



Hypersonic Research Collaboration between Sweden and People's Republic of China

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A BluePath Labs Report

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General Overview

This paper is part of a larger program of study into the aerospace industrial base of the People's Republic of China (PRC). As part of the CASI report, "An exploratory Analysis of the Chinese Hypersonics Research Landscape", done by BluePath Labs, a number of research connections were uncovered.

This article is not intended to point fingers at any particular person or institution, and really uses Sweden in general as simply a test case. The intent is rather to show the depth and breadth of the PRC's systematic targeting of top quality programs and personnel across the globe in order to further their national security agenda and to strengthen the armed wing of the Chinese Communist Party (CCP), the People's Liberation Army (PLA). This is often, as this report highlights, done publicly or through overt means. Nations, governments, institutions, scientists, and academics around the world need to be aware of this systematic effort, and its combination, through the Military-Civil Fusion (MCF) national level strategy of China, of the Party-State-Research apparatus. There is no such thing as simply "science for science sake" when it comes to advanced technologies and China, there is always a military component.

This report uses Sweden as a test case, but there are plenty of examples from around the world. In this case, Sweden proves useful to demonstrate the scope of the challenge. Indeed, the intuitions listed in table one, "Top Collaborating Swedish Institutions", are in fact really just the "Top Swedish Institutions" when it comes to hypersonics research. No one is beyond China's gaze.

This paper is intended to inform, and to highlight, so that future collaboration with the PRC on these types of leading-edge technologies are done so in the full light of realization of the scope, scale, and ultimate purpose and beneficiary- strengthening the PLA.

Sweden's Case

The degree of collaboration between the People's Republic of China and the Kingdom of Sweden in the field of hypersonic flight was examined using the same corpus of open-source scientific works used in the original CASI report. The total number of documents found with both Chinese and Swedish authorship was 61 out of a corpus of 13,373. The number of collaborative publications between these two countries per year has been relatively low (Fig 1, left), via a limited number of Swedish institutions (Fig 1, right).

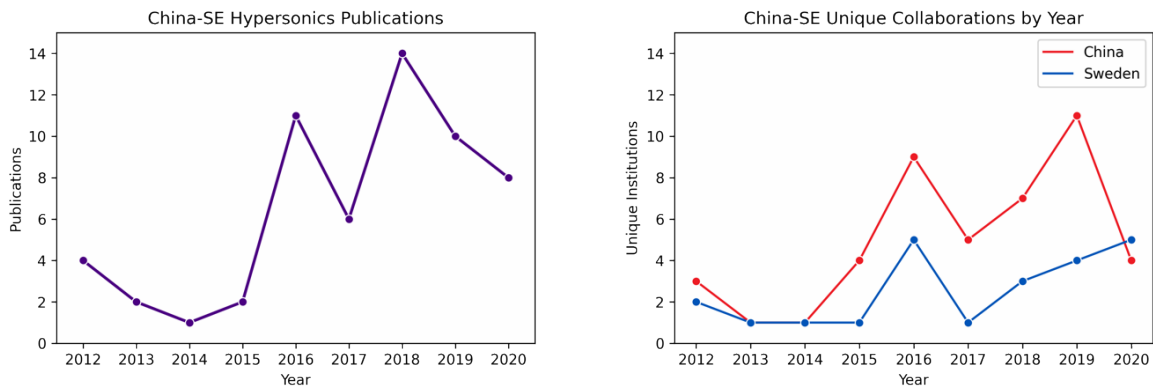


Figure 1. Number of publications with institutional affiliations of both China and the Sweden relating to hypersonics (left) and the number of unique Chinese and Swedish institutions in hypersonic publications (right) per calendar year.

The previous report clustered publications from Chinese institutions into six major categories of hypersonic vehicle technology as described by Cai Guobiao [蔡国飙] and Xu Dajun [徐大军] in their 2012 book titled *Hypersonic Vehicle Technology* [高超声速飞行器技术]:

- C1 - Overall Integrated Design Technology [总体技术]
- C2 - Propulsion Technology [推进技术]
- C3 - Materials / Processing / Manufacturing Technology [材料/工艺/制造艺术]
- C4 - Testing and Verification Technology [试验验证技术]
- C5 - Flight Navigation, Guidance, and Control Technology [飞行导航制导与控制技术]
- C6 - Flight Demonstration and Validation Technology [飞行演示验证技术]

The difference between distribution of categories in collaborative publications between China and Sweden compared to the Chinese hypersonics corpus was statistically significant, with collaborative works focusing much more in the “Overall Integrated Design Technology” (C1) and “Propulsion Technology” (C2) categories, and much less in the “Flight Navigation, Guidance, and Control Technology” (C5) category (Fig 2). Due to the small sample of Chinese hypersonics publications with Swedish co-authorship, growth trends in each of the hypersonics categories between 2012 and 2020 could not be meaningfully determined.

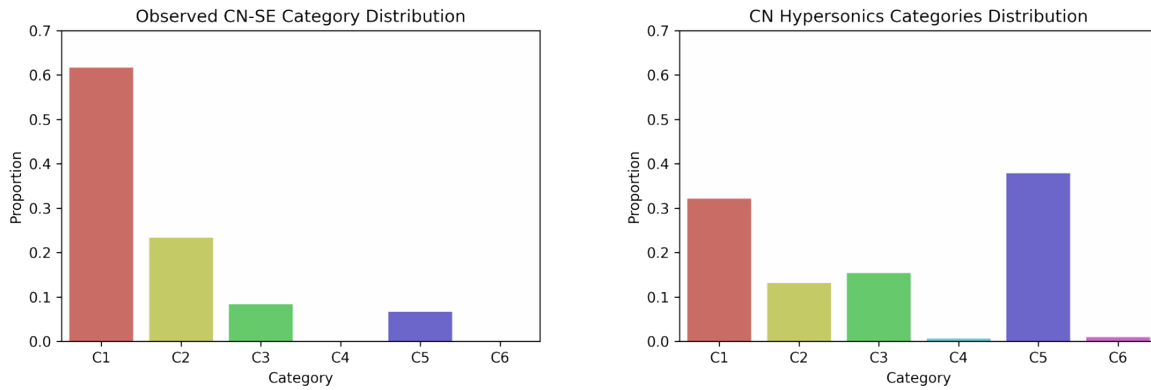


Figure 2. Distribution of hypersonic publication category with Chinese and Swedish authorship (left). Distribution of hypersonic publication category from Chinese hypersonic corpus.

Featured Promising Chinese Researchers

Mingbo Sun, a promising hypersonics Chinese researcher featured in the previous report, had 9 publications with one collaborating Swedish university: Lund University. These publications were mostly in the C1 and C2 categories and had an average citation count higher than the other collaborative documents from Lund University. Citations for a sample of Dr. Sun’s works is provided in Appendix A.

Top Performing Chinese and Swedish Institutions

There were 31 unique collaborating institutions from China and Sweden within the hypersonics corpus, of which 22 were Chinese and 9 were Swedish. The top 9 institutions with the most unique collaborations and the top 9 with the most citations within the corpus produced 9 unique institutions for Sweden and 10 for China, shown in Table 1 and Table 2. Overall, the average citation count for the collaborating publications from these Swedish institutions (15 citations/publication) slightly underperformed the citation count of the Chinese hypersonics (19 citations/publication).

Table 1. Top Collaborating Swedish Institutions

Institution	Collaborating Researchers at Institution	Chinese Collaborating Institutions	Collaborative Publications	Total Citations	Avg Citation	Max Citation
Lund University	111	14	56	845	15	103
Stockholm University	12	4	4	50	12	20
Royal Institute of Technology	15	4	4	50	12	21
Chalmers University of Technology	21	2	5	75	15	51
Umeå University	13	2	2	4	2	2
Uppsala University	9	1	1	51	51	51
Luleå University of Technology	2	1	1	1	1	1
Linköping University	4	1	1	18	18	18
Scania AB	6	1	1	21	21	21

Table 2. Top Collaborating Chinese Institutions

Institution	Collaborating Researchers at Institution	Swedish Collaborating Institutions	Collaborative Publications	Total Citations	Avg Citation	Max Citation
Northwestern Polytechnical University*	45	4	23	304	13	52
Tsinghua University	16	3	3	42	14	20
Huazhong University of Science and Technology	9	2	2	102	51	51
National University of Defense Technology	30	1	12	201	16	44
Central South University	12	1	4	24	6	19
Zhejiang University	14	1	4	141	35	103
Harbin Institute of Technology*	16	1	4	61	15	28
Xi'an Jiaotong University	13	1	3	35	11	24
Tianjin University	8	1	3	5	1	3
Harbin Engineering University*	8	1	2	56	28	44

Security Concerns

Notably, several of the Chinese institutions which appear on the list of frequent collaborators are closely associated with the both the People's Liberation Army (PLA) and the Chinese military-industrial complex. In all, four of the top ten universities collaborating Swedish universities on hypersonic technologies are either outright military institutions or closely affiliated with the Chinese military.

Most alarmingly, the number four collaborator on the list, the National University of Defense Technology (NUDT), is in fact a military academy directly subordinate to the PLA. NUDT is one of the primary research institutions for the Chinese military, conducting research on a wide range of military technologies, including hypersonic missiles.¹ The Australian Strategic Policy Institute has extensively documented NUDT's practice of partnering with foreign academic institutions to collaborate on cutting edge research which is then put to use for military purposes. This includes one researcher who disguised his affiliation with NUDT to conduct research on hypersonic flight vehicles in Norway.² NUDT has been listed on the U.S. Commerce Department Entity List since 2015 for its military activities.³ It should thus be assumed that any dual-use research collaboration between Swedish institutions and NUDT will be put to military use.

Beyond NUDT, several other institutions on the list also raise significant concerns. Three of the listed institutions (the number one institution, Northwestern Polytechnical University, as well as the Harbin Institute of Technology and Harbin Engineering University) are members of the so-called "Seven Sons of National Defense" [国防七子], a consortium of seven universities which are known for their particularly close connections to the PLA and China's defense industry.¹ Unlike most Chinese universities, these universities are directly overseen by the State Administration for Science, Technology and Industry for National Defense (SASTIND), a Chinese government body tasked with defense research and procurement, making their mission fundamentally military in nature. Thus, these universities contribute a disproportionately high amount of China's military research and workforce. For instance, nearly three-fourths of researchers recruited by China's major defense conglomerates in 2019 graduated from one of these seven universities.⁴ Further, a BluePath Labs survey of China's top-level defense labs found that the Seven Sons oversaw two-thirds of all top-level defense labs assigned to universities.⁵ The military research conducted by these labs extends into hypersonic technologies. For example, in 2022 researchers at Northwestern Polytechnical university recently test-launched a new hypersonic rocket in conjunction with the Chinese defense conglomerate CASC.⁶

All members of the "Seven Sons" are listed in the US Commerce Department Entity List.⁷ Further, in 2020, the US banned entry of scholars affiliated with these universities for study or research.⁸ Given their primarily military mission, it should thus be assumed that any dual-use research collaboration between Swedish institutions and the Seven Sons will be put to military use.

¹ These are Beihang University, Northwestern Polytechnical University, Nanjing University of Aeronautics and Astronautics, Harbin Institute of Technology, and Beijing Institute of Technology

Second Order Network Connections

Technology transfer often entails pathways through complex collaborative or social networks. Publications from all Swedish authors that co-authored with a Chinese collaborator in the field of hypersonics were collected to obtain a top level view of the landscape of this network and possible technology transfer pathways. For the purposes of this analysis, first-order authors and institutions are defined as the non-Chinese entities appearing in the original hypersonics corpus, which all contain at least one Chinese author. All publications from the period of 2012-2020 from the first-order authors, regardless of relevance to hypersonics, were collected, yielding 6,603 documents; these documents are defined as second-order documents. New institutions and authors appearing within second-order documents are defined as second-order entities.

Smart High Tech, a Swedish company specializing in high temperature materials and thermal management, was the most prominent second-order institution by publications (Fig 3). Notably, the Swedish Defense Research Agency was the second most prominent second-order institution.

The second order institutions appearing within this set were down selected by their possible association to military-related institutions by a simple word filter based on their names (e.g., defense/defence appearing within their name). Defense institutions from four unique countries were found within this subset (Table 3). The Air Force Engineering University, which is a Chinese military institution, did not appear within the first-order document set.

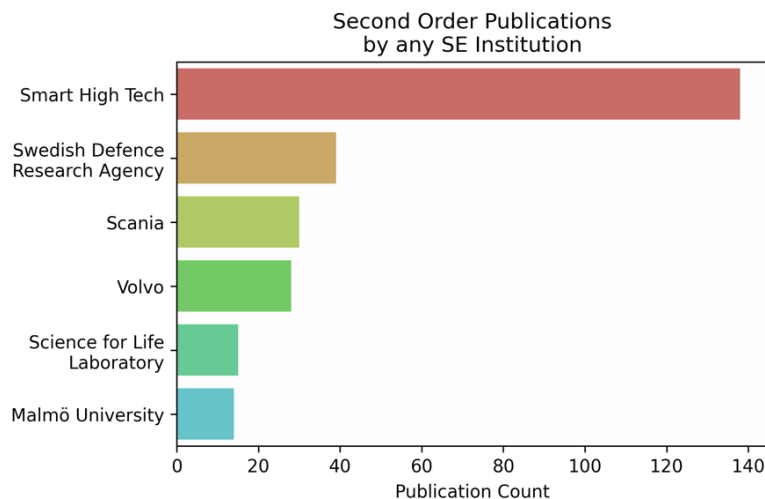


Figure 3. Top 6 second-order institutions by number of publications.

Table 3. Second-Order Publication Counts from Military Institutions

Institution	Country	Count
Swedish Defence Research Agency	Sweden	23
Air Force Engineering University	China	4
Swedish Defence University	Sweden	2
Australian Defence Force Academy	Australia	1
University of Defence	Czech Republic	1

Appendix A– Methodology

Chinese Hypersonics Paper

- This paper is about hypersonics and has at least 1 Chinese author
- This paper is Zero order
- Its Chinese authors are Zero order
- Its Non-Chinese authors are **First order**
 - The Non-Chinese authors are directly connected to a Chinese hypersonics researcher
- Its Chinese Institutions are Zero order
- Its Non-Chinese institutions are **First order**

First Order Paper

- Authored by a First order author
- Is not necessarily about Hypersonics but could be
- Its Non-First-order authors are **Second order**
 - These authors could be from any country, including China or Sweden
 - These authors are connected to an author that HAS directly collaborated with a Chinese hypersonics researcher
 - This is a "friend of a friend" of a Chinese researcher.
- Its Non-First-order institutions are **Second order**

Appendix B – Selected Citations from Promising Authors

Large Eddy Simulation of the fuel transport and mixing process in a scramjet combustor with rearwall-expansion cavity
Acta Astronautica. 2016. 126. 375.

Zun Cai^{1,2}, Xiao Liu^{2,3}, Cheng Gong², Mingbo Sun¹, Zhenguo Wang¹, Xue-Song Bai²

¹ National University of Defense Technology - China

² Lund University - Sweden

³ Harbin Engineering University - China

Citations: 65

Effect of combustor geometry and fuel injection scheme on the combustion process in a supersonic flow

Acta Astronautica. 2016. 129. 44.

Zun Cai^{1,2}, Zhenguo Wang¹, Mingbo Sun¹, Xue-Song Bai²

¹ National University of Defense Technology - China

² Lund University - Sweden

Citations: 41

Effect of cavity geometry on fuel transport and mixing processes in a scramjet combustor

Aerospace Science and Technology. 2018. 80. 309.

Zun Cai¹, Mingbo Sun¹, Zhenguo Wang¹, Xue-Song Bai²

¹ National University of Defense Technology - China

² Lund University - Sweden

Citations: 64

Large eddy simulation of hydrogen combustion in supersonic flows using an Eulerian stochastic fields method

International Journal of Hydrogen Energy. 2017. 42. 1264.

Cheng Gong¹, Mehdi Jangi², Xue-Song Bai¹, J-H Liang³, Mingbo Sun³

¹ Lund University - Sweden

² Murdoch University - Australia

³ National University of Defense Technology - China

Citations: 36

Ignition processes and modes excited by laser-induced plasma in a cavity-based supersonic combustor

Applied Energy. 2018. 228. 1777.

Zun Cai¹, Jiajian Zhu¹, Mingbo Sun¹, Zhenguo Wang¹, Xue-Song Bai²

¹ National University of Defense Technology - China

² Lund University - Sweden

Citations: 38

Three-dimensional flow structures and droplet-gas mixing process of a liquid jet in supersonic crossflow

Aerospace Science and Technology. 2019. 90. 140.

Peibo Li¹, Zhenguo Wang¹, Xue-Song Bai², Hongbo Wang¹, Mingbo Sun¹, Liyin Wu³, Chaoyang Liu¹

¹ National University of Defense Technology - China

² Lund University - Sweden

³ China Aerodynamics Research and Development Center - China

Citations: 33

*Citations as of 2023-02-07

Endnotes

¹ See, for example: Jiang Yonggang [姜勇刚] et al., "Development of Microwave Transparent Materials for Hypersonic Missile Radomes" [高超音速导弹天线罩透波材料研究进展], 硅酸盐通报, 2007, 26(3):500-505. http://www.alljournals.cn/view_abstract.aspx?pcid=5B3AB970F71A803DEACDC0559115BF0A068CD97DD29835&cid=3FCF8B1A330466D5&jid=CD0AE7464AC1DB25E3B503085456C422&aid=FF0B78F0290FA792&yid=A732AF04DDA03BB3

² Alex Joske, "Picking Flowers, Making Honey," Australian Strategic Policy Institute, 30 October 2018, <https://www.aspi.org.au/report/picking-flowers-making-honey>

³ "Addition of Certain Persons to the Entity List; and Removal of Person From the Entity List Based on a Removal Request," Federal Register, 18 February 2015. <https://www.federalregister.gov/documents/2015/02/18/2015-03321/addition-of-certain-persons-to-the-entity-list-and-removal-of-person-from-the-entity-list-based-on-a>

⁴ Ryan Fedasiuk, Emily Weinstein, "Universities and the Chinese Defense Technology Workforce," Center for Security and Emerging Technology, December 2020, <https://cset.georgetown.edu/wp-content/uploads/CSET-Universities-and-the-Chinese-Defense-Technology-Workforce.pdf>

⁵ Alex Stone, Ma Xiu, "The PRC State & Defense Laboratory System: an Overview," China Aerospace Studies Institute, April 2022, https://www.bluepathlabs.com/uploads/1/1/9/0/119002711/2022-04-11_the_prc_state_defense_laboratory_system_-_an_overview.pdf

⁶ "Northwestern Polytechnic University's 'Feitian-1' rocket launched successfully, verifying many key technologies for the first time in the world" [西北工业大学“飞天一号”火箭发射成功 国际首次验证多项关键技术], CCTV, 6

July 2022, https://content-static.cctvnews.cctv.com/snow-book/index.html?toc_style_id=feeds_default&share_to=wechat&item_id=14992563985687363157&track_id=E279B5C7-B451-4CD1-B8E9-939FC669F3EC_678773839584

⁷ "Foreign Universities Sanctioned by the Commerce Department," Brown University, Accessed January 2023, <https://www.brown.edu/research/foreign%20universities>

⁸ Elizabeth Redden, "New Restrictions for Chinese Students With Military University Ties," Inside Higher Ed, 29 May 2020, <https://www.insidehighered.com/news/2020/05/29/us-plans-cancel-visas-students-ties-universities-connected-chinese-military>