DR. ARTHUR J. BRANDENBERGER*
Laval University
Quebec, Canada

Economic Impact of World-Wide Mapping

Photo surveying and mapping can provide the preliminary cartographic exploration needed to alleviate world-wide under-nourishment.

(*Abstract on next page*)

GENERAL CONSIDERATIONS

ONE OF THE MAIN reasons for the existing political instability in many countries is the difference in standards of living. This difference is the result of an uneven distribution of wealth or is due to historical, political or religious conditions; the climatic environment also plays a role. To improve the situation, economic and technical assistance programs have been established. The goal of these programs is to achieve a sounder balance of the varying standards of living all over the world with the purpose of creating more stable economic, social and political conditions.

Undoubtedly this problem is one of great concern due to the fact that today more than half of the world's population is already under-nourished. Moreover, it should be taken into consideration that the growth of the population all over the world follows a geometric progression. The present day's three billions of people living on the earth will multiply up to six billions in the year 2000. This growth of population has to be considered in connection with the fact that in the middle of the last century, only one third of the world's population was living in urban areas while in ten years from now, this ratio will have raised up to three-quarters in many countries.

To cope with the problem of under-nutrition which mainly exists in developing countries, it will be necessary to increase heavily the production of food by means of large scale argricultural engineering projects such as agrarian reforms, land improvement, irrigation, drainage, etc. In the *first phase* of their realization, such urgent projects call for an appropriate cartographic preparation. At this stage, aerial photography will play a predominant role as a basis for a preliminary exploration and as support for cartographic compilations. Extensive argricultural projects require funds often exceeding the financial capacity of a nation and possibly even that of the world's finances in case of projects of continental size. This is where the well known problem of lack of capital arises. To solve it, there is usually only one means, namely, the rapid exploitation of the existing natural resources and conversion of these resources into mobile capital. It is evident that this is a formidable task. This task necessarily comprehends, as its first phase, the establishment of an inventory of the existing natural resources. Essential operations of this phase

DR. ARTHUR J. BRANDENBERGER

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are a preliminary photo interpretation of the aerial photography made available and cartographic compilations by aerial photogrammetry.

As already mentioned, many countries do not have available the necessary means to improve efficiently their agriculture nor to exploit and develop adequately their natural resources. On an international level, an attempt is made to solve this problem, at least partially, by multi or bilateral economic and technical assistance from international organizations and highly developed countries.

In dealing with such projects as far as the cartographic phase is concerned, the following questions will necessarily arise:

· What is the actual status of the cartographic exploration in various countries? This question refers to the actual coverage and present condition of geodetic triangulations, aerial photographic coverage, percentage of mapping compiled at different scales and other pertinent information in various countries and on a world-wide level.

· Can the annual progress accomplished at the present time in these fields be considered as sufficient and satisfactory for an efficient technical and economic development of the areas in question?

· What percentage of the national revenue and of the public expenditure is presently spent for cartographic exploration and cartography in general? It is indispensable to know this percentage, particularly for the countries that have recently achieved independence and are facing for the first time the problem of preparing a national budget including an appropriation for the cartographic exploration.

· Are the actual yearly expenditures for cartographic exploration adequate for an efficient technical and economic development of the country or area in question?

· If the yearly achievement in cartographic exploration for a given country is considered as insufficient, what has to be done to improve the situation?

The wording *cartographic exploration* has been frequently used in this paper. This term shall be understood in a very broad sense and is meant to include: geodetic triangulation and trilateration, determination of ground control, aerial and terrestrial photography, photointerpretation, compilation of all possible kinds of maps by photogrammetric methods, cadastral surveying, compilation of special maps like photo-geological or geophysical maps, maps and plans for civil engineering and map reproduction. Any strictly military mapping is however excluded from the following discussion because the related documents might be classified and consequently have a rather limited value for the economic and technical development of a country.

Since about two years ago, the Department of Photogrammetry, Laval University, has been concerned with a research program dealing with some of the above listed questions in particular, and with the economical aspects of surveying and mapping, i.e., cartographic exploration in general. This program was initiated by the Cartographic Section of the Organization of the United Nations and is now sponsored by the National Research Council of Canada. The program includes the collection of data on a world-wide level such as geodetic networks, photographic and cartographic coverage, annual progress, number of personnel involved in these operations, percentages of the national revenue and national expenditures spent annually for the cartographic exploration, as well as the dollar values per capita and per square kilometer. Up to date, the values are complete for more than 60 countries. The major scope of this research program is to find out where we stand with our profession and our products in the framework of national and international economy.

ABSTRACT: *An analysis shows that the actual world-wide progress in surveying and mapping is not sufficient to cope with some of the world's major problems such as under-nourishment of large portions of the population and population explosion. It will be necessary to spend in the future a higher percentage of the national revenue and of the public expenditures for these operations to diminish the delays in the exploitation of the natural resources and the development of the agricultural potential. The performance of economics research and efficient planning will become imperative in the immediate future.*

ACTUAL STATUS OF WORLD-WIDE CARTOGRAPHIC EXPLORATION

Since *geodetic networks* provide valuable control for the cartographic compilation, it is of interest to assess the geodetic coverage all over the world. Such an inventory shows that presently about half of the land area of the

earth is covered by principal arcs of triangulation and by Shoran and Hiran nets. The gaps between the triangulation arcs or the Shoran and Hiran stations measure approximately between 100 and 1,500 kilometers. In many countries, these gaps are filled in with first-order geodetic triangulation and trilateration, and with first order levelling as well as trigonometric heights. It will however take many more years to cover the land area of the earth with a homogeneous network of first-order horizontal and vertical control of a sufficient density, i.e., with an average distance of 50 to 100 km. between adjacent points. The situation becomes even more problematic when this requirement is extended over the water areas of our planet.

For most development purposes, medium scale maps at scales 1:250,000 to 1:50,000 are essential. The compilation of such maps requires a network of control of a density much higher than provided by first-order horizontal and vertical control networks. This means that lower-order horizontal and vertical geodetic control should be available. An inventory of the existing networks all over the world reveals that much less than half of the land area of the earth is covered by geodetic networks sufficiently dense to permit the compilation of medium-scale maps.

In urban areas, large-scale maps at scales 1:25,000, 1:10,000, 1:5,000 and larger are required. To compile maps at these scales, particularly at scales larger than 1:5,000, one control point per square kilometer is desirable. Such a density of geodetic control exists for only about one percent of the land area of the world.

As a result of this brief analysis, one can conclude that in the future, the extension of geodetic control networks must progress at such a rate that the cartographic compilation at different scales, and consequently the technical and economic development of most countries will not be handicapped. A more intensified use of the latest methods for the extension of geodetic control, such as electronic distance measurement and aerial triangulation, seems to be at least a partial answer to this problem.

With reference to the *cartographic compilation* on a world-wide level, the greatest progress has been made in small-scale mapping, such as The International World Map at the scale 1:1,000,000. This project is coordinated by the United Nations (Cartographic Section) and is almost complete. Maps at this particular scale are already available and cover about 85 percent of the land area of the earth.

The percentage of mapping at larger scales actually completed all over the world (in recent years nearly entirely by photogrammetric procedures) is approximately as follows at the respective scales:

1:250,000 or larger—35 percent
1:100,000 sale range—15 to 20 percent
1: 25,000 or larger—not more than 5 percent, including cadastral plans.

For the exploration of natural resources, *topographic maps at scales larger than 1:100,000* are particularly valuable. According to the preceeding inventory, mapping completed at this scale covers only about 15 percent of the land area of the world. Assuming that this cartographic coverage could be completed within approximately 50 years, the annual average progress would be equal to only 0.3 percent of the land area of the world, or approximately 400,000 square kilometers per year. Fortunately, the annual progress during the last few years has considerably increased due to the development of more efficient methods. It is also necessary to take into consideration that large areas of the world are considered as having very limited economical potential for quite some time to come. Nevertheless, it must be concluded that at the present rate of yearly progress, the completion of an adequate map coverage for the entire land area of the world at scales larger than 1:100,000 might take another 100 to 150 years. Consideration of the correlation between topographic cartography and the solution of problems like under-nutrition in many areas of the world, and the population explosion, leads to the conclusion that the cartographic progress is still too slow and that there is an absolute necessity to increase considerably the efforts in this field; otherwise, it is very likely that the economic and technical development of many countries is or will be hampered by too slow an advance in cartographic operations.

An inventory of map coverage on a national as well as on an international level must necessarily include an evaluation of the present status of *map revision*. Such an analysis does not produce a very bright picture. There are relatively few countries in which map revision is up to date. In a much larger portion of the world, the existing maps are of reduced value because they were or they are not periodically revised. It is doubtless that in this field, i.e., in map revision, much greater efforts must be made in the future, particularly *in urban areas*. As already mentioned, the world's population will be doubled by the year 2000 and the urban

areas might eventually amount to more than 15 percent of the world's entire land area. With adequate efforts, we might be able to satisfy the mapping requirements in these areas, i.e., the map compilation at medium- and large-scales. But how about map revision in these areas? Planimetry and even topography in urban areas change so fast, and will even change faster in the future, that map revision becomes a real bottleneck and we might have to consider complete remapping in cycles which will become always shorter and shorter. If we extend this kind of projection over the next few centuries, we might find that then the world's population would have increased to such an amount that for each human being, there remains in average only a few square meters of living space. What will then happen with regard to mapping requirements, map specifications, map revision and remapping cycles? A real challenge exists for future surveyors, photogrammetrists and cartographers!

Cartographic Exploration in the Framework of National and International Economy

The expenditures for the cartographic exploration on a national level as well as on a world-wide basis must be to a certain extent proportioned to the national revenue and the yearly public expenditures. To be more explicit, it is necessary to determine first the amount spent for this purpose at the present time for various countries as well as for the entire world. The determination of these values is not an easy task due to the fact that a large amount of information must be collected. We have made an attempt to determine some approximative values based on the available information from more than 60 countries all over the world. The following approximative values were obtained for the year 1966:

- Total yearly expenditures for cartographic exploration in the entire world: approximately $1,350,000,000.
- or 0.08 percent (or approximately 1/1,000) of the National Revenue (1).
- 0.26 percent (or approximately $\frac{1}{4}$ of one percent) of the Public Expenditures (2).
- Or $10.30 (or approximately $10) per sq. km. (3).
- Or $0.41 (or approximately half a dollar) per inhabitant (4).

These average values could be used as a preliminary thumb rule to estimate the average yearly funds which might be spent at the present time in various countries for the cartographic exploration. When using formulas (1), (2), (3) and (4) successively for one given country, one must be aware that four different values will be obtained and it is up to the authorities involved to decide which one is the most adequate and relevant. Generally speaking, countries with very little cartographic coverage and eager to make an inventory of the natural resources as soon as possible would use formula (3), especially if the population density of the country in question is low. For a country with a high population density, formula (4) appears to be more adequate. The problem is rather complex and more statistical material must be collected and analyzed. This is presently done at the Department of Photogrammetry, Laval University, with the purpose of arriving at more differentiated and more accurate values for formulas (1) to (4).

Based on these values, it is intended to determine what are the annual losses in billions of dollars in the world's economy due to too slow an annual progress in cartographic exploration, and consequently by what rate the annual progress in cartographic exploration must be increased in the interest of an efficient economical and technical development throughout the world.

Conclusions and Recommendations

The following conclusion may be drawn from the previous sections: the undernourishment problem on a world-wide level and the population explosion necessitate an increase of efforts for the exploitation of natural resources and an acceleration of food production. Similar efforts should be made in the field of cartographic exploration because these operations supply the necessary basis for the planning and the initiation of projects of technical and economic development. This implies that in the national budgets, the appropriations for the cartographic exploration and the national cartography will have to be comparatively increased in most countries.

The cardinal problem is here to determine by what percentage these appropriations should be increased. This question can only be solved by performing extensive research. Such research must give answers to the question of what must be the appropriate annual output of cartographic exploration, i.e., of surveying and mapping in the interest of an efficient economical and technical development of the country in question. Furthermore, this research must give the answer to the question of what the losses are

in the national economy due to a cartographic exploration which is too slow. If this question can be answered, then the necessary bases are available to justify increased appropriations for cartographic operations.

There are other questions for which future research should provide appropriate answers. Such questions are, What is the present, and what should be the future ratio of appropriations between geodetic, photogrammetric, cartographic and land surveying operations? Or, what is the present, and what should be the future work distribution between governmental and commercial mapping agencies?

When the present arrears in cartographic exploration on a world-wide level is considered, it seems mandatory that the appropriations for these operations should be substantially increased. Such increased financial efforts are, however, only justifiable if the countries involved have or will make available immediately an adequate number of qualified specialists such as geodesists, photogrammetrists, cartographers and land surveyors. In many countries, their number is far below the requirements. To improve this situation, it will be necessary to determine in each country the required number of specialists that would allow an efficient cartographic exploration. The determination of this number (including the ratio between specialists with a university degree, technicians and auxiliaries) should be considered in many countries as one of the prime research tasks in the immediate future. Taking as a basis the results of such a study, it would then be possible to determine the number of specialists to be educated and trained each year in each country to satisfy the requirements for the cartographic exploration. In turn, such an investigation would permit the determination of the number of schools or departments of higher learning in this field required for the training of an adequate number of specialists.

As a final conclusion, it might be emphasized once more that in the near future intensive planning will be a necessity if the cartographic exploration is to fulfill its task in the framework of an efficient economic and technical development of many countries.

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