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Revisiting the U.S.-Soviet space race: Comparing two systems in their competition to land a man on the moon☆

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ABSTRACT

The Cold War space competition between the U.S. and the USSR, centered on their race to the moon, offers both an important historical case and larger implications for space and technology development and policy. In the late 1950s, under Premier Nikita Khrushchev's direction and Chief Designer Sergei Korolev's determined implementation, Moscow's capabilities appeared to eclipse Washington's. This called the international system's very nature into question and prompted President John F. Kennedy to declare a race to the moon. Despite impressive goals and talented engineers, in the centralized but under-institutionalized, resource-limited Soviet Union feuding chief designers playing bureaucratic politics promoted a cacophony of overambitious, overlapping, often uncompleted projects. The USSR suffered from inadequate standardization and quality control at outlying factories and failed to sustain its lead. In marked contrast, American private corporations, under NASA's well-coordinated guidance and adjudication, helped the United States overtake from behind to meet Kennedy's deadline in 1969. In critical respects, Washington's lunar landing stemmed from an effective systems management program, while Moscow's moonshot succumbed to the Soviet system, which proved unequal to the task. In less than a decade, Soviet space efforts shifted from one-upping, to keeping up, to covering up. This article reconsiders this historic competition and suggests larger conclusions.

1. Overall dynamics

1.1. Political system shapes technology development

National political systems shape technological development within them because modern organizations must develop standardized rules and procedures to create and sustain the bureaucracies that coordinate it.[1] Central to its advantage over the USSR was the United States' successful development and implementation of several management and organizational processes for developing technology that are used to this day. The most all-encompassing process, systems management, synthesizes best practices from systems engineering, operations research, and project management to administer complex technological and organizational relationships spanning diverse specialist cultures and bureaucratic interests. The related processes of configuration management and change control, "at the heart of aerospace and software engineering from the late 1950s to the present," help to "coordinate engineering modifications," forecast costs, and maximize reliability.[2]

Effective systems management is "a set of organizational structures and processes [for coordination of large-scale technology development to] rapidly produce a novel but dependable technological [product] within a [relatively] predictable budget."[3] Its genesis and initial successes were intimately connected with another U.S. advantage: a sophisticated public-private partnership in which private firms competed for government contracts and winners selected and supervised their own subcontractors. Systems management was conceived in the early

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[2] Stephen B. Johnson, *The United States Air Force and the Culture of Innovation, 1945–1965* (Washington, DC: Air Force History and Museums Program, 2002), quotation from 226; see also 16, 209, 225–26.

[3] Thomas P. Hughes, *Rescuing Prometheus: Four Monumental Projects That Changed the Modern World* (New York: Pantheon Books, 1998); Johnson, *The Secret of Apollo: Systems Management in American and European Space Programs* (Baltimore, MD: The Johns Hopkins University Press, 2002), 17.

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post-war years, pioneered at the U.S. firm Ramo-Wooldridge (later, TRW)[4] and developed further by AT&T Corporation.[5] It proved itself in Lockheed's Polaris submarine-launched ballistic missile for the U.S. Navy,[6] Convair's Atlas intercontinental ballistic missile (ICBM) and Martin's Titan ICBM as well as Douglas's Thor intermediate-range ballistic missile for the U.S. Air Force (USAF),[7] and multiple corporations' contributions to the Apollo moon-landing program. The culture of American aerospace innovation was highly contested, reflecting the interplay of many interest groups, but by 1960 systems management was "the standard for large-scale project development." NASA embraced it almost immediately. In early 1961, the USAF adopted systems management recommendations championed by General Bernard Schriever. In 1965, with Defense Secretary Robert McNamara's support, technology management and organization processes were embraced and being implemented throughout the defense aerospace and computing industries. By this time, most major military and civilian aerospace projects utilized aspects of systems management and related best practices. Systems management's core elements—sound initial design, "quality assurance, configuration control, and systems integration testing [—have been] among the primary factors in the improved dependability of ballistic missiles and spacecraft."[8] For Apollo, NASA in September 1961 adopted the Navy-developed Program for Evaluating and Reviewing Technique. Accordingly, 90,000 key events for 800 major entities were sorted among five levels by schedule, sequence, person-hours, and duration.[9]

Because it derives from constant, transparent "negotiations among various organizations, classes, and interest groups,"[10] systems management is typically more difficult to achieve in a closed authoritarian system than in a capitalist democracy or even a hybrid authoritarian system like China's today. NASA, for instance, received consultation from private corporations AT&T (Bellcom Group), Boeing—a global aircraft leader with both defense and commercial experience, TRW,[11] and McKinsey.[12] "When you put something complicated together you get into systems engineering whether you recognize it or not," former Lunar Module (LM) program director and Grumman president Joseph Gavin Jr. emphasizes, but "the Soviets had no AT&T" to help them maximize efficiency.[13]

1.2. Comparative space development: critical Cold War test

The Cold War was "a sustained competition in power creation,"[14] with space as one of its central theaters, and a race to land a man on the moon at the core. Moscow's failure in that quest foreshadowed limitations in national capabilities that fatally undermined its core identity as the vanguard of socio-technological progress.[15] Having started the space race, therefore, Moscow felt compelled to keep ahead. The comparatively agile, innovative U.S. system met Moscow's challenge and won the moon race. American technology proved to be both more advanced than Soviet technology and ultimately more affordable thanks to both the dynamic economy supporting it and its numerous civilian spin-offs. Cold War competition and the extreme space environment left little margin for error.[16] Indeed, "The really significant fallout from the … endless experimentation of Project Apollo [was] of a sociological rather than a technological nature; techniques for directing the massed scores of thousands of minds in a close-knit, mutually enhancive combination of government, university, and private industry."[17]

Soviet loss of the moon race represented not a singular but rather a systemic failure. Attempts to dominate aerospace with improved military aircraft, supersonic transports, and digital avionics all failed for similar reasons.[18] It was not Soviet ignorance of advanced management systems that doomed Soviet aerospace; it was ideological constraints precluding their implementation. Moscow's space program was further handicapped with outdated organization and development techniques such as use of multiple test flights, as opposed to Apollo's methodical, relatively economical ground testing. These techniques had been inappropriately transplanted from Moscow's World War II artillery corps, whose leaders had commandeered both the emerging manned spaceflight program and the dominant Strategic Rocket Forces that funded it.[19] The Soviet system was highly secretive with even worse bureaucratic fights than the U.S. system. Pervasive secrecy and bureaucratic competition could only be overcome through productive relationships. Breaking through the secretive structures required personal connections and trust, which was difficult to achieve in a communist system recovering from Stalinism, but which Korolev often achieved. Nobody else replicated that effectively, as shown by problems after his death in 1966. In the end, America's federal-corporate system channeled competition into a single, effective program that landed the first, as well as the only set of, astronauts on the moon. The centralized Soviet system decreed multiple efforts to make the first-ever piloted circumlunar flight and lunar landing. It sponsored multiple moon rockets and associated programs chaotically. It achieved very few positive results.

1.3. Contest for the highest high ground

Having achieved the world's first satellite launch on October 4, 1957, Khrushchev believed that a new era of missiles could "demonstrate the advantages of socialism."[20] Building on Stalin's assertion that technology decided everything,[21] Khrushchev quickly cited *Sputnik* as proof that—thanks to its superior system—the USSR was surpassing the West. Washington's failure to match Moscow's feat—despite plans to orbit a satellite since 1955—alarmed many Americans, who, like those in other nations, believed Khrushchev's exaggeration.[22] Realizing the U.S. reaction, Moscow stepped up propaganda and programs. Its November 3 launch of a 1120-pound satellite carried canine cosmonaut Laika into orbit. The Soviet public and foreigners alike remained unaware that all Sputnik launches were one-off, or hastily assembled, projects. Speaking to Chinese students in Moscow on November 17, 1957, Mao Zedong asserted, "Now, the Soviet Union has launched two Sputniks. … This is a great turning point … in the comparative strength of the world's two blocs. From now on, the west wind will not prevail over the east wind. The east wind would surely prevail over the west

[4] Johnson, *The United States Air Force*, 224.

[5] Joseph G. Gavin Jr., interview, December 11, 1998.

[6] Harvey M. Sapolsky, *The Polaris System Development* (Cambridge, MA: Harvard University Press, 1972).

[7] Data from here through the remainder of the paragraph are from Johnson, *The United States Air Force*, 22, 16, 231, 211.

[8] Johnson, *The Secret of Apollo*, 221.

[9] Ibid., 287.

[10] Ibid., 3.

[11] Davis Dyer, *TRW: Pioneering Technology and Innovation Since 1900* (Cambridge, MA: Harvard Business Review Press, 1998).

[12] Roger E. Bilstein, *Stages to Saturn: A Technological History of the Apollo/Saturn Launch Vehicles* (Washington, DC: NASA History Office, 1996), 42.

[13] Gavin, interview, August 6, 2005.

[14] Aaron L. Friedberg, *In the Shadow of the Garrison State: America's Anti-Statism and its Cold War Grand Strategy* (Princeton, NJ: Princeton University Press, 2000), 4.

[15] Bruce Parrott, *Politics and Technology in the Soviet Union* (Cambridge, MA: MIT Press, 1985), 303.

[16] Johnson, *The Secret of Apollo*, 4.

[17] Tom Alexander, "The Unexpected Payoff of Project Apollo," *Fortune*, July 1969.

[18] "The Soviet Space Program," *National Intelligence Estimate 11-1-67*, U.S. Central Intelligence Agency (CIA), March 2, 1967, www.astronautix.com/articles/ciah1967.htm.

[19] Sergei N. Khrushchev, *Nikita Khrushchev and the Creation of a Superpower* (University Park, PA: Pennsylvania State University, 2000), 277–78.

[20] Asif A. Siddiqi, *Challenge to Apollo: The Soviet Union and the Space Race, 1945–1974* (Washington, DC: NASA, 2000), https://history.nasa.gov/SP-4408pt1.pdf, 168.

[21] Walter A. McDougall, …*The Heavens and the Earth: A Political History of the Space Age* (New York: Basic Books, 1985), 17.

[22] William B. Breuer, *Race to the Moon: America's Duel with the Soviets* (Westport: Praeger Publications, 1993), 149.