THE APPLICATION OF PHOTOGRAMMETRIC METHODS IN THE DEVELOPMENT OF THE CAPITAL CITY OF PRAGUE

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Abstract

The development of the city of Prague, maps and map documentation for designing, management and administration of the city, applications of photogrammetric methods - numerical and digital - in the acquisition of data on topographic objects, altimetry, public parks and green areas, needed to build databases of the Urban Information System, analytical triangulation for densing of pass-points, orthophotogrammetry as a means for compiling orthophotoplans serving to update existing maps, applications of terrestrial photogrammetry for surveying historically valued buildings and buildings slated for modernization. Applications of photogrammetry in the monitoring of negative impacts of air pollution on the urban environment.

1. INTRODUCTION

Prague, the capital city of Czechoslovakia, has more than a thousand years' history. It was founded by Slavonic tribes, probably as early as in the sixth century. Its convenient position, together with comfortable fords across the Vltava River, had predestined Prague as an important crossroad of trade routes, as confirmed by an authentic historical record of the Arabian merchant Ibrahim ibn Yakub. Approximately in the second half of the ninth century, two main settlements were established, the Prague Castle and the right-hand riverside town with a market place, covering an area of approximately 500 hectares. The population at that time is estimated to be several thousands. One of the most important days in the thousand years' history of Prague is March 8th, 1348, the day when the well-known foundation decree of the New Town of Prague was issued, where the Czech King and Roman Emperor Charles IV explained reasons and aims of the most extensive urban development project ever undertaken in the medieval Europe. In a very short time, the new settlement was built on an area of 240 hectares, and Prague thus became a capital worthy of the Roman Empire. At that time, Prague had more inhabitants than London or Paris.

During turbulent centuries following the peaceful reign of Charles IV, Prague and its surroundings frequently served as a stage for numerous wars decelerating the city's further development. No sooner than in the beginning of the 19th century, in the period of the establishment of factories and manufactories, Prague's development was able to continue. After the Prussian-Austrian war of 1866, Prague ceased to function as a fortress, its fortifications were torn down and settlements started emerging at the outskirts, which

were then one by one promoted to independent royal towns. After these settlements and other villages were merged into a single unit, Prague had 677,000 inhabitants and covered an area of 17,100 hectares as of January 1st, 1922.

At present, the territory of Prague occupies some 49,500 hectares and Prague's population amounts to 1.2 million inhabitants. During the last two decades, new housing schemes have been built, comprising some 150,000 apartments, and 80 kilometres of new communications and roads. The extensive upbuilding required, apart from other prerequisites, also surveying and map documentation. Photogrammetric methods have been employed for these demanding tasks, which are dealt with in the following chapters.

2. PREPARATION OF MAP DOCUMENTATION FOR BUILDING PURPOSES

In the early seventies, Prague authorities decided to build a housing scheme in the district of Prague 5, the so-called Southwestern Township, envisaged to provide housing for more than 100,000 inhabitants. The extensive project was entrusted to Projektový ústav výstavby hlavního města Prahy (Design Institute of the Upbuilding of the Capital City of Prague), hereafter acronymized as PÚ VHMP. Geodézie, National Enterprise, Prague, Photogrammetric Division, was commissioned to prepare map groundwork on a 1 : 500 scale.

At that time, the only maps depicting the envisaged project site were 1 : 1,000 (partly only 1 : 2,880) cadastral maps. Owing to substantial topographic changes in the maps of the housing project site, a decision was adopted to make use of results of a numerical evaluation of aerial photographs for supplementing the contents of the existing 1 : 1,000 cadastral maps and for complementing topographic and altimetric data in those parts, where only the 1 : 2,880 maps were available. In addition, orthophotoplans were to be prepared on a 1 : 1,000 scale to provide for a fast supplementing of topographic data into the 1 : 1,000 maps.

Because of poor visibility, the territory of the Southwestern Township was covered by aerial surveying photographs on a 1 : 4,000 scale no sooner than in December 1974. As the entire site was covered by a snow layer at the time of the photographing, which made the identification of white cross signals in pass-points more difficult, a new series of aerial photographs was taken in October 1975, using an MRB 150/230 survey camera and on a 1 : 3,500 scale. The resulting photographs were used both for block analytic triangulation and for numerical and graphic plotting of the topography, altimetry, public parks and green areas, as well as for compiling 1 : 1,000 orthophotoplans.

A third aerial photographing took place in 1978, using the same camera as in the preceding two operations, but not a panchromatic (black and white) photographic material; instead, a three-layer colour camera film was used. The negatives obtained in this way were used to prepare colour blow-ups to a 1 : 5,000 scale, which were employed to detect any changes which might have taken place since 1975.

Numerical values of the plotting of topographic and altimetric data and data on public parks and green areas, as well as results of cartometric digitization of existing topographic objects in the 1 : 1,000 maps, were processed at Projektový ústav dopravních a inženýrských staveb (Design Institute of Civil Engineering and Transportation Structures), hereafter acronymized as PÚDIS. In the process, methods of the so-called Localization and Information System for Design Purposes (LISPÚ) were employed.

The LISPÚ belongs to land information systems (LISs - complying with the definition of the International Federation of Surveyors), i.e. systems dealing with localized (topographic) objects.

The term "localized/topographic" object denotes such objects whose map presentation can be a point, a line or an area, and whose position can be related to a coordinate and altimetric system.

The data system-processed by the LISPÚ is associated with both real and planned objects and phenomena on the construction site. The following principles are employed :

- system-conceived organization of data into databases, making use of latest knowledge in information sciences,
- parallelism of digital and graphic forms, including mutual transformations, i.e. digitization of graphic forms and graphic presentation of digital data files,
- efficient cooperation of automated procedures and non-automated human jobs, which also includes suitable and convenient forms of user-to-computer dialogues in an automated query answering, specification of control data allowing for modified or variable retrievals, different scales of graphic outputs depending on the amount of detail required etc.

The system-conceived organization of data on objects on a building site, which makes use of the LISPÚ system, allows for multiple uses of the data and its storage into three areas :

- initial state objects (the existing state of the objects on the site,
- objects in the process of design/planned
- objects gradually materializing due to construction works.

The experience with the processing of data using the LISPÚ system in the territory of the Southwestern Township has recently been made use of in the upbuilding of the Urban Information System of the Capital City of Prague, as presented in a contribution at the XVIIth FIG Congress.

The accuracy of the results of the numerical evaluation of the topographic and altimetric data was checked by the customer and was found to be in compliance with assumptions set forth in the project of the mapping works :

$$m_x = \pm 4.0 \text{ cm} \qquad m_y = \pm 2.9 \text{ cm} \qquad m_z = \pm 7.5 \text{ cm}$$

Drawing from the works carried out in the framework of the Southwestern Township project, where photogrammetric methods were extensively employed, some innovative ideas have been formulated, the application of which in similar projects will bring about a further economization of photogrammetric procedures :

a) A thorough and complete registration of all data on magnetic media, which will allow for a smooth flow of data into subsequent steps of automatic map compilation and into designing of structures,

b) a point evaluation of altimetric data, including "singular" altimetric points, which enables to create an unambiguous digital terrain model for plotting contour lines, sections, axonometric and perspective views, calculations of volumes of excavated earth etc.,

c) an as extensive as possible use of analytic photogrammetry (which gives a better accuracy than existing numerical photogrammetric methods) in the evaluation (plotting) of aerial photographs).

3. THE USE OF ORTHOPHOTOMAPS IN THE CITY DEVELOPMENT

Recently, large-scale (1 : 1,000 or 1 : 2,000) orthophotomaps have been finding a broad scale of applications in the upbuilding of the capital city of Prague, starting with land-use planning, in the process of elaboration of preparatory documentation for buildings, and ending with the documentation of completed construction projects.

The orthophotomaps covering territories where 1 : 1,000 topographic and cadastral maps were available, but whose content did not represent the topography, altimetry, public parks and green areas etc. accurately enough, have substantially speeded up the entire designing process and reduced its costs. The use of the orthophotomaps has contributed to designers being better informed on construction sites as well as to higher-quality projects.

The first large-scale concentrated building project employing principles of orthophotogrammetry was the Southwestern Township.

Here, orthophotos (employed mainly for updating the topographic content of cadastral maps) were prepared using the aerial photos taken in 1974 and 1975 (see Chapter 2). The orthophotos on a scale corresponding to that of the cadastral maps were made using a WILD A 8 + PP08 unit which has proven very useful and is still being used, even after ten years of work.

The ground control of the re-plotting process was represented by the existing topographic and altimetric maps on the 1 : 1,000 scale. During a very short time, amounting to few months, tens of orthophotos were prepared, covering an area of approximately 20 sq.km, so that the updating of the topographic content of the 1 : 1,000 maps was accomplished very quickly.

Drawing from the experience obtained with the orthophotogrammetric applications in the territory of the Southwestern Township, more than a hundred of 1 : 2,000 orthophotomaps were prepared some years later, covering an area of about 150 sq.km in the territory of the planned Eastern Township project. The maps were ordered by Prague's Chief Architect's Office for land-use planning purposes.

At present, orthophotogrammetric methods and procedures seem advantageous mainly in the maintenance and updating of large-scale maps, as their resulting products reflect the actual topography of the area of interest faithfully enough and, when compared with other photogrammetric and geodetic methods, can be obtained quickly and at low costs.

4. THE USE OF TERRESTRIAL AND CLOSE RANGE PHOTOGRAMMETRY FOR DOCUMENTING BUILDINGS

The use of terrestrial and close-range photogrammetric methods has a long tradition of over fifty years in Prague. Lately, these methods have also been advantageously employed for documenting historically valued buildings. The experience gained in the course of these works can also be used to prepare documentation pertaining to buildings about to be redeveloped in the framework of the Housing Fund Modernization Project, with both their exteriors and interiors going to be modernized.

In the future, apartments in Prague will be provided not only in the framework of new housing projects, but also through the modernization of existing buildings.

During the late 1800s and early 1900, many apartment blocks were built in Prague. At present, however, these flats do not comply with current requirements in terms of their area and

equipment. Unfortunately, no technical documentation has been preserved since those times, so that investment and design organizations of the General Directorate of the Development of the Capital City of Prague are now facing a grave problem - that of obtaining the documentation indispensable for modernization works as fast as possible and economically.

In this respect, terrestrial and close-range photogrammetric methods are available, which would provide for obtaining numerical and graphic documentation of these buildings and, above all, their façades. To cope with such an extensive task, the range of instruments now available at various companies all over Prague will have to be expanded. It may be expected that applications involving numerical evaluations of geodetic photographs and processing of the obtained data using computer technology and automated graphics will be preferred. It would also be advisable to store the data into system-designed databases.

Taking into account that the number of flats to be obtained through the modernization of old buildings since 1986 till 1990 should be 4,000 (nearly twice this number in the following years), the volume of surveying works involved is very great. These surveying works could be speeded up and maybe even made cheaper if terrestrial and close-range photogrammetric methods were used.

5. PHOTOGRAMMETRIC MEASUREMENTS OF THE PRAGUE SUBWAY

The Subway System (Metro) is the largest civil engineering project of the 20th century in Prague. Three lines, whose total length is nearly 30 kilometres and which comprise 34 stations and 7 kilometres of connecting (manipulation) tunnels, are constructed under difficult geological, topographic and urban conditions.

Enormous requirements placed upon check measurements during tunnel driving operations and before the hand-over procedure could be met only owing to mass applications of close-range photogrammetry for measuring cross-sections of tunnel lining in tunnel tubes, stations and inclined tunnels for elevators.

Using the procedures described in the paper presented on the occasion of the Commission V Symposium held from June 16th till June 19th, 1986, in Ottawa, Canada, a total of 84,000 cross-sections were plotted since 1974 till 1985. For this purpose, 15,000 stereograms were taken (an annual average of 640 stereopairs). It is probably one of the most extensive uses of close-range photogrammetry in the framework of a single civil engineering project.

6. CONCLUSION

Results of the applications of photogrammetry in Prague achieved so far and the economic advantages involved have convinced competent authorities to purchase hardware for further applications of modern photogrammetric methods.

Methods of digital terrain modelling will be employed to an ever-increasing extent for processing data obtained by the photogrammetric methods.

At present, works have begun on databases for information systems serving the city administration and managerial purposes. Hence, data obtained by the photogrammetric methods must meet requirements of these systems as far as the topological and descriptive components are concerned. Several organizations in Czechoslovakia have been dealing in this field and the results achieved hitherto will be presented to the participants of the XVIth ISPRS Congress in Kyoto.