



# Policy Brief No. 20

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### *Innovation in China's Defense Research, Development, and Acquisition System*

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#### Summary

This policy brief examines how innovation takes place within the Chinese defense research, development, and acquisition (RDA) system. This begins with a short review of the evolving frameworks of analysis of technological innovation in industrial systems, with prominence given to the coupled technology-push, market-pull model. Over the past 60 years, the Chinese defense RDA system has evolved from a top-down to a coupled model of interaction between weapons developers and military end-users. Important reforms have been taking place in the Chinese defense RDA system since the late 1990s, but serious structural impediments continue to exist that threatens to blunt the effectiveness of these improvements and keep the system in a trapped transition.

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## EVOLVING MODELS OF INDUSTRIAL INNOVATION AND THEIR APPLICATION TO THE DEFENSE RDA PROCESS

The understanding of how technological innovation takes place in industrial systems, including the defense RDA process, has made considerable progress over the past half a century. The first analytical frameworks emerged in the 1950s and simply viewed industrial innovation as linear in nature. Technology push became the first widely-adopted explanation, which broke down the process into sequential steps: basic research, applied research, development, and production/diffusion. As more investigation took place, the market-pull model gained prominence in the 1960s.

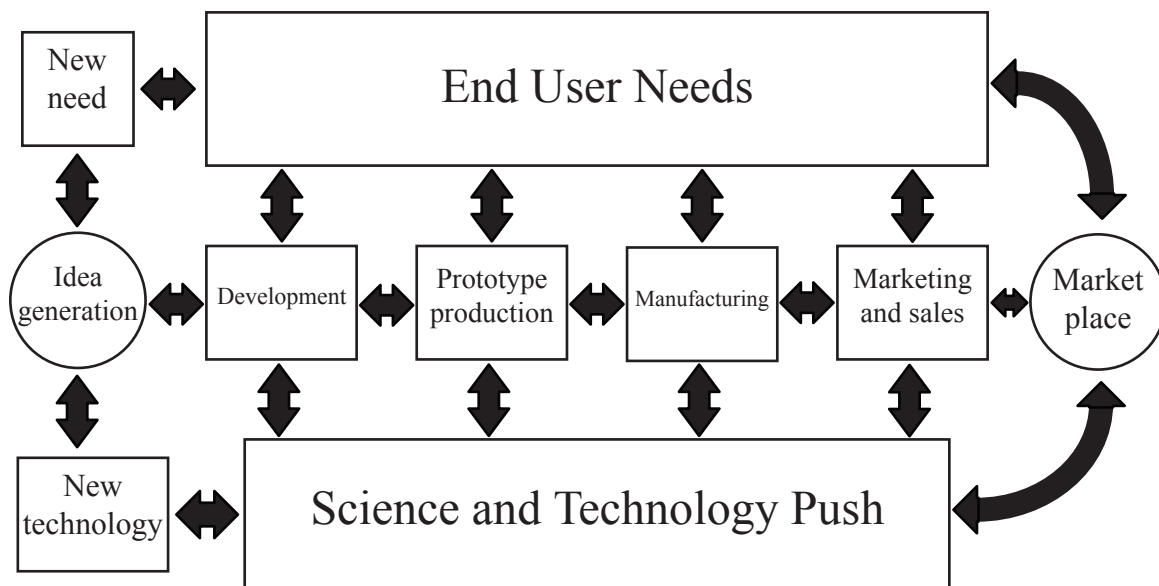
These push and pull variants were combined into a third generation ‘coupling’ model in the 1970s that incorporated feedback loops to allow for interactions between research and development (R&D) and market needs (see Figure 1). While this model offered some functional integration between the push and pull processes, it remained a linear-sequential framework of analysis. This coupling model has been refined in recent years. One popular version employed within the U.S. defense RDA apparatus is the stage-gate model that organizes the innovation process into

successive stages with reviews (feedback loops) at pre-determined milestones to evaluate whether work can progress onto the next stage or needs to be revised.

A critical limitation of these linear models is the inherent lack of functional integration among the different activities. In response, the fourth-generation model emerged in the 1980s and viewed the innovation process as parallel but integrated activities across organizational functions. Activities such as ideas generation, R&D, testing and evaluation, manufacturing, and marketing would occur in parallel but with close coordination through integrated product teams made up of representatives from all these different disciplines. This model was first popularized in the commercial automobile industry in Japan and adopted by a growing number of U.S. firms in the 1990s. The U.S. Defense Department also embraced the practice in the mid-1990s.

As the general study of innovation shifted toward a more systems-oriented approach in the 1990s, the latest generation of models has focused on the development of comprehensive frameworks of analysis that seek to capture the complex interactions between different networks. Different versions of this systems model include open and closed innovation models. In analyzing the Chinese defense RDA system, the coupling model

**Figure 1.** Coupling Model of Industrial Innovation



will be used as it reflects the current realities of the highly compartmentalized and linear Chinese process.

## DEVELOPMENT OF THE CHINESE DEFENSE RDA SYSTEM

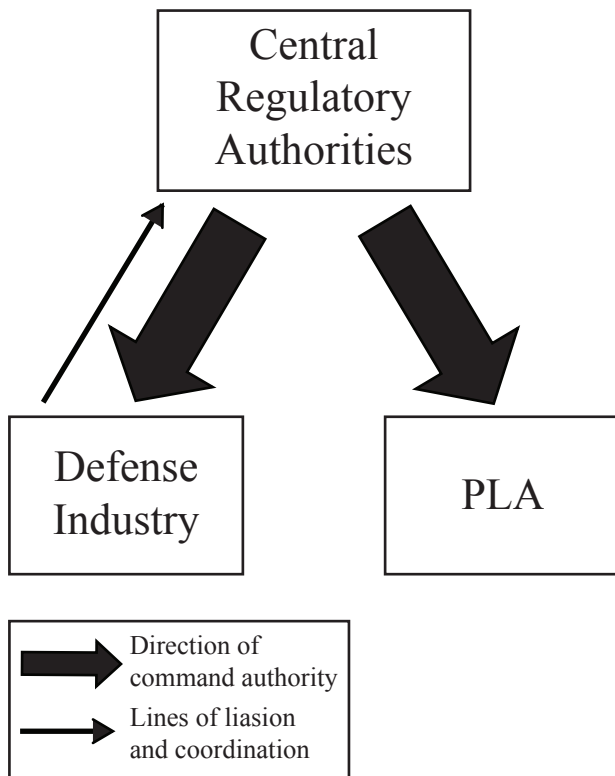
The development of the Chinese defense RDA system has been markedly different from Western approaches, especially during the era of central planning before the 1980s. The opening development phase began in the 1950s and extended to the early 1980s and can be characterized as a top-down sequential model (see Figure 2). The central authorities maintained pervasive control over all aspects of the innovation and industrial process from R&D to manufacturing. Innovation came overwhelmingly from foreign technology and knowledge transfers and technology-push and demand-pull factors played a peripheral role. The strategic weapons industry was a notable excep-

tion. In this industry, which was responsible for the development of nuclear weapons and strategic missiles, technology-push was the dominant model of innovation.

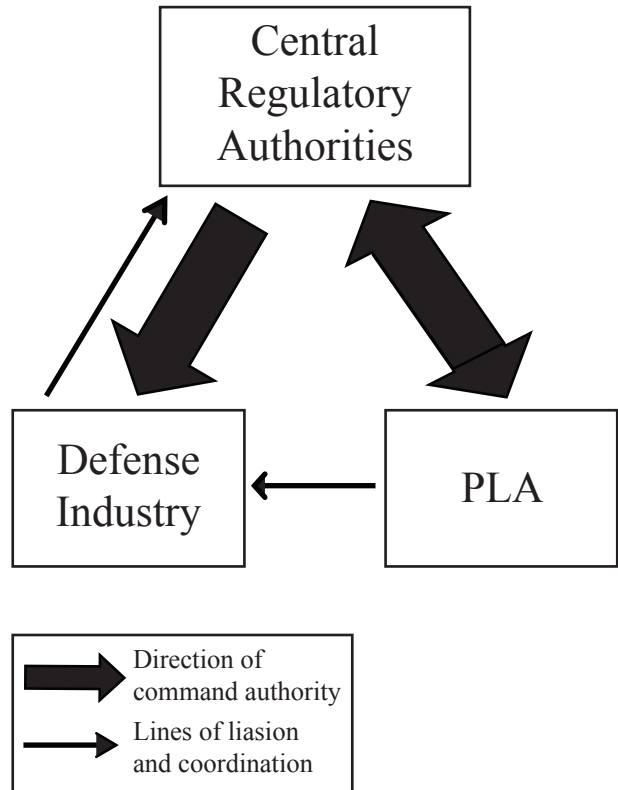
In the second stage starting in the mid-1980s, demand-pull drivers began to assert growing influence as the PLA's role in defense RDA grew, but the top-down model persisted because of the dominance of the Commission for Science, Technology, and Industry for National Defense (COSTIND). Moreover, as the defense industry underwent a prolonged downturn during this period amid a sharp drop in military orders and a large shift to civilian output, these pull factors had little impact in improving innovation (see Figure 3).

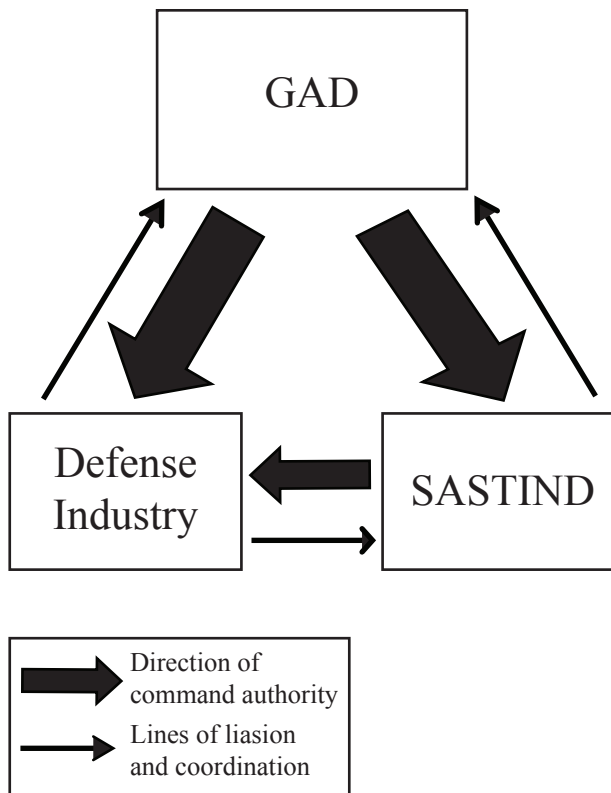
Since the end of the 1990s, the push-pull coupling model has emerged as the principal model of Chinese defense industrial innovation. There have been intensifying efforts to forge closer interactions between the RDA apparatus and military end-users. The establishment of the GAD and its

**Figure 2.** Top-Down Command Model of Chinese Defense Industrial Innovation, 1950s–1970s



**Figure 3.** Weakening Top-Down Model of Chinese Defense Industrial Innovation, 1980s–1990s





**Figure 4.** Emerging Coupling Model of Chinese Defense Industrial Innovation, 2000s–Present

active involvement in weapons research and development has been pivotal in allowing the military apparatus for the first time to occupy a central role in the defense industrial innovation system. Allied with this has been the curtailment in the authority and role of the COSTIND and its successor SASTIND from a direct to an indirect regulator. From its inception, GAD’s relationship with the defense industry was loosely coupled (see Figure 4). Interaction between the two parties was often adversarial and lacked trust. The defense industry’s abysmal performance and inability to meet the PLA’s needs led military chiefs in the 1990s and the early 2000s to implement competitive mechanisms in the acquisition process by looking overseas for arms to meet some of its critical needs. Competition was injected into the R&D system through the overhaul of the traditional practice of spreading funding across large numbers of projects with little consideration for performance; instead, research budgets were con-

centrated on select high-priority projects. Efforts were also made to corporatize large numbers of R&D institutes by allowing major defense conglomerates to take them over.

As the defense industry undertook major reforms and GAD’s involvement in the RDA process grew, the relationship began to shift toward a more tightly coupled framework of interaction. Cooperation increased as the PLA’s trust in the defense industry began to be restored as new generations of local weapons finally emerged from the development pipeline. Domestic orders rose while foreign imports fell.

An important dimension of this coupled relationship is the role of defense firms. Before the reforms of the late 1990s, the defense enterprise groups that controlled each of the five key defense industrial sectors were state-owned bureaucratic monopolies that had little independence from the central government. The post-1998 reforms have turned around the fortunes of these conglomerates. They have been transformed into profit-oriented, shareholding entities that enjoy operational autonomy while remaining wholly state owned. Moreover, each defense conglomerate was divided into two entities in an effort to promote limited competition within their industrial sectors. This arrangement was intended to foster friendly cooperation between these firms and the PLA through credible commitments, extensive information sharing, and other hallmark features of a tightly coupled relationship.

While the nature of these linkages between defense corporations and the PLA has yet to be fully mapped out, these enterprises appear to have benefited handsomely from improved cooperation with the PLA. Revenues and profits for the entire defense industry have grown strongly since the early 2000s (see page xx)

The deepening cooperation and coordination between the PLA and the defense industry appears to be occurring at multiple levels ranging from high-level strategic and doctrinal planning and policy-making at the center to factory floors around the country. PLA, civilian defense industry officials, and S&T experts have been cooperating on long-range S&T development plans since the early 2000s. This includes the drafting of the

2006–2020 Defense Medium- and Long-Term S&T Development Plan.

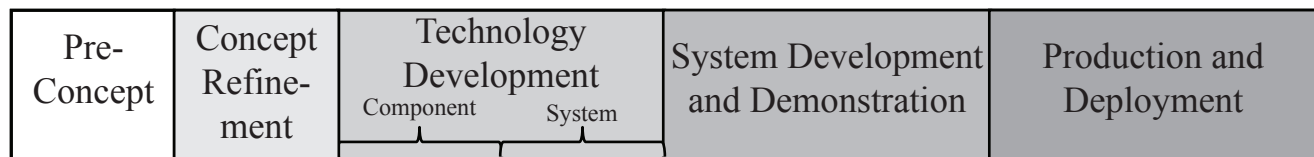
A longer-term question is whether the PLA and the Chinese defense industry will adopt integrated parallel models to help advance the innovation process. These approaches, such as the DOD’s Integrated Product and Process Development, appear to offer faster, more effective, and perhaps more creative solutions to the development of new technological capabilities. But they can also carry substantial risks, especially if management systems are lacking or if product designs are subject to change and uncertainty because of their immaturity or changing end-user requirements. Under these circumstances, reworking is costly and time-consuming. Some PLA weapons analysts believe that deeply-entrenched, traditional, compartmentalized organizational and management practices are major obstacles that stand in the way of the adoption of new and more efficient parallel processes such as integrated product teams.

### THE CHINESE DEFENSE RDA PROCESS

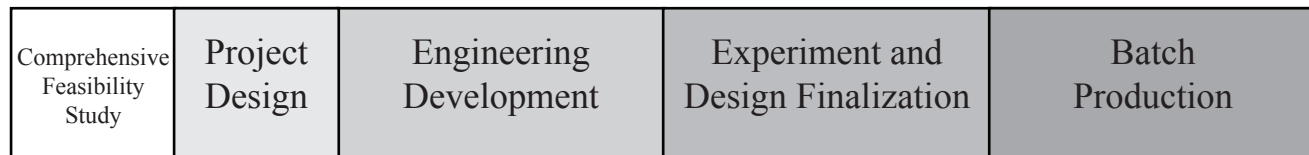
The PLA and defense industry have scrutinized and adopted many of the features of the U.S. defense industrial innovation system. The Chinese defense RDA process resembles the five key phases of the U.S. approach (see Figure 5):

1. *Comprehensive Feasibility Study*: This is a joint undertaking by military end-users and defense industry R&D entities to examine the operational needs of war-fighters for equipment, tactical and technical requirements and specifications, and acquisition and life-cycle costs. The feasibility study provides the basis for the drawing up of R&D work contracts.
2. *Project Design Stage*: R&D entities are contracted to carry out comprehensive project design, model development, full life-cycle analysis, and the scientific and practical demonstration and verification of the new equipment. The GAD then reviews the results for approval to enter the development phase.
3. *Engineering Development Stage*: Full-scale development takes place, which includes full-scale design, trial manufacturing, and development and evaluation of test models. Preparatory work also begins for small batch production and computer simulation of production processes. Once design requirements are met, reports are submitted for finalization tests.
4. *Experiment and Design Finalization Stage*: Final inspection of the designs and standards of the equipment is carried out. This includes testing of both development and batch production equipment.

**Figure 5.** The Phases of the Chinese and U.S. Defense RDA Processes



A. Chinese Defense RDA Process



b. U.S. Defense RDA Process



Specialized testing centers and frontline military units carry out this testing.

5. *Batch Production Stage:* After experiment and design finalization is approved, batch production takes place.

A noteworthy feature of the Chinese system is the need for close collaboration between the PLA and defense industry R&D and industrial entities throughout all the stages of the process. In principle, feasibility studies are a joint undertaking by PLA end-user units and R&D entities. While R&D organizations are responsible for project design and engineering development, PLA organizations led by GAD review and approve the work done before it is allowed to progress to the next phase. Testing is also undertaken by defense and PLA organizations. The extent to which this process is actually implemented is far from clear, but the adoption of this tightly coupled arrangement is a promising and important step forward in the development of the Chinese defense industrial innovation system.

## **THE OUTMODED NATURE OF THE CHINESE DEFENSE RDA REGULATORY SYSTEM**

A fundamental problem for the long-term prospects for reform of the Chinese defense RDA system is the lack of effective reforms to its regulatory mechanisms of control. The defense RDA system is an example of a classic command and control regulatory system in which authorities rely on administrative coercion and threats to achieve compliance, state agencies are responsible for direct micro-management and rule-making, and the primary focus of rules and regulations are on what enterprises do and not their performance or outputs.

While such an approach fits into a centrally planned system, it becomes ineffectual in market-based environments. This is why many other civilian sectors of the Chinese economy are adopting independent regulatory models of governance, in which the emphasis is on indirect-rules based regulation. The Chinese defense industry appears to be inching in this direction, but key portions of the defense RDA system remains mired in the command and control regulatory framework.

## **CONCLUSIONS**

Important reforms have been taking place in the Chinese defense RDA system since the late 1990s. But serious structural impediments continue to exist that threatens to blunt the effectiveness of these improvements. A core fundamental problem is the persistence of an outdated regulatory control system and the lack of modern market-based management and economic incentive mechanisms, especially in areas such as product pricing and the use of competitive contracts. Nearly all major weapons programs are single sourced through the increasingly defunct mandatory planning process.

Without concerted implementation of new reform initiatives, especially the overhaul of the cost-plus 5 percent profit margin pricing model as well as the military representative system, the defense RDA system may find itself continuing to be in a trapped transition between central planning and the market. This would have serious negative ramifications for the modernization efforts of the PLA and defense industry.

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