ADAM TECHNOLOGY

PROMAP ORTHO System 2 vs. Digital Softcopy: A Comparison

Introduction

ADAM Technology is often asked to explain the benefits and disadvantages of using a hybrid system like the PROMAP ORTHO instead of a pure Softcopy system. While ADAM obviously has a vested interest in the answer to this question, this report is an honest attempt to compare the two approaches and highlight the benefits and disadvantages of each.

Four types of photogrammetry-related work will be considered. These are:

1. Traditional vector mapping,
2. Aerotriangulation,
3. DTM generation, and
4. Orthophoto production

Analytical systems are normally used for vector mapping, aerotriangulation, and DTM generation, while Softcopy systems are generally used for aerotriangulation, DTM generation, and orthophoto production. The ADAM PROMAP ORTHO System 2 bridges the gap between these two distinct technologies, allowing a single, cost-effective system to be used in all four areas.

PROMAP ORTHO vs. Softcopy

There are two key differences between an analytical system like the PROMAP and softcopy technology. The first is that a softcopy system requires an extra pre-processing step, as the images it needs to function must be transferred into digital format by scanning. The second is that softcopy systems offer the ability to automate some aspects of production — notably aerotriangulation and DTM generation. Whether the automation abilities of softcopy technology are worthwhile depends on a number of factors that will be outlined below.

Scanning

Analytical systems like the PROMAP always operate directly with the original diapositives with full access to all available information. Softcopy systems are dependent on the digitised versions of those images, generated by a photogrammetric scanner. There are several aspects of scanning that are often overlooked when considering a softcopy system:

- **Price.** Photogrammetric scanners range in price from slightly less than a PROMAP to more than three times the price of a PROMAP. In order to make such a purchase cost-effective, most users only purchase a scanner when they also have a considerable number of softcopy systems that will use the data produced by it. Users with a small number of softcopy systems generally pay a third party to scan the images for them instead. By doing this, they then sacrifice control of the production process and become dependent on that third party when trying to meet timing commitments.
- **Storage requirements.** In order to capture all of the information contained in a diapositive, scanning pixel sizes in the 6–12 micron range would be required. However, even at 8 microns per pixel, a single 230mm × 230mm image would require a total of 2.4 *gigabytes* of storage — or approximately four CD-ROMs! Even at a more modest 21 microns per pixel, each image requires over 340MB of storage.
- **Time.** The time taken to prepare an image for use in a softcopy system is often grossly underestimated when looking at the scanning speeds advertised for photogrammetric scanners. It can easily take 10 minutes to configure the scanner for operation, another 5–10 minutes to scan per image, up to 10 minutes to transfer each image across a 10Mbit Ethernet network, and around 10 minutes to prepare ("pyramid") each image prior to operation! If a third party is performing the scanning, the time taken to organise, schedule, and transfer the images must also be taken into account. Also, while the images are with the third party for scanning, they cannot be used with any analytical systems in the meantime.
- **Accuracy.** As mentioned above, scanning at a resolution that would capture all of the information that is available to an analytical operator results in images that are unmanageable by any current system, and will remain that way for some time to come. To overcome this problem, softcopy users typically scan at much lower resolutions, in the order of 15–21 microns per pixel, although even at these sizes only one image can fit onto a single CD-ROM.

The issue of accuracy with softcopy systems has become so serious that the Western Australian Department of Land Administration (DOLA) recently issued a statement that only data captured with an analytical stereoplotter will be accepted from their sub-contractors for updating their cadastral information.

In addition to these problems, there are three more factors related to scanning that differentiate a softcopy system from the PROMAP ORTHO System 2:

1. When an image is scanned for a softcopy system, the entire image needs to be scanned in order for the softcopy system to see the fiducials necessary for an interior orientation. These fiducials are not needed by the PROMAP ORTHO System, because the interior orientation has already been performed in the normal manner. With standard model overlaps, just the central 28% of the image area needs to be scanned (40% of the width and 70% of the height).
2. The accuracy of any operation on a softcopy system is determined by the accuracy of the original images. For this reason, small pixel sizes are required to capture the data in the original image. When producing an orthophoto, however, pixel sizes of 30 microns or larger are perfectly adequate. An entire image scanned at 30 microns requires less than half the storage of an image scanned at 21 microns, and ¼ the storage of an image scanned at 15 microns!
3. The PROMAP ORTHO System 2 orthorectifies the scanned image on-the-fly — only pixels that will be present in the final orthophoto are ever written to disk. A softcopy system needs to store the original images on disk first, and these images will need to be read from and written to many times over the course of production.

The PROMAP ORTHO System 2 is therefore a very cost-effective solution to all of these problems:

- The marginal cost of adding the ORTHO System 2 to a PROMAP is much less than the cost of any photogrammetric scanner of similar quality that we are aware of.
- Because images only need to be scanned for the final orthophoto production stage, just 28% of the area of any image needs to be scanned, and it can be scanned at far lower resolutions that needed for softcopy systems.
- The extra time taken to scan an image once it has already been set up for digitising is extremely small. On a modern PC, it can take as little as an extra 2 minutes to scan and orthorectify the model area of the current image (Table 1).
- Because the original diapositives are used for all data capturing work at all times, the maximum possible accuracy is always maintained. The potential loss of digitising accuracy caused by scanning the images first is eliminated.

Table 1. Orthophoto generation times (only central 28% of image scanned).

Pixel Size (microns)	File Size (MB)	Scanning Times (MM:SS)	
		533MHz Celeron	1GHz Athlon
30	47	2:21	1:56
25	68	3:34	2:19
20	106	5:33	3:42
15	188	9:07	5:22
8	662	29:51	15:40

Table 2. Full image scan times.

Pixel Size (microns)	File Size (MB)	Scanning Times (MM:SS)		
		533MHz Celeron PROMAP ORTHO 2	1GHz Athlon PROMAP ORTHO 2	Vexcel Ultrascan 5000
30	168	8:15	6:09	N/A
25	242	12:21	8:23	~7 minutes
20	378	17:57	11:11	N/A
15	673	30:37	17:05	N/A

Automation

The biggest advantage of softcopy is the ability to automatically measure a large number of points in a pair of images for DTM or aerotriangulation purposes. Especially for aerotriangulation, as long as the source images are scanned at a reasonably high resolution, the results are very good. The reason for this is simple: "bad points" can easily be rejected.

There are two types of mistakes made by the image correlation techniques used in softcopy systems:

1. Points that do not correspond to the same feature are mistakenly matched.
2. "Inappropriate" points are matched.

In the first case, two points that really are *not* the same point are correlated and give incorrect 3D information. This can happen when there are many areas of the image that look similar when viewed very closely — different waves on a body of water, different trees in a forest, or different furrows in a field that has been ploughed. Most points of this type can be rejected during aerotriangulation, because the 3D information generated for the bad points will not be consistent with the model that is being formed. (Some bad points will still be accepted because they happen to be consistent with the model, but they do not matter for aerotriangulation purposes. For this reason, operators are sometimes surprised when they look at the points actually used for the model orientation — not all of them are valid, but it doesn't matter.)

Unlike aerotriangulation, DTM generation has no such "magic bullet" that can eliminate bad points of this type.

The second type of "mistake" is of no consequence for aerotriangulation, because all legitimate points will help form a correct orientation. When forming a DTM that is meant to represent the underlying terrain, however, there are many types of features that a human operator would not even think to digitise, because they can distinguish between the ground and other features quite easily. The image correlation software of a softcopy system, however, will quite happily detect points on the tops of houses and dense vegetation, as this recent article in GeoInformatics highlights:

"The data acquisition of Digital Elevation Models (DEM) by manual photogrammetric measurements has widely been replaced by automatic image matching… [These] techniques are generating digital surface models (DSM) with points located on top of buildings and dense vegetation and not on the ground, like mainly requested. Especially in urban areas and forests, a high percentage of points is not belonging to the solid ground. The manual editing of the DSM is very time consuming, limits the advantage of the new techniques and is a brake within the chain of automation." — Karsten Jacobsen, "New Developments in Digital Elevation Modelling — Problem of Automatic DEM Generation", GeoInformatics, June 2001.

Because of this, the performance gain of having the DEM points generated automatically is then largely lost by having to verify that all the points are indeed correct.

While advances are being made to rectify these problems, for now the biggest advantage softcopy systems have is in aerotriangulation — provided the costs and efforts of scanning make the advantages worthwhile.

Application Suitability

With the above background information, we are now in a position to assess the suitability of the PROMAP ORTHO System 2 and softcopy systems in each of the application areas mentioned in the introduction:

1. **Traditional vector mapping**. While softcopy systems *can* be used for traditional vector mapping, it is not as common as the other uses simply because they offer no real advantages over an analytical system, and suffer the disadvantages of accuracy limitations due to the image size tradeoffs and performance disadvantages due to the time it initially takes to set up a model for digitising (scanning, image transfer, pyramiding, etc.).
2. **Aerotriangulation**. Softcopy systems offer a real advantage in this area — they can quickly generate hundreds of points per model and automatically reject bad points when they are found. Aerotriangulation would have to form a significant proportion of a typical company's job mix before it became cost-effective to use softcopy technology, however.
3. **DTM generation**. The benefits in this case are less clear than above, simply because human intervention is required to ensure the DTM is accurate. When coupled with the overheads of using a softcopy system in the first place, the benefits of automation are largely lost in this case.
4. **Orthophoto production**. While both types of system perform this task well, the advantages inherent in the on-line approach adopted by the ORTHO System 2 can be a major advantage.

Conclusion

Which system to purchase depends heavily on individual circumstances. Both are capable of performing the work possible with the other, but the appropriateness and cost-effectiveness of each varies depending on the application.

The only situation where we think softcopy provides a significant advantage would be in a large company that spends a significant portion of its resources on aerotriangulation in a country where operator wages are high. Even in such a situation, however, unless the scanning workload is very high and a dedicated scanner is warranted, the ORTHO System 2 add-on to the PROMAP can be a very effective photogrammetric scanner for output to softcopy systems. The combined system is cheaper than most scanners, and it can still be used productively even when there are no images to scan.

In all other situations, the ADAM Technology PROMAP ORTHO System 2 is an excellent, low-risk alternative to purchasing a softcopy system:

- It features proven and reliable analytical technology that provides the accuracy demanded by the most exacting jobs without having to sacrifice the ability to produce orthophotos; and
- It allows an organisation to maintain complete control over the production process without having to purchase an expensive scanner that would sit idle most of the time.

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