network of control elevations by improved radar altimetry. We can then make full and effective use of modern photogrammetric and electronic methods and aerial transportation to provide maps for the defense and development of Alaska. I agree with Mr. Waugh that new methods and techniques now being studied or perfected may very greatly expedite our mapping of the Arctic. Here, perhaps, is a field where photogrammetry can make one of its most spectacular contributions to modern mapping at greatly reduced cost.

U. S. Mapping in the Arctic and Sub-Arctic Regions of the Western Hemisphere

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Because of the short time available, this discussion will be limited to the "Why," rather than the "How," of Military Mapping in the Arctic.

The graphic story of mapping in the arctic and sub-arctic areas of the world, and specifically in the Western Hemisphere, parallels closely the search for economic resources, and the establishment and operation of military defense facilities therein. Accomplishment of such mapping, generally, has been extremely difficult, time-consuming, and beset with many dangers. These conditions have been due to many factors, such as the lack of communications facilities, the limited season for surveying and flying activities, the complexities of logistical support, the adverse weather conditions, and the rugged terrain. In addition to these reasons, the unique and characteristic requirements of the civil and military, and the lack of funds, have also affected the attainment of optimum mapping coverage of the arctic areas.

Historically speaking, active participation of U. S. military forces in arctic and sub-arctic mapping began with the efforts expended in Alaska soon after its purchase from Russia. Later, during World War II, a more intensified program was undertaken, both in Alaska and in Greenland. In spite of these efforts and those of others, the results from the standpoint of military adequacy were far from satisfactory. The situation could be summarized as follows: map coverage available for military use was, in many cases, of irregular and widely separated areas; field surveys, in many instances, were local and isolated in nature; and topographic maps did not generally meet standard accuracies nor were they adjusted to a common datum.

In 1947, the General Staff of the Department of the Army, confronted with new military requirements and recognizing the deficiencies in the military mapping of the northern outposts of this hemisphere, initiated the preparation of a consolidated map plan to meet military needs, and took steps to implement it. In the preparation of the plan consideration was given to many factors, the more important of which will be discussed at this time.

One of the most important concepts pertaining to the strategic defense of the Western Hemisphere is the necessity for the direct physical control of the large masses of land lying on the northern extremities of that hemisphere. Relative to these same masses of land are certain other important factors as well; namely, their size, shape, relative location and geographical characteristics. Considered from the standpoint of the defenders of the Western Hemisphere, such areas become important as listening and early warning posts; as bases for air defensive measures; as weather observing outposts; as bases for ground troops protecting existing military facilities; as natural barriers to mass-movement of opposing forces; and, finally, as possible sources to fulfill the subsistence, shelter and survival needs of the military forces operating therein. When considered from the standpoint of a country contemplating offensive action against the Western Hemisphere, such land masses offer strategic obstacles to both the overland and the overhead movement of military forces toward the U. S.; in addition these land masses afford sites from which ground and air operations could be launched against such an attacking nation.

Alaska may aptly be considered just such an area as described. From the U. S. standpoint, it has natural barriers to land inva-

sion such as extensive mountain ranges, tundra, river basins and glaciers; it has winter ice-bound shorelines on its northern approaches; and has suitable sites for potential defensive air bases. From the standpoint of foreign nations interested in employing long-range bomber planes as offensive threats to this country, by way of the polar routes, Alaska serves as an adequate interceptor barrier. This new threat of the long-range bomber (a threat which was not present in World War II) has resulted in marked expenditure of military efforts by the United States in this northern outpost. Such efforts are bound, in turn, to have a profound effect on the economic growth and development of that portion of the world. Planners for the future, therefore, must take into consideration these potential economic changes—and they must determine where these changes will take place and to what extent.

Let us consider the situation in Alaska from this latter aspect: its economic development invariably has been tied closely to its lines of communication. In the early days its development was associated with inter-island, coastal and river traffic; later with its road and railroad lines; and still later with its air transport centers. Wherever the function of transportation was coupled with a multiplicity of other functions—such as mining, lumbering, administration, fishing, fur trapping, agriculture, or military defense—development along more permanent lines has resulted. This has been especially true in the main military defense and air transport centers of Fairbanks, Anchorage, Kodiak and Nome.

Military mapping requirements must of necessity, therefore, center around these main waterway, railway and highway lines of communication; around the weather station sites, as well as around the ports and strategic coastal and island areas. In all such cases, large scale maps are required, either 1:25,000 or 1:50,000, with suitable contour intervals and accuracies commensurate with artillery fire needs.

In other parts of Alaska, outside the areas just mentioned, only generalized information, at a relatively smaller scale (such as 1:250,000), may be all that is necessary. In such other regions, information as to whether they are completely covered by mountains, broad swamps, glaciers, permafrost, dense forests, broad streams, or by large stretches of tundra is important not only in formulating the hemisphere plans of defense but in determining the capabilities of enemy forces as well. Such information may well determine the following: (1) whether enemy forces could construct air bases and lines of communication; (2) whether they could use a particular area for mounting military operations, and in so doing, whether they would need to resort to amphibious, mountain, forest, armored or infantry tactics; (3) whether their operations could be carried out successfully only in winter, or only in summer, or in some other limited time period of the year; (4) whether they could use some areas, such as those containing extensive mountain ranges or forest belts, for flank protection, without the expenditure of additional troops for maintaining such protection; (5) and whether their operations would be handicapped in any way by the presence of such factors as dense fogs, extreme winds and temperatures, or by the presence of extreme hours of daylight or darkness (as occurs above the Arctic Circle).

Elements of information, such as those illustrated, determine whether military use will be made by opposing forces of the particular region in question. A determination of the military uses, in turn, will determine the ranges of map scales required; contour intervals to be used; and also the additional intelligence data to be included (such as names, aids to navigation, land-mark features, etc.)

Although stress has been given in this paper to the military requirements for mapping, it must be pointed out that they often overlap civilian mapping requirements, but not necessarily in the same priority, or for the same reasons. For instance, map information pertaining to the location of forest cover may be of prime value to the civilian for economic development and processing; to the military, it may be of value for determining the possibility of concealment of personnel and equipment, for determining its use as an obstacle to cross-country movement, or its use as a supply of fuel or construction material.

Where both military and civilian mapping requirements exist, cooperative efforts have been expended, commensurate with the availability of funds and facilities. Since the start of the Korean hostilities the

need for urgency has been all the more apparent. Consequently, the coordinated mapping program has been greatly accelerated. To intensify these combined mapping efforts, new short-cut techniques have been incorporated; military units such as the 30th Engineer Base Topographic Battalion have been deployed to the northern areas; and utilization has been made of helicopter and light plane units, as well as of naval landing craft units, to insure adequate logistic support.

The problems thus encountered in the mapping of the Arctic and Sub-Arctic have not been simple ones—there are difficult problems even when mapping is being done in the Temperate Zones of the world—but these problems are being met. Needless to say, the Department of the Army will continue to pursue energetically its mapping efforts in the Arctic, and will continue to be alert to new techniques applicable to the efficient accomplishment of such mapping.

Questions and Answers

MODERATOR BOYER: Mr. Smith of the hydrographic survey of Canada is asked to give the percentage of the Canadian Arctic waters covered by modern hydrographic surveys.

MR. SMITH: Except for Hudson Strait and the Hudson Bay Route in general, very little modern charting has been accomplished in the Arctic islands. There are a number of useful charts, but they are not the standard charts such as we are used to in the more southern latitudes. We call them provisional charts, and they contain a great deal of useful information.

MODERATOR BOYER: Here is a question directed to Col. FitzGerald. "What do you consider the outstanding development of recent years for expediting mapping in the Arctic?"

COL. FITZGERALD: I think it is unquestionably trimetrogon reconnaissance mapping because it provided us with a means of rapidly covering vast areas with a limited amount of control. It is still being used both in Arctic Alaska and in the Canadian Arctic to cover many remote areas. There are many other pending, partly developed techniques that are perhaps as important or more important, but at the present time trimetrogon has made the largest contribution.

MODERATOR BOYER: I request Lieutenant Colonel Gremmler to explain why there is a need for special selection of personnel involved in mapping programs.

COLONEL GREMMLER: To me the selection of personnel is most important because they are the key to all your systems, to all your equipment and everything else. You can have outstanding equipment, outstanding procedures, and programs, but if the personnel are not properly selected for the particular mission, in this case aerial photography, then your whole program can collapse very easily. There are a lot of personnel that are interested in the programs for reasons other than the actual accomplishment of the end result. However, it is most desirable to get the personnel who are interested in accomplishing the end result, the maps.

MODERATOR BOYER: Another question could be answered by Mr. Ney. "What methods of transportation were used to reach the control stations already established in the Arctic?"

MR. NEY: North of the tree line, most of the stations were established during the summer months using pontoon-equipped airplanes for transportation. In other cases, steamboats, auxiliary schooners, and heavy freight canoes were used. In more southerly latitudes, tractor train and pack trains have been afforded.

MODERATOR BOYER: Colonel Gremmler is asked why such interest was shown during the recent survey of one of his major commands, in joining the mapping organizations.

COLONEL GREMMLER: I believe there were a number of reasons. Some no doubt had a direct interest in the programs because of their past experience and background. At the same time, many probably desired to join an organization which appeared to travel considerably. As I mentioned before, our objective is the selection of the individuals who have the greatest back-

ground and interest in the success of the program.

MODERATOR BOYER: Dr. Nicholson can answer two questions since the paper we have just heard gives a full account of exploration in Canada. "What was the role of explorers in Alaska? Were the motives for exploration there the same as in the rest of Arctic North America?"

DR. NICHOLSON: In general, I think it can be said that the motives were the same. There were some minor differences, however. In the paper of Colonel FitzGerald it was brought out that the search for Franklin was also carried on from the west to the east. Also the search for the Northwest Passage was carried on from the Pacific side working toward the Atlantic. That was one reason why Cook got so far north and did so much work in Alaska. There was a Spanish explorer who was really searching for the Northwest Passage from the Pacific side. Then, too, there is a parallel between the role of the Hudson's Bay Company in Canada and the Russian-American Fur Trading Company in Alaska before its purchase by the the United States. It was mostly the fur traders who went inland, just as the Hudson's Bay employees went inland, as I mentioned earlier. The main difference is that the trading company in Canada was established very much earlier than the Russian trading company, and the Russian trading company's activities were, I believe, preceded by activities on the part of the Russian Government and many of the Russian Naval officers did some exploring purely to find the economic possibilities in the area.

MODERATOR BOYER: A short question relates to something very vital to everyone. "What about drinking water? Is it a problem in the Arctic?"

COMMANDER PATON: Drinking water for large bases probably presents no problem at all. Generally the base is located near a lake which is too deep to freeze solid, and a hole through the ice is kept open and water is transported to the camp. However, the small survey groups that are moving along the coast and camping on low sandy islands, do have quite a problem. They probably will have to dig ice out of a frozen fresh water lake for their fresh water supply in the spring. In the summertime it will be a question of going back in the interior and hauling water from a fresh water lake. That is almost an impossibility. To get around it, the best solution is to have ice cut in the fall from interior fresh water lakes and haul it to the camp site at the beach for using during the summer. A temporary storage ice house can preserve the ice well enough so that the ice will last through the summer.

COLONEL FITZGERALD: On the coast we used ice from the polar pack; the ice on the top of the melted ice floes was good fresh water. The polar pack wasn't always inshore, but in 1924 to 1925 it provided us with most of our fresh water on the Arctic coast.

MODERATOR BOYER: Wing Commander Ross is asked what provision was made to store film at the operating temperatures being used.

COMMANDER ROSS: The storage facilities in the aircraft were all magazines, with special heating arrangements. The normal heating in the aircraft turned out about 60,000 BTU's in the fusilage section. To supplement this, we put in a special heater that turned out 100,000 BTU's so we have about a total of 150,000 BTU's blowing back into the camera section and also into the film storage section.

MODERATOR BOYER: A question for the Surveyor General of Canada, Mr. Waugh, is "what large-scale mapping has been completed in the Canadian Arctic?"

MR. WAUGH: I haven't a complete list of all the completed large-scale mapping with me. On the 1:50,000 scale, 18 segments are of strategic importance with the position determined by the astronomic fixes. The oblique methods of 1930 account for 62,000 square miles for the Canadian map. I believe 55,000 square miles were patroled horizontally by electronic measurements.

MODERATOR BOYER: Commander Thomas is asked the functions of Arctic weather teams.

COMMANDER THOMAS: The Arctic weather team is organized to assemble and coordinate the weather information produced from the Canadian Arctic and also

information fed in from the Alaskan field. With that information they are making forecasts for many agencies in the Arctic which need more exact weather information than the routine forecaster can provide.

MODERATOR BOYER: On behalf of the members of the panel, I thank you very much for the attention paid to the delivery of the papers and for the questions that have been asked. The size of the audience, the attention given and the interest evidenced makes me hope that the panel members have fully accomplished what they desired to do.

PRESIDENT WHITMORE: We are greatly indebted to Mr. Boyer and the international authorities here for their contributions. As far as I know, this is the most complete symposium ever held on this particular subject. It will make a very interesting volume for PHOTOGRAMMETRIC ENGINEERING. We will have to provide an unusually large number of overrun copies for extra sale.