Under Control: Constructing the Nerve Centers of the Cold War

by

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Abstract

Cold War architecture reveals narratives of both faith and fatalism. American federal agencies, such as the Department of Defense and NASA, financed the creation of command and control centers that operated in digital, real-time environments during the postwar years. Contemporaneous advances in communications technology and computer systems enabled the construction of these spaces, and their architecture reflects presumed national security needs during the Cold War. This dissertation explores the design of these control rooms as new technologies and uncovers how these spaces—and their varying levels of public visibility—served as symbols of military authority and political policy. These Cold War artifacts embody commitment to a centralized headquarters, which would fade in the following years. Four case studies develop my argument. These sites are: (1) NASA's Mission Control Center in Houston, (2) the Strategic Air Command headquarters at Offutt Air Force Base in Nebraska, (3) the North American Air Defense Command's Combat Operations Center in Cheyenne Mountain, Colorado and (4) the "Blue Cube" at Onizuka Air Force Station near Sunnyvale, California. Due to the goals of the agencies financing these spaces—such as advocating the policy of deterrence and boasting their ability to control air and space—the resultant command and control centers were politically and socioculturally charged artifacts. Through employing innovative design techniques, along with media portrayals of these spaces, the American government attempted to use command centers to appease domestic Cold War fears while at the same time deterring the enemy, with varying degrees of efficacy. My investigation of these spaces showcases how historians can use physical manifestations of political and military ambitions to better understand the past.

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CHAPTER 1. Controlling the Cold War

Under Control: Constructing the Nerve Centers of the Cold War traces the history of command and control centers in Cold War America in an effort to understand how these spaces were conceived, utilized, and perceived. Today these rooms are iconic and ubiquitous, their design a *fait accompli*, but they were non-existent until the second half of the twentieth century. For many Americans, their first glimpse of a computer-supported control center was via television, of NASA's Mission Control Center in Houston during the Apollo missions. Organization men donning headsets faced large display screens from behind tiered consoles and successfully supported the landing of men on the Moon. Designers had determined that this was the most efficient spatial configuration for remotely monitoring spaceflight, and largely due to the successes facilitated from this space, later engineers and managers would agree. Since that time, this model has been appropriated by so many other industries—military, commercial, educational, and so on—that the arrangement of furniture, computers, and other equipment in such a space has become taken for granted as the ideal layout. Proof of its efficacy and persisting replication of the model, however, does not explain how and why designers initially conceived of and created this space.

These spaces are architectural expressions of a particular era, which enables a narrative in the history of technology that is largely overlooked. These physical constructs embodied meanings—be they political or otherwise—and conveyed messages to workers within the space and to those viewing the space from the outside. In other words, these spaces were both socially constructed and societally impactful, making their examination a means of better understanding the people that constructed them. A number of architectural historians (in particular) argue that the end-products of architectural efforts are microcosms of the values of society at large.[1] American Cold War command centers are exemplary artifacts to study in order to understand this production, as they (1) occupied definable physical spaces composed of networked machines, allowing for examination not only of the room as a space but also as an artifact, (2) integrated cutting-edge computer and communications technology, and (3) were developed in direct response to the particular needs of military and political leaders during the Cold War. It is also relevant that both NASA and the Air Force were relatively new agencies forging their institutional identities and authority through utilization of new technologies, and such imperatives permeate the character of these centers.

In addition to these characteristics, what differentiates Cold War spaces of command and control from war rooms or operations rooms of the past (for example, Winston Churchill's Cabinet War Rooms) is that they were non-redundant hubs for global networks. They highlight the belief that one could survey and direct activities across the entire planet from a centralized headquarters. New technologies enabled a distinctly modern dynamic in the command center; commanders did not simply monitor a local battlefield, but they endeavored to survey and react globally. These rooms speak to the challenge of living in an era under the threat of the atomic bomb. The tendency toward centralization was eventually dropped in favor of decentralization. In the late

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[1] Carla Yanni, *The Architecture of Madness: Insane Asylums in the United States* (Minneapolis: University of Minnesota, 2007), 1; 5; 8; Annabel Jane Wharton, *Building the Cold War: Hilton International Hotels and Modern Architecture* (Chicago: University of Chicago Press, 2001); Simon Richards, *Architect Knows Best: Environmental Determinism in Architecture Culture from 1956 to the Present* (Burlington, VT: Ashgate Publishing Company, 2012), 148, 126. Psychologists also argue that spaces can be created that influence people in particular ways. See Sally Augustin, *Place Advantage: Applied Psychology for Interior Architecture* (Hoboken, NJ: John Wiley & Sons, 2009).

1950s, however, the existence of these centers proves that American military officials believed that pursing means of global surveillance, the creation of a massive deterrent force of bombers and nuclear weapons, and sites for monitoring global threats that were "hardened" against nuclear attack were keys to either surviving until the Cold War ended, or quickly retaliating once it started.[2] A number of command room from the Cold War era might come to mind. For example, Royal Air Force command centers and other Command Information Centers (CIC) utilized similar design principles, but lacked the advanced electronics equipment, user interfaces, and embedded systems that are characteristic of the spaces discussed here. These sites are also national or geographically wide-ranging in scope, as opposed to air traffic control centers, FEMA control centers, missile silos, or command centers that direct the operations aboard one vessel (for example, a submarine). Finally, Cold War spaces of command and control were the key nodes in their network. Despite the later movement toward decentralization, these headquarters served as centralized bastions of military strength. They were not just technologically innovative and shared a similar aesthetic; the motivations behind their design were based on promoting the command center—not just the objects that it commanded—as a sign of national strength.

Much as Thomas Hughes argued that national power systems are evolving cultural artifacts and "embody the physical, intellectual, and symbolic resources of the society that constructs them," Cold War command centers reflected the national zeitgeist

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[2] As an example of the movement toward decentralization, current military intelligence systems are widely dispersed. See David. E. Pearson, *The World Wide Military Command and Control System* (Maxwell AFB, Alabama, Air University Press, 2000).

of the United States military and American political leaders during the middle of the twentieth century.[3] Paul Edwards observed that the development of control rooms embodied, "Cold War nuclear anxiety, quantitatively oriented 'scientific' administrative techniques, and the global objectives of U.S. military power."[4] He argued that mid-century electronics development catalyzed a movement toward centralization and created a closed-world discourse, because computers "allowed practical construction of central real-time military control systems on a gigantic scale." These spaces "facilitated the metaphorical understanding of world politics as a sort of system subject to technological management."[5]

American command and control centers served as analogous constructions of reassurance that the United States was prepared to defend its borders, attack its enemies, and save its people. Within a short period of time, however, these centralized systems were no longer seen as being the technological answer to avoiding global holocaust. In fact, quite a few media portrayals questioned the ability of these command and control behemoths to deliver on their promise to deter the Soviet Union, and some critics even suggested that the mere existence of these spaces escalated tensions and made nuclear attack *more likely*. These case studies describe how and why these environments were both byproducts of their designers' intent, as well as symbols appropriated by others.

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[3] Thomas Hughes, *Networks of Power: Electrification in Western Society, 1880-1930* (Baltimore, MD: Johns Hopkins University Press, 1983), 2.

[4] Paul N. Edwards, *The Closed World: Computers and the Politics of Discourse in Cold War America* (Cambridge, MA: MIT Press, 1997), 6.

[5] Ibid., 7.

NASA's Mission Control Center in Houston, which began operations in 1964, might be the most familiar of these command and control centers. The original Mercury Control Room at Cape Canaveral was in desperate need of updating to support the Gemini and Apollo missions. Due to the new technological capability to monitor launches and spaceflight further away from the launchpad, a new site could be selected at a geographically distant location. Houston was selected due to its proximity to required resources (as well as due to some congressional pork-barreling), and the center came online to support Gemini 4. The new control space was named the Mission Control Operations Room, but was more commonly known as the Mission Control Center (MCC) or simply, Mission Control. It held some design features in common with the Mercury Control Center: operators sat at consoles that faced a large map that depicted the orbital path of a space vehicle using a motorized icon that traversed the screen. At Mission Control Houston, however, these movements were shown digitally and in real time, utilizing on-site, state-of-the-art computer systems. This structure was designed by Philco contractors and their subcontractor, IBM. Examining the construction of this space showcases the roles of contractors in the creation of the most well-known command and control room in American history. Those involved did not necessarily design Mission Control Houston with its potential for symbolism in mind, yet it became the face of the American space program, more so than NASA headquarters in Washington, DC. Architectural historian Nicolas de Monchaux provocatively dissected a material object in *Spacesuit*, in which he observes that Cold War command and control centers represented the imperatives of their era:

> the multiscreen control spaces of midcentury had their beginnings in America's postwar nuclear defense. Developed in symbiosis with the virtual spaces of

> aircraft and spacecraft simulators, these multiscreen theaters would have their public apogee in the stage-set of Apollo's Mission Control—a two-word phrase inseparable from the architecture of the space race....[6]

Certainly, Mission Control became the public face of NASA, and this visibility led to the replication of its aesthetic in the following years. Monchaux, however, situates this space in a lineage of combat centers and situation rooms, and Mission Control and the other centers examined here were not mere war rooms. They were digital, global *command and control centers* that served as symbols of military and political authority, and should be examined as particularly Cold War spaces of command and control. Even their name was a novel pairing; "command and control" was new to the lexicon. These two terms were not married until the 1960s, but quickly became inseparable. Later, communications and information would be added to the duo, creating the acronym, C^3I.[7]

The Strategic Air Command (SAC) Headquarters at Offutt Air Force Base in Nebraska, also known as Building 500, was an architectural expression of command and control. SAC was established in 1946 to monitor (and possibly deliver) the Air Force's supply of nuclear weapons, but the Command came into its own when Curtis LeMay became the Commander-In-Chief Strategic Air Command (CINCSAC) in 1948. LeMay took a largely disorganized assemblage of personnel and planes and turned it into one of the most efficient military branches. When updating the operation, LeMay requested a new headquarters, and argued that it should be constructed underground, hardened against nuclear attack. After a few years of lobbying, construction began in 1955 and

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[6] Nicholas de Monchaux, *Spacesuit: Fashioning Apollo* (Cambridge, MA: MIT Press, 2011), 273.
[7] Ibid., 131.

operations began at HQ SAC in 1957. Buried forty-six feet underground, men on cherry-pickers mapped information such as weather conditions and fleet locations on huge plotting boards and wall maps, and operators sat at consoles facing these displays. An IBM 704 provided information and supported communications. The Strategic Air Command headquarters epitomized utilization of advanced technology, and through LeMay's dedication to efficiency and maintenance of a global network, it projected an image of rationality and military strength. At the risk of hyperbole, the architecture of HQ SAC served just as effectively in deterring enemy aggression as the bombers and missiles it directed. At the very least, this space reflected and embodied common mentalities of the era, such as the policy of deterrence. The Strategic Air Command's regular air demonstrations, record-setting competition showings, and underground control room exemplified an operation that was well under control.

Historical study of the connection between advanced technologies and assertions of control is not without precedent. In Miriam Levin's edited volume, *Cultures of Control*, contributors examine "technologies… [as] material culture whose design is intimately related to special historical contexts" and which are constructed in ways that assert or structure authority.[8] Thomas Hughes contends that these authors "show that 'control' and 'technology' have similar connotations and are nearly interchangeable."[9] The history of command and control centers supports this argument; these spaces were assembled of advanced technologies designed to achieve a primary Cold War ambition—

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[8] Miriam Levin, "Preface," in Miriam R, Levin ed., *Cultures of Control* (London, UK: Harwood Academic Publishers, 2000).

[9] Thomas P. Hughes, "Introduction," in Levin, ed., *Cultures of Control*, 1.

control in the skies and beyond. They were also more than mere containers of assembled technologies, but were new, holistic technologies within themselves; their underlying architecture contributed to a movement toward a systems approach in the postwar period. Hughes argues that technologies that facilitated information-gathering and sorting became crucial as large systems, such as the networks that powered these command and control centers, grew increasingly complex.[10] The communication systems implemented in the control rooms examined here are highlighted due to their contributions to this transition to a global communications network.

The North American Air Defense Command (NORAD), now the North American Aerospace Defense Command and headquartered near Colorado Springs on Peterson Air Force Base, was operationally connected to the Strategic Air Command, but shares commonalities with all of the spaces examined here. After World War II, American military leaders initiated the creation of an air defense network to protect against enemy bombers, which led to the creation of the Air Defense Command at Ent Air Force Base in Colorado in the early 1950s. Soon after, air defense became the responsibility of a multi-service unified command, the Continental Air Defense Command (CONAD), also located at Ent AFB. In 1956, CONAD asked the US Air Force to construct an underground Combat Operations Center for the Command, one similar to the new Strategic Air Command headquarters, but this request went unfulfilled. In the meantime, the United States and Canada signed the NORAD Agreement, and established the North American Air Defense Command at Ent AFB in September 1957. The following year,

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[10] Hughes, "Introduction," in Levin, ed., *Cultures of Control*, 6-7.

CINCNORAD General Earle E. Partridge told the Joint Chiefs of Staff that he needed a remote Combat Operations Center that would need to be able to withstand thermonuclear attack, and his request was approved. Excavation of nearby Cheyenne Mountain began in 1961, and the Combat Operations Center moved from Ent AFB into a complex of buildings resting on shock-absorbing springs buried within Cheyenne Mountain in 1966. NORAD's job was to watch the skies for incoming weapons, warn the Strategic Air Command (and other interested parties) of any suspicious observations, and defend against an attack. NORAD had surface-to-air missiles and fighter interceptors at its disposal in the event that it needed to intercept bombers; massive retaliation was the job of the Strategic Air Command.

Most histories start before the time of the Combat Operations Center, and focus on the system that provided the basis for the one implemented in Colorado Springs. That is, the Semi-Automatic Ground Environment (SAGE) system, a computer-based air defense system developed by MIT's Lincoln Laboratory (whose spinoff, the MITRE Corporation, would later design NORAD's Combat Operations Center).[11] By the time of its deployment in 1958, the SAGE system was largely obsolete, as it had been designed to detect incoming bombers and not the ICBMs which had become the dominant threat. SAGE's command, control, and communications system, however, provided the model for later air defense and air traffic control networks, and this system introduced the

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[11] Edwards, 75. The story of SAGE has been told by other scholars. See Kent C. Redmond and Thomas M. Smith, *From Whirlwind to MITRE: The R&D Story of the SAGE Air Defense Computer* (Cambridge, MA: MIT Press, 2000), and Robert R. Everett, Charles A. Zraket, and Herbert D. Benington, "SAGE—A Data-Processing System for Air Defense," *Annals of the History of Computing*, Volume 5, Number 4, October 1983, 330-339. The MITRE Corporation was chartered by Congress in 1958 as a private, not-for-profit corporation to provide technical and engineering guidance to the federal government.

technology necessary for such systems to work: digital computers capable of real-time information-processing.[12]

Hughes argues that the importance of SAGE lies in the fact that it "exemplifies the collective management structure now labeled the military-industrial complex," a structure which explains "the present-day preeminence of the United States in the creation of large systems."[13] He asserts that the developments in systems engineering, and in systems analysis and research, needed to create such structures "generated a managerial revolution comparable to that brought about earlier by Taylor's scientific management."[14] Paul Edwards also emphasizes the significance of SAGE, asserting that it was "far more than a weapons system. It was a dream, a myth, a metaphor for total defense, a technology of closed-world discourse."[15] Edwards utilizes the SAGE story to develop his "closed world" thesis, in which he argues that "the key theme [in the closed world]…was global surveillance and control through high-technology military power. Computers made the closed world work simultaneously as technology, as political system, and as ideological mirage."[16] Edwards notes that in the 1950s, "the Air Force command traditionalists who had opposed the computerized air defense system either became, or were replaced by, the most vigorous proponents of centralized, computerized warfare anywhere in the American armed services."

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[12] Thomas Hughes, *Rescuing Prometheus* (New York: Pantheon Books, 1998), 30; 66.
[13] Ibid., 4-5.
[14] Ibid., 9.
[15] Edwards, 111.
[16] Ibid., 1.

One reason this happened was because leaders realized that missiles, which could reach targets far more quickly than airplanes and could not be intercepted, would become the dominant delivery system. Only systems that could process massive amounts of information in real time would provide the information necessary to guard against attack and/or retaliate. In response to this threat, new, centralized command and control systems were constructed. SAGE provided the model for such centers, including the NORAD system—425L—which connected to distant early warning systems originally used by SAGE (among other data-gathering sites).[17] As noted by Hughes: "The command, control, and communications system that interconnected SAGE facilities, for instance, became the model for the Air Force's massive system for connecting far-flung bomber bases and headquarters into a single network."[18] Command and control systems were inspired by the SAGE structure, but surpassed its technological capabilities and necessitated their own built environments. In addition, although experiments dealing with human factors and systems engineering took place in SAGE defense centers, they became more prevalent as the military increased its dependence on electronic communications, digital displays, and the use of computers.[19] The NORAD Combat Operations Center provides a useful case study for understanding how computerized command and control

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[17] Ibid., 106-107. "The new command and control systems, or L-systems as they were officially designated, covered a wide variety of functions. A sampling might include the following: continental air defense (SAGE, 416L), traffic control and landing (431L), weather observation (433L), intelligence handling (438L), ballistic missile warning (BMEWS, 474L), air communications (480L), and satellite surveillance (496L). Unfortunately, the several L-systems were not conceived according to any sort of master plan, nor was their early development marked by a coordinated approach. In short, there was no guarantee that they would operate compatibly." *MITRE: The First Twenty Years* (MITRE, 1979), 33.

[18] Hughes, *Rescuing*, 15; 66.

[19] Henry McIlvaine Parsons, *Man-Machine System Experiments* (Baltimore: The Johns Hopkins University Press, 1972), 9.

came to be adopted and accepted by both military and civilian organizations during the Cold War. According to anthropologist Joseph Masco, the COC was "the most advanced bunker facility of its time and perfectly illustrates the passions of the Cold War nuclear project" due to the massive investment in its infrastructure to support (or, ostensibly, deter) nuclear war. Echoing Edwards, Masco asserts that during the time of its construction, the military's concept of command and control—that is, one that surveys the world as a "collection of data points on technologically mediated screens"—became a predominant civilian view as well, which enabled the normalization of a permanent war economy in the United States.[20]

The "Big Blue Cube" was a spy satellite surveillance building, part of the Air Force Satellite Control Facility, in what is now Silicon Valley. The letters "AFSCF" designated its attachment to the base, and it was highly visible from neighboring freeways 237 and 101, not to mention from overhead. Three parabolic dish antennas gathered data from tracking stations and displayed it to operators within this massive, windowless, concrete box painted Air Force Blue. It was from this site that military satellites were monitored by the National Reconnaissance Office (NRO) from 1961 to 2007, most notably, for the Corona program (cover name, Discoverer), but it also supported many Shuttle missions that had DoD imperatives tacked onto their assignments. Its distinct architecture—one both emphasizing boldness and suggesting top-secret operations—instigated years of speculation as to the exact activities conducted within the building. The Satellite Control Facility was *very* secretive about the particulars

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[20] Joseph Masco, "Life Underground: Building the Bunker Society," *Anthropology Now*, Vol. 1, No. 2, Special Atomic Issue (September 2009), 17.

of its activities, and the majority of its buildings were under high security, projecting an image of both fear *of* and fortification *from* espionage. The Blue Cube's unusual shape and color drew attention to its mission of surveillance and defense. It also served as a decoy; its blatant display and association with military activities forces eyes upon it (and not elsewhere), and perhaps that was the intention of its builders. Either way, its highly visible structure is an instance of constructing provocative architecture behind closed gates to meet image-making objectives.

This case study differs from the others in a few ways. Unlike HQ SAC and the NORAD COC, the Blue Cube and other buildings of the Satellite Test Center (STC, the Sunnyvale component of the Satellite Control Facility) were built above ground—at least more than 100 feet of them were. Also, although the STC buildings were concrete and looked "hard," they were not promoted as "hardened" against nuclear attack as were the other spaces. Instead, the spy satellites were the objects that were hardened. This could mean encasing the satellite's components in sheet metal, coating lenses so that they were laser-resistant, or using gallium arsenide in place of silicon parts.[21] New strategies aimed to mitigate damage through redundancy and object-hardening, in an effort to prevent the total collapse of a system that had become vital to national security. Yet this space was as tightly guarded as the others. Clearance was so high to enter this site that in 1968 even Vice-President Hubert Humphrey was once denied access. In addition, virtually no photographs of the interior of the building (which has since been torn down) have been made available to the public. Examination of the Satellite Test Center considers how this

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[21] William E. Burrows, *Deep Black: Space Espionage and National Security* (New York: Random House, 1986), 260.

Cold War site was incredibly secretive as to its operations, yet flaunted its existence with conspicuous architecture.

These four sites were chosen for a number of reasons. The same contractors designed and built them. They were constructed at roughly the same time, and without obvious precedents. For the purpose of uncovering Cold War attitudes, the window is suitable; the secrecy of the design specifications of the earliest of these centers, the Strategic Air Command, renders the time differential in construction essentially meaningless. In addition, each of these command centers played a role in the Cold War, some by boosting American morale and showcasing ingenuity (NASA), and others through classified endeavors, such as gathering intelligence (the Blue Cube). Where they differ, however, also makes these apt selections. These spaces can be plotted along a spectrum of public visibility. NASA operations at the Mission Control Center in Houston were publicized as completely transparent. That was part of the agency's appeal. This was not the way the Soviet space program operated; American taxpayers had the right to see their funds at work and thus the space program (purportedly) operated with full disclosure to its constituents. This act was deliberate and carried with it many implicit promises, mostly of a reassuring variety. Yet the ostensibly civilian space program has always had ties to the military, and its assertions of openness and public transparency should be regarded with more skepticism than they have typically received.[22]

Moving along the spectrum, and into military territory, the headquarters of the Strategic Air Command boasted of its capabilities and allowed photographs of its facility.

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[22] See, James E. David, *Spies and Shuttles: NASA Secret Relationships with the DoD and CIA* (Gainesville, FL: University Press of Florida, 2015).

Its location in Nebraska, out of the reach of Soviet bombers, indicates an isolation deemed necessary for an important military base (or target). Going into the era of the ICBM, however, the inland location was no longer safe from enemy attack, so Curtis LeMay lobbied to have a new command post built underground. Secrecy permeated the project, yet the SAC public relations machine was still at work, promoting the command and control center as a technological marvel while also denying access to potential critics. For example, Curtis LeMay gave the producers of the 1963 film *A Gathering of Eagles*, in which Colonel Jim Cardwell (played by Rock Hudson) whips an inefficient SAC base into shape, unprecedented access to SAC facilities.[23] In contrast, Stanley Kubrick's satirical *Dr. Strangelove: Or How I Stopped Worrying and Learned to Love the Bomb*, which depicts a trigger-happy SAC General-gone-mad who sets World War Three into motion, had to rely on stock footage of B-52s, and its set designer, Ken Adams, did not have any access to SAC facilities. When asked if he had based his war room design on a real place, Adams replied, "I don't know what government facilities look like!"[24] Even without the access, however, Adams managed to get the aesthetic right; he had even wanted the war room to be split-level, which would have more closely resembled HQ

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[23] Film has been proven as an effective means of uncovering prevailing public ideas. See H. Bruce Franklin, *War Stars: The Superweapon and the American Imagination* (New York, NY: Oxford University Press, 1988); Christopher Frayling, *Bad, Mad and Dangerous? Scientists in Cinema* (London, UK: Reaktion Books, 2005); Stephen Pendo, *Aviation in the Cinema* (Metuchen, NJ: Scarecrow Press, 1985); James H. Farmer, *Celluloid Wings, The Impact of Movies on Aviation* (Blue Ridge Summit, PA: Tab Books, 1984); Michael Paris, *From the Wright Brothers to Top Gun: Aviation, nationalism, and popular cinema* (Manchester, UK: Manchester University Press, 1995); Thomas Allen Nelson, *Kubrick: Inside a Film Artist's Maze* (Bloomington, IN: Indiana University Press, 2000); Robert Kolker, *A Cinema of Loneliness* (Oxford, UK: Oxford University Press, 2000); Carl Boggs and Tom Pollard, *The Hollywood War Machine: U.S. Militarism and Popular Culture* (Boulder, CO: Paradigm Publishers, 2007).

[24] David Hayles, "Is This The Best Film Set Ever Designed? On Dr. Strangelove's War Room," *Newstatesman*, 5 November 2014, accessed 7 January 2016, http://www.newstatesman.com/culture/2014/11/best-film-set-ever-designed-dr-strangelove-s-war-room

SAC (if not the Situation Room), but Kubrick vetoed the idea.[25] This is all to say that even without having access to actual facilities, the presumed layout was already in the public consciousness through press releases and media portrayals. These films, in turn, served as inspiration when SAC was updated over the years in attempts to meet the technological standards of its fictionalized image.[26]

The NORAD Combat Operations Center, buried within Cheyenne Mountain in Colorado, had placed a literal, granite barrier between the site and outsiders. Its exact operations and means of conducting them were highly secretive and its computer systems classified, yet anyone who cared to read a newspaper knew of the center's existence and was vaguely aware of its purpose. In fact, as soon as NORAD formed in 1958, the Command publicly promoted itself as the organization that tracks Santa Claus across the skies. As the story goes, a 1955 ad in the local Colorado Spring paper gave a phone number and instructed kids to call and talk to Santa, but the number printed was incorrect, and actually connected children with the CONAD operations center. Since 1958, NORAD has taken this responsibility as its own, and fields more than 70,000 annual calls to Santa, as well as maintains a Twitter account that posts his global whereabouts on Christmas Eve.[27] Beginning in the 1970s, NORAD opened the Cheyenne

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[25] Justin Morrow, "'It Was Nerve-Destroying': Legendary Set Designer Recalls Working with Kubrick," *No Film School*, 20 August 2013, accessed 7 January 2016, http://nofilmschool.com/2013/08/set-designer-sir-ken-adam-working-with-kubrick

[26] Daniel J. Hoisington, "Historic American Building Records," Offutt Air Force Base, Headquarters, Strategic Air Command, HABS NO. NE-9-M, N, O, Nebraska State Historic Preservation Office, Folder SY04-175 BLDG #500 SAC HEADQUARTERS

[27] NORAD, "NORAD Tracks Santa," accessed 7 January 2016, http://www.norad.mil/AboutNORAD/NORADTracksSanta.aspx ; https://twitter.com/NoradSanta

Mountain Complex to tours, although that option disappeared in the wake of the attacks of September 11, 2001.

The NORAD COC has also featured prominently in popular culture. For just a few examples: the Cheyenne Mountain Complex was the target of rock missiles from *Luna*, the rebellious moon colony in Robert Heinlein's 1966 novel, *The Moon is a Harsh Mistress*. In an episode of the animated series *South Park*, one of the characters has a Trapper Keeper notebook that becomes sentient and travels to Cheyenne Mountain to absorb NORAD's supercomputer, wreaking devastation along the way. Cheyenne Mountain was the primary backdrop for the 1980s cult classic *Wargames*, in which a teenager accidentally hacks into the NORAD system and starts playing the game "GLOBAL THERMONUCLEAR WAR," which he later finds out is real.[28] *Wargames* portrays the COC as high-tech yet vulnerable, although its real-life counterpart was thought too old-fashioned to be accurately depicted in the film. A large portion of the movie is staged in a Hollywoodized version of the Combat Operations Center. This is unsurprising, as the control room often serves as "the public face of an otherwise invisible empire," one which commands authority while also encouraging speculation as to exact operations.[29] Command control centers were often imagined to be more sophisticated than their reality. In fact, *Wargames* screenwriters noted in a director's commentary of the film that they had to make the COC set look more technologically

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[28] For additional examples (although some are a stretch), see: Ben Mitchell, "From 'War Games' to 'Interstellar': NORAD's bunker is a film favorite," *USA Today*, 12 June 2015, accessed, 12 January 2016, http://www.usatoday.com/story/news/2015/06/12/cheyenne-mountain-norad-pop-culture/71074868/

[29] Stuart W. Leslie, "Spaces for the Space Age: William Pereira's Aerospace Modernism" in Peter J. Westwick, ed., *Blue Sky Metropolis: The Aerospace Century in Southern California* (Berkeley, CA: University of California Press, 2012), 153.

sophisticated and futuristic than the real one in order to meet public expectations. A commander of the Air Force Cyberspace Command who was once stationed at NORAD saw the movie and recalled wondering, "'Gee, where can we get such cool-looking displays?'…It required us to all of a sudden say, 'If it really can look like this, why doesn't it?'"[30] After significant updating of the COC, a journalist visited the site in 2009 and described the layout to his readers as "recognizable from the movie *Wargames* and the *Stargate* TV series."[31]

Lastly, the Blue Cube is largely absent from popular culture, which is telling in itself.[32] The Air Force, however, never obscured its existence. If the US military or CIA actually wanted to keep secret installations *secret* during the Cold War, perhaps we have yet to be made aware of a truly classified project from the Cold War era. The gradations of concealment shown here, however, showcase the paradox faced by military and political leaders when deciding how much of each site to unveil. For example, if you

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[30] Scott Brown, "Wargames: A Look Back at the Film That Turned Geeks into Phreaks and Stars," *Wired*, 21 July 2008, accessed 7 January 2016, http://www.wired.com/2008/07/ff-wargames/ ; There are a number of other such instances in which life imitates art. For example, while the design of the bridge aboard the original Star Trek *USS Enterprise* was based on the bridges of contemporary naval vessels, news articles in 2013 accused the NSA director of modeling its "Information Dominance Center" after the bridge of Star Trek's Starship *Enterprise*. It looks eerily similar. See Glenn Greenwald, "Inside the mind of NSA chief Gen Keith Alexander," *The Guardian*, 15 September 2013, accessed 8 December 2015, http://www.theguardian.com/commentisfree/2013/sep/15/nsa-mind-keith-alexander-star-trek ; "NSA director modeled war room after Star Trek's Enterprise," *PBS*, 13 September 2013, accessed 8 December 2015: http://www.pbs.org/newshour/rundown/nsa-director-modeled-war-room-after-star-treks-enterprise/

[31] Daniel Terdiman, "NORAD's alternate command center illustrated," *CNET*, 7 August 2009, accessed 8 January 2016, http://www.cnet.com/news/norads-alternate-command-center-illustrated-10305509/

[32] This does not mean, however, that sites stayed out of public memory (as would be argued by Mihir Pandya, who believes that there is little contemporary interest in the aerospace past of California due to the covert nature of stealth programs). Pandya does astutely note, however, that many high-technology, secret centers were nested within public spaces, as was the Blue Cube just off the Silicon Valley freeway. See Mihir Pandya, "The Vanishing Act: Stealth Airplanes and Cold War Southern California," in Peter J. Westwick, ed., *Blue Sky Metropolis: The Aerospace Century in Southern California* (Berkeley, CA: University of California Press, 2012).

really do not want a command center to get nuked, instead of locating the command center in a hardened site, you could just make sure no one knew about it. The Blue Cube remained relatively unknown until the 1990s and exists in historical obscurity today, which suggests that spaces could be made more secret than others. Even the Blue Cube, however, was a known space and its memorable architecture actually drew attention to its location. So while secrecy was a strategic option, there are no examples of truly secret command and control centers from this period that have subsequently been declassified and come to light, at least for now. These spaces, ranging along a spectrum of concealment, highlight the irony of secrecy in an open political system.

The built environment created to facilitate the nation's improving air and space systems dramatically changed the American landscape. These spaces are cultural markers of the Cold War, and their designs allow us to discover which images were being projected in the fight for global leadership. For example, the brutalism of Cold War buildings—particularly prevalent in Southwest Washington, DC—reminds residents of a past time when retreat to an underground fallout shelter seemed like a real possibility. These spaces are cold and severe, "characterized as they are by bold, rectilinear masses in exposed, rough concrete."[33] Similarly, command and control center architectural forms produced cultural meanings and reflected contemporary anxieties.

Parallels exist between Cold War command and control centers and civil defense initiatives. The "headquarters" aesthetic might have been so pervasive, in fact, that it

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[33] David Monteyne, *Fallout Shelter: Designing for Civil Defense in the Cold War* (Minneapolis, MN: University of Minnesota Press, 2011), xii.

fueled the proliferation of smaller HQs (shelters).[34] This is not what actually happened, and one can deduce a number of possibilities for why this was not the case. Perhaps the public had faith in the ability of command centers to deter the enemy (because if a first-strike were launched against the United States, the response capability was to launch a massive retaliatory attack, not to intercept an incoming weapon). Or perhaps people doubted the efficacy of the threat of Mutually Assured Destruction and, further, did not believe in the possibility of surviving a nuclear attack, even if one got into a fallout shelter. Judging from satirical popular culture responses to the Soviet denotation of an atomic bomb, hardly anyone believed that "duck and cover" offered protection from a nearby nuclear blast (and forget a direct hit). The public found itself caught between feelings of faith in the military and "skepticism of its protective power."[35]

Kenneth Rose outlined the situation in *One Nation Underground*, in which he argues that the public did not buy into the government's shelter program. The Gaither Report had recommended building a national system of shelters, but the Eisenhower administration's policy advocated a DIY approach (or, Do It If You Like). Under President John Kennedy, however, federally orchestrated civil defense became a priority.[36] Americans appeared willing to fight a war with the Soviet Union, but they were hesitant to take measures to protect themselves, such as construct fallout shelters.[37] Less

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[34] I am certainly not the first person to call attention to the parallels between command centers and fallout shelters. Recently, journalist Eric Schlosser pointed out the similarity in his condemnation of the efforts of the Strategic Air Command, in Eric Schlosser *Command and Control: Nuclear Weapons, the Damascus Accident, and the Illusion of Safety* (New York: Penguin Press, 2013).

[35] Laura EcEnaney. *Civil Defense Begins at Home: Militarization Meets Everyday Life in the Fifties* (Princeton, NJ: Princeton University Press, 2000), 38; 41.

[36] Rose, 29; 34; 37.

[37] Ibid., 10.

than half a percent (0.4%) of Americans constructed fallout shelters. Even though shelter construction initially received support from the popular press, such as *Life* magazine, the fallout shelters quickly came under attack, and these bunkers became "popular objects of vilification."[38] Secret bunkers for politicians were built, such as under the Greenbrier resort in White Sulphur Springs, West Virginia but, like their military counterparts, which housed aircraft and ordnance, these shelters were hardly secret. The public saw shelter-building as war-mongering, another element prolonging the arms race, and the moral implications of possible shelter life led to these spaces becoming a metaphor for shame and barbarism.[39] These conceptions were mirrored in the 1961 *Twilight Zone* episode, "The Shelter," in which neighbors turn on one another after a Civil Defense announcement of impending nuclear attack. The family members who own the shelter lock themselves inside, only to have friends beat down the door in a hysterical effort to find safety. When the warning turns out to be false, the intruding neighbors are both relieved and ashamed. Writer of the episode Rod Serling later said that although he had considered building a fallout shelter, he decided against it: "It's my feeling now that if we survive, what are we surviving for? What kind of a world do we go into? Ya know, if it's rumble and poison water, and inedible food, and my kids have to live like wild beasts, I'm not particularly sure I want to survive in that kind of a world."[40]

Many Americans feared that technology had gotten out of control, but their leaders reassured them with promises of "good" technology:

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[38] Ibid., 70; 81; 187.
[39] Ibid., 114; 180; 93; 112.
[40] Bob Crane radio interview with Rod Sterling, 1961, accessed 28 January 2016, https://www.youtube.com/watch?v=TghYXxm3wq8

> More frequently, as in the years after 1947, it has been those in the Pentagon, the think tanks, the military industries, and the White House who have played upon our fear to win us over to their conviction that somewhere down an endlessly receding road—or somewhere out in space—exists the definitive technological solution that will free us of our fear at least and make us safe and secure in a nuclear world.[41]

Further advances in technology and communications were employed to try to compensate for the collective anxiety Americans experienced while living in an age of nuclear weapons, but not everyone believed that more technology was the solution. Rose challenges a popular notion that Americans in the postwar years were a "simpler" people who naively believed that the government—or a DIY fallout shelter—would save them from nuclear Armageddon. The reality, as Rose argues, is that most Americans knew exactly what time is was, but expressed their fatalism in different ways than we might do today.[42] Thomas Pynchon, the Boeing-tech-writer-turned-American-novelist noted that in his writing,

> Our common nightmare The Bomb is there too…There was nothing ever subliminal about it, then or now. Except for that succession of the criminally insane who have enjoyed power since 1945, including the power to do something about it, most of the rest of us poor sheep have always been stuck with simple, standard fear. I think we all have tried to deal with this slow escalation of our helplessness and terror in the few ways open to us, from not thinking about it to going crazy from it.[43]

In fact, the true purpose of fallout shelters was largely psychological, as the "presence of shelters, complete with food, water, and clothing, gives a sense of security to the

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[41] Paul Boyer, *By the Bomb's Early Light: American Thought and Culture at the Dawn of the Atomic Age* (New York, NY: Pantheon Books, 1985), 106.

[42] Ibid., 188.

[43] Thomas Pynchon, *Slow Learner: Early Stories* (Boston, MA: Little, Brown and Company, 1984), 18.

people…[and]…merely constructing shelters was a useful exercise in promoting discipline and therefore in maintaining social order and cohesion. The motivations for building the immense bunkers…[had] little or nothing to do with the belief that the structures [would] make a real difference in the event of nuclear war.”[44] As with the global command and control centers, image-making was a key response to assuaging Cold War anxiety.

By the 1970s, fear of technology had reached new heights. The film *Colossus: The Forbin Project* (1970) depicts two war-mongering, sentient computers that are no longer under human control. The command and control room is depicted as a space in which people are powerless to stop these unhinged machines. One reason that confidence in centralized command and control of nuclear weapons and their delivery systems had waned is because their guardians had become the potential bringers of destruction. Over the years, there were a number of broken arrows, or accidental events that involved nuclear weapons but that did not create the risk of nuclear war, as well as potential Pinnacle or NUCFLASH false alarms, which *could have* resulted in a nuclear confrontation. A number of authors and journalists have penned (often somewhat sensationalist) accounts of how truly *out of control* nuclear weapons development and deployment was during the Cold War era.[45] For example, Cheyenne Mountain systems generated false missile warnings on more than one occasion. In 1979, a computer

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[44] Quoting William Colby in William E. Burrows, *Deep Black: Space Espionage and National Security* (New York: Random House, 1986), 17.

[45] For example, see Eric Schlosser, “Almost Everything in ‘Dr. Strangelove’ Was True, The New Yorker, 17 January 2014, and Eric Schlosser, *Command and Control: Nuclear Weapons, the Damascus Accident, and the Illusion of Nuclear Safety* (New York: NY: Penguin, 2014).

communications failure sent out warning signals to USAF command posts worldwide.[46] This happened again on 2 June 1980, when a technician loaded a test tape but forgot to switch the system status to "bypass." Both times Pacific Air Forces had nuclear bombers in the air. SAC did not follow procedure (that is, it did not set massive retaliation into effect), because officers knew that these were false alarms; SAC had its own sensor reports that did not match those of NORAD. Thankfully, human operators could determine that the warnings were inaccurate, but such mistakes held a real possibility for global disaster, which fueled American collective anxiety over the bomb.

As a result of declining confidence, centralization was being quickly abandoned in favor of widely dispersed and redundant command centers; there was a collective loss of faith in the effectiveness of global control from one location. Over time, each of these control centers was replaced or its responsibilities diminished. Jennifer Light's central argument in *From Warfare to Welfare* is another example of the transition period discussed here, one in which massive, expensive, centralized systems experienced a loss of confidence from both the military and the American public. As she writes, "Beginning in the mid-1960s, the Vietnam War and the Apollo Program became symbolic targets for city planners and managers who argued that society's spending priorities were misplaced during an era of urban crises at home."[47] This was the beginning of détente, and the forcefully sold, government-packaged reassurance of Cold War defense centers was no

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[46] Matthew Hansen, "Inside bunker, SAC crew feared WWIII was on its way," *Omaha.com*, 8 June 2014, accessed 8 January 2016 http://www.omaha.com/eedition/sunrise/articles/inside-bunker-sac-crew-feared-wwiii-was-on-its-way/article_2ad53a3d-03a6-54b0-a46c-0a4fa330027f.html

[47] Jennifer S. Light, *From Warfare to Welfare: Defense Intellectuals and Urban Problems in Cold War America* (Baltimore, MD: Johns Hopkins University Press, 2005), 2; 4.

longer seen as essential. Certainly, these spaces began to be represented in different—less triumphalist, even satirical—terms in popular media, pointing to an eventual widespread skepticism of centralized American military structures.

CHAPTER 2. Innovating NASA's Mission Control Center

Secrecy Classification: OFFICIAL

"All in all it was quite an undertaking. The Mission Control center had three floors, each about 200 ft. on a side and each stuffed with equipment that was substantially completely interconnected throughout the building and through radio, television and phone lines to most of the rest of the world."

"Continuing on with what the floors of the Mission Control Centers looked like, on each floor, surrounding its centrally located [Mission Control Operations Room], were special rooms where the assisting teams for each flight controller were located….All in all, it was a honeycomb of small offices all wired together and all sucking data from the same source with separate straws. It was our job to make it all work."

- Walter LaBerge, Manager of Philco Houston Operations[1]

NASA's Mission Control Center in Houston epitomized how modern computing and communications technologies enabled exploration of previously inaccessible environments in the middle of the twentieth century. The Mission Control Center, or MCC, began directing spaceflight operations in 1964, and its architectural design soon became a template for any organization that wished to project an image of confidence and technological savvy. Operators at workstations retrieved data from the most advanced technological tracking systems of the day in real time, and massive screens filled with aggregate data faced these stations to help facilitate complex missions. This aesthetic has its roots in NASA and military command and control room predecessors, such as the headquarters of the Strategic Air Command; however, the construction of the MCC

[1] Unpublished memoirs of Walter LaBerge, *For My Children*, 1996.

also required new design approaches particular to the needs of the space organization, which were innovated by NASA staff and contractors.[2] The MCC in Houston became the most recognizable of these spaces, solidifying this command center archetype in public consciousness.

The MCC also served as a symbol of political and military authority during the Cold War. When considering the economic impact and legacy of the American spaceflight program, it becomes clear that its value cannot simply be expressed in fiscal terms. Instead, it needs to be measured in terms of the prestige, faith, trust, and hope for the future its organizational structure and technological acumen instilled in the American public. The modernist, efficient styling of the Mission Control Center allayed domestic fears while showcasing engineering prowess. Its architecture both symbolized and physically embodied the nation's potential to triumph over the USSR through its support of spaceflight feats of technological sophistication. These demonstrations also carried more implicit threats. As is true today, to innovate in aerospace technologies strongly correlates with a nation's economic, political, and military dominance. While no one at NASA ordered that the MCC be designed specifically with these goals in mind, its public relations team was happy to provide photos of the Center to the media which highlighted NASA’s confidence and wizardry. This attention increased the value of the center in

[2] Tracing the lineage from the very first inception of what one might regard a “war room” or “control room” or “operations room” would require a book-length investigation. My intention is not dismiss the fact that prior examples of spaces of control existed; these prototypes and archetypes certainly had bearing on the composition of the spaces examined here. What is new about these spaces, and what was not present until the middle of the twentieth century, was the ability for a headquarters to speak to far-flung subcommand units and issue orders in real time. This ability required and resulted in the architecture discussed here. This investigation is not about the evolution of the war room but of the novel emergence of a type of space that embodied a particular ideology in addition to its ostensibly primary functions.

terms beyond its operational functions. The MCC became a three-dimensional advertisement for a new organization dependent on political support and taxpayer dollars.

Figure 1. Operators monitor consoles and large displays at the front of the room during Apollo 8. Source: NASA

Literature on NASA's Mission Control Center in Houston focuses almost exclusively on how people within the room supported spaceflights.[3] Certainly, the achievement of landing a man on the moon, the dramatic rescue of three astronauts during the life-threatening circumstances of Apollo 13, and other accomplishments deserve attention. Ground controllers proved that support from Earth could save lives in space, and historians should recount these instances. This approach, however, neglects

[3] One author examines ground facilities of NASA, ESA, and JPL, but is concerned with how these places facilitated spaceflight, not their sociocultural impact. See Michael Peter Johnson, *Mission Control: Inventing the Groundwork of Spaceflight* (University Press of Florida, 2015).

one of the Mission Control Center's most crucial aspects: the innovation of Mission Control itself. In the early 1960s, new communications technologies and high-speed computer processors made the creation of this high-tech ground control station possible. Its design assembled technologies which enabled men to tackle real-time control of space missions. After the initial forays into space undertaken during the Mercury missions, NASA administrators recognized the need for a more technologically sophisticated mission control center to support the Gemini and Apollo programs. They knew that computers, displays, and communications equipment would be critical components of the new center, but they did not have any (unclassified) existing model on which to base its design. NASA delegated this task to contractors, primarily Philco Western Development Laboratories.[4]

Philco employees conceived of the space, prioritized layout, and preserved a hierarchy from the previous center.[5] Philco's design resulted in the most famous iteration

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[4] For the sake of readability, I use "Philco" to refer to the primary contractor in the design of NASA's Mission Control, even though this designation is not completely accurate. Philco was an electronics company that was acquired by Ford in 1961, leading to the new name of Philco-Ford. Soon after, the Western Development Laboratory was created as a division within Philco-Ford (Philco-Ford WDL) that fulfilled Ford's desire to win aerospace-related contracts in the 1960s. When NASA contracted Philco-Ford WDL to design the Mission Control Center in Houston, a subdivision of Philco-Ford was created to support the project—Philco Houston Operations—although documentation for the initial design refers to the contractor as Philco-Ford WDL. To further complicate this business history, in the late-1970s, Philco-Ford and its subdivisions were renamed Ford Aerospace. Philco employee of almost 20 years (1965-1983), John Abbitt, articulated the confusion in his memoirs: "In 1975 the corporation changed its name to Aeronutronic Ford and in 1976 to Ford Aerospace & Communications Corporation (FACC). Philco Houston Operations (PHO) was transferred from WDL to the Engineering Services Division, and we became Space Information Systems Operations (SISO), replacing the PHO name but still belonging to Ford Motor Company!!" He did, however, also note that "During all these management name changes the local operation was essentially autonomous, while fitting into the overall financial structure of the corporate staff. Little notice of these changes was required by NASA (our customer), at least during my tenure." Unpublished memoirs, *Life and Times of Colonel Charles W. Abbitt, United States Air Force, Retired* (1 March 2001), 30; 21.

[5] This paper does not privilege the "genius" architect or scientist as the creator of command centers, and rightfully so: in the age of Big Science, the lone inventor had largely disappeared. More often,

of a particularly mid-century technology: the global Control Center. The MCC in Houston, filled with consoles and computers and displays of real-time data, became iconic. It was reproduced by both military and civilian operations, from American defense headquarters to casino surveillance rooms. Historians have neglected the roles that contractors have played (and currently play) in the American space program. NASA has long been one of the largest customers of the American aerospace industry, creating demand for, and to a certain extent subsidizing, aerospace companies.[6] The history of the Mission Control Center allows for a number of previously ignored connections to be recounted. High-profile contractors designed a center that would not only be functional but would wow onlookers both domestically and abroad.

The First Mission Control

Christopher "Chris" Columbus Kraft, Jr., best known as Flight Director during the first decade of the agency's activity, is often credited with the design of NASA's control centers.[7] The first American room that was dedicated to tracking space capsule movements was called the Mercury Control Center (MCC), and it was built in a former photography warehouse at what is today the Kennedy Space Center in Cape Canaveral,

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teams of people worked together to create new technologies, and that was certainly the case for the massive technology of the command center. This remains, however, a story about people.

[6] The aerospace industry's dependence on the federal government has been examined by a number of authors. For example, see Ann Markusen, et al., *The Rise of the Gunbelt: The Military Remapping of Industrial America* (New York: Oxford University Press: 1991).

[7] Kraft, however, credited the Philco and IBM teams for the design of Mission Control Center in Houston. Henry C. Dethloff, *Suddenly, Tomorrow Came: A History of the Johnson Space Center* (NASA SP-4307, 1993), 86.

Florida in 1959.[8] Kraft recalled in his memoirs that he did not know who started calling the room *mission* control, as "MCC had meant Mercury Control Center to us, but *mission* control was okay, too. It had a nice ring to it."[9] Kraft had strong ideas about the proper layout and functionality of this room. He did not want the command center to be a site of mere passive surveillance, but instead the space needed to allow people to actively participate in the missions and remotely support flights.[10] Kraft and his operations team considered the types of consoles they would need, including: an environmental systems console, which would be monitored by a flight surgeon; a systems console to be watched by an engineer; a communications console, whose operator would relay all messages between the MCC and a capsule (which would most likely be manned by an astronaut); a console from which to keep track of the worldwide network of remote sites, to be monitored by someone from the Department of Defense; a console to monitor the rocket; a flight director's console; and a procedures console, which was the "hall monitor" and kept track of every procedure for every console in the configuration. Kraft noted that this last position would later be filled by his "alter-ego," or right-hand man (even though he would be physically located on Kraft's left side).[11]

Sensitive to the needs of bureaucracy, Kraft noted that additional consoles would be needed, even if they were not directly related to flight operations. Each operations director would need a place, as would senior officials from the Department of Defense, a

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[8] Interview with James M. Satterfield by Robert B. Merrifield, 13 March 1968, 5; Chris Kraft, *Flight: My Life in Mission Control* (New York, NY: Plume, 2002), 87.

[9] Kraft, 124.

[10] Ibid., 100; Ground control of the vehicle was not possible in the Mercury Control Center. Once the capsule was launched, ground control could only communicate with the vessel. Dethloff, 55.

[11] Kraft, 100-101.

public affairs officer, and contractors. All of these positions would work together to remotely monitor—and eventually control—spaceflight from a central location. A separate, adjacent command center was responsible for recovering the capsules.[12] After dedicating so much careful thought to the design of Mercury Control, Kraft was understandably angered when rocket guru and German émigré Wernher von Braun said that ground control of a space flight was a "dumb idea." Kraft recalled that if von Braun had said that phrase one more time, he might have punched him.[13] This disagreement underscores the originality of Kraft's ambition for ground control of spaceflight.

Figure 2. The Mercury Control Center at Cape Canaveral utilized design principles later used in Houston. Source: NASA

[12] Ibid., 102.
[13] Ibid., 103.

To supplement the consoles, contracted employees from Philco and Western Electric designed and built the huge, front wall display for Mission Control in Florida. It was a large map of the world, which tracked a capsule's progress as it was detected by different tracking stations around the globe. Kraft was initially skeptical of its utility. He recalled, "It was a beautiful display. I understood what it was for, but I still thought it was superfluous." He quickly changed his mind, however, admitting that "[t]he map was filled with vital information. The graphic format made it easy to grasp. A Mercury capsule symbol moved along the sine wave, or ground track. I knew instantly where it was."[14] Flight controller, and later Flight Director, Gene Kranz remembered the map in somewhat less glamorous terms, recalling watching a "toylike spacecraft model, suspended by wires, mov[ing] across the map to trace the orbit."[15]

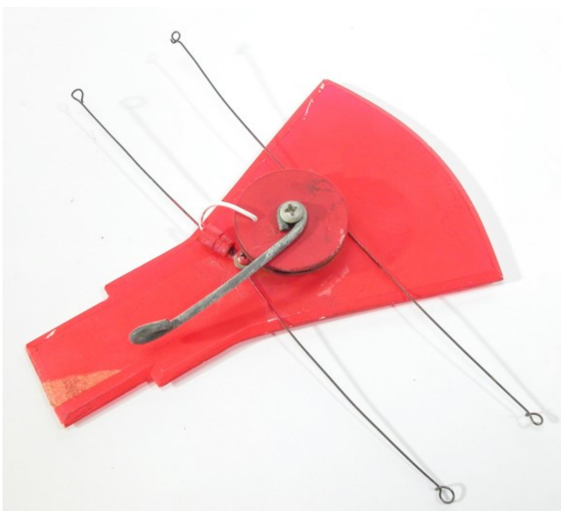

Figure 3. This tracking icon, shaped like a Mercury capsule, was used to indicate the position of the spacecraft on the front display board in the Mercury Control Center. It is now in the collections of the National Air & Space Museum in Washington, DC. Source: NASM

[14] Ibid., 133.
[15] Kranz, 22.

For the Mercury program, NASA was dealing with simple, one-man spacecraft. Once in space, there were no extravehicular activities (or “spacewalks”), nor any maneuvering, guidance, or rendezvous. The missions of Gemini and Apollo would require all of these tasks.[16] And even Project Mercury’s relatively simple orbital missions, such that of John Glenn, first American in orbit, necessitated constant updating of equipment and procedures. The communications system was particularly limited, as there was no global voice network at the time; remote monitoring sites took up to fifteen minutes to respond to Mercury Control Center queries.[17] The upcoming Gemini missions would demand more technologically complex monitoring, and the system would have to be completely retooled. NASA engineers and contractors recognized that off-the-shelf electronics gear would be insufficient to control future missions.[18] They would need to custom-design an entirely new control center, and a cornerstone of this upgrade would be the computer system.

The deficiencies of the Mercury Control Center computer further underscore the problem. The machines that ran the system at Cape Canaveral were actually located hundreds of miles away, in an IBM building on Washington, DC’s Pennsylvania Avenue. Tracking data was sent north from Florida, the computers in DC processed trajectories, then sent this information over telephone lines back to the Cape, and finally the information was available for display on the control center’s plot board. Glynn Lunney,

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[16] NASA Johnson Space Center Oral History Project, Oral History Transcript, Glynn S. Lunney interviewed by Roy Neal, Houston, Texas, 9 March 1998, pp. 12-26 – 12-27.

[17] Gene Kranz, *Failure Is Not An Option: Mission Control From Mercury to Apollo 13 and Beyond* (New York, NY: Simon & Schuster, 2009), 70.

[18] Dethloff, 85.

the Flight Dynamics Officer at Mercury Control, allowed that he found it “a relatively crude system.” There were not any television screens to display telemetry data, only mechanical meters.[19] For the new center, this outdated meter system would be transitioned to a digital computing schema. This proposed upgrade worried some operators. NASA controller Rodney “Rod” Loe recalled that NASA men who had worked on Mercury felt more secure with viewing data on meters, because they were “hard meters, and the meters had limits, you could set [them]. You [could] pull a tab down, and then if the needle got above that tab, you’d get a red light.” This physical interaction with the consoles was important to its operators. As Loe explained, with digital computers, “Here was another piece of equipment that could fail, that would be between us and the spacecraft, and would cause us to lose data.” It was a concern that paralleled those of pilots transitioning to instrument flying—users needed to learn to trust the computers. To ease the transition, when computers replaced the meters in the later control center, data was displayed on digital representations of meters. Operators later admitted that it was silly to have the computer depict data on graphical meters, but it illustrates why the transition to a digital format was not an obvious choice.[20]

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[19] Glynn S. Lunney interviewed by Roy Neal, NASA Johnson Space Center Oral History Project, Houston, Texas, 9 March 1998, pp. 12-11.

[20] T. Rodney “Rod” Loe interviewed by Carol L. Butler, NASA Johnson Space Center Oral History Project, Houston, Texas, 30 November 2001, pp. 1-2; A great source for the exacts of the transition to Houston can be found in the in-house magazine, the *Roundup*!, which are archived online at: http://www.jsc.nasa.gov/history/roundups/roundups.htm. For example, one article details how a Gemini simulator went on display at the old Mercury Control Center after the move to Houston, thus initiating public exposure to these spaces of control. “‘Old MCC’ At Cape Refitted with Gemini Mission Simulator,” *The Roundup*! 8 January 1964.

Moving to Houston

The change from meters to digital displays exemplifies the scope of changes needed within the Mission Control Room to support the next decade of planned NASA missions. The number of upgrades required was too large to implement within the existing space in Cape Canaveral. Kraft noted, "To manage and control missions to the moon, we'd need a new and bigger center, along with changes still unknown in the worldwide tracking network."[21] In 1961, Chris Kraft, along with fellow NASA employees Dennis Fielder, Tec Roberts and John Hodge, initiated a study to determine the location for a new command center.[22] After rejecting a move to the Goddard Space Flight Center, due to that facility's small size and managerial conflicts, Kraft and his team looked to other potential sites. NASA administrators required that the location include: "access to water transportation by large barges, a moderate climate, availability of all-weather commercial jet service, a well established industrial complex with supporting technical facilities and labor, close proximity to a culturally attractive community in the vicinity of an institution of higher education, a strong electric utility and water supply, at least 1000 acres of land, and certain specified cost parameters."[23] Houston fit the bill on almost all of these counts, and it surely did not hurt that it was located within Vice-President Lyndon Johnson's home state of Texas, as well as in the congressional district of Albert Thomas, the chairman of the body that oversaw NASA's budget.[24] The city of Houston enthusiastically welcomed the space agency and was particularly pleased that local firms

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[21] Kraft, 144.
[22] Dethloff, 85.
[23] Ibid., 36; 38.
[24] Dethloff, 41; Kranz, 81.

received 29 of NASA's 32 subcontracts for the design and construction of the site.[25] On 19 September 1961, NASA announced that a new "spaceflight laboratory" would be located in Houston on 1000 acres of land that was donated to the government by Rice University (another 600 acres were purchased to give the site direct access from the highway).[26] Gene Kranz later admitted that he initially thought that the control center should have remained near the launch site in Cape Canaveral, but it was convenient to be located near a feeder university like the University of Houston, from which NASA could recruit young people with technical training in subjects like cryogenics and computers, and who lent a "youthful exuberance" to the workplace.[27]

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[25] Stephen B. Oates, "NASA's Manned Spacecraft Center at Houston, Texas," *The Southwestern Historical Quarterly*, Vol. 67, No. 3 (January 1964), 370.

[26] Dethloff, 33; 48.

[27] Eugene F. Kranz interviewed by Roy Neal, NASA Johnson Space Center Oral History Project, Oral History Transcript, Houston, Texas, 19 March 1998: 12-11; 12-14.

Figure 4. Overhead view of the Manned Spacecraft Center in Houston. Source: NASA.

The Manned Spacecraft Center (MSC), as NASA officially named the complex, was built about 28 miles south of downtown Houston, close to the shore of Clear Lake, which provided access into Galveston Bay.[28] Within the 1600-acre site, NASA built Building 30, which housed the Mission Control Center, in November 1964.[29] This three-story structure consisted of (1) a Mission Operations Wing, (2) an Operations Support Wing, and (3) an interconnecting Lobby Wing. The Mission Operations Wing was built by the Army Corps of Engineers and a general contractor, ETS-Holden-Galvin. The

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[28] Kraft, 171.
[29] "Real Property Record – Buildings," from "MCC History Notes.pdf," JSC History Office.

Corps of Engineers selected the architect and construction firms. Their choice—the Texas firm Brown & Root and the designer Charles Luckman of Los Angeles—received a $1.5 million design contract for the center.[30] Once the building's exterior structure was in place, the interior space was ready to be outfitted with computers, communications links, and consoles.

To meet Gemini mission requirements, the new Mission Control Center needed real-time data displays. Flight controllers would be stationed at consoles, as they had been at the center in Florida, at which they would receive critical mission information via computer screens. This space was officially named the Mission Operations Control Room (MOCR), and there were actually two of them: identical and located on the second and third floors of Building 30.[31] These Flight Control Rooms (or FCRs, pronounced 'Fickers') were where flight controllers got information from personal console computer displays, or from projected displays on the wall at the front of the room, where they would work "feverishly at their consoles, headsets in place." The third floor FCR was primarily designated to monitor the Department of Defense payloads, but either space could be used as NASA's manned spaceflight mission control, or two missions could be conducted simultaneously.[32] These innovative spaces, each approximately 100,000 square feet, housed the people who directed America's space program. These rooms became commonly known among the public as "Mission Control."[33] While the accomplishments

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[30] Dethloff, 48.

[31] "MCC: Mission Control Center," from "MCC History Notes.pdf," JSC History Office.

[32] "NASA Facts: Mission Control Center," from "MCC History Notes.pdf," JSC History Office.

[33] In NASA and Philco documentation, it is also referred to as the Integrated Mission Control Center (IMCC). The name is shortened for both brevity and adherence to common usage.

of the Mission Controllers have been well-documented in popular media, its origin story has remained largely untold. Its construction was, in fact, an investment in innovation on the part of NASA, one that should be largely credited to the contractors who created a control room for the future.

Remembering the Contractors

Prior to the construction of Building 30, NASA hired two contractors to design the computer system and operational layout of Mission Control. In 1962, IBM was awarded the Real Time Computer Complex (RTCC) contract to build a complex digital command system which could control the Gemini spacecraft, its target vehicle Agena, and the Apollo craft. The final design consisted of five IBM 7094 IBM main processors using a customized IBM operating system. This system processed "telemetry, trajectory and command data. The data was routed to recorders, meters, and the digital-to-TV displays."[34] Also in 1962, Philco-Ford was contracted to perform a development study for "Manned Space Flight Operation Control and Support" in Houston. Primarily a human engineering study, it explored how data processing and display systems, which would be powered by the underlying IBM architecture, would work together in a holistic way that promised missioned success.[35] Philco may seem an odd candidate for designer of NASA's Mission Control Center, but the company—once a pioneer in early radio and television products—had changed hands and focus by the 1960s. Philco had begun

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[34] Letter from Robert D. Legler to John Getter titled "Responses to Questions About Historical Mission Control," 7 April 1997, from "Facts About MCC.pdf," JSC History Office.

[35] Transcript of oral history interview with Walter LaBerge, conducted at behest of NASA, 31 July 1968. Walter edited the transcript and sent it to Robert B. Merrifield at the Manned Spacecraft Center on 4 December 1968, 1. Courtesy Philip LaBerge.

cultivating aerospace contacts Ford Motor Company acquired the enterprise in December 1961.[36] A former employee speculated that Ford's acquisition of Philco was a marketing ploy meant to cultivate a high-tech image to sell to the well-funded space program.[37] Regardless of the company's motivations, the strategy worked. In 1963, Philco-Ford Western Development Laboratories was awarded the NASA contract for the design, development, implementation, maintenance, and operation of the Mission Control Center in Houston (MCC-H). This contract required that Philco-Ford WDL establish the Philco-Ford Houston Operations (PHO), which would be awarded further contracts for maintaining and upgrading the center in the following years.[38] In 1965, for example, Philco replaced almost 400 black-and-white scanners with color televisions in Mission Control.[39]

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[36] Carlos A. Altgelt, "A Brief History of Philco," accessed 2 November 2012 at URL: http://www.oldradio.com/archives/hardware/philco.htm; Early history available in William Balderson, *"Philco": Autobiography of Progress* (New York: The Newcomen Society, 1954); In 1963, FMC folded its Aeronutronic Company into Philco; the larger company was rechristened Philco-Ford in 1966.While Philco was sold to General Telephone and Electric in 1974, the aerospace component of Philco-Ford, which was responsible for the design of Mission Control, became Aeronutronic Ford Corporation in 1976, then Ford Aerospace the following year, and was eventually sold to the Loral Corporation in 1990 (which was acquired by Lockheed in 1996).

[37] *For My Children*, the unpublished memoirs of Walter LaBerge (1996): 131. Courtesy Philip LaBerge.

[38] Ray Loree, "MCC Development History," 1990, p. 1, from "Ray Loree MCC History.pdf," JSC History Office; "Contractual History of Major Implementation and Operations Milestones," 10 January 1985, from "Contractual MCC History.pdf," JSC History Office.

[39] Press Release, Ford Motor Company, "Philco Corp. – Mission Control Center in Houston – Dr. W. B. LaBerge," no date, Ford Motor Company LaBerge Presentation press release no date.pdf. Ford Motor Company Archives.

Figure 5. Photo signed by Chris Kraft sends best wishes to Walt LaBerge. Courtesy: Philip LaBerge

So much support was needed, in fact, that a headquarters for Philco Houston Operations was built near the Manned Spacecraft Center, which accommodated approximately 500 employees.[40] Philco advertisements from the time detailed visions of the future as a time when many tasks would be automated by computers and processes would be visualized on gigantic television screens.[41] NASA directors, such as Chris Kraft, held the same sort of vision for their Mission Control, although they insisted that responsibilities be delegated to particular flight consoles in the same way that they had

[40] Press Release, Philco Corporation News Department, 17 March 1965, Philco Mission Control Center Facts and Figures press release 3-17-1965.pdf, Ford Motor Company Archives.

[41] "Philco-Ford," accessed 2 November 2012, http://davidszondy.com/future/Living/ford_philco.htm

been at the Mercury Control Center.[42] It was Philco's job to implement this vision in Houston. The project was spearheaded by Philco's program director for the design of the MCC, Walter "Walt" LaBerge. Born near the north side of Chicago in 1924, he was inclined toward a liberal arts education, especially after covering sports for his high school newspaper, but his father convinced him that pursuing an applied science education at Notre Dame would be more prudent from a job security standpoint.[43] LaBerge went to the university in 1941 as a physics major, and also enrolled in Notre Dame's ROTC (Reserve Officers Training Corps) program. In July 1943, due to the escalation of the Second World War, he and his classmates became full-time Navy seamen. Upon graduation with a bachelor of Naval Science degree in January 1944, LaBerge was commissioned and sent to active duty. After the war, he returned to Notre Dame to finish his Bachelors of Science degree in physics, and due to the opportunity afforded by the GI Bill, he decided to pursue a PhD in the field. After completing his graduate work, and due to his Naval Reserve status, he relocated to the Naval Ordnance Test Station, China Lake in the middle of the Mojave Desert. Walt noted in retrospect that jobs were lean, as physicists were not yet in high demand, as they would be after Sputnik ushered in the space race.[44] While at China Lake, Walt co-invented the

[42] For an impressive detailing of the functions of every console during the Apollo setup, see Lee Hutchinson, "Apollo Flight Controller 101: Every console explained," *Ars Technica*, 31 October 2012. Accessed 13 November 2015 http://arstechnica.com/science/2012/10/apollo-flight-controller-101-every-console-explained/

[43] His journalistic inclinations never faded, however, as his prolific writing in later years attests. *For My Children*, 1.

[44] This goes against conventional wisdom that the heyday for physicists began in and was sustained after the Manhattan Project. *For My Children*, 87.

Sidewinder heat-seeking air-to-air missile, for which he received much acclaim, and which brought him to Philco-Ford.

Figure 6. Walt LaBerge poses in front of an SR-71 Blackbird. Courtesy: Philip LaBerge.

Philco Research Laboratory in Philadelphia was contracted to manufacture the production version of the Sidewinder guidance unit. In 1957, the head of the Philco team asked LaBerge if he would be interested in joining him in a new Philco venture in Palo Alto, California; the company had recently received a contract from Lockheed in Sunnyvale that necessitated a local presence. Walt decided to leave government service and try his hand at a management position in the private sector. It was an exciting time to join the aerospace industry. In 1961, President Kennedy committed the nation to sending a man to the moon before the end of the decade, and the industry scrambled to design rockets, spacecraft, and ground launch and control systems. To secure the contract for the design of the Mission Control Center for Philco-Ford, LaBerge cited the company's impressive high-tech track record in a presentation given to NASA executives. He noted that Philco's Western Development Laboratories had developed *Courier*, the first active repeater satellite; had performed classified work for the Air Force; and had constructed military antennas and telescopes as part of a military communications satellite system.[45] He recalled the atmosphere in which he gave the presentation as quite intimidating. "[Chris Kraft] and his staff were clustered around an auditorium built like a gladiator's fighting pit," he wrote in his memoirs. "It was so much so that I almost blurted out as I began my presentation the traditional 'We who are about to die salute you.'"[46] Joking aside, LaBerge thought in retrospect that the selection officials at NASA chose Philco because they were convinced that the contractor could meet deadlines and would be easy to work with. The resulting contract was worth $33.8 million out of the total MCC cost of $100 million.[47]

LaBerge was named the general operations manager of Philco's Houston operation, for which he headed a task force which included scientists, engineers, technicians, and administrative personnel. He had a difficult time recruiting for this venture, probably because, as LaBerge admitted, "[Houston] was thought to be about the

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[45] Press Release, Philco Corporation News Department, 17 March 1965, Philco Mission Control Center LaBerge Presentation press release 3-17-1965.pdf. Ford Motor Company Archives.

[46] For My Children, 132.

[47] Ibid., 132. Press Release, Philco Corporation News Department, 17 March 1965, Philco Mission Control Center Facts and Figures press release 3-17-1965.pdf, Ford Motor Company Archives.

world's worst place to live."[48] NASA had the same problem; the hurricane-prone, humid area lacking in cultural amenities did not entice recruits. It soon became apparent that Walt's team was not large enough to complete the "low-tech, manually intensive" work of wiring connectors to computers to consoles and then making and verifying "literally a zillion connections."[49] Further, the Philco team initially did not have good relationships with IBM, the Real Time Computer Complex contractor. Walt mused that the computer company had a superiority complex and did not appreciate being subcontractor to Philco.[50] It was Philco's decision, however, that the RTCC used a five IBM 7094 configuration for Mission Control, instead of opting for its own systems, which resulted in a $36 million dollar contract for Big Blue.[51] James "Jim" Satterfield, an aerospace technologist for NASA, concurred that "[IBM] sure didn't want anybody like Philco telling them what to do."[52] It was necessary to cultivate a professional working relationship, however, as the computers and the display systems needed to be integrated. The project moved along after a slow start, and the Philco team soon was responsible for constructing one of the most iconic control rooms in American history.

While LaBerge's administrative acumen led to the successful completion of the Mission Control Room, other men played large roles in the technical design and implementation of technologies within the space. One was Otto G. Schwede, a German

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[48] Transcript of oral history interview with Walter LaBerge, conducted at behest of NASA, 31 July 1968. Walter edited the transcript and sent it to Robert B. Merrifield at the Manned Spacecraft Center on 4 December 1968, 12. Courtesy Philip LaBerge.

[49] For My Children, 133.

[50] Ibid., 135.

[51] James Tomayko, "Chapter 8: Computers in mission control," in *Computers in Spaceflight: The NASA Experience*, an e-book prepared by NASA, available at URL http://www.hq.nasa.gov/pao/History/computers/Ch8-1.html

[52] Interview with James M. Satterfield by Robert B. Merrifield, 13 March 1968, 22.

scientist brought to the United States after the Second World War as part of Project Paperclip. Born in 1912, Otto Schwede was one of 12 German scientists—primarily aircraft, rocket, and missile specialists—brought to work at the Naval Air Missile Test Center in Point Mugu, California in 1947. Schwede became Technical Director for the Range Instrumentation department there, and filed a number of patents during the 1950s, including the Angular Discriminating Ocular Device, an Engine Fuel Flow Regulator, and an Isotope Separator.[53] By 1960, all of these émigrés had left Point Mugu either to start their own companies or to work in private industry.[54] Along with fellow Paperclip Theodore Sturm, who had headed the Guidance Division at Point Mugu and had worked on the V-2 program in Germany, Schwede founded an industrial research laboratory, the Electronic Systems Development Corporation in Ventura, California. The company focused on special purpose digital and analog computers, solid state electronic devices, liquid rocket engine control malfunction protection systems, and other instrumentation and control systems. One former employee recalled that Schwede and Sturm were "brilliant guys."[55] With his credentials, is no wonder that Schwede was recruited by Philco to be Chief Engineer in Houston, responsible for designing the technical aspects of the Mission Control Center. LaBerge referred to Schwede as "a "crusty old German Paper Clip" while also asserting that he "truly enjoyed and trusted Otto, but most

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[53] United States Patent US2722862 filed 12 September 1949; United States Patent US2923129 filed 8 May 1953; United States Patent US2917628 filed 15 December 1959.

[54] Edward Jones, *Playing With Fire: Memoirs of a 1950s Rocket Science Pioneer*, 2011. Available at URL https://sites.google.com/site/playingwithfirememoirs/title-page accessed 30 November 2012.

[55] Oral History of Floyd Lvamme, interviewed by John Hollar for the Computer History Museum, Mountain View, CA, 18 October 2001.

everyone else feared to work with him because of his unbridled competence."[56] Schwede's work for Philco is preserved in the comprehensive technical reports that he prepared for NASA, which showcase the Philco team's design choices.

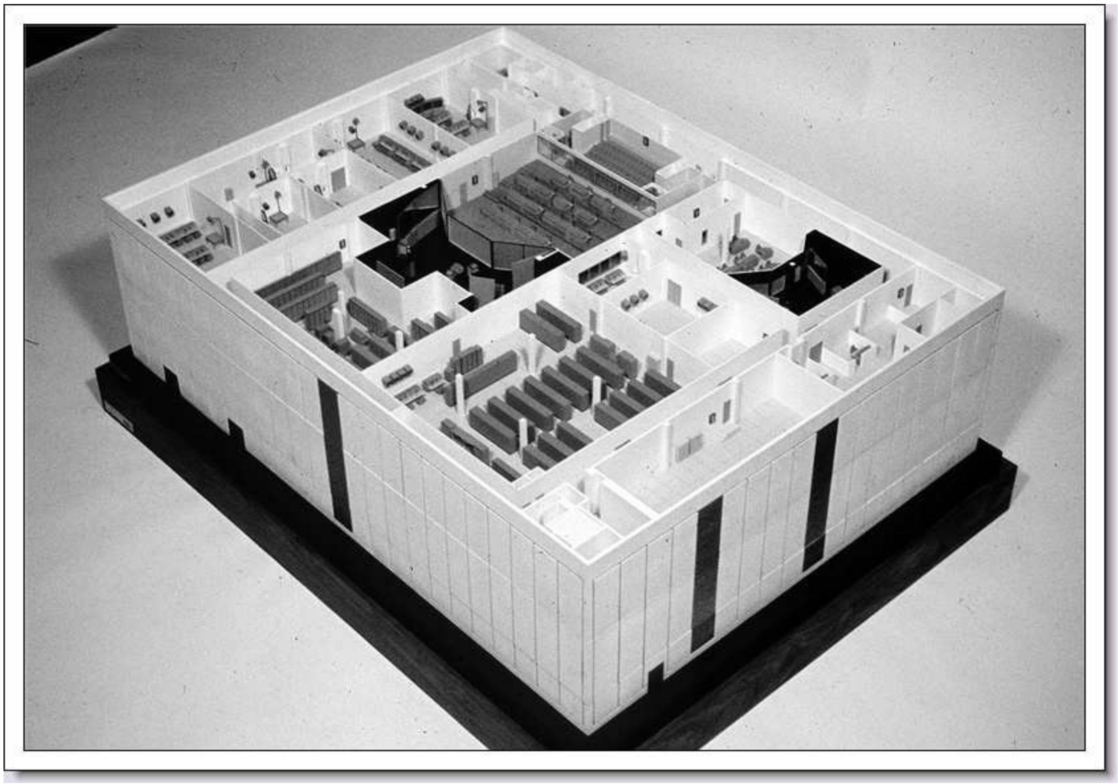

Figure 7. Proposed model of the MCC produced by Philco. Source: NARA.

The first report in a series of eight prepared for NASA by Philco in 1962 focused on what facilities would be required within MCC. The company considered the needs of the room in great detail, giving thought to demands involving power, structural integrity,

[56] For My Children, 132.

air-conditioning, noise levels, and personnel access to equipment.[57] With this foundation, the next document considered how equipment would be integrated to support Gemini and Apollo. Particular attention was paid to display consoles, data processing systems, and communications requirements.[58] Displays were a crucial component, as they provided the interface between mission personnel and the systems, and they needed to convey information as quickly as possible so that a console operator could react to the data. Philco determined, out of numerous display formats such as text, graphs, diagrams, and clocks, that alphanumeric text would be optimal in most situations. Drawings, however, were determined to be more effective for displaying flight paths and maps; although "written language is now one of man's most indispensable tools of communication, it is not necessarily the simplest or most efficient means of representing thoughts."[59]

Designers aspired to be as flexible as possible with displays while also staying within a reasonable budget.[60] A second major decision with regard to the display system was the *amount* of information that should be shown on console screens, as the human eye can only observe so much data at one time. Thirdly, Philco considered what information should be visible on the group displays in the front of the room, which were ten feet high and totaled 60 feet in width, and to what extent this information should

[57] Philco Western Development Laboratory, Facility Requirements and Criteria, Contract No. NAS-9-366, Design and Development Study for Manned Space Flight Operations Control and Support, WDL Technical Report E112-3, 7 September 1962: 2-2.

[58] Philco Western Development Laboratory, IMCC Systems and Performance Requirements Specification, Contract No. NAS-9-366, WDL Technical Report E120, 7 September 1962: 1-1.

[59] Ibid., 2.1.2-4.

[60] Ibid., 5.1.2-2.

replicate or supplement data available at consoles.[61] The Philco team thought that the group display was advantageous for a number of reasons, including: allowing the group to efficiently coordinate its efforts, reducing the amount of equipment needed, providing operational reliability through its redundant nature, and providing a feeling of continued participation to temporarily idle operators.[62] The console displays, however, also had their advantages. These screens could display specific information needed by a particular user, and the displays could be changed without disrupting the work of others.[63] Every decision was considered from the standpoint of guaranteeing mission success.

Modernized communications were an essential part of the control room. Colonel Charles "Chuck" Abbitt had spent a portion of his US Air Force career as the Department of Defense chief who coordinated the Mercury missions. In 1963, a flight surgeon grounded him for glaucoma in both eyes, and Abbitt applied for disability retirement at the age of 43. The Air Force only offered 30 percent of his retirement package, so when Abbitt visited Walter LaBerge in Houston and was offered a job, he took it. Abbitt's new position was manager of the Ground Operations Support System (GOSS) unification project for Philco Houston Operations, pending Abbitt's retirement from the Air Force.[64] Abbitt's assignment as manager of the GOSS project was to maintain successful communication with the different actors involved in a space flight. These players

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[61] Press Release, Philco Corporation News Department, 17 March 1965, Ford Motor Company Archives.

[62] Philco Western Development Laboratory, IMCC Systems and Performance Requirements Specification, Contract No. NAS-9-366, WDL Technical Report E120, 7 September 1962: 5.1.2-7.

[63] Ibid., 5.1.2.-7-8.

[64] Unpublished memoirs, Life and Times of Colonel Charles W. Abbitt, United States Air Force, Retired, 1 March 2001: 19-20. Courtesy Lawrence Reeves.

included astronauts aboard spacecraft, as well as operators at worldwide tracking stations, launch facilities, and launch and recovery control complexes.[65] These spaces would be integrated by a communications network, with the Mission Control Center serving as the focal point. The arrangement of these systems required consensus between the various contractors involved. According to Abbitt, there was "much bickering" between Univac (the communications contractor), IBM (the computer contractor), and Philco (the lead contractor) about whether or not the center would be ready to control Gemini IV. Philco wanted to err on the side of caution, but Chris Kraft decided to make the center prime—that is, the primary control space—for Gemini IV. The mission was a success, especially because it included an American astronaut's first spacewalk.[66] LaBerge recalled that Abbitt did an excellent job of making the various contractors "mesh in a fruitful way."[67] Functioning together, display, communications, and data monitoring systems resulted in an integrated command center. Philco workers deliberately understated their role as technical management, as "actual control of the manned spacecraft…rests ultimately with the astronauts."[68]

[65] Ibid., 22.

[66] Ibid., 24.

[67] Transcript of oral history interview with Walter LaBerge, conducted at behest of NASA, 31 July 1968. Walter edited the transcript and sent it to Robert B. Merrifield at the Manned Spacecraft Center on 4 December 1968, 1.

[68] Philco Western Development Laboratory, Information Flow Plan (Gemini Rendezvous Operation), Contract No. NAS-9-366, WDL Technical Report E114-2, 9 July 1962: 1.2-1.

Figure 8. The MCC-H came online as the primary control center for Apollo 4. Source: NASA.

Building a Legacy for NASA

Center personnel needed to be able to predict all possible contingencies and provide solutions in the event that plans changed or equipment malfunctioned. If, for example, the spacecraft crew were responsible for rendezvous with another vehicle, it was the job of ground support to "provide the crew with the necessary information regarding the status and attitude of the target vehicle, and the required maneuvers necessary to effect docking."[69] Along with this responsibility, Philco listed almost 60 explicit tasks that Mission Control must monitor and complete during a spaceflight mission. The design of

[69] Ibid., 2.2.11-2.

the control center made these tasks possible. The Gemini program can be regarded as an intermediary set of missions in which tasks that would be vital to Apollo, such as rendezvous between two orbiting vehicles, were proven feasible. But it was also an essential program in its own right. Philco realized that the engineering feats of Gemini were no less important than the over-arching political aim of NASA's organizational agenda: "Establish the U.S.A as the first nation to achieve manned lunar landing and return (alive)."[70] In order to accomplish this goal, administrators and technicians at Philco knew that the system needed to be mission-specific while also having a flexible architecture that would enable trouble-shooting and on-the-fly fixes. Philco created an information flow plan to support the Apollo missions, based on NASA-expressed mission concepts. As in its assessment of Gemini, Philco asserted that the primary function of mission control was to "give as much responsibility as possible to the astronauts and the on-board systems" while remaining alert and ready to support the astronauts from the ground station.[71] The Control Center was labeled a "major information source" for the completion of a mission. The MCC computer provided the ability to generate information based on tracking and navigation data from a spacecraft (or ephemeris, which is a table of coordinates of an orbiting body tabulated at constant intervals in time). This data would be sent to the Flight Dynamics Officer and other crew members to enable them to make mission-crucial recommendations, such as maneuver thrust, which was used to orient the

[70] Philco Western Development Laboratory, IMCC Systems and Performance Requirements Specification, Contract No. NAS-9-366, WDL Technical Report E120, 7 September 1962: 5.1.2.-7-8.

[71] Philco Western Development Laboratory, Information Flow Plan (Manned Apollo Mission), Contract No. NAS-9-366, WDL Technical Report E121, 21 August 1962: 3.1-1.

vehicle.[72] This example illustrates that the MCC was a dynamic space whose design was created and implemented with almost every possible contingency considered. The Philco team's integration of display, communication, and data-processing technologies within the Center made a manned mission to the Moon possible.

In March 1965, Mission Control came online to serve as a backup for the Gemini III mission. In June 1965, MCC-H became the primary control center for all manned NASA flights. Chris Kraft was satisfied when the space was completed, noting that "[t]he Houston center was spacious, the computers were faster and had much more capacity, the modern intercom system worked, and we were surrounded by support rooms where bright young systems people kept us supplied with every detail we requested. The words *control center* now encompassed all of it."[73] The design drew inspiration from control centers of the past, but its high-tech components had necessitated novel interior architecture. While worldwide communications had been pioneered by the Department of Defense in construction of the North American Air Defense Command and DEW Line radar defense systems, most of this work was classified, so little experience of those systems was available to those who designed NASA's control center. These types of innovations were left to NASA and their contractors. According to NASA's official history, "Human spaceflight 'drove' a reformation and near revolution in the civilian sector of communications and computer technology."[74] Ford Motor Company recalled its accomplishment proudly: "The project transformed science fiction into reality, because it

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[72] Philco Western Development Laboratory, Information Flow Plan (Manned Apollo Mission), Contract No. NAS-9-366, WDL Technical Report E121, 21 August 1962: 4.4.4-1.
[73] Kraft, 219.
[74] Dethloff, 83.

meant that manned space activities would be conducted with full ‘Earth Control’—a big leap at the time.”[75] NASA executive James Satterfield asserted that Philco’s ability to complete the contract was due to Walt LaBerge’s acumen as a technical administrator. Satterfield recalled that Walt “was a very smooth talker and a very competent technical person. I believe he could sell anybody anything if he set his mind to it.”[76]

Figure 9. The MCC projected the face of celebratory victory after the feat of Apollo 11. Source: NASA.

The Mission Control Room has been called the “most highly automated information correlation center in existence,” because of the vast amount of information it

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[75] “Company Milestones: Our Role in Putting a Man on the Moon,” on the Ford Motor Company website, accessed 2 November 2012, http://corporate.ford.com/our-company/heritage/company-milestones-news-detail/683-nasa-mission-control

[76] Interview with James M. Satterfield by Robert B. Merrifield, 13 March 1968.

received, organized, and displayed. Data included the heartbeats of astronauts, space-suit temperatures, and almost 300 other types of information related to spaceflight.[77] In 1965, Philco Corporation reported that the Mission Control Center housed the largest assembly of television switching equipment in the world—larger even than commercial studios in New York City—as well as the "largest solid-state switching matrices of 20 megacycle bandwidth." This system was driven by more than 1100 cabinets of electronics equipment, 140 command consoles, 136 television cameras, and 384 television receivers. According to Gene Kranz, "This room [was] bathed in this blue-gray light that you get from the screen, so it's sort of almost like you see in the movies kind of thing."[78] Ten-thousand miles of wire connected this behemoth, with more than two million wire connections. All of this construction resulted in a highly sophisticated system that was capable of storing high-density, real-time data on server computers, which was then accessible to many different users via primitive client software.[79] Philco developed a TV matrix that enabled operators to call one of up to 20 television stations for display on their console.[80] John "Jack" Garman, who advised flight controllers during the Apollo missions and later served as a NASA executive, recalled the awe that the space inspired:

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[77] Press Release, Ford Motor Company, "Philco Corp. – Mission Control Center in Houston – Dr. W. B. LaBerge," no date, Ford Motor Company LaBerge Presentation press release no date.pdf. Ford Motor Company Archives.

[78] NASA Johnson Space Center Oral History Project, Oral History 2 Transcript, Eugene F. Kranz interviewed by Rebecca Wright, Houston, Texas, 8 January 1999: 13-37.

[79] Press Release, Philco Corporation News Department, 17 March 1965, Philco Mission Control Center Facts and Figures press release 3-17-1965.pdf, Ford Motor Company Archives.

[80] Johnson Space Center Oral History Project Oral History Transcript, Henry E. "Pete" Clements interview by Carol Butler, Melbourne, Florida, 31 August 1998: 12-25; According to NASA executive James Satterfield, the initial system of projection and television screens had been developed by Finsky, Fisher & Moore in California for the Air Defense Command Headquarters in Colorado for displaying tactical data. Philco modified the system to work at Mission Control. I cannot substantiate this claim with other sources. See interview with James M. Satterfield by Robert B. Merrifield, 13 March 1968, pp. 20-21.

"So when you walked into mission control…what you saw down on the first floor, was all these big IBM mainframes with the spinning tape drives and the lights blinking and all that…It doesn't mean anything to anybody today. That's how computers work today, right? But in those days, if you spent your life in front of a keyboard typing punch cards and when the computer ran, you got it back on paper, to be able to see things happening on the screen in real time was absolutely awesome, particularly if you knew anything about computers."[81]

Another key feature of the Mission Control Center was redundancy. Every piece of equipment in the room had a spare or auxiliary. The Real Time Computer Complex housed five IBM 7094 computers, of which two were needed to coordinate a mission, and the remaining three could either operate as redundant spares or be used for training for future missions.[82] The electrical power supply was backed up by diesel-driven generators, in the event that the Center lost electricity from Houston Light and Power.[83] But even beyond the high-tech equipment and dazzling displays, the Mission Control Room expressed an intangible spirit that the work being conducted in this space was important. In Gene Kranz's words: "…[It is] the room's atmosphere, it's the smell of the room, and you can tell people have been in there for a long period of time. There's enough stale pizza hanging around and stale sandwiches and the wastebaskets are full. You can smell the coffee that's been burned into the hot plate in there. But you also get this feeling that

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[81]John R. "Jack" Garman interviewed by Kevin M. Rusnak, NASA Johnson Space Center Oral History Project, Oral History Transcript, Houston, Texas, 27 March 2001: 14.

[82] Press Release, Philco Corporation News Department, 17 March 1965, Philco Mission Control Center press release 3-17-1965.pdf. Ford Motor Company Archives.

[83] Dennis E. Fielder interviewed by Carol Butler, NASA Johnson Space Center Oral History Project, Oral History Transcript, Houston, Texas, 6 July 2000: 29.

this is a place something's going to happen at. I mean, this is a place sort of like the docks where Columbus left, you know, when he sailed off to America or on the beaches when he came on landing."[84] The space also held an odor of stale cigarettes, as smoking was not banned until 1987.[85]

NASA scientist James Head III recalled that during missions, everyone in the control center was pumped up on adrenaline and oblivious to the outside world. "It's like, there are just no windows," he said, "so you can be in there for days and not know what's going on [outside]."[86] Unfortunately, there was unequal access to this awe-inspiring space. Women were not allowed out on the floor of the Mission Control Operations Room. Engineer Jeanne Crews recalled that she "spent many times on the Skylab experiments in the back rooms, and then if I'd walk in the elevator, there would be comments by the two people I referred to, like, 'Well, it's certainly good we keep women out of the Mission Control.'"[87] Nor were the systems perfect; operators constantly revised the room's features. For example, one NASA official recalled that "We had problems with people leaning over the consoles and touching buttons and switches, and so we wanted a cover on the command switches. We had a good idea, but people didn't know

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[84] Eugene F. Kranz interviewed by Rebecca Wright, NASA Johnson Space Center Oral History Project, Houston, Texas, 8 January 1999: 13-38.

[85] Letter from Robert D. Legler to John Getter titled "Responses to Questions About Historical Mission Control," 7 April 1997, from "Facts About MCC.pdf," JSC History Office.

[86] James W. Head, III interviewed by Rebecca Wright, NASA Johnson Space Center Oral History Project, Providence, Rhode Island, 6 June 2002, 35.

[87] Jeanne L. Crews interviewed by Rebecca Wright, NASA Johnson Space Center Oral History Project, Satellite Beach, Florida, 6 August 2007: 17.

how to do it, so guys would take the plastic home and cook them in the oven, and that's how we made the first ones. There was a lot of creativity by people like that."[88] Further, Mission Control used a pneumatic tube system to carry hardcopy messages and printouts of the television displays.[89] Hundreds of messages littered the floor after hectic shifts. As Gene Kranz remembered it, after one such day, flight controller officer John Llewellyn, "a former Marine, stood up, stretched, and in a voice for all to hear declared: 'I think I am back in the trenches again with my fire control team, surrounded by empty 105 howitzer canisters.'"[90] Despite these exceptions, the MCC was as technologically state-of-the art as possible, and its innovative qualities cannot be exaggerated. The MCC not only served to facilitate NASA's spaceflight goals, but its design aesthetic added an archetypal control center space to America's cultural consciousness, as well as bolstered the prestige of the space program.

With all of its press coverage, Americans came to identify Mission Control with the Gemini and Apollo spaceflight accomplishments between 1965 and 1972. Johnson Space Center historian Jennifer Ross-Nazzal rightly noted that "One of the most popular images was taken after the Apollo 11 crew safely returned home and features flight controllers celebrating the conclusion of the first successful mission to the moon."[91] After years of coming in second to the USSR, this space came to symbolize American technological and political might during in the Cold War. NASA's sociopolitical purpose

[88] Jones W. "Joe" Roach interviewed by Carol Butler, NASA Johnson Space Center Oral History Project, Oral History Transcript, Houston, Texas, 24 January 2000, 12-4.

[89] Interview with James M. Satterfield by Robert B. Merrifield, 13 March 1968, 26.

[90] Kranz, 141.

[91] Jennifer Ross-Nazzal, "Landmarks at Johnson Space Center," *Houston History*, Volume 6, Number 1, Fall 2008, 45.

was “civil offense.” The space agency attacked the Soviet Union with each successful mission in the war for technological supremacy, world recognition, and economic dominance.

Figure 10. Much of the center’s original hardware served well into the STS years. Source: NASA.

Given this triumphalist history, today many people feel elated at the thought of taking a visit to this historic site. As one journalist observed, “Some people are awed when they go to St. Paul's Basilica, others by visiting Disney World. To me, neither place holds a candle to the Johnson Space Center—this is the place where, 50 years ago, men and women helped execute the greatest engineering achievement in all of human history."[92] Even John McCullough, head of NASA's flight director office in 2011, could not help referring to Building 30 as a "cathedral of spaceflight." A former flight director, in response, chuckled at the hyperbole but asserted that it was, indeed, a very important space: "When you take people's lives in your hands, it's a serious business. It's a serious responsibility. And we do it in full public view."[93]

Concluding Remarks

In 2011, NASA renamed Johnson Space Center's Building 30 the Christopher C. Kraft Mission Control Center. Then JSC Director Michael Coats lauded Kraft in a speech: "He is a space pioneer without whom we'd never have heard those historic words on the surface of the moon, 'Houston, Tranquility base here. The Eagle has landed.' Those words effectively put Houston, and this building behind us, on the intergalactic map forever."[94] Gene Kranz similarly acknowledged Kraft's contributions:

> I think Kraft's name, Christopher Columbus, was entirely appropriate for this guy because he was the pioneer in Mission Control. He launched each one of the Mercury missions. But most important, he was the mentor, the teacher, the tutor for this first generation of young people who became known as Mission Controllers. He set the mold for everything that would be done thereafter; and in particular, he set the mode for the flight director and the flight director being able to take any action necessary for crew safety and mission success.[95]

[92] By the by, this journalist also did a fantastic job of reporting on the specific technological layout of the Mission Control Operations Room. Lee Hutchinson, "Going boldly: Behind the scenes at NASA's hallowed Mission Control Center," *Ars Technica* 31 October 2012.

[93] Seth Borenstein, "After shuttle lands, Mission Control to go quiet," *Lubbock-Avalanche Journal*, 19 July 2011.

[94] NASA, "NASA Names Mission Control for Legendary Flight Director Christopher Kraft," 14 April 2011, accessed 2 November 2012, http://www.nasa.gov/mission_pages/shuttle/behindscenes/kraft_mcc.html

[95] Eugene F. Kranz interviewed by Roy Neal, NASA Johnson Space Center Oral History Project, Houston, Texas, 28 April 1999: 14-46-14-47.

Kraft certainly deserves the praise lavished upon him for directing NASA operations and supervising the landing of men on the Moon, among many other accomplishments. NASA, however, also owes debts to the contractors who imagined and implemented the high-tech systems that made the feats of manned spaceflight possible. What they created was an embodiment of a commitment to centralization coupled with high-technology that was particular to the Cold War era.

CHAPTER 3. The Most Secret Site Ever Publicized, HQ SAC

Secrecy Classification: RESTRICTED

"The events of World War II clearly show us that the days of the slow moving war are gone. Air power has no regard for geographical barriers. – Distance holds no terror for it. – And the sun need not shine for it to operate. That was one lesson the past war taught us."

- Excerpt from a Speech by General Curtis E. LeMay
Albany Hotel, Denver, Colorado, 16 March 1949.[1]

"SAC's vigilance—day and night, fair weather or foul—keeps us alive and free to pursue happiness as we choose."

– Charles M. Harper[2]

The Strategic Air Command's headquarters is a prime example of how a physical space encapsulated American response to the technological development of the atomic bomb, as its architecture represented the national policies of containment and deterrence. This narrative extends the analysis of Paul Edwards' *The Closed World* by showing how the Cold War was actually a story of controlling the battlefield from a distance, and of not tactical, but strategic defense. Although billed as a secret site, the headquarters of the Strategic Air Command was never much of a secret. Popular American films brought

[1] Library of Congress. Curtis LeMay Papers. BOX B95, Folder VI-2-A (SAC) OFFICIAL Documents – Extracts from speeches and articles on B-36

[2] John T. Chain, Jr., *SAC: Proud Heritage* (New York: Newcomen Society of the United States, 1988).

attention to the space. Sometimes they praised the creation of the subterranean HQ, such as in *Strategic Air Command* and *A Gathering of Eagles*—both Air Force-sanctioned films. At other times, as in the case of the satirical *Dr. Strangelove: Or How I Stopped Worrying and Love the Bomb*, movie producers had to muster a creative vision for what the headquarters looked like, as they were denied access to the site.

Figure 11. The war room in Dr. Strangelove is an infamous portrayal of a Cold War space of control. Source: Columbia Pictures.

Historian and former SAC KC-97 navigator and intelligence officer Bruce Franklin noted that, starting around 1949, "endless propaganda sought to convince the American people that they were living in peril of an imminent nuclear attack from the Soviet Union." Within this context, some films portrayed SAC as an effective deterrent that could retaliate if necessary. Kubrick, however, "saw that the subject was too bizarre for realism" and critiqued the absurdity of Mutually Assured Destruction in *Dr. Strangelove*.[3] The point is that the Soviets knew about the existence of this space, and the US military wanted them to, because the command and control center was as much a signifier of the policy of deterrence as were long-range bombers. This was deterrence through architecture, and the headquarters' design highlights the particular Cold War mentality of survival instinct mixed with paranoia and some (PR-manufactured) reassurance.

The Strategic Air Command (SAC) adopted the motto "Peace is Our Profession" in 1957, as its global bombing force and sophisticated command center were meant to intimidate would-be attackers into holding back on an offensive strike. SAC's mission was to "convinc[e] hostile nations of the futility of starting a global war."[4] After all, if nations starting using nuclear weapons, then the true value of nuclear weapons—their ability to deter war—would be lost.[5] Thus, the Air Force's commitment was to an "efficient global striking force" that would satisfy the role of a nuclear deterrent.[6] Another element was crafted to serve the same purpose: a modern, technologically sophisticated command and control center that could deploy bombers to their targets at a moment's notice and withstand nuclear attack. Studying the creation of headquarters

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[3] H. Bruce Franklin, "'Peace is Our Profession'": The Bombers Take Over," in Dominick Pisano, ed., *The Airplane in American Culture* (Ann Arbor, MI: University of Michigan Press, 2003), 342.

[4] "SAC, The Convincer," *Nebraska on the March*, no. 12, Division of Nebraska Resources, September 1956.

[5] L. Douglas Keeney, 15 Minutes: General Curtis LeMay and the Countdown to Nuclear Annihilation (New York: St. Martin's Press, 2011).

[6] Walton S. Moody, *Building a Strategic Air Force* (Washington, D.C.: Air Force History and Museums Program, 1995), 236.

SAC as a snapshot in time allows for a deeper understanding of how computing and communications technologies, coupled with Cold War imperatives, created an atmosphere in which the construction of a command and control center—one in which global actions and warfare could be conducted from a centralized, remote location—was possible. Not only that, the center's architecture symbolizes both the anxiety of the Cold War era and the belief that technology offered the solution to avoiding Armageddon. This was a time in which revolutionary technological change and revolutionary cultural change were inextricably linked.[7]

Origins of the Strategic Air Command

The Strategic Air Command was formally established on 21 March 1946 as one of three major US-based combat subcommands of the United States Army Air Force, the other two being the Tactical Air Command and the Air Defense Command.[8] The Strategic Air Command was a particularly influential subcommand because it was assigned control of the Air Force's arsenal of nuclear weapons, a role formally assigned to it on 1 May 1946. As the arsenal grew over the years, so did the strength of SAC. The nation's store of nuclear weapons had increased significantly by 1951, to 650, and grew at a quickened pace, with an arsenal of 5,450 nukes available in 1957.[9] In October 1946, SAC moved operations from Bolling Field in Maryland to the neighboring Andrews Air Force Base,

[7] Margot A. Henrikson, *Dr. Strangelove's America: society and culture in the atomic age* (Berkeley, CA: University of California Press, 1997), x.

[8] Lindsay T. Peacock, *Strategic Air Command* (London: Arms & Armour Press, 1988), 9.

[9] Ibid., 13; 27. In 2015, the National Security Archive declassified a list of SAC's offensive targets. See William Burr ed., "U.S. Cold War Nuclear Target Lists Declassified For First Time," 22 December 2015, accessed 13 January 2016, http://nsarchive.gwu.edu/nukevault/ebb538-Cold-War-Nuclear-Target-List-Declassified-First-Ever/

tasked with conducting global offensive operations.[10] Within two years, defense officials were scouting for a new location for SAC headquarters—one further away from the nation's capital, which was considered a prime Soviet target. The Secretary of the Air Force, Stuart Symington, decided upon Offutt Air Force Base, just outside of Omaha, Nebraska, due to its "midcontinent location, good runways, large hangars, and comfortable offices, [and]…vital advantage of public support."[11] While long-time Commander-in-Chief SAC Curtis LeMay is often credited with insisting on a move away from Andrews, in his memoirs, he asserts that the decision to relocate had already been decided prior to his arrival at his post at SAC.[12]

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[10] John R. Correll, "SAC's Half Century," *Air Force Magazine*, March 2013, 75.

[11] The History of Fort Crook, 1888 [and] Offutt Air Force Base, 1976, Published by the 3902d Air Base Wing, the host unit at Offutt Air Force Base. Borrowed from the Creighton University Alumni Memorial Library in Omaha, Nebraska, 91. Cites the *World Herald* 21 May 1948.

[12] Curtis E. LeMay with MacKinlay Kantor, *Mission With LeMay: My Story* (Garden City, NY: Doubleday & Company, Inc., 1965), 429.

Figure 12. Outside of Offutt Air Force Base, a billboard displayed the motto of the Strategic Air Command, "Peace is Our Profession." Source: US Air Force.

Figure 13. A memorial bench outside of the Strategic Air & Space Museum in Ashland, Nebraska displays the motto of the Strategic Air Command. Source: Author's photograph.

On 9 November 1949, SAC headquarters relocated to Offutt.[13] The site in the center of the country soon became obsolete in an era of ICBMs, although the generally low-population density in southeastern Nebraska probably still made a strong case for the location.[14] This meant that in the event of a direct attack only SAC personnel and a few hundred civilians would face elimination. This obviously did not ease the fears of residents of the region. Fallout shelter programs intensified. The Office of Defense, Civil Defense negotiated a contract with the University Extension Program at Lincoln for courses in radiological monitoring and in "Community Fallout and Shelter Management" in order to facilitate fallout shelter procedures.[15] Administrators struggled to design shelters in the case of nuclear attack. One summarized his exasperation when he wrote, "Part of our dilemma is due to the fact that we do not know exactly what we are facing and how much of it we may have to face. It is somewhat like trying to provide a suit for a man whose size, weight and measurements you do not know—but you still have to provide a suit just the same."[16]

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[13] Alwyn R. Lloyd, *A Cold War Legacy, A Tribute to the Strategic Air Command, 1946-1992* (Missoula, Montana: Pictorial Histories Publishing Company, Inc., 1999), 119.

[14] "By the time SAGE became fully operational in 1961, SAC bases were unprotectable [sic] anyway (because of ICBMS), and SAGE control centers would have been among the first targets destroyed in a nuclear war." Paul N. Edwards, *The Closed World: Computers and the Politics of Discourse in Cold War America* (Cambridge, MA: MIT Press, 1997), 110.

[15] Request for Quotations from the Office of Civil Defense to the Board of Regents of the University of Nebraska at Lincoln March 1964, University Archives Special Collections University of Nebraska-Lincoln. Subject Files, to 1974 A – Civil D. Series No. 24/1/5 Box No. 1. Folder Civil Defense, 1963/1964.

[16] W.A. Ross "The Role of School Personnel in Civil Defense," 15 November 1950, University Archives Special Collections University of Nebraska-Lincoln. RG#05/15/01 Office of the Chancellor Clifford M. Hardin. Subject Correspondence, 1947-1969 Chear-Cline Box 13. Folder Civil Defense 1950-1951 2/14/1

The Face of SAC: General Curtis Lemay

Lieutenant General Curtis LeMay became Commanding General of Strategic Air Command on 19 September 1948, and was promoted to General on 29 October 1951. In April 1955 his title changed to Commander-in-Chief Strategic Air Command (CINCSAC).[17] His tenure at SAC is seen by many Air Force historians to be the Command's "golden age."[18] Depicted by some as trigger happy (indicated in the nickname "Bombs Away" LeMay), and by most as stubborn and authoritarian (evidenced by another nickname, "Old Iron Ass"), LeMay was the face of the Strategic Air Command for ten years, and his image continues to be inextricably linked with SAC. It is a portrait of a seasoned general who demanded perfection from those under his command, delivering orders with a cigar constantly between his teeth. One historian described him as a "man who wears a cigar like a cocked revolver. The fragrance of choice Havana leaf is always about him, a burnt masculine perfume."[19] The cigar served an addition image-making purpose. Due to prolonged exposure during flight at high altitude, LeMay suffered from Bell's palsy, a type of facial paralysis. He smoked cigars to mask this condition.[20]

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[17] Alwyn R. Lloyd, *A Cold War Legacy, A Tribute to the Strategic Air Command, 1946-1992* (Missoula, Montana: Pictorial Histories Publishing Company, Inc., 1999), 116.

[18] Peacock, 14.

[19] Richard G. Hubler, *SAC: The Strategic Air Command* (New York, NY: Duell, Sloan and Pearce, 1958), 154.

[20] Lloyd, 117.

Figure 14. General Curtis LeMay directed SAC during its "golden age." Source: USAF.

The depiction of LeMay as a bomb-happy general à la General Buck Turgidson in *Dr. Strangelove*, eager to launch a pre-emptive strike, is not without basis. Its origins predominately lay in a damning statement attributed to LeMay in his autobiography. In this book, *Mission With LeMay*, written by himself and MacKinlay Kantor, he is quoted as saying that he wanted to bomb North Vietnam "back into the Stone Age." This one sentence crystalized an image of LeMay in the minds of many Americans, much to his dismay. LeMay later said that his co-author had misquoted him, and he had actually said that the US had the *capability* to bomb North Vietnam back into the Stone Age, but this statement either came too late or people had already hardened their opinions about the general.[21] One Air Force historian condemns this portrayal:

> There are some who decry General LeMay as a megalomaniac who wanted to start World War III, but this is blatantly false. These pundits and historians claim that LeMay would exit his underground command post in Omaha to state "bomb 'em back into the stone age" and then retreat into his bunker. Some academicians hale [sic] those who demonize LeMay and unfortunately those who attempt [to] rewrite history in such a manner have little or no concept of what America and the free world was up against, or have an agenda of their own.[22]

The debate will surely continue, but as long as quotes such as the following exist, but his own words belied his position as a peacekeeper. In a speech given to the Omaha Chamber of Commerce in 1948, he said that

> we must be ready to project American Air power to the skies of our enemy, destroy his sustaining resources and thereby prevent him from bringing the war to our country. Our targets will be the vital industrial complexes of his homeland, his critical materials, and the will of his people to sustain a major war.[23]

As for the second common depiction of LeMay—that he was a tough man to work for and demanded perfection from those under his command—plenty of evidence exists to support this claim.[24] In fact, he was brought to SAC for his dedication to detail and heavy-handed management style. When Curtis LeMay took the helm, SAC was in poor shape, mostly due to postwar demobilization and ineffective leadership. In the year before he was stationed at SAC, only two of 11 groups were ready to conduct operations,

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[21] John R. Correll, "SAC's Half Century," *Air Force Magazine*, March 2013, 79.

[22] Lloyd, 254.

[23] Library of Congress. Curtis LeMay Papers. BOX B95, Folder VI-2-A (SAC) OFFICIAL Documents – Extracts from speeches and articles on B-36, Speech by Lt. General Curtis E. LeMay, Strategic Air Command, Public Affairs Luncheon of Omaha Chamber of Commerce, 16 November 1948.

[24] For a portrait of LeMay depicting his time at the Strategic Air Command, see Charles Bosanko, "The Architect of Armageddon: A History of Curtis LeMay's Influence on the Strategic Air Command and Nuclear Warfare" (MA Thesis: California State University, Fullerton, 2000).

crews were not trained, and aircraft were grounded.[25] The small fleet was manned by poorly trained men who consistently failed in bombing competitions. In 1948, Senator Arthur Vandenberg (R-MI) asked celebrated aviator Charles Lindbergh to evaluate the state of SAC's facilities and methods. In his report, Lindberg asserted that crews were inadequately trained, living conditions were poor, and that the fleet was undermanned.[26] LeMay endeavored to remedy these shortcomings. He insisted that SAC achieve intercontinental range by supporting construction of the B-36 "Peacekeeper," a piston engine bomber built in 1949 by Convair, and he encouraged the development of efficient aerial refueling for medium-range bombers.[27] He was also committed to improving training and procedures, which after his initial inspection he found sorely deficient. LeMay recalled in his autography: "Soon after I went to Offutt some of the newspapers and magazines quoted me, while on a tour of SAC bases, as saying, 'Today I found a sergeant guarding a hangar with a ham sandwich.' I was quoted correctly. That was par for the course in SAC at the time."[28]

Operations improved slowly but surely. In 1948, sixty close-calls and minor accidents occurred per every 100,000 hours flown, and there were also injuries on the ground.[29] To improve these figures, LeMay implemented checklists, and by 1950 SAC had the lowest accident rate in the Air Force.[30] Yet there was still much room for

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[25] Correll, 75.
[26] Walton S. Moody, *Building a Strategic Air Force* (Washington, D.C.: Air Force History and Museums Program, 1995), 226-228.
[27] Ibid., 231.
[28] Lemay and Kantor, 436.
[29] Moody, 224-225.
[30] Correll, 76.

improvement. A RAND study in 1952 by Albert Wohlsetter stated that SAC's forward bomber bases would be "easily annihilated by a surprise first strike."[31] The Strategic Air Command in the mid-1950s was far weaker than many people might have imagined. In 1953, "SAC had only three combat ready wings, no accurate target intelligence, personnel turbulence, maintenance problems, inadequate overseas basing, and an aging bomber force."[32] Thankfully for SAC, the Soviet detonation of an atomic bomb in 1949 and the Korean War provided catalysts for an increased Air Force budget, and LeMay was able to move forward with his plans to revitalize the force.[33] By 1955, SAC had almost 200,000 men and 2,800 aircraft stationed all over the world, ready to retaliate against the USSR. LeMay had secured 1,200 B-47 jet bombers, and pilots had logged more than a million hours of simulated combat flight.[34] But there was still one addition that LeMay deemed necessary to making SAC an elite, modern deterrent force: a command and control headquarters.

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[31] Edwards, 118.

[32] William S. Borgiasz, The Strategic Air Command: Evolution and Consolidation of Nuclear Forces, 1945-1955 (Westport, Connecticut: Praeger, 1996), xi.

[33] Ibid., 143

[34] Thomas M. Coffey, *Iron Eagle: The Turbulent Life of General LeMay* (New York, NY: Crown Publishers, Inc., 1986), 337.

Figure 15. View of Building 500, SAC headquarters at Offutt Air Force Base. Source: USAF.

As early as 1950, LeMay cited the need for a new command post, but Air Force budget limitations continued to push back the date for its construction.[35] Thus his operation remained for quite a few years in the original HQ SAC, a space that did *not* evoke the authority that one would expect from the epicenter of an elite military power. It was located in a vacant World War II Glenn L. Martin bomber plant that once produced B-26s and B-29s. LeMay recalled that, when he arrived in Nebraska, "There wasn't much to Offutt except for a big bomber plant and a cockeyed runway ending in a steep bank.[36] LeMay insisted on constructing a new headquarters because, as one historian astutely

[35] Moody, 431.
[36] Lemay and Kantor, 432.

noted, "By themselves, of course, bomber and missile assets would achieve little in the absence of adequate command and control facilities."[37] In his autobiography, LeMay asserted: "We simply had to have a Headquarters and Control Center whereby we could be in instantaneous control of SAC bases scattered all over the United States and elsewhere in the world. And be in instantaneous touch with every plane we had in the air."[38] Yet LeMay encountered obstacles selling this need to the Air Force, which in turn had to justify the expense to the Secretary of Defense, the Bureau of the Budget, and Congress.

The type of building he was requesting also created problems. LeMay firmly believed that the control center needed to be built underground, but the Truman administration said it would be far too expensive, so LeMay relented and solicited bids to build the center above ground. Then, in 1953, the Eisenhower administration halted construction and reviewed the project. Their assessment was, "How stupid can you get in this day and age, building a headquarters *above* ground? Don't you know that you ought to be *below* ground?"[39] Development eventually went ahead with construction of a headquarters that was partially above ground and partially below. Lieutenant General Francis H. Griswold, former vice commander of SAC, remembers an additional important detail. As told to historian Thomas Coffey in a 1983 interview: "LeMay was indeed frustrated in his efforts to procure a new headquarters. For six years, Congress and the Air Force had been throwing out plan after plan. And the outlook was bleak." One

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[37] Peacock, 80.
[38] Lemay and Kantor, 441-3.
[39] Ibid., 441-3.

day, however, Griswold and LeMay got together and one of them said, "'Let's not call it a headquarters. Let's call it a control center. No congressman's got enough guts to say SAC can't have a control center.' And sure enough, the next year we got it into the budget."[40]

Building Headquarters SAC

Construction began on the "Pentagon of the West" on 15 April 1955, with a tight completion deadline of little more than two years. The building's 500,000 square feet of floor space required 14 acres of asphalt tile, its slab foundation required 30,000 yards of concrete, and it was air-conditioned by a 2,200 ton refrigeration system.[41] Another huge component of the construction project was the drilling of a well 2,200 feet deep to provide the center with its own water supply.[42] The Omaha area was well-served by this construction project, which poured more than $8 million into the local economy, augmenting Offutt Air Force Base's preexisting annual payroll of almost $18 million.[43] The Omaha-based architectural firm Leo A. Daly was contracted to design the building. The firm was initially established in 1915 to specialize in church architecture. During the war, Leo Daly, Jr. joined his father's firm and secured military work designing air bases. Leo Daly urged his father to get into government work, but his father grumbled that there was "too much red tape." After his father's death in 1952 and with the younger Daly's inheritance of the firm, within years the business became "military and highways." Leo

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[40] Coffey, 333.

[41] "SAC Goes Underground," *Northwestern Bell*, 37 no. 2, March 1957, 8.

[42] "SAC's Control Construction Means Racing Against Time," *Sunday World-Herald, Omaha*, 20 November 1955.

[43] "'Military Industry' Big Business Here," *Sunday World-Herald, Omaha*, 25 November 1951.

A. Daly began to specialize in "comprehensive architecture," offering services from design and engineering to site selection and interior furnishing.[44] Thus, the firm had the experience needed to design SAC's new headquarters, which came with a price tag of almost $9 million.[45] The underground structure was one of the first "hardened" facilities in the United States, meaning that both people and equipment would withstand anything but a direct hit by a high-yield nuclear weapon.[46] Headquarters construction was completed on schedule, and on 26 January 1957 staff and equipment moved into Building 500, otherwise known as HQ Strategic Air Command.[47]

Building 500 was composed of two interconnected structures—an above-ground three-story administrative building, described by one historian as "completed in bland late-fifties style…like something from a typical Midwestern college campus," and a three-level subterranean headquarters.[48] The command post, along with its communications and computer equipment, was housed in the underground facility. To

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[44] "From Omaha to Brazil," *TIME*, Vol. 83 No. 21, 22 May 1964; Almost 40 years later, in 1995, Leo A. Daly designed the Strategic Air & Space Museum in Ashland, Nebraska.

[45] In the late 1950s, Leo Daly II felt that the future for his firm laid in securing military installation work, and after designing the SAC headquarters, the firm also DEW line outposts in the Aleutians, Loran C stations in Alaska, and a Trident station in Washington State, naval bases, and Wherry housing. However, the firm also secured massive undertakings, such as the construction of hospitals, airport terminals, Las Vegas hotels, and two military cities in Saudi Arabia. See Gary Johansen, "Daly Buildings Bridge the World," *Sunday Magazine of the Midlands*, 6 March 1977; "His Excellency, Dr. Ghazi Algosaibi, Minister of Industry and Electricity, signs exclusive Cooperation Agreement between Saudi Consulting House and Leo A. Daly," *Arab News International*, 19 September 1979.

[46] Ted Landale, "Plans for $120 Million of Buildings," *Sunday World-Herald Magazine*, 19 July 1959; Later, SAC was designated a "soft" site, and alternate command centers were built in mountains.

[47] The History of Fort Crook, 1888 [and] Offutt Air Force Base, 1976, Published by the 3902d Air Base Wing, the host unit at Offutt Air Force Base. Borrowed from the Creighton University Alumni Memorial Library in Omaha, Nebraska, viii, 97; Norman Polmar, ed., *Strategic Air Command: People, Aircraft, and Missiles* (Annapolis, MD: The Naval and Aviation Publishing Company of America, Inc., 1979), 49.

[48] Bill Yenne, *A Primer of Modern Strategic Airpower: SAC* (Novato, CA: Presidio Press, 1985), 25; *The Development of the Strategic Air Command, 1946-1973* (Offutt Air Force Base, Nebraska, 1974), 54.

enter this area from the above-ground headquarters, one went through a tunnel eight-feet in diameter, with two-foot thick reinforced concrete walls, descended a concrete ramp, and approached a set of seven by seven foot steel doors, which served as the gateway to the command and control center.[49] If SAC were to have gone to war, these blast- and gas-proof steel doors would have slammed shut, sealing off SAC operations, leaving it to operate on its emergency power system, well water supply, and other stored supplies.[50] The walls consisted of hardened reinforced concrete two feet thick; there were two ten-inch thick intermediate floors, and the roof varied in thickness from two to four feet.[51]

[49] "U.S. Strategic Command Command [sic] Center," accessed 30 September 2013, http://www.fas.org/nuke/guide/usa/c3i/cmdctr.htm ; Daniel J. Hoisington, Historic American Building Records, Offutt Air Force Base, Headquarters, Strategic Air Command, HABS NO. NE-9-M, N, O, Nebraska State Historic Preservation Office, Folder SY04-175 BLDG #500 SAC HEADQUARTERS

[50] Yenne, *A Primer of Modern Strategic Airpower: SAC*, 25.

[51] Ibid., 25.

Figure 16. In the subterranean headquarters, men on cherry-pickers updated walls of vital statistics, such as fleet locations. Source: NARA.

Forty-six feet underground, the Commander-in-Chief Strategic Air Command (CINCSAC) and his battle staff monitored massive wall maps and plotting boards running along a 264-foot wall that were updated constantly with the location and status of all aircraft in the fleet worldwide.[52] Before being replaced with video screens and projectors, the boards were updated manually by personnel in cherry-pickers, “making

[52] Lloyd, 237-8.

the setting more theatrical through its frontal suspended lighting and drawn curtain."[53] Computing technology was state of the art: an IBM 704 crunched numbers and supported the communications links which "permitted near-instantaneous contact with the forces at its disposal, with the National Command Authorities in Washington and with other major USAF commands."[54] Northwestern Bell, in conjunction with AT&T, was contracted to engineer the communications facilities for the subterranean command post. Lieutenant General Francis H. Griswold, vice commander of SAC, stated, "Communications is the basis of the war deterrent strength of the Strategic Air Command. It would be impossible to control and deploy a modern strategic air force without some effective means of communicating with its various elements."[55] An observer's balcony overlooked the main floor, and provided a space from which the CINCSAC and his battle staff could monitor controllers on the lower level, manning desks and electronic consoles filled with lights, switches, and telephones.[56]

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[53] "U.S. Strategic Command Command [sic] Center," http://www.fas.org/nuke/guide/usa/c3i/cmdctr.htm (accessed 30 September 2013).
[54] Peacock, 43-44.
[55] "SAC Goes Underground," 6.
[56] Brochure, The Progressive Development of the Strategic Air Command, 1946-1965 (Offutt Air Force Base, Nebraska, no date), 55.

Figure 17. A few of the original phone consoles from HQ SAC are now on display at the Strategic Air & Space Museum in Ashland, NE. Source: Author's photograph.

Phones served as the primary means of receiving information and directing orders, and their roles were distinguished by colors. The notorious red phones put personnel in touch with every bomb wing, tanker wing, and (later) missile launch center.[57] Next to these phones were banks of indicator lights, which allowed operators to acknowledge receipt of orders.[58] In addition to the red phone, the Primary Alerting System that linked SAC to its bomber bases (and later missile sites), there were also: gold phones providing unsecured lines to the Pentagon, over which would come the order to go to war; black phones which encrypted a voice was sent from one end of the line and decoded at the other; gray phones that linked to other global SAC operations; blue phones connected to the command of the North American Air Defense Command; pink phones

[57] Correll, 78.
[58] Brochure, 55.

used for normal, direct-dial calls; and white phones were part of the internal Offutt base system.[59]

Maintaining communications in the control room was considered of the utmost importance. LeMay insisted on conducting frequent tests of the system's potential vulnerabilities. In response to such tests, he received recommendations that radio be used in place of landlines in emergencies, and that existing landlines be re-routed around "potential target areas," which were implemented.[60] Beyond testing existing systems, LeMay was eager to implement new technology in the control room. To juggle both voice and text communications, a 607A manual switchboard was installed by Western Electric, an isolated dial PBX for internal communication that did not connect with any facilities outside of the center was installed, and teletype machines that could process 100 words per minute were utilized. In no small addition, the command center was outfitted with fax machines, consoles to monitor long distance lines, and a multi-channel radio system for relay of information between control sections and plotters. This intranet necessitated more than 735 miles of wire in just one room.[61]

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[59] Daniel J. Hoisington, Historic American Building Records, Offutt Air Force Base, Headquarters, Strategic Air Command, HABS NO. NE-9-M, N, O, Nebraska State Historic Preservation Office, Folder SY04-175 BLDG #500 SAC HEADQUARTERS

[60] Curtis LeMay Papers. Library of Congress, Box B50 Folder BLAKE, GORDON, Letter from Curtis LeMay to Major General Gordon A. Blake 15 January 1955.

[61] "SAC Goes Underground," *Northwestern Bell*, 37 no. 2, March 1957, 7-8.

Figure 18. Plotting boards were replaced by projection screens by 1965, when this photo was taken. Source: Air Force Research Historical Agency

In 1955 LeMay solicited bids from television manufacturers to provide a direct visual link between SAC and NORAD.[62] Benjamin W. Chidlaw, commander in chief of the Continental Air Defense Command, similarly saw the benefit in using television to display data. In a letter to LeMay, he wrote, "I have been interested in TV for this command for some time…I believe that color TV is the only practical means of depicting a true televised air situation of the North American Continent as it is displayed in the [command center], because the types of plots, radar installations, and other important

[62] Curtis LeMay Papers, Library of Congress, BOX B51 Folder CHIDLAW, Letter from Curtis LeMay to General Benjamin W. Chidlaw, Commander Air Defense Command, 1 February 1955.

details are shown in [a] variety of colored paints, lights and crayons."[63] Chidlaw assured LeMay that he would keep the requirements of SAC in mind while investigating a move to this type of system, and further upgrades were implemented over the years.

The Strategic Air Command headquarters epitomized a utilization of advanced technology, and through LeMay's dedication to efficiency and maintenance of a global network, it projected an image of rationality and military strength.

The Power of SAC as a Deterrent

From this headquarters, LeMay promoted the mission of SAC: to deter war. As one historian notes, "The threat of nuclear annihilation to enforce peace may be a paradox but, in effect, it amounts to putting an unacceptable price tag on war as a forcible means of spreading Communism. Keeping the price tag unacceptably high [was] the constant concern of SAC. It [was] a formidable task."[64] Because SAC's deterrent mission was inherently psychological, SAC not only spent time training its crews and preparing them to go to war within minutes, they also openly demonstrated their capabilities to their enemies, such as in Operation Big Stick, in which SAC flew a mass fleet of B-36 bombers to the Far East.[65] One historian asserted that indeed, "SAC flexed its muscles regularly to hone its skills and to provide a show of force for the Soviet Union lest it believe that the West had lost its resolve and was an easy mark."[66] SAC aviators

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[63] Curtis LeMay Papers, Library of Congress, BOX B51 Folder CHIDLAW, Letter from B. W. Chidlaw to Curtis LeMay 22 January 1955.

[64] Clifford B. Goodie, *Strategic Air Command: A Portrait* (New York, NY: Simon and Schuster, 1965), 12.

[65] SAC 20: The Story of the United States Air Force's Strategic Air Command (Offutt Air Force Base, Nebraska, 1966), 27.

[66] Lloyd, 198.

participated in bombing competitions, made record-setting long-distance flights—such as the circumnavigation of the globe by the B-50A *Lucky Lady*, and mastered the art of aerial refueling.

SAC also used its participation in the Korean War as an instance to showcase its "prowess at bombing," and its involvement in this conflict led to a doubling of the number of active bomber units.[67] Indeed, SAC might have been the "most efficient and far-reaching fighting machine ever created—in order to ensure that there [would] be no fighting." While the situation was readily acknowledged to be similar to living under the sword of Damocles, the presence of SAC ostensibly achieved its goal (World War III never occurred) and its technical sophistication appeared to assuage the anxiety of the American people, at least in Nebraska.[68] In 1958, SAC was "hailed" at a reception in Omaha as a "warm and friendly neighbor and as the organization which has employed cold efficiency to contain the threat of Russian aggression."[69] Yet given the economic benefits Omaha received as a result of the installation, it is unsurprising that local citizens had nothing but praise for the Strategic Air Command. One reporter noted that "it's a novel companionship. It is a union of Nebraska's oldest town with one of the capitals of the space age." He quoted the mayor as saying that "SAC means a lot to us. There is no doubt it means a lot to the economy of the town."[70] Curtis LeMay was confident that

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[67] Peacock,19; Lloyd, 208.

[68] Richard G. Hubler, *SAC: The Strategic Air Command* (New York, NY: Duell, Sloan and Pearce, 1958), 14, 5.

[69] "SAC, World's Peace Force, Saluted on 10th Anniversary," *Sunday World-Herald*, 10 August 1958. "City Called Air Power Center of the World."

[70] "Bellevue, SAC Friendly Neighbors," *Sunday World-Herald*, 10 August 1958. Reports that the Omaha suburb of Bellevue has welcomed the influx of soldiers.

citizens across the nation similarly felt a debt of gratitude to SAC, even more so than to the other branches of the armed forces. He asserted: "By the middle 1950s, the power, efficiency, and publicity of SAC had become so impressive that in the public mind, this relatively new organization, less than ten years old, overshadowed not only the rest of the Air Force but the Army and Navy as well. Could the Army or Navy protect us against Russian atomic bombs? Could the Army or Navy deter Russian aggression by threatening to retaliate? No one thought so. Only the atomic umbrellas of SAC had the power to frighten the Soviets and thus prevent war."[71]

In popular media, however, SAC's ability to effectively deter war and LeMay's effectiveness at the helm were susceptible to criticism. The prime example is Stanley Kubrick's 1964 film *Dr. Strangelove: Or How I Learned to Stop Worrying and Love the Bomb*, which satirizes the theory of mutual assured destruction, the nuclear strategy executed by SAC. The Strategic Air Command is depicted as lacking effective fail-safe procedures and portrays a general (a thinly-veiled Curtis LeMay) as a war-mongering hothead who orders a pre-emptive strike on the USSR. LeMay, however, did not react with public outrage at the depictions of either himself or of SAC in this dark comedy. He dismissed the film, writing in his autobiography:

> Do not fail to recognize, however, that the people in the Command have been grateful for interest and coverage awarded them by the press, nationally and internationally. It would seem now that the world at large is more familiar with operations and growth of SAC than with any other part of the United States Air Force or any other air force. SAC became a blanket, a bulwark. It was winning the Big War—the One Which Didn't Have to Be Fought—purely because of the existence and might of SAC. Even the circulation of certain novels and the presentation of motion pictures which maligned the organization or offered an

[71] Coffey, 337.

> entirely false picture of what went on within our structure, could not undermine the solid confidence which, I'm glad to say, the bulk of civilian population has in SAC.[72]

Despite this rhetoric, it is difficult to believe that LeMay was not angered by mockeries of his command and the suggestion that SAC was not in complete control of its nuclear arsenal. On at least one occasion, he publicly pronounced his distaste for SAC's representation in *Dr. Strangelove*: "This emphasis on positive control is one of the least understood, and most important features of the entire command and control structure of SAC. Many of its officers still bear scars left by a popular novel, and later a movie, of some years back. The widespread public acceptance of the fictitious exaggerations of 'Dr. Strangelove' has been a traumatic experience for SAC, and still clouds its relations with the outside world."[73] LeMay also made appeals to the Air Force, asking for them to limit publications editorializing about the Command. In a 1955 letter to Major General John A. Samford, LeMay wrote,

> Newspaper and magazine articles continue to ridicule, criticize, and condemn the security system under which we operate…The need is obvious for immediate positive action to improve the management of our public information program and deny the Soviets as much information as possible regarding our air weapons. The more we are able to deny them information, the more we reduce the accuracy and precision of Soviet counterplanning.[74]

We will probably never know if this plea was truly motivated by national security concerns; perhaps it was primarily driven by embarrassment, or by a bit of both.

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[72] Lemay and Kantor, 499.

[73] David A. Anderton, *Strategic Air Command: Two-Thirds of the Triad* (New York, NY: Charles Scribner's Sons, 1976), 16.

[74] Curtis LeMay Papers, Library of Congress, Box B51 Folder CARROLL J. J. (Unclassified) Report To Chief of Staff, USAF on Public Release of USAF Technical Information, 23 July 1950.

Those sympathetic to the mission of the Strategic Air Command tend to cite public misconceptions about positive control being deleterious to SAC's image. Historian of the Air Force David Anderton cites one officer as saying that, "If we really had been dumb enough to operate [as they did in *Strangelove* and in *Fail Safe*]…Then the authors would have done us, and their country, a great service by pointing it out. But they were just 180 degrees out of phase." In his enthusiastic history of SAC, Anderton writes that he hesitates to retell the plot of *Strangelove* even in order to debunk it, "for fear it will be used once again, out of context."[75] SAC publications further dismissed the possibility of a Dr. Strangelove scenario:

> But in all the automation, all the computerisation [sic], all the science-fictional appearance of the control command post, one factor remains constant. The vital messages originate from people. There are no pre-formatted computerised [sic] 'go-codes' that could be triggered into action accidentally. Positive controls are everywhere, at every step along the route of war messages. 'Dr. Strangelove' was a movie; but SAC's positive control of its command structure is real.[76]

These anecdotes provide evidence that SAC was highly image-conscious, and its image-making was frequently linked to depictions of its underground command center. In contrast to the Cold War military spaces described in Paul Edwards' *The Closed World*, SAC headquarters was not a secret space. In fact, it was "one of the most visible military buildings in the world. The Commander in Chief frequently hosted presidents and congressional leaders, as well as luminaries from the entertainment world."[77] Images of the headquarters and its operations permeated the media in both popular and Air Force-

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[75] Anderton, 16.

[76] Ibid., 18-23.

[77] Daniel J. Hoisington, Historic American Building Records, Offutt Air Force Base, Headquarters, Strategic Air Command, HABS NO. NE-9-M, N, O, Nebraska State Historic Preservation Office, Folder SY04-175 BLDG #500 SAC HEADQUARTERS

created films, neither of which would have been released if such imagery truly held the potential to compromise national security. While *Dr. Strangelove* may have satirized nuclear strategy, the war room in that film is both austere and technologically sophisticated, which reflects both Hollywood's imaginings of the space and reinforced this image of SAC in the mind's eye of the global public. Air Force educational films were also widely distributed. They showed images of controllers at work on complex consoles, large screens filled with data, and rows of bombers ready to take flight, projecting the image of an efficient military force ready to strike.[78] These films were produced as much for the American public as they were for military commanders in the USSR. SAC commanders readily acknowledged that their operation was under scrutiny, both domestically and from aboard, and kept up-to-date on how the Command was depicted to the larger public. Some engineers even used language based on this recognition, such as using the term "Hollywood hard" to describe a space that visually appeared reinforced but was not truly hardened.[79] SAC's presence in popular media shows how the Air Force wanted to let the world know—and especially leaders in Russia—that it was technologically sophisticated, efficient, and ready to retaliate. As Dr. Strangelove exclaims, "The whole point of the doomsday device is lost if you keep it a secret!" And while bombers and missiles served as deterrent forces, the command and control center also played a significant role in combatting the possibility of Soviet aggression.

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[78] Air Force Special Film Project 1236, "SAC Command Post," available on Archive.org (accessed 2 October 2013).

[79] "U.S. Strategic Command Command Center," *Federation of American Scientists*, accessed 30 September 2013, http://www.fas.org/nuke/guide/usa/c3i/cmdctr.htm

Concluding Remarks

This headquarters was so envied that other commanders requested that their air force bases be outfitted with their own control centers, albeit on smaller scales. Major General George W. Mundy requested one for himself at Barksdale Air Force Base, and requested that Curtis LeMay offer his support, to which LeMay replied tepidly that the AF budget for the fiscal year had already been submitted, and sent Mundy back to the drawing board with requests for more specific designs.[80] The creation of this space became a part of LeMay's legacy and one of his greatest accomplishments during his tenure at SAC, but he was not to remain at this command indefinitely. Soon after the move into the new headquarters, when LeMay gave a speech at Air University in February 1957,

> He sounded as if he realized that his own days at SAC were numbered. He had been there eight and a half years, a long time in any command, and he had undoubtedly heard new rumors of a shift in the making. Perhaps it was for that reason he made the opening of the new SAC headquarters (or "control center" as he and Griswold dubbed it) an occasion for a big celebration at New Year 1957. It had taken him a long time to get that headquarters built, but by God, he had managed it before his departure.[81]

LeMay left SAC for the position of Vice Chief of Staff of the United States Air Force in July 1957 and remained in this position until 1961, when he was made the fifth Chief of Staff of the United States Air Force, a post he held until 1965.

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[80] Curtis LeMay Papers, Library of Congress, BOX B56, Folder Mundy, Geo. Letter from George W. Mundy to Curtis LeMay, 9 February 1957; Letter from Curtis LeMay to George W. Mundy, 3 May 1957.

[81] Coffey, 343.

Figure 19. A contemporary view of the Curtis LeMay Building looks much as it did forty years ago. Source: Air Force Space Command

In March 1962, the Air Force awarded a $1.4 million contract for the modification of the SAC control center and work began in the same month. The project, involving all three subterranean floors, involved extensive modification of the facility and a major revision of electrical wiring in order to accommodate new computing and communications equipment.[82] In the 1990s, author Tom Clancy quipped that an upgraded command post was built because "Hollywood's rendition of such rooms was better than the one SAC had originally built for itself, and the Air Force had decided to alter its

82 The History of Fort Crook, 1888 [and] Offutt Air Force Base, 1976, Published by the 3902d Air Base Wing, the host unit at Offutt Air Force Base. Borrowed from the Creighton University Alumni Memorial Library in Omaha, Nebraska, 97.

reality to fit a fictional image."[83] Given events such as the Bay of Pigs fiasco and the Cuban Missile Crisis, being only 46 feet below ground and unable to withstand a direct hit no longer seemed acceptable. Headquarters SAC was re-designated a "soft" as opposed to a hardened site. The Kennedy administration saw this as a liability and began construction of two hardened command posts, both in mountains: the Alternate National Military Command Center in Pennsylvania and NORAD's Combat Operations Center in Cheyenne Mountain.[84]

The Strategic Air Command's response, as it could not build a mountain around itself, was to maintain a constant airborne Combat Operations Center. The aircraft used was the Boeing EC-135C, flown by pilots and crews from the 2nd Airborne Command Control Squadron, of SAC's 55th Strategic Reconnaissance Wing. Starting in 1961, these aircraft, codenamed *Looking Glass*, flew in random circles above Offutt Air Force Base in eight hour shifts. "The airborne communications systems duplicate[d] many of the ground-based ones, and [were] tied directly to the primary alerting system, to North American Air Defense Command, SAC's underground command post, USAF's command post, and to the National Military Command Center." These planes were outfitted with sophisticated communications links, teletype machines, and launch control systems that could fire Minuteman missiles.[85] Yet Looking Glass and HQ SAC would soon become artifacts of another era, while decentralized military command and control

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[83] Daniel J. Hoisington, Historic American Building Records, Offutt Air Force Base, Headquarters, Strategic Air Command, HABS NO. NE-9-M, N, O, Nebraska State Historic Preservation Office, Folder SY04-175 BLDG #500 SAC HEADQUARTERS

[84] Ibid.

[85] Brochure, The Progressive Development of the Strategic Air Command, 1946-1965 (Offutt Air Force Base, Nebraska, no date), 55.

became the dominant architecture. Its limited secrecy and visibility point to competing interests specific to the Cold War. That is, there was value in both promoting the site as a stronghold and in protecting the true extent of its technological advances.

CHAPTER 4. NORAD's Combat Operations Center

Secrecy Classification: CONFIDENTIAL

"A strange game. The only winning move is not to play.
How about a nice game of chess?"

-War Operation Plan Response (WOPR),
Supercomputer in *Wargames* (1983)

The North American Air Defense Command (NORAD) Combat Operations Center (COC) inside Cheyenne Mountain embodies Cold War deterrence policy, and the history of its construction and design showcases how engineers and operators transitioned from manual systems to complex, computer-driven architecture. Automated command and control during the 1950s set the stage for how and why the COC was constructed and utilized. Not all commentators weighing in immediately approved of the technocratic solution, and they emphasized caution when moving toward automated systems. For example, while acknowledging the military's need for automatic equipment to gather and process information, author Thornton Read asserted that "there are serious dangers in looking to technology as a substitute for good organization, clear policies, and conceptual understanding."[1] Yet military leaders could not ignore how innovations in communications and computer technology were changing the face of warfare in the twentieth century. Writing in 1960, one Air Force pundit asserted that the branch was

[1] Thornton Read, *Command and Control* (Princeton, NJ: Princeton University Center of International Studies, 1961), 46.

"riding the wave of what some call 'the electronic revolution'" where instantaneous communications are necessary for "modern-day control of our weapons […] to facilitate complex decisions."[2] Writing in 1959, Air Force Captain William M. Mack noted that the recent "aerospace revolution" had made the design and construction of ground facilities as important as the development of weapons such as missiles.[3] After all, these weapons were useless if they could not be controlled.

Indeed, creating command and control systems and proper spaces to house them was a pressing military concern during the Cold War. This was due to both utilitarian military imperatives—identifying attackers and being prepared to retaliate—and to more abstract goals, such as projecting the image of American power. One systems designer observed in 1965 that "[a]utomated command and control has become extremely fashionable in recent years, achieving some appeal as a military status symbol."[4] The Combat Operations Center was *revolutionary*, not evolutionary. This change was driven by the Cold War arms race, which spurred both rapid technological development and its implementation in military systems. According to political scientist Paul Bracken, the late 1950s was a time when "the military may have absorbed more technological change in a shorter time than any other organization in history."[5]

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[2] John F. Loosbrock, "Command and Control for Missiles and Space," *Air Force Magazine*, April 1960.

[3] William M. Mack, "Groundwork for Spacepower," *Air Force Magazine*, December 1959.

[4] D.R. Israel, "System Design and Engineering for Real-Time Military Data Processing Systems" (Bedford, MA: The MITRE Corporation, 1965), 13.

[5] Paul Bracken, *The Command and Control of Nuclear Forces*, New Haven, CT: Yale University Press, 1983), 179.

The necessity for new, technologically advanced command and control systems created widespread concern in engineering communities. Reports and evaluations of what we now call "systems engineering" (a term also used by contemporary actors) proliferated in an effort to correct any then-current command and control system flaws, as sites often "went live" without benefit of being tested. Designers also created guidelines and templates for how systems should be constructed in the future. While they concerned themselves with the development of these sites, the United States government promoted architecture to project images of technological superiority. The Combat Operations Center within the Cheyenne Mountain Complex was the archetype of Cold War systems engineering. As historian William J. Astore eloquently described it, this "Cold War citadel" was meant to "corral and contain our nuclear fears" while also serving as a "repository of our technological dreams and a response (however feeble) to our technological nightmares."[6] Indeed, while the construction of this space accomplished a technological feat, its symbolism is just as historically important.

[6] William J. Astore, "Leaving Cheyenne Mountain," *The Nation*, 17 April 2008.

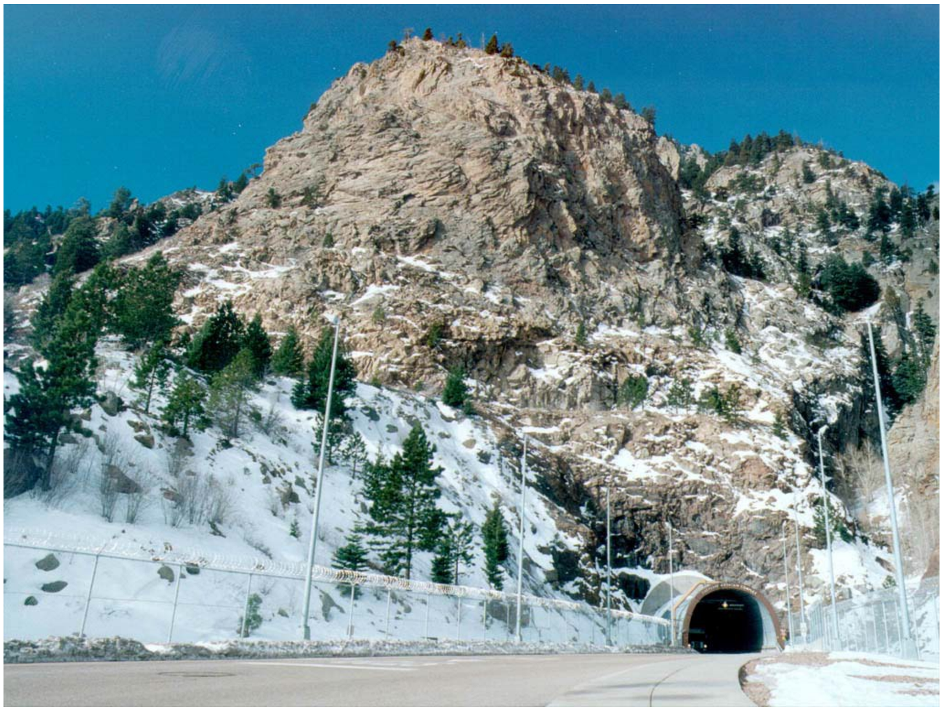

Figure 20. View of tunnel entrance to the Cheyenne Mountain Complex. Source: NORAD.

What is NORAD?

The Ogdensburg Declaration of 18 August 1940, which outlined a plan for mutual defense, marked the beginning of a joint United States and Canadian commitment to defense of the North American continent.[7] After World War II, the alliance strengthened, and in response to the Soviet bomber threat, the United States and Canada constructed the Pinetree radar network in 1951 (completed in 1954), the Mid-Canada Line (or McGill Fence) in 1954 (300 miles north of Pinetree and completed in 1957), and the Distant Early Warning (DEW) Line in 1955 (constructed 200 miles north of the Arctic circle).

[7] Douglas Murray, "NORAD and U.S. Nuclear Operations" in Joel J. Sokolsky and Joseph T. Jockel, eds., *Fifty Years of Canada-United States Defense Cooperation* (Lewiston, NY: The Edwin Mellen Press, 1992), 209; David Cox, *Canada and NORAD, 1958-1978: A Cautionary Retrospective* (Ontario, Canada: The Canadian Centre for Arms Control and Disarmament, 1985), 4.

This radar defense network gave North America two to three hours of warning in the event of a bomber attack.[8] Its primary functions were to prevent destruction of the Strategic Air Command bomber force by surprise attack and reduce Soviet capability to attack North American population centers.[9] Quite a few Canadian historians and political scientists are retrospectively critical of these joint projects, and depict the United States as imposing its ambitions onto its northern neighbor.[10] According to the most vocal of these scholars, Joel Jockel, "no sooner had the Second World War ended in Europe and the Pacific than the Canadian government was confronted by pushy US airmen intent on erecting in the Canadian Arctic what many critics called a Maginot line of the north. As early as 1945 Canada seemed in danger of swiftly becoming, because of its location between the U.S. and the U.S.S.R., the world's next Belgium."[11]

Hyperbole or not, the decision to integrate air defenses in the postwar years did pose problems for Canadian leaders who were concerned about sovereignty. Beginning in 1954, study groups in both countries examined the possible issues involved in monitoring radar lines, and gave their recommendations to military and political leaders. Three years

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[8] Victor E. Renuart, Jr., "The Enduring Value of NORAD," *Joint Force Quarterly*, issue 59, third quarter (2009), 93.

[9] Daniel C. Dosé, *NORAD: A New Look* (Kingston, Ontario: Centre for International Relations, 1983), 5.

[10] Much of the history of NORAD is dominated by Canadian scholars, most of whom critique the arrangement between Canada and the United States as being monopolized by American interests and as one that has marginalized Canada's political decision-making power. For only a few examples, see Joel J. Sokolsky and Joseph T. Jockel, eds., *Fifty Years of Canada-United States Defense Cooperation* (Lewiston, NY: The Edwin Mellen Press, 1992), David Cox, *Canada and NORAD, 1958-1978: A Cautionary Retrospective* (Ontario, Canada: The Canadian Centre for Arms Control and Disarmament, 1985), Ann Denholm Crosby, *Dilemmas in Defence Decision-Making: Constructing Canada's Role in NORAD, 1958-96* (New York, NY: St. Martin's Press, Inc., 1998), Richard Evan Goette, "Canada, the United States and the Command and Control of Air Forces for Continental Air Defence from Ogdensburg to NORAD, 1940-1957" (PhD diss, Kingston, Ontario, Canada, Queen's University, December 2009).

[11] Joseph R. Jockel, No Boundaries Upstairs: Canada, the United States, and the Origins of North American Air Defense, 1945-1958 (Vancouver, Canada: University of British Columbia Press, 1987), ix.

later, a satisfactory agreement was reached, and in September 1957 the United States and Canada established the North American Air Defense Command (NORAD) at Ent Air Force Base in Colorado Springs. This structure would be headed by an American commander-in-chief (CINCNORAD) and a Canadian deputy commander. Although these positions can be held by either nationality, this configuration has always been the case. These commanders would be responsible to the Joint Chiefs of Staff of the United States and to the chief of Canadian Defense Staff. The Command would include subcommands from the US Army, the US Naval Forces, the Air Defense of Canada, and others.[12] Canadian scholars again call attention to the imbalances in this alliance. According to Jockel, the fact that NORAD shared its commander, its headquarters, and its operations center with a purely US command was another form of "divided authority."[13] The US command he is referring to is the Continental Air Defense Command (CONAD), created in 1954 from Air Force Defense Command, which shared the space at Ent AFB with NORAD and was responsible for US responsibilities outside of NORAD's jurisdiction, such as delivery systems for atomic weapons.[14]

During the early years of the Cold War, NORAD's job was to watch the skies for suspicious objects, warn the Strategic Air Command and others of any observations, and defend against an attack from Soviet bombers carrying nuclear weapons to North America. NORAD had surface-to-air missiles and fighter interceptors at its disposal in

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[12] David F. Winkler, *Searching the Skies: The Legacy of the United States Cold War Defense Radar Program* (Langley AFB, VA: Headquarters Air Combat Command, 1997), 32.

[13] Joseph T. Jockel, *Canada in NORAD, 1957-2007: A History* (Montreal, CA: McGill-Queen's University Press, 2007), 1; 6.

[14] Kenneth Schaffel, *The Emerging Shield: The Air Force and the Evolution of Continental Air Defense, 1945-1960* (Washington, D.C.: Office of Air Force History, 1991), 252.

the event that it needed to intercept bombers. NORAD was tasked with intercepting an incoming threat; massive retaliation was the job of the Strategic Air Command. In a hypothetical attack scenario: the DEW line radars would detect unidentified planes approaching via a polar route, it would broadcast this information to NORAD's Combat Operations Center, SAC bombers would be alerted, forward-based inceptors would be dispatched to confirm the identity of the plane, and if it were found to be an enemy, the fighters would destroy it.[15]

By the time this process was configured, however, the Soviets had launched *Sputnik*, and NORAD's mission was no longer to defend against bombers, but against Intercontinental Ballistic Missiles (ICBMs). Much as Curtis LeMay recognized the need to shield the Strategic Air Command's headquarters (by burying it underground), NORAD's first CINCNORAD General Earle E. Partridge requested that "the Air Staff consider an underground location for the COC [command operations center] from which its personnel could, by using computers, oversee the decentralized air defense battle and assume control of ICBM defense when the threat developed."[16] Thus, air defense systems buildup in the postwar years, along with the development of ICBMs, facilitated the creation of computer-oriented command and control systems, as well as reaffirmed the

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[15] Kenneth Schaffel, "The U.S. Air Force's Philosophy of Strategic Defense: A Historical Overview" Stephen J. Cimbala, ed., *Strategic Air Defense* (Wilmington, DE: SR Books, 1989), 15-16. For information about Soviet Strategic Air Defenses see Daniel Gouré, "Securing the Skies of the Motherland: Soviet Strategic Air Defenses" in Stephen J. Cimbala, ed., *Strategic Air Defense* (Wilmington, DE: SR Books, 1989).

[16] Schaffel, "The U.S. Air…."

perceived need for hardened sites.

Figure 21. On the NORAD crest the blue air, yellow land, and turquoise oceans signify the three environments in which defense could take place. Silver wings symbolize the armed forces and military strength, the sword points north to the shortest distance to the potential aggressor (the USSR), and the two yellow lightning bolts portray NORAD's instantaneous striking power. This image encapsulates NORAD's motto: DETER, DETECT, DEFEND. Source: NORAD

Going Into the Mountain

After the 1958 construction of SAC's underground command center and its redesignation as a "soft" site that would not survive a direct nuclear weapon hit, two commissions reviewed the need for a hardened site for military command operations.[17] One was the Winter Study, which was composed of two dozen panels and more than 100 participants drawn from both the military and industry; the other was the Partridge Study, ordered by defense secretary Robert McNamara and headed by NORAD officials. Both commissions

[17] Other "soft" sites included the National Military Command Center on the third floor of the Pentagon and the White House Situation Room, a small, windowless wooden box located in the basement of the West Wing.

reached the same conclusion: command centers should be "hardened" to survive a direct hit by a nuclear warhead. They asserted that this could be done either by locating them deep underground, or by making them airborne, like *Looking Glass*.[18]

Figure 22. The excavated mountain interior. Source: Henry W. Hough, NORAD Command Post: The City Inside of Cheyenne Mountain (Denver, CO: Green Mountain Press, 1970).

[18] David E. Pearson, *The World Wide Military Command and Control System* (Maxwell Air Force Base, Alabama: Air University Press, 2000), 37-38; The Partridge Report is particularly significant for its emphasis on the creation of a centralized command system. As Pearson writes, "If NORAD and its sensors were the body's eyes and ears, if SAC were its muscles and its fists, the new command system would constitute its brain and central nervous system—the network that permitted all of the parts to operate as a single coherent identity" (38). In the 1970s, this structure was brought into being; it was called the World Wide Military Command and Control System.

Prior to its move into Cheyenne Mountain, NORAD's Combat Operations Center was not only "soft" but completely unprotected. It was located in above-ground cinder block buildings in Colorado Springs, and all communication was done over AT&T telephone lines that were not designed to withstand an attack. In fact, according to one historian, "a few hand grenades could have blacked out the nation's entire warning system."[19] In March 1959, the Joint Chiefs of Staff decided to relocate the NORAD Command Operations Center to inside Cheyenne Mountain. Land was soon purchased and the access roads to Cheyenne Mountain were completed. After a slight delay, when the project underwent further review, in 1960 the Air Force approved plans and requested funds from the Department of Defense. The Air Force also directed its Systems Command to proceed with a systems design study, which included authority to solicit proposals from the MITRE Corporation and the Systems Development Corporation on a structure for the internal command and control system.[20]

While plans went forward, debate existed over whether it was really worth the cost to harden sites. According to political scientist Paul Bracken,

> The theory behind the 'soft' design for command and control was that the purpose of all of these systems was to get warning in order to launch a nuclear attack. In the 1950s, there were no plans to fight a limited or controlled nuclear war. War plans were posited on a single massive salvo of weapons. The assumption in the United States was that the military command posts had no function after they launched their missiles.[21]

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[19] Paul Bracken, *The Command and Control of Nuclear Forces* (New Haven, CT: Yale University Press, 1983), 187-188.

[20] North American Air Defense Command and Continental Air Defense Command: Historical Summary January – June 1961 (Directorate of Command History, Office of Information, Headquarters NRAD/CONAD, 1 November 1961), 65

[21] Bracken, 187-188.

Indeed, if NORAD's true ambition were to deter war, then any attack against North America would mean that it had already failed its mission. This outlook did not resonate, however, with those who optimistically believed that a limited war could still be fought, such as civilian planners at the RAND Corporation. They argued that not only was it imperative that military installations be moved into hardened sites, but that plans to locate NORAD inside of Cheyenne Mountain needed to be re-evaluated, as the current design would not protect it against a direct hit. To make the site truly hardened, RAND planners argued, the structure needed be located *underneath* the mountain instead of inside of it. They were overruled, however, and although NORAD was built "harder" than before (able to withstand 500 to 1,000 psi), it would not survive a direct assault.

Cheyenne Mountain is a subordinate triple-peaked landmark eroded from the Precambrian Pikes Peak batholith.[22] It was chosen for its granite composition and its proximity to Colorado Springs and Fort Carson, which enabled relatively quick and cheap completion.[23] The Combat Operations Center's location on the east slope of Cheyenne Mountain and its orientation were determined by the presence of the best granite to "permit free-standing arch-roof chambers capable of withstanding the effects of a nuclear weapon detonation."[24]

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[22] Merwin H. Howes, *Methods and Costs of Constructing the Underground Facility of North American Air Defense Command at Cheyenne Mountain, El Paso County, Colo.* (Washington, D.C.: US Department of the Interior, Bureau of Mines, 1966), 7. There was a far lesser-known combat operations center built around the time of Cheyenne Mountain in North Bay, Ontario, and both posts served as nerve centers. Victor E. Renuart, Jr., "The Enduring Value of NORAD," *Joint Force Quarterly*, issue 59, third quarter (2009), 94.

[23] Howes, 4.

[24] Ibid., 7.

Figure 23. A worker poses within the 1400-foot tunnel. Source: Marian Talmadge and Iris Gilmore, NORAD: The North American Air Defense Command (New York, NY: Dodd, Mead & Company, 1967).

The underground facility was designed and engineered by Parson, Brinkerhoff, Quade, and Douglas in three phases: (1) excavation, (2) construction of steel buildings in chambers, and (3) installation of electronic equipment in the buildings. The Army Corps of Engineers oversaw the first two phases, and the Air Force the third. Utah Construction & Mining Company won the contract to excavate the site with their low bid of approximately $6 million and a completion schedule of 365 days. Excavation started in July 1961, but was completed a little behind schedule because 95 modifications to the original contract raised the cost to more than $12 million and pushed the completion date (for this phase) back to June 1964.[25] Meanwhile, the Bureau of Mines used this project as an opportunity to study large-size, controlled blasting techniques, and the hollowed-out granite was used to fill in a nearby canyon to make a parking lot for the facility, creating another postwar landscape.[26]

Figure 24. Massive blast doors could be opened within 30 seconds. Source: Marian Talmadge and Iris Gilmore, NORAD: The North American Air Defense Command (New York, NY: Dodd, Mead & Company, 1967).

After excavation, work began on the construction of the Complex. The chamber that houses the group of buildings lies at the intersection of two tunnels. The weakened

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[25] Ibid., 5; 63.
[26] Ibid., 1.

rock between the tunnels would not support a concrete dome roof, so the designers shaped the chamber as a concrete sphere pierced by the tunnels. [27] The entrance tunnel is 60 feet high and stretches 1,400 feet into the mountain. Located at the end of this tunnel is the entrance to the building complex: two huge steel-blast doors, each more than three feet thick and weighing more than twenty-five tons, set in concrete pillars fifty feet apart, and which could be opened or closed hydraulically in thirty seconds. For further protection, the doors were encased in seventeen-foot-thick concrete collars, and the two access tunnels were placed so that if a nuclear blast swept down one tunnel, it would go straight on through and out the other one. Beyond these doors was a "windowless city" in a 4.5-acre grid of excavated chambers and tunnels. Eleven alternating green-and-yellow free-standing, steel buildings—which did not make contact with their granite enclosure—were linked by passages. Eight of the buildings were three stories tall, the others were one and two stories, and all together they provided 200,467 square feet of floor space.[28] (More buildings were added in later years.) The building shells were made of three-eighths-inch continuous welded steel plates and were supported by steel frames. Although aluminum or other light-weight metals would have been cheaper and easier to use, steel was the material deemed best to withstand a nuclear blast.[29]

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[27] "Concrete Sphere Cast in Mountain," *Engineering News-Record*, 28 March 1963, 32.

[28] Henry W. Hough, *NORAD Command Post: The City Inside of Cheyenne Mountain* (Denver, CO: Green Mountain Press, 1970).

[29] Marian Talmadge and Iris Gilmore, *NORAD: The North American Air Defense Command* (New York, NY: Dodd, Mead & Company, 1967), 47-49.

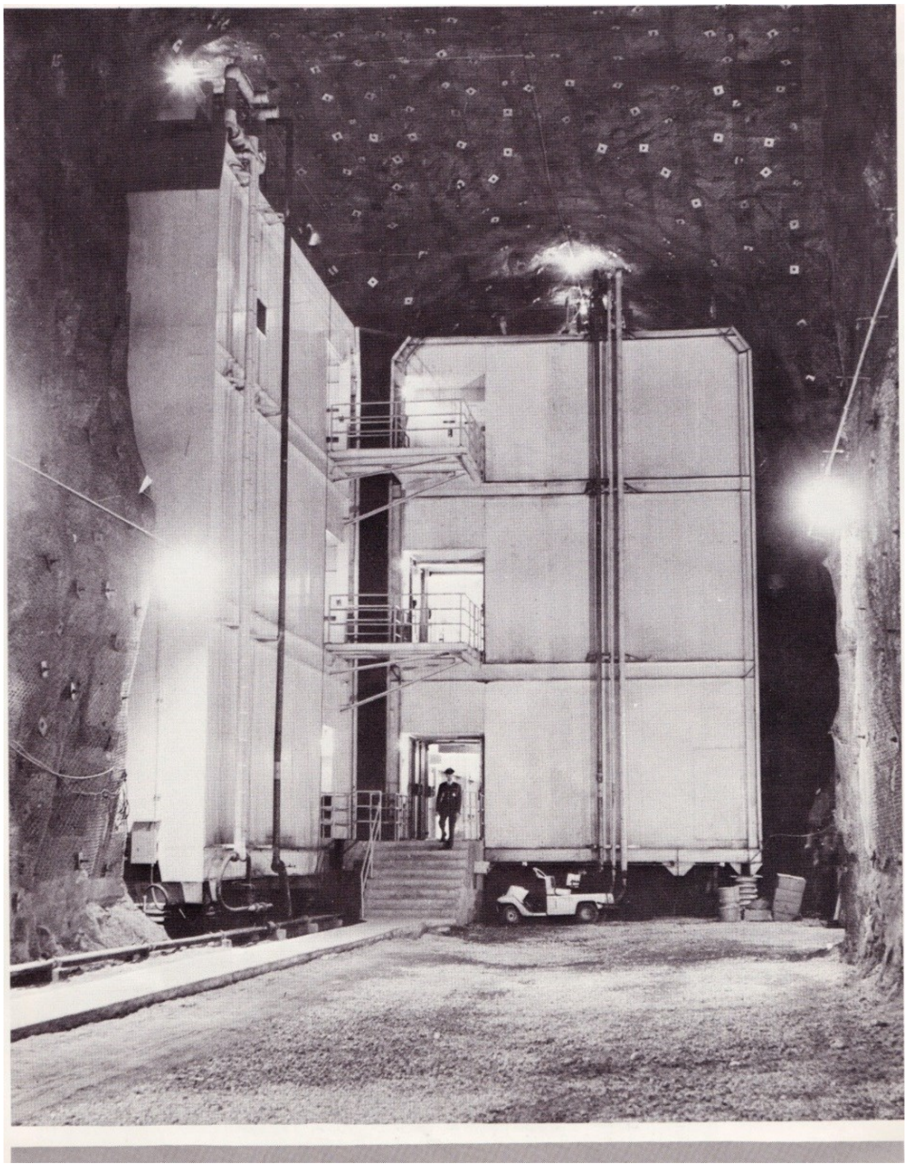

Figure 25. Fifteen buildings provided more than 200,000 square feet of floor space. Source: Henry W. Hough, NORAD Command Post: The City Inside of Cheyenne Mountain (Denver, CO: Green Mountain Press, 1970).

All of these buildings rested on massive steel springs (more than 900 total), each made from 3-inch diameter steel rods and weighing one-thousand pounds, which would work as hydraulic shock absorbers in the event of an explosion or an earthquake.[30] Also designed in light of a doomsday scenario, blast valves in concrete bulkheads protected water and sewer lines and air portals, and diesel engines produced electrical power, fed by a fuel reserve that could keep the complex running for about 30 days.[31] Engineers encountered a major problem when they needed to devise a way to remove heat created by power-generating equipment. One solution was to store water underground to provide a heat sink, but engineers chose instead to provide cooling towers in the protected area that use filtered air from outside of the mountain to absorb the heat. While this scheme required more air, it needed less water, and this advantage outweighed that of any other solution.[32] Other unexpected engineering challenges came up throughout the construction process, and engineers concocted solutions on an ad hoc basis.

[30] Hough.

[31] Daniel J. Hoisington, Historic American Building Records, Offutt Air Force Base, Headquarters, Strategic Air Command, HABS NO. NE-9-M, N, O, Nebraska State Historic Preservation Office, Folder SY04-175 BLDG #500 SAC HEADQUARTERS p. 47-48

[32] Theodore O. Blaschke, "Underground Command Center—problems in geology, shock mounting, shielding," *Civil Engineering*, May 1964: 36-37.

Figure 26. The buildings rested on more than 900 steel springs, meant to absorb the shock of an earthquake or nuclear explosion. Source: Henry W. Hough, NORAD Command Post: The City Inside of Cheyenne Mountain (Denver, CO: Green Mountain Press, 1970).

Once the buildings were constructed inside the mountain, it was time to fill these spaces with the electronic equipment necessary to make this site the nerve center from which NORAD might provide instant alert warnings to the Strategic Air Command, to the governments of the United States and Canada, and to civil defense posts throughout these nations. Writing in 1967, one journalist called the computers powering NORAD's command and control system, "probably the Western world's most important military data processing installation."[33] Yet it was not quite that glamorous. The system was composed of three standard commercial digital computers, Philco 2000/212s, and as the design was frozen in 1963, the computers were outdated by the time the post began operation. The system's ability to process information, however, remained impressive. On 21 November 1960, the Air Force assigned the MITRE Corporation the task of designing the system that would network the Combat Operations Center, with Burroughs Corporation as system contractor.[34] The resulting infrastructure provided a constant stream of information to the CINCNORAD and his battle staff, including data from: the Ballistic Missile Early Warning System (BMEWS),[35] the Distant Early Warning (DEW) line and coastal radar networks, picket planes and ships, and other information sources and field commands. The system was designed so that the NORAD commander could view a large group display, measuring 12 by 16 feet, with data aggregated from smaller console displays operated by his staff.

To create the large display, information was first assembled on the console displays. Then, this data (in three colors: red, green, blue) was photographed as three adjacent frames on a roll of 35-millimeter film, and these pictures were projected through color filters and a lens system so that they were superimposed on the screen. Under battle conditions, the group display could be updated every 14 seconds but typically would be updated every minute or so, and under low-threat circumstances it was only updated

[33] Robert T. Stevens, "Norad's computers get all the facts," *Electronics*, 20 February 1967, 113.
[34] MITRE: The First Twenty Years (MITRE, 1979), 30.
[35] Built in 1959, the Ballistic Missile Early Warning System (BMEWS) was connected to the Combat Operations Center by about 225,000 miles of cable and radio circuits, and it cost more than $895 million to construct, although according to one contemporary writer, "for the peace of mind and security [it] give to America, [it was] a bargain indeed." C. B. Colby, *North American Air Defense Command: How the U.S.A. and Canada Stand Guard Together* (New York, NY: Coward-McCann, 1969), 37.

every five minutes. While the process might sound cumbersome, the lack of a real-time group display was not considered a serious problem, as the battle staff could instantly alert the CINCNORAD to any significant events that appeared in real time on their consoles.[36]

The Bell System provided communications systems for the command post, with its priority being to ensure the survivability of the system. Engineers achieved this by building redundancy into the structure and by developing automatic route restoral plans. "The result," according to a Bell publication, "is a self-healing system that instantly detects changes in transmission status and rapidly adjusts to new conditions by automatic switching."[37] The COC was truly a command and control center of the future, filled with advanced and occasionally autonomous modern electronics. By the time of its completion in 1966, the Combat Operations Center had cost $142.2 million from R&D through construction through test operations of the equipment.[38]

Unlike other underground headquarters, such as that of the Strategic Air Command, the Combat Operations Center closely resembled a massive fallout shelter. It was a far larger space and employed more people who worked longer shifts. In addition, the Combat Operations Center was but one element of this facility. Due to the bunker nature of the Cheyenne Mountain Complex and long hours spent by workers within the

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[36] Stevens, 118.

[37] H.C. Franke, "Communications for NORAD Headquarters," *Bell Laboratories Record*, January 1967, 8.

[38] Henry W. Hough, *NORAD Command Post: The City Inside of Cheyenne Mountain* (Denver, CO: Green Mountain Press, 1970); Bernard C. Nalty, ed., *Winged Shield, Winged Sword: A History of the United States Air Force* (Washington, D.C.: Air Force History and Museums Program, 1997). – Volume II 1950-1997. See especially, chapter 14, Walton S. Moody, Jacob Neufeld, and R. Cargill Hall, "The Emergence of the Strategic Air Command," 58.

space, this structure was designed not only to withstand attack, but to allow people to live comfortably within it for prolonged periods of time. Thus, necessary amenities, such as dedicated space for leisure and ample food provisions were available so that residents would not simply survive being locked within these buildings in the event of nuclear attack, but they would enjoy a suitable quality of life. These comforts improved the stress of day-to-day-operations as well. There were sleeping rooms with three-decker bunk beds, a dining hall (with "heat ovens [that] can cook ten-ounce steaks in thirty seconds!"), a small hospital facility, a pharmacy, and a dental office. Other comforts included television and radio hookups, movies, and a library.[39] Despite these amenities, the reality of working inside the mountain was, according to one Air Force lieutenant, "decidedly unglamorous," as there was no natural light and the air circulation system was noisy. Although, he continued, tongue in cheek, "Exposed pipes and cables gave the mountain a style that might be termed 'early industrial chic'—one you sometimes see echoed today in high-end lofts and dance clubs."[40]

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[39] Talmadge and Gilmore, 52.
[40] William J. Astore, "Leaving Cheyenne Mountain," *The Nation*, 17 April 2008.

Figure 27. Battle staff worked on a lower level while commanding officers surveyed operations from the second tier. Source: Marian Talmadge and Iris Gilmore, NORAD: The North American Air Defense Command (New York, NY: Dodd, Mead & Company, 1967).

While these spaces may not have evoked great awe, the Combat Operations Center (COC) created an impressive atmosphere of austerity. Within this space, the NORAD commander-in-chief was located on the center level of the three-dais command post along with the director of the COC, the command director, an assistant operating the command and control system, and three technicians handling communications and displays. Above the CINCNORAD, on the third level, the intelligence watch officer was monitoring the Intelligence Data Handling System, along with members of the Civil Defense National Warning Center, and officers of the Federal Transport Agency and the Canadian Department of Transport. The lower level was manned by other members of NORAD battle staff, including commanders of the Canadian Forces Air Defence

Command, the US Air Force Air Defense Command (ADC), the US Army Air Defense Command (ARADCOM), and commanders of Navy forces.[41] These operators observed the influx of overhead monitoring data at consoles and also via the group display to understand global events in real time. Again, the amount of data and its means of transport to the COC were innovative.

Writing in 1967, NORAD "officer-wives" Marian Talmadge and Iris Gilmore marveled at how data taken at distant locations could be displayed in the COC without ever having gone through a human operator: "Some of these systems are so fast that they work in what scientists call 'real' time—that is, faster than the human brain can experience…The man-made intelligence that functions in the depths of giant Cheyenne Mountain appears to work with an assurance that is almost superhuman." They were sure, however, to remind their readers that "the human brain…is still necessary. This cannot be pointed out too often. In addition to the electronic logic of the computers, the human brain must make final decisions. It still takes human fingers to punch the buttons which control North America's defense."[42] This insistence underscores how hypothetical failures of complex command and control systems, such as a computers gaining autonomy and ushering in nuclear Armageddon, became a cultural trope for nuclear fear, as reflected in films from *Colossus: The Forbin Project* in the 1960s to *Wargames* and *The Terminator* in the 1980s.[43] While Talmadge and Gilmore did not work inside the

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[41] Talmadge and Gilmore, 19.
[42] Ibid., 21-22.
[43] Edwards, 106-107. The possibility of systems failures (aka broken arrows) resulting in nuclear accidents remains a popular topic well into the present. See Eric Schlosser, *Command and Control:*

mountain, according to a 1970 publication, sixty-six women were employed at the command post at jobs such as computer operator, space analyst, secretary, stenographer, and telephone operator. According to one contemporary male writer, they referred to their workplace as “The Cave” and “d[id]n’t mind being dubbed ‘cave women.’”[44]

Figure 28. The depiction of the NORAD Combat Operations Center in the movie Wargames was decidedly more glamourous than the actual post. Source: United Artists.

Architecture of Deterrence

The cornerstone of Eisenhower’s New Look national security policy, and the foundation upon which NORAD rested, was deterrence as a military strategy, borne of the creation of weapons against which we had (and have) no defense. The power of deterrence strategy does not lie in the military’s ability to defeat an adversary, but instead lies in a

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Nuclear Weapons, the Damascus Accident, and the Illusion of Safety (New York, NY: The Penguin Press, 2013).

[44] Hough; Roger Rapoport, “Dug In For Doomsday,” *Los Angeles Times*, 17 May 1970, W18.

military's *capacity* or *potential* for violence. During the Cold War, the most effective weapons became those that could influence behavior or achieve bargaining power. In other words, strategic forces are instruments of threat, coercion, and intimidation rather than of military muscle.[45] Given this definition of a weapon of deterrence, the NORAD Combat Operations Center was a strategic weapon in and of itself; this semi-hardened installation was meant to deter the enemy through its mere existence.[46] When Americans summoned a mental image of the North American Air Defense Command, they envisioned the tiered workstations and theater-size screens of the COC in Cheyenne Mountain. As Talmadge and Gilmore succinctly wrote: "NORAD *is* the cave-like command post" [emphasis added].[47] This arrangement has become synonymous with technological sophistication, and has served as a template for any space that wants to be associated with efficiency and efficacy. As the central, visible hub of North America's air defense system, NORAD's high-tech Combat Operations Center provided a symbol that soothed the fears of citizens while at the same time being poised to initiate massive retaliation. Of course, our "deterrent depends on what we would be capable of doing if war came."[48] This capability was predicated on the construction of technologically

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[45] Bruce G. Blair, *Strategic Command and Control: Redefining the Nuclear Threat* (Washington, D.C.: The Brookings Institution, 1985), 17.

[46] I have been asked by colleagues whether people thought that building complex structures underground was not a display of strength, but was instead seen as cowardly, as though military leaders were hiding from the enemy. I have not encountered any evidence that this is the case, and I believe that is for a few reasons, including: (1) the Soviet Union also built many subterranean structures, so this was considered a matching of ways of utilizing natural resources as shields, and (2) these were not fallout shelters, they were fortressed command posts from which to direct—and win—war. Inhabitants would not be hiding in these spaces, but would be annihilating the enemy, directing electronically launched weapons while remaining invulnerable to attack.

[47] Talmadge and Gilmore, 74.

[48] Read, 19.

sophisticated command and control centers, such as the Combat Operations Center, from which responses would be launched.[49]

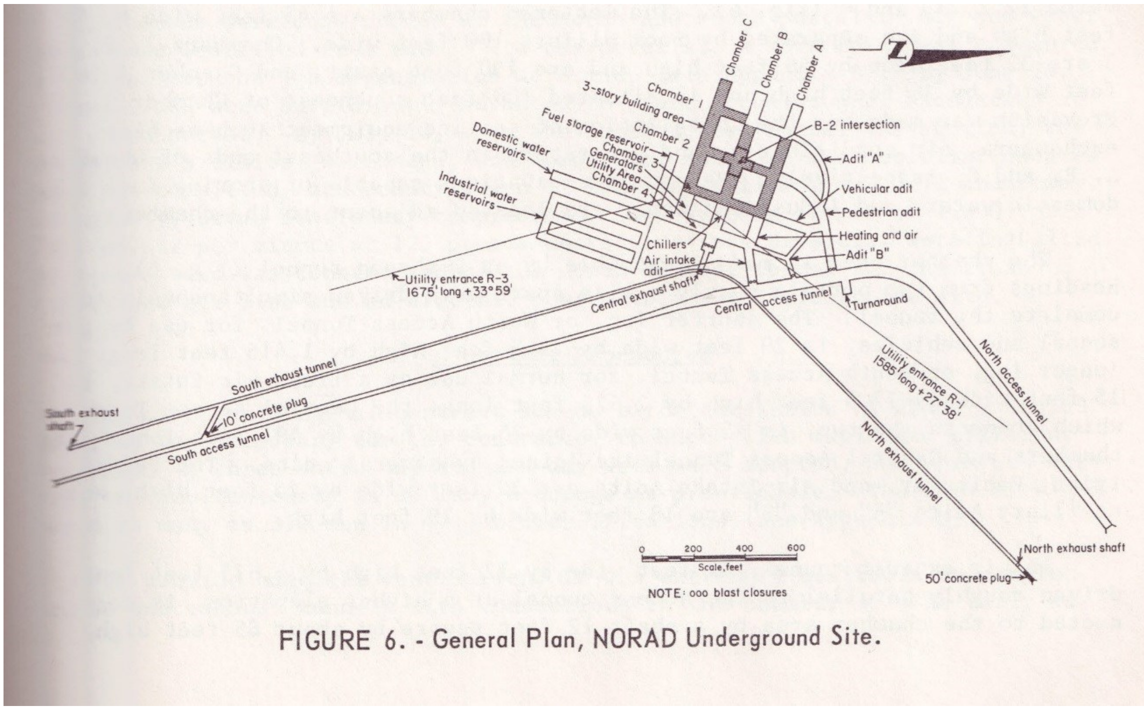

Figure 29. The plan for the Cheyenne Mountain complex details water reservoirs, fuel reserves, and access routes. Source: Merwin H. Howes, Methods and Costs of Constructing the Underground Facility of North American Air Defense Command at Cheyenne Mountain, El Paso County, Colo. (Washington, D.C.: US Department of the Interior, Bureau of Mines, 1966).

Fictional accounts of computer-initiated nuclear holocaust have permeated American popular culture since the end of the Second World War, and NORAD has figured prominently in many of these tales. Despite popular conceptions that the Combat Operations Center was a secret military installation, that has never been the case. As with Headquarters SAC, the existence of the COC was highly publicized by the US military—indeed, it only had deterrent value if the enemy knew of its existence. In a 1970

[49] Blair, 4.

publication meant for the general public, published as a color catalog with large print and plenty of pictures, an author gives full details about the construction of the post within Cheyenne Mountain, descriptions of the spaces inside, and provides operations reports to the reader. The author himself even wonders, "Why does NORAD tell so much about itself?...The answer lies in the philosophy and aims of deterrence." Indeed, NORAD's Combat Operations Center played a significant role in the military strategy of "strategic dissuasion."[50] Another example of how NORAD publicized itself and its new command post is the Department of Defense's creation of a number of informative videos about NORAD that highlight the space as a symbol of destructive capability. In one video, an image of the COC is displayed as a voice proclaims, "*This* is NORAD."[51] And if these are not evidence enough that the Cheyenne Mountain site was heavily publicized, the Combat Operations Center has been open to public tours since at least the early 1970s.[52] NORAD has become synonymous with Cheyenne Mountain.

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[50] Hough.

[51] Referring especially to "NORAD Command Briefing," produced by the US Air Force. and "Skywatchers," available on DVD, and "NORAD 1960s-1970s" compiled and sold by www.militaryvideo.com; Another anecdote is that NORAD has been "tracking Santa" since 1955 (http://www.noradsanta.org/). The tale goes that Sears department store published an advertisement in a Colorado Springs newspaper that told children to call the phone number in the ad to talk to Santa Claus; but the number was misprinted, and when children dialed the number, they ended up being connected to the Continental Air Defense Command (CONAD). The colonel on duty that night instructed his staff to give the children the current location of Santa Claus, birthing a tradition that continued when CONAD came under the umbrella of NORAD.

[52] Anthony Ripley, "Day After the 'Alert': NORAD Tells Visitors of Electronic Marvels," *New York Times*, 22 February 1971, p. 6. After 11 September 2001, security was tightened and the number of tours provided was reduced, but it is still possible to go on a tour of the facility (although many of NORAD's operations continue at Cheyenne Mountain, as of 2008 the Combat Operations Center relocated to neighboring Peterson Air Force Base).

Contributions to Systems Engineering

Making the Combat Operations Center function required a significant engineering effort, and it served as a testbed for the MITRE Corporation's concepts in systems engineering. A system is defined as an integrated assembly of interacting elements designed to cooperatively carry out a predetermined function.[53] Systems engineering as an independent, defined, and organized discipline was developed during the twentieth century. In fact, it was not until the 1940s that systems engineering started to become professionalized, and as late as the 1960s, its exact definition was still a matter of dispute.[54] A general consensus existed, however, that systems engineering held qualities in common with operations research, namely: engaging in the analysis of complex man-machine systems; the utilization of multi-discipline teams; and an emphasis on the "whole system" being something more than the sum of its parts.[55] Systems engineering, however, focuses on hardware construction, whereas operations research examines how machines are used in practice.

The catalyst for the increased attention given to systems engineering was the drastic rise of automation following World War II. Ralph E. Gibson, director of the Applied Physics Laboratory in 1961, wrote in that same year that "[s]ystems engineering is an activity forced on us by the demand for more and more automatic devices" and that "the design and engineering of systems is a laborious enterprise which mankind has

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[53] Ralph E. Gibson, "The Recognition of Systems Engineering," in Charles D. Flagle, William H. Hughes, and Robert H. Roy, eds., *Operations Research and Systems Engineering* (Baltimore, MD: The Johns Hopkins Press, 1960), 58.

[54] Robert H. Roy, "The Development and Future of Operations Research and Systems Engineering," in Charles D. Flagle, William H. Hughes, and Robert H. Roy, eds., *Operations Research and Systems Engineering* (Baltimore, MD: The Johns Hopkins Press, 1960), 9.

[55] Ibid., 23.

brought on itself in its tireless striving for a better standard of living [through automation]."[56] If a better standard of living included heightened national security, then Gibson was correct. The large, complex weapons systems and defense networks of the Cold War certainly contributed to the rise of the field of systems engineering. One of the earliest formalizations of systems engineering, in fact, was penned by the Department of Defense for contractors bidding to develop its weapons systems.[57] Along with the growth of the field of systems engineering came increased interest in what we would today call human factors or ergonomics. When designing both machines and spatial placement of machines in a system, human factors specialists would consider how to best fit the machine to the human, rather than the human to the machine, as had been the dominant practice prior to the Second World War. Both systems engineers and human factors specialists evaluated the hardware and practices of the NORAD Combat Operations Center. Their findings are indicative of the embryonic state of these fields in the 1960s, and offer insight as to how these new specialists believed that command and control systems should be designed going forward. The development of these control systems significantly promoted the professionalization, visibility, and prestige of these disciplines in the United States.

The MITRE Corporation designed the NORAD system using data acquired from previous command and control experiments, such as those conducted by the RAND Corporation's Systems Research Laboratory in the early 1950s, instead of conducting

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[56] Gibson, 66; 79.

[57] "Military Standard: System Engineering Management," Department of Defense, MIL-STD-99 (USAF), 1969.

new research in its MITRE-ESD Systems Design Laboratory. MITRE personnel did, however, conduct an evaluation of the deployment and testing of the NORAD COC on site.[58] The resulting report examined the experiments, exercises, demonstrations, and tests that were conducted in the NORAD COC in order to make the system operate at optimal performance. Observers hoped to "arrive at some conclusions regarding the utility of exploratory experiments and systematic testing in evolving large-scale information systems of the type discussed."[59] System testing began with an analysis of the prior manual systems that provided the basis for the automated system, then moved into an experimental facility to study the efficacy of console locations and man-machine interactions, as well as the operability of computer programs.[60] Finally, over the course of seventeen months, the system was stressed by simulating hypothetical war conditions and operators were required to perform demonstrations of potential actions that might take place in the Combat Operations Center.[61]

According to the report: "The lack of documented procedures and the consequent difficulty in developing operator proficiency capable of exploiting system potential, were considered serious deterrents to the achievement of system operating levels which would permit valid and reliable measures of operator dependent system performance."[62] In other words, it would be impossible to know what the systems were capable of if the operators

[58] Parsons, 163; 181; 365.
[59] Walter Lesiw, "Field Experiments and system tests in NORAD COC development," in Donald E. Walker, ed., *Information System Science and Technology: Papers prepared for the Third Congress* (Washington, D.C.: Thompson Book Company, 1967), 273.
[60] Ibid., 274-278.
[61] Ibid., 284.
[62] Ibid., 285.

did not know what they were doing. For the most part, however, the observers admitted that "[d]espite situational factors, a partly installed system, programming problems, and an abruptly cancelled schedule of experiments, the objectives of experimentation were realized in limited form" resulting in: a developmental concept of system operations; a working system; a concept of simulation for the system; trained experimental system operators; estimates of data handling capabilities; and resolutions of command post design.[63] Recommendations for future systems testing in similar sites included: a separate facility for testing; extensive documentation plans for experiments; early development of simulation technology; the additions of a systems engineer to troubleshoot issues found during tests and a simulation supervisor to ensure the credibility of the simulation; and implementation of a phased approach to system evolution.[64] Not surprisingly, the systems engineer stressed the necessity of systems engineering in the testing process.

The NORAD COC was seen as a proper site in which to implement rapidly-developing knowledge from the field of human factors engineering. The postwar development of plan and position indicators (PPIs), the familiar radar display in which a radius sweeps around a circle, laid the groundwork for new man-machine systems that could be studied for human factors improvement.[65] Centers such as the Beavertail Laboratory at Johns Hopkins studied factors involving the efficient operation of PPIs in

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[63] Ibid., 279.

[64] Richard M. Longmire, "Command Control Systems Field Experimentation," in Donald E. Walker, ed., *Information System Science and Technology: Papers prepared for the Third Congress* (Washington, D.C.: Thompson Book Company, 1967), 272.

[65] Parsons, 108.

the late 1940s.[66] As air defense systems increased in complexity, so did the number of considerations to be taken into account by human factors specialists. By the time of the construction of the Combat Operations Center, not only were individual machines being evaluated with human needs in mind, but entire systems composed of these machines went under study. The MITRE Corporation contributed to this growing field as well. In a report written for the Air Force, David R. Israel at the MITRE Corporation provided an overview of systems engineering and human factors considerations that should be made when designing command and control systems. Such factors included the way that men and machines interacted, and how a system could be designed to accommodate future change and growth. He noted the difficulty in evaluating complex, real-time systems prior to their implementation.[67] He also conceded that only statistical or probabilistic models could be used in systems engineering, as human behavior is unpredictable. Therefore, the performance of a system that incorporates humans cannot be computed deterministically.

He described some potential engineering pitfalls and made suggestions for systems design; a large component of his suggestions was to take human operators into account during the engineering process.[68] One device he noted for improvement was the display console, a machine that was upgraded or replaced at a slower pace than contemporary computers because there were few off-the-shelf units available. Israel asserted that "there are few systems in which the user is satisfied with his display

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[66] Ibid., 112.

[67] D.R. Israel, "System Design and Engineering for Real-Time Military Data Processing Systems" (Bedford, MA: The MITRE Corporation, 1965), 1-3.

[68] Ibid., 9.

console." Common complaints included the inability to view alpha-numeric characters and irritating screen flickers. In order to remedy these shortcomings, Israel insisted that designers should use a standard console design (this would also allow for rapid replacement of broken consoles), weigh the benefits of alpha-numeric display against cost, and monitor ambient lighting to reduce reflections on the screen.[69] He also suggested that more attention be paid to the degree of automation in the system, and to consider the costs and complexities of automation against the needs of human operators.[70] Some tasks are better suited to automation due to human shortcomings (such as delayed reaction time and inability to process large amounts of data simultaneously) than others, and vice versa; however, to automate certain complex tasks might require such massive amounts of time and resources that a human operator might be preferred.

This is only a brief introduction to and early example of what has become a vast literature on human factors engineering. Its inclusion here is to underscore the significant engineering developments catalyzed by the creation of modern command and control rooms, demonstrated here by the tie between the NORAD COC and the MITRE Corporation. Command and control environments initiated extensive study of the design of complex systems as well as increased the number and type of man-machine interactions available for study.

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[69] Ibid., 43-45.
[70] Ibid., 18-19.

Concluding Remarks

Since the time of its construction, the Combat Operations Center's physical attributes, missions, and technologies have changed. For example, the Space Defense Center moved into the mountain in 1967, buildings were added, the COC's systems hardware was updated over the years, and NORAD became the North American *Aerospace* Defense Command in 1981. This snapshot of NORAD's Combat Operations Center at the time of its construction emphasizes the historical importance of this site as an architectural time capsule, a politically charged artifact of deterrence theory, and a catalyst for the development of burgeoning fields in engineering.

CHAPTER 5. Espionage from the Blue Cube

Secrecy Classification: SECRET

"The adversarial machines face each other, as they always do, with one watching, the other listening. That is the nature of space reconnaissance."

–Burrows, *Deep Black*, 224

Inveniemus Viam vel Faciemus
We will either find a way or make one.

– Motto of the Air Force Satellite Control Facility

The Air Force Satellite Test Center in Sunnyvale, California is the most secretive of the spaces examined here, although it hid in plain sight. The Satellite Test Center (STC, pronounced "stick") was established in 1959 on what became an Air Force Station, from which Lockheed contractors and Air Force and CIA personnel directed spy satellite programs throughout the Cold War. Most famously, this command post supported and the activities of the National Reconnaissance Program for the then-black National Reconnaissance Office. This space shares many features with those discussed in previous chapters, including: (1) a similar command center architecture and aesthetic, (2) its creation and operation were driven by Cold War imperatives, (3) details of the new technologies implemented in its center and its programs were tightly under wrap, and (4) the construction of its systems was predicated on the development of key technologies, such as launch vehicles and sensors in this case. Yet its disproportionately high level of secrecy does make the STC a unique case study. It is the only space here that was utilized by an agency whose existence would remain classified for decades (the NRO); it is the only space in which the CIA possessed any explicit directional oversight; and its walls were deemed so secret, that when it was eventually closed, its buildings were demolished, burying its secrets underneath crushed concrete panels in the dead of night.

Figure 30. One of the few photographs of a control center in Building 1001 of the Satellite Control Facility, 1961. Source: Historical Overview of the Space and Missile Systems Center, 1954-2003, History Office, Space and Missile Systems Center, Los Angeles, CA, 2003.

Yet the STC was not entirely secret. American newspapers speculated on the activities conducted at the STC (spy satellites) and many of them were correct (spy satellites). The STC was *very* secretive about the particulars of its activities; its windowless buildings suggested both fear of and fortification from espionage. In the age of the ICBM, it no longer made sense to create underground facilities. One massive block was painted Air Force Blue and was visible from a proximate freeway. The message was clear: “Yes, we’re here and we’re watching you.” The building’s clear affiliation with surveillance operations served as a deterrent, a strategy similar to those implemented by other command posts. While the STC buildings were constructed of concrete, unlike HQ SAC and the NORAD COC, they were built above ground (at least more than 100 feet of them were). The Satellite Test Center buildings looked “hard” but were not promoted as “hardened” against nuclear attack as were other spaces. Instead, the spy satellites were the objects that were hardened against physical attack or electronic jamming. The new strategies were to create redundancy on the ground and to protect objects in space.

Few studies in aerospace history have concentrated on satellite ground facilities. This is an oversight, as “What stays on the ground is at least as worthy of study as what goes into space.”[1] The places from which space-based technologies are monitored and controlled are in many ways *more* influential and crucial to national defense than are the air- and spacecraft they observe and control. Ground facilities do not just launch satellites into orbit and collect data. Operators need to keep the satellite properly positioned. Spacecraft tend to wander, and they need human observers with command capabilities to ensure that they are positioned in a way to, say, take an overhead photograph of the Soviet Union. This was an ambition of the most well-known program conducted from the Satellite Test Center, Corona. Code-named Discoverer, between 1959

[1] David Christopher Arnold, *Spying from Space: Constructing America’s Satellite Command and Control Systems* (College Station: Texas A&M University Press, 2005, 2008), 167.

and 1972, Corona satellites completed 145 successful missions, capturing photographs of more than one billion square miles of the Earth's surface.

Map 2: US Air Force Satellite Test Center Historic District

Figure 31. The California State Historical Preservation Office unsuccessfully attempted to add the STC site to the National Historic Register in 2010, which would have consisted of six interconnected "contributing resources", buildings 1001, 1002, 1003, 1004, 10031, and 10032, and two "non-contributing resources" buildings 1015 and 1025. Source: Anne Jennings and Allison S. Rachleff, "California State Historic Preservation Office, Historic American Building Survey, September 2010.

Spy Satellites in America

As early as the 1940s, the potential for using artificial satellites for overhead reconnaissance was moving from science fiction into the realm of possibility. It was

Major General Curtis E. LeMay, in fact, deputy chief of staff for R&D for the Air Force, who first directed Douglas Aircraft's R&D Group (which later morphed into the RAND Corporation) to start investigating satellite development. The Strategic Air Command identified needs for overhead reconnaissance, such as: learn "exactly where SAC targets were, what kind of explosives would be necessary to 'take them out,' how they were defended (including radar coverage), and what the terrain was like on the approach to targets and along the way out."[2] Photomapping had the potential to answer these questions and more, so SAC solicited a study from RAND. The 1951 RAND report, "The Utility of a Satellite Vehicle for Reconnaissance," was the "first, detailed report in the evolution of satellite command and control. RAND took a major step by stating the technical and engineering possibilities for a reconnaissance satellite employing television techniques for data readout to ground stations."[3]

Yet satellites were not under construction with any great enthusiasm in the United States. Programs existed, but there was not any outward urgency. Some notable early events in the creation of an American spy satellite program include the Air Research and Development Command's (ARDC) 1954 establishment of Western Development Division (WDD) in southern California, which would develop Weapon System 117L

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[2] William E. Burrows, *Deep Black: Space Espionage and National Security* (New York: Random House, 1986), 84, 65. The Strategic Air Command, however, would not govern the nation's satellite effort. According to historian Arnold, there were concerns "that operation of WS-117L by SAC might 'embarrass the United States in future international negotiations concerned with space sovereignty.' America's declared space policy called for 'peaceful uses of space,' so placing the nuclear SAC in charge of a major U.S. space program seemed politically unwise" (Arnold 79).

[3] Arnold, 13; 15.

(WS-117L), also known as “Pied Piper.”[4] Lockheed’s Missile and Space Division was also awarded a contract to develop ways of gathering signals and photographic intelligence for WS-117L.[5] The project conducted reconnaissance satellite studies from 1954 to 1957. In 1957, the WDD was redesignated the Air Force Ballistic Missile Division. It attempted to prioritize programs for satellite espionage, such as Corona (satellite optical reconnaissance), Samos (a rival to Corona) and Midas (an early, yet failed attempt at creating a system of infrared early-warning satellites). The WDD would later be responsible for the development of the Thor Intermediate Range Ballistic Missile (IRBM), which first launched from Cape Canaveral in 1957.

Beginning in 1956, overhead surveillance was mostly handled by U-2s or long-range bombers. While these missions were dangerous and satellite reconnaissance was an obvious alternative, military coffers were instead directed into development of ICBMs.[6] Eisenhower had approved the use of bombers and high-altitude balloons in the early 1950s for intelligence-gathering, but these craft were vulnerable to anti-aircraft artillery and fighter-interceptors**.** The CIA requested designs from aerospace manufacturers for a new craft that would not be as susceptible to attack. The solution came from within a company that had not been solicited for a design. Kelly Johnson at Lockheed’s Skunk

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[4] As known as Advanced Reconnaissance System. For more WS-117L information, see “Historical Report: Weapon System 117L, WDD HQ, ARDC, 1956, #273 on nro.gov, and “Chronology, WS 117L Background,” 10 Oct 1961, among many, many other declassified documents on this program.

[5] Ibid., 5.

[6] For more information about the U-2 program and its technical specifications, see “Short Historical Explanation, WS 117L, Discoverer, Sentry and Midas Chronology, 1946-1952,” 27 Sept 1959, 269, nro.gov. Anne Jennings and Allison S. Rachleff, “California State Historic Preservation Office, Historic American Building Survey, Level II-Type Documentation, US Air Force Satellite Test Center (Onizuka Air Force Station) City of Sunnyvale, Santa Clara County, California,” Department of the Air Force, Headquarters/Air Force Center for Engineering and the Environment, Lackland Air Force Base, Texas, September 2010, DRAFT, 6-7.

Works (the alias of the company's Advanced Development Projects division) submitted his proposal for the U-2, which is basically a glider with a jet engine and a panning camera in its belly. It was a slow craft and visible on radar, but it compensated for these deficiencies with its high-altitude capability. The U-2 was able to cruise at heights of more than 70,000 feet, out of the reach of Soviet surface-to-air missiles and interceptors (at least for a time). Codenamed Project Aquatone, U-2 production was approved by Eisenhower in November 1954. A joint AF-CIA project, this aircraft had great successes flying along the borders of the Soviet Union, eventually completing 24 successful missions.

Eisenhower had wanted to conduct aerial reconnaissance covertly to avoid provoking Soviet leaders. Unfortunately, the U-2 was never a stealthy aircraft, and they were detected on radar as soon as their overflights began. While Soviet leaders knew about U-2 surveillance and expressed outrage, there was little they could do about it. Their missiles could not hit the U-2s nor could their interceptors reach their altitude. This was until May 1960, when a surface-to-air missile explosion knocked down the U-2 of Gary Powers over Soviet airspace. While Eisenhower attempted to push the cover story of the flight conducting a meteorological study, the Soviets had recovered film from the plane—not to mention its pilot—and the jig was up. Soviet overflights ceased and the U-2 continued its missions over places with less sophisticated air defense systems.

Eventual cessation of overflights was not unanticipated. The U-2 was not promised to be the end-all in reconnaissance aircraft. In addition to not being stealthy, the U-2 would never have been able to photograph all of the Soviet Union, and it could not return to high-priority targets for fear of establishing a pattern that would make interception more likely.[7] Given these drawbacks, even before the Powers incident, CIA director Richard Bissel had commissioned a study to determine the characteristics for a reconnaissance aircraft that could not be shot down. The investigation determined that the new craft would need to be supersonic and have a small radar cross-section. For this purpose, again, Kelly Johnson at Skunk Works designed the A-12 (codename Oxcart), which briefly operated with the CIA before the Air Force's version, the SR-71, assumed responsibility for reconnaissance activities in East Asia. In the following years, SR-71s operated out of Kadena Air Force Base on Okinawa, Japan, flying missions over Laos, North Vietnam, and North Korea.

Airplanes were not destined, however, to continue conducting reconnaissance over the Soviet Union. The successful 1957 launch and orbit of Sputnik made satellite research and development top priority, and having cameras in space, rather than aboard aircraft, was strongly pursued. The US responded by reviving the Army's Project Orbiter, now called Explorer, and the Explorers program launched the first American satellite in 1958. The Air Force followed suit and put projects Samos and Midas back on the fast-track with healthy budgets. Eisenhower created the Advanced Research Projects Agency (ARPA, later DARPA) and NASA in 1958. The Air Force, however, became the only branch allowed to launch space boosters, giving it a de facto monopoly on space, and this was exactly what the Air Force had been lobbying for: getting space under its jurisdiction. Air Force Chief of Staff General Thomas D. White is often credited with, if not coining, popularizing the term "aerospace" in an effort to make Air Force dominance

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[7] Burrows, 103.

in the skies and beyond seem both obvious and inevitable. In the 1959 edition of *Air Force Manual I-I (AFM I-I), United States Air Force Basic Doctrine*, writers used "aerospace power" in place of the previous term "air power."[8] The Air Force proceeded to independently contract with Convair to build Atlas (the first operational American ICBM), then Thor (an IRBM by Douglas) and Titan (a larger missile built by Martin). These Air Force vehicles were used to launch satellites for the National Reconnaissance Office.

The National Reconnaissance Office, a top-secret entity created in response to the limitations of aerial reconnaissance and the national security imperative for a space-based reconnaissance program, oversaw the Corona missions.[9] One historian called the creation of the NRO the "most important bureaucratic innovation to come out of the Eisenhower administration where overhead reconnaissance is concerned."[10] James Killian Jr., then president of the Massachusetts Institute of Technology, believed that Corona needed oversight by a new civilian, secret organization. Polaroid CEO Edwin H. "Din" Land, a

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[8] Arnold, 39; Air Force Space Systems Development Program, AFBMD Headquarters, Air Research and Development Command, 1959, 54, nro.gov

[9] Since the records of the NRO began to be declassified in the 1990s, a number of historians have skillfully provided the history of this super-secret organization. For an early history of the NRO see Gerald Haines, "The National Reconnaissance Office: Its Origins, Creation, and Early Years," in Dwayne A. Day, John M. Logsdon, and Brian Latell, eds., *Eye in the Sky: The Story of the Corona Spy Satellites* (Washington, D.C.: Smithsonian Institution Press, 1998), 143-156. Also see, Matthew L. Hughbanks, *National Reconnaissance Office: Past, Present, Future Concepts Paperback* (Research Paper from Air University, Maxwell Air Force Base, Alabama, 2006). Jeffrey Richelson is a prominent author in this field. See Jeffrey Richelson, *The U.S. Intelligence Community* (Cambridge, MA: Ballinger Publishing Company, 1989), esp. 26-29; Richelson, *American Espionage and the Soviet Target* (New York: William Morrow and Company, Inc., 1987); Jeffrey Richelson, *America's Secret Eyes in Space: The U.S. Keyhole Spy Satellite Program* (New York: Harper & Row, 1990 (here Richelson describes the value of Keyhole-gathered intelligence up through the Bush administration); Jeffrey Richelson also wrote about the surveillance activities of America's Cold War nemesis in *Sword and Shield: Soviet Intelligence and Security Apparatus* (Cambridge, MA: Ballinger Publishing Company, 1986). Corona records were declassified in 1995.

[10] Burrows, 135.

scientist heavily involved in the early Corona missions, also encouraged President Eisenhower to create this overseeing body.[11] On August 25, 1960, Eisenhower approved the creation of the NRO "amid great secrecy and after several months of debate within the White House, the CIA, the Air Force, and the Defense Department."[12] The NRO was then established by acting CIA director General Charles Cabell in September 1961.[13] Meanwhile, Secretary of Defense Robert McNamara made the NRO responsible for the National Reconnaissance Program, which included Corona and Samos. The following year the DoD and the CIA signed an agreement that the NRO would be headed by a Defense Department civilian designated by the Secretary of Defense, in an effort to appease interservice rivalries. These arrangements changed over the years in expectedly complicated ways, but the NRO still managed to get things done. According to one historian, "A certain amount of conflict between the Department of Defense and Intelligence Community is an inherent part of the NRO's history, and remains a challenge for running the organization today. It will not go away because it is driven by a budget that is inevitably finite, and differences in organizational priorities, which are themselves inevitable and which also change over time."[14]

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[11] Jennings and Rachleff, DRAFT 6-7.

[12] Burrows, 135.

[13] Berkowitz. Its missions were largely influenced by the recommendations of the Purcell Panel Report, a reconnaissance report commissioned by the CIA which, among other things, suggested developing a drone-variant of the A-12 (the failed M-21/D-21) and lauded the accomplishments of Corona. See Purcell Panel Report, 3 July 1963, 1B0029, nro.gov

[14] Berkowitz, 343-344. There is a plethora of excellent existing secondary literature on the history of the National Reconnaissance Office, particularly the massive 1973 multi-volume set written by Robert Perry, *A History of Satellite Reconnaissance*. While I do not cite it often directly, it has been the basis for many of the more recent works cited, and despite its ink-stained redacted pages, it still holds high value as an early history of these programs. Robert Perry, *A History of Satellite Reconnaissance, Volume I – Corona*, National Reconnaissance Office, 1973. Note that other historians have mined the Robert Perry

When the NRO was created, the Air Force was no longer in command of reconnaissance satellite programs. The Air Force provided launch and tracking support, but was removed from handling the actual intelligence gathered. The NRO's representatives at the Satellite Test Center most likely had their offices in the Technical Director Room of Building 1001.[15] According to satellite historian Arnold,

> "The U.S. space program now had three branches: one concerned primarily with space science and political prestige (NASA); one, with military support missions (the defense department); and one, with reconnaissance operations (the NRO). Later presidents and secretaries of defense formally endorsed these divisions, which largely remain in effect today."[16]

There were a few contenders for early reconnaissance satellite systems.[17] The Air Force and the CIA focused on developing imagery intelligence (IMINT), while the Navy investigated gathering signals (SIGINT).[18] For imagery, Project Corona held special

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histories of the NRO and of the Corona program in particular, describing all the launches and the technology in its not being called Discoverer because the cover story was not working when it when fully undercover in 1962 and so Ill footnote these secondary sources for those who are interested in the details, and instead here focus on the buildings and the secret site of operations.

[15] Jennings and Rachleff, FINAL, 13.

[16] Arnold, 74.

[17] For a tie back to the Strategic Air Command and to NASA: The RAND Corporation warned the Air Force in the 1950s that if they wanted clear photographs—that is, ones of something other than clouds--from overhead recon satellites, they would need accurate meteorological data of the areas over the Soviet Union. The of creating and orbiting meteorological satellites fell to the newly formed NASA, but NRO officials (Under Secretary of the Air Force and NRO director Joseph V. Charyk, felt that their programs—notably Tiros—weren't developing quickly enough to meet national security needs, so Charyk lobbied for an interim meteorological satellite program that would meet the needs of the NRO. This program also fashioned the technology and flight operations for what would become the polar orbiting, low-altitude national weather satellite administered by NOAA (26-37). These satellites would be launched and controlled by the Air Weather Service's Air Force Global Weather Control located in Headquarters SAC. See R. Cargill Hall, *A History of the Military Polar Orbiting Meteorological Satellite Program* (Office of the Historian, National Reconnaissance Office, 2001), 118.

[18] Grab (Galactic Radiation and Background—its cover) was the first SIGINT (electronic intelligence collection) satellite (basis for which was Navy's Vanguard). It was later replaced by Poppy and its NRO records were declassified in 1998. Many NRL engineers went to NASA (Goddard) in 1958 but others stayed and formed the Satellite Technologies Branch, which became the Naval Center for Space Technology. Grab detected signals from air defense radars over the Soviet Union and transmitted them to

promise. Corona's origins are found in the WS-117L program. In December 1957, the WS-117L program was broken up to focus exclusively on film recovery, inheriting a system from Project Genetrix, a program that photographed Soviet territory using balloons that had ended in 1956.[19] The Corona program necessitated a home base from which to begin conducting operations, and it made sense to initially set up shop near the existing infrastructure at Lockheed Missiles and Space in northern California.

A Home for the Satellite Test Center

The Sunnyvale site would be completely unfamiliar today. At the beginning of the twentieth century, the Sunnyvale economy was agricultural, and the landscape rural and filled with wheat fields and orchards. Beginning in the First World War, the Joshua Hendy Iron Works and the US Army Air Corps' Moffett Field brought some industrialization to the area, but workforce numbers at these places significantly declined in the years after World War II. In response, the City Council annexed surrounding land and provided space for industrial development, marketing itself in national newspapers such as *The Wall Street Journal*. By 1952, ten companies had relocated to Sunnyvale and the city was expanding its housing and services to accommodate the influx of new residents. A few years later, Lockheed Missiles and Space Division became one of these newcomers; the mild climate and proximity to Stanford served as selling points, and

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ground control centers in friendly territory, revealing the location and capabilities of each Soviet radar installation. Grab 1 launched by Thor Able Star on 22 June 1960, becoming first successful recon satellite (220). Others came later, such as Poppy. See Bruce Berkowitz, *The National Reconnaissance Office at 50 Years: A Brief History, Center for the Study of National Reconnaissance*, National Reconnaissance Office, 2011, Kindle Edition.

[19] Donald Steury, *A Tribute to the People of the Air Force Satellite Control Facility: The National Security Impact of Its CORONA Satellites*, Center for the Study of National Reconnaissance, National Reconnaissance Office, Chantilly, VA, 2007, Kindle Edition.

Lockheed purchased a 275-acre tract of land adjacent to Moffett Field. Despite these new industries, Sunnyvale remained largely rural and undeveloped. This changed with the creation of the Satellite Test Center. Its construction was instrumental in shifting the long-term economic mainstay of the area from farming to high-technology. It is not too bold to claim that the Air Force and the CIA—along with the preexisting Lockheed complex—built the foundation upon which the area's path toward Silicon Valley was paved.

The early operations of the Air Force Satellite Control Facility began at a field office of the Air Force Ballistic Missile Division of the Air Research and Development Command at the Lockheed Missile and Space Division facility in Palo Alto in 1958. This group was responsible for getting a Thor IRBM into orbit and for supporting an "Aero-biomedical program" that would support manned spaceflight ambitions, and the facilities were provided by Philco-Ford.[20] In 1959, the Air Force activated the 6594th Aerospace Test Wing (successor to the 6593rd Test Squadron), the first unit tasked with military satellite operations.[21] Working closely with Lockheed Missiles and Space Division and the CIA, the 6594th Air Test Wing first worked in Palo Alto, staffed by the Field Test Force: one Air Force lieutenant colonel and one Lockheed engineer.[22]

These operations soon moved to the Lockheed-designed Interim Development Control Center within the Lockheed complex, where controllers completed operations

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[20] Jernigan, 4. For more on the move to Sunnyvale, see Erica Schoenberger, *The Cultural Crisis of the Firm* (Cambridge, MA: Basil Blackwell, 1997).

[21] Redesignated 6594th Test Wing (Satellite) on 15 Jan 1960. Reassigned to Space Systems Division (of Air Force Systems Command) on 1 Apr 1961. Redesignated as 6594th Aerospace Test Wing on 1 Nov 1961. Discontinued on 1 Jul 1965. See "6594th Aerospace Test Wing" brochure, #853 on nro.gov

[22] Arnold, 48.

using a 100-bit-per-second teletype circuit, a phone line, and a 60-bit-per-second secure teletype circuit.[23] Data came from various locations around the globe to the primary control center, including from three remote operating locations (Edwards, Chiniak, Annette Island) and from five tracking stations (Annette Island, Chiniak, Kaena Point, New Boston, Vandenberg). The 6594th Air Test Wing also operated the 6594th *Launch Squadron*, which assisted with satellite launches at Vandenberg Air Force Base, whose location on the northern Pacific and close to the jet stream was ideal for launching vehicles into polar orbit.[24] Permanent facilities for a command and control center, however, had not yet been acquired or constructed.[25]

The Air Force decided to locate its satellite control center in Sunnyvale due to the proximity of Lockheed, which supplied a number of engineers, and due to the availability of land, which was scarce at the Air Force Ballistic Missile Division headquarters in Los Angeles. Thanks to Lockheed, operations at Sunnyvale had a "decidedly nonmilitary flavor" and the operation "ran much more like a corporate undertaking than a military one, reflecting the influence of Lockheed and its partners."[26] In June 1960, the Air Force purchased about 12 acres in the southeast corner of Lockheed's massive property, including Lockheed Building 100 (the interim station), for the price of one dollar. The

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[23] Ibid., 117.

[24] Anne Jennings and Allison S. Rachleff, "California State Historic Preservation Office, Historic American Building Survey, Level II-Type Documentation, US Air Force Satellite Test Center (Onizuka Air Force Station) City of Sunnyvale, Santa Clara County, California," Department of the Air Force, Headquarters/Air Force Center for Engineering and the Environment, Lackland Air Force Base, Texas, September 2010, DRAFT, 9.

[25] Arnold, 71.

[26] Arnold, 65. Note that the Air Force did have jurisdiction, despite the strong influence of Lockheed. Secretary of Defense Robert McNamara on 6 March 1961 reassigned air force direction of field operations "including operations in Sunnyvale, a step beyond merely supervising the contractor's work" in DoD directive 51.60.32. (Arnold, 87).

command rooms of the Satellite Test Center are located within a cluster of eight buildings that were built between 1959 and 1984 on this site. Even though it was only an official name for a very short period in its organizational history, "The acronym STC continued as the distinction between the operational nerve center of the AFSCF network and the facility as a whole at Sunnyvale."[27] The nerve center of the STC was Building 1001, the Development Control Center. In 1960, operations continued in an interim Satellite Control Room within Building 1001 while the new control room was under construction in another part of the building. Building 1001 also housed administrative and planning facilities, a weather forecasting station, a cafeteria, and other amenities. By early 1961, all satellite control operations had moved to into Building 1001, and the site overall was named Sunnyvale Air Force Station. By March 1961, the control room could support up to three satellites at the same time using two CDC 1604 computers.[28] It dedicated most of its resources to the Corona program.

In 1963 the STC supported the Vela program, satellites which were designed to detect nuclear detonations.[29] From 1962 to1964 the STC also supported the Defense Meteorological Satellite Program. Most significantly, however, the Satellite Test Center supported more than 50 Corona satellites whose film accurately mapped all twenty-five

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[27] Roger A. Jernigan, "Air Force Satellite Control Facility: Historical Brief and Chronology, 1954-Present," AFSCF History Office, 1989, 82. The eight buildings are: 1001, 1002, 1003, 1004, 10031, 10032, 1015, and 1025; I focus on the two buildings mainly responsible for command and control functions: 1001 (original control center) and 1003 (the Blue Cube). Note: the 1982 creation of the AF Space Technology Center (later Phillips Laboratory) is NOT the same STC examined here. The Air Force Satellite Test *Facility* includes the STC as well as its tracking stations. For an insider look at the structure of tracking stations from someone who was stationed at the Kodiak tracking station for many years, see Bob Siptrot's personal website: http://www.kadiak.org/af_track/bob_afscf_index.html

[28] Jernigan, 5-7.

[29] Vela satellites operated for many years and particularly useful in monitoring compliance with the Nuclear Test Ban Treaty.

of Moscow's long-range missile sites as well as identified China's growing nuclear capabilities.[30] Corona satellites took pictures of the Soviet Union from low-Earth orbit and then dropped physical canisters of film back to Earth for mid-air recovery of the "satellite recovery vehicle" (SRV) by a C-119J "Flying Boxcar" twin-boomed cargo aircraft.[31] With the canister recovered, the cargo plane would fly to Moffett Naval Air Station in Sunnyvale, then to a Lockheed facility to be opened, and then delivered the film in an unmarked container to Eastman-Kodak's Hawkeye Facility in Rochester for developing. Finally, the processed film was delivered to the CIA's National Photographic Intelligence Center (NPIC), as well as to other unnamed beneficiaries of this intelligence.[32] Yet it is worth mentioning that the Corona program was, as one writer has noted,

> rooted in the burgeoning west-coast aerospace industry—the list of contractors involved in the program is a roster of west-coast industry leaders, including Lockheed's famous 'Skunk Works.' CORONA's operational elements also resided on the west coast—only the intelligence functions were elsewhere. Vandenberg Air Force Base, on California's rock-bound coast north of Los Angeles, launched the satellites, supported by Sunnyvale Air Force Station. Remote tracking stations dotted the coast from Kodiak, Alaska to Point Mugu, California. The Air Force Satellite Control Facility controlled the satellites when they were in orbit. The C-119Js of the 6593d Test Squadron (Special) trained at

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[30] Jennings and Rachleff, DRAFT, 18-20.

[31] Note that the SRV was rigged to sink with 72 hours if the canister was not retrieved to avoid it falling into enemy hands. Jennings and Rachleff, DRAFT, p. 6-7; 14. For information on film recovery efforts see: Ingard Clausen and Edward A. Miller, *Intelligence Revolution 1960: Retrieving the CORONA imagery that Helped Win the Cold War*, Center for the Study of National Reconnaissance, 2012, and Robert D. Mulcahy Jr., ed., *Corona Star Catchers: Interviews with the Air Force Aerial Recovery Flight Crews of the 6593d Test Squadron (Special), 1958-1972* (Chantilly, VA: Center for the Study of National Reconnaissance, 2012).

[32] Donald Steury, *A Tribute to the People of the Air Force Satellite Control Facility: The National Security Impact of Its CORONA Satellites*, Center for the Study of National Reconnaissance, National Reconnaissance Office, Chantilly, VA, 2007, Kindle Edition.

Edwards Air Force Base—although they moved to Hawaii in time for the first recovery operation.[33]

The CIA thought that Corona would soon be made obsolete by programs with more efficient transmission capabilities. For example, Samos was currently under development and would transmit images via television. Corona was so successful, however, that the program continued for more than a decade. From 145 successful Corona launches, 165 film capsules were recovered, encompassing four increasingly high-resolution photo systems (KH-1 through KH-4A and KH4B) until it was discontinued in 1972, when the first electro-optical imaging system became operational.[34]

Success only came after much trial and error. As with most early space efforts, Corona faced challenges. Its first dozen missions failed due to problems like faulty launch vehicles and recovery system malfunctions. The thirteenth mission succeeded, launched on a Thor rocket in February 1959 from Vandenberg AFB, but it was not carrying any film. It did, however, prove the efficacy of operational elements, such as the launch complex, tracking and control stations, the Lockheed Missiles and Space Division computer center, and the film recovery force. Work at the STC's Building 1001 proved particularly successful; the center provided processing and tracking data for determining

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[33] Steury.

[34] The totals of launched and "successful" Corona satellites are inconsistent in available literature. Some say that from 1959 to 1972, 95 out of 121 launches were successful. Others say that the numbers are 120 out of 145. I trust Jim David's count and language: From 145 successful launches, 165 film capsules were recovered. For more information on a camera used in the Corona program, see James E. David, "The Corona KH-4B Camera," in Michael Neufeld, ed., *Milestones of Space: Eleven Iconic Objects From the Smithsonian National Air and Space Museum* (Minneapolis, MN.: Zenith Press, 2014).

flight status using a Remington-Rand 1103 computer along with a telephone and teletype network.[35]

Corona, operating under codename Discoverer 14 (KH-1 9009), which was ostensibly gathering scientific data considering biological effects of the space environment on mammals, performed the first successful satellite photoreconnaissance mission in August 1960.[36] It was a 1700-pound satellite coupled with a 300-pound reentry capsule, and it circled the Earth every 94.5 minutes at almost 18,000 NM per hour. Historian Arnold describes the tension in the command center during this achievement:

> At the windowless Satellite Test Center, Col. Alvin N. Moore, commander of the 6594th Test Wing (Satellite), along with high-ranking air force commanders and Lockheed engineers, kept a close vigil on the vehicle. Information from the tracking stations at Vandenberg, Alaska, New Hampshire, and Hawaii and at sea from the USNS Private Joe E. Mann poured into the center by voice and teletype.[37]

Its canister returned more than 3000 feet of film, which was more than the entire U-2 program had amassed to date. The satellite had imaged 1.65 million square miles of

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[35] "Discoverer I: System Test Evaluation Report," Lockheed Missile and Space Division, Lockheed Aircraft Corporation, Sunnyvale, CA, LMSD-445138, 20 April X, approved by Lt. Col. USAF Charles G. Mathison, 13-14.

[36] Arnold, 88. Numerous documents available on nro.gov that detail the plans for this cover story. For a few examples: Letter from S.E. Anderson to Assistant Vice Chief of Staff, 1 December 1958, 1A0010; Memo to the Secretary of the Air Force from Roy W. Johnson, 4 Dec 1958, 1A0012; see also references in document 1B0044 and 143, "Memo: Project Corona" by Gordon Gray, 17 March 1959, and especially "Corona Cover Plan," 8 Dec 1958, 132, nro.gov

[37] Arnold, 88. Note that the Air Force Satellite Control Facility replaced the 6594th in 1965; both performed satellite control functions.

Soviet territory.[38] Scholars of the Corona program note the program's 'firsts' in space technology, such as:

> first photoreconnaissance satellite; first recovery of an object from space (and first mid-air recovery of an object from space); first mapping of Earth from space; first stereo-optical data from space; and first program to fly more than 100 missions in space. In all, some 120 of the 145 CORONA missions were complete or partial successes. CORONA resulted in the exposure of over 2.1 million feet (almost 400 miles) of film and took over 800,000 photographs. CORONA photographed a total land area of 557 million square miles.[39]

Corona's ultimate triumph was in dispelling the myth of the missile gap. In 1959 and 1960 National Intelligence Estimates had the Soviet Union in possession of as many as 300 operational ICBMS, but Corona imagery showed that there were only twenty-five.[40]

In January 1963, a secure circuit was activated between the STC and the Pentagon which facilitated immediate information relay between the agencies and branch offices, notably those of the NRO. Also around this time, US satellite programs became classified. The CIA noted that Soviet Officials quoted US newspapers as sources for

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[38] Once again, I would like to acknowledge the existing literature, particularly these volumes that were released soon after the declassification of many NRO documents: Dwayne A. Day, John M. Logsdon, and Brian Latell, eds., *Eye in the Sky: The Story of the Corona Spy Satellites* (Washington, D.C.: Smithsonian Institution Press, 1998; Curtis Peebles, *The Corona Project: America's First Spy Satellites* (Annapolis, MD: Naval Institute Press, 1997). Also see his earlier effort: *Guardians: Strategic Reconnaissance Satellites* Hardcover – July 1, 1991. Other historical documents because declassified over time, such as this one in 1997: Frederic C.E. Oder., James C. Fitzpatrick, Paul E. Worthman, *The Corona Story* (Sunnyvale, CA, 1988). You can also go straight to the primary sources themselves, mostly available on nro.gov. For example, Memo for Dr. Flax from William A. Tidwel, 9 Feb 1968, 1B0010; "History: Corona Program," 2C0024, nro.gov

[39] "Introduction" Dwayne A. Day, John M. Logsdon, and Brian Latell, eds., *Eye in the Sky: The Story of the Corona Spy Satellites* (Washington, D.C.: Smithsonian Institution Press, 1998), 7. This volume contains a chapter on the Soviet counterpart to Corona, named Zenit. Peter A. Gorin writes in "Zenit: The Soviet Response to CORONA," that the programs shared many similarities…and differences. The existence of this contemporaneous analog underscores my assertion that the Soviets knew that Americans were launching spy satellites, if for no other reason that they were pursuing this technology as well.

[40] Steury, 174; Interesting sidebar: In the 21st century, archaeologists use declassified Corona images to uncover sites. While modern aerial photography can provide higher resolution, these images go "back in time" and show sites that had yet to be developed/urbanized/built over. http://news.nationalgeographic.com/news/2014/04/140425-corona-spy-satellite-archaeology-science

information about US satellite programs. Even though a lot of the information in the newspapers was deliberately misleading, they *did* depict an accurate picture of US capabilities, so CIA officials decided to classify further missions. Even Corona's cover story—Discoverer—faded to black after the launch of Discoverer 38 in 1962. Its program was simply designated an internal number—Program 162.[41] Satellites were launched but unexplained to the press, the term 'Keyhole' began to designate satellites, and Corona satellites were retroactively designated 'KH.' The site itself also became increasingly high-security. After February 1958, Eisenhower had ordered the Air Force to stop publicly pursuing their film recovery effort, and to instead continue their work secretly under the auspices of the Central Intelligence Agency.[42] This was not an easy order to follow. While the government wanted this program to go black, the Air Force leaked details of its operations anyway because it wanted to promote its accomplishments, which underscores the newness of this endeavor: young project leaders were trying to find their place in a complicated hierarchy. The Air Force had asked ARPA to declassify certain

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[41] Richelson, *America's*, 65. "The new secrecy meant oblivion for the Air Force film *To Catch a Falling Star*. The film, which had been made on an unclassified basis for public release, was a documentary concerning the effort to recover Discoverer capsules from space. Four hundred ninety-seven prints of the film were made and sent to the Air Force Media Depository to await public release, but in light of the new secrecy restrictions the film was withdrawn overnight. In addition, public information officers were instructed by their superiors that if asked for information about the film 'you know of no such motion picture' and to avoid further discussion. Although a subsequent film was made on the recovery efforts, it was a classified effort for training purposes." Richelson, *America's*, 53. Historian Burrows speculates that while Eisenhower had a relatively open system, Kennedy changed it to top secret to avoid escalation and an arms race, as well as to protect arms control negotiations. In addition, like Eisenhower, Kennedy did not want to taunt Soviet leaders because he felt that it might invite an attack on American spacecraft (or worse). Perhaps most practically, the blackening would attempt to hide the administration's enormous reconnaissance budget and prevent constant Air Force-CIA bickering from becoming public knowledge (Burrows 132-134).

[42] Berkowitz, 244-245. "While attention in Washington focused on problems with the booster and the space vehicle itself, preparations for recovering the film capsules were underway. Corona inherited its film recovery system from Project GENETRIX, a program from photographing Soviet territory with drifting balloons," which had ended in 1956 (94).

details of WS-117L, which the ARPA director denied because he did not want to invite international political debate over the use of reconnaissance satellites. The Air Force ignored the director's order and publicized its activities in press releases and magazine articles. President Kennedy was frustrated by the non-compliance and "according to one staffer, apparently 'every time the Air Force put up a space shot and any publicity was given to it, he just went through the roof.'"[43]

Figure 32. An aerial view of Building 1001 in 1959 shows the beginnings of what would become a large complex. Source: Onizuka AFS

The Satellite Test Center succeeded in its duties in large part due to its sophisticated communications systems. Its computers fed information between controllers at their stations in Sunnyvale as well compiled data from ground tracking

[43] Arnold, 76

stations. Descriptions of the space are similar to those of other Cold War spaces of control:

> The test controller—the operator who sent commands to the satellite—and the test director—the expert on all on-board systems—had closed-circuit televisions screens, push-button communications panels, and two-way headsets all feeding them information. Other consoles recorded the communications. Twenty-six television cameras showed the plotting boards for the satellite and reentry capsule. Incoming and outgoing messages on the teletype systems and various combinations of voice conferences kept the test crews informed and up-to-date. Viewgraph screens showed current weather conditions over the recovery site, maps, plots, and everything else the operators needed to know.[44]

In the very few photos available of the STC's Mission Control Centers, the configuration looks much like its NASA and military counterparts. Operators face a row of eight projection screens that would display information such as satellite positions on maps, weather conditions, and orbital attitudes. Above the space, much as in HQ SAC and the Combat Operations Room, there was a balcony from which Air Force, CIA, and Lockheed higher-ups could observe the lower floor, as well as the displays. While these control rooms were built above-ground, it did not mean that there was no concern about security leaks, and precautionary measures were taken to ensure secrecy, such as covering the walls of the control room in acoustical tile to prevent espionage.[45]

At tracking stations, the facilities were not quite as advanced. One operator at Kodiak reported that computer systems were not installed at the tracking stations until 1964, when they received Control Data Corporation computers (CDC-160As)—one for tracking and the other for telemetry—in addition to equipment manufactured by Philco

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[44] Arnold, 93.
[45] Ibid., 10-12.

Ford. Each computer had a memory of 48K, equivalent to one of today's compressed Web images, and the data line to California was 2400 bits per second, the minimum rate at which small file transfers were possible.[46] The STC was linked to tracking stations by voice, data, and teletype circuits. These circuits also connected the STC to the Recovery Control Center in Hawaii—which was responsible for retrieving film canisters—during launch, orbiting, and recovery. During these operations, the "Mission Controllers" at the STC used the voice call sign "Dice."[47] Tracking station operators analyzed and interpreted most of a satellite's data. It was from Sunnyvale, however, that controllers actually directed the satellite.[48]

The Air Force Satellite Control Facility, a larger, umbrella body which now contained the Satellite Test Center, was established in 1965. Due to the increased responsibility given to the STC, the Air Force decided to implement a "Mission Control Center" concept that would disperse control centers throughout the complex instead of just having a single control room. Building 1001 was reconfigured starting in 1966, but the original Satellite Control Room remained unchanged, continuing to serve as the control room for Corona. The MCCs included

> a control console with seven twenty-channel television monitors, remote controlled 35mm projectors, secure and non-secure telephones, and time display units. In 1965, the Satellite Test Center logged more than 20K hours of satellite flight support and by the next year this number was up to almost 30K hours. In 1965 the STC supported approximatively 14 satellites; in January 1967, the STC

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[46] Bib Siptrott, "Miscellaneous Tracking Station Information, http://www.kadiak.org/af_track/bob_misc.html, accessed 16 June 2015

[47] Bob Siptrott, "CHAPTER 1: GENERAL DESCRIPTION OF THE AFSCF," *Air Force Satellite Control Facility*, accessed 6 June 2015, http://www.kadiak.org/af_track/bob_afscf_index.html : (1-1).

[48] Arnold, 92.

supported 31 satellites per day, and by June that number was 44 and was only expected to increase.[49]

Further upgrades to the facilities continued under the auspices of the Air Force's modernization effort, the Multiple Satellite Augmentation Program, which required that the STC be upgraded to support multiple missions and that tracking stations become identical in their technical capabilities.[50] While the STC supported the Samos and Midas programs in addition to Corona, the Satellite Control Room in Building 1001 was only designed to support one orbiting satellite at a time. Prior to the upgrade, the launch and orbiting sequences had to be configured so that there would not be any overlap.[51] New systems made this workaround no longer necessary. Communications systems throughout the STC were also upgraded, including: "installation of a semi-automatic teletype switch, which provided near real-time capabilities, and the installation of high-frequency, high-power radio station. The switchboard capacity was also increased to 1000 lines."[52] Four computers were added for a total of six CDC 1604 computers, and connections between the STC and tracking stations were reinforced. Building 1002 was planned by Kaiser Engineers, which had existing connections to Sunnyvale-based Hendry Iron Works.

[49] Ibid., 23.

[50] Things monitored, generally (1) 100-200nm short lifespan, short pass, low-altitude, more monitoring in each revolution (2) medium-altitude, 200-1000nm, one year+ monitoring duration, 10-20 min pass (3) about 10nm+ high-altitude, very long missions, less frequently serviced, perhaps geosynchronous vehicles have constant contact (4) ballistic missiles and suborbital test vehicles, short periods obviously, supported by tracking stations (5) "other" orbital vehicles such as the Shuttle. See "Air Force Satellite Control Facility," by Space and Missile Systems Center, produced by Aerospace Audiovisual Service: Military Airlift Command, F1-D1369/009 /detachment 1369th S-3580 AVS, Los Angeles, CA, Los Angeles AFB YouTube user, estimated 1980, https://www.youtube.com/watch?v=ZX9cq3_vgkI

[51] Jennings and Rachleff, FINAL, 16.

[52] Jennings and Rachleff, DRAFT, 22. Note that the key difference between say, NASA operations, and inability to work in real-time with satellites, was that it wasn't a life or death scenario in the latter case. However, the loss of any national security information was a worry. Also loss of very expensive equipment a concern, perhaps more so than the PR fiasco of losing an astronaut, depending on how cynically you feel toward the federal government

Construction of Building 1002 was completed in late 1962, constructed in an "L" shape that anticipated the later addition of another "L" to result in a rectangular building with an interior courtyard. Building 1002, connected to Building 1001 by a hyphen, provided much-needed administrative spaces, such as offices, libraries, and conference rooms. Around this time, Kaiser Engineers also made additions to and upgraded HVAC and plumbing systems in Building 1001.

Building 1003, the "Big Blue Cube"

Building 1003, the "Blue Cube," was just that: a massive, windowless box painted a pale "Air Force Blue" surrounded by three parabolic dish antennas that fed data into the center from remote tracking stations. This building is another artifact of deterrence, a bold structure that proclaimed that its residents were prepared to defend the nation from within its walls. It was also a decoy; its display and association with military activities drew eyes upon it, and perhaps that was the intention of its builders. The letters "AFSCF" emblazoned on its side designated its attachment to the base, and it was easily visible from neighboring freeways 237 and 101, not to mention from overhead. Its distinct architecture instigated years of speculation as to the exact activities conducted within the building. According to a local reporter, "The mystery only burnished the legend."[53]

[53] Scott HerHold, "Herhold: The closing of the legendary Blue Cube," *San Jose Mercury News*, 28 July 2010. http://www.mercurynews.com/news/ci_15624641

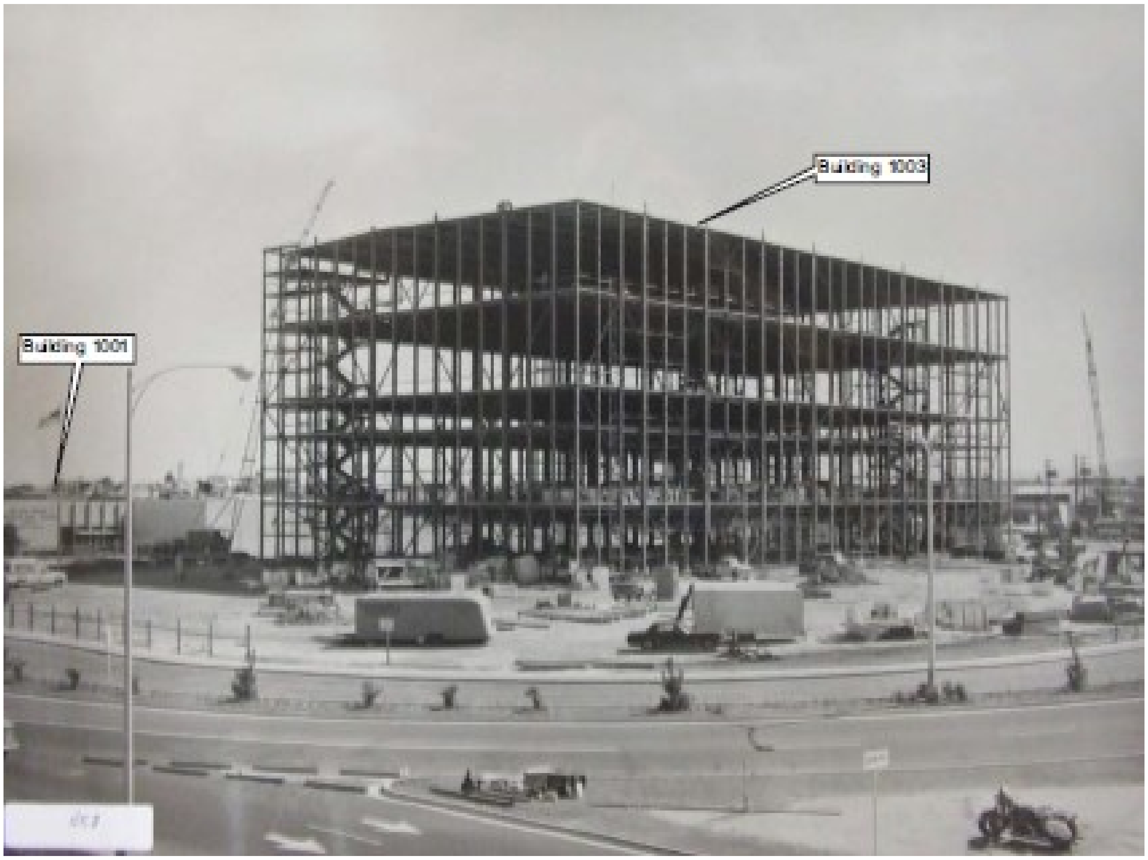

Figure 33. The Blue Cube, Building 1003, under construction in 1968. Original photograph source: Onizuka AFS. Annotated by Jennings and Rachleff.

In the mid-1960s, the Air Force decided that it would operate the Manned Orbiting Laboratory—a proposed military space station—from Sunnyvale rather than from NASA Mission Control in Houston, which greatly expanded responsibilities of the Satellite Test Center. The idea behind the Manned Orbiting Laboratory was that a Titan III booster rocket would carry a modified Gemini B capsule attached to a space laboratory into orbit. Astronauts would conduct military reconnaissance and scientific experiments, as well as assess man's suitability to living and working in space. This project required a ground facility that could house large mainframe computers, and C.F. Braun & Company drafted plans for the Blue Cube in 1966. Air Force funds were appropriated to acquire additional land from Lockheed and construction began in 1968. Contemporary *San Jose Mercury News* articles correctly speculated that the Blue Cube and other additions were to support the Manned Orbiting Laboratory program. These articles also emphasized that activities at the Blue Cube would be top secret, initiating years of public fascination with the site.[54] The 1969 DoD cancellation of the Manned Orbiting Laboratory briefly halted work on the building, but construction soon resumed; the Blue Cube's upgraded technological spaces would support other programs.

Completed in 1969, the result was a 164,000-square-foot, windowless, pre-cast concrete-panel building painted sky blue, achieved at a cost of $8 million. The 104-foot-tall building was technically four stories, because each floor had 25-foot-high ceilings to accommodate the mechanical and computing equipment required for conducting multiple missions. The building also featured a mezzanine in between the second and third stories that housed mechanical equipment, including electrical panels and massive air handling units. Later architectural historians noted that "The first story housed communications and crypto equipment, data distribution center, mechanical equipment and storage, and the second story housed four CDC 3800 computer rooms and a tape library." Three Mission Control Centers (D, F, M) were located on the third story, which supported high and low-orbit satellite programs as well as ballistic programs. The fourth floor had offices for field detachment and training as well as three additional known Mission Control Centers (B, C, D) which supplemented those still in Building 1001. Types of mission support included: flight planning, on-pad shuttle and payload examination, tracking,

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[54] Jennings, Lesson Plan, 19; Arnold, 145.

telemetry, controlling craft in altitudes above 400 NM, and interfacing with the crew during satellite deployment and retrieval.[55] Next door, newly constructed Building 1004 housed twelve 75- kW 1000 horsepower Solar Aircraft Company gas turbine generator sets, creating a two-story power plant at a cost of almost $10 million. It provided all the electrical and mechanical power required to support Buildings 1001 and 1003.[56]

Over time, more decision-making became centralized at the Blue Cube, as tracking stations became increasingly automated. Its operators played prominent roles in the STC's support of DoD missions and the NRO's reconnaissance efforts, as well as in the Apollo lunar missions and, much later, in the designs and launches of Navstar (GPS) and the Space Shuttle.[57]

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[55] Jennings and Rachleff, DRAFT, 33.
[56] Ibid., 25-27.
[57] The NRO was involved in the Shuttle's development and design to meet the needs of satellite reconnaissance (for example, requiring a larger cargo bay for military payloads). Ibid., 29, 32.

Figure 34. The console configuration within the Satellite Test Center evokes images of other control centers, namely NASA's Mission Control Center. Source: "Air Force Satellite Control Facility," by Space and Missile Systems Center, Los Angeles AFB YouTube user, estimated 1980, https://www.youtube.com/watch?v=ZX9cq3_vgkI

Upgrades to the Satellite Test Center

In 1981, a mission control center on the fourth floor of the Blue Cube was reconfigured to support the Shuttle program. This was a significant upgrade. "The new mission control console had seven television monitors on which the operators could select any one of twenty separate telemetry channels, all coming into the complex in real time, thanks to the space-ground link subsystem modification."[58] Walls were removed to make some Mission Control Rooms larger, and other spaces were divided with partitions. Other walls were repainted, new tile and carpeting was installed, and a sophisticated security system

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[58] HerHold.

was implemented. New lock and alarms permitted access to only designated personnel.[59] Around 1982, a DoD data modernization program affected Sunnyvale facilities, which needed to upgrade to meet the needs of SDI (a Reagan-era proposed missile defense system), such as the Delta Mission 181 intelligence-gathering program. This update included a $500 million introduction of database-driven computer hardware and software to replace outdated systems.[60]

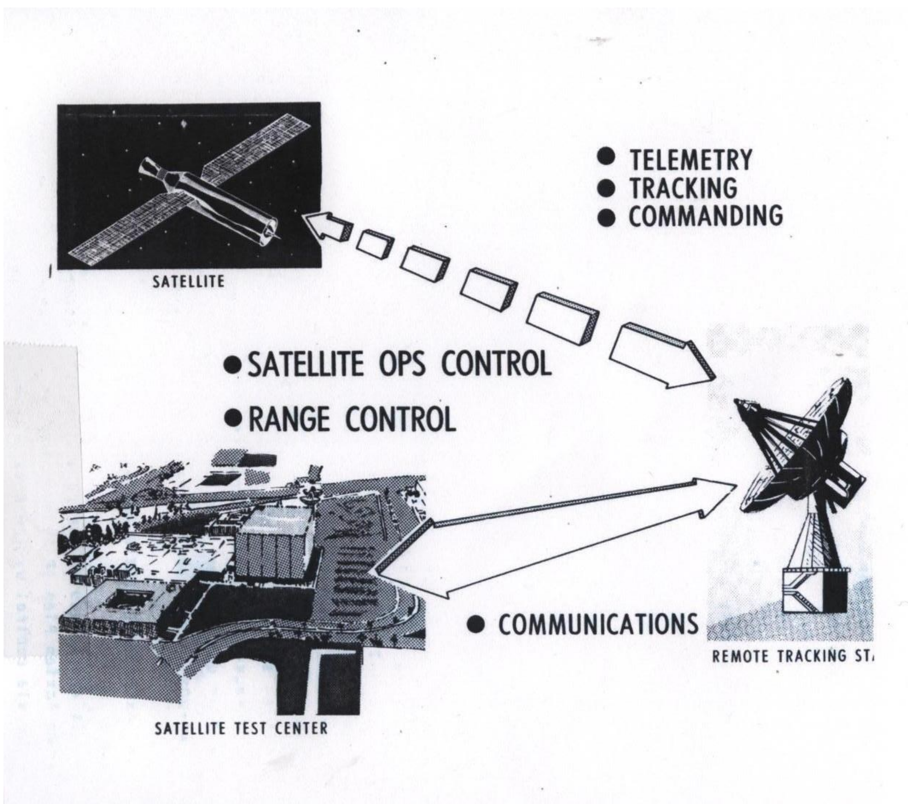

Figure 35. This graphic depicts the rudiments of how data arrived at the Satellite Test Center. Source: "Air Force Satellite Control Facility," http://www.kadiak.org/af_track/bob_afscf_index.html

[59] Jennings, Lesson Plan, 20.

[60] "Defense Dept. establishes organization to control military spending in space," *Aviation Week & Space Technology*, 1 February 1988, 39; Jennings and Rachleff, DRAFT, 34.

The STC's relationship with NASA might seem incongruent given the civilian agency's mission of peaceful and scientific uses of space. But the space agency has always been deeply tied to the American military.[61] In fact, when the NACA was transformed into NASA in 1958, it was intended to ease Soviet suspicion of American spacecraft. Ever since, NASA, "a purportedly civilian body that was supposed to advance the peaceful uses of space while championing freedom of travel in it," has often provided a cover for the activities of the Air Force and CIA.[62] NRO and NASA operations and technologies have also overlapped, such as when NASA used NRO-developed earth-imaging systems in its Lunar Orbiter camera.[63] The STC likewise supported Space Shuttle missions, including the first mission flown by Columbia in 1981, as well as the fourth Columbia mission in 1985, which carried aboard a military payload (most likely a communications satellite). Most poignantly, the Blue Cube supported *Challenger* in 1986, which tragically exploded after launch, killing its seven crew members. Challenger astronaut and mission specialist Lieutenant Colonel Ellison S. Onizuka had trained at Sunnyvale Air Force Station. The base was soon renamed Onizuka Air Force Station in his memory, and in 1987 a memorial to Lieutenant Colonel Onizuka was placed in the lobby of Building 1003.[64] This relationship with the military was seen by many at NASA as a distasteful fiscal necessity:

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[61] The Air Force saw the primary differentiation between its own space operations and civilian (NASA) space aspirations, as the latter being interested in deep space, not in orbital, routine operations, which the military branch felt was within their obvious jurisdiction. See USAF Space Programs, 19451962, Vol. II, 1963. Available as document #854 on nro.gov

[62] Burrows, 106. See also, James E. David, *Spies and Shuttles: NASA Secret Relationships with the DoD and CIA* (Gainesville, FL: University Press of Florida, 2015).

[63] Berkowitz, 159. Note another NASA/military link is Project Upward (on NRO site).

[64] Jennings, Lesson Plan, 20.

> The old-timers at NASA had come to cherish the agency's civilian orientation (though it had never been wholly free of military involvement, as was evident by the fact that the Mercury, Gemini, and Apollo astronauts were all military officers). But there had not been money to go around for all of the space programs everyone wanted at the end of the sixties and into the seventies, so NASA had been forced to rely on Air Force funding for part of the shuttle's development. There were some at the space agency who tended to think of their relationship with the Air Force as being roughly equivalent to that of an impoverished prodigy who is forced to live off the largess of a well-heeled but slightly unsavory host. But they took the money.[65]

Arms control monitoring was another component of the work done at the Blue Cube.[66] Systems operators ensured that the Soviets were adhering to arms control agreements, especially after Nixon took office in 1969, when there was an expectation that both sides would orbit these types of satellites, as explicitly articulated in the 1971 SALT agreement. Classified NRO systems were responsible for distinguishing between large and small missiles, as well as for assessing the volume of Soviet missile silos. Around this time, senior officials in the Nixon administration considered publicly acknowledging satellite reconnaissance and the NRO, but decided against it.[67]

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[65] Burrows, 301-2.

[66] Burrows, 21.

[67] Berkowitz, 361-363. Keeping the purpose of remote tracking stations classified was a bit trickier, and their operations were declassified sooner than were those at the headquarters. "By the mid-1960s the United States no longer concealed its active reconnaissance satellite program. With the help of the state department and the Danish Foreign Ministry, the AFSCF quietly declassified its reconnaissance satellite operations at the Thule tracking station in 1969." Arnold, 111.

Figure 36. The Big Blue Cube was proximate to and highly visible from a number of busy freeways in Silicon Valley. Source: Lockheed

Figure 37. This image shows the text "AFSCF" emblazoned on the side of the Blue Cube. Its operations were no secret. Source: Jennings and Rachleff.

Beyond these broad contours, however, little is known about the exact activities that took place in the Blue Cube, or what it was like to work there. Historians and journalists have speculated as to the various contractors and tasks involved.[68] One historian asserts that only contractors worked within the STC, no Air Force "blue-suiters," but Air Force personnel did work at the Blue Cube. They oversaw launching duties, but did not issue direct intelligence-gathering orders to the CIA-directed workers.[69] Many of these details remain undisclosed. Even after the building was demolished, only anecdotes existed as to the interior landscape of Building 1003. One local newspaper quotes a former secretary as describing the interior doors as looking so similar that getting around was like navigating a maze. The same article provides nostalgic stories shared by engineers about how they used butcher paper and felt pens to predict timing when computer resources were unavailable, and the time when, after supervisors asserted that the Russians could see a manhole cover from space, whimsical employees wore hats that bore pictures of manhole covers.[70] At a ceremony for the STC's closure in 2010, General Sheridan only attested that the facility had supported 3.4 million satellite "operations," but that "Much of the details of this work are still classified and we cannot talk openly about it, but…the operations conducted by the NRO from this site have made our nation a tremendously safer place to be."[71] But for all of this talk of secret

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[68] Burrows, 199-200.
[69] Arnold, 131.
[70] HerHold.
[71] Steve Bauer, "Onizuka AFS closes, operations move to Vandenberg," Schriever Air Force Base, 2 August 2010, http://www.schriever.af.mil/news/story.asp?id=123215915

operations, the space itself was not much more secret than the places examined in previous chapters.

This Was a Known Space

The ambitions of the STC's flagship program, Corona—whether identified as Corona or as Discoverer—were public knowledge from the beginning. The true nature of the Discoverer program was reported in the *New York Times*, *Aviation Week*, and elsewhere and the Kremlin had already suspected that these satellites were target-mapping. Within a week of the launching of Discoverer 17 on November 12, 1960, the authoritative Soviet journal *International Affairs* issued two warnings that were to be repeated on a number of occasions during the following three years: no matter what the spy satellites' altitude (it mentioned Discoverer, Samos, and Midas by name and outlined their missions), their flights over Soviet territory were illegal, and the USSR had the right and means to bring down the orbiting intruders just as it had brought down Gary Powers seven months before.[72]

While it was unlikely that the Soviets could have done anything, as they did not have anti-satellite capabilities, the response of the Kennedy administration was to avoid further provoking the enemy by making its spy satellite programs highly classified. Even Corona's shade of black, however, was really only a dark grey, and both superpowers continued to embark on space-based reconnaissance. The NRO was in charge of

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[72] Burrows, 111.

investigating Soviet anti-satellite and anti-ICBM capabilities.[73] Meanwhile, lawyers and politicians proclaimed freedom of the skies as an inherent right for the United States. One law professor in 1963 wrote that "the right to know of warlike preparations within a closed society like the Soviet Union is essential to the security and even the survival of the free world and is therefore a legal right."[74] Beyond couching space-surveillance in terms that would make it more akin to self-defense rather than espionage, lawyers also noted haughtily that outer space is outside of any nation's sovereignty and encouraged the Soviet Union to construct its own satellite system.

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[73] Memo for Deputy Director from Lyman B. Kirkpatricks, 30 Apr 1962, 1A0034, nro.gov; Note that while the sites in previous chapters became 'hardened' against nuclear attack, the same language was used to describe protective techniques used to prevent satellites from attack. This could mean encasing the satellite's components in sheet metal, coating lenses so that they are laser-resistant, or using gallium arsenide in place of silicon parts (Burrows 260). Also: The most insidious way to make a satellite dysfunctional is not by physically attacking it but by electronically interfering with it, jamming it. Great story in Burrows (282) of when someone hacked HBO's satellite.

[74] Howard J. Taubenfeld, "Surveillance from Space: The American Case for Peace Keeping and Self-Defense, *Air Force Magazine*, October 1963.

Figure 38. Stills from a video provide rare glimpse of what the interiors of the Satellite Test Center's facilities looked like. Source: Stills from "Air Force Satellite Control Facility," by Space and Missile Systems Center, Los Angeles AFB YouTube user, estimated 1980, https://www.youtube.com/watch?v=ZX9cq3_vgkI

Such dares were invoked with the knowledge that the USSR already had ambitions for its own system. America's satellite reconnaissance network was not only concerned with investigating Soviet capabilities and maintaining diplomacy, but with guarding the STC's own infrastructure. Historian Burrows, writing 1986, depicts the contemporary dedication to keeping Cold War secrets hidden:

> The opposition's possession of accurate information regarding the true extent and full capability of this vast and intricate [intelligence] system, much of which has been engineered to be redundant for multiple coverage and backup capacity in case on element malfunctions, would amount to a decisive intelligence coup for the opposition and most probably a severe, if not fatal, loss for the West. U.S. intelligence would be practically deaf, dumb, and blind, and the nation would be commensurately vulnerable. It is for this reason that the system that does all of this watching and listening is so pervasively secret—so black—that no individual, including the chairman of the Joint Chiefs of Staff and the director of Central Intelligence, knows all of its hidden parts, the parts they collect, or the real extent of the widely dispersed and deeply buried budget that keeps the entire operation functioning.[75]

Certainly, much secrecy was upheld. Americans knew, however, that there were secret military operations and that they involved launching cameras into space. So did Soviet leaders, who had easy access to the American newspapers, and their satellites could see American installations and confirm media reports.[76] The National Reconnaissance Office's efforts were known not only from media and espionage efforts; the Soviet Union was building its own satellite systems and expected its enemy to be doing the same.[77] In

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[75] Burrows, 22.

[76] Robert Perry, A History of Satellite Reconnaissance, Volume V – Management of the National Reconnaissance Program: 1960-1965 (National Reconnaissance Office, 1973), 56-57.

[77] See V.D. Sokolovskiy, *Soviet Military Strategy* (New York: Crane, Russak & Company, Inc., 1968, 1975) for one type of evidence of what we thought we knew about the USSR, published a number of times between 1962 and 1968. Note that the Soviet counterpart to CORONA, Zenit, is in this volume, where he "demonstrates that some aspects of the Soviet space reconnaissance program were very similar to the American CORONA, whereas others were very different" Peter A. Gorin, "Zenit: The Soviet Response

1959 a former Air Force Colonel argued that "war-fighting deterrence—deterrence based on an ability to prevail in a nuclear war—required secrecy and superiority. On the other hand, retaliatory deterrence—deterrence based on an ability to inflict severe damage in retaliation for nuclear attack—required openness about weapons and information systems."[78]

In the early 1960s, the existence of an American reconnaissance system could be inferred from political actions and reactions, such as when Corona and Samos satellite footage supplemented intelligence gathered by U-2s during the 1962 Cuban Missile Crisis. Kennedy acknowledged American reconnaissance capabilities when he warned Khrushchev to remove missiles from Cuba. Further, "To a certain extent each side…[came] to depend upon the other's strategic reconnaissance apparatus, and especially the satellites, to validate its retaliatory capability."[79] The Cuban Missile Crisis provided a turning point in which war was narrowly averted through dual recognition of unambiguous technological prowess, as "The satellites substituted imagery for imagination and provided a realistic look at what the opposition had and did not have."[80] The same can be said for the ground stations that controlled these systems.

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to CORONA," in Dwayne A. Day, John M. Logsdon, and Brian Latell, eds., *Eye in the Sky: The Story of the Corona Spy Satellites* (Washington, D.C.: Smithsonian Institution Press, 1998), 157-170. Also note this with earlier note argument that we knew they knew what we were doing because they were doing it too. Peebles, *Guardians*, also has a chapter on Soviet and other countries' spy satellite programs. "According to Dr. Hans Mark, who was under secretary [sic] of the Air Force (and therefore director of the NRO) in the Carter administration, the openness of American society allows the Russians to have a technologically inferior reconnaissance system—which he readily acknowledged—because they can purchase at nominal cost or even obtain for free what U.S. technical collectors must pay dearly to get" (Burrows 266).

[78] Jeffrey Richelson, *America's Secret Eyes in Space: The U.S. Keyhole Spy Satellite Program* (New York: Harper & Row, 1990), 71.

[79] Burrows, 132; Jeffrey Richelson, *America's Secret Eyes in Space: The U.S. Keyhole Spy Satellite Program* (New York: Harper & Row, 1990), 71.

[80] Ibid., 149.

Satellites could also be tools of diplomacy. For example, the Interdepartmental Committee on Space recommended that NASA photographs of foreign territory be released. That way, they argued optimistically, foreign leaders would be accustomed to having their territories observed, and they would concede that satellite imagery had potential for peaceful uses of space. The committee did not recommend, however, sharing the technological specifications of imaging technology. There was also discussion of sharing such photographs with Soviet leaders in order to call their bluff on missile holdings, but those opposed to such a bold move successfully argued that any revelations would have only resulted in increased countermeasures to surveillance, such as camouflage and concealment.[81]

American reconnaissance satellite systems were not explicitly acknowledged until 1978, when President Jimmy Carter confirmed that the United States used satellites to verify arms control treaties. The existence of the National Reconnaissance Office was not *officially* revealed until 1992, but its presence was known much earlier.[82] In 1973, due to an error in a Senate Committee Report, the name 'NRO' was not deleted from a list of intelligence agencies that the committee had recommended should make their budgets public. In the following years, the *Washington Post* had a story about the NRO and information was published in Victor Marchetti and John D. Mark's 1974 *The CIA and the Cult of Intelligence*.[83] No doubt a large amount of information about the NRO had also

[81] Richelson, *America's*, 71-73.
[82] Day and Logsdon, "Introduction,"13.
[83] Richelson, *The U.S. Intelligence Community*, 28. Victor Marchetti and John D. Marks, *The CIA and the Cult of Intelligence* (Alfred A. Knopf, 1974).

been discovered by this time through Soviet espionage efforts.[84] But this does not limit the historical importance of the agency. Using American spy satellites, the CIA and Air Force discovered massive underground command posts near Moscow, as well as dispelled the myth of the missile gap.[85] These were key contributions to US intelligence, and American survival in the Cold War could have easily hinged on such information.

Figure 39. The Blue Cube was demolished in 2014. This still was taken from a video captured by a private UAV equipped with a GoPro. Source: "Goodbye Blue Cube, Sunnyvale, CA," https://www.youtube.com/watch?v=YOwb49SQ-x4

Concluding Remarks

At the end of the Cold War, the Air Force began operating with more public transparency at Onizuka, even taking in visitors, with the hope of securing dwindling

[84] An American traitor also gave the Soviet intelligence about the Keyhole program as described in Jeffrey Richelson, *America's Secret Eyes in Space: The U.S. Keyhole Spy Satellite Program* (New York: Harper & Row, 1990), 157-183. Additional information about the NRO surfaced in 1978, notably during the trial of a former CIA employee who was convicted for stealing a system manual with the intention of selling it to Russian officials (Berkowitz 361-363).

[85] Burrows, 7.

DoD funding. The NRO was declassified in September 1992, and President Clinton signed an order that authorized the Director of Central Intelligence to declassify the Corona program in 1995.[86] In 2011 a massive declassification occurred in celebration of the fiftieth anniversary of the NRO, revealing the Gambit program, which utilized a high-resolution camera and began operations in 1963. After Gambit's addition, Corona had focused on searching for targets, while Gambit concentrated on surveillance. The NRO's most recently declassified system, Hexagon, replaced Corona in 1972, and these satellites combined the technologies of both Corona and Gambit.[87] These revelations, however, did not halt the demise of the Satellite Test Center. The trend toward decentralization led to the subsequent dismantling of this facility. Such sites were rendered obsolete, and its years of service were soon relegated to Cold War history.

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[86] Berkowitz.

[87] James D. Outzen, *A History of Satellite Reconnaissance: The Perry Gambit and Hexagon Histories* (Chantilly, VA: Center for the Study of National Reconnaissance, 2012). Here are additional sources to explore on other satellite programs likely controlled—to some extent—from the STC: *20th Century Spy in the Sky Satellites: Secrets of the National Reconnaissance Office (NRO), Volume 1-GAMBIT Photoreconnaissance Satellite, 1963-1984*. Progressive Management, Kindle Edition; Douglas J. Mudgway, *Uplink-Downlink: A History of the Deep Space Network 1957-1997* (Washington, D.C.: NASA History Series, 2001); James R. Hansen, *Spaceflight Revolution: NASA Langley Research Center From Sputnik to Apollo* (Washington, D.C.: NASA History Series, 1995); Phil Pressel, *Meeting the Challenge: The Hexagon KH-9 Reconnaissance Satellite* (Reston, VA: American Institute of Aeronautics and Astronautics, Inc., 2013). The Robert Perry histories are also of great value, although they are very conspicuously lacking in any historical information about the STC. And, to reiterate, my intention is not to replicate or summarize the massive work undertaken by Perry. In fact, people have already done just that (mentioned in the footnotes throughout) in very well-written and comprehensive secondary monographs. See Robert Perry, *A History of Satellite Reconnaissance, Volume IIIA – GAMBIT – NRO History*, National Reconnaissance Office, 1973; Robert Perry, *A History of Satellite Reconnaissance, Volume IIIB – HEXAGON – NRO History*, National Reconnaissance Office, 1973; Robert Perry, *A History of Satellite Reconnaissance, Volume IV – NRO History*, National Reconnaissance Office, 1973. Robert Perry, *A History of Satellite Reconnaissance, Volume IIA SAMOS* - , National Reconnaissance Office, 1973; All of the (heavily redacted) Perry docs are available here: http://forum.nasaspaceflight.com/index.php?topic=20232.0

CHAPTER 6. Epilogue

Washington DC residents love to complain about the Metro's late, missing, or packed trains, its horrific accumulation of preventable accidents, and its appalling safety record.[88] One journalist took his indictment to the Internet and wrote a blog in which he sought to understand how this once-lauded public transportation system became so consistently unreliable. At first glance, upon seeing the control of the system, the Metro appears to be an advanced technological marvel. One journalist told the story of a 2014 recruit at the Metro's Rail-Operations Control Center who was awestruck when he first saw the center's digital plotting board depicting the locations of all of the trains in real time. "Wow, he recalls thinking. It looks like a miniature NASA mission control." The recruit's admiration for the system soured after he observed inadequately trained employees.[89] The control center itself, however, had once again commanded respect, and in this case, the recruit's immediate association was with NASA's Mission Control Center.

While anecdotal, this reaction seems common. The command and control center configuration from the 1960s remains a powerful image. For example, when most Americans envision NASA, they do not imagine NASA's headquarters in Washington, DC; their mind's eye shows operators at Mission Control in Houston as representative of

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[88] There is even one website that continually updates the answer to a simple question, "Is the Metro on Fire?" Accessed 10 December 2015. Currently, the answer is, "No." See http://www.ismetroonfire.com/

[89] Luke Mullins and Michael Gaynor, "The Infuriating History of How Metro Got So Bad," *The Washingtonian*, 9 December 2015, accessed 10 December 2015, http://www.washingtonian.com/blogs/capitalcomment/transportation/why-does-metro-suck-dangerous-accidents-escalator-outages.php

the organization that put men on the Moon. While military command and control centers had projected images of their spaces in years prior, NASA built the most public of these facilities, and solidified the command center architectural archetype in public consciousness.

NASA, however, has strong ties to the military. As historian Maura Mackowski notes, NASA hardly had a degree of separation from military technologies or forces, as they hired,

> only military men as astronauts, disguise[ed] them as civilians, and launch[ed] them aboard civilian rockets that were based on military technology. The first man on the moon, Neil Armstrong, was touted as a civilian astronaut, but he had learned to fly courtesy of the US military in a school they called the Korean War. It was not until the very last Project Apollo mission in 1972, when geologist Harrison Schmitt landed on the moon, that a civilian with no military ties whatsoever flew for NASA.[90]

An additional similarity is that the space program and American military branches utilized the same contractors and engineering firms. The sustained volume of federal support given to these companies in the construction of these spaces of control, in turn, was partially responsible for a larger shift in the economy toward dependency on high-technology aerospace-related goods and services. Philco Ford is an example of one beneficiary that threads together the case studies examined here. By the 1980s, successor to Philco Ford, Ford Aerospace annually secured more than $1 billion in space and defense contracts and employed an increasing number of Ford's overall labor force. Ford Aerospace provided parts and service to all four organizations examined here, from

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[90] Maura Phillips Mackowski, *Testing the Limits: Aviation Medicine and the Origins of Manned Space Flight* (College Station: Texas A&M Press, 2006), 213.

custom electronic components and systems for NASA, to satellite operations support at the Blue Cube and its network of tracking stations. Other contractors provided hardware and software necessary to run the systems of the Strategic Air Command headquarters and the Combat Operations Center in Cheyenne Mountain, as well as contributed to systems for precision-guided munitions, or smart bombs, which would go to task if detection systems alerted radar sensors of an incoming attack.[91] Today's prominent aerospace companies, all of whom assisted in the construction of these systems, such as Lockheed Martin, Northrop Grumman, and Boeing, played roles in the creation of Cold War spaces of control. While a downturn in the defense needs of the 1990s instigated numerous mergers, these companies have weathered the storm and in the world of the post-September 11th attacks, have emerged stronger than ever.

The fates of the spaces of control examined here are most strongly linked by how they showcase the movement away from the centralized headquarters as best practice. Each space became obsolete as decentralization and distributed networks became the accepted characteristics of a command and control super-structure. The question became: What to do with these relics? Perhaps they should be preserved as museums, artifacts of the Cold War, the embodiment of a particular way of thinking about the world that was no longer operational. Or they could be repurposed, with their missions limited or facilities home to new guard. Another alternative would be to completely demolish their architecture.

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[91] Lennie Siegel, "Ford's New Idea: Space," *News Monitor*, Volume 4 Number 3, March 1983.

NASA Mission Control facilitated a number of spaceflight feats, but the agency as a whole suffered from budgetary limitations beginning even before the time of the Moon landing, never to return to its initial, generously funded heyday. By the 1990s, the once-revolutionary technology that supported Mission Control was outdated to the point that the entire center needed to be redesigned. In July 1995, an upgraded Mission Control center, which implemented the latest generation of cutting-edge technology, began operations. The Apollo-era MCC was set aside as a national historic facility, and tours are available through Space Center Houston, located in the Visitor's Center of Johnson Space Center.

The Strategic Air Command remained poised to launch a counterattack on the Soviet Union until just after the end of the Cold War. As part of post-Cold War US Air Force reorganization, in 1992 SAC was "de-established." Its personnel and equipment were distributed among other Commands, and the complex at Offutt Air Force Base was transferred to SAC's successor, the newly created US Strategic Command (StratCom), whose duties include global command and control, intelligence, surveillance, and reconnaissance (C^4ISR). US StatCom occupies Building 500, now titled the Curtis LeMay Building, and will continue to do so until its new home across the street is completed. Building 500 could no longer accommodate HQ StratCom's computing and HVAC needs; the space suffers from constant fires sparked by inadequately cooled wiring, and from flooding due to the underground location and proximity to the Missouri River. The new StratCom command and control center will be able to withstand the radiation burst that accompanies a nuclear blast, and will be located underneath a concrete plaza, "inside a thick steel cube, encased in a concrete shell, beneath the surface and surrounded by catwalks and scaffolding." After StratCom moves to its new home, the Air Defense Command's 55th Wing will take residence in the historic building.[92]

The Cheyenne Mountain Complex could never be truly hardened. According to former Air Force lieutenant William J. Astore, who served in Cheyenne Mountain in the waning years of the Cold War, everyone working within the site knew that the operations could be taken out by a nuclear attack. "Our job," he wrote in *The Nation*, "was simply to detect the coming nuclear attack by the Soviets and act quickly enough to coordinate a retaliatory strike—to ensure that the Soviet part of the planet went down—before we were obliterated."[93] This morbid mission continued throughout the Cold War, and necessary upgrades have been made to the computer systems well into the present. After the attacks of September 11, 2001, hundreds of millions of dollars of modernization work was done in Cheyenne Mountain, and in 2002, it became home to the newly created US Northern Command (NorthCom), established to provide command and control of DoD homeland defense efforts. Within less than a year, however, then-NORAD/NorthCom commander Navy Admiral Timothy Keating initiated the move of NORAD and NorthCom from Cheyenne Mountain to neighboring Peterson Air Force Base. He complained that the traffic between Peterson and Cheyenne Mountain was time-consuming and that he should not risk being stuck in gridlock while attacks might be

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[92] Steve Liewer, "At worksite at Offutt, $1.2 billion StratCom HQ taking shape," *Omaha.com*, 16 March 2015, accessed 8 January 2016, http://www.omaha.com/news/military/at-worksite-at-offutt-billion-stratcom-hq-taking-shape/article_5687667c-2ee2-5492-87f1-0b466d262c03.html ; Email from Steve Liewer to Layne Karafantis, received 7 January 2016.

[93] William J. Astore, "Leaving Cheyenne Mountain," *The Nation*, 17 April 2008.

hitting the homeland.[94] He also asserted that moving operations to Peterson would save millions of dollars annually, although inspectors from the Government Accountability Office found no documentation to support this claim.[95] NORAD spokesman Captain Jeff Davis asserted that NORAD just got too big for Cheyenne Mountain, while other sources cited changing priorities and ambiguous new objectives.[96]

The Cheyenne Mountain location had proved itself increasingly valuable over the years due to its granite enclosure, which provides protection against electromagnetic radiation (EMP). Such radiation might come from a high-altitude nuclear test and has the potential to knock out communication systems, and Cheyenne Mountain is the "country's single-best EMP-protected complex." Despite concerns that the above-ground location of NORAD HQ at Peterson leaves the site vulnerable to attack, the move to Peterson was completed in 2008, and the Cheyenne Mountain Combat Operations Center was redesignated the "NORAD and USNORTHCOM Alternate Command Center." This Center will continue to operate as a redundant command, appeasing fears about possible attack on the primary command center.[97] Reports from 2015, however, indicated NORAD's possible move back into the mountain, for the very reason that it offers EMP-

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[94] T. R. Reid, "Military to Idle NORAD Compound," *Washington Post*, 29 July 2006, accessed 12 January 2016, http://www.washingtonpost.com/wp-dyn/content/article/2006/07/28/AR2006072801617.html

[95] Michael de Yoanna, "Stop sign for NORAD," *Colorado Springs Independent*, 20 December 2007, accessed 12 January 2016, http://www.csindy.com/coloradosprings/stop-sign-for-norad/Content?oid=1141302

[96] Trevor Hughes, "NORAD's hidden bunker keeps the (data) snoops out," *USA Today*, no date, accessed, 12 January 2016, http://www.usatoday.com/story/news/2015/06/12/norad-cheyenne-mountain-bunker/28689013/ ; Jerome R. Corsi, "NORAD's New Home," *WND*, 19 June 2007, accessed 12 January 2016, http://www.wnd.com/2007/06/42136/

[97] Michael de Yoanna, "NORAD move raises security concerns," *Washington Post*, 27 March 2009, accessed 12 January 2016, http://www.washingtontimes.com/news/2009/mar/27/norad-move-raises-concerns/

protection, citing as evidence a $700 million federal contract for Raytheon to upgrade communications within the site.[98] US Air Force classified operations currently occupy 70 percent of the Complex.

The Air Force deactivated the Satellite Control Facility in October 1987, creating four new organizations.[99] A new satellite control center—the Consolidated Space Operations Center (CSOC, pronounced see-sock), which would eventually subsume the responsibilities of the Satellite Test Center—was constructed at Falcon AFB (now Schriever AFB) in response to concerns about Sunnyvale's vulnerability to earthquakes and terrorism.[100] As articulated by one historian, "Sunnyvale's Big Blue Cube not only stands above a fault that is considered to be ripe for a major earthquake, but is also within bazooka and other weapons' range of a busy thoroughfare."[101] Some operations remained at Onizuka Air Force Base, but the station was selected for closure by the Base Realignment and Closure Program in 2005, and the Air Force relocated Onizuka's remaining operational units to Ellison Onizuka Satellite Operations Facility at Vandenberg Air Force Base.[102] The NRO officially removed its presence from Onizuka in 2007 and continues to operate from the Pentagon and a Chantilly, Virginia location with a budget of some $10 billion. After transfers were completed, Onizuka Air Force

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[98] Pam Zubeck, "NORAD returns to Cheyenne Mountain bunker, sorta," *Colorado Springs Independent*, 14 April 2015, accessed 12 January 2016, http://www.csindy.com/IndyBlog/archives/2015/04/14/norad-returns-to-cheyenne-mountain-bunker-sorta

[99] The AFSCN was not an official body in itself but a collection of autonomous installations, one of which was the STC. See "Force Support—Air Force Satellite Control Network," http://www.au.af.mil/au/awc/awcgate/au-18/au18004a.htm

[100] Potentially active major fault zones include San Andreas, Hayward, and Calaveras. See "Restoration Management Action Plan," 50th Space Wing, US Air Force Space Command, Onizuka Air Station, California, November 1995, D-1.

[101] Burrows, 201.

[102] Jennings and Rachleff, DRAFT, 40.

Station was closed on 30 September 2010. The closing ceremony featured a color guard, a brass band, and was presided over by Lt. Gen John T. "Tom" Sheridan, commander of the Space and Missile Systems Center at Los Angeles Air Force Base.[103]

The California State Historical Preservation Office unsuccessfully attempted to add the STC site to the National Historic Register in 2010, which would have consisted of six interconnected "contributing resources", including the Blue Cube, and two "non-contributing resources."[104] Historians at the Office asserted that the space they designated the Satellite Test Center Historic District was significant not only at the local but at the national level, and that reconnaissance efforts conducted at its buildings "represent the massive investment of the United States to combat the perceived threat posed by the Soviet Union during the Cold War."[105] For undisclosed reasons, the Blue Cube and many of the STC facilities were demolished in 2014. After the demolition, District Chancellor Linda Thor said the renovated site would be "very respectful" of the Blue Cube's historical significance, including a transfer of the memorial of astronaut Onizuka to the new facility, and it would repurpose the site's blue tiles as a pathway. As of 2014, the site was slated for construction of a large annex to a local community college.[106]

Speculation as to the demise of the Blue Cube circles back to the questions of how agendas can be built into architecture, and how secret any of these sites were meant to be. Perhaps, unlike the Museum-displayed, Apollo-era NASA Mission Control Center, few Americans would want to reflect on military Cold War command centers with a

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[103] Bach; Bauer.
[104] Jennings and Rachleff, DRAFT.
[105] Jennings and Rachleff, FINAL, 1-5.
[106] Bach.

quaint nostalgia, as time capsules of a national past. Or perhaps the Blue Cube's technology and operations were more advanced than we could imagine, are still highly classified, and the building needed to be destroyed to protect its secrets. Leaving the public guessing probably does more for the aims of national security than does disclosure. The symbolic architecture and high-profile "secrecy" of the Blue Cube served the purpose of keeping people at home and abroad uncertain as to its exact activities, while simultaneously reinforcing an image that sophisticated, technological tasks were indeed being conducted to keep the populace safe. Its demolition may indicate that it was successful in this task, and that in a new era these centers are no longer necessary.

Command centers, whether civilian or military, remain a distinct expression of Cold War culture, of an era confident in its ability to control the future. In the twenty-first century, we no longer feel that this is a realistic outlook, and struggle to find stability in a complicated world that is out of our control. No longer are there distinct physical markers of a protective structure. The new architecture of command and control is found in the network, not in the building.

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Curriculum Vitae

Layne Karafantis was born on 10 June 1982 in San Diego, California. After high school she worked in a record store, then traveled for a few years before moving to San Francisco to begin college coursework. After a few more moves around California, she graduated from San Francisco State University in 2007 with a bachelor of arts degree in Technical and Professional Writing, specializing in multimedia design, journalism, and computer science. She worked as a software manual writer in the East Bay for a few years while also taking courses at City College of San Francisco; eventually she decided to return to school to study American history. Layne attended the University of Nevada, Las Vegas, where she served as a research assistant for the Women's Research Institute of Nevada, conducting interviews for the Las Vegas Women Oral History Project. Working under the tutelage of Dr. Eugene Moehring, she completed fields in urban history, history of the American West, and public history, earning a master of arts in History in 2010. Her master's thesis examined postwar urban growth accompanying the arrival of Sandia Laboratories in Albuquerque, NM and Livermore, CA.

After finishing at UNLV, Layne moved to Baltimore to study the history of technology with Prof. Bill Leslie at the Johns Hopkins University, during which time she wrote this dissertation, inspired in no small part by Bill's enthusiasm for space age architecture. At JHU, she also studied the history of aerospace with Dr. Roger Launius, urban history with Dr. Mary Ryan, and cultivated treasured collegial relationships with JHU faculty and peers. Layne published while in graduate school, most notably: on extreme laboratory environments in *Historical Studies in the Natural Sciences*; on postwar geographies and military technology in *Vulcan*; a popular depiction of the

Mission Control dissertation chapter for *Engineering & Technology*; and an economically focused take on the creation of MCC-H for the edited volume, *Seeds of Discovery*. She also co-authored a trip report on behalf of the International Committee for the History of Technology for *Technology & Culture*; co-authored a chapter on Skylab for the volume *Milestones of Space*; and wrote review articles for scholarly publications.

In addition to her publication work, Layne kept active in professional societies, presenting at two or three conferences per year throughout her graduate career. These included annual meetings of the History of Science Society, the Society for the History of Technology, and the International Committee for the History of Technology. As a teaching assistant, Layne supported instruction of a variety of courses within the history of science and technology department at Johns Hopkins, including: Technological Transformations; Ecology, Health, and the Environment; the History of Latin American Science; and Spaceflight and Society. In fall 2014, under the auspices of a Dean's Teaching Fellowship, Layne developed her own course—Aviation in America—which she taught to JHU undergraduates. Other accepted awards included a J. Brien Key Graduate Student Assistance Grant, Mellon Foundation funding, supplemental department funding, numerous travel grants to various society meetings, and a grant-in-aid from the American Institute of Physics. Layne was also awarded a Daniel and Florence Guggenheim Fellowship by the National Air & Space Museum, which she declined in favor of taking a permanent position with the Museum.

Layne currently serves as curator of the Modern Military Aircraft collection at the National Air & Space Museum in Washington, DC.