IGI's Airborne Systems

An Expanded Product Range!

IGI is a small but innovative German high-technology company that, for over twenty years, has been in the forefront of the development of computer-based flight navigation, guidance and management systems for use in airborne survey and mapping missions. However, recently the company has extended its activities into the development of airborne digital cameras and airborne and ground-based laser scanning systems. The products resulting from this development have started to make a significant impact within these fields, while, at the same time, the company has retained its major presence in the area of in-flight positioning, navigation, guidance and sensor management systems.

by Gordon Petrie


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Fig. 1 - (a) A CCNS4 airborne navigation and guidance system showing the main Computer Control Unit (CCU) with the blue Ashtech GPS unit sitting on top of it and the round white GPS antenna placed in front of it. The Command & Display Unit (CDU) with its TFT screen is situated to the right.
(b) - The pilot of this survey aircraft is flying it on its planned track using the CCNS4's Command & Display Unit (CDU) fitted above the aircraft's main instrument panel.

Background

The IGI (Ingenieur-Gesellschaft für Interfaces) company was formed in 1978 by Professor Albrecht Grimm, who, at that time, was on the academic staff teaching practical surveying and photogrammetry at the Fachhochschule (now University of) Siegen. The company's facility is located in the small town of Kreuztal, near Siegen, located 100 km to the east of the city of Cologne. At first, the company was concerned principally with the interfacing of digitizers and plotters to computers, mainly for industrial applications. However, in 1982, it undertook the development of a ***Computer-controlled Photo Navigation System (CPNS)***. This was designed specifically for navigation and the guidance of aerial photographic missions over Nigeria where frequent interruptions to flights take place due to cloud. Thus precision flying was needed to ensure that the resulting gaps were filled during subsequent flights. In turn, this led, in 1984, to the development of the first ***Computer Controlled Navigation Systems (CCNS)***. These were used on the Dornier DO-228 aircraft that undertook extensive aeromagnetic surveys during the GANOVEX (German Antarctic NOrth Victorialand EXpedition)-IV expedition, controlling 50,000 line km of flying. The positioning and guidance elements of these initial CCNS systems were provided using Portable Distance Measuring Equipment (P-DME) whose base stations were powered by solar panels. As a result of this project, IGI combined the information given by the aircraft directional gyro with the positional information.
Moving on to the early 1990s, another notable success for IGI was the provision of a positioning system based on a dual chain LORAN-C installation operating in rho & hyperbolic mode. This was used in conjunction with GPS (then with only a few satellites available) and installed on three Canadian maritime fisheries patrol aircraft operating over the Grand Banks of Newfoundland. LORAN-C based systems were also used at that time to position helicopters carrying out systematic gamma ray spectrometry flights for IAEA, Vienna over extensive areas of the Syrian Desert. This was followed in the mid-1990s with the installation of guidance and sensor management systems in the Czech (An 30) and German (Tu 154M) reconnaissance aircraft employed in the 'Open Skies' overflight program. By this time, the full constellation of GPS satellites had been made operational and was available for civilian use.

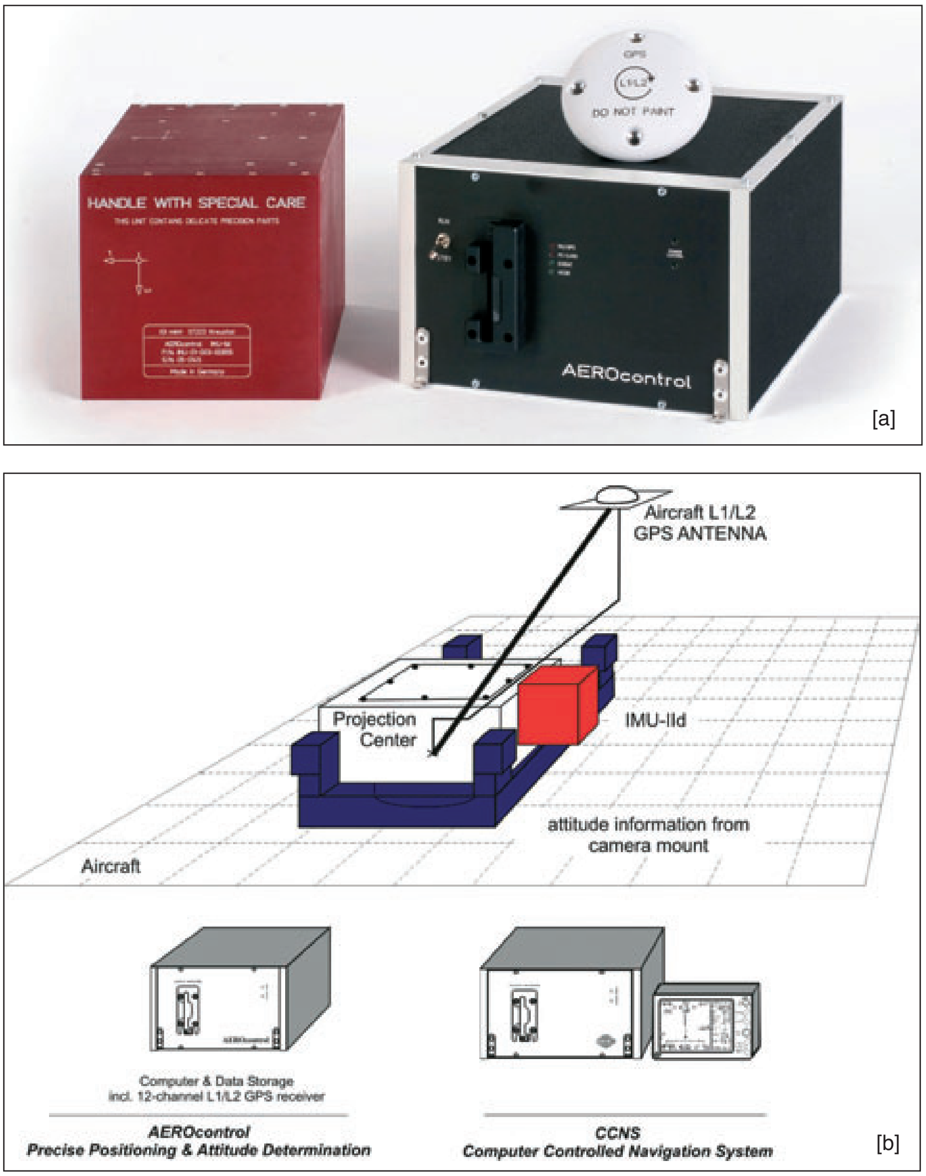

Fig. 2 - (a) An AEROcontrol-IId system with the integrated DGPS/IMU unit housed in the red box on the left while the computer and data storage unit is on the right with the white round GPS antenna sitting on top of it.
(b) - The diagram shows the AEROcontrol lever arm correction that relates the position of the GPS antenna to the projection centre of the aerial camera.

In 1992/93, five CCNS systems equipped with GPS receivers were supplied to the Hansa Luftbild mapping company and, in 1998, an aircraft engaged on minefield detection in Mozambique was equipped with a CCNS that obtained its positional information from the wide-area ***OmniSTAR*** differential GPS service using satellite broadcast technology. From then on, the CCNS systems have relied almost exclusively on GPS and aircraft directional gyro technology for their positional information and automatic drift/crab correction. In 1996, IGI also introduced its ***AEROcontrol*** unit as an optional addition to its CCNS4 system. This utilizes an integrated GPS/IMU system to measure the position and attitude of an airborne camera at the instant of the exposure of its image. The resulting data can be used as exterior orientation data when carrying out an aerial triangulation to provide control for mapping or, in suitable situations, for the direct georeferencing of the camera images.

Mission Planning

An obvious requirement for systems such as CCNS is the provision of suitable software that will allow precise flight planning to be carried out prior to the actual mission being flown. This will include the drawing of the proposed flight lines overlaid on a suitable background map and the entry of suitable waypoints, exclusion zones, hazards and other important navigation features. Originally IGI provided a DOS-based software package, ***WWMP*** (= World Wide Mission Planning) complete with a tablet digitizer and graphics plotter for the purpose. However this has been superseded by Windows-based software, called ***WinMP*** (= Windows-based Mission Planning). This can accept digital map data in numerous raster or vector formats and from different sources, including data from Google Earth. The flight planning can be carried out using either Lat/Long geographic coordinates or a local (national) rectangular coordinate system. If available, DTM data can also be utilized in the flight planning. The WinMP software creates optimal flight line patterns and exposure positions for different airborne imagers with specified overlaps both for blocks (areas) and for corridor-type applications (along rivers, canals, roads, railways, et cetera). The planned flight data that has been prepared using WinMP is then automatically transformed to WGS84 co-ordinates and stored on a PC-card for insertion into the CCNS system. This combination of WinMP and CCNS4 allows photos to be taken at the planned position within metres and to repeat them later with the same accuracy.

CCNS4

This is the current version of the CCNS system and comprises a central computer unit ***(CCU)*** and a command and display unit ***(CDU)*** fitted with a small (5 inch or 9 inch) TFT screen. These two units are equipped with standard aircraft interfaces and connectors to facilitate their installation in a wide variety of aircraft. The CCNS4 system is designed to be operated in conjunction with all commonly used airborne film and digital cameras, pushbroom line scanners and laser scanners. The system gets its positional information (and speed) from a GPS receiver that is normally mounted inside the CCU and can be optimized for real-time differential GPS operation via OmniSTAR. Information about the aircraft heading can be obtained from the aircraft's directional gyro if this is available. If the optional AEROcontrol unit has been fitted, then the directional information is obtained from the IMU and utilized directly by the CCNS system. This possibility allows the automatic drift setting of the camera or scanner mount.

A distinctive feature of the CCNS system is its CDU, which is designed to look like and to operate in the same way as other standard aircraft instruments. The operation of the CDU is controlled using a set of knobs and buttons (similar to those used in modern cockpit instrumentation) and the information derived from the CCU is displayed on the TFT screen in a typical EFIS (Electronic Flight Information System) format. Thus the main part of the CDU screen displays information on the flight track in graphical form. The pilot can observe the actual flight track being plotted continuously in real time against the planned track. This allows him to make the appropriate corrections to enable the planned flight lines to be implemented. Along the side of the display,

Fig. 3 - (a) The DigiCAM-H airborne digital camera is shown as a complete unit at top left. The individual components of the camera comprising (from left to right) the Imacon digital back, the modified Hasselblad camera body and the lens are shown in the lower right part of the picture.
(b) Two DigiCAM-H cameras are shown mounted side-by-side in a cylindrical box that fits into a SOMAG GSM3000 gyro-controlled camera mount. The AEROcontrol DGPS/IMU unit sits on a small shelf mounted above the two cameras.

auxiliary data from the aircraft's other instruments or from the airborne sensors that the CCNS system is controlling are displayed continuously in numerical form. If needed, the CCNS4 system can control the operation of two devices, e.g. two cameras of different makes and models or a camera and a laser scanner, simultaneously. In total, more than 250 CCNS systems are currently in operational use for flight control and management purposes world-wide.

AEROcontrol

The AEROcontrol GPS/IMU unit was developed for the accurate measurement of the position and attitude of the aerial camera at the precise moment of exposure of each individual image as required for Direct Georeferencing (DG). It first appeared in 1996. The IMU comprises three accelerometers and three gyroscopes together with their associated electronics. These components are mounted in a single compact block within a metal box that is attached directly to the airborne camera. Initially the IMUs used dry-tuned gyros, but with the introduction of the ***AEROcontrol-IId*** model in the year 2000, fibre-optic gyros (FOGs) have been used instead. These IMUs are manufactured in Germany and are therefore subject to German licensing regulations regarding their export. The AEROcontrol system can be operated using various types of high-performance dual-frequency GPS receivers, installed either internally inside the AEROcontrol computer/storage box or as an external receiver. In many cases, 12-channel L1/L2 Ashtech or NovAtel units have been supplied to customers. Now receivers are available to receive signals from the GLONASS and Galileo satellites as well as the usual GPS satellites.

The complete AEROcontrol unit also includes a computer unit that collects and stores the measured data from the IMU and the GPS receiver on a PC-card for later post-processing operations. A real-time computation allows the collected data to be used in-flight as navigation data by the CCNS4 unit. The AEROcontrol can either be operated as a stand-alone system or be operated by the CCNS. The CCNS4 and the AEROcontrol computer can be supplied either as separate devices or they can be integrated together in a single rack. A combined CCNS/AEROcontrol system is also available linked to an OmniSTAR-HP (High

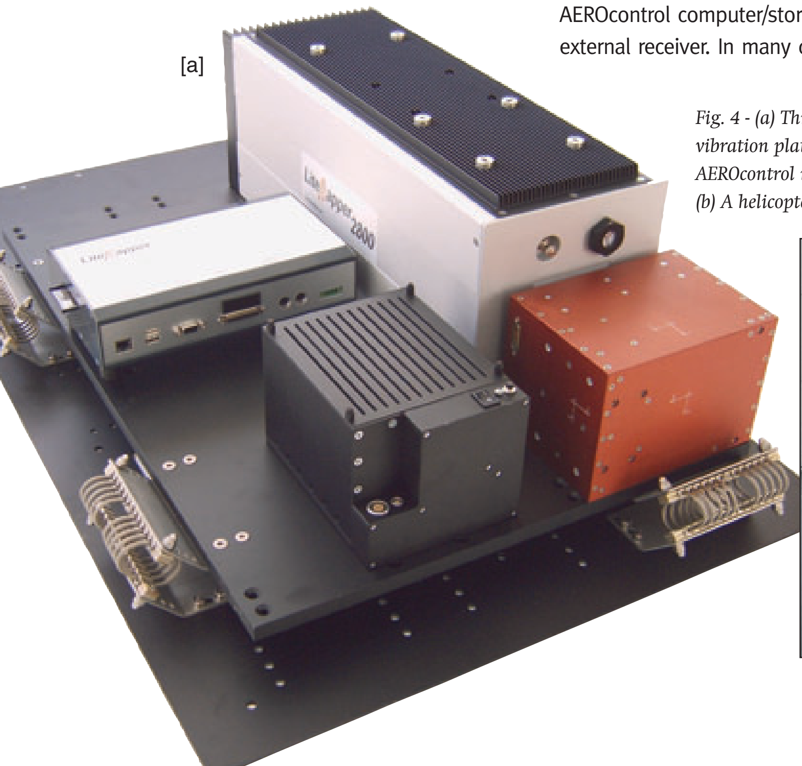

Fig. 4 - (a) This LiteMapper airborne laser scanning system is mounted on a purpose-built anti-vibration platform. The Riegl laser is the large white box sitting at the back with the AEROcontrol unit placed alongside in front of it.
(b) A helicopter fitted with a specially-built Helipod box containing the LiteMapper system.

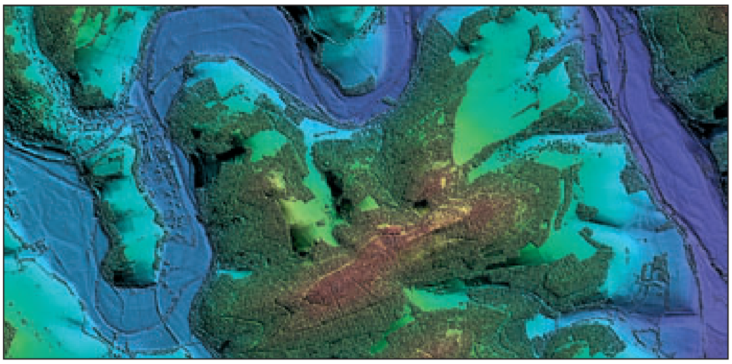

Fig. 5 - A Digital Surface Model (DSM) of an area near Arfeld in North-Rhine Westphalia, Germany produced from the data acquired by a LiteMapper 2800 airborne laser scanning system.

Precision) system, which means that the exterior orientation (position and attitude) parameters are then available prior to the aircraft landing. Currently there are more than 70 AEROcontrol units in operation. Most of Vexcel's UltraCam airborne digital cameras have been supplied with CCNS/AEROcontrol units. Several other units have been supplied for use with Intergraph DMC airborne digital cameras.

AEROoffice

Just as there is a need for flight planning software (WinMP) prior to an actual mission, so there is a need for software to carry out the post-processing of the data that has been measured and collected by the AEROcontrol DGPS/IMU system. This is provided by IGI in the form of its AEROoffice software. This Windows-based package provides tools for handling the measured data and subsequently processing it. The software includes a Kalman filter that acts as the core for the computation of the combined GPS/IMU data and the ***GrafNav*** software package from the Waypoint division of NovAtel in Canada to process the DGPS data. Additional programs carry out the transformation of the resulting exterior orientation elements into the local mapping coordinate system. AEROoffice also incorporates a special customized version of the ***BINGO*** aerial triangulation software from the GIP company. This features a reduced capacity of 30 stereo-models instead of the thousands that may be used in aerial triangulation. This BINGO-30 program allows the precise bore-sighting of the camera system over a selected sub-part of the flown block for use in direct geo-referencing operations.

DigiCAM

At the technical exhibition of the ISPRS Congress held in Istanbul in 2004, IGI introduced the ***DigiCAM-K/14*** medium-format airborne digital camera based on the Kodak DCS Pro 14n SLR (producing a 14 megapixel color image). After the first sales of this type of camera, Kodak decided to withdraw completely from the professional camera market in 2005 and ceased to manufacture its DCS Pro 14n model - which caused difficulties to the several other system suppliers who had based their products on this camera, as well as IGI.

Later on, IGI developed a 22 megapixel model named ***DigiCAM-H/22***. This model is based on a modified Hasselblad medium-format camera equipped with an Imacon digital back, Imacon having been bought by Hasselblad. The overall DigiCAM-H system comprises a calibrated camera system with its modular body, lens and 22 megapixel digital back; the ***DigiControl*** computer; a so-called ***Image Bank*** for the storage of 850 exposed images; and an 8 inch TFT touch screen for monitoring and display purposes. A wide range of interchangeable lenses with different focal lengths (35mm to 300mm) is also available, allowing the acquisition of either RGB or CIR images. A new DigiCAM model featuring a 39 megapixel digital back will be available soon and a large storage unit that can store more than 2500 images will be delivered with this camera. The touch screen acts as the user interface to the system, allowing the operator to view the exposed images as they are taken and to alter the exposure settings if required.

The DigiCAM cameras can be triggered by a CCNS system in accordance with the preplanned flight lines and parameters that have been stored in the system. The camera can also be operated in conjunction with an AEROcontrol system to determine the exterior orientation parameters for each exposed image. Multiple DigiCAM systems can be operated within a specially designed cylindrical box that can sit within a standard gyro-controlled aerial camera mount such as the SOMAG GSM-3000, Leica PAV30 or Intergraph T-AS. If images have to be exposed at intervals of less than 2.5 seconds, two DigiCAMs can be placed side-by-side and operated to fire alternately. Indeed up to five DigiCAMs can be accommodated within the cylindrical adapter box.

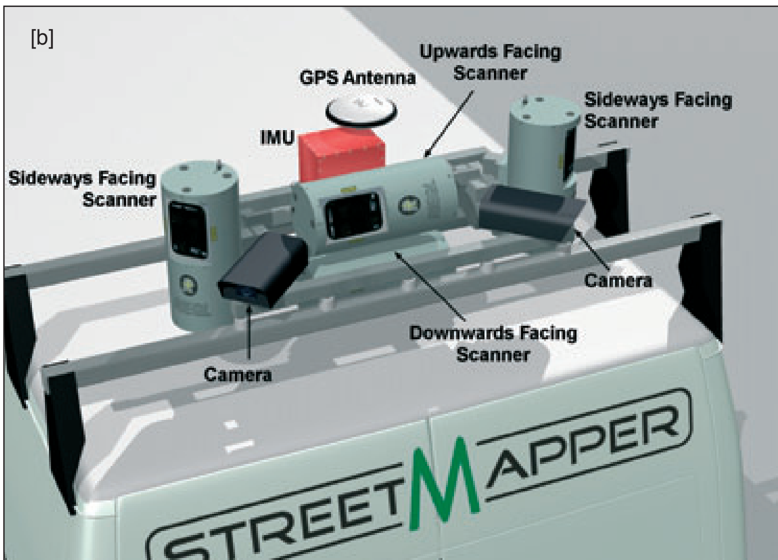

Fig. 6 - (a) A StreetMapper van equipped with laser scanners mounted on the vehicle's roof rack.
(b) Components of a StreetMapper system mounted on the roof rack of a vehicle showing the laser scanners, TERRAcontrol DGPS/IMU unit and the GPS antenna.
(c) The displays associated with the StreetMapper system mounted on the front facia (dash-board) of the van.

LiteMapper

IGI also entered the field of airborne laser scanning in 2003. The basic hardware components of the system, called LiteMapper, comprise a laser scanning engine built by Riegl in Austria; the CCNS/AEROcontrol DGPS/IMU system discussed above; and a special ***LMcontrol*** computer-based system to control the operation of the laser scanner. The accompanying software includes the WinMP and AEROoffice packages discussed above, together with ***LMtools***, developed by IGI for data registration and visualization purposes in-flight and ***LasTools***, developed by GeoLas for LiDAR geocoding, transformations and projections. The final LiDAR data processing and generation of DEMs is normally carried out using the ***TerraScan*** and ***TerraModeler*** software packages from the Finnish Terrasolid company.

Initially LiteMapper was offered with a choice of two models - ***LiteMapper 1400*** for low-altitude flights (up to 300m) from a helicopter aimed at corridor mapping; and ***LiteMapper 2800*** for higher-altitude flights (up to 900m) from a fixed wing aircraft to provide wide-area mapping, including the recording of return signal intensity. These have been replaced respectively by the current models - the ***LiteMapper 2400*** for low-altitude surveys (up to 450m) and the ***LiteMapper 5600*** for high-altitude surveys (up to 1,800m), including the recording of the full intensity waveform. Of course, the DigiCAM can be integrated into a LiteMapper system for the simultaneous collection of images and laser data. So far, six LiteMapper systems have been delivered to customers; more are currently under construction.

StreetMapper

IGI is a partner with the 3D Laser Mapping company from Nottingham in the U.K. in the recent development of the *StreetMapper* mobile mapping system that scans and maps roads, buildings, and trees from a moving van equipped with scanning lasers. The system comprises three (or more) lasers mounted on a roof rack that are operated in conjunction with IGI's ***TERRAcontrol*** GPS/IMU unit (derived from its AEROcontrol unit) and the IGI software and hardware solutions for the control of all laser scanners and data storage. IGI also contributes its ***TERRAoffice*** software (derived from its AEROoffice package) for the processing of the IMU data. The GrafNav software is again used to process the DGPS data. Finally the TerraScan/TerraModeler/TerraMatch suite of programs from Terrasolid is utilized for the processing of the laser scanner data and its transformation into the final 3D model data.

Conclusion

As can be seen from the above account, over the last ten years, IGI has developed steadily from its original status as a specialist supplier of computer-based flight planning, navigation and guidance systems for survey aircraft into a quite diversified company with a substantial range of high-tech products and systems for use in both airborne and ground-based mapping applications.

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