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WALSH, Kathleen A.

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## China's Defense Technology Acquisition System, Processes, and Future as an Integrator and Supplier

Kathleen A. WALSH

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If China's defense industrial system is to deliver radically innovative defense products to the People's Liberation Army, a fundamental shift in the logic that underlies its defense technology and acquisition system will be necessary, from one that develops and integrates technology in linear, follow-on fashion to one that takes a systems-based approach. Ongoing defense industrial reforms and advances made in Chinese science, technology, and research capabilities have aided the defense sector's extensive technology acquisition and integration processes, resulting in more rapid development and modestly innovative products in recent years. Yet China's past defense industrial processes have to date followed the more traditional, linear, industrial-age development model, which is likely to limit the type of innovation realized. As China continues its pursuit of civilian-military integration (CMI) and focuses on mastering both the art and the science of innovation as applied to the defense sector in shifting to a system-of-systems development model more conducive to the information age, we are likely to see significant changes in China's approach to—and potentially advances in—defense innovation.

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China's defense industrial sector is undergoing two fundamental changes: 1) transformation and integration of the defense industry and research community into a national innovation ecosystem in ways that mimic innovation-oriented policies, dynamics and mechanisms experimented with over decades in China's commercial technology sector in order to better leverage dual-use, military-civilian technology spillovers; and 2) a shift from the more traditional, linear production mode of defense industrial development and acquisition characteristic of the industrial age to a systems-based development model made possible in the information age. During such a period of flux, opportunities as well as hazards abound.

Beijing's top-down, strategic, and yet now also experimental approach to fostering more risk-accepting, innovative activities in the defense sector in order to incentivize more CMI and bottom-up technology development is an important factor in China's present-day defense innovation efforts. An "exploratory" approach to technological development and innovation, for instance, was particularly important to the United States' "revolution in military affairs" and is likely to be similarly critical to China's own efforts to transform its defense technology acquisition and integration processes.

As scientists, researchers, and producers in the defense sector become more intimately familiar with commercial counterparts, their practices and attitudes, and the "art" of innovation through expanded CMI and innovation efforts, the more likely we are to see risk-taking, innovation, and entrepreneurship taking hold in the defense sector (as it has to a degree in the commercial sphere) since such behavior is now encouraged and, therefore, safe to pursue. The jury is still out, however, on whether China's continuing innovation-oriented policy reforms will have their intended effect, or whether they might have un-

intended, but nonetheless innovative effects, in this period of experimental policy churn.

Beijing's new approach to a systems-oriented defense technology development model that is more closely integrated with the civilian sector is outlined in a detailed CPC Central Committee and State Council document dated late 2012 and titled "Opinions on Deepening the Reform of the Scientific and Technological System and Speeding up the Building of a National Innovation System." Among other things, the document spells out that:

[e]fforts will be made to improve the mechanism for integrating technologies for military use and those for civilian use, to construct innovation bases and transfer platforms for dual-use technologies, and to expand the scope of research of national defense technologies that can be undertaken by private research institutes and technological enterprises.

Through policies, plans, and strategies such as this, Beijing is continuing to try to master also the science of innovation.

Serious obstacles nonetheless remain to China's realization of a robustly innovative defense industrial sector, particularly with regard to risk acceptance both in technological and policy terms. Even in China's commercial sector, Chinese enterprises tend to be risk-averse, preferring for economic and, perhaps, cultural reasons to rely on already-proven technologies. Copying in China, including of technology, is not only an art form but also a business model, as demonstrated most clearly in the acceptance of "*shanzhai*" (imitation or copycat) goods. Despite operating with often incredibly slim profit margins, many Chinese enterprises exist off a business model that produces items technologically similar to market-proven Western technology products, but that are produced in volume

and marketed at lower prices with the trade-off being often lower, but good-enough quality (i.e., containing similar features or capabilities as market leaders but with less overall technological capability and perhaps featuring new adaptations aimed specifically at the Chinese market). This general approach characterizes much of China's defense production, which regularly produces near-replicas of foreign weapons systems based at least in part on Russian, Ukrainian, French, Israeli or U.S. designs but aspires to be more indigenously innovative. To the extent that this risk-averse approach to technology development remains profitable, it is likely to continue in both commercial and defense sectors and stymie efforts aimed at the acceptance of greater risks (both financial and technological) in developing indigenous and more advanced innovative capabilities.

In short, even once China's integrated national innovation system, processes, and incentive programs and policies are in place and promoting greater cross-cutting, CMI innovation, this might not suffice to overcome the incentives that exist in the China market to produce a technological solution that is "good enough" to meet consumer demands and/or defense standards. The progress China has made to date in defense industrialization and innovation is based on many factors, but much of this is because China's defense firms are largely reproducing science and technology that is already known and has been engineered and developed elsewhere. While still an impressive (and to some, surprising) feat, China's defense industrial progress to date has not reflected disruptive innovation capabilities.

In order to realize more radically innovative capabilities in the defense sector, China is adapting its defense industrial development model from one that includes *systems integration* (SI) (particularly of domestic and myriad foreign technologies) and

produces somewhat innovative products at the end of a traditionally linear process to a more fully systems-based defense research, development, and acquisitions (RDA) model and processes that also include advanced **systems engineering** (SE), particularly in the initial concept and development stages. In fact, China has all of the ingredients needed to do so: 1) a strong scientific and basic research capability; 2) increasingly strong applied technological and industrial capabilities with growing CMI possibilities; and 3) a reasonably effective defense industrial acquisition and marketing process. What China lacks most is the crux of systems-of-systems development: the critical connections between, among, and across these three elements such that the output resulting from systemic collaborations represents more than the sum of its parts.

While China has yet to fully establish a systems-oriented defense acquisition and integration process, the strategy to do so is evident, as are continued efforts to strengthen each component of the system. China's support for and growing strength in basic science, for instance, suggests the potential to contribute more in terms of new scientific discoveries yet is plagued by rising challenges to scientific integrity (e.g., scientific funding scandals cited in the Chinese press). Integration of the basic science function with the rest of the innovation ecosystem also remains weak, with some progress evident in establishing cross-institutional, military-civilian collaboration but with much more necessary in order to build solid, lasting, systemically strong connections. The need for more expansive and enduring cross-system collaborations is especially relevant with regard to China's development of more advanced SE/SI skills.

It is the second component—determining and developing tangible defense applications—that poses the greatest near-term challenge to

China's ability to both integrate and effectively acquire more advanced defense technologies. The internal decision-making processes serving this function are too restricted to top Party officials, with coordination and policy implementation scattered across too many separate bureaucracies. This vital link in a systemic approach to defense innovation and production—where new scientific and technological discoveries are: 1) known and the fundamentals understood to those charged with determining defense strategy and technology requirements; and 2) translated into innovative defense programs and processes—is the weakest in China's overall innovation system and will remain so until more bottom-up, innovative, S&T and entrepreneurial inputs from both military and civilian sectors are allowed to influence policy decision-making in areas of defense science and technology.

Beijing's ongoing, experimental approach to policy reforms is intended to encourage this dynamic to the defense sector. But while such efforts do provide a more supportive (or at least not prohibitive) environment for wider-ranging innovative and entrepreneurial inputs to influence decision-making, such opportunities appear insufficient at present to allow the type of radical, disruptive, or frontier S&T-based innovation Beijing seeks. A less opaque defense requirements and industrial development system is likely necessary as well, to make clear the fundamental logic that is intended to underpin the more advanced systems-oriented development model (at least to those involved in these and related processes), and thereby allow more risk-taking, innovation, and integration to take place.

The last component, technology development, acquisition, and marketing, represents another function where China has a reasonably well-demonstrated ability in the commercial sector and, increasingly, in defense. But the current *shanzhai*-like

approach to much commercial and defense technology development will condemn China to the ranks of adaptive innovators. This is not the sort of leapfrogging technology revolutions PRC leaders seek, nor will it produce the system-of-systems-oriented RDA process intended by current reforms. As long as the *shanzhai* development model remains attractive and risk aversion persists, China's defense enterprises are likely to continue to provide the People's Liberation Army with increasingly advanced technologies (continuing on a more linear, production model approach) but not with radically innovative, disruptive, technologically integrated or innovatively engineered systems.

To address this gap, China is in the process of developing new policies, programs, and plans to promote and experiment with just the sorts of cross-cutting, systemic connections that are essential to more advanced innovation. Beijing has supported open-access, nation-wide information databases and scientific libraries, as well as other information-based, resource-sharing platforms for researchers while encouraging greater cross-institutional S&T endeavors. These efforts are reflected in the growing number of scientific and engineering articles published in Chinese academic journals by authors from more than one academic institution and from different parts of the country or across different industry sectors. But enduring progress in this regard is likely to take time, as achieving these sorts of cross-cutting, organic connections reflect more the art than the science of innovation.

In shifting to a more systems-based model of development, structural changes and new ways in which information and understanding of science, technology, engineering, and commercial practices—both domestic and global—enter the defense industrial development system and processes will be necessary. Policy reforms regarding how require-

ments are generated and approved in China's defense industrial development system and processes can be expected, including the role played by China's defense conglomerates, which is likely to grow. The enactment of these reforms and the degree of resistance to or acceptance of them will be a key indicator of how technologically ambitious and innovative China's defense and commercial researchers, engineers, scientists, and contractors collectively can and are likely to be (or not), singly or collectively.

Also likely to change will be the role(s) played by the General Armament Department, particularly its Science and Technology Committee, the PLA's Military Representative Office (MRO) officials, and foreign investors in the defense sector, among others, as China shifts from the industrial age, follow-on development model to a more systems-of-systems model that is likely to require more decision-making authority lower down the bureaucratic hierarchy.

Finally, while China has demonstrated progress in each systems-oriented component, if progress in and connections among each of the components are not in sync, then the whole system is likely to proceed haltingly at best. That is, even if Chinese scientists were to make world-shattering scientific discoveries, if the technology application and development components of the system are not keeping pace, then these discoveries are likely to fall by the wayside. Or worse for China, in an era of global science and technology, others might exploit these scientific discoveries for their own defense and/or commercial technology development needs, leaving China to follow.

The nature of systems is that they are often only as strong as their weak-

est link, which in this case is China's ability to convert what is possible (as understood in scientific, technological, and engineering terms) into tangible and newly innovative or inventive defense applications. Cross-cutting connections, collaborations, and advanced systems engineering and integration skills throughout the process are necessary in a systems environment to do so effectively and constitute, therefore, the main thrust of China's present defense industrial and innovation reform efforts.

Some indicators that China might be making progress in its transition to a more systems-based RDA model would include the following:

- China's defense literature reflects a sophisticated understanding of complex systems, systems theory, and related RDA decision-making structures and processes, also reflected in policy documents and institutional restructuring efforts.
- The basic logic underlying China's intended RDA system and processes is clear and transparent, at least among China's defense community, including officials, industry, researchers, and engineers.
- China's defense standards and requirements generation processes are collaborative and more decision-making authority is distributed at the working level, among other likely changes in how defense requirements are generated and approved (including changes in the role played by China's defense conglomerates).
- Advanced SI/SE skills and processes are developed, particularly vis-à-vis decisions made at the beginning of the RDA process (in other words, allowing the ability to conduct substantial

systems engineering and integration processes to determine what shape, design, and so forth any output should have before building anything). Advanced 3D printing/advanced manufacturing might play an important role here, particularly if conducted across different industrial sectors.

- Training and education aimed at enhancing defense systems engineering and integration.
- Changes in the role and functions of the MROs (or other authorities) charged with ensuring defense system-wide information sharing and integration is taking place and informing not only policymakers in decision-making processes but ensuring that ideas raised by scientists and engineers in labs, on the factory floor, or in military commands are included.
- Increased cross-sector and CMI-oriented collaboration in published scientific and technical papers and patents that are recognized by international authorities.

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**Kathleen (Kate) WALSH** is associate professor of national security affairs. She teaches policy analysis in the National Security Affairs Department of the U.S. Naval War College and is an affiliate of the China Maritime Studies Institute (CMSI). Her research focuses on China and the Asia-Pacific region, particularly security and technology issues.

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