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Hearing on China in Space: A Strategic Competition?

Building China's SpaceX: Military-Civil Fusion and the Future of China's Space Industry

Introduction

Days after SpaceX successfully launched the Falcon Heavy last year, several experts from the China Aerospace Academy of Systems Science and Engineering (CAASSE) wrote, "the lack of utilization of social resources has become an important issue that restricts the better and faster development of China's space industry."[1] The *Global Times* put the implications of SpaceX's achievement for China in more blunt terms: "Our country finds itself in a surprising position where it must desperately catch up with a private company."[2]

China has responded to the rise of the U.S. commercial space industry by building its own commercial space industry through military-civil fusion 军民融合.[3] Military-civil fusion or *junminronghe* is the catch-all term for China's two-decade-long push to enlist private enterprises to upgrade China's defense industrial base through developing scale and efficiency in dual-use sectors like information technology, robotics, and aerospace. Under the tenure of General Secretary Xi Jinping, China has doubled down on military-civil fusion as a means to modernize the People's Liberation Army (PLA), particularly in emerging sectors like space. In June 2017, General Secretary Xi called for "a great effort to turn the space domain into the foremost sector in the development of military-civil fusion."[4]

The commercial space industry has been a notable priority and early success of Xi's military-civil fusion drive. Over the past four years, a crop of private launch providers and small satellite makers

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[1] Xue Huifeng, Zhu Bin, Kangxi Tong, Li Chengfang, Zhang Kui, and Zhang Hao, " How to View the Falcon Heavy Launch from the Perspective of U.S.-China Space Development," Military-Civil Fusion in ICT Magazine, February 13, 2018, https://mp.weixin.qq.com/s/fKIA7xMQQr1bkNMYvaMWmQ.

[2] "Americans complete a major feat in the early morning, showing us how large the gap is between the U.S. and China [美国人凌晨完成一项壮举，告诉我们中美差距还有多么巨大], Global Times, February 7, 2018, http://world.huanqiu.com/article/2018-02/11589880.html.

[3] The correct translation of *junminronghe* is somewhat contested. "China's State Council uses 'civil-military integration' as the official translation. However, Greg Levesque and Mark Stokes convincingly argue that 'military-civil fusion' underscores the ways in which *junminronghe* is qualitatively different from traditional attempts to promote civil-military integration in other countries. For the purpose of this testimony, I use 'military-civil fusion' to denote the ways in which *junminronghe* not only aims to build connections between the military and civilian economy, but 'fuse' them together. For more, see Greg Levesque and Mark Stokes, "Blurred Lines: Military-Civil Fusion and the 'Going Out' of China's Defense Industry," Pointe Bello, December 2016, https://static1.squarespace.com/static/569925bfe0327c837e2e9a94/t/593dad0320099e64e1ca92a5/1497214574912/062017_Pointe+Bello_Military+Civil+Fusion+Report.pdf.

[4] "Strive to establish new era in deep development of military-civil fusion in Shanxi" [努力开创新时代山西军民融合深度发展新局面], Provincial Defense S&T Industry Office, September 28, 2018, http://sxgfgb.gov.cn/gongzuodongtai/4508.html.

have heeded the government's call and entered the previously closed-off sector. The push dovetails with technological advances in miniaturized satellites like cubesat, which are less capital intensive to produce and launch than traditional satellite technology, and therefore, provide a viable commercial model for small startups. This has allowed military-civil fusion to move ahead in the space sector, even as it struggles to gain traction in other sectors.

Military-civil fusion has two central mechanisms:

- On one side, there is the converting defense technology and resources to civilians (spin-off) component *junzhuanmin* 军转民, which calls for the military and defense industrial base to spin-off defense technology with commercial potential.

- On the other side, there is the "opening up" (or spin-on) component *mincanjun* 民参军, which denotes efforts to increase commercial enterprise participation in defense development and production.

In the case of China's nascent commercial space sector, both mechanisms are at work. The military and state-owned defense industrial base are actively supporting China's fledgling space startups through transferring technology and technical know-how. At the same time, China's Central Military Commission (CMC) and The State Administration for Science, Technology and Industry for National Defense (SASTIND) are beginning opportunities for private enterprises to participate in defense research and procurement.

Military-Civil Fusion Becomes a Priority

Close watchers of Chinese industrial policies noticed a subtle but meaningful development in China's commitment to military-civil fusion starting in 2016. In March 2016, the Central Politburo raised military-civil fusion to the status of "national strategy."[5] Less than a year prior, China's State Council unveiled Made in China 2025, which targeted many of the same dual-use industries relevant to military-civil fusion, including space. In January 2017, Xi Jinping established the Central Commission for Integrated Military and Civilian Development, a high-level body to oversee the implementation of military-civil fusion. Several months later, in March 2017, the Equipment Development Department of the CMC released nearly 3,000 patents related to defense technology to the public, marking the first time the PLA has declassified defense patents.[6]

Taken together, these developments have amounted to a significant shift in how China's state-owned defense sector and People's Liberation Army (PLA) interact with the private economy. Nowhere has that shift been more pronounced than in China's fledgling private space industry. In 2014, the State Council announced that it would allow private capital and enterprises to enter the previously closed-

[5] Lorand Laskai, "Civil-Military Fusion: The Missing Link Between China's Technology and Military Rise," *Net Politics*, January 29, 2018, https://www.cfr.org/blog/civil-military-fusion-missing-link-between-chinas-technological-and-military-rise.
[6] Meia Nouwens and Helena Legarda, "China's Declassification of Defence Patents: Novel, but not (yet) a game changer," IISS, January 2018, https://www.iiss.org/-/media/images/comment/military-balance-blog/2018/february/chinas-declassification-of-defence-patents.ashx?la=en&hash=6191B53451810369DC90075E31961C3F5099CC4D.

off sector.[7] A series of guiding opinions and action plans released throughout 2017 referenced the space industry as a key sector in the military-civil fusion drive. The 13th Five Year Plan Sci & Tech Military-Civil Fusion Development Special Plan, for instance, specifically named manned spaceflight as a military-civil fusion "mega project," suggesting that private entities would likely have a role in developing China's Tianhe-1.[8] In a strong signal to the private sector, the PLA Rocket Force recruited 13 private sector consultants to work on key projects in October 2018, marking the first time that the PLA has allowed civilians to participate in sensitive defense projects.[9]

Policies like these are starting to have an impact. For decades, two state-owned defense conglomerates, China Aerospace Science & Industry Corporation (CASIC) 中国航天科工集团 and China Aerospace Science and Technology Corporation (CASC) 中国航天科技集团, have had a near monopoly on launch and space technology. Within the course of several years, regulatory changes have given rise to a crop of private-funded startups like OneSpace 零壹空间 and LandSpace 蓝箭空间科技 that are attempting to develop affordable launch technologies. Around these launch companies, an ecosystem of startups specializing in niche segments like nanosatellites and microsatellites, satellite-based geopositioning and internet services, and specialized components is starting to take shape.

A mature commercial space industry would accord several significant benefits to China's national space program and the PLA.

- On the *spin-off* side, the commercial sector can develop a scale and efficiency that the defense sector is unable to achieve. In the same way that U.S. companies like SpaceX and Blue Origin are poised to drastically lower the launch cost, the hope is that Chinese companies can reduce cost of launching payloads, first with small satellites and then eventually with larger payloads. Some in the commercial space sector believe that as the commercial space industry gradually matures, the military will withdraw from its direct involvement in rocket development and production and instead act as a customer in a competitive market place.[10] This would free up resources within the PLA and state-owned defense industrial base to focus on more ambitious projects like the Long March 9.

- On the *spin-on* side, the blurring between commercial and military ventures in the space industry will make it easier for Chinese entities for evade U.S. export controls and capture important technologies. Over time, a robust commercial space sector built through military-civil fusion will help the PLA absorb and integrate space-related technologies from abroad that it currently lacks. In December 2018, the *Wall Street Journal* reported that a startup

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[7] "Guiding Opinion on Encouraging Social Capital in Investment and Financing Mechanism in Key Innovations Areas" [国务院关于创新重点领域投融资机制鼓励社会投资的指导意见], State Council, November 16, 2014, http://www.gov.cn/zhengce/content/2014-11/26/content_9260.htm.

[8] "13th Five Year Plan Sci & Tech Military-Civil Fusion Development Special Plan" ["十三五"科技军民融合发展专项规划]," Ministry of Science and Technology, September 11, 2017, http://news.sciencenet.cn/htmlnews/2017/9/387703.shtm.

[9] Liu Zhen, "China's military recruits private experts to work on defence projects," South China Morning Post, October 12, 2018, https://www.scmp.com/news/china/military/article/2168385/chinas-military-recruits-private-experts-work-defence-technology.

[10] Analyzing China's commercial space market: Launch companies cannot burn money like bike-share companies," [中国商业航天市场解析：火箭企业不如共享单车烧钱], China Economy Weekly, November 27, 2018, http://www.xinhuanet.com/finance/2018-11/27/c_1210003050.htm.

controlled by a Chinese state-backed investment firm had succeeded in placing an order with Boeing for an advanced satellite with restricted technology.[11] Boeing had then obtained an export license from the Commerce Department, despite the clear Chinese money trail. While Boeing canceled the order after the WSJ story, the incident illustrates the challenges U.S. officials will face in distinguishing legitimate commerce in space-related industries from state-linked efforts to extract critical technology as China's space ambitions.

Running with a Familiar Concept

The drive to integrate military and commercial sectors springs, in part, from the PRC's close study of the U.S. experience cultivating commercial-military ties. One study by two Chinese scholars in 2012 attributed China's weakness in key dual-use industries like semiconductors and aerospace to the lack of civilian coordination with the defense industry.[12] State-media often cites data showing that in the United States 85 percent of the military's core technology comes from the private sector and 80 percent of firms that supply the US military also sell commercially.[13]

Many Chinese military planners would prefer a U.S.-style defense industry that promotes the efficient allocation of resources through commercial-sector collaboration and procurement. In January 2018, a study group at the State Council's Development Research Center tasked with researching a potential Military-Civil Fusion Law produced a study outlining the role of legislation like the Federal Technology Transfer Act of 1986 and Federal Acquisition Reform Act in the development of dual-use industries in the US.[14]

In China's space industry, U.S. companies like SpaceX and OneWeb have been held up as examples of the efficiencies and innovation to be had if China's successfully implements military-civil fusion. "SpaceX has achieved huge breakthroughs in a short period of time, which is inseparable from military-civil fusion the U.S. space field," wrote Wan Jing, a professor at the PLA's National University of Defense Technology.[15] In the view of Chinese aerospace experts, SpaceX's close cooperation with NASA and the U.S. Air Force, which yielded the company access to technical support, spin-off technology, and lucrative contracts, was central to its success.[16]

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[11] Brian Spegele and Kate O'Keeffe, "China Maneuvers to Snag Top-Secret Boeing Satellite Technology," The Wall Street Journal, December 4, 2018, https://www.wsj.com/articles/china-maneuvers-to-snag-top-secret-boeing-satellite-technology-1543943490.

[12] Xie Xuanting and Liu Yun, "Lessons for China from U.S. efforts to push military-civil integration style development" [美国推动军民融合的发展模式及对我国的启示], National Defense Technology Base, October 2012, available at: http://www.cnki.com.cn/Article/CJFDTOTAL-GFJC200704012.htm.

[13] For example, see "Shanghai's Minhang district: Military-civil fusion helps local industries upgrade" [上海闵行区：军民融合助地方产业升级], Reference Times, August 1, 2017, http://finance.chinanews.com/cj/2017/08-01/8292315.shtml.

[14] "Notable characteristics and lessons from military-civil fusion legislation in the United States" [美国军民融合法律体系的特点及启示], Development Research Center of the State Council, October 24, 2017, http://www.drc.gov.cn/n/20171024/1-224-2894553.htm

[15] Wan Jing, "Viewing SpaceX's rise from the perspective of civil-military integration in the U.S. space industry" [从 SpaceX 崛起看美国航天领域军民融合], Defense Technology Review, Vol. 39 No. 3, June 2018, pg. 111.

[16] Also see Danghui Liu and Yunxia Yin, "Opportunities and Challenges in Commercial Space Launches" [商业航天发射的机遇与挑战], Journal of Aerospace Science and Technology, Vol. 6 No. 04, November 2018, https://image.hanspub.org/Html/2-2980101_27743.htm; an Cun Cao, "Analysis of SpaceX's Latest Civil-Military Integration" [SpaceX 公司最新军民融合实践分析], China Academy of Launch Vehicle Technology R&D Center, November 2017, http://www.doc88.com/p-9962814377552.html.

However, military-civil fusion in China extends beyond traditional efforts to promote civil-military integration in other countries through public-private partnerships. Under military-civil fusion, private enterprises are at best an appendage of the state-owned defense industrial base. The state-owned defense ecosystem remains dominant on account of the scale of state-owned defense conglomerates, as well as their privileged access to defense R&D institutes and government financing. In addition, the lack of IP protection for commercial enterprises creates an asymmetrical relationship between private enterprises and defense sector.

The unique relationship between the private sector and defense industrial base under military-civil fusion manifests in the financing ecosystem that has taken shape in dual-use sectors. So-called 'guidance funds' 引导基金 and other state-backed investment vehicles play a central role in supporting nascent dual-sectors related to military-civil fusion.[17] These funds essentially pool together state-owned and private capital, thereby obfuscating the line between the state and private investment and allowing the state to guide investment into enterprises deemed strategically valuable.

Currently, the top seven state funds dedicated to investing in military-civil fusion industries claim to have over RMB 362 billion ($56.85 billion) in capital.[18] A 2017 State Council guiding opinion called for provincial and municipal governments to set up investment funds that target dual-use industries, as well as for the State Administration for Science, Technology and Industry for National Defense (SASTIND) to set up a national military-civil fusion fund, presumably to assist local development.[19]

Surveying the Landscape of China's Commercial Space Sector

China's commercial space industry has rapidly expanded since 2015, growing from a virtually non-existent industry to a crowded field of launch provider and satellite makers. As top-level support for commercial space has become clear, entrepreneurs and investors have flocked to the sector. Private space launch startups include OneSpace, LandSpace, LinkSpace 翎客航天, ExPace 航天科工火箭技术有限公司, and I-Space 星际荣耀. Commercial micro/nano-satellite makers include Spacety 天仪研究院, Commsat 九天微星, and Changguang Satellite Technology 长光卫星技术有限公司.

Chinese launch providers lag significantly behind international leaders like SpaceX and Blue Origin. Despite multiple attempts, no Chinese startup has successfully delivered a payload to orbit**.** Moreover, the industry is largely reliant on solid-fuel rockets, which are less sophisticated and adaptable than the liquid-fuel rockets used by OneSpace and BlueOrigin. Nevertheless, Chinese companies are making rapid technical progress in a short period of time. I-Space and OneSpace have both successfully launched suborbital rockets. The industry is also quickly moving towards more

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[17] Guidance funds function as "mother funds" that provide anchor capital to sub-funds. This allows government officials to spread state-owned capital via multiple sub-funds and dilute the government's direct share of individual investments to a minority and allows non-government capital (although often still state-owned) to play a leading role. Some top-level guidance funds like the Ministry of Science and Technology's National S&T Commercialization Guidance Fund 国家科技成果转化引导基金 have nearly twenty sub-funds.

[18] Lorand Laskai, "In Drive for Tech Independence, Xi Doubles Down on Civil-Military Fusion," Jamestown's China Brief, May 9, 2018, https://jamestown.org/program/in-drive-for-tech-independence-xi-doubles-down-on-civil-military-fusion/.

[19] "Local governments lend energy to establishing two types of fund to promote military-civil fusion" [各地借力两类产业基金推进军民融合], Securities Daily, June 19, 2018, http://fund.jrj.com.cn/2018/06/19075724693400.shtml http://www.gov.cn/zhengce/content/2017-12/04/content_5244373.htm.

advanced launch technology. LinkSpace has tested a vertical take-off, vertical landing rocket, similar to SpaceX's reusable rocket system.[20] In January 2019, LandSpace (not to be confused with LinkSpace) began testing a technologically-advanced liquid oxygen-methane rocket engine. If successful, LandSpace will make China the third country after the United States and Russia with a private company capable of developing liquid-oxygen/methane engines.[21]

There is a strong entrepreneurial ethos that runs through China's commercial space sector. With the exception of ExPace which is a subsidiary of CASIC, all entrants into the sector are privately-owned. China's first private launch company LinkSpace, for example, was established in 2014 by Hu Zhenyu 胡振宇, a then 21-year-old rocket enthusiast who received seed capital from internet mogul Nick Yang. Naturally, entrepreneurs in the industry revere Silicon Valley titans Elon Musk and Peter Thiel and view them as examples to be replicated. The perception of Chinese space startups as commercial in nature, rather than extensions of the state-owned defense sector, is important since Chinese launch providers and satellite markers see foreign customers—primarily, in the Middle East, Africa, and Europe—as critical to their success.

Nevertheless, the Chinese state and PLA play a formidable guiding role in the industry's development. The Central Military Commission (CMC) maintains a monopoly over the approval process for commercial rocket launches, meaning private enterprises cannot conduct the business of launching rockets without the military's blessing. For the most part, the military sees a clear advantage in allowing commercial launches to proceed. "If commercial rockets succeed and prosper, then the military can pit commercial rockets against state-owned rockets to extract the best value, which is good for the military," explained LinkSpace founder Hu Zhenyu.[22]

The links between the commercial space sector and the state-owned defense industrial base also runs deep. The technical teams of commercial space startups are filled with former employees of defense conglomerates and state research institutions.[23] OneSpace's Chief Technology Officer Chen Xiaojun, for instance, worked at the China Academy of Launch Vehicle Technology (CALT) before joining the company.[24] I-Space founder Mao Hongtao 毛洪涛 continues to work for an undisclosed aerospace research institute.[25] Founder and CEO of LandSpace is Zhang Changyu 张昌武 returned to China through the Thousand Talents Program 千人计划 after a 15-year stint working at the European Space

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[20] "Linkspace successfully launches NewLine Baby (RLV-T5) reusable rocket, China's first sub-orbital rocket landing," Room.eu, April 3, 2019, https://room.eu.com/news/linkspace-successfully-launches-reusable-rocket-prototype.

[21] "LandSpace completed successful test of 80-tonne thrust engine" [蓝箭航天 80 吨发动机燃气发生器点火试车成功], LandSpace Sci & Tech, Jan. 6, 2019, https://mp.weixin.qq.com/s/nZbyyCBlwcL9gKzlWJMH0g; Blaine Curcio and Tianyi Lan, "The rise of China's private space industry," SpaceNews, Mar. 25, 2018, https://spacenews.com/analysis-the-rise-of-chinas-private-space-industry/

[22] "Analyzing China's commercial space market: Launch companies cannot burn money like bike-share companies."

[23] OneSpace states on their website that 70 percent of the startup's technical team are from institutions like CASIC, CASC, AVIC, and the Chinese Academy of Science, among other institutions. http://www.onespacechina.com/electronic/

[24] "Private space companies welcomes spring as OneSpace's launch plans receives approval" [民营航天迎来春天 零壹空间火箭方案已通过评审], Xinhua, October 28, 2016, http://news.ifeng.com/a/20161028/50170329_0.shtml

[25] "The Elon Musks of Yizhuang."

Agency and worked at a state-owned aerospace company for several years before founding LandSpace.[26]

Beyond talent, launch vehicle enterprises require three inputs: capital, technology, and a manufacturing base. China's state-owned defense base has provided China's fledgling commercial space enterprises access to all three. Despite attracting sizable private investment, China's space startups rely heavily on state investors for funding. SASTIND has provided early-stage funding to several startups including iSpace and OneSpace.[27] Municipal and provincial-level guidance funds were early backers in OneSpace and LandSpace.[28] Spacety and Commstat have received several rounds of financing from two Chinese Academy of Science (CAS)-backed venture capital funds.[29] This melding of private and state-owned capital is typical of dual-use sectors where the Chinese government has clear strategic aims.

The breakneck speed at which many startups have launched rockets suggests that at least some companies also rely on the military and defense sector for "spin-off" technology. While most launch startups are working on their developing their own rocket technology, "spin off" technology from the defense sector is clearly crucial. In March 2017, LandSpace had to explain to investors and customers that the company had to scrap its first rocket launch plans after a defense conglomerate pulled out of an agreement to supply the rocket's engine.[30] A year earlier, a LandSpace representative told a *Quartz* reporter that the company was utilizing designs from a flight-proven rocket, possibly the Long-March 11.[31] Analysts have suggested that OneSpace's OS-M rockets may use propulsion technology from retired PLA missiles.[32] One employee at I-Space described the benefits of "spin-off" technology as like "standing on the shoulders of a giant."

Even when commercial space startups develop their own proprietary technology, they need a place to manufacture it. Chongqing Aviation Industry Investment Group co-invested in a manufacturing facility with OneSpace. The Wuhan municipal government and CASIC are building the country's first national-level commercial space manufacturing base for launch and satellite companies; state-

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[26] "The Elon Musks of Yizhuang."; Tim Fernholz, "The SpaceX of China aims to commercialize a mysterious rocket on the world stage," Quartz, Sept. 27, 2016, https://qz.com/791879/landspace-the-spacex-of-china-plans-to-commercially-launch-a-rocket-based-on-the-long-march-11/.

[27] "The Elon Musks of Yizhuang."

[28] "LandSpace announces Rmb 200 million in b-round fundraising" [蓝箭航天宣布完成 B 轮 2 亿元融资], Xinhua, July 4 2018, http://www.xinhuanet.com/info/2018-07/04/c_137301106.htm.

[29] "Spacety raises Rmb 150 million in B-round financing led by Legend Capital" [天仪研究院完成 1.5 亿元人民币 B 轮融资，君联资本领投], PEDaily.cn, July 20, 2018, https://pe.pedaily.cn/201807/433740.shtml; Commsat finishes RMb 100 million plus a-round financing" [「九天微星」 完成过亿元 A+轮融资，将发射一箭七星], 36KR, November 30, 2018, https://36kr.com/p/5164676.

[30] "Uncovering China's SpaceX: China's rocket startups are on the rise" [揭秘中国版 SpaceX：中国的火箭创业公司正在崛起], Economic Observer, February 11, 2018, http://tech.sina.com.cn/d/2018-02-11/doc-ifyrmfmc1387262.shtml.

[31] Tim Fernholz, "The SpaceX of China aims to commercialize mysterious rocket on the world stage," September 27, 2016, https://qz.com/791879/landspace-the-spacex-of-china-plans-to-commercially-launch-a-rocket-based-on-the-long-march-11/.

[32] Rui C. Barbosa, "Maiden launch of OneSpace OS-M rocket fails," NASA Spaceflight, March 27, 2019, https://www.nasaspaceflight.com/2019/03/maiden-launch-of-onespace-os-m-rocket-fails/; Stephen Clark, "Chinese startup OneSpace fails in first orbital launch attempt," Spaceflight Now, March 27, 2019, https://spaceflightnow.com/2019/03/27/chinese-startup-onespace-fails-in-first-orbital-launch-attempt/.

media claims that 19 enterprises including Commsat have registered and that the base will have an annual production capacity of 50 carrier rockets and 140 commercial satellites by 2020.[33]

Implications for the United States

China is not yet a near competitor to the United States in the commercial space sector. China's share of the global space market is estimated at around 3 percent, and within China, commercial space companies still holds a negligible share of the market in comparison to CASIC and CASC.[34] Nevertheless, military-civil fusion in China's space industry presents a unique set of challenges to the United States and may portend more significant competition in the future.

China's burgeoning commercial space sector, on one hand, will challenge U.S. export controls and inbound investment screening process, creating opportunities for Chinese state-backed entities to capture critical technologies or co-opt promising emerging technologies before they fully develop. The influx of private capital into China's space sector will help disguise state-owned capital, and in some cases, allow state-linked investment vehicles to acquire critical technology under the guise of being private investors.[35] Even where state-owned capital is not involved, increased interlinkage between China's space sector and the international market will create opportunities for informal technology transfer.

The Boeing-Global IP incident was a warning sign. Two other recent examples should give policymakers pause:

- In December 2018, U.S. startup Global Constellation accepted a minority investment from HCH Group, a Hong Kong-based subsidiary of Haier Group, a Chinese appliance and electronics giant with an opaque ownership structure.[36] The startup aims to launch a constellation of low-orbit satellites that will act as a space-based cloud computing center.

- Chinese tech giant Tencent led B-round fundraising for Satellogic, a Buenos Aires-based microsatellite startup with an office in the United States.[37] The startup aims to launch a constellation of remote sensing satellites with hyperspectral capabilities. It recently reached an agreement with a CASC subsidiary to launch 90 smallsats on as many as six long March 6 rockets.[38]

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[33] "19 enterprises join Wuhan national-level space industry base" [19 家企业入驻武汉国家航天产业基地], China News Service, April 24, 2018, http://www.chinanews.com/cj/2018/04-24/8499221.shtml.

[34] "China's share of global space industry is only 3 percent—room for commercial space development is large [中国航天产业总收入仅占全球 3% 商业航天发展空间巨大], Daily Economics News, December 12, 2018, https://baijiahao.baidu.com/s?id=1620379225475294873&wfr=spider&for=pc.

[35] For examples of state-linked funds acquiring critical technology in the semiconductor space, see Emily Feng, "How China acquired mastery of vital microchip technology," Financial Times, January 29, 2019, https://www.ft.com/content/7cfb2f82-1ecc-11e9-b126-46fc3ad87c65.

[36] "Cloud Constellation Corporation Receives $100M Series B Commitment," PR Newswire, December 20, 2018, https://www.prnewswire.com/news-releases/cloud-constellation-corporation-receives-100m-series-b-commitment-300769736.html; "HCH Group," Crunchbase, https://www.crunchbase.com/organization/hch-group#section-overview.

[37] "Tencent leads $27m series b in satellite data service provider Satellogic," Deal Street Asia, June 27, 2017, https://www.dealstreetasia.com/stories/tencent-series-b-satellogic-76095/.

[38] Jeff Foust, "Satellogic selects China Great Wall to launch satellite constellation," Space News, Jan. 15, 2019, https://spacenews.com/satellogic-selects-china-great-wall-to-launch-satellite-constellation/.

On the other hand, the rise of China's commercial space industry has the potential to cut into the market share of U.S. companies. Revealingly, in an interview last year, OneSpace founder and CEO Shu Chang 舒畅 said his goal was not to be "China's SpaceX," but to be the "Huawei of the space industry."[39] The goal is not so much to push the bounds of commercial space technology as to commercialize existing technology and sell it at a lower cost. Some launch companies have offered small satellite companies free launch services as a way to gain market share.[40] The chairman of CASIC-subsidiary ExPace has said the company will attempt to price satellite payloads on its Kuaizhou rockets at less than half the prevailing commercial price.[41] This cost-cutting approach might not work in the medium and heavy-lift launch market, especially if it involves cutting corners, but it could provide a competitive advantage in the growing market for small satellite launches and services.

Conclusion and Recommendations

China's military-civil fusion drive in the space industry presents clear challenges. As the United States responds, there will be a clear tension between defending U.S. technology and enabling U.S. companies to compete against Chinese newcomers.

With this in mind, Congress should consider the following:

1. **Embrace a "small yard, high fence" approach to export controls and inbound investments.** In the past, over regulation of satellite-technology under International Traffic and Arms Regulations (ITAR) led to a loss of U.S. market share to European competitors with "ITAR-free" technology. [42] In the future, similar overregulation could lead to a loss of U.S. market share to Chinese competitors, facilitating the rise of China's commercial space industry. This prospect means that Congress should adopt what former Secretary of Defense Robert Gates called a "small yard, high fence" approach defending U.S. space technology"—that is, selectively choosing technologies to defend, but aggressively defending them.[43]

   Export control reform under the Obama administration significantly reduced the number of space-related goods and services on the U.S. Munitions List (USML) and moved the USML towards a "positive list" with precisely defined technology. However, the Export Control Reform Act of 2018's mandate to restrict "emerging and foundational technologies" could

[39] "OneSpace CEO Shu Chang: In comparison to SpaceX, we are more interested in becoming the space industry's Huawei" [零壹空间 CEO 舒畅：相比中国 SpaceX 更想做航天业的华为｜前行者], Zhihu Zhuanlan, March 27, 2018, https://zhuanlan.zhihu.com/p/35002700

[40] Echo Huang, "A startup aims to launch China's first privately backed orbital rocket," Quartz, March 23, 2019, https://qz.com/1577395/china-private-rocket-company-onespace-attempts-orbital-launch/

[41] Peter B. de Selding, "New Chinese commercials-launch company advertises high launch rate, low price," SpaceNews, November 29, 2016, https://spacenews.com/new-chinese-commercial-launch-company-advertises-high-launch-rate-low-price/

[42] "U.S. Space Industry 'Deep Dive' Assessment: Impact of U.S. Export Controls on the Space Industrial Base,' Prepared by U.S. Department of Commerce Bureau of Industry and Security Office of Technology Evaluation, February 2014, https://www.bis.doc.gov/index.php/documents/technology-evaluation/898-space-export-control-report/file.

[43] Lorand Laskai and Samm Sacks, "The Right Way to Protect America's Innovation Advantage," Foreign Affairs, October 23, 2018, https://www.foreignaffairs.com/articles/2018-10-23/right-way-protect-americas-innovation-advantage.

mark a return to a broad, subjective list. Congress should ensure that ECRA is not implemented in a way that significantly impedes the development of the U.S. space industry.

2. **Preemptively defend supply chains critical to U.S. competitiveness in the space industry**. Given Beijing's support for advanced manufacturing through Made in China 2025, the rise of China's commercial space sector has the potential to chip away at important manufacturing competencies within the United States, particularly in emerging, low-cost industry segments like micro/nano-satellite technology. Senator Mark Warner and Mark Rubio's proposed legislation to create the Office of Critical Technologies and Security, which would be responsible for coordinating an inter-agency strategy to defend U.S. supply chains and manufacturing capacity, is a welcome step to increase the U.S. government's ability to preemptively defend important technologies and our ability to manufacture them.[44]

3. **Continue to leverage and scale up public-private partnerships to encourage innovation.** It's important to remember that the success of public-private partnerships in the United States is the reason why China is pursuing military-civil fusion in the space industry. The success of companies like SpaceX and Blue Origin have convinced Chinese leaders that the statist model towards space is insufficient. The United States should continue leveraging these types of partnerships and extend them to a new generation of startups. Innovation outfits within the Pentagon like DIU and AFWERX are doing positive work incubating startups developing microsatellite technology. In general, developing, iterating, and commercializing hardware is far more capital intensive than software. Congress, therefore, should fund capital programs specifically for dual-use hardware like the National Security Innovation Capital (NSIC).[45] As long as China cannot guarantee IP protections and impartial arbitration for private enterprises, the United States will have a first mover's advantage in public-private partnerships and should make full use of them.

[44] "Warner, Rubio Introduce Bipartisan Legislation to Combat Technology Threats From China," Office of Senator Mark Warner, January 4, 2019, https://www.warner.senate.gov/public/index.cfm/pressreleases?ID=9D405E99-2E31-4A2D-A79F-9F3FF3B32122.

[45] "Pentagon seeks $75m for dual-use tech venture capital program," Inside Defense, March 19, 2019, https://insidedefense.com/daily-news/pentagon-seeks-75m-dual-use-tech-venture-capital-program.