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S T U D I E S   I N S T I T U T E

# Hypersonic Research Collaboration between the United Kingdom and People's Republic of China

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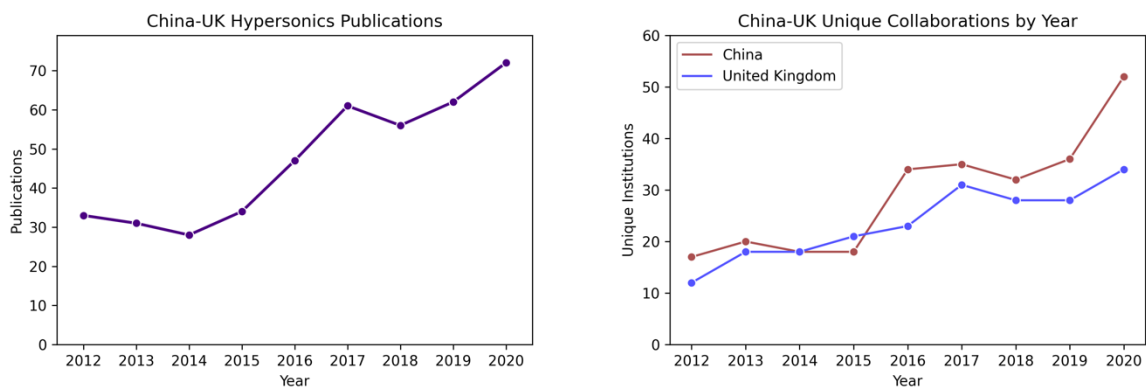
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## General Overview

The degree of collaborative research between the People’s Republic of China (PRC) and the United Kingdom (UK) in the field of hypersonic flight was examined using the same corpus of open-source scientific works used in CASI’s prior report, “[An Exploratory Analysis of the Chinese Hypersonics Research Landscape](#).” The total number of documents found with both Chinese and UK authorship was 424 out of the original corpus of 13,373. The quantity of hypersonics publications from the period of 2012-2020 increased by a factor of approximately 2.2 (Fig 1, left) and the number of distinct Chinese and UK institutions within a given calendar year increased by factors of approximately 3 and 2.8 for China and the UK respectively.

The results show that some of the most active Chinese universities collaborating with UK institutions have strong ties to the People’s Liberation Army (PLA) and China’s defense industry, meaning that any research collaboration with these universities is at risk of being utilized for military purposes.

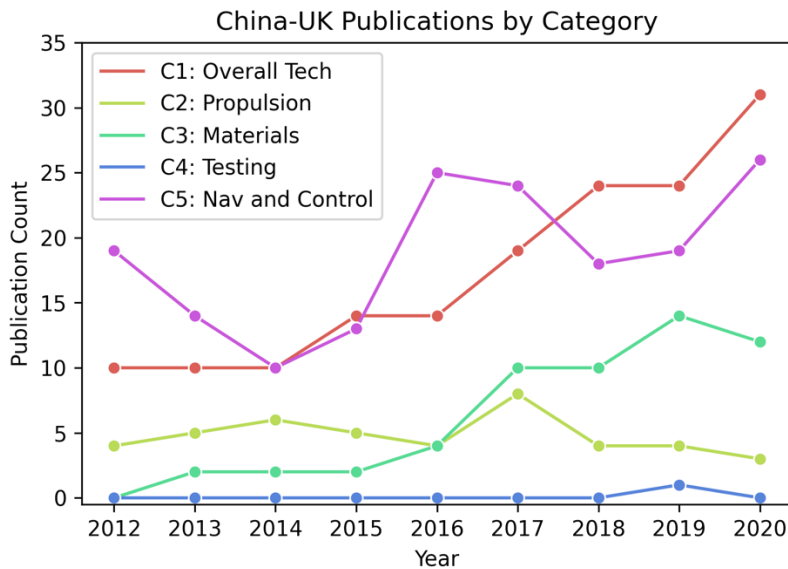


**Figure 1.** Number of publications with institutional affiliations of both China and the UK relating to hypersonics (left) and the number of unique Chinese and UK institutions in hypersonics publications (right) per calendar year.

BluePath Labs’ 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 largest steady increase in publications since 2012 examined with China-UK authorship were in category C1 (Overall Integrated Design) and category C3 (Materials / Processing / Manufacturing) (Fig 2). The difference between the overall distribution of the papers in each technology category compared to the broader Chinese hypersonics corpus was not found to be statistically significant; that is, the subgroup of Chinese hypersonics publications with collaborations with UK institutions were not focused in any particular category compared to all of the Chinese hypersonics publications.



**Figure 2.** Number of China-UK hypersonics publications by category described by Cai and Xu per calendar year. There were no publications assigned to the category of C6 – Flight Demonstration and Validation Technology.

## Featured Promising Chinese Researchers

Mingbo Sun and Fei Qin, two promising hypersonics Chinese researchers featured in the previous report, were found to have 15 publications across 4 unique collaborations with UK institutions. These UK institutions were: University College London, the University of Sheffield, the University of Leeds, and the University of Southampton. Both authors’ publications fall exclusively into the C1 (Overall Integrated Design) and C2 (Propulsion) categories. Notably, Dr. Sun has 14 publications across 3 unique institutional collaborations, some of which have a high citation count. Citations for a sample of these authors works is provided in Appendix A.

## Top Performing Chinese and UK Institutions

There were 182 unique collaborating institutions from China and the UK within the hypersonics corpus, of which 107 were Chinese and 75 were from the UK. The top 8 institutions with the most unique collaborations and the top 8 with the most total citations within the corpus produced 12 unique institutions for the UK and 11 for China, shown in Table 1 and Table 2, respectively. Some of these institutions have produced highly influential work relative to other publications in the Chinese hypersonics corpus; the average citation count for the hypersonics documents used in this analysis was 19. The documents from the top performing institutions from both countries are cited significantly higher than those from the larger body of work; the average count of these top institutions from both countries was 56.

**Table 1. Top Collaborating UK Institutions**

Institution	Collaborating Researchers at Institution	Chinese Collaborating Institutions	Collaborative Publications	Total Citations	Avg Citation	Max Citation
Brunel University London	59	22	45	2887	64	291
University of Manchester	74	16	38	1226	32	130
University of Strathclyde	77	14	30	404	13	100
University of Southampton	66	14	26	248	9	32
Swansea University	37	13	20	1129	56	179
University of South Wales	31	10	26	4105	157	591
Loughborough University	40	10	25	2754	110	731
University College London	35	10	11	1095	99	320
Cranfield University	39	9	31	777	25	263
King's College London	42	9	29	3096	106	265
University of Sheffield	52	9	26	594	22	79
University of Portsmouth	13	2	3	882	294	474

**Table 2. Top Collaborating Chinese Institutions**

Institution	Collaborating Researchers at Institution	UK Collaborating Institutions	Collaborative Publications	Total Citations	Avg Citation	Max Citation
Beihang University*	139	20	55	2244	40	731
Northwestern Polytechnical University*	119	17	36	612	17	227
National University of Defense Technology*	92	15	48	1029	21	79
Nanjing University of Aeronautics and Astronautics*	81	15	30	542	18	125
Tsinghua University	85	15	22	864	39	227
Harbin Institute of Technology*	94	14	41	5359	130	591
Xi'an Jiaotong University	113	11	26	575	22	320

<b>Beijing Institute of Technology*</b>	42	8	27	513	19	179
<b>Southeast University</b>	32	5	17	1892	111	731
<b>Bohai University</b>	24	2	13	1544	118	265
<b>Chongqing University</b>	12	2	5	1152	230	351

## Security Concerns

Notably, several of the Chinese institutions which appear on the list of frequent collaborators are closely associated with the both the PLA and the Chinese military-industrial complex. In all, six of the top ten (and five of the top six) universities collaborating with UK universities on hypersonic technologies are either outright military institutions or closely affiliated with the Chinese military. These are noted with an asterisk in Table 2.

Most alarmingly, the number three collaborator on the list, the National University of Defense Technology (NUDT), is a military academy directly subordinate to the PLA. NUDT is one of the primary research institutions for the Chinese military and conducts research on a wide range of military technologies, to include hypersonic missiles.<sup>1</sup> 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.<sup>2</sup> NUDT has been listed on the U.S. Commerce Department Entity List since 2015 for its military activities.<sup>3</sup> It should thus be assumed that any dual-use research collaboration between UK institutions and NUDT will be put to military use.

Beyond NUDT, several other institutions on the list also raise significant concerns. Five of the listed institutions<sup>1</sup> 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. 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.<sup>4</sup> 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.<sup>5</sup> The military research conducted by these labs extends into hypersonic technologies. For example, a key defense lab for missile technology at Beihang University<sup>6</sup> has conducted research into improved guidance and accuracy for hypersonic flight vehicles.<sup>7</sup>

All members of the “Seven Sons” are listed in the US Commerce Department Entity List.<sup>8</sup> Further, in 2020, the US banned entry of scholars affiliated with these universities for study or research.<sup>9</sup>

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



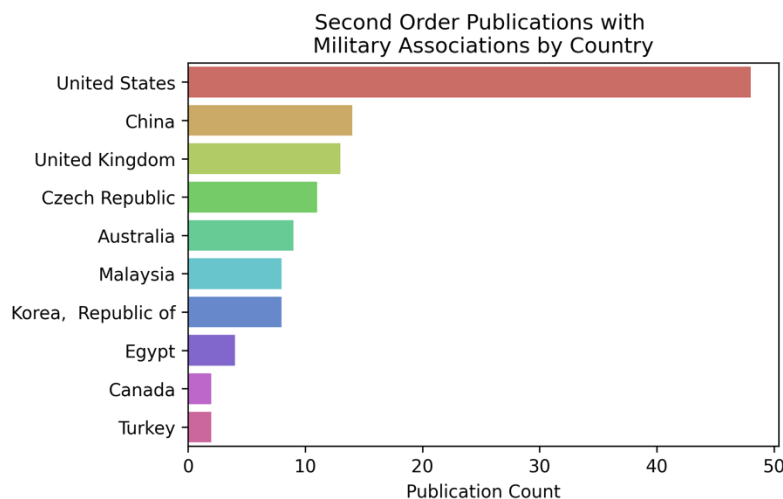
Given their primarily military mission, it should thus be assumed that any research collaborations between UK institutions and the Seven Sons is for PLA military end-use.

## Second Order Network Connections

Technology transfer often entails pathways through complex collaborative or social networks. Publications from all UK authors that co-authored with a Chinese collaborator in the field of hypersonics were collected to obtain a high level perspective 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 hypersonics relevance, were collected, yielding 26,000 documents; these documents are defined as second-order documents. New institutions and authors appearing within second-order documents are defined as second-order entities.

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). This down selection produced a subset of 123 documents with 31 military-related institutions. The number of publications from these second-order military-related institutions were tabulated and grouped by country and the top 10 are displayed in Fig 3. A sample of the top institutions by publication count from the countries in Fig 3 can be found in Table 3 (note: some publications may have more than one military-related institution and count for multiple institutions).

Again, the results show multiple instances of collaboration with Chinese military institutions, most notably the Air Force Engineering University, one of the primary military academies and research institutions of the PLA Air Force. It can be presumed that any research conducted between UK institutions and this university will be utilized for military purposes.



**Figure 3.** Top 10 second-order countries by publication count from military-related institutions over the period of 2012-2020.

**Table 3. Second-Order Publication Counts from Military Institutions**

<b>Institution</b>	<b>Country</b>	<b>Count</b>
United States Naval Research Laboratory	United States	18
University of Defence	Czech Republic	11
Defence Science and Technology Group	Australia	10
United States Army Research Laboratory	United States	10
Agency for Defense Development	Korea, Republic of	8
National Defence University of Malaysia	Malaysia	8
United States Air Force Research Laboratory	United States	8
Defence Science and Technology Laboratory	United Kingdom	6
Air Force Engineering University	China	5
Defence Academy of the United Kingdom	United Kingdom	5
Military Technical College	Egypt	4

## Appendix A – Selected Citations from Promising Authors

### **Large eddy simulation of a hydrogen-fueled scramjet combustor with dual cavity**

*Acta Astronautica*. 2015. 108. 119.

Hongbo Wang<sup>1</sup>, Zhenguo Wang<sup>1</sup>, Mingbo Sun<sup>1</sup>, Ning Qin<sup>2</sup>

<sup>1</sup> National University of Defense Technology - China

<sup>2</sup> University of Sheffield - United Kingdom

Citations: 133

### **Combustion characteristics in a supersonic combustor with hydrogen injection upstream of cavity flameholder**

*Proc Combust Inst*. 2013. 34. 2073.

Hongbo Wang<sup>1</sup>, Zhenguo Wang<sup>1</sup>, Mingbo Sun<sup>1</sup>, Ning Qin<sup>2</sup>

<sup>1</sup> National University of Defense Technology - China

<sup>2</sup> University of Sheffield - United Kingdom

Citations: 130

### **Simulation of liquid jet primary breakup in a supersonic crossflow under Adaptive Mesh Refinement framework**

*Aerospace Science and Technology*. 2019. 91. 456.

N. Liu<sup>1</sup>, Zhenguo Wang<sup>1</sup>, Mingbo Sun<sup>1</sup>, Ralf Deiterding<sup>2</sup>, Hongbo Wang<sup>1</sup>

<sup>1</sup> National University of Defense Technology - China

<sup>2</sup> University of Southampton - United Kingdom

Citations: 22

### **Detonation stabilization in supersonic flow: effects of suction boundaries**

*AIAA Journal*. 2020. 58. 1348.

Xiaodong Cai<sup>1</sup>, Ralf Deiterding<sup>2</sup>, Jianhan Liang<sup>1</sup>, Mingbo Sun<sup>1</sup>, Dezun Dong<sup>1</sup>

<sup>1</sup> National University of Defense Technology – China

<sup>2</sup> University of Southampton - United Kingdom

Citations: 3

### **Artificial neural network based chemical mechanisms for computationally efficient modeling of hydrogen/carbon monoxide/kerosene combustion**

*International Journal of Hydrogen Energy*. 2020. 45. 29594.

Jian An<sup>1,2</sup>, Guoqiang He<sup>1</sup>, Kaihong Luo<sup>2</sup>, Fei Qin<sup>1</sup>, Bing Liu<sup>1</sup>

<sup>1</sup> Northwestern Polytechnical University - China

<sup>2</sup> University College London - United Kingdom

Citations: 20

\*Citation Count as of 1/19/2023

## Endnotes

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- <sup>1</sup> 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=5B3AB970F71A803DEACDC0559115BFCF0A068CD97DD29835&cid=3FCF8B1A330466D5&jid=CD0AE7464AC1DB25E3B503085456C422&aid=FF0B78F0290FA792&yid=A732AF04DDA03BB3](http://www.alljournals.cn/view_abstract.aspx?pcid=5B3AB970F71A803DEACDC0559115BFCF0A068CD97DD29835&cid=3FCF8B1A330466D5&jid=CD0AE7464AC1DB25E3B503085456C422&aid=FF0B78F0290FA792&yid=A732AF04DDA03BB3)
- <sup>2</sup> Alex Joske, "Picking Flowers, Making Honey," Australian Strategic Policy Institute, 30 October 2018, <https://www.aspi.org.au/report/picking-flowers-making-honey>
- <sup>3</sup> "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>
- <sup>4</sup> 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>
- <sup>5</sup> 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](https://www.bluepathlabs.com/uploads/1/1/9/0/119002711/2022-04-11_the_prc_state__defense_laboratory_system_-_an_overview.pdf)
- <sup>6</sup> Ma Xiu, "The PRC State & Defense Laboratory System Part Two: Defense S&T Key Lab Directory," China Aerospace Studies Institute, Forthcoming February 2023.
- <sup>7</sup> Yu Yue [余跃], Wang Honglun [王宏伦], "Deep Learning-based Reentry Predictor-corrector Fault-tolerant Guidance for Hypersonic Vehicles" [基于深度学习的高超声速飞行器再入预测校正容错制导], Acta Armamentarii 04 (2020)
- <sup>8</sup> "Foreign Universities Sanctioned by the Commerce Department," Brown University, Accessed January 2023, <https://www.brown.edu/research/foreign%20universities>
- <sup>9</sup> 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>