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Higher Education and China's Defense Science and Technology Establishment

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China's rapid military modernization is built upon the acquisition of advanced technologies and the development of talented personnel. The education of China's defense science and technology workforce is a key determinate of China's future success in continuing to modernize its defense industry and military. However, Chinese policymakers appear frustrated that its institutes of higher education are not better preparing scientists and researchers to undertake the types of cutting-edge research needed to be a leader. This grievance appears equally directed at civilian and military universities undertaking defense research. Universities within China's defense S&T establishment are now deeply integrating themselves with global research networks in order to raise their technical proficiency. This global integration is a key determinate of their ability to improve the level of education they offer and their future success in applied research. As Chinese universities continue to refine their contribution to the defense S&T establishment, this global integration will largely determine the impact of their contribution to China's defense S&T modernization.

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INTRODUCTION

On June 6, 2014, Chinese President Xi Jinping stood before China's leading scientists and proclaimed that "scientific and technological innovation serves as the strategic foundation for improving productivity and overall national strength, and it must be positioned as the core of China's overall development." Underlying Xi's pronouncement was a call for scientific innovation driven by talented personnel. Xi's stark assessment of the Chinese science and technology (S&T) workforce noted that although China has the world's largest S&T cadre, it also trails the world's leaders and faces enormous challenges. From lacking global talent, to an inability to commercialize technology, Xi emphasized that the Chinese S&T workforce must undergo a dramatic change.

At the same time that Xi called for a continued focus on S&T innovation, he has also emphasized the necessity of the People's Liberation Army (PLA) to better prepare to fight and win wars. Similar to Xi's remarks on S&T, the need for increasingly talented personnel underlies China's strategy for defense modernization. The future success of the Chinese defense establishment is dependent on the ability of its personnel, whether it is scientists pursuing research on advanced weapons, or enlistees learning to operate cutting-edge technologies. The recruitment of talented S&T personnel is key for both the uniformed ranks and the civilian cadre tasked with leading China's state-owned defense industries.

Chinese universities sit at the intersection of S&T innovation and defense modernization as China pursues rapid advances in defense S&T. But the role of Chinese defense S&T universities is in flux, with continued frustration at these universities' inability to overcome entrenched shortcomings at home, while they simultaneously undergo a rapid expansion in their global engagement with

the world's leading S&T institutions. The seven top-tier universities affiliated with China's defense industry embody this paradox, showing signs of continued underperformance in transferring technologies out of their labs and cultivating entrepreneurial defense startups in their affiliated science parks, while simultaneously integrating themselves into leading global research. China's universities focused on defense S&T, and in particular the Ministry of Industry and Information Technology's (MIIT) subordinate universities, will be a key determinate of China's ability to achieve its ambitious goals for defense modernization.

CHINA'S DEFENSE SCIENCE AND TECHNOLOGY UNIVERSITIES

China has more than 2,100 universities, forming a large pool of institutions capable of undertaking R&D that could contribute to defense innovation. However, there are several key groups of universities that are primarily defense actors. First, there are seven national-level universities in China that are directly affiliated with the defense industry through their management by MIIT, which also oversees the state-owned defense industry. Second, the PLA has more than 60 universities directly under its supervision. The most prominent of these universities engaged in S&T is the National University of Defense Technology, the PLA's premier university for S&T education and research. Finally, of the more than 2,000 remaining universities in China that are considered non-military universities (非国防高校), many still contribute a great deal to defense S&T research, either by sending graduates to work in the defense industry or through a historical relationship between one of its departments and the defense industry. For example, Tsinghua University was a pivotal contributor to China's

earliest nuclear weapons and propulsion systems, serving as both the country's leading civilian engineering university and a key defense contributor.

The Seven National-level Universities Subordinate to MIIT

MIIT's seven universities are unique in their role as the key institutions tasked with educating members of China's defense industrial base, while also directly participating in defense research and development (see Table 1). These universities are primarily focused on engineering and S&T more broadly, and are individually ranked among China's premier engineering institutions. Each university is nationally ranked among China's top 60 universities, and all are among the top 25 highest-ranked science and engineering universities, with four of the seven being ranked in China's top 11 schools.

These seven universities' student enrollment has expanded dramatically over the last two decades. As of 2013, there were more than 200,000 students enrolled in these institutes.

Like all universities in China, they are deeply integrated with and guided by the Chinese Communist Party (CCP). As of 2010 there were 15,000 members of the CCP among the approximately 20,000 professors at the seven universities, with 47,000 student members out of the approximately 200,000 total students in attendance. The party's influence in these schools is dominant and all-encompassing, similar to other Chinese universities.

NUDT: the PLA's Key Defense S&T Training Ground

The National University of Defense Technology (NUDT/国防科学技术大学) serves as the PLA's premier institution for education and research on defense S&T. Similar to the MIIT schools, NUDT is also a national-level university, which is directly

TABLE 1. The seven defense S&T-related universities subordinate to MIIT

English name	Chinese name
Beihang University (formerly Beijing University of Aeronautics and Astronautics)	北京航空航天大学
Beijing Institute of Technology	北京理工大学
Harbin Engineering University	哈尔滨工程大学
Harbin Institute of Technology	哈尔滨工业大学
Nanjing University of Aeronautics and Astronautics	南京航空航天大学
Nanjing University of Science and Technology	南京理工大学
Northwestern Polytechnical University	西北工业大学

subordinate to the Central Military Commission, while also maintaining an association with the Ministry of Education. NUDT is recognized as one of China’s premier S&T universities, and although it is only one of over 60 universities subordinate to the PLA, NUDT is unique in its openness and willingness to interact with scientists and scholars from outside its walls. It is self-described as the Chinese military’s institution that is “open to the public.” Unlike nearly all other PLA universities focused on S&T, NUDT frequently interacts with individuals outside of the military and even outside China.

Unlike the civilian graduates of MIIT’s universities that are heavily recruited to join the civilian defense S&T workforce, graduates of NUDT are all expected to serve in the military following graduation. These uniformed individuals serve across the PLA as experts on technological needs or as commanding officers. Students are able to train in many subjects beyond the hard sciences, although science and engineering are NUDT’s strongest subjects.

NUDT has significantly increased the global integration of its research in recent years, with pockets of world-class research, such as supercomputing. The university now claims global partnerships with more than 100 international institutions from over 40 countries. The research conducted at

NUDT covers a wide spectrum of defense and dual-use technologies. The university has established four collaborative innovation centers that highlight their strongest research topics: high performance computing; laser technology and applications; satellite navigation and positioning; and near space vehicles and microsatellite technology.

Non-Defense-Focused University Contributions to Defense S&T

At both the national and local levels, many of China’s civilian universities also contribute to the defense S&T establishment. Exact figures for the number of common civilian universities participating in defense research programs are not available. However, one report states that “only a small percentage” of the non-defense schools are contributing to the defense industry. The contributions by this minority appear to often be significant, but unlike MIIT-affiliated universities, defense S&T is not a key function of their existence. Instead, defense S&T work is more localized to specific departments in these universities. Today, the relationship of many of these universities with defense S&T appears based on their historical ties to the defense establishment.

Writings from Chinese S&T policy analysts make clear that they hope for a continued deepening of defense contributions from these universities.

One key factor preventing many of these schools from deeper integration with the defense industry is that they do not have the certificates in place to undertake classified research or directly contribute to weapons systems. An additional inhibitor is the lack of incentives for premier institutions to take on larger-scale defense research across multiple departments. In an era of evaluation based on strict publishing quotas and other external quantitative measures, labs and scholars at leading universities are less inclined to aggressively pursue the conversion and commercialization of defense and dual-use research findings.

THE CONTRIBUTIONS OF MIIT’S DEFENSE S&T UNIVERSITIES

Institutes of higher education contribute to a country’s defense innovation and industrialization in three primary areas. First and most obviously, universities are principally responsible for educating the next generation of scientists, managers, and technicians that will guide a country’s defense industrial base. Second, universities are responsible for undertaking original scientific research that makes significant contributions to the broader academic community. If successful, these research findings can then be applied to real-world products. Third, universities today are also often expected to

contribute directly to a country's economic development through the establishment of commercial entities. Known as the third mission of universities, this role often focuses on economic development through the spin-off of companies closely associated with a university.

Education: The Core Investment

Within the Chinese defense industry there seems to be a general discontent with the level of education graduates receive before entering the workforce. Researchers at one university have noted that the requirements of a modern military (among them, information technology, precision technology, aviation, new energy, and stealth) do not match with the focus of education at the seven MIIT schools. These researchers call for greater efforts to integrate real-world technologies researched by defense industry personnel, in order to open more effective communication and lead to a more synchronized education process between academic and industry actors.

An additional challenge facing China's industrial apparatus is the tension between students seeking potentially higher-paying jobs in the private sector versus more stable employment in a state-owned industry. Graduates today have a tremendous amount of agency in where they chose to stake their futures. A global marketplace that anticipates individuals moving freely between firms is difficult to reconcile with the entrenched nature of the Chinese defense industry, where individuals often join an institute with an expectation that they may spend their entire careers moving up the rungs of that establishment's career ladder.

Defense S&T Research at MIIT's Universities

Beyond educating, MIIT's defense universities are also expected to undertake meaningful defense S&T research that can be applied in realized weapons and equipment, not sim-

ply discussed in academic literature. Defense industrial universities are seen as one of China's principal forces for fundamental research and achieving breakthroughs on bottlenecks in the defense S&T community.

Although the seven MIIT schools are deeply fused into China's larger defense industry, these institutes appear to still underperform in their research production, contributing fewer applied and commercialized technologies than leaders expect. Similar to the broader Chinese research community, the seven universities struggle with their ability to apply technologies into commercialized products. This problem is seemingly heightened by the isolation of defense research at Chinese universities, which is often separated from the university's broader work.

Despite these challenges, these universities are currently building significant bonds with leading universities in the United States and around the world. This deeper global integration includes research collaboration and international joint laboratories, as well as global talent recruitment. The future trajectory of these universities will be significantly determined by their level of integration in the global research order.

Directly Participating in Defense: Few Incentives, Few Entrepreneurs

Beyond education and research, modern universities are also called upon to contribute to the so-called "third mission" of a university; direct involvement in a country's economic development. This mission pushes universities out of their traditional roles, asking that they engage in the country's economic development through the creation of companies. Such firms come in many shapes and sizes, but are generally thought of as entrepreneurial spin-offs by university-affiliated researchers.

Chinese universities are attempting to embrace this third mission, but unlike their U.S. counterparts, these

activities are seldom organic and are more often enforced by government mandate. The Chinese government's initiative tasked with attempting to foster this development is the Ministry of Science and Technology's Torch Program. All seven MIIT universities participate in the Torch Program, and are affiliated with university science parks under the Torch Program's purview that are ostensibly dedicated to encouraging entrepreneurship and innovative S&T activities. These parks are generally located near universities, with the hope that collocation will encourage the clustering of like-minded firms, sparking innovative spillover.

CONCLUSION

China's defense S&T establishment has a vast network of universities available to draw from in educating its workforce, undertaking research, and cultivating entrepreneurial firms. Many universities are capable of undertaking dual-use research of potential military use, but only a few main nodes within this network undertake core defense research efforts.

MIIT's seven subordinate universities serve as China's elite training ground for educating defense industry personnel and undertaking defense research. These universities are in a decade-plus run of increased student enrollment and rapidly growing research budgets. Yet despite these reforms, these universities, like nearly all Chinese research institutions, continue to struggle with transferring defense S&T innovations out of their laboratories and into applied weapons and equipment.

The Chinese government has made numerous efforts over the past decades to spur greater defense technological innovation from China's universities. These efforts range from the establishment of state-sponsored key laboratories to the creation of collocated university science parks. But underlying all of these efforts appears

to be a lack of personal incentive on the part of Chinese researchers to break out of the traditional norms of a career in Chinese academe. China's university-based defense researchers often appear to perceive little financial incentive to work outside of traditional university research mechanisms. This is difficult to prove quantitatively, but unlike in the U.S. research system where university-

affiliated researchers often receive significant financial incentives for driving defense innovation on and off campus, their Chinese counterparts provide relatively fewer examples.

Despite many reasons to doubt the ability of the seven MIIT universities to improve their contribution to China's defense S&T establishment, their rapidly expanding global ties hold the potential for significant

changes in the future. As this global engagement continues, MIIT's universities and the researchers staffing their respective laboratories will be key players in determining the future success of the Chinese defense establishment.

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