From CORONA to GRAB and CLASSIC WIZARD: Radical Technological Innovation in Satellite Reconnaissance

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Abstract

This paper aims to explain what causes attempts at radical technological innovation in the military sphere to succeed or fail. Using four United States satellite reconnaissance programs as test cases, the paper also clarifies and enriches the associated historical record using recently declassified sources. Three hypotheses are derived from the military innovation and organization theory literatures: (H1) Interorganizational competition causes radical technological innovation; (H2) Radical technological innovation is the product of a permissive and stimulating organizational environment; (H3) Radical technological innovation stems primarily from requirements generated by the civilian leadership in response to external security challenges and forced upon military or intelligence organizations, which makes innovation more likely in the crucial problem areas that manage to capture the civilians' attention. The analysis shows that a permissive organizational environment (H2) is a necessary condition for and also the most proximate cause of radical technological innovation. Furthermore, although it acted only as an intervening variable in two of the three successful programs, the third—the Navy's GRAB signals intelligence satellite—shows that in organizations that encourage initiative, have shorter chains of command and are generally more decentralized, it is possible for a wholly internally generated drive to independently produce radical technological innovation.

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Introduction

The purpose of this paper is twofold. First, it looks at some of the most critical events in the field of satellite reconnaissance and clarifies and enriches the associated historical record. The technological breakthroughs that obtained not only kept the United States' capability for conducting overhead reconnaissance alive after Francis Gary Powers was shot down in 1960—which led to a cessation of U-2 overflights of the Soviet Union—but also quite literally allowed intelligence gathering to reach new heights.[1] Second, on a more general level, the paper aims to contribute to the literature on military innovation by analyzing what explains success in cases of "radical technological innovation." In the military context, radical technological innovation is defined as the development and introduction into service of an individual weapon or sensor system that greatly enhances a military organization's capacity for conducting operations in one or more areas of warfare or allows it to exploit a new dimension of the battlefield.[2] The two goals are in fact very closely related, as good theory should be able to inform policymaking, and in terms of substantive policy significance, it would be difficult to find a question more rewarding than that of how the unprecedented expansion of US intelligence gathering capabilities during the Cold War came about.

The debate about which factors were crucial in the establishment and expansion of the United States' satellite reconnaissance infrastructure does not offer a systematic overview of the pertinent variables. The two satellite reconnaissance-specific works that perhaps most directly address the question of success in radical technological innovation are Robert Kohler's article and Dennis Fitzgerald's reply thereto in the CIA journal *Studies in Intelligence*, but both offer only atheoretical perspectives.[3] Hence, the literature review and theoretical framework section of the paper sorts these claims into three different categories, and, fleshing them out with mechanisms proposed by the seminal works on military in-

1. For an overview of the literature on Cold War-era United States reconnaissance programs, see David W. Waltrop, "Critical Issues in the History and Historiography of U.S. National Reconnaissance," *Quest* 17, no. 3 (2010): 20–28, http://www.nro.gov/news/articles/2010/2010-04.pdf and *Bibliography of Historical Publications* (Chantilly, VA: NRO History Office, 1998), http://www.governmentattic.org/6docs/NRObiblioHistPubs_1998.pdf. For the US intelligence apparatus more generally, see Michael Warner, "The Rise of the U.S. Intelligence System, 1917-1977," in *The Oxford Handbook of National Security Intelligence*, ed. Loch K. Johnson (Oxford: Oxford University Press, 2010), 107–121, and Jeffrey T. Richelson, *The US Intelligence Community*, 6th ed. (Boulder, CO: Westview Press, 2012).

2. This parallels the definition of "radical innovation" used in discussions of matters relating to financial systems. In the financial sphere, "radical innovation," Richard Deeg explains, is defined as "innovations that entail major changes in the production process or the development of entirely new products." Richard Deeg, "Institutional Change in Financial Systems," in *The Oxford Handbook of Comparative Institutional Analysis*, ed. Glenn Morgan et al. (Oxford: Oxford University Press, 2010), 314.

3. Robert Kohler, "One Officer's Perspective: The Decline of the National Reconnaissance Office," *Studies in Intelligence* 46, no. 2 (2002), https://www.cia.gov/library/center-for-the-study-of-intelligence/csi-publications/csi-studies/studies/vol46no2/article11.html; Dennis Fitzgerald, "Commentary on 'The Decline of the National Reconnaissance Office': NRO Leadership Replies," *Studies in Intelligence* 46, no. 2 (2002), https://www.cia.gov/library/center-for-the-study-of-intelligence/csi-publications/csi-studies/studies/vol46no2/article12.html.

novation more generally, frames said categories as testable hypotheses. The hypotheses are as follows: (1) Interorganizational competition causes radical technological innovation; (2) Radical technological innovation is a product of a permissive and stimulating organizational environment; (3) Radical technological innovation stems primarily from requirements generated by the civilian leadership in response to external security challenges and forced upon military or intelligence organizations.

These three hypotheses are then tested against four cases of attempts at radical technological innovation in satellite reconnaissance, which display large variation on both the dependent variable and the three potential independent variables. Furthermore, all four satellite programs under analysis are of "intrinsic importance."[4] The way in which they were managed (or mismanaged, in the case of SAMOS) heavily influenced the intellectual legacy that manifested itself in the creation and shaping of the National Reconnaissance Office—the United States' umbrella overhead reconnaissance organization—not to even mention that the successful satellite systems that emerged from the programs served as the technological basis for nearly all future development efforts. The cases are: (1) The Air Force's unsuccessful attempt at developing an imagery intelligence (IMINT) satellite under the aegis of program SAMOS (also referred to as WS-117L and SENTRY before being renamed SAMOS); (2) the series of the highly successful early CORONA IMINT satellites—jointly developed by the Air Force and CIA—which would also decisively shape the United States' subsequent space IMINT efforts; (3) the Navy's simple but effective entrance into the electronic intelligence (ELINT) sphere with the development of the GREB satellite system, which was used primarily to map Soviet air defenses; and (4) the victorious conclusion of the Navy's quest for a dedicated ocean surveillance satellite with the POPPY-WHITE CLOUD/PARCAE satellite series.

Analysis of the four cases outlined above finds that the second hypothesis' postulated key independent variable—the permissiveness of the organizational environment—is the most proximate cause of radical technological innovation. Although it can act as the independent variable, it does so only in the GRAB case. In the other two cases of successful technological innovation, it acts as an intervening variable: CORONA was set into motion primarily by civilian intervention, and POPPY-WHITE CLOUD, the successor to GRAB, was largely a product of competition.

The next section lays out the three hypotheses, which are then tested against the evidence. That is followed by a systematic comparison of the case findings. The paper concludes with suggestions for future work on radical technological innovation.

Literature Review and Theoretical Framework

Kohler's article and Fitzgerald's reply thereto each advance a number of claims about the sources of radical technological innovation in satellite reconnaissance, but do so in

4. The term "intrinsic importance" is borrowed from Stephen Van Evera, *Guide to Methods for Students of Political Science* (Ithaca, NY: Cornell University Press, 1997), 86–87.

an atheoretical manner, mixing and matching these claims as they please. While those combinations of claims may well reflect the impressions the authors garnered while participating in various development efforts, a more systematic perspective is required. This section draws on mechanisms described in the broader literature on military innovation and on comparative institutional analysis, and, breaking down Kohler and Fitzgerald's claims, forges three distinct but potentially complementary lines of argument.

The Intensity of Interorganizational Competition and Organizational Perceptions of Threat

The first line of thought can broadly be characterized as conceiving of radical technological innovation as a product of competition between organizations. As competition intensifies, the likelihood of radical innovation increases accordingly, with the main pathway for this being the creation of structures that bring competing organizations into closer contact with each other. The fundamental premise of this argument is that interorganizational competition leads to radical technological innovation. This is grounded in the work of Owen R. Coté, who writes that "[o]ne can deduce a process where one service begins to exploit a new technology for which it has an internal lobby or as a result of civilian intervention, and where this initiative provokes an innovative response by a competing service in the absence of either intraservice or civil-military conflict."[5] Although Coté's argument is focused on doctrinal innovation, the above mechanism can easily be modified to fit the radical technological innovation context. The mechanism's logic translates into the notion that efforts by an organization to produce radical technological innovation will prompt other organizations that perceive the emerging weapon or sensor system as threatening to try to develop their own version. Per this hypothesis, innovation in satellite reconnaissance was first and foremost a product of conflict between the Air Force and the CIA in the SAMOS and CORONA cases, between the Navy and the Air Force in the GRAB case, and between the Navy and all who viewed ocean surveillance as a waste of resources—which was most of the other services and members of the intelligence community (IC)—in the POPPY-WHITE CLOUD case.

One issue with using Coté's argument alone is that it cannot serve as a means for predicting whether individual organizations' efforts at radical technological innovation will be successful or not. That is, it tells us that competition will lead to rival efforts by multiple organizations to develop a specific technology, but it does not predict which one will innovate successfully. Hence, the intensity of competition as a function of information saturation is introduced as an intervening variable. As Stephen Peter Rosen argues, "[t]echnological innovation is strongly characterized by the need to develop strategies for managing uncertainty."[6] More specifically, he posits that it is the availability and qual-

5. Owen R. Coté, "The Politics of Innovative Military Doctrine: The U.S. Navy and Fleet Ballistic Missiles" (PhD diss., Massachusetts Institute of Technology, 1996), 87, https://dspace.mit.edu/handle/1721.1/11217#files-area.

6. Stephen Peter Rosen, *Winning the Next War: Innovation and the Modern Military* (Ithaca, NY: Cornell

ity of information about the adversary that is crucial.[7] A slight twist on this mechanism makes it easily incorporable into the framework built in the beginning of this section: Radical technological innovation will be more likely and more rapid in cases where the competing organizations keep abreast of each other's undertakings and are thus better able to focus their resources.

Framed slightly differently, the intervening variable of interest here is the degree to which an organization is privy to information about threatening efforts to develop a new technology. Of course, ambiguity can be reduced through many different means, but most are only temporary and increase information flow irregularly. Civilian oversight, for example, along with other monitoring mechanisms, might expose the flaws of a program under development and enable a competing service to capitalize on remedying those shortcomings in its own R&D efforts, but such information comes only in bursts. Integrating organizational structures, on the other hand, provides a steady stream of information to each of the involved competitors by putting them in very close contact with each other. This increases the availability of information, and even more importantly, it increases the degree of constant exposure to that information, thereby prompting intensification of an organization's efforts to develop its own version of the weapon or reconnaissance system.[8] The organization that feels most threatened will prioritize the development of a competing system—in terms of manpower and funding—and will triumph over its rivals.

Concretely, according to this hypothesis, the NRO increased the exposure of the competing Programs A, B, and C to information about potentially threatening projects, thus intensifying competition between the parent organizations considerably and producing feats of innovation that traditional organizational structures could not have replicated with the same amounts of time and resources.[9] In the Eisenhower era, conflict between the services was often moderated by the White House itself, but post-Eisenhower has generally been managed through the Joint Chiefs of Staff (JCS), with the Office of the Secretary of Defense (OSD) as final arbiter.[10] The creation of the NRO in 1961 undermined this. It brought into contact the different organizations' lower-level constituent elements, which, working on a fairly narrowly defined set of environmental challenges, tended to

University Press, 1991), 52.

7. Rosen, *Winning the Next War*, 44–45.

8. The author would like to thank Richard H. Steinberg for the point that if an organization knows too much about competing development efforts, especially about the problems they are encountering, it might start to invest less energy and funds and in the end perhaps even fail to innovate radically. However, the nature of the involved organizations' tasks seems to inculcate in them a proclivity for worst-case analysis. As Paul Maddrell summarizes Ernest May's argument, "prudence generally causes intelligence analysts and policymakers to overestimate their enemies' capabilities, understanding, and skill." Paul Maddrell, introduction to *The Image of the Enemy: Intelligence Analysis of Adversaries since 1945*, ed. Paul Maddrell (Washington, D.C.: Georgetown University Press, 2015), 18. Although this refers to national adversaries, it is just as applicable to analyses of competing organizations.

9. Program A was the Air Force component, Program B was the CIA component, and Program C was the Navy component.

10. Coté, "The Politics of Innovative Military Doctrine," 15–16.

be, if anything, more parochial than their respective service chiefs and civilian secretaries. However, because this became a conflict over more than just control of individual satellite programs—indeed, the NRO fight was in essence a fight for control of the entire overhead reconnaissance mission—service secretariats were absorbed into conflicts over technical details, as even minute increases in platform efficiency could translate into an organizational victory.[11] Of course, the decisions still had to be approved by the Under Secretary of the Air Force (SAFUS)—serving as the Director of the NRO (DNRO)—who had a broader, if nonetheless service-specific perspective, but that did not change the fact that the NRO structure allowed Programs A, B, and C to keep close tabs on each other's designs and thus enabled them to react much more directly to initiatives they found threatening. In Robert Kohler's words: "The competitive atmosphere fostered different technical solutions to each intelligence problem and forced the NRO director (and often the Secretary of Defense and the DCI [Director of Central Intelligence]) to choose between different approaches."[12]

H1: As rival organizations are brought into closer contact with each other, competition will intensify, and the more threatened an organization feels, the more it will invest in its development efforts and the more likely it will be to produce radical technological innovation.

Permissiveness of the Organizational Environment

The second line of thought holds that the primary determinant of success in radical technological innovation is the permissiveness of the organizational environment, which is itself shaped by structural incentives and the difficulty of pursuing those incentives within an organizational hierarchy—that is, how long chains of command are, and, relatedly, how centralized or decentralized an organization is. Organizations in which subordinates have more latitude in pursuing those incentives will be more likely to produce radical technological innovation. This is closest to the "pragmatic constructivist" strand of political economy, which Kathleen Thelen characterizes in the following manner:

> Not just labour and managers cooperate to solve shared problems, but sup-

11. For more on the NRO, see Gerald Haines, "The National Reconnaissance Office: Its Origins, Creation, and Early Years," in *Eye in the Sky: The Story of the Corona Spy Satellites*, ed. Dwayne A. Day, John M. Logsdon, and Brian Latell (Washington, D.C.: Smithsonian Institution Press, 1998), 143–156; Jeffrey T. Richelson, "Restructuring the NRO: From the Cold War's End to the 21st Century," *International Journal of Intelligence and CounterIntelligence* 15, no. 4 (2002): 496–539; Jeffrey T. Richelson, *Civilians, Spies, and Blue Suits: The Bureaucratic War for Control of Overhead Reconnaissance, 1961-1965*, http://nsarchive.gwu.edu/monograph/nro/; Jeffrey T. Richelson, "Undercover in Outer Space: The Creation and Evolution of the NRO, 1960–1963," *International Journal of Intelligence and CounterIntelligence* 13, no. 3 (2002): 301–344; Bruce Berkowitz, *The National Reconnaissance Office at 50 Years: A Brief History* (Chantilly, VA: Center for the Study of National Reconnaissance, National Reconnaissance Office, 2011), http://www.nro.gov/history/csnr/programs/NRO_Brief_History.pdf; and especially Robert L. Perry, *A History of Satellite Reconnaissance: The Robert L. Perry Histories*, ed. James D. Outzen (Chantilly, VA: Center for the Study of National Reconnaissance, National Reconnaissance Office, 2012), 23–80.

12. Kohler, "One Officer's Perspective."

> plier firms and their customers also look to one another for innovation and learning. In the process, roles and identities are worked out 'through repeated interaction and reciprocal efforts to define the possibilities and limits of a jointly defined project.' In this endeavour, actors are not bound by institutions and rules so much as they use them creatively to achieve shared objectives. The metaphor one tends to run across repeatedly in this literature is jazz improvisation, which underscores both the collaborative and the improvisational aspects of these interactions.[13]

Kohler argues along similar lines, averring that the critical breakthroughs that occurred within the NRO framework were the product of the involvement of a contingent of civilian experts from the CIA, which as an organization had low turnover rates and produced bolder and more risk-acceptant personnel, who were consequently more successful as innovators. Namely, he asserts that the crucial innovations "did not come out of an arduous requirements process, but, instead, resulted from CIA experts knowing the needs of the Intelligence Community, imagining what technology could do, and offering decisionmakers a solution to a need, sometimes before they knew they had a need."[14]

In a reply to Kohler's article, the then-Deputy DNRO (DDNRO) Dennis Fitzgerald opined that the NRO successes were not a product of the CIA's approach in the Program A-Program B race to the top but rather of the efforts of the private companies that were awarded the design and development contracts. The satellite programs may have been managed by the NRO, but the credit for coming up with the technical solutions belongs to the contractors.[15] Although Fitzgerald does not elaborate upon this further, it is possible to frame both his and Kohler's argument as being premised upon the centrality of the permissiveness or constrictiveness of the organizational environment. In this framing, the main dispute is over interpretation of the historical record—with one author lauding the CIA and the other giving credit primarily to the contractors hired by the CIA and Air Force—and not over which organizational dimension is most relevant for innovation. This underlying premise is shared and best summarized as the following:

H2: Organizations that encourage independent initiative in innovation, have shorter chains of command and are generally more decentralized will be more likely to succeed in radical technological innovation.

The External Security Environment and Civilian Requirements

Finally, the third line of argument focuses on how the external security environment produces requirements that the civilian leadership then conveys to the pertinent government

13. Kathleen Thelen, "Beyond Comparative Statics: Historical Institutional Approaches to Stability and Change in the Political Economy of Labor," in *The Oxford Handbook of Comparative Institutional Analysis*, ed. Glenn Morgan et al. (Oxford: Oxford University Press, 2010), 53.
14. Kohler, "One Officer's Perspective."
15. Fitzgerald, "Commentary on 'The Decline of the National Reconnaissance Office'."

organizations. Civilians assess the strategic situation, generate broad requirements, and then choose the best program from among competing alternatives offered by those organizations. The more pressing the need for a solution to a particular issue is perceived to be, the greater the degree of fiscal latitude accorded to the services and intelligence organizations in developing a solution. To a certain extent, civilians can "push" innovation through.

In this conception, therefore, innovation is not a product of incentives generated at and operating on the organizational level, but rather stems from demands that emerge at the very top of the decision-making hierarchy and are then transmitted downward. As Barry R. Posen writes, "civilian intervention in military affairs is a key determinant of integration and innovation," and "[b]alance of power theory can help explain the causes of such intervention."[16] However, while civilians do have full latitude to shape limitations, they cannot effect innovation on their own. As Posen further explains, for a particular problem requiring innovation, the civilians have to resort to "choosing from the thin innovation menu thrown up by the services," with the latter quashing internal attempts to innovate in other areas, especially in ones that fail to capture the attention of the civilians.[17] Posen is addressing doctrinal innovation, but the mechanism does not have to be altered to be applicable to the radical technological innovation sphere as well.

Fitzgerald's rebuttal of Kohler in large part appears to rest on this kind of view; that it is external security issues, and not organizational dynamics, that are the most important limiting—if not the decisive—factor in the realm of innovation. He divides the NRO's existence into two periods: The "Technology Driven era, roughly 1970 to 1990," when "NRO space systems were based primarily on what technology would permit," and the post-Cold War "Peace Dividend world" that is dominated by the "formal requirements process."[18] The underlying premise is only implied, but can broadly be characterized as underscoring the influence of the external security environment. During the Cold War, national security needs were perceived to be so dire that the possible, not the affordable, was the limit, but with post-Cold War US unipolarity and the disappearance of a pressing need to innovate, the brakes were quickly applied.

H3: The civilian leadership devotes varying amounts of attention and resources to different projects, depending on how pressing a national requirement they address. This makes radical technological innovation more likely in the crucial problem areas that manage to capture the civilians' attention.

16. Barry R. Posen, *The Sources of Military Doctrine: France, Britain, and Germany between the World Wars* (Ithaca, NY: Cornell University Press, 1984), 233.
17. Ibid., 57.
18. Fitzgerald, "Commentary on 'The Decline of the National Reconnaissance Office'."

Cases

Case Selection

As noted in the introduction, one of the criteria that was used in selecting the four cases is the extent to which they are of intrinsic importance, since while this paper does aim to test the three proposed hypotheses, it also strives to shed light what is without a doubt the most important juncture in the history of the United States' overhead reconnaissance efforts and potentially intelligence gathering in general as well. Although CORONA and GRAB were developed in parallel with the A-12/SR-71 strategic reconnaissance aircraft, the incredible success of the former two ensured that the United States would thereafter rely on satellite systems for a mission that had until the U-2 disaster rested firmly in the hands of the aviators. Alexander L. George and Andrew Bennett correctly write that "[o]ne should select cases not simply because they are interesting, important, or easily researched using readily available data," but fortunately, the four intrinsically important cases of attempts at radical innovation in satellite reconnaissance are also well suited to what the two authors deem essential—"provid[ing] the kind of control and variation required by the research problem."[19]

These two sets of paired cases were chosen because they satisfy the "control" criterion, articulated by Stephen Van Evera as "cases . . . [being] well matched for controlled cross case comparisons [emphasis removed]."[20] First, SAMOS and CORONA appear to be promising candidates for a "method of difference" comparison, as while the first got bogged down and the second succeeded, they should be fairly similar on the proposed independent variables—after all, CORONA was brought directly out of the SAMOS program. Second, GRAB and POPPY-WHITE CLOUD—both successes—should do well in a "method of agreement" comparison; even though they were both managed by the Navy and developed by the Naval Research Laboratory (NRL), they had very different proximate goals, with GRAB having been directed almost exclusively at Soviet air defense assets, and with POPPY-WHITE CLOUD having been first and foremost an ocean surveillance satellite. Finally, having three successes and one failure, which when combined should have large variation across case characteristics, should also allow for identification of necessary, sufficient, or necessary and sufficient conditions.

SAMOS and the "Interim" CORONA

The Air Force's WS-117L/SENTRY/SAMOS IMINT satellite project and the joint Air Force-CIA program named Discoverer/CORONA are treated as discrete test cases, but the evolution of the two programs was so tightly intertwined that they are outlined together in the following section. The program that eventually came to be known as

19. Alexander L. George and Andrew Bennett, *Case Studies and Theory Development in the Social Sciences* (Cambridge, MA: MIT Press, 2005), 83.
20. Van Evera, *Guide to Methods for Students of Political Science*, 84.

SAMOS originated in a RAND study of satellite reconnaissance options for the Strategic Air Command (SAC), with the design putting a premium on satisfying the need for intelligence collection in a nuclear warfighting scenario.[21] The program was not exactly a priority for the Air Force. As Robert L. Perry observes, given the nature of the then-reigning Massive Retaliation doctrine, "reconnaissance from space represented a useful but scarcely essential capability."[22] The program was suddenly thrust under the spotlight when the United States found itself in the satellite frenzy prompted by the launch of the Soviet Sputnik.[23] A solution was needed, and fast.

However, WS-117L was plagued by delays and various other problems, and the goals that had brought the program into existence did not align well with President Eisenhower's preference for peacetime intelligence, which led to the decision to take promising WS-117L components and use them in the development of CORONA, an "interim" program which was to satisfy more immediate requirements.[24] Work on the WS-117L, later known as SAMOS, continued in parallel with efforts to develop and put CORONA into orbit. The road of SAMOS IMINT was paved with mediocrity and by early July of 1963, the last remaining variant in development (the E-6) had been cancelled.[25] CORONA, in contrast, was a striking success and remained operational until 1972. It would exert a profound influence on the future of satellite reconnaissance; in the words of Robert A. McDonald, "CORONA, and its follow-on programs, started a revolution in how the US collected, analyzed, and used foreign intelligence."[26] Why did one fail and the other succeed? The following discussion begins to provide an answer by testing the three hypotheses against the SAMOS and CORONA cases.

Competition

WS-117L was not the only satellite program under development in the 1950s, but interservice competition did not play a significant role in its initial development. Even though the Army and Navy also both had their own programs—Explorer and Vanguard, respectively—neither effort was directly related to developing an overhead reconnaissance capability. Furthermore, Explorer and Vanguard could hardly have been perceived by as a serious challenge; a flurry of activity involving these two programs, intended to show that the United States was in fact not far behind despite the Soviets' Sputnik launch, was, as Perry bluntly puts it, a "flat failure," adding that "Vanguard launches . . . probably rep-

21. Albert D. Wheelon, "CORONA: A Triumph of American Technology," in *Eye in the Sky: The Story of the Corona Spy Satellites*, ed. Dwayne A. Day, John M. Logsdon, and Brian Latell (Washington, D.C.: Smithsonian Institution Press, 1998), 31.

22. Perry, *A History of Satellite Reconnaissance*, 25.

23. Ibid., 87.

24. Wheelon, "CORONA: A Triumph of American Technology," 32–33.

25. Perry, *A History of Satellite Reconnaissance*, 216.

26. Robert A. McDonald, "CORONA: Success for Space Reconnaissance, A Look into the Cold War, and a Revolution for Intelligence," *Journal of the American Society for Photogrammetry and Remote Sensing* 61, no. 6 (June 1995): 711.

resented the most widely publicized set of failures in modern history."[27] The one time that the Army tried to directly challenge the Air Force and made a proposal to the Department of Defense for developing a reconnaissance satellite, the idea was rejected by President Eisenhower.[28] The emergence of the National Aeronautics and Space Administration (NASA) and its acquisition in 1959 of prominent scientific personnel and the entire manned spaceflight mission seemed to have all but finished off the teetering Army and Navy space programs.[29]

Particularly telling is also the fact that during this time, satellite reconnaissance was merely one of a multitude of different programs on Air Force R&D's plate, and the attention it received in the budget was accordingly far from generous.[30] Had the Air Force viewed the other programs as threatening, much more funding would have gone into satellite reconnaissance. As already discussed, the initial push for the program was generated internally, by SAC planners, and not by the threat posed by other programs.

Even though CORONA eventually proved a great success and was kept in service for many years while SAMOS was largely scrapped, competition between the two programs did not reach high levels. CORONA was genuinely intended to be an interim program that would be superseded by SAMOS as soon as the latter grew into its shoes.[31] Even though some suspicion did exist on the SAMOS side, the evidence indicates that only mild competition occasionally played a role. Perry mentions that the conviction of SAMOS personnel that CORONA was merely an interim measure was disturbed by the failure of the CIA to "specify a completion date." That, he continues, "induced some members of the Samos group to conclude that the Corona people were erecting a rival effort which they intended to operate independent of the 'unified' satellite reconnaissance program."[32]

Sentiments among the higher echelons of the Air Force, however, were mixed: SAFUS Joseph V. Charyk very much desired to gain control over CORONA and accordingly incorporated the Air Force element of the CORONA program into SAMOS management, but General Robert E. Greer, the head of SAMOS, and Colonel Paul E. Worthman, who was at the helm of the Air Force contingent involved in CORONA, did not seem particularly disturbed by this administrative change; indeed, the form of Air Force involvement in CORONA was left unperturbed. Perry concludes that "[n]o open antagonism was apparent, but the divergence of interest between Samos and Corona suggested that dangerous friction could have developed had the personalities of Greer and Worthman been different."[33]

27. Perry, *A History of Satellite Reconnaissance*, 87.

28. Jeffrey T. Richelson, *America's Secret Eyes in Space: The U.S. Keyhole Spy Satellite Program* (New York: Harper & Row, 1990), 24–26.

29. Frederic C. E. Oder, James C. Fitzpatrick, and Paul E. Worthman, *The CORONA Story* (Chantilly, VA: National Reconnaissance Office, 1987), 70, http://www.nro.gov/foia/docs/foia-corona-story.pdf.

30. Perry, *A History of Satellite Reconnaissance*, 25.

31. Dwayne A. Day, "The Development and Improvement of the CORONA Satellite," in *Eye in the Sky: The Story of the Corona Spy Satellites*, ed. Dwayne A. Day, John M. Logsdon, and Brian Latell (Washington, D.C.: Smithsonian Institution Press, 1998), 70–71.

32. Perry, *A History of Satellite Reconnaissance*, 124.

33. Ibid., 122.

What is likely to have further moderated the levels of competition and prevented a true rivalry from emerging was the fact that the Air Force was involved in both programs, running one and participating in the other. Had the entirety of the CORONA program been assigned to the CIA, acrimony and severe competition would probably have ensued. Although a bitter rivalry involving CORONA and the NRO did develop between the CIA and Air Force later on, it did not involve many design decisions, as those were already more or less set in stone by then. Furthermore, program CORONA itself was relatively benevolent toward SAMOS.[34] The emergence of WS-117L was in no significant way a product of competition, and although SAMOS and the initial CORONA development program did sometimes bump into each other, the competition was of low intensity.

Organizational Environment

The SAMOS program structure appears to have been fairly hierarchical and not especially conducive to incentivizing innovation until it was reorganized, but that happened relatively late on, and fixed primarily problems of form, not of substance. After the Sputnik crisis of 1957, WS-117L had become a prominent candidate for providing an overhead reconnaissance capability, but the Air Force program, then also known as SENTRY, had effectively been taken hostage by the Advanced Research Projects Agency (ARPA), which, Perry explains, "had custody of program funds and exercised a directive authority over the technical content of the effort."[35] Frustration with the employed management style, and with the Air Research and Development Command's (ARDC) and Air Staff's maneuvering and intransigence when Air Force civilians tried to intervene, led to the establishment of a SAMOS Project Office that answered to the Office of the Secretary of the Air Force.[36]

The new SAMOS structure was advantageous in that, as Perry further notes, had "short, quick-reaction lines of communication," and could "reprogram funds to considerable advantage without the difficulties that attended such a process in the 'normal' Air Force."[37] However, while the structure may seem functional, certain problems with the substance of management nonetheless appear to have existed. Namely, the head of the program, General Greer, believed that the way to solve issues was by inundating problem areas with money: "The effect of all the words I use to contractors is dwarfed into insignificance when compared to the effect on them of cutting off money or adding money. This gets their attention and is the fundamental yardstick the contractor uses to determine

34. Perry notes that the "personalities" of individual program managers mattered most, which is why "[t]he lust of CIA and Air Force program participants for one another's assigned programs did not become an important consideration in the national reconnaissance effort until Charyk and [Richard M.] Bissell [the CIA program manager] had left office." They "had an effective working relationship that more than offset the organizational imperatives their subordinates usually experienced." Perry, *A History of Satellite Reconnaissance*, 123 (footnote).

35. Ibid., 90.

36. Ibid., 101, 107–109.

37. Ibid., 124.

how serious one is on a given issue."[38] The structural incentives for innovation, therefore, were not abundant; structural rigidity had to be overcome with an influx of funds.

Another way of putting this is that the SAMOS Project Office could not shake itself free of persistent Air Force legacies, where incentives for innovation were not an organic part of the organization. This is to a certain extent true for all bureaucracies; far from being designed to innovate, they are supposed to and in fact do actively oppose such change.[39] What compounds this tendency is the fact that the Air Force, being what Coté describes as a "single combat arm organization," is highly cohesive and centralized.[40] This kind of mentality is built into the Air Force, as the way it gained independence from the Army was precisely by adhering to the principle of centralized command.[41] As Jonathan E. Lewis writes, "[b]y the mid-1950s, historical forces had left the Air Force with a military procurement bureaucracy celebrated for its arcane procedures and tedious pace of decision-making."[42] The SAMOS case, in short, was characterized by a lack of organizational incentives for innovation and a generally constrictive organizational environment.

CORONA was run in a completely different manner. The management structure for CORONA was modeled after the Air Force-CIA partnership that produced the U-2, and was intended to replicate those levels of groundbreaking innovation.[43] With the prominent exception of DDNRO Fitzgerald, nearly all the writing on the subject of CORONA puts an almost overwhelming emphasis on the role of the way in which the program was structured and managed. CORONA was a far cry from the bitter enmity between the Air Force and CIA as they battled over and within the NRO in the first half of the 1960s; it was rather the epitome of cooperation between not only different government agencies but also between the government and private sector contractors.[44] In the words of the CIA program manager Richard M. Bissell,

> The program was started in a marvelously informal manner. [Brigadier General Osmond J.] Ritland and I worked out the division of labor between the two organizations as we went along. Decisions were made jointly. There were so few people involved and their relations were so close that decisions could be and were made quickly and cleanly. We did not have the problem

38. Perry, *A History of Satellite Reconnaissance*, 116.

39. James Q. Wilson, *Bureaucracy: What Government Agencies Do and Why They Do It* (New York: Basic Books, 2000), 221–226.

40. Coté, "The Politics of Innovative Military Doctrine," 21.

41. Daniel Baltrusaitis, "USAF Command Doctrine of Centralized Control with Decentralized Execution: Never Divide the Fleet?," http://www.dtic.mil/dtic/tr/fulltext/u2/a466500.pdf.

42. Jonathan E. Lewis, "Tension & Triumph: Civilian and Military Relations and the Birth of the U-2 Program," in *CORONA Between the Sun and the Earth: The First NRO Reconnaissance Eye in Space*, ed. Robert A. McDonald (Bethesda, MD: American Society for Photogrammetry and Remote Sensing, 1997), 15.

43. Albert D. Wheelon, "Corona: The First Reconnaissance Satellites," *Physics Today* 50, no. 2 (February 1997): 26.

44. Curtis Peebles, *The Corona Project: America's First Spy Satellites* (Annapolis, MD: Naval Institute Press, 1997), 146; McDonald, "CORONA: Success for Space Reconnaissance, A Look into the Cold War, and a Revolution for Intelligence," 693; Day, "The Development and Improvement of the CORONA Satellite," 84–85.

> of having to make compromises or of endless delays awaiting agreement. After we got fully organized and the contracts had been let, we began a system of management through monthly suppliers' meetings—as we had done with the U-2. Ritland and I sat at the end of the table, and I acted as chairman. The group included two or three people from each of the suppliers. We heard reports of progress and ventilated problems—especially those involving interfaces among contractors. The program was handled in an extraordinarily cooperative manner between the Air Force and CIA. Almost all of the people involved on the Government side were more interested in getting the job done than in claiming credit or gaining control.[45]

The kind of flexibility described by Bissell truly fostered a very permissive environment in the sense that initiative was strongly encouraged, which worked well in a program with as few personnel as CORONA. It is not only that structural incentives for innovation existed; the entire management structure of the program was designed to spur on innovation. As McDonald writes: "Fundamentally, people were given a job and empowered to do it; their cooperation was informal without bureaucratic layers."[46] Furthermore, an astonishing degree of latitude in satellite design was accorded to the contractors working on CORONA, with Lockheed essentially having been given a free hand.[47]

While CORONA should and does serve as an exemplar of constructing a permissive environment that incentivizes innovation, and is in many aspects unique, larger structural factors also played a very important role. Granted, the specific vision of how cooperation, independent initiative, and flexible relationships with contractors would be interwoven to produce the first operational reconnaissance satellite can in large part be attributed to Bissell's own genius and previous experiences.[48] However, this kind of thinking was not unique to Bissell. Involvement in the Bay of Pigs debacle forced Bissell out in 1961, and Herbert Scoville, Director of the Office of Scientific Intelligence (OSI), took over the various CIA overhead reconnaissance programs. However, he resigned soon after and was replaced by a young and enterprising Albert D. Wheelon in 1962. Although the issue was by then no longer of developing CORONA but more of running it efficiently, Wheelon's approach very much resembled that of his illustrious predecessor Bissell. Wheelon matter of factly states that as Director of OSI, "I went around re-aiming people. That irritated some folks, but I felt that we had a lot of important problems to solve."[49] This kind of attitude—let alone such an approach—was simply not cultivated by any aspect of the

45. Kenneth E. Greer, "Corona," in *CORONA: America's First Satellite Program*, ed. Kevin C. Ruffner (Washington, D.C.: Center for the Study of Intelligence, Central Intelligence Agency, 1995), 8–9.

46. Robert A. McDonald, "Lessons and Benefits from Corona's Development," in *CORONA Between the Sun and the Earth: The First NRO Reconnaissance Eye in Space*, ed. Robert A. McDonald (Bethesda, MD: American Society for Photogrammetry and Remote Sensing, 1997), 256.

47. Lewis, "Tension & Triumph: Civilian and Military Relations and the Birth of the U-2 Program," 15.

48. Ibid., 14–15.

49. Ed Dietel, "An Interview with Former DDS&T Albert Wheelon," *Studies in Intelligence*: 36, https://www.cia.gov/library/readingroom/docs/DOC_0000863247.pdf.

military command structure. Rather, it was generally suppressed, but the CIA's approach to these matters kept it alive.

Of course, the Air Force had many brilliant officers, but what always looms in the background of military decision-making is the general principle that regardless of how talented an individual, there are standard operating procedures that must be followed and chains of command that must be adhered to. The CIA, on the other hand, is often prepared to explore alternate routes and inculcates personnel with this mentality. Wheelon himself attributed the CIA's successes to its focus on one mission and one mission only—intelligence gathering and processing—infrequent turnovers in personnel, and much greater flexibility in budget and program management than is the case for other government agencies, but as Frederic C. E. Oder, James C. Fitzpatrick, and Paul E. Worthman comment, "[t]here were [also] other advantages Wheelon did not cite: he could begin new studies more easily than could the Department of Defense (he had a very short chain-of-command to convince), his hirings would be sheltered by a Special Schedule in the Civil Service system, he could offer higher salaries than the DoD, and he had the enthusiastic support of his boss."[50] With the exception of the last factor, which can be very capricious, all the advantages were a product of the premium the CIA puts on initiative and flexibility. This accords very closely with Kohler's claims about what gave the CIA an edge.

To summarize, the Air Force invested considerable effort into reorganizing the SAMOS program to make it more responsive to various needs and problems, but did so relatively late on and could not change the fundamental problem, which is the fact that it would have been necessary to give initiative almost completely free rein. That would have gone counter to deeply ingrained Air Force ideas about how command structures should operate. Even though CORONA was a joint effort involving both the Air Force and the CIA, the latter's emphasis on flexibility and fast-paced, informal decision making dominated. The CORONA structure succeeded in providing the incentives and freedom that SAMOS could not, primarily due to the CIA's guiding hand.

Civilian Requirements

As was discussed earlier, SAMOS (or WS-117L, as it was known in the earlier stages) was initially a response to an internal SAC-generated requirement, but as the question of satellite reconnaissance became increasingly salient, WS-117L started receiving more attention from upper echelons. In 1957, it was the only viable platform for competing with the success of Sputnik, and eyes thus became fixed on it.[51] Soon, however, the President's Board of Consultants on Foreign Intelligence Activities (PBCFIA) deemed the Air Force program unsatisfactory, and the President decided to prioritize CORONA and OXCART (the A-12/SR-71 strategic reconnaissance aircraft effort) instead.[52] The Air Force would

50. Oder, Fitzpatrick, and Worthman, *The CORONA Story*, 103.
51. Perry, *A History of Satellite Reconnaissance*, 87.
52. Wheelon, "CORONA: A Triumph of American Technology," 32–33.

continue to put effort into SAMOS, but it was CORONA that would be receiving the bulk of the civilian leadership's attention.

CORONA was generously funded and strongly supported by civilian elements. For example, when ARPA refused to release additional funding for additional Thor rocket boosters, Bissell forwarded the request directly to Eisenhower, who in the words of Dwayne A. Day "was not one to like these kinds of financial requests" but nonetheless acquiesced to the request.[53] This was not a unique occurrence: Bissell explains that for CORONA as well as for the U-2 and SR-71, "there was strong support at the highest levels of the government. Even members of Congress approved when informed about the projects."[54] What underlay this support was precisely that which had prompted the articulation of a need for an overhead reconnaissance satellite: The exigencies of the external security environment. As Bissell also notes, "[t]he desperate rivalry of the cold war, . . . provided the major stimulus for our activities."[55]

This follows H3 closely—civilians generated requirements, and then chose from among the options offered by the military and intelligence community; indeed, such was the need for an overhead reconnaissance capability that the PBCFIA and Eisenhower intervened extremely directly and carved CORONA out of the SAMOS structure. This provides strong support for the "civilian intervention" line of argument, but a comparison of only SAMOS and CORONA does not allow us to make any definitive conclusions just yet, as successful innovation in the latter case was overdetermined, with both a permissive organizational environment and strong civilian intervention having played a major role in the program.

The Navy's ELINT Satellite Saga: From GRAB to POPPY and WHITE CLOUD

The Navy's success in developing and deploying the ocean surveillance satellite known as PARCAE or WHITE CLOUD cannot be understood without reference to GRAB and its successor POPPY, the earlier programs upon which WHITE CLOUD was itself based. Hence, like with SAMOS and CORONA, GRAB and POPPY-WHITE CLOUD are treated as discrete test cases but are covered by the same narrative.

Much like with SAMOS and CORONA, GRAB was most fundamentally a response to the increasing impenetrability of the Soviet defense apparatus. More knowledge about the Soviet air defense web had to be acquired since, as Tom Johnson et al. put it, "[u]ntil this was done, strategic aerial attack plans were just guesswork" and SAC could not perform its mission.[56] By the end of 1957, the Navy had submitted a development proposal

53. Day, "The Development and Improvement of the CORONA Satellite," 49–50.

54. Richard M. Bissell, Jr., with Jonathan E. Lewis, and Frances T. Pudlo, *Reflections of a Cold Warrior: From Yalta to the Bay of Pigs* (New Haven, CT: Yale University Press, 1996), 140.

55. Ibid., 93.

56. Tom Johnson et al., "The Story of POPPY" (unpublished manuscript, Washington, D.C., February 24, 1998), 6.

for an ELINT satellite to the Armed Forces Policy Council.[57] Eisenhower approved the proposal developed by the Naval Research Laboratory (NRL) on August 24, 1959, and less than a year later, on June 22, 1960, the first GRAB satellite was launched into orbit. GRAB filled the gap created by the decision to halt U-2 overflights and shed light on the incredible depth of Soviet air defenses, thereby demonstrating the need for further efforts to develop ELINT satellite capabilities.[58]

On July 23, 1962, the GRAB program was incorporated into the NRO as part of Program C—the Navy element of the NRO—and was renamed POPPY soon afterward.[59] As the direct successor of GRAB, POPPY followed in the former's footsteps and, despite being a Navy-developed and Navy-operated satellite, was, like GRAB, used primarily to satisfy the intelligence needs of the Air Force.[60] As Day points out: "POPPY was a US Navy programme that primarily benefited other government agencies rather than the Navy and its missions. The Air Force and National Security Agency used POPPY's data more than the Navy."[61] The Navy had long had its sights set on ocean surveillance, however, and having demonstrated the feasibility and utility of ELINT satellites, began to push in that direction.

After a bitter bureaucratic battle against unfavorable odds, the Navy managed to get the United States Intelligence Board (USIB) to approve ocean surveillance as a key intelligence collection objective and, in July 1970, assign a number of POPPY Missions to the task.[62] Furthermore, development of the POPPY automated processing systems (PAPS) was initiated in 1971.[63] Bradburn et al. note that in late 1972, "DNRO [John L.] McLucas was shown the speed and ease of PAPS operations when two Soviet Naval combatant ships were located and reported."[64] It would therefore appear that PAPS was intended to demonstrate the feasibility of the large-scale ocean surveillance mission.

PAPS's success paved the way for WHITE CLOUD to succeed POPPY. A POPPY working group study was commissioned sometime between 1974 and 1975, and it recommended, inter alia, that POPPY operations cease and that "PAPS software [DELETED]" should be supplied "to be used with [DELETED] processing equipment."[65] This undoubtedly refers to supplementing WHITE CLOUD systems with PAPS; indeed, the transition

57. Johnson et al., "The Story of POPPY," 3–4.

58. Ibid., 7–8.

59. David D. Bradburn et al., *The SIGINT Satellite Story* (Chantilly, VA: National Reconnaissance Office, 1994), 50–51, http://www.nro.gov/foia/declass/sigint/SIGINT_Satellite_Story.PDF.

60. Dwayne A. Day, "Atop the Highest Mast: The Development of American Ocean Surveillance Satellites —Part 1—POPPY," *Spaceflight* 51, no. 11 (November 2009): 432.

61. Dwayne A. Day, "Atop the Highest Mast: Development of US Ocean Surveillance Satellites—Part 2—PARCAE and White Cloud," *Spaceflight* 51, no. 12 (December 2009): 463.

62. Ronald L. Potts, *U.S. Navy/NRO Program C Electronic Intelligence Satellites (1958-1977)* (Chantilly, VA: LEO Systems Program Office, SIGINT Directorate, National Reconnaissance Office, 1998), 191, http://www.nro.gov/foia/docs/U.S.%20Navy-NRO%20Program%20C%20Electronic%20Intelligence%20Satellites%20(1958-1977).pdf.

63. Ibid., 211–213.

64. Bradburn et al., *The SIGINT Satellite Story*, 70.

65. Potts, *U.S. Navy/NRO Program C Electronic Intelligence Satellites (1958-1977)*, 219–220.

to the new satellite system occurred not long afterward. The first WHITE CLOUD mission (PARCAE 1) was launched on April 30, 1976,[66] allowing POPPY to be retired in 1977.[67] After a considerable amount of maneuvering by the Navy and overall USIB-related rancor, the first dedicated ocean surveillance satellite had been put in orbit.

Competition

GRAB was in development at roughly the same time as SAMOS—which in addition to the IMINT component also had two ELINT elements, the F-1 and F-2[68] —but there was no particularly strong competition between the Navy and Air Force. The Air Force initially reacted with suspicion, but the Navy did not perceive itself as competing with SAMOS and took steps to calm the situation. Ronald L. Potts notes that at the outset, "[d]uplication with Samos and the value of potential intelligence from Tattletale [the initial designation for what became known as GRAB] were challenged. There were fears, too, that Tattletale could jeopardize Samos."[69] The Navy did not perceive itself as competing with the Air Force and in fact stated its preference for SAMOS over CORONA in a 1959 report, further recommending that a joint Army-Navy-Air Force command be set up to synchronize the services' efforts in this sphere.[70]

Air Force concerns persisted, however, and that prompted Deputy Secretary of Defense Thomas Gates to forward an ARPA-Department of the Navy (DoN) letter to Eisenhower averring that "this proposal [CANES, as Tattletale—later GRAB—was known at the time] is a complement to, and not a substitute for the SAMOS satellite system."[71] The White House found this explanation unsatisfactory, and another letter from Secretary of Defense Neil McElroy presented the Air Force's views as well.[72] Finally, a memorandum by scientific advisor Dr. George Kistiakowsky concluded that while CANES "is of no overwhelming value," it "may provide useful information, and since Project SAMOS will probably be delayed, this information will come at an opportune time."[73] The program was approved by Eisenhower.[74] While mild tensions did exist between the Navy and the Air Force, the period of competition was brief and neither prompted nor spurred on the development of Tattletale/CANES/GRAB.

The ocean surveillance mission of POPPY and the resulting enhanced capabilities upon which WHITE CLOUD would later be based, on the other hand, were to a large extent pushed and pulled by competitive dynamics, which were brought into sharp fo-

66. Day, "Atop the Highest Mast: Development of US Ocean Surveillance Satellites—Part 2—PARCAE and White Cloud," 464.

67. Potts, *U.S. Navy/NRO Program C Electronic Intelligence Satellites (1958-1977)*, 220.

68. Dwayne A. Day, "Ferrets Above: American Signals Intelligence Satellites During the 1960s," *International Journal of Intelligence and CounterIntelligence* 17, no. 3 (2004): 450.

69. Potts, *U.S. Navy/NRO Program C Electronic Intelligence Satellites (1958-1977)*, 26.

70. Ibid., 28.

71. Ibid., 30.

72. Ibid., 31–33.

73. Ibid., 33.

74. Ibid.

cus by closer contact between the different services and intelligence community agencies within the NRO and USIB. As Potts observes, "[r]ecognition by the foreign intelligence community that satellites were an effective means of technical collection was followed by a community quest for cost-effective systems. Programs and technologies began competing. Competition fostered ideas for improved capabilities and increased technical oversight to evaluate them."[75] The NRL, which oversaw the development of POPPY, also came into closer contact with other NRO elements and programs through "[d]iscussions and papers."[76] This facilitated the flow of information, and consequently, nurtured even more intense competition.

USIB not only brought the services into closer contact, but also generated a direct push for innovation. The problem for the Navy was that USIB's subsidiary Committee on Overhead Reconnaissance (COMOR) had in 1966 laid out a set of intelligence collection preferences that "neglect[ed] . . . 'mobile targets and smaller tactical radars of concern to Navy and Army.'"[77] This meant that other missions would be given tasking priority during POPPY operations and ocean surveillance was performed only on a "not-to-interfere basis," which, explains Potts, led to DoN attempts "to get the USIB to recognize ocean surveillance as a national intelligence objective. *Tasking constraints provided an impetus for development of dedicated resources* [emphasis mine]."[78] It was competition and the initial unwillingness of USIB to recognize the Navy's needs that led to work on POPPY ocean surveillance capabilities, thereby paving the road for the development and introduction of WHITE CLOUD.

Organizational Environment

As was alluded to above, the initial push to develop an ELINT satellite was largely internally generated. Of course, the larger context of Sputnik launches and increasing pressures on the services and intelligence community to "do something" cannot be ignored, but the manner in which the Navy approached the issue is almost as exemplary of permissiveness of the organizational environment and incentivization of innovation as was CORONA. The Chief of Naval Operations (CNO), far from applying downward pressure like the Air Force liked to do with SAMOS, simply solicited proposals from pertinent Navy elements, writing: "All hands to consider how they could use space in their design ideas for the Navy."[79] This gave Navy elements like the NRL an incredible degree of latitude in pursuing a very broadly defined mission.

The CNO's decision to let Navy innovators get to work and convey proposals upward paid off. Robert A. McDonald and Sharon K. Moreno describe the moment of brilliance that would lead to GRAB's birth: "While stranded in a Pennsylvania restaurant during a

75. Potts, *U.S. Navy/NRO Program C Electronic Intelligence Satellites (1958-1977)*, 109.

76. Ibid.

77. Ibid., 115.

78. Ibid., 157.

79. *History of the Poppy Satellite System* (Chantilly, VA: National Reconnaissance Office), 2, http://nro.gov/foia/docs/History%20of%20Poppy.PDF.

March blizzard," NRL engineer Reid D. Mayo "pondered the application to space reconnaissance of crystal video technologies he had developed for submarines ... He penciled range calculations on a paper placemat and determined that such a system could in fact intercept Soviet radar signals up to an altitude of 600 miles."[80] Just like that, the seed out of which GRAB, POPPY and WHITE CLOUD would grow had been planted. Mayo told NRL countermeasures chief Howard Lorenzen about this possible route, and with the latter's help, the idea coursed upward through the DoD and IC.[81]

Admittedly, GRAB still had a long way to go, but the Navy's management structures were such that the innovative idea easily survived the otherwise potentially fatal path over bureaucratic pits and chasms. The Technical Operations Group (TOG), which handled GRAB for the Director of Naval Intelligence (DNI), was a relatively small enterprise personnel-wise and had clearly delineated tasks assigned to each participating element, which preserved NRL's freedom to pursue the design; most importantly, "[t]he NRL developed the overall system concept; ... designed, fabricated, tested, and calibrated the satellite systems from concept through launch injection into orbit, and provided engineering and technical direction through the operational exploitation phase."[82] The CORONA management structures were likely even more efficient in spurring on innovative proposals, but the Navy's TOG would also perform the task well.

When GRAB was brought under the aegis of the NRO, management arrangements changed, but the underlying modus operandi remained very much alive. Bradburn et al. report that "[t]he NRO project teams, charged with building and operating SIGINT satellites, brought these new spacecraft into existence in a short time and brought them to bear on the intelligence problems of the nation quickly and effectively. POPPY typically achieved new models within one or two years."[83] The same appears to be true for the innovations that eventually produced WHITE CLOUD; a team that included "veterans from NRL" developed the crucial PAPS in a mere six months.[84]

Given NRL's long history of being at the cutting edge of innovation, relying on it for reconnaissance satellite development was as wise a move the Navy ever made, but these repeated successes also reflect a more fundamental way in which the Navy is run and runs things. The service as a whole is very decentralized—as Coté observes, "[d]octrine within ... [Navy] communities and among them is put together in decentralized fashion and often changes."[85] Were it not for this trait, it seems unlikely that the CNO would feel comfortable just encouraging various Navy elements to pitch proposals for "space," and it would have been even less likely that someone like Mayo would have exercised the degree of independent initiative that he did and even received support from upstairs. A per-

80. Robert A. McDonald and Sharon K. Moreno, *Raising the Periscope... Grab and Poppy: America's Early ELINT Satellites* (Chantilly, VA: Center for the Study of National Reconnaissance, National Reconnaissance Office, 2005), 4, http://www.nro.gov/history/csnr/programs/docs/prog-hist-03.pdf.

81. Ibid., 4–5.

82. *History of the Poppy Satellite System*, 4.

83. Bradburn et al., *The SIGINT Satellite Story*, 262.

84. Potts, *U.S. Navy/NRO Program C Electronic Intelligence Satellites (1958-1977)*, 216.

85. Coté, "The Politics of Innovative Military Doctrine," 22.

missive organizational structure and embedded incentives to innovate played a hugely important role in producing GREB as well as POPPY and WHITE CLOUD.

Civilian Requirements

Although the Sputnik launch in 1957 prompted the civilian leadership to start signaling its need for effective satellite programs, an ELINT satellite was never explicitly requested; rather, as shown above, the potential for innovation in this sphere was identified more or less independently by the Navy (and by the Air Force, who tacked the requirement onto SAMOS). With CORONA, the civilian leadership's signal was clear: They wanted something that could perform what had been the U-2's task—not to mention do it more effectively and more efficiently—and they wanted it fast. The need for ELINT, however was initially not a national requirement: It was first explicitly articulated by the Air Force in March of 1955.[86] Fortuitously, the Navy shared that need.[87] In what can be described only as a remarkable feat of prescience, the Navy did not present the ELINT satellite as an ocean surveillance platform that would be used in naval warfare—in the late 1950s and even early 1960s, the Soviet Navy did not present itself as much of a threat in the minds of the civilian leadership, the other services, or the IC—and instead sold it as a means for sniffing out Soviet air defenses, an issue that soon became very salient. GRAB, and to a certain extent POPPY as well, were the Navy's foot in the door—they proved that ELINT was feasible and that it worked well. Only then could ocean surveillance begin to be discussed.

However, the reliability of GRAB and POPPY and their successes in mapping out Soviet air defenses were not enough to make other parts of the national security apparatus swallow the ocean surveillance mission. The civilian leadership seemed actively unconcerned about the Soviet Navy: In 1967, Secretary of Defense Robert McNamara wrote about how "the military applications of Soviet power, such as recently increased naval activity in the Mediterranean, appear to be primarily diplomatic gestures."[88] It was never a foregone conclusion that the Navy would manage to turn ocean surveillance into a national intelligence requirement—the fact that it did can in large part be attributed to skilled bureaucratic maneuvering, but without tried and tested ELINT satellites to bootstrap the mission onto, it never would have happened. Civilian intervention prompted innovation in neither the GRAB case nor the POPPY/WHITE CLOUD case. If anything, it came quite close to quashing the ocean surveillance initiative.

86. Day, "Ferrets Above," 450.
87. Potts, *U.S. Navy/NRO Program C Electronic Intelligence Satellites (1958-1977)*, 3–4.
88. Johnson et al., "The Story of POPPY," 14.

Results and Assessment

Case	Perceived Level of Threat Stemming from Competition (None/Low/High)	Organizational Environment (Constrictive/ Permissive)	Level of Civilian Intervention (None/Low/ High)	Radical Technological Innovation (Yes/No)
SAMOS	Low	Constrictive	Low	No
CORONA	None/Low	Permissive	High	Yes
GRAB	Low	Permissive	None/Low	Yes
POPPY-WHITE CLOUD	High	Permissive	None	Yes

The evidence from the four case studies strongly suggests that a permissive organizational environment with embedded incentives for encouraging individual initiative is a necessary condition for technological innovation. All three cases in which success obtained are characterized by a permissive organizational structure and imbedded incentives for innovation. On the other hand, SAMOS—the only case in which radical innovation failed to occur—was characterized by heavy handed management, with top-down directives drowning out independent initiative.

Furthermore, a permissive organizational structure appears to be the most proximate cause of radical technological innovation. Using Mill's method of difference to compare WS-117L/SENTRY/SAMOS with Tattletale/CANES/GRAB yields the conclusion that successful innovation in the latter case was the product of the Navy's decentralized structure and higher echelons' encouragement of and reliance on individual initiative. A method of agreement comparison of GRAB with POPPY-PARCAE/WHITE CLOUD further corroborates the claim that permissiveness of the organizational structure is the decisive factor. This is not so readily apparent in the CORONA case: It would likely not have achieved such high levels of success had it not been for the way in which the CIA fostered genius and initiative on both upper and lower levels of the hierarchy, but the program would not have come into being at all without direct civilian intervention. A further comparison of CORONA with SAMOS in large part resolves this tension. Given that an important part of the civilian intervention mechanism is the generous budgetary attention that accompanies high levels of civilian involvement, it is possible to partially control for civilian intervention: Both CORONA and SAMOS received lavish amounts of funding, albeit from different sources (the Air Force inundated SAMOS with its own funds), meaning that it was most fundamentally organizational structure that made the difference between success and failure.

Despite these findings, it is difficult to discern whether there exists a stable pattern of independent and intervening variable combinations. While the case of GRAB indicates that permissiveness of the organizational structure can act as the independent variable, it also appears that in the CORONA case, the independent variable was the level of civilian intervention, with permissiveness operating as the intervening variable. Furthermore, competition can also act as the independent variable. After GRAB had been assigned to Program C, the Navy started encountering friction within the NRO and especially on USIB—as the IC and different services came into closer contact with each other and started interacting much more directly, competition intensified. WHITE CLOUD, and POPPY to a certain extent as well, were pushed by these dynamics. While the NRL's involvement was still essential for continuous successful innovation, ideas seem to have been shaped more prominently by the severity of competition than by internally generated requirements. What further complicates matters is that the question of ocean surveillance was not just a new technology but also a new mission seeking acceptance. In general, dissociating doctrinal innovation from technological innovation may seem to be analytically desirable, but as POPPY and WHITE CLOUD show, it can sometimes create very artificial boundaries and potentially present an unrealistic picture of the world.

Conclusion

To recapitulate, this paper finds that the key variable of interest for radical innovation is the permissiveness of the organizational environment and, relatedly, the effectiveness of incentive structures within that organization. A permissive organizational environment is a necessary condition for radical technological innovation and also the most proximate cause thereof. However, in cases where innovation appears to have multiple causes, it can be difficult to determine how the potential independent variables relate to each other—the four instances of efforts to develop satellites with overhead reconnaissance capabilities selected for this analysis do not exhibit a stable pattern of independent variable/intervening variable hierarchies. Permissiveness of the organizational environment can act as the independent variable—as GRAB shows—but can also operate as merely an intervening variable; in the CORONA case, the independent variable of interest is civilian intervention, and in the POPPY and WHITE CLOUD case, it was organizational competition that drove the development effort.

Of course, the hypotheses explored by this paper are by no means comprehensive. Rather, they serve as general categories for sorting specific claims about the origins of success in the development of satellite reconnaissance systems. To make these claims amenable to empirical evaluation, the parent hypotheses are built on mechanisms borrowed from the dominant extant theories of military innovation, which yields three different, but, as the results show, often complementary lines of argument. Further work on the topic of radical technological innovation could explore the effect of other factors, such as, for instance, Pentagon intellectual property regulations and technology policy more broadly.[89] It should be evident that these two potential groups of factors are not completely discrete; that is, Pentagon intellectual property regulations might play an important role in accelerating or arresting the development of a specific weapon or sensor

89. The author would like to thank Richard H. Steinberg for this point.

system, but they themselves seem to be a product of civilian preferences and perhaps of interservice interactions as well. Similarly, technology policy does not seem easily dissociable from civilian responses to the vicissitudes of the external security environment.

Potential additional hypotheses should therefore not be understood as amenable to being simply tacked onto the framework of three general explanatory categories proposed in this paper. Although further hypothesis testing is desirable and indeed necessary to better understand radical technological innovation, it is important to bear in mind that most additional hypotheses would operate at a lower level. In other words, what is needed now are explanatory factors that allow for the identification of finer gradations across the independent variables proposed and tested by this paper.

In addition, drawing a line between instances of "successful" and "unsuccessful" attempts at radical technological innovation is sufficient for the purposes of this paper, but to construct a more rigorous model, it would be necessary to identify finer gradations within the dependent variable as well. This could potentially be achieved by creating an interval level metric for measuring the level of technological innovation, although as Rosen observes, previous attempts in this sphere have not met with success.[90] Another possibility would be creating an ordinal level measure that explicitly links the level of technological innovation with the goals of the pertinent newly-emergent doctrine, and although that does not solve the problem of finding a way to operationalize independent variables in the same way, it would allow greater precision in the proposed causal claims.

90. Rosen, *Winning the Next War*, 48–52.

References

Baltrusaitis, Daniel. "USAF Command Doctrine of Centralized Control with Decentralized Execution: Never Divide the Fleet?" http://www.dtic.mil/dtic/tr/fulltext/u2/a466500.pdf.

Berkowitz, Bruce. *The National Reconnaissance Office at 50 Years: A Brief History*. Chantilly, VA: Center for the Study of National Reconnaissance, National Reconnaissance Office, 2011. http://www.nro.gov/history/csnr/programs/NRO_Brief_History.pdf.

Bibliography of Historical Publications. Chantilly, VA: NRO History Office, 1998. http://www.governmentattic.org/6docs/NRObiblioHistPubs_1998.pdf.

Bissell, Jr., Richard M., with Jonathan E. Lewis, and Frances T. Pudlo. *Reflections of a Cold Warrior: From Yalta to the Bay of Pigs*. New Haven, CT: Yale University Press, 1996.

Bradburn, David D., John O. Copley, Raymond B. Potts, and Roger Thayer. *The SIGINT Satellite Story*. Chantilly, VA: National Reconnaissance Office, 1994. http://www.nro.gov/foia/declass/sigint/SIGINT_Satellite_Story.PDF.

Coté, Owen R. "The Politics of Innovative Military Doctrine: The U.S. Navy and Fleet Ballistic Missiles." PhD diss., Massachusetts Institute of Technology, 1996. https://dspace.mit.edu/handle/1721.1/11217#files-area.

Day, Dwayne A. "Atop the Highest Mast: Development of US Ocean Surveillance Satellites—Part 2—PARCAE and White Cloud." *Spaceflight* 51, no. 12 (December 2009): 463–468.

———. "Atop the Highest Mast: The Development of American Ocean Surveillance Satellites —Part 1—POPPY." *Spaceflight* 51, no. 11 (November 2009): 427–432.

———. "Ferrets Above: American Signals Intelligence Satellites During the 1960s." *International Journal of Intelligence and CounterIntelligence* 17, no. 3 (2004): 449–467.

———. "The Development and Improvement of the CORONA Satellite." In *Eye in the Sky: The Story of the Corona Spy Satellites*, edited by Dwayne A. Day, John M. Logsdon, and Brian Latell, 48–85. Washington, D.C.: Smithsonian Institution Press, 1998.

Deeg, Richard. "Institutional Change in Financial Systems." In *The Oxford Handbook of Comparative Institutional Analysis*, edited by Glenn Morgan, John L. Campbell, Colin Crouch, Ove Kaj Pedersen, and Richard Whitley, 309–334. Oxford: Oxford University Press, 2010.

Dietel, Ed. "An Interview with Former DDS&T Albert Wheelon." *Studies in Intelligence*:31–43. https://www.cia.gov/library/readingroom/docs/DOC_0000863247.pdf.

Fitzgerald, Dennis. "Commentary on 'The Decline of the National Reconnaissance Office': NRO Leadership Replies." *Studies in Intelligence* 46, no. 2 (2002). https://www.cia.gov/library/center-for-the-study-of-intelligence/csi-publications/csi-studies/studies/vol46no2/article12.html.

George, Alexander L., and Andrew Bennett. *Case Studies and Theory Development in the Social Sciences*. Cambridge, MA: MIT Press, 2005.

Greer, Kenneth E. "Corona." In *CORONA: America's First Satellite Program*, edited by Kevin C. Ruffner, 3–39. Washington, D.C.: Center for the Study of Intelligence, Central Intelligence Agency, 1995.

Haines, Gerald. "The National Reconnaissance Office: Its Origins, Creation, and Early Years." In *Eye in the Sky: The Story of the Corona Spy Satellites*, edited by Dwayne A. Day, John M. Logsdon, and Brian Latell, 143–156. Washington, D.C.: Smithsonian Institution Press, 1998.

History of the Poppy Satellite System. Chantilly, VA: National Reconnaissance Office. http://nro.gov/foia/docs/History%20of%20Poppy.PDF.

Johnson, Tom, Ron Potts, R. Cargill Hall, David Hatch, and David van Keuren. "The Story of POPPY." Unpublished manuscript, Washington, D.C., February 24, 1998.

Kohler, Robert. "One Officer's Perspective: The Decline of the National Reconnaissance Office." *Studies in Intelligence* 46, no. 2 (2002). https://www.cia.gov/library/center-for-the-study-of-intelligence/csi-publications/csi-studies/studies/vol46no2/article11.html.

Lewis, Jonathan E. "Tension & Triumph: Civilian and Military Relations and the Birth of the U-2 Program." In *CORONA Between the Sun and the Earth: The First NRO Reconnaissance Eye in Space*, edited by Robert A. McDonald, 13–24. Bethesda, MD: American Society for Photogrammetry and Remote Sensing, 1997.

Maddrell, Paul. Introduction to *The Image of the Enemy: Intelligence Analysis of Adversaries since 1945*, 1–27. Edited by Paul Maddrell. Washington, D.C.: Georgetown University Press, 2015.

McDonald, Robert A. "CORONA: Success for Space Reconnaissance, A Look into the Cold War, and a Revolution for Intelligence." *Journal of the American Society for Photogrammetry and Remote Sensing* 61, no. 6 (June 1995): 689–720.

———. "Lessons and Benefits from Corona's Development." In *CORONA Between the Sun and the Earth: The First NRO Reconnaissance Eye in Space*, edited by Robert A. McDonald, 255–267. Bethesda, MD: American Society for Photogrammetry and Remote Sensing, 1997.

McDonald, Robert A., and Sharon K. Moreno. *Raising the Periscope... Grab and Poppy: America's Early ELINT Satellites*. Chantilly, VA: Center for the Study of National Reconnaissance, National Reconnaissance Office, 2005. http://www.nro.gov/history/csnr/programs/docs/prog-hist-03.pdf.

Oder, Frederic C. E., James C. Fitzpatrick, and Paul E. Worthman. *The CORONA Story*. Chantilly, VA: National Reconnaissance Office, 1987. http://www.nro.gov/foia/docs/foia-corona-story.pdf.

Peebles, Curtis. *The Corona Project: America's First Spy Satellites*. Annapolis, MD: Naval Institute Press, 1997.

Perry, Robert L. *A History of Satellite Reconnaissance: The Robert L. Perry Histories*. Edited by James D. Outzen. Chantilly, VA: Center for the Study of National Reconnaissance, National Reconnaissance Office, 2012.

Posen, Barry R. *The Sources of Military Doctrine: France, Britain, and Germany between the World Wars*. Ithaca, NY: Cornell University Press, 1984.

Potts, Ronald L. *U.S. Navy/NRO Program C Electronic Intelligence Satellites (1958-1977)*. Chantilly, VA: LEO Systems Program Office, SIGINT Directorate, National Reconnaissance Office, 1998. http://www.nro.gov/foia/docs/U.S.%20Navy-NRO%20Program%20C%20Electronic%20Intelligence%20Satellites%20(1958-1977).pdf.

Richelson, Jeffrey T. *America's Secret Eyes in Space: The U.S. Keyhole Spy Satellite Program*. New York: Harper & Row, 1990.

———. *Civilians, Spies, and Blue Suits: The Bureaucratic War for Control of Overhead Reconnaissance, 1961-1965*. http://nsarchive.gwu.edu/monograph/nro/.

———. "Restructuring the NRO: From the Cold War's End to the 21st Century." *International Journal of Intelligence and CounterIntelligence* 15, no. 4 (2002): 496–539.

———. *The US Intelligence Community*. 6th ed. Boulder, CO: Westview Press, 2012.

———. "Undercover in Outer Space: The Creation and Evolution of the NRO, 1960–1963." *International Journal of Intelligence and CounterIntelligence* 13, no. 3 (2002): 301–344.

Rosen, Stephen Peter. *Winning the Next War: Innovation and the Modern Military*. Ithaca, NY: Cornell University Press, 1991.

Thelen, Kathleen. "Beyond Comparative Statics: Historical Institutional Approaches to Stability and Change in the Political Economy of Labor." In *The Oxford Handbook of Comparative Institutional Analysis*, edited by Glenn Morgan, John L. Campbell, Colin Crouch, Ove Kaj Pedersen, and Richard Whitley, 309–334. Oxford: Oxford University Press, 2010.

Van Evera, Stephen. *Guide to Methods for Students of Political Science*. Ithaca, NY: Cornell University Press, 1997.

Waltrop, David W. "Critical Issues in the History and Historiography of U.S. National Reconnaissance." *Quest* 17, no. 3 (2010): 20–28. http://www.nro.gov/news/articles/2010/2010-04.pdf.

Warner, Michael. "The Rise of the U.S. Intelligence System, 1917-1977." In *The Oxford Handbook of National Security Intelligence*, edited by Loch K. Johnson, 107–121. Oxford: Oxford University Press, 2010.

Wheelon, Albert D. "CORONA: A Triumph of American Technology." In *Eye in the Sky: The Story of the Corona Spy Satellites*, edited by Dwayne A. Day, John M. Logsdon, and Brian Latell, 29–47. Washington, D.C.: Smithsonian Institution Press, 1998.

———. "Corona: The First Reconnaissance Satellites." *Physics Today* 50, no. 2 (February 1997): 24–30.

Wilson, James Q. *Bureaucracy: What Government Agencies Do and Why They Do It*. New York: Basic Books, 2000.