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Artikel: Digital Mapping Camera DMC : designed for practical use

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Digital Mapping Camera DMC – designed for practical use

With the introduction of the new aerial digital mapping cameras, the operational aspects for aerial photo flight projects will change. New task, like digital image data handling and data copy in the field, will be implemented into the workflow. Instead of a film, digital data will be shipped and archived. The camera operators and the crew have to get familiar with the new work steps. The Z/I Imaging DMC Digital Mapping Camera System is used as an example to explain the benefits of a digital photoflight process.

Mit der Einführung der neuen digitalen Kameras ergeben sich für die Kamerabedienung neue Gesichtspunkte. Neue Dinge, wie z.B. der Umgang mit digitalen Bildern oder auch die Datensicherung unterwegs, müssen in den vorhandenen Workflow einbezogen und berücksichtigt werden. Anstelle des Films werden digitale Bilder verschickt und archiviert. Der Operateur und die Flugzeugbesatzung müssen sich mit dem neuen Arbeitsablauf vertraut machen. Am Beispiel der DMC (Digital Mapping Camera) sollen die Vorteile des digitalen Bildflugs erläutert werden.

Avec l'introduction des nouvelles caméras numériques, de nouveaux points de vue apparaissent en ce qui concerne leur maniement. De nouveaux éléments, comme par exemple, l'emploi d'images numériques ou la sécurité de transmission des données doivent être intégrés dans le workflow existant dont il faut en tenir compte. Au lieu du film, on envoie et archive des images numériques. L'opérateur et l'équipage de l'avion doivent se familiariser avec le nouveau déroulement du travail. A l'exemple du DMC (Digital Mapping Camera) les avantages du vol aérien numérique seront expliqués ci-après.

Con l'introduzione delle nuove fotocamere digitali cambieranno gli aspetti operativi dei progetti dei voli fotografici aerei. A livello operativo si introdurranno dei nuovi compiti, come la gestione dei dati dell'immagine digitale e il salvataggio dei dati sul posto. I dati digitali non saranno su film ma saranno inviati e archiviati. L'operatore e l'equipaggio dell'aereo devono padroneggiare le nuove fasi di lavoro. Partendo dall'esempio del Z/I Imaging DMC Digital Mapping System si presentano i vantaggi del volo fotografico digitale.

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1. Flight planning

Usually the photo flight starts with the mission planning. A digital mapping camera thinks in ground samples distance (GSD) or ground resolution and not in photo scale. The flying height, the focal length and the pixel size of the CCD sensors are the parameters used for the calculation. For frame based cameras like the DMC, side overlap and forward overlap for stereo coverage follow basically the same rules like for film cameras.

ISMP ImageStation Mission Planning software is a modern tool for photo flight mission planing. Raster backdrops can be displayed to support the user, DTM's can be used for correct overlap calculation. The ISMP software is a stand alone product, but it is also part of the DMC system.

2. Camera operation

The camera operation of a frame based digital camera like the DMC is very similar to the operation of an analog camera. The film magazine is replaced by a ruggadized mass storage unit, which can be, in case of the DMC, exchanged in the air during the flight to extend the capacity, like swapping film rolls. A new generation of flight management systems like the Z/I ASMS Airborne Sensor Management System controls the camera system and provides information for the pilot on a display in the cockpit. A big advantage is that the camera operator can have access to the acquired image data between the flight lines or during the flight back from the mission to the air field. This is a huge benefit against film cameras because it allows a real time image quality assessment. But this is only true for frame sensor based cameras not for push broom or CCD line sensors based cameras.

To maintain the quality for a photo flight, information about cloud coverage is very important. Therefore the ASMS (Airborne Sensor Management System) has an integrated video camera which displays the image scene during the time the exposure is taken. A video thumbnail pertains to each exposure, the thumbnails can be mosaicked to an overview to get an impression of the complete mission (see figure 2). The camera operator can then easily identify each exposure where the cloud coverage was to much and mark these images for second shot.

3. DMC digital mapping camera

The Digital Mapping Camera DMC is a frame based large format aerial camera, designed for high precision large scale engineering application as well as for small scale mapping projects. The DMC uses CCD frame sensors with a 12 micron pixel size, which means 144 square micron of light sensitive area.

It is the nature of a CCD that the light sensitivity increases straight linear with the light sensitive area, which means that a 12 micron CCD is approx 3.5 times more sensitive comparing to a 6.5 micron CCD – the typical format of a line sensor pixel. In connection with the much longer exposure time possible, the frame sensor has an up to 50 times higher sensitivity resp. better signal-to-noise ratio than a line sensor. This enables you to fly under

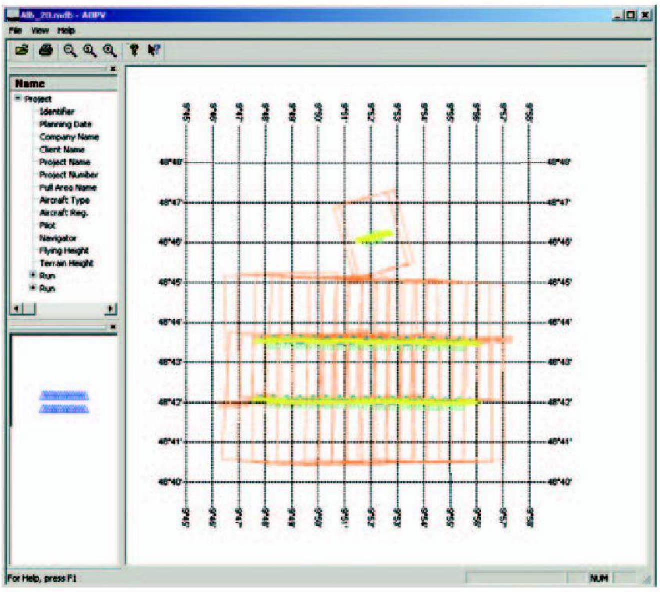

Fig. 1: Flight project overview.

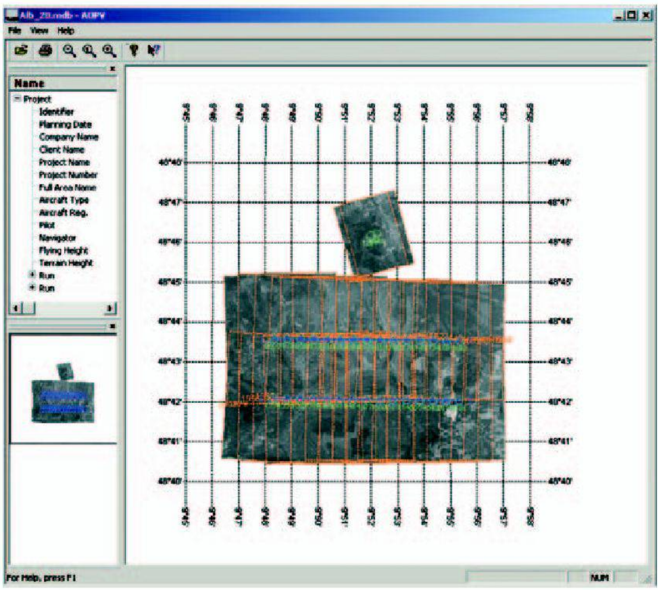

Fig. 2: AOPV airborne on-board project viewer.

worse light conditions or with lower sun angles and still fulfill the quality requirements of the mapping standards.
Because of it's multi sensor multi spectral design the camera also fits perfectly for remote sensing application, like forestry analysis or agriculture monitoring. Forward motion compensation FMC is used for aerial film cameras to improve the image quality and to avoid image blurring. The DMC has an implemented electronic FMC, which is a huge advantage and not possible with CCD line sensors. For large scale mapping project or for photo flights with long exposure time (weak light conditions) a FMC is a perquisite.
The DMC is a wide angle camera with a focal length and a field of view similar to a RMK TOP 15 film camera. The final image size of the DMC is 13824 x 7680 pixel. The footprint of this image has the same width of a film based aerial image (across track) and approx 60% of the length (along track, in flight direction). Thus, the number of flight lines will remain the same compared with a film camera, and so the flying costs.

4. FDS flight data storage

The DMC camera system is using FDS (Flight Data Storage) units. Three units are required for a system; each FDS can store 250 GB of data, which means in total 750 GB, equivalent to 2200 aerial images. They will be installed in the aircraft with a base plate, usually mounted to the seat rails of the aircraft. The FDS can be installed and removed without disconnecting cables and without using any tools. If multiple FDS's are available, an exchange will be possible in the air during the photo flight to extend the storage capacity.
The FDS is a flexible and versatile data storage system, designed for airborne operation. It can be operated up to 5000 m or 16000 ft (8000 m or 26000 ft are optionally available) flying altitude in an non-pressurized aircraft. The FDS is extremely robust and shock proofed, data safeness is absolutely assured. For image data post processing, the FDS can be connected directly to a workstation in the office via a standard fiber channel interface.

5. Data handling in the field

After an aerial photo flight mission is completed the crew has to carry the data to the PPS station. Very often the airplane is on an «outbound mission» where the crew does not have access to the ground based post processing facility or the airplane has to get ready for the next mission as soon as possible. To save the da-

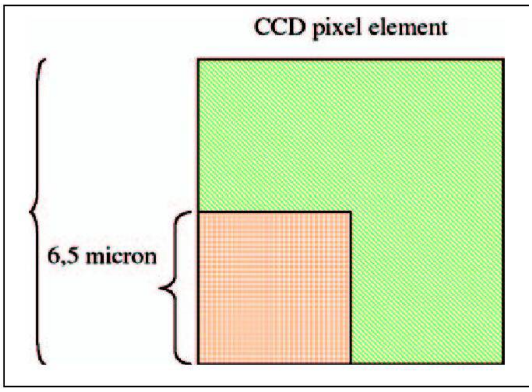

Fig. 3: light sensitive area of a CCD pixel element.

Fig. 4: flight data storage unit FDS.

Project	1	2	3	4
Area	City, Germany	County, Germany	City, Asia	State, US (DOQQ)
Area size [km^2]	890	12,000	230	
Photo scale , overlap	1:5,000; 60/30	1:13,000; 60/30	1:2,500; 60/30	1:40,000, pin-point
Runs , line [km]	50; 1,400	60; 6,300	59; 900	150; 45,000
Number of images	3,600	3,000	3,850	12,000
Flying time [h] , speed [kn]	13.5; 140	36; 160	12; 140	230; 180
Film type	Agfa X 100	Kodak SO359	Agfa X 100	Kodak Panatomic
Total project costs [$ US]	104,000	113,000	102,000	440,000
Savings by a DMC [%]*	79.5	65.5	81.5	56.5
Savings by a DMC [$ US]*	82,680	74,015	83,130	248,600

Table 1: aerial photo flight project dates.

* cost for a digital hardcopy approx. 50% of an analog hardcopy

ta in this case, Z/I Imaging had developed a mobile field data copy station to copy from the onboard mass storage device to a removable media like hard disks, USB disk drives or tape drives. The user can do this either in the aircraft, in an office or hangar at the airfield or in a hotel room. A full set of FDS can be copied in less than 4 hours to removable IDE disk drives. After the copy process, the media (e.g. removable hard disk drives) will be shipped to the home office like an undeveloped film.
The copy station can also be used as a utility for on-site image quality inspection. Software tools are provided to perform a quick view of the acquired images. The radiometric image quality can be evaluated immediately. This is a benefit against the film based camera, because the user gets an immediate feedback on the success of the mission.
A block diagram should illustrate the data flow.

6. Data post processing

Frame sensor based cameras have a straight forward way for the image data post processing by using standard photogrammetric algorithms. Because of the stable X-Y sensor geometry, GPS/IMU data are not required to create the final output image. The post processing time is much shorter comparing to line sensor cameras. The software is running on standard workstations and is not requiring any special computer infrastructure.
With a minimum level of user interaction the software automatically post processes the raw image data into the final frame. The output format can be specified, multiple formats like RGB and CIR can be created in parallel. It is possible to get high

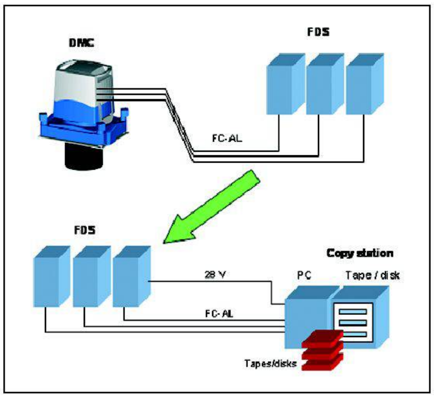

Fig. 5: Flight data storage connected to the copy station.

resolution color imagery or color infrared images within 24 hours after the photo flight.

7. Results

The photogrammetrical results using DMC imagery are impressive. All tests show that the precision of an automatic aerial trangulation as well as the automatic DTM calculation are twice as good as the results achieved with scanned analog images. The RMS of a aerial triangulation has a dimension of 15% of the pixel size, and the mean error of an automatically generated DTM measured against independent control points is better than 75% of the pixel size (i.e. with images flown at an altitude of 1500 m the mean error of the DTM is smaller than 10 cm!).

8. Cost comparison

If the costs for a photo flight with an analog and a digital camera are compared, it will turn out that the user can save money with the new digital technology. There are no costs for consumable material, like film and film chemistry. A statistic analysis of 4 aerial projects flown in the US, Asia and Europe (figures based on customer information) has shown that the costs for film and film development are between 16 and 20% of the total project costs (see figure 4).
Because of the 100% digital workflow, hardcopies and contact prints can be generated directly on high performance laser plotters, which is also a cost reduction comparing to analog copies. The costs for contact prints are between 13 and 19% of the total project costs. A direct digital print is approx. 50% cheaper with the same quality. The costs for film scanning are between 34 and 52% of the total project costs.
Table 1 shows the huge cost saving potential of a digital mapping camera. For these examples, the calculation of the savings are based on the Z/I Imaging DMC Digital Mapping Camera.

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