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The Incomplete Shield: The Distant Early Warning Line and the Struggle for Effective Continental Air Defense, 1950-1960

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**The Incomplete Shield: The Distant Early Warning Line and the struggle for effective
continental air defense, 1950-1960**

By

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in partial fulfillment of the requirements for the degree of
MASTER OF ARTS

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Chapter 1. Introduction

In the early days of the Cold War, the United States, faced with the need to protect its long northern border against the prospect of Soviet long-range bombers equipped with nuclear weapons, built a chain of radar stations, called the Distant Early Warning (DEW) Line, along the northern coast of North America. Consisting of sixty-three stations positioned along the Alaskan and Canadian Arctic, the DEW Line stood watch along the northern reaches of North America from nuclear bombers, seeking to backstop U.S. nuclear forces against a Pearl Harbor-type surprise attack by the Soviet Union.

The demanding tasks and remote location of the DEW Line meant that solutions to considerable technological problems had to be found in order to make the chain of radar stations a reality. These technological hurdles included automatic signal processing to reduce manpower requirements, secure and reliable communications system to connect the DEW Line with the air defense and nuclear command and control systems of the United States and Canada, and the logistical difficulties of building and maintaining such a large system in the remote Arctic wilderness. The exceptional technological sophistication and construction difficulties of the DEW Line place it in the pantheon of Cold War technological systems.

But while the DEW Line and its supporting systems were considerable feats of technology, these accomplishments obscured a flawed implementation of the original design concept and embodied the evolving U.S. concept of nuclear deterrence. The

Massachusetts Institute of Technology Lincoln Laboratory Summer Study Group, which consisted of people from academia, industry and the armed forces and whose 1952 report on U.S. and Canadian air defenses initiated the construction of the DEW Line, understood very clearly the difficulties of defending North America against nuclear-armed Soviet bombers. However, the Study Group's proposal was not fully implemented by the U.S., and the truncated design that was built sacrificed the effectiveness of continental air defenses in favor of a tripwire system meant to trigger a nuclear retaliatory response. In this way, the DEW Line embodied both the logic and the rhetoric of Massive Retaliation.

The result of this flawed conceptual foundation and the limits of the technologies involved meant the DEW Line never fulfilled both the early warning and air defense roles its designers envisioned. But as understanding of its limitations grew, the role of the DEW Line evolved from a tripwire into one of a number of overlapping detection systems that constituted the nation's early warning systems. Their continued operation throughout the Cold War to this very day demonstrates the continued utility and success of these systems.

Despite its size, cost and significance, the DEW Line has been the subject of only limited scholarly examination. Two United States Air Force publications, Kenneth Schaffel's *The Emerging Shield: The Air Force and the Evolution of Continental Air Defense, 1945-1960* and David F. Winkler's *Searching the Skies: The Legacy of the United States Cold War Defense Radar Program* both devote a few pages to the history of the DEW Line, and both examine development and implementation of the DEW Line. Although Winkler's work looks at component technologies of the DEW Line, neither Winkler or Schaffel discusses

the DEW Line's capabilities as a technological system and how it fit into other such systems that made up North American continental air defenses. Joseph T. Jockel's *No Boundaries Upstairs: Canada, the United States, and the Origins of North American Air Defenses* discusses continental air defenses in the context of a thorough examination of the U.S.-Canadian defense relationship. The most thorough scholarly work on the DEW Line is James Louis Isemann's dissertation entitled *To Detect, to Deter, to Defend: The Distant Early Warning (DEW) Line and Early Cold War Defense Policy, 1953-1957*. Isemann examines the origins of the DEW Line from early concepts of strategic bombing and air defense to the final implementation of the DEW Line in 1957. Although an excellent work in many regards, Isemann argues that the DEW Line improved both the U.S. nuclear retaliatory capability and continental air defenses. This paper respectfully disagrees and argues instead that the DEW Line was a flawed implementation of the Summer Study Group's original concept and that, although it and other systems enhanced U.S. early warning capabilities, the DEW Line did not significantly improve continental air defenses.

Chapter 2. The Air Defense Lessons of the Second World War

The U.S. and its allies gained extensive experience in air defense during World War Two, and they developed sophisticated air defense systems to defend against air attacks on land and at sea. While individual technologies like radar played an important role in these defenses, these technologies were only a part of larger system of air defense. The ability to quickly gather, process, and disseminate information about incoming enemy air raids, and effectively allocate defensive weapon systems based on that information, proved crucial to the success of any air defense.

The successful defense of British airspace during the Battle of Britain is perhaps the most famous example of a successful air defense system. The Chain Home system of air defense radars is often cited as the key to the British victory over the German Luftwaffe. However, these radars were only a component of a larger air defense system that allowed Fighter Command to maximize the effectiveness of its aircraft. Raw information from the radars was fed into a raid reporting system that fused it with information from other sources, including ground spotters and signals intelligence. The processed information from these “filter rooms” would be integrated on large map table displays at regional command centers where local commanders could allocate air defense assets in the most effective manner.¹ This system is also notable because of the large geographic area that had to be defended and the myriad number of scattered air defense forces that had to be

¹ David Zimmerman, *Britain's Shield: Radar and the Defeat of the Luftwaffe*, (Stroud: Sutton, 2001), 160-61, 173-174, 208-210.; Norman Friedman, *Network-Centric Warfare: How Navies Learned to Fight Smarter through Three World Wars*, (Annapolis: Naval Institute Press, 2009), 51-52.

coordinated. Even so, Britain's air defenses operated on the same principle of effective data fusion and dissemination and control of interception employed by the U.S. Navy in the Pacific.

The U.S. Navy employed a similar concept during World War Two, and the Pacific Theater provided U.S. Navy with extensive experience in managing air battles. Historian Norman Friedman argues that the key to American success was picture-centric warfare—that is, the ability to gather and process incoming tactical information into a cohesive tactical picture and effectively disseminate that picture to appropriate end users. Although radar and other sensing technologies (including the human eyeball) could provide a wealth of tactical information, the sheer amount of that information could quickly overwhelm the ability of tactical commanders to use it effectively unless it was processed into a form that was easily understandable. This data then had to be shared appropriately before it could be effectively used. The solution was the Combat Information Center—a shipboard data fusion center that enabled incoming information from sensors and spotters to be quickly processed and shared via a visual display of the tactical situation. This tactical picture could then be used by the relevant commanders to direct aircraft, ship-borne guns and other weapons in a way that maximized their effectiveness.²

The success of both the British and the U.S. Navy in managing their respective air defense battles provided a useful model for U.S. post-war defense planners. However, the development of jet aircraft and nuclear weapons raised both the tempo and the stakes of

² Friedman, *Network-Centric Warfare*, 57-61.

an air defense battle. The U.S. would struggle for the next fifteen years to adapt the wartime model to new conditions in the effort to create effective continental air defenses.

Chapter 3. The Origins of Continental Air Defense

Bomber generals who believed strategic bombing won the Second World War and would be the key to winning the next conflict dominated the postwar Air Force. These generals increasingly viewed continental air defense as merely an adjunct to strategic bombing, which was the ultimate guarantor of U.S. national security. The air defense system that emerged from this logic had one primary objective: to serve as a tripwire activating a U.S. nuclear retaliation, thereby preventing the destruction of the U.S. nuclear deterrent, i.e. the bombers of Strategic Air Command.

In addition to dominating the planning process for nuclear bombing, the Air Force also dominated planning for the defense against nuclear attack by the Soviet Union. This role was in part due to geography, since the shortest route between the United States and the Soviet Union was across the Arctic, where neither the Army nor Navy could operate well.³ Although there was general agreement among U.S. military and civilian intelligence agencies that the Soviets would not have nuclear capability until 1952, the Joint Chiefs of Staff recognized as early as the autumn of 1945 that the most likely routes of any U.S. or Soviet attacks on each other would be over the North Atlantic and polar region.⁴

The U.S. was slow to develop a program of air defense in the period immediately after the Second World War. The national experience of the United States had not

³ David R. Mets, "Technology, Thought, Troops: General Carl Spaatz and the Dawn of the Nuclear Age," in David R. Mets and William P. Head, *Plotting a True Course: Reflections of USAF Strategic Attack Theory and Doctrine: the Post-World War II Experience*, (Westport, CT: Praeger, 2003), 22-23.

⁴ Kenneth Schaffel, *The Emerging Shield: the Air Force and the Evolution of Continental Air Defense, 1945-60*, (Washington, D.C.: Office of Air Force History, U.S. Air Force, 1991), 57-58.

prepared the country for the possibility of an attack on the United States with a nuclear weapon. Likewise, there had previously been no reason for the U.S. to make radical changes in defense or foreign policy based on developments in weapon technology.⁵ General Henry “Hap” Arnold, the head of U.S. Army Air Forces during World War Two, stated in 1945 that the Soviet Union was not a threat in part because the primitive state of Soviet technology was not capable of posing a threat to the United States. Arnold’s belief reflected the widely held view of postwar planners that the Soviet Union required decades to acquire the sophistication required to mount an air attack of the U.S. homeland, and only then would the Soviet Union be a serious threat to the United States.⁶ But by the late 1940s, the Air Force and the Joint Chiefs believed that Soviet Union had numerous bombers that could reach cities in the U.S. and Canada from bases in Siberia. Nuclear armament meant that those cities could be destroyed in such an attack. For the first time, both the U.S. and Canada had to seriously plan for the air defense of North America.⁷

In 1947, the U.S. concern about the state of air defense grew after the Soviet Union showed off its copy of the B-29, known as the Tu-4. These planes were thought to be able to bomb all of the U.S. on one-way missions. Concern grew in 1948 when Pentagon planners estimated that the Soviets had 200 Tu-4s and would have as many as 1,000

⁵ Kent C. Redmond and Thomas M. Smith, *From Whirlwind to MITRE: The R&D Story of the SAGE Air Defense Computer*, (Cambridge: Massachusetts Institute of Technology Press, 2000), 6.

⁶ Perry M. Smith, *The Air Force Plans for Peace 1941-1945*, (Baltimore: Johns Hopkins Press, 1970), 81-82.

⁷ Robert Bothwell, *Alliance and Illusion: Canada and the World, 1945-1984*, (Vancouver: UBC Press, 2007), 116.; JCS 2084/15, First Interim Report on the Evaluation of Air Defense Weapons and Weapon Systems, Records of the U.S. Joint Chiefs of Staff Geographic File 1951-1953, RG 218, Box 56, National Archives II, College Park, Maryland.

sometime by 1949.⁸ Early warning of Soviet air raids was also required to ensure that Strategic Air Command and the nuclear retaliatory capability it constituted was not eliminated in a surprise attack; if that capability was destroyed, the West would probably have no option other than to surrender. In this context, North America could be seen as a strategic unity, since whether Soviet bombers attacking North America over polar routes were targeting the U.S. or Canada did not matter for planning purposes.⁹

In October 1948, the Joint Chiefs approved an interim radar system appropriately known as “Lashup”. Composed entirely of World War Two-vintage radars, Lashup provided only limited coverage over areas of the country considered absolutely essential to defend against air attack during the event of a war. This area included the population centers of the Northeast (including Washington, D.C.) Southern California, the industrial areas of Great Lakes region, and the nuclear facilities in Washington State, New Mexico and Oak Ridge, Tennessee. The name of the system was changed to “Permanent” after legislation authorizing expanding the system was passed by Congress in February 1949.¹⁰

⁸ Joseph T. Jockel, *No Boundaries Upstairs: Canada, the United States, and the Origins of North American Air Defense*, (Vancouver: University of British Columbia Press, 1987), 31-32.

⁹ Bothwell, *Alliance and Illusion*, 116.

¹⁰ Jockel, *No Boundaries Upstairs*, 34.

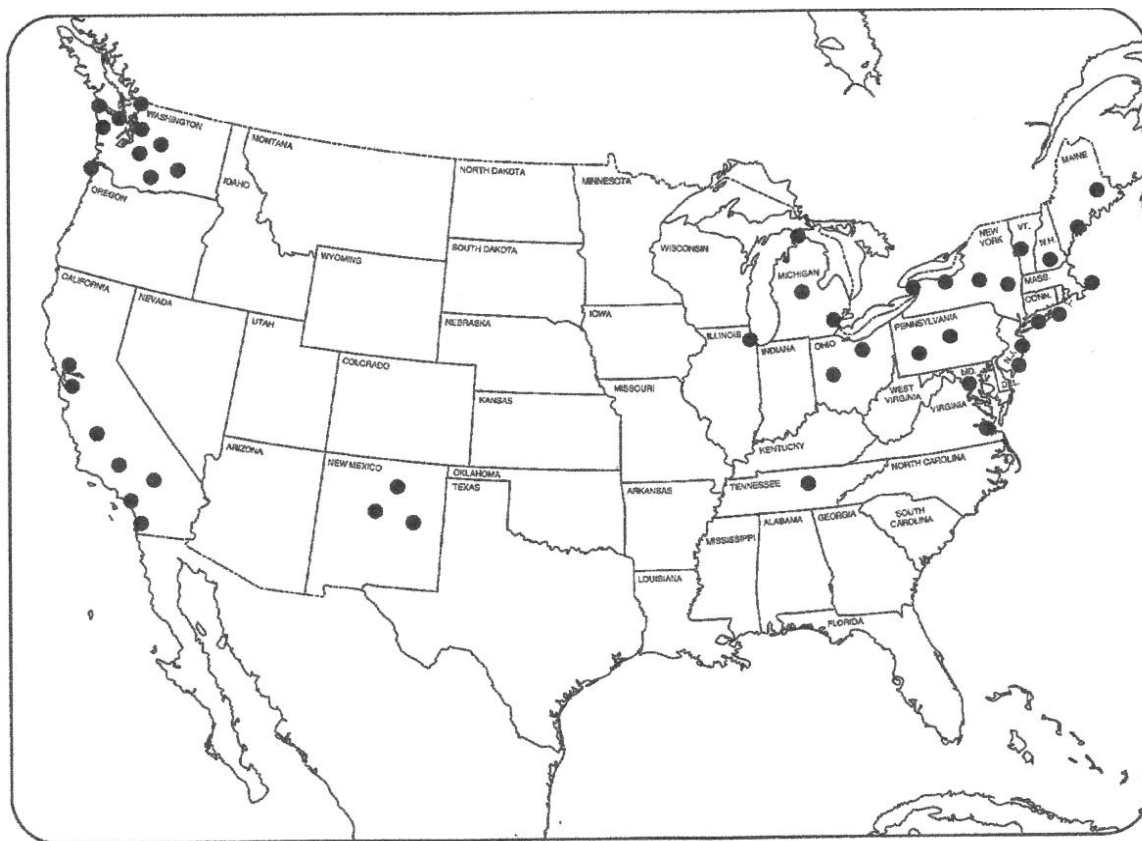


Figure 1 Map of Lashup System Radar Sites, April 1950 (<http://www.fas.org/nuke/guide/usa/airdef/1997-06-01955.pdf>)

Although Lashup and the Permanent system greatly expanded the radar coverage of the continental United States, this expansion was not matched by increased sophistication of the command and control portion of the air defense system on the order required by the development of long-range jet bombers. While a ground-controlled intercept capability existed with both systems¹¹, both the Lashup and Permanent systems lacked the ability to coordinate air defenses effectively against large raids, especially under conditions of a surprise attack. However, U.S. defense planners regarded the Permanent System as an adequate response to a Soviet threat that was not yet in possession of

¹¹ Schaffel, *The Emerging Shield*, 210.

nuclear weapons. The purpose of the system was to limit damage from conventional attacks through gradual attrition Soviet bombers while the U.S. initiated its nuclear response. The limitations of this strategy underpinning the Permanent line began to show themselves after the Soviet detonated their first atomic bomb in 1949.

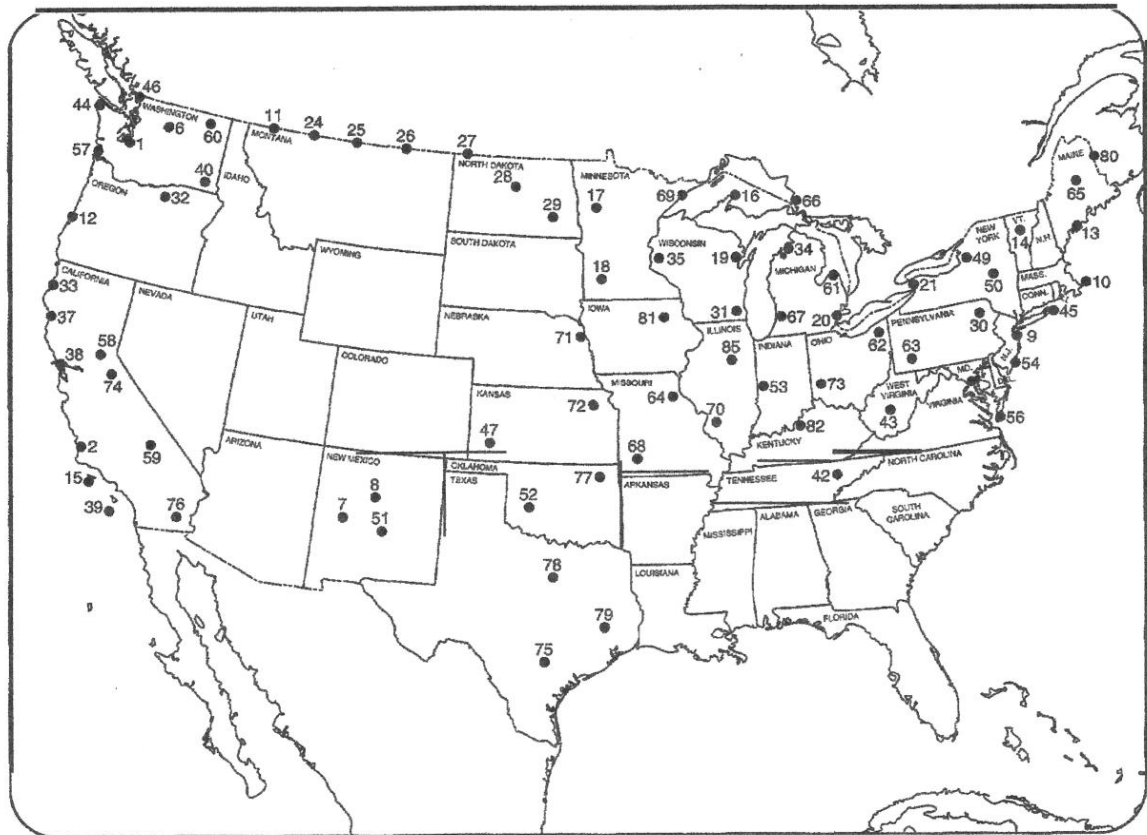


Figure 2 Map of Permanent System Radar Sites, June 1952 (<http://www.fas.org/nuke/guide/usa/airdef/1997-06-01955.pdf>)

Although the United States had certainly improved its early warning radar system in the closing years of the 1940s, it was still a long way from having anything close to a

comprehensive air defense system. The inadequacy of this system was the subject of a December 1950 report of the Weapon Studies and Evaluation Group (WSEG). The Joint Chiefs of Staff requested the report, entitled "First Interim Report on the Evaluation of Air Defense Weapons and Weapons Systems," three days after the Soviet Union detonated their first atomic bomb on August 29, 1949. Its conclusions were alarming. The WSEG assumed that the Soviet Union would only have about thirty atomic bombs available for a strike against the United States, and that only half of those bombs would be used in a first strike. If such a Soviet air strike was carried out using Tu-4 bombers¹² against the U.S. without warning and during daylight hours, the WSEG estimated that U.S. air defenses would be unable to stop a single bomber from delivering its payload. Given two hours of warning, air defense forces might be able to stop as many as half of the Soviet bombers, but only in daylight and good weather conditions. A similar strike carried out at night or during bad weather could expect a 85-100% success rate.¹³

The WSEG report stated that the chief reasons behind these findings were a complete inadequacy of early warning and surveillance radars and the inability to control the ongoing air battle. The models that the WSEG used in its estimates assumed that the Soviet strike would only include nuclear-armed bombers and not long-range fighter escorts or electronic countermeasure aircraft. However, the U.S. air defense system wouldn't even be able to handle an unsupported strike. The root of the problem was the inability of the

¹² WSEG assumed the aircraft shared the same features and characteristics.

¹³ JCS 2084/15, First Interim Report on the Evaluation of Air Defense Weapons and Weapon Systems, Page 92, Records of the U.S. Joint Chiefs of Staff Geographic File 1951-1953, RG 218, Box 56, National Archives II, College Park, Maryland.

U.S. to distinguish enemy aircraft from friendly military and civil air traffic. The chief advantage of a few hours warning was that it allowed U.S. authorities to clear the airspace of civilian and unnecessary military aircraft, the sheer number of which would likely overwhelm the ability of U.S. radar operators to discern friend from foe under normal conditions. Although this would greatly simplify the identification and tracking capabilities of the air control and warning system, WSEG projections indicated that only two out of the fifteen Soviet bombers would be destroyed before they delivered their payload.¹⁴

In many ways, the WSEG report was a statement of the basic problem facing the U.S. in the age of nuclear-armed intercontinental bombers. Incremental increases in the existing radar and interception control were simply not adequate to the task of defending U.S. airspace. A true solution to this dilemma would require a much more radical solution than had yet been offered.

¹⁴ *Ibid.*, 96-98.

Chapter 4. NSC-68

The U.S. had already begun to lay the foundations of such a solution by the time the WSEG report was issued on December 27, 1950. These changes represented the early stages of the U.S. response to several events that occurred between 1949 and 1953. The first of these was the detonation of the first Soviet atomic bomb in August 1949, followed that October by a communist victory in China. The following year marked the invasion of South Korea by the communist North Koreans. Finally, the Soviet Union detonated a thermonuclear bomb in August 1953. Included in the broad U.S. response to these developments were three formative documents of American air defense efforts: National Security Council Report 68 (NSC-68), the Final Report of Project Charles, and the 1952 Summer Study Group Report of the Massachusetts Institute of Technology's Lincoln Laboratory. These documents were the origin of the mature form of the U.S. continental air defenses before the advent of the intercontinental ballistic missile.

In April 1950, the National Security Council issued the results of a broad re-evaluation of U.S. national security policy in light of recent actions by the Soviet Union and other communist states. Based on the assumption that the Soviet Union was determined to defeat the United States, this report, known as NSC-68, advocated increased military capabilities to defend the free world by force, if necessary.

The lingering fear of a Pearl Harbor-style attack runs throughout the section of NSC-68 that concerned nuclear capabilities, and the perceived need to defend against such an

attack resulted in NSC-68's air defense recommendations. Although NSC-68 stated that the deterrent shield provided by the U.S. nuclear stockpile was then adequate, this deterrent would only be effective until the Soviet Union had a comparable nuclear capability. At that point, there would be a possibility for the Soviet Union to destroy existing U.S. nuclear and conventional military strength in a surprise attack.¹⁵ In response to such a threat, NSC-68 recommended "greatly increased air warning systems, air defenses, and... a civil defense program which has been thoroughly integrated with military defense systems."¹⁶ These recommendations were adopted along with the rest of NSC-68.

¹⁵ "A Report to the National Security Council- NSC 68", April 12, 1950. President's Secretary's File, Truman Library.

¹⁶ *Ibid.*

Chapter 6. Project Charles

Although NSC-68 established the policy basis for expanded continental air defenses, it contained no specific recommendations about how to best implement that policy. The Air Force turned to the scientific and academic community for recommendations on how to proceed.¹⁷ Two reports about air defense were subsequently issued by study groups located at the Massachusetts Institute of Technology that would have a dramatic impact on continental air defenses.

The first of these was the Project Charles report issued in August 1951 which established two foundational principles which were the basis of all subsequent continental air defense projects in the 1950s. The first of these principles was the recognition of the valuable, possibly decisive, effect that tactical early warning could provide to the U.S. The report was the first to recognize the value of a distant early warning system that could provide two to six additional hours of warning of Soviet bombers approaching along transpolar routes. Because this additional time could mean the difference between the survival of the U.S. nuclear deterrent or its destruction on the ground, the committee considered such a distant early warning system across the Arctic region of North America highly desirable. However, Project Charles' members thought such a system was not feasible; in addition to the difficulty of construction, operation and supply in such a remote, forbidding location, the unpredictable electromagnetic conditions of the Arctic

¹⁷ Samuel P. Huntington, *The Common Defense: Strategic Programs in National Politics*, (New York, Columbia University Press, 1961), 328-29.

regions would make radio communications highly unreliable. However, the Project Charles report endorsed the extension of radar coverage north of the border into Canada.¹⁸

The scientists and academics of Project Charles were not the first to see the value of extending radar coverage north of the U.S.-Canadian border, and significant dialogue between the U.S. and Canada on this problem had been ongoing since the formation of the Permanent Joint Board on Defense in 1940. As the U.S. began to construct a radar network for its air defense system, the defensive disadvantages of U.S. geography became apparent. Many of the U.S. centers of industry were very close to the U.S.-Canadian border, giving U.S. air defense forces only minutes warning of incoming Soviet bombers in the event of an attack. At the same time, the Canadians had a very spotty system of radar coverage; by 1950, only four or five radar stations were built or programmed for construction in all of Canada. The Canadians were reluctant to spend more money on a radar network because it lacked the number of interceptors to defend the expanded coverage and could not afford both more radar sites and more interceptors. The realities of the air defense problem of North America required the U.S. and Canada to cooperate. Canada would not be capable of creating an effective air defense system without American resources, and the close proximity of major U.S. centers of population and industry meant that the U.S. would be incapable of mounting an effective air defense without the advantages that Canadian geography could provide.¹⁹ Because the needs of providing

¹⁸ Jockel, *No Boundaries Upstairs*, 61-62.

¹⁹ Schaffel, *The Emerging Shield*, 251.; Jockel, *No Boundaries Upstairs*, 50.; *Foreign Relations of the United States, 1952-54* [after abbreviated as *FRUS*], National Security Affairs II, Part I, "Report of the Special Evaluation Subcommittee": 332-34.

basic radar coverage for interceptor control over Canada corresponded closely with the U.S. desire to extend its early warning coverage northward, the U.S. agreed to pay for roughly two-thirds of a total network of thirty-two stations of the radar line along the U.S.-Canada border that would come to be known as the Pinetree Line.²⁰ These radars provided both early warning of air raids and ground-controlled intercept (GCI) direction for interceptor aircraft and became operational in 1954.²¹

²⁰ "Memorandum for the Secretary of the Air Force," dated March 14, 1951, Folder 17, Records of International Military Agencies, Permanent Joint Board on Defense, Canada-United States Section, Top Secret Correspondence, 1941-1956, RG 333, Box 3, National Archives II, College Park, Maryland; also "Memorandum for the Record: Extended Radar System in Canada," dated March 12, 1951, same location; also Jockel, *No Boundaries Upstairs*, 44-45.

²¹ Jockel, *The Emerging Shield*, 210.



Figure 3 Map of the Pinetree Line, Mid-Canada Line and the DEW Line (<http://www.journal.dnd.ca/vol10/no2/07-fawcett-eng.asp>)

In the early 1950s the Canadian government began efforts to extend the warning time available to its air own defenses, beginning with construction of an early warning line across Canada at the 55th parallel. The Mid-Canada Line (sometimes known as the McGill Fence, after the university where the technology was developed) only provided notification that something had flown overhead, along with the speed of the object; the Mid-Canada

Line's radar system could not provide additional tracking information, such as exact course, heading, and altitude.²²

The second major principle established by Project Charles was the use of automation provided by digital computers to help manage the defensive air battle over North America. Although non-automated interceptor control had been sufficient during the Second World War for both the U.S. and British, the higher speed of post-war jet-powered bombers meant that an air battle could develop faster than human intercept controllers could effectively manage. In addition, nuclear bombs meant that a single bomber could devastate a city or a military base, so a successful defensive air battle required an interception rate as close to 100 percent as possible. Air Force leaders had begun to recognize the advantages of automating air defense functions and minimizing human involvement in the air defense control system as early as April 1947 and suggested that automation might be necessary for the successful intercept of high-speed aircraft a year later.²³ Project Charles indicated that the best way to improve continental air defense was to improve the ability to track and plot the air battle through computerization. The work of Project Charles ultimately led to the development and deployment of computerized command and control systems such as the Semi-Automatic Ground Environment (SAGE) and Back-up Interceptor Control (BUIC), which would help direct the combined interceptor force in the event of an attack.²⁴ The concept behind SAGE was

²² Ibid., 66; Schaffel, *The Emerging Shield*, 210.

²³ Redmond and Smith, *From Mitre to Whirlwind*, 13.

²⁴ Daniel C. Dose, *NORAD: A New Look*, (Kingston, ON, Center for International Relations), 5-6.

simple: all of the radar tracks of incoming targets would be fed into the nationwide SAGE system that would automatically compile the information and present human operators with a tactical picture of the ongoing defensive air battle via a visual display. The controllers could then select which assets would be used to destroy the incoming aircraft. In some cases, these aircraft—namely F-102 and F-106 interceptors—could be automatically guided into firing position by the SAGE computers. Theoretically, this system would effectively unify the command and control of all U.S. interceptor forces.²⁵ In practice, SAGE had several limitations, many of which stemmed from the inability for early computers to replicate adequately all of the human functions their designers sought to replace. In addition, the system was vulnerable to jamming, and it probably would have failed under actual combat conditions.²⁶

²⁵ Friedman, *Network-Centric Warfare*, 72-73

²⁶ Paul N. Edwards, *The Closed World: Computers and the Politics of Discourse in Cold War America*, (Cambridge: MIT Press, 1996), 105-107; Paul J. Bracken, *The Command and Control of Nuclear Forces*, (New Haven: Yale University Press, 1983), 11-12.

Chapter 6. The 1952 Lincoln Laboratory Summer Study Group

In 1952, MIT's Lincoln Laboratory Summer Study Group convened with a goal of improving continental air defenses. Chaired by the MIT's J.R. Zacharias and consisting of a broad group of representatives from industry, academia (including J. Robert Oppenheimer) and the armed services of both the U.S. and Canada, this informal group met over the summer of 1952 to discuss the problem of continental air defense. The report generated by those meetings was a remarkable document, showing that the Summer Study Group understood not only the strategic dilemma of continental air defense in the nuclear age but also the strategic geography of North America and the implications new and emerging radar detection, communication and weapon technologies. Ultimately, the Study Group's report would result in the construction of the Distant Early Warning Line, a massive system of early warning radars located in the Alaskan and Canadian High Arctic. Although this report articulated the problems of North American air defense very well and proposed solutions to those problems, the final implementation of the DEW Line would instead reflect a different set of priorities as demanded by the doctrine of Massive Retaliation.

The Summer Study Group began their report with a stark assessment of the potential threat that a nuclear-armed Soviet Union equipped with intercontinental bombers represented. The report estimated that 20 atomic bombs dropped on certain population centers in the Northeast would result in over ten million deaths, and that a hundred atomic bombs dropped on population centers would result in an estimated twenty million deaths. Apart from the massive suffering such an attack would cause, the

deaths of millions of industrial workers would threaten the nation's ability to fight and win a general war.²⁷ A single successful raid could overcome the strategic advantage provided by geography and deprive the U.S. of both the workers and the industrial base required to fight a long war. Moreover, the Summer Study Group concluded that the Soviet Union would soon have the ability to deliver such a crippling blow to the United States, that the U.S. did not have the defensive capability to defend against such an attack, and that mounting a defense was possible if the U.S. was willing to create such a defense on a scale that had not yet been considered. The most important task of such a defense was to prevent tactical surprise.²⁸

To prevent such a surprise, the Summer Study Group recommended the construction of a Distant Early Warning System. Such a system would provide early warning of a Soviet nuclear attack and would allow SAC to launch its bomber and tanker forces and begin its retaliatory strike. Early warning would also alert Air Defense Command and allow the early activation of its defenses. The four-to-six hours of warning provided meant that both interceptor forces and fixed defenses on the ground (such as missiles and anti-aircraft artillery) could be brought to full alert. This warning would maximize their mission effectiveness by allowing them to stand up only during alerts and would make defense forces more affordable by only activating them when needed. In addition to mobilizing active defenses, passive defensive measures could also be implemented. Civil

²⁷ Lincoln Laboratory, *Final Report of the Summer Study Group 1952, Vol. I*, (Cambridge, Massachusetts Institute of Technology, 1953), 2.

²⁸ *Ibid.*, 4-5.

air traffic could be brought under strict control, minimizing any confusion due to unidentified but harmless civil aviation. The Control of Electronic Radiation (CONELRAD) could be implemented in the hope of depriving Soviet bombers of navigation information gained from civilian and military radio use. Naval and merchant shipping could be cleared from harbors, and civil defense could be activated.²⁹

The United States needed to erect a workable defense against long-range bombers, and the report identified early warning as the key to such a defense. The Study Group report called for:

“[a]n alert zone of two or more alerting lines with supporting “fill in” developed as time permits. The most distant of these lines should be 2000 miles or more from our boundaries and provide 3 to 6 hours’ warning. Such a zone can be made effective against aircraft at any feasible altitude. This distant early warning (DEW) zone is fundamental to all effective military and civil defense measures...”³⁰

This Distant Early Warning zone would be 200-400 miles deep and would use land-based radars with airborne backup. The northernmost line would run along the north shore of North America, extending to Greenland and possibly connecting to a European-based warning net. The second line would diverge from the first and eventually connect to existing Pinetree Line radar stations in Newfoundland. The logistical difficulties of the remote location would be minimized through the use of technology. By equipping the stations with automatic signal processing, crews would no longer have to constantly stare

²⁹ *Ibid.*, 5-6.

³⁰ *Ibid.*, 16-17.

at radar scopes, vigilant for any intrusion. Computers would automatically process radar signal returns, alerting crews with an audible alarm if the radars detected a possible airspace intrusion. In addition, the report called for anti-spoofing equipment to be used to minimize the effectiveness of Soviet jamming and other electronic warfare support. The seaward edge of the line would be extended by using Airborne Early Warning (AEW) aircraft to cover the sea approaches from Alaska to Hawaii, backed up with picket ships also equipped with audible-presentation radar. Finally, existing tropospheric-scatter technology, which used radio waves refracted through the troposphere to extend the range of signals hundreds of miles, would provide long-distance communications. The group suggested placing priority on the quick installation of the DEW Line Number One (the northernmost line). Furthermore, the report stated that technological development should focus not only on radar and communications technologies, but also on technologies necessary for the data-gathering and intercept portions of the system.³¹

" A distant warning zone that properly exploits our geographic position makes possible measures not now considered in our defense planning [original emphasis]. It appears technically feasible, for example, to establish an airborne data-gathering net which, on receiving warning, will track the attack well in advance of its contact with the defense perimeter. Once this kind of tracking data is available, the possibility of concentrating mobile defense forces, over and above present fixed defenses, can be considered. The Study Group did not reach definite conclusions concerning the economics

³¹ Ibid., 6-9.

of such mobile defenses. This phase of the problem deserves continuous and intensive study.”³²

The report recommended that the Outer DEW Line start construction as quickly as possible, preferably in the spring of 1953.³³

The Summer Study Group understood that early warning alone was insufficient to realize the full potential of the DEW system. This system had to connect with the existing portions of the continental air defense and provide it with useful information to maximize the effectiveness of the defensive air battle. The report called for

“...an information and tracking zone that can be erected operationally upon advice from the DEW zone. Upon acquisition of the enemy by this zone, information within it should be relatively continuous, though the information zone need not necessarily be contiguous with the alert zone (see Chap. 5).”³⁴

The Study Group Report referred to this vast space between the DEW zone and the detection and tracking radars of southern Canada and the U.S. as the “Data Zone”, which gathered data about raid strength, speed and direction. Erecting any sort of ground-based system in this region was very difficult, and the report pointed out that the DEW stations, which were located by the sea, were easier to reach than the vast interior of the Canadian Arctic. (The Mid-Canada Line, located along the 55th parallel, roughly marked the northern limit of the Canadian railroad system.) Although a detailed solution to the Data Zone

³² Ibid., 5.

³³ Ibid., 20.

³⁴ Ibid., 16-17.

problem was not found, the Study Group report suggested that tracking could be accomplished by AEW aircraft operating together to provide both radar coverage throughout the Data Zone and line-of-sight communications between aircraft and ground command centers. The barrier formed by these aircraft could be “erected operationally,” i.e., launched during an alert from appropriately located airfields. Five aircraft would form a single data unit one thousand miles across, and five of these data units would provide coverage throughout the data zone in northern Canada. A further two more data units would provide data zone coverage for the seaward extensions of the DEW Line.³⁵ Tracking and other raid information collected in the data zone would minimize the effectiveness of enemy tactics by providing tracking and other raid information and allowing interceptor forces to concentrate on appropriate areas for maximum effectiveness. In addition to the requirement that coverage within the data zone be contiguous, that coverage needed to be contiguous with the zone of interception as well.³⁶

³⁵ *Ibid.*, 81-83.

³⁶ *Ibid.*, 21-22.

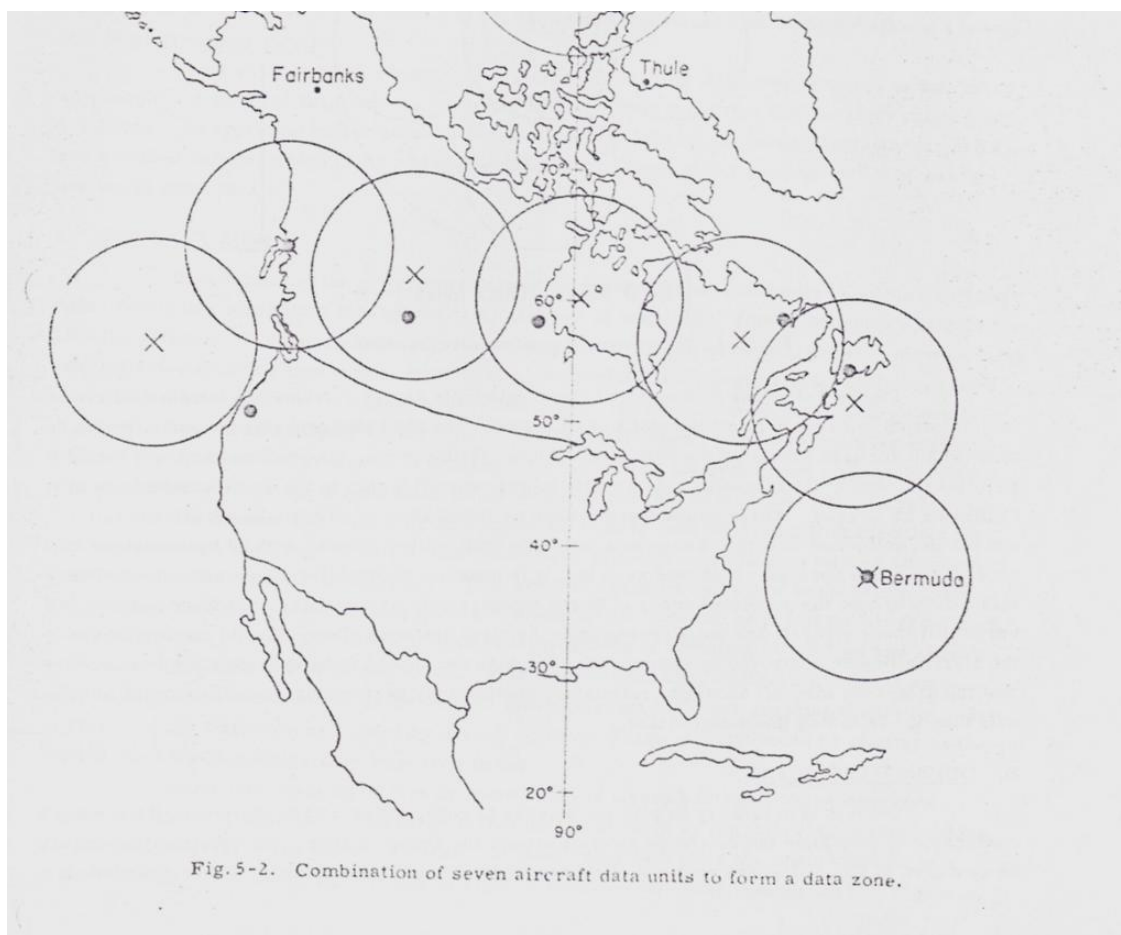


Figure 4 Map of Data Zone as proposed in the Summer Study Group Report

The report identified concerns about an early warning system like the DEW Line. Enemy countermeasures were a major concern, and one of the main benefits of a land-based DEW zone likely backed up by an airborne data-gathering zone was the system's reduced vulnerability to enemy action. The Summer Study Group stressed the entire system had to be flexible and resilient to function under the stresses of an actual enemy attack.³⁷ The senior USAF leadership was initially reluctant to support the DEW System proposal because they felt that it was the first step in an air defense system that would

³⁷ *Ibid.*, 87.

reduce the need for the deterrent provided by SAC and drain funds away from the Air Force.³⁸ Critics from the Air Force and elsewhere often articulated comparisons of the DEW Line with the Maginot Line—the system of French fortifications that were easily bypassed by the Germans in 1940—arguing that the DEW Line would foster a “Maginot Line mentality”. The report specifically addressed the criticism that the DEW Line and its defensive cohorts were akin to the Maginot Line. It argued that a ‘Maginot Line mentality’ is one that relied excessively on a single weapon system, and the chief failure of the Maginot Line was the failure to back up the defensive system of fortifications with adequate offensive systems. The report went on to state that relying on SAC offensive forces could result in scenarios in which the U.S. would be vulnerable, such as a preemptive strike by the Soviets or the construction of a DEW-like system in the Soviet Union.³⁹

Despite this reasoning, the immediate reaction of the U.S. defense establishment to the Summer Study Group’s proposal was overwhelmingly negative, and the report initially wasn’t able to find a suitable party to bring it before the National Security Council for consideration.⁴⁰ The Army, Air Force, and Navy, along with the Rand Corporation, felt that such a line would have gaps in radar coverage, would be vulnerable to deception measures, and would be too far away from fighter cover to be effective.⁴¹ At the same time, the Air Force had earlier expressed its willingness to support a four-site test bed project to prove

³⁸ (Schaffel 1991) Schaffel, *The Emerging Shield*, 211.

³⁹ Lincoln Laboratory, *Summer Study Group Report*, 24-25.

⁴⁰ Huntington, *The Common Defense*, 330.

⁴¹ *FRUS 1952-54*, National Security Affairs II, Part I “Memorandum of Conversation, by Carlton Savage of the Policy Planning Staff”: 234-36.

the involved technologies.⁴² The Air Force likely supported such a cautious approach in order to slow down the project, thereby keeping appropriation dollars flowing to SAC. If so, the effort was successful; although the DEW Line project would be approved and funded, the initial effort would be limited to the test project while the concept was further developed.⁴³

The Summer Study Group Report issued their report at a time of reformulation of American defense policy. On October 30, 1953, the National Security Council issued NSC-162/2, which laid out the national security policy of the Eisenhower Administration. The following December a defense program was approved that, in addition to ensuring SAC's massive retaliation capability and approving the development of tactical nuclear weapons, called for defenses to be erected that would defend the country and its ability to retaliate. Over the next seven years the U.S. would build defensive systems meant to detect and intercept Soviet bombers and submarines, and create survivable command posts to ensure continuity-of-government. Among these systems were SAGE; the U.S. Navy's Sound Surveillance System (SOSUS) for detecting Soviet submarines; the Ballistic Missile Early Warning System (BMEWS) and Missile Detection Alarm System (MIDAS) for detecting ICBM launches, and the Distant Early Warning Line.⁴⁴

⁴² *FRUS, 1952-54*, National Security Affairs II, Part I, "Meeting of the National Security Council, Tuesday, October 14, 1952": 164.

⁴³ *FRUS, 1952-54*, National Security Affairs II, Part I, "Paper Drafted by Paul H. Nitze and Carlton Savage of the Policy Planning Staff": 182-84.

⁴⁴ *FRUS, 1952-54*, National Security Affairs II, Part I, "Report to the National Security Council", 593-594; David A. Rosenberg, "The Origins of Overkill: Nuclear Weapons and American Strategy," *International Security* 7, no. 4 (Spring 1983) 28-32.

Chapter 7. The DEW Line

Feasibility testing for the DEW Line started with a single site on Barter Island, Alaska in early 1953. Construction of an eighteen-site string of test sites on a stretch of coast in northeastern Alaska and northwestern Canada started in July 1953. By 1954, the U.S. Air Force felt that the feasibility of the technologies involved had been proven, and the Canadian government agreed to the DEW Line in principle in a diplomatic note. The Joint Chiefs of Staff consented to the construction of the DEW Line in 1955, and a formal U.S.-Canadian agreement was signed in May 1955. Construction of the fifty-seven stations of the basic system stretching from Alaska to Baffin Island took place between 1955 and 1957. Because Canada had paid for the entire cost of the Mid-Canada Line, it felt justified in asking the U.S. to foot the entire bill for the much more expensive DEW Line.⁴⁵

A committee composed of U.S. and Canadian military personnel and the Western Electric contractors who were building the DEW Line known as the Location Study Group determined the location of the system's radar stations. The desire by some of the involved parties to move the locations of the radar sites southward to ease construction and logistical burdens, which first appeared very early in the planning process⁴⁶, was still evident. Despite this southward pull, both the Location Study Group and the Canadian government desired to position the DEW Line as far north as possible. The Location Study Group placed a priority on maximizing the warning time provided by the radar line, while

⁴⁵ Schaffel, *The Emerging Shield*, 212-15.

⁴⁶ *FRUS, 1952-54*, National Security Affairs II, Part I, "Memorandum of Conversation, by Carlton Savage of the Policy Planning Staff": 234-236.

the Canadians did not wish to sacrifice the warning time for their cities for the sake of U.S. contractors.⁴⁷

Although the original Summer Study Group proposal had called for two lines of radars across the Arctic, only one of these lines was constructed. There is no information in the available documentary and archival sources that explains the omission of the second line. Although there is evidence that a second DEW Line was still in consideration after the Summer Study Group's report⁴⁸, the proposal for the second DEW line seems to have just disappeared.⁴⁹ Although there is no documentary evidence that specifies exactly the reason for the omission of the second line, it is likely that it happened during the location planning process. Three reasons for this action suggest themselves. First, defense planners felt that the DEW Line as constructed adequately served the purpose of activating the U.S. nuclear retaliation in the event of a Soviet first strike, and this capability both fulfilled the early warning function that both Project Charles and the Summer Study Group identified as critical to the protection of the nuclear deterrent. This would represent an institutional compromise between those in the defense establishment who felt that SAC

⁴⁷ "First Report of the Location Study Group" Records of the United States Joint Chiefs of Staff Central Decimal File, 1954-56, 413.44, RG 218, Box 129, National Archives II, College Park, Maryland; *Documents on Canadian External Relations*, Vol. 20 (1954), Chapter V: Relations with the United States, Part 1: Defense Issues, Sect. B: Distant Early Warning and Mid-Canada Line, Document 479, " November 6, 1954 Memorandum from Assistant Under-Secretary of State for External Affairs to Undersecretary of External Affairs." Retrieved October 3, 2011 from <http://www.dfait-maeci.gc.ca/departement/history-histoire/dcer/details-en.asp?intRefid=653>

⁴⁸ *Documents on Canadian External Relations*, Vol. 18 (1952), Chapter VIII: Relations with the United States, Part 1: Defence Issues, Section M: Project Lincoln, Document 765, "December 9, 1952 Memorandum from Defence Liaison (1) Division to Acting Under-Secretary of State for External Affairs." Retrieved October 11, 2011 from <http://www.dfait-aeci.gc.ca/departement/history/dcer/details-en.asp?intRefid=4261>

⁴⁹ Jockel, *No Boundaries Upstairs*, 64-66, 70.

nuclear deterrent was the only reliable defense, and those who wished to construct a comprehensive continental air defense. Secondly, the increasing number of Soviet nuclear weapons caused defense planners in the U.S. and Canada to reconsider the value of defensive systems designed to help defeat Soviet nuclear forces versus systems designed to enhance the deterrent effect of the U.S. nuclear arsenal. Third, although an operational Soviet intercontinental ballistic missile (ICBM) capability was still thought to be years away, defense planners may have understood the implications of such a capability on continental air defenses. The DEW Line could not detect or contribute to a defense against ICBMs or their cousins, submarine-launched ballistic missiles (SLBMs). Although the original DEW Line proposal would have greatly improved continental air defenses, that improvement alone did not have the same value to U.S. defenses in the face of new delivery technologies.

The original DEW Line was composed of six main stations, twenty-three auxiliary stations, and twenty-eight intermediate stations divided into six sectors, with one main station and whatever combination of auxiliary and intermediate stations needed to create a seamless band of radar coverage. Detection was accomplished with two different radar systems. The main and auxiliary stations were equipped with dual-beam radar systems, with both beams operating back-to-back as they were mechanically scanned within a protective radome. Intermediate stations using Doppler systems covered any low-altitude gaps between the main and auxiliary stations. This technology was similar to that used on the Mid-Canada Line, and although the intermediate stations provided indication of an

object passing overhead, they offered little other information that could be used to determine the course, speed, or direction of an unidentified contact. The U.S. deactivated the intermediate stations when the other radar systems appeared to be adequate for the task of providing early warning.⁵⁰

Tropospheric-scatter communication systems provided communication, and could transfer radar detection and other data to the nearest main station using voice and teletype formats. Each main station had a data center that would evaluate radar contacts and pass the information to Air Defense Command (later NORAD) as deemed necessary.⁵¹ The original DEW Line plan called for lateral communications between stations to be provided by the Tropospheric Scatter Communications System, which had a range of about 100 miles. An Ionospheric Scatter Communications System would link the main stations and higher command headquarters. However, advances in reliability and capacity made the tropospheric scatter system much more attractive, particularly in light of the heavier demands placed on the system after the deployment of the Ballistic Missile Early Warning System (BMEWS), with which it shared a communication system. As a result, the U.S. deactivated the ionospheric scatter systems and used tropospheric scatter systems in their place.⁵² Additionally, AM radios provided emergency backup communications, although

⁵⁰ Federal Electric Corporation, Early Warning Systems Division, Operations Department, *The DEW System*, (Paramus, NJ, ITT Service, Federal Electric Corporation, n.d.), 2-3.

⁵¹ *Ibid.*, 2.

⁵² *Ibid.*, 3-4.

the radios could be used by licensed Ham radio operators when not needed for operational purposes.⁵³

The DEW Line was in an extremely isolated and unprotected location. In spite of airstrips, the vast majority of logistical support occurred annually between late June and early September using primarily sea transportation in the Annual Sealift/Airlift Resupply.⁵⁴ In addition to this isolation, there was no provision against any sort of armed attack. Although the DEW Line's communications rearward had some built-in redundancy, a given sector of the line could be cut off from the rest of the network by severing communications in as few as two places. Although the Summer Study Group report recognized these vulnerabilities, they did not see them as threatening the tactical warning function of the DEW Line since the destruction of any portion of the line would itself constitute a tactical warning.⁵⁵

⁵³ *Ibid.*, 5.

⁵⁴ *Ibid.*, 13.

⁵⁵ Lincoln Laboratory, *Summer Study Group Report*, 24-25.

Chapter 8. The DEW Line: An Analysis

The DEW Line as constructed differed in two important aspects to the DEW System proposed by the Lincoln Laboratory. First, only one of the two proposed lines was built, although the eastern portion of the northern DEW Line was built further south than the Summer Study Group had proposed. Secondly, the data zone portion of the DEW System composed of AEW aircraft was never constructed. The absence of the data zone shifted the function of the DEW Line in important ways.

Planning for the air defense of North America against nuclear bombers with intercontinental range was fundamentally different from previous air defense battles. These differences, including geography, speed of the aircraft, and the ability for a single nuclear-armed bomber to do the work of thousands of conventionally armed bombers, created certain requirements for the continental air defense system. As constructed, the DEW Line only partially met those requirements. The system that was actually built quietly emphasized the trip-wire function that was seen by many to be essential for the effectiveness of the nuclear deterrent. This emphasis would dramatically reduce the value of the DEW Line's air defense function and put the effectiveness of the entire continental air defense system into question.

The Second World War gave defense planners plenty of experience with defensive air battles. Two models of such battles stand out: the Battle of Britain and the numerous defensive battles fought around the U.S. carrier forces against the Japanese in the Pacific.

However, there are important differences between a continental air defense battle and these historical precedents.

The first of these differences was the destructiveness of nuclear weapons. During the Battle of Britain, the bomb load of an individual bomber would have to be delivered many times in order to achieve a strategically relevant result. Air commanders compensated for this fact with raids consisting of hundreds of bombers aimed at a single target. In these conditions, successful destruction of 10 percent of a raid would be considered a success because the destroyed aircraft would not be available for later raids. On the other hand, nuclear weapons made large raids on single targets unnecessary. Theoretically, a single bomber armed with a nuclear weapon of sufficient yield could destroy any single target, and a raid by a handful of nuclear-armed bombers would virtually guarantee the target's destruction. An interception rate of 10 percent against such a raid was no longer acceptable, since even a single successful bomber could devastate its target.

The second of the major differences was one of dimensionality. The tactical problem confronting any air defense exists in two basic dimensions: time and space. A successful intercept requires that the defenders detect an incoming raid with enough time to intercept the incoming aircraft with defensive weapons before the intruder can strike its target. In an air defense scenario, time is a function of distance, and early warning sensors such as radar derive their effectiveness by their ability to detect intruders at greater distances than the human eye or ear. However, early warning alone does not provide sufficient information to carry out a successful intercept. The location, course and speed

of the intruder must be determined with enough accuracy to guide an interceptor to within weapons range. This information is the basis for the spatial requirement of a successful intercept.

The air defense battles of World War Two were dominated by the dimension of time, primarily because the relatively compact nature of the battlespace they were fought over minimized the relevance of space. The operational distances for the Luftwaffe were short: some targets in southern England were only 100 miles from bases in northern France, and even targets in Scotland and northern England were only about 500 miles from the farthest bases in southern Norway. The Royal Air Force fighter aircraft used for interception were well-dispersed across Britain, and although machine-gun armament of those aircraft required that the interception take place at visual range, the speed of the aircraft in proportion to the size of the battlespace meant that the requisite numbers of interceptors could be quickly concentrated to make the interception; the trick was doing so before the German bombers struck their targets. This early detection was accomplished using Britain's Chain Home radar system.

The carrier air battles of the Pacific functioned in a similar manner, although there were some important differences. Because aircraft carriers could move, the dimension of space was a tactical variable in the battles, requiring both hostile strike aircraft and their interceptors to find their targets. As the war progressed, radar would play a greater role in raid detection, reducing this variable. Nonetheless, the basic dynamic remained the same

despite the tactical variable of aircraft carrier mobility: once radar detected enemy aircraft, the trick was to intercept them before they could strike their targets.

The continental air defense of North America differed fundamentally from both World War Two models because the dimension of space was equally as important as the dimension of time. Although both the Battle of Britain and the carrier battles of the Pacific could take place over two hundred thousand square miles, the area of Canada alone was almost four million square miles. The distances involved—especially along the east-west axis—and the speed and range of both the incoming Soviet bombers and the intercepting aircraft meant that defensive aircraft from across the perimeter might not be able to concentrate sufficiently to successfully intercept the incoming aircraft unless supplied with both adequate warning time and pre-intercept tracking of the target. For example, a defensive air battle to protect New York State could not utilize interceptor aircraft assigned to the Pacific Northwest or even much of the Upper Midwest unless there was both early warning and tracking of the raid as they travelled southward across Canada.

The 1952 Summer Study Group understood this basic fact of strategic geography, and the DEW System they recommended was designed to handle both the temporal and spatial dimensions of the air battle. The extreme northern location of the DEW Line early warning radars would provide at least three to six hours of warning before Soviet bombers travelling at high-subsonic speeds could transit the polar region and reach their targets over southern Canada or the United States. After this initial early warning, the early warning aircraft of the data zone would provide additional information, including raid

strength, course and speed. Although radar coverage of the data zone's AEW aircraft may not have been contiguous with the interception zone's coverage provided by the Mid-Canada and Pinetree Lines, even intermittent tracking provided by the data zone would allow air defenses to plot an appropriate response. The data zone was supposed to allow the U.S. and Canada to operate effectively in the spatial dimension of the defensive air battle over North America.

However, the data zone recommended by the Summer Study Group was not implemented in the construction of the DEW Line. As a result, nearly a thousand linear miles of uncovered airspace existed between the DEW Line along the 69th parallel and the beginning of coverage of southern Canada provided by the Mid-Canada Line at the 55th parallel. The existence of this gap in radar coverage was a serious deficiency in continental air defense. In addition to the absence of tracking information across this zone, the gap would allow incoming bombers to make significant changes in course, perhaps even executing a lateral transit across the breadth of Canadian airspace. This gap in coverage presented opportunities for feints or other deceptive tactics to displace or otherwise diminish the effectiveness of air defenses, allowing incoming Soviet bombers to exploit the vast spaces of northern Canada for tactical advantage. In short, the DEW Line without a data zone put at risk the ability to manage the special dimension of the air defense battle; it was little more than a tripwire, and it would have provided little more than warning.

The data zone proposed by the Summer Study Group would have minimized this defensive problem by providing continuous information on the location, speed, and

heading of the raid, as well as other information such as the number of aircraft. As the raid passed through the Data Zone, interceptors could be launched and concentrated to destroy the raid. As Soviet bombers flying from bases in Siberia crossed from the data zone into the northern reaches of the intercept zone, they would find themselves confronted by U.S. or Canadian interceptors.

Although the missing data zone left open a large hole in the coverage of Canada, that hole would not have existed across the entire northern perimeter of North America. Bombers transiting Alaska would run into the defensive radars and aircraft of Alaskan Air Command. Likewise, bombers penetrating Canadian airspace over eastern Newfoundland would encounter U.S. and Canadian air defenses. However, the Soviet Union knew about the existence of these defenses and would likely direct bombers through less-defended territory as a result. A vast portion of central Canada did not have such defenses, and bombers penetrating that airspace could head toward any part of the U.S. or Canada. In addition, the seaward extensions of the DEW Line also did not have data zones, complicating the defensive task in those areas.

There is no mention of the data zone in the available evidence after the initial Summer Study Group report. However, there were several instances of discussion about the difficulties imposed by the lack of tracking capability south of the DEW Line. The first such mention was during a meeting that took place on December 7, 1952 between the Canadian Defense Research Board, members of the Lincoln Laboratory, and military personnel from both the U.S. and Canada. The group highlighted difficulties imposed by a

lack of tracking information south of the DEW Line was highlighted as a main concern, although it made no mention of neither the data zone nor its constituent AEW aircraft. The data zone proposal seems to have fallen out of consideration in the four months after the Summer Study Group report. This meeting was also the last mention of the second, southern DEW Line. It is likely that the proposal for the second DEW Line was simply folded into the northernmost DEW Line. However, no such explanation is suggested for the lack of the Data Zone, the disappearance of which seems all the more unusual in light of discussion about tracking concerns it was meant to remedy.⁵⁶ A similar set of concerns were evident in a memorandum of a conversation by Carlton Savage of the State Department's Policy Planning Staff, in which military leaders expressed reservation about the Summer Study Group's proposal on the grounds (among others) that the proposed line would be easy to spoof and that the 70th parallel would be too far north to effectively control interceptor aircraft based further south. Again, no mention is made of the data zone.⁵⁷

⁵⁶ *Documents on Canadian External Relations*, Vol. 18 (1952), Chapter VIII: Relations with the United States, Part 1: Defence Issues, Section M: Project Lincoln, Document 765, "December 9, 1952 Memorandum from Defence Liaison (1) Division to Acting Under-Secretary of State for External Affairs." Retrieved October 11, 2011

from <http://www.dfait-aeci.gc.ca/department/history/dcer/details-en.asp?intRefid=4261>

⁵⁷ *FRUS, 1952-54*, National Security Affairs II, Part I, "Memorandum of Conversation, by Carlton Savage of the Policy Planning Staff": 234-236.

Chapter 9. Rising Doubts

The DEW Line became operational in August 1957. Two months later the Soviets launched Sputnik, and the world woke up to the possibilities of rocket technology and the potential threat of intercontinental ballistic missiles (ICBMs). The implication of the launch was that a deployable ICBM was not a distant dream for the Soviets but rather an immediate prospect. The half-hour flight time of a hypothetical Soviet ICBM triggered immediate questions about the survivability of the U.S. deterrent and the usefulness of existing early warning systems.

The looming prospect of operational Soviet ICBMs caused a noticeable shift in the nuclear calculus of the U.S., and doubts began to emerge about the effectiveness and usefulness of the DEW Line's air defense and tactical warning functions. The DEW Line radars had no value against ICBMs and could not be used to issue tactical warning of an Soviet ICBM strike. Unlike modern electronically-scanned phased-array ICBM detection radars, the mechanically-scanned DEW Line could be overflown by ICBMs. Since the launch locations were deep inside the Soviet Union, Soviet ICBMs would be boosted out of the atmosphere outside of detection range and pass over the DEW Line on their way to their targets in the US and Canada.⁵⁸

⁵⁸ Letter from W.E. Bradley to Dr. Killian re: Radar Coverage of the Continental U.S. at Altitudes Above 70,000 ft., Folder: Air Defense (August 1958-December 1961)(I), Box 4, White House Office, Office of the Special Assistant for Science and Technology (Killian and Kistiakowsky): Records, 1957-1961. Eisenhower Library. The DEW Line's maximum detection altitude was 70,000 ft. This is far below the altitude required to detect a sub-orbital ICBM.

Although predicted well in advance by the Eisenhower Administration, the successful launch of Sputnik shocked the American public in many ways and prompted many questions about existing and future U.S. technological capabilities. Among the many government responses to this crisis was the creation of new government bodies such as the President's Science Advisory Committee (PSAC), which advised President Eisenhower on how to close the gap perceived between American science and technology and that of the Soviets. Like the Lincoln Laboratory, PSAC focused on technical aspects of defense requirements, and although their mission may have led them to take contrarian views on air defense subjects, their findings are consistent with the state of air defense technologies at the time.⁵⁹ Their reviews cast doubt on the efficacy of existing early warning and air defense systems. A report of a PSAC Ad Hoc Panel on Continental Air Defense meeting to assess continental air defense stated that existing early warning systems (presumably including DEW) "appear effective enough to provide reasonable assurance of warning against a mass bomber attack." However, the systems were not adequate to assure detection of a small number of bombers penetrating at low altitude. This inadequacy indicated the possibility of a small sneak attack destroying U.S. retaliatory forces before a larger force delivered a devastating blow to the U.S. Importantly, the report also stated that a system did not exist to indicate that such a sneak attack by the Soviet Union was underway, although the Air Force was constructing a bomb-alarm system that would be

⁵⁹ See Edwards, Bracken, Friedman

completed in January 1960.⁶⁰ The same report described the continental air defense system as “weak because it is only partially operative.” As examples, the report mentioned “data handling, data processing and control system is still largely manually operated.” And although the air defense system “can be expected to perform reasonably well against medium and high-altitude mass attack in a non-ECM environment,” its effectiveness “varies continually in a completely unpredictable manner”. These variations could be solved through improved doctrine and training. Even so, the “existing Air Defense System... even in the absence of ECM” was “incapable of effective performance against low-altitude attack. From the viewpoint of active defense, it is apparent that the low-level radar coverage (i.e., altitudes below 5,000 feet) is essentially worthless.” If a raid was accompanied by a “determined ECM effort,” the system’s performance was degraded by as much as half.⁶¹

Another PSAC report was more specific in its criticism. It discussed the results of Exercise Top Hand conducted in September 1958 by the North American Air Defense Command (NORAD) and SAC as a test of the various early warning systems—including the DEW Line, Mid-Canada Line, and the barriers over the Atlantic and Pacific—as well as to evaluate the air defense system effectiveness. The test was supposed to be a no-notice test, although the report stated that the surprise nature of the test had been compromised

⁶⁰ Report by J.B. Wiesner, “Warning and Defense in the Missile Age,” Page 2-3, Box 1, Series 1, Alphabetical File, 1957-60, subseries A, White House Office, Office of the Special Assistant for Science and Technology (Killian and Kistiakowsky): Records, 1957-1961, Eisenhower Library.

⁶¹ W.E. Bradley to Dr. Killian re: Operation of U.S. Ground Radars in the Presence of ECM, Air Defense Folder (August 1958-December 1960)(I), Box 4, White House Office, Office of the Special Assistant for Science and Technology (Killian and Kistiakowsky) Records, 1957-1961, Eisenhower Library.

in a variety of ways. Even so, the test results were disturbing. Although the early warning lines' ability to detect high-flying aircraft was good, the raid information they produced was of dubious value. The portion of the report merits quoting at length:

“Raid assessment by the individual early warning lines was inadequate. The analysis indicated that it was highly doubtful that raid assessment by individual lines was good enough to justify committing the interceptor forces on the basis of their information. (Estimates of the numbers of aircraft varied from about 80 per cent high to 50 per cent low.) The analysts point out that in attempting to plan interceptor commitment prior to penetration of the land-based contiguous cover, the ability to estimate correctly what was coming in terms of numbers, speeds and altitudes and from various directions was important and that the early warning lines did not provide such estimates accurately. [original emphasis]”⁶²

Another NORAD exercise held in October 1958, codenamed Exercise Desk Top, came to similar conclusions. After simulating conditions of an actual attack, the exercise determined that NORAD Systems (presumably including SAGE) were overloaded with unclassified aircraft tracks, that discrepancies in the radar systems led to duplicate tracks, and that the time necessary to activate “engineered circuits” was too long to ensure their availability in an actual surprise attack. The exercise report also noted that the assumptions of the exercise were optimistic and “did not, in any way, approximate the true

⁶² Memorandum by Jerome B. Wiesner and H.B. Watters “Report of the Result os the 29-30 July 1959 Meeting of the Ad Hoc Panel on Continental Air Defense”, Page 3-4, Folder: Air Defense (August 1958-December 1960)(1), Box 4 White House Office, Office of the Special Assistant for Science and Technology (Killian and Kistiakowsky): Records, 1957-1961, Eisenhower Library.

situation.”⁶³ Friedman has noted that although SAGE proved the concept of computerized air defense, the SAGE system design unreliable in part because of its vacuum-tube design. A successful naval combat-direction computer system, the Naval Tactical Data System, served a function similar to SAGE but used solid-state component; the U.S. Navy did not complete development and begin to deploy the system until the early 1960s.⁶⁴

Among the main fears that these and other tests created was that the U.S nuclear deterrent—the preservation of which had been one of the original goals of the DEW Line—would be vulnerable to a Soviet surprise attack. Because of the central role the deterrent played in national security policy, the Air Force initiated urgent efforts to remedy the problem. Since the existing early warning systems seemed inadequate to the task, several other options for ensuring preservation of the deterrent were explored. One result of these efforts was the creation of additional sensors for detecting both incoming and ongoing Soviet nuclear strikes. Efforts to create the SOSUS system to detect Soviet submarines (and therefore help prevent a surprise nuclear attack using submarine-based weapons) had been underway since the early 1950s.⁶⁵ Although the Soviet Union would not deploy ICBMs until the early 1960s, no existing radar line had the capability to detect Soviet ICBMs except in the terminal seconds of flight. As a result, the Air Force initiated the research and development of a Ballistic Missile Early Warning System. A nuclear detonation detection system, which would alert air defense forces if a Soviet nuclear attack

⁶³ Ibid., 4.

⁶⁴ Friedman, *Network-Centric Warfare*, 71-82.

⁶⁵ *FRUS, 1952-54, National Security Affairs II, Part 1, “Status of The National Security Programs of the United States of America in Relation to Approved Objectives”*, :166-72

was already underway, and programs to use satellite-based infrared detection of ICBM launches were also proposed and quickly approved.⁶⁶ The U.S. launched the first satellite-based launch detection system, the Missile Defense Alarm System (MIDAS), beginning in 1960. In 1963, the U.S. also started launching the Vela satellite constellation. Though ostensibly intended to monitor Soviet compliance of the Partial Test Ban Treaty, the Vela satellites also functioned as a nuclear detonation detection system.⁶⁷

At the same time, the U.S. either did not approve or did not expand several initiatives to protect the deterrent by passive measures. Although U.S. ICBMs would eventually be stored in hardened underground silos, proposals to do the same for the U.S. bomber force were not adopted. Air Force planners also rejected expansion of SAC airborne alert force, which sought to prevent the destruction of the U.S. deterrent by keeping bombers aloft at all times, on the basis that the expense of the airborne alert could be more usefully invested in sensors such as BMEWS.⁶⁸

As the diversification and reliability of early warning sensors improved, the perceived need to protect the deterrent forces diminished, reflecting an enhanced trust by U.S. policymakers in the early warning system. Although the early warning and air defense

⁶⁶ *FRUS, 1958-60*, National Security Policy; Arms Control and Disarmament (1958-1960) III, "Memorandum of Discussion at the 417th Meeting of the National Security Council" 322-23; *FRUS, 1958-60*, National Security Policy; Arms Control and Disarmament (1958-1960) III, "Memorandum of Conference with President Eisenhower, March 4, 1959": 185-87.

⁶⁷ Bracken, *Command and Control of Nuclear Forces*, 16, 36.

⁶⁸ *FRUS, 1958-60*, National Security Policy; Arms Control and Disarmament (1958-1960) III, "Memorandum of Conference with President Eisenhower, November 16, 1959,": 333.

Name of System	Date First Deployed	Location	Purpose
Lashup	1948	Northeastern U.S., Southern California, Great Lakes region, nuclear production facilities in Washington State, Tennessee and New Mexico	Detection and Ground-Controlled Intercept (GCI)
Permanent	1949	Throughout Continental United States and Alaska	Detection and GCI
Pinetree Line	1952-54	U.S. and Canada along 50 th parallel, Newfoundland and Labrador coast	Early warning, detection and GCI
Mid-Canada Line (aka McGill Fence)	1953-1957	Across Canada along 55 th parallel	Early warning
Distant Early Warning Line (DEW Line)	1956-1957	Across Alaskan and Canadian Arctic along 70 th parallel	Early warning
Semi-Automatic Ground Environment (SAGE)	1959-1963	22 Sector Direction Centers in U.S. and Canada	Automatic data fusion and GCI
Sound Surveillance System (SOSUS)	1959	Underwater sensors in Atlantic and Pacific oceans	Detection of submarines
Ballistic Missile Early Warning System (BMEWS)	1959	Clear, Alaska; Thule, Greenland; Fylingdales Moor, England	Detection of ICBMs in flight
Missile Defense Alarm System (MIDAS)	1960	orbital	Detection of ICBM launches
Vela (Nuclear Detonation Detection System)	1963	orbital	Worldwide detection of nuclear detonations

Figure 5. U.S. Defensive Systems Deployment

control systems that resulted from Project Charles and the Lincoln Laboratory's 1952 Summer Study Group were built using technology that was then cutting-edge, the effectiveness of the whole system rested on the ability of the DEW Line to provide reliable early warning. The failure of this technology in the event of an actual Soviet raid would have resulted in the failure to manage the temporal dimension of the air battle, which

would also put at risk the ability of SAGE to manage the spatial aspect of the battle. The irony of the ICBM is that while it decreased the warning time of an impending nuclear strike to less than a half-hour, it also had distinct ballistic flight and infrared characteristics that allowed tactical launch and flight detection through multiple—and therefore redundant—sensor technologies. Space-based sensors can detect the large amounts of infrared energy given off by the rocket plume of an ICBM launch. Ground-based radars can also easily distinguish the ballistic path of an ICBM in flight. Although ICBMs could strike with less than a half-hour of warning, the U.S. now had a more reliable system of warning to detect an incoming Soviet strike. Armed with this knowledge, the U.S. now had the technological basis to back away from promises of massive retaliation without reducing the deterrent value of its nuclear arsenal.

Chapter 10. Conclusion

The end of the age when strategic bombers dominated nuclear war plans was cold comfort to millions of Soviet and American citizens. The fear of swift death by ICBMs that was a mere half-hour away augmented the older fear of nuclear bombers. And unlike air-breathing bombers, there was no way to stop ICBMs; once launched they could not be recalled or destroyed. The world had added one fear to another.

Along with this new fear came a new way of organizing for nuclear defense. With multiple sensors for detecting an approaching nuclear attack, such as the DEW Line, BMEWS, MIDAS and SOSUS at its disposal, the nation's confidence in tactical early warning improved. At the same time, NORAD was helpless to defend against ballistic missile attack. But it could still defend against bombers, and for that task it still relied on the warning provided by the Distant Early Warning Line. The DEW Line came online in 1957 as North America's front-line warning system against attack by Soviet bombers. The 1952 Summer Study Group, in its proposal for the DEW Line, took for granted that Strategic Air Command's nuclear deterrent was defensively oriented and would only strike the Soviet Union in response to Soviet aggression. The role of the DEW Line in such a scenario was to sound the alarm and help air defense forces keep defensive air battle as far north as possible while allowing U.S. strategic bombers to take off and execute their retaliatory mission. Other systems such as SAGE brought a high-degree of automation in the effort to coordinate such an air battle. Through the use of a robust early warning system combined with picture-centric battle management technology, U.S defense planners sought to

automate and perfect the air defense systems pioneered by the U.S. Navy and Great Britain during World War Two.

The final design of the DEW Line reflected other priorities and an evolving concept of nuclear deterrence. Paired down from two warning lines and Airborne Early Warning aircraft to provide tracking information, the single line that remained was adequate for only one operational task: to provide tactical warning of a Soviet attack. Once this task was complete, the DEW Line could provide only information of limited value for the air defenses whose task was to intercept and destroy the intruders. Moreover, the DEW Line was built at the limit of existing technology, and its ability to provide warning of a sneak attack under operational conditions was open to debate. Together with similar performance reliability questions about SAGE, the resulting system lacked the ability to manage either the spatial or temporal dimensions of a defensive air battle, which cast doubts on the survivability of the nation's deterrent. As a result, the only deterrence that the combination of the U.S. air defense system and Strategic Air Command was able to provide was pre-emptive deterrence—in which the DEW Line could have no role.

The limited advantages provided by the DEW Line was not a failure of the DEW Line or its designers. The Lincoln Laboratory's concept was sound. And even though the DEW Line as built could not contribute to continental air defense as effectively its designers promised, it still provided a tripwire that was as effective as then-current technology could muster. The effectiveness of the nation's deterrent depended not only on **the** technology of the nation's defenses, but also the planning and procedures required to maximize that

technology's potential. The DEW Line could never be more effective than the nuclear doctrine, plans, and procedures in place to use the warning it provided. Fortunately, the DEW Line was never tested in combat conditions. The launch of Sputnik and the deployment of intercontinental ballistic missiles that followed forced needed changes to the U.S. nuclear deterrent. New sensor technologies like MIDAS and BMEWS supplemented and partially replaced the DEW Line in its primary warning function, and the importance of its air defense role faded as the threat of ICBMs grew. By the early 1960s the DEW Line had become one of several overlapping technological systems designed to detect and confirm that a Soviet strike was underway. The role of the DEW Line in the U.S. nuclear deterrent thus shifted away from air defense while maintaining its early warning function, which it now shared with other systems.

By the early 1960s the function of the DEW Line was approximately the same as that of its modern descendent, the North Warning System: to detect airborne intrusion of North American airspace. But the biggest improvement in continental air defense was not in the sensor technologies such as the DEW Line or North Warning System or the weapons that could be brought to bear on an intruding aircraft. By doing away with the short-sighted reliance on a single early warning technology, the U.S. reduced the possibility of a successful Soviet surprise attack, as well as its own fear of such an attack. In this way, the switch to multiple early warning technologies helped ensure that the warning they could provide would never be needed.

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