High resolution imagery for remote sensing

Peter Fricker
Leica Geosystems Geospatial Imaging
USA

The ADS40 Airborne Digital Sensor is currently the only commercial sensor capable of acquiring colour and false colour strip images in the low decimeter range at the same high resolution as the black and white stereo images. This paper delves into the technicalities of ADS40 and the role of high resolution colour imagery for orthomaps and remote sensing

Introduced in 2001, the Leica ADS40 was the first digital airborne sensor delivered commercially to the photogrammetric community. The primary guiding principle in the design of this sensor was to create an airborne imaging system which was not hampered by limitations known to the established photogrammetric community. The new design allows for an optimal adaptation to the needs of the digital workflow. The ADS40 Airborne Digital Sensor is currently the only commercial sensor capable of acquiring color and false color strip images in the low decimeter range at the same high resolution as the black and white stereo images. The high resolution of 12,000 pixels across the entire swath and 100% forward overlap in the image strips allow a variety of mapping applications to benefit from this sensor.

Orthogonal Projection
Although digital data processing opens the opportunity to implement computational methods to convert central perspective projection into an orthogonal projection, the line sensor's parallel perspective geometry offers a unique opportunity to produce images, which in the flight direction can be considered quasi-orthogonal projections. Line sensor data is as close to a map's orthogonal projection as is technically possible.

The nadir line CCD produces an image strip also called pixel carpet. This quasi-orthogonal image is as close to a perfect orthogonal image of the earth's surface as any image made through a single lens will ever get.

It is this close relationship between the nadir image captured from a push-broom sensor and a truly orthogonal projection which makes the ADS40 images attractive for further processing. The production of true orthophotos requires the determination of a Digital Surface Model (DSM) from all three panchromatic stereo images. Apart from this, the line sensor's 100% overlap of stereo strip imagery has other benefits:

- Minimal data for least occlusions in true-ortho maps
- Height/base ratio
- Forward Motion Compensation is inherent in the image acquisition principle
- Nadir image strip only uses the best part of the field of view
- Streamlined mosaiking of image strips
- Excellent tool for BRDF

Geometric Resolution
Since its market introduction, the ADS40 has been able to record panchromatic images with a ground sampling distance (GSD) as small as 5cm and RGB images with 15cm GSD under normal lighting conditions. Above 15cm GSD, both panchromatic and RGB images can be acquired simultaneously at the same high resolution. At the flying height of 1500m above ground where the ADS40 collects a 15cm GSD RGB image, a typical digital frame sensor camera collects an RGB image directly at 70cm GSD, which then has to be pan-sharpened to get closer to the ADS40's performance.

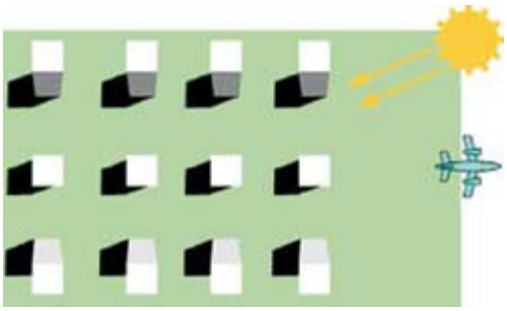

Fig 1 Parallel perspective from a push-broom sensor produces quasi-orthogonal images

The so-called high resolution RGB images from digital frame sensor cameras are in fact based on the technique of colorizing panchromatic images with a color pixel up to twenty-two times larger than the pan pixel. This pan-sharpening technique was rejected in 2003 by the U.S. Department of Agriculture (USDA) in the NAIP project because the radiometric information content can be distorted.

Proof of the exceptional image quality and area coverage capability of the ADS40 is the one million sq km flown in the National Agriculture Imagery Program (NAIP) project in the United States in 2004. The project required the delivery of one-meter resolution, colour images delivered as DOQQ sheets and county mosaics. One team was tasked with airborne digital acquisition of 90,000 square miles, comprising nearly 5,900 digital ortho quarter quads (DOQQs) of agricultural land. The required deliverables were completed within the 90-day timeframe, and image quality proved to be significantly better than film. The result was imagery with much higher detail that provided a uniform radiometric balance across the covered area.

Radiometric Resolution

The non-overlapping spectral bands of the ADS40 are designed specifically to satisfy the needs of photo interpreters and remote sensing applications concerned with vegetation classification. The main advantage of the ADS40 lies in the fact that the resolutions of the RGB images are the same as those of the panchromatic image. Thus no pan-sharpening (colorizing) techniques are required to produce a high resolution RGB composite.

Map Scale

Experience with digital images in the last three years has dispelled uncertainties concerning the relation of GSD and Map Scale. For mapping from digital imagery a certain GSD is required for the x-y accuracy. Practice has shown that for data extraction from directly acquired digital images, a GSD twice as large as that provided by digitized film imagery can be used to achieve the same positional accuracy as that which would be achieved with film based photogrammetry. An equivalent 10cm GSD resolution from color film in practice corresponds to a 20cm GSD from directly acquired digital imagery.

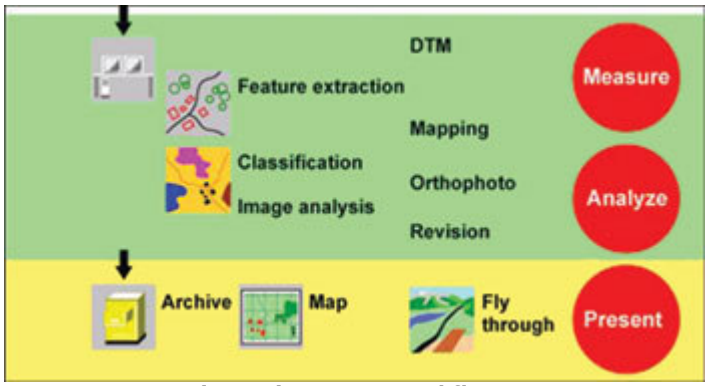

Fig 2 Leica ADS40 workflow 1

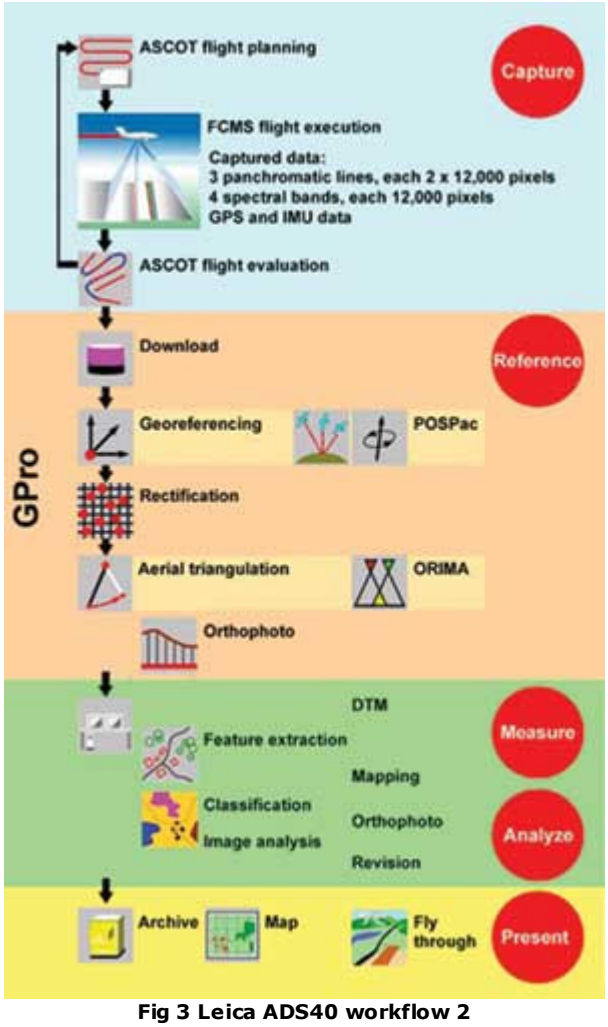

Fig 3 Leica ADS40 workflow 2

Reliable Digital Surface Models

The ADS40 is an excellent tool for true-orthophoto production when used with post-processing software that calculates a reliable DSM (Digital Surface Model) based on multiple image matching. The DSMs are also better than those derived from aerial photography because imagery from three or more viewing angles can be used to match points.

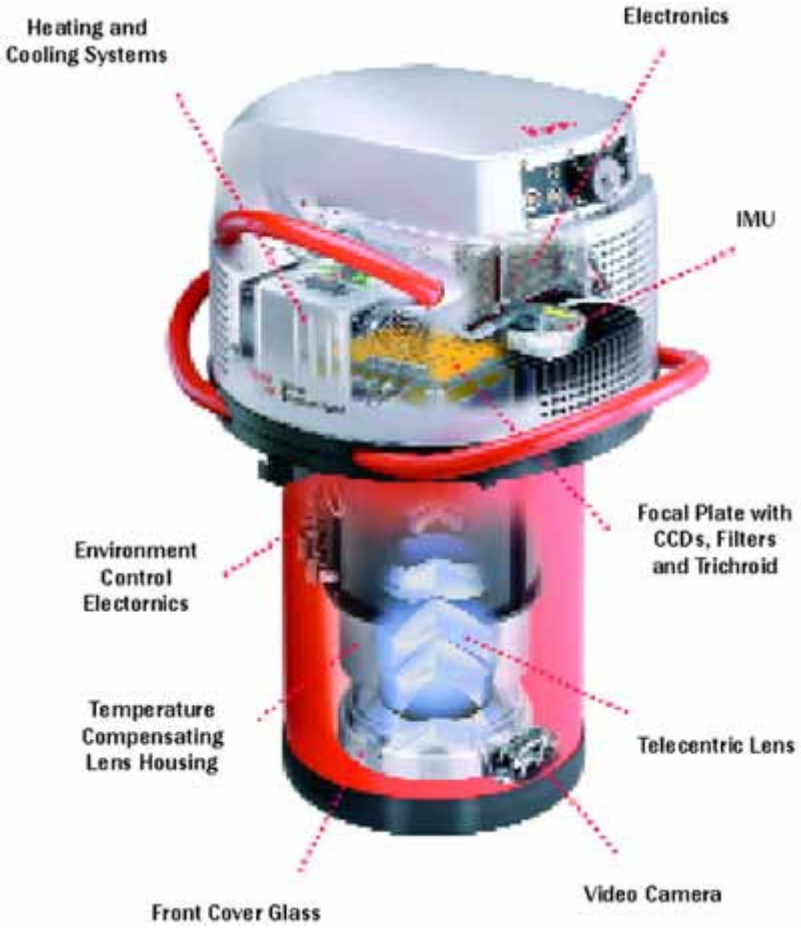

Fig 4 ADS40 Sensorhead

Fig 5 15cm-RGB, Vaihingen houses and backyards

Fig 6 5cm-Pan, Vaihingen houses and backyards

ADS40 as BRDF research tool in RS

Digital airborne surveys have become an integral part of forestland management, precision agriculture, environmental change detection and urban planning; in large part replacing extensive field surveys. With current digital mapping capabilities, acquiring fast, accurate imagery is now not only essential, but also cost effective. Whatever the user's needs he faces the challenge of choosing the best technology for his investment.

Precision techniques yielding high-resolution, geo-referenced, airborne digital imagery are designed to enhance human interpretation, classification and quantification techniques and to make trouble spots apparent at very short notice or well before any damage occurs. With the introduction of the airborne multiple-line, high-resolution push-broom scanner with its forward, nadir and backward looking scenes of the same area, a new tool has emerged which allows research in reflection properties of vegetation and soil - the so-called BRDF.

ADS40 Delivers

Only a large format surface array of 12,000 x 12,000 pixels having five transparent layers sensitive in the spectral bands red, green, blue, near-infrared and panchromatic could compete with the technology provided by the ADS40 equipped with multiple 12,000 pixel line sensors. Even if such a large surface array with 12,000 x 12,000 pixels and a pixel size of 6.5 microns would exist, it would also have to be able to store a staggering 720 mega pixels per image taken approximately every two seconds to compete with the present performance of the ADS40.

The ten image strips acquired simultaneously at the same high resolution - both in panchromatic and RGB spectral bands - makes the Leica ADS40 the only true large format high resolution multi-spectral digital sensor.