

# IGI

## History – Present – Future

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### ABSTRACT

IGI is one of the world's leading geospatial companies and conducts business worldwide. Our success is driven by our people and their commitment to get results the right way – by operating responsibly, executing with excellence, applying innovative technologies and capturing new opportunities for the best possible accuracy. For more than 30 years, IGI is active in the field of aerial survey developing guidance and sensor management systems as well as precise positioning and attitude determination systems. Since 10 years, special developments for clients resulted in airborne laser and digital camera systems. Since 8 years mobile mapping systems are offered as well. Together with the UK based company 3D Laser Mapping, IGI develops the StreetMapper technology.

IGI is celebrating its 35<sup>th</sup> anniversary and is proud at its five past world premieres. These will be addressed in this paper.

## 1. HISTORY

### 1.1. The CPNS – Computer-controlled Photo Navigation System

IGI, founded in 1978, is based in Kreuztal in the middle of Germany, located 150km north of Frankfurt a. M. in an idyllic countryside with beautiful surroundings. In its first four years, IGI was busy in the design of Programmable Logic Controllers (PLC) for industry machines, such as interfaces and computers for foam cutting machines. Therefore the company name Ingenieur-Gesellschaft für Interfaces (engineering company for interfaces) was chosen. After selling about 50 PLC units, the companies Bosch and Siemens created their portfolio for this market at a favourable price which meant the end for IGI's PLCs.

At that time the Geodata survey company of Olpe, close to Kreuztal, had to execute a huge mapping project in Nigeria, surveying of the new capital Abuja. Photogrammetry should be used. Because of the local weather conditions – daily development of clouds and desert like areas – they were looking for a guidance and management system, keeping the survey aircraft on pre-planned flight-lines and firing the camera at pre-planned locations.

Giving guidance information to survey aircraft has been a special task. Specialists to fulfil this job were rare. Flying straight lines, not only over woods or sandy deserts, resulted in wavy flight-lines. For that reason a system had to be developed which could and should replace the navigation sight, give direct guidance information to the pilot and fire the camera at pre-planned positions.

Geodata asked Zeiss-Oberkochen and Wild-Heerbrugg, but there was no interest for a development of such a system. Although Dr. Robert Schlund of Zürich-Kloten, a photogrammetrist and pilot, gave Geodata the hint, to contact IGI, located near to their premises.

IGI accepted that request from Geodata. Enabling a development of such a system the knowledge of the actual position of the aircraft is essential!

At that time, GPS was not available. Companies involved in that development reported: „Wait, GPS will solve your problems!“.

But a position with a necessary accuracy was needed today and not the day after tomorrow!

Available at that time were:

- VOR/DME stations,
- Portable P-DME networks, e.g. Thomson-CSF Trident,

- Loran-C (US), Tschaika/Chayka (RU) and
- Portable Loran, e.g. Motorola.

In West-Germany a dense network of DME/Tacan stations for general and military aviation was available. For that reason, IGI started operations with two 3-channal DME-42 of Rockwell-Collins, allowing to receive up to six ranges for computing the actual position. In-flight calibration of this DMS/Tacan network resulted in a positioning accuracy of better than 30m.

The mission to be flown was planned in the office, transferred to the aircraft computer and the guidance information consisting of two lines, planned & flown line, had to be brought together. This info was displayed on a 5 inch b/w display to the pilot. The metric film camera was fired automatically at the pre-programmed positions.

The CPNS was born and IGI was the first company to introduce a guidance and sensor management system for aerial survey flight missions worldwide.

### **1.2. Replacing Ground Control by AEROcontrol – „The Lake of Constance Test“**

For operating the CPNS in areas without a dense network of DME stations it was decided to use a mobile DME network based on Thomson-CSF Trident. The Trident was expensive, four ground stations and one airborne interrogator about 0.5 Mio DM, but was able to deliver positioning accuracies in the range of 3m. In conjunction with Prof. Ackermann of Stuttgart University a first test was established, where the possibilities of the system and the stored coordinates for each photo taken, could be used in an aero-triangulation for saving expensive ground control points. The mission took place at the Lake of Constance in the summer of 1982 with a Dornier Do-28 of DLR-Oberpfaffenhofen and the RC10A prototype of Wild-Heerbrugg. For using camera attitude data, an aircraft directional gyro was fixed to the camera.

The result: It could be demonstrated that by operating CPNS/Trident positioning data in an integrated aero-triangulation/block adjustment, the need for ground control points could be reduced dramatically.

Prof. Ackermann wrote in PFG journal 2003: “This was a test conceptual breakthrough that prepared the process methods which a decade later have been implemented with the GPS technology. If you read former publications today (Ackermann 1984, 2003), it is surprising that the current status of aerial triangulation with and without control points has been anticipated and designed already in 1982.”

The Lake of Constance test marks the take-off towards today's GPS applications for aerial triangulation. On this event, Prof. Corten of ITC-Enschede created the phrase „aero control replaces ground control“.

IGI was one of the first companies to consider IMU technology for aerial surveys. Today AEROcontrol and TERRAcontrol, for terrestrial applications, are at the heart of each solution IGI provides. Our solutions achieve the best possible accuracy at every survey to ensure quality in the data and a minimum effort in the field.

### **1.3. GANOVEX-IV, German Antarctic North Victoria Land Expedition, resulting in CCNS**

At the International Air-Show in Hannover, which took place end of May 1984, IGI got notice that guidance systems for POLAR-2 and POLAR-3, two special mission aircraft of the type Dornier Do-228, were requested by the Federal Institute for Geosciences and Natural Resources (BGR-Hannover) for operations in the Antarctic summer of 1984/85. A huge area over the Ross Sea and snowy/icy Victoria Land had to be flown with aeromagnetic sensors. IGI made a proposal to use the CPNS, based on a network of six P-DME stations and received a contract to deliver the system in October!



Figure 1: POLAR-2 & POLAR-3 based on Dornier Do 228 aircraft.

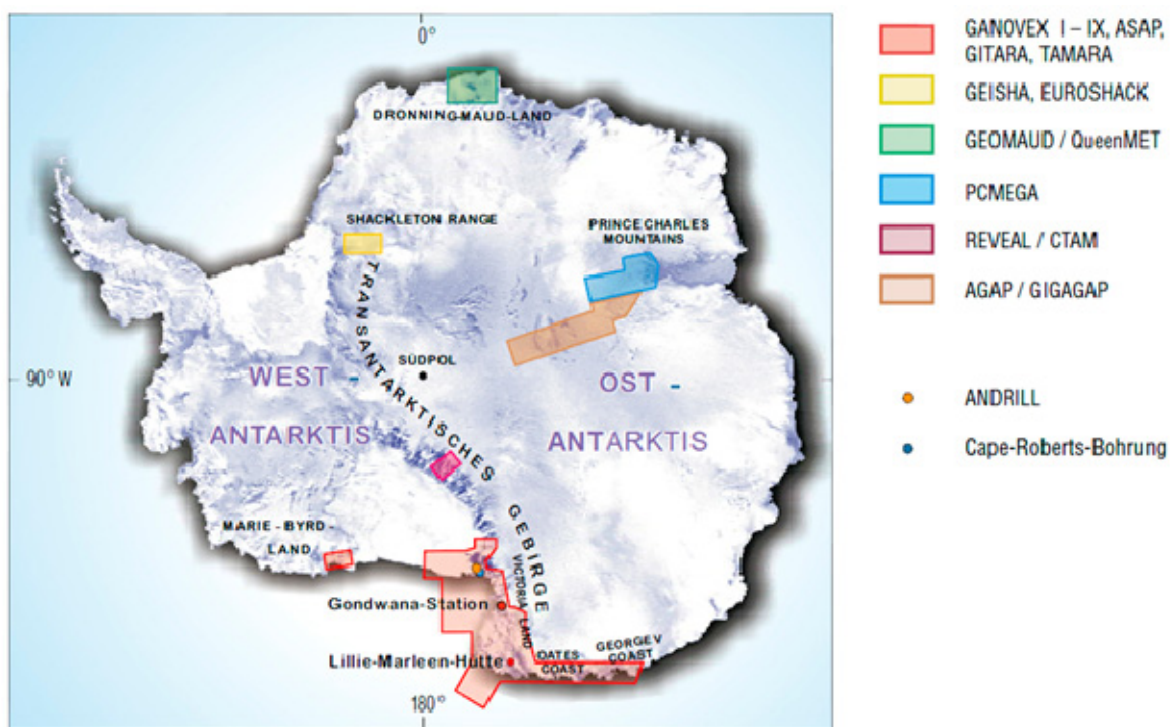


Figure 2: Antarctica with the operation area “Victorialand” and “Ross Sea” of the GANOVEX IV project. The base was Gondwana-Station.

The range of the Trident system had to be extended from 250km to 500km, which was executed by Thomson-CSF engineers even during the summer holiday period. But where to get the electricity for operating the DME ground stations? Instead of the proposed Honda generators, which would have needed two helicopters for gas service, IGI proposed the use of solar panels together with coldness acclimatized aircraft batteries. This power source operated nicely during sunshine. More than 60,000 line-km were planned to be executed by the two Do-228 aircrafts over Victoria Land and the Ross Sea. Unfortunately already in the early beginning of the project one Do-228 had a hard landing and could not be used for the mission operations. Finally just one POLAR aircraft with two crews could be used for the survey. This POLAR aircraft executed 50,000 line-km with excellent results related to track positioning.

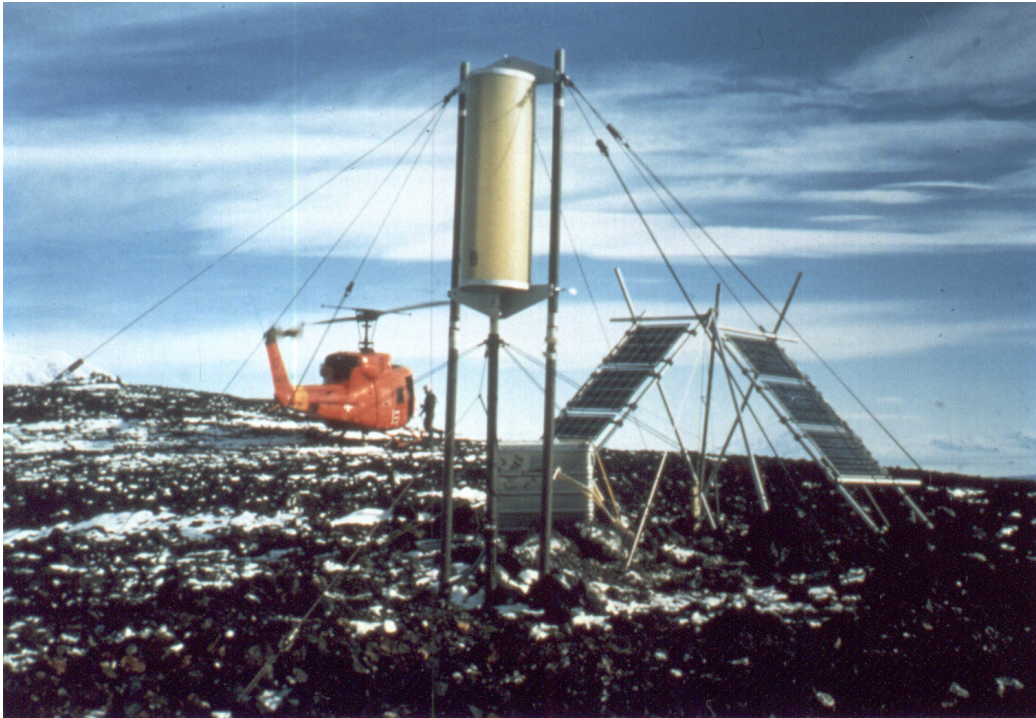


Figure 3: Trident station powered by solar energy at Mount Erebus.

To avoid unstable guidance information on the pilots display (because of range intervals and their unstable accuracies) it was decided to introduce aircraft directional gyro information into the Kalman filtering process of the guidance display.

Because no photos were taken during the GANOVEX project and the CPNS had shown its operability for other sensor missions as well, the name of the system was changed into CCNS, Computer Controlled Navigation System.

#### 1.4. CCNS for German Government and Other Projects

The most popular large format topographic map in Germany is the German Basic Map 1:5000 with 2km by 2km coverage. Pin-pointed aerial photography was introduced with the CCNS, flying parallel lines of 2km distance and photos taken every kilometre.

When Rick Hoffmann, pilot and co-owner of Surdex, Chesterfield MO, USA, had a demonstration of the CCNS together with a LMK-2015 at Berlin-Schönefeld in 1990, he stopped his own developments for a guidance system and bought a CCNS together with the LMK.

Hansa Luftbild, the major German aerial survey company, tested the CCNS. When a student-navigator, using the CCNS, came back with better results than the old experienced navigator by operating maps and navigation sight, in the same year all five aircraft of the company were equipped with the CCNS!

A sophisticated flying took place during the “BOSOSA – Border Survey Oman Saudi Arabia”, executed by Hansa Luftbild in 1997/98. Flying the border with four parallel strips and BOSOSA – Border Survey Oman Saudi Arabia pin-pointed aerial photography was impossible over a desert with haze and only navigation sight. With the guidance of the CCNS they could solve this problem easily. When Hansa Luftbild presented the photo index of the missions flown, the Saudi and Oman controlling officers could not believe that this was real. They asked to demonstrate the perfect pin-pointed photography by preparing a mosaic from the single aerial photographs. Checking this mosaic, the Saudi General involved, expressed his congratulations to the Hansa Luftbild directors.



Figure 4: Map of Oman with surveyed border in red.

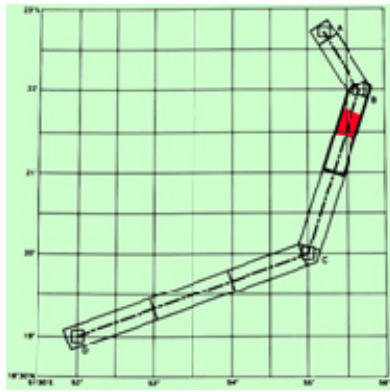


Figure 5, 6: Part of the surveyed border with appropriate images.

The missions for the border survey between Jemen and Saudi Arabia in the year 2000 was guided by the CCNS as well. Today the CCNS is available in version 5 which has been introduced to a global audience at the 53<sup>rd</sup> Photogrammetric Week two years ago. A total of 330 units are in operation until today, some of them are in use for more than 28 years!

### 1.5. Open Skies

After the German reunification, the Helsinki/Vienna Conference on Security and Cooperation in Europe in the year 1992, had an agreement, that military aircraft of the Warsaw Pact states could operate in NATO airspace and vice versa, the Open Skies project (OS) was established. In Germany a Tupolev TU-154M passenger aircraft was available from the INTERFLUG airline.



Figure 7, 8: Open Skies operation area (dark green) in logo and German Air Force Tupolev-154M/OS.

IGI was entrusted with the development of the sensor management system, and sensor integration of a total of 11 sensors.

The first draft (OSEF) of the Tupolev equipment:

- IGI Sensor Management System (SMS) for seven sensors of the type:
  - 3x film cameras of the type Carl Zeiss Jena, LMK-2015
  - (1x vertical, 2x oblique)
  - 3x video cameras of the type Zeiss-Oberkochen,
  - VOS-60 (1x vertical, 2x oblique)
  - 1x laser (height above ground)

The final draft (OSRK) of the Tupolev equipment:

- IGI Sensor Management System (SMS-1) for 11 sensors of the type:
  - Sensors of the first draft (OSEF) plus
  - 1x panorama-camera of the type Zenit-Krasnogorsk, A-84
  - 2x IR-line scanner of the type Pacific Sierra Research, AN/AAD-5
  - 1x ROSSAR, synthetic aperture radar of the type Kulon / Dornier
  - 1x radar altimeter, replacing the laser altimeter

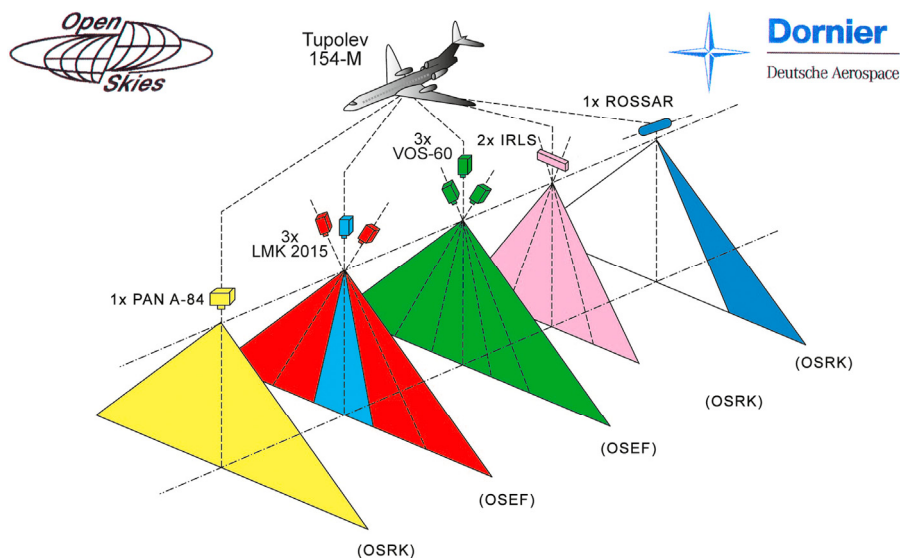


Figure 9: Open Skies Sensors.

The complete sensor management system for the seven and later for the 11 sensors has been delivered by IGI in the year 1994. Also the control-terminal for the Zenit A-84 panorama-camera was developed by IGI and accepted by Dornier as the leading party of the project.

## 1.6. AEROcontrol (GNSS & IMU)

As mentioned in chapter 1.2, the first trial was executed in the year 1982 with “The Lake of Constance Test” to use positioning and attitude information for saving ground control points in photogrammetric projects. When GPS became operational, IGI mounted an IMU together with aerial cameras of different manufacturers for the correct lever-arm determination. This solution was a clear step to use the attitude of the sensor/camera for the determination of the exterior orientation elements for each surveyed image.



Figure 10-12: RC30 with IMU-IIb; LMK-2000 and RMK-TOP with IMU-IId.

Today with the help of GNSS (Global Navigation Satellite System) and INS (Inertial Navigation System) high-precision determination of the exterior orientation elements for each event has come to a standard. IGI was one of the first companies to consider IMU technology for aerial survey.

The AEROcontrol is at the heart of every solution where accuracy matters. Today this technology is also used for LiDAR sensors, SAR, thermal, hyperspectral and further sensors. In the year 2005, IGI and their UK based partner 3D Laser Mapping introduced the StreetMapper, a mobile mapping system based on the AEROcontrol technology. Operating high grade IMU's and ruggedized Sensor Management Units (SMU) the AEROcontrol technology is continuously developed by IGI. For mobile mapping applications the name TERRAcontrol was added to the portfolio. Together with the post-processing software AEROoffice / TERRAoffice the system is a complete solution for determining the orientation of one sensor or multi sensor systems. The software AEROoffice and TERRAoffice only differ in their licensing options, although different forward / backward Kalman filter algorithms are implemented for airborne, land, water and rail applications. To use one system and one post-processing software is an advantage for the customer. Designed as an open system and prepared for the communication with different sensors the unit is available for customisation, e.g. the German DLR uses the AEROcontrol in their High Altitude Long Range (HALO) Research Aircraft to test different sensors. With a total weight of 3kg the system is also capable of operating in unmanned systems. AEROcontrol / TERRAcontrol is one tool for a variety of applications. A total of 250 units are in operation until today.

## 2. PRESENT

### 2.1. Airborne Laser Scanning, the LiteMapper

Based on the proven CCNS and AEROcontrol technology, IGI started developments in the year 2000 for an airborne laser scanning system. The LiteMapper was created. Firstly introduced at the 49<sup>th</sup> PhoWo the system was based on a Riegl LMS-Q560 laser scanner. Today the LiteMapper is a turn-key solution from mission planning to post-processing based on all airborne laser scanners from Riegl in Austria. The IGI technology is also integrated in the Chiroptera from Airborne Hydrography (AHAB) in Sweden.



Figure 13, 14: Certified Pod for AS-350 (FAA, CAA, EASA); R44 with LiteMapper system.

## 2.2. Mobile Mapping, the StreetMapper and RailMapper

One further step was to use the airborne technology for a mobile mapping system (MMS) on the land. IGI partnered with 3D Laser Mapping of Bingham, UK to develop the StreetMapper, which became the first operational commercially available MMS. The StreetMapper mobile laser scanning system was initially developed to meet a demand for measurement and recording of highway assets, but has since been developed for other applications as well. The system is easily deployed on a range of different vehicles and the first StreetMapper system has been operating since early 2005. One significant advantage is that the system is capable of surveying with the standard traffic. Today the solution has been used on boats, trams and trains as well and the TERRAcontrol positioning unit has evolved with the system to e.g. process Direct Inertial Aiding Plus and Zero Velocity Updates from different distance measuring instruments. Depending on needs of construction or railway companies, the RailMapper system can be installed as well on track vehicles, as has been demonstrated with the TVT-700 or DiagnoseVT of German Railways.



Figure 15, 16: RailMapper system with two laser scanners on a TVT-700 (red) and with three laser scanners on a DiagnoseVT (yellow).

At the 54<sup>th</sup> PhoWo IGI is presenting the first European two-way (hi-rail) vehicle, capable of surveying on land and on rails. Mounted on a cross-country car the system is completely operational on land. The rail system is prepared for the normal track width (1435mm) but can be changed to other track widths as e.g. Russia (1520mm) by the operator himself.





Figure 17, 18: Rail- & StreetMapper system on a two-way car with two Zoller+Fröhlich lasers.

Depending on field of application the Rail & StreetMapper mobile mapping systems can be equipped with laser scanners from the companies Rieggl, Zoller+Fröhlich, Velodyne and Faro.

### 2.3. DigiCAM, the Digital Camera from IGI

For airborne laser scanning projects, it is very useful to operate one or more cameras in parallel. With the technology change from analogue to digital, IGI tested several consumer cameras and found an excellent medium-format camera with the Hasselblad models. By employing IGI's core competence in airborne developments, the camera is modified by IGI for aerial survey applications and is calibrated in house. One sensor head is available in 40, 50 or 60 megapixel resolution. Fitting into IGI's Modular System Concept one camera unit can be extended with multiple cameras e.g. to a Quattro DigiCAM or Penta DigiCAM solution. Sharing one graphical user interface, all cameras are controlled on one operator screen.



Figure 19: 9" operator screen, SMU, DigiTHERM camera head, DigiCAM camera head.

The Quattro and Penta DigiCAM constellations are part of the IGI portfolio since 2008 and are based on up to five DigiCAM modules which are arranged in nadir and/or oblique orientation. Because of the Modular System Concept the camera can be used as a large format solution with 235 megapixel resolution or it can be converted by the customer to an oblique system. In this way one camera head can be used for multiple tasks from capturing large format areas to urban mapping and 3D city modelling.

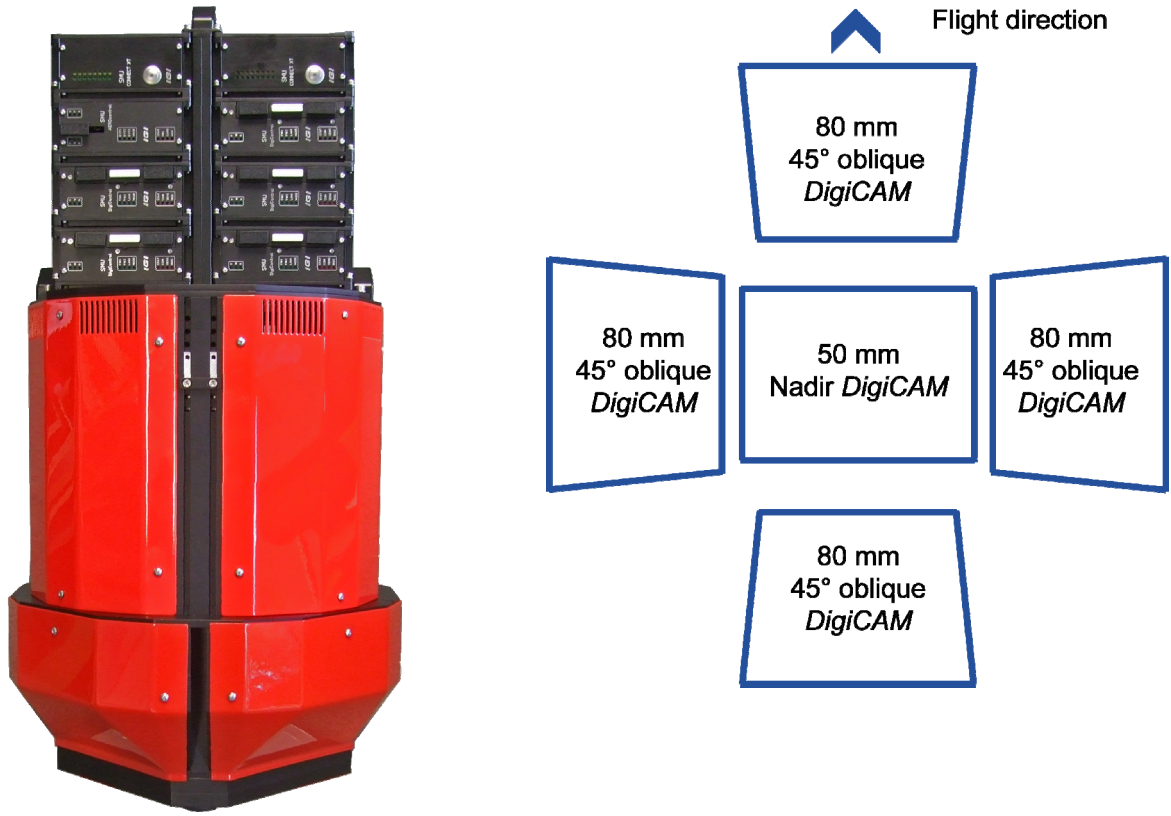


Figure 20, 21: Penta DigiCAM with one possible footprint.

Figure 22 shows the footprint of a Quattro DigiCAM solution. On the left side is the large format camera constellation and on the right side the oblique constellation. The conversion from large format to oblique system is done by the operator. This is a unique feature for aerial photogrammetry. In this way the Quattro DigiCAM can be used for vertical aerial photography and for oblique aerial photography.

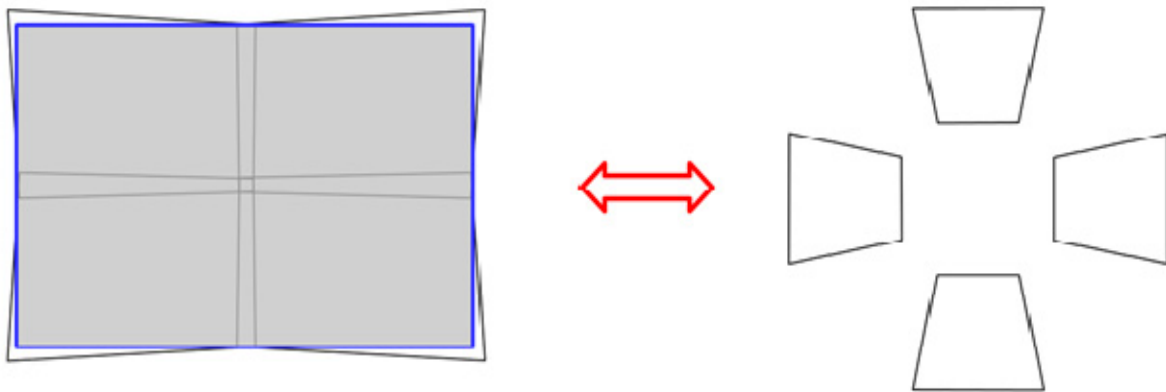


Figure 22: Quattro DigiCAM nadir footprint (one large format image) and oblique footprint (four single oblique images).

Nowadays multi sensor constellations are more of importance and some clients operate up to five DigiCAMs (1x vertical & 4x oblique) together with a LiteMapper system. Constellations for optical and hyperspectral cameras together with a LiteMapper have also been established.

## 2.4. UAVs and New Airborne Platforms

At the 50<sup>th</sup> PhoWo in the year 2005, IGI was the first company to present an UAV of the company Microdrones for aerial surveys. This unit was able to carry 0,3kg of payload for about half an hour. Today a Microdrone UAV is capable of carrying up to 1kg of payload and is a versatile platform for industrial projects, emergency operations and surveys.

In the year 2009 at InterGEO in Karlsruhe, IGI together with the company Geocopter presented the first UAV helicopter with integrated AEROcontrol and DigiCAM.



Figure 23, 24: UAV equipped with AEROcontrol & DigiCAM at Intergeo 2009; Cavalon Aerial Survey.

IGI also tested the Swissdrones UAV which uses the Flettner double rotor system. Difficulties with any UAV units are the lack of operating permissions and the very high asset cost.

The alternative was found in a gyroplane of the company AutoGyro in Hildesheim, Germany. Gyroplanes have been invented in the year 1923. Due to their design, they are particularly good for aerial surveys and there are different regulations than with UAVs. A first test survey was conducted in summer 2012 at Hessigheim, at the Neckar river, north of Stuttgart, Germany. In this pilot project, the results were compared with positioning methods in which a UAV had been used. The complete survey from takeoff to landing took two hours and 900 images with 80% forward overlap and 60% sideward overlap were captured. The typical altitude was 470m AGL at an average flying speed of 90 km/h (50 knots). The block of aerial photography with a GSD of 5.5cm was evaluated by the ifp, Prof. Fritsch. He stated “our expectations were exceeded. Since standard software for aerial triangulation is used, it requires, no expensive preprocessing by special algorithms as for UAV systems”. The Gyrocopter is an “ideal platform for photogrammetry on demand”, he continued. The quality of the images is excellent. Further advantages are that a gyroplane is costefficient in operation, cheap to run, can easily be transported in a trailer which can be used as well as hangar. Not least because of this positive experience, IGI has continued the developments in this field. Since the model Cavalon is best suited within the AutoGyro product range as a platform, IGI has centered on this model which was introduced to the market in 2011. The “Cavalon Aerial Survey” is prepared to be operated by one person (pilot = operator) and will be equipped with IGI sensors for photogrammetry, airborne laser scanning and 3D city modelling.

### 3. FUTURE

The last 35 years have been amazing for airborne and terrestrial applications in the areas of photogrammetry, remote sensing and GIS. The technology change from analogue to digital offered much faster processing capabilities. The globe with an image on top is available through Google Earth since the year 2005. Today the first 3D city models are available and it is a matter of month when this technology will be available to the globe. More information layer will follow with different kind of information. Sensor systems are capable of capturing massive data and it is now the time to process these data sets and get the important information in a handy format.

Although the surveyor does not like the clouds, today everybody is talking about them. Of course in a different manner but the future will be in the cloud. User interfaces will become easier to manage and more sensors will be available as a one system solution. Data will become available everywhere and on different devices. We may not see the data directly but geospatial data is becoming more and more important for everybody in his daily life.

During the last five years a lot has changes in the business field. The major competitors in the field of aerial survey are now working under the Hexagon umbrella. Who would have thought this possible?

IGI is still a privately owned company and very proud to offer sophisticated solutions together with a streamlined workflows to our customers special needs. With our smart geospatial solutions from mission planning by mission execution and data capturing to post-processing, IGI offers the right customized tools for a variety of applications.

We do not know what the future will bring to us but when the next 35 years will be as amazing as the last, there is a lot to look forward to.

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- <http://www.igi.eu/products.html>
- <http://www.streetmapper.net>