Geofocus: Aerial photography/orthophotos

Images of desire

THOMAS KERSTEN and WILLIAM O'SULLIVAN outline the attraction and potential of digital orthophotos, and hazard the suggestion that they may even supplant conventional maps at some future point

Developments in computer technology and graphical data processing have generated a growing need for digital topographical information as basic GIS data.Spatial data and high quality maps are required for diverse applications and digital orthophotos (DOPs) derived from satellite or aerial images offer an ideal solution (see inset overleaf).Their attraction in this context may be summarised as:

- Blanket coverage data is easily obtainable.
- High quality scanners can digitise analog images and other data.
- Digital terrain models (DTMs), as a basis for DOP generation, are available at varying levels of quality using several data acquisition methods, e.g. digital image correlation, laser scanning, etc.
- Necessary control point information can be acquired by GPS in an accurate, fast and reasonable way.
- Data processing and storage platforms are available at reasonable cost.
- Commercial software for orthophoto generation is available from a variety of vendors.
- Digital cartography increasingly makes use of DOPs for map restitution.
- Officially-approved surveying in Switzerland employs DOPs for the restitution of ground coverage outside urban areas and to verify large scale maps.
- DOPs represent an important and up-to-date information level in GIS.
- With reasonable visualisation software on PCs, digital orthophotos will move increasingly into the public domain.

When one considers that the cost of data acquisition can represent 75 per cent of the cost of building a GIS, the importance of readily-available, up-to-date and blanket coverage data becomes self-evident. This was certainly the thinking behind a privately-financed initiative (project SWISSPHOTO).

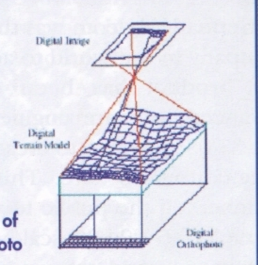


Fig.1: Principle of digital orthophoto generation

Spearheaded by Swissphoto AG, the project commenced in the Spring of 1995 with the intention of delivering up-to-date geodata derived from aerial images for the entire area of Switzerland (42,000 km^2).

Take-off

The 1995 survey (fig.2) was flown in three phases using colour and infra-red film simultaneously. Urban areas and the northern part of the country were flown between June and August while the southern part of the country and the southern valleys were covered between August and October. Some smaller areas where bad weather hampered acquisition were re-flown the following year

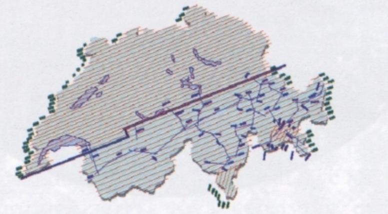


Fig.2: Flight lines flown between 1995 and 1996.

The photo scale varied between 1:22,000 (non-mountainous areas) and 1:55,000 (Alps). Wild RC30/20 camera station co-ordinates were derived from DGPS signals using an on-board Leica GPS receiver and up to three reference stations on the ground. Additional co-ordinates were derived from 104 well-distributed points of the, then, new Swiss GPS primary network, LV'95.

Touch down

Post-flight data processing employed photogrammetric equipment from Helava/Leica; two Digital Photogrammetric Workstations (DPW770) and one Digital Scanning Workstation (DSW200). Computer platforms for these stations were furnished by three SUN SPARC Station 20/71. For the test phase, SOCET 3.1.6b (beta version) from LH Systems was employed, while for production, the most recent release of SOCET SET was always utilised.

Data production, with a high level of automation, was allocated to several processing modules for optimal results, the basic steps being as follows:

- Scanning
- Data Archiving
- Digital Aerial Triangulation
- Automatic Digital Terrain Model Generation
- Automatic Digital Orthophoto Generation
- Mosaicing
- Data Management
- Data output and transfer

In total, 7,081 colour images were scanned in RGB mode on an LH Systems' DSW200 Digital Scanning Workstation over the period August 1995 to January 1998. A second rented DSW200 was used for parallel production for seven months of 1996/97.

The resulting 25µm resolution images correspond to a footprint of 0.6 to 1.3 m on the ground. The digitised colour images were converted to greyscale in order to conserve disk space and a block of 6,063 aerial images was triangulated between October 1995 and July 1998 using the Helava Automated Triangulation System (HATS) from LH Systems. To achieve maximum efficiency and system performance, Switzerland was divided into 43 sub-blocks with between 82 and 333 images per block. All sub-blocks were connected through overlap strips. This aspect of the project is described in full in Kersten, 1999.

Orthophoto generation

For orthophoto generation, a digital terrain model was produced by image correlation for one third of the area of Switzerland while, for the remaining two thirds, production was stepped-up by editing the existing DHM25 digital elevation model compiled by the Swiss Federal Office of Topography. DPW770 digital photogrammetic workstations from LH Systems were utilised for this purpose.

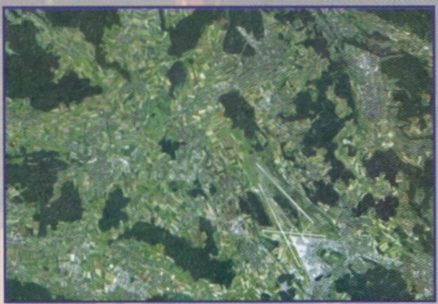


Fig.3: Orthophoto mosaic representing map sheet 1171 (Zurich airport, Kloten)

Orthophotos with a pixel size of 0.75 m were batch generated, image by image, on the DPW770. For orthophoto mosaicing (Fig.3), SysImage from ISM was used on the NT-based digital orthophoto workstations. Finally, the orthophotos were exported in TIFF format in the following tile sizes (sheets): (a) 3 km x 3 km with a pixel size of 0.75 m, (b) 4,375 m x 3,000 m with a pixel size of 0.625 m (see Fig.4). The orthophotos can be delivered in three different quality standards (see Fig. 5): (i) RAW quality without any image processing, (ii) GIS quality for data processing on the monitor by image processing with Photoshop, or (iii) PRINT quality for printing of maps by further image processing.

Fig.4: Orthophoto tile 1171_14, shown here at 5m resolution

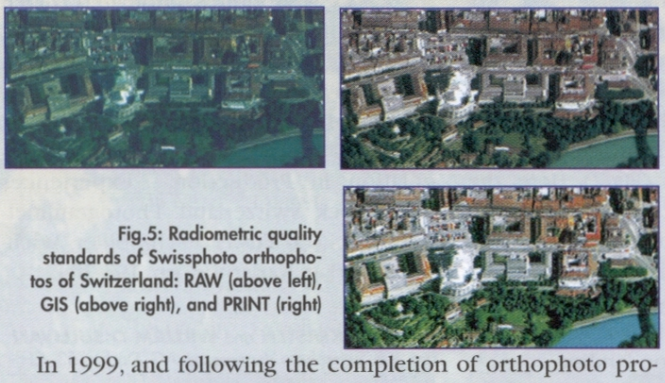


Fig.5: Radiometric quality standards of Swissphoto orthophotos of Switzerland: RAW (above left), GIS (above right), and PRINT (right)

In 1999, and following the completion of orthophoto production, Swissphoto generated a national digital surface model with a grid space of 10 m (DSM10) covering the whole coun-

Digital orthophotos: potential applications

Surveying
- Digital revision of vector data of 1:10000 and 1:5000 maps
- Visual verification of cadastre maps and revi-sion of ground objects.

Water resource management
- Information system for monitoring drinking water with integrated GIS using orthophotos for land classification
- water sources information system
- drainage of settlements
- hydrological maps, etc.

Agriculture
- Determining crop areas and revising slope angles

Planning
- Acquiring community-related inventories
- Generating synthetic 3-D views for regional planning

Networks
- DOPs as overlays for utility/telecoms network schematics

Environment
- Land use mapping
- Noise abatement (cadastre)
- Pollutant emissions (cadastre)
- Danger zones (cadastre)

Infrastructure
- Temporal orthophotos for developments relating to agri-culture, forestry, urban property, leisure activities, etc.

Geomarketing
- Digital orthophotos combined with statistical data (e.g. population density, spending power, etc.) can be used to optimise the location of business outlets and public ser-vices.

Navigation
- DOPs provide a basis for acquiring vector data for vehicle navigation systems

Simulation
- Training systems for fixed-wing aircraft and helicopters
- Computer animation and video games

Tourism
- Digital orthophotos as a new form of excursion and city maps, tourist guides, etc.

Transport
- Road surface and condition cadastre, traffic control, acci-dent statistics
- Railway cadastre

try, using image correlation techniques on the DPW 770 workstations. Basic data included b/w digital images from project SWISSPHOTO at map scales ranging from 1: 22,000 to1:55,000. Orientation data from the digital aerial triangulation were used to generate the DSM using SOCET SET Automatic Terrain Extraction and much of the work consisted of intensive editing of the correlated data. The DSM10 is available in 12km x 17.5km tiles of the Swiss 1:25,000 map sheet series. A shaded DSM10 relief of Switzerland is illustrated in fig.6. The precision of the model typi-cally lies within the range 2-5m in non-mountainous areas and up to 10m in mountainous areas. One of the primary application for DSM10 is in planning mobile telecommunications networks.

Fig.6: Shaded relief of the national digital surface model (DSM10)

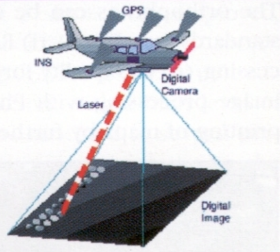
Delivering the goods

The SWISSPHOTO data have satisfied the needs of many for up-to-date digital images, DTMs and orthophotos. The ver-satility and flexibility of DOPs will be increasingly exploited, and custom maps in which users define the required fea-tures, perimeter, scale and form of out-put, will become standard. Indeed, it is not beyond the realms of possibility to envisage orthophotos replacing conven-tional maps at some future point. This trend will also add to the popularity of hybrid, as opposed to vector-oriented Geographic Information Systems.

With speed of data acquisition and pro-cessing a key consideration in DOP pro-duction, a future vision is of the entire process being undertaken in-flight. For this purpose, the aircraft would be equipped with a digital camera, a GPS and Inertial Navigation System (INS) and a laser scanning system (Fig.7). Here, the camera station stores the high resolution GPS/INS georeferenced imagery on a real-time disk, while the DTMs are derived by laser scanning. The on-line data process-ing is performed in flight, with digital orthophotos available on landing.

Most of the technical requirements needed to achieve this goal can now be

Fig.7: In-flight production of digital orthophotos



satisfied, but await the arrival of a digital camera with a respolution exceeding 16 K x 16 K pixels that can store such an amount of image data in real-time.

References

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THOMAS KERSTEN and ***WILLIAM O'SULLIVAN*** are with Swissphoto Vermessung AG, Dorfstr. 53, CH - 8105 Regensdorf-Watt, Switzerland. Phone +41 1 871 22 22, Fax +41 1 871 22 00. Email: [thomas.kersten, willie.osullivan]@swissphoto.ch