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Project # 3500

INTELLIGENCE RESEARCH PROJECT

PROJECT NO. 3506 DATE 13 January 1947

POSSIBILITIES OF TRANS-ARCTIC ATTACK ON THE UNITED STATES

COPY NUMBER 6

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Project No. 3506

13 January 1947

POSSIBILITIES OF TRANS-ARCTIC ATTACK ON THE UNITED STATES

Statement of Project

This paper presents all available data on the possibilities in the next few years for an attack on the United States from or through the Arctic regions, including the weapons and means of warfare available to a potential enemy, the bases from which such an attack could be launched, and the various routes of approach.

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POSSIBILITIES OF TRANS-ARCTIC ATTACK ON THE UNITED STATES

1. Weapons and Means of Warfare

a. Guided Missiles

The U. S. S. R. has practically all the information the Germans possessed on guided missiles as well as many of their scientists, technicians, and production facilities. It is known that the Soviets are continuing the German work, with the help of these facilities, on V-1 and V-2 types of missiles, and it is likely that they are also working on glide bombs of the Hs-293 type for use against ships and on some sort of antiaircraft missile of the Wasserfall type. It is believed that a modified form of the V-1, launched from the vicinity of Stolp (Polish-administered Germany) or from Estonia and the Baltic islands of Dagö or Oesel, was responsible for the recent reports of "ghost rockets" over the Scandinavian countries. These reports, however, have been greatly exaggerated and augmented by a large number of natural phenomena such as meteors. In any case, it is probable that the V-1 type of missile with a range of 500 to 600 miles, but with rather poor accuracy (three or four percent of the range), could be developed and used by the U. S. S. R. within a year or two. Such missiles could be launched from naval vessels.

Progress on a long-range rocket of the V-2 type is much less probable. No reasonably authentic reports of actual test firings of even the standard German V-2 have yet been received, but it is known that a test and development program is being set up at Peenemünde. It is not likely that any such missile can be developed in the next ten years, with a range greater than 500 miles, that will have a satisfactory accuracy and a sufficiently large warhead to be useful for other than psychological effects. It could not be a real threat to the continental United States. The German V-2, with a maximum range of about 200 miles and an accuracy of about three percent of the range could, and probably will, be produced by the U. S. S. R. within the next two years. The use of such missiles against England would be quite logical, but the rest of Europe could be attacked to better advantage by more conventional bombing methods.

b. Pilotless Aircraft

The use of long-range "drone"-type aircraft by the U. S. S. R. within a few years is certainly a possibility, but due to the lack of precision instrument facilities, the extreme difficulty of developing any satisfactory long-range control or navigation system, and the fact that a human pilot would be so much better and easier to use, it is not believed that such drones would be used by the Soviets. It is believed that most of their real scientific effort in the next five to

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ten years will be devoted to work on atomic bombs, to minor improvements in the effective types of German guided missiles, and to the development and production of defensive radar and fire-control equipment.

c. Arctic Warfare

There is no information available regarding specific Soviet experiments in Arctic warfare or in Arctic tactical or logistic techniques applicable to warfare other than their well-known skill in constructing and using large ice breakers.

d. Atomic Weapons

If the Soviets continue to devote the effort that they now appear to be placing on atomic research, they could have a few bombs by 1950 to 1953, but they could not have more than 100 by 1956. It is unlikely that any guided missile capable of carrying atomic warheads could be developed in this period.

e. Biological Warfare

The U. S. S. R. is believed to have been conducting research in BW since the middle 1930's and may well be capable of effectively utilizing this mode of warfare at the present time. A period of five years would suffice to permit the U. S. S. R. to wage open, large-scale warfare. However, this is contingent on the Soviets' abilities to produce the large number of long-range aircraft which would be necessary to attack as large an area as the United States.

2. Bases

There is no information to show that any bases are held by potential enemies in the Arctic regions in Iceland or in the southern part of Greenland.

3. Routes of Approach

There are two Intelligence Division studies attached which give terrain data on Northern Canada, Northern Siberia, and the northeastern approaches to North America. These studies, though not of recent date, have not been revised as they are consistent with the latest information on the subject. The studies in addition contain discussions of routes of advance by land, sea, and air and of possible bases and launching sites in the above areas. The studies are:

Appendix A - "Geographic and Economic Study of the Western Hemisphere North of 50° North Latitude", dated 4 Oct 45.
Appendix B - "Topographic Study of the Northeastern Approaches to North America", dated 11 Oct 46.

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APPENDIX A

TITLE: Geographic and Economic Study of the Western Hemisphere North of 50° North Latitude.

I. Statement of Project.

1. This project presents a geographic and economic strategic study of Canada, Greenland, and Alaska (excluding the Aleutian Islands). It analyzes these areas as avenues of attack on the United States proper by describing present and possible means of transportation by land, sea, air and ice pack into and through the area. Possible avenues of approach to the United States by hostile forces from outside the Western Hemisphere are considered. This part of the problem involved a study of land, sea, and air transportation in Siberia, north of the 50th parallel, and east of the Ural Mountains. Staging areas for airborne forces, bases for long-range weapons, and (in Canada and Greenland) areas containing critical minerals are considered.

II. Conclusions.

1. Tentative conclusions are that large areas are suitable for lodgement and for basing long-range weapons and airborne forces in subject areas. Problems of logistics are formidable, and the size of the forces which can be brought to bear are entirely dependent on the solution of such logistical problems.

2. A waterborne attack within the area of this study is extremely difficult and involves many uncertainties in the necessary buildups, initial assault and in supply. Small forces could probably be moved via the Northern Siberia Sea Route, or even over the Arctic ice floes, but chiefly in limited support of forces utilizing other routes of approach. Larger forces could approach Alaska or the North American Pacific coast directly across the North Pacific, the Bering Sea or Bering Strait. Summer is the only time that the Northern Sea Route is open, and at that period soil conditions are such that overland movement and heavy construction are extremely difficult.

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3. Large-scale air attack, including the landing of troops is, perhaps, the most feasible method of attack from northern Siberia. Weather conditions for flying are best in winter when the ground is most suitable for further movement, but all operations in winter may be handicapped by long hours of darkness and extremely low temperatures. Air facilities are available in both North America and Asia for take-off and landing. Transport planes which can negotiate the distances involved probably will be available within a few years. No estimate can be made at this time of the size of forces which could be ferried by air directly across the Arctic or North Atlantic via Greenland.

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Geographic and Economic Study of the Western Hemisphere North of 50° North Latitude

A. General. The following preliminary study analyzes the possibilities by which Canada, Greenland and Alaska (excluding the Aleutians) could provide avenues of attack on the United States proper. The vastness of the area involved and the relative paucity of statistical information, particularly on the Soviet areas, makes desirable a continuing study of this problem. The present study considers only the approaches from the northern Soviet Arctic to the American Arctic. The staging of assault from bases in Kamchatka, the Kuriles, or the Soviet Maritime Province involve a different set of problems which are not considered here, since using such bases would almost inevitably involve the Aleutians, which are excluded from the present study. Direct assault on the Pacific coast of Canada or Alaska is therefore not analyzed, although consideration of such an attack across the North Pacific must not be excluded from the problem of defending the northern frontier of the United States.

1. Tentative conclusions are that large areas are suitable for lodgement and for basing long-range weapons in subject areas. Problems of logistics are formidable, and the size of the forces which can be brought to bear are entirely dependent on the solution of such logistical problems.

2. A waterborne attack within the area of this study is extremely difficult and involves many uncertainties in the necessary buildup, initial assault and in supply. Small-scale forces could probably be moved via the Northern Siberia Sea Route but chiefly in limited support of forces utilizing other routes of approach. Larger forces could approach Alaska or the North American Pacific coast directly across the North Pacific, the Bering Sea or Bering Strait. Summer is the only time that the Northern Sea Route is open, and at that period soil conditions are such that overland movement and heavy construction is extremely difficult.

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4. The body of the report falls into three phases; a. The Siberian Sector, b. Routes across and around the Arctic Sea, and c. The North American Sector.

B. Soviet-Sector.

1. Routes from the Trans-Siberian Railway to the Soviet Arctic Coast (See Map I).

a. Land and River Routes. There are four through routes connecting the Trans-Siberian Railway with the Northern Sea Route, and one connecting the Okhotsk Sea with the Northern Sea Route. Since the data necessary to determine capacities of Siberian transport systems are scarce, no through capacity figures are included in the general description of the five systems, but capacities have been estimated for individual railways, roads, and rivers. At present, the rivers are probably the main limiting factor in through capacities. The chief problems involved in the use of the river systems are the short summer navigational season, periodic fluctuations in water level, difficult navigation (due in part to inadequate river surveys and channel markings), lack of shipping and ship-building facilities, and trans shipment bottlenecks. Most of these deficiencies could be overcome by a determined effort on the part of the Soviet, and in addition the rivers can be used as highways in winter, when the ice is 3 to 5 feet thick. The rivers here considered are the Ob', Yenisey (Yenisei), Lena, Kolyma, and Anadyr'. Other rivers, but of less importance, are the Indigirka, and Yana. The Kamchatka and Amur Rivers are excluded from this preliminary report. Data on capacities of all waterways are old and inadequate for the purposes of this report, and must be considered as the most rough approximations. The latest figures available are for 1937, and are given for river basins and groups of rivers. The figures used in this report are of necessity nearly 10 years old. Considerable development may have been accomplished since their release. The five through routes, from west to east, are:

1. From Omsk on the Trans-Siberian via the Irtysh and Ob' Rivers to Novyy Port; or the alternate route from Novosibirsk on the Trans-Siberian via the Ob' to Novyy Port.

2. From Krasnoyarsk on the Trans-Siberian via the Yenisey River to Igarka, thence by ocean vessel to Yenisey Gulf and Dikson Island.

3. From Irkutsk on the Trans-Siberian up the surfaced highway to Kachug, thence via the Lena River to Tiksi; or, if the

western section of the Baykal-Amur Trunkline is in operation, from Tayshet by rail to Ust'-Kut, thence via the Lena to Tiksi.

4. From Never on the Trans-Siberian by rail or motor road to Tynda, thence via motor road to Yakutsk, and from Yakutsk down the Lena to Tiksi. Yakutsk is the largest Soviet air base in northeastern Siberia.

5. From Nagayevo, Okhotsk Sea port, by highway to Magadan and Seymchan, thence down the Kolyma River to Ambarchik.

(1) Railways.

(a) Trans-Siberian. The double-tracked Trans-Siberian is the sole railway connecting Siberia with the rest of the Soviet Union. As such it serves as the main land route for supplies flowing to the Soviet Far East. Its average daily capacity is estimated at 15,000 short tons per day.

(b) Baykal-Amur Trunkline. The status of this railway is still uncertain. When completed, it will roughly parallel the Trans-Siberian, beginning at Tayshet and running north of it along the route Ust'-Kut - Bodaibo - Tynda - Komsomol'sk - Sovgavan'. The western section, Tayshet - Ust'-Kut, and the eastern section, Komsomol'sk - Sovgavan', have been reliably reported as completed. That the line from Ust'-Kut to Tynda has been built and joined to the Trans-Siberian south of Tynda is considered probable by the U.S. Military Mission in Moscow. Capacity of the completed sections is not known.

(c) Never - Tynda. Completion of this 160-kilometer branch of the Trans-Siberian was recently mentioned in the Soviet press. It is probably single track, with a capacity between 4,000 and 6,000 short tons daily. This line will increase the capacity of the through route Never - Tynda - Yakutsk - Tiksi.

(d) Volochayevka - Komsomol'sk - Sovgavan'. The entire line, roughly 670 kilometers long, is single track. The Volochayevka (near Khabarovsk) - Komsomol'sk section has been in use for several years, but the Komsomol'sk - Sovgavan' line did not begin operation until July 21, 1945. Capacity of the latter section is unknown.

(2) Roads.

(a) Irkutsk - Kachug. This hard-surfaced motor road is roughly 300 kilometers long, with a daily capacity estimated

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at 500 to 1,000 short tons. It connects the Trans-Siberian Railway with the navigable Lena River.

(b) Never - Yakutsk. Recently completed as far as Yakutsk, this hard-surfaced highway, together with the Lena River, forms a through route from the Trans-Siberian to the Arctic Ocean. The road is 1,200 kilometers (745 miles) long. One section of 650 kilometers has 1,236 bridges. During the winter, snow fences must be placed on the road shoulders to keep traffic open. The estimated daily capacity is between 500 and 1,000 short tons. In 1935 a fleet of 350 trucks was reported in operation on the highway.

(c) Magadan - Seymchan. From Magadan, the town built in conjunction with the port of Nagayevo, a 2-lane gravel all-weather motor road runs approximately 450 kilometers to Seymchan on the Kolyma River. There are fuel stations, repair shops, and garages at frequent intervals. The main repair shop and an auto assembly plant are located at Magadan. A fleet of 1,800 trucks, mainly charcoal-burning, serves the highway. The road is kept in good condition; snow is removed by heavy mechanical equipment. Capacity is estimated at about 1,000 short tons per day. The highway is the southern link in the communication system between Nagayevo and Ambarchik ports; the Kolyma River serves as the northern artery.

(3) Rivers.

(a) The Obskaya. The average date for the beginning of the ice break-up on the Obskaya is late April at Novo-Sibirsk on the Trans-Siberian railroad and early June at Salekhard near the mouth, but it is early May and June respectively before the river is clear. Ice begins to form in late October or early November, and the river is frozen throughout by early November. Barges are used to carry cargo from Tomsk and Novosibirsk to Novyy Port on Ob' Bay (Obskaya Guba), which can be reached by ocean vessels of 15 foot draft. Navigation between Novyy Port and the Kara Sea is difficult. There is a 1935 estimate of 1,021,800 tons of freight being carried on the Ob', but this figure probably includes at least 70,000 tons of log rafts.

(b) Yenisey. The ice in the Yenisey River usually begins to break up between early May and June depending on the latitude. The annual flood period normally begins in the last week of April and accelerates the break-up in the lower part of the river. In Yenisey Gulf (Yeniseyskiy Zaliv) the mean date of the break-up is mid-July, and in the northern part of the Gulf it may come as late as 28 July.

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The lower section of the river freezes over not earlier than the last week in September. The average freeze date is 15 October for the mouth, 5 October for the southern part of the gulf and 28 October for the northern part. Parts may not freeze solid until late November. Navigation conditions, at least on the lower part, are favorable from about 15 July to 1 October. The channel permits sea-going vessels drawing over 20 feet to reach Igarka. River boats and barges of 8 foot draft operate regularly between Igarka and Krasnoyarsk on the Trans-Siberian Railroad. While no specific statistics have been released for nearly a decade, it is believed that the amount of shipping and equipment actually available on the Yenisey is far from adequate to meet the demand, which, it is claimed, has been growing substantially from year to year. Only a small part of the river's capacity has been exploited thus far. The latest figure (1935) mentioned for annual traffic on the Yenisey is something over 400,000 tons, but at least 100,000 tons of this is timber floated down in the form of rafts. About 50 boats were operating on the Yenisey just before the war. Twelve of these had passenger accomodations, while the others were freight boats or tugs drawing 8 ft. It is said to be possible to send 100,000 tons of supplies up to the Trans-Siberian railroad at Krasnoyarsk by river barges in one navigation season.

(c) The Lena. The average date for the opening of the mouth is 25 June, according to a 1938 Soviet source (other sources give early June). At Yakutsk, the river remains navigable from about the middle of June to mid-October. The mouth usually freezes over in early October; the river freezes at Yakutsk, 1,120 miles from the mouth, in late October. Both thaws and freezes produce great ice jams, which often dam up the water to 40 or 50 feet above normal. Kachug, connected with Irkutsk by an auto road, is nominally the head of navigation, but steamers can reach it only during high water. Vessels drawing about 6½ feet can proceed to Ust'-Kut, another 1,158 miles. In the three most important of the many distributaries through the Lena Delta, the minimum depth of the channel is 4 to 5 feet and the average depth 12 to 20 feet. Banks and shoals prevent the entrance of sea-going vessels, and also limit navigation to a draft of 7 to 9 ft. all the way up to Zhigansk (585 miles from Tiksi Bay). In 1935, 116,200 tons, including some 35,000 tons of timber in rafts, were transported on the rivers of the Lena system. An estimate for 1937 is 226,000 metric tons, but another source estimated the 1941 season at 130,000 tons. A 1943 study recommended the provision of shipping sufficient to handle 325,000 tons a year -- 36 river steamers with 6-foot draft and 215 river barges with 500-ton capacity -- for hypothetical delivery of lend-lease material to the Trans-Siberian Railway via the Lena River.

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(d) The Kolyma. The Kolyma breaks up in the first half of June and freezes over in the first half of October. At Nizhnekolymsk, over a period of 18 years, the average date of final clearing is 6 June and the average date of complete freeze-up 5 October. The Kolyma is reported to be navigable for ships of 5-foot draft as far as Srednekolymsk. From there to Verkhnekolymsk only flat-bottomed boats can be used, and even these only until mid-August. Ocean-going vessels of 13-foot draft can go up as far as Nizhnekolymsk.

(e) The Anadyr. Vessels drawing 4 feet can navigate to Markovo, about 250 miles upstream. The river is open from about the first of July to mid-October. No recent information is available concerning the amount of traffic on the Anadyr' River.

b. Air Routes. Civilian air transport activities in the Soviet Union are controlled by the Civilian Air Fleet (GVF). Such activities include transport of mail, freight and passengers, polar exploration and arctic development, aerial prospecting and cartography and other services of benefit to the national economy. During war time the GVF was operationally subordinate to the Soviet Air Force. It, however, maintained its own administrative status and with the end of hostilities has probably reverted to its former independent role. No individual statistics are available on transport activity in the Soviet Far East. In 1938, according to Soviet claim, their air transport service carried a total of 49,000 tons of mail and cargo and 237,000 passengers. In the same year U.S. airlines carried an estimated 15,726 tons of mail and cargo and approximately 1,500,000 passengers. Soviet air routes in 1940 were reported at 72,000 miles against 94,000 for U.S. airlines. Although the GVF reached a low ebb in the early stages of the war due to fuel shortages and the transfer of its trained personnel to the Soviet Air Force, it underwent a revamping in 1942. Lend-Lease planes, increased aircraft production in Russia, and an improved fuel situation permitted an expansion in its operation. Air routes such as those to Alaska and Iran were extended and maintained, and extensive supply, troop carrying and general transport operations were carried on for the Soviet army and the Air Force.

(1) Strength. A German source of June 1944 estimated the size of the Civilian Air Fleet at between 1,300 and 1,500 aircraft. While a portion of this force was made up of light courier and training aircraft, at least 1,000 are estimated to have been either twin-engined transport types or Soviet twin-engined bombers utilized for supply activities. This force could readily be augmented from reserves or

bomber and transport units of the Long Range Air Force (ADD). Thus it appears that the GVF could have a minimum of 1,500 aircraft available for operations on its routes at the present time. It should be noted that only a relatively few obsolete four-engined aircraft are reported still in use in the Soviet Union. To date there have been no reports of any effort on the part of the Russians to construct a fast, high-altitude transport.

(2) Transport Routes in Siberia. Principal Soviet air transport routes in the Siberian area, as reported from various German and Japanese intelligence sources, are shown on Map I. Except in the case of the ALSIB air line, almost nothing is known about any of these routes. In several cases their existence is uncertain. For example the route from Tiksi Bay to Velkal along the Arctic Ocean is apparently a seasonal route and possibly is utilized primarily to service polar weather stations or by ice patrol aircraft. Available data on the ALSIB air route is fragmentary but provides the only clue to Soviet long-range transport operations in Siberia. Although the Russians have demonstrated the feasibility of operations in the northern areas, the concensus indicates that, despite continuing improvement, facilities, transport conditions, at least between Krasnoyarsk and Velkal, are still rudimentary by American standards. Unusual technical difficulties in airfield construction and maintenance, in radio communication and in supply are manifold throughout the northern area. In the matter of fuel for the ALSIB route alone, supply is an extremely difficult problem. Depots are located in the drainage areas of such rivers as the Lena and can only be replenished in the summer months by ship or lighter from the Arctic Ocean.

(3) Summation. Considering the lessons learned by the Soviets in operating the ALSIB route, and in view of what is already known about the Soviet Air Force, the advantages and disadvantages surrounding any expansion of northern Siberian transport routes may be summarized as follows.

(a) Advantages:

1. Adequate supply of medium transport aircraft.

2. Large cadre of pilots trained in "cold weather" operations.

3. Extensive operational experience in Arctic flying during the war and in operating the ALSIB air route.

(b) Disadvantages:

1. Present deficiency of Soviet pilots in navigational training and night flying.

2. Lack of suitable airfields and the attendant difficulties of climate and terrain affecting their construction.

3. Extremely difficult weather conditions.

4. Problems of supply.

5. Lack of multi-engined, high-altitude transport aircraft suitable for long-distance flights.

(4) Conclusions. The relatively large number of transport aircraft now available, together with a large pilot pool, unquestionably will mean the expansion of air routes and of existing facilities in Siberia as a whole. To what extent the development of air transportation in northern Siberia is carried out is largely dependent on intricate problems involving Arctic terrain and weather, as well as those of supply and communication. Present information on that area indicates only the most primitive aviation facilities.

2. Terrain along Soviet Arctic Coast.

a. Suitability of terrain for use as staging areas. Terrain suitable for staging areas is available in most parts of the Arctic Siberian coast. The low flattish coastal tundra belt has many shallow lakes and poorly drained sections, but intervening areas are easily drained, and have low sparse vegetation, and thin rocky frozen soils. Wide gravel terraces along major rivers and sandy beach flats near river mouths are the most accessible of such areas. Nearly level smooth bed-rock surfaces are also available especially in the interstream areas. The chief disadvantage of tundra soils is their instability during the summer thaw season. Then the soils become soft, boggy masses several feet deep which are very difficult to traverse or stabilize for installations. Although soils and loose rock are permanently frozen to depths of as much as several hundred feet, the surface layers thaw to depths of 2 to 6 feet each year (June to September) if the vegetation cover is removed and no special protective measures are taken. Lakes and marshes of northern Siberia are frozen to depths of 3 to 5 feet from late December to early May. These ice surfaces form hard, firm, smooth runways for ski-equipped planes. Runways for year-around use can be constructed on the nearby flat, hard, permanently frozen soil and bedrock surfaces.

(1) The chief limiting factor in the construction of staging areas, including airstrips, on the Siberian coast is the limited means of transportation to and along the coast (see section B 1). Therefore, actual staging areas probably will be on or near the major established transportation lines which reach the coast. All of these routes are rivers, the Obskaya, Yenisey, Lena, Kolyma, and Anadyr'.

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The Soviet Arctic sea route from European USSR is ignored because as yet it is unreliable and inefficient (see section C 2 a). The river routes are important because they serve inland areas, 100 to 200 miles away from the coast. Weather conditions (particularly visibility and winds) are more favorable here than on the coast. In these inland areas dwarf trees are found but are easily removed. The high, flat benches along the streams and adjacent flattish plateau uplands furnish many good sites for staging areas. None of these areas need be more than a few miles away from the stream banks. If in the future the Soviet could build and operate staging areas in zones reached only by air transport, then the great plateau areas between the Yenisey and the Lena and along the middle Kolyma would offer a great number of sites not now available.

b. Suitability of terrain for use as launching sites for long-range weapons. Any of the present and potentially available sites for staging areas in northern Siberia could also be used as launching areas for long-range weapons. The maximum weight of the newest A-10 German rocket (still in the drafting stage) is estimated to be about 100 tons. This is approximately three times the weight of the heaviest Soviet bomber reported (TB-7, 35 tons). Therefore, some of the potential staging sites along the more developed Siberian streams (Ob, Yenisey, Lena, Kolyma, Anadyr') could also be utilized as launching zones, provided roadways capable of supporting 100-ton loads were constructed from the bomb-assembly area to the actual launching site. Such roadways could be located and constructed on the available dry hard rock and deep frozen-soil surfaces, It is possible that the weapon can be transported in separate parts to the launching site. If in the future, the launching areas could be served by air transport exclusively, they could be scattered even more widely on the great plateaus (west of the Lena) and in the broad mountain valleys of the Chukot and Kamchatka peninsulas.

3. Ports on the Siberian Coast. The ports here considered, with the exception of Nagayevo, were built in connection with the Northern Sea Route. So far as is known, they are still in a poor state of development and have few port facilities of any kind. Their capacity is further limited by the following facts: They are icebound a good part of the year; and, in most cases inland communication is dependent on rivers which have a short navigation season and inadequate shipping facilities. During the war, Provideniya Bay trans-shipped large amounts on Lend-Lease to settlements along the Northern Sea Route. According to the information available, Nagayevo is by far the best equipped and has the greatest inland clearance capacity of the ports discussed below.

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a. Novyy Port (Obskaya River). In 1937 it was reported that the port possessed berths for sea-going deep-draft vessels and that there were warehouse accomodations. The anchorages are said to be safe even in strong winds. Ships can winter here, as the bay freezes solid and the ice breaks up gently. The average date over a 10-year period is 18 June for the break-up of the ice in this part, and 5 November for the complete freeze-up.

b. Dikson Island (near Yenesey River). Dikson Island, near the mouth of the Yenesey River, serves as a transfer point for cargoes carried by river craft to and from ocean vessels. It is closed by ice about 8 months of the year. The average dates, based on 19 years' observation, are 23 June for the beginning of the break-up, 27 July for the final clearing, 18 October for the appearance of sludge ice, and 25 November for the complete freeze-up, with the ice attaining a maximum thickness of 5 feet by late January. Dikson Bay is reported to provide anchorage for as many as 40 ships, in 40 to 50 feet of water. Reports on docking facilities vary. A Red Navy Lieutenant and a Soviet shipmaster in 1944 reported 5 docks, of which 3 are about 300 feet long, and 2 are over 400 feet long and have accommodated Liberty ships. In the same year, another Soviet master stated there is one pier, used for coaling only; depths alongside are only 7 to 10 feet, so that ships have to be unloaded by barge. In 1939, 500 tons of cargo were loaded and 800 tons unloaded daily during the ice-free season. The following equipment has been reported at Dikson: 1 50-ton movable crane, 10 trucks, 1 diesel tractor, 2 snowplows, 2 3,000-ton barges, 4 60-ton tugs, 3 75-horsepower motorboats, and 1 electric coal conveyor 210 feet long. There is unlimited open storage area, a frame warehouse 400 feet by 200 feet, and a coal yard about 50 feet by 25 feet. Minor ship repairs can be done at a machine shop in the village. Dikson is connected with the Trans-Siberian Railway at Krasnoyarsk via the Yenesey River and is the terminus of an air route along the Yenesey from Krasnoyarsk.

c. Igarka (Yenesey River). Igarka, about 400 kilometers upriver from the mouth of the Yenesey, was built to export lumber. It is accessible to sea-going vessels with drafts of not more than 24 or 25 feet. Supplies brought in by sea are trans-shipped to barges and river steamers. The port is completely ice-free only 2 months of the year. A British merchant ship's officer who visited Igarka in 1933 reported one wooden wharf which could take 5 or 6 ships of 4,000 to 5,000 gross tons each. A British shipmaster who visited the port in 1938 and 1939 stated that the wharves could handle simultaneously 4 ships the size of his vessel, which was 350 feet long, had a 22-foot draft when loaded, and a gross tonnage of 45,000 tons. Another source reported 6 berths for simultaneous handling of 6 vessels, in addition to which 5 or 7 ships could be unloaded in the streams. No cranes are available, so far as is known. In 1940 there were reported to be 47 river steamers and barges, about 225 feet long and with a draft of 8 feet.

d. Tiksi (near Lena River). Tiksi is the trans-shipment point between the Northern Sea Route and settlements on the Lena River. It is ice-free for about 3 months. According to many years' observations, the movement of the ice in Tiksi Bay begins in the mid or late June, and the bay freezes over between 1 and 10 October. It was believed that the navigation season would be lengthened by the arrival of an ice-breaker which was expected in 1939. There is anchorage in the bay for about 100 vessels, but it is not secure against prevailing north winds. It was reported in 1942 that the port had only one wharf, 65 feet long, with 8 feet of water alongside. However, Soviet masters visiting Tiksi in recent years reported a pier which can take two 5,000-ton ships, although some cargo has to be lightered since depth at the pier is only 12 feet. In 1942 there were 2 cranes on barges, a 400-ton mechanized barge barge holding 3,000 tons of coal, and some motor launches for towing barges (in high seas these launches cannot enter Tiksi Bay). There is a coal dock (one master said that this is the only pier in the port) with conveyors to load coal. Water is available, as are facilities for very minor ship repairs. Most of the port labor is done by women. Tiksi is connected with the Trans-Siberian Railway at Never via the Lena River to Yakutsk and thence by motor highway to the railroad. Tiksi is also the terminus of an airline from Khabarovsk through Yakutsk.

e. Ambarchik (near Kolyma River). Although now serving as the chief transshipment point on the Kolyma River, Ambarchik is not considered satisfactory because of its shallow waters, and it may in time be replaced by the port of Krailes, about 90 kilometers up the river. Ambarchik is frozen from October to June. Transfer of cargo from ocean vessels to river boats or barges takes place 5 to 10 miles offshore. The anchorage is exposed and operations are frequently interrupted by storms. In 1931 there were 2 piers, each 165 feet long. The following equipment has been observed: 3 barges, 15 fishing boats, 1 tug, a number of trucks and a tractor. Coal and water are obtainable in emergencies but no fuel oil or food. There are 6 wooded warehouses, each 40 feet by 12 feet. In 1931 the port was said to have a forge and fitting shop and a shipyard for the construction of iron barges.

f. Provideniya Bay (East Siberia opposite Nome, Alaska). Provideniya Bay is the home port for the Soviet merchant fleet operating in the eastern part of the Arctic Sea. Here, cargo is transferred from large vessels to ones which can reach ports inaccessible to deep-draft ships. During the war Lend-Lease was supplied to Arctic settlements by this transshipment method. In July 1944 the aggregate gross tonnage of ships arriving amounted to 640,000 tons. The bay is closed by ice from 24 December to 24 June. The harbor provides safe anchorage for about 40 large ships. Little is known about port facilities, but it has recently been reported that there are 3 docks, at least one of which can handle a fully loaded Liberty; 3 new warehouses, each about 200' by 45'; a new coal pier at which 2 Liberty's can dock; a small shop for minor ship repairs; and electric lighting for night work. Ships must use their own gear for handling cargo. A shortage of barges and stevedores has also been reported.

g. Anadyr' (Anadyr River). There is practically no information on facilities at Anadyr'. The river is ice-free from July to October. Ocean vessels anchor directly off the village; transfer of cargo from ocean to river ships may take place at anchorage. In 1943 a Soviet shipmaster said Anadyr' Bay offered no protection from storms at sea. His ship carried 5 LCT's which were launched by careening the ship; they in turn were used to discharge other cargo, and were left at the port for that use in the future. According to another master, some wharves and warehouses have been built here. Anadyr' is on the ALSIB air route over which Lend-Lease planes were ferried to the U.S.S.R. during the war.

h. Nagayevo (Okhotsk Sea). Nagayevo, on the Okhotsk Sea, is one of the 3 principal Soviet Pacific ports. Nearly all supplies for the Kolyma river gold mines are imported through this port, coastwise steamers call regularly from Vladivostok, and during the war Nagayevo received large Lend-Lease shipments. It is closed by ice from 1 December to 30 April, although with the aid of icebreakers it is reported to be open to navigation 2 months longer. Nagayevo Bay provides first-class sheltered anchorage for more than 100 vessels, and wharfside berthage for 2 Exporter-type ships (473 feet long, 27 foot draft). Estimated daily capacity is 500 short tons. The following equipment has been observed; 10 to 15 motor-driven cranes of 3-ton maximum capacity, 1 electric belt conveyor, about 500 trucks, a number of tractors, 10 to 15 barges of 500 to 1,000 tons capacity, 1 tug of 1,000 H.P., about 10 motor launches of 75 to 100 H.P., and 1 schooner of 500 to 800 tons capacity. Labor is plentiful, and work is carried on 24 hours a day in 12-hour shifts. There are 10 warehouses with a total capacity of about 20,000 tons, an extensive open storage area between Nagayevo and Magadan, and 7 or 8 fuel tanks. Oil and water are available at all times; coal and food in emergencies. Repair facilities consist of a power station, 3 repair shops, and an unknown number of crude wooden ways for repair and construction of small craft. Two sets of narrow-gauge rails extend from a 400-foot pier back to the repair yard. Two-lane gravel roads lead from Nagayevo to the piers, and another road connects Nagayevo with the all-weather highway from Magadan to Srednikan on the Kolyma. Magadan is the southern terminus of an airline from Nizhnekolymsk. It is to be emphasized that the Soviet air base at Siemchan is being adequately supplied over this route.

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C. Routes across the Arctic Ocean.

1. Air Routes.

a. Climate and weather.
The part of the northern hemisphere north of 50° latitude consists of three main climatic regions (1) The true Arctic, including the Arctic Ocean and adjacent litteral north of 65° ., (2) the continental sub-Arctic, including most of Canada, Alaska, and Siberia (between 50° and 65° N.), and (3) the maritime temperate seas, which comprise the North Atlantic and Bering Sea regions north of 50°.

(1) The True Arctic. The true Arctic, although mostly oceanic and therefore maritime, is subject to long, cold, dry winters which last from October through May and even June. During this period temperatures seldom rise above freezing, and sub-zero weather is more protracted than is the case in the continental sub-Arctic where temperatures sometimes reach lower extremes. The middle and late winter (January-May) is the best season, in most respects, for flying, as anticyclonic conditions prevail a high percentage of the time. Clear skies, relatively few storms, and frontal passages; infrequent fog and icing in clouds; constantly frozen soil, lakes, rivers, and sea surface; and a fairly consistent snow cover provide advantages for landing on skiis and for flights over great areas of the Arctic. The disadvantages of greater amount of darkness in midwinter is partially offset by the phenomenally good visibility and the illumination provided by the bright moonlight and frequent aurorae. After the first of March the difference in amount of daylight and illumination is in the favor of the Arctic over the temperate regions. Summer (mid-June through September) is a bad season for flying in the Arctic, and bad flying weather sometimes continues through November and December. Cyclonic storms frequent the entire Arctic, and a great amount of moisture is carried into the polar regions by the prevailing southerly flow in the sub-Arctic. Cloudiness at all flying levels, fog, icing, turbulence, and uncertain soil and ice conditions provide hazards which offset the advantages derived from constant daylight, moderate temperatures, and winds and freedom from snow at the surface.

(2) The Sub-Arctic. The chief problem in the sub-Arctic is protection against extreme variability in temperature and against sudden storms and constant, strong, cold winds in exposed places during winter. The winter season is not so protracted as in the Arctic,

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November through April usually being considered the winter months, June, July, and August the summer months, and May, September, and October the transitional months. Ice begins to break and snow to melt in the middle courses of most drainage basins in April, in the lower courses of the rivers in May, and around the mouths of the rivers such as the Yukon, Mackenzie, Lena, Yenisei, etc., in June. The Bering Sea is usually free from ice late in June, but on the northern shores of Alaska and Siberia the ice is away from the shore only in August some years, and in July, August, and September in the best years. The freeze occurs on the rivers and lakes in October or early November, and by late November most rivers are safe for landing light planes. Flying weather is best in late winter, although periods of good weather sometimes occur in summer or autumn. Problems encountered in some localities are: (a) city smoke and fog contaminating the air for several miles around settlements such as Fairbanks, in calm, cold weather; (b) strong local winds and blizzards in mountainous regions and exposed sea coasts; (c) ice-crystal fog at extremely low temperatures, making landing on snow surfaces confusing or hazardous by the uncertain light of the moon or aurora; (d) magnetic storms and snow static which frequently interrupt radio and ground communications; (e) thunderstorms which may be severe and accompanied by heavy turbulence and hail in summer; (f) floods at the time of break-up of ice in May or June; (g) soft ground in the period of thaw, break-up, or summer rainy season; (h) icing in clouds which are present most of the time in summer and autumn; (i) extreme cold, sometimes 65° F. or 75° F. below in North America and 85° F. to 95° F. below in east central Siberia.

(3) The Maritime Temperate Seas. The maritime regions of the North Atlantic and Arctic Seas north of Europe are subject to greater storminess, more cloudiness, precipitation, icing danger and gales both at the surface and aloft than are the drier, more anticyclonic sections of the continental regions (Siberia-North America) and the solid pack-ice zone north of Bering Strait.

b. Air routes across the Arctic[1] (See Map 2). In making an analysis of meteorological conditions affecting flying over various routes, consideration must be given to factors which are non-meteorological but which are so closely allied with the weather factor that they cannot be omitted. These factors are:

1. Problems of supplying Arctic bases.

2. Difficulties in establishing and maintaining bases and facilities under extreme conditions of snow, wind and cold.

3. Navigation problems over unknown territory, without landmarks, in the vicinity of the magnetic pole and with frequent magnetic storms.

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1. The data in this section are advisory, and are not an official or conclusive analysis of flying conditions or flyability over the Arctic. The Weather Central Division, Headquarters AAF Weather Service is not responsible for its use for any other purpose.

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4. Limitations due to darkness in mid-winter and to uncertain light in the twilight periods.

5. Difficulty in forecasting weather with incomplete network of stations in the Arctic, and complete lack of stations over the Arctic Basin. Communication difficulties due to magnetic storms and snow static increase difficulty in forecasting as well as in accurate reporting of weather for immediate flights.

6. Operations limited to the best prepared air fields in summer and to skiis in winter where snow-removal equipment is not available.

7. Limitations of various types of aircraft with various ranges, ceilings, landing speeds, etc.

(1) The meteorological conditions affecting flight across the Arctic are briefly summarized by routes. Best and poorest seasonal estimates are based on minimum facilities and present type aircraft.

Route I. Kirensk-Anadyr-Fairbanks-Edmonton
Best season for flying--late winter through summer
Poorest season for flying--autumn and early winter

Limitations for flying--winter; shallow smoke and fog in valleys having poor air drainage and near settlements; drifting snow in exposed locations; summer: clouds, fog, icing and turbulence. Worst conditions in coastal and mountain sections. Difficulties may be minimized by providing alternate landing fields in different topographical situations

Route II. Kirensk-Bulun-Aklavik-Edmonton
Best season for flying: Late winter and spring
Poorest season for flying: Late summer and autumn

Limitations to flying--winter: shallow fog in lower Mackenzie and Lena Valleys; drifting snow at exposed points; summer: fog and low stratus over Arctic Seas; icing in fog and stratus.

Route III. Archangel-Rudolf Island-Aklavik-Edmonton
Best season: spring
Poorest season: autumn.

Limitations: The long hop over the Arctic Ocean with the probability of adverse weather over the Barents Sea makes this route difficult to fly at any season. Increased flying range, improved terminal facilities and weather reporting network would improve the percentage of successful flights.

Route IV. Archangel-Green Harbor (Spitzbergen)-Thule-Churchill
Best season for flying: Spring and early summer
Poorest season for flying: Winter

Limitations to flying: frequent cyclonic storms over the Barents Sea throughout the year. High percentage of cloudiness (70%-90%) over the Atlantic or Barents Sea sections. Fog, low stratus, icing and gales in summer and autumn.

With adequate facilities and forecasting experience these routes could be developed to handle considerable traffic in spring and early summer.

Route V. Kirensk-Khatanga-Thule-Churchill
Best season: spring
Poorest season: Late summer and autumn

Limitations to flying: vast expanses of uninhabited land and ocean areas, lack of reporting facilities and difficulty of supplying bases on American side. Frequent fog in summer and blizzards in winter in the Cheliuskin region; icing over the polar seas in summer and autumn when cloudiness is extensive.

Route VI. Archangel-Bear Island-Reykjavik-Julianehaab-Northwest River

The flyability of the Reykjavik to Presque-Isle leg of this route was demonstrated to be very low until facilities were improved. The bad weather over the Iceland-Archangel sector throughout the year, due to high frequency of storms, almost constant cloudiness and icing, and the long hop over water reduce the probable flyability along this route any season.

c. Facilities in Greenland.

(1) Land. There are no roads or railroads in Greenland. Overland travel by dog sled connects the sparsely populated communities in the winter.

(2) Sea. Except for a short period during the summer, most of Greenland is ice-bound. The principal communities on the southwestern shores of the island are located on inlets which are ice free throughout the year, but the presence of icebergs following the spring breakup hampers navigation. The settlements at Sukkertoppen, Godthaab, Ivigtut and Julianehaab are ice free throughout the year, but settlement north of 68 degrees are free only for short periods of the year. The US Army and Navy have establishments on the southwest coast of Greenland and one on the east coast near Angmagssalik which have been serviced by combined sea and air transport throughout the war.

(3) Air. Until the establishment of the United States bases on Greenland aircraft were virtually unknown in Greenland. Seaplanes could land on the protected waters of the fiords but there were no developed landing fields. The more important military establishments maintained by the United States in Greenland are located near Angmagssalik on the east coast of the island and at Julianehaab, Ivigtut and west of Holsteinsborg on the southwestern coast.

d. Air approach to Eastern Canada. If Southampton Island at the northern entrance to Hudson Bay is taken as a point approximating the geographical center of the Canadian Eastern Arctic, this island (on which is located an abandoned US Army Air Base) is almost equidistant from all points on the Siberian coast between the Yenesi delta and Murmansk - a coastline over 3000 miles in length. The distance from all points on this coast to Southampton Island approximates 2800 miles. Franz-Josef Land, to the north of the Siberian mainland is only 2400 miles from Southampton Island and only slightly less distant from Aklavik in the Western Arctic. Between Franz Josef Land and Southampton Island stretches an air route which, without deviation from the great circle course, passes close to only three established communities - Pond Inlet on Baffin Island and Etah and Thule in Greenland. From the Yenesi delta a great circle course approaches no established community until the route passes between Fort Ross on Somerset Island and Arctic Bay on Baffin Island, a gateway 175 miles wide.

(1) The routes described above, or approximations of these routes, have the following advantages:

1. Distances are minimum

2. A wide selection of suitable landing grounds exist

3. Surprise may be achieved

(2) The North American Arctic is characterized by a myriad of lakes, channels and bays and these offer almost limitless landing possibilities throughout the northern continental area. Although fewer lakes exist in the Arctic Archipelago, protected bays and inlets provide ample opportunity to land. The suitability of water or ice surfaces for landings will be governed by the state of those surfaces. During two seasons of the year--spring and autumn--lakes, bays and inlets present surfaces of loose ice and open water which are hazardous to flying operations. In northern North America water surfaces will be unsuitable for military flying operations as follows:

	Spring	Autumn
Lat. 55°-65°N	15 June - 15 July	20 Sept. - 15 Nov.
Lat. 65°-75°N	15 July - 15 Aug.	25 Aug. - 15 Oct.

The above stated limits are very rough estimates and it must be emphasized that seasonal variations in climate, size of water bodies, exposure, depth, tides and local characteristics will affect freeze-up and break-up. Summer conditions, while suitable for water landings, offer little encouragement for deployment of forces. The dense pattern of lakes and interspersed tundra combine to eliminate the possibility of successful military movement with equipment at present available. No natural waterways offer access to the interior of the continent from the Eastern Arctic and the only practicable routes open to military forces are those making use of the two railways which terminate at Churchill and Moosonee (see paragraph D6b (3). Summer operations are further prejudiced by unfavorable weather conditions which exist over the northern fringes of both Siberia and North America and which would mitigate against mass air movements.

(3) It is believed that the choice of the summer months for an airborne attack against the Eastern Arctic is remote with equipment at present available, and that the most profitable use to which this season might be put is the installation of bases for long range missile projectors or for the development of bases for wheel equipped aircraft. These would, in all probability be established north of latitude 70°.

2. <u>Sea Routes.</u>

a. <u>Northern or Siberian Coast, Sea Route.</u>

(1) <u>Organization.</u> The Northern Sea Route covers a distance of about 4100 miles, from Murmansk to Providenlya Bay. It was developed primarily to achieve a shorter, all-Russian water route between European Russia and the Soviet Far East. The sea distance from Murmansk to Vladivostok via the Arctic Sea is 6250 miles, compared to 10,800 by the shortest alternate maritime route. A secondary motive was exploitation of the rich fur, timber, and mineral resources of the vast territory served by the route and its connecting rivers. Intensive development began in the early thirties under an organization called the "Chief Administration for the Northern Sea Route." This administration controls the merchant marine, ports, river shipping, commercial aviation, weather stations, mining, construction work, and commercial enterprises in the

entire Soviet Arctic. Great difficulties have been encountered in development, since ice closes the route 10 months a year and the region was originally undeveloped with a sparse tribal population. The exact degree of success achieved in the undertaking cannot be determined because of the scarcity and diversity of published statistics on the subject, and the lack of first-hand observations.

(2) Routes. The Northern Sea Route crosses five seas, the Barents, Kara, Laptev, East Siberian, and Chuckchee, and enters a sixth, the Bering, through Bering Strait. Vil'kitskiy Strait between the Kara and Laptev Seas will continue to be the critical point of the entire Northern Route so long as no alternate passage has been found feasible. One shipmaster in 1938 argued in favor of Shokal'skiy Strait, between the two islands of Severnaya Zemlya, as most likely to be passable when Vil'kitskiy is blocked by ice. Another bottleneck on this route is Laptev Strait (between the Laptev and East Siberian Seas) which is limited to ships not exceeding a draft of 21.3 feet. An alternate route is through Sannikov Strait where the depth is about 30 feet but ice conditions are less favorable. Floe ice crowds the ships to within 20 to 40 miles of the shore in the East Siberian Sea.

(3) Ice conditions. Ice conditions vary considerably from year to year in the Soviet Arctic Seas. In a good year the route can be kept open with the aid of icebreakers for about 2½ months. Depending primarily on the direction of the prevailing winds, the ice upon breaking up may be piled against the continental shore, preventing approach to the river mouths for a long time after the opening of the seas themselves; or, in other years, it may be driven northward by the winds, leaving the coastal zone more or less free of ice at an early date. The conditions may be quite different in one and the same sea in short successive periods, or in the five seas during the same season. Thus, the Laptev Sea may be clear for an unusually long time, but may still be inaccessible through the adjoining seas. The days of freeze and break-up likewise display a much great variability than Table A would suggest. Some of the changes in ice conditions are so sudden that it would be impossible to take advantage of them or avoid their effects even if promptly observed and reported. The worst stretches are from Dikson Island to Khatanga Gulf, between the New Siberian Islands and the mainland, and to a lesser degree in De Long Strait between Vrangel' Island and the mainland. Icebreaker aid is imperative at all times along these stretches, but under normal conditions about half the journey can be made without icebreakers. Ships proceed independently whenever possible. When ice conditions necessitate, air patrols signal to ships and icebreaker to arrange a rendezvous. In bad visibility, these signals are made by radio. Normally, it is possible for an icebreaker to lead 10 ships at a time. Vessels with more powerful engines, which have been strengthened against ice, might possibly be convoyed up to 15 at a time by one icebreaker. This larger figure is not often possible and is perhaps improbable.

(4) Operation. By 1940 over 100 cargo ships of 3,000-5,000 tons operated annually on sections of the route. The average yearly haulage, taken over a period of 5 years, was 190,300 tons, and the top figure for any one year was 270,000 tons. It is known that a considerable part of this tonnage did not make the entire trip. The ships carried mainly food and equipment to Arctic settlements and returned with Arctic produce such as timber and furs. The icebreaker fleet was reported to include between 8 and 13 units, in addition to which some of the cargo ships were strengthened for use in ice. Each year a few ships sailed the entire route, a trip taking 6-13 weeks. In 1938 two convoys of 10 ships each were reported to have completed the passage from east to west, and one icebreaker made the journey in both directions. However, as late as 1939 there was criticism in the Soviet press regarding the general organization of the route and the lack, inadequacy, or primitiveness of the port facilities. In 1937 a number of merchant ships and nearly half of the icebreaker fleet was caught and had to winter in the Arctic Sea. During the war, most of the Arctic Sea fleet was diverted to trans-Pacific haulage. In 1944 only 34 ships carried Lend-Lease to the Soviet Arctic, compared with the 100 operating there before the war. Wartime industrial expansion in the area has apparently been limited to attempts to become more self-sufficient, exceptions being the large increase in Pechora coal output and Yenesey nickel smelting. In 1944 Lend-Lease supplies to the Soviet Arctic totaled 128,000 tons, compared with the 190,300 tons average annual shipment along the route in peacetime. There are no figures available on sabotage in the region during the war. Lend-Lease consignee lists indicate that U.S. and Canadian food and equipment took the place of Russian supplies formerly brought into the Arctic each year to support its deficit economy.

(5) Conclusions. The shortness of the season probably limits merchant ships to one voyage a year for the entire Northern Sea Route, but ships based in the Pacific could pick up troops and supplies at Tiksi and points east and have time to return to the Pacific. Table B gives the time taken by actual through voyages. During the war, some ships carrying Lend-Lease from the Pacific went as far west as Tiksi and returned in the same season. The majority, however, discharged cargo at Provideniya for transfer to smaller vessels before proceeding along the Northern Sea Route. It is difficult to estimate the total capacity of the route per season. Past figures are poor indications, since most of the traffic was serving local needs only. A true figure would depend upon the number of ships and icebreakers available for the through voyage. As of 1945 there were 285 Soviet vessels totaling 1,155,453 gross tons operating in the Pacific. Of these, 30 were under 1,000 gross tons and 104 were ships transferred to Russia under Lend-Lease. The Lend-Lease vessels included 3 icebreakers and about 36 Liberty ships. In reference to the use of Liberty ships in the Artic, one Soviet shipmaster said that this type is too long and unwieldy for use there even under the most favorable conditions. The Pacific icebreaker fleet in 1945 amounted to 10 icebreakers (3 of which were Lend-Lease) and 15 icebreaking tugs.

TABLE A

ICE CONDITIONS ON THE NORTHERN SEA ROUTE

Points	For the years	Break-up	Final clearing	Appearance of slush	Complete Freeze-up	Days with ice	Greatest thickness mm
Yugorskiy Shar	1910-1934	28 June	24 Aug.	20 Oct.	20 Nov.	204	107
Matochkin Shar	1924-1934	9 July	23 Aug	10 Oct.	28 Oct.	310	137
Malyye Karmakuly	1924-1930	26 June	10 July	17 Oct.	---	247	109
Ostrov Kolguyev	1925-1930	14 June	4 July	4 Nov.	---	233	79
Ostrov Vaygach	1913-1934	17 June	22 July	22 Oct.	25 Nov	346	112
Mare-sale	1913-1934	17 June	17 July	14 Oct.	26 Nov.	348	145
Novyy Port	1924-1933	18 June	6 July	9 Oct.	5 Nov.	266	147
Salegard	1926-1933	30 May	29 June	29 Oct	3 Nov.	217	---
Ostrov Diksona (sea)	1916-1934	23 June	27 July	18 Oct.	25 Nov.	---	158
Indigirka River	11 yrs.	---	16 June	---	4 Oct	---	235
Ust'-Yeniseyskiy Port	1924-1933	7 June	17 June	22 Oct	25 Oct	241	144
Nizhnekolymsk	18 yrs	---	6 June	---	5 Oct	---	20
Ostrov Vrangelya (sea)	1927-1935	16 July	None	---	---	---	---
Mys Shmidta (Cape Shmidt)	1911-1913	---	20 July	---	5 Oct	---	---
Uelen	3 yrs.	20 June	28 July	---	15 Nov	---	---
Bukhta Provideniya (Providence Bay)	5 yrs.	---	24 June	9 Oct	24 Dec.	---	---

Mouth of the Lena River: Break-up. . . . . 25 June Freeze-up 2 Oct.
Yenisey Gulf: river part: " 15 June " 15 Oct.
gulf: " 15 July " 5 Oct
North part of gulf " 28 July " 28 Oct

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TABLE B

Time taken by actual through voyages across the Northern Sea Route:

Murmansk to Vladivostok 24.7.35 - 11.9.35	7 weeks;	a merchant ship
Vladivostok to Murmansk 25.6.35 - 15.9.35	12 weeks;	a merchant ship
Murmansk to Provideiya Bay just over a month, 1938		?
Archangel to Vladivostok 24.7.39 - 27.10.39	13½ weeks;	the ice-fording ship "Malygin"
Archangel to Vladivostok 1941	6 weeks;	3 merchant ships epecially strengthened against ice.

b. Bering Sea Approach to Alaska. The Bering Sea offers the shortest water approach to North America from Soviet Territory and, of all sea approaches, is favored by the fewest obstacles to navigation. From May until late October the ports of the Seward Peninsula are ice free and thereafter the sea ice consists largely of detached floes, continuously in motion. A large port might be established at Teller, at the western end of the Seward Peninsula. This could be used throughout the year by using ice-breakers. These floes become densest in March and April when the southern limits of pack ice reach the approaches to Bristol Bay. Even at its greatest extent it is considered possible that the Yukon or Kuskoquim deltas and points on the Seward Peninsula could be reached by ice breakers. Inasmuch as the ice of Bering Sea is continuously in motion and has many open water leads, it is not considered that military travel in force across this surface is possible.

c. Approaches to the Canadian Arctic. The Canadian Arctic falls into two strategic regions; that sector which is most conveniently reached from the west and that more readily gained from the east. The boundary between the Eastern and Western zones may be taken as a line through Somerset Island Boothia Peninsula and the barren lands between Hudson Bay and Great Slave Lake.

(1) Routes to Western Canadian Arctic. Access by sea to the Western Canadian Arctic is possible during August and September when the pack ice of the Beaufort Sea recedes sufficiently from the north coast of Alaska to permit vessels to reach the Mackenzie Delta and to enter Amundsen Gulf and its eastern connecting waters. It is not unusual for these more easterly bodies of water to remain open to navigation for considerable periods after the ice has closed against the Alaska coast, and local navigation in Amundsen Gulf, Dolphin and Union Strait, Coronation Gulf and Queen Maud Gulf may be continued until mid-October. Due to the freezing of bays and inlets prior to the freezing of open water, ice-breakers would be required to effect lodgment on the coast after 1 October in an average year. It is very doubtful if a convoy could approach the Mackenzie Delta or more easterly points, discharge its cargo and return west past Point Barrow Alaska in the same season. Moreover, shoal waters will limit the draft of vessels attempting a northern approach to not more than 12 to 15 feet. Since the loss of several ships in the 1920's, navigation of the Western Canadian Arctic waterways has been restricted to vessels of schooner type, stressed for work in ice and in shoal waters.

(2) Routes to the Eastern Canadian Arctic. Any seaborne approach to the Eastern Canadian Arctic must pass south of Cape Farewell in Greenland. From this point two approaches are possible; the Hudson Bay route and that afforded via Davis Strait and Baffin Bay. The former must be considered a primary route and the latter of secondary importance for direct penetration of the continent. Landing on the southern Labrador Coast in or near Hamilton Inlet are a third possibility but such landings are outside Arctic North America and should be considered in connection with the defense of Newfoundland and the St. Lawrence.

(a) Hudson Bay Route. Penetration of Hudson Bay permits seaborne access to the only North American railheads directly feeding Arctic sea lanes; those of the ports of Churchill and Moosonee. Churchill accomodates ocean going vessels, while Moosonee in James Bay is visited only by vessels of shallow draft (8-12 feet). The only lane into the Hudson Bay from the east is via Hudson Strait. This is the only practical entrance to the entire Bay since the Strait of Fury and Hecla, connecting Foxe Basin with the Gulf of Boothia on the north, is shallow and almost continuously blocked by ice. Hudson Strait probably does not freeze solidly but is difficult to navigate from mid-October until mid-July owing to large floes of ice which are carried back and forth by the winds and tides between the belts of coastal ice. This coastal ice and offshore floe combine to feed the floes which move eastward out of the Strait along the south or Ungava coast. Similar floes move west, toward the Bay on the north or Baffin Island coast. Like Hudson Strait, Hudson Bay probably does not freeze over. Nevertheless a belt of landfast and pack ice extends seaward for many miles. During formation this ice frequently is broken up and rafted by storms and presents an impenetrable barrier to sea-going vessels. Coastal ice begins to form in mid-October in Hudson Strait and Bay and by mid-November the pack ice of Baffin Bay may be expected to have enveloped the eastern approaches. The normal navigation season into Hudson Bay may be taken as from 25 July to 31 October.

(b) Davis Strait and Baffin Bay. Access to waters of the Eastern Canadian Arctic by surface vessels, like that into Hudson Bay, must pass south of Greenland. North and East from Farewell the waters of Davis Strait and Baffin Bay connect with the multitude of straits and bays encompassing the islands of the Arctic Archipelago. Neither Davis Strait nor Baffin Bay freeze solidly at any time yet massive floes heavily charged with icebergs provide a formidable barrier to navigation. While the waters surrounding Baffin Island on the east, north and west (the above named straits, Lancaster Sound and Prince Regent Inlet) do not freeze solidly, land fast belts of ice prevent direct access to the coasts during a large proportion of the year. Coastal ice normally forms in bays and inlets of Baffin Island in late October, while at Pond Inlet and Arctic Bay at the northern extremities of the island coastal ice may be expected during the first week of October. Break-up comes in mid-August in the north while southern inlets may not be open to navigation until even later dates due to the drifting of floes into harbors. Since seaborne approach to the Arctic Archipelago from the east is controlled by the state of the ice in Davis Strait, it may be said that normal navigation is denied that area from mid-October to mid-August. However, exceptional conditions may extend the navigation season somewhat, and through the use of the most powerful icebreakers, it is conceivable that northern Baffin Island might be approached as early as July or as late as December.

(c) Suitability of Greenland as a staging area and site for launching long range weapons. In considering the eastern sea approaches to North America, it is necessary to evaluate Greenland as an intermediate staging area and base for long-range weapons. Greenland, the worlds largest island, measures 1,650 miles north-south by 200 to 750 miles east-west. Chief terrain features of Greenland are: a vast ice-covered upland in the interior and rugged, barren, ice-carved mountains along the coast. The coastal mountains are cut into small blocks and narrow fringe-like strips by long deep arms of the sea (fiords and inlets). Many of the coastal mountain segments are barren rocky islands completely surrounded by deep, narrow channels. A few of the ice-free coastal areas are high flat-topped blocks or low flattish shorelands but most of these marginal lands are steep barren ridges of 4,000 to 10,000 feet elevation. The great central ice cap rises above the coastlands in a series of broken crevassed (deeply cracked) steps, and reaches elevations of 8,000 to 10,000 feet over much of the interior. The dome-like ice surface of the interior has many areas of deep cracks, shallow valleys and broad hollows to break the contour of the apparently smooth snow covered surface. Suitability of this ice surface for the landing of aircraft is in dispute and careful ground surveys, and ice soundings should be made before any but emergency landings are attempted. Convoys could approach the southern coasts of Greenland (south of 70° N) only during the period when the winter shore and bay ice has melted. This increases from 3 weeks (August 15 - September 5) at Scoresby Sound on the east, to 4 to 8 months on the south and west coasts. However, drifting icebergs broken from the margins of the great ice cap drift down the inlets and along the shores at all times during the period when annual winter shore ice is gone. Invasion by air and quick expansion of preliminary bases established by small seaborne forces appears to be less of a risk.

1. Level, firm, hard rock and deep frozen soil surfaces, suitable for use as staging areas, are available on the coasts of Scoresby Sound and Foster Bugt (Bay), on the southeast coast, at the heads of a few fiords, and on the extreme north, particularly at Independence Fiord. This latter area is never ice free and may be reached by air only. If the southeastern fiords (Holsteinborg to Julianehaab) were seized and developed for use by planes of 2,500 mile range (5,000 mile round-trip) the enemy could reach all points northeast of a line from Central British Columbia through Kansas City to Savannah, Georgia. If the west and north Greenland coast areas were used a range of 3,000 to 4,000 miles would be necessary in order to blanket the same general sections of Canada and the United States. Difficulties due to unfavorable flying weather in Greenland and in the approaches from the nearest Soviet territory (Archangel to Murmansk Coast) are discussed briefly in Section C 1 b of this report.

2. Any of the flat, low, firm (rock) areas listed above as possible staging areas could also be used as launching sites for long-range rockets. Such sites could also be established in even smaller and more confined, fiord areas. If submarines were used to make the initial contacts, such bases might be set up secretly in the maize of deep inlets and fiords north of Scorsby Sound just as the secret weather stations were established there by the Germans during the battle of the Atlantic. It should be noted that in order to blanket the densely inhabited and industrially developed northeastern quadrant of the United States (Duluth-St. Louis-Baltimore) the missals would have to possess a range of 3,000 miles. This distance is 500 miles more than the estimated 2,500 mile range of the A-10, the largest of the German rockets to reach the planning stage by V-E day. Knowledge of this rocket and many technicians familiar with it are without doubt now in the hands of the Soviet Staff.

3. Over Ice Routes. In order to succeed, a winter operation across the Arctic Sea ice would have to reach its objective prior to 15 May. To take advantage of the vehicles used in the sea crossing for further southward penetration while winter conditions still obtain, the months of January or early February appear to offer the conditions best suited to this type of operation. During February, storms and fog are nearly absent, semi-darkness favors undetected approach and ice conditions at sea are most favorable for travel. The most difficult phase of over-ice attack is encountered at the beginning and end of the march where, by reason of the proximity of land, the ice surface, though stable, will be distorted into a jumbled mass of hummocks and troughs. Maximum turbulence of ice will be encountered along the junction of sea ice and land-fast ice and this junction may occur from the coast to 30-40 miles off-shore. A less congested mass is usually present at the coast line itself. Although these congested areas are obstacles to progress they can be traversed by judicious selection of routes. That military operations over sea ice are possible with over-snow vehicles presently available is evinced by the success which attended Canadian Army Exercise "Lemming" which during the winter 1944-45 travelled along the west coast Hudson Bay from Churchill to Padlei, N.W.T. and returned to Churchill; a total distance of 653 miles. An average of 65 miles was achieved per travelling day and on one occasion 94 miles were covered in a day on the ice near shore. Assuming an attack against the Mackenzie Delta mounted from the mouth of the Kolyma River in Siberia, the travelling distance would approximate 1600 miles. This distance might well be covered by a force of all arms (anticipating resupply by air on arrival at objective) in approximately 25 days. The presence of heavy ice ridges (10 to 20 feet high) and leads of ocean water would probably necessitate the use of amphibian vehicles and carrying of much special equipment. Long detours are to be anticipated. Supplies and fuel would have to be brought by air.

4. Air - Ice - Sea Approach. It is quite possible that an attack on the North American continental frontiers might combine airborne and amphibious phases. It is entirely feasible to land aircraft on the frozen stretches of the Arctic Ocean and from the "coastal" margin thereof to launch amphibious operations against the mainland. This would involve using the ice itself as the immediate staging area. However, areas suitable to the landing of aircraft on sea ice exist only in the open sea itself because tides, storms and currents so agitate the inter-island waterways of the Arctic Archipelago that smooth expanses of ice are not permitted to be maintained. A joint airborne-amphibious attack against Arctic North America could be launched from the Beaufort Sea. This area is one of the better zones for flying from the weather standpoint, although the summer months are in general poorer than the winter period. Not only is it favorably located relative to North America but also the ice of the Beaufort Sea is the most stable of the entire Arctic Ocean. It was on the less stable ice floes near the North Pole that the Russian Expedition landed repeatedly in 1937. In the month of June or July it might be possible for an airborne attack to land on floes to the west of Banks Island, and to launch an amphibious assault against the Mackenzie Delta. Such an assault would entail the use of landing craft stressed for ice navigation since, from their point of launching to the mainland, they would encounter broken floes and drifting ice. An operation of this kind would avoid the sea lanes confined to the proximity of the Alaskan coast and would permit approach within probably less than 100 miles of the North American coast with minimum fear of detection. Another objective of a similar operation might be aimed against the low level west coast of Banks Island (1941 population 52 persons) for the purpose of air base development or for the installation of long range missel projectors.

D. North American Sector.

1. Major Terrain Regions in Northern North America. The major terrain regions of northern North America are arranged in four roughly parallel belts oriented southeast to northwest (Map 3).

a. The easternmost terrain region is a broken belt of rugged mountains and high ice-covered table lands. It extends north along the west coast of Newfoundland and the east coasts of Labrador, Baffin, Devon, and Ellesmere Islands. North of 60° this belt is duplicated on the east by the great ice-covered highland of Greenland with its broken edges and mountainous outer coastlands (see paragraph C 2 c (2) (c). The uplands increase in height from south to north, reaching 2,000 to 4,000 feet in Newfoundland - Labrador and 7,000 to 10,000 feet in Ellesmere Island - Greenland.

b. West of the Labrador - Ellesmere highland strip is a 1,000 to 1500 mile wide belt of low, ice-scoured, lake dotted, plateaus with some belts of coastal plain west and north of Hudson Bay. The belt includes all lands around Hudson Bay as well as the Central and western Arctic Islands (from western Baffin Island to Banks Island). The western edge of the plateau is marked roughly by the string of large lakes which extend northwest from Lake Superior to Great Slave and Great Bear Lakes. The rolling plateau surface varies from 1,000 to 2,000 feet in height. Many rock ridges and low ranges rise 100 to 1500 feet above the general level. Thousands of lakes dot the surface, especially west of Hudson Bay. Low narrow coast plains extend along the south and west sides of Hudson Bay and a belt of similar lowland reaches diagonally northwest across the barren lands to central Victoria Island (Map 3). Other bits of low plains land are scattered among the smaller Arctic Islands.

c. The third terrain belt of northern North America is a string of lowlands along the west side of the great Hudson Bay plateaus (Map 3). On the south (at 50°N) the flat prairie plains are 450 miles wide but northward they narrow rapidly until the lowland strip along the Mackenzie River is only 20 to 50 miles in width. An outlying part of this lowland is the Alaskan Arctic Coast Plain north of the Brooks Range. (Map 3). The southern (or prairie) lowlands are flat, lake-dotted, grass and crop-covered plains; but the northern (Mackenzie and Alaska Coast) strips are mostly poorly drained, forest- and tundra-covered flats. Although the southern plains are generally flat they rise gently toward the mountain on the west and reach elevations of 2,000 to 3,000 feet along the mountain front. The middle and lower Mackenzie valley, and Alaskan Coast Plain are mostly under 1000 feet in elevation.

d. The westernmost terrain belt of northern North America is a series of high southeast - northwest mountain ridges separated by a central zone of dissected plateaus. The general southeast-northwest orientation of the highland system is changed to a dominantly east-west direction in central and western Alaska. Mountain ranges in this great belt of highlands are steep and sharp throughout. Average heights vary from 8,000 to 12,000 feet in most of Canada and southern Alaska, to 3,000 to 4,000 feet in northern Alaska. The plateaus between the ranges reach 5,000 to 6,000 feet elevation in the south but decline to 1,500 to 2,500 feet in the Yukon River Basin of Central Alaska. The high marginal ranges are all broken in many places by low narrow gaps. These are made by the larger rivers which flow in broad flat-floored valleys across the interior plateaus and then out through the mountain rim in narrow canyon-like valleys.

e. All of the four terrain belts of northern North America have arctic tundra (grass - moss) vegetation on the north and extensive taiga (fir-spruce - pine - aspen) forests on the south. However, the eastern (Labrador - Greenland) mountains and great central plateau have forests only along their southern margins, while the Prairie - Mackenzie lowlands and the western mountains and plateaus are forested almost to their northern tips. The diagonal southeast-northwest boundary between the forest and tundra zones is shown on Map 3. In addition to the heavier vegetation cover, the forested areas in general have deeper snowdrifts and consequently shallower freezing of surface soil layers. These conditions are handicaps to the passage of troops overland in all but the most recent types of oversnow vehicles (see "Exercise Lemming", CACRG Report No. 25, 1945).

2. Suitability of Terrain for Lodgment by an Invader. Areas of possible lodgement of an enemy are available in all of the terrain regions of Northern North America. Particularly exposed areas of flat firm (rock or permanently frozen) ground are: (1) the larger Fjords of Labrador, (2) the coast of Northern Greenland, (3) western Baffin Island and Southampton Island, (4) southern Victoria Island, (5) the flat lowland and plateaus west of Hudson Bay, (6) the lower Mackenzie lowland, and (7) Seward Peninsula and the Yukon-Kuskokwin coastal lowlands of Alaska (Map 3). All of these areas are on or near the coast in zones that can be quickly reached from one of the possible trans-arctic (Soviet-North American) air routes (see paragraph C 1 a and b). In each of these areas frozen lake and stream surfaces provide large firm ready-made airstrips from late November to April-May. Adjacent level snow-covered soil and rock surfaces

could be utilized as bomb launching sites and camp sites during this period and developed into usable year-round airstrips before the spring thaw (April-May). The Seaward Peninsula and lower Yukon River - Kuskokwin areas in Alaska are exposed to attack from the sea. This type of attack would necessarily come in summer (May to October) when the seas and coasts are ice free. All other lodgement areas as listed above (with the possible exception of the Labrador fjords) could be invaded by air, probably in deep winter (December to April) when 3 to 5 feet of ice on the lakes and deeply frozen ground would supply many large ready-made runways. In order to reach the northern possible lodgement areas (north of 60°N) from points on the Siberian coast west of the Lena River, the invading planes would have to possess a 2500 mile range of operation (5000 mile round trip). There is no reason to believe that such a range of operation will not be available to the Soviet within the next 5 years at most. If Soviet planes were restricted to the shorter 2000 mile one way range now possessed by their largest planes they could only reach northwestern North America as far east and south as Great Slave Lake and Prince Rupert. In order to reach even these outlying parts of North America the Soviet staging areas would have to be located in extreme eastern Siberia on the Kamchatka and Chukhot Peninsulas. This zone in turn is most exposed to counter attack from Alaska and northwest Canada. An additional advantage of the longer (2500 mile) range for Soviet invasion plains would be the potential blanketing of all Canada and the United States by such planes if operated from lodgement areas in the lower Mackenzie Valley and eastward to Southward to Southampton Island.

a. The foregoing considers non-stop airborne penetration of Arctic North America initiated from the Asiatic mainland. It is, however, necessary to consider points at which intermediate landings could be made or bases for land based aircraft established. The possibility of using patches of smooth sea ice on the Arctic Ocean for air landings has already been mentioned, and the ice of the Beaufort Sea seems the most stable sea ice for air operations. While less stable than Beaufort Sea ice, that between the North Pole and Greenland could also be used especially during the winter months.

b. Of the land areas in the North American Arctic several sites are believed favorable to the establishment of airfields:

(1) The north coast of Greenland is largely free of glacier ice and during the summer months supports both plants and animals. A number of sites are reported to be suitable to the construction of airstrips in as much as little leveling would be required and an abundance of gravel exists for runway construction.

(2) Banks Island in the Western Canadian Arctic offers several possible sites. That at De Salis Bay on the southeast coast was reported well adapted to airstrip construction by the Royal Canadian Air Force.

(3) Victoria Island offers a number of areas suitable for airport construction. Of these, two were reported by the Royal Canadian Airforce to be particularly well suited; one at Lady Richardson Bay on Dolphin and Union Strait, Southeast Victoria Island, and the other at Holman Island at the northern entrance to Prince Albert Sound, western Victoria Island.

c. The above possibilities are not set forth as indicating the only suitable sites for air installations. The entire Arctic Archipelago, with the possible exception of Ellesmere Land, Axel Heiberg Island, eastern Baffin Island and Devon Island doubtless affords a wide selection of sites whereon air facilities could be installed. Even the rugged terrain of these islands should not be excluded from consideration for valleys and coastal plains abutting against mountain ranges commonly afford suitable topographic sites. An example is the US Army Air Base at Frobisher Bay, Baffin Island (Crystal II), which is situated adjacent to rugged terrain. Even more striking examples are the US Bases in Greenland BW8, BW1 and BE2. Local winds from the high ice covered uplands are local handicaps in all these coastal areas especially in summer and fall (June-October).

3. Suitability of Areas for Long Range Weapons. Any of the possible Lodgment Areas listed above could be developed as a launching site for long range weapons. The only condition required for the latest model (planned) German rocket, the A-10, is a firm hard area capable of supporting the 100 - ton weight of the rocket. The hard rock and permanently frozen soil surfaces of the northern lodgement areas would support the weapon. The estimated 2500 mile radius of the A-10 rocket would blanket all of Canada and all but the southern border of the United States if the launching sites were located west from Southampton Island to the lower Mackenzie River.

4. Winter Operations. Summer conditions are largely unfavorable to a military penetration of the Canadian Arctic, but winter and spring months are well suited. Fresh and salt water bodies are frozen, as is the tundra, and the land presents a surface well suited to airborne operations and almost universally favorable to mobility of ground forces. Flying conditions over the Arctic Ocean and the Arctic Archipelago in late winter and spring are as favorable as they may ever be expected to be and may be considered as increasingly favorable as

aircraft enter the North American sector. The month of February is favored for an airborne operation aimed at the heart of the North American continent. At that time the cold is severe but, rather than being a drawback is an advantage, for cold weather is usually clear, fog and storms being associated with the spring to summer transition period. Light is ample for the approach and lodgement and the predominant darkness an aid to concealment. Ice conditions on lakes are then at their best for the snows of early winter will have consolidated, and the tundra and other ground will have become as firm as the season permits. The firmness of the ground which underlies snow is governed largely by early winter conditions. Early and heavy snow will insulate the tundra or other moist surfaces and prevent freezing. Conversely, early cold and light snow will ensure a well frozen travelling surface. Ice conditions on lakes are similarly governed; early snow and mild weather after the first skim ice will retard ice growth, whereas early cold and sparse snow will permit ice to grow to maximum thickness. An airborne operation initiated in February will allow the ensuing two months to be used for southward penetration, as well as for the introduction of heavy equipment into rear areas for the construction of air bases, and/or long range weapon sites.

a. As concerns the utilization of lakes as airheads, the experience of Canadian Army winter warfare exercises "Eskimo" and "Polar Bear" undertaken January-April 1945, shows that ski equipped aircraft can land almost at will on lakes characteristic of the Eastern Arctic. Since snow cover in the areas surrounding Hudson Bay is not heavy (generally less than 40 inches total snow fall per year) no serious problem is presented in making ice surfaces suitable for the landing of heavy aircraft. Many of the lakes available are shallow and freeze to the bottom; nevertheless ice thicknesses exceeding 36 inches are common and adequate to support the landing of heavy bombardment or transport aircraft.

b. During the winter 1945-46 the Canadian Army will undertake an exercise designed to study military travel and logistics in Arctic Canada. A small force will proceed from Churchill on Hudson Bay to the Arctic Coast, cross Queen Maud Gulf to Victoria Island then turn southward and reach Edmonton, Alberta via Coppermine, Great Bear Lake, the Mackenzie Valley and the Alaska Military Highway. This undertaking will be exclusively equipped with oversnow and other tracked vehicles. It will be supplied by air with air drops, air landings, and the use of gliders. At least one advance air base will be established, probably at Baker Lake, inland from the northwest coast of Hudson Bay. This base will be established by air alone and without assistance from the ground party. The results of this exercise, which will include a large proportion of personnel experienced in Arctic life and travel, cannot fail to contribute greatly to the store of military knowledge on winter warfare and to guide future thinking on such operations. United States observers will be invited to accompany this exercise which will assemble in January at Churchill.

5. Possible routes toward the United States. (See Map 4)

a. Routes through the Western Mountains.

(1) Terrain. A series of narrow, moderately steep valleys and depressions form natural lowland routes across the western highland belt of northern North America. These strips of lowland are actually alternate routes in one general system of passageways which extend east and southeast from the possible lodgement areas in western Alaska to the upper Mackenzie Lowlands and the basins of central British Columbia (map - 3). These trans-mountain passageways terminate in the military sense at the first railroads, Dawson Creek, and Prince George, British Columbia. In general the routes follow the valleys of the Kobok and Yukon River systems through central Alaska and then cross the intermountain plateaus of the Yukon Territory and northern British Columbia to the flats along the upper Liard River, tributary of the Mackenzie. From that point the main developed route continues southeast along tributaries of the Liard and through a low pass in the Canadian Rocky Mountains to Port Nelson on the upper Mackenzie plains. At Fort Nelson the route turns south and extends across the plains to the rail head at Dawson Creek. The Alaska Highway follows this route from Fairbanks, Alaska to Dawson Creek, British Columbia. (Map 5). An alternate natural route runs southeast from the upper Liard flats by way of the Rocky Mountain trough to Prince George, British Columbia. This feature is a great natural depression along the west side of the Canadian Rocky Mountains. The trough continues on south of Prince George into northern Montana and there ends among rugged mountains. There is no road and few trails along the Rocky Mountain trough between Prince George and the upper Liard flats.

(a) Only the Alaska Highway section of these routes has been adapted to summer traffic. This highway may be difficult to keep open in the spring thaw and break-up season (May - June) when bridges are damaged by ice jams and road fills tend to sink into muskeg bogs. Other parts of the route where no modern roads have been built are impassable to ordinary land vehicles during the spring-summer period of soft soil and unfrozen streams (May-October).

(b) Other handicaps to overland movement in summer on the undeveloped sections of the trans-mountain route are; a dense growth of small timber, much loose rock on side slopes, and dense swarms of mosquitoes and flies.

(c) In winter, special oversnow vehicular columns could move on most parts of the route. Such columns could use the frozen surfaces of streams and lakes as open passageways and could clear narrow paths through forestland with special bulldozer-tank type vehicles (see reports of Canadian Army on winter exercise "Eskimo"-1945). It should be noted, however, that the topsoil may freeze to a depth of only 1 to 2 feet under snow drifts in the forest and this is not sufficient to support heavy military vehicles especially if the unfrozen sub-soil is saturated and tends to flow. Only firewood is available along most of the route so that supplies would have to be brought up by air in the sections not served by the Alaska Highway.

(d) The chief navigable waterways in this trans-mountain passageway is the Yukon system which is open from the Bering Sea to Whitehorse Yukon Territory from June to October. Boats for use in navigating the Yukon would have to be brought by an invader because only a few boats operate on the river at the present time (see paragraph D6a(3) of this report).

(2) Climate. The following paragraphs give a summary of the relation of climate to ground operations along the Yukon Valley - Alaska Highway Route (Nome-Fiarbanks-Whitehorse-Dawson Creek). This route may be subdivided into 3 main climatic or topographic regions:

1. Western Alaska tundra, including the Seward Peninsula, the Kobuk, Koynkuk and the Lower Yukon valleys.

2. Tanana and upper Yukon Valleys, including the wooded region from Tanana through Fairbanks to Whitehorse.

3. Rugged mountain region of southern Yukon and British Columbia: Whitehorse to Dawson Creek.

(a) The western Alaska tundra region is snow covered from November through mid-May. Blizzards are frequent, and drifting may be excessive, but snow depths seldom exceed 2 feet on level ground. The climate is essentially cool, windy, foggy and damp. Minimum temperatures are never as extremely low as in the interior valleys, but lack of protection from wind and gales adds to the severity of the winters, and the spring is late and chilly. Summer is short and wet. Ice in rivers breaks in June, often attended by flooding. The freeze-up occurs in late October. Most soils in this region are untrafficable from late May through September. Closely packed sand or gravel bars or beaches are the best for traffic between July and October. Extreme variability in weather occurs from year to year at all seasons. The Kobuk and Kayukuk Valleys (Kotzebue to Nulato) are much drier than the lower Yukon, and probably offer a more trafficable route into the interior.

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(b) Tanana and upper Yukon Valleys are more wooded and mountainous than western Alaska. More protection is offered against gales and blizzards, drifting and cold winds. Calms occur a high percentage of the time in winter, hence the cold is not so keenly felt, and the winter and spring sunshine is warm and effective. Snow is dry and the surface usually crusted. Snow cover lasts from November through March or mid-April, and reaches a depth of about 2 feet in January or February as a rule. Ice appears on the rivers in late October, is thick enough for traffic in early December, reaches a thickness of 4 to 6 feet in March, begins to thaw or break in April and melts in May, often attended by floods. Temperatures may reach 65° below, often reach 50° below, and usually go below zero about 120 days between late October and early May, and occasional frosts after late August and before mid-June. Summers are unusually war and humid. Soils often remain moist through the entire summer and sometimes flood in May, June, July or August. Permanent frost honeycombs the soils of this region, appearing at the surface on northerly slopes, but thawing for several feet in most places, and to great depths in other places. Most of the precipitation is rain from May through September.

(c) The Rocky Mountain region from Whitehorse to the Dawson Creek is a maze of high ridges and deep gorges. Snow is not excessive because of the protection offered by high coastal ranges. Freezing occurs on low-lying lakes and rivers from about 1 November to 15 May. In calm weather, which is frequent in winter, extremely low temperatures may occur, On the other hand, thaws occur in winter on lee slopes. Precipitation is heaviest in autumn and lightest in spring. Occasional blizzards invade the valleys when cold waves come through from the north.

b. The Mackenzie Valley Lowland.

(1) Terrain. The Mackenzie Valley Lowland is the shortest and most direct natural route from the true Arctic (north of 65) toward the United States. From the Mackenzie Delta area to the nearest railheads at Waterways and Peace River the overland route along the lowland is 1200 to 1300 miles. This route could easily be followed in winter (November to May) by oversnow vehicle trains. These vehicles could utilize the smooth level hard-frozen surface of the Mackenzie waterway system for much of the way. Supplies and fuel for the train could be brought up by air as is planned for the Canadian Army 1945-1946 winter exercise in the Arctic barrenlands and Mackenzie Basin. Additional small amounts of fuel might be obtained at Norman Wells oilfield on the lower Mackenzie unless the tanks and wells were first destroyed by defense forces. Terrain factors which would hinder the southward

movement of land vehicles and infantry along the Mackinzie Lowland are: low mountains with projecting spurs commanding the river, and numerous lakes and muskeg bogs during the summer-fall thaw season (April to November). The lakes and bogs are distributed all along the Mackenzie Lowland but the rugged areas are located chiefly in the stretch between Fort Good Hope (west of Great Bear Lake) and the outlet of Great Slave Lake. In summer, early July to early October, the Mackenzie system is ice free throughout and can be navigated by river boats. There is one portage of more than ten miles between Fort Smith and Fitzgerald. Many more boats could be used on the river than the traffic now warrants but these would have to be brought in and towed up-stream. Lack of experienced Mackenzie River pilots would be a handicap to such movement. See Section 3b below on inland waterway travel in Canada.

(2) Climate. The following is a summary of climate conditions along the Mackenzie Lowland. This lowland is a very dry region with about 10 inches of precipitation a year. Most of it falls as rain from June through September. The heaviest snows occur in the moist autumn. Trafficability will be very poor from May through October except on the sand and gravel bars. Frozen soils will be trafficable from November through April except where drifts are excessive. Rivers and lakes are frozen from October through June. Ice sometimes remains on lakes in July. Cold winds and blizzards are common in winter in the open Mackenzie Valley and over the lakes. Along the Arctic Coast, milder temperatures but stronger winds occur than in the upper Mackenzie and lakes region. At Fort Good Hope a record low of $-79^{o}F$. in December is the coldest ever officially recorded in America, yet in summer a high of 95^{o} above has occurred. Snow accumulates to a depth of 3 or 4 feet in the southern part of Mackenzie Territory, but except in drifts is seldom over 18 inches deep in the north.

c. Hudson Bay Route.

(1) Terrain. The Ports of Churchill and Moosonee provide gateways to the interior from Churchill via the right-of-way of the Hudson Bay Railway to the main continental network at Hudson Bay junction, and also from Moosonee via railway right of way to Cochrane on the main line of the Canadian National Railway. Of the two approaches, that via Churchill merits primary consideration since that port is equipped to accomodate ocean going vessels, has an airfield (US Army Airbase evacuated August 1945) and associated installations, and is 200 miles closer to point of origin than Moosonee. Further progress southward, especially in winter, would be favored by heavy frozen lakes which would be suitable for air landings or as avenues of military transport. This route leads directly to the heart of the United States via Winnepeg while that from Moosonee leads to the industrial heart of Canada, the Province of Ontario and Quebec.

(a) Following the close of the navigation season in Hudson Strait (about 15 October) it is not conceivable that a military operation over sea ice and aimed at the eastern Arctic could be undertaken with any likelihood of success. If such an operation were attempted, an amphibious technique would be required, the force being transported by sea to a point off Northern Labrador and crossing successively the Ungava Peninsula and Hudson Bay with the aid of amphibious oversnow vehicles. This operation involves great difficulty in terms of logistics and security. It is by no means impossible, however, than an approach from the vicinity of the Lena or Yenesi deltas could be effected over the ice of the Arctic Ocean. The distance from almost any coastal Siberian point to Southampton Island at the northern entrance to Hudson Bay approximates 2800 miles. Such an approach would be favored by stable ice conditions and a good travelling surface until the Arctic Archipelago is reached, whence careful route selection would be required for the remainder of the journey. Such an undertaking might be attempted with the object of preparing air bases and sites for long range missile projectors or as the ground component of an airborne operation. Considered solely as a ground operation against the continent without airborne assistance such an approach would be exceedingly difficult. As affecting the practical solution of trans-Arctic over-ice travel, it should be noted that types of oversnow vehicles presently available may be quite capable of accomplishing such a journey. Canadian Army Exercise "Lemming" demonstrated in April 1945 that travel over sea ice is practical for a military force. A 650 mile journey was undertaken from Churchill on Hudson Bay to Padlei, N.W.T. and return. The average daily milage was 65 miles and on one day 94 miles of sea ice was covered. Should such an operation as above envisaged be undertaken, it would have to utilize the months of January, February and March in order to take advantage of favorable ice conditions. These months are those of minimum daylight, most stable weather, and good travelling conditions on the ice.

(2) Climate. Winds are strong and blizzards frequent in the northern portions of this route (Churchill-Saskatchewan). West of Hudson Bay, the snowfall is heavier than farther west or north, reaching 3 or 4 feet in spring. The northern part is frequently bare of snow cover in winter, where winds have free access, but in the protected hollows snow remains all summer. Much of the country is open rocky tundra in the north, but the southern portion is lake and bog country with scrubby trees in clumps. Rivers and lakes are frozen from September through July in the north and from November through April in the south. Temperatures are not so low in midwinter, but much lower in spring than in Alaska and western Canada. Summers are moist and cool, and the ground is generally boggy from May through September.

d. Routes from Southern Labrador to the St. Lawrence Lowland.

(1) Terrain. No road, trail, or easy natural route leads south or west from Labrador. However, during the winter freeze-up (December to early May) a column of modern oversnow vehicles could start from possible staging areas at Goose Bay or on the plateau nearby

and with difficulty follow major drainage lines (frozen stream - lake surfaces) first southwest and then south to the Saint Lawrence Estuary opposite Anticosti Island. From there amphibious type vehicles could follow the coast west and south to the north shore highway at Tadoussac. All supplies for the column would have to be delivered by air. Bulldozer type vehicles would be necessary to clear paths through the dense inter-stream forests with their 6 to 10 foot snow drifts. In spite of such specialized vehicles, the very rough terrain between streams, and the numerous thinly-frozen muskeg bogs between the low solid rocky ridges would severly handicap movement through this country even in winter. In summer the numerous deep bogs and many streams and lakes would prohibit movement by any types of land vehicles now available. In addition to these handicaps their is the constant exposure of a moving column to air attack during the long (600 to 700 mile) journey through difficult country. It should be noted that the same handicaps would limit any ground action against an enemy lodgement area if once established in southern Labrador.

(2) Climate. This route is rendered difficult from November through mid-May by deep snows, reaching 6 to 8 feet in places. The southern portion is the most moist, and the northern the driest. Rivers and lakes are frozen from November through mid-May in the south, and from November to mid-June in the north. Soils are marshy from late April until November. Cold winters (30° or 40° below zero F. at times) are made more intense by frequent and sometime prolonged gales and storms.

6. Established Routes in Canada and Alaska.

a. Alaska.

(1) Railroads. Alaska does not have a railroad net covering the Territory. Alaska's railroads consists mainly of a few individual lines with short spurs which extend from the coast to interior points. The White Pass and Yukon Railway was built to facilitate transportation over the mountains between the ocean and the gold fields in the Upper Yukon Valley. The Copper River and Northwestern Railroad, which is no longer in operation, was built from Cordova to the copper mines in the interior. The Alaska Railroad, a Federal road, accomplished three objectives: to connect mining areas along the interior waters with one or more open Pacific harbors on the Southern coast; to make one or more coal areas accessible; and to contact lands suitable for agriculture. A limited mileage of narrow gauge road has been built in Seward Peninsula in response to mining needs. Other short, disconnected railroads have been constructed in various areas for special needs.

(a) Alaska Railroad. The main line of the Alaska Railroad extends from Seward to Fairbanks, a distance of 470 miles. The mileage of branch lines, chiefly in the Matanuska Valley are less than 50 miles. This total includes the new low grade line to Whittier on Prince William Sound.

(b) White Pass and Yukon Railway. The White Pass and Yukon Railway a single track narrow gauge railway, extends from Skagway, Alaska by way of White Pass, (elevation 2,855 feet) to Whitehorse, Yukon Territory, Canada, a distance of 110.7 miles. There are no branch lines. From Skagway to White Pass, a distance of 20.4 miles, the railway is in Alaska.

(c) Copper River and Northwestern Railroad. Before the tracks were removed this road extended from Cordova inland to Kennecott, a distance of 195 miles. The portion of the railway in operation on February 1, 1944 by the United States Army consisted of 13 miles from Cordova Dock to Mile 13 at Sheridan. The remaining right of way remains except where local washouts have occurred.

(d) Seward Peninsular Railway. The Seward Peninsula narrow gauge railway extends northwest from the seaport of Nome to Bunker Hill, situated on the Kuzitrin River, for a total distance of 78 miles.

(c) Yakutat and Southern Railway. The railway consists of a switching line for freight service between Situk and Lost River and Yakutak. It has a total trackage of 15 miles.

(2) Roads. Alaska road construction has been developed along simple lines. It has been found that a gravel surface is necessary for practically all roads which are to be used by automobiles. Economic considerations have not warranted the construction of concrete or other hard-surface roads. In general, roads and trails have been constructed to the centers which, by their natural location and importance, have demanded this type of outlet. A few roads have been built for tourist attraction and recreation and to break down the isolation of certain sections.

(a) Extent and status. At the end of the fiscal year, June 30, 1941, there were 2,286 miles of road, 80 per cent of which was suitable for automobiles in all summer weather, 1,435 miles of winter sled road, 6,427 miles of trail, and 224 miles of marked trail. Considerable improvement and extension of the road system has been made since that date. In general, the condition of roads in Alaska (Feb. 1944) was poor, unreliable and impassable at certain seasons. Some roads are useable only in the winter, when soft ground is frozen to permit passage of heavy vehicles, while others are often impassable in winter due to heavy snows. Many sections of Alaska are without roads of any description and rely on pack trails for transportation. In the past two years much has been done by road building agencies and the U.S. Army Engineers to relieve this condition; in many places, the conditions of roads have been improved 50 to 100 percent. The Glenn and Haines Highways are examples of important, new construction; they are still in the process of improvement, and are being widened, regraded, and in many places rerouted. Other new construction consists of limited extension of existing roads where warranted. The Richardson and Steese Highways have undergone considerable improvement and are now dependable routes of transportation. The Anchorage-Matanuska Valley, Juneau, and Seward areas contain some of the best maintained road nets in Alaska; the Nome road net is in fair condition. There are many other local roads in scattered communities throughout Alaska which have no part in the general road net, and, therefore, are relatively inaccessable. These local roads are generally poorly maintained and, therefore, are useable only in winter by tractor drawn sleds when the road beds are frozen sufficiently to support heavy loads. Many of these tractor, pack, and dog trails are widely used in these communities, as the only means of transportation, and are generally equipped with shelter cabins at intervals along the route.

(b) Kinds of roads and trails.

1. Roads. Most of the funds expended in Alaska on roads has been for the construction of these suitable for motor

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vehicles. These are graded, surfaced with gravel, and provided with bridges. Most of these are two-way highways.

2. Sled roads. These are found mostly in the interior and on the Bering Coast. They are drained sufficiently to prevent their destruction from rain and summer thaws, but are not graded. They are used primarily to service outlying mining villages and camps under winter snow conditions. Double bobsleds drawn by caterpillar tractors are very adaptable to winter use, and are capable of hauling large quantities of supplies.

3. Trails. These include any passageway requiring less construction than roads and sled roads. They are suitable for dog sleds or single horse-drawn sleds of the doubleender type in winter and pack trains in summer. Except where frozen river surfaces are used, some work is always necessary to permit the use of dog teams.

4. Marked or portage trails. These trails frequently follow trails that have been made by big game animals. Improvements include some drainage, clearing of brush, and installation of footlogs. In winter, many short cuts across frozen lakes and streams are possible. These trails are principally used by prospectors, trappers, and sportsmen.

(3) Inland waterways. Steamers are operated between Nenana and Yukon River points, to Marshall and return, leaving Nenana once every two weeks during the season of navigation. There are connections at Marshall for St. Michael and Nome. Alaska railroad services connect at Seward with the Alaska steamship company (the "Alaska Line"), operating between Seattle and Seward, at Nenana with steamer services of the American-Yukon Navigation Company, maintained between Whitehorse and Dawson, Yukon Territory, and Nenana, Alaska, and at Fairbanks with the Richardson and Steese Highways.

(4) Sea Routes to Alaska. Over 99 per cent of Alaska's commerce is carried on with the United States. Since the purchase of Alaska in 1866, shipping has been the principal means of transportation with the Territory. Roughly, there are about 100 ports in Alaska with dock facilities that will accomodate ocean going steamers. A large majority of these ports are salmon canneries located in outlying places along the south and southeast coasts. Practically all the canneries except those in Bristol Bay, have docks that will accomodate ocean steamers. Lighter service, cold storage facilities, cranes and other equipment are available at most of the ports. The principal ports are located at Tangas Harbor, Ketchikan, Wrangell, Petersburg, Juneau, Sitka, Skagway, Yakutat, Cordova, Valdez, Whittier, Seward, Anchorage, Kodiak and Dutch Harbor.

(5) Airfields.

(a) Landing Fields. There are over 250 landing fields of all classes and types in Alaska, including military fields. Most of these were primarily developed by Alaskan interests to serve mining, fishing, and fur industries. Mining companies, municipalities, private individuals, the Alaska Road Commission, and the C.A.A. have all had a part in the development of the local fields. There are about 23 commercial air lines or charter services operating in Alaska, of which Pan American Airways is the most important, operating scheduled services from Seattle to Juneau and other Alaskan points and to Whitehorse. In addition, carriers on contract to the Army Air Force are operating from Seattle and Edmonton to points in Alaska. With smaller airlines, flight departures are usually arranged to suit the needs of traffic, and schedules are very seldom maintained. With the outbreak of hostilities in Europe, an extensive program for development of airports suitable for military purposes was begun by the C.A.A. and the Army Engineers. Since the United States entered the war, additional airports, including auxiliary airports, have been constructed under the supervision of the U.S. Army. As conditions warrant, airports constructed and operated by the C.A.A. were taken over by the Army and operated as military bases or staging fields. Most of the important commercial fields are surfaced with gravel. In contrast, many of the Army Air bases are constructed with concrete runways, and the Naval base runways at Kodiak are of asphalt. It has been found that asphalt or asphalt emulsion type of paving is generally best. Steel matting has been used on some fields. Only in fields where runway lengths have been considerably extended, or where recent ones have been constructed, has the problem of artificial drainage been developed. In a great number of cases, the fields have natural surface drainage, a condition which must be closely watched during the thaw period. Alaska is now provided with an airways system extending from Ketchikan to Nome and Attu, a system which is constantly being developed and expanded.

(b) Seaplane anchorages. Along the coast, especially in Southeastern Alaska, local commercial aviation is conducted primarily by means of amphibians, Towns and cities such as Ketchikan, Petersburg, Juneau, Cordova, and Anchorage that serve as centers for this type of air service are all equipped with hangar and float facilities. In addition to these facilities, most of the towns, villages, and canneries along the coast that are served by aircraft charter service have ramp and float facilities. In the Aleutian area, few of the anchorages are of sufficient size or well enough protected from the weather to be considered as operating bases. Deep water, hard bottom, and strong winds are typical handicaps. Williwaws are always a hazard. In all cases where the land is high and rugged, the wind is strong and gusty on the lee side; violent gusts are common and come from different directions in rapid succession.

(c) Post V-J Day Alaskan Air Bases. Since the cessation of hostilities many of the air establishments in Alaska and the Aleutian Islands have been abandoned or placed on a standby basis. Of those remaining, the U.S. Army Air Forces has large fields with extensive facilities at Nome, Galena, Fairbanks, Big Delta, Tanana Crossing, Northway and Anchorage in Alaska Proper. On the islands the A.A.F. continues to maintain bases for aircraft at Unimak Island, Umnak, Tangga Island and Amchitka. The U.S. Navy maintains extensive naval aircraft facilities at Kodiak, Dutch Harbor, Adak, and on the Near Islands at Attu and Aggatu. There are auxiliary fields throughout Alaska maintained by the U.S. Army Air Forces, and some by the C.A.A. but future disposition of military establishments for aircraft is not definitely known at this writing. The fields and establishments in this list represents the situation at the end of August 1945.

b. Canada.

(1) Roads and Railroads in Western Canada. Edmonton is connected with the Pacific coast at Prince Rupert and Vancouver, B.C. by rail line. Since all overland traffic to the northwestern areas of Canada and to Alaska channel thru Edmonton, this city is a key point in the transport net of western Canada. North of Edmonton the railroads run, single track, to waterways and Peace River, Alberta, and Dawson Creek, British Columbia. The secondary road which links Edmonton and the southern end of the Alaska highway is being surfaced for all year traffic (1945). Peace River is connected with the southern and western shore settlements of Great Slave Lake by a pioneer trail passable to tracked vehicles. Fort Providence near the southern end of the Mackenzie River is also reached by a branch of the trail. Other tractor trails serve settlements along most of the Mackenzie river valley. An all-weather highway parallel to the Canol Pipeline from Fort Norman (Norman Wells) to Whitehorse, Y.T. was abandoned in 1945.

(2) Roads and Railroads in Central Canada. In central Canada the single track railway from Churchill, Manitoba on the west coast of Hudson Bay, connects with the trans-continental system at Hudson Bay Junction, Saskatchewan. This junction also connects the Churchill (Hudson Bay) Railway with the substantial system of railroad and first class highways in the wheat growing areas of the prairie provinces. This system is bounded on the east by Lake Winnipegosis and on the west by the Calgary-Edmonton highway and raillines. It should be pointed out that this rail system of west central Canada lies largely within 200 miles of the northern border of the United States and the system is connected with the main lines of the United States at many points.

(3) Roads and Railroads in Eastern Canada. The only rail-head in eastern Canada falling north of 50 degrees is located at Moosonee,

Ontario on Moose River near the southern shore of the James Bay. This line connects with the transcontinental system about 200 miles south at Cochrane, Ontario. There is no road in eastern Canada running north of the 50th parallel.

(4) Inland Water Transportation in Northern Canada. The most significant waterway in the far north is the Mackenzie river. At present flat bottomed river boats navigate the stream during the summer months, but because the river freezes during the winter air transportation and tracked vehicles supplant the boats. Beginning at Fort Providence, N.W.T., the Mackenzie river ice breaks up about the middle of May and freezes about the middle of October. At Aklavik near the mouth of the river, the breakup of ice does not occur until late in June and the river freezes over toward the end of September.

(5) Sea Routes in Northern Canada. Transportation by sea to the arctic areas of Canada is extremely limited. The Hudson's Bay Company and the Royal Canadian Mounted Police send annual supply boats into the northern waters. Commercial traffic, undertaken exclusively by the Hudson's Bay Company, is limited to furnishing outposts of Eskimos and a few white settlers. For a few years the Hudson's Bay Company sent ships around the northern tip of Alaska to supply Aklavik and the western Arctic settlements, but after loosing two of its ships on this route, the Company finally abandoned sea traffic to this area of Canada. Supplies are now sent down the Mackenzie and distributed along the western Arctic Coast by small coastal vessels. During the ice-free season of the Eastern Arctic (July to October) Canadian government ships and those of the Hudson's Bay Company visit settlements on Labrador, Hudson Bay, Hudson Strait, Baffin Bay and connecting channels. No ships have been lost there in recent years but one or two outlying posts have been blocked off by ice for two successive years. A few grain boats visit Churchill during the ice-free season (July to November) but traffic has never been large. A Canadian Government patrol vessel guides these ships through the dangerous, iceburg infested waters of Hudson Strait.

(6) Air Routes in Canada. In general, there are three established types of air facilities in Canada: (a) The commercial routes served by Trans-Canada Airlines and Canadian Pacific Airlines which, for the most part, fall south of the 50th parallel and only touch important cities at north of the 50th parallel at Regina, Saskatoon, Calgary, Edmonton and Moose Jaw; (b) Regularly scheduled air routes of secondary importance which connect the principal cities of the south with the mining settlements of the far north. These in-

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clude the "bush" lines which operate on a charter basis to small northern outposts; (c) the military air routes and bases developed by the United States Air Forces and the Royal Canadian Air Force during the war. The routes of the Trans-Canada Air Lines and Canadian Pacific Air Lines may be disregarded for purposes of this paper because of their proximity to the U.S. The CPAL and "bush" lines serve the mining areas and remote settlements of northwest Canada. Beginning at Edmonton a regularly scheduled service is available to McMurray, Chipewyan and Resolution. At Resolution the lines break into two forks, one going north to Yellowknife, Rae, Port Radium and coppermine on the Arctic coast. The other line runs northwest and serves Providence, Simpson, Nolman, Oklavik and other settlements along the Mackenzie river valley. Tributary areas are accessible by charter planes. The military air routes that were extensively developed during the war may be divided into routes to Europe and those to Alaska and the northwest. The routes to Europe have well-developed fields at Mingan, Quebec, at Goose Bay, Labrador, at Chimo on Ungava Bay, Quebec, In central Canada there is a first class airport at Churchill, Manitoba and at Coral Harbor on South Hampton Island. The base at Coral Harbor, was abandoned in 1945. On the Northwest Staging Route, the principal airports are located at Calgary, Edmonton, Watson Lake, Fort Smith, Norman Wells and Whitehorse. In addition to these fields there are many landing strips for emergency landings along the Alcan Highway area to Alaska and in other parts of Canada. In winter months, frozen lakes and rivers of the area afford excellent sites for emergency landings.

7. Strategic and Critical Materials.

a. Canada. The critical ore in all northern Canada is uranium. Deposits are found in the region of Great Bear Lake, Great Slave Lake and Lake Athabaska. The Canadian government now controls mining of the ore, said to be the largest single source of U-235 in the world. Like the uranium deposits, other minerals in commercial quantities are found in the western section of Canada but because of the poorly developed transportation facilities, exploitation of the minerals in quantity has been limited largely to an area within 200 miles of the north border of the United States. Uranium ore is being transported by Mackenzie River and southern rail routes to refineries near the United States border. There are no refineries near the mines. Assuming that the invader established himself somewhere in the region of the Mackenzie river, the oil field at Norman could be exploited to supplement his oil stores. The wells at Norman do not produce enough oil, however, to service any force of effective size; the principal oil stocks for an invasion of the northern area would have to be brought in by plane or ships. The refinery for the Norman field was located in Whitehorse, Y.T. prior to its dismantling in 1945. The wells and installations at Norman have been offered for sale by the United States and Canadian governments. The facilities are rapidly deteriorating.

b. Greenland. The world's chief commercial source of natural cryolite is found near Ivigtut, on the southwest shores of Greenland. This mineral is used to process base ores into finished aluminum. It may be largely replaced by a synthetic substitute. There are no other important commercial mineral deposits in Greenland.

c. Alaska. Alaska does not contain deposits of critical or strategic minerals in sufficient amounts to imperil war production in the United States if an invader gained control of the territory. Oil deposits have been discovered in Alaska but little development has taken place to date. Test drilling was carried on near Point Barrow during the war. Drilling and refining equipment would have to be brought in if the fields were to be exploited.

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APPENDIX B

11 October 1946

TOPOGRAPHIC STUDY OF THE NORTHEASTERN APPROACHES TO NORTH AMERICA

A. Introduction.

The islands included in this study have strategic locations on sea and air routes from Europe to North America. Lying close to the great circle route between these continents, Spitsbergen, Iceland, Jan Mayen and Greenland are actual or potential stepping-stones across the North Atlantic and the Arctic. In spite of natural limitations, they provide sites for both existing and potential anchorages, naval and air bases, and radio and weather stations. They are important elements in the control of these oceans and the defense of North America. Similarly the Azores occupy a strategic position on the southern route from the Mediterranean. They provide existing and potential naval and air base sites and may also serve as cable, radio and weather stations. They are an important element in the defense of eastern North America.

B. Spitsbergen (Svalbard).

(1) General. This group of five large islands and numerous islets and rocks is situated in the Arctic Ocean about 500 nautical miles north of Tromso, Norway; 600 miles northwest of Alexandrovsk, Russia, and 1100 miles northeast of Reykjavik, Iceland. They extend about 300 miles north-south and about the same distance east-west. Longyearby, the chief town, is at 78° 13'N. and 15°38'E.; on the south margin of Isfjord. This is one of the most accessible areas of the Arctic. It is open to shipping ordinarily from early June through October and provides suitable areas for anchorages, for seaplane bases, for radio and weather stations and possibly for landing fields. The islands also contain large reserves of coal. Their location gives them an important role in the control of the northern sea route from North America to northern U.S.S.R.

(2) Specific. Several features are characteristic of the entire Spitsbergen group. Most of the surface is rugged and hilly or mountainous, and extensive areas are covered with permanent ice and snow. Small areas of relatively level terrain are found near bays and fiords. The southern quarter of Prince Charles Foreland is also fairly level and low. Nearly everywhere the surface is stony, while about two feet below the surface, the subsoil is permanently frozen. During the short summer, July to September, tidal areas become muddy and stream valleys become boggy or completely flooded. Better drained areas are somewhat dried out by late summer. Throughout the long winter, November to June, the ground is frozen and covered with wind-blown snow. Vegetation is sparse and scattered, consisting of mosses, lichens, low herbs and dwarf shrubs. There are no trees. Shipping is possible for four to five months, June through October. Clear weather suitable for air operations is limited to short periods in summer. Snowfields provide emergency landing areas. The shores of Isfjord, a large indentation on the west coast of West Spitsbergen Island, are relatively favorable for landings, and contained the most important settlements, centered about the coal mines. Possible anchorage, landing sites, and shelter may also be found in the Cross Bay-Kings Bay (Krossfjord-Kongsfjord) areas to the northwest.

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The remaining islands of the Spitsbergen group are of minor significance. Northeast Land (Nordaustlandet) is largely ice-covered and has no permanent population. Edge Island (Edgeoya), Barents Island (Barentsoya), King Charles Land (Kong Karls Land), White Island (Kvitoya), Hope Island (Hopenoya) and Bear Island (Bjornoya) are barren and windswept, partly covered with ice and snow, generally unfavorable for operations of any kind. Bear Island did have a small radio and weather station at Tunheim, on the northeast coast, a possible anchorage site at Sorhamna, on the southeast coast, and abandoned huts of trappers and whalers.

(3) Summary. The chief potential uses of the Spitsbergen group are: (a) as a site for a weather and radio station, (b) as a naval base in summer or (c) as a fueling station. In spite of generally rough topography and poor flying conditions, small areas on Spitsbergen are capable of development for air fields. During the war, one landing field was built 2 miles southeast of Longyearby, and was used daily, when weather permitted. Several other sites are considered suitable for development.

(a) Navigation without the aid of ice-breakers is practicable for only four to five months from June through October. The use of ice breakers will probably add two months at each end of the navigation season.

(b) It is completely dependent upon outside sources for all supplies and equipment.

(c) Except in summer, living conditions are harsh.

C. Jan Mayen.

Politically a part of Svalbard (Spitsbergen), Jan Mayen lies about 250 miles east of Scoresby Sound on the east coast of Greenland. It is nearly 600 miles southwest of Isfjord, Spitsbergen. The island is about 29 miles long, northeast-southwest, 1½ to 10 miles wide, shaped like a war club, and mostly hilly or mountainous. Beeren Mountain (Beerenberg), an extinct, 8,347 foot volcano, occupies the northeastern part. The central part is lower and narrow, containing nearly all the level land on the island. The southwestern part is rugged and 2,700 to 2,800 feet high. The ground is frozen and snow-covered about nine months of the year. However, the Arctic ice pack surrounds the island only in March and April. In June, melting snow fills every stream and saturates the ground. By mid-July, the snow is mostly gone and the ground begins to dry. Vegetation is sparse, consisting of moss and shrubs as on Spitsbergen. The most favorable areas for landings and the most favorable terrain for operations are found on the narrow middle portion near North and South Lagoons. Limited areas of level land and short periods of favorable flying weather are factors against the use of Jan Mayen by land-based planes. The area of greatest potential usefulness is the middle portion. With its lagoons and relatively level ground, this is the most favorable site for development. Here, also, near Jameson Bay, is the Ekerold radio and weather station. The same natural restrictions and limitations apply to Jan Mayen as were noted for Spitsbergen.

D. Iceland.

(1) General. Iceland lies between 63° 23' and 66° 33' N., and between 13° 32' and 24° 32' W. Its east-west length is 305 miles and its north-south breadth is 194 miles, making its area about 40,000 square miles, about that of Kentucky. Shortest distances to neighboring land areas are as follows: East Greenland 150 nautical miles, Faroe Islands 225 miles, Shetland Islands and Scotland 435 miles, Norway 520 miles and Denmark 810 miles. Other significant distances are (nautical miles from Reykjavik): Archangel, Russia 1,874 miles; Argentia, Newfoundland 1,584 miles; Longyearby, Spitsbergen, about 1,100 miles. The name Iceland is a misnomer as only 1/8 of the surface is ice-covered.

(2) Specific. The surface is largely a bleak, rugged upland, averaging 2,200 to 3,300 feet above sea level. Above this upland rise numerous peaks and volcanoes, whose summits reach 4,000 to 5,000 feet. Around this upland are narrow borders of rugged coastal land, valleys leading into the interior and a few small low areas in the south and west. Settlement is limited to the coastal areas and the valleys---the rigorous climate, barren, desert-like terrain, lava fields and glaciers make the interior of Iceland virtually uninhabitable. The coast varies from the deeply indented, fjord coast of the east, north and west, to the low, sandy, surf-beaten south shore. Headlands are commonly steep and precipitous. The bars along the south shore are backed up by lagoons and river deltas. Shores favorable for landings are found at heads of fjords and in limited places elsewhere. Fog and storms are constant hazards. Coasts are completely ice-free from August to December. At other times ice may block the north and east coasts. Heavy precipitation and melting glaciers cause the numerous Icelandic rivers to have periodically heavy run-off. Numerous waterfalls and the generally swift currents prevent navigation. Also, the swift currents and deep channels hinder crossings. Glacier-fed streams are particularly hard to cross. Maximum flow on glacier-fed streams occurs in July; minimum in April; on sunny days maximum flow comes from 8 to 12 p.m., minimum from 5 to 8 a.m. Only a small part of Iceland is covered with a continuous carpet of vegetation. Even in the low-lying inhabited districts, large areas are rocky, stony, sandy or lava wastes, bare of plant life. In summer, lowlands in the south appear as a monotonous grey-green carpet sprinkled with bright green or yellow patches. In winter most lower areas are snow-covered, while some higher portions are blown bare of snow. Practically all of Iceland above 2,000 feet is a desert-like waste-land. Naturally favorable areas for airfield development are: the Midnes Peninsula, some 20 miles west-southwest of Reykjavik, the Melrakkasljetta Peninsula, 66° 20' N., 16° 20' W., and the Eyja Fiord, near Akureyri. The Reykjavik area is the most important; it contains the main port and largest city. Roads are adequate only in this vicinity. There are no railroads. Freight transport to any coastal area is easiest by sea.

(3) Summary. Because of its size, its suitability for air or naval bases, and its position dominating the northern air and sea routes from Europe to North America, Iceland is vitally important to the United States. Unfavorable terrain features include: barren interior plateau, steep, dangerous or surf-beaten coasts, numerous stream barriers, storms, fog, snow, ice, winter darkness, frost and dust. Military operations here require

careful preparation and vigorous execution, because of physical conditions. As on Spitsbergen, several natural limitations will affect operations: (a) Navigation on all coasts is practicable without the aid of ice breakers only from August to December. South and west coasts are generally ice-free. (b) Iceland is largely dependent upon outside sources for supplies and equipment. (c) Winter living conditions are rigorous, but not so harsh as on Spitsbergen.

D. Greenland.

(1) General. The largest island in the world, Greenland, lies across the northeastern approaches to North America, occupying a wedge-shaped area, 1,650 miles north-south and 790 miles east-west. It is about the size of Mexico. Distances in nautical miles from Julianehaab, southwest Greenland, to other points are:

Reykjavik, Iceland	--	800 miles
Glasgow, Scotland	--	1600 miles
St. Johns, Newfoundland	--	1000 miles

Shortest distances, nautical miles, from Greenland to nearby points are:

Reykjavik, Iceland	--	165 miles
Tromso, Norway	--	760 miles
Longyearby, Spitsbergen	--	390 miles
Jan Mayen Island	--	250 miles

Like Iceland, the name Greenland is misleading, because about 85 per cent of its surface is snow or ice. In spite of harsh living and travelling conditions, Greenland is important for its existing and potential naval, air and weather bases, and for its cryolite mine at Ivigtut.

(2) Specific. Coastal areas are deeply fjorded, and consist of rocky, rugged, glacier-scoured hills and mountains 1,000 to 5,000 feet and more in height. However, Peary Land, in the northeast, is a rolling, sharp-edged plateau. The ice-cap surface varies from flat to rugged, in places is blanketed with snow, while elsewhere it is wind-blown ice. The edges of the ice cap are steep, very rugged, and consitute the most effective terrain barrier on the island. Vegetation is sparse and consists of low shrubs and mosses. Floods occur near the coast in summer. Fog, ice and storms are constant hazards near the coast. Wind and blowing snow, dazzling summer sun-light, and low temperature, particularly in winter, are frequent dangers on the ice-cap. Settlement is mostly limited to the southwest coast. Many fjords, such as Scoresby Sound on the east (open 2 months) and Sondre Stromfiord on the west (open 9 months), provide anchorages and suitable areas for landings. The southern coast is accessible to ocean shipping from June to October. Areas suitable for air landings are found at the heads of some fiords. Military air fields were built on at least four of these sites during the war; near the head of Sondre Stromfiord (Bluie West 8); about 50 miles southeast of Godthaab (Teague); about 40 miles northeast of Julianehaab (Bluie West 1), and about 35 miles northeast of Angmagssalik (Bluie East 2, Ikateq). Small planes have landed on the shores of Mygbukta (Mackenzie Bay). Air landings have also been made on the ice-cap.

(3) Summary. The importance of Greenland lies in its possibilities for naval anchorages or air bases and for military air bases near the coast or on the ice-cap. It could also provide sites for radio or weather stations. The same natural limitations affect the use and development of Greenland as have been noted in the paragraphs on Spitsbergen and Iceland. Rough topography, poor flying conditions, variable periods of ice-bound coast, dependence upon outside sources for supplies and equipment, and harsh living conditions are factors limiting the extent of operations here. Weather here moves from west to east; thus possession of westernmost lands (North America) and islands (Greenland, Iceland) has an advantage over those lying to the east in determining weather conditions in the Arctic area.

E. Azores Islands (Portuguese, Acores).

(1) General. The Azores are an archipelago of nine principal islands and several islets lying in the eastern North Atlantic between 36° 40' and 40° N. latitude and 24° and 32° W. longitude. They extend in a NW-SE direction over about 410 miles of ocean. In size, they range from San Miguel, 288 square miles to Corvo, with but 7. Flores and Corvo form the northwestern group; Graciosa, Terceira, San Jorge, Fayal and Pico comprise the central group; while San Miguel and Santa Maria make up the southeastern group. Their importance lies in their location close to the southern sea and air routes across the Atlantic, and their consequent value for naval or air bases. Distances to various Atlantic points are given below:

Plymouth, England	1,268 miles
Gibraltar	1,103 miles
Dakar, Fr. W. Afr.	1,559 miles
Natal, Brazil	2,670 miles
Guantanamo, Cuba	2,673 miles
Bermuda	1,808 miles
New York	2,070 miles
Botwood, Nfld.	1,309 miles
Cape Farewell, Grnland	1,530 miles
Reykjavik, Iceland	1,610 miles

The Azores are also a cable station and a radio and weather reporting center. Whoever controls these islands is astride many trans-Atlantic shipping routes between the United States and Southern Europe, has at least partial command of trans-Atlantic communications, and can partly forecast European weather conditions.

(2) Specific. In appearance, the various islands are generally similar, being conical, mountainous, rugged and precipitous. With highest elevations of 2,460 to 7,612 feet, all may be sighted from considerable distances (Mt. Pico on Pico Id. from 75 miles). Coasts are mostly high, precipitous and rocky. Except for the three main ports of Ponta Delgada, Horta and Angra de Heroismo, ports and landing places are small and few in

number. The terrain is generally very irregular. Volcanic craters are numerous; hill and mountain slopes are generally steep; lowlands and valleys are stony or rocky. Climate, vegetation and cultivation of the coastal areas are similar to those of Hawaii; while in the more elevated parts they resemble those of southern and Mexican California. Summits are often bare or have scrub; upper slopes are forested; while lower areas are largely cultivated to fruit, grain or grapes. Terraces and stone walls abound tending to break the area into small compartments. Near the towns, walls may be 12 to 16 feet high; elsewhere, they are usually about 6 feet high. Peculiar features of the landscape are the volcanic craters or caldeira, whose bottoms are sometimes occupied by lakes. Weather conditions will not ordinarily hamper cross-country movement on the islands, but storms at sea particularly in winter, may interfere with amphibious operations. The most important strategic places are: the harbor of Ponta Delgada and the Santa Anna airport, on San Miguel Island; Horta harbor and cable center on Fayal Island, and Angra de Heroismo harbor and Lagens and Achada airfields on Terceira Island. In addition, Santa Maria airfield is on the western part of the island of that name.

(3) Summary. Their location on the southern trans-Atlantic routes provides the Azores with more than ordinary importance. They are useful for naval and air bases, cable, radio and weather stations. Chief natural limitations are occasional storms at sea, rugged terrain, restricted areas suitable for development of air facilities, and limited anchorages or beaches suitable for landings.

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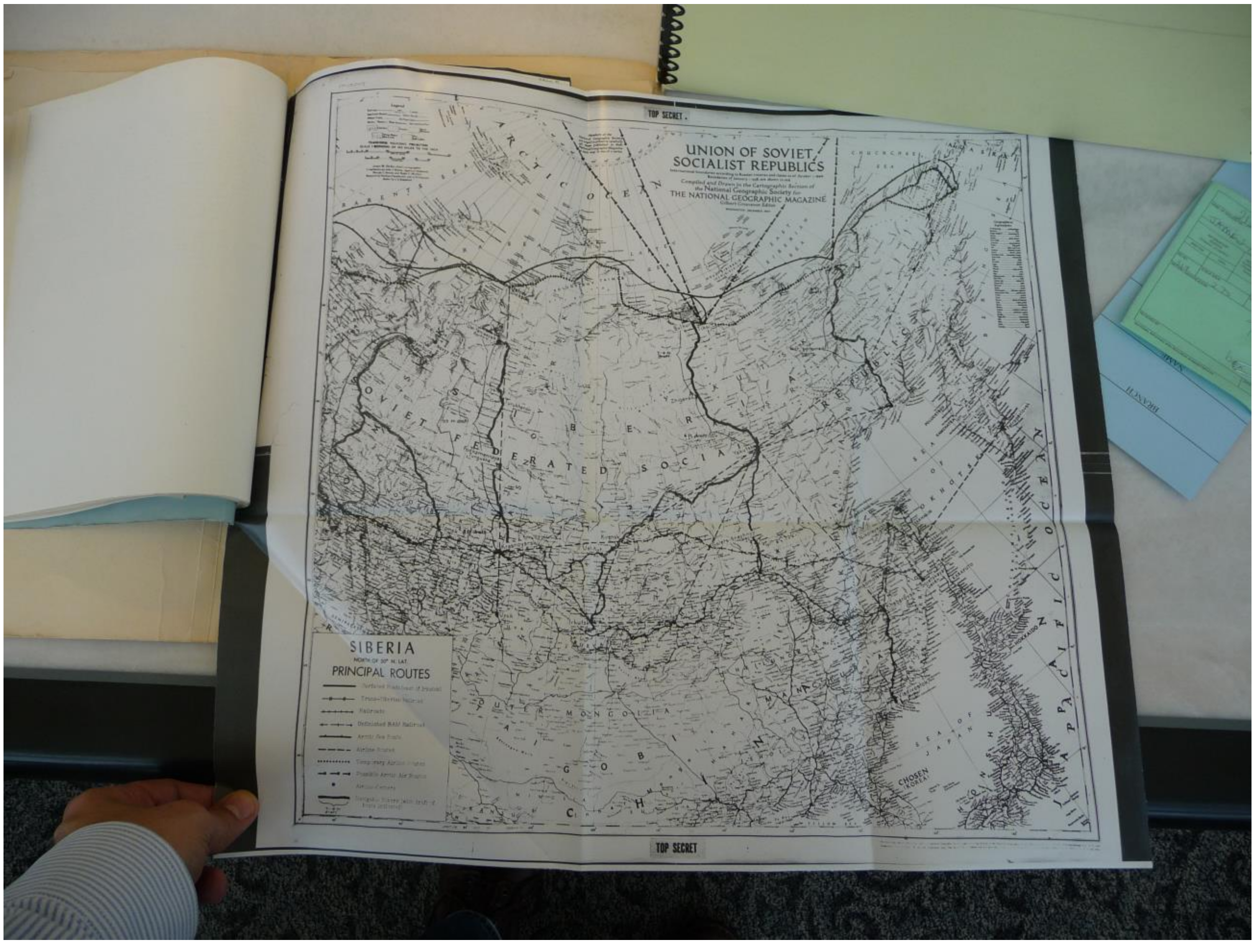
TOP SECRET
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Compiled and Drawn in the Cartographic Section of the National Geographic Society for
THE NATIONAL GEOGRAPHIC MAGAZINE
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SIBERIA
PRINCIPAL ROUTES
OUTER MONGOLIA
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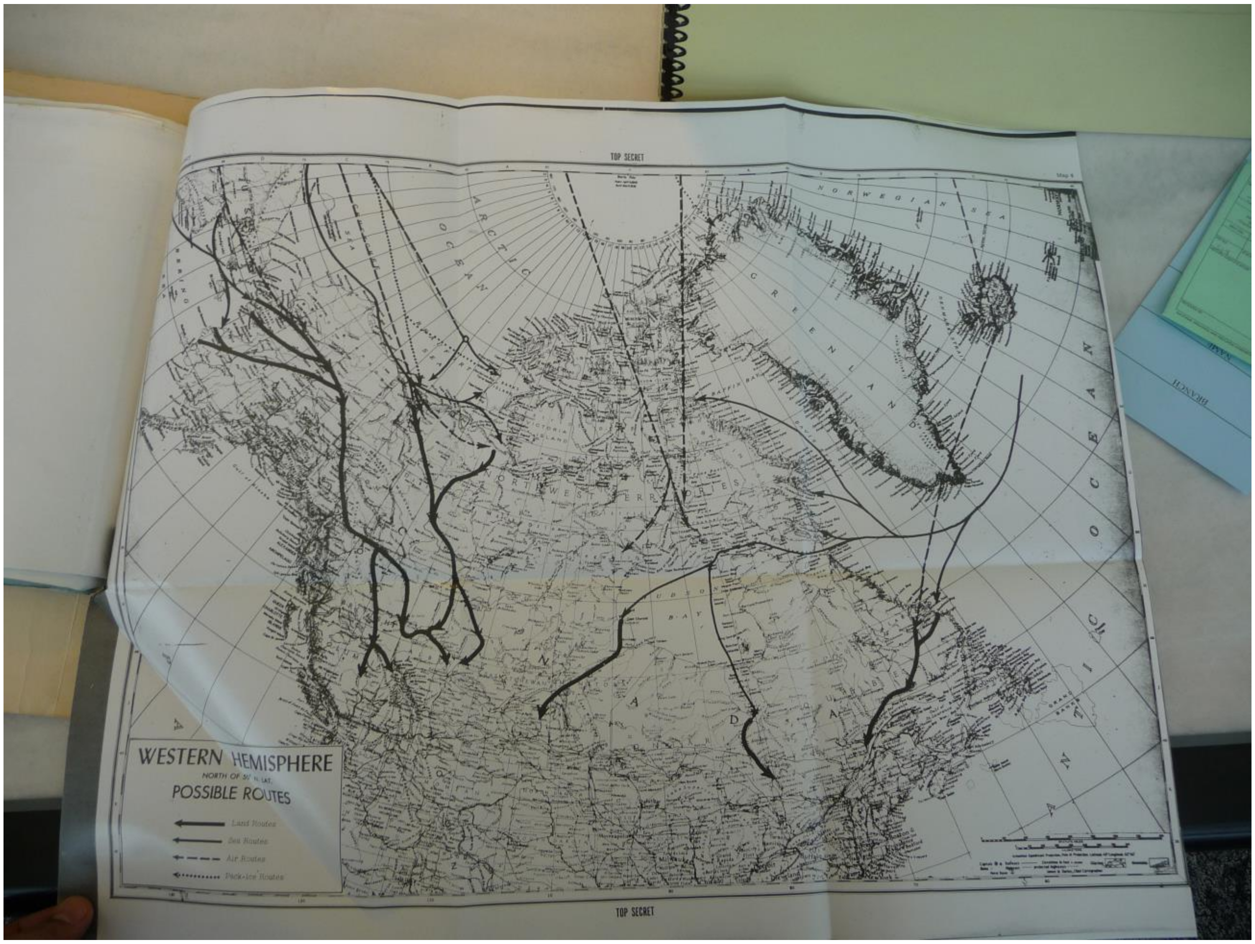
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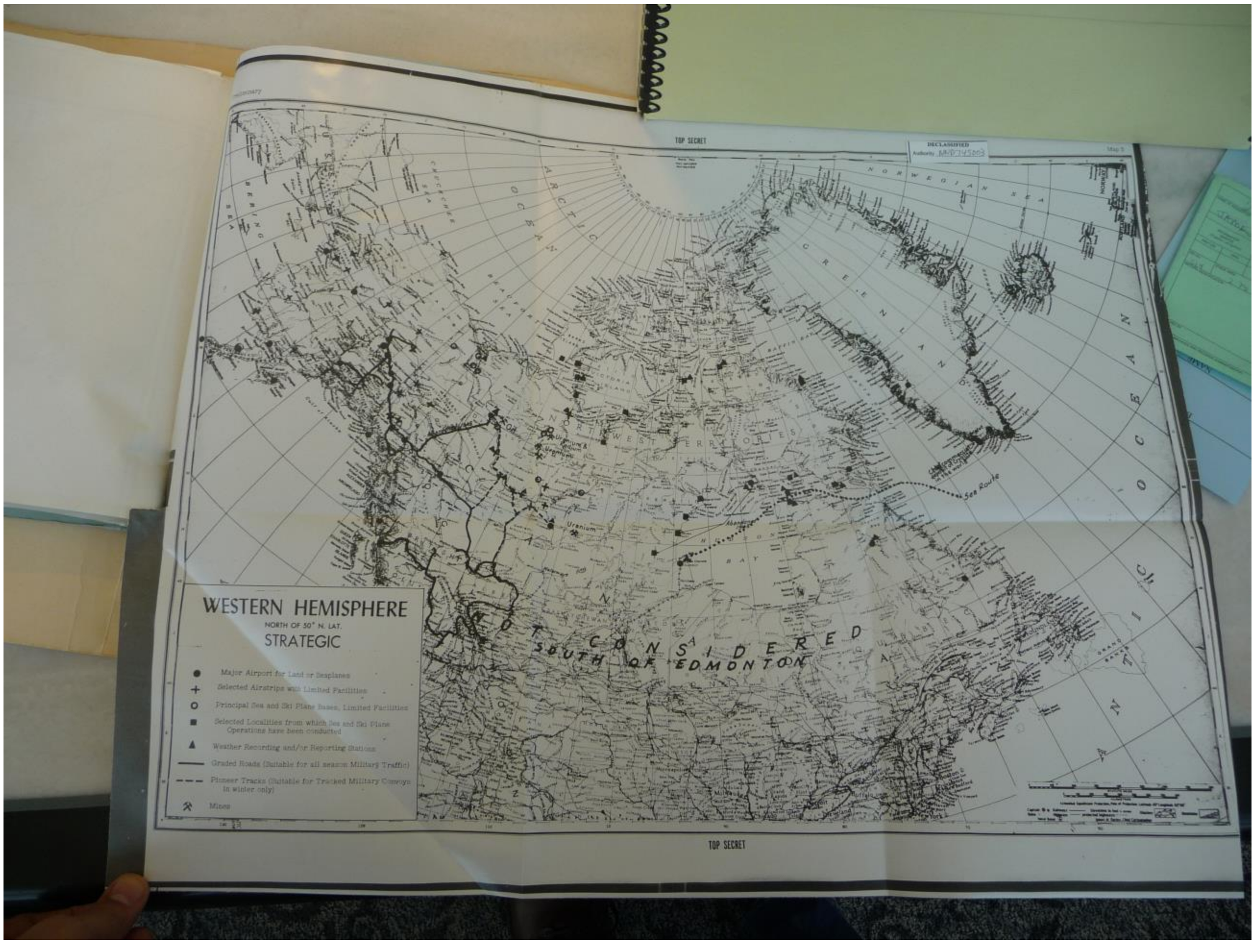
ARCTIC OCEAN
NORWEGIAN SEA
GREENLAND
NORTHWEST TERRITORIES
HUDSON BAY
CANADA
ATLANTIC OCEAN
WESTERN HEMISPHERE
NORTH OF 50° N. LAT.
POSSIBLE ROUTES
Land Routes
Sea Routes
Air Routes
Pack-ice Routes
TOP SECRET


TOP SECRET
DECLASSIFIED
ARCTIC
OCEAN
NORWEGIAN SEA
GREENLAND
Sea Route
NORTHWEST TERRITORIES
BAY
NOT CONSIDERED
SOUTH OF EDMONTON
WESTERN HEMISPHERE
NORTH OF 50° N. LAT.
STRATEGIC
Major Airport for Land or Seaplanes
Selected Airstrips with Limited Facilities
Principal Sea and Ski Plane Bases, Limited Facilities
Selected Localities from which Sea and Ski Plane Operations have been conducted
Weather Recording and/or Reporting Stations
Graded Roads (Suitable for all season Military Traffic)
Pioneer Tracks (Suitable for Tracked Military Convoys in winter only)
Mines
TOP SECRET

CITATION

Project /1

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13 Jan. 47 /3

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Project /1

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13 Jan. 47 /3

(Possibilities of Trans-Arctic Attack on the U.S.)
(416)

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Project # 3506