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World-Wide Mapping Survey

An analysis of photogrammetric surveying and mapping is considered essential for national and international planning.

(Abstract on next page)

GENERAL CONSIDERATIONS

WE ALL KNOW THAT today, and even more so in the future, we have to solve some crucial problems such as:

- Increase the agricultural output in developing countries whose population amounts to 70 percent of the world's population.
- Accelerate the exploration and exploitation of natural resources as a measure to increase national wealth and to reduce poverty.
- Cope with the staggering population concentration in urban areas.
- Solve the problem of securing sufficient water and power supply.
- Provide adequate facilities to have available an efficient transportation and communication system.
- Cope with the problem of air and water pollution.

The solution of these problems requires intensive planning on a national as well as on a international level. On an international level, because financial and technical assistance to developing countries is becoming more and more indispensable, to create more stable economical and social conditions on a world-wide basis. The organization of the United Nations requests that the industrial countries contribute one percent of their Gross National Product to such assistance programs (the present contribution falls short of this figure and amounts to only about one-half of one percent).

Here the question arises, where do we as surveyors and map makers fit into this world-wide development program, and what is our present role and what will be our future obligations. This applies also to the photogrammetrists. Already at the present time a large portion of the world's surveying and mapping tasks are solved by photogrammetry; this will be even more so in the future. For this reason, I believe it is justified to discuss these problems as a photogrammetrist.

The solution of the problems listed above requires, as already mentioned, extensive planning. Surveying and mapping in general, and photogrammetry in particular, have to provide the necessary bases for such planning. To satisfy this requirement, it will evidently be necessary to make an inventory of the surveying and mapping status and potential in various countries and on a world-wide basis. The Department of Photogrammetry at Laval University is presently involved in such a project which is sponsored by the National Research Council of Canada.

Some specific data are presented herein on the surveying and mapping activity for the four countries of the world with the greatest populations, namely the USA, the USSR, India and China (Mainland). The conbined population of these four countries at the present time amounts to about half of the world's population.

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THE USA

The USA, with a population of 197 millions and an area of 3.6 million square miles (sq. mi.) (including Alaska), is the country with the highest growth of urban population in the entire world. Presently, 3/4 of the American population live in urban areas resulting in an annual increase of urban land of 0.05 percent of the country's entire area. Only 9 percent of the population is involved in agriculture distributed over 3.2 million farms.

The *geodetic framework* of the country is well advanced. About 70 percent of the main triangulation network is completed (115,000 marked horizontal control points). For the main levelling network, the percentage is about 80 percent (400,000 marked vertical control points).

ABSTRACT: *The solution of some of the world's major problems in the future (such as population explosion, insufficient agricultural output in developing countries, the staggering population concentration in urban areas, water and power requirements, air and water pollution, etc.) requires an ever increasing planning activity on a national as well as on an international level. Surveying and mapping in general, and photogrammetry in particular, have to provide the necessary bases for such planning. To satisfy this requirement, we must necessarily make an inventory of the surveying and mapping status and potential in various countries and on a world-wide basis. The Department of Photogrammetry at Laval University is presently concerned with such a project. Some specific information is given on the surveying and mapping activity for the four countries of the world with the greatest populations, namely USA, USSR, India and China (Mainland).*

There is full *aerial photography* coverage, particularly at the scale 1:20,000, but also at smaller and larger scales.

As far as the *mapping status* is concerned, there is full map coverage at the scales 1:1,100,000, 1:500,000 and 1:250,000. There is partial map coverage at larger scales such as the topographic map at the scale 1:24,000 which covers about 40 percent of the country.

Federal, state and local governments occupied in the years 1966/68 a *surveying and mapping personnel* of about 16,000 with annual expenditures in the order of $300 millions US.

In 1966, the federal government had on its pay-roll the following personnel in the field of surveying and mapping (geodesy, photogrammetry, cartography, surveying and hydrography):

Professional scientific and technical personnel (at least half with a college degree): 3,400 (1.7 percent of the total)

Non professional scientific and technical personnel (technicians, etc.): 7,600 (7.1 percent of the total)

The average annual salary for the 150,000 scientists and engineers working for the federal government was $12,300 in 1966, whereas the average annual 1966 salary for scientists and engineers working in surveying and mapping was only $10,300, i.e. $2,000 less than the overall average. This is possibly due to the fact that quite a number of professionals in surveying and mapping attended fewer college years or have no complete college education when compared with other professions. It is interesting to note, however, that also on the technician level, surveying and mapping was nearly as much below the average annual salary ($6,400 compared with the overall average of $8,300). Only the professional scientific and technical personnel in agricultural sciences, forestry and micro-biology earned a lower average annual salary than the surveyors and map makers in the federal government. The other 40 groups of professional scientific and technical personnel in the federal government earned average salaries in 1966 in excess of those for the surveyors and map makers.

Much more difficult it is to evaluate the potential of *private surveying, photogrammetry and cartography offices and companies*. According to estimations of various people, between 60,000 to 80,000 persons are involved in the private sector. The overall annual turn-over of private surveying and mapping enterprises for the years 1966/68, after subtraction of direct contract work for government agencies, is estimated to be in the neighborhood of $400 millions.

Surveying and mapping is presently taught to various extents at about 400 higher *educa-*

tional institutions. At more than 40 universities, photogrammetry is covered by one or more special courses. The annual influx of professional surveyors (including professional engineer-surveyors and photogrammetrists) appears to be in the neighborhood of 1,200.

From the foregoing inventory, it follows that *the United States presently spends about $700 millions per year for surveying and mapping.* This amount represents 0.087 percent of the Gross National Product, (GNP), ($796 billions for 1967) or 0.31 percent of the total annual public expenditures (approximately $225 billions for 1967) or $3.60 per capita, or approximately $200 per sq. mi. The ratio of the number of professional surveyors to the number surveying technologists and surveying technicians is larger than 1, and one person is employed in surveying and mapping out of 2,700 inhabitants.

The amount of $700 million annual expenditures for surveying and mapping represents a minor figure in the national economy; nevertheless, it is higher in comparison with some other professions, for instance, geology (excluding mining) or geography.

As far as *photogrammetry* is concerned, the available information and material allows only a first guess. Evidently more than 10,000 full-time or part-time photogrammetrists of different levels are active in the United States. The annual expenditures for photogrammetric operations is estimated to be in excess of $100 millions.

THE USSR

The Soviet Union with a population of 234 millions (1966) has an area of 8.75 million sq. mi., which is about 1/6 of the entire land area of the earth. A strong trend toward urbanization exists. This is evident from the fact that the proportion of rural population has fallen from 82 percent in 1926 to 48 percent in 1964. In 1966, the percentage of population in agriculture was 36 percent distributed over 36,500 collective farms (average area: 50 sq. mi.) and 12,200 state farms (average area: 190 sq. mi.).

The USSR is covered by a fairly homogeneous *network* of main triangulation (system of chains with distances between the chains varying from about 150 miles to 700 miles). Large portions of the country are covered by second-order triangulation and, in some areas, third- and fourth-order triangulation also does exist. Vertical control (levelling of first order and of lower order) is of less density when compared with the USA.

Complete *air photo coverage* exists at scales between 1:35,000 and 1:70,000 (mostly Russar super-wide angle photography), and in urban areas photo coverage is at larger scales.

As far as *map coverage* is concerned, particularly the scale 1:100,000 should be mentioned: topographic mapping was completed in 1955. Map coverage at 1:50,00 scale has been completed in some areas, and maps at the scales 1:25,000 and 1:10,000 exist in urban areas.

Several reports are available on the *professional and educational status* of surveying and mapping in the Soviet Union. Of particular interest is a report prepared by the office of Mr. M.V.P. Yelgutin, Minister of Higher and Specialized Secondary Education.

From the available information, it can be concluded that the total surveying and mapping personnel in the USSR is approximately 100,000 (20,000 surveying engineers, 45,000 surveying technicians and 35,000 auxiliary personnel).

The average annual salaries are (year 1966): Survey engineer, (US) $2,900; Survey technician, $2,000; Auxiliary personnel, $1,600.

No *private enterprise* surveying and mapping activity exists in the USSR.

Surveying and mapping is taught as a special discipline at some large *institutions of higher education*, e.g. at the Moscow University (Moscow Institute of Geodesy, Photogrammetry and Cartography), at the Leningrad Mining Institute and at Novosibirsk Institute of Technology. Survey technicians are trained at specialized secondary educational institutions. In 1965/66, the total enrolment at both levels was:

Surveying students at college and university level 7,700 (0.19 percent of the total).
Surveying students at technician level: 7,300 (0.18 percent of the total).

For 1965, the number of graduates in surveying and mapping was: University level, 900 (0.22 percent of the total); Technician level, 1,100 (0.18 percent of the total).

In practice, presently a ratio of 1:2.3 exists between surveyors with a college degree and surveying technicians. It is planned to modify this ratio to 1:3 by 1970.

From the available information, it can be estimated that *the Soviet Union presently spends about US $280 millions per year for surveying and mapping.* This amount represents 0.106 percent of the GNP ($264 billions for 1966), or 0.16 percent of the total annual public expenditures ($175 billions for 1966), or $1.20 per capita, or approximately $36 per

sq. mi. Presently one person is employed in surveying and mapping out of 4,300 inhabitants.

As far as *photogrammetry* is concerned, one can assume that the photogrammetry potential of the Soviet Union personnel and expenditure wise amounts to about 10 to 20 percent of the national surveying and mapping potential.

INDIA

India, with a population of 520 millions (1967) and an area of 1.19 million sq.mi., is mainly an agrarian country with only 18 percent of the population living in urban areas. In spite of this situation, the country faces some serious problems in the existing urban areas. Cities are overcrowed and population densities are staggering. For instance, areas in the city of Calcutta have population densities up to 650,000 persons per sq.mi.

At least 40 percent of the country is covered by a fairly homogeneous *network* of main triangulation (system of chains with distances between the chains from about 150 miles to 400 miles). Prime vertical control is of a density somewhere between that of the USA and that of the USSR.

Air *photo coverage* is complete, mainly at the scales 1:30,000 or 1:60,000. Air photo coverage at the scale 1:10,000 is also in some urban areas.

Mapping of the country is done almost entirely by the Survey of India at the scales 1:50,000 (topo maps), 1:25,000 (topo maps) and at larger scales. Also maps exist at smaller scales which are however often of older date. Apparently the new 1:50,000-scale topo map has been compiled for about 10 to 20 percent of the entire area of the country.

From the available information, it can be estimated that the *personnel* properly concerned with surveying and mapping is somewhat in excess of 25,000.

The average annual salaries are (years 1966-68): Professional surveyor, (US) $700; Survey technician, $400; Auxiliary personnel, $300.

Private enterprise surveying and mapping activity is negligible and includes only about 50 persons.

Training in surveying and mapping is mainly done as *in house* training in the Survey of India. Also some universities offer surveying and mapping courses as part of the civil engineering program. Worthwhile mentioning is the Roorkee University with about 15 students majoring in photogrammetry.

Based on the available information, it can be estimated that *India presently spends slightly more than US $10 millions per year for surveying and mapping.* About 2/3 of the country's surveying and mapping personnel as well as of the expenditures are engaged by the Survey of India. The $10 millions represent 0.025 percent of the GNP (about $40 billion for the years 1966-68), or 0.11 percent of the total annual public expenditures (about $9 billion for the years 1966-68), or $0.019 per capita, or appriximately $8.50 per sq. mi. Presently one person is employed in surveying and mapping out of about 20,000 inhabitants.

With regard to the *photogrammetry* potential of India, only estimations can be made at this time: the number of photogrammetrists is somewhat in excess of 500 and that the annual expenditures for photogrammetric work exceeds $1 million.

CHINA (MAINLAND)

China's population exceeds by far the population of any other country of the world. With 760 million people distributed over an area of 4.49 million sq.mi., China's population amounts to nearly ¼ of the world's population. A major portion of the population, i.e. about 80 percent, depends on agriculture which is mainly concentrated in a relatively small area of 425,000 sq.mi., representing only 11 percent of the total area of the country.

According to GUCK, *the Central Administration of Geodesy and Cartography of the Chinese People's Republic,* it was planned to complete the first-order *triangulation* by 1961. Based on available information, it is impossible to verify whether this goal has been reached. However, it can be stated that a large portion of the country is covered by triangulation of various orders. Already before 1950, the office of the Minister of Interior, Tsao-Mo, (at that time) reported that the following numbers of points have been determined: First-order, 930; Second-order, 9,142; Third and Fourth-order, 62,357.

Comparable progress has been made as far as *vertical control* is concerned. Already before 1950, 30,000 km. of first-order and 56,000 km. of second-order levelling were completed.

Photo coverage exists for a major portion of the country (a considerable amount of the photography is Russar super-wide angle photography).

Again according to GUCK, topographic *mapping* at the scales 1:100,000 and 1:50,000 was supposed to be completed by 1967. Not enough

information is available to verify whether this goal has been reached. According to the program, mapping at scales 1:25,000 and larger in specific areas was supposed to start in 1967.

Based on available information, it can be estimated that the total *surveying and mapping personnel* in China is approximately 160,000 (20,000 surveying engineers, 60,000 surveying technicians and 80,000 auxiliary personnel).

The average annual salaries are (1966): Surveying engineers, (US) $2,000; Surveying technicians, $700; Auxiliary personnel, $550. No *private enterprise* surveying and mapping activity exists in China.

Surveying and mapping is taught at a limited number of the 400 *universities and colleges*, such as at the Tonching University in Wuhan. The number of annual graduates in surveying engineering is presently about 2,000.

In practice, a ratio of 1:3:4 exists between surveyors with a college degree, surveying technicians and auxiliary personnel.

From the above information, it can be estimated that *China presently spends about $150 million per year for surveying and mapping*. This amounts to 0.20 percent of the GNP (about $76 billions for 1966), or 0.37 percent of the total annual public expenditures (approximately $40 billions for 1966), or $0.20 per capita, or $33 per sq.mi. Presently one person is employed in surveying and mapping out of approximately 5,000 inhabitants.

Concerning *photogrammetry*, it is known that at least 20 survey airplanes, 20 first-order plotters and more than 200 Multiplex are in China. Furthermore, photogrammetric instruments of Chinese make are evidently manufacutred. Considering this situation, it must be assumed that several thousand photogrammetrists are employed in China and that possibly an amount in excess of 19 percent of the overall surveying and mapping costs is spent for photogrammetric work.

Conclusions

If the four countries (USA, USSR, India and China) representing about half of the world's population are combined, the following average values for the annual *expenditures* for surveying and mapping are obtained (years 1966–68):

0.097 percent of the GNP
0.25 percent of the total public expenditures
$0.67 per capita
$63 per sq. mi. or $25 per km.

The *personnel* involved in these operations is in the order of 410,000 including at least 40,000 photogrammetrists.

It is obvious that for the entire world, somewhat different values would result.

It is believed that analyses of the kind as presented in this paper are indispensable for planning purposes on a national as well as on an international level, and it seems evident that much more effort must be undertaken in the future in performing such analyses. The results will in many cases be surprising and will show quite large differences in the surveying potentials of various countries, as is evident already in analyzing the four countries considered in this paper.

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Numerous additional references.

Errata

Cartwright Aerial Surveys was inadvertently omitted from the list of Sustaining Members of the American Society of Photogrammetry in the June, July and August issues of PHOTOGRAMMETRIC ENGINEERING in 1969.