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First experiences using digital photogrammetric stereo workstations at the ICC

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ABSTRACT

The paper reports on our experiences trying to set digital photogrammetric stereo workstations into operation for stereoplotting. The approach taken here has been to describe what we have done so far and the problems and solutions implemented for two different commercial systems. Although a complete description and comparison of these systems is outside the scope of the paper, some space is devoted to describing their most relevant features because of their impact on the proposed solutions, systems architecture and operational workflows of our project.

1. INTRODUCTION

The end of 1993 will see the completion of the first version of the 1:5000 topographic map of Catalonia, which has been produced over the last seven years with computer assisted analog stereoplotters. The 1:5000 orthophotomap series was finished during late 1992; this series has been produced digitally at high production rates since 1988 (Colomina91) using a 15x15m DTM grid interpolated from the profiles and breaklines collected for the topographic map.
Tasks defined for the second revision of both series were set to a) update the 1:5000 topographic map, b) produce a new version of the 1:5000 B/W orthophoto and c) update and improve the quality of the DTM Database. Existing ICC analog and analytical systems were considered inadequate for tasks a) and c) because of the lack of image superimposition. Monoplotting on top of digital orthophotos using the existing DTM Database for interpolating elevations was not considered because the DTM itself has to be corrected and updated with new 3D information.
Because no analytical stereoplotter with 3D superimposition supporting our existing MicroStation files without format translations was found on the market, the Zeiss/Intergraph PS1 scanner (Faust89) and an Intermap digital stereo workstation from Intergraph (Kaiser91) were purchased and installed at the end of 1991. Digital photogrammetry was thus the selected technology for the above mentioned projects. Our envisaged digital environment for the future will look like the one shown in Figure 1.
The first generation of the Intermap system was not considered truly operational because of the lack of an accurate cursor device; in addition, the software was not sufficiently developed to be able to use the internal VITEC-50 image processor hardware either for visualization or for batch jobs. Because of the announcement of a second generation of Intermaps in the spring of 1992 we stopped our integration tasks for a while to await new hardware and software. In February 1993 our system was upgraded to a new 6487 model with software for the VITEC-50, a faster CPU with 64 MB RAM and the JPEG compression board. In mid-April 1993 the hand-held photogrammetric cursor was installed and development resumed. At the ISPRS'92 Congress in Washington, the PC-based DiAP digital stereo workstation was demonstrated by International Systemap Corporation; this system was installed at the ICC in early March 1993.
This paper reports on the operational and functional aspects of a map updating photogrammetric workflow based on digital technology for scanning and stereoplotting. Topics like image matching or the integration of digital point transfer in our current aerotriangulation workflow will be addressed in a second implementation run after the stereoplotting environment becomes fully operational, and are not covered in this paper. It is necessary to point out that this paper is based

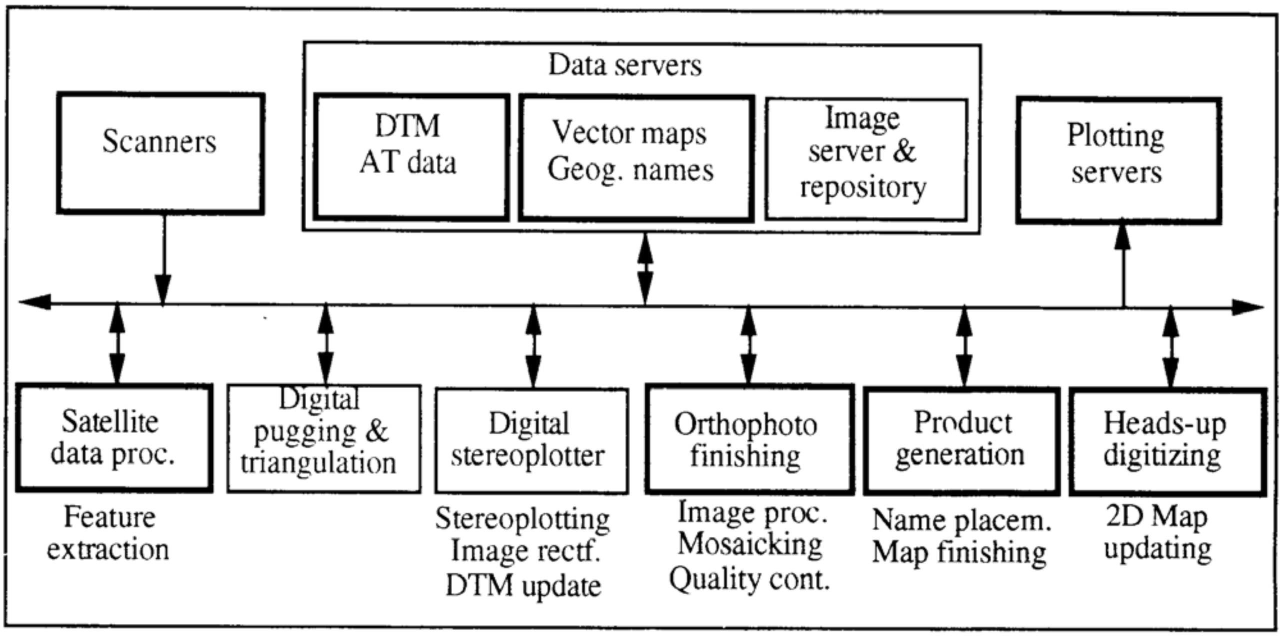

Figure 1: Systems architecture for digital photogrammetry.
(boxes with thin outlines signify systems in development)

on the present capabilities offered by our two photogrammetric systems; therefore, some decisions being taken at this moment or some comments made about their current or near future functions are likely to become obsolete quite soon.

2. OVERVIEW OF THE WORKFLOW

Looking at old maps superimposed on top of new photos leads to a variety of decisions that can range from simply discarding the old map and compiling it again ab initio, or leaving it unchanged. Errors in the old maps are clearly visible with superimposition, leading to the same type of decisions as those mentioned above. In order to obtain homogeneous criteria for the updating processes, an experienced operator will orientate the stereopair, retrieve the old map, examine it on the stereo workstation and decide what to do with the map. He will then save the orientation and image files on an Exabyte tape or on the data servers via Ethernet. Production operators will then retrieve the image and orientation files and perform the updating tasks.

For updating DTM data, we will take advantage of the stereo superimposition to interactively check and edit old profiles and breaklines. Breaklines corresponding to new planimetric features (new roads, rivers, etc.) will be added to the old ones and used in computing the triangular model from which contours are derived. The derived 3D contour lines will be visually checked on screen and profiles and breaklines edited if errors are discovered. Finally, the triangular model will be converted to our standard 15x15m DTM grid and stored as a tile in the DTM database. In order to assess continuity on this database, superimposition will be used again for checking the new inserted grid with the neighbor DTM tiles.

For the digital orthophoto subproject, the system we have developed ourselves is certainly suitable for the job, but we plan to split the undertaking in two parts: image rectification will be done after the DTM update on the stereo workstations and the most delicate part (radiometrically continuous mosaics, image enhancements and quality control) on our existing environment. The reason for splitting our workflow comes from realizing the fact that over the years the rectification software has remained largely unchanged, while the image processing part has undergone continuous developments for implementing new capabilities as new kinds of requirements have been set, or problems asking for special ad-hoc software have appeared[1].

3. SCANNING

The scanning environment for digital photogrammetry relies on the Zeiss/intergraph PS1 scanner. The PS1 is a flatbed B/W and color scanner that uses a CCD linear array as the scanning device. The PS1 is able to deliver up to 7.5 μm 8 bit pixels proportional to either transmissivity or density values from positive or negative photographs and to optionally compress the image on-the-fly using a hardware board that implements the JPEG compression standard (Wallace91). In all the cases, the system scans at 7.5 μm and delivers output resolutions at 7.5, 15, 30, 60 and 120 μm. The PS1 can scan any user-defined area on the photograph and relate this area to the fiducial marks, thus eliminating the need to scan the entire film just to include them. However, in the present software release, the inner orientation is not passed along to other application software (ie. orientations in the photogrammetric workstation); this option is therefore not used in our workflow.
The measured maximum and minimum density values of the photo are used by the PS1 software to compute an on-line mapping function which converts the internal 13 bit input to the 8 bit per pixel output. The mapping function is linear in the case of selecting transmissivity as the scanning mode, and logarithmic in the case of scanning in density mode. The system can also deliver output values according to a user-adjustable logarithmic curve; in this case, the operator can use three parameters for controlling the output radiometry: the minimum and maximum density values and the parameter of the curve. From our relatively limited experience of operating the PS1 it can be said that good results can normally be obtained by setting only the minimum and maximum densities measured from the densitometer and by using the system's default mapping function for densities. However, the situation is different when radiometrically difficult photos are to be scanned; in this case we use a trial and error methodology, resembling the methods frequently used by operators in graphics arts for top quality scanning. To help the user in this process of trial and error and to provide quality control, the PS1 provides image visualization tools, including histogram and pixel analysis and interactive visual evaluation of the results of changing the logarithmic curve parameter.
In our normal workflow, negatives are converted to density range reduced diapositives using a dodging contact copier. Since the PS1 can deliver a positive image from a scanned negative one can theoretically spare photolab processing. As mentioned, results with standard parameter settings are normally satisfactory, except in the case of negatives with wide density ranges (ΔD on the order of 1.6D), where vertical stripping might appear on extreme dark areas (on the negative) depending on the selected scanning parameters. Although acceptable for visual interpretation during stereoplotting, any artifact can become even more visible after edge enhancement processing during image rectification. In summary, quality scanning is a critical issue for digital photogrammetry which deserves full attention and effort, not only in terms of maintaining the system in a perfect

[1]For example, we are currently focusing on the problems of image reconstruction for eliminating the atmospheric turbulence on color high altitude flights.

calibration status[2], but also of achieving the necessary level of expertise in setting scan parameters for radiometrically difficult photographs.

3.1 Image compression

As implemented on the PS1, the JPEG compression/decompression hardware uses a parameter (Q parameter) for controlling the degree of compression to be applied to the image. It is up to the user to set a value for this parameter, which affects the final size of the image file and thus the compression ratio achieved. This ratio is different for each image (and for the same image scanned with different scan parameters or resolutions) because the JPEG compression is data dependent: for a given value of Q, images with many fine details achieve a lower compression ratio. The Q parameter is not related to any quantitative measure of the information lost during the compression process; therefore, the user has to choose it subjectively by using a visual tool which displays an uncompressed window around a user-selected point and the corresponding compressed one. He/she can then interactively increment or decrement the Q parameter and view the results. The manufacturer advises the user not to go above a Q value of 35 from a scale that ranges from 1 (no compression) to 799, and to use a value of 25 for images that are to be compressed again, as happens during epipolar resampling.
Although we visually tested higher compression ratios with no apparent loss of feature sharpness, aggressive compression produces blocking artifacts along the boundaries of the independent basic unit of processing of the JPEG algorithms (8x8 pixels), specially on homogeneous areas. Note again that any artifact can become potentially enhanced by image resampling/enhancement algorithms, and thus potentially endanger for the final quality of the printed orthophotomaps. In summary, after visually testing the compression effects on small details at 7.5 and 15 μm images, and even though our inclination was towards higher Q values, we decided to use a value of 30. Achieved average compression factors are roughly of the order of 4 for 15 μm images and 5 for 7.5 μm ones. The same Q value used during the epipolar sampling process (which involves a decompression and a compression) leads to average compression factors of 3 for both resolutions. Loss of geometric accuracy with other Q-values has not been tested.

4. DIGITAL STEREO WORKSTATIONS

A brief summary of the Intermap 6487 and DiAP photogrammetric stereo workstations installed at the ICC can be found in Table 1. In what follows in this section, we will review some of their features in relation to the topics discussed in this paper.

[2]Two good tips for achieving stable quality scans on the PS1 are the following: periodically control the CCD gains and offset coeficients computed during the self radiometric normalization step and used by the system to compensate for the individual radiometric behavior of each CCD element; and calibrate the scanner to the user's densitometer readouts.

	DiAP	Intermap 6487
CPU	Compaq 486/66-32MB	Clipper 400-64MB
Disk	2x1GB	3x1GB
Image processor	no	VITEC 50 (300Mops)
Compression hardware	no	JPEG
Screen	Hitachi 21"	Intergraph 27"
Graphics adapter	Artist XJS (TMS34020)	Intergraph EDGE II+
Frame buffer (pixels)	1024x768	1664x1248
Screen dot size	319 μm	318 μm
Video RAM (VRAM)	2MB (on the Artist XJS)	40 MB (VITEC-50)
Colors	256	16 Mi
Stereo technology	Shutter - CristalEyes	Shutter - CristalEyes
Menu tablet	no	yes
Cursor and controls	foot pedals and hand wheels	10 button hand-held cursor
Basic graphics software	μStation	μStation
TIN/Contouring	yes	yes
Digital orthophoto	yes	yes

Table 1: Current configuration of the stereo workstations installed at the ICC.

Besides the JPEG compression board, the main hardware difference between the DiAP and the Intermap 6487 is the VITEC real-time image processor. The VITEC takes care of the real-time image roaming and of all radiometric interpolations, including those available for display (Table 2). On the configurations without the VITEC processor (or with the VITEC turned off) the CPU takes care of the interpolations carried out in the batch processes (epipolar resampling and image pyramid generation), but does not actually support either bilinear or cubic convolution interpolated display zoom or real-time image roam. On the DiAP, bilinear sampling is used for image pyramid generation and nearest neighbor interpolation for zoom. Image roaming is implemented directly on the Artist XJS board; however, at the time this paper is being written, continuous roaming with vectors superimposed only works reasonably well (ie. without jittering) on quite small windows.

Function	Options available	Options currently used
Write/Read image to/from disk	JPEG comp/decomp.	JPEG with Q=30
Epipolar sampling (geometry)	Anchor points	Anchor point spacing=32
Epipolar sampling (radiometry)	NN/BI/CC†	CC with edge sharpening
Image pyramids	Averaging/Subsampling	Pixel averaging
Interpolated display zoom	NN/BI/CC	BI if zoom > 2.0/NN if less

†NN: Nearest Neighbor, BI: Bilinear, CC: cubic convolution

Table 2: Interpolation and resampling methods in the Intermap 6487.

Although interpolation methods do not add more information to the images, they allow the user to identify and draw features faster[3], at the price of delaying screen update times (see section on display dynamics below). Without bilinear or cubic convolution interpolation, the pixel staircase effect starts to become visible at zoom factors greater than 2.

4.1 Display dynamics

The DiAP and the Intermap 6487 are able to work in two modes: fixed cursor/moving image (continuous roaming) and fixed image/moving cursor. In the first mode, the cursor remains fixed in the center of the screen and the displayed image follows the movements of the operator by continuously updating the screen at video rates. In the second mode, the image remains fixed and the cursor moves on the screen. In this mode, the operator has to explicitlly change windows in order to move across the image; this action involves the complete update of the screen. In order to free the operator from this task, systems implement automatic window centering (step roaming) that automatically centers a new display area around the cursor when approaching the edges of the window; this action involves a complete update of the screen. The step roaming technique is an economical alternative to continuous roaming, since no special hardware is required for implementing it. In our case, this technique is the one used on the DiAP because of its weakness in continuous roaming. The 6487 can also be operated using this technique by simply switching off the VITEC processor.
The user obtains free x-parallax vision around the cursor by removing it with 'z' and updating the screen. If the terrain is too hilly, the user must frequently launch screen updating, thus delaying stereoplotting. In continuous roaming, the system is constantly resampling the images using the actual 'z' value, thus no specific screen update command is necessary. In addition to not having to delay stereoplotting, this operation mode has been considered more comfortable since the operator does not have to force his or her vision to compensate for x-parallax.
In order to achieve acceptable display timings, both systems use main memory for buffering image tiles before loading them to the display hardware. Delays 2.5 times longer than the ones shown in Table 3 can occur if the system has to access the disk to load new tiles not found on memory. In the case of the Intermap 6487 in fixed image/moving cursor mode with the VITEC turned on, the image tiles are also loaded to the image processor for interpolated zoom (the VITEC also buffers image tiles). In continuous roaming, the image tiles are dynamically prefetched to the VITEC in advance; however, the user may find delays in waiting for disk transfers if roaming is too fast (usually when one tries to merely roam around wihtout drawing anything). Good practices for IO and memory tuning are required in both configurations, including spreading the stereopair files on two disk drives. Both systems use the image pyramids to speed up the image display at low zoom factors. As is easy to imagine, 24 bit color images suffer from higher delay penalties because of the increased demand for memory.
Screen update delays also depend on the selected display window size and the interpolation method used for zoom. Some figures are given in Table 3 for typical window sizes and 15 μm images during step roam without any disk access. 30 MB free main memory and 40 MB VRAM on the VITEC were available on our 6487 stereo workstation for image buffering. No equivalent figures were known for the DiAP, except the VRAM size of the graphics controller (2MB).

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[3]The productivity on updating the 1:50000 topographic map using 2.5 meter pixel digital orthophotos from a 1:70000 flight was improved by 8% once we changed the pixel interpolation from bilinear to cubic convolution with edge sharpening during the orthophoto generation and after improving the image contrast with local stepwise functions.

	DiAP	Intermap 6487
Typical working window size (pixels)†	≈ 1000x650	≈ 1521x1069
Update time (zoom≈2.0, nearest neigh.)	≈ 2"	≈ 3" (VITEC off) / ≈2" (VITEC on)
Interpolated display (zoom>2.0)	NA	BI ≈ 7" / CC ≈ 9"

†Note that the 6487 typical window size exceeds the one in the DiAP by a factor of 2.5. If one reduces the 6487 window to the DiAP size, the timings are NN=1", BI≈4" and CC≈5.5".

Table 3: Typical display timings.

From the point of view of display timings, it is clear that one should avoid high order interpolated display as much as possible, even in continuous roaming mode (the systems supports faster roams if nearest neighbor sampling is used for zooming). Perhaps recognizing this fact, a recently announced software version for the 6487 will provide for discrete zoom factors (ie. 0.5, 1.0, 2.0, etc.), which are expected to speed up screen update time thanks to the simplification of the interpolating algorithms. Whether or not this discrete zooming will also be implemented for display interpolations in the non-VITEC configurations of the Intermap is not known to the author at present.
Changing zoom while in continuous roaming mode is not supported in the present version of the Intermap 6487. Instead, one has to disable continuous roaming, choose the desired zoom factor and enable enable continuous roaming. Since for this mode the system has to build a special vector display list for the superimposition, changing zoom can take a couple of minutes if the amount of graphic information is large. The available image enhancement functions cannot be used in continuous roam mode either; again, one has to quit the mode, set the new parameters, and enable it again, as explained before.
When we made practical tests of the two mentioned operation modes, step roaming was considered an acceptable alternative to continuous roaming, but only for map revision tasks. This was quite an attractive result since systems with only this feature are appreciably cheaper (ie. the 6487 without VITEC or the DiAP with its currently rather limited roaming). However, we also concluded that continuous roaming was absolutely necessary for compiling new maps (specially for contour lines), and that bilinear or cubic convolution interpolation methods should be used for zoom display if pixel shapes are visible.

4.2 Epipolar resampling and image pyramid generation

There is currently no need for epipolar resampling on the DiAP. The image pyramids used to speed up display at low zoom factors are generated during the reformatting process (from sequential to tiled) and add 33% more information to the image files. On the 6487, the epipolar resampled images are smaller than the original ones since during the process the images are clipped to the model area or to any user-defined (smaller) area inside the model. This latter feature is very interesting for projects in which only a small zone is to be compiled (ie. a road trace for road design projects). As in the DiAP, the size of the final images is increased by 33% because of the image pyramids, but can be reduced to 8% by simply eliminating the 1/2 pyramid level used for display at the (seldom used) zoom factors between 0.25x and 0.5x. File sizes and timings on Table 4 are for the full set of pyramid levels. Epipolar resampling and image pyramid generation can be done using the VITEC for radiometric interpolations or entirely on the workstation CPU, in which case the processing times shown on Table 4 will be multiplied by 4 (only case at 15 μm has been tested).

5. PUTTING THE SYSTEMS INTO OPERATION

5.1 Scanning resolution

The 1:5000 topographic and orthophoto updating projects rely on our standard country-wide 1:22000 B/W flight with photos taken by last generation cameras with FMC and high resolution film. We can thus assume 60 lp/mm photographs (0.37 m/lp ground resolution). This resolution doubles the available one used in the first version of the map (0.73 m/lp) and satisfies the recommended 0.5 m/lp ground resolution for 1:5000 mapping in Germany (Jacobsen92). Assuming a perfect scanning process, pixel resolutions for our 1:22000 are 0.33 m/pixel for 15 μm scans and 0.17 m/pixel for 7.5 μm. As is known, conversion factors for translating m/lp to m/pixel vary from 2 to $2\sqrt{2}$; by taking the average of both factors it is easy to see that 15 μm scans barely honor the resolution used so far with the old imaging systems, and does not match the recommended ground resolution for this scale. Changing the 1:22000 photo scale was not under discussion because it allows for the direct production of 1:5000 orthophotomaps (without mosaic) for the majority of mapsheets[4].

5.2 Data management

From the point of view of data management, 7.5 μm resolution file sizes (1.0 GB per full image) were considered difficult to manage, specially for data transfer and storage, and for preprocessing (epipolar sampling and image pyramid generation). The typical figures to be dealt with can be found in Table 4. Our average scanning throughput for 'easy' photographs is one full 15 μm scan every 22 minutes and a 7.5 μm scan every 53 minutes including operator overhead time for parameter set-up and visual quality control. For radiometrically difficult photos, the scanning throughput is considerably less.

With compression, timings for data saving/restoring operations to/from Exabyte 2.5 GB tapes are quite acceptable for 7.5 μm images (13 minutes), and almost negligible for 15 μm scans (6 minutes). Furthermore, it is possible to save scanned images to 2.5 GB Exabyte tapes in batch while the PS1 is scanning the next image, and to load images during stereoplotting on the 6487 without any noticeable penalty in display dynamics. The same situation for non-compressed images leads to 21 minutes for 15 μm images and 83 minutes for 7.5 μm ones; restoring image files on the the DiAP PC in parallel with stereoplotting is of course not possible.

Management of free disk space can be a complicated issue, specially if the system is configured short on disk, but can be solved with a strict operational methodology (ie. epipolar sampling requires three times the original file space because it opens an input, an output, and a temporary file simultaneously which should be on separate disk drives for maximum IO efficiency; furthermore, display dynamics are improved if the image files forming the model are stored in two separate disk drives).

On the other hand, compression does not reduce data processing times in the preprocessing tasks. Since the VITEC is allocated for dynamic roaming, it is not possible to run VITEC-based epipolar resampling and stereoplotting simultaneously. However, preprocessing can run overnight or on a remote node, so processing time should not be a problem while no future additional heavy computational tasks (ie. image reconstruction or similar image enhancement algorithms) are

[4]On our existing production system (based on a VaxStation 3100/76 workstation - roughly equal to a 486/66 Mhz PC for such tasks), a digital orthophoto at 1:5000 can be produced every 45 minutes of elapsed time without mosaic, but at a rate nearly 4 times less if mosaicing is involved.

required. In this case, a powerful image server devoted to such preprocessing tasks would be the solution.
We did not test 7.5 μm scans on the DiAP; however, one can estimate that the system would have to deal with approximately 2.6 GB files per stereopair (2x1.3 GB stored on two separate 2 GB disks) after file reformatting and image pyramid generation. We are now trying to achieve low data transfer times by installing an Exabyte tape and a JPEG board which would allow us to decompress off-line on the PC.

System	resol. μm	size MB	comp. size	scan time	save+restore times‡	preproc. time†	final size MB)
6487	7.5	1000	165	53'	0'+0'	2x110'	2x130
6487	15	250	63	22'	0'+0'	2x25'	2x65
DiAP	7.5	1000	NA	53'	30'+83'*	80'*	2x1300*
DiAP	15	250	NA	22'	0'+21'	20'	2x300

†Epipolar sampling, model clipping and full pyramids on 2 images on the 6487. Tiling and pyramids on 1 image on the DiAP.
‡Saving/restoring can be done in parallel with scanning and also with plotting on the 6487.
*Not tested. Values estimated from the 15 μm case.

Table 4: Systems management parameters assuming one of the two images forming the stereopair is already at the workstation.

In summary, 7.5 μm images do not appear to be so difficult to manage if data compression and enough data processing resources are available. However, our experience on other image processing applications shows that high data volumes make computer environments far from being sufficiently flexible in day-to-day situations. Note anyway that these types of resources (disk and CPU) are the ones experiencing the biggest growth (and biggest reduction in prices) in the computer industry, in contrast to the situation for display subsystems, where high capacity and high performance image processors are still very expensive, specially if true 24 bits color and real-time processing are required.

6. RESULTS

Even though our data management concerns for 7.5 μm images were considerable alleviated after the first tests, we still wanted to carry out practical tests to find out wheter 15 μm images were really unable to fulfill the requirements for our 1:5000 topographic map. The obvious reason for this was to make the systems environment more flexible, specially regarding the DiAP. Therefore, we compiled a stereopair at 7.5 and 15 μm resolutions on the 6487 in continuous roaming mode and checked them together for completeness, drawing quality and accuracy.
Images coming from negatives were preferred to photographic diapositives, and 7.5 μm images were preferred to 15 μm images, although film grain became visible depending on the zoom factor used. Zoom factors for 7.5 μm images were 1.6 on urban areas and 1.2 on open areas. The 15 μm images were rated as barely acceptable, specially on urban areas where operators were using a zoom factor of 2.3; a zoom factor of 2 was used on open areas. The pixel staircase effect was not present because of the bilinear interpolated zoom, but images started to appear slightly blurred. The same 15 μm images on the DiAP showed the staircase effect because of the lack of bilinear interpolation.

When we superimposed the maps compiled at different resolutions, minor differences were found on open areas, but drawing quality problems (notably non-squared buildings) were discovered on dense urban areas. Geometric accuracy requirements (0.2 mm at the map scale) were, however, honored in all cases. The results of our tests can be summarized as follows: with the 1:22000 photo scale, there is a real need for 7.5 μm scans for stereoplotting on densely built-up areas, but 15 μm images can be used in open spaces. In both cases, zoom factors are less then 2, thus allowing for the fastest display dynamics in step roaming mode. In this mode, only moderate map updating can be performed; continuous roaming is required for more intense updating.

6.1 Additional remarks

Operators really appreciated the advantages of the color stereo superimposition, but noticed how critical a proper choice of the color palette for graphics can be. The very thin graphic elements used in the special display list for continuous roam should not use pale colors because they can hardly be perceived on high contrast areas; in addition, colors used for highlighting or rubber-banding graphic elements should not be white or of a too pale color. Fortunately, these problems can be avoided to some extent by carefully designing the color palette used for vectors and by interactively changing the contrast and lightness of the screen. As a general rule, it is advisable to provide middle tone images for stereoplotting operators.
A second comment comes from the realization of the fact that superimposition can mislead operators in cases where lines are snapped to the 2D projection of a 3D graphic element. In this case, vectors visually appear to overshoot rather than to perfectly connect together, as can be verified by setting the stereo workstation in 2D display mode, or having a second screen just for vector display.
Proper configuration of the screen area is another important issue, since a larger screen area devoted entirely to display of the stereoimage allows for a larger field of view. Therefore it seems wise to control the number of menu panels permanently open on screen. Using pull-down menus to reduce this problem was not really a good solution because operators were constantly selecting menu buttons just to start a new data capture command. After some time using pull-down menus, they were discarded in favor of the well known menus attached to the sensitive table of the 6487. At the time of writing, this option was not available on the DiAP.

7. CONCLUSIONS

In this paper we have presented our initial experiences in establishing a stereoplotting environment for map updating based on digital photogrammetric scanners and stereo workstations. It is worth reiterating that some of the comments, remarks and conclusions are to be put in the context of the current functionalities of our systems because the development of computer technology brings new hardware and software releases with constantly enhanced capabilities.

Based on work undertaken so far, our major concern arises from the realization of the fact that the potential for mapping from smaller photo scales offered by new cameras and films is pushing scanning and digital photogrammetric technology to its current limits. Although experiences with 7.5 μm images have been positive enough, we know that operating at the limits of a technology is not particularly confortable for day-to-day operations, and that it requires costly high-end systems and skilled manpower just for systems management. As they stand, digital photogrammetric stereo workstations are probably questionable if used for single stereoplotting-only projects. For the time being, a wise approach is to become familiar with this technology by undertaking projects involving automatic DTM generation and digital orthophoto, and to take advantage of this type of projects as a means of becoming familiar with digital photogrammetry and then to work out one's own conclusions.

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