

GIS - goes aerial for RS-data acquisition

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ABSTRACT: Powerful modern GIS-components support real-time access to navigation-data in airplanes. This enables to develop sufficient applications for planning and guiding very different projects. GIS components based on the OGC-standard have access to many other pre- or post-processing tools as well as to photogrammetric workstations. Access to technical stuff goes both ways, one to GPS and/or INS as input, managing cameras, emitters or scanners on the output-side. One system has been developed for aerial imaging. Tools for the planning can use different raster and vector data of different format and coordinate systems. The flight management consists of a Windows-Cockpit PC including INS-GPS instruments, components to control the camera and its heading-correction and the application with rebuilt flight instruments for the pilots navigation. Still in the air, the done job can be observed and analysed for additional work. Similar application was made for scanner-flights even with access to the scanner and its INS system. This works with Laser-Scanners as well as with MS-Scanners or geophysical sensors. Also here the immediate control of the done work is extremely useful. A third application was done for emitting of materials, f.e. fertilisers. RS-Data, already interpreted and vectorised, can be used for this aerial job perfectly. Other applications, f.e. for controlling of electric power-lines or pipelines are under construction. The variety of such a system is big, especially for remote sensing and photogrammetry. New software components combined with modern PC-technology and other sensors, open a wide field for further applications, which more less easily can be adapted. It is the first time, GIS really goes aerial for the RS-operations.

INTRODUCTION:

There exists a real need, to have a GIS based application for aeronautics and avionic, mostly for planning and managing aerial photographs and also for scanning operations. GIS enable the access to a huge number of tools which can be used for the planning and also the navigation and controlling part of the system. Easily the data can be imported or exported to other systems and data-exchange can be done form and to very different platforms. Such a solution is embed into the geo-data-world and not a single solution. Most of the existing applications are made for such a specific purpose, the flexibility is small in that case. They are limited in the connection to sensors and also in the data-exchange. Existing technologies seldom allow to monitor the done work in real time. Rapid updating of sensor data have to take place and the use of the software application has to be made for cockpit environment.

The newly developed system aims to helps companies and the pilots to undertake effective campaigns in aerial photography or scanning operations (f.e.laser scanning). The system is based on software and hardware components including GPS, INS, cockpit-PC, GIS-application and real-time navigation with control-functions. Also a stabilized mount can be used to reduce rotation of camera axes.

APPLICATION FOR AERIAL IMAGING – PREPLANNING

Based on TopoL NT technology a tool for preplanning flight campaigns for taking aerial images with analogue or digital cameras has been created. The system supports both, raster- and vector-data and has the possibility to georeference them by different linear and non-linear transformations. As a specific function, different geocoded data (f.e. Gauss-Krüger, Krassovskii...) can be combined into a new geodata-window

with the target-coordinate system for the later flight- campaign (f.e. WGS84-UTM). Rasters like TIF, JPG, BMP, CIT, SID... and vectordata like DGN, Block, DXF, Shapefile... can be used. A wizard guides through all settings and procedures. We can chose between single projects for areas, river projects with buffer and combined areas and meta-projects for a combination of several areas and rivers. First the boundary has to be selected, imported or created and the project area can be defined. Next step is the definition of the flight- axe (track), either automatically by searching the longest line inside the area or manually. The camera parameters (focus length and film size) have to be defined or can be taken out of a calibration-protocol. A box for the technical settings enable the selection of the overlaps between strips and photos, the flight-altitude, the scale, the scanning accuracy.

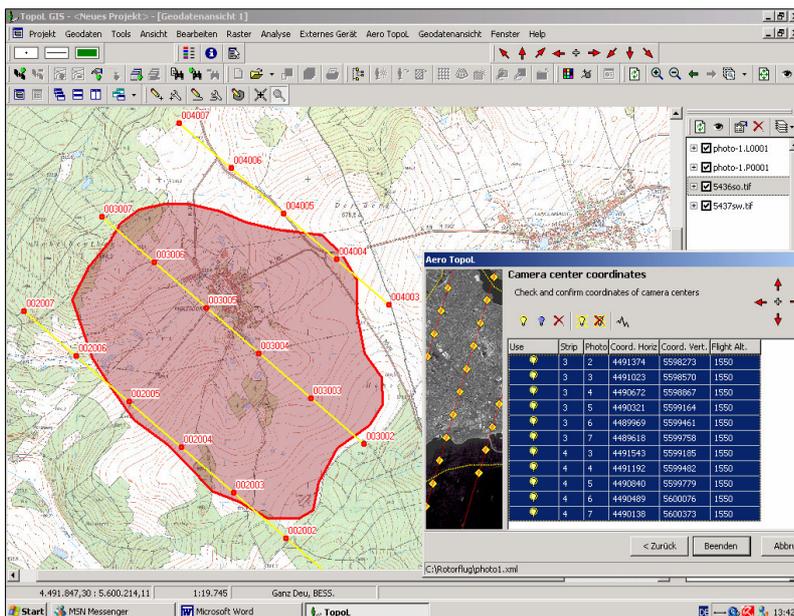


Figure 1: AeroTopoL Photoplan – application for planning of aerial photo missions

Finally AeroTopoL recalculates missing values and gives a computed accuracy in position and heights as well as the number of strips and photos. Some values can be changed and AeroTopoL computes always the new set of parameters. Now AeroTopoL computes the strips with the snap-points for the camera. This result is displayed on the map and can be modified. The covered Area of single or more photos can be displayed, the tracks and photos added or deleted or additional photos inserted. There can be entered an average height of the terrain or a digital terrain model. Especially the last one can provide a better planning and a control of the effective coverage also during the flight. If these procedures are done, the planning will be saved for the navigation, can be printed in selected scale or exported for other systems.

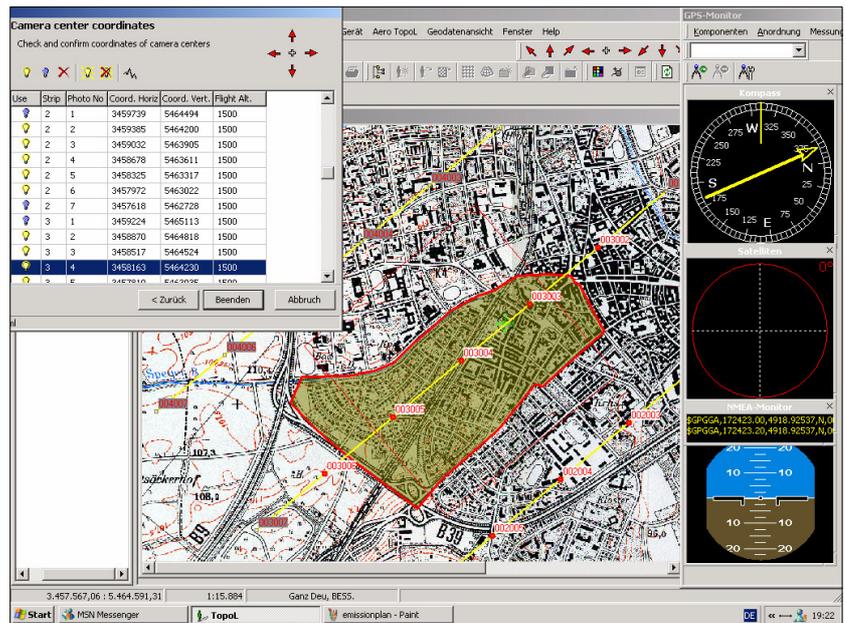


Figure 2: The screen during the flight-campaign in AeroTopoL photofly

APPLICATION FOR AERIAL IMAGING FLY:

The heart of the entire system is the Soft- and Hardware Solution for the plane. Besides the Software, which is running on a cockpit-PC, specific avionic technology have to be implemented.

The hardware consists of an intelligent board, which synchronizes GPS-Data and the output of an INS. The GPS can be either a fast tracking c/a L1 board with carrier-phase smoothing, which runs with 5 Hz and gets dynamic results in combination with Egnos of typically 0,5 m. There exists also the possibility, to integrate an RTK-system which has an fast NMEA output but besides an internal Flash connected with an event-in connector to store L1/L2 raw-data for a post processing with a final accuracy of < 10 cm. The INS, here we used a PFD 2525, delivers a resolution of 0,1° in for the roll, pitch and heading-rotations, the integrated Kalman-filter uses the calibrated gyro-data, acceleration-data, airspeed, barometric height and fluxgate data to compute a very stabile result of even better than 0,3° during a complete days work. This INS is placed on the same platform like the camera or on the cameras back. The platform itself don't has to be stabilized, but we also have already under construction such a stabilized mount which keeps the rotation angles (roll, pitch and heading) under controll.

The binary data string from the INS, incoming with 8,33 Hz, is connected to the Trimus-K+ Aero, which contains the GPS, has got 8 other analogue inputs and synchronized all data to one new NMEA-string by the frequency of the GPS. This data can be used for navigation and for photogrammetric initialization as well. Logging-function, initialization-functionality and GPS technology by request can be provided in this system very flexible. The complete track can be logged as a redundant data-management beside the cockpit-computer as well. If an already existing GPS-INS System is on board, also this data can be used instead of the Trimus-K+ Aero.

The cockpit-computer is in fact nothing special, also notebooks can be used for this purpose. Usually we built in a aluminum box together with the other electronic components an embedded industrial PC, which has got a separate

keyboard, trackball-mouse and a suitable TFT-display. The main advantages of such computers are the power-connection (12-24 Volts), the separate daylight-visible monitors and the shock-mounted hard disk. A back-up batteries provides against broken power-connection and higher voltage impulses. Especially the display is an important part. It should be visible even under daylight conditions, small to be mounted in the cockpit besides other instruments, good in view to the pilot and with most high resolution to display all data with high contrast and sharp. The size is between 6,4" and 12", VGA and XGA resolution and typically 400 candela.

The system is able to support any camera type with external electric or mechanical shutter. The camera will be connected to a switch-box on the second serial port (or the spitted out TDX of the first one), where the shutter-signal comes as an impulse from the software. With a magnetic switch nearly any Camera can be controlled.

The software is based on TopoL-NT Technology and uses the data of the preplanning Tool. The area, the flight axes (track) and the photo centers are already defined as well as the flight-altitude. We have to define now minimum (inner) and maximum (outer) snap-radius around the points. The software guides now the plane to the area and exactly to the tracks. At the serial port from the sensors are coming with 5 Hz the information about the 3d-position, the heading and the roll- and pitch values and other data. Coordinate-transformation is provided by the software. Instruments placed inside the software show the pilot an artificial horizon, a track-guidance with the offset parameters and the heading and also a goal-assistance to catch the snap-point in 3d. Besides these 3 instruments the pilot sees the plane over the raster and vector data and the view of the camera on the ground as a photo frame (rectangle or trapezoid) using the rotation-parameters as well. If the outer snap radius is reached, the system is enabled to make the photo and tries to come most near to the inner snap-radius. If the computed distance starts to become bigger, the system makes the image while the software gives an impulse to the parallel port where the camera is connected. The camera takes the picture and gives itself an impulse to the sensor, which informs the software again to store the data (y, x, z, roll, pitch and yaw) and the photo frame on the monitor. If all images are taken,

analyses over the correct overlap can be done immediately to see, if additional photos are needed. The data can be used as initialization-parameters for photogrammetric orientation and bundle-block adjustment in aero triangulation software.

Figure 3: Screenshot of the planning tool for scanning campaigns

APPLICATION FOR SCANNING

The application for scanning, f.e. with aerial lidar or optical MS-sensors, is similar like for aerial imaging. Usually already a GPS-INS is installed, to far a interface to such a sensor can be defined.

In the planning part, the scan angle and the flight altitude has to be defined, as well as the overlap of the strip. The other things are moreless the same as for aerial photographs.

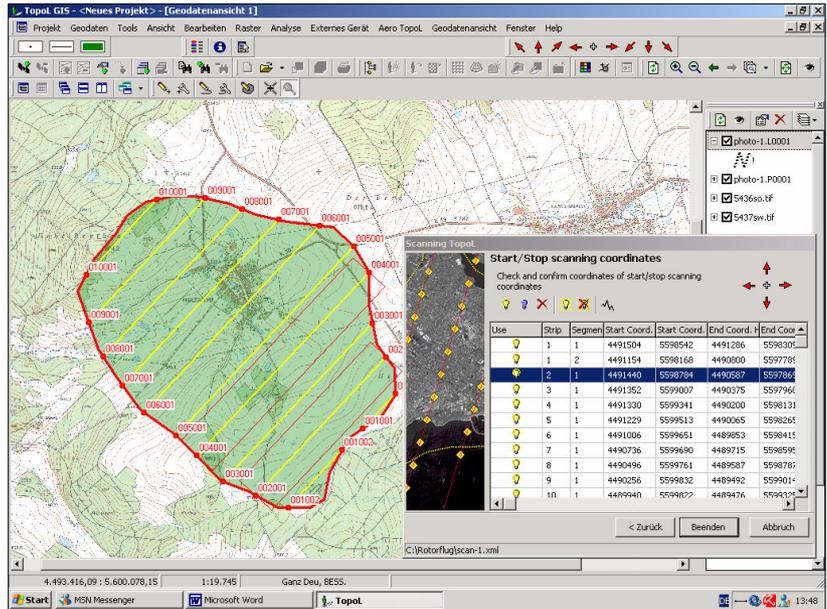
The scan width is directly connected to the roll parameter and the terrain. In some sensors, the distance of the outer points are computed online, so far the width can be computed directly. As an online-monitor, the implemented displays show the roll values and its limits. The already scanned area will be displayed as a more less straight strip. Up to now the scanner is controlled separately and this application is used for navigation only. In a further step also the sensor can be controlled by this software. Important is here the use of a digital terrain model, especially if the scan angle is wide. With this data, a real-time control if the done work is possible and missing parts can be captured still in the air.

SYSTEM FOR EMITTING OF MATERIALS- FORESTRY APPLICATION



Figure 4: Helicopter for chalking forestry areas with the emitter under it

In Europe and also world wide, the forest has sickness because of air pollution and in the case of SO₂ pollution, problems with acid rain and acidification of forest soils. Since several years, the forest-institutions under-take



chalking campaigns against the soil acidification. In the meantime, the emitting via helicopters is the most used variant of this application. Usually it will be done by private companies, which get the job after tenders from the countries forest administrations. In Germany, every year several thousands of hectares are chalked by helicopters, done by external companies and managed by the countries forest administrations. There exists a big need to document the emission of chalk by helicopters and planes. Not only for planning and navigation, also for documentation of the done work and also to control the firms doing this job. In the frame of ISO 9001 and upcoming European rules, a documentation of such applications has to be done as well. So far a system, based on GIS, GPS, Sensors and avionics, has been developed.

Heart of the system is the Trimus AeroLogger which was developed on base of the Trimus K++ technology. In the case of fast movements, a rapid updating of the position is needed. We built in a fast GPS-board, which gives an accuracy of 1 m with a refresh rate of ≥ 5 Hz. The accuracy is guaranteed by a C/A and L1 code smoothed measurement in combination with EGNOS-correction.

The GPS is combined with a processor-unit, which connects 1 other serial port, 8 analogue ports with 12 bit and an event-in switch. All data, from the GPS, the serial and analogue ports, and the event-in switch are synchronised to the frequency and the watch of the GPS. As a redundant, difficult to manipulate, data-logging system, the Trimus AeroLogger has a SM Drive to store either the entire track or controlled by the event-in switch (f.e. during the application event). This data are stored in 1 Hz on the SM-Card and are processed separately. The AeroLogger sends continuously besides the logging a modified MNEA-string to a Cockpit-Computer with ≥ 5 Hz, to navigate the pilot to the application places. The Computer is able to start, stop or interrupt the emitter, map its work and display the result directly on the monitor. The signal for emitting will be given by the software, but also a manual control is possible. A related signal will be given from the emitter to the AeroLogger and again back to the computer. This event will be monitored.

The software is based on 2 parts. One tool supports the preplanning of the campaign, the other manages the application during the flight. For the planning most important

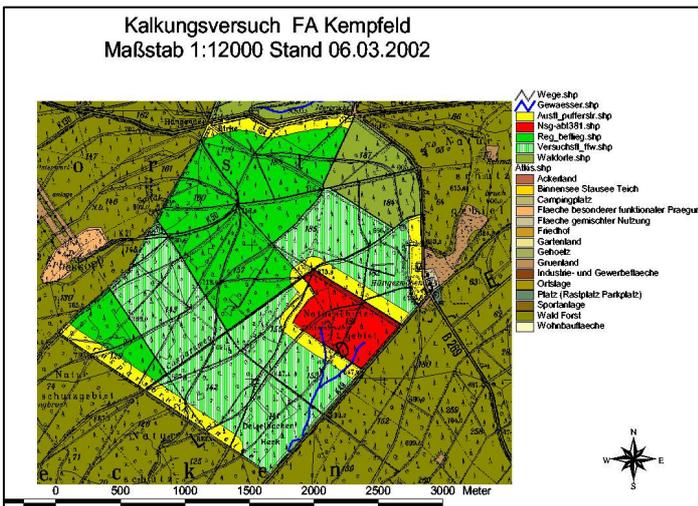
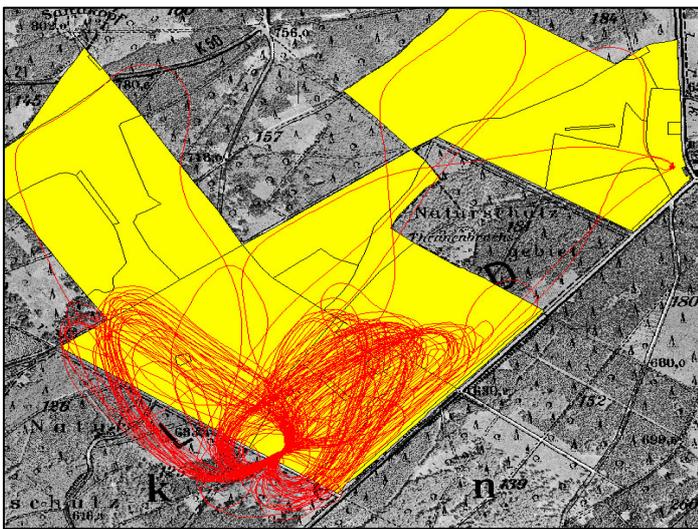
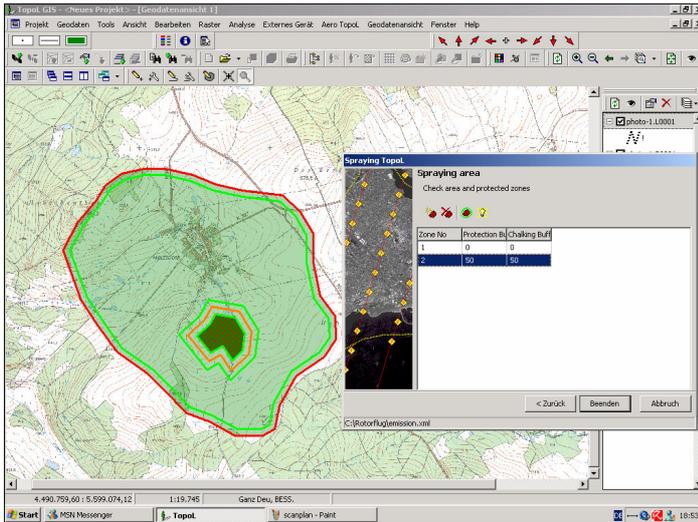


Figure 5-7: Up the preplanning tool of the work with zones of different protection status, in the middle the track of the helicopter and down a application map of the forestry work

are the areas to be worked on. They are either already given by the forest-organisation or they have to be digitised onscreen in the software. The areas have to be defined and might be also the intensity-level. Very important is the definition of protected areas, where not any chalk should go

in. To support both, sure chalking and sure not any chalk, buffers can be defined around this types of areas. That's the main feature in this tool.

More complex is the software for the flight itself. The system needs for the computation of the drift, information about the wind-speed, the wind-heading, the average drop speed of the chalk-corn and either a value of the flight altitude over ground or information of a digital terrain-model, which also can be used in the software.

Further on we need an information about the spray-width of the emitter. With this information we can start the flight and the GPS continuously show the position of the helicopter on the moving map and a bar where the chalk would fall down. If we reach the area, a signal (optically and acoustically) will be given. If we have set the automatic mode, the computer gives a signal to the parallel port of the computer and a switch there opens the emitter. The signal, that the emitter is opened to spray the chalk, will be given to the Aerologger as well and the information will come back to the software. The software computes either by the predefined altitude over ground, or by the combination of the GPS-height and the terrain model the drop-height of the chalk-corns. The influence of the wind and its direction take place and the final place where the chalk meets the ground will be mapped. Finally, a strip will be mapped on the screen to show, what is done. If we reach the buffer of a protected area, the emitter suddenly will be switched of and a warning appears. The overlap between the flown strips have to be controlled manually.

One result will be the mapped tracks of the Aerologger and the software itself. Visible on the screenshot on the left are the tracks, which guide always back to a central place, where the chalk is loaded. The emission of 1000 kg of chalk needs 20-40 seconds. That's the reason, why the track is relatively big and a lot of turns lead back to a central place.

A second result is an application map to see, what has been done. This helps for further planning and the control of the effect of the work. Such an application map can be seen down.

In a next development will be integrated a digital camera, which takes frequently images during the application. The camera has to be controlled completely by the software. The name of the image in the camera has to be linked to a point with coordinates in the database. Only a view digital cameras allow access from an outside software. This tool is under development.

This application can be easily adapted to any other field. It does not have to be airborne as well, it is an interesting technology for agricultural as well. To manage fertilisation by machines, pesticide-spays with planes and many others could use this technology. The system can be enlarged by several sensors for any monitoring and implicational job.

AEROtopoL CONTROL – AERIAL INSPECTION WORK



Figure 8: photo of a helicopter of the company Rotorflug GmbH during an inspection of powerlines, already operation with an AeroLogger system

Helicopters are frequently used for the control of power lines, pipelines and other sensitive objects. Not only the control also first repairing from helicopters on the power line are undertaken, where exact navigation has to take place.

This application is the most near to classical GIS but with even simplified and easy to use menus. GPS is used for precise navigation and vector data capturing with predefined database fields are base for the data collection. Special features like length-splitting, intersection and others are used for this work. Especially for pipelines, which are under the soil, navigation is very important to detect dangerous activities near the pipeline. In Germany already Gas-pipelines are controlled by such a system.

Electric power lines easily can be seen, but often several lines are going parallel and here an exact navigation with 1 m accuracy is needed do detect problems on the correct line.

One big advantage of the application is the possibility, to update the already collected data. More less automatically the existing database can be opened if such an inspection-point is reached. By this way the history can be observed which gives a good information about the problem.

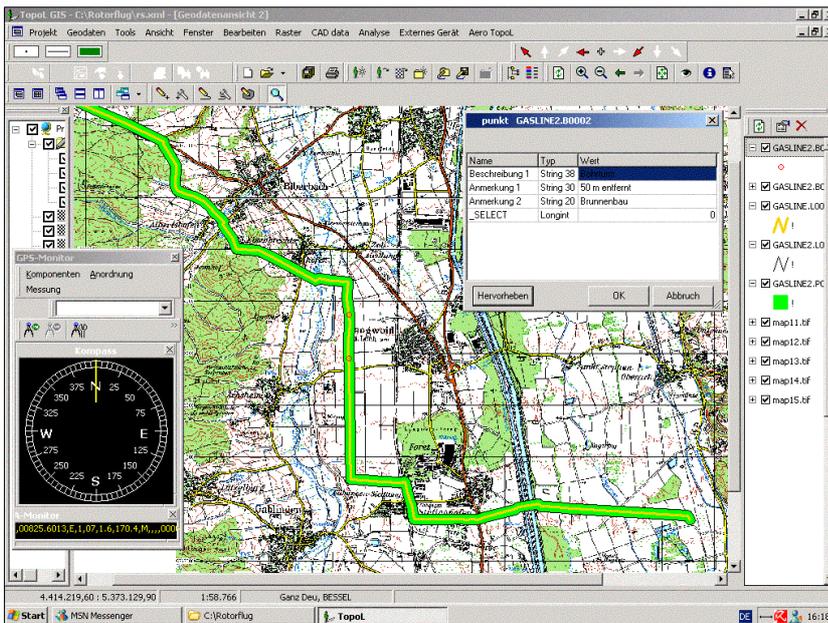


Figure 9: Main screen of the navigation and controlling system AeroTopoL Control while inspecting a gas-pipeline