

## SURVEYING IN SWITZERLAND

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### *Abstract*

*The author traces the development of the Swiss official surveying System from its origins according to the federal law in 1912 until the System of the renewed cadastre 93, Standards for which were recently issued. He summarizes the techniques applied today in the official surveying System and describes the commercial Situation of the private surveyors and surveying companies.*

### INTRODUCTION

#### *The Legal Basis of Cadastral Surveying*

CADASTRAL SURVEYING began in Switzerland, as in many other countries, at the beginning of the 19th Century. Before the constitution of the *Confoederatio Helvetica* of 1848 was in force, Switzerland was a loose bond of independent states. At that time the cadastral survey was based on decrees of these states. The Swiss federal government owned only the Topographic Bureau, responsible for the high order triangulation and for the small scale maps down to 1:25 000. Today this bureau is called the Federal Topographic Service and it still has the same tasks.

The federal law for cadastral surveying was introduced with the Swiss Civil Code in 1912. This law prescribes that every piece of property has to be recorded in a land register. The entry in the register has legal force to prove the property of the landowner. The first entry and all changes afterwards must be based on a field survey by a registered land surveyor.

#### *The Organisation of Swiss Land Surveying*

The organization of the official Swiss land survey is shown in Fig.1. According to the law of 1912, the Federal Directorate of Cadastral Survey was founded for administering the national cadastre as a branch of the Department of Justice. It works independently of the Federal Topographic Service, but it may receive some technical support from this Institution.

#### *The Duties of the Administrative Departments and the Surveying Offices*

This paper will not discuss the activities of the Federal Topographic Service and its map production, but will be confined to the civil surveying part.

The Federal Directorate of Cadastral Survey has a staff of about 20 employees, 10 of them with university degrees. They issue the Standards of cadastral work and they conduct and supervise the cadastral survey as the head office of the cantonal surveying departments. Their main task is administrative control, confirming the contracts between the private surveying Offices and their clients, the political communities. They approve the federal attestation when a surveying lot is finished. Furthermore, it is their task to administer the financial contribution of the federal government. This is normally less than a quarter of the entire costs of the surveying work, but it may go up to 80 per cent in the mountainous areas of poor cantons. The federal investment in cadastral surveying is approximately 30 to 50 million Swiss francs per annum.

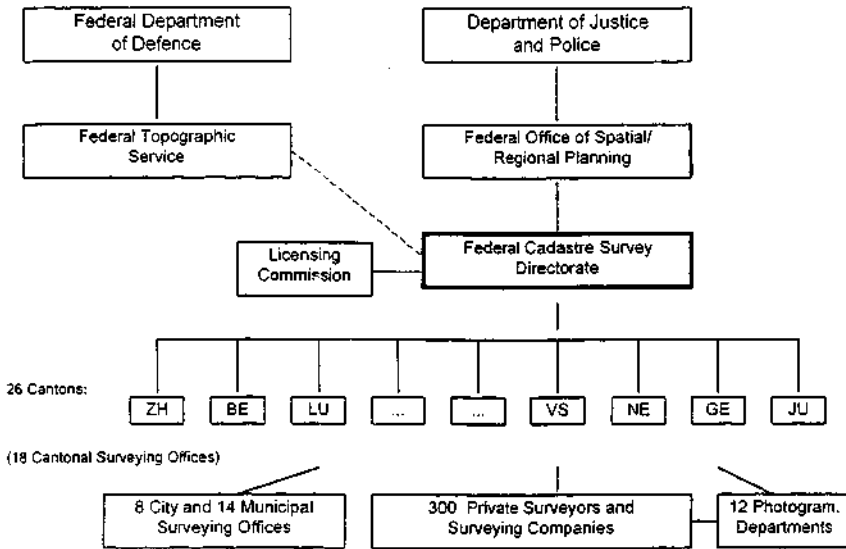


FIG. 1. Organization diagram of the official Swiss survey Services.

Cantonal surveying authorities exist in almost every canton. Only eight small cantons delegate their duties to the federal board. The task of these cantonal institutions is mainly the technical supervision of the work done by the surveying Offices. Every step of the official survey, beginning with the boundary marking and the field measurement up to the data management in the land information System and the Output of the maps, is quality controlled by cantonal experts. These experts are experienced in doing this Job by random sampling methods. Furthermore, cantonal authorities are responsible for the maintenance of both the fourth order triangulation and the general overview cadastral map at the scale of 1:5000. Depending on the size of the canton, the staff of these cantonal surveying Offices ranges from five up to 30 employees.

The surveying work is carried out by federal licensed surveyors and municipal Offices. There exist about 22 municipal Offices in larger towns and about 300 surveying companies or private surveyors with an average staff of 10 technical skilled employees. The municipal Offices and also the private firms in large agglomerations are dealing only with cadastral and similar surveying work but several private firms in rural regions are also busy with planning and supervising civil engineering constructions. Twelve of these surveying companies also run photogrammetric departments with one or two analogue or analytical plotters.

The Flotron AG office in Meiringen is a typical private Swiss surveying Company in a mountainous area. It is presented here as an example. It is situated in the Bernese Oberland and we have 20 employees. We are concerned with the official surveying work in the district which includes some alpine valleys and a large area of high mountains. It is one of the largest surveying districts one can find in Switzerland but, regarding the number of inhabitants, it is one of the smallest. Hence our cadastral surveying department, renewing or updating the official cadastre, is responsible for only a third of the turnover of the firm. Another third of the turnover is earned in civil engineering work. About five of our employees plan and supervise the construction of roads, water supplies and sewer Systems with purification plants. They also cope

with rural improvement tasks such as agricultural development of mountainous areas and land consolidation. An important part of the business is engineering surveying. We are, for instance, monitoring the behaviour of large dams, glaciers and rocks. We own several total stations, a Kern Mekometer 5000 and five GPS receivers in a pool with other firms. The photogrammetric department is small compared with international Standards but it is of average size for Swiss circumstances. We own two Leica analytical plotters and an Intergraph Workstation to produce digital orthophotographs. Aerial triangulation is measured on the Kern DSR 15 high precision analytical plotter. For calculating the aerial triangulation, we installed the BUND Software from the Technical University of Zürich on a Vax. We use the MAPS200 program System and the TA10 flatbed plotting table for tasks with graphic Output. The ordinary photogrammetric restitution with digital Output is done with the Kern DSR 14 and plotted with raster or pen drum plotters with Intergraph drawing Software. Early in 1994, we started the production of orthophotographs, especially for official surveying tasks in regions of low ground value. In the near future, orthophotographs will replace many drawn and printed maps, because their production is cheap as long as the number of copies is not too big. For compiling the orthophotographs, we use the Intergraph Unix Software.

### CADASTRAL SURVEYING BEFORE THE REFORMED CADASTRE 93

A short explanation of the old System and its documents is necessary as a basis for understanding the new System.

#### *Technical Aspects*

The technical instructions were issued in 1917. They prescribe how to perform the official cadastre and they were still in force until 1993. According to these rules, the Swiss cadastre consisted of the fourth order triangulation, the cadastre overview map at 1:5000 scale and, as the main part, the maps of the land property and buildings at scales of 1:200 to 1:2000. Five stages of different accuracy were defined for basis points and for boundary points of parcels ranging from a few centimetres in townships up to half a metre in rural regions in the mountains.

Cadastral data were processed fully graphically. Since 1930, the use of metal reinforced paper was compulsory. Co-ordinates were calculated only for the basic points, which were usually determined by traverse measurement. Since 1974, "partly numeric processing" was compulsory, so that all boundary points of parcels had to be represented by co-ordinates in the official land survey System.

#### *The Stare of the Work*

The fourth order triangulation with a density of up to four points per square kilometre is completed except in a few mountainous regions. The problem we have today is maintaining this high density network, especially in the Alps. We know of many regions in the mountains where soil movement of several centimetres a year is quite common, so a constant updating of the entire network is almost impossible. The 1:5000 scale overview map which also gives height Information with contour lines at 5m or 10m interval was also completed several years ago. The drawing on transparent sheets was made very carefully. These maps are used for many purposes, especially for all planning work in agricultural regions thanks to the good Information on terrain altitudes.

The main task is, of course, the cadastral survey. Its progress was rather slow, because the survey of boundary points and buildings had to meet high requirements of accuracy and reliability and it was not properly funded. In 1968, a new tariff was worked out by the private surveyor board which was accepted by the Directorate of Cadastre and by the cantons. This table of rates included every task of the official survey and it stimulated the progress of the work considerably, because it was now profitable to do official surveying. For this reason new companies were founded and the existing ones expanded their activities.

Today the cadastral survey of the parcels is more or less completed for the entire surface of Switzerland, with only some alpine regions incomplete. But for some areas the survey is up to 100 years old and it does not meet the requirements of the new System for more than 50 per cent of the area of Switzerland. No doubt, good surveying work was established and maintained regarding the basis points, the boundary points and the buildings, but the other elements of the map such as roads and woods, are not updated over large areas, because their revision was not compulsory. These elements need to be updated soon because they are now also a part of the new official and multipurpose cadastre. Furthermore, the buildings and all other topographic details were still stored and displayed graphically and only the parcel boundaries of recently established surveys are available in digital form. Hence there is still a lot of surveying and digitizing work to do.

#### THE OFFICIAL SURVEYING SYSTEM AV93

The renewal of the regulations and a new surveying concept was discussed for many years. The aim was to establish a fully digitized cadastre which met the requirements of the legal cadastre according to the civil law code and which could also be the basis of a multipurpose cadastre. For the authors of the regulations, it was not easy to come to an agreement with all the Swiss institutions which are interested in large scale surveying.

The new surveying regulations have been in legal force since 1993. They brought several changes to the old rules. First of all, there is, of course, a new technical concept, but also new organizational, financial and economical aspects and methods were introduced as will be shown in the following paragraphs.

#### *Financial Resources*

As long as the cadastral documents could serve only legal aims, they had to be paid for by the land proprietors, by the communities and by subsidies from the federal government. With the new concept, the cadastral data will be used by all other administrations which need land related information. The idea is that the electric power supply and telecommunication companies, the proprietors of Utilities and other ground administration authorities should be customers of this cadastral data and that they would probably pay high rates for reliable, accurate data which are easily accessible. Two Standard Software Interfaces were introduced, "Interlis" to transmit the entire data set and "Geobau" for transmitting mainly geometric information.

The principle seems to be quite successful. Swiss Telecom and several Utility owners already have contracts and are ready to pay for digital surveying data.

#### *Free Choice of Methods*

The old cadastre regulations had strict prescriptions about the surveying method that had to be applied. For example, a special grant of the Federal Directorate of Cadastre Surveying was necessary to use photogrammetric restitution for cadastral purposes. According to the new regulations it is now up to the surveyor to choose the appropriate method. He will look for the most economic solution of the surveying problem and this will be a good opportunity to introduce photogrammetry for many more purposes than was previously the case.

With several pilot projects, the photogrammetrists showed that photogrammetric methods will now play an important role in cadastral surveying. One of these projects contained the area of the entire canton of Nidwaiden for which the cadastre was about 70 years old. The results of the pilot projects proved that the photogrammetric data gathering is reliable and accurate enough for the requirements of the new cadastre.

#### *The Call for Tender Principle*

In the new System, the communities no longer give contracts to the surveyor according to the tariff but they have to call for tenders. The paper for the call is

prepared and the organization is supervised by the cantonal surveying authority. This new System is a very important change from the former principles. The tariff System was leading to a kind of trust which stabilized the prices at a rather high level. The result obviously involved a good profit for the surveyors but there were few reasons to consider change or even to adopt new structures or techniques.

According to the new law, the call for tender is compulsory in a limited circle for contracts with a value above 100 000 Swiss francs. If costs exceed 200 000 Swiss francs a public announcement is prescribed. Every licensed surveyor in Switzerland and in neighbouring countries can submit an offer.

Under earlier arrangements, profits were leading to high production capacity in many surveying companies. Because of the high capacity and the Stagnation of the market that we generally have today in Switzerland, a fall of prices has resulted for all surveying contracts. The fight for contracts among surveyors is rather hard as can be shown by the following example. The price of a small surveying lot in our region was estimated at an amount 15 per cent less than the price according to the tariff. A colleague submitted a tender for half of that price. Such a difference is an exception, but the price level has reduced generally by about 20 per cent.

The call formender System is, of course, not favourable for the earnings of surveyors but, on the other hand, it stimulates the search for new technical Solutions. This fact gives advantages to companies with photogrammetric equipment. Quite a lot of surveyors realize now that photogrammetric restitution is less expensive than conventional methods and they ask photogrammetric companies for collaboration. For the time being, the capacity of the Swiss photogrammetric firms is not too great. The responses to the call for tenders for photogrammetric tasks are normally at a price level which covers salary costs and the cost of Instruments, so the economic Situation in the photogrammetric business is still satisfactory.

### *The New Technical Concept*

All data have to be stored in a land information System. These data have to be in different levels as shown in Fig. 2. The land information System must be based on a relational database in order to query all elements in their correlation.

The first level, A, contains the basic points of the whole triangulation network from the first order down to the fourth order points and also the basis points of the cadastral survey. The second level, B, shows the covering of the ground by buildings, roads, woods, agricultural land, water bodies and so on. The elements of this level have to be consistent areas, determined by a closed line string. The third level, C, is complementary to the second one; it contains all topographical objects displayed as a single line like walls and sections of buildings, or as single points like trees. All elements of terrain altitudes are stored in level D. They may be single points with or without spot heights or elements of a digital terrain model. The E level is dedicated to nomenclature such as names of townships, streets and buildings. In the next level, F, all elements of the legal cadastre are stored. Its content is almost the same as we had in the old cadastral survey, but without buildings. The Utilities according to the federal law, the pipelines for gas and petrol, are stored in the seventh level, G. The boundaries of political bodies or administration areas belong to level H. Any other levels to make the multipurpose cadastre more comprehensive may be added, for example to store the elements of Utilities and all other soil related data.

The data quality requirements are specified for every level and for the various terrain values. Regarding elements of fixed points and the points of the property boundaries in built up areas, they are quite similar to the old ones but they are less rigorous in mountainous areas. New tolerances were created for boundaries determined by natural lines and for topographic elements.

### THE SUBITO PROJECT

The Society of the Consultant Photogrammetrists of Switzerland compiled a program named "Subito" to gather actual data of the covering of the ground surface (the levels B and C) with photogrammetric methods in all regions with obsolete

# Level Structure of RAV

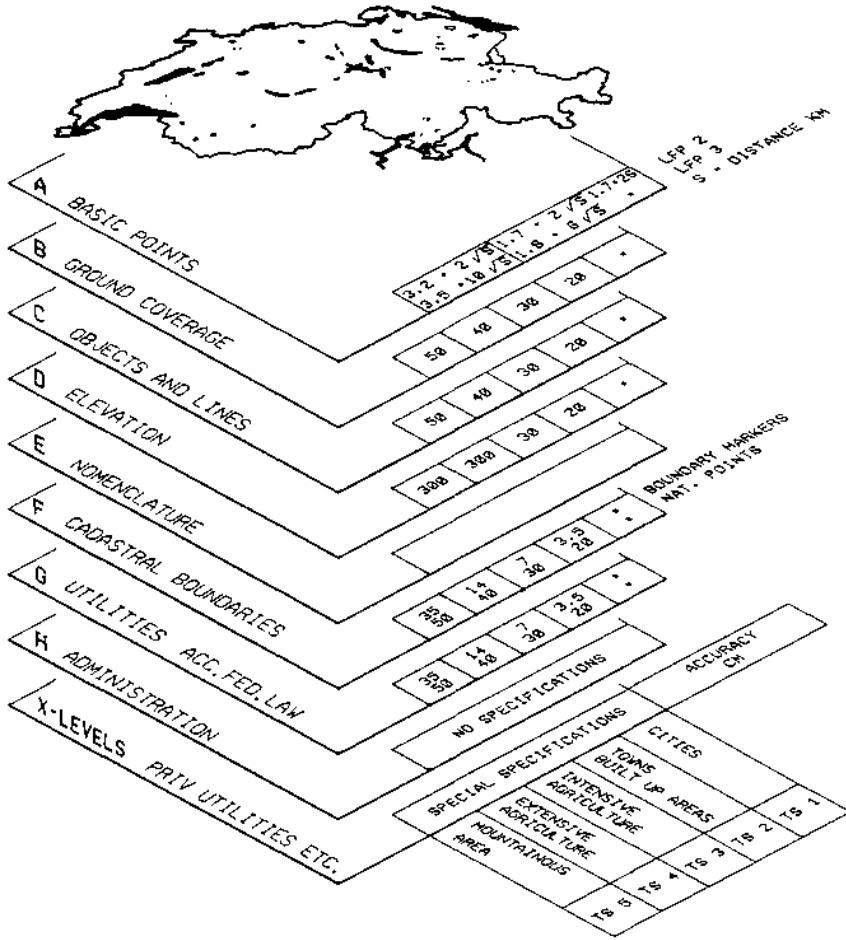


FIG. 2. The level structure of the Swiss land information system

cadastral maps or without any information about ground data. The name "Subito" for this concept showed that it would be possible to achieve the aim in a short time. Unfortunately, financial restrictions of the federal and cantonal budgets are delaying this project. It will not be realized as expected as a unit over all parts of the country within a short time, but only in small Steps as parts of the official survey. A summary of the principles and techniques which were proposed for this project will be provided, because they will be applied as Standards.

According to the accuracy requirements of AV93, flights will be planned for photoscales of 1:5000 in built up areas and the regions with valuable ground, 1:8000 in the agricultural regions and 1:15 000 in the mountains. In built up areas, we can find enough points determined by terrestrial means for setting stereomodels, but in the agricultural and mountainous areas, the fixed point net is rather sparse. In this region, we need additional control points which will be determined by aerial triangulation. With this method, it turned out that, in zones with steep, wet ground, the old triangulation fixed points may have moved significantly. In this case, aerial triangulation also serves to determine the new co-ordinates of fourth order triangulation points. Higher order triangulation points will usually be surveyed with GPS methods.

The main aim of the photogrammetric restitution is, of course, to gather the topographic details which are elements of the levels B and C of the new System. Marked boundary points will usually not be photogrammetrically compiled, because it is expensive and it takes too much time to mark these points so that they can be observed reliably on the aerial photographs. They are surveyed, as are the corners of the buildings, by terrestrial means. But all boundary lines which can be identified in the photographs because they follow natural lines, such as rivers, will be plotted photogrammetrically.

With the new System, the terrain height is an optional element of the official cadastre. For several communities, a DTM has to be measured. A high accuracy of the DTM interpolated points of about 0-2 m is required in built up zones. In agricultural areas, the height information must be stored digitally to the same accuracy that we had previously in the overview maps. The collection of these data will be a considerable task for the photogrammetrists. In the woods, where the DTM cannot be measured, the height information will be based on the contour lines of the existing overview maps which were originally surveyed by plane table.

#### PHOTOGRAMMETRIC TASKS IN FOREIGN COUNTRIES

It is the dream of many consultants to acquire large contracts in foreign countries. It is rare for a Swiss firm to compete with photogrammetric companies of other countries. The main reason is that Swiss salaries are probably the highest in the world.

Some Swiss companies are working now as Consulting surveyors in eastern European countries. In 1992, the Swiss government passed a resolution to donate a large amount of economic aid to these countries. Several of these countries began demanding the support of Swiss surveyors to renew their cadastre after 50 years of communism. It is a fascinating task to plan a new surveying System for an entire country.

#### *Resume*

*L'auteur retrace le developpement du Systeme de mensuration officielle suisse, depuis ses origines, qui remontent à la loi federale de 1912, jusqu'au Systeme de renovation cadastrale de 1993 (MO93), qui vient de faire l'objet de normes recentes. U resume les techniques utilisees actuellement dans le Systeme des leves officiels, et presente la Situation commerciale des geometres prives et des societes prives qui effectuent des leves.*

#### *Zusammenfassung*

*Der Autor skizziert die Entwicklung des amtlichen Schweizer Vermessungssystems von seinen Anfängen im Bundesgesetz im Jahre 1912 bis zum*

*System des erneuerten Katasters AV93, für das kürzlich Standards herausgegeben wurden. Er faßt die im heutigen amtlichen Vermessungssystem angewandten Techniken zusammen und beschreibt die kommerzielle Situation privater Vermessungsfachleute und Firmen.*

## DISCUSSION

*Chairman (Major-General Wood):* We've all admired Swiss maps over many, many years and known the great dedication that goes into their production. You have indicated this evening that what we thought was exactly right, that they are excellent. Now to questions.

*Professor Harley:* There are a lot of questions that I'd like to ask but I'll restrict myself to one. In most cadastral survey Systems, there is a hierarchy of evidence which is accepted for the Identification of a land parcel boundary. Normally the surveyor's mark in the ground has the highest priority; and then occupation (fences) while co-ordinates have a lower priority. Furthermore, in most Systems, when there is gradual accretion or movement of ground, the boundary moves with the ground, provided that it moves slowly. What is the Situation in Switzerland, or in your canton, and how does it relate to the methods with which you measure your fourth order points?

*Mr. Flotron:* Boundaries are determined by boundary marks or fences where no official surveying exists. But if an official survey exists, then maps or co-ordinates in modern surveys have the higher priority. The law assumes that the surveying is correct.

The moving of ground is an important problem in Switzerland and we didn't have a clear regulation until the new law. According to the old law, the legal place of an officially surveyed boundary point was the place of its first determination. Now, according to the new law, the legal boundaries, that's to say the legal positions of the parcels, move with the ground. An entry in the Land Register shows that the ground of that property is moving. So everybody who may be interested in this land parcel finds out that the ground is moving and a purchaser has to take all the risks that may be attached to the problem of moving ground.

*Mr. Leatherdale:* I was very interested by your description of the organization of cadastral surveying in Switzerland. What I do find difficult to understand is why it was decided in 1993 that, when you already had one of the best, most detailed and most accurate cadastral Systems in the world, it was necessary to start all over again and do it more thoroughly. As you know, in this country our System is right at the opposite end of the spectrum. We have a System which is simple and as inexpensive as possible. H. M. Land Registry has always been self funding from the fees charged for registering land transactions. It has never been subsidized. Within a few years, our national survey will also be totally funded from sales of maps and information. I am wondering whether the surveying profession is much more powerful politically in Switzerland than here. Is it that the cost of the cadastre is not so evident to the user because the land owner doesn't actually pay the real cost of surveying and registration, or are there deeper cultural reasons why the Swiss want to record their land so much more thoroughly than we do, at any cost?

*Mr. Flotron:* It's true that we have a very accurate and reliable cadastre in the regions where the official survey exists but about 20 per cent of the surface of Switzerland is still not officially surveyed. As a matter of fact, high reliability exists only regarding the fixed points and the boundary points but not on the other elements of the maps. because it wasn't compulsory to update them. You can find cadastral maps in Switzerland showing woods and roads as they were years and years ago. These drawings must be updated in the near future and we intend to do it with photogrammetric measurement. Furthermore, a large part of Swiss official surveying is still in a graphical System. It must be upgraded in digital form and stored as a land information System.

*Chairman:* Do you mean by that there has not been revision of the cadastre in that time? Have just new properties been added as they have been built?

*Mr. Flotron:* The revision was compulsory for property parcels and for buildings. but not for any other elements of the maps.

*Mr. Varshosaz:* You have explained some problems of the historical background.



but is the biggest problem in the cadastral System legal or technical?

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*Mr. Flotron:* We don't deal with legal problems. We surveyors have to have a basic knowledge of the laws, of course, but it's not our task to answer legal questions. The legal basis is tied with the Civil Court law of 1912 and I suppose it will still remain so for a long time. Our biggest problem is technical and consists in integrating the technical evolution and the existing surveying.

*Mr. Varshosaz:* Please could you explain a little more about the photogrammetric and surveying difficulties?

*Mr. Flotron:* The main problem is to Upgrade the very accurate and very valuable graphical data of boundary points and to save them in the numerical System of the official survey. Because some accuracy was lost by mapping the surveyed points, we don't just digitize the old maps but we calculate the co-ordinates by evaluating the old original field measurements.

The second problem is to Update all topographical detail. Of course, in built up areas and even in small towns, the topographic elements have been revised (more or less) but you can find deficiency in rural regions. I showed you the example of the Community of Sonvilier, which was officially surveyed in 1880. The boundary points of this survey will be digitized from the maps, but of course the topographical details of a 120 year old map are no longer useful. We have to carry out a new survey, which will be done photogrammetrically.

*Mr. Taft:* You mentioned that contracts were now going to competitive tender and therefore prices were coming down. Are the survey companies or any survey association taking any measures to stop those prices going down any further?

*Mr. Flotron:* We don't have this problem under control. We have far too much surveying capacity in Switzerland. I told you the example of a tender of a colleague of mine which was about half of the sum calculated by the official tariff. This is an exceptional case but I estimate that the prices decreased about 20 per cent to 25 per cent compared to the prices given by the tariff and I hope that they won't go lower. They have reached the lowest level at which it is possible to secure some profitability. I think for the time being, as long as we have a high capacity, we have no means of stopping this price decrease.

*Chairman:* I must draw the discussion to a close now. I would like to thank Mr. Flotron very much indeed for answering the questions and for the lecture. I think it's perhaps rather familiar to hear about prices being squeezed down. A number of those who are in commercial surveying practice here will recognize that problem. As photogrammetrists, we can be encouraged by the fact that you found photogrammetry to be a very cost effective solution and that you were not suffering the same kinds of problem, at least not to the same extent, as the field surveyors. I am not sure if that's the same in this country. I also found it very interesting to see the way you obviously integrate the field survey and the photogrammetry and obtain the best combination. We must congratulate you on doing that so effectively. This evening, as well as being fascinated by all the technical activities of the organizational and legal aspects, I think most of us who have done any surveying, whether it be from photographs or out in the field, love mountains. I must thank you very much for bringing so many beautiful photographs of your magnificent country. Thank you very much indeed for coming to London and for giving us such a fascinating evening.