

**AUTOMATION IN DIGITAL PHOTOGRAMMETRIC PRODUCTION**  
Summary report of an OEEPE Workshop held in Paris in June 1999

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**ABSTRACT**

The article gives a short outline of the state of the art of 'Automation in digital photogrammetric production' as it was presented at a workshop of OEEPE. This conference was held in Paris in June 1999, frequented by practitioners and vendors, in particular INPHO Stuttgart, LH Systems and Z/I Imaging.

**1. INTRODUCTION**

From June 21 to 24 1999, OEEPE (European Organisation on Photogrammetric Experimental Studies) organised a Workshop under the title "Automation in Digital Photogrammetric Production" in Champs-sur-Marne, in the new premises of the University of Geographic Sciences of IGN.

The OEEPE is concerned with the development of effective and efficient digital photogrammetric production lines, including standardisation (guidelines for the production processes and standards for the various products), optimisation and financial and logistic aspects. To be successful, this development needs to be done through close co-operation with manufacturers and users. The Workshop should serve as a platform to discuss issues related to the optimisation of digital photogrammetric production lines.

In totally, 160 persons from 25 different countries participated. During the workshop the different topics were introduced through conferences given by experienced photogrammetrists and vendors were invited to give demonstrations on standardised test material. The following manufacturers were invited: LH Systems, Z/I Imaging (Intergraph and Zeiss), Inpho Stuttgart; furthermore DVP, Virtuozo and Erdas participated in discussions and in the exhibition. In the following we give a short overview of the main discussion topics reflecting the state of the art of last year. The full text of the lectures including the discussions are published as Volume 37 of OEEPE publications and can be consulted on the Website of the Institute of Photogrammetry of the Technical University of Lausanne under :

<http://dgrwww.epfl.ch/PHOT/workshop/wks99/toc.htm>.

**2. DIGITAL CAMERAS** (chaired by Y. Egels, France)

B. Dierickx (Belgium) analysed the obtainable image quality with electronic image sensors compared with photographic films. He predicted that the CMOS technology will also replace the CCD technology in the high end and will slowly reach the capacity of photographic films for large formats also.

Nevertheless, manufacturers are already involved in the development of digital photogrammetric cameras (R. Sandau, Switzerland). There are 2 systems in direct competition. The 3-line camera which is currently being developed by LH Systems in collaboration with the DLR (Deutsche Luft- und Raumfahrt); and the frame camera on which important development work is done by IGN (C. Thom, France), a line which is also preferred by Zeiss respectively Z/I Imaging. The 3-line camera of LH Systems has the advantage that one can use much larger image formats; one currently tests an engineering model with a sensor array of 12,000 pixels but the functioning model should show an array of 20,000 pixels. On the other hand, the digital frame camera currently shows sizes of only 4,000 x 4,000 pixels. However, the number of pixels gives only limited information on the real optical resolution. Under ideal conditions, the pixel resolution allows one to determine directly the modulation transfer function and the image resolution as described by B.Dierickx. However, optics and then the eventual post-processing of the images can substantially affect the optical quality. The success of the 3-line camera will consequently depend largely on the quality of the stabilization of the camera. If it is possible to largely correct the pitch and roll movements of the airplane, then a very efficient system

should emerge. However, the technical requirements for the stabilisation (GPS and INS) call for considerable efforts. On the other hand, the technical effort for the frame camera is very modest and allows the use of relatively small survey planes, although with the disadvantage of a relatively small image format.

Both systems are currently still limited by the speed of the data registration. With the frame camera (4000x4000 pixels) one can get an image every 4 seconds. For similar limitations, it is not currently possible with a line camera to get a pixel resolution on the ground higher than 30x30 cm. Which means that for a flying speed of 200 km/h during the flight mission, one requires about 1/200th of a second to read and register one complete array.

The French firm ISTAR (L. Renouard, France) has already had practical experience with the use of the 3-line camera. This firm uses a prototype, also developed by DLR. The camera is used for the elaboration of town models as they are required by telecommunication. In this case, one has to elaborate the DTM and to model the houses, and orthophotos are also required. The image correction and DTM elaboration is done largely automatically; but the post-treatment of the data and the editing requires about 6 hours – 2 days per km<sup>2</sup>. The precision obtained is indicated to within  $\pm 1$  m.

### 3. DIGITAL SCANNERS (chaired by O. Kölbl, Switzerland)

Without any doubt, photogrammetric scanners have reached a very high standard. The most important achievements of the last years are certainly the incorporation of devices for the treatment of uncut rollfilm and unsupervised scanning of a whole series of photographs. The DSW300 of LH Systems as well as the Scai Scanner (Z/I Images) offer this possibility. Many improvements have also been made in order to increase the geometric precision (M. Baltsavias, Switzerland, concerning the progress from the DS200 to the DS300). The dynamic range has been extended to about 2D due to the progress made in the sensor technique. However checking the modulation transfer Function of the digitised images gives the impression that the image quality of digital images is considerably below that of the original images. Also the colour reproduction of the scanned images shows certain deviations which can however be corrected purely numerically to a certain extent (O. Kölbl, Switzerland).

The archiving of data remains great problem of digital photogrammetry. According to Lukas Rosenthaler, Switzerland, there is no real long-term solution available for this task. Great institutions like NASA have had the misfortune to lose a certain amount of their data, in this case all numerically registered image data from the first-generation satellite. The rapid changes in technology were mainly and the limited stability of the digital storage media were mainly responsible for this problem. He only can advise to plan for a copying cycle of all digital image data, at least every two years if one has in mind to build up an image archive, and he currently recommends DLT as data media, as the magnetic traces of this media are in the direction of the tape which makes them relatively insensitive to mechanical interference.

### 4. AUTOMATION IN PHOTOGRAMMETRIC DTM ELABORATION (chaired by A. Dupéret, France)

The automatic DTM derivation from aerial photographs is a research area that has been intensely dealt with for about 2 decades. Meanwhile, this technique is facing competition from laser scanning but also from the 3-line camera. The most important software products currently used in Europe in practice are those of LH Systems (Socet.Set) and Match-T. The later is integrated in the Intergraph ImageStation (Clix and Windows) as well as in Phodis (Zeiss). For the DTM derivation for topographic requirements, the Socet.Set of LH Systems is mainly used. The conferences by A. Dupéret (IGN France) and M. Cory (OS Ireland) showed the efficiency of the LH-System software in production, allowing an improvement of productivity by a factor of 3 about compared to the plotting of the contour lines on an analytical plotter with the same quality requirements. However, the preparation of the data and the successive editing requires much experience (T. Blaudet, France). A serious competition to photogrammetric DTM measurements arises from Laser-scanning (B. Petzold, Germany).

### 5. AUTOMATIC AERIAL TRIANGULATION (chaired by T. Kersten, Switzerland and C. Heipke, Germany)

Great progress has been made in the last 2 years in the area of automatic aerial triangulation. At the past workshop, about 2 years ago, the only experiences available were done on the ImageStation of Intergraph with the ISDM software package. This software package allowed semi-automatic processing, meaning that the operator has to choose the tie points but can use a module for the automatic point transfer to the neighboring images. Very often, however, point transfer is done purely manually. Nevertheless, this method has led to a considerable rate of production. It was indicated that an operator is able to handle up to 60 images and even more per day in this way.

Today, practitioners essentially have a choice between the 3 following procedures :

- HATS by LH Systems
- Match-AT by Inpho also as stand-alone version but also integrated in the Image Station
- Phodis-AT by Zeiss or integrated in the UNIX station of Z/I Imaging

Manufacturers as well as practitioners have reported on these 3 software packages. All procedures have shown high efficiency and satisfying results. However, all procedures also show certain weaknesses. For the detection of blunders, it is important that the process of the automatic point transfer is densely coupled with a numerical control over the algorithm of the block adjustment. All manufacturers working intensively on this aspect; however, these modules have not yet been introduced in practice. A user-friendly procedure for the correction of blunders is also important. In this respect, the ImageStation with the module ISDM which allows for simultaneous monitoring and measurement of up to 12 images or 6 images and 6 enlargements offers a considerable advantage. The control of the connection of the images, in particular with images on neighboring strips is also still problematic. Users of LH Systems and Match-AT software have written special control software for this objective. According to explanations given by Scott Miller of LH Systems, this problem will be solved by the next NT version of HATS, with the help of the ORIMA block adjustment program.

The efficiency of automatic aerial triangulation is also characterized by the fact that many institutions which have digital workstations use only digital procedures for aerial triangulation, even if the plotting is done on analytical plotters. However, some problems might result from the transfer of the orientation elements coming out from the bundle block adjustment, due to the use of special parameters.

## **6. ORTHOPHOTO PRODUCTION** (chaired by O. Kölbl, Switzerland)

Digital workstations have doubtlessly been most widely used in orthophoto production; today, these documents are practically exclusively produced by digital techniques. Consequently, the different manufacturers have invested heavily in software tools for orthophoto production. In an overview conference, U. Weidman (Hansa Luftbild, Germany) stated that the rather complex chain of production requires a combination of different products for the proper rectification, computation of the mosaics, optimal tone adaptation and final output for the printing of the images. The manufacturers (Interrgraph, LH Systems and Zeiss) showed important new developments during the demonstration, in particular for tone adaptation and image enhancement. The uniform task concerning the combination and adaptation of colours of 4 aerial photographs of medium quality was demonstrated by the manufacturer in a convincing manner.

One of the standard reproduction techniques for printing of orthophotos is without any doubt the HP-DesignJet of Hewlett-Packard. A representative of this firm (R. Raychoudhury, Spain) explained the principle of the digital printing technique and concentrated mainly on the inkjet technique. Standard resolution of the 2000 and 3000 series as well as of the series 1000 is 600 dpi for colour printing. Intensive work is being done on a further refinement of the colour resolution. For the graphic industry the 2000 and 3000 series has been special developed, allowing the use of dye colours and of pigment colours. The latter are very resistance to light and it should be possible to store them for practically unlimited period of time. Meanwhile photo plotters on photo material still provide an alternatives to inkjet plotters for high quality requirements. (M. Gubler, Switzerland).

A complete chain of software packages for orthophotos production up to the driver for printing is delivered by Intergraph. In particular for the output for printing, many other firms prefer foreign products. Postscript is definitely an upcoming general standard in this respect.

## **7. LOGISTICS, MANAGEMENT AND FINANCIAL ASPECTS** (Chaired by R. Héno, France and J. Colomer, Spain)

Digital photogrammetry poses considerable logistic problems. Already the enormous mass of data which are yielded by the image data, the necessity to have as many operations as possible to run as batch processes and to load the operator with a minimum of data manipulation require a very rigorous organisation of the data management. These logistic aspects were presented in conferences by T. Kersten, Switzerland and G. Toth, France, as representatives of private offices and Margarita Torre, Spain, representing a national topographic mapping institution. Also of interest concerning data management are the overview diagrams regarding the system configuration at Instituto Cartografía de Catalunya and the diagrams of the various working processes given in the ahead-mentioned paper. Furthermore, the various logistic and management problems were dealt with in an extended discussion; the main topics has been summarised by R. Héno and J. Colomer in an overview paper.

Already for image storage, one has to state that questions on the image format and the possible data compressions have only been partly solved. Doubtlessly, TIFF has imposed itself largely as a standard but it remains open whether the data should be archived in a compressed form. The problem of the long-term storage of all technical data concerning image registration, flight mission and data restitution, etc also remains open.

For large enterprises, it is also of great interest whether the image and project data of the various processes can be handled on a central image server. It has been clearly stated that current network technology and the efficiency of the storage media are not capable of providing sufficiently rapid data access. In particular, the access to the mass storage devices still considerably limits the speed of image processing, much more than the computation capacity of the processors.

Another question which was not completely clarified either concerns display technology. It is true that the various automated processes of image treatment allow one to achieve a high performance. However, the image quality as it is presented on the monitor to the operator does not by far reach the same standard as a high-quality optical observation system in an analytical plotter. It is true that the digital plotting systems are accepted very easily by young operators; however, the detail recognition remains below the standard of an analytical plotter.

It is evident that training, technical assistance as well as the exchange of experiences are of the utmost importance for such a complex matter as digital photogrammetry in a production environment. It is understood that manufacturers, the various training institutions, but also practitioners are making great efforts in this field. Nevertheless, the costs for the introduction of a digital workstation in a production environment are considerable and it takes a long time to obtain a more or less optimal usage. In this field, it would be important to enhance the efforts especially on the manufacturer side.

In an overview conference concerning the financial aspects J. Piedfort (Switzerland) in particular showed the extremely large variations of prices, especially in international tenders. Very generally, the wish has been expressed to introduce a certain ethic when working out tenders and to avoid ruinous and unrealistically low bids. It is understood that no real solution has been found thus far in this field.

## 8. CONCLUSIONS

The workshop obviously showed the general tendencies and demonstrated the great progress made in digital photogrammetry. Digital photogrammetry is a mature technique mainly in the field of processes, which can be largely automated, like aerial triangulation, orthophoto production and also the derivation of precision DTMs. With respect to plotting, it was less evident whether digital workstations are preferable, due to the low degree of automation.

