IGI Company Report

Based on
Excursion to IGI mbH, Kreuztal
November 10, 2008

GEOENGINE
3rd generation students
11/28/2008
Introduction

IGI was founded in 1978 by Prof. Albrecht Grimm. Since 1982, the company has specialized in the design and development of guidance, positioning, attitude determination and sensor management systems for aerial survey flight missions - the CCNS – Computer Controlled Navigation System.

Some exemplarily projects with participation of IGI:


Main products of the IGI company includes: CCNS, Mission Planning & Documentation, AEROcontrol, DigiCAM, LiteMapper, StreetMapper.

**CCNS**

The CCNS (Computer Controlled Navigation System, 4th generation) is a guidance, positioning and management system for aerial survey flight missions. The standard system consists of the Central Computer Unit (CCU), the 5 inch TFT Command and Display Unit (CDU), and necessary cabling and mounting.
Mission Planning & Documentation

WinMP is a software package to plan and document aerial photography and other aerial survey flight missions. IGIplan is an advanced mission planning software package and follow-up product.

AEROcontrol

AEROcontrol is IGI’s GPS/IMU system for Direct Georeferencing of LiDAR and image data. It can be used as a stand-alone system or form a fully integrated system with IGI’s CCNS4.
DigiCAM

IGI’s DigiCAM is a medium-format airborne digital camera system for professional, but affordable digital aerial photography.

LiteMapper

LiteMapper is IGI’s airborne LiDAR terrain mapping system. It consists of a CCNS4 to guide the aircraft or helicopter, an AEROcontrol DGPS/IMU system to georeference the LiDAR and digital image data and an accurate airborne laser scanner.
StreetMapper

Using robust and reliable laser scanning technology coupled with the high precision navigation system TERRAcontrol, IGI and 3D Laser Mapping have joined forces to offer a novel 3D mobile mapping system to scan roads, buildings and trees from a moving vehicle.

1. Digital Airborne Camera

Digital airborne cameras are now penetrating the fields of photogrammetry and remote sensing. Due to the last decade's results in research and development in the fields of for instance detector technology, computing power, memory capacity
position and orientation measurement it is now possible to generate with this new
generation of airborne cameras different sets of geometric and spectral data with high
geometric and radiometric resolutions within a single flight.

The IGI DigiCAM is a medium-format airborne digital camera system for
professional. By using IGI’s competence in airborne developments, the digital camera
is built by IGI for airborne conditions and aerial survey applications. Combined with
IGI’s flight management system, the DigiCAM forms a complete solution for a rapid
and automated workflow for the generation of directly georeferenced images.

DigiCAM is a modular designed system. Its components consist of one or
multiple cameras, two storage units for 6400 images and an 8 inch TFT touch-screen.
The system provides online flight information e.g. preview, histogram, GSD and
remaining images.

Lenses

The lenses for each DigiCAM are selected in order to fulfill all demands of digital
aerial photography. All lenses are of high precision and high luminous intensity.

Lenses options:
- Exchangeable lenses with bayonet mount
- Integrated electronic shutter (central shutter)
- Exchangeable filters for RGB and CIR mode (optional)
- Lenses from 28mm to 300mm available

Performance benefits

- 39 Megapixels high resolution system, large CCD frames will be in use soon
- Image repetition rate: 1.9 sec
- Automatic workflow and release of exposures at pre-planned positions
- Loss-free raw rate format of photographs
- Integration with other system

Modular System:

DigiCAM is a modular designed system. The system can be customized to satisfy the
customers’ individual convenience. Many different arrangements are possible and the
following have been accredited.

- DigiCAM
  - Stand alone with 39 Mpixles resolution
  - Ideal solution with airborne LiDAR
- Double-DigiCAM
  - 2x DigiCAM arranged vertically. Two possibilities:
  - Alternating shots for higher flight speed
Similar images with RGB and CIR mode

- Dual-DigiCAM
  - 2x DigiCAM for a total resolution of 74 Mpixels

- Dual-DigiCAM Oblique
  - 45°Images for 3D City Modeling

- Triple-DigiCAM
  - Extreme wide swath width-total resolution of 111 Mpixels

- Quattro-DigiCAM
  - 4x DigiCAM for a total resolution of 145 Mpixels

- Quattro-DigiCAM Oblique
  - 45°Images for 3D City Modeling

- Penta-DigiCAM
  - 4x DigiCAM oblique
  - 1x DigiCAM vertically
  - System for 3D City Modeling

As mentioned, if the number of DigiCAM increases, then the resolution and the precision also increase.

Applications

- Geographic Information System (GIS)
- Remote sensing
- Corridor mapping, e.g. power lines, pipelines, highways
- Rapid response applications
- Infrastructure and urban applications, tourism
- Support of all LiDAR applications

2. Laser scanning (terrestrial / airborne)

Airborne Laser Scanning

IGI company product, LiteMapper systems (airborne lidar terrain mapping system), are fully integrated sensor packages for highly accurate 3D laser measurements of the earth's surface, including: high resolution laser measurement system; scanning LiDAR (= Light Detection and Ranging); high accuracy precise positioning and attitude determination system for GPS data and inertial data from the IMU (Inertial
Measurement Unit) - AEROcontrol; sensor system control and data logging unit (LMcontrol); Flight Management System - CCNS (Computer Controlled Navigation System); Software for mission planning, system operation, data registration, geocoding and processing of GPS/IMU and all LiDAR data; Optional: DigiCAM - medium-format airborne digital camera system.

The theoretical figure of airborne laser mapping is showing below:

![Airborne LiDAR Mapping](image)

All components are engineered for operation on airborne platforms. The compact and lightweight design and low power requirements make the LiteMapper systems ideal for small survey aircraft and helicopters. A high degree of automation and tight integration with the flight guidance system CCNS make it easy to operate. A dedicated LiDAR operator is often not required.

**One of LiteMapper series: LiteMapper 5600**

The LiteMapper 5600 is the choice for high-resolution wide-area mapping from fixed-wing aircraft or helicopter, and any application that requires detailed and truly three-dimensional information. This system has the unique ability to record the entire echo waveform for detection of unlimited returns from every laser shot, yielding the vertical structure of vegetation/forest areas in detail. Also, this feature optimizes the accurate detection of ground even under a complex vegetation canopies and in the presence of low vegetation, and provides accurate ground height also in sloped and rough terrain. The LiteMapper 5600 features the highest measurement rate, providing high point density/high resolution surface coverage even from fixed-wing aircraft. An almost complete (90%) surface closure can be achieved with the -12 option which in conjunction with waveform processing can yield accurate break line information. While very capable, even the LiteMapper 5600 will fit into small helicopters and aircraft without excessive burden on aircraft power and payload weight limitations.

**Terrestrial Laser Scanning**
Another important product of IGI company in Terrestrial Laser scanning is StreetMapper, which using strong and reliable laser scanning technology together with the high precision navigation system to give a novel 3D mobile mapping system to scan roads, buildings and trees from a moving vehicle. Surveying of a moving vehicle of about 70km/h can reach to a relative accuracy of 30mm (point-to-point within the data) and absolute accuracy of 50mm-1m (depending on GPS quality).

Main applications of this high technology are following:

♦ **1st City modeling:** Rapid data acquisition makes it possible to generate proper medium resolution 3D city models.

![City Modeling](image1.jpg)

♦ **2nd Highways:** For the use of upholding and asset management of road surface and street furniture.

![Highways](image2.jpg)

♦ **3rd Coastal Surveys:** To measure the area and length of coast line and a 3-D model could also be built. (In the mean time, using airborne laser scanner to do such a job is much more expensive.)

![Coastal Surveys](image3.jpg)
4th High-load route planning: Accurate and rapid mapping of route clearance for transportation of oversize cargos.

5th Overhead Wire Surveys: Wires down to 3mm diameter can be accurately located and heights measured.

Benefits comparing to airborne laser scanner:
- Rapid and cost effective deployment (much lower cost to mobilise than an aircraft)
- Direct 3D positioning and measurements for GIS data
- High point density means increased resolution so that smaller features can be
mapped
- Fast mapping of overhead wire infrastructure with measurements of height over ground and vegetation proximity
- Low cost data processing workflow using GeoCue and TerraScan
- Flexible deployment. The system can be also used on a high-roof van, 4x4, quad bike or boat.

3. Flight planning and aircraft guidance

IGI Systems presented an overview of their products and capabilities in the area of flight planning and aircraft guidance. These comprise pre-flight planning software, in-flight control systems, and post-flight analysis tools.

Flight planning

One of the tools demonstrated was IGIplan. It allows the user to define an area of interest and the software defines automatically the best flight paths and photo stations to cover the area. The interactive controls allow the user to change the parameters such as picture overlap, camera properties, flight altitude and so on.

The screenshot here shows the IGIplan software with the interactive controls. Once the plan has been defined, it can be transferred to the in-flight control units for automatic triggering of the camera unit(s) or laser scanner.

The software is capable of using Google Earth’s KML format to allow interaction with other software. When the land in question has severe altitude variations, it can be that the calculated photo separation is insufficient for the high-altitude sections of the terrain. With the aid of a terrain model for the selected area, a flexible photo separation can be defined which changes according to the altitude, thereby ensuring that the photos adequately cover all parts of the area.

IGIplan software is written in-house by IGI systems and is Windows-only PC software.
Aircraft guidance

The computer control navigation system (CCNS4-fourth generation) is the guidance positioning and sensor management for aerial survey missions. The standard system consists of:

- Central Computer Unit
- Command Display Unit
- GPS receiver with GPS antenna, necessary cabling and shocking absorbing mounting plate

The system is universally usable and can operate and integrate all common digital and analogue camera systems.

Fully Automated Flight Control

CCNS4 has the benefit of fully automated flight control system for aerial surveying and reconnaissance. It consists of a pilot control & display unit (primary) and a pilots control display unit (secondary). All operations are activated via dial and five buttons. The pilot merely has to follow the lines. Final output is found with selectable sensitivity for HIS and CDI instruments.

CCNS4 and Aero Control

All operations and management of the AEROcontrol system is controlled by CCNS4. All raw data is stored in AEROcontrol data card for post processing. AEROoffice is a data handling and post processing software for the aero control system. The software used a forward backward Kalman filters algorithm to achieve the optimal results.

Worldwide Systems in Operations

The CCNS4 is able to control up to two cameras. The actual flight data including aircraft’s positioning in WGS84 coordinates or a local grid system are computed and can be provided for data annotation on film.

Waypoints, photo data, flight information and GPS positions are stored and
transferred to CCNS4 mission card for post flight processing and analysis to complete the mission.

CCNS4 is a reliable system with more than 300 installations, the system has advantage of no moving parts, no floppy disk to crash or wear out from dust, humidity, acceleration and vibration.

### 4. Integrated GPS/inertial systems for sensor georeferencing

Direct georeferencing connects information of an airborne sensor with a position in space. The direct measurement of exterior orientation parameters for example
- enables a faster acquisition of the exterior orientation.
- removes limitations to the flight path during image acquisition.
- avoids additional problems of image matching required for automatic aerial triangulation.

The different aspects mentioned above have shown the potential applications of direct georeferencing. Using integrated GPS/Inertial systems many applications can be realized more efficiently and economically. In its final stage even traditional aerial triangulation (AT) might become obsolete if
- the exterior orientation is obtained with sufficient accuracy from integrated GPS/inertial systems.
- there are no remaining errors in the calibration of the multi-sensor system (GPS, IMU and camera).

Direct georeferencing is based on the combination of GPS and inertial sensor components. GPS offers the possibility to determine world-wide position and velocity information at a very high absolute accuracy. The principle of inertial navigation is based on the measurements of linear accelerations and rotational rate increments of a body relative to an inertial coordinate frame. The actual position, velocity and attitude information is obtained from an integration process. INS are self contained systems but due to the integration process the accuracy is not constant but time dependent. The relatively high short term accuracy deteriorates with increasing time. Therefore, both sensors are of complementary error behaviour. The integration of GPS/inertial components will
- improve the system reliability
- provide higher accuracy and higher data rate
- determine the complete set of exterior orientation parameters
Aerial Photogrammetry using single photo instead overlapping photos, and without using control point(s)

**Accuracy:**

Position (GPS): Accuracy is as good as the aspired accuracy of the final result (cm to m).
Attitude (INS): Good enough to reach “cm to m” accuracy on the ground: e.g. TOP10DK, corresponding image scale: 1:25000 (3825m)

![Diagram](image)

\[
\tan(\alpha) = \frac{dx}{h} \quad \tan(\alpha) = 1m / 3825m \\
\alpha = 0.015°
\]

**DGPS:**

GPS Accuracy is about 5-10m, depends on:
- distance from the base station
- satellite configuration (number and position of the satellites)
- reception conditions
- rate 1 - 20 Hz
- no attitude measurement
Differential GPS using phase and Doppler measurements allows much higher accuracy in the range of 10cm when in kinematic environments.

**Inertial Navigation:**

High data acquisition rate(> 50 Hz) is required. Also attitude measurement could be done as “good as you like”, but may be costly.
GPS/IMU Integration:

By IMU, the calculation of initial position, attitude and velocity (the initial state) could be done. Then the calculation of the actual state with the IMU data (“strapdown algorithm”) is possible.

![Strapdown Algorithm](image)

When GPS measurements occur, using Kalman Filter estimation of optimal state, including IMU properties would be possible.

**Summary**

The IGI mainly focuses on the follow 3 domains:

- Guidance and Sensor Management, the products of which are IGIplan (supporting Google Earth kml-format) for mission planning, and the CCNS as a fully automated flight control system for aerial surveying and reconnaissance.
- Georeferencing with GPS/IMU systems, the products of which are AEROcontrol for direct georeferencing of LiDAR and image data and AEROoffice for handling and post processing for AEROcontrol using Kalman filter to achieve optimal results.
Integrated sensor systems for special applications, the products of which are the DigiCAM, a medium-format airborne digital camera system built in modular design, and LiteMapper, an airborne terrain mapping system using LiDAR which consists of CCNS and AEROcontrol system, and StreetMapper, a system with the very latest laser scanning technology combined with TERRAcontrol running in terrestrial applications.

This IGI excursion mainly includes the following 5 parts:

- IGI company introduction and its history
- Digital Airborne Camera
- Laser scanning (terrestrial/airborne)
- Flight planning and aircraft guidance
- Integrated GPS/inertial systems for sensor georeferencing

During the excursion, the staffs from IGI company introduce us many terrestrial and airborne surveying techniques, hardware and software which launched by their company. The main techniques are covered in the presentations, we also had the opportunity to try these systems ourselves. It really helps a lot for us to understand how the instruments work.