone-takes-shape

[59] "'Dark Sword' UAV" ["暗剑"无人机], *Sina*, http://mil.news.sina.com.cn/p/2007-10-19/0734468114.html.

[60] "Details on China's Dark Sword Unmanned Combat Aerial Vehicle" [详解中国暗剑无人战机], Sina, October 19, 2007, http://www.sina.com.cn.

capabilities and expand its capacity to engage in long-distance precision strike, with adverse operational implications for U.S. posture in the Asia-Pacific.

Intelligent Unmanned Systems:

The PLA appears to prioritize the development of "intelligent" unmanned systems, which could operate autonomously in complex electromagnetic environments. Although it is difficult to estimate the PLA's progress, the research and experimentation undertaken thus far indicates that these efforts have advanced considerably. Without access to additional technical information, the extent of the degree of "intelligence" of these systems cannot readily be determined, although it likely remains relatively limited for the time being. However, concurrent Chinese advances in artificial intelligence in academic, commercial, and military contexts could enable further increases in their sophistication.

Autonomous UUVs:

Multiple research institutes and designated key laboratories have focused on the development of autonomous UUVs, which appears to be a priority for the PLAN, including to advance its anti-submarine warfare capabilities. For instance, the Beijing University of Aeronautics and Astronautics has developed a robofish UUV prototype,[61] and Tianjin University has tested the *Haiyan* unmanned underwater glider, which could potentially be used for underwater combat and patrol.[62]

Intelligent UAVs and Swarming:

Recently, there appear to have been significant breakthroughs in UAV swarming.[63] In November 2016, the China Electronics Technology Group Corporation (CETC), a prominent state-owned defense industry conglomerate,[64] in partnership with Tsinghua University, revealed its progress in swarm intelligence (集群智能) with a formation of nearly seventy small UAVs that operated autonomously.[65] In a recent demonstration of swarming techniques, there was a record-breaking demonstration of a formation of 1,000 UAVs at the Guangzhou Airshow in February 2017. Military experts quoted in Chinese media at the time highlighted that this technique could be used to create a distributed system with payload modules mounted on small drones.[66]

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[61] Liang Jianhong,, Wen Li, and Guo Yuxiao, "Experimental design and performance of underwater vehicle based on capacity of voyage," in *Robotics, Automation and Mechatronics, 2008 IEEE Conference*, 2008.
[62] "2014 PLA Six Major Science and Technology [Advances]: a UUV that Could Protect Drilling Platforms" [2014 解放军六大科技:水下无人机护卫钻井平台], *Xinhua*, July 21, 2014, http://news.xinhuanet.com/mil/2014-07/21/c_126774520.htm
[63] "Our Country Breaks a Number of World Records for Fixed-Wing UAVs Swarm Flying" [我国打破世界固定翼无人机集群飞行飞机数量纪录], China Military Online, November 6, 2016, http://www.81.cn/jfjbmap/content/2016-11/06/content_160924.htm
[64] Ibid.
[65] "The China Airshow Displays the World's Largest Model of an Unmanned Aerial Vehicle Cluster Experiment" [中国展示世界最大规模集群无人机实验], CETC, November 1, 2016, http://www.cetc.com.cn/zgdzkj/hzzt/wmgz/453128/index.html
[66] "Drone swarming technique may change combat strategies: expert," *Global Times*, February 14, 2017.

Intelligent Unmanned Surface Vehicles:

In the future, intelligent or autonomous USVs may be integrated into the PLAN and/or Chinese Coast Guard for wartime contingencies or to establish a persistent presence in disputed waters in peacetime. To date, there have been multiple versions of one particular intelligent USV tested, the *Jinghai* (精海), designed by the Underwater Engineering Research Institute at Shanghai University. This project started in 2010, and the vessel undertook its maiden voyage in the South China Sea, around the Paracel and Spratly Islands, in 2013.[67, 68] Reportedly, it has the capability to navigate autonomously and intelligently avoid obstacles in support of sensing and reconnaissance missions. The *Jinghai* was evaluated by the former General Armaments Department and the PLAN Equipment Department, perhaps an indication of the PLAN's intentions to acquire such a system.[69, 70]

Intelligent Unmanned Ground Vehicles:

Chinese advances in technologies for driverless cars may be transferred to intelligent unmanned ground vehicles. For instance, an 'intelligent' driving test zone has been established as a partnership among multiple institutions, including the Chinese Academy of Sciences' Institute of Automation (中科院自动化所) and the National University of Defense Technology,[71] which will be used for civilian and military intelligent unmanned vehicles.[72]

Technological Uncertainties:

Despite these evident advances, Chinese capabilities to design and produce advanced unmanned systems face continued challenges.[73] Reportedly, Chinese engines, data links, and airborne

[67] "Our Country's First Unmanned Boat First Sails the South China Sea" [我国第一艘无人艇南海首航[, PLA Daily, April 18, 2013, http://newspaper.jfdaily.com/jfrb/html/2013-04/18/content_1009462.htm.
[68] Ibid.
[69] ""Jinghai Series" Unmanned Sensing Boat Debuts" [精海号"无人测量艇亮相], November 4, 2015, http://ocean.china.com.cn/2015-11/04/content_36975694.htm.
[70] The Jinghai has reportedly been delivered to the China Maritime Bureau, the State Oceanic Administration, and other units for use in the East China Sea, South China Sea, Yellow Sea, and Antarctic.
[71] "CMC Intelligent Unmanned Systems and Systems of Systems Science and Technology Domain Specialist Group" [军委智能无人系统及体系科学技术领域专家组], October 10, 2016, http://www.wenziyuan.com/p/mqybvsvy.html. "Hunan's First Unmanned Driving Test Opens Construction" [湖南首个无人驾驶测试区开建], October 29, 2016, http://k.sina.cn/article_2288064900_88611984020001pl8.html?cre=aspect&mod=r&loc=7&r=9&doct=0&rfunc=0&vt=4
[72] "CMC Intelligent Unmanned Systems and Systems of Systems Science and Technology Domain Specialist Group" [军委智能无人系统及体系科学技术领域专家组]. "Hunan's First Unmanned Driving Test Opens Construction" [湖南首个无人驾驶测试区开建], October 29, 2016, http://k.sina.cn/article_2288064900_88611984020001pl8.html?cre=aspect&mod=r&loc=7&r=9&doct=0&rfunc=0&vt=4
[73] Jin Diwei, Li Dongdong, and Wang Chaowu, "An Unmanned Aerial Vehicle Suddenly Experienced a Malfunction on Its Way Home; 10 Landing Attempts in a Row Failed; If the Plane Crashed Into Residential Quarters the Consequences Would Be Disastrous. Hence … An Emergency Forced Landing," *People's Navy*, June 13, 2013. Thanks to Ken Allen for sharing this source.

electronic devices for unmanned systems remain less advanced than their U.S. counterparts.[74] For instance, despite reported improvements, engine technology is still considered a bottleneck in the development of military-use unmanned systems.[75] In some instances, these challenges may motivate attempts at licit or illicit technology transfers or the acquisition of related materials to redress these weaknesses. While there is limited technical information available, there appear to have been recent advances in Chinese UAVs' data links, which are a critical determinant of their operational capabilities.

Data Links:

Although the PLA has only recently started to rely on satellite linkages to control its UAVs, this capability could enable future split operations.[76] Whereas the *Cai Hong*-4 ("Rainbow," 彩虹), developed by the China Aerospace Science and Technology Corporation (CASC), had previously been controlled primarily through a "line of sight" link that gave it a range of 250 kilometers at a maximum, it has demonstrated the capability, as of the summer of 2016, to be controlled via satellite, at a distance of up to 1,000 kilometers.[77] This option of satellite control could allow UAVs to be operated and transmit real-time intelligence at much greater distances. Potentially, this could enable China to engage in split operations overseas comparable to those undertaken by the U.S. in counterterrorism operations. Future Chinese unmanned weapons systems may similarly utilize satellite control, thus expanding their potential range. However, the PLA has focused on operations under complex electromagnetic conditions, in which UAVs operating via satellite control could be especially vulnerable to interference, whether through jamming or hacking. Given its recognition and apparent exploitation of these vulnerabilities,[78] it is possible that the PLA might be less inclined to operate future unmanned weapons systems via satellite control than the U.S. and instead focus on progressing more rapidly toward autonomy, as the intensified focus on "intelligent" unmanned systems may indicate.

China has sought to improve its UAV data links to ensure their reliability and resilience, which are integral to their functionality and continuity of operations. Reportedly, the Chinese

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[74] Zhao Lei, "Foreign buyers eye Chinese drones," *China Daily*, June 20, 2013, http://usa.chinadaily.com.cn/china/2013-06/20/content_16638664_2.htm.

[75] "China's UAV R&D Encounters the Bottleneck of Engine Technology" [中国无人机研发遭遇发动机技术瓶颈], *Science and Technology Daily*, September 26, 2015, http://digitalpaper.stdaily.com/http_www.kjrb.com/kjrb/html/2015-09/26/content_318382.htm?div=-1

[76] "Still Use for Advertisements? Caihong-4 UAV Combat Video Spreads throughout the World" [还用广告？彩虹-4 无人机实战视频在全球传播], China Military Online, June 3, 2016, http://www.wxrw123.com/zgjs/20160603/1057297.html

[77] Ibid.

[78] According to media reports, there have been incidents in which U.S. Global Hawk long-range surveillance drones over the South China Sea were electronically jammed by the PLA, after previous technical research in the journal *Aerospace Electronic Warfare* on options to jam Global Hawk flights as well as RQ-170 drone operations. See: Bill Gertz, "Chinese Military Using Jamming Against U.S. Drones: Global Hawk targeted over disputed South China Sea Islands," *Free Beacon*, May 22, 2015, http://freebeacon.com/national-security/chinese-military-using-jamming-against-u-s-drones/.

Electronics Technology Company (CETC) has recently developed a Ku-band UAV data link.[79] This data link is intended to ensure the accurate transmission of sensor data, at up to 300 megabits per second, in order to ensure high-speed and real-time access to the information transmitted. In addition, CETC claims that this Ku-band data link is more resistant to interruption or interference than those previously used. Similarly, recent research has focused on mitigating the vulnerability of unmanned weapons systems to electronic countermeasures, which is reflected in publications and procurement focused on anti-interference, anti-intrusion, and anti-spoofing measures.[80] However, it is difficult to evaluate the degree to which various Chinese UAVs may have been hardened against such measures.

Missions of the PLA's Unmanned Weapons Systems:

The PLA recognizes the utility of unmanned weapons systems throughout the land, air, sea, space, and information battlefields, including to enhance its A2/AD capabilities. The primary categories of missions for the PLA's unmanned weapons systems include, but are not limited, to the following:

Intelligence, Surveillance, and Reconnaissance (ISR):

A range of UAVs, equipped with various sensors, will be utilized for battlefield reconnaissance, locating targets, directing artillery fires, and battle damage assessment, including in support of long-range missile strikes. The PLAAF's advanced UAVs, such as the GJ-1, could be used for precision strike. In future combat contingencies, the PLAN's USVs and UUVs may be used for tasks such as reconnaissance, tracking, surveillance, target designation, mine detection and hunting, and anti-submarine or anti-ship operations.[81,]

Integrated Reconnaissance and Strike (侦打一体).

Certain of the PLA's most advanced UAVs, such as the GJ-1, are optimized for integrated reconnaissance and strike, capable of carrying multiple forms of precision weapons. These capabilities might be utilized in conventional conflict or counterterrorism scenario. [82] For instance, one influential PLA strategist from the Academy of Military Science has argued that advanced UAVs could be used for power projection in "long distance operations," in order to

[79] "China's latest UAV Data Link Internationally Advanced, Extremely Difficult to Cut Off" [环球网：中国最新无人机数据链国际先进 极难被斩断], *Global Times*, November 2, 2016, http://mil.huanqiu.com/china/2016-11/9624313.html.

[80] e.g., "Navy Pre-Research - Counter-Interference and Decoy Technology for Unmanned Aerial Vehicle Under Complex Electromagnetic Conditions" [复杂电磁环境下无人机抗干扰诱骗技术], March 30, 2016, http://www.weain.mil.cn/cgxq/yy/yjjsl/526866.html

[81] "Unmanned Operations More Suited to Reality" [更贴现实的无人作战], July 25, 2014, http://www.81.cn/jmtt/2014-07/25/content_6063690.htm.

[82] e.g., "Multivariate Reconnaissance Constructs a Transparent Information "Skynet," UAVs Destroy the Enemy's Command Center" [多元侦察构筑透明信息"天网" 无人机虎口拔牙直捣敌指挥中枢, *PLA Daily*, September 1, 2014.

enable the PLA's "long-arm counterattack" capabilities.[83] The PLAN might employ ship-based and carrier-based UAVs,[84] including to strike an adversary's aircraft carrier or assault an enemy-occupied island or reef.[85] In the future, attacks by UAV swarms might seek to overwhelm the defenses of high-value weapons systems, particularly in the context of naval warfare.[86]

Data Relay:

The PLA will likely utilize multiple models of UAVs for data relay, including communications relay and guidance for missiles engaged in over-the-horizon (OTH) targeting by long-range missiles.[87] In a scenario in which satellites communications were compromised, the PLA might utilize UAVs to replace that capability.[88]

Anti-Submarine Warfare:

The PLAN's UUVs and USVs could be utilized to enhance the PLAN's limited anti-submarine warfare capabilities. For instance, there have been reports that the PLAN is seeking to establish an "underwater Great Wall" (水下长城) that might utilize UUVs to enhance underwater monitoring capabilities.[89] In the future, the PLAN might seek to employ USVs for continuous trailing of enemy submarines, perhaps in imitation of DARPA's Anti-Submarine Warfare Continuous Trail Unmanned Vehicle program.[90]

Information Warfare:

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[83] Jiang Yamin [蒋亚民], China's First: On Long-Arm Counterstrike [中国的拳头：论张臂反击], Military Science Press [军事科学出版社], 2014.

[84] "Indigenous UAVs in the Future Will Be on Aircraft Carriers" [国产无人机未来可上航母?], People's Daily, December 7, 2016, http://military.people.com.cn/n1/2016/1207/c1011-28931888.html

[85] Xiao Tianliang [肖天亮], Science of Military Strategy [战略学], National Defense University Press [国防大学出版社], 2015.

[86] "Swarm-Style Assaults: Will UAVs Chang Future Naval Warfare?" [蜂群式攻击:无人机将改变未来海战？].

[87] See, for instance: Liang Yong [梁勇] and Zhou Shaolei [周绍磊], "UAV Over-the-Horizon Guidance Methods" [无人机超视距引导方法], *Missile and Aerospace Vehicle Technologies* [导弹与航天运载技术], 2010. Qin Zhilong [秦志龙] and Wang Hua [王华], "The Tentative Idea of Uxing UAVs to Assist Anti-Ship Ballistic Missile Strikes against Aircraft Carriers" [利用无人机协助反舰弹道导弹打击航母的设想], *Winged Missiles* [飞航导弹], 2010. That fewer open-source publications have addressed this topic within the past several years could be an indication of a transition from conceptualization to actualization.

[88] For instance, the PLA Navy has often utilized the *Yin Ying* ("Silver Eagle," 银鹰) for communications relay in exercises. "The Chinese Navy Fielded the Silver Eagle UAV, [Which] Can Be Used for Long-Distance Communication" [中国海军列装银鹰无人机 可用于远程通信], July 18, 2011.

[89] "Thoughts on the Construction of China's Ocean Undersea Monitoring System" [构建我国海洋水下观测体系的思考], China Ocean News, December 2, 2015, http://www.oceanol.com/keji/ptsy/yaowen/2015-12-02/53812.html.

[90] "PLA Daily Commentator: Unmanned Submarines in the Ascendant" [解放军报评论：无人潜艇方兴未艾], China Navy Network, http://navy.81.cn/content/2013-08/22/content_5449152.htm.

The PLA's employment of UAVs may often support its engagement in information operations, especially electronic warfare. The PLA's training exercises frequently take place in a complex electromagnetic environment (CEME) in which UAVs are often used for electronic countermeasures.[91] According to influential AMS information warfare theorist Ye Zheng (叶征), information operations are developing in the direction of unmanned technologies, since UAVs have become a "multipurpose electronic warfare platform capable of executing a variety of electronic warfare tasks," which include electronic reconnaissance, electronic jamming, anti-radiation attacks, and battlefield target damage effect assessment.[92]

Military Operations Other Than War (MOOTW):

The PLA will likely employ unmanned systems in MOOTW (非战争行动), including for peacekeeping and defense of national borders and territorial claims. For instance, in Peace Mission 2014, a counter-terrorism drill organized through the Shanghai Cooperation Organization, the PLAAF used the GJ-1 for integrated reconnaissance and strike.[93] In the East and South China Sea, the PLAN and/or China Coast Guard might utilize USVs in order to assert maritime territorial claims.[94]

Training with Unmanned Systems:

The PLA's capability to utilize unmanned weapons systems to pursue these missions is inherently a function of the sophistication of its training and human capital.[95] Indeed, the PLA has sought to improve the sophistication of training exercises with UAVs.[96] In recent years, the incorporation of UAVs into the PLA's high-level joint exercises, which involve confrontations between "Red" (PRC) and "Blue" (enemy) forces, has become prevalent. Some of the PLA's major exercises, including the "Firepower" (*Huoli*, 火力) and Stride (*Kuayue*, 跨越) exercises have incorporated UAVs, including for purposes of battlefield reconnaissance, electronic

[91] "The 'Electromagnetic Condor' Winning on the Informationized Battlefield" [驭**"电磁神鹰"制胜信息战场**], *PLA Daily*, May 5, 2015, http://nj.81.cn/content/2015-05/05/content_6473197.htm.
[92] Ye Zheng [叶征], Lectures on the Science of Information Operations [信息作战学习教程], Military Science Press [军事科学出版社], 2012, p. 94
[93] "China's 'Pterosaur,' tailored UAV for global counter-terror action," *China Military Online*, November 4, 2014, http://english.chinamil.com.cn/news-channels/china-military-news/2014-11/04/content_6210989.htm.
[94] Ibid.
[95] The PLA has trained UAV operators at multiple military academic institutions since at least the late 1990s. In 2001, the PLA drafted its first "UAV Outline of Military Training and Evaluation" (UAV OMTE, 无人机训练与考核大纲).
[96] e.g., "Battalion Commander Li Changyong Created the Whole Military's First Five-Part UAV Flight" [少校营长李长勇：创造无人机飞行 5 项全军第一"], *PLA Daily*, August 15, 2014, http://www.81.cn/jwgz/2014-08/15/content_6095338_3.htm.

warfare, and integrated reconnaissance and strike, in coordination with manned systems, under complex electromagnetic conditions.[97, 98]

Potential Operational Impact:

The PLA anticipates that future warfare will be "unmanned, intangible, and silent" ("无人、无形、无声"战争), which will create and necessitate "revolutionary changes" in doctrine and force structure.[99] Future unmanned systems, especially those utilizing artificial intelligence, nanotechnology, and stealth, will have an "increasingly prominent function" on future land, sea, air, and space battlefields, while existing as a force multiplier for the PLA's C4ISR and strike capabilities.[100] In the foreseeable future, PLA strategists expect that autonomous combat by unmanned systems and the joint operations of unmanned and manned systems will have a dramatic impact on traditional operational models.[101] Increasingly, unmanned weapons systems have the capability to operate with greater degrees of autonomy and integration across platforms. In particular, the PLA's focus on swarm warfare (集群战), involving the operations of "intelligentized" (智能化) systems, reflects recognition of the likely utility of these tactics in to saturate and overwhelm the defenses of high-value weapons platforms. Ongoing theoretical and technical research appears to support such new operational approaches.[102] This next frontier for Chinese unmanned weapons systems will be enabled by the weaponization of artificial intelligence.[103]

Chinese Advances in Artificial Intelligence:

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[97]"Our Military First Group of UAV Specialty Graduates Li Changyong, Five Records Achieved" [我军首批无人机专业毕业生李长勇 5 创纪录"].

[98] Wan Xuelin [万学林], "How to Carry Out the Current Reform, Look to See How the Older Generation Does It" [改革当前怎么干，看看前辈怎么做], *China Military Online*, December 8, 2015, http://nj.81.cn/content/2015-12/08/content_6804903.htm.

[99] Academy of Military Science Military Strategy Research Department [军事科学院军事战略研究部] (ed.), *The Science of Military Strategy* [战略学], Military Science Press [军事科学出版社], 2013, 97-98.

[100] Ibid.

[101] Xiao Tianliang [肖天亮], "Adapting to the Tide of the Military Revolution [and] Seize the Initiative in Reform" [顺应军事变革潮流把握改革主动], *PLA Daily*, January 5, 2016.

[102] For instance, there has been exploratory research on the command and control of formations of manned and unmanned systems by researchers affiliated with the Navy Equipment Department. Chen Xiaodong [陈晓栋], Liu Yuefeng [刘跃峰], and Chen Zhoudong [陈哨东], "Manned and Unmanned Aerial Vehicle Formations Command and Control Systems, Decision-Making, and Distribution" [有人/无人机编队指挥控制系统决策分配], *Electro-Optics and Control* [电光与控制], 2013.

[103] According to the official PLA dictionary, intelligent weapon (智能武器) is defined as: "weapons that utilize artificial intelligence technology automated-ly (自动) pursue, distinguish, and destroy enemy targets, often, composed of information collection and management systems, knowledge base systems, assisting strategic decision systems, and mission execution systems, such as intelligent ammunition and military-use robots." All-Military Military Terminology Management Committee [全军军事术语管理委员会], *People's Liberation Army Military Terminology* [中国人民解放军军语], Military Science Press [军事科学出版社], 2011, p. 660.

The rapidity of recent Chinese advances in artificial intelligence indicates the capability to keep pace with or perhaps even overtake the U.S. in this critical technology. The dynamism of private sector initiatives in artificial intelligence in China has been clearly demonstrated by the successes of major Chinese companies, including Baidu, Alibaba, and Tencent, and even start-ups, such as Iflytek, Uisee Technology, or Turing Robot.[104] From speech recognition to self-driving cars, Chinese efforts in artificial intelligence are cutting edge.[105] Although the military dimension of Chinese advances in artificial intelligence has remained relatively opaque, there is also sophisticated research on artificial intelligence and automation occurring in PLA research institutes and the Chinese defense industry. Evidently, the PLA recognizes the disruptive potential of artificial intelligence in warfare.[106] Looking forward, the PLA anticipates that the advent of artificial intelligence will fundamentally alter the character of warfare, ultimately resulting in a transformation from today's "informatized" (信息化) ways of warfare to future "intelligencized" (智能化) warfare.[107]

High-Level Prioritization of Artificial Intelligence:

The Chinese leadership has prioritized artificial intelligence at the highest levels, recognizing its expansive applications and strategic implications. The initial foundation for China's progress in artificial intelligence was established through long-term research funded by national science and technology plans, such as the 863 Plan.[108] Notably, the China's Thirteenth Five-Year Plan (2016-2020) called for breakthroughs in artificial intelligence, which was also highlighted in the Thirteenth Five-Year National Science and Technology Innovation Plan.[109] The new initiatives focused on artificial intelligence have been characterized as the "China Brain Plan" (中国脑计

[104] Since there have been multiple recent reports on the topic in Western media, I will focus primarily on the military dimension of China's advances in artificial intelligence. See, for instance, John Markoff and Matthew Rosenberg, "China's Intelligent Weaponry Gets Smarter," *New York Times*, February 3, 2017, https://www.nytimes.com/2017/02/03/technology/artificial-intelligence-china-united-states.html

[105] Although China appears to have overtaken the U.S. in the quantity of research in artificial intelligence, it is difficult to compare the quality of research conducted in the U.S. and China. See, for instance: "China overtakes US in quantity of AI research," *South China Morning Post*, October 20, 2016, http://www.scmp.com/lifestyle/article/2029101/china-has-now-eclipsed-us-quantity-ai-research

[106] The operational impact of artificial intelligence will be amplified by the concurrent employment of the military Internet of Things, big data, and cloud computing. However, for the purposes of this testimony, I will focus more narrowly on artificial intelligence in particular.

[107] Although the term "智能化" might also be translated as "smart," I choose to use the translation "intelligentization" for consistency with the translation used in a recent article from *China Military Science*, a journal released by the influential Academy of Military Science, and also to highlight the parallel to the PLA's concept of "informatization" (信息化). See: China Military Science Editorial Department [中国军事科学 编辑部], "A Summary of the Workshop on the Game between AlphaGo and Lee Sedol and the Intelligentization of Military Command and Decision-Making" [围棋人机大战与军事指挥决策智能化研讨会观点综述], *China Military Science* [中国军事科学], April 2, 2016.

[108] "The National "863" Plan Computer Subject's Thirty-Year Anniversary: Leapfrog-Style Development and the Realm of Necessity" [国家"863"计划计算机主题 30 年拾遗：跨越式发展与必然王国], *Science Net*, February 8, 2017, http://news.sciencenet.cn/htmlnews/2017/2/367416.shtm

[109] ""China Brain Plan" Urgently Needs Good Direction" ["中国脑计划"急需定好方向], Shanghai Science and Technology Commission, http://www.stcsm.gov.cn/xwpt/kjdt/344990.htm

划), which seeks to enhance understandings of human and artificial intelligence alike.[110] In addition, the "Internet Plus" and Artificial Intelligence Three Year Implementation Plan (2016-2018) emphasizes the development of artificial intelligence and its expansive applications, including to unmanned systems, in cyber security, and for social governance.[111] Beyond these current initiatives, the Chinese Academy of Engineering has proposed an "Artificial Intelligence 2.0 Plan," which focused on big data, intelligent sensing, cognitive computing, machine learning, and swarm intelligence.[112] The Ministry of Science and Technology has reportedly tasked a team of experts to draft a plan for the development of artificial intelligence through 2030.[113] The apparent intensity of this support and funding will likely enable continued, rapid advances in artificial intelligence with dual-use applications through a range of national key laboratories, university research institutes, and private companies.[114]

Civil-Military Integration in Artificial Intelligence:

China's significant progress in artificial intelligence must be contextualized by the national strategy of civil-military integration or "military-civil fusion" (军民融合). This agenda has become a high-level priority under Xi Jinping's leadership,[115] reflected by the establishment of the Civil-Military Integration Development Commission (军民融合发展委) in early 2017, which is headed by Xi Jinping himself.[116] China's strategy of civil-military integration is consistent with the dual-use nature of this emerging technology and may enable the PLA to take advantage of the resulting synergies. For instance, An Weiping (安卫平), deputy chief of staff of the PLA's Northern Theater Command, has highlighted the importance of deepening civil-military integration, especially for such strategic frontier technologies as artificial intelligence.[117] Pursuant to this strategy, it is not unlikely that China's civilian advances in artificial intelligence will eventually be utilized in a military context.

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[110] "The "China Brain Plan"" Is About to Start" [中国脑计划"即将启动], *People's Daily*, June 29, 2015 , http://webcache.googleusercontent.com/search?q=cache:AmvbnzlqPUkJ:paper.people.com.cn/rmrb//html/2015-06/29/nw.D110000renmrb_20150629_3-12.htm+&cd=3&hl=en&ct=clnk&gl=us

[111] ""Internet+" Artificial Intelligence Three-Year Activities Implementation Plan Issued" ["互联网+"人工智能三年行动实施方案印发], *Xinhua*, May 26, 2016, http://news.xinhuanet.com/info/2016-05/26/c_135390662.htm

[112] "The Internet Has Become a Driving Force for Medical Change" [互联网成为医疗变革推动力], *Xinhua*, November 18, 2016, http://news.xinhuanet.com/health/2016-11/18/c_1119937185.htm.

[113] "Dean Feng Jianfeng Appointed to the "China Artificial Intelligence 2.0 Plan" Preparation Group of Experts" [冯建峰院长受聘担任"中国人工智能 2.0 计划"编制组专家], Fudan University, September 1, 2016, http://istbi.fudan.edu.cn/zh/feng-jianfeng-president-of-the-china-artificial-intelligence-2-plan-the-preparation-of-the-group-of-experts/.

[114] Although an extensive listing of these institutions would be beyond the scope of this paper, the relevant research institutes include Turing Robot, the HIT Robot Group, the Chinese Academy of Sciences' Institute of Intelligent Machines, and the State Laboratory of Intelligent Technology and Systems at Tsinghua University.

[115] The CMC Strategic Planning Office (战略规划办公室) includes a subordinate Civil-Military Integration Bureau (军民融合局) that may be responsible for related initiatives.

[116] "Civil-Military Integration Development Committee Established" [军民融合发展委成立], *Xinhua*, January 23, 2017, http://news.xinhuanet.com/finance/2017-01/23/c_129458492.htm

[117] "An Weiping: Promote Civil-Military Integration towards Deeper Development" [安卫平：推进军民融合向深度发展], *Global Times*, January 24, 2017, http://opinion.huanqiu.com/1152/2017-01/10010428.html

Given this approach, the boundaries between civilian and military research and development tend to blur, and the PLA is often closely linked to cutting-edge research in artificial intelligence. At the CMC level,[118] the PLA has reportedly established an Intelligent Unmanned Systems and Systems of Systems Science and Technology Domain Expert Group (军委智能无人系统及体系科学技术领域专家组), which may establish strategic objectives and requirements, while perhaps also liaising with academia and industry.[119] In a notable case, Li Deyi (李德毅) acts as the director of the Chinese Association for Artificial Intelligence, and he is affiliated with Tsinghua University and the Chinese Academy of Engineering. Concurrently, Li Deyi is a major general in the PLA who serves of deputy director of the 61st Research Institute under the CMC Equipment Development Department.[120] His academic activities, such as the development of systems for self-driving cars, often have clear military applications. Indeed, the PLA's apparent focus on the integration of elements of artificial intelligence and related technologies into military equipment has resulted in the establishment of a variety of partnerships and collaborations. For instance, in November 2016, the Military-Civil Fusion Intelligent Equipment Research Institute (军民融合智能装备研究院) was established as a collaboration between the Northern University of Technology (北方工业大学) and a private technology company.[121] The institute has received support from the Naval Equipment Research Institute, the Army Equipment Department, the Rocket Forces' Unit 966658, and other military organizations, and it will focus on topics including intelligent robotics, artificial intelligence, unmanned systems, and military brain science.[122]

The PLA's Initial Thinking on Intelligentized Warfare:

The PLA expects that advances in artificial intelligence will revolutionize warfare, through accelerating the transition from contemporary informatized warfare to future intelligencized warfare.[123] Given current trends in research in artificial intelligence – and especially since the U.S. announcement of the Third Offset – PLA strategists have anticipated the "dawning of the military revolution of intelligencization" and articulated concerns about the consequences of a

[118] The CMC Equipment Development Department, the successor to the former GAD, and the new CMC Science and Technology Commission (军委科技委), which has been characterized as a Chinese version of DARPA, may also undertake leading roles in this effort.

[119] "CMC Intelligent Unmanned Systems and Systems of Systems Science and Technology Domain Specialist Group" [军委智能无人系统及体系科学技术领域专家组], October 10, 2016, http://www.wenziyuan.com/p/mqybvsvy.html.

[120] "Li Deyi" (李德毅), Chinese Academy of Engineering [中国工程院院], http://www.cae.cn/cae/jsp/jump.jsp?oid=20111231115339500679747

[121] "Beijing Engineering University Established the Civil-Military Integration Intelligent Equipment Research Institute" [北工大组建军民融合智能装备研究院], *Science and Technology Daily*, November 28, 2016, http://www.stdaily.com/cxzg80/kebaojicui/2016-11/28/content_349218.shtml

[122] "Civil-Military Integration Intelligent Equipment Research Institute Established" [军民融合智能装备研究院成立], *People's Daily*, November 4, 2016, http://finance.people.com.cn/n1/2016/1104/c1004-28834080.html.

[123] "Artificial Intelligence: An Accelerant for the Evolution of the Form of Informatized Warfare" [人工智能：信息化战争形态演变的助推器], *Xinhua*, June 17, 2016, http://news.xinhuanet.com/science/2016-06/17/c_135444311.htm

U.S. "technological surprise attack" in this new domain.[124, 125] Thus far, the PLA's initial approach to artificial intelligence appears to have has been informed by its careful examination of U.S. military initiatives but could increasingly diverge as a function of its distinctive strategic culture. Based on recent writings, PLA officers recognize that artificial intelligence will cause disruptive changes to the dynamics of military operations.[126] In the foreseeable future, artificial intelligence may have impactful applications across virtually all aspects of warfare, from the automation of multiple weapons systems to intelligence support for decision-making[127] to cyber warfare.[128] Thus far, the PLA's initial approach to artificial intelligence has been informed by its careful examination of U.S. military initiatives but could increasingly diverge as a function of its distinctive strategic culture. For instance, several NDU academics anticipate that the impactful military applications of artificial intelligence include intelligentized command and control, as well as support to decision-making; intelligent unmanned military platforms; and the expansion of human stamina, skills, and intellect through artificial intelligence.[129]

The PLA's Progress in Intelligentization:

Thus far, the PLA appears to have achieved notable progress in "intelligentization" and evidently aspires to actualize multiple military applications of artificial intelligence. Based on an initial analysis of PLA writings and research, this testimony will highlight indications of the PLA's prioritization of progress in swarm intelligence, intelligentized missiles, and the intelligentization of command and control. The PLA's future progress in multiple additional military applications of artificial intelligence merits continued analytical attention.[130]

Swarm Intelligence:

The Chinese defense industry has accomplished unexpected breakthroughs in UAV swarming, demonstrated at fall 2016 airshows, and appears to be on track for continued advances in this technique. Multiple military and civilian research institutes appear to be working on swarming UAVs, based on their published research and patents on the topic. These include CETC's 54th

[124] Pang Hongliang [庞宏亮], "The Intelligentization Military Evolution Starting to Dawn—from the Third Offset Strategy Interpret the Trajectory of the Development of Military Technology" [智能化军事革命曙光初现——从美'第三次抵消战略'解读军事技术发展轨迹], *PLA Daily*, January 28, 2016, http://www.mod.gov.cn/wqzb/2016-01/28/content_4637961.htm.

[125] Hu Xiaofeng [胡晓峰], "The Man-Machine Game: Who is the "Big Winner" in Future Warfare" [人机博弈：谁是未来战争"大赢家"], PLA Daily, March 24, 2016, http://jz.chinamil.com.cn/n2014/tp/content_6974469.htm

[126] "An Weiping: Promote Civil-Military Integration towards Deeper Development" [安卫平：推进军民融合向深度发展], *Global Times*, January 24, 2017, http://opinion.huanqiu.com/1152/2017-01/10010428.html

[127] Several research institutes may be focused on the topic, including the Intelligent Sensing and Computing Research Center (智能感知与计算研究中心) within the Institute of Automation at the Chinese Academy of Sciences (中国科学院自动化研究所).

[128] "Artificial Intelligence: An Accelerant for the Evolution of the Form of Informatized Warfare" [人工智能：信息化战争形态演变的助推器].

[129] Zhu Qichao [朱启超], Wang Jingling [王婧凌], Li Daguang [李大光], "Artificial Intelligence Knocking to Open the Door to Intelligentized Warfare" [人工智能叩开智能化战争大门], *Xinhua*, January 23, 2017, http://news.xinhuanet.com/mil/2017-01/23/c_129459228.htm

[130] Please note that this is an initial review of the issue, and the author's analysis of the topic is ongoing.

Research Institute, CASIC's Third Institute's UAV Technology Research Institute (302nd Institute, 中国航天科工三院无人机技术研究所), the Harbin Institute of Technology's National Key Laboratory of Robotic Systems and Engineering (机器人技术与系统"国家重点实验室), Tsinghua University's Department of Automation (自动化系), the Beijing University of Aeronautics and Astronautics, and Northwest Polytechnic University.[131] The PLA has commissioned research on data link technologies for "bee swarm" (蜂群) UAVs that focused on options for network architecture, navigation, and anti-jamming measures.[132]

The intense focus on the technologies associated with swarm intelligence reflects the PLA's recognition of the tremendous operational potential of this technique. Zhao Jie (赵杰), director of the 863 Plan Intelligent Robotics Expert Group, has highlighted that "swarm intelligence" acts as a disruptive technology…which is a breakthrough for future unmanned combat." [133] In particular, the anticipated advantages of intelligent swarming UAVs include their functional distribution, high system survivability, and low operational cost. [134] These intelligent unmanned systems will likely serve as an asymmetric means through which to target high-value U.S. weapons systems, including aircraft carriers.

Intelligentized Missiles:

The sophistication of advanced Chinese missiles may be further augmented through the incorporation of artificial intelligence and automation. In remarks to the media, Wang Changqing (王长青), from China Aerospace Science and Industry Corporation's (CASIC) Third Academy's General Design Department claimed, "our future cruise missiles will have a very high level of artificial intelligence and automation," such that commanders will be able "to control them in a real-time manner, or to use a fire-and-forget mode, or even to add more tasks to in-flight missiles." In a more detailed account of his presentation, Wang Changqing, who is also the deputy director of CASIC's Advanced Guidance Technology National Defense Key Laboratory (先进制导控制技术国防重点实验室), highlighted the potential applications of artificial intelligence to mission management systems, flight management systems, and control and execution.[135] In particular, artificial intelligence could enable missiles to have advanced capabilities in sensing (感知), decision-making (决策), and execution (执行) of missions, including through gaining a degree of "cognition" (认知) and the ability to learn.

[131] This list has been compiled based on a review of patents available through Google that reference terminology related to UAV swarming (e.g., 无人机蜂群 or 集群).

[132] "Data Link Technology for Swarm UAVs" [蜂群无人机数据链技术], August 1, 2016, http://www.weain.mil.cn/cgxq/yy/yjjsl/526969.html

[133] "Our Country Breaks a Number of World Records for Fixed-Wing UAVs Swarm Flying" [我国打破世界固定翼无人机集群飞行飞机数量纪录], China Military Online, November 6, 2016, http://www.81.cn/jfjbmap/content/2016-11/06/content_160924.htm

[134] "Our Country Breaks a Number of World Records for Fixed-Wing UAVs Swarm Flying" [我国打破世界固定翼无人机集群飞行飞机数量纪录].

[135] Wang Changqing [王长青], "The Application and Prospects of Artificial Intelligence in Cruise Missiles" [人工智能在飞航导弹上的应用与展望], http://chuansong.me/n/711504451360

Given the lack of credible technical details available, it is infeasible to verify these claims or determine the sophistication of these reported capabilities. Nonetheless, CASIC's initial focus on "missile intelligentization" dates back to the early 2000s, and Chinese research on the topic appears to have continued consistently since then.[136] CASIC's Third Academy claims to have expertise in artificial intelligence and intelligent robotics and recruits new talent with those specialties.[137] Despite the limitations of the available information, it does seem plausible that the Chinese defense industry has achieved at least initial progress in the intelligentization of missiles and is working towards enhancing these capabilities in the future.

Intelligent Command and Control:

At the highest levels, the PLA appears to prioritize the intelligentization of its command and control information systems and may already have achieved considerable progress in this endeavor. Notably, the CMC Joint Staff Department has called for the PLA to accelerate its construction of a joint operations command system, which will require progress towards intelligentized command and decision-making that takes advantage of the potential of artificial intelligence, as well as big data, cloud computing, and other advanced technologies.[138] The JSD's commentary highlighted that the victory of Google's AlphaGo's in the 'man-machine war' of *Weiqi* (Go) demonstrated the tremendous potential of artificial intelligence in operational command,[139] program deduction (方案推演), and support to decision-making (辅助决策).[140] Indeed, the success of AlphaGo is considered a turning point that demonstrated the potential of artificial intelligence to engage in complex analyses and strategizing comparable to that required to wage war, not only equaling human cognitive capabilities but even contributing a distinctive advantage that may exceed the human mind.[141] Eventually, the demands for cognitive speed in warfare could result in progression towards a battlefield "singularity," a point at which the

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[136] Guan Shiyi [关世义], "Preliminary Exploration of Missile Intelligentization" [导弹智能化技术初探], Tactical Missile Technology [战术导弹技术], July 2004.

[137] "China Aerospace Science and Industry Corporation's Third Institute [中国航天科工集团第三研究院], http://yz.chsi.com.cn/sch/schoolInfo--schId-367814,categoryId-483322,mindex-1.dhtml

[138] CMC Joint Staff Department [中央军委联合参谋部], "Accelerate the Construction of a Joint Operations Command System with Our Nation's Characteristics—Thoroughly Study Chairman Xi's Important Sayings When Inspecting the CMC Joint Operations Command Center [加快构建具有我军特色的联合作战指挥体系—— 深入学习贯彻习主席视察军委联指中心时的重要讲话], *Qiushi* [求是], August 15, 2016, http://www.qstheory.cn/dukan/qs/2016-08/15/c_1119374690.htm

[139] Coincidentally, there have been reports that a Chinese team plans to challenge Google's AlphaGo. Recently, Baidu's Deep Learning Lab entered its own artificial intelligence robot in a contest against human competitors. See: "Chinese AI team plans to challenge Google's AlphaGo: state media," Reuters, http://www.reuters.com/article/us-science-intelligence-go-idUSKCN0WX0NN. Meng Jing, "Baidu's AI Robot Upstaged by Google's AlphaGo in show down against humans," South China Morning Post, January 5, 2017, http://www.scmp.com/tech/article/2059655/baidus-artificial-intelligence-bot-square-against-humans-live-tv-broadcast.

[140] CMC Joint Staff Department [中央军委联合参谋部], "Accelerate the Construction of a Joint Operations Command System with Our Nation's Characteristics—Thoroughly Study Chairman Xi's Important Sayings When Inspecting the CMC Joint Operations Command Center [加快构建具有我军特色的联合作战指挥体系—— 深入学习贯彻习主席视察军委联指中心时的重要讲话],

[141] Hu Xiaofeng [胡晓峰], "The Man-Machine Game: Who is the "Big Winner" in Future Warfare" [人机博弈：谁是未来战争"大赢家"], PLA Daily, March 24, 2016, http://jz.chinamil.com.cn/n2014/tp/content_6974469.htm

rapidity of reactions required in operational command exceeds human capabilities.[142] Under such conditions, artificial intelligence could take on a critical role in strategic and operational command, acting as a "computer joint staff" (电脑参谋).[143]

The JSD's directive for the intelligentization of command and decision-making is consistent with and will be advanced based on ongoing theoretical and applied research on this challenge. For instance, Major General Hu Xiaofeng, who has been responsible for the PLA's computer war-gaming effort,[144] has been focused on simulations of intelligentized warfare.[145] His recent research has focused on DARPA's Deep Green program,[146] which sought to provide an automated system that supported rapid generation of options and decision-making, as an example of the incorporation of intelligent technologies into military information systems.[147] PLA academics from the Academy of Military Science anticipate that the trend towards future "informationized intelligent warfare" (信息化智能战争) renders imperative the intelligencization of equipment and integration of artificial intelligence into command and control, especially for information operations forces.[148] Concurrently, the China Command and Control Society has focused intensively on the intelligentized command and control in its recent forums and publications.[149] It recently entered into a partnership with a private company, Dawn (曙光公司) to promote the intelligentization and automation of command and control systems.[150] It may also be of note that Major General Li Deyi, president of the Command and Control Society, is an expert in artificial intelligence and command automation who serves as the deputy

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[142] Chen Hanghui [陈航辉], "Artificial Intelligence: Disruptively Changing the Rules of the Game" [人工智能：颠覆性改变"游戏规则], China Military Online, March 18, 2016,http://www.81.cn/jskj/2016-03/18/content_6966873_2.htm

[143] Yuan Yi [袁艺], Will Artifical Intelligence Command Future Wars?" [人工智能将指挥未来战争？], China Military Online, January 12, 2017, http://www.81.cn/jmywyl/2017-01/12/content_7448385.htm

[144] For a more detailed account of the PLA's wargaming efforts, see: Dean Cheng, "The People's Liberation Army on Wargaming," War on the Rocks, February 17, 2015, https://warontherocks.com/2015/02/the-peoples-liberation-army-on-wargaming/

[145] Hu Xiaofeng [胡晓峰], "The Man-Machine Game: Who is the "Big Winner" in Future Warfare" [人机博弈：谁是未来战争"大赢家"], PLA Daily, March 24, 2016, http://jz.chinamil.com.cn/n2014/tp/content_6974469.htm

[146] J.R. Surdu, K. Kittka, "Deep Green: Commander's tool for COA's Concept," *Computing, Communications and Control Technologies: CCCT 2008*, 29 June - 2 July 2008, Orlando, Florida, http://www.bucksurdu.com/Professional/Documents/11260-CCCT-08-DeepGreen.pdf. For a Chinese analysis of the program, see this extensive analysis of DeepGreen by Hu Xiaofeng: "Chief Engineer Hu Xiaofeng, General Manager of China's Bingqi Program, Delivered a lecture: the Challenge of the Intelligentization of Command information Systems" [中国兵棋工程总师胡晓峰少将演讲：指挥信息系统的智能化挑战], July 13, 2016, 2016-http://chuansong.me/n/434595151184

[147]Guo Shengming [郭圣明], He Xiaoyuan [贺筱媛], Hu Xiaofeng [胡晓峰], Wu Lin [吴琳], Ou Wei [欧 微], "Challenges and Trends in the Intelligentization of Military Information Systems" [军用信息系统智能化的挑战与趋势], *Control Theory & Applications* [控制理论与应用], Vol. 33 No. 12, December 2016, http://jcta.alljournals.ac.cn/cta_cn/ch/reader/create_pdf.aspx?file_no=CCTA160470&year_id=2016&quarter_id=12&falg=1

[148] *Outline for Combat Forces Development* [作战力量建设概论], Military Science Press, 2012.

[149] "China Command and Control Society Hosts the Fourth China Command and Control Conference in Beijing" [中国指挥与控制学会在京举办第四届中国指挥控制大会], China Association for Science and Technology, July 8, 2016, http://www.cast.org.cn/n17040442/n17045712/n17059079/17289485.html

[150] "Accelerate the "Cloud-ization" and Intelligentization of Military Command Information Systems" [推进军事指挥信息系统"云"化和智能化], *Global Times*, January 17, 2017, http://www.js7tv.cn/news/201601_33024.html

director of the 61st Research Institute, which took a leading role in China's development of its integrated command platform.[151] Indeed, this new focus on the intelligentization of command systems may reflect the initial phases of the stage subsequent to command automation in the PLA's ongoing modernization of its command and control capabilities.[152]

The PLA may already have achieved significant progress towards this command intelligentization, based on media accounts. Liu Zhong (刘忠) of the National University of Defense Technology, with its Key Laboratory of Information Systems Engineering (信息系统工程重点实验室) has been engaged in a multi-year research effort, which dates back to 2006, to optimize and increase the intelligentization of the PLA's command and control systems.[153] Recognizing the complexity of the battlefield and the challenges of command decision, his research has explored options to integrate increased levels of artificial intelligence and automation into the PLA's existing command systems, in order to enable rapid planning and decision-making.[154] Their work has focused on the development of a Joint Operations Command and Control Advanced Concepts Demonstration System (联合作战指挥控制先期概念演示系统).[155] Reportedly, as of December 2015, his team completed their research and development process and their command and control system was formally equipped to units.[156] Liu Zhong has been praised extensively for his work, which has been characterized as creating an "external brain" (外脑) to assist commanders.[157] Although there is not detailed information available about the extent and functionality of this new system's intelligentization, this achievement indicates that the PLA may be on track to achieve such advances in its command and control capabilities for joint operations.

Strategic Implications:

Ultimately, China's advances in artificial intelligence may have immense strategic implications for the U.S. Initially, the U.S. military was able to ensure an uncontested advantage in Second Offset technologies. However, the uncertain trajectory of current defense innovation initiatives will be inherently complicated by the reality that today's technological trends, particularly in

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[151] Kevin Pollpeter, Eric Anderson, Joe McReynolds, Leigh Ann Ragland, and Gary L. Thomas, "Enabling Information-Based System of System Operations: The Research, Development, and Acquisition Process for the Integrated Command Platform," SITC Research Briefs, January 2014, http://escholarship.org/uc/item/6f26w11m

[152] e.g., Zhao Wei [赵伟], Pan Siwei [庞思伟], "Problems Regarding the Intelligentization of Command and Control Systems" [智能化指挥控制系统问题], February 2010.

[153] "National University of Defense Technology's Liu Zhong: Creating a Powerful "External Brain" for Command and Control" [国防科大刘忠:为指挥控制打造强大"外脑"], *People's Daily*, December 28, 2015, http://military.people.com.cn/n1/2015/1228/c401735-27986608.html

[154] "The Story of National University of Defense Technology Information Systems and Management Institute Chief Engineer Professor Liu Zhong" [国防科技大学信息系统与管理学院总工程师刘忠教授故事集], Xinhua, December 15, 2015, http://news.xinhuanet.com/mil/2015-12/30/c_128559188_5.htm

[155] "An Interview with National University of Defense Technology Information Systems and Management Institute Chief Engineer Professor Liu Zhong [记国防科技大学信息系统与管理学院总工程师刘忠教授], *China Daily*, December 29, 2015, http://china.chinadaily.com.cn/2015-12/29/content_22850844_2.htm

[156] Liu Zhong: A Chief Engineer On the Road [刘忠：一直在路上的总工程师], *Xinhua*, December 29, 2015, http://www.81.cn/2015lz/2015-12/29/content_6836338.htm

[157] Yuan Yi [袁艺], Will Artifical Intelligence Command Future Wars?" [人工智能将指挥未来战争？], China Military Online, January 12, 2017, http://www.81.cn/jmywyl/2017-01/12/content_7448385.htm

artificial intelligence, are not conducive to the preservation of such a decisive, undisputed edge. The rapidity of technological diffusion has increased dramatically, and it is difficult to control, since cutting-edge research and development with dual-use applications increasingly occurs within the private sector. At this point, it is difficult to verify the current status of the PLA's efforts to operationalize artificial intelligence for multiple military purposes, and the future prospects for its progress in intelligencization remain uncertain. Regardless, China evidently possesses the potential to compete with – or even leapfrog – the U.S. in artificial intelligence, among other critical emerging technologies. China's rise as a major power in artificial intelligence could thus become a vital force multiplier for its future military capabilities.

Potential Issues of Technology Transfer:

The PLA's focus on advancing the capabilities of its unmanned systems and artificial intelligence may result in incentives for licit and illicit technology transfers. Historically, the PLA's development of unmanned weapons systems has been enabled through the reverse engineering of U.S. and Russian systems.[158] In certain cases, the resemblance between current U.S. and Chinese UAVs may be more than coincidental. In the past several years, there have been several incidents that appeared to reflect attempts at the theft of intellectual property and relevant components related to unmanned systems. The persistent efforts by hackers associated with the Third Department of the former General Staff Department (3PLA) often focused on the theft of drone technology and designs from US defense contractors.[159] After Lockheed Martin's RQ-170 Sentinel, which was lost or potentially hacked, landed intact in Iran,[160] representatives of the GSD and GAD, along with experts from the Aviation Industry Corporation of China (AVIC), reportedly traveled to Iran in 2012 to inspect that downed drone.[161] Photos that have since emerged on the Chinese Internet of an unknown Chinese UAV happen to resemble the RQ-170. In April 2016, a woman was charged with smuggling components and materials for UUVs to the Harbin Engineering University, a state-owned university engaged in research on underwater drones.[162]

Given China's strategy of civil-military integration, Chinese research institutes and private companies that engage in partnerships with, investments in, or acquisitions of U.S. and international companies with relevant technological expertise and intellectual property may

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[158] "The Explosive Development of China's UAV" [中国无人机井喷发展], *China Youth Daily* [中国青年报], January 23, 2015, http://mil.huanqiu.com/observation/2015-01/5481399.html.

[159] Edward Wong, "Hacking U.S. Secrets, China Pushes for Drones," *New York Times*, September 20, 2013, http://www.nytimes.com/2013/09/21/world/asia/hacking-us-secrets-china-pushes-for-drones.html?_r=0&pagewanted=all.

[160] Dave Majumdar, "Did Iran Just Create a Stealth Drone from Captured American Tech?," *National Interest*, November 14, 2014, http://nationalinterest.org/feature/did-iran-just-create-stealth-drone-captured-american-tech-11683.

[161] "Chinese secret delegation enter Iran for getting RQ-170 drone," August 15, 2012, http://www.china-defense-mashup.com/chinese-secret-delegation-enter-iran-for-getting-rq-170-drone.html..

[162] Office of Public Affairs, "Florida Woman Charged in 18-Count Indictment for Conspiracy to Illegally Export Systems, Components and Documents to China," April 21, 2016, https://www.justice.gov/opa/pr/florida-woman-charged-18-count-indictment-conspiracy-illegally-export-systems-components-and

eventually turn the resulting advances to dual uses.[163] Increasingly, Chinese research in artificial intelligence has been able to take advantage of world-class talent. Baidu's establishment of an artificial intelligence lab in Silicon Valley, led by artificial intelligence scientist Andrew Ng, has enabled it to enjoy this innovation ecosystem and its human resources, including with its recent hire of former Microsoft executive Qi Lu.[164, 165] Baidu has also partnered with U.S. chipmaker Nvidia to build an artificial intelligence platform for self-driving cars.[166, 167] Looking forward, Baidu aspires to become a "global leader" in artificial intelligence and appears to be on track to achieve that objective.[168] Similarly, leading Chinese cyber security firm Qihoo360, which is believed to collaborate closely with the Chinese government, has partnered with Microsoft on artificial intelligence.[169] Although there are certainly valid commercial applications, Qihoo has also highlighted its advances in artificial intelligence to support cyber security, which could contribute to cyber defense in a government and military context.[170] Although scientific engagement and partnerships can be mutually beneficial, U.S. individuals and institutions should remain cognizant of the associated business risks, as well as the potential that the results of the collaboration could ultimately be utilized for military purposes.

Recommendations for Policy Responses:

Given these trends, Congress might consider the following measures:

- Support extensive monitoring and analysis of the PLA's ongoing advances in unmanned weapons systems and artificial intelligence, including through encouraging, if necessary, the prioritization of these topics within existing intelligence requirements.

- Sustain U.S. R&D funding for these critical technological domains, ensuring that the focus on next-generation capabilities associated with the Third Offset is advanced despite challenges of present readiness.

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[163] Vincent Lanaria, Google Tests Chinese Waters With $300 Million Investment In AI Startup Mobvoi," Tech Times, October 21, 2015, http://www.techtimes.com/articles/97663/20151021/google-tests-chinese-waters-with-300-million-investment-in-ai-startup-mobvoi.htm#sthash.Ef98hWTG.dpuf

[164] "Baidu hires Microsoft expert in artificial intelligence push," January 17, 2017, https://phys.org/news/2017-01-baidu-hires-microsoft-expert-artificial.html

[165] Jamie Condliffe, "In 2017, China Is Doubling Down on AI," *MIT Technology Review*, January 17, 2017 https://www.technologyreview.com/s/603378/in-2017-china-is-doubling-down-on-ai/

[166] Kirsten Korosec, "Baidu and Nvidia to Build Artificial Intelligence Platform for Self-Driving Cars," Fortune, September 01, 2016, http://fortune.com/2016/09/01/baidu-nvidia-ai-self-driving-cars/

[167] Note the dual use implications of such a platform for unmanned ground vehicles that might be used in a military context.

[168] "Baidu hires Microsoft expert in artificial intelligence push."

[169] "Microsoft to cooperate with Qihoo 360 amid security concerns in China," *Reuters*, June 9, 2014, http://www.reuters.com/article/microsoft-qihoo-idUSL4N0OR0X620140610

[170] "Cyber Security Week, Baidu First Diligent in Action to Inject Artificial Intelligence into the Security Domain" [网络安全周百度力行 将人工智能注入安全领域], *Xinhua*, June 2, 2015, http://news.xinhuanet.com/politics/2015-06/02/c_127870900.htm

- Take measures to mitigate the risks of intellectual property theft, including through cyber espionage, for cutting-edge U.S. unmanned weapons systems, intellectual property related to artificial intelligence, and related technologies and materials.
    - Recognize that the dual-use nature of these technologies may merit additional caution and oversight for Chinese investments in these technologies in the U.S. and partnerships with U.S. companies.

- Advance the development of more sophisticated countermeasures for Chinese UAVs, such as electronic warfare capabilities and directed energy weapons, including measures through which to counter the saturation problem posed by swarming capabilities.

- Encourage further hardening of existing U.S. unmanned systems against jamming, given indications of the PLA's active development of counter-UAV measures targeted at U.S. UAVs.