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Summary

What is military innovation? How should we think about Chinese military innovation? By developing an analytical framework that captures both the components of military innovation (technology, doctrine, and organization) and the continuum of change, we can better assess the nature, extent, and importance of contemporary Chinese military innovation.

MILITARY INNOVATION

Military innovation—change in how militaries prepare for, fight, and win wars—is a multifaceted phenomenon. It is about the development of new ways and means of doing business, new products and processes, and the application of new ideas to practice. As depicted in the "military innovation triad," there are three components:

- Technology;
- Doctrine/operational art; and
- Organization.

Technology, particularly in the form of weaponry and weapons systems, doctrine, and organization may be improved or new, or integrated in an improved or new
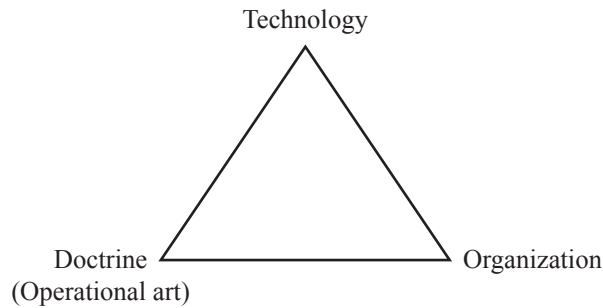
Figure 1. The military innovation triad

way. The extent and nature of change may be located anywhere along the continuum between advance and breakthrough, continuous and discontinuous, sustaining and disruptive, incremental and transformational, minor and radical, or evolutionary and revolutionary. Military innovation encompasses both "modernization" and "transformation" and spans the spectrum between the two. Hardware—technological—and software—doctrinal/operational and organizational—innovation can be slow or rapid, simultaneous or sequential, modest or profound.

Multiple agents and actors, producers, and users are involved in national innovation systems and processes. Innovation agents hail from both the public and private sectors and take the form of institutions as well as individuals. They may occupy positions in executive or legislative institutions, be located in research, development, and production enterprises, or emerge from a user community. Military innovation may be championed by the military or by civilians—or by a coalition of the two. Intended users may embrace or resist innovation; innovation conceived, funded, developed, and, even, deployed, is not necessarily innovation implemented.

The role of external competitive pressures in driving innovation is often emphasized. Even with such pressures, military resistance to change may be so entrenched that civilian intervention is required to bring it about. Innovation may be the work of singular military or civilian visionaries, or mavericks, willing to break the eggs needed to make an omelet. It can be driven as well by inter- and intra-service competition for roles, missions, and resources that must be adjudicated by civilians.

INNOVATION: A CONTINUUM OF CHANGE

Despite the preoccupation with "revolutions in military affairs" (RMA) and "transformation," military innovation need not entail major, large-scale change. A wide range of too-often over-looked military innovation is located between the bookends depicted in the military innovation spectrum. On the spectrum, or continuum, of military innovation depicted in Table 1, the bulk of the action is located on the left.

Table 1. Continuum of military innovation

Ordinary	⟷	Extraordinary
Modest	⟷	Profound
Advance	⟷	Breakthrough
Continuous	⟷	Discontinuous
Sustaining	⟷	Disruptive
Incremental	⟷	Transformational
Minor	⟷	Radical
Evolutionary	⟷	Revolutionary

Most military innovation is distinctly less than revolutionary or transformational. It consists of incremental, often near-continuous, improvements in existing capabilities. These fundamentally routine incremental advances in technology, doctrine, and organizational capabilities should not be dismissed. On the hardware front, it is called "modernization."

This sustaining, as opposed to disruptive, innovation—improvements in existing capabilities in support of established performance metrics—is commonplace, even mundane. Sustaining innovation's incrementalism does not, however, diminish its significance. It is what military organizations, following standard operating procedures, pursue on a regular basis. Technology advances. Doctrine is refined. Organizations evolve. Existing capabilities are optimized.

BREAKTHROUGHS

Discontinuous innovation poses the potential of technological or architectural "breakthroughs." Breakthroughs are infrequent and surprising, and most military innovation is to be found in quad-

	Hardware (Weapon/platform/system)	
	Incremental	Discontinuous
Software (Doctrine/organization) — Incremental	Sustaining innovation	Technological breakthrough (Weapon/platform/system)
Software (Doctrine/organization) — Discontinuous	Architectural breakthrough (Doctrine/organization)	Disruptive, revolutionary innovation

Figure 2. Military innovation matrix

rants of the matrix (Figure 2) other than that within which disruptive, revolutionary innovation appears. As Stefik and Stefik note, breakthroughs "create something new or satisfy a previously undiscovered need" and enable us to do something that we didn't know was possible—to fly, to venture into space, to harness the power of the atom.[1] Their uses and consequences may be unintended. They can result in the transformation or even displacement of existing practices.

Discontinuous weapons, platforms, or systems change, even in the context of incremental doctrinal and/or organizational change, constitutes what in the matrix is labeled a "technological breakthrough." Discontinuous doctrinal and/or organizational—or software—innovations represent what are depicted as "architectural breakthroughs." Architectural innovation redefines or reconfigures the way in which the components of technologies, doctrines, or organizations are linked and features major changes in the relationships among and integration of hardware (technology) and software (doctrine and organization). Dramatic departures in operational concepts or organizational structure—particularly the development of new doctrine or the establishment of new organizations—that result in technology being used in ways it hasn't been used before qualify as architectural breakthroughs.

Discontinuous technological and architectural innovations both occur much less frequently than

sustaining innovations. Examples of past discontinuous technological innovations include the introduction of battleships, aircraft, tanks, aircraft carriers, and, more recently, GPS. Today, UAVs and other unmanned, robotic systems are examples of discontinuous technological breakthroughs. The all-volunteer force, "jointness," and maneuver warfare are recent examples of architectural innovation. Blitzkrieg is a well-known historical example of an architectural breakthrough.

REVOLUTIONARY CHANGE

The discontinuous, disruptive innovation that underlies revolutions and transformations is extraordinary rather than routine. Technology leaps ahead. Doctrine is reformulated. Organizations are (re)created anew. Competitors are left behind.

Disruptive, revolutionary innovation is the result of the confluence of discontinuous technological, doctrinal, and organizational changes; it occurs when discontinuous hardware and architectural changes coalesce and come together in a coherent, integrated whole. Existing capabilities are not optimized but rendered obsolete and displaced. New dominant technologies, doctrines, and organizations are established and integrated as never before. New performance metrics are embraced.

The disruptive, profound, revolutionary change evident in the phenomena characterized as "military revolutions," "revolutions in military affairs," and "military-technological revolutions," which include each of military innovation's three components, is relatively rare. According to Andrew Krepinevich, only ten military revolutions occurred from the fourteenth through the twentieth centuries.[2] Three of these revolutions, the land, naval, and interwar revolutions, were components of the industrialization of warfare that spanned portions of the nineteenth and twentieth centuries. If the three are collapsed into one, just eight military revolutions are evident during this 700-year period.

Discontinuous innovation need not require simultaneous technological, doctrinal, and organizational breakthroughs. Indeed, simultane-

1 Mark Stefik and Barbara Stefik, *Breakthrough: Stories and Strategies of Radical Innovation* (Cambridge, MA: MIT Press, 2004), 3.

2 Andrew Krepinevich, "Cavalry to Computer: The Pattern of Military Revolutions," *The National Interest* 37 (1994): 30–42.

ous hardware and architectural breakthroughs appear to be the exception rather than the rule. One tends to lead while the other lags and must catch up—if disruptive innovation rather than either a technological or architectural breakthrough alone is to be the result. Breakthrough doctrinal and organizational innovations have often lagged behind breakthrough technological innovations. The technological breakthroughs represented by the development of the tank and the aircraft carrier were not initially disruptive; that awaited the doctrinal and organizational breakthroughs of the interwar period.

In the nuclear realm, too, technological (as well as scientific) breakthroughs preceded the equivalent doctrinal and organizational innovations, although the technological breakthroughs that yielded the Trinity "gadget," "Little Boy," and "Fat Man" were the result of an unprecedented wartime organizational breakthrough known as the Manhattan Project. Today, doctrinal and organizational developments trail the development of two disruptive technological innovations: robotics and information technologies for cyberattack, cyberdefense, and cyberexploitation. Extant missile defense doctrine and organization that have long awaited the requisite technological capabilities indicate that architectural breakthroughs need not trail technological breakthroughs.

IMPLICATIONS FOR CHINA

This brief discussion of the multidimensional phenomenon of military innovation suggests a series of questions that enable us to take the measure of the nature, extent, and importance of contemporary Chinese military innovation:

1. To what extent do U.S. capabilities and actions serve as the spur—the strategic rationale—for Chinese military innovation?

2. Are there champions, whether institutional or individual, civilian or military, of military innovation in China?

3. Where do China's military innovation programs fall on the innovation spectrum? Are program objectives modest or profound?

4. Where are China's military innovation programs located in the innovation matrix?

Is China focused primarily on sustaining innovation, or is it pursuing breakthroughs? Are its military innovation efforts focused on particular niches or on a broader array of capabilities? Is China pursuing disruptive innovation? Does Chinese military innovation have the makings of a RMA? What might be the nature of a RMA with Chinese characteristics?

5. Is the Chinese emphasis on hardware innovation or on software innovation? Is technological innovation being accompanied by architectural innovation? Is new doctrine in the works? Are new organizations being stood up?

6. The systems of systems and networks of networks that are a striking feature of contemporary military operations place a premium on systems integration. Does China possess the requisite systems integration skills?

7. Are strategically significant resources being spent on military innovation?

8. Have China's military innovation programs yielded concrete payoffs such as new military capabilities? What can the People's Liberation Army, Air Force, and Navy do now that they couldn't do before? What might they be able to do in the future that they can't do now?

9. Will China's military innovation programs provide it with durable or only fleeting competitive advantages?

10. What are the implications for its military innovation efforts from China's relatively poor showing in national innovative capacity rankings?

11. Will the balance between the public and private sectors of China's national innovation system facilitate or impede its military innovation efforts?

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