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The Distant Early Warning Line: Geographies, Infrastructures, and Environments of Warning

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THE DISTANT EARLY WARNING LINE:

GEOGRAPHIES, INFRASTRUCTURES, AND

ENVIRONMENTS OF WARNING

by

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ABSTRACT

The Distant Early Warning Line:

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The Distant Early Warning (DEW) Line was a Cold War era project aimed at providing advanced warning of incoming Soviet attack via the northern periphery of Canada and the United States. The Line was comprised of radar stations across the 69th parallel, spanning from Western Alaska to Baffin Island, about 200 miles north of the Arctic Circle. Academic institutions and research labs, private corporations, and military entities collaborated to develop the DEW Line. The domes used to shield the radar from the extreme terrain were designed by architectural icon Buckminster Fuller, who was elaborating upon a symbolic language of security and enclosure. DEW Line designers' use of advanced technology, which they infused into the infrastructural built environment they produced, promised to address newfound anxieties of unboundedness, fueled by a transformed geographic imaginary, through the tactic of warning.

After years of research and planning, construction began rapidly in the Spring of 1955 and was completed an astounding two years later. Yet by 1958, missile technology had surpassed the scope of the DEW Line's warning capacity and the sites would endure a slow process of decommissioning over the next forty years. The remnants of the sites have permanently altered the landscape of the Arctic, made all the more apparent by rapidly changing climates.

This thesis traces the history of the DEW Line, which remains relatively unknown, in order to examine the delicate intersection of geography, infrastructure, and environment as systems of an ideology of warning. DEW Line advisors imagined the distant north through the promise of warning as an exercise in boundary-making, and as a symbol of a networked future. The DEW Line warns against these potential environmental futures. Though the DEW Line cannot be separated from its history as an agent of warning, that history itself has largely been erased.

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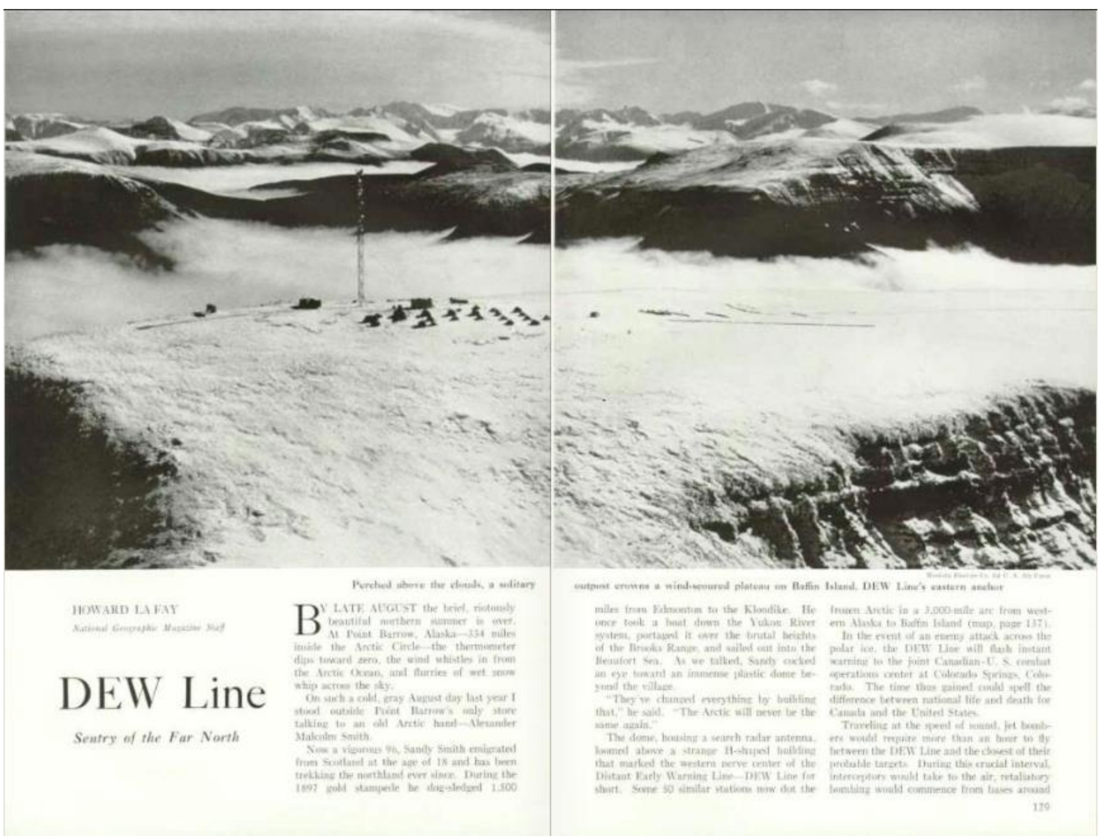
INTRODUCTION

In 1958, Howard La Fay, a staff member at National Geographic, published a fifteen-page article in the magazine titled “DEW Line: Sentry of the Far North.” Accompanying the opening title was a full-spread black-and-white photograph of an icy landscape, mountains and fog unbounded. The center of the image is a plateau with a handful of scattered shelters that draw the eye inward; a tower looms above the cluster’s edge. This is an image of Baffin Island, the fifth largest island in the world, a Nunavut territory that straddles the Arctic Circle in the far northern region of Canada. The island also housed the eastern edge of the Distant Early Warning line, or DEW line, a pivotal Cold War-era infrastructure undertaking that today remains primarily unknown.



Perched above the clouds, a solitary outpost crowns a wind-scoured plateau on Baffin Island, DEW Line's eastern anchor

HOWARD LA FAY
National Geographic Magazine Staff

DEW Line

Sentry of the Far North

BY LATE AUGUST the brief, riotously beautiful northern summer is over. At Point Barrow, Alaska—334 miles inside the Arctic Circle—the thermometer dips toward zero, the wind whistles in from the Arctic Ocean, and flurries of wet snow whip across the sky.

On such a cold, gray August day last year I stood outside Point Barrow's only store talking to an old Arctic hand—Alexander Malcolm Smith.

Now a vigorous 96, Sandy Smith emigrated from Scotland at the age of 18 and has been trekking the northland ever since. During the 1897 gold stampede he dog-sledged 1,500 miles from Edmonton to the Klondike. He once took a boat down the Yukon River system, portaged it over the brutal heights of the Brooks Range, and sailed out into the Beaufort Sea. As we talked, Sandy cocked an eye toward an immense plastic dome beyond the village.

"They've changed everything by building that," he said. "The Arctic will never be the same again."

The dome, housing a search radar antenna, loomed above a strange H-shaped building that marked the western nerve center of the Distant Early Warning Line—DEW Line for short. Some 50 similar stations now dot the frozen Arctic in a 3,000-mile arc from western Alaska to Baffin Island (map, page 137).

In the event of an enemy attack across the polar ice, the DEW Line will flash instant warning to the joint Canadian-U. S. combat operations center at Colorado Springs, Colorado. The time thus gained could spell the difference between national life and death for Canada and the United States.

Traveling at the speed of sound, jet bombers would require more than an hour to fly between the DEW Line and the closest of their probable targets. During this crucial interval, interceptors would take to the air, retaliatory bombing would commence from bases around

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Figure 1: Spread from *National Geographic* article “DEW Line: Sentry of the Far North"

"They've changed everything by building that," the article quotes. *"The Arctic will never be the same again."* (La Fay 1958, 129).

Barely a year after the construction was completed, La Fay's interviewee, 96-year-old Sandy Smith, warned of the project's complex future. The impact, as Smith so aptly put it, was irreversible—and he wasn't wrong to place blame. The public-facing narrative, however, sees this warning in a different light. The project, in the simplest of terms, was a string of radar stations across the northern frontier of the Arctic from Western Alaska to the pictured Baffin Island, about 200 miles north of the Arctic Circle, and 1400 miles from the North Pole. The line was meant to warn against Soviet attack via the northern periphery, a scenario that was purported as the most likely—the United States' weak spot was a transpolar air raid.

Given the scope of this undertaking, research played a key role in the years prior to groundbreaking at the fifty plus sites. The article mentioned the Massachusetts Institute of Technology's Lincoln Laboratory, perhaps the most public of Cold War-era research facilities, but certainly not the only one involved. The complex network of institutions collaborated to develop the infrastructure of the DEW Line. Their relationship and the processes involved tell us more than just the history of the DEW Line; they tell us about the pervasiveness of an ideology of warning in the United States, the anxiety of impending threat from outside forces, and the acute desire to create symbolic boundaries around geographic terrain. The implementation of advanced technology, infused in the infrastructural built environment of the DEW Line, promised to address these newfound anxieties of unboundedness through the tactic of warning.

The details of the project's construction are staggering from a material standpoint: the challenges of construction, importing of materials and goods, labor practices accounting for

Indigenous populations, and the environmental footprint of a previously untouched landscape. Certainly, it was a feat of coordination. The main operations were handled between military branches and private corporations, in particular Western Electric and Bell Telephone Laboratories. The insularity of the stations, made compulsory by the extreme climate, can be read as an experiment in community building or modernist visions of utopian housing, also tested and prototyped heavily at this time, and surely in the decades that followed. This reading would certainly appease critics of the inherent militarism in the northern cold war enterprise, but it cannot go unmentioned. The visual interest in the DEW Line's design is grounded in the architectural style of modernism—a tower in the park typology reinvented for the Arctic. In parallel with modernist visions of architecture, the DEW Line encapsulated the integration of burgeoning technologies as a means of promoting order, structure, and function—all words that can be easily transplanted into a military context.

The star of the station—its function—is the radar, connecting the outposts with an invisible trip wire. The radar is housed in a radome, a geodesic dome structure on a pedestal that is visually distinctive amongst the simple structures around it. The radome, and the architect who designed it, made the DEW Line achievable in an environment with such harsh winds and freezing temperatures. Rather unexpectedly, the architect in this case was not an unknown government contractor, but a prominent figure in visionary design: Buckminster Fuller, or "Bucky." Fuller, alongside his disciples and collaborators at elite institutions across the country, as well as those he employed at his venerable think-tank style firms, designed a structure to enclose and protect the radar in "35-foot bubbles" made of "translucent diamonds, bolted together, [to] permit free passage of radar beams" (La Fay 1958, 140). The enclosure signals a sense of protection, of boundary-making at the distant reaches of the North American continent.

By 1958 however, at the time of La Fay's article, technology had surpassed the manned bomber of the early fifties. Instead, developments in missile technology presented a new threat that the DEW line likely could not catch in time to prevent. La Fay writes, "DEW Line radar cannot presently cope with intercontinental ballistic missiles. However, military realists believe that—at least until 1960—manned bombers will remain the chief threat" (La Fay 1958, 131). The Line was rapidly becoming less advantageous.

The story doesn't end here, given the immense labor, material infrastructure, and financial investment of the project. A Western Electric journal chronicling the technical specifications of the Line, makes the following proclamation: The DEW Line "may become, in time, a textbook classic of Arctic construction, a project that required the exercise of outstanding skill and ingenuity in almost every main division of engineering" (Brannian, Donohue, Baltera 1957). The Editors of the Journal continue, "it is certain that, in the months and years to come, much more will be published about this remarkable adventure in engineering." Interestingly, however, the information available on the DEW Line succumbs to a drastic drop, and appreciating what happened across the 69th parallel between 1958 and 1993, when the last station was officially closed, is like piecing together a puzzle.

What has become increasingly clear in recent years is the physical toll the project had on its surrounding environment. Abandoned stations left to freeze over in the arctic were pillaged by local communities, permanently altering their vernacular shelter constructions, oftentimes with asbestos ridden materials, for example. Decommissioned transformers loaded with PCBs, a chemical that has since been banned due to its hazardous health implications, were left to erode into food and water systems. Waste left behind was put in makeshift landfills, which have since been affected by a widespread melting of the permafrost due to a rapidly changing climate. As examples of the DEW Line's legacy, these are critical pieces that cannot be left out of the story.

The problem we are faced with is how to understand this enormous program that spanned across agencies, departments, and countries in light of the physical ramifications it caused. It challenges us to consider control as a method of dominance: control of information, control of environment, and certainly control of territory. In examining the DEW line from the vantage point of systems of warning, in particular the geographies, infrastructures, and environments of warning, it becomes apparent that warnings are intricately related to the construction and maintenance of boundaries. A warning against something is an infiltration of a stasis, symptomatic of a shift or change that constitutes a threat. The DEW line, in the various ways it accounts for warning, is, at its core, participating in a project of boundary-making. From cultivated secrecy to "frameworks for enclosing space," the invisible trip wire built in the farthest regions of the continent is an assertion of the nation protected and secure.

The following chapters cover nearly fifty years in North American diplomacy in broad strokes, paying careful attention to key individuals, institutions, and reports, some recently declassified, that molded the DEW operation. Surely, this does not function as an exhaustive history, nor does it signify a rewriting. Instead, it aims to observe the DEW Line as a built environment, one that was quietly and expensively implanted on a terrain, drawing a lateral line in the frozen ground. Doing so asserted an American project of national security in its most literal sense, and has a relevant place in numerous fields of research. The DEW line, both symbolically and materially, serves as a link between disparate disciplines, and perhaps itself warns of the consequences of letting those links go unnoticed.

The *National Geographic* article ends: “Through untold centuries the Arctic slept in frozen solitude, inviolate in its chaste, cruel beauty. But man has now invaded their white wilderness in force; his technology has come to stay” (La Fay 1958, 146). From any angle, the simple truth of the DEW Line, an astonishingly unknown military operation, is that it fundamentally altered the Arctic region. The DEW Line, even in its absence, “has come to stay.”

CHAPTER 1:
GEOGRAPHIES OF WARNING

The Arctic: desolate, savage, remote. A wilderness of unending barren distance. Through most of the year locked in bitter cold and almost endless darkness; in the short summers a swamp-like morass. Not too bad for caribou or polar bears but no place for human beings. Yet this roof of the world holds a stark menace to our country, to our very existence. The menace lies in the basic new fact of our time that no two nations on earth are any longer cut off from each other by geography. We all live at the edge of the same ocean, the air ocean which envelops the globe. (*DEW Line Story*, Western Electric)

So begins a promotional video, produced by Western Electric's Defense Projects Division for the United States Air Force. The scene is set with footage of an arctic lunar landscape spanning boundlessly into the distance, over a track of howling winds and the crackle of dated film footage. This video, and several others like it, produce an archive of visual material about a specific moment in North American history, embodied in the anxiety and technological fervor of a single infrastructure project. Those involved trace an ideological arc between technocratic utopianism, architectural modernism, and militaristic conquest, all the while constructing radical notions of geographical space and national borders—the frontier myth reconsidered for the high arctic.

Figure 2: Stills from *DEW Line Story*, Western Electric

"DEW LINE" extends across the screen in a thick red typeface, with a faintly recognizable icy tundra in the background. The video continues, expelling dated notions of territorial space as synonymous with safety and suggesting that new technologies have corrupted those geographies and replaced them with a potentially chaotic, overly-networked new form of global space. In a post-World War II moment, where Americans were beginning to see their nation as a global power—a “unified, unbounded sphere of American influence” (Van Vleck 2013, 4)—geographies of power and security began to shift with the aid of aviation and radio technologies. The film introduces the main figure in the story, the unfamiliar region located at the earth’s most northern circle.

The Arctic is a unique body of land for a multitude of reasons, one of which being its national linkages: eight nations are members of the Arctic Council (Canada, Denmark, Finland, Iceland, Norway, Sweden, the Russian Federation, and the United States), alongside representatives from six indigenous populations, deemed permanent participants (Aleut International Association, Arctic Athabaskan Council, Gwich’in Council International, Inuit Circumpolar Council, Russian Association of Indigenous Peoples of the North, and Saami Council)—all of which navigate the jurisdiction of the Arctic on a consensus basis. The Arctic Council was formally established as an intergovernmental forum in 1996 with the signing of the Ottawa Declaration; it is charged with promoting sustainable development and environmental protection in the Arctic. Before the 1990s, no collaborative agreement existed between the nations with sovereignty over territory in the Arctic on the protection of its environment. It comes as no surprise, then, that the Arctic has historically encountered narratives of subjugation, control, and, in some cases, modernization. In nearly every instance of external engagement in the Arctic, the military has played a leading part. At the moment of an increasingly globalized post-WWII world, the Northern reaches of the continent came to hold a significant place in changing geographic imaginaries. With advancements in aviation and radar technology, the Arctic took hold as a military object, an essential frontier in the vertical arc of the globe. In considering the Arctic, and more specifically the Canadian North, as a military object, the DEW Line shows how the United States has taken the lead in cultivating and implementing technologies of warning as a tool for reconsidering territorial boundaries.

"Just by being there," the voice over continues, "those impassable stretches assured against attack from the north. But no more." Dramatic musical tones signal the forthcoming assertion: "When men conquered the air, they changed the meanings of geography. Now from any point on the globe, the air ocean provides an open path to any American city, town, village, or cornfield." This shift in the conception of aerial distance as protection, towards a newfound fear of attack from anywhere, is grounded in the practice of warning as a tactic not only for military engagement, but also as ingrained in American ideology. The thread of warning is a sub-current throughout the story of the DEW Line, and in its development, the Arctic became the theater for an ideology of warning. Inasmuch as the DEW line functioned as a technological barrier, it also elevated Canada during a moment of geographic reconsideration.

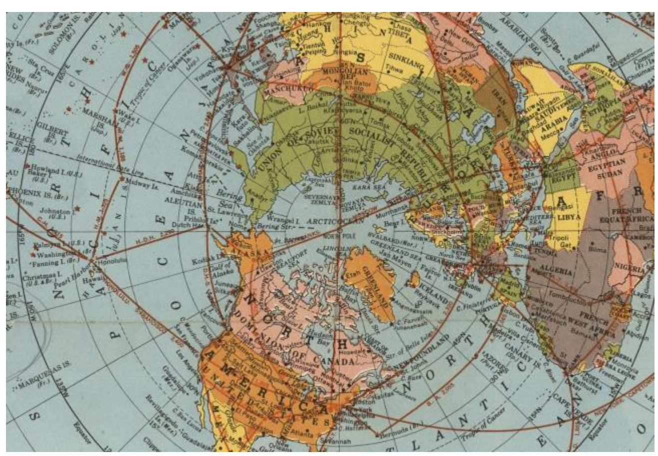

Figure 3: *Left*, C.S. Hammond & Co.'s "Air Age Map of the World"; *Right*, Detail of North Pole.

Canada emerged in newfound relevance because of its unique geographic placement in the northern hemisphere. First, one must go back to what historian Jenifer Van Vleck calls "logic of the air"—in which a new geography (*fig. 3)* was "unbound from the flat Mercator projection that [had] dominated human thinking for centuries" due to advancements in aviation technology (Van Vleck 2013, 3). An optic emerged, Van Vleck argues, in which the globe could be seen from an aerial perspective, "which looked down on the world as a unified, unbound sphere" (Van Vleck 2013, 4)[1]. The Mercator map, having mainly been used as a guide for traveling by sea, portrayed the world as a two-dimensional space, with a distinct separation between East and West hemispheres. With the escalation of air-based travel, an "air world" map emphasized the poles as a way to portray the earth's sphere. In doing so, the east west axis was joined by the north and south hemispheric division. Suddenly, Canada was recognized as sandwiched in between the United States and the Soviet Union, thus occupying a critical space in the uncertain inter-war period.

In the middle to late 1940s, the United States and Canada were navigating their neighboring relationship with the understanding that continental defense had the potential to be mutually beneficial. The "Joint Statement on Defense Collaboration," published on February 12, 1947, gave precedence to individual national sovereignty, while establishing a Permanent Joint Board on Defense. It stated, "As an underlying principle, all cooperative arrangements will be without impairment of the control of either country over all activities on its own territory" (Jockel 1987, 2). The strategy that defined post-war American policy making was closely tangled

[1] One of Van Vleck's guiding assertions is that aviation catalyzed a new understanding, and desire, of American world power: "Just as the airplane facilitated global inter-connectedness, the "logic" of the air helped Americans to understand and literally to visualize the United States' global ascendancy." She continues, "Aviation both created and legitimized a new international order in which power itself was increasingly defined in extra-territorial terms" (Van Vleck 2013, 4-5).

with questions of space and range, angling to keep “potential enemies” at a “maximum distance” (Jockel 1987, 6). Articles began appearing in the American press suggesting the integration of American and Canadian military defense; in some cases, it was even proposed that the American military claim authority over Canadian defense efforts, or that American defenses could be permanently deployed in the high arctic (Jockel 1987, 1) [2]. On the other side, however, Canadians worried about this joint venture as a slippery slope into a loss of sovereignty, with articles in the Canadian Publication *The Financial Post* with headlines such as “Canada ‘Another Belgium’ in U.S. Bases Proposal?” and “Maginot Line is Feared” (Jockel 1987, 24). The Maginot Line is referenced quite a bit as a precursor to the radar lines implemented during the Cold War, and in most cases, served itself as a warning against the construction of such a defense tactic. [3] At the intersection of these two North American countries, with the various risks at stake, the conception of continental space took on the role of distant boundary-making. Distance as a means of defense, however, is only valuable when paired with a means of warning.

Simultaneously, architectural icon R. Buckminster Fuller was developing a mathematical formulation for an engineered structure composed of rounded tetrahedrons strengthened by its regular pattern. U.S. Patent number 2,682,235 was filed on December 12, 1951 and registered three years later (*fig. 4*). The document is associated with the name R.B. Fuller and lists its

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[2] *Readers Digest*, 1946, “Partners Against Attack: Safety Demands that Canada’s Military Establishment be Integrated with Ours”

[3] The Maginot Line was a defensive line of fortifications and weapon installations built in France during WWII as a means to protect against German invasion. The expensive endeavor is mostly cited as an example of constructing a false sense of security termed the “Maginot Mentality” in the book *Fortress France: The Maginot Line and French Defenses in World War II* by Kaufmann and Kaufmann. The Maginot Line was also compared to the Cold War frenzy around fallout shelters, where a popular critique was that the fallout shelter might function within the Maginot Line psychology of a false sense of security. Kenneth Boulding, in the introduction to “Conflict and Defense” (1962), writes “The ancient concept of defense symbolized by the wall, whether the walled city, the Great Wall of China, the Maginot Line, or even DEW Line, has crumbled in ruins” (Boulding 1962, v).

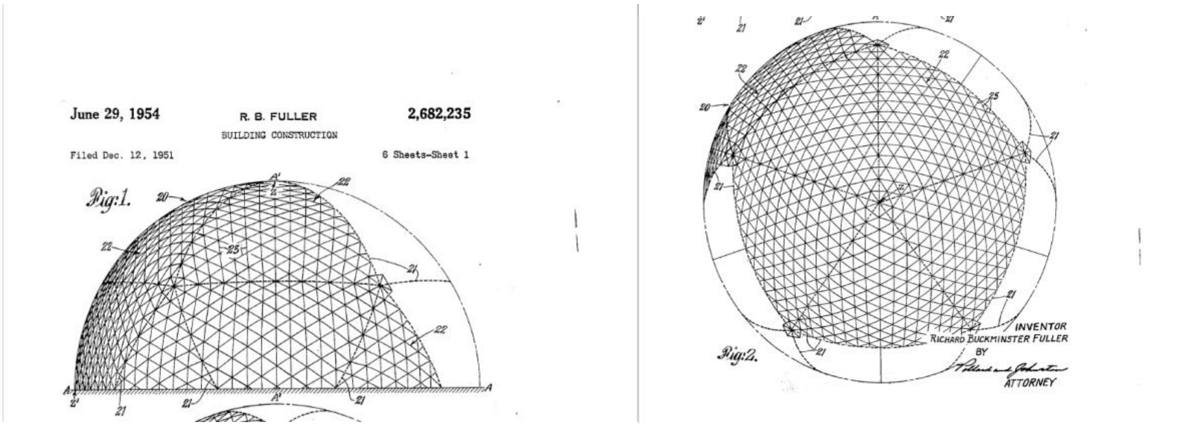

Figure 4: U.S. Patent number 2,682,235, "Framework for Enclosing Space"

function as a “framework for enclosing space.” The geodesic design stemmed from Fuller’s interest in efficient shelter, embodied in his term “dymaxion”—a combination of “dynamic,” “maximum,” and “tension”—which sought to produce “maximum gain of advantage from minimal energy output” (McHale 1962, 17). His patented design takes its geometry directly from the dymaxion project, not the Dymaxion Car or House that is most frequently associated with the term, but with Fuller’s Dymaxion World.

Fuller’s intellectual production and architectural practice implicated modern geographic imaginations as a usable factor. The “one continent” map, also known as the “Dymaxion Map,” from which the geodesic typology originated, was first developed in 1938 and used geometric structures to portray land masses in relative scale. Fuller’s “Dymaxion World” aimed to reconsider the basic tenets of cartography, the problem of depicting a flat surface on a spherical globe. Rather than distorting scale, direction, or configuration, Fuller proposed adjusting the requirements to distribute them evenly both between each other and on the globe. The concept was first publicized in *LIFE* magazine in March of 1943. The article asserted, “For the layman, engrossed in belated, war-taught lessons in geography, the Dymaxion World map is a means by which he can see the whole world fairly and all at once," projected onto a globe that "can be revolved in any direction and studied in the changing perspectives of war's strategy" (LIFE, March 1943, 41f). In his geographic project, Fuller participated in contemporary conversations about territorial boundary-making, negotiating the anxieties between bounded and un-bounded space, territorial power and networked power, geography in theory and in practice.

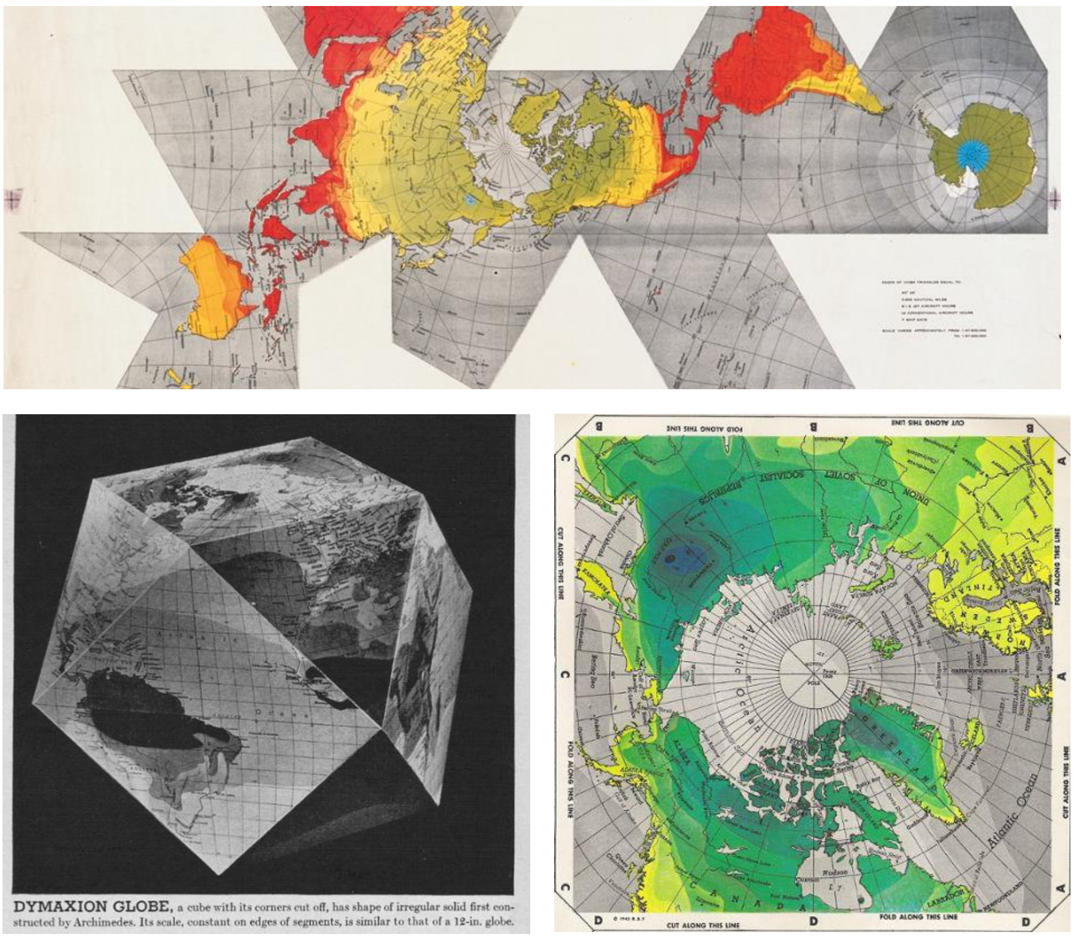

Figure 5: *Above*, Dymaxion Map; *Below, Left*, Dymaxion Globe, *LIFE* Magazine; *Below, Right*, Close-up of Dymaxion Map, North Polar Square, *LIFE* Magazine

The Dymaxion Map reconsidered a global continental order in which the Arctic was bordered by North America and Russia. Fuller and David Cort's joint report explained, "(T)his means instantly that it is U.S. and U.S.S.R, not the Axis, who hold the 'interior' lines. The world battle fronts become two trans-Arctic lines from Australia through China to the Aleutians and from the Atlantic through Greenland down through Russia to the Middle East" (Fuller and Cort,1). The triangles that depicted the north pole (*fig. 5*) included the following analysis: "North Pole layout of segments shows the world in new focus of air power. The U.S., Canada and Russia control almost the whole coastline of the Arctic Ocean. One of the first to recognize the strategic importance of the Arctic region, Mr. Fuller designed his first polar projection as an end paper for his *Nine Chains to the Moon* (*LIFE* 1943, 53)[4]. The article's discussion of air power along the northern pole stops here, but it is alluded to with the several detail images that showcase the region and its ever-shifting boundaries. The map asks to be unfolded and rearranged; while continental geography is not rearrangeable, and "does not easily yield precise calculations," (*LIFE* 1943) the sentiment was embodied in the Distant Early Warning Line, and the Cold War's implication of geography. The north, as a distant lunar landscape, called for a geographic imaginary.

It is apparent, then, that Fuller's project had direct ties to conceptions of geography, warning, and a defense strategy. Trans-polar warfare, as it was beginning to be called, constructed an anxious ideology of nuclear aerial threat from the country's northern edge. The Arctic already played a role in the most recent wartime conflict when, in 1942, Americans first began to imagine the potential of the Arctic in planning for defense. P. Whitney Lackenbauer[5], in his essay "Agency in High Arctic Modernism" in *Many Norths,* writes,

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[4] Analysis of some of Fuller's early writings, though valuable, fall outside the scope of this project. Future examination on Fuller's implication of geography would certainly look at *Nine Chains to the Moon* as well as some of his other geographic imaginings.

[5] Lackenbauer, a professor of history at St. Jerome's University in the University of Waterloo, Ontario, is one of the few scholars studying the DEW Line. In particular, his books *Canada and the Changing Arctic: Sovereignty, Security, and Stewardship* and *Arctic Front: Defending Canada in the Far North* have been invaluable sources.

"Frobisher Bay (Iqualit) on Baffin Island was a prime example in 1942, when the Americans transformed it from a seasonal Inuit fishing spot to a permanent military base, an outpost in the far North, almost overnight" (Lackenbauer 2017, 335). Lackenbauer continues, "These military activities catapulted the Arctic into the mental map of defense planners, with the corresponding dilemma for Canada of how to balance the demands of continental security with the imperative to safeguard sovereignty." The DEW line's use of the north as a line of defense took the militarization of Frobisher Bay to new heights. Rather than interference and transformation in a consolidated area, the DEW line linked stations across the entire continent, both an invisible fence and manifestly present infrastructure program. The perceived desolate landscape certainly posed an architectural challenge, but also aided in strengthening the ideology of warning from afar.

Fuller's albeit hypothetical design for the "one-continent" map illustrates a general lack of knowledge about the geography of the far north. The points that would become DEW line stations were previously uncharted territory. A scheme of strategic mapping and surveying of the far North was the first phase in the project[6], as it carried out the physical and symbolic work of rendering the landscape legible. From the most fundamental standpoint, the physical geography was permanently transformed: "Bulldozers tore permafrost off the ground, disrupting ecosystems and creating impassable quagmires. Forest fires, logging, over-hunting, and over-fishing depleted resources in the region. Arriving workers brought diseases, from measles to VD, which devastated indigenous populations" (Lackenbauer and Farish 2007, 925). The region was, for the

[6] Lackenbauer and Farish further explain: "The DEW Line was made possible by a comprehensive exercise in military geography: exhaustive terrain, climatic and coastal surveys undertaken with the aid of the Canadian Joint Intelligence Bureau and arms of both national militaries. This was, in effect, a vast catalog of environmental data…" (Lackenbauer and Farish 2007, 928).

first time, connected to the rest of the country (and continent), and modernized in a one-size-fits-all manner. A previously disconnected expanse, now networked with visible and invisible infrastructures: geographic surveys plotted the terrain, telephone systems, generating plants, and requiring particular acculturation from Indigenous populations, the introduction of wage employment (Lackenbauer and Farish 2007, 925). Modern infrastructure was introduced in the region but was standard and not customized for the harsh environment. Alongside the physical manipulation of the terrain, the interventions were intensely symbolic, as the Arctic, once the harsh lunar landscape, inhabitable by humans, became a modernized frontier responsible for the defense of the continent.

It did not take long for Fuller to realize the commercial potential of his geodesic dome design, an easily replicable shape that has since been produced over 300,000 times worldwide (Buckminster Fuller Institute), in projects spanning from national defense to counterculture housing, world exhibitions to arctic radar shelters. In the early development of the geodesic framework, Fuller wrote to Charles Edison, then Governor of New Jersey (Buckminster Fuller Institute):

> "I have several technical devices which might, I believe, be developed into important weapons, fairly easy to produce in mass. How to get them into production swiftly and secretly is the problem. I believe that it could best be done within the structure of the navy department…To do a good job, I will need some real authority, materials and machine work, and considerable latitude and patience on the part of the department" (cited in Wong 1999, 132).

Fuller certainly received this considerable latitude, most influentially in the form of military funding for the research and design phases of his structure. One estimate places his annual salary following military buy-in at one million dollars (Chu 2018, 8)[7]. The regularized pattern of the

[7] When adjusted for inflation, this salary would approximate nine million dollars per year.

pieces enabled Fuller's design to be mass produced, leaving space for commercial and military appeal. The modular, mass-production prototype could be manufactured and deployed quickly and to any distance, a key factor for successful military installations. With institutional backing, the "framework for enclosing space" would facilitate the implementation of an early warning infrastructure in the "desolate, savage, and remote" Arctic landscape.

CHAPTER 2:
INFRASTRUCTURES OF WARNING

In September 1949, a US military aircraft landed at Eielson Air Force Base in Alaska, having collected samples from east of the Soviet Union's Kamchatka Peninsula that showed unusually high levels of airborne radioactive debris from "Joe 1," the Soviet Union's first nuclear weapon test. On the 23rd of that month, President Truman issued a statement, announcing a new threat:

> I believe the American people, to the fullest extent consistent with national security, are entitled to be informed of all developments in the field of atomic energy. That is my reason for making public the following information. We have evidence that within recent weeks an atomic explosion occurred in the U.S.S.R. Ever since atomic energy was first released by man, the eventual deployment of this new force by other nations was to be expected. This probability has always been taken into account by us. … This recent development emphasizes once again, if indeed such emphasis were needed, the necessity for that truly effecting enforceable international control of atomic energy which this Government and the large majority of the members of the United Nations support. (Truman 1949)

This announcement spurred anxiety amongst the general public, and scientific inquiry into a defense strategy that would directly institute the governmental interest in the formation of research groups dedicated to the development of a nuclear defense strategy. As an infrastructure of warning, the Distant Early Warning (DEW) Line sought to address this challenge.

This chapter demonstrates that research groups and published reports functioned as a form of warning. The reports, commissioned by military, governmental, and private institutions, were necessitated by the assumed authority of warning as a defense paradigm. Alongside key institutions that shape the infrastructure of nation-making, highly trained individuals in the science and technology sector were charged with developing the warning argument. With the threat of tangible nuclear disaster, both private and public sectors received the institutional backing, both symbolic and material, for the rapid deployment of a warning infrastructure.

George Valley was an associate professor in the MIT physics department and a member of the Electronics panel of the Air Force Scientific Advisory Board, a Federal Advisory Committee that provides recommendations on matters related to science and technology, and was in one instance described as a "slightly cantankerous visionary."[8] Valley was principally concerned about Soviet nuclear weapons and the quality of U.S. air defense (Freeman 1995, 2). Following a visit to a radar station operated by the Air Force Continental Command, he witnessed what he saw as the implications of outdated technology insufficient for detecting long-range aircrafts, Valley penned a letter to the Advisory Board November 8, 1949. His concerns traveled up the chain of command until a committee was organized on December 15th of the same year with the sole purpose of analyzing the air defense system and proposing potential improvements (MIT Lincoln Laboratory History). The Air Defense Systems Engineering Committee (ADSEC), colloquially named the Valley Committee, was assembled, and their recommendations would dictate one of the largest and most expensive infrastructure projects ever conceived by the U.S. military.

ADSEC was founded upon envisioning a specific type of Soviet attack and it developed a solution to the problem that this attack posed: the bomber would "fly over the North polar region at a high altitude, and then descend as it approached its target. While the aircraft flew at high altitudes, it would be able to detect ground radar before the radar could detect the aircraft, at low altitudes, it could fly under the beam and be virtually undetectable" (Freeman1995, 3). This necessitated the development of technology that would allow the military to receive and interpret

[8] Matthew Farish, *Contours of America's Cold War,* 154. Farish writes about Valley, that his "concerns were both patriotic and personal; he realized that the location of his new home in Lexington, with its striking view of the Boston skyline, also offered little blast protection from that direction" (Farish 2010, 154).

signals from a multitude of radars, thus requiring a means to transmit data to a central location where it could be consolidated. Perhaps more challenging was the essential requirement of a way to detect and intercept a "hostile aircraft" via a computer that could "analyze the data in real time" (Freeman 1995, 4). The factor of time embedded within detection and analysis is once again a product of an American ideology around warning, functioning ultimately as a selling point for institutional involvement in the development of such technologies.

MIT's reluctance, as an academic institution, to participate in establishing a research center alongside the government and military, was notable, following their participation in the Radiation Laboratory[9] and other war-time projects. It was suggested by Louis Ridenour, chief scientist of the Air Force, that MIT's involvement in a laboratory that addressed the problem of air defense could function as a "stimulus for the nation's small electronics industry," and that "the state that became the home of the new laboratory would emerge as a center for the electronics industry" (MIT Lincoln Laboratory History). From February to August of 1951, a study was conducted that determined the need for Lincoln Laboratory. This project, Project Charles as it was named, resulted in the final report "Problems of Air Defense." This report was the first of many that would be produced over the course of the coming months and years, in which various recommendations were made, contradicted, and rejected. Their report begins:

> The task of PROJECT CHARLES has been to study air defense. In the four months available to us, we have found it necessary to limit ourselves to specific subjects within this very large field. Our primary concern has been with the air defense of the continental United States, with only occasional attention to the protection of overseas areas and of naval task forces. While the group represented experience in many fields of science and engineering, the dominant background was electronics, and our Report reflects a major interest in problems of detection and control. (Loomis 1951, v)

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[9] In November of 1949, U.S. Air Force Chief of Staff Vandenburg urged the Joint Chiefs of Staff on two matters: First, to advise the Secretary of Defense on the need for technological development in the area of air defense; Second, to establish "an air defense Manhattan Project" (Jockel 1987, 60).

The Project Charles Report (*fig. 6, left)* was unable to predict, or accurately warn, the percentage of enemy bombers of which such a new, hypothetical air defense system might be able to defend. The report also claimed to be "unable to point to any new invention, comparable with radar, that would provide a simple solution to the air defense problem" (Loomis 1951, v). While acknowledging the value in erecting an arctic radar line, the research's ultimate recommendation suggested the redirecting of funds towards improving the current air defense systems tracking and plotting capabilities.[10] The potential radar line, it explained, posed "problems with false alarms and unreliable equipment," as well as the difficulties of establishing such infrastructure in the harsh climate and isolation of the Canadian North (Jockel 1987, 61). Their conclusion was that the region was "physically inaccessible for permanent manned radar station" (Loomis 1951, xx). Though the report warned against attempted development of this new, harsh frontier, the assessment was ultimately sidestepped and envisioned instead as a technological challenge.

With the Project Charles Report's recommendations made clear, the Lincoln Laboratory turned to computerization as the method for a new rapid air defense data handling, creating a networked system to mediate the institutional and technical infrastructures.[11] The Lincoln Transmission System was introduced in 1953 and was later renamed Semi-Automatic Ground

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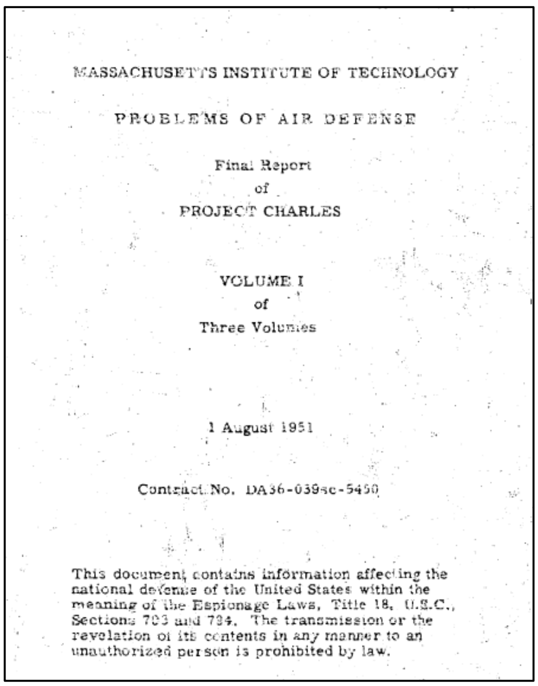
[10] The report states, "We endorse the concept of a centralized system as proposed by the Air Defense Systems Engineering Committee, and we agree that the central coordinating apparatus of this system should be a high-speed electronic digital computer" (viii).

[11] Given the rapid schedule for testing such a warning system, existing radar models were considered for modification rather than designing an entirely new model. As Naka and Ward explain in the *Lincoln Laboratory Journal*, the AN/TPS-1D was selected because of its simple and lightweight structure that allowed for relatively uncomplicated transportation to the sites. Bell Telephone Laboratories developed the antenna to increase range and altitude detection for the far north; the radar and antenna combination was named AN/FPS-19 (Naka and Ward 2000, 184). The main adjustment to the existing radar technology was the ability to produce audible detection, accounting for human response time in its increased detection range. Naka and Ward also note that the manufacturer, Raytheon, was located near Lincoln Laboratory near Boston. (Naka and Ward 2000, 183). During the initial radar development phase, testing considered an acceptable false alarm rate of one per day. (Naka and Ward 2000, 188)

Environment (SAGE). It incorporated digital communication, a real-time software system, networking, and a completely reliable computer (Freeman 1995, xii). The SAGE system demonstrated the ability to fulfill ADSEC's technological call: the collecting and analysis of signals from a group of radars, the transmission of data to a central computer, and then the aggregation of the data for human interception. This invention would provide the technological capacity for the DEW Line infrastructure, coordinating warning with receptive transmission strategies.


MASSACHUSETTS INSTITUTE OF TECHNOLOGY

PROBLEMS OF AIR DEFENSE

Final Report
of
PROJECT CHARLES

VOLUME I
of
Three Volumes

1 August 1951

Contract No. DA36-039sc-5450

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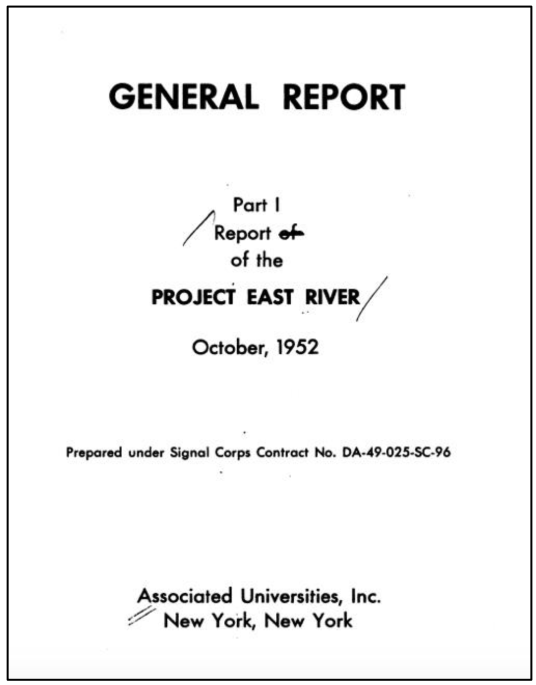
GENERAL REPORT

Part I
Report ~~of~~
of the
PROJECT EAST RIVER

October, 1952

Prepared under Signal Corps Contract No. DA-49-025-SC-96

Associated Universities, Inc.
New York, New York

Figure 6: *Left*, Problems of Air Defense, MIT, 1951; *Right*, General Report, Associated Universities, 1952

Similar to Project Charles, and shortly after the release of the report[12], the Department of Defense solicited a similar study alongside the National Security Resources Board and the Federal Civil Defense Administration; the study was to be administered by Associated

12 Simultaneously, the secretaries of the Army, Navy, and Air Force solicited research from the California Institute of Technology on the problems of ground and tactical air warfare, with a focus on the defense of

Universities, Incorporated, affiliated with Princeton University. Named Project East River (*fig. 6, right)* after the river alongside Manhattan where the group was located (Jockel 1987, 63), the group's participants shared more than relevant technical skill—all but two of the East River group's twelve members had participated in either Project Charles or Project Lincoln. Notably, many of the participants had also worked together during World War II on the atomic bomb project at Los Alamos or the Radiation Lab at MIT (Holbrow 2006, 40). The mindset of WWII-era laboratories surely carried over into the government-solicited research in the early years of the Cold War. The East River study was commissioned to investigate civil defense with a focus on tangible preparations such as bomb shelters and evacuation procedures and was led by Lloyd V. Berkner, a naval reserve captain who had been a member of the wartime Research and Development Board (Futrell 1989, 330). Instead, the group all but bypassed these desired suggestions and looked at the active defense of the North American continent from Soviet attack—nominally indistinguishable from the call for Project Charles.

The final report's conclusion differed from the recommendations of the Charles Report, stating that a couple hours of advance warning could be useful for strengthening civil defense. The report urged: "Under these conditions, it becomes imperative that a system of air defense be

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Western Europe. This study was named Project Vista, after the Vista del Arroyo Hotel in Pasadena, California where the study was headquartered (Elliot 1986), and was headed by California Institute's President Dr. Lee A. DuBridge and directed by William A. Fowler. The Vista Report was completed on February 4, 1952. It recommended that the United States "should assume responsibility for developing a NATO tactical air force and tactical air direction centers." The Report reads: "The crux of our present danger is in our complete dependence upon the 'Strategic Striking Force' as the principle element in our defense. This Maginot-Line type of thinking can be out-maneuvered by an intelligent enemy by any one of a number of ways. Opposed to the Maginot-Line concept of 'putting all our eggs in one basket,' is the balanced and flexible force" (Vista Report, quoted in Futrell 1989, 331). While other Summer Study's culminated in subsequent government contracts or the development of a laboratory, Project Vista ended with the report. It participated, however, in what Patrick McCray has called "a social reality in which working on military problems was an accepted norm, if not indeed a sign that one was truly a well-connected, top-notch researcher" (McCray 2004, 340).

devised that aims at destroying substantially all of the airborne attackers prior to the time that they reach the United States. If this is not achieved, civil defense becomes unmanageable and largely futile" (Associated Universities 1952, 28)[13]. They proposed an outer warning network that would be situated no less than 2000 miles from the continental limits of the United States, also asserting that "the severity of arctic weather conditions has been generally overestimated" (Associated Universities 1952, 18). As Jockel writes, this was a "curious development," since many of the East River scientists had been a part of the Project Charles group that had established the Arctic as physically inhospitable to a radar system.

The inconsistencies between the two reports seems to have caused internal departmental turmoil, as the Department of Defense quickly renounced the East River report and suggested that the group return to the contractual job of devising civil defense measures. Instead, two members of the East River group joined forces: Jerrold R. Zacharias, a physics professor at MIT, approached Albert G. Hill who was recently named director of Project Lincoln. What resulted was the Summer Study at Lincoln Laboratory, hosted in the summer of 1952 at the MIT campus in Cambridge, Massachusetts. The Cambridge gathering is perhaps the most referenced of the various research associations during the Early-Cold War.

The Summer Study at Lincoln Laboratory examined the vulnerability of the United States to a potential surprise attack. The study was chaired by Zacharias, the atomic physicist who was involved in both the Radiation Laboratory and the Manhattan Project. The group was comprised

[13] The East River Report differed from the Project Charles Report in this area. The Project Charles Report read: "It is not feasible to provide an ideal early-warning system that gives unequivocal warning of all possible attacks. A less-than-ideal but valuable system that has a fair probability of detecting likely forms of enemy attack is recommended" (Loomis 1951, 25-26).

of forty-five members and consultants, including scientists, engineers, and military personnel.[14] Tasked with assessing a hypothetical Soviet attack on the United States, they claimed such an attack would consist of five raids, for which they predicted the Soviets could cause "one megadeath per one megaton," with an anticipated total around 20 million civilian deaths (Jockel 1987, 64).[15] Such a figure was shocking, considering that U.S. military losses during the Second World War had been approximately 300,000[16]. This Summer Study is most commonly cited as the incubator of the DEW Line, while the series of research groups and reports that preempted the Summer Study are left outside of the narrative. To include Project Charles and Project East River in the popular account of the Cold War infrastructural undertaking, would be to reveal uncertainty at the core of the project's foundation.

Nonetheless, the Summer Study Group recommended that a "network of surveillance radars be deployed north of the 70th parallel from Alaska across the Northern reaches of Canada to Newfoundland" (Naka and Ward 2000, 181)[17]. The goal was to provide a warning of approximately three to six hours of an impending threat (Freeman 1995, 3). Reestablishing

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[14] One notable member was J. Robert Oppenheimer, the leader of the Manhattan Project (Jockel 1987, 64). Oppenheimer had also served as a consultant at Caltech's Project Vista (see footnote 6) (McCray 2004, 341).

[15] Joseph Jockel, in his 1987 book *No Boundaries Upstairs: Canada, the United States, and the Origins of North American Air Defense, 1945-1958* writes, "The attack would consist of five raids: the first on the northeastern industrial heartland, where 20 bombs on target would cause 10.8 million deaths; the second on other targets in the northeast (27 bombs, 2.65 million deaths); the third on the south (17 bombs, 2.62 million deaths); the fourth on the far west (14 bombs, 1.8 million deaths); the fifth on the east coast (22 bombs, 1.47 million deaths)." He continues, "It appears now, in light of research done since 1952 on the effects of atomic weapons, that the Summer Study Group may have underestimated the effects of such a nuclear strike… 20 million deaths now seems a small figure" (Jockel 1987, 65).

[16] "Secrecy laws prohibited the very scientists who knew the most about such weapons and their astonishing destructiveness from speaking about them. Whether the scientists thought a super bomb was immoral, impractical, strategically dangerous, or just useless and unnecessary, they could not make the case to the public, or even to Congress" (Holbrow 2006, 43)

[17] This was no small recommendation, as the Summer Study Group estimated that their proposed DEW Line would cost $370 million plus another $106 million in annual operating and maintenance costs; it later expanded this figure to include the computerized air direction centers, with a total cost of $20-billion (Futrell 1989, 330). Calculating for inflation, this figure translates to over $189 billion in 2018.

pieces of the East River group's suggestions, the Summer Study called for the strengthening of the national air defense system, pointing to recently developed technology developed at both Lincoln Laboratory and McGill University that would allow an aircraft flying into radar coverage to set off an auditory alarm. This technological development impacted the Line's hypothetical labor force, where "in low traffic areas, such as the North, it would not be necessary for men at radar stations to remain at their posts, constantly watching radar screens for intruders; as a consequence, substantially fewer personnel would be required" (Jockel 1987, 66) [18]. Similar to the fallout of the East River Report, the Summer Study Report was critiqued by the Air Force and Department of Defense—the liaising offices notably refused to bring the report to the National Security Council (Futrell 1989, 169). This was not the end of the proposed DEW Line, despite strong military opposition.

Jack Gorrie, then chairman of the National Security Resources Board[19], referred the report back to the Department of Defense for reconsideration. One final review, consisting of a panel of civilians under the supervision of Mervin J. Kelly, head of Bell Laboratories, occurred alongside the RAND Corporation's[20] review of the Summer Study Report. RAND's report stated that "under certain conditions [the line] could give useful warning against a surprise attack," while its ultimate conclusion was that the construction of a DEW Line should not be a priority (Jockel 1987, 68-69). It suggested, as other reports did, a focus on the development and

[18] The development of audible alerting was aided by psychological testing, wherein "psychologists and engineers who worked to optimize the interaction of humans to detect and track radar returns on a plan-position-indicator (PPI) display. The engineers in the group often served as guinea pigs in the tests conducted by the psychologists" (Naka and Ward 2000, 196).
[19] Gorrie had also sponsored the Summer Study Group's report in the National Security Council
[20] The RAND Corporation, standing for Research and Development, is a California-based think tank that had been founded by the United States Air Force in 1948, with whom it still maintained close ties.

improvement of other air defense measures.[21] In a now unsurprising move, East River's Berkner enlisted co-workers support in finding a way to submit a DEW Line policy statement to President Truman, despite the opposing recommendations.[22] On December 31, 1952, with barely three weeks left in his presidential term, President Truman approved the DEW Line policy statement, named NSC-139, which called for the Department of Defense to commence development of an early warning system that could give the United States three to six hours of warning of an aircraft approaching. It provided a deadline for the implementation of such a system: December of 1955 (Jockel 1987, 70). Zacharias, an early participant in the Summer Study's, exclaimed, "Air defense was finally sold to Truman over the dead body of the air force" (Quoted in Holbrow 2006, 44).

Several institutions were collaborators in the complex development of the DEW Line, as well as institutions within the United States Military apparatus. Ultimately, the Air Force awarded the contract for the development of the surveillance radar network to Western Electric, a branch of telecommunications company AT&T. So began a complex and frenzied attempt to plan for the implementation of an early warning system, made all the more convoluted by the election of Dwight D. Eisenhower, who did not perceive the same sense of urgency around the construction of the DEW Line.

The findings of the various reports differed, but all showed hesitation—minimal or acute—towards the construction of a north warning system in the high arctic, functioning themselves as warnings for the implementation of such a program. They warned against the

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[21] More specifically, the RAND report listed: the improvement of low-altitude detection for the existing Permanent system, an extension of radar coverage off the coasts, and the development of the computerized data-handling systems recommended by Project Charles (Jockel 1987, 69).

[22] Berkner enlisted Paul Nitze, the director of the State Department's Policy Planning Staff and White House confidant, who had followed the group's work closely. Nitze then turned to Secretary of State Dean Acheson who helped draft the DEW Line policy statement.

technological feasibility of such a system, the valuation and cost for level of benefit, the quantification of error, and the disruption of the balance between defense and offense. Though all evidence led to the concept being overly ambitious, and the reports left an ambivalence surrounding the implementation of a radar warning line in the high Arctic, a shift occurred with President Eisenhower's administration. Factions for and against the construction of such infrastructure emerged, and formal conversations with Canadian officials continued. By May of 1955, the Canadian Ambassador and the State Department formalized an agreement: "Statement of Conditions to Govern the Establishment of a Distant Early Warning System on Canadian Territory" (Jockel 1987, 83). There were several pieces left to be developed, planned, and designed, whilst navigating gaps in knowledge about the distant terrain, and the potentially abbreviated construction schedule.

Academic and military institutions played a crucial role in the development of an infrastructural typology suited for the Arctic. The necessary infrastructure was both systemic and built, visible and invisible. In particular, Buckminster Fuller's geodesic structure for housing the radar envisioned defense infrastructure emboldened with the elevation of warning. Fuller's original geodesic configurations were developed at Black Mountain College[23] and the Institute of Design-Chicago. Prototyping was not without failures: at Black Mountain College in the Summer of 1948, Fuller, aided by his class, attempted to construct a geodesic dome with a 48-foot diameter out of venetian blind slats (*fig. 7, left*). The slats, meant to curve, collapsed and thus gave rise to the use of rigid struts for the structure. Even with these stumbles, when Maj.

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[23] Fuller accepted a last-minute appointment at Black Mountain College, the small art school in North Carolina, and came with ideas for innovating models, geometry, and geography. "Shortly before his departure, he had sketched out a project on 15 June: the construction of a transparent geodesic dome that would enable its occupant to locate his or her correct position in the universe. This was clearly the origin of the idea that was connected to the construction of geodesic domes. Fuller called it 'Your Private Sky'" (Krausse and Lichtenstein 2017, 316).

Gen. Gardner visited Fuller at Black Mountain College to see the dome prototype, he agreed to provide financial support for the project. It was 1949, and the Summer Study group, named "Advanced Architecture" was backed by the GI Bill (Wong 1999, 240)—another example of research-based projects receiving financial support from the defense industry, not unlike Lincoln Laboratory itself. [24]

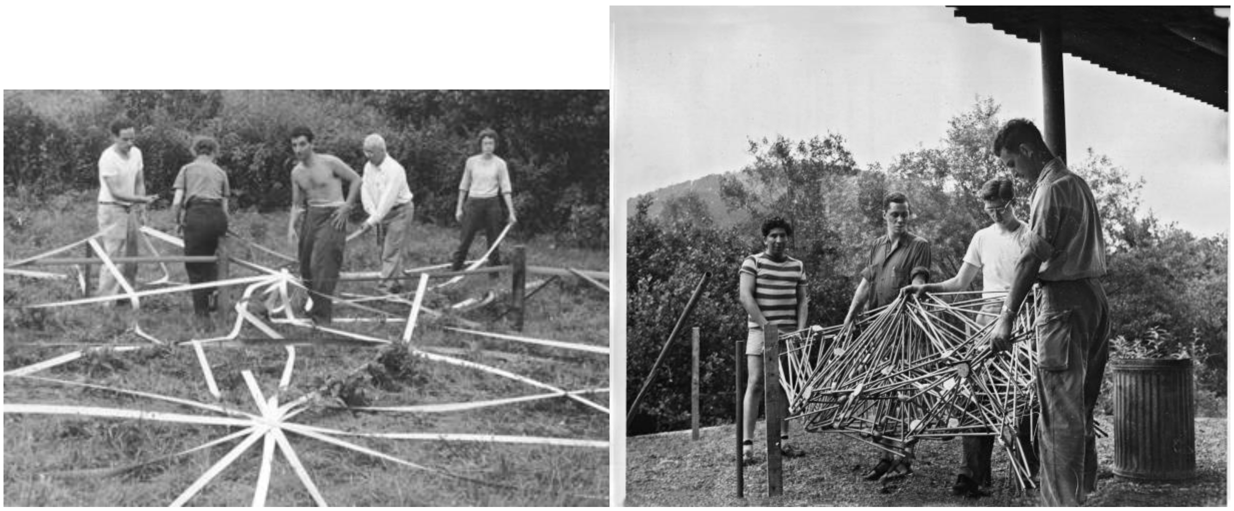

Figure 7: *Left*, Black Mountain College, 1948, Photo by Beaumont Newhall; *Right*, Black Mountain College, *Architectural Newspaper*

MIT was central in the development of the DEW Line, housing the Lincoln Laboratory and its Summer Study Group in 1952. Moreover, Fuller's introduction into the project has parallel institutional ties. Thus far, the project had encountered one major technological barrier: the structural composure of shelters in the high arctic. "Lincoln Laboratory solved the problem of sheltering rotating DEW Line radar antennas by developing a family of rigid-space-frame Radomes that are essentially transparent at the radar frequencies of interest" (Naka and Ward

[24] Other early institutional locales included: Cornell University, which housed the Aeronautical Laboratory where an air-supported radome was first developed in 1948, and the University of Michigan, whose Aeronautical Engineering Department served as the location for the dome's structural tests (Wong 1999, 256)

2000, 200). “Radome” is a contraction of radar-dome, and was first developed by Walter Bird at Cornell’s Aeronautical Laboratory in 1948 (Dessauce 1999, 130). Bird’s radome was an air-supported, pneumatic structure that was at once rigid enough to protect radar equipment, and permeable enough so that radar waves could be easily detected.[25] Fuller's radome would follow the same premise, but would implement his geodesic design for increased strength and mobility.

By 1952, the Engineering Design and Technology Division of Lincoln Laboratory began conversations with Fuller for the implementation of his geodesic dome concept with two prototypes. Fuller’s development of the geodesic structure was entirely dependent upon the potential for mass production—replicability on a large scale was built into the foundation of the design.[26] As a business, the enterprise unfolded with the establishment of two companies, in 1954, by the names “Geodesics, Inc.” and “Synergetics, Inc.” (Wong 1999, 301). In relation to the infrastructural development of the DEW Line, the former is of particular interest. Geodesics, Inc. was incorporated in September 1954 to “carry on the work of Mr. Fuller of designing and prototyping, directly or indirectly for the Armed Forces of the United States, geodesic structures embodying his patented principles” (cited in Wong 1999, 302). Implicit in this statement of incorporation is Fuller’s collaboration with the Armed Forces, a contracted think-tank for the generation of military ventures.

Fuller was a regular participant in strategic defense conversations in various capacities. In October of 1941, he participated in a secret working group in Washington DC that set out to advise the OSS on war strategies (Wong 1999, 238). Billed as a “post-Pearl-Harbor Seminar,” the group comprised of (at least in part) Buckminster Fuller, David Cort (Fuller’s former

[25] http://www.all-art.org/Architecture/25-18.htm
[26] “In light of the burgeoning air defense budget, the radome was a sure-fire commercial proposition” (Wong 1999, 325)

associate at *LIFE* magazine), John G. Underhill, Babe Paxton, and Hubbie Kay. This was during the same period of time that Fuller was working on his "One-Continent" or "Dymaxion" Map, first published in *LIFE* magazine. The document they submitted in May of 1942 was titled "Energy Focused to Win" (Wong 1999, 238). The report recognized territories and geography as a potential frontier of defense, and that architecture could play as strategic role in its relevance.

From an early stage, military figures took note of Fuller's construction, realizing its practical applications in northern localities (Wong 1999, 237). In particular, Major General Grandison Gardner, the Director of Air Installations, had been following Fuller's work, writing him a letter in which he states: "We have what appears to be a possible and very important application of this (Geodesic) principle for shelter of fighter type aircraft in northern localities. I am not sure, however, that this particular construction is adaptable to that purpose on account of the requirements for very large doors" (Gardner to RBF, cited in Wong 1999, 237). Similarly, Gardner suggested prototyping the dome in a cold hanger as a way to evaluate its thermal potential (Wong 1999, 236). The dome design's main purpose was protecting the radar from a hostile environment in a region with temperatures as low as -30 degrees Fahrenheit and with winds as much as 150 miles per hour. The laboratory-science approach made collaborations with military infrastructures comprehensible.[27]

Geodesics, Inc. had two branches, one located in Raleigh, North Carolina, and the other in Cambridge, Massachusetts (near Lincoln Laboratory). The Raleigh branch mainly worked for the U.S. Marines to develop a framework of aluminum or magnesium for the geodesic structure, testing various synthetic coatings both external and internal to the frame (Wong 1999, 302). The

[27] "Geodesics Inc. was a well-poised sub-contractor to larger, prime defense opportunities…Though Geodesics Inc.-Cambridge prototyped for the armed forces, its immediate clients were the prime defense contractors" (Wong 1999, 331).

Cambridge branch was the one closely working on the development of the radome with Lincoln Laboratory for implementation on the DEW Line. Their strategy was "focused on designing and prototyping dome-shaped structures where framework and skin of polyester resin [was] reinforced with fiberglass. These elements were molded together in panels which, when fastened together and erected, would constitute a geodesic structure" (Wong 1999, 302). Early designs had considered using air-supported, or inflatable, domes, similar to the earlier Bird typology, but found that the necessary blowers and control equipment to maintain the airtight platforms were too easily impaired with extreme weather, thus exposing the radar to the elements and causing a "break" in the invisible line. The radome's icosahedral design[28] accommodated for the 150 mile per hour winds not uncommon in the arctic. Set on a supporting platform, the dome was accompanied by a steel tower consisting of a system of trusses and columns to stabilize the structure. With the added complication of the difficult terrain, it was important for the assembly was to be rather straightforward—an aspect of the design was that the radome could be assembled in fourteen hours.[29] The cutting edge-nature of the radome project at Geodesics, Inc. was further amplified by the materials being used in innovative ways.

By April of 1954, Fuller and his Geodesics, Inc. team delivered the first of these Radomes, and installed it on top of Lincoln Laboratory's "Building C" (Naka and Ward 2000, 200). A timely storm (Hurricane Carol in August 1954) tested the structure against 110-mile-per-

[28] The DEW line radomes were three-quarter domes, meaning that the support structures intersected the base of the sphere higher than a full sphere. The radomes were approximately 55-feet in diameter, stood forty feet high, and weighed 12,000 pounds (Popko 2012, 36).
[29] The DEW Line's radomes were made up of 235 diamond-shaped major panels, 40 partial base panels, and 86 hubs. The Western Electric specifications explain, "The predrilled, color coded panels, are bolted together in sequential order to form the structure. Neoprene gaskets are then installed at the joints between panels to make the structure weather tight…. To assure the success of the erection operations in the field, detailed instructions covering the preparation of the staging area at the site and the sequence of assembly and erection of antennae and radomes were prepared by the engineers" (*DEW Line Story*, Western Electric, 11).

hour winds. It was subsequently relocated to Mount Washington in New Hampshire (*fig. 8, right*), where it survived the Winter of 1954-55, remaining intact enough for radio frequency testing at the Air Force field in Ipswich, Massachusetts (Naka and Ward 2000, 200).

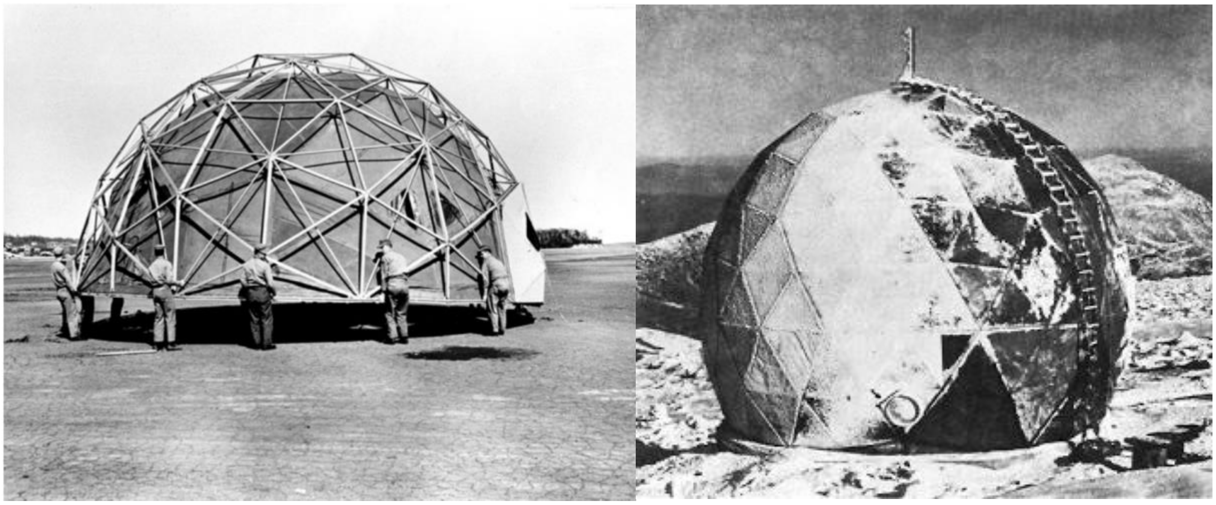

Figure 8: *Left*, US Marine Corps Dome Installation, Quantico VA, 1954; *Right*, Radome testing on Mount Washington, New Hampshire, 1954-55

The structure is intriguing as an artifact of scientific, aesthetic, and military histories. Embodied experimentation and the evolution of technological means are embedded within the shape and potential of the radome—what Fuller described as "architecture out of a laboratory" (Wong 1999, 250). The laboratory, however, is one profoundly linked with the industry of war. As has been discussed with Fuller's early realizations around the militaristic potential of his design, the laboratory is not dissociated from the socio-political climate. In fact, the laboratory here being Lincoln Laboratory, founded by the Department of Defense, is representative of technology and politics as couple. As William Borden so aptly put it in his 1946 book *There Will Be No Time*, "There is no geographical approach to U.S. strategy which does not wind up finally in the laboratory" (Borden 1946, 166).

While the Marine domes were prototyped in full view of the public, the DEW Line radomes required a high level of security clearance (Wong 1999 320). Secrecy was utilized as a Cold War strategy as a way to limit and control information flows, and to restrict debate of controversial research. As the Summer Studies remained secret, so did the DEW Line prototyping with Lincoln Laboratory, Western Electric, and Fuller's Geodesics team. This veil of secrecy was also strategic on Fuller's part, as his role in military research, while profitable for his larger dome enterprise, might have been viewed critically by architectural contemporaries. The Geodesic identity was focused on portraying a streamlined architecture, available to the masses, whereas the radome encapsulated a deeply militarized project to which only those with a high level of security clearance were granted access.

Fuller introduced the aesthetic component of the program. The dome itself, as can be seen in later decades with its appropriation into counter-cultural movements, epitomizes an aesthetic of lightness and technological regularity with its straight lines and repeating patterns, forming a true sphere; an eye-catching form, easily manufactured en masse. The aestheticized radome is, on its own, devoid of political implication. As a fundamentally technological enterprise, Fuller was able to separate himself from the deeply militarized employment of his design.[30] The dome structure is certainly the most famous of Fuller's creations, and has over time been used widely and for a large variety of purposes. Conceived as "environmental valves, differentiating human ecological patterns from all other patterns," (quoted in Chu and Trujillo 2009, 94) "operating as a valve between inside and outside" (Chu and Trujillo 2009, 94)—inside and outside the harsh

[30] "While Fuller claimed that he had no "proprietary interests," he nevertheless benefitted from the royalties accruing to both these licenses – Western Electric in procuring the Fuller geodesic radomes, and Geometrics in adopting his patented design. Under this arrangement, Geometrics operated directly as a commercial front for Fuller's structural systems, enabling Fuller to act in a detached manner from the world of business." (Wong 1999, 333)

arctic environment, inside and outside national boundaries, and inside and outside technology and human intervention—the dome as boundary is an apt description. This more pared down description is not to say that Fuller was naïve to its function, in fact, his early recognition of the design's potential use in a strategic military capacity, easily replicable and mass produced, is an acknowledgement of war-time prospect.

Fuller's ideology surrounding war is worth mentioning within this context. Adopted as a technological figure of counter-cultural movements, his designs associated with hippie communes and eco-villages, his business was dependent upon defense contracts. In a 1995 interview, one of Fuller's collaborators, William (Bill) Wainwright, said, "We generated enough money so that he could go on being Bucky Fuller, which was a more useful function than designing radomes… I believe that the radome program was by far the biggest moneymaker in the geodesic world" (quoted in Wong 1999, 334).[31] Defense contracts, specifically the radome program with Lincoln Laboratory and the Air Force, financed Fuller's geodesic enterprise. This is controversial for a figure publicly associated with peace movements and speculative, abstract projects[32]. His rationale was tied to notions of self-preservation and preparedness, as well as technological innovation: "The Marines' formidable efficiency has gained through their ability to maintain scientific weapons at any advanced point by incorporating shelters in the form of geodesic radomes as weapons thus making possible the aeronautical delivery of scientific environment controls simultaneous with advanced position landings" (Quoted in Wong 1999, 336). As a behind-the-scenes figure of the Cold War, Fuller saw the geodesic radome as

[31] "On average, the royalty per radome was approximately $2,000; and even at this conservative estimate, Fuller's royalty on the entire geodesic rigid radome program alone was no less than two million dollars" (Wong 1999, 334).
[32] For example, Fuller developed a project titled "Dome Over Manhattan" that literally envisioned placing a dome over part of Manhattan to control energy use and reduce changes in climate. Even more conceptual was his project and book titled *Operating Manual for Spaceship Earth*.

fulfilling an “ideological and political role in affirming American technological ingenuity” (Wong 1999, 362). Yet, he still separated himself from the undercurrents of warning, and instead extolled the capacity for technology to bring about peace. He explained that a “totally controlled environment will constitute a sustainable world ‘peace’” (quoted in Wong 1999, 362)[33].

Geodesics captured the promise of both war and peace; the vast distance between these worlds, both symbolically and geographically, allowed for them to exist simultaneously. Fuller is not known for his military contracts. In fact, it is rare to find more than a passing mention in the numerous texts written about him. Within the context of the DEW line, Fuller’s design for a rigid radome manipulated a harsh environment and functioned as a technology of control. As an architectural artifact, the design was a powerfully boundary-laden object that facilitated a system of warning in the far north.

[33] Fuller continues, “The side which has the superior fly-in-able environment controls will win the peace…. Cool barrel of the Geodesic structures as weapons—inadvertently adopted by the Marine Corps—is the barrel which can now hit directly, instantly, and effectively at the heart of every peace-time economic pattern the world around without unleashing hot war—and if we win the cool war first, then there will be no hot war” (quoted in Wong 1999, 362).

CHAPTER 3:
ENVIRONMENTS OF WARNING

The DEW Line construction process was a complex maneuver, requiring strategic planning around time, weather, populations, and landscape, aiding in the provision of warning. The terrain for which the DEW Line was intended was, at least in part, unknown and unmapped. Western Electric's *DEW Line Story* claims that "[s]ome station sites had never been seen from the ground by white men before the siting crews arrived" (*DEW Line Story*, Western Electric). As early as 1953, Western Electric was beginning reconnaissance flights over the selected DEW Line route to identify viable station sites—"Maps, hydrographic charts and RCAF photographs were studied with a view to pinpointing potential sites that, from the standpoint of strategic location and topography, were readily accessible to logistical supply routes via water, land and air, and best lent themselves to DEW Line Operations" (*DEW Line Story*, Western Electric, 16).

The sites themselves required an intricate set of necessary criteria, all of which made scarce by the harsh landscape and minimal knowledge of the region. They necessitated the following: easy access by water for the initial construction phase and subsequent resupplying, access via land travel to other stations, unencumbered radar ranges, a proximity to airstrips, sturdy ground for constructing the bases (or if not, access to a supply of gravel), a clear radar view to the north, fresh water, and access to local labor by way of native settlements (Neufeld 2002, 7). The Western portion of the line was flecked intermittently with towns, the largest being Point Barrow, then with a population of approximately one thousand, all indigenous (*DEW Line Story*, Western Electric). In comparison to the Eastern portion, however, the West was populated; the occasional Royal Canadian Mounted Police Post and settlement of migrant indigenous people kept the 2000 miles between the Mackenzie River and Baffin Island from being entirely uninhabited (*DEW Line Story*, Western Electric). Western Electric's *DEW Line Story* describes the line's location as a "flat, treeless tundra along the shores of the Arctic Ocean. It is soggy muskeg during the short warm period; then for nine months of the year it lies covered with so much ice and snow that it's hard to tell where the land ends and the sea begins. It makes little difference, anyway, for the thick sea ice is practically as solid and substantial as the earth itself" (*DEW Line Story*, Western Electric). The region's foreign landscape at once made the project a viable distant line of defense, and made the construction a scientific feat—rendering the DEW Line at once lucrative and nearly impossible.

As a 1953 study by the Air Force's Arctic, Desert, and Tropic Information Center (ADTIC)—a curious amalgam of extreme environments—of survival experiences in the north, yet another study that preempted the actual deployment of construction materials, warned, the region was "not to be entered casually or in an unprepared state. The environment presents unique problems not met elsewhere in the world" (Lackenbauer and Farish 2007, 927). Though materials were tested in cold climates, the remoteness of the proposed DEW Line location was a major variable. It is likely that many of the Western Electric topographical maps were the first of its kind in that region. By Western Electric's account, mapping teams traveled more than one million miles and reviewed more than eighty-thousand aerial photographs during the planning process (*DEW Line Story*, Western Electric). The program exemplifies a conquering of nature, reconceiving it into something increasingly legible; Western notions of civility with paved roads and access to air travel translated onto an untouched landscape.

The pervasive notion and rhetoric around the land being a blank slate, uninhabited and unsettled, is most obviously a falsehood, and signifies precisely the moment in history in which this project was being developed. The land was inhabited by a range of indigenous populations, dating back centuries (Zellen 2008, xxi). In fact, the agreement made between the US and Canada that allowed for the construction of stations on Canadian territory explicitly outlined regulations on interactions with its indigenous people. The heading "Matters Affecting Canadian Eskimos" is introduced with the following disclaimer:

> "The Eskimos of Canada are in a primitive state of social development. It is important that these people be not subjected unduly to disruption of their hunting economy, exposure to diseases against which their immunity is often low, or other effects of the presence of white men which might be injurious to them. It is therefore necessary to have certain regulations to govern contact with and matters affecting Canadian Eskimos" (Annex, Statement of Conditions to Govern the Establishment of a DEW System in Canadian Territory, point 13).

The Department of Northern Affairs and National Resources was the approving body on contact with "Eskimos," ranging from employment to medical care, construction on or near settlements, burial places, and hunting grounds, and disposal of waste. Should the Department of Northern Affairs and National Resources certify it, decisions could be made by the Royal Canadian Mounted Police. Indigenous labor was also a factor in the agreements between the United States and Canada during this period, including numbers employed, types of compensation, and the interruption of nomadic lifestyles.[34] Of particular interest, is the clause regarding the use of land for the station that might have previously been occupied by locals for settlements, burial places, or hunting grounds. The agreement stipulates: "the United States shall be responsible for the removal of the settlement, burial ground, etc., to a location acceptable to the Department of Northern Affairs and National Resources." Rather than requiring that the project relocate to accommodate settlements of the likes of burial grounds, the condition is for it to be relocated.

[34] In a more recent article in *The Star*, a man was interviewed, recollecting on what it was like when the DEW Line apparatus manifested: "When the white people came, my body absorbed the white culture really well."

By the end of 1954, the Canadian government signed off on the construction of DEW Line stations on Canadian soil. The agreement specifies that the United States would be responsible for all construction and operation costs, with the exception of Canadian military personnel should they be required. The period of operation was set to ten years, subject to the availability of funds and mutual defense needs. When construction began in the Spring of 1955, a strict schedule had to be followed in order to take advantage of the short months of the year in which climate would accommodate construction. Two out of four seasons were workable, and materials would have to be imported from many different locations, through many different means—water, land, and air.[35]

The amount of material transported to the line in the far north is remarkable, and is perhaps best illustrated in facts. “The logistics of DEW Line construction can be told only in superlatives. The sealifts provided by the Navy, and the job of moving the machines, fuel oil and supplies from ships to shore to DEW Line sites don’t by Army Personnel was one of the largest projects of its kind in history” (Sheppard and White 2017, 301). Some available statistics include the transportation of: 12,000 acres of bedsheets, 9.6 million cubic yards of gravel, 22,000 tons of food, 75 million gallons of petroleum—this made up part of the 140,400 tons of material transported by aircraft[36], 281,600 tons by sea, and included 45,000 commercial flights over the course of thirty-two months (*DEW Line Story*, Western Electric, 19). In one example, it is stated

[35] “By ship, supplies were sailed eastward and westward, respectively, from the Pacific and Atlantic. By rail and truck they moved northward to Waterways, Alberta, thence, by barges on Mackenzie River, they were floated northwestward to six sites. Also by rail, supplies were transported to Churchill, Canada, from whence they were airlifted northward to several points.” (*A History of the DEW Line*, 28)

[36] In 1955 alone, 127,000 tons were delivered by sealift, even given the fact that waterways between Point Barrow and Herschel Island experienced record-breaking ice conditions that year. (*A History of the DEW Line*, 30)

that the amount of gravel transported for the construction could have built a road spanning from Vancouver to Halifax—from one coast to the other (Bird 1959).

Since all supplies had to be brought into the region, the logistics of transportation were paramount to the timely construction of the line. A report from 1955 notes this: "Because of the geographical location of the stations, all equipment, material, supplies, including POL [petroleum, oil and lubricants] and sustenance items must be either flown in, delivered during the very short period of the summer by sea, or hauled laterally to a site by cat train operating in the winter season" (Lackenbauer 2013, 14).[37] The logistical design of the DEW Line required stations to be placed approximately every 50 miles, with a combination of main stations, intermediate stations, and auxiliary stations. The auxiliary stations were the smallest of the three and were only visited by crews every few months. The intermediate stations were continually staffed with at least one station chief, a cook, and a mechanic. The largest station type served as significant regional hubs, a "self-contained community, set in the middle of nowhere" (*DEW Line Story*, Western Electric, 12). The seven main stations on the line varied in numbers of crew, but featured resources such as libraries, entertainment, and recreation equipment (Sheppard and White, 2017, 328). At first, the recreational equipment had been considered by the employees to be inadequate, so with an influx of new personnel came extensive additions to the entertainment repertoire.[38]

[37] Lackenbauer continues, "Convoys of up to 57 vessels and 15,000 men (in the case of the western sealift during the 1955 season) plied the Arctic waters, charting the Arctic coastline and waterways through the southern islands of the Arctic archipelago. Annual sealift operations established new sea routes, improved knowledge of ice conditions, and resupplied Arctic settlements" (Lackenbauer 2013,14).

[38] One account from Lynden T. Harris is particularly detailed: "Each station was provisioned a major library with hundreds of books; weekly newspapers, and monthly magazines. All kinds of games were provided – cards, chess, checkers, ping pong, pool tables, fishing equipment and some outside supplies such as footballs, softballs, etc. Bridge, pinochle, poker and checkers were major games played after dinner and on Sunday afternoon. Poker was normally "penny" ante and the games never got out of hand or created problems. Due to inadequate recreational space, the dining room was utilized, after clean up

The main stations incorporated a design that was unique to the arctic, in which all frequently accessed facilities were housed in two long structures, connected by an enclosed overhead bridge—forming an “H” shape. All structures were sure to be located off of the ground, and strategically angled with respect to wind patterns, to protect particularly large snow drifts from burying them. The auxiliary and intermediate stations were variations off of this general design language, but certainly remained far more compact. What linked the stations in purpose and design was the necessity of a structure to house the radar. The weathertight dome that protected the radar antenna at both the main and auxiliary stations was built on a platform and steel stilts up to fifty feet above the permafrost ground covering. Located nearby, large reflectors aid in the communication network. The radome-covered radar at the main and auxiliary stations utilized a dual-beam radar system, with both beams functioning simultaneously. At the smaller intermediate stations, another type of radar “fills in the chinks in the electronic fence” (*DEW Line Story*, Western Electric, 14) using a Doppler system that covered lower-altitude gaps. These radar, however, were unable to provide some of the more specified data that the larger dual-beam radar could detect, such as speed and direction. Not long after, with technological advancements altering the DEW Line’s functionality, the intermediate stations would be the first to be disabled.

Buckminster Fuller's radome design engaged with the environment in its capacity to construct a controlled space, separated from the harsh terrain outside the thin, modular barrier. In fact, this functional attribute is woven into Fuller's understanding of the design as a potential tool for defense. Fuller asserted that a "totally controlled environment will constitute a sustainable

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each night to permit employees to have an area to play cards and read. Each station was provided a tape recorder and tapes of music; a 35mm movie projector and 3 movies per week. Again, due to overpopulation, the dining facility had to be used as a theater. In order to go a year without seeing the same movie twice, Hollywood would have to produce 156 new movies each year – an impossibility. We just ran the same movies over and over about every couple of months” (Wilson).

world 'peace'" (quoted in Wong 1999, 362). This environment could be scaled up to the enclosure of entire communities and cities and was an integral system for the evolution of technologically advanced industrial activity (Pang 1996, 181). By commanding dominance over environment in the form of an air-tight partition, Fuller saw the radome as a symbol of effective American ascendancy[39] over untamed parts of the globe. Technological systems representing modernization were implanted in the environment, using a mechanism of warning to assert power over the region.

In many ways, the DEW Line functioned as a modernizing[40] agent. These infrastructural systems, deployed in the distant reaches of the continent, engaged with a rationale of warning against potential destruction through a means of technological advancement. Certainly one can find the inherent imperial undertones of "advancing" communities with American notions of modernity in this project. The physical transformation of the environment most significantly impacted the indigenous populations of the regions (*fig. 9*), where some scholars have argued that the project was a "conspiratorial, concerted effort by the federal government to lure Inuit into settlements, where they could be controlled, overwhelmed with social services, and ensnared in the web of welfare colonialism" (Lackenbauer 2017, 336). Lackenbauer, in his essay in the

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[39] Fuller saw the adoption of the dome globally as the adoption of "the American economy and the democratic processes which provide the synergetic strength of the USA" (quoted in Pang 1996, 183).

[40] Further study might examine the role of modernism in the Arctic, or "high modernism" as Lackenbauer asserts. Modernity and modernism were deployed in the region in numerous ways. For example, the Frobisher Development Group Committee, which was formed in 1958, was devoted to establishing a model town in the arctic. A joint collaboration between the Department of Public Works and the Department of Northern Affairs and Resources, the project imagined housing one thousand people in a series of clustered towers, all radiating around a central dome (Lackenbauer 2017, 34). Design development can be seen in *The Canadian Architect* issue from November of 1958. This relates back to the DEW Line in many ways, one significant reason being the planning and design process that occurred *outside* of the arctic—"Even the test-site for the DEW Line was established in a farmer's field in Illinois, an example of how technologies were meant to be deployed to a distant frontier rather than conceived within the arctic as a unique place" (Lackenbauer 2017, 340).

compilation *Many Norths*, argues that this view of a "grand diabolical scheme" is "fantasy," and that these consequences were in fact unintended. Instead, he focuses on the transformation of the north during this time as not just a physical one, but also a perceptual one, in which the public perception of the region shifted from "terra incognita to defensible frontier" (Lackenbauer 2017, 301). This alternative to the tabula rasa of the arctic was inscribed in the land through manifested changes in the terrain, in which one cannot be separated from the other.

Figure 9: "Native Eskimoes looking at newspaper in dump," photo by Lyall LaLonde, 1961

Ultimately, the construction of the DEW Line across the 69th parallel in the far north functioned as a mechanism for making a foreign landscape legible to western defense systems. With the development and operation of the stations, the "psychological barrier of the remote north was broken down" (Neufeld 1998, 12). The line functioned for several years before technological advances surpassed the infrastructure it was founded upon. By the early- to mid-1960s, radar technology began to be updated, and the DEW Line sites abandoned.

On July 16, 1963, Canadian newspaper *The Globe and Mail* published an article with the headline "28 Stations on DEW Line Abandoned." The article began, "Ottawa- Canada and the

United States have agreed to abandon 28 of the smaller stations of the Distant Early Warning Line radar chain." Just a couple of years after the line became fully operational, the two countries initiated the process of rendering the stations obsolete, a process that would waffle between periods of rapid abandonment and a slower withdrawal. The environment was embedded with an ideology of warning with the development and perpetual decay of the DEW Line—a process that continues to this day.

In beginning to close the smaller stations, the defense institutions signaled towards a shift in priorities. The *Globe and Mail* article continues, "Department officials said the move is part of the new cost-cutting approach to the United States' gigantic military budget now progressing under the direction of Defense Secretary Robert McNamara" (Westall 1963, 25). The reporter explains, "the U.S. Government had suggested that a reappraisal of the effectiveness of the line indicated that certain adjustments may be made in the equipment configuration and still provide acceptable warning." The line's effectiveness was being scrutinized, similar to the multitude of research groups and reports that evaluated it's potential prior to its physical construction.

The reconsideration of the DEW Line's effectiveness was not purely related to McNamara's "cost-cutting" agenda. The Cold War outlook had shifted with technological developments in the Soviet Union. Just as the evidence of the Soviet's nuclear capabilities kickstarted the hurried DEW Line construction, evidence of the development of intercontinental ballistic missiles gave pause to the north's function as an environment of warning. The hypothetical of intercontinental ballistic missiles (ICBM's) replacing manned bombers became a real possibility with the Soviet's launch of Sputnik in 1957. The DEW Line would no longer be able to warn against a Soviet attack on two fronts: speed and altitude. Rocket technology provided the basis for an operational ICBM to inflict a nuclear attack with a flight time of a mere thirty minutes, thus rendering the three to six hours of warning insignificant. The DEW Line radar's maximum altitude detection was 70,000 feet; Soviet ICBM's were likely capable of reaching sub-orbital heights, crossing over the line by a significant distance. As such, the process of dismantling and re-appropriating the DEW Line stations began.

The conclusion of *The Globe and Mail* article looks to the then future of the line: "Walter G. Dinsdale, former minister of northern affairs, asked if the changes had taken into consideration 'the diminishing bomber threat.' No, said Mr. Hellyer, but he said that in view of Mr. Dinsdale's previous interests he would be glad to assure him that every effort would be made to use the facilities as constructively as possible" (Westall 1963). The promise of constructive use of the extraordinarily expensive infrastructure project was largely overlooked, as the out of sight, out of mind principle of the distant north provided a veil of isolation from apprehensive citizens.

The argument has been made that the DEW Line functioned as a modernizing force in the far northern region. While opinions vary on the value or ethics of this shift, the fact of the shift itself is undeniable. Materials such as sheet metal, steel, and plywood were brought into the region for the first time (Lackenbauer 2017, 121). By 1972, remnants of the DEW line, its construction, and maintenance were scattered around the environment. The range of materials left behind is immense: from drums of oil to building debris, batteries to asbestos. Inuit communities surrounding the stations, which had migrated in an ad-hoc manner, scavenged the sites and dumps for scrap metal that was left behind, which Lackenbauer asserts caused a high mortality rate (Lackenbauer 2017, 42). An article in *The Star* introduces David Kanatsiak, an Inuit who had moved around the region as a child, who recalled learning that discarded building material from FOX-Main DEW line station was left in a mountainous heap, ripe for the taking—

people scavenged wood, metal, sheets, clothes, and even discarded food.[41] Shack-style housing was assembled from these materials, which one critic states "rivaled those found in many third world countries" (Tester 2009, 138). "From this," Lackenbauer states, "it seems that architecture is responsible, directly or indirectly, for many of the social and cultural ills of the Candian North from the 1950s – 1970s" (Lackenbauer 2017, 44).[42]

Figure 10: *Left and Right,* Historic American Buildings Survey, *POW-3 Distant Early Warning Line Station, Bullen Point, Prudhoe Bay, North Slope Borough*, 1933; *Right*, Back of master electrical fuse panel and generator

Photographs of the abandoned stations (*fig. 10, fig. 11*) show vacant spaces with peeling paint and crumbling ventilation systems, electrical fuses pulled apart and wires exposed. A more recent wave of interest in the northern climate has sparked expeditions to the abandoned stations. Photographs like those of Toke Brødsgaard's show station interiors turned over as if they had been raided—drawers left open, frames dangling from the wall, file cabinets ajar. It is unclear if

[41] Kanatsiak also recalls the dump being located on the ice; "when spring and summer came, the ice melted and the whole dump vanished into the sea" (Contenta 2012).
[42] "The shacks were public health "hellholes," with no floors, leaky roofs and no sanitation. Epidemics of tuberculosis and chicken pox broke out. Tester says that the Inuit mortality rate "with the onset of 'modernization' in the 1950s actually rises." He notes that in some communities, four out of 10 infants died" (Contenta 2012)

the stations were left like this when decommissioned, or if it is the result of indigenous communities looking for usable materials; the latter is the more widely accepted account. In either case, an overwhelming disregard for the impact these empty stations might have on the landscape is undeniable. The icy tundra of the distant north provided the ideal location for an abandoned government program that had little to show for its fiscal and environmental cost.

Figure 11: *Left and Right*, Toke Brødsgaard, *Abandoned DEW Line site*, DYE-2

The other major effect of the introduction and speedy abandonment of the DEW Line in the arctic was its continued impact on the environment. As such, it functions in its aftermath as its own type of warning, a warning of what happens to rapidly constructed infrastructure in a changing climate. Barry Scott Zellen, in his book titled *Breaking the Ice: From Land Claims to Tribal Sovereignty in the Arctic*, writes that the project "did not require an environmental assessment or review process, nor any local or regional regulatory approvals or oversight. As strict military missions, they were accomplished using military know-how and efficiency: completion of their construction as quickly as possible was the primary objective" (Zellen 2008, 246). Waste was accounted for in the early agreements for the project, in the "Statement of Conditions to Govern the Establishment of a Distant Early Warning System on Canadian Territory." The agreement reads:

> Ownership of all removable property brought into Canada or purchased in Canada and placed on the sites, including readily dismountable structures, shall remain in the United States. The United States shall have the unrestricted right of removing or disposing of all such property, PROVIDED that the removal or disposition shall not impair the operation of any installation whose discontinuance has not been determined in accordance with the provisions of paragraph 9 above, and PROVIDED further that removal or disposition takes place within a reasonable time after the date on which the operation of the installation has been discontinued.

The agreement uses the language of the United States having the “right” to remove property, rather than the responsibility. Several paragraphs later, the issue is revisited in relation to the indigenous population under the heading “Matters Affecting Canadian Eskimos.” It reads:

> There shall be no local disposal in the north of supplies or materials of any kind except with the concurrence of the Department of Northern Affairs and National Resources, or the Royal Canadian Mounted Police acting on its behalf. Local disposal of waste shall be carried out in a manner acceptable to the Department of Northern Affairs and National Resources, or the Royal Canadian Mounted Police acting on its behalf.

The Department of Northern Affairs and National Resources was established in 1953 and today is called the Department of Indian Affairs and Northern Development (DIAND), or Indigenous and Northern Affairs Canada (INAC).[43] With the gradual closing of the stations, the Canadian Department of National Defense transferred the infrastructure and its accompanying liability to the hands of the Department of Indian and Northern Affairs, a symbolic shift in the perception of threat and the line’s viability as an environment of warning.

Between 1989 and 1993, just prior to the closure of the last stations, assessments were convened for how to go about remediating the existing materials. The DEW Line Clean Up Protocol, or Criteria, was a government directive that addressed toxic and volatile waste as well as landfill leeching and other debris at the decommissioned DEW sites. The team of experts were

[43] “As Eddie Dillon, former Mayor of Tuktoyaktuk, observed, the long presence of a DEW Line site in his Arctic coastal village did not lead to substantial social integration of the military and the Inuvialuit. As time when by the DEW Line became more a reminder of the continued gulf that existed between these two very different worlds that met there, rather than a melting pot for them” (quoted in Zellen 2008, 246).

privy to the same conditions the DEW line construction workers had navigated decades prior. The last of the DEW Line sites was closed in 1993, thirty years after the initial abandonment of the smallest intermediate stations. Five years after the last station closed, attention officially turned toward the question of remediation. Over the years, materials and waste were discarded in makeshift dumps, some left in situ, and others foraged by local communities for shelter. K.L. Capozza's article in the *Bulletin of Atomic Scientists* titled "The DEW Line: Ditched Drums and All" references "mountains of rusted oil drums, leaking transformers, discarded heavy machinery, solvents, and batteries" (Capozza 2002, 14). An understanding of the materials brought into the arctic during the rapid months of construction provides insight into just what types of harmful materials were left behind (*fig. 12)*.

Figure 12: DEW Line cleanup at Cape Dyer, eastern edge of Baffin Island, *Toronto Star*

One particularly pressing concern was the remediation of polychlorinated biphenyls (PCB's)[44], of which thirty tons were brought into the region in the mid- to late-fifties for both

[44] Recent scientific knowledge has shown that PCB's can cause cancer, bacterial infection, liver lesions, and genetic defects in animals, which the local communities hunt and eat (Capozza 2002, 15). Point Hope, a small hunting community near the Cape Lisbourne DEW line site, is one such instance of

construction and maintenance (Capozza 2002, 14). PCB's, which have since been banned, were mainly used in transformers made to withstand the extreme temperatures and high electrical currents; their composition prevents them from breaking down in the environment. These, and other toxic substances, have begun leeching into the environment.[45] Robert Eno, a Canadian hazardous waste specialist, has observed of the abandoned sites, "looking at what we found there, you'd think that the Americans took big hoses and sprayed PCB liquid all over the site" (quoted in Capozza 2002, 15). Eno was a member of the team that first assessed the sites in the early nineties, discovering the previously unknown situation with PCBs. A "halo of contamination" was found surrounding the former DEW stations (Contenta 2012).[46]

The remediation protocol was aimed at making the region environmentally safe—as Lackenbauer and Farish so aptly put it, "environmental and human security became inseparable" (Lackenbauer and Farish 2007, 940). The toxic waste such as the materials contaminated with PCBs would need to be transported to allocated sites for incineration. Less hazardous waste is buried on site, using an established landfill technique of gravel walls and coverings. However, there is concern that with the changing climate, the landfills will quickly weaken. In one instance, at a site in the Northwest Territories, a rainstorm caused the side of a landfill to erode, which then had to be rebuilt (Contenta 2012). Even more concerning is the gradual melting of

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pollution from the station impacting local food systems. The mayor of Point Hope, Caroline Canon, wrote in 2002 that "we know that there's a possibility of our food being affected, but we believe that the food we eat is part of who we are" (quoted in Capozza 2002, 16).

[45] "The frigid Arctic climate and lack of sunlight impede the natural breakdown of pollution. Five decades later, PCB, heavy metal, and fuel contamination persist in the delicate Arctic ecosystem. 'In the Arctic, fat is the economy of life. Animals eat each other's fat in order to stay warm because it's the most efficient way of transferring heat and energy," says Hild. 'When they [PCBs] get into the environment, they don't break down, and they bio-accumulate because they stick to fat and move through the food chain'" (Capozza 2002, 15).

[46] One study used the Potential Environmental Risk Classification system to evaluate the landfills, which received a score of 150. On their scale, above 100 classifies the risk at "high" (Nahir, Ankersmit, Ingham 2004).

the region's permafrost, instituting the need for higher landfill coverings. The remediation team has advised that the goal is to "prevent the summer thaw from causing the landfill to leach" (Contenta 2012).

The remediation proposal was extensive and costly. One source valued the cost of Canadian clean-up at $470 million, another at $583 million. While precise records for the overall cost of the construction of the DEW line are either unavailable or remain classified, popular opinion estimates that, when adjusted for inflation, it approaches $750 million. This does not account for materials and maintenance after the initial construction phase. By 1998, after enough diplomatic pressure from Canadian government, the United States agreed to contribute $100 million to the clean-up effort. However, the funds were only transferrable in the form of credit towards the purchase of American military equipment. The "arms-for-cleanup deal," as Capozza has deemed it, is an unsurprising conclusion to the United States' military undertaking on Canadian soil.

The environment itself, as a legacy of geographies and infrastructures of warning, is left with the DEW Line hardware seeping into its systems. Contemporary understandings of the distant north have participated in the promise of warning as an exercise in boundary-making, and as a symbol of a networked future. The DEW Line warns against these potential environmental futures. Though the DEW Line cannot be separated from its history as an agent of warning, that history itself is largely erased.

CONCLUSION

By 2014, the Canadian Department of National Defense announced that the DEW Line clean-up project was complete. Federal Treasury Board President Tony Clement stated that the "remediation work of each site typically consisted of demolition of infrastructure, cleaning up or removing of contaminated soils, stabilizing of landfill sites and the construction of new and innovatively engineered landfills designed to stand the test of time" (CBC News 2014). The DEW Line, as has become increasingly clear, was not built to stand the test of time in any sustainably-minded sense of the phrase. Rather, its resilience against the natural decay of time was second to strengthening the Line's fortitude against its surrounding environment. Contemporary knowledge of materials such as PCBs showcase an alternative view of longevity—one that, in its very persistence, manages to permanently damage the land it was trying to protect. The history of the DEW Line, told accurately, embodies multiple such contradictions. Its legacy, though shrouded in layers of government secrecy, includes the transformation of Arctic geographies and imaginaries, as well as an object lesson in how militaristic technologies are taken up as part of everyday life and transformed to have wildly different cultural meanings.

The geographic transformation of global space that occurred with technological advancements in air travel remade the Arctic as a frontier of the North American continent. With the understanding of routes by air rather than by sea or land, the region was suddenly situated at the heart of Cold War tensions, an unbounded border that needed to be secured. Thus, geography plays a role in the DEW Line's story through its dynamic with assertions of territory and control. Alongside newly developed technologies in both radio and aeronautics, topographic space became increasingly boundless. Communication and travel opened up the possibility of globalization like never before. Geographic imaginings of the north were permanently altered with the use of technology to create boundaries.

The DEW Line is evidence of an ideology of warning completely inseparable from power and control. As a piece of infrastructure it can be understood as both symbolic—documented and theorized through the numerous research groups and published reports—as well as material—physically manifested through architectural forms. As such, the DEW Line produces a built environment with its own history. Yet, as a tactical measure that impacted past and future understandings of northern boundaries, the DEW Line is surprisingly absent from contemporary discourse in many of its related fields. There are numerous explanations for this, some of which are kept secure by military and inter-governmental agreements. From the records that are publically available, it does not seem that the DEW Line ever had the opportunity to fulfill its call to warn of incoming attack from the north. While warning takes many shapes, and its sheer presence in the arctic surely had an effect, the trip wire along the 69th parallel was established with technologies that rapidly became obsolete. The legacy of this immense project, then, is not just underpinning an ideology of warning, but also one of erasure.

One particularly vivid narrative of erasure is the symbolic legacy of the geodesic dome design. As early as 1952, the geodesic rigid radome was exhibited at New York's Museum of Modern Art in an exhibit titled "Two Houses, New Ways to Build." Outside of the context of the DEW Line, and its functional, militaristic purpose, the structure was displayed as an art object, a product of design potential and innovative shelters. The original function of the geodesic rigid radome was mentioned briefly in the wall text, in which curator Arthur Drexler wrote that "this particular dome is used to house radar installations on the Arctic Distant Early Warning Line" (Chu and Trujillo 2009, 129). Instead, the curator emphasized the radome's potential future as an infrastructure of industry, enclosing TV studios, ball parks, swimming pools, and houses (Chu and Trujillo 2009, 129-30). As the DEW Line was just taking shape, its legacy as a militarized warning system was already being erased.

Figure 13: The Community Building at Drop City, ca. 1967

As many architectural and cultural scholars have noted, the geodesic dome perhaps most glaringly signifies the counter-cultural prospects of the 1960s and 70s—an "empty vessel in which a new, egalitarian society could be contained" (Pang 1996, 167). The Drop City domes in Trinidad, Colorado, (*fig. 13*) an icon of communes appropriating the dome design, was constructed using building manuals such as *Domebook* out of pieced together materials including car hoods, plywood, and wire. The cooperative nature of these communities was intricately tied to the politics of boundary-making: the egalitarian society would be "contained" within the jumbled dome. Fuller, the paragon of alternative architecture and the promise of design science, was held up by what today we would recognize as the military-industrial complex. How does this complicate our understanding of iconic figures like Fuller? We come to understand Fuller as at once a participant in the ideology of warning that was so pervasive at the time, yet simultaneously celebrated for his pacifist visions of world peace. What is clear is that visionary ideas about the built environment are never simple, and always reverberate outwards. Visionary ideas about warning function similarly.

What does the legacy of the DEW Line, told accurately, including the ways it impacted geographies, infrastructures, and environments across the continent, tell us about American notions of power? How might we view the Arctic in light of this history? What does the erasure of all traces of military origins in the popular imaginary of the geodesic dome reveal about the power of ideologies of warning and security to permeate everyday life? Such questions are especially urgent as contemporary forms of securitization, largely focused on surveillance, emerge directly out of the warning ideologies embodied by the DEW Line. Indeed, though such projects use ever more advanced technologies, they still operate and exploit the same delicate intersection of geography, infrastructure, and environment as the DEW Line. Surveillance and warning are close allies; as we enter an age in which mechanisms for surveillance penetrate all facets of modern life, lessons can and should be learned from legacies of the Distant Early Warning Line.

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