The Benefits of an Airborne Digital Sensor

An Advanced System for High-resolution Web-based Multi-spectral Imagery

by Peter Fricker

High-tech Pushbroom Capabilities

Airborne digital sensors are high-tech pushbroom scanners with in-track stereo as employed in the imaging satellites.

One such scanner is the Leica ADS40 Airborne Digital Sensor which was designed to incorporate the advantages of both the aerial camera and satellite pushbroom sensors in the airborne environment. Putting a pushbroom sensor on an aircraft was a special challenge achieved by putting a total of 10 Charge-Coupled Device (CCD) lines in the focal plane of a single high-resolution lens system.

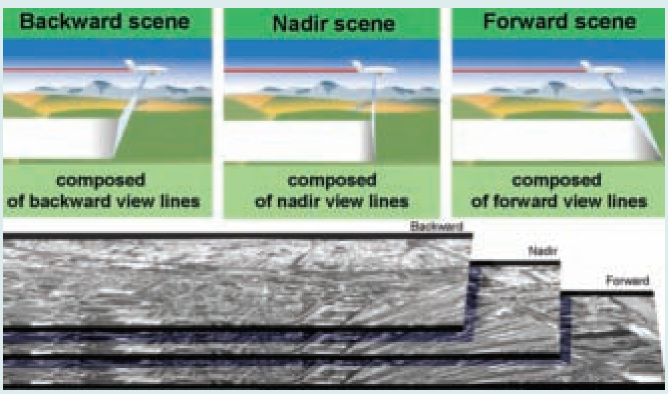

Figure 1. Three panchromatic CCD in backward, nadir and forward viewing angles provide in-line stereo imagery.

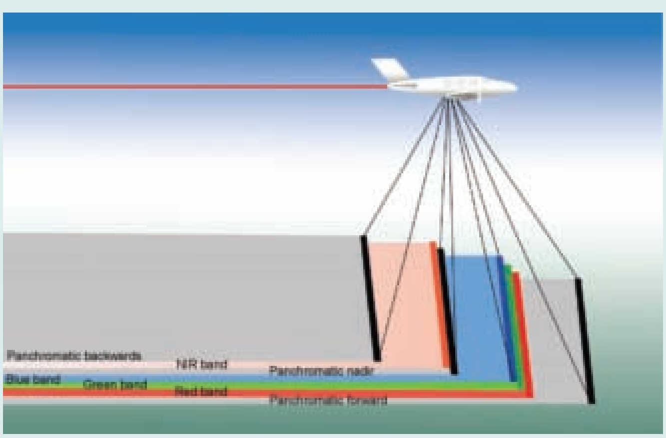

Figure 2. Additional 4 multi-spectral CCD's provide the color information.

Why is Spaceborne Imagery Not Replacing Airborne Imagery?

Although it is theoretically possible for spaceborne sensors to achieve better resolutions than 1m, there is a limit to the usefulness of the radiometric information contained in such a pixel. The atmosphere with all its impurities acts as an energy filter and has the effect of a dispersing media.

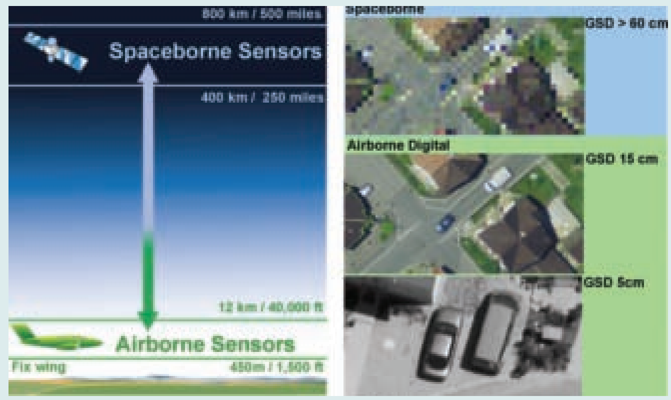

Figure 3. While satellite pushbroom sensors provide ground resolutions ranging from 60 cm to 30 m for mapping purposes, the ADS40 has a resolution range from 5 cm to 1 m.

Radiation energy diminishes with the square of the distance from the source. The further the sensor, which captures the reflected sunlight, is away from the object, the more difficult it is to resolve position and spectral information with accuracy.

Airborne sensor systems will always be able to exceed satellite system capabilities with respect to their combined spatial, spectral and signal-to-noise (S/N) ratio performance, because of the longer integration times available to airborne sensors (mainly due to the different platform speeds: airborne 60 m/sec compared to spaceborne 6000 m/sec).

Another advantage of airborne over satellite borne push-broom scanners is data on demand. This means location, time, image type and image resolution are driven by the application. Satellite images are only available if the fixed orbit and fixed resolution by coincidence suit the application. Most of the satellite imagery taken is plagued by cloud covers and time contiguous vegetation maps are difficult to come by. To cover large areas where the ground status has to be captured within a small time window, various airborne sensors can be flown simultaneously. This is impossible with current satellites – worse still, satellite revisit cycles are sometimes two weeks. Also, up-to-date airborne stereo multispectral imagery is still significantly less costly than satellite imagery, which still cannot provide resolutions in the range of half a meter or lower.

Raw Images With 10 to 100 Times Higher Resolution

Even the lowest possible satellite orbit is about 40 times higher than high-flying aircraft. These 1.3 to 2.5 Mio feet of space between spaceborne and airborne sensors will always result in differing performance. Stratospheric platforms, which theoretically could fill this gap, are experimental and characterized by largely uncontrollable trajectories. High Altitude Long Endurance Unmanned Aerial Vehicles (HALE UAV) which can stay at altitudes of 40-65,000 feet for

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months are still on the drawing boards or are extremely expensive military solutions.

While satellite pushbroom sensors provide ground resolutions ranging from 60 cm to 30 m for mapping purposes, the ADS40 has a resolution range from 5 cm to 1 m. The ADS40 can directly acquire RGB images with the same resolution as pan images from GSD sizes above 10 to 15 cm without having to resort to pan-sharpening or colorizing the pan image with a lower resolution RGB image.

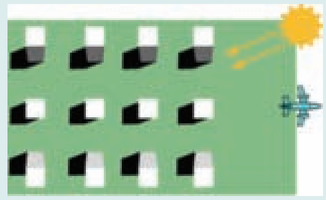

Figure 4. Parallel line perspective from a pushbroom sensor produces quasi-orthogonal images.

Orthophotos from Quasi-orthogonal Imagery

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 pushbroom sensor and a truly orthogonal projection which makes images such as those captured by the ADS40 attractive for further processing. The production of true orthophotos requires the determination of a Digital Surface Model (DSM) from all three panchromatic stereo images. However, the simple geometry of parallel perspective images makes the final product the most straightforward for automatic production.

Figure 5. Digital Surface Model (DSM) derived from Leica ADS40 stereo imagery. Image courtesy of EarthData Inc.

Figure 6. True orthophoto based on images and DSM derived from Leica ADS40 data. Image courtesy of EarthData Inc.

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