Airborne Laser Scanning

New Systems & Services Shown at INTERGEO 2006

Attempting to review all the products and services being offered on the stands of over 500 companies and organisations at the INTERGEO 2006 trade fair would require a squad of reviewers and occupy a whole issue of this magazine. Thus, when asked by the publishers to contribute a review based on my visit to INTERGEO, it seemed best instead to concentrate on a single well-defined area where a lot of activity was taking place at the fair. The most obvious area for someone with my interests was airborne laser scanning. Here quite a number of interesting new products and technical developments were to be seen, together with the provision of a growing number of related services. So I have tried to review this particular area under two main headings - (i) system suppliers; and (ii) service providers.

By Gordon Petrie

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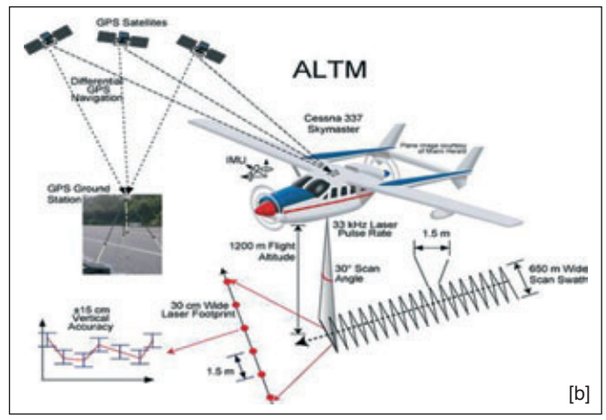
(a) The Optech ALTM Gemini system that was introduced at INTERGEO 2006. At back left is the case containing the control electronics; at back right is the scanning laser unit; at the front are the monitoring and operator control screens. (Source: Optech))



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(b) - Diagram showing the operational concept of the Optech ALTM airborne laser scanners, including the use of GPS in the aircraft and at the ground base station. Note the zig-zag pattern of the points being measured on the ground. (Source: Florida International University)

I - System Suppliers

(a) Optech

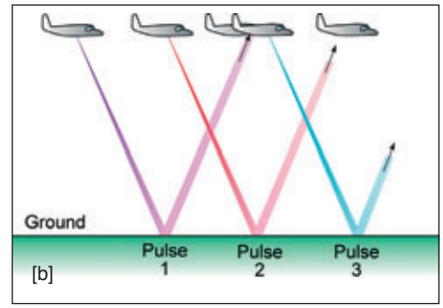
In terms of the overall installed base of airborne laser scanners, when viewed on a world-wide basis, currently the Optech company from Canada is the leading supplier in this field. Starting with its initial 1020 model from the early 1990s, Optech has steadily developed its ALTM (Airborne Laser Terrain Mapper) range of laser scanners via its ALTM 2000 series through to its current ALTM 3100 series that was first introduced in January 2004. In January 2006, it added its ALTM 3100EA (Enhanced Accuracy) model with a claimed accuracy of ±5cm in elevation from a flying height of 500m under optimum conditions. This particular model has sold well with sales to New Zealand Aerial Mapping (NZAM); Airborne 1 and the Carnegie Institution in the U.S.A.; TerraPoint in Canada; and Blom in Europe over the last few months. At INTERGEO 2006, Optech announced the latest model in its range, called the ALTM Gemini. This maintains the accuracy and performance of the ALTM 3100EA, but now offers its peak 100kHz pulse repetition rate at a much higher flying height - up to 2km - than before. In turn, this will allow a higher rate of area coverage of the terrain.

Optech has also offered medium-format digital cameras as an option that can be integrated with its ALTM laser scanners to generate imagery that can then be merged with the lidar elevation data from the scanners. In the past, Optech has used for this purpose the DSS cameras from Applanix, which also supplies the DGPS/IMU unit for the ALTM laser scanners. However, in 2005, Optech also concluded a formal agreement with Rollei for the development and supply of its digital camera. Since then, it has supplied a number of these for use together with its ALTM scanners.

(b) Leica Geosystems

In 2001, Leica Geosystems entered the airborne laser field by purchasing the small Azimuth company based in Massachusetts that had built a few of its AeroScan laser scanners prior to this takeover. After this acquisition, Leica then entered the field on its own account with the ALS40 scanner, followed by the upgraded and much more compact ALS50 model in 2003. This has had a considerable

(a) - The new Leica Geosystems ALS50-II airborne lidar showing (1) the laser scanning unit; (2) the laptop control unit with its touch screen; and (3) the control electronics box. (Source: Leica Geosystems)



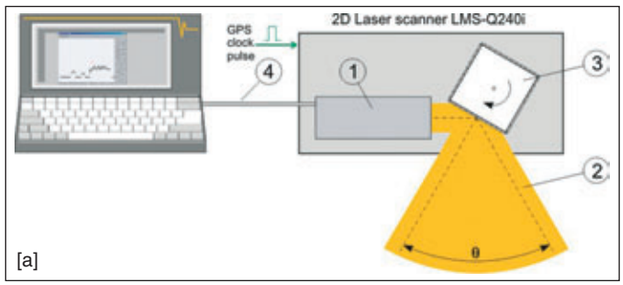
(b) - Diagram showing the concept of "Multiple Pulses in Air" (MPiA) that was introduced by Leica Geosystems at INTERGEO 2006. The technology will allow the next measurement cycle to begin before the ground reflections from the previous cycle have been received by the scanner. (Drawn by Mike Shand)

sale, especially in North America, where ALS40 & 50 scanners are in use with several of the larger commercial mapping companies, including EarthData, Horizons Inc., Kucera, LandAir, Merrick, North West Group and Woolpert, as well as a number of smaller companies.

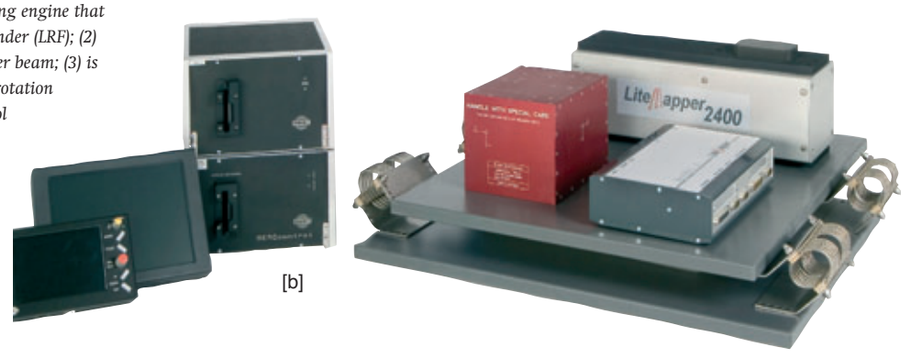
The ALS50 has now been replaced by the new ALS50-II model that was introduced at the ASPRS Annual Conference held in Reno in May 2006. Production of the ALS50-II is now being undertaken in Leica Geosystems main manufacturing plant in Heerbrugg, Switzerland instead of Massachusetts. The new ALS50-II model was again on show in Munich, complete with a smaller and lighter weight electronics unit and the new IPAS (Inertial Position & Attitude System) DGPS/IMU system. The IPAS system is also being employed in the second-generation ADS40 airborne pushbroom scanner that was also introduced at the INTERGEO 2006 fair. Some more details also emerged at INTERGEO 2006 regarding the high-performance European inertial units from iMAR (labelled NUS4) and Sagem (NUS5). These can, if required, act as the IMU com ponent of the IPAS10 unit in place of the American-made inertial units sourced from Litton (DUS5) and Honeywell (CUS6). This overcomes the restrictions placed by the U.S. government with regard to the supply of these American units to certain countries. In particular, the use of the European manufactured IMUs has allowed Leica to offer its airborne scanners to Chinese agencies.

Another very interesting and potentially very important announcement from Leica Geosystems at INTERGEO was that of its new ***"Multiple Pulses in Air" (MPiA)*** technology. This gives the capability for a laser rangefinder to fire off a new pulse without waiting for the reflection from the previous pulse being received at the rangefinder. Thus more than one measurement cycle can be taking place at any moment of time. The technology can be applied to both airborne and ground-based laser scanners. As a first step, Leica expects to offer its airborne lidar customers an upgrade path from the 150 kHz data acquisition rate of the ALS50-II to even higher rates. This will allow users of its airborne laser scanners to cover a significantly wider swath over the ground at the same densities as now or they can acquire greater densities of points within the present swath widths.

Like Optech, Leica Geosystems has supplied quite a number of medium-format digital frame cameras that have been integrated with its ALS laser scanners. They can be used to generate digital imagery that can be merged with the elevation data generated by these laser scanners. These cameras have been supplied by Applanix (DSS), Spectrum (NexVue) and Rollei (AIC). Apparently only a few of Leica's customers use its large-format ADS40 digital imager in conjunction with the ALS laser scanners. Indeed for many applications, such a combination could be regarded as overkill both in technical and financial terms. However, if a substantial proportion of the ALS scanners are being operated together with much less expensive medium-format digital frame cameras, then one could imagine that Leica might decide to keep the business in-house and



(a) Diagram showing the basic features of the Riegl laser scanning engine that is being used by several system suppliers. (1) is the laser rangefinder (LRF); (2) shows the angular coverage of the unidirectional scan of the laser beam; (3) is the rotating four-faced reflective polygon having an adjustable rotation speed; and (4) is the Ethernet LAN connection between the control computer and the laser rangefinder. (Source: Riegl)



(b) IGI's LiteMapper 2400 system. Sitting on an anti-vibration mount occupying the right side of this picture are the (white) Riegl laser scanning engine and the (brown) AEROcontrol GPS/IMU unit. On the left are the AEROcontrol computer and data storage units and the monitor and TFT touch screens. (Source: IGI)

The TopoSys Harrier 56 system (on the left) also uses a Riegl laser scanning engine. On the right is the control electronics unit for the Applanix DSS camera that is also offered optionally as part of the system. (Source: Applanix)

build its own medium-format digital frame cameras. Certainly it has the technical and manufacturing capabilities to do so.

(c) Riegl

Riegl from Austria has taken a totally different approach to the business of building and selling airborne laser scanners to that of the two market leaders discussed above. Instead it sells its LMS-Q240i and LMS-Q560 laser scanner engines comprising a laser rangefinder and a rotating polygon scanning unit to several different German system suppliers. They then add their own control electronics and DGPS/IMU units to make up a complete system that they can then offer to their customers. Three of these Riegl-based airborne laser scanner systems were shown or presented at INTERGEO:-

(i) IGI is supplying its LiteMapper 2400 and 5600 systems using the Riegl Q240 and Q560 laser scanning engines integrated with its own AEROcontrol DGPS/IMU unit. The LiteMapper system can also be supplied together with IGI's own DigiCAM digital camera based on the Hasselblad medium-format digital camera. Already six of these LiteMapper systems have been sold.

(ii) TopoSys is offering its Harrier 24 and 56 systems using the same two Riegl laser scanning engines as IGI, but in this case, integrated with Applanix POS-AV DGPS/IMU units. The Applanix DSS medium-format digital camera can also be supplied and integrated together with a Harrier system. Earlier this year, TopoSys announced the sale of a Harrier 56 system to a customer in Chile.

(iii) iMAR gave details of the iAIRSURV-LS1000 system that it has built for the ***Bewag Geoservice*** company (its Bewag parent being an Austrian power and energy supply group). This system also utilizes a Riegl scanner engine in conjunction with a DGPS/IMU unit of iMAR's own manufacture. This system also offers the possibility of a medium-format digital camera being integrated into the system - in this case from Rollei.

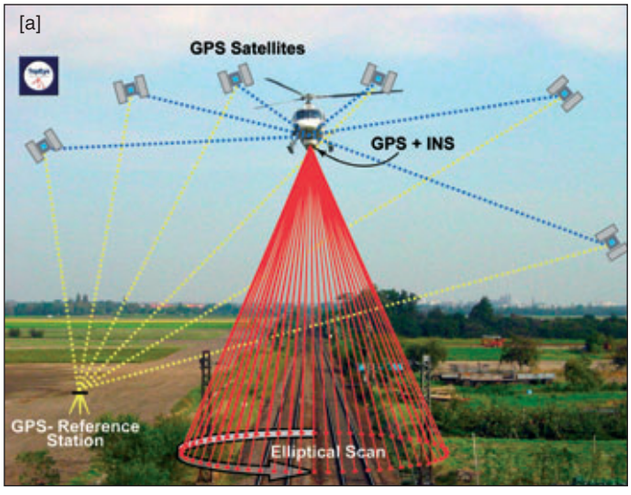
In addition to the supply of laser scanning engines to these three system suppliers, we also saw at INTERGEO 2006 that ***Riegl*** has built a complete airborne laser scanning system called the LMS-S560. This utilizes three of its LMS-Q560 laser scanning engines together with an IGI AEROcontrol DGPS/IMU system and a digital camera. This complete system has been mounted in a pod that has been fitted to the underside of an aircraft of the newly-formed Diamond Airborne Sensing company. It will be interesting to see how Riegl manages its relations with all these different competing system suppliers to whom it is supplying laser scanning engines, while still building and supplying a complete system on its own account.

(d) TopoSys (Falcon)

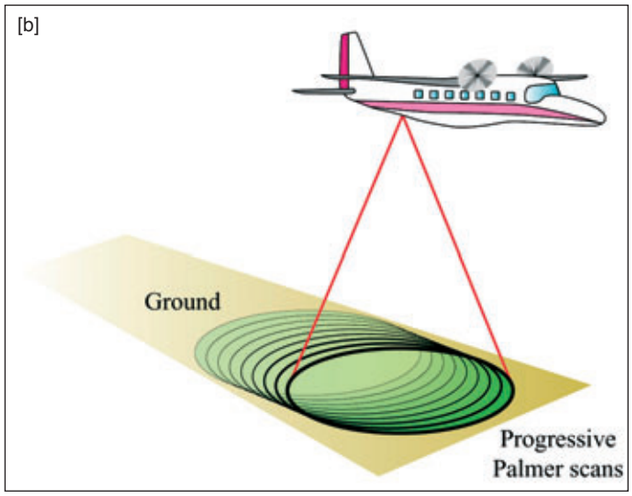
It is also worth recording that TopoSys showed an incomplete example of its Falcon III (first announced at INTERGEO 2005) on its stand at the exhibition. The previous Falcon I and II models with their distinctive fibre-optic laser scanner technology have been very well known in the past: indeed the Falcon I dates from around 1995. However only one or two of these earlier models have been sold over a ten year period. Thus the Falcon I and II have mainly been used by TopoSys to provide extensive airborne laser scanning services in partnership with a substantial number of commercial mapping companies all over Europe. The Falcon III will feature a higher data collection rate than the previous models.

(e) TopEye

The TopEye airborne laser scanner was another early system from the mid-1990s. Originally it was developed by a consortium of Swedish companies, principally Saab Combitech and Osterman Helicopters under the title of Saab Survey Systems. In 1999, Osterman purchased all the shares of Saab and changed the name



(a) The overall concept of the latest TopEye Mk. II system showing its elliptical (Palmer) scan of the ground and its use of GPS both in the air (in conjunction with an INS) and at the ground reference station. (Source: TopEye AB)



(b) The ground coverage of the TopEye Mk. II system using progressive Palmer scans. (Drawn by Mike Shand)

(a) Digital Surface Model (DSM) of part of the town of Novyi Urengoi located in the Tyumen region of Western Siberia. This DSM has been derived from airborne laser scanning carried out by the Geokosmos company for the Gazprom organization during its mapping of the large area of gas fields located in this region.

(b) The corresponding image of the same area formed by merging the elevation data of the DSM with the image data collected (in colour) simultaneously by a Rollei medium-format airborne digital camera. (Source: Geokosmos)

of the company to TopEye AB. In June 2005, Blom bought the TopEye AB company. At INTERGEO 2006, TopEye AB shared a stand with one of its partners, the German company, ***Nebel & Partner***, which uses TopEye AB to provide its airborne laser scanning services, mainly for surveys of transmission lines and other corridor-type applications. I was informed that all of the original TopEye Mk. I scanners have been upgraded recently by the Swedish AHAB company that was set up by three former Saab employees. The resulting TopEye Mk. II systems have new lasers, scanning optics and electronics. They also feature their distinctive elliptical (Palmer) scanning of the ground so that all ground objects are illuminated from two sides. Digital cameras from Rollei and Hasselblad have been used in combination with the TopEye scanners. Currently six of these second generation TopEye Mk. II systems are being operated in-house by the Blom group, while the other two are operated by the Aerotec company in the United States. All of these TopEye Mk. II scanners are being operated at lower altitudes (up to 800m) from helicopters, with the Blom Group using Optech ALTM scanners mounted on fixed-wing aircraft operating at higher altitudes for large-area coverage.

On the back of all this recent development carried out for TopEye AB, ***AHAB (Airborne Hydrography AB)*** is now offering its very similar ***TS 3.5*** airborne laser scanner to other customers for surveys being carried out over land. AHAB has also completed the HawkEye II airborne laser scanner that is being used for bathymetric surveys of areas of shallow water by ***Admiralty Coastal Surveys*** - which is a joint venture between the UK Hydrographic Office (UKHO), TopEye AB and AHAB. The two HawkEye Mk. I scanners developed originally by Saab and dating from the mid-1990s have been operated extensively (i) by the Swedish Maritime Administration, and (ii) by the Blom Nusantara company to carry out bathymetric surveys on behalf of the Indonesian Navy in the shallow waters around Indonesia's island archipelago.

A helicopter is being used by the Hansa Luftbild mapping company to acquire terrain elevation data utilizing an IGI LiteMapper 5600 airborne laser scanning system mounted externally in a Helipod box. (Source: IGI)

Conclusion

It can be seen that a significant number of important technical developments from the suppliers of airborne laser scanners were introduced or announced at the INTERGEO 2006 trade fair. In particular, the announcement of the new MPiA technology by Leica Geosystems could be very important in the future development of laser scanners. It is interesting to note also the quite different approaches being taken by system suppliers regarding the actual mechanisms being used to scan the ground. Thus the two market leaders, Optech and Leica, both use oscillating mirrors resulting in a zig-zag scanning pattern over the ground; those systems using the Riegl scanning engine employing a continuously rotating polygon give rise to a pattern of parallel scan lines; the TopEye Mk. II scanners are now using nutating mirrors to generate an elliptical Palmer scan pattern; while TopoSys has its unique fibre optic technology to generate a parallel set of line scans.

II - Service Providers

Turning next to the providers of airborne laser scanning services with stands at INTERGEO 2006, not unexpectedly, the vast majority of these were from Germany and Austria. However there were one or two notable exceptions - for example, the Russian Geokosmos company and Helica from Italy.

(a) Geokosmos

Currently this large company, with 250 employees, operates five ALTM 2050 and 3100 series airborne laser scanners. These are supplemented by Kodak DCS 760 and SLR Pro 14n digital cameras and by Rollei medium-format digital cameras. Recently the company has put a Vexcel UltraCam D large-format digital frame camera into service. Geokosmos has carried

out numerous airborne lidar surveys to create DTMs and DSMs of linear transportation infrastructure features such as roads, railways, canals, etc. It has also carried out flood plain mapping and the generation of 3D city models for telecommunication planning from airborne lidar data. In combination with aerial photography, it also produces ortho-rectified mosaics and maps. Furthermore, the company has also carried out numerous surveys of electric power lines and the associated power distribution infrastructure. While most of these operations have been carried out in Russia and the CIS states, Geokosmos is steadily extending its operations into the rest of Europe. To this end, its Geokosmos International arm has opened offices in Germany and the U.K. and has set up a joint venture company called ***G2B*** in partnership with the ***Groupe FIT*** company located in Nantes in France.

(b) Helica

This company is based in Amaro in north-east Italy close to the country's borders with Austria and Slovenia. It specializes in airborne laser scanning using a helicopter-mounted Optech ALTM 3100 system operated in conjunction with a RolleiMetric digital camera. Helica works in close collaboration with the Italian ***National Institute of Oceanography & Applied Geophysics (OGS)*** which is located close by in Trieste and undertakes much of the post-processing of the airborne lidar data and the production of DTMs and digital orthophotos. With this particular combination of expertise, much of the airborne laser scanning has involved coastal and flood plain monitoring and the mapping of hydro-geological hazards such as landslides. Interestingly, the partnership has also carried out a trial survey of the Marano Lagoon lying between Trieste and Venice in north-east Italy in collaboration with Optech using the latter's SHOALS airborne bathymetric laser scanner.

(c) Hansa Luftbild & TopScan

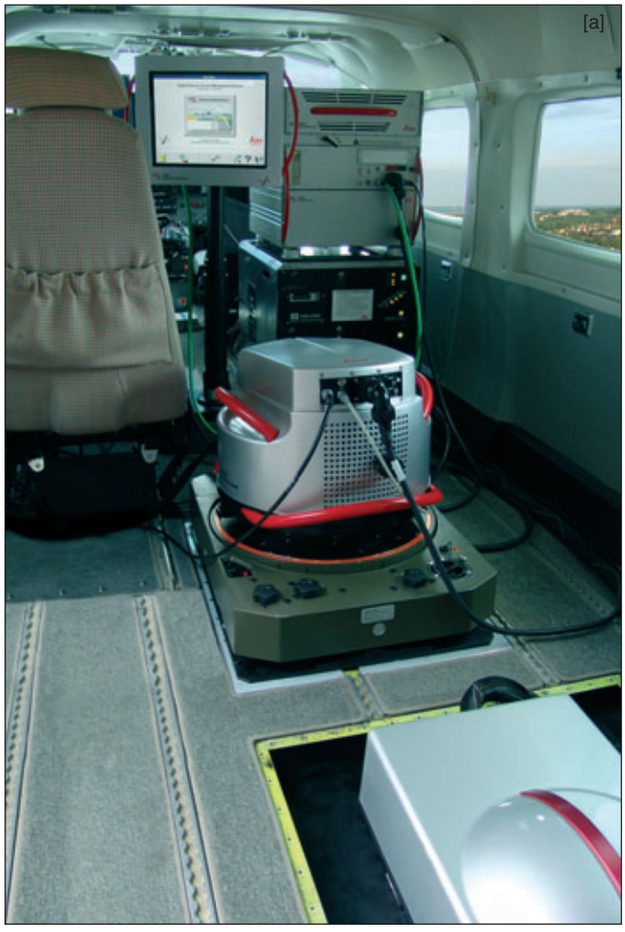
Hansa Luftbild is one of the oldest and largest German air survey and mapping companies and operates on a world-wide scale. For its airborne laser survey operations, it possesses an IGI LiteMapper system that is used especially for corridor mapping. However it has also carried out many projects in partnership with the ***TopScan*** company which specializes in airborne lidar. The latter company acquired one of the very first Optech 1020 scanners in 1993. Indeed this particular device, called "Big Blue", was being displayed on TopScan's stand at INTERGEO 2006. Since then, TopScan has acquired three additional scanners from Optech. These were ALTM 1225, 2050 and 3100 models that were purchased in 2000, 2003 and 2005 respectively. Each is equipped with a Rollei digital camera. The projects carried out jointly by the two companies include the same type of applications carried out by Geokosmos, but they also include the surveys of open-cast coal mines in the Ruhr and elsewhere. TopScan has also partnered with ***Terralmaging*** which has its head office in Amsterdam and branch offices in Berlin, Germany and Hautmont in France. It will be seen that this type of partnering is typical of this sector of the mapping industry and helps to offset the very large investment needed to purchase even a single airborne laser scanning system and to keep it fully employed.

(d) TopoSys

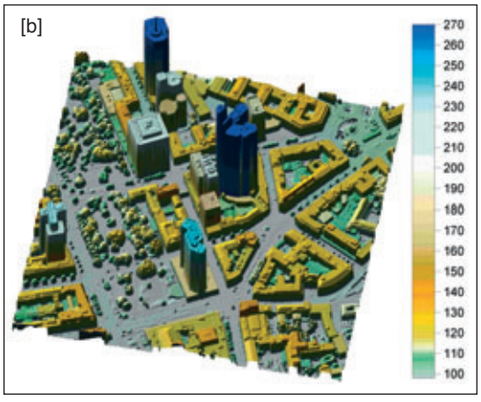
As noted above, the TopoSys company has used its home-built Falcon I & II scanners extensively for the provision of airborne lidar data. Of its German partners, the ***Geoplana*** air survey and mapping company also had a stand in the INTERGEO 2006 exhibition. This company possesses a Cessna 340 aircraft which is usually fitted with Zeiss RMK photogrammetric film cameras. However whenever the company receives contracts for the provision of lidar data, it replaces these cameras with one of the Falcon airborne lidar systems hired in from TopoSys. According to the TopoSys Web site, besides its network of German partners, the company appears to have similar relationships with the ***Aerodata, Eurosense*** and ***Sodiplan*** mapping companies based in Belgium and with the ***TTI*** company in France.

(e) Astec

Just prior to the INTERGEO 2006 fair, the ***Terra Digital*** company has been re-organised and re-branded as Astec. The company has been well known for some time as an operator of both of Leica's airborne digital sensor products - the ALS50 laser scanner and the ADS40 pushbroom scanner. In practice, the company has carried out projects all over Europe; only 20 to 30 % have been undertaken within Germany. Many of these projects have been collaborations with partner companies from other countries who do not own an airborne laser scanning system. They provide knowledge of the particular national market within which the contract is being undertaken, with part of the technical work being shared with the national partner. In a number of these contracts involving wide-area mapping, the ADS40 and ALS50 have been operated



(a) Dual operation of a Leica ALS50 laser scanner (in the foreground at bottom right) and an ADS40 large-format pushbroom line scanner by Terra Digital (now Astec).



(b) A 3D perspective view of part of the centre of the city of Frankfurt that has been constructed from airborne lidar elevation data acquired by an ALS50 laser scanner. (Source: Astec)

(a) This twin-engined Diamond DA42 MPP (Multi Purpose Platform) aircraft has been equipped with a specially built pod fitted below the aircraft to accommodate the Riegl LMS-S560 airborne scanning system.

(b) A close-up view of the belly pod containing the Riegl laser scanning system attached to the DA42 MPP aircraft. (Source: Diamond Airborne Sensing)

together in tandem. The resulting lidar elevation data is used first to create a DTM, which is sold as a separate product. The data is then used again in combination with the ADS40 linescan image data to generate digital orthophotos. For corridor mapping, a Rollei AIC medium-format digital frame camera is used in conjunction with the ALS50 laser scanner. The projects undertaken by Astec cover a wide and varied field, including 3D city modelling; surveys of open-cast pits; coastal monitoring and corridor mapping.

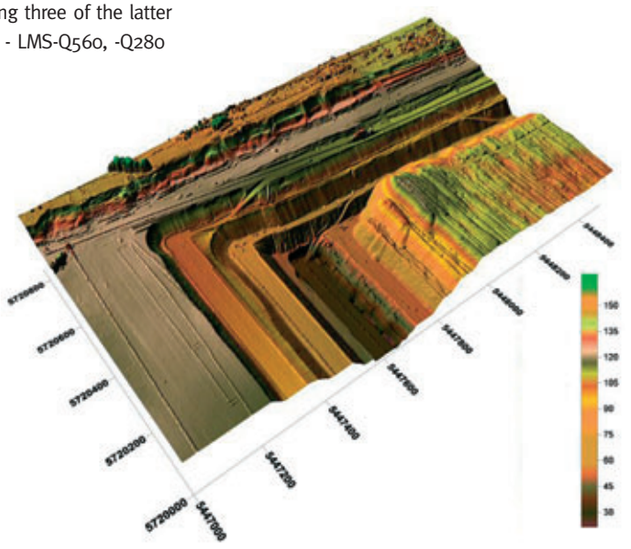
(f) Diamond

Diamond Aircraft Industries is a manufacturer of light aircraft with factories in Wiener Neustadt, Austria and London, Ontario, Canada. At INTERGEO 2006, the company entered the remote sensing market through its formal introduction of its ***Diamond DA42 MPP (Multi Purpose Platform)***. This is a heavily modified version of its DA42 twin-engined carbon-fibre aircraft designed specifically for use in airborne imaging. This is achieved through the addition of a range of pods that can be fitted to the aircraft either in its nose or under the main fuselage of the aircraft. So far, three specific pods have been developed - (i) an underslung belly pod that houses the Riegl LMS-S560 airborne laser scanning system mentioned above; (ii) a nose-mounted pod that can accommodate a Vexcel UltraCam large-format digital frame camera; and (iii) an alternative nose-mounted gimballed turret from PolyTech in Sweden that can be fitted with any one of a range of video or thermal infra-red cameras, including a high-resolution example from the Russian Ural Optical Mechanical Plant (UOMZ). These alternative versions of the Diamond DA42 MPP aircraft were shown on the stand that it shared with Riegl using beautifully constructed scale models and a series of eye-catching short films shown on a large video monitor. Two DA42 aircraft have been modified to act as demonstrators. Apparently a further production aircraft has already been sold to a Chinese operator.

Besides which, Diamond has also entered the market as an airborne imaging service provider through the formation of a 100% owned subsidiary called ***Diamond Airborne Sensing GmbH***. Using the two demonstrator aircraft, this new company will offer a range of airborne sensing services employing the Riegl airborne laser scanner and the Vexcel UltraCam digital
camera mentioned above. If required, the photogrammetric processing of the resulting data can be carried out by various Austrian companies that have been recruited as partners. The aircraft fitted with the turreted video camera can be used to provide observation and surveillance services for police and homeland security agencies.

(g) Milan Flug

This German company also cooperates strongly with Riegl utilizing three of the latter company's laser engines - LMS-Q560, -Q280 and -Q140 - in conjunction with IGI's CCNS and AEROcontrol systems. The systems can be mounted either in a helicopter or a light plane. The main emphasis appears to be on DTM and DSM production for 3D landscape and city modelling, but surveys of open-cast pits have also been undertaken.



A perspective view in colour of an open-cast pit derived from digital elevation and image data captured by a Riegl/IGI airborne scanner system operated by Milan Flug GmbH. (Source: Milan Flug)

Conclusion

From the discussion above, it can be seen that the market for the elevation data produced by airborne laser scanning is steadily increasing in size. It could also be seen that the high cost of ownership of airborne laser scanners has resulted in many different types of partnerships being formed and implemented to provide the varied services required by the user community.

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