

INTRODUCTION OF THE 3-DAS-1 DIGITAL AERIAL SCANNER

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ABSTRACT:

This paper describes the capabilities and preliminary results from a new digital photogrammetric scanner, the 3-DAS-1, which is a joint development between Wehrli & Associates and Geosystem. The system consists of the camera, a new stabilized platform, modules for power, control, and data collection, and software for diagnostic evaluation, system operation, and photogrammetric image processing. The system is based on the three line scanner approach, and is designed to address the photogrammetric needs of the civil mapping community. First aerial imagery is, at the time of writing, just about to be collected. Laboratory imagery and evaluations are presented in the paper.

1. INTRODUCTION

Based on work done collaboratively between Wehrli & Associates and Geosystem during the last decade to develop and manufacture a series of photogrammetric film scanners, it was decided in 2001 to continue this collaboration with the development of a digital airborne scanner for the direct acquisition of digital photogrammetric imagery. The 3-DAS-1 is based on the well known three line scanner principle, hence the acronym. It is designed to address the civil mapping market. Wherever possible, all components of the system have been selected to modular, COTS (commercial off the shelf), and upwardly mobile. A pre-production model of the system has been completed, see Figures 1 and 2, and laboratory evaluations have been carried out. At the time of writing, first airborne data is about to be collected.



Figure 1. 3-DAS-1



Figure 2. 3-DAS-1

2. SYSTEM DESCRIPTION

The three sensors are part of the Kodak family of KLI trilinear (RGB) CCD arrays. This family of sensors is available with 6000x3 12 micrometer pixels, 8000x3 9 micrometer pixels, and 14400x3 5 micrometer pixels. Mechanically and electronically, the three types are interchangeable. Early computations indicated that, at typical line rates for fixed wing aircraft, the 8000x3 array would accumulate sufficient charge to support high quality intensity quantization. The higher pixel count array might be suitable for slower line rates associated with helicopter platforms, and provide a migration path for higher spatial resolution.

Rather than attempting the use of a single, exotic objective lens to cover the entire field of view over the forward, nadir, and backward looking arrays, a separate objective lens is used for each array. We have selected the well known family of Rodenstock Sironar HR objectives. This family of lenses is of recent design, especially created for use with digital sensors. The lenses are available in focal lengths of 35mm, 60 mm, and 100mm. The 100mm lens has been selected for the current

model of the 3-DAS-1. Figure 3 shows an evaluation of the modulation transfer function for this lens.

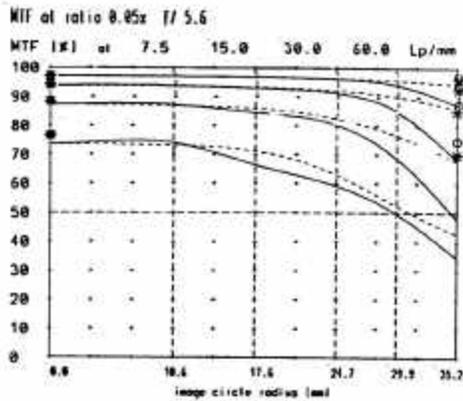


Figure 3. MTF for 100mm lens

The 3-DAS-1 system software runs under Windows XP. The scanner electronics, designed by Geosystem, is in firmware and thus upwardly mobile with technical developments and future requirements. The transfer of image data from the sensor electronics to the computer is by the Camera Link standard, at 12 bits, to a PCI-X 64 bit line grabber. The camera link also provides a control channel and the downloading of new firmware. Tests show that data from all 9 lines can be simultaneously recorded to disk at 800 lines per second. A suitable computer with adequate mass storage for a typical 3-4 hour should host the system. The geometry of the convergence has the central camera looking at nadir, the forward looking camera inclined at 26 degrees, and the after looking camera inclined at 16 degrees. This provides two channels with conventional base-height configuration, and a third channel to provide additional, redundant parallax, but also to provide fill-in in case momentary turbulence degrades the nadir channel. Measured lens distortion data are shown in Tables 1 and 2. The angles are decimal degrees and the distortion is in millimeters. Figure 4 shows a block diagram of the system.

Pixel	Angle	Dist.
150	-18.750	-0.002
350	-17.825	0.002
550	-16.893	0.001
750	-15.950	0.003
950	-15.000	0.002
1150	-14.040	0.004
1350	-13.074	0.000
1550	-12.100	0.000
1750	-11.118	0.000
1950	-10.130	-0.003
2150	-9.136	-0.003
2350	-8.137	-0.006
2550	-7.131	-0.006
2750	-6.123	-0.008
2950	-5.107	-0.005
3150	-4.092	-0.008
3350	-3.071	-0.005
3550	-2.046	0.000
3750	-1.024	-0.001
3950	0.000	0.000

Table 1. Lens distortion data

Pixel	Angle	Dist.
4150	1.023	-0.001
4350	2.047	0.001
4550	3.070	0.004
4750	4.088	0.001
4950	5.108	0.006
5150	6.120	0.003
5350	7.132	0.008
5550	8.136	0.004
5750	9.136	0.003
5950	10.132	0.005
6150	11.118	0.001
6350	12.100	0.000
6550	13.074	-0.002
6750	14.040	-0.004
6950	14.999	-0.004
7150	15.949	-0.005
7350	16.891	-0.004
7550	17.824	-0.004
7750	18.749	0.001
8000	19.885	0.002

Table 2. Lens distortion data

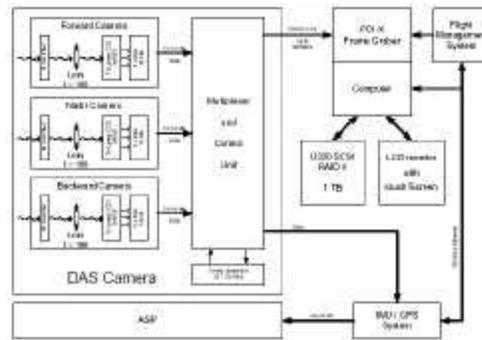


Figure 4. System block diagram

Early computations indicated that existing stabilized platforms designed for use with film cameras were not accurate enough for use with aerial three line scanners. This prompted us to design a new stabilized platform, ASP-1. Our platform is a very simple kinematic design where the pitch and roll actuators tilt the camera adapter plate as commanded by the IMU module. Initial evaluation for this platform indicate an accuracy of 0.02 degrees for pitch and roll, and 0.05 degrees for yaw. A unique feature of this new platform is the capability (for frame cameras) to provide forward motion compensation, FMC. We consider the ASP-1 to be an integral module of the 3-DAS-1. Compatible IMU-GPS systems would be the Applanix 410 or 510. Integration is also being made with the Trackair Flight Management System.

An overview of software for the 3-DAS-1 is summarized in the following lists.

DAS scanning software:

- Compresses and displays grabbed image in real-time mode, allows to switch cameras while running.
- Builds histograms for every camera image in real-time mode.

- Calculates statistics for every camera image in real-time mode (minimum, maximum, average, median and deviation).
- Allows to display image in different modes: RGB, R, G, B and Gray scale.
- Performs gamma-correction for every camera image.
- Allows to adjust LUT for every color channel using curves (curves can be saved and loaded for further use).
- Supports different operation modes taking into account color lag.
- Allows to adjust internal program parameters like number of buffers and size of buffers manually.
- Provides different image saving options:
 - Selecting cameras to write and cameras to ignore.
 - Color depth for every camera (8 ... 14 bits per channel).
 - Color channel for every camera to save (RGB, R, G, B, Gray scale).
 - Image compression (lossless, lossy) – not realized yet.
- Reads and writes camera's registers using terminal.
- Contains settings window with simple hierarchical structure to adjust most used board registers (frequency, exposition, etc).
- Saves received images to HDD applying image correction and visualizes writing process.
- Automatically creates image map (for further comfortable work with large raster files) and saves it to HDD.
- Automatically numerates output files, creates info-files with all necessary information about images.
- Displays total size of saved image, free disk space, writing time, etc.

DAS Viewer:

- Opens RAW-files of unlimited size, supports both color and gray scale images with bit depth from 8 to 16 bits per channel.
- Uses image map for quick image navigation.
- Saves image fragments to RAW, BMP and TIFF formats with various bit depth.
- Cuts images to fragments with defined size and overlap.
- Builds histogram of user-defined image fragment for every color channel.
- Performs image correction (brightness, contrast, gamma or curves) in 16-bits per channel mode.

DAS Photogrammetric Processing:

- Level 0 to Level 1 conversion
- Channel pairwise rectification for stereo compilation and matching
- DEM generation
- Ortho rectification

3. RESULTS

As mentioned the 3-DAS-1 is just about to acquire first aerial data. The following terrestrial image, Figure 5, was acquired from one channel out of a window in the laboratory. Figure 6

shows a zoomed in detail of the antenna mast in the background. The antenna was 2.3 kilometers from the camera.



Figure 5. Terrestrial image from 3-DAS -1



Figure 6. Close-up of antenna

4. CONCLUSIONS

Directly acquired digital imagery is seeing widespread acceptance in the photogrammetric community. The combination of a wide field of view three line scanner and a new, high performance stabilized platform appear to make the 3-DAS-1 an attractive system for large scale topographic mapping, and associated tasks. Coming tests with aerial imagery over controlled target fields will be made to quantify geopositioning performance.

5. REFERENCES

1. Gruen, A., Zhang, L., 2002. Sensor Modelling for Aerial Mobile Mapping with Three-Line_Scanner (TLS) Imagery. ISPRS Commission II Symposium on Integrated System for Spatial Data Production, Xi'an, PRC
2. Hoffman, O., Nave' P., Ebner, H., 1982. DPS A Digital Photogrammetric System for Producing Digital Elevation Models and Orthophotos by Means of Linear Array Scanner Imagery. *Int.*

- Arch. of Photogrammetry*, Vol. 24, Part B3, p. 216, Helsinki.
3. Muller, F., 1991. Photogrammetrische Punktbestimmung mit Bilddaten digitaler Dreizeilenkameras. *Deutsche Geodatische Kommission, Reihe C*, Nr. 372, Munchen
 4. Sandau, R., et al., 2000. Design Principles of the LH Systems ADS40 airborne digital sensor. *Int. Arch. of Photogrammetry and Remote Sensing*, Vol. 33, Part B1, p. 258
 5. Tempelmann, U., et al. 2000. Photogrammetric Software for the LH Systems ADS40 Airborne Digital Sensor. *Int. Arch. of Photogrammetry and Remote Sensing*, Vol. 33, Part B.