Preliminary Proposal to

National Aeronautics and Space Administration

UPPER MICHIGAN RANGE

Submitted by

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PART I. USES OF THE PROPOSAL FACILITY

A. INTRODUCTION

The possible advantages of a mid-continent rocket launching site have been under investigation at The University of Michigan for several months, following upon a suggestion that rocket operations might be usefully carried out on the Keweenaw Peninsula in Upper Michigan. An immediate and vital use of such a facility would be to add a station to the Meteorological Rocket Network. Expansion of the Network has been urged by the National Academy of Sciences and by COSPAR, and the large gap in data coverage of the North American continent has been pointed out in the literature. Small rockets (70 km peak altitude) fired from the Keweenaw site would fill this need in an ideal way. The next logical step in synoptic aeronomy is upward to the 100-200 km range, a region now covered by two-stage rockets such as the Nike-Cajun and Nike-Apache. In our opinion it is inevitable that, with the advent of cheaper payloads and rockets, the work of the MRN will be extended to this region. We urge that the proposed rocket facility be planned to accommodate present-day rockets and payloads for 200 km. Thus, not only would expansion of MRN capabilities be enhanced but experiments in aeronomy and other disciplines for such purposes as the International Year of the Quiet Sun (IQSY) would be made possible.

A preliminary inspection of the Keweenaw site indicated that, insofar as operations at the immediate launch site are concerned, the establishment of facilities to handle one- and two-stage sounding rockets presents no problems. Consequently, a more elaborate feasibility study[1], in which all factors were examined, was carried out under University sponsorship. From this study it was concluded that rockets up to the Nike-Apache in performance could be handled at Keweenaw with little logistic difficulty and without crossing the U. S. - Canadian border.

These findings were presented to NASA together with a proposal dated January 1963, that a few ARCAS rockets be fired in the spring of 1963 to demonstrate the feasibility of rocket operations. It was NASA's reaction, however, that the feasibility report amply demonstrated its conclusions and that the next useful step would be to propose a complete facility to handle one- and two-stage rockets together with a prospectus of the uses of such a facility.

B. THE METEOROLOGICAL ROCKET NETWORK

The Meteorological Rocket Network was established in October 1959 at the request of the Chief Signal Officer of the U. S. Army. The coordinating group was the Meteorological Working Group of the Inter-Range Instrumentation Group (IRIG-MWG). The impetus for establishing a coordinated launch system was twofold: need and opportunity. The development of missile systems had introduced requirements for synoptic knowledge of the structure of the atmosphere between 30 and 100 km that were impossible to meet with balloons and prohibitively expensive to meet with aeronomical sounding rocket experiments. But these latter experiments had stimulated the development of small rockets and the imagination of experimenters so that they were encouraged to think of rocket firings in synoptic patterns. Several techniques were tried in small rocket payloads and three or four proved useful, if not ideal, in providing structure measurements up to 60 or 70 km. These are: a) bead thermistors for temperature; b) falling spheres for density and wind; and c) chaff and parachutes for wind. Various devices are still under development.

The first MRN series of firings, in October 1959, yielded 18 sets of data from two stations. The second series, in January 1960, yielded 42 sets from three stations and a steadily increasing pace has characterized the program ever since. The growth is best illustrated by noting the plans for FY 64, which call for two firings per week from six stations: PMR, WSMR, Wallops Island, Eglin AFB, Ft. Greeley, and Ft. Churchhill. This series of over 600 launchings will be funded by the multi-service Joint Meteorological Rocket Network Steering Committee. The program will be augmented by many additional firings carried out to meet the requirements of the various ranges and by special efforts made during the International Year of the Quiet Sun, 1964-65. Effort on a continuing basis is also being expended on the development of new measuring techniques and payloads and on new, less expensive and more reliable sounding rockets to supplement the ARCAS, HASP, and Loki vehicles now in use. Concurrently with the improvements in hardware and schedules has been the development of data handling and dissemination methods. The latest regular IRIG-MWG Data Report prepared by the U. S. Army Electronics Research and Development Activity at White Sands (the second monthly report, No. 14-63, dated May 1963) contains data from 123 rocketsonde observations from nine stations made during the month of October 1962. (In addition to the six stations listed above, data were included from Ascension Island; Kauai, Hawaii; and Tonapah, Nevada.)

Expansion of the Meteorological Rocket Network on a national and international basis has been called for by various scientific groups. In numerous publications the National Academy of Sciences has urged the addition of stations and development of techniques. The Academy's attitude is perhaps best summed up by the following statement of the Working Group on Meteorological Rockets and Satellites:

> "We note that a number of independent scientific committees have strongly urged a program of meteorological rockets to probe the atmosphere above 30 km on a synoptic basis, among these ICSU's Comite Internationale Geophysique (CIG) and Committee on Space Research (COSPAR), the World Meteorological Organization's Committee on Aerology, and the National Academy of Science's Space Science Board and Committee on Atmospheric Sciences. Meteorological rockets are specified as an important part of the International Year of the Quiet Sun (IQSY). A Northern Hemisphere map showing the 'Potential Meteorological Rocket Network' (as proposed by COSPAR May, 1962) is appended.* COSPAR strongly urged an increase in the number of stations from the present 20 to 25 to at least 50 in the Northern Hemisphere. With such a virtually universal endorsement, the question is: What is being done to provide such a capability?"[2]

COSPAR's own attitude is given in the Recommendations of Working Group 2 drawn up at the 1962 COSPAR meeting in Washington:

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*Reproduced as Fig. 1 in this proposal.

"COSPAR, recognizing the valuable and unexpected results that have emerged from the present sporadic and localized launchings of meteorological rocketsondes, strongly urges an increase in the number of stations from the present or proposed 20-25 to at least 50, so that reasonably complete maps can be drawn of the wind temperature patterns in the Northern Hemisphere. Launches should be scheduled in accordance with the program for aerological observations recommended by CIG, to the extent that rockets and facilities are available."

More specifically relevant to the proposed Upper Michigan facility is the resolution drawn up by the Committee on High Altitude Rocket and Balloon Research of the Space Science Board, NAS, at its meeting in El Paso, Oct. 31-Nov. 1, 1962:

"The Committee was informed about a preliminary study in progress by The University of Michigan of a possible new meteorological rocket site on the Keweenaw Peninsula in Northern Michigan. It notes that a station in this region would fill a long recognized gap in the present MRN, and would significantly enhance the scientific value of the U. S. contribution to the meteorological program of the IQSY. It therefore strongly urges further support of this study. It recommends that the SSB convey by letter this endorsement to The University of Michigan and to those government agencies whose support and cooperation may be required."

Endorsements of the Michigan proposal for a new station on the MRN arising from the foregoing resolution were received by Dr. Ralph A. Sawyer, Vice President for Research at the University, from the U. S. Weather Bureau and from the Space Science Board of the National Academy. They are included as Appendix B of this proposal.

A glance at the map provides a convincing explanation of the interest in the Upper Michigan site for meteorological rockets. Figure 1 shows the world-wide distribution of stations recommended by COSPAR. Figure 2 shows the position of the Upper Michigan site with respect to other North

American stations of the MRN.

We submit that the establishment of a station of the Meteorological Rocket Network in the Great Lakes region constitutes, by itself, a potent argument for the proposed Upper Michigan Range.

C. MEDIUM ALTITUDE SOUNDING ROCKETS

Although an added MRN station seems to be sufficient reason for establishing an Upper Michigan range, the history of other facilities indicates that new uses are usually found for an established site. In this section we will suggest what additional uses for the proposed facility might be. Then, in subsequent sections, the establishment of the range will be treated in three phases. Phase I provides a range which is adequate for the purposes of a station on the MRN and which also permits summertime launchings of Nike-Cajuns and Apaches (or economical replacements thereof) having simple ground support requirements. Phase II adds the equipment for all-seasons firings of Nike-boosted rockets with more elaborate ground support. Phase III fills in the gaps between a minimum facility and a complete facility.

The most readily predictable need for more launching sites of rockets in the 70 to 200 km class is the extension of synoptic meteorological measurements to these altitudes. During the IGY, direct evidence [3,4] of coupling between events in the Arctic mesosphere (60-80 km) and in the troposphere was obtained. The breakdown of the polar vortex in late winter with the accompanying abrupt warming detected by rockets in the mesosphere was correlated with the so-called "explosive warming" phenomenon measured by balloons. The interest in the warm Arctic winter mesosphere stimulated by its relationship to tropospheric conditions led Kellogg[5] to suggest that the energy of recombination of atomic oxygen with accompanying subsidence from above 100 km to the mesosphere could account for the warming. Young and Epstein[6] have examined this concept quantitatively and Maeda[7] has examined the relative contributions of corpuscles and radiation to the required dissociation of oxygen. Maeda notes: "Finally, it should be emphasized that direct measurement of atomic oxygen in the upper atmosphere, which has not been possible so far because of experimental difficulties, is very desirable in order to clarify the mysterious warm polar night mesosphere and the irregular warming of middle-latitude mesospheres." This exemplifies the kind of investigation which could now benefit from a mid-latitude survey and which eventually will be added to the phenomena to be studied synoptically by meteorological rockets. Rocket aeronomists are actively investigating other details of atmospheric structure between 70 and 200 km which, it can be predicted confidently, will require synoptic knowledge in the foreseeable future. Simultaneous firings of structure experiments at Wallops and Churchill and at Wallops and Sardinia have already been carried out in an attempt to shed light on northern hemisphere upper air circulation patterns. During the IQSY the addition of data points in mid-North America directed at mesospheric warming and mesospheric winds would be of great interest. Incidentally, the location of the Upper Michigan site at 47° 25'N, in addition to providing a latitude point not now covered, is very close to the 45°N to which the U. S. Standard Atmosphere, 1962 values are adjusted. Atmospheric structure values taken here would therefore provide "normalized" values directly, without extrapolation or interpolation.

It is of interest to inquire whether or not the rocket techniques now used above 70 km have the potential of being developed into the relatively inexpensive instrumentations required for increased numbers of launchings. It is presently true that, because of costs, the number of data points which can be afforded in the balloon-and rocket-only region (that is, below the 200 km minimum perigee of satellites) is an inverse function of the altitude. Amelioration of this fact requires that the rocket-borne instrumentation be quite simple, whereas the ground gear can be more elaborate and expensive as it is amortized over many flights. Of the various aeronomical experiments now in use, three have sufficiently simple payloads to be considered candidates for numerous* firings. The simplest of these is the passive inflatable falling sphere tracked by radar. Indeed, the so-called "ARCAS-ROBIN" version of this experiment is already one of the mainstays of the MRN program, regularly yielding densities to 70 km and winds to 60 km. Similar spheres carried in higher rockets have measured densities to 100 km and $C_D\rho$** to 122 km. The cost

*Firings of the Meteorological Rocket Network during the first six months of 1962 totaled 302. In the same period 18 sounding rockets carrying aeronomical experiments between 112 and 211 km were launched in the U. S.

**$C_D\rho$ (the product of coefficient of drag and density) lacks only satisfactory experimental values of C_D at low Reynolds numbers to yield the densities over 100 km.

of the sphere instrumentation is very low. A complete Nike-Cajun nose cone with three spheres can be built for $2800 and a single ejector designed to be strapped to the outside of a rocket costs $500.

The rocket grenade technique for upper air winds and temperature also has a relatively simple payload. At present no design for a rocket as small as the ARCAS exists but the evolution of the grenade instrumentation has carried it from the V-2 to the Aerobee to the Cajun, and it is very likely that another miniaturization will be attempted. The ground equipment has also undergone considerable simplification. The microphone array can be irregular so as to be accommodated to the terrain, and the DOVAP (doppler) tracking system has been compressed to a single station. Thus the grenade experiment is definitely a candidate for use on an expanded scale at simplified ranges and has been undertaken by at least two countries which are just entering upon programs in aeronomy. The forte of the grenade experiment is the measurement of winds (as well as temperature) to 100 km. Much of our knowledge of mesospheric circulation has been obtained from grenade firings.

A third experiment in upper air structure which has been applied to two-stage rockets and might be applied to smaller rockets is the sodium release technique. Measurements of winds and of diffusion coefficients to over 200 km have been obtained from photographs of the trails. Ambient temperatures can also be calculated from measurements of widths of the resonance lines. Sodium release rockets have been launched simultaneously at Wallops, Eglin, and Churchill, indicating the interest and potential in this experiment as a synoptic technique.

There are, of course, many experiments in aeronomy which would be desirable to fly at a mid-continent site. Mass spectrometry for composition and other techniques for pressure, temperature, density, and winds are in use and during the IQSY may be sufficiently numerous to permit flights in Upper Michigan. The requirement of electronics in the payloads, however, makes it less likely that these techniques will be used synoptically to the extent that spheres, grenades, and sodium have been and will be used. In our opinion the latter three techniques already indicate the need and the potential for extending MRN-type operations to phenomena of meteorological significance up to 200 km. It will soon be as desirable to fill the gap in continental coverage at the higher altitudes as at the 70 km level.

An informal telephone survey of the extent to which the proposed Upper Michigan Range might be used by U. S. aeronomers was conducted. Senior investigators at Ballistics Research Laboratories, Geophysics Corporation of America, Naval Research Laboratory, and The University of Michigan (including one group not associated with this proposal) responded affirmatively to the following question: "If such a range, at which 200 km rockets could be launched, were in existence, would you use it?" More or less in order of frequency and emphasis, the reasons given for the affirmative response were:

a. Intermediate latitude point between Wallops Island and Fort Churchill.

b. Latitude point of particular interest, i.e., near 45°N.

c. Geographical point of particular interest aeronomically, i.e., center of the North American land mass.

d. Presumed simplicity of operations compared with the largest existing ranges; also relief from crowded schedules of these ranges.

e. Other: intermediate magnetic latitude, distance from sea to check free sodium, ease of access, check point for winds used in predicting balloon drift, trials of experiments under minimum GSE situation, other types of stations such as balloon and satellite read-out.

Scientists of the Aeronomy and Meteorology Division of Goddard Space Flight Center responded that although it was desirable to add an MRN station in Upper Michigan, the funds required for installing facilities for intermediate rockets might better be expended on other sites—in Alaska, for example.

In this prospectus of uses for the proposed facility we have concentrated on meteorology and aeronomy because these are within our own area of competence and also because they provide the most obvious and compelling reasons for a new rocket site. Investigations in ionospheric physics are closely allied to aeronomy and would benefit from the kind of coverage offered by the Meteorological Rocket Network. Indeed, measurements of electron density in the D and lower E regions will be undertaken shortly at some stations of the MRN and we can expect the same extension upward in altitude on a synoptic basis as is now taking place in aeronomy. Other scientific disciplines which use sounding rockets also have needs for latitude surveys; although there is no immediate prospect of their firing on the scale of the MRN, these disciplines, especially during the IQSY, will no doubt provide additional uses for the range.

D. UNIVERSITY INTEREST

It is proposed that The University of Michigan's High Altitude Engineering Laboratory assume responsibility for the initial establishment and operation of the range during Phases I and II—that is, for at least two years.

This group has been active in the development of aeronomical sensors for the 30 to 100 km region as well as in the application of small solid propellant rockets to upper air research, has built and operated DOVAP and optical tracking stations, and takes a direct interest in high altitude meteorology through its work with satellite meteorological sensors and its contact with the Meteorological Rocket Network. The Laboratory has taken a particular interest in using simple techniques with minimum payloads applicable to small rockets and requiring minimum ground support. It has participated directly in the development and use of both the sphere and grenade experiments. This interest and experience puts the Michigan group in a good position to understand the needs of other disciplines and to cooperate not only with experimenters in those disciplines who may wish to employ simplified techniques but with foreign scientists being encouraged by NASA to undertake established experiments as a first step in rocket upper air research. Also, the authors of this proposal have had preliminary conversations with the faculty of Michigan Technical College at Houghton (40 miles from the launch site) which established a definite interest by these people in assisting with support operations of the facility.

E. REFERENCES

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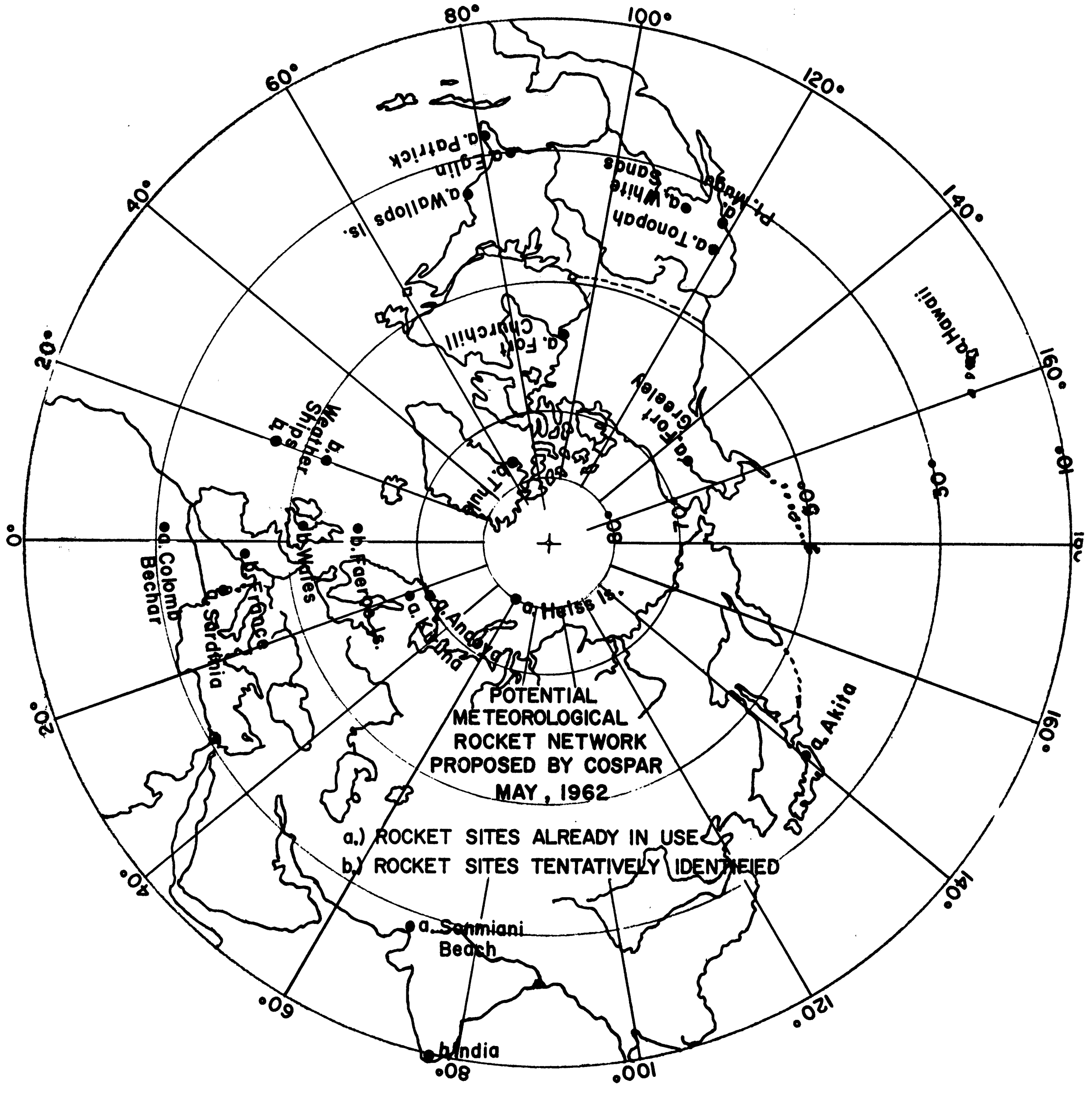
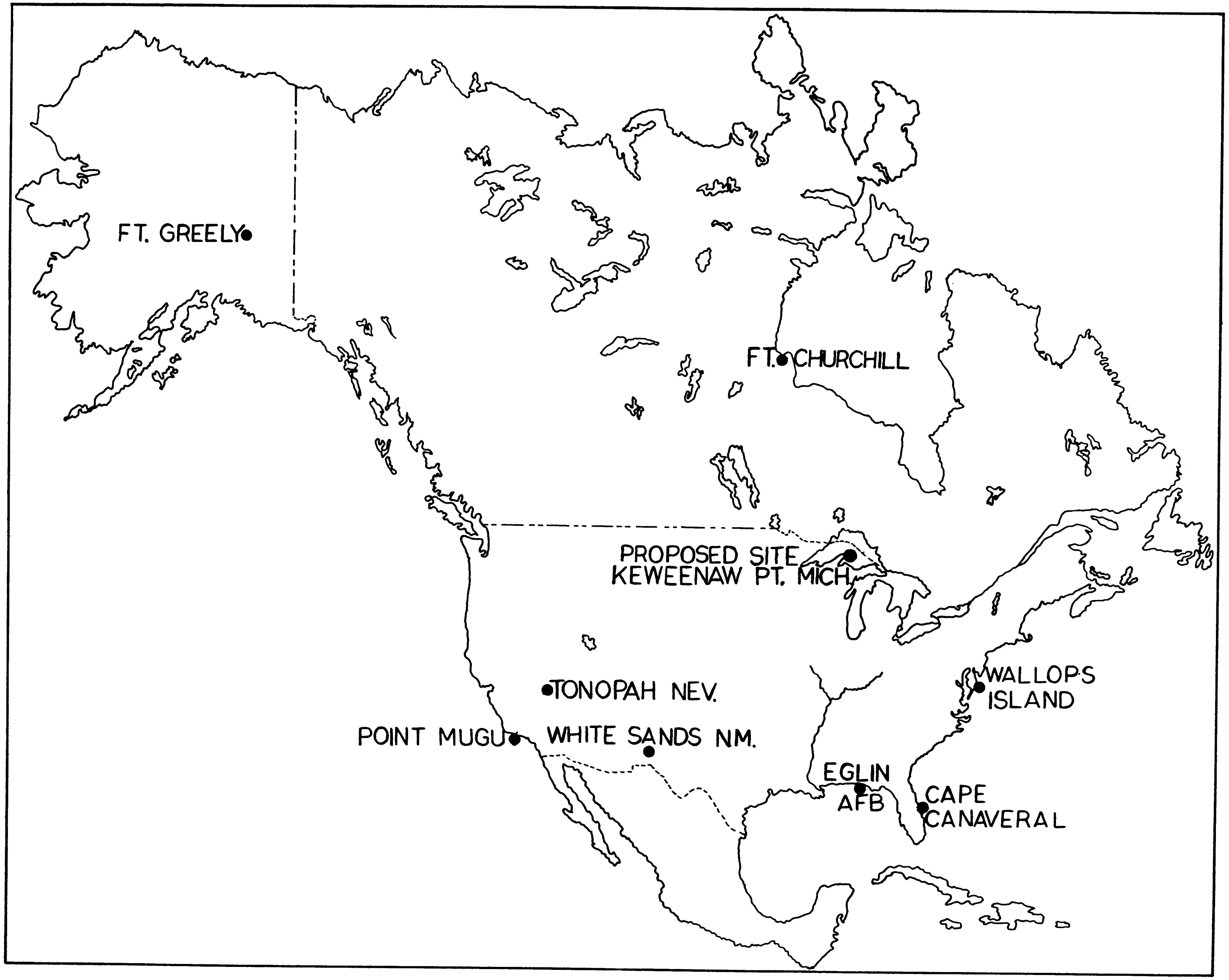


Fig. 1. Potential Meteorological Rocket Network, proposed by COSPAR, May 1962.



DISTRIBUTION OF SMALL (50KM APOGEE) METEOROLOGICAL ROCKET STATIONS IN NORTH AMERICA

Fig. 2. Meteorological rocket stations in North America.

PART II. DESCRIPTION OF THE PROPOSED FACILITY

This proposal has been prepared as a followup to a feasibility study[1] carried out by The University of Michigan in December 1962 at the request of the National Science Foundation, the Space Science Board of the National Academy of Sciences, the U. S. Weather Bureau, and other interested agencies. The feasibility study indicated that the east end of the Keweenaw Peninsula could be used as a launch site for meteorological rockets of the ARCAS and Loki types throughout the year, and that two-stage rockets using the Nike-Ajax booster could be launched routinely during the winter months, when lake traffic is at a minimum. Such rockets could be launched during the summer, but surface surveillance would involve more problems and delays of considerable duration could be anticipated. Air surveillance will be carried out by the Sault Ste. Marie Sector of the NORAD (SAGE) network, with headquarters at K. I. Sawyer AFB.

The proposal is divided into three consecutive phases, which are summarized in the following sections.

A. PHASE I: SUMMARY

This phase comprises installations for launching ARCAS and Loki-type rockets with chaff, inflatable spheres, or similar types of payloads tracked by radar. If Rawinsonde AN/GMD-1 equipment is available, the sonde-type payloads can be used, with joint operation of radar and GMD equipment. The capacity of the range upon completion of Phase I will provide for the firing of 50 ARCAS rockets per year, 50 Loki-type rockets per year, and 6-8 Nike-Cajun rockets per year (the latter during the summer only). The estimated cost of construction for Phase I is $147,400. (This does not include cost of land, cost of bringing power to the site, or cost of telephones.)

Snow and temperature conditions during the winter are such that the ARCAS and Loki launchers must be enclosed. A Nike launcher is included so that trial launchings of two-stage rockets can be carried out during the summer. This launcher must also be enclosed if firings are to be carried out during the winter season: otherwise, launching Nike-boosted rockets would involve a high degree of difficulty, inconvenience, and discomfort.

The following installations and expenditures are proposed for Phase I:

1. Site Preparation
2. Blockhouse
3. Rocket Assembly Building
4. Nike Launcher (without enclosure)
5. Small Rocket Launch Enclosure
6. Heating Plant and Utility Building
7. 50' Pole for Wind Profile Measurements
8. Storage Bunker
9. Office Trailer (temporary)
10. Tracking Radar
11. Rawinsonde AN/GMD-1A (if available)
12. Miscellaneous Furnishings and Equipment (mobile and fixed)

The above installations represent an adequate station for the Meteorological Rocket Network, with the added capability of launching Nike-boosted rockets during the summer. A mobile telemetry station owned by The University of Michigan can probably be made available during short periods of time for occasional Nike-Cajun or similar rocket flights. The arrangement of all installations proposed in Phase I provides for additional facilities if experience indicates that there will be a continuing need for the occasional launching of Nike-boosted rockets throughout the year.

B. PHASE II: SUMMARY

This phase expands the range to the point where Nike-boosted rockets can be launched occasionally during the entire year. The capacity of the range will be expanded to approximately 50-100 ARCAS and Loki-type rockets per year and 10-20 Nike-Cajun rockets per year. The cost estimate is approximately $140,000.

The additional installations and expenditures proposed for Phase II are as follows:

1. Nose Cone Preparation Building
2. Nike Launcher Enclosure
3. Covered Passageway (Rocket Assembly Bldg. to Nike Launcher)
4. Vehicle Garage
5. Office Trailer
6. Telemetry Van
7. Second Theodolite
8. Road (to Upper Radar Site)
9. Tracking Radar (at Upper Radar Site)
10. Rawinsonde AN/GMD-2 and Enclosure (at Upper Radar Site)
11. Miscellaneous Furnishing and Equipment (mobile and fixed)

If there appears to be a demand for more frequent firings of the Nike-boosted rockets on a continuing bases, the capacity of the range can be increased to the point where 50 Nike-Cajun or equivalent rockets can be launched per year by providing the installations listed for Phase III.

C. PHASE III: SUMMARY

This phase completes the range installation, filling in the gaps between a minimum facility and a complete facility. The final capacity of the range will be 50-100 ARCAS-Loki rockets per year, and 50 or more Nike-Cajun rockets per year. The cost estimate is approximately $173,000.

The additional installations and equipment proposed for Phase III are as follows:

1. Forward Rocket Storage Building
2. Covered Passageways (Rocket Assy. Bldg. to Blockhouse, Rocket Assy. Bldg. to Nose Cone Prep. Bldg., Rocket Assy. Bldg. to Forward Storage Bldg., and Forward Storage Bldg. to Small Rocket Launch Area)
3. 150' Meteorology Tower
4. Additional Instrumentation in Blockhouse
5. General Utility Building
6. Third Theodolite
7. Single Station DOVAP
8. Surveillance Radar
9. Long Focus Tracking Camera
10. Miscellaneous Construction Costs (including hard surface roads and parking area)
11. Miscellaneous Furnishing and Equipment (mobile and fixed)

Quite possibly, it will be considered desirable to purchase additional land at Keweenaw Point for an auxiliary small rocket launch site. Small rocket firings to the south fly over land and would not be possible if this land became developed at a later date.

The various installations and expenditures for each of the three Phases are described (with individual cost estimates) in Part III of this proposal.

PART III: PHASES OF THE PROPOSED FACILITY (WITH INDIVIDUAL COST ESTIMATES)

The feasibility study mentioned earlier contains descriptions of the Lake Superior Area in general and the Keweenaw Peninsula in particular. Figures 3 and 4 are reproduced from that study for the convenience of readers of this proposal. It should be noted that Fig. 3 entirely supersedes Fig. 10 of the feasibility study as regards the radius of proposed impact areas. Figure 5 shows the general layout of the proposed research range and locates the four sites which will be referred to throughout the remainder of this proposal: Site A, the Launch Area; Site B, the Rocket Storage Area; Site C, the Non-Hazardous Area; and Site D, the Upper Radar Site.

A. PHASE I

During this phase, work will be done on the three sites located within the proposed research range. Work on Site D, the Upper Radar Site, will not be undertaken until Phase II. The next three sections contain brief descriptions of the installations planned for Sites A, B, and C during Phase I.

1. Site A (Launch Area)

a. Proposed Layout.—The installations to be made during Phase I in Site A, the Launch Area, are shown in Fig. 6.

b. Site Preparation.—The exact soil conditions at the site are not known. There appears to be a fairly thin overburden over bedrock. The estimated cost of clearing and grading the site is $7500. There will be 1350' of 10' gravel roads and 150' of gravel parking area at the site, and construction costs are estimated at $3000. Total costs for site preparation are thus estimated at $10,500.

c. Blockhouse.—Figure 7 is a keyed diagram, drawn to scale, of the Blockhouse. This will be a 20' x 30' x 8' building with reinforced concrete walls, roof, and floor. It will be heated to 70°F at 0°F outside temperature and 20 MPH wind. The walls are 1' thick, with steel mesh reinforcing on both sides. The roof is 2' thick, with steel mesh reinforcing top and bottom. The Blockhouse is the only building at Site A which will be occupied during actual launchings. Its capacity is limited to the following: Range Test Conductor, Range Safety Officer, Launch Crew Chief, two Launch Crew personnel, User Project Scientist, and five User personnel—total, 12 persons. There are two telephones and one intercom.

The cost of the building, including lighting and power outlets, is estimated at $20,000, using 6,000 lb concrete.

The following furnishings, equipment, and instrumentation will be installed:

2	Desks	$250
4	Swivel Chairs	188
8	Straight Chairs	128
1	Filing Cabinet	70
1	Range Intercom	185
	Workbenches	370
1	Desk Calculator	900
	Coat Racks	21
	Launch Control Console	500
	Range Safety Console	250
3	Wind Direction and Velocity Meters	7200
1	Plotting Board	1000
1	Theodolite	1200
	Miscellaneous Instrumentation	1000
	Monitor Cables to Launcher	1500
		$14,762

d. Rocket Assembly Building.—Figure 8 is a diagram of the Rocket Assembly Building. This will be a 20' x 30' x 12' structure, with a 10' garage door at one end and a 1-1/2 ton chain hoist on a monorail running the length of the building. It will be heated to 70°F at 0°F outside temperature and 20 MPH wind. It will be equipped with explosion-proof light fixtures and 90 psi compressed air. There is one telephone and one intercom.

In this climate, a properly insulated "Butler" type steel building costs approximately as much as concrete block, so the latter type of construction is proposed for the Rocket Assembly Building as well as for most of the other heated buildings on the range.

The estimated cost of the Rocket Assembly Building is $12,000.

The following furnishings and equipment will be supplied:

1	Desk	$125
1	Swivel Chair	47
1	Filing Cabinet	70
3	Straight Chairs	48
1	Range Intercom	185
	Workbenches	450
	Stools	54
2	Platform Scales	350
4	Rocket Dollies	500
1	Air Compressor and Tank	280
	Miscellaneous Hand Tools	200
	Storage Cabinets	184
	Air-Operated Tools	250
	Chain Hoist and Monorail	2250
	Small-Parts Bin	125
	Stainless Steel Double Sink	300
	Locker-Type Coat Rack	113
		$5531

e. Nike Launcher.—The launcher itself will be Government Furnished Equipment. The estimated cost of modifying and installing the Nike-Ajax "military" launcher on a concrete pad is $5,000. A detailed list of modifications required on the "military" launcher is given in Appendix C.

f. Small Rocket Launch Enclosure.—A rudimentary sketch of the Small Rocket Launch Enclosure is given in Fig. 9. The building will be of concrete block, 30' x 10' x 8', with garage-type doors at each end. The launchers will be mounted on carts riding on rails. After loading, the launchers will be rolled outside and clamped to the rails, and the azimuth and elevation adjusted for launching. There will be one ARCAS launcher and one Loki-type launcher. The building will be heated to at least 45°F at 0°F outside air temperature and 20 MPH wind. There will be explosion-proof lighting, and the outside platforms will be floodlighted.

The launchers themselves will be Government Furnished Equipment.

The estimated construction costs of the building are $6,000, with an additional $2,500 for the concrete pad, steel rails, and bed, for a total of $8,500.

There are no furnishings other than the following:

1	Range Intercom	$185
2	Carriages, with Flanged Wheels and Positive Locating Locks	600
		$785

g. <u>Heating Plant and Utility Building</u>.—Figure 10 is a sketch of the proposed Heating Plant Utility Building. This will be a 20' x 30' structure, with a central boiler for heating all buildings at Site A. A water tank and pump are located in the furnace room, and a lavatory and lunch room are provided for the convenience of personnel.

The construction costs are estimated as follows:

Building	$10,000
Boiler and Controls	3,500
Piping to Other Buildings	1,200
Insulated Duct for Piping	3,500
Water Supply System	3,800
	$22,000

The following furnishings will be supplied:

3	Tables	$210
15	Chairs	240
	Range Intercom	185
	Coat Racks	21
		$656

h. Wind Profile Pole.—A 50' wind profile pole, with three wind velocity and direction indicators, will be provided for wind profile determination. The cost of the instruments is included with the Blockhouse costs. The cost of procuring and erecting a standard 50' sectional steel flagpole and installing the weather instruments is estimated at $1,000.

i. Total Costs, Site A, Phase I.—A compilation of costs noted in the preceding subsections gives the following:

Site Preparation and Roads		$10,500
Blockhouse		
Building Cost	$20,000	
Furnishings, Equipment, and Instrumentation	14,800	
		34,800
Rocket Assembly Building		
Building Cost	12,000	
Furnishings and Equipment	5,600	
		17,600
Installation of Nike Launcher		5,000
Small Rocket Launch Enclosure		
Building Cost	8,500	
Furnishings and Equipment	800	
		9,300
Heating and Utility Building		
Building Cost	10,000	
Heating Plant	8,200	
Water Supply System	3,800	
Furnishings and Equipment	700	
		22,700
50' Wind Profile Pole		1,000
Total Estimated Costs, Site A, Phase I		$100,900

2. Site B (Rocket Storage Site)

a. Road.—A gravel road will be installed from Site A, and the 1200' of construction are estimated at $2,400.

b. Storage Bunker.—A 15' x 30' storage bunker will be constructed of semicircular corrugated sections 7-1/2' high and will be covered with earth. The bunker will be heated to 40°F by means of forced convection through an insulated duct from a small building 25' distant. The bunker will be located at least 1200' from the boundary of the range and will have no lights, power, or furnishings. The cost of the bunker, including grading and the heating plant, is estimated at $5,500.

c. Total Costs, Site B, Phase I.—A compilation of costs noted in the preceding subsections gives the following:

1200' Gravel Road	$2,400	
Storage Bunker	5,500	
Total Estimated Costs, Site B, Phase I		$7,900

3. Site C (Non-Hazardous Area)

a. Site Preparation.—Site preparation for the Non-Hazardous Area, including gravel roads and a parking area, is estimated at $2,500.

b. Office Trailer.—A 10' x 30' heated trailer will be provided as a base of operations for the Range Supervisor, the Range Engineer, and the Range Safety Officer. The delivered cost of such a trailer is estimated at $3,500 and the cost of installation at $1,000 for a total of $4,500.

The following furnishings and equipment will be provided:

3	Desks	$375
3	Swivel Chairs	140
6	Straight Chairs	96
1	Filing Cabinet	70
1	Drafting Table	250
1	Drafting Machine	125
1	Drafting Stool	9
1	Desk Calculator	900
1	Table	70
1	Typewriter	200
1	Book Case	50
1	Coat Rack	12
		$2,297

c. Tracking Radar.—The radar itself will be Government Furnished Equipment. Shipping and installation costs are estimated at $5,000.

d. Rawinsonde AN/GMD-1A.—This equipment, as well as the shelter for it, will also be Government Furnished Equipment, if it is available. Shipping and installation costs are estimated at $5,000.

e. Mobile Equipment.—A few items of mobile equipment will be required for transportation of personnel and equipment between sites, and for maintenance of roads and grounds. These are arbitrarily included with estimates for Site C, and are as follows:

1	Jeep	$2,000
1	6-Passenger, 4-Wheel-Drive Pickup Truck	3,500
1	Tractor, with Mower and Scraper Blade	3,500
		$9,000

f. Total Costs, Site C, Phase I.—A compilation of costs noted in the preceding subsections gives the following:

	Site Preparation		$2,500
1	Office Trailer		
	Retail Cost	$3,500	
	Furnishings	2,300	
	Special Installation	1,000	
			6,800
1	Tracking Radar	GFE	
	Shipping and Installation Costs	5,000	
			5,000
1	Rawinsonde AN/GMD-1A (if available)	GFE	
	Shelter for GMD	GFE	
	Shipping and Installation Costs	5,000	
			5,000
	Mobile Equipment		
	Jeep	2,000	
	Pickup Truck	3,500	
	Tractor	3,500	
			9,000
	Total Estimated Costs, Site C, Phase I		$28,300

4. Total Costs, Phase I

The total costs for all three sites of Phase I are as follows:

	Buildings and Construction	Furnishings and Equipment	Total
Site A	$79,000	$21,900	$100,900
Site B	7,900	---	7,900
Site C	16,000	12,300	28,300
	$102,900	$34,200	$137,100
Building Design and Layout etc., (approximately 10% of construction costs)			10,300
		Total	$147,400

B. PHASE II

During this phase, work will be done on two of the sites located within the proposed research range and also on Site D, the Upper Radar Site, which is located on a bluff 3-1/2 miles from the Launch Area. The next three sections contain brief descriptions of the installations planned for Sites A, C, and D during Phase II.

1. Site A (Launch Area)

a. Proposed Layout.—The installations to be made during Phase II in Site A, the Launch Area, are shown in Fig. 11.

b. Nose Cone Preparation Building.—Figure 12 is a rudimentary sketch of the building to be used for nose cone preparation. This will be a 30' x 20' x 8' structure, heated to 70°F at 0°F outside air temperature and 20 MPH wind. It will be supplied with 110-220 V, single phase, 60 cycle power; with telephone and range intercom, and with 90 psi compressed air. There will be monitor cables to the Nike launcher and the Blockhouse. A drill press and bench grinder will be located in this building, as no electric power tools are permitted in the Rocket Assembly Building so long as rockets are there.

The estimated construction cost of the Nose Cone Preparation Building (including additional insulated steam lines for heating) is $10,000.

The following furnishing will be supplied:

Range and User Intercom	$360
Work Benches	270
Electronic Work Benches	300
Storage Cabinets	92
Drill Press	150
Bench Grinder	35
Stools	54
Coat Racks	21
Monitor Cables to Blockhouse and Launcher	1500
	$2,782

c. Nike Launcher Enclosure.—Figure 13 is a sketch of the Nike Launcher Enclosure and Fig. 14 is a sketch of the Enclosure frame and monorail. This will be a 40' x 16' x 12' structure which can be rolled back over the "tunnel" on rails. The doors at the south end must be capable of withstanding the overpressure resulting from firing the rocket, and the roof must be capable of supporting a smaller overpressure in addition to snow loads. The blast doors are opened when the Enclosure is rolled back, and are closed again over the end of the "tunnel" before firing. The Nike-Ajax, or "military," launcher is modified to mount on a 14' diameter circular track for training in azimuth. The enclosure is lighted, has explosion-proof fixtures, and is heated to at least 45°F at 0°F outside air temperature and 20 MPH wind. A 1 ton monorail is mounted on the center line. The ramp is externally floodlighted when the enclosure is retracted.

The Enclosure has a steel frame, with welded bents, as shown in Fig. 14. It will be covered with heavy gauge corrugated steel. Details of wheels, axles, and doors, the method of sealing, etc., have not been worked out as yet. The structure will be moved by means of a tractor and cable.

The cost of the Enclosure, including doors, rails, and installation, is estimated at $18,000. The cost of additional steam lines for heating is estimated at $1500, for a total of $19,500.

d. Covered Passageway.—A covered passageway will be provided in order to convey rockets conveniently from the Rocket Assembly Building to the Nike Launcher Enclosure. This passageway will be constructed of curved and straight panels of corrugated sheet steel, with a cross section approximately as shown in Fig. 15. The temperature of the passageway will be maintained above freezing by the steam lines to the Enclosure.

The estimated cost of the passageway is $10,000.

e. Total Costs, Site A, Phase II.—A compilation of costs noted in the preceding subsections gives the following:

Nose Cone Preparation Building		
Building Cost	$10,000	
Furnishings and Equipment	2,800	
		$12,800
Nike Launcher Enclosure		19,500
Covered Passageway		10,000
Total Estimated Costs, Site A, Phase II		$42,300

2. Site C (Non-Hazardous Area)

a. Vehicle Garage.—With year-round operation of the range for the Nike-boosted missiles, additional mobile equipment will be required, which must be housed for efficient winter operation. The proposed vehicle garage comprises the following areas:

Vehicle Storage Space (heated to 45°F in winter)	1300 sq. ft.
Vehicle Maintenance Area (heated to 70°F; used for repair, lubrication, etc., of all mobile equipment)	400 sq. ft.
Damage Control Area (heated to 70°F; used for housing the fire truck, which must start immediately in emergencies)	400 sq. ft.
Lavatory	200 sq. ft.
Total	2300 sq. ft.

The estimated cost of the vehicle building is $31,000.

The following equipment will be provided:

1	Range Intercom	$ 185
	Vehicle Maintenance Equipment	2,000
	First Aid Equipment	180
	Work Benches	200
	Water Pump and Tank	230
	Camera and Accessories	625
		$3,420

b. Office Trailer.—A second office trailer will be required for expanded range safety and meteorology operations, and also to provide a desk for the Range User. The total cost of the trailer plus furnishings and installation is estimated at $6,800 (see cost breakdown in Site C, Phase I).

c. Mobile Equipment.—Three additional items of mobile equipment, which are included arbitrarily with these estimates for Site C, will be required for safety control and for maintenance of roads and grounds. These items are:

1	Fire Truck	$11,000
1	Small Dozer or Loader	5,000
1	General Purpose Tractor	5,000
		$21,000

d. Telemetry Van.—The van itself will be Government Furnished

Equipment. Installation costs are estimated at $5,000.

e. Second Theodolite.—As noted in Phase I, the first theodolite is to be located in the Blockhouse. The second and third theodolites are to be located in separate stations at opposite corners of the proposed research range (see Fig. 5). The cost of the second theodolite is estimated at $1,200.

f. Total Costs, Site C, Phase II.—A compilation of costs noted in the preceding subsections gives the following:

Vehicle Garage	
Building Cost	$31,000
Furnishings and Equipment	3,420
Office Trailer	6,800
Mobile Equipment	21,000
Telemetry Van	GFE
Installation	5,000
Second Theodolite	1,200
Total Estimated Costs, Site C, Phase II	$68,420

3. Site D (Upper Radar Site)

a. Road.—A gravel road will be installed from the end of the existing road to the Upper Radar Site, a distance of less than 1 mile. The cost is estimated at $10,000.

b. Tracking Radar.—The radar itself will be Government Furnished Equipment. Shipping and installation costs are estimated at $5,000.

c. Rawinsonde AN/GMD-2.—This equipment, as well as the shelter for it, will also be Government Furnished Equipment. Shipping and installation costs are estimated at $5,000.

d. <u>Total Costs, Site D, Phase II</u>.—A compilation of costs noted in the preceding subsections gives the following:

Gravel Road	$10,000
Tracking Radar	GFE
Installation Costs	5,000
Rawinsonde AN/GMD-2 and Enclosure	GFE
Installation Costs	5,000
Total Estimated Costs, Site D, Phase II	$20,000

4. Total Costs, Phase II

The total costs for all three sites of Phase II are as follows:

	Buildings and Construction	Furnishings and Equipment	Total
Site A	$39,500	$2,800	$42,300
Site C	37,800	30,620	68,420
Site D	10,000	10,000	20,000
	$87,300	$43,420	$130,720
Building Design and Layout, etc. (approximately 10% of construction costs)			8,700
		Total	$139,420

C. PHASE III

During this phase, work will be done on all four sites and costs will also be incurred for miscellaneous construction.

1. Site A (Launch Area)

a. <u>Proposed Layout</u>.—The installations to be made during Phase III in Site A, the Launch Area, are shown in Fig. 16.

b. Forward Rocket Storage.—The Forward Rocket Storage Building will be a 20' x 30' x 8' structure with explosion-proof light fixtures and no power outlets or other permanent fixtures or furniture. The building will be heated to at least 45°F at 0°F outside air temperature and 20 MPH wind. The construction cost is estimated to be $9,000, and the cost of additional steam lines is estimated to be $1,500, for a total of $10,500.

c. Covered Passageways.—Rockets will be moved on dollies through passageways which are approximately 10' x 8'; these passageways should be level. The dimensions of the passageways used for personnel and small rockets will be 6' x 8'; these can be on a gradient if necessary. All passageways will be heated to at least 45°F at 0°F outside temperature and 20 MPH wind. Enclosures will be constructed of Armco or similar semicircular corrugated sections and straight corrugated panels. The location and estimated cost of the five passageways are as follows:

Rocket Assembly Building to Nose Cone Preparation Building	$3,500
Rocket Assembly Building to Forward Storage Building	3,500
Rocket Assembly Building to Blockhouse	3,125
Forward Storage Building to Small Rocket Launch	2,500
Blockhouse to Utility Building	750
	$13,375

d. Meteorology Tower.—This tower will consist of a 150' steel pole, guyed. It will be weather instrumented at 30' intervals for wind profile determination. The estimated cost of procurement and construction is $7,500.

e. Additional Instrumentation in Blockhouse.—During Phase III, instrumentation estimated at $10,000 will be installed in the Blockhouse.

The major items are:

- 1 Programmer
- 1 Range Timer
- 1 Ballistic Wind Computer

f. Total Costs, Site A, Phase III.—A compilation of costs noted in the preceding subsections gives the following:

Forward Rocket Storage Building		
Building Cost	$9,000	
Additional Steam Lines	1,500	
		$10,500
Covered Passageways		
Rocket Assembly Building to Nose Cone Preparation Building	3,500	
Rocket Assembly Building to Forward Storage	3,500	
Rocket Assembly Building to Blockhouse	3,125	
Forward Storage to Small Rocket Launch	2,500	
Blockhouse to Utility Building	750	
		13,375
150' Meteorological Tower		7,500
Additional Instrumentation in Blockhouse		10,000
Total Estimated Costs, Site A, Phase III		$41,375

2. Site B (Rocket Storage Area)

The only installation on this site anticipated during Phase III is a storage bunker identical to the one described in Phase I. The cost of this bunker is also estimated to be $5,500.

3. Site C (Non-Hazardous Area)

a. General Utility Building.—The major installation during Phase

III will be the General Utility Building, which will contain the following areas:

Machine Shop	450 sq. ft.
Carpenter Shop and Paint Shop	400 sq. ft.
Heating Plant and Water Supply	200 sq. ft.
Shipping and Receiving	300 sq. ft.
Photo Lab	200 sq. ft.
Range Safety Office	200 sq. ft.
Meteorology Office	200 sq. ft.
Lavatories	250 sq. ft.
Range Supervisor	150 sq. ft.
Total	2,350 sq. ft.

The construction costs for the building are estimated at $45,000.

The following equipment will be required:

12	Desks	$1500	
12	Swivel Chairs	564	
30	Straight Chairs	480	
	Work Benches	300	
2	Range Intercoms	370	
			$3,214

Machine Shop Equipment

Lathe and Accessories	3000	
Heavy Duty Drill Press	600	
Bridgeport Mill and Accessories	4000	
DoAll Saw and Accessories	2000	
52" Sheet Metal Shear	570	
48" Sheet Metal Brake	810	
Pedestal Guider	180	
Torch and Accessories	150	
Arc Welder and Accessories	1500	
Stock Racks	200	
Miscellaneous Tools and Fixtures	1000	
		14,010

Wood Working And Paint Shop Equipment

Table Saw	235
Band Saw	95

Sander	$ 85	
Drill Press	150	
Portable Compressor	150	
Paint Spray Equipment	50	
Paint Spray Hood and Fan	350	
		$1,115

<u>Photo Lab Equipment</u>

16 mm Silent Projector	300	
16 mm Sound Projector	900	
35 mm Slide Projector	150	
6' x 8' Wall-Mounted Screen	70	
4" x 5" Enlarger	300	
Print Washer	450	
Print Dryer	400	
Fiberglas Sink	300	
Sink Stand	100	
Cabinets	200	
Temperature Control	165	
Contact Printer	125	
Refrigerator	200	
Miscellaneous Small Items	200	
Storage Cabinets	92	
		3,952

<u>Cameras and Accessories</u>

16 mm High Speed Camera, 200 fps, 400' cap	675	
Heavy Duty Tripod	380	
Miscellaneous Accessories	500	
10" Telephoto Lens	135	
20" Telephoto Lens	350	
16 mm Turret Reflex Camera with Lens and Accessories	2500	
35 mm Reflex Camera (Still)	330	
with Lens and Accessories	170	
Telephoto Lens	250	
		5,290
Total Equipment and Furnishings		$27,581

When the General Utility Building is completed, one of the office trailers will be transferred to Site D.

b. Third Theodolite.—A third theodolite will be supplied at an estimated cost of $1,200.

c. Miscellaneous Range Instrumentation.—Range Instrumentation estimated at $10,000 will be required. This instrumentation will include such items as an intercom system, a WWV receiver, and a secondary time standard.

d. Mobile Equipment.—The mobile equipment required during Phase III is a snow plow and a station wagon. This equipment is estimated at:

Snow Plow	$2,000	
Station Wagon	2,600	
Total		$4,600

e. Single Station DOVAP.—This will be Government Furnished Equipment. Shipping and installation costs are estimated at $5,000.

f. Total Costs, Site C, Phase III.—A compilation of costs noted in the preceding subsections gives the following:

General Utility Building		
Building Costs	$45,000	
Furnishings and Equipment	30,000	
		$75,000
Third Theodolite		1,200
Miscellaneous Range Instrumentation		10,000
Mobile Equipment		4,600
Single Station DOVAP		GFE
Installation Costs		5,000
Total		$95,800

4. Site D (Upper Radar Site)

a. Surveillance Radar.—This will be Government Furnished Equipment. Shipping and installation costs are estimated at $5,000.

b. Long Focus Tracking Camera.—This will also be Government Furnished Equipment, with shipping and installation costs estimated at $5,000.

c. Transfer, Office Trailer.—The cost of transferring one of the office trailers after completion of the General Utility Building and installing the trailer at Site D is estimated at $1,000.

d. Total Costs, Site D, Phase III.—A compilation of costs noted in the preceding subsections gives the following:

Surveillance Radar	GFE	
Installation Costs	$5,000	
Long Focus Tracking Camera and Enclosure	GFE	
Installation Costs	5,000	
Transfer of Office Trailer and Installation at Site D	1,000	
Total Estimated Cost, Site D, Phase III		$11,000

5. Miscellaneous Construction

The following costs, not attributable to any specific site, will be necessary during Phase III:

Balloon Launch Facilities	$4,000	
Theodolite Enclosures	4,000	
Camera Site Enclosure	2,000	
Total Estimated Miscellaneous Construction Costs, Phase III		$10,000

6. Total Costs, Phase III

The total costs for all four sites of Phase III and for construction are as follows:

	Buildings and Construction	Furnishings Equipment, and Instrumentation	Total
Site A	$31,375	$10,000	$ 41,375
Site B	5,500	---	5,500
Site C	45,000	50,800	95,800
Site D	---	11,000	11,000
Miscellaneous Construction	10,000	---	10,000
	$91,875	$71,800	$163,675
Building Design and Layout, etc. (approximately 10% of construction costs)			9,200
		Total	$172,875

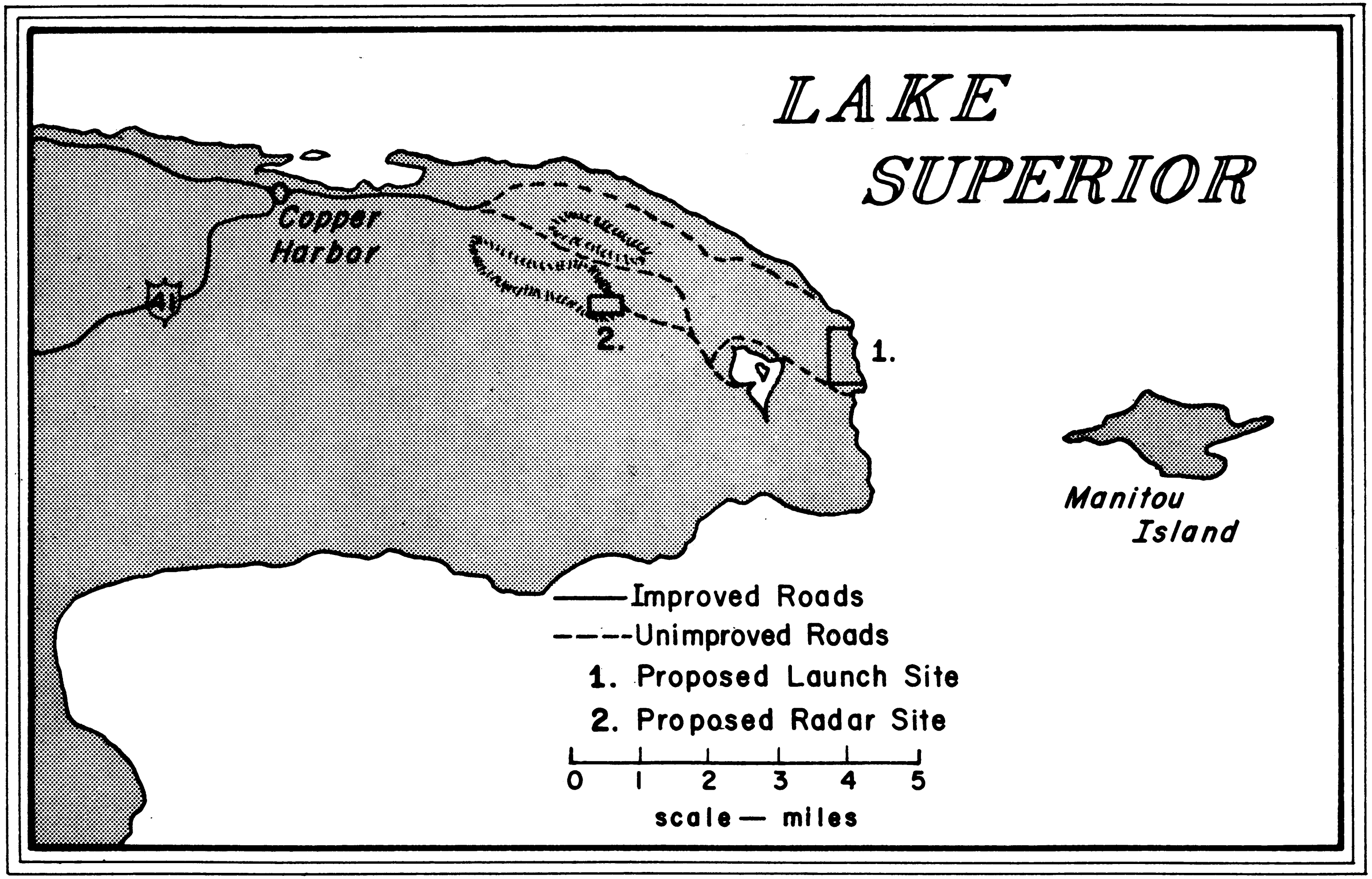


Fig. 4. East portion of Keweenaw Peninsula.

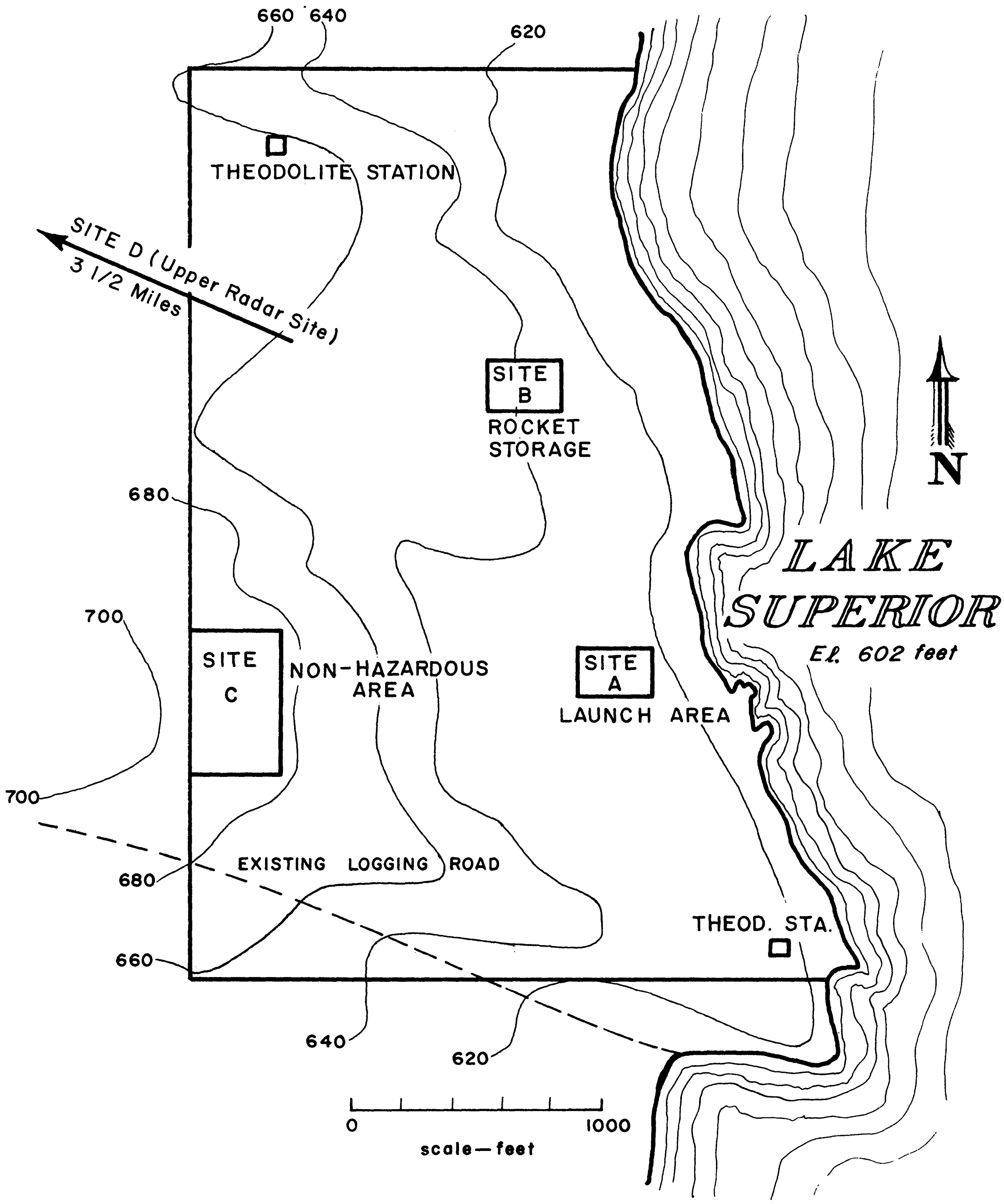


Fig. 5. Proposed research range, with site locations.

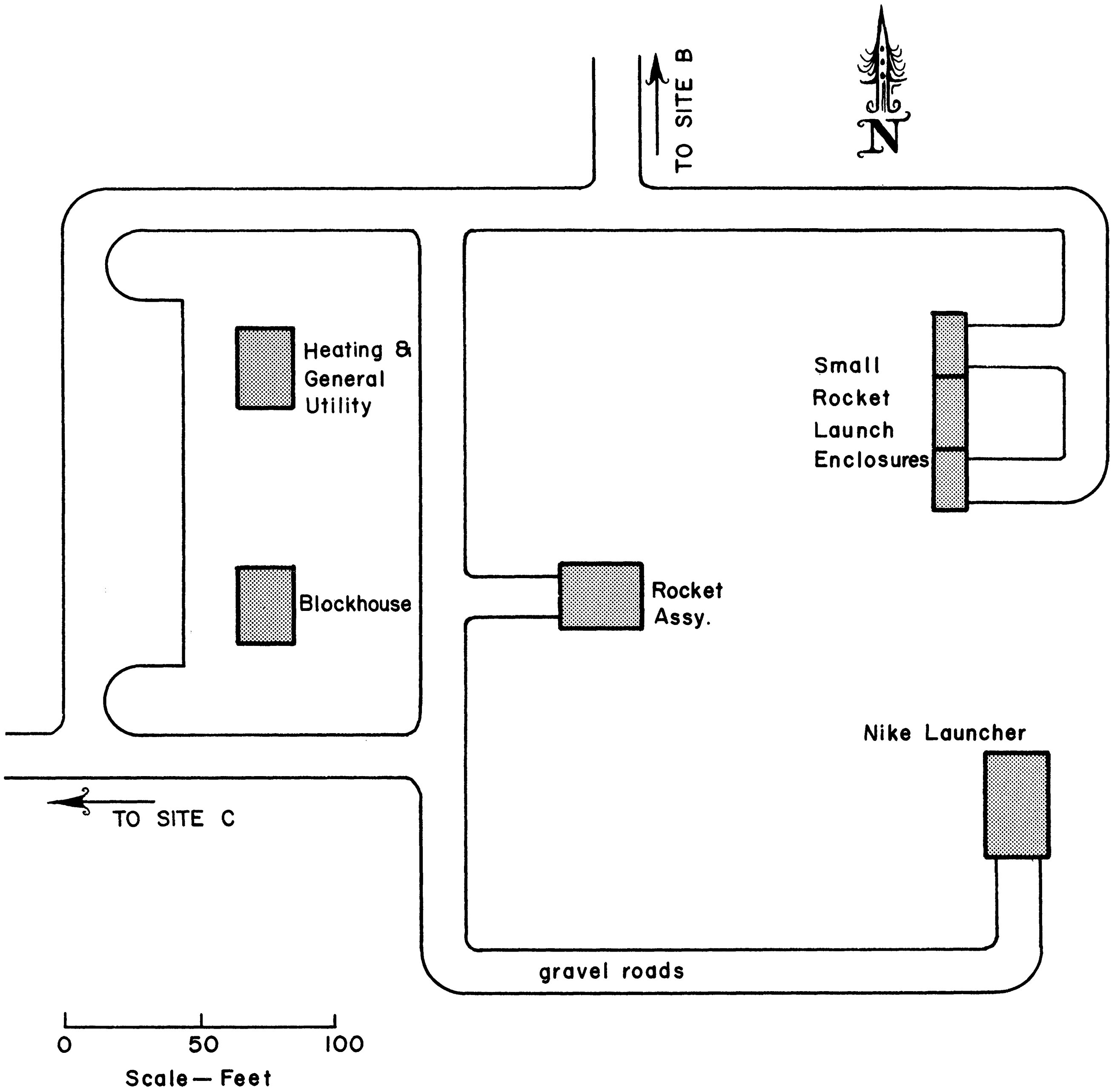


Fig. 6. Launch area: installations during Phase I.

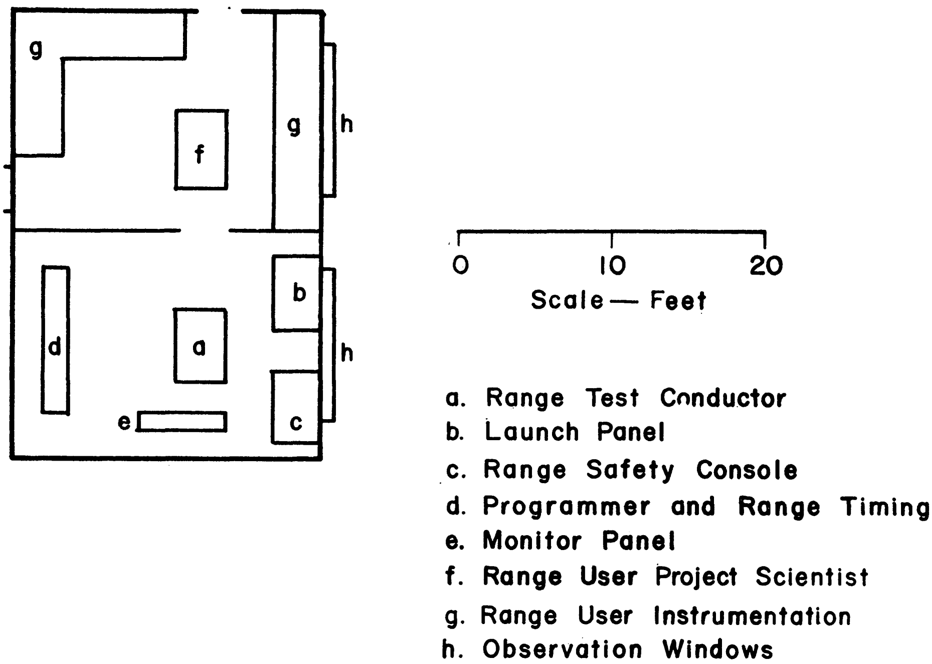


Fig. 7. Blockhouse.

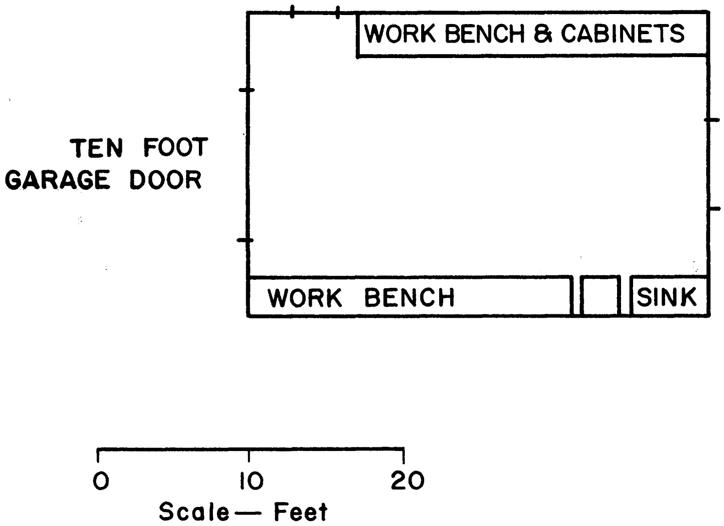


Fig. 8. Rocket assembly building.

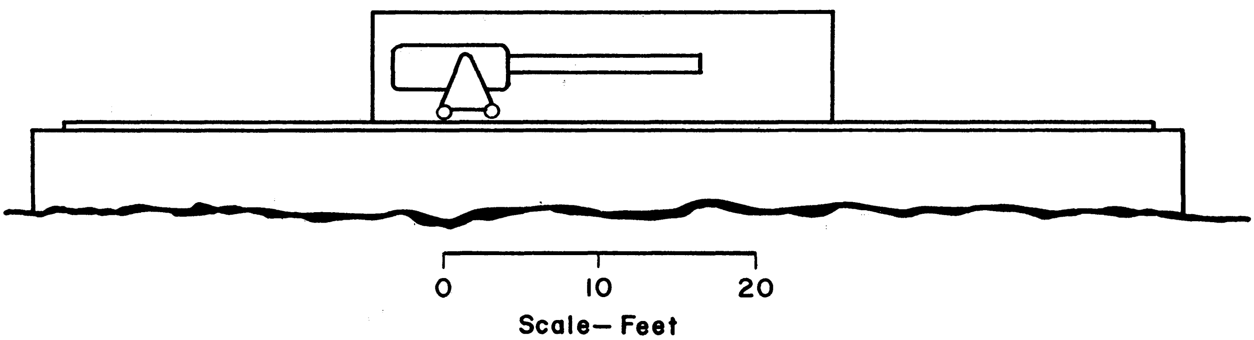


Fig. 9. Small rocket launch enclosure.

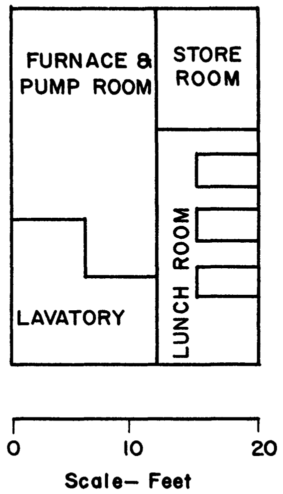


Fig. 10. Heating plant and utility building.

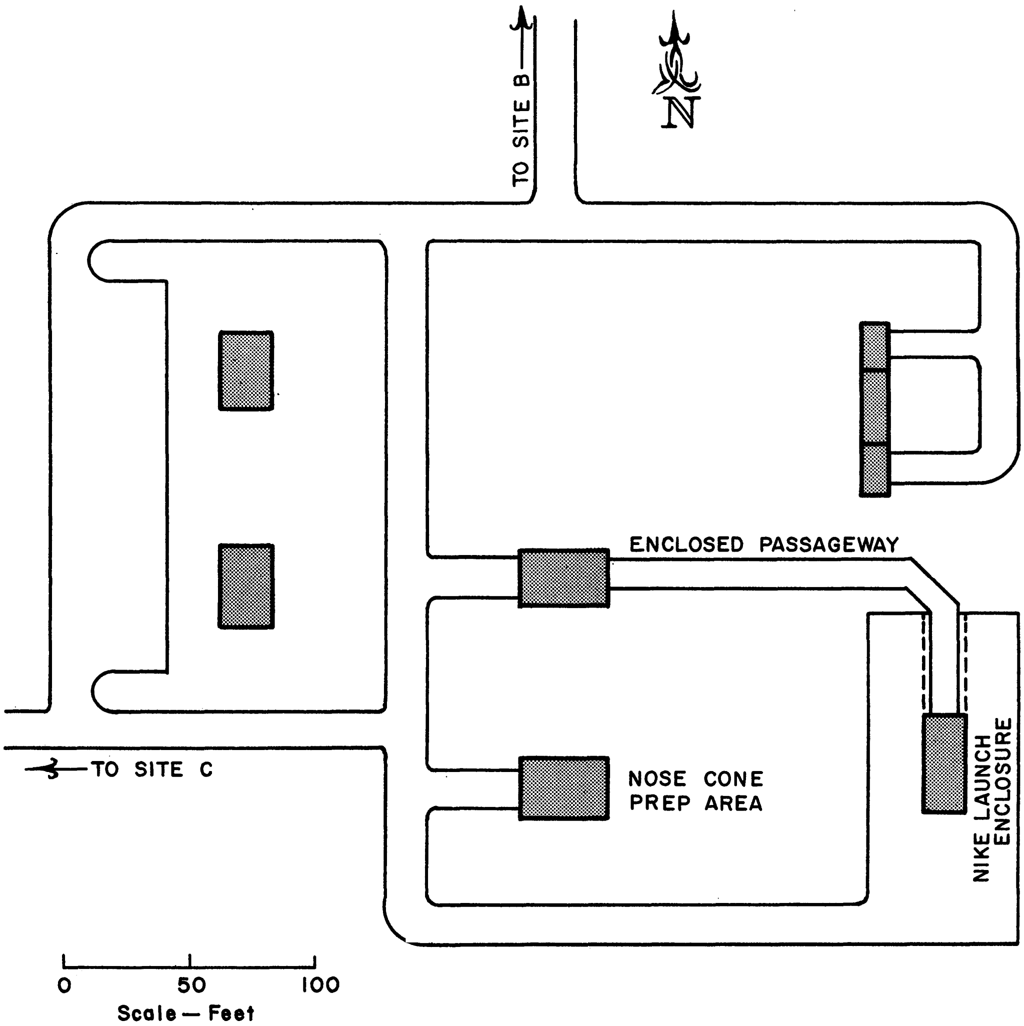


Fig. 11. Launch area: installations during Phase II.

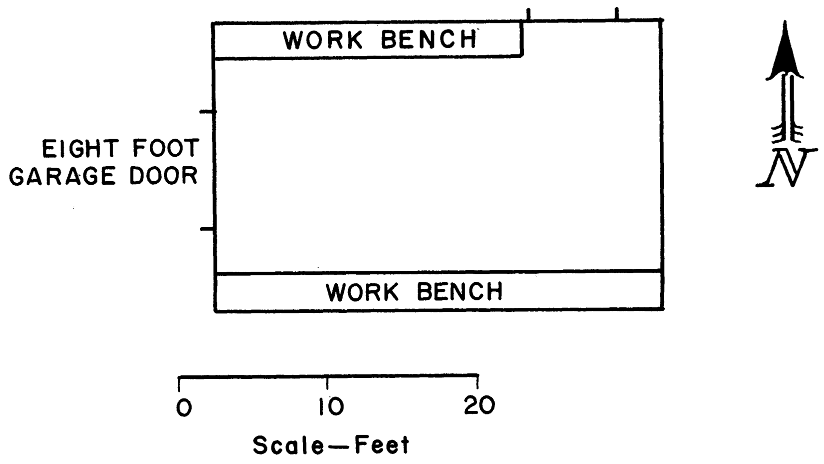


Fig. 12. Nose cone preparation building.

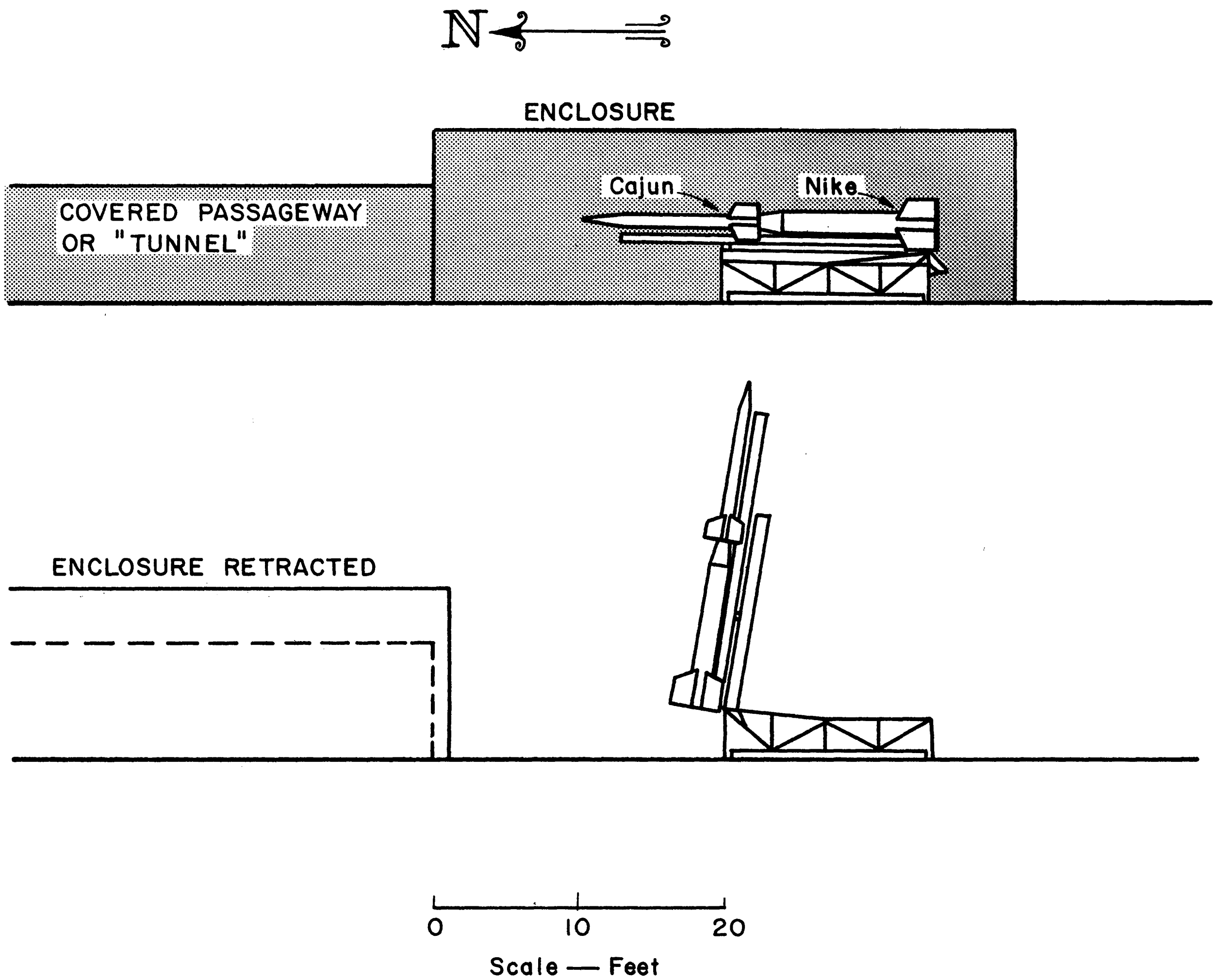


Fig. 13. Nike launcher enclosure.

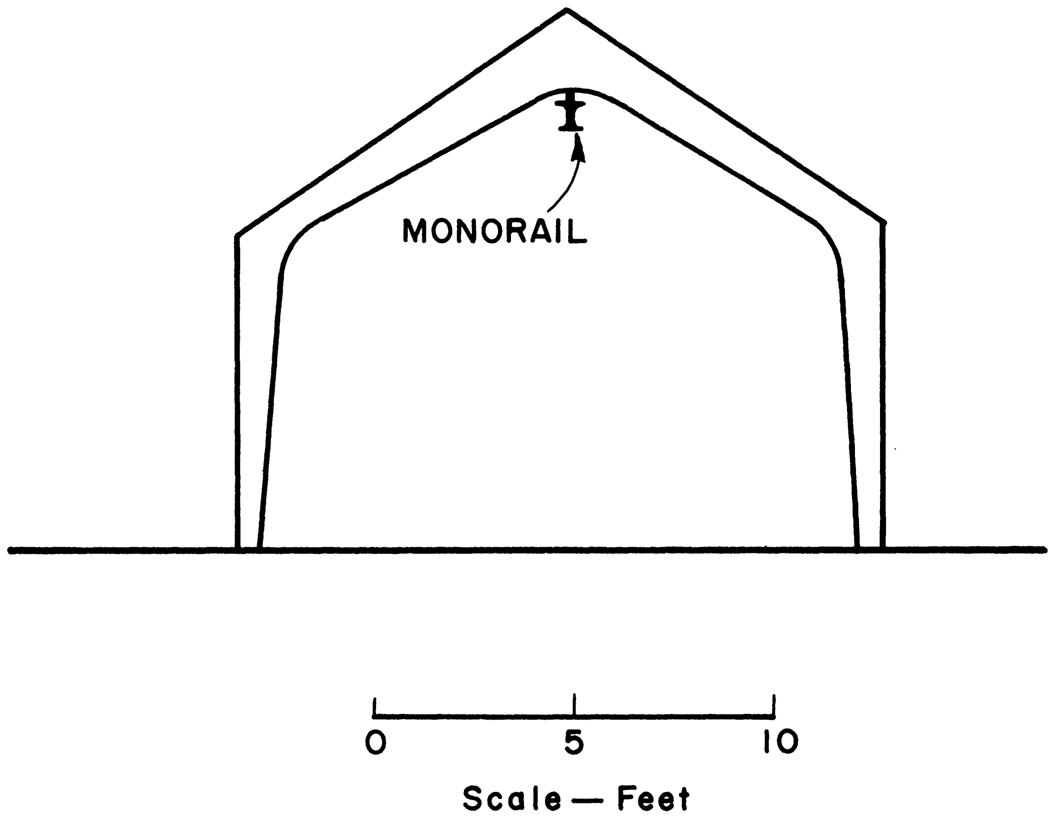


Fig. 14. Nike launcher enclosure—frame.

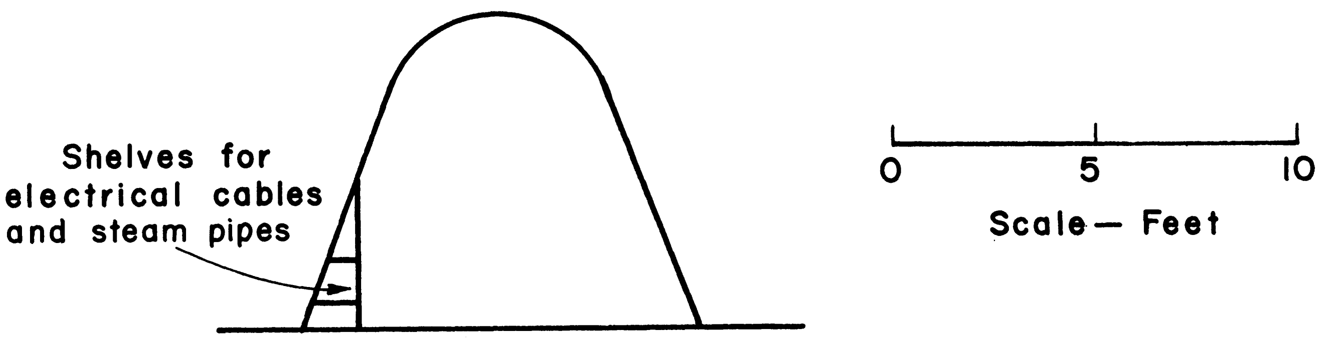


Fig. 15. Cross section of covered passageway.

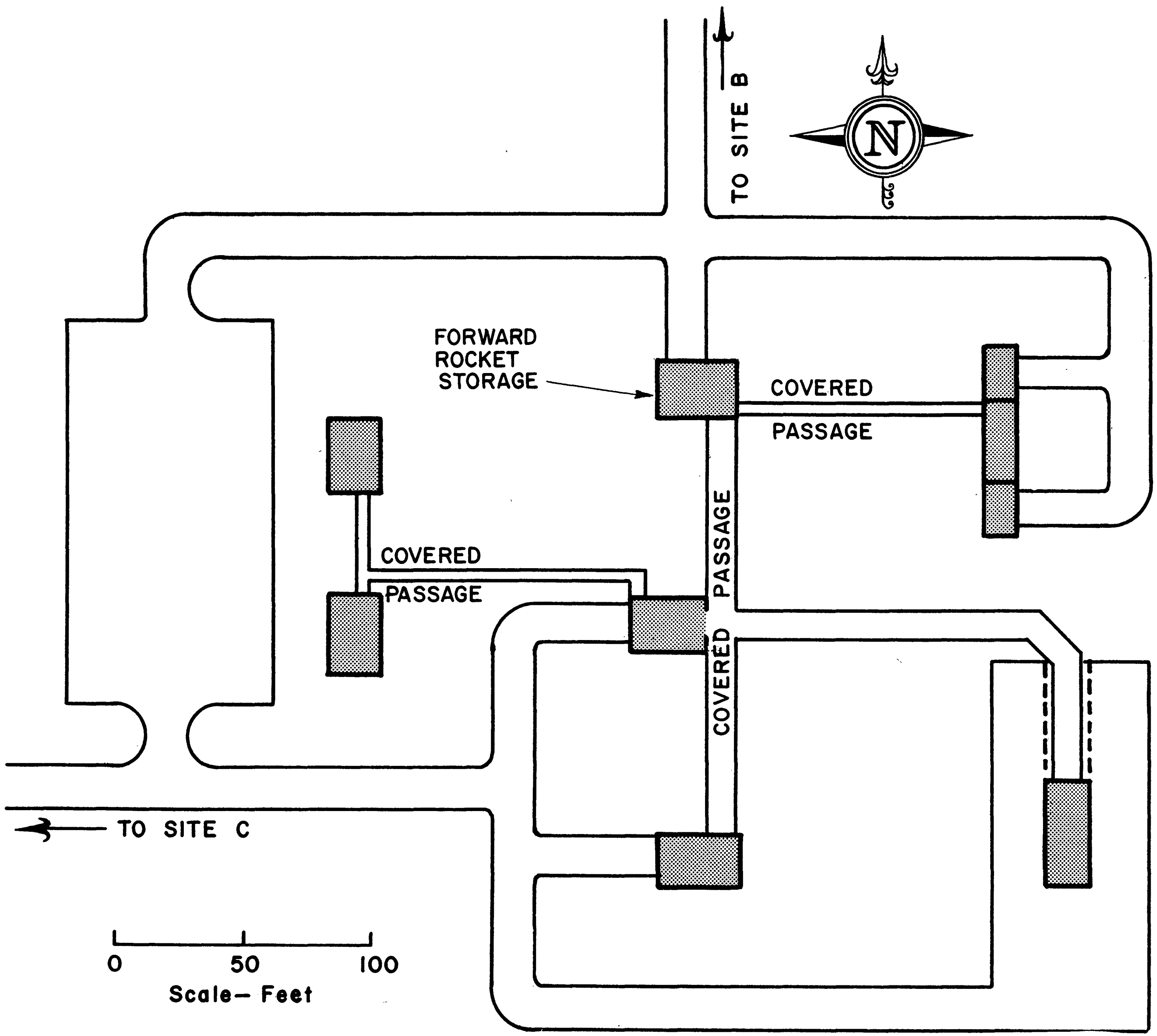


Fig. 16. Launch area: installations during Phase III.

PART IV. TIME SCHEDULE

It is requested that the starting date of this project be September 1, 1963. Firings of small rockets of the Meteorological Rocket Network can then take place in the spring of 1964. If authorization of Phase II is also given in September 1963, launchings of Nike-boosted rockets will be possible in September 1964.

PART V. OVERALL BUDGET

A compilation of total costs* for each of the three phases of the proposed Upper Michigan Range, plus the appraised market value of the property (see Appendix B), yields the following:

Appraised Market Value of Range Property	$ 66,000
Total Estimated Costs, Phase I	147,400
Total Estimated Costs, Phase II	139,420
Total Estimated Costs, Phase III	172,875
Total	$525,695

Estimated personnel requirements are given in Appendix A, along with estimated costs of salaries, wages, and overhead for the first three years of operation.

*Costs of bringing power and telephone to site not available when these estimates were prepared.

APPENDIX A

ESTIMATED PERSONNEL REQUIREMENTS: ESTIMATED COSTS OF SALARIES, WAGES AND OVERHEAD FOR THE FIRST THREE YEARS OF OPERATION

Estimated costs of operating personnel for the first three years of operation. The persons necessary to operate Phase I will start upon completion of the construction of Phase I. In the ensuing year construction of Phase II will occur and at the end the additional operating people for Phase II will start; similarly for the transition year from Phase II to Phase III.

Position	Phase I			Phase II			Phase III		
	No.	Rate	Amount	No.	Rate	Amount	No.	Rate	Amount
Range Supervisor	1	$15,000	$15,000	1	$15,000	$ 15,000	1	$15,000	$ 15,000
Launch Crew Chief	0	---	---	1	10,000	10,000	1	10,000	10,000
Launch Crewman	1	6,000	6,000	1	6,000	6,000	2	6,000	12,000
Range Safety Officer	1	10,000	10,000	1	10,000	10,000	1 1	10,000 8,000	18,000
Meteorologist	0	---	---	1	9,000	9,000	1	9,000	9,000
Photographer	0	---	---	1	8,000	8,000	1	8,000	8,000
Range Engineer	1	10,000	10,000	1	10,000	10,000	1	10,000	10,000
Radar and GMD Operators	1 1	8,000 7,000	8,000 7,000	1 2	8,000 7,000	8,000 14,000	1 3	8,000 7,000	8,000 21,000
Telemetry and DOVAP Operators	0	---	---	1	8,000	8,000	1 2	8,000 7,000	8,000 14,000
Machinist	0	---	---	0	---	---	1	8,000	8,000
Vehicle Driver	0	---	---	0	---	---	1	6,000	6,000
Vehicle and Equipment Mechanic	1	7,000	7,000	1	7,000	7,000	1	7,000	7,000
Buildings and Grounds Maintainers	0	---	---	1	7,000	7,000	2	7,000	14,000
Damage Control Supervisor	0	---	---	0	---	---	1	8,000	8,000
Building Custodians	0	---	---	1	6,000	6,000	2	6,000	12,000
Secretary	0	---	---	1 1	5,000 4,000	5,000 4,000	1 2	5,000 4,000	5,000 8,000
TOTALS			$63,000			$127,000			$201,000
Overhead at 55% of Personnel*			34,650			69,850			110,550
Total Personnel and O.H. Costs, Each Phase			$97,650			$196,850			$311,550
Total Personnel and O.H. Cost, Three Years, Three Phases						$606,050			

*Present provisional rate for The University of Michigan. Subject to change depending on institutional connection of employee.

APPENDIX B

ENDORSEMENTS OF THE PROPOSED FACILITY

(U.S. WEATHER BUREAU, NATIONAL ACADEMY OF SCIENCES)

UNITED STATES DEPARTMENT OF COMMERCE
WEATHER BUREAU
WASHINGTON

February 25, 1963

IN REPLY, PLEASE ADDRESS
CHIEF, U. S. WEATHER BUREAU
WASHINGTON 25, D. C.
AND REFER TO

S-1.1

Dr. Ralph A. Sawyer
Vice President for Research
University of Michigan
Ann Arbor, Michigan

Dear Dr. Sawyer:

Mr. David S. Johnson, Chairman, Joint Meteorological Rocket Network Steering Committee has requested me to forward the following resolution that was adopted unanimously by the JMRNSC.

> "Mr. L. M. Jones and Dr. Harold F. Allen described the results of a technical study carried out by the Institute of Science and Technology of the University of Michigan on the possibilities for a small-rocket launching site in Northern Michigan. The committee unanimously endorsed the University's efforts indicating the desirability of having such a station in that area which could operate as a part of the National Meteorological Rocket Network. The NMRN Plan now being completed includes plans for a station in this area as a part of the network".

We wish you every success in this venture and the committee is willing to assist the University in any way possible.

Sincerely yours,

Eugene E. Duff

Eugene E. Duff, Secretary
Joint Meteorological Rocket
Network Steering Committee

NATIONAL ACADEMY OF SCIENCES

OFFICE OF THE PRESIDENT
2101 CONSTITUTION AVENUE
WASHINGTON 25, D. C.

December 20, 1962

Dean Ralph A. Sawyer
Vice President for Research
University of Michigan
Ann Arbor, Michigan

Dear Dean Sawyer:

On behalf of Dr. Frederick Seitz, President of the National Academy of Sciences, I am glad to transmit herewith a letter to you from Dr. Harry Hess, Chairman of our Space Science Board, dated December 18, 1962. Dr. Hess expresses the keen interest of the Board in the prospects for a small rocket-launching site now being explored by your Institute of Science and Technology, and their hope that the site study can be completed.

I know that the Space Science Board will be glad to lend whatever assistance it can as your work progresses.

Yours sincerely,

S. D. Cornell

S. D. Cornell
Executive Officer

2101 CONSTITUTION AVENUE
WASHINGTON 25, D. C.

CABLE ADDRESS: NARECO
WASHINGTON, D. C.

NATIONAL ACADEMY OF SCIENCES
NATIONAL RESEARCH COUNCIL
OF THE UNITED STATES OF AMERICA

SPACE SCIENCE BOARD

18 December 1962

Dean Ralph A. Sawyer
Vice President for Research
University of Michigan
Ann Arbor, Michigan

Dear Dean Sawyer:

At a meeting of the Space Science Board's Committee on High Altitude Rocket and Balloon Research on November 1, 1962, Mr. L. M. Jones and Dr. Harold L. Allen described the technical study being carried out by the Institute of Science and Technology of the University of Michigan on the possibilities for a small-rocket launching site in Northern Michigan. It appears from a preliminary investigation that the Keweenaw Peninsula in Lake Superior may be feasible for such a site, and we understand that the study is continuing.

The need for a small-rocket launching facility in the region of the Great Lakes has been recognized for some time. All the present launching sites are located in a semi-circle reaching from Alaska, along the Pacific Coast, then along a line across the lower boundary of the U. S. is the Meteorological Rocket Network, which makes it possible to observe conditions in the atmosphere above the level attainable by balloons on a regular basis. However, it is clear that this network, based on present launching sites, has a gap in its very center, a gap that would be filled if there were a rocket site in the Great Lakes region.

In addition to serving as a base for meteorological rocket firings, a new launching site in Michigan would undoubtedly be used for other rocket probes involving the smaller rockets, i.e. rockets with ceilings under, say, 500 km. The Midwest has many research groups who would welcome such a nearby facility. Furthermore, it provides a location farther north and closer to the geomagnetic pole than any other U. S. launching site except that at Ft. Greeley, near Fairbanks. Coordinated experiments with rockets, many of which are being planned for the period of the International Year of the Quiet Sun (IQSY), 1964-65, would almost certainly take advantage of this new site if it were available, and it would therefore significantly enhance the scientific value of the U. S. contribution to the IQSY.

The Space Science Board Committee on High Altitude Rocket and Balloon Research considered all these factors, and strongly urges further university support of this site study. We will also convey this endorsement (by copy of this letter) to those government agencies whose support and cooperation may be required in order to bring this study to fruition.

Sincerely yours,

H H Hess

H. H. Hess
Chairman, Space Science Board

cc: Prof. W. C. Nelson
Aeronautical and Astronautical
Engineering, U. of Michigan
Mr. L. M. Jones
Aeronautical and Astronautical
Engineering, U. of Michigan
Dr. Harold L. Allen
Institute of Science and Technology
University of Michigan
Mr. M. Dubin, NASA Hqs.
Dr. Homer E. Newell, Jr., NASA Hqs.
Dr. M. Tepper, NASA Hqs.
Mr. D. Johnson, USWB
Dr. Earl Droessler, NSF
Dr. Robert Fleischer, NSF

APPENDIX C

"APPRAISAL OF KEWEENAW RESEARCH RANGE"

GOODMAN LUMBER DIVISION

CALUMET & HECLA, INC.

CALUMET, MICH.

PLANTS:
GOODMAN, WIS.
MOHAWK, MICH.

PHONE 345

June 6, 1963

Dr. Harold F. Allen, Research Engineer
Dept. of Aeronautical & Astronautical Engineering
The University of Michigan
Ann Arbor, Michigan

Dear Dr. Allen:

Pursuant to your letter of May 29, 1963, we have inspected the proposed site for your Keweenaw Research Range and accompanying radar installation and have made an appraisal of the surface, timber and Lake Superior frontage.

We submit herein more detailed data pertaining to the description and value estimate of this property.

In our opinion, the market value of this property on June 6, 1963 is:

SIXTY-SIX THOUSAND ($66,000) DOLLARS.

Yours very truly,

C. E. Hein

)rester

Other Considerations

Reservation of existing or pending mineral interests to Calumet & Hecla, Inc.

Further discussion on use and maintenance of access roads.

Existing Facilities

Logging road access to proposed Launch, Storage and Support areas and to within a quarter mile of proposed radar installation.

Telephone line crosses proposed Launch area.

Power line terminates approximately 7 miles to the West.

Fresh, pure water readily available from Lake Superior. A one-third acre pond is situated in the northwest corner of the proposed radar site.

Remarks

The proposed Launch site is located on the extreme easterly tip of the Keweenaw Peninsula. The topography appears level with a gradual descent from an elevation of 680 feet on the west boundary to 602 feet at the waters edge. The apparent shallow soil supports a timber growth composed primarily of white pine and white birch sawtimber and spruce and balsam pulpwood. The timber on part of this area has been harvested during the past 5 years on a partial cutting or selective logging basis. The Lake Superior frontage generally has a scalloped appearance with ledge rock forming the extensions or protrusions into the lake at 100 to 150 foot intervals and pea to marble sized beach rock filling the concave depressions in between. In other words, it has the appearance of a series of small bays. The frontage is unique in that it occupies a position on the end of Keweenaw Point and affords a most scenic view of the Manitou Island area.

The proposed radar site is located on the relatively flat topped level summit of East Bluff at an elevation of about 1300 feet. A one-third acre pond is situated in the northwest corner of this parcel. The timber is generally pole to small sawtimber size short hardwood and again has been part harvested under a selective logging forest management program. An existing logging road terminates about a quarter mile away to the north.

Charles E. Hein

Charles E. Hein
Administrative Forester

APPRAISAL

of

KEWEENAW RESEARCH RANGE

Submitted To

Dr. Harold F. Allen, Research Engineer, Department of Aeronautical and Astronautical Engineering, University of Michigan.

Reason for Appraisal

Dr. Allen's letter of request dated May 29, 1963.

Legal Description of Proposed Site

N1/2 NW1/4 NW1/4	Section 7,	T58N-R27W
NE1/4 NW1/4	Section 15,	"
Lot 1	Section 15,	"
Lot 3	Section 10,	"
Lot 4	Section 10,	"

All in Grant Township, Keweenaw County, Michigan.

Timber Cruise By

C. E. Hein, Registered Forester, Registered Land Surveyor
C. A. Lebo, Registered Forester

June 4, 1963

Subject Appraised

All timber
Land - surface only
Lake Superior frontage

Date of Appraisal

June 6, 1963

Acreage

T58N - R27W		Acres
N1/2 NW1/4 NW1/4	Section 7	20.00
NE1/4 NW1/4	Section 15	40.00
Lot 1	Section 15	30.30
Lot 3	Section 10	52.75
Lot 4	Section 10	60.40
	Total	203.45

Lake Superior Frontage Distance

Total distance was determined from U. S. Government meander notes to be 4,455 lineal feet.

Timber Volumes & Values

Sawtimber	Volume		Market Value	
White Pine	147Mbm	@	$30/Mbm	$ 4,410.00
White Birch	105 "	@	55 "	5,775.00
White Cedar	43 "	@	10 "	430.00
Hard Maple	7 "	@	30 "	210.00
Soft Maple	1 "	@	20 "	20.00
Red Oak	14 "	@	35 "	490.00
Total Sawtimber	317Mbm			$11,335.00
Pulpwood				
Spruce	305 cd.	@	$ 9.50/cd	$ 2,897.50
Balsam	505 "	@	6.00 "	3,030.00
Aspen	30 "	@	2.00 "	60.00
Total Pulpwood	840 cd.			$ 5,987.50

Land Value

203.45 acres @ $20.00 per acre	$ 4,069.00

Lake Superior Frontage Value

4,455 lineal feet @ $10.00 per front foot	$44,550.00
Grand Total Value	$65,941.50
Grand Total Value Rounded Off	$66,000.00

APPENDIX D

MODIFICATION OF NIKE LAUNCHER

As noted in Phase I of this proposal, there is no enclosure at Site A of the proposed research range. The steps in modifying and installing a Nike-Ajax "military" launcher on a concrete pad will be as follows:

1. Replace 400 N system by 60 N, 110 v system.

2. Install adjustable elevation stop.

3. Remove forward pivot and outriggers.

4. Install flanged wheels on frames at each end, 14' apart. Reinforce end frames as required.

5. Provide 14' diameter circular tracks and steel railroad rail, 90-100 lb/yard.

6. Install tie down and azimuth locating clamps at each end.

7. Install outriggers at least 4' long at aft end, with arrangement for clamping to rail. As an alternate, the folding outriggers of the military launcher can be left on, and unfolded by hand after azimuth has been set.

8. Install pivot bearing at center of circular track.

9. Cut down arms holding removable launch rail to clear fins on a 4 fin rocket.

10. Limit azimuth to 0° to 180°, approx.

11. Install lift-off, or first motion, switch.

12. Install monitor cable terminal boards, firing lines, etc., in blast proof box near S. end of launcher.

APPENDIX E

ABSTRACT OF FEASIBILITY STUDY

Summary

The technical feasibility of firing small sounding rockets from a site at the eastern end of the Keweenaw Peninsula at the point shown on the map, Figure 1, was investigated from the following standpoints:

A. Suitable Rockets, and Type of Installation

B. Weather

C. Impact Area Availability

D. Range Safety

E. Site Availability

F. Range Instrumentation

G. Support Facilities

H. Possible Project Support

It is concluded that, although the site is not perfect and there are many problems involved, it is entirely feasible to fire small meteorological sounding rockets, such as the Arcas, Loki, or Hasp, from the tip of the Keweenaw Peninsula a reasonable percentage of the time, especially during the winter months, with adequate range safety. A site of adequate size can be made available, with unimproved access roads, which are actually better in winter than in summer. Electric power is not available at the site, so a small generator will be required initially. A private telephone line, owned by the U. S. Coast Guard, passes the site, and can be tapped for interim communication.

Radar coverage of airspace over the proposed range is carried out by the SAGE air defense net, and surface surveillance can be provided in good weather by aircraft from K. I. Sawyer Air Force Base. Surface surveillance can be dispensed with during the winter months.

Range instrumentation will pose few problems. Arcas rocket launchers and M-33 radars are available, but require modification. Rawinsonde GMD-1 or GMD-2 telemetry tracking equipment has not been located as yet. The U. S. Weather Bureau is anxious to increase the number of stations in the Meteorological Rocket Network, (Figure 2), which currently comprises six stations in the continental United States, one in Alaska, and one in Canada. The Weather Bureau will provide rockets as soon as the capability of firing them exists, and can be expected to assist in locating suitable GMD equipment. Michigan College of Mining and Technology is interested in the proposed range, and, although unable to offer much assistance at this time, hopes to be able to participate in the future.

Feasibility firings can be carried out with a minimum of equipment, and could possibly be accomplished by late spring of 1963. A proposal to the U. S. Weather Bureau is being prepared.

<u>A - Suitable Rockets, and Type of Installation</u>

Sounding rockets can be classed in three general groups, according to range requirements:

1. Small meteorological sounding rockets, usually single stage, with payloads of a few pounds and peak altitudes approximately 75 kilometers. These impact between 10 and 30 miles from the launcher when fired at

85^{o} elevation. The cost is less than $2000 per rocket, including payload. Examples are Arcas, Loki, Judi, Metroc, and Hasp.

2. Medium size, two stage, general purpose sounding rockets, using Nike-Ajax, Terrier, or similar boosters, with Cajun, Asp, Apache, Recruit, or similar rockets as second stages. Such rockets reach peak altitudes of the order of 150 km with payloads up to 100 pounds, and impact 30 to 50 miles from the launcher. The cost of a Nike-Cajun without payload approximates $5500.

3. Multi-stage rocket combinations, such as Javelin, Exos, Strongarm, Trailblazer, and others. These reach altitudes as high as 1500 km with 100 pound payloads, and the upper stages may impact several hundred miles from the launcher.

The third classification of rockets cannot be fired from the Keweenaw Peninsula because of the presence of inhabited areas in Canada north of Lake Superior. It is possible to fire the second classification of rockets from the Keweenaw Peninsula, but the second stages might impact north of the international boundary, and would therefore require some sort of arrangement between the United States and Canada. The first class of small rockets can be fired in an ESE direction from the east end of the Keweenaw Peninsula and the impact area will be entirely clear of Canadian waters on the north, and the shore of Lake Superior on the south.

It is therefore proposed that only the small meteorological rockets be considered for firings in the near future from this site. The Arcas rocket is currently the standard vehicle of the Meteorological Rocket Network, and therefore, all preliminary plans will revolve around this rocket. The rocket itself is an end-burning, solid propellant motor, 4.5" in diameter, 5 feet long, and weighs 65 pounds without payload. The payloads range from 18" to 38" in length, and weigh from 5 to 20 pounds. The rocket is fired from a closed breech launcher, which is essentially a steel tube about 20 feet long, capable of being trained in azimuth and elevated to any desired launch angle. The usual launch elevation is about 84°, which gives peak altitudes of 200,000 feet for the heavier payloads and up to 350,000 feet with light payloads. The payload is ejected at apogee, and the spent rocket casing impacts about 25 to 30 miles from the launcher. Figures 3-8 illustrate operations required for launching an Arcas rocket.

The Arcas rocket has a low thrust and therefore, a low acceleration, which is an advantage in payload design. However, it has to burn for 30 seconds in order to reach the required velocity, and this causes the impact point to be considerably affected by winds. Winds have to be known to a fair degree of precision to 60,000 feet altitude, and the uncertainty in this knowledge results in fairly large dispersion. The average dispersion approximates 9 nautical miles, and this figure is usually multiplied by 2.5 or 3 to give the radius of the impact area. For planning purposes, an impact area approximately 60 statute miles in diameter will be assumed.

Three types of payloads are used. The first is a radiosonde, ejected from the rocket at apogee, and lowered by parachute. There are two types of sonde. The Arcasonde 1 weighs 3 pounds, and is tracked by Rawinsonde AN/GMD-1A, which gives only azimuth and elevation information, besides telemetry. The AN/DMQ-6 payload weighs 6.5 pounds, and includes a transponder for slant range determination in conjunction with an AN/GMD-2. Each instrument is lowered by a 15 foot parachute which is radar-reflective, so the payload can be tracked by radar, to give range information and to serve as a backup. The meteorological information includes temperature and wind direction and velocity.

The second type of payload is the so-called "Robin." This is a one-meter constant diameter mylar sphere, automatically inflated after ejection. It contains a radar corner reflector, and is tracked by precision radar. This gives wind direction and velocity and also density from rate of descent. The third type of payload is radar-reflective chaff, for determination of wind direction and velocity.

Very small sonde payloads are being developed for the small Loki and Judi rockets, which are high-thrust, short-burning rockets, with small impact dispersion. When these become available, the size of the impact area will be greatly reduced, thus simplifying the range surveillance problem. The performance of these rockets is substantially equivalent to that of the Arcas.

The launcher should be located at least 500 feet from unbarricaded, inhabited buildings, to reduce the danger from a possible runaway rocket. There is no explosion hazard with the Arcas propellant, though there may be a fire hazard. Consequently, a small barricaded launch control building, or blockhouse, will be required, with demensions of 10' X 20' for a permanent installation. A 20' X 40' rocket preparation building will be required at least 500 feet from the launcher. A 10' X 20' heated bunker, well separated from other installations, will be required for rocket storage. Some sort of launcher enclosure should be provided, because of the severe weather and snow in winter. An elaborate building with a hinged roof, such as at Fort Churchill, will probably not be required. A simple 10' X 30' building with a garage-type door at one end can serve the purpose. The launcher can be mounted on rails, loaded inside the building, and rolled out to a concrete pad outside the door just before launching. Preset stops on the elevation, and azimuth circles simplify the operation, which should not require more than a very few minutes. Heating facilities should be provided in a small building, separated from the launch building for fire safety.

For best results, the tracking radar and telemetry site should be located at least 5000 feet from the launcher in order that the maximum angular tracking rate of the GMD will not be exceeded as a result of the vertical velocity of the rocket. If a surveillance radar is to be located at the same site, it would be desirable to locate it at as high an elevation as possible, for best line-of-sight distance.

In some instances, especially temporary field operation, the radar and GMD are located adjacent to the launcher, for convenience, and to reduce the personnel requirements. In this case, the rocket is not tracked from launch, but is picked up at altitude, a somewhat more uncertain procedure. Figure 9 shows an aerial view of the Meteorological Rocket Network station at Fort Greely, Alaska, which is operated by a 4-man crew from White Sands Missile Range. The initial installation at the Keweenaw Peninsula will probably be roughly equivalent to the Fort Greely station.

The installation discussed above represent absolute minimum requirements for a permanent installation. However, feasibility firings can be carried out with little equipment other than a launcher and GMD, as discussed in other sections of this report.

B - Weather

Weather elements at several stations on and near the Keweenaw Peninsula were examined, and compared with the weather at Fort Churchill, Manitoba, which illustrates an operating range in an area where extremely severe weather is often encountered. The following stations are represented:

1. Houghton (Houghton-Hancock Airport)
2. Eagle Harbor (on Keweenaw Peninsula)
3. Marquette
4. Ontonagon
5. Grand Marais
6. Coast Guard Station Manitou Island (east of Keweenaw Point)
7. Fort Churchill, Manitoba (for comparison)

Temperature. The highest temperature will exceed 90°F at infrequent intervals. Temperatures of 40°F and below will be encountered during 10 months of the year, and extremes as low as -10°F can be expected occasionally during the three winter months. The temperature range is much less than that at Fort Churchill, where temperatures as low as -50°F can occur during five months of the year.

Precipitation. Precipitation is fairly uniform, with slightly more in summer than in winter. Much of the winter precipitation is in the form of snow, which can occur during 5 to 7 months of the year. The maximum depth of snow frequently exceeds two feet between November and March, although persons familiar with the area stated that the snow accumulation on the extreme tip of the Keweenaw Peninsula is usually less than at Eagle Harbor or Houghton. The snow situation is roughly equivalent to that at Fort Churchill, where the total snowfall is less, but there is no loss by melting at any time during the winter.

Wind. The prevailing wind direction is generally westerly or northwesterly. There are few severe storms, and gale winds are infrequent, although the average wind velocity is fairly high (6 to 10 mph). Both average and maximum wind velocities are less than those at Fort Churchill.

Reduced visibility occurs a smaller percentage of the time on the peninsula itself than on the mainland. The visibility is below 4 miles less than 100 hours per month during the summer months, and the winter visibility is better than in summer. Figures on sky cover are not available in summary form, but clear skies can be expected about 80% of the time in summer, and about 20 to 30% in fall and early winter.

There are no aspects of the weather which would constitute a serious hindrance to the firing of meteorological rockets throughout the year. However, wind chill factors of 1600 to 1800 calories per square meter per hour are occasionally encountered for fairly long periods of time during the winter (wind chill of 1200 is rated as bitterly cold), and this, coupled with fairly heavy snow cover, establishes requirements, at a permanent range, for the following installations and equipment:

1. Enclosed launcher and GMD equipment.
2. Heated rocket preparation building.
3. Enclosed launch control center, or blockhouse.
4. Heated bunker for rocket storage.
5. Mobile plows or blowers for snow clearance.
6. Four-wheel drive vehicles.
7. Vehicle garage and maintenance building.

The relative remoteness of the site also makes it desirable to establish a "fallback" building, with limited berthing, messing, and office facilities, where crew and visitors can wait out the long delays which seem to be inherent in experimental rocket firing.

Feasibility firings for the sake of proving out the range can be carried out without the above facilities. At the cost of considerable discomfort, Arcas rockets can be fired from an unsheltered launcher, and can be prepared for firing in a small truck or van.

C - Impact Area Availability

The calculated and experimental dispersion of the Arcas rocket impact point is approximately 9 nautical miles. For adequate safety, this is usually multiplied by a factor of 2.5 or 3. Assuming the latter figure for this range, the impact area required will be a circle 54 nautical miles in diameter. This can be located with its center at a point 27 nautical miles or more SE of Keweenaw Point without involving land areas (other than Manitou Island) or waters north of the international boundary, (Figure 10). Manitou Island is not inhabited except for the Coast Guard station, which is manned eight months each year. It will therefore be necessary to evacuate the Coast Guard crew, or to provide a bomb-proof shelter if firings are to be conducted during the navigation season.

The Loki and Judi rockets, for which payloads are being developed, will require much smaller impact areas, probably about 20 miles in diameter. Such a circle, with its center SE of Keweenaw Point, would be completely clear of all land areas.

D - Range Safety

The impact area must be clear of ships and aircraft before a rocket can be fired. The airspace over the entire region is under continuous surveillance by radars of the Sault Sainte Marie Sector of the North American Air Defense (SAGE) net, with headquarters at K. I. Sawyer Air Force Base at Marquette, Michigan. The Air Force can furnish information at any time as to the condition of the area. They have direct lines to the FAA regional Air Traffic Supervisor at Detroit Metropolitan Airport, and can relay any required information regarding rocket firings, so that commercial pilots will be informed, and under certain circumstances may detour to avoid the impact area. The Air Force is willing to pull their own aircraft out of the area for a firing except during practice alerts which occur without warning.

The Air Defense Sector normally has no capability for surface surveillance, but in good weather, can usually determine the presence of shipping and relay the information. They have aircraft in the air practically continuously.

The availability of the impact area is assured during the winter months, but during the navigation season, it is compromised by lake shipping. The best estimate of the number of ships movements in the area is provided by the record of ships passing through the locks at Sault Sainte Marie. In 1961, there were 10,000 cargo ship movements between 1 April and 18 December, an average of nearly 38 ships per day. These follow three main tracks from the "Soo", the two most important of these passing through or near the impact area. The principal cargoes are iron ore and grain. The ore carriers travel all three tracks, while the grain is carried principally on the north and center tracks. The most northerly course, along the international border, handles approximately 6 to 10 ships per day. The southerly track, from Marquette to the "Soo", which is outside the impact area, has only one or two ships per week. The central channel, which passes three to ten miles north of the Keweenaw Peninsula, handles 30 to 40 ships per day on the average. This track passes only a short distance north of the center of the impact area, so each ship will require 3 to 4 hours to cross the area. With 30 to 40 ships per day in the navigation season, it is readily apparent that lake traffic poses a major problem. However, those familiar with the Lake insist that the ships are not evenly distributed, and that there will be times during almost any day when it will be possible to fire rockets, although it may frequently be necessary to wait many hours for a clear space.

Studies of the lake commerce for the past 60 years indicate that the problem of ship traffic will probably not increase in the foreseeable future, and may even decrease slightly. The grain traffic has increased fairly steadily, with some fluctuation, for the entire 60 year period, and will probably continue to increase, now that the St. Lawrence Seaway is in operation. The grain traffic accounts for about 25% of the lake traffic. The gross tonnage of iron ore, on the other hand has shown no increase since World War II, and for the last three years, has been consistently below the post-war average. This has resulted in a leveling off of the total freight commerce. At the same time, the average tonnage per cargo has increased, so that there are fewer ship movements. The total number of vessels in the Great Lakes cargo fleet has decreased nearly 20% in the past decade, and the annual total of ships passing through the locks has decreased an even greater amount in the same interval.

A surveillance radar on the top of East Bluff could scan out about 30 miles to the north and east, but could not determine if the outer half of the Arcas impact area is clear, although this would be adequate for Loki or Judy firings. In good weather, the Air Force can furnish information as to the condition of the impact area. This should certainly suffice for feasibility firings, and possibly for a schedule calling for not more than one rocket per week. It is believed that a system can be worked out with the Coast Guard whereby the positions of ships in the area can be reported by marine radiotelephone with sufficient frequency for tracking purposes. A plot initiated a few hours before a scheduled firing should suffice for range safety purposes.

In winter the area is clear except for occasional commercial fishermen. However, there are only half a dozen boats active. They use steel hulled boats averaging 40 to 50 feet in length, which should give good radar returns. It should be no problem to keep track of these few boats through their commercial association. The Coast Guard station on Manitou Island is manned during the navigation season, so it may be necessary to evacuate the personnel or provide a bomb shelter during Arcas firings. Loki and Judi firings can be carried out with Manitou Island and all ship channels entirely outside the impact area.

Although far from insurmountable, range safety will present the major problem at this range. Feasibility firings should be conducted before the start of the 1963 navigation season, if possible, in order to defer the surveillance problem for a firing or two, thus simplifying the problems at the start.

E - Site Availability

The best launch site is at the north end of High Rock Bay, on the east end of the Keweenaw Peninsula, (Figure 11), with an unimproved access road and a Coast Guard telephone line to the site. There is a good radar site on the top of East Bluff, four miles NW of the proposed launch site. This point is at an elevation of 1322 feet above sea level, or 720 feet above Lake Superior. There is an access road within about half a mile from this point, and there is said to be no difficulty anticipated in extending this road to the top of the bluff. Both sites are on land owned by the Goodman Lumber Division of Calumet and Hecla, Inc. Representatives of the company have stated there will be no difficulty in obtaining these sites, although they have not yet defined their terms.

Lumbering is being carried out in the area, and the roads are said to be better in winter than in summer. Township officials stated that the roads could be improved, and that they could furnish a trailer for temporary shelter during feasibility firings, and also that they could pour a concrete pad for launcher mounting.

F - Range Instrumentation

The principal items of range instrumentation required are the Rawinsonde GMD-2 telemetry tracking equipment and the precision tracking radar. At least two available Arcas launchers have been located, but no

GMD equipment as yet. M-33 radars are available. We already have located one in the Detroit area. Although it is not complete, it can serve as a valuable source of parts. The Weather Bureau is having two others allocated to this project. These radars require considerable modification in order to adapt them to the purpose of precision tracking. This includes slaving the radar to a GMD-2 to assure target acquisition. During the launch phase, the GMD tracks the beacon in the payload through the plastic nose cone, and is therefore on target at release. White Sands Missile Range has unofficially offered technical advice and the use of their facilities for radar modification and checking, and crew training.

For feasibility firings, the radar can be dispensed with, and the sonde payload tracked with a GMD-2, which can be temporarily located, without shelter, at a site near the launcher. Power can be supplied by a portable generator.

Photographic facilities for general purpose record photography, as well as high speed motion picture equipment will be required for a permanent range, but can be supplied by the ORA photo lab for feasibility firings.

G - Support Facilities

A permanent range in this area should include the following as a minimum:

1. Enclosed launcher
2. Rocket preparation building
3. Launch control center, or blockhouse
4. Heated rocket storage bunker

5. Fallback building (headquarters)

6. Radar vans

7. GMD enclosure

8. Vehicle garage

9. General workshop and storage building

10. Water supply sewage facilities and heating plant

Not all of these will be required in the immediate future, but will ultimately become necessary.

Mobile equipment such as bulldozer, snow plow or blower, fire fighting equipment, pickup truck, or carryall, four-wheel drive vehicles, and rocket trailer will be required for year-round operation. All-weather roads must be provided to the radar and launch sites, and access roads and parking areas within each site will be required. Improvement of existing roads can be carried out as required, by Keweenaw County.

Central station power and adequate telephone service will be required, neither of which is currently available. High voltage lines exist within about 5 miles from the radar site and 9 miles from the launch site. The Upper Peninsula Power Co. is making an estimate of the cost of extending these lines. No public phone service exists in Grant township, which comprises the eastern half of the Keweenaw Peninsula, although franchise applications from three telephone companies are now before the Public Service Commission. A private line, owned by the U. S. Coast Guard, exists at the Launch Site. Permission of the Coast Guard to tap this line for interim communication purposes has been requested.

For the purpose of feasibility firings, passable roads exist, power can be supplied by a portable generator, and the Coast Guard phone line can probably provide communication with the GCI primary radar site P-16 at Gratiot Lake, 22 miles west of the launch site. P-16 can relay information to K. I. Sawyer Air Force Base and the FAA Air Traffic Supervisor. Upper air winds and forecasts can be supplied by the weather station at Marquette, with information relayed through Sawyer Air Force Base. Local winds will be obtained from Pibal launches at the site. Fire fighting equipment on the Peninsula includes an 800-gallon pumper at Copper Harbor, about ten miles from the launch site, and a 400-gallon pumper at Bete Grise about 15 miles distant. The Michigan Department of Conservation also has fire fighting equipment in the area during the summer months, when fire hazard is greatest.

Assuming the launching and data-recovery capabilities can be made available, the above interim support facilities are considered sufficient for initial feasibility firings. It must be recognized that it will be necessary to exercise a certain amount of ingenuity and to accept a considerable degree of inconvenience in order to get the job done.

H - Possible Project Support

Members of the Balloon and Rocket Meteorology subcommittee of the Space Science Board, and the Joint Meteorological Rocket Network Steering Committee have expressed great interest in the possibility of firing small sounding rockets from the Keweenaw Peninsula. Existing stations in the Network are located generally around the periphery of the North American Continent, and it is considered highly desirable that a station or stations be established somewhere in the interior of the continent. A proposal to the Weather Bureau is being prepared.

Personnel of the Air Force Cambridge Research Laboratory and the Goddard Space Flight Center, of the National Aeronautics and Space Administration have indicated a definite interest in firing larger rockets, such as Nike-Cajuns, from this range. It is believed that there will be no dearth of projects, once the capability of firing rockets has been established.