Such communities develop on the periphery of trade areas along natural routes of communication. Unlike cities that function as central places in a hexagonal or circular service area, a gateway city is located to one side of its service hinterland and has "an elongated, fanshaped service area which extends outward in the direction away from the national core area" (*25*). Such gateway cities are market communities serving both local and long-distance trade. Chalcatzingo was a highland center that also fulfilled a gateway function for the Gulf Coast (and other areas of demand to the southeast) (*26*).

We believe that a small number of Gulf Coast elite were among those present on the site, but that the Olmec aspects of Chalcatzingo should not be overstressed. While we have mentioned the Middle Formative Gulf Coast influences at the site, more than 98 percent of the artifacts relate to Chalcatzingo as a part of the local highland culture. The site's highland role was equally if not more important than its interactions with the Gulf Coast.

References and Notes

1. M. Coe, in *Magnetometer Survey of the La Venta Pyramid and Other Papers on Mexican Archaeology* (Archaeological Research Facility, Univ. of California, Berkeley, 1970), No. 8, pp. 21–34.
2. Public architecture with lime plaster appears in the Tierras Largas phase, 1450 to 1150 B.C., in Oaxaca [K. Flannery, Ed., *Preliminary Archaeological Investigations in the Valley of Oaxaca, Mexico, 1966–1969* (University of Michigan, mimeographed);_____ and J. Marcus, unpublished manuscript on file in the Department of Anthropology, University of Michigan]. Stone-faced ceremonial architecture that may be as old as monumental architecture on the Gulf Coast occurs in at least two sites in Chiapas [T. Lee, in *Mesoamerican Archaeology, New Approaches*, N. Hammond, Ed. (Univ. of Texas Press, Austin, 1974), pp. 1–20]. D.C.G. believes that early sophisticated ceramics in West Mexico from about 1400 to 1200 B.C. indicate cultural complexity there as well [D. Grove, *Am. Anthropol.* **75**, 1138 (1973); J. Oliveros, in *The Archaeology of West Mexico*, B. Bell, Ed. (West Mexican Society for Advanced Study, Jalisco, Mexico, 1974), pp. 182–20]; I. Kelly, in *ibid*, pp. 206–211].
3. Prior to our research, test excavations were carried out at the site in 1952 by R. P. Chan [*Inst. Nac. Antropol. Hist. Mex. Inf. No. 4* (1955)].
4. C. Gay, *Chalcacingo* (International Scholarly Book Services, Portland, Ore., 1972).
5. I. Bernal, *The Olmec World* (Univ. of California Press, Berkeley, 1969), p. 141.
6. P. Drucker, R. Heizer, R. Squier, *Excavations at La Venta, Tabasco, 1955* (Bulletin 170, Government Printing Office, Washington, D.C., 1959), pp. 253–270.
7. D. Grove, in *Dumbarton Oaks Conference on the Olmec*, E. Benson, Ed. (Dumbarton Oaks, Washington, D.C., 1968), pp. 179–185.
8. P. Tolstoy, in *Chronologies in New World Archaeology*, C. Meighan, Ed. (Seminar Press, New York, in press).
9. D. Grove, *San Pablo, Nexpa, and the Early Formative Archaeology of Morelos, Mexico* (Publications in Anthropology No. 12, Vanderbilt Univ., Nashville, 1974).
10. M. Porter, *Viking Fund Publ. Anthropol. No. 19* (1953), p. 34; D. Grove, *Am. Antiq.* **35**, 62 (1970). D.C.G. has also observed probable Early Formative architecture at other sites in Morelos.
11. Figurine analysis was carried out by Dr. M. Harlan, University of New Mexico. More than 6000 figurine fragments have now been computerized [M. Harlan, thesis, University of Arizona (1975)].
12. P. Tolstoy (personal communication) indicated to D.C.G. that few, if any, sherds from his excavations at Zacatenco, El Arbolillo, or Tlatilco resemble the Chalcatzingo polychromes. Earlier published works also lack references to this distinctive type.
13. R. M. R. Robles, thesis, Escuela Nacional de Antropologia e Historia, Mexico (1971), p. 369; personal communication.
14. The fact that undated monolithic altars occur at both San Lorenzo and La Venta, are limited in number, and have strong stylistic similarities suggests that these altars occur at both of these Formative sites around 900 B.C. ± 100 years. For the same reasons we believe that the Chalcatzingo altar is contemporaneous with Gulf Coast examples.
15. M. A. Cervantes, *Anales* (Instituto Nacional de Antropologia e Historia, Mexico, 1967–1968), vol. 1, pp. 37–51.
16. J. Carlson, *Science* **189**, 753 (1975). Although the site is not directly mentioned in the text, the cover illustration depicts Relief I at Chalcatzingo, thereby implying that Chalcatzingo is an Olmec site and should be aligned within the Gulf Coast pattern.
17. The map used by Carlson [figure 2 in (*16*)] uses two different true norths, one for the main La Venta complex, the other for the Stirling group. A 22° rather than a 15° difference is shown.
18. Personal communication from D. Wolfman, who collected the 1972 Chalcatzingo samples for R. DuBois, University of Oklahoma, Norman.
19. Fifty samples from Chalcatzingo were analyzed by Dr. B. J. Evans of the University of Michigan, who has analyzed iron ore sources, manufactured mirrors, and the like in Oaxaca. Only two samples showed similarities to Oaxacan sources although it is known that Oaxacan iron ore commodities were widely traded during the Formative period [J. W. Pires-Ferreira, thesis, University of Michigan (1973)].
20. Conducted in cooperation with the Illinois Geologic Survey laboratories.
21. *Inst. Geol. Mex. Bol.* **40**, 260 (1923); *ibid.* **41**, 92 (1923).
22. Dr. C. Thomson received a Wenner-Gren Foundation grant to study the Chalcatzingo jadeite and serpentine artifacts.
23. At the time of the reconnaissance our ceramic analysis had not made a phase B and phase C separation in the Middle Formative, thus in the reconnaissance data we can speak only of general Middle Formative trends. All reconnaissance samples are being restudied to determine the phase B and phase C patterns.
24. K. Hirth, thesis, University of Wisconsin–Milwaukee (1974), pp. 233–237. In using the term gateway city, we are not implying that Chalcatzingo was itself a city.
25. A. Burghardt, *Ann. Assoc. Am. Geogr.* **61**, 269 (1971).
26. Chalcatzingo does not appear to have been alone in its role of gateway community for the Gulf Coast economy. The site of Chalchuapa, El Salvador, may have served a similar function. Olmec style bas-relief carvings occur at Chalchuapa together with the earliest monumental architecture known in that region—an interesting parallel to Chalcatzingo. See R. Sharer, *Curr. Anthropol.* **15**, 165 (1974).

27. The project was under the direction of D.C.G. and codirectors J. Angulo and R. Arana. Funding was through NSF grant GS-31017 with supplementary funds in 1972 and 1973 from the National Geographic Society. K.G.H. was in charge of the reconnaissance, D.E.B. took responsibility for the ecological and palynological investigations, and A.M.C. took charge of the ceramic analyses. The cooperation of Instituto Nacional de Antropologia e Historia and the work of many participants, both Mexican and American, contributed greatly to the results discussed in this article.

NEWS AND COMMENT

Nuclear Navy: Rickover Thwarted Research on Light Weight Reactors

As a result of years of technical censorship of Navy research by Vice Admiral Hyman G. Rickover, the officer credited with having built today's nuclear navy, the Navy today sponsors no significant research on light weight, small reactors which many researchers believe have the potential for revolutionizing naval shipbuilding by enabling the construction of smaller but more powerful nuclear powered vessels.

Interviews with dozens of Navy officers, research administrators, scientists, and a former chief of Navy research indicate that, over the years, when Rickover has learned of proposals or studies concerning light weight reactors, he has gotten on the telephone to the research sponsor, become furious, used profane language, and told the sponsor's superiors that the work is a waste of time. On one occasion, he threatened to try to abolish the Office of Naval Research (ONR), the Navy's independent research arm. On another occasion, Rickover's office is credited with preventing a university engineer from giving an invited technical paper on light weight propulsion to a professional society meeting, and, subsequently, bringing about the termination of his $64,000 research contract.

Navy policy since 1975 has been to avoid doing research on light weight reactors, although studies of other aspects of light weight propulsion systems are allowed. "There's no reason for us to do research at complete loggerheads with the line organization of the Navy," says Assistant Secretary of the Navy for Research and Development, H. Tyler Marcy.

However, some researchers feel that Rickover's interference in ONR research matters has violated ONR's legislative mandate, which specifies that "all the duties [of ONR] shall be performed under the authority of the Secretary of the Navy, and its orders shall be considered as emanating from him." The purpose of this passage, which is in ONR's 1946

founding legislation, was to protect ONR from vested interests in the Navy bureaucracy.

Some researchers say that, although Rickover's technical criticisms of ONR's research have often been valid, the vehemence and persistence of his attacks indicate that his motive could be to protect the pressurized water reactor (PWR) and its successors from competition. Says one naval expert, "The father of the last technological revolution is in the ideal position to stamp out the next one."

Rickover's position, according to his executive director, William Wegner, is that his office is charged with doing all R & D on naval nuclear propulsion. ONR and other groups may do basic research, Wegner explained, but the business of reactor design is not in their mission.

Rickover's own plans for the next generation of naval reactors are for larger, water-cooled reactors. Many Navy vessels, including the controversial Trident submarine, have been sized by the scales of these bigger propulsion plants.

Hyman G. Rickover was a little-known captain when, in 1946, he was assigned to the Oak Ridge National Laboratory to study the possibilities for naval nuclear propulsion. Overcoming many obstacles, not the least of which was the view of some senior naval officers that nuclear power was not feasible, Rickover persisted, and in 1954 the *Nautilus*, the first nuclear submarine, was launched. Since then every naval nuclear power plant constructed has been built under his direction. And, they have had a remarkable record of safety and reliability.

Rickover's authority is enhanced by the fact that he has a second job as director of naval reactors division of the Energy Research and Development Administration (ERDA), formerly the Atomic Energy Commission (AEC). Finally, over the years, he has cultivated very close ties to Congress. Thus, today, although he is only Deputy Commander of the Naval Sea Systems Command for nuclear power, and is formally outranked by officials such as Marcy, Rickover's de facto power is often much greater than theirs.

However, there have been recent signs that Rickover's authority is on the wane. The Senate this year refused funds for new nuclear ships, which Rickover had sought in an extra-official request and which the House obediently passed. In recent weeks, the Chief of Naval Operations, James L. Holloway, 3rd, and Navy procurement officer Gordon Rule have blasted Rickover publicly—something that few Chiefs of Naval Operations and even fewer Navy procurement officers, if any, have dared to do in the past.

At issue in the light weight reactor controversy is whether the Navy should sponsor long-range basic research on gas-cooled and liquid-metal reactors, as well as on other components of submarine propulsion, which could combine with them in smaller, more powerful systems. Preliminary looks at this problem have often led to the conclusion that these alternatives could lighten naval engines by factors of 2, 3, or even 5. Rickover's position has been that none of the work that he has seen warrants research support. He has also argued that alternatives proposed thus far cannot be made to compete with the PWR for safety, reliability, and ease of maintenance at sea.

PWR vs. High Temperature System

Reactors are typed according to the substance used to "cool" them, that is, to conduct heat from the radioactive core outward to a heat exchanger where the heat is converted to mechanical and then electrical energy. In a PWR, the rate at which heat can be transferred out of the core is limited by the fact that the water must not be allowed to boil (steam interferes with the cooling of the core). Thus, to get more heat from a PWR system, the cooling system must be made larger, or several reactors must be combined in a single ship. Although greatly simplified, this is the basic reason why successive naval vessels, including the controversial Trident submarine, have been designed to be bigger than their predecessors.

High temperature, light weight reactors have seemed attractive because their coolants, either liquid metal or gas, can be heated in the reactor core to dramatically higher temperatures. Thus, they can extract more heat and make more mechanical energy from a given reactor core. For this reason, these types of reactors have often been viewed as promising for very powerful compact engines.

The Navy today is being clobbered by massive inflation in shipbuilding costs while also embarking on a fleet modernization program and on the replacement of both its aircraft carriers and strategic submarines. In addition a 1974 law, passed at Rickover's initiative, requires all major combattant ships to be nuclear powered. In the case of large ships, this can increase their cost to $1 billion; the price tag for smaller boats can be increased several times if nuclear reactors are installed. If it existed, a small, powerful nuclear propulsion system could rescue the Navy from this dilemma by restricting the growth of the size of ships and, hence, making them cheaper.

(Soviet submarines are able to go faster for their size than can American submarines, according to informed sources. Some people believe that Soviet submarines may be propelled by more advanced reactors.)

The ONR became interested in light weight reactors most recently in March 1974, when the then Chief of Naval Operations, Elmo Zumwalt, Jr., was looking at propulsion for the high-speed surface effects ship. At that time, a panel, including scientists from the Westinghouse Astronuclear Laboratory which had worked on the gas-cooled reactor for the nuclear rocket program, presented proposed applications of the reactor in the surface effects ship. Rickover's staff, as well as ONR, were consulted about the merit of the proposal, which was, in everyone's opinion, dubious. Rickover's staff criticized the Westinghouse plan pitilessly in a blunt memo on the subject.

However, the incident aroused the interest of the then Chief of Naval Research, Rear Admiral Merton D. Van Orden, and some ONR staffers in light weight reactors such as the gas-cooled reactor. The subject came up again at an ONR-sponsored workshop in Rhode Island also in 1974 on the future of submarine design. Since many other submarines besides the Trident are sized by their propulsion plants, the question of a more compact propulsion system naturally arose. After the workshop, Van Orden says he received an irate telephone call from Rickover, who asked for a written report of the proceedings.

When Van Orden personally delivered the report to Rickover, and discussed possibilities for future ONR research with him, Van Orden says that Rickover repeatedly became furious, used profane language, and threatened to recommend to Congress that ONR had outlived its usefulness and should be abolished. Van Orden says he offered to come along when Rickover did this, to testify in defense of ONR. As it happened, Rickover's threat was not carried out.

ONR's interest and the Rhode Island workshop stirred inquiries from university researchers and private companies interested in pursuing light weight reactor work.

By mid-1974, Van Orden and his staff decided to hold a second workshop, this one on the topic of light weight reactors as such. Rickover learned of the plan and made another irate, profane call to Van Orden.

Van Orden recalls asking Rickover if he was ordering him not to hold the workshop. He says that Rickover replied he

had no authority to do so. However, the same day Van Orden's boss, David S. Potter, Assistant Secretary for Research and Development, called Van Orden and asked what he was doing that had stirred Rickover up. Eventually, Potter ruled that the amount of public funds required to hold the workshop, which were less than $5000, would not be a wasteful expenditure, and the workshop was held.

Epitomizing the wall of silence which appears to divide the Rickover technical staff from other researchers interested in reactor development, Rickover and several of his reactor experts were invited to attend; however, only two staffers came; observers who were there say they barely participated in discussion and quietly took notes.

By the end of October 1974, Potter had been succeeded by Marcy, and Van Orden briefed his new boss on the dispute with Rickover over light weight reactor research. Marcy subsequently brought the subject up in a "get-acquainted" meeting with Rickover in Rickover's office. Van Orden recalls that Marcy emerged from the meeting "completely cowed." Marcy says Rickover emphasized to him that light weight reactor work had no technical merit.

Afterward, during the first half of 1975, Marcy says he "redirected" ONR's research program away from work on reactors and specified that only work on features of the propulsion systems other than the reactor should go forward. Marcy says his understanding was that researchers were to assume that the PWR was the primary heat source for future vessels.

Asked by a reporter whether this "redirection" of research following his interview with Rickover did not constitute Rickover "controlling" ONR's research, Marcy replied, "No. He doesn't. We shared in Rickover's opinion."

(Wegner, Rickover's executive director, declined to comment on Rickover's role in these events. He said that Rickover had made his views known in memorandums which are classified, and therefore could not be discussed publicly.)

In 1974, ONR had let a number of small contracts to study compact propulsion systems, including the reactor question if it seemed appropriate. In 1975, much of this work was stopped or redirected away from the reactors, according to principal investigators at those places contacted by *Science*. In July of 1975, Van Orden retired for several reasons, he says, of which the light weight reactor issue was only a small part.

An ongoing research project with C. H. Wolgemuth and G. E. Robinson at the Applied Research Laboratory at Penn State University was not renewed for fiscal 1976, after an incident in which Wolgemuth was not granted permission to give an invited paper about his work to a meeting of the Marine Technology Society in September 1975.

Wolgemuth told *Science* that he sent a copy of his paper to the Navy administrative unit through which ONR funds are transferred to his laboratory. Routinely, such requests for clearance of unclassified papers are approved promptly in writing. But in this case Wolgemuth heard nothing. Contacting ONR, he learned that the paper had been sent to Rickover's office for clearance and that the Rickover staff would not allow him to give the talk.

Rickover's argument has been that his group has responsibility for looking at alternative naval reactors. But this work has never been examined by independent experts, as far as *Science* could determine. For example, in 1974, the office of Defense Research and Engineering, which has policy responsibility for all military R & D, commissioned a study of future propulsion systems. The Institute for Defense Analyses executed the study, but IDA's consultant on naval nuclear propulsion, Peter Bertelson, was barred from holding any discussions with Rickover's staff. Bertelson, a private consultant from Franklin, Michigan, says he contacted Rickover program staff at Knolls Atomic Power Laboratory and at Electric Boat Co., and in both cases was told that "Washington" would have to give permission for an interview. Bertelson then wrote to Rickover requesting an interview with him or his staff. A Rickover lieutenant wrote back denying the request on the grounds that "it is impractical for us to discuss individual studies with the authors."

Incidents such as these do not surprise those who have been close to the nuclear submarine program in the last 30 years. Rickover's group had lots of experience, at least in the early days, with attempts to design liquid-metal or gas-cooled reactors for Navy ships. In 1955, Rickover himself thought the sodium-cooled reactor sufficiently promising to have an experimental one built for the submarine *Seawolf*, launched in 1955. However, leaks of radioactive sodium through the pipes into the steam generator made the reactor unreliable, and in 1956 Rickover decided to dismantle the *Seawolf*'s liquid-metal reactor and replace it with a PWR.

At about the same time, Rickover got into a dispute with General Electric's Knolls Laboratory, one of his principal industrial sources of expertise, and with his Navy superiors over whether alternatives, particularly the gas-cooled reactor, should be considered. According to the official history of the Rickover program—a book *Nuclear Navy: 1942–1962* by Richard G. Hewlett and Francis Duncan—in 1955–56, Knolls proposed and Navy leaders encouraged a plan for General Electric and two other companies to study alternative reactor propulsion systems. Within a year they concluded that a gas-cooled reactor looked like the most promising, compact alternative despite the fact that Rickover had been demolishing their reports on technical grounds. Hewlett and Duncan, who are not prone to criticize key officials, analyzed the resulting dispute thus:

> For . . . others in the Navy, the issue was whether the Navy could rely on Rickover's judgment alone to determine the technical feasibility of new ideas. The technical competence of Code 1500 [Rickover's group] was unquestionably strong, even outstanding, but was it wise to let one technical group decide what path the Navy would follow in developing nuclear propulsion? . . . Although Rickover's technical judgment in this case seemed correct, the absolute certainty with which he asserted his opinion did not help to convince others that Code 1500 was open-minded on the subject of new reactor designs. It was tempting to conclude that Rickover was simply trying to establish a monopoly to keep himself in power.*

The proposal was finally killed in 1958.

Those who have fought for research on gas-cooled and liquid-metal reactor systems recently argue that a great deal has changed in the last 20 years since *Seawolf* and the Knolls-led research. The AEC has invested heavily in the liquid-metal fast breeder reactor for civilian, land use, hence advanced the knowledge of this reactor type. Furthermore, government programs looking at nuclear airplanes and nuclear rockets have led to more work on small, powerful, gas-cooled reactor systems. Van Orden, for one, believes that "one day, gas-cooled reactors will be found on Navy ships."

Moreover, there have been advances in materials which can withstand high temperatures, in steam-driven turbines, in superconductivity. In addition, in the crucial area of shielding the reactor from virtually all impacts and preventing any possible contamination in the event of an accident, new work on heat pipe technology, by which heat is removed, offers a good chance for considerable shielding reduction. Moreover, say many researchers, Rickover's argument that the proposed high temperature alternatives cannot compete with today's PWR is unfair; his PWR is the result of a major expenditure in time, money, and expertise—none of which appears to have been

*Richard G. Hewlett and Francis Duncan, *Nuclear Navy: 1942–1962* (University of Chicago Press, Chicago, 1974), pp. 277–278.

done in a concentrated form for the alternatives.

Samuel Koslov, an aide to Marcy, has made a rough estimate that the development of an alternative, light weight compact reactor could cost from $6 billion to $7 billion. Other scientists have estimated it could take as long as 10 years. ($6 billion to $7 billion is the amount of increase in the Navy procurement budget—most of which is shipbuilding—which the Department of Defense has officially attributed to inflation.)

A senior naval expert alleges that in the mid-1960's Rickover should have instigated long-range research into light weight reactors which could be paying off today in the form of some definite answers as to whether to employ them. "Hopefully, our new models will employ 20 years of technology and will be more advanced. . . . No technology will help submarines more than improving their power plants. . . . But because of this technical censorship, today we have nothing. We're just pouring money down the drain to get marginal improvements in the PWR's."

At present, two issues remain unresolved. One is whether the technical evidence warrants the Navy or ERDA undertaking a long-term basic research effort devoted to all facets of light weight nuclear propulsion technology—including the reactors. Whether such a program is timely is by no means clear, and the fragmentation and secretive political environment in which such studies have been conducted has done little to elucidate the question. The answer also cannot be resolved without open discussion between Rickover's experts in this area and knowledgeable, but independent, outsiders.

Weinberg, Ray Back Research

Science solicited the opinions of two prominent scientist administrators in the nuclear field, Alvin Weinberg, the long-term former director of Oak Ridge, and Dixy Lee Ray, former chairman of the AEC, on this question. Both replied unequivocally that they thought such a program should be going on. Weinberg said:

> The matter of ship propulsion is so important a matter that it is imprudent to view the matter with technical blinders. There should be an effort that is sufficiently serious to really determine what the situation is regarding alternate systems in addition to pressurized water reactors. On various occasions, I have urged that alternatives be looked at.

Ray said:

> I do believe the Navy should be looking at alternate reactor propulsion systems. I believe the technology is available for alternate nuclear propellants. The Navy must look at this if it is doing its job and making preparations and planning for the future.

The second unresolved issue is whether, if such a program were undertaken, it would be under the direction of Rickover. Marcy told *Science* that if ONR received "brilliant and imaginative" proposals for light weight nuclear propulsion systems, it would probably send them to Rickover's office for consultation. In fact, he added, if they warranted funding, perhaps Rickover's office, rather than ONR, should sponsor the research. The opposing school of thought is that this course would too much resemble turning the fox loose on the chickens, or, more precisely, turning the chickens into the foxes' den. "There can be no serious work on alternative reactor systems until after Admiral Rickover is gone," one scientist gloomily predicted.

Both unresolved issues may come under active study this summer, when the National Academy of Sciences' Naval Studies Board, a group of non-Navy scientists and engineers, takes a sweeping look at missing links in Navy research. And the Naval Research Advisory Committee, which advises ONR on research problems and in the past avoided tangles with Admiral Rickover, is reported to be actively interested in studying the issue.—DEBORAH SHAPLEY

Project Seafarer: Critics Attack National Academy's Review Group

The Navy's controversial Sanguine/Seafarer communications system has encountered rough seas in recent weeks. It has received a rousing vote of "don't put it here" from residents of the Upper Peninsula of Michigan, the site most favored by the Navy after two other sites were abandoned because of citizen opposition. Part of its budget has been targeted for slashing by two congressional committees. And a National Academy of Sciences committee that is examining possible biological and ecological effects of the system has been hit with charges that it is "rigged" and "biased," an allegation which distinguished members of the committee indignantly deny, while retorting that their critics are themselves biased. Whatever the merits of the flaps at the Academy, some participants believe it has revealed serious flaws in the procedures by which the Academy seeks to ensure that its committees are balanced or objective in outlook.

The communications system at issue has been under development by the Navy for some 17 years at a total cost so far of about $100 million. Its chief goal is to provide assurance that, in the event of a nuclear war, orders to retaliate would get though to the submarines that carry nuclear-tipped missiles. The communications systems now in use require submarines to place an antenna at or near the surface of the water, thus rendering them potentially vulnerable to enemy detection. But the proposed new system would use ELF (extremely low frequency) radio transmissions that can penetrate hundreds of feet below the surface and, according to the Navy, are virtually impossible to disrupt by man-made jamming or natural interference.

The system originally proposed by the Navy—known as Project Sanguine—was to be mammoth in scale. Some 6000 miles of antenna cable were to be buried in northern Wisconsin in a grid-like pattern covering some 22,500 square miles (41 percent of the state). The area was chosen largely because the underlying rock—the Laurentian shield—does not conduct electricity easily, a circumstance which enhances the efficiency of the antennas. Transmitters were also to be buried, thus making the system relatively impervious to enemy attack.

But political opposition drove the project from Wisconsin, and also from a fallback site in Texas. There were fears the system would attract an enemy strike against the area that accepted it or that it would drive down property values. There were assertions that it really was not vital, or even desirable, for military purposes. And there were worries that it would be harmful to the environment, as well as to animals and people who would be exposed to electromagnetic radiation.