APPLANIX DIRECT GEOREFERENCING *and* FLIGHT MANAGEMENT SYSTEMS FOR AIRBORNE MAPPING

The Better Way to Reduce the Cost of Airborne Mapping

applanix
A TRIMBLE COMPANY


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Applanix Direct Georeferencing and Flight Management Systems for Airborne Mapping

The Better Way to Reduce the Cost of Airborne Mapping

What is Direct Georeferencing?

Direct georeferencing is the geocoding of data from an imaging sensor by directly measuring its position and orientation relative to the earth. These measurements are derived by integrating position information from the Global Navigation Satellite System (GNSS) with acceleration and angular rates measured with an Inertial Measurement Unit (IMU). Imaging sensors can be active or passive, and include digital cameras,multi or hyperspectral line scanners, Light Detection and Ranging (LIDAR) scanners or Synthetic Aperture Radars (SAR).

Applanix pioneered the use of direct georeferencing for airborne mapping, and offers a complete portfolio of products, software and solutions.

Why Use Direct Georeferencing?

Direct georeferencing improves the efficiency of aerial mapping. It reduces costs, increases profits and lessens environmental impact. Direct georeferencing is proven for most, if not all, applications.

Increased Productivity

Applanix systems for direct georeferencing and Flight Management are easily integrated with today's airborne imaging sensors. Improving the efficiency of collecting and geocoding data from the air allows:

Reduced field costs // The number of ground control points established by a survey crew is significantly reduced. In some cases only a few are necessary for checking the final map's accuracy.

Faster completion // For many photo projects, the aerotriangulation (AT) step is eliminated, reducing processing time significantly. This is important in rapid response applications.

Seamless workflows // Data workflow and quality control is streamlined and automated. Tight project deadlines are met by eliminating extensive ground survey and reducing time as well as costs.

DIRECT GEOREFERENCING & PHOTOGRAMMETRY

Using Applanix POSTrack and a digital aerial camera on a stabilized mount, images are taken exactly at pre-planned locations where the correct overlap for stereo applications and reducing the number of flight lines required has been determined. Each image is then directly projected onto the earth using the measured position and orientation, reducing or even eliminating the number of ground control points required. If employing a bundle adjustment, the measured position and orientation improves the accuracy and efficiency of the point matching algorithms – regardless of the scene content.

POS AV™

The POS AV is an integrated GNSS + Inertial system built for airborne applications. It is available as a stand-alone product or as an OEM board set for systems integrators. POS AV includes the POS Computer System (PCS) with an embedded 220 channel survey grade multi-frequency GNSS receiver. The PCS computes position and orientation in real-time at rates of up to 200 times per second. The IMU is mounted separately and directly attached to the active sensor. Outputs are available in the sensor frame and the aircraft frame.

Orientation accuracy with the POS AV depends on the IMU used – there are several options. Systems are available with commercial IMU units – not controlled under defense regulations – or with military grade IMUs – when extended operational temperature range is desired.

APPLICATIONS

The POS AV is versatile and can be integrated with virtually any airborne sensor

Photogrammetry

① **Film Cameras //** Stable and robust, and fitted with Forward Motion Compensation (FMC) and gyro-stabilized mounts, aerial film cameras are efficient and complete methods for collecting map products.

② **Digital Frame Cameras //** Large and medium format digital frame cameras are becoming the photogrammetric sensors of choice. Producing high-resolution digital imagery with up to four color channels (red, green, blue, and near-infrared), projects can be performed in low light conditions with an all-digital workflow.

POS AV not only improves the productivity of the aerotriangulation (AT) process when flying block photography, but also enables mapping to be done without any AT.

A **Single Stereo Model Mapping //** A photogrammetric model is made using a stereo pair of images. The exterior orientation provided directly by POS AV determines the 3D object point coordinates, reducing time and cost as AT is no longer required and blocks do not have to be flown.

B **Single Photo or Strip Orthorectification //** Orthophotos can be directly produced by using digital terrain model (DTM) data and the exterior orientation from POS AV.

POS AV Rear View

Features

- Compact, low-power, lightweight computer system or board set
- Rugged construction for increased durability
- Conduction cooled for improved reliability
- Meets airborne environmental operational requirements
- Full in-air alignment support
- High-performance, survey-grade multi-frequency 220 channel GNSS receiver
- Simple to use and operate with auto-log and auto-start functions
- Real-time leveling and yaw drift correction of stabilized mounts
- Removable USB data logging with unique sealed port
- Embedded Omnistar SBAS correction service for improved real-time performance (purchased separately)
- Internal data logging for redundancy
- Dynamic lever arm support when IMU is mounted on rotating mount separate from the GNSS antenna
- Commercial grade IMUs for ease of export
- Multiple interfaces for simple integration with imaging sensors
- High-performance, low profile FAA certified GNSS-L Band antenna
- Single power connection for entire system (IMU and PCS)

SAR (Synthetic Aperture Radar)

SAR systems generate high resolution imagery using the long-range, broad-area characteristics of radar and its unique frequency response to terrain details. SAR systems are unaffected by adverse atmospheric conditions and are used to map large areas of terrain very efficiently. As with LIDAR, the POS AV is used to georeference the range information from the radar data.

Digital Line Scanner

High-performance airborne digital scanners can generate accurate multispectral or hyperspectral data. As they continuously scan the ground, the aircraft's motion builds up a continual strip of imagery. The POS AV is used to georeference each line of imagery and then remove all motion artifacts. Blur-free imagery is possible due to the high relative accuracy of the POS AV systems.

LIDAR (Light Detection and Ranging)

LIDAR uses return-signal intensity laser light to measure the range of collected digital terrain and surface model information, effective for generating accurate topographic data over large areas of complex terrain. The POS AV computes the ground coordinates of each laser pulse, generating a 3D point cloud which is filtered and processed to produce terrain and surface information.

Precise Motion Measurement for Scientific Applications

The high accuracy and low noise of the POS AV system makes it ideal for high fidelity measurements of aircraft motion for many scientific applications.

POSTrack™

The Applanix POSTrack, available as a stand-alone product or as an OEM board set, consists of a POS AV system tightly integrated with an advanced Flight Management System (FMS). The FMS provides mission planning, pilot guidance and sensor control – important for reducing time in the air and improving data quality. Time spent in the air is a significant cost of airborne mapping. More time in the air means more fuel used, more aircraft maintenance, as well as more pilot and operator expenses. Completing a project with minimal in-flight hours means higher profitability, more projects flown and minimized environmental effects.

Features:

- Daylight readable Smart Pilot touch display complete with yoke mount
- Integrated power and network switch with direct connect for up to two smart displays
- Real-time sensor control with precise camera triggering and forward motion compensation using DEM information
- Ruggedized, compact, low power hardware
- Automatic leveling of stabilized mounts and yaw drift correction to maintain parallel and level images
- Automated on/off stabilization control
- Powerful yet easy to use mission planning software with digitization support using imagery from multiple sources
- Worldwide DEM coverage for mission planning

POSTrack delivers significant benefits:

- Missions are planned using digital elevation model information, minimizing flight lines and time in the air
- Imagery is collected automatically at precisely the right location in space to ensure proper coverage
- Parallel and level images are ensured
- Pilots are guided efficiently, lowering time in transit and turns

STRENGTH BUILT ON EXPERIENCE

Applanix' proven engineering expertise and pioneering technology drive the largest user community in the airborne sensor market. A Trimble company, Applanix has priority access to state-of-the-art inertial and GNSS technology. Applanix' continued status as an industry leader with best-in-class dedicated customer service is assured.

Global Customer Support is available 24/7 with:

- Maintenance programs
- Integration support
- Extended warranties
- Full upgrade path
- Scalable options

POSPac™ MMS

The Applanix POSPac™ MMS (Mobile Mapping Suite) office software processes data from Applanix POS AV and POSTrack to accurately georeference data from airborne mapping sensors. Using GNSS and inertial technology, POSPac MMS is optimized for the airborne environment and compatible with a variety of mapping sensors. It is "smart" software, achieving maximum accuracy and maximum efficiency for direct georeferencing.

With a sophisticated user interface, the revolutionary Applanix SmartBase™ module and Applanix IN-Fusion™ technology, POSPac MMS provides unequalled productivity, accuracy and robustness to the airborne mapping professional.

It contains all the tools required to:

- Import, manage and assess data from POS AV, POSTrack and GNSS reference stations
- Produce highly accurate position and orientation solutions
- Compute smoothed trajectories, optimized for SAR motion compensation
- Perform mission specific quality assessment and control of direct exterior orientation, camera calibration and datum transformations
- Document and provide reports of a mission's solution performance
- Plan and manage complete DSS missions
- Develop DSS imagery
- Generate direct exterior orientation of images and export to third party photogrammetry software
- Perform IMU to camera boresight and datum calibration
- Generate RapidOrtho™ products directly from DSS imagery

POSPac MMS IS YOUR KEY TO CONSISTENT, RELIABLE, AND ACCURATE RESULTS... EVERY FLIGHT.

An Easy-To-Use Interface for Enhanced Productivity

POSPac MMS provides a modern and customizable user interface, letting you work the way you want:

- User definable toolbar buttons and menus – add external tools directly to the toolbar to customize the workflow
- Simultaneous multiple user views (3D, 2D, and points tables)
- Interactive display plots with multiple selection features for overlaying plots
- Layered based viewing – overlay real-time and post-processed solutions, base station locations and other data for quick visualization of projects
- User defined display style configuration for trajectory by type
- Collapsible project explorer menu with quick access to properties of various data sets
- Convenient, unified global project settings
- Project management and reporting options
- Batch manager provides capability for processing large volumes of data with a minimum of user interaction.

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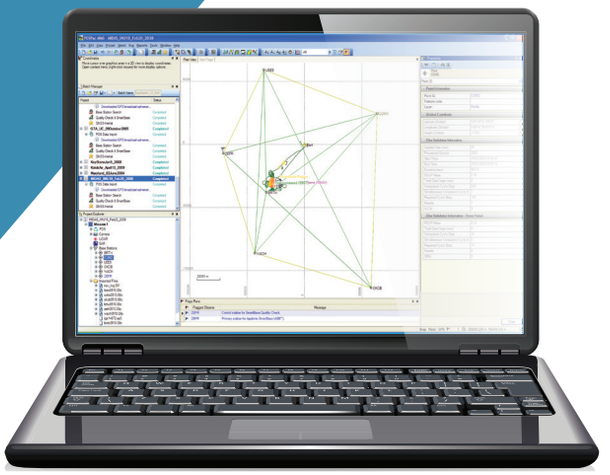
POSPAC MMS: A START TO FINISH WORKFLOW FOR DIRECTLY GEOREFERENCING AIRBORNE SENSOR DATA



POSPac MMS Laptop

1. Import and analyze data
2. Download data from the internet
3. Automated selection of network: Smart Select
4. Process a GNSS-aided inertial solution
5. Compute the exterior orientation of your images
6. Produce orthophotos and plotter ready imagery from your DSS
7. Compute a smoothed solution for your synthetic aperture radar (SAR)

① Import and analyze data // Importing data from POS AV or POSTrack into POSPac MMS is simple – browse to the logged POS file on your computer or flash card and click go. POSPac MMS automatically analyzes the files and imports what it needs. POSPac MMS then runs an automatic quality check on every file, letting you know any issues that might affect data post-processing. For more detailed analysis, the real-time position, orientation, Kalman Filter and mission status are easily plotted.

② Download data from the Internet // Reference station and precise ephemeris data are imported from the internet in one easy step. Users can search, preview, and download all reference stations in an optimized multi-base network with a single mouse click.

③ Automated selection of network: Smart Select // Smart Select automatically selects and downloads the best available network of reference receivers and imports them. Smart Select not only chooses the tightest network fully encompassing the trajectory, it also validates the observation data quality to determine station suitability for the network.

④ Process a GNSS-aided inertial solution // Aircraft time and ground crews are expensive, so the direct georeferencing solution must be right the first time; re-flights are not an option. Whether mapping forest stands in remote regions with a sub meter accuracy requirement, or mapping highway corridors with LIDAR where every centimeter counts, you need the right tool for the job. With processing options ranging from Inertially-Aided Precise Point Positioning (IAPPP) to the Applanix SmartBase module and IN-Fusion technology with full GPS and GLONASS support, the GNSS-Aided Inertial Processing Tools supplied in POSPac MMS provide everything you need.

Applanix SmartBase and IN-Fusion technology for an unequalled level of accuracy and productivity

The GNSS-Aided Inertial Processing Tools in POSPac MMS feature the Applanix SmartBase software module and Applanix IN-Fusion technology, significantly increasing the efficiency, accuracy, and robustness of mapping and surveying using GNSS. GNSS network and inertial post-processing methods work in direct cooperation, reducing or eliminating restrictions associated with high accuracy GNSS positioning. Reliable accuracy (decimeter level or better) is obtained from existing reference station networks without dedicated stations located close to the project area. Based on the industry leading Trimble VRS™ technology, SmartBase uses data logged from a network of GNSS reference stations to create a set of GNSS observables corrected for atmospheric and geometric errors at the remote receiver's location in the aircraft.

All the observables are post-processed with data from the Inertial Measurement Unit using Applanix IN-Fusion to simultaneously solve for the GNSS ambiguities and position and orientation of the aircraft. SmartBase

corrections ensure the error due to atmospheric delays is minimized everywhere within the network of receivers. Tight integration with inertial data allows the software to maintain memory of ambiguities during cycle slips or even full outages.

IN-Fusion PPP (Precise Point Positioning) is a proprietary inertially-aided technology taking Precise Point Positioning to new levels of robustness. It uses precise clock and ephemeris information to converge to decimeter level position accuracy without base stations or expensive commercial SBAS subscriptions. This is an ideal, cost effective method of positioning for aerial surveys in remote areas, or wherever centimeter level accuracy is not required.

PPP will degrade with loss of GNSS signal and then require significant time to re-converge to full accuracy. Applanix IN-Fusion overcomes this using inertial data to mitigate signal outages and retain full solution convergence before and after outages. This means high-banked, fast turns can be flown, reducing time in the air and increasing productivity, while maintaining accuracy.

Higher accuracy, improved robustness, reduced cost

SmartBase and IN-Fusion together deliver operational efficiencies to aerial mapping operations and benefits over standard GNSS Kinematic Ambiguity Resolution (KAR). Better accuracy is obtained from existing reference station networks without dedicated stations close to the project area, and aircraft can be flown with bank angles greater than 20 degrees. This reduces the costs of establishing reference station infrastructure by shortening the duration of the flight. Fifty reference stations can be processed simultaneously, with a minimum of four recommended for accuracy and robustness.

SmartBase and IN-Fusion currently supports L1 and L2 GPS as well as GLONASS observables.

Rigorous quality assurance and control

Quality check functionality for reference station data is included with SmartBase, bringing "best survey practices" to airborne mapping. Bad reference station data? Bad antenna heights? Bad reference station coordinates? Unlike traditional multiple reference station GNSS processing, errors are detected and corrected with the quality control step in SmartBase before the remote GNSS data logged in the aircraft is accessed. Before starting airborne trajectory processing, network coordinates, data, and antenna heights are known to be correct, eliminating any uncertainty during or after the trajectory processing.

Ongoing quality assurance and control of network coordinates and raw observations is simple with the new user-intuitive interface

⑤ Compute the exterior orientation of your images //

To input data into photogrammetry software, it must be transformed into exterior orientation (EO) with respect to a local mapping frame and projection, and the proper calibration parameters (IMU boresight, datum shift) must be computed. Experts at Applanix have created a set of industry leading photogrammetry tools, providing everything to ensure the highest productivity and accuracy:

Calibration

- IMU to camera boresight
- Datum shift

Mission specific quality control

- Boresight check and repair
- Datum shift check and repair
- Camera calibration check and repair
- GNSS base station coordinates check and repair
- Exterior orientation check

Generation of direct exterior orientation

- Exterior orientation for each image in user specified datum and projection

Calibrate IMU to camera boresight and local datum shift

Boresight angles are the physical misalignments of the IMU with respect to the camera. The local datum shift is the residual constant offset often present in the mathematical transformation from one datum to another. These need to be calibrated to higher accuracy than required to georeference the imagery. Applanix' unique and powerful approach using automatic image point matching and a traditional photogrammetric bundle adjustment solve the boresight angles and the datum shift directly in the adjustment process. *Continued... next page*

Perform mission specific quality control

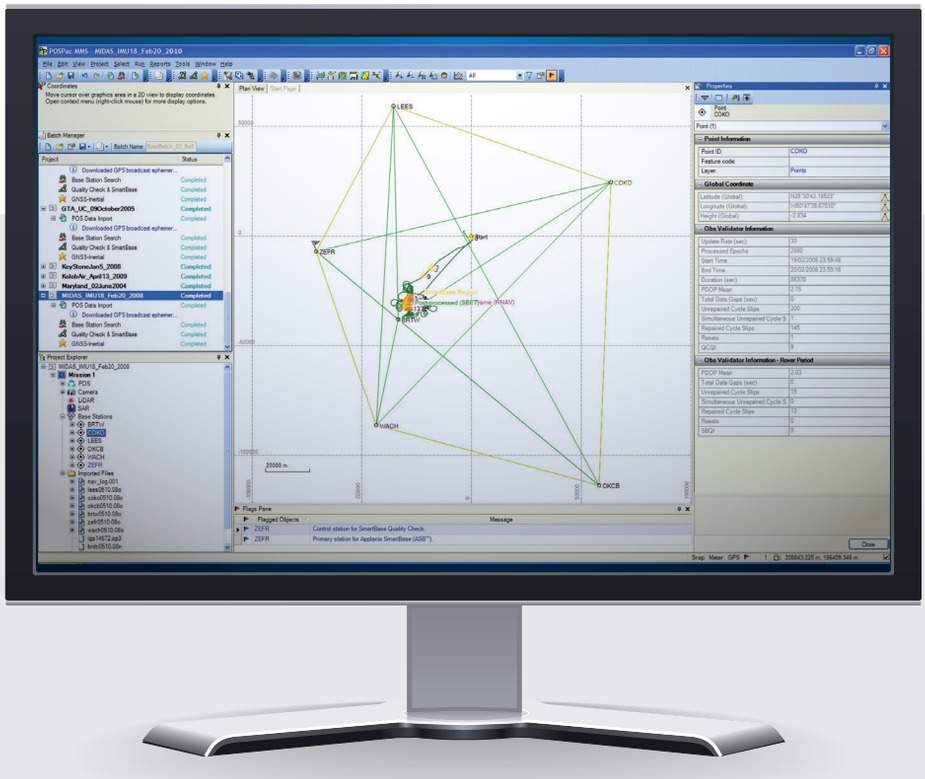
Direct georeferencing relies on the accuracy of the system's calibration and direct EO to achieve the final ground accuracy. While the calibration of mapping cameras is stable, changes can occur over time. Ongoing quality assurance and control of the calibration's parameters is crucial for success. This is done quickly and easily by using a few overlapping images from each mission and checking the system calibration parameters using the automatic point matching and bundle adjustment. This ensures the highest quality results each and every mission.

⑥ Produce orthophotos and plotter ready imagery from your DSS // The DSS Tools allow you to manage data and produce directly georeferenced orthophotos from your DSS. Simply point to the raw image files, POS AV file, and an existing DEM, and a powerful batch RapidOrtho processing module takes over to produce full-resolution or sub-sampled orthophotos automatically corrected for radiometric lens falloff, shutter effects, lens distortion and other effects. Or simply run ImageView to produce individual color corrected images ready for input into any 3rd party photogrammetry software package.

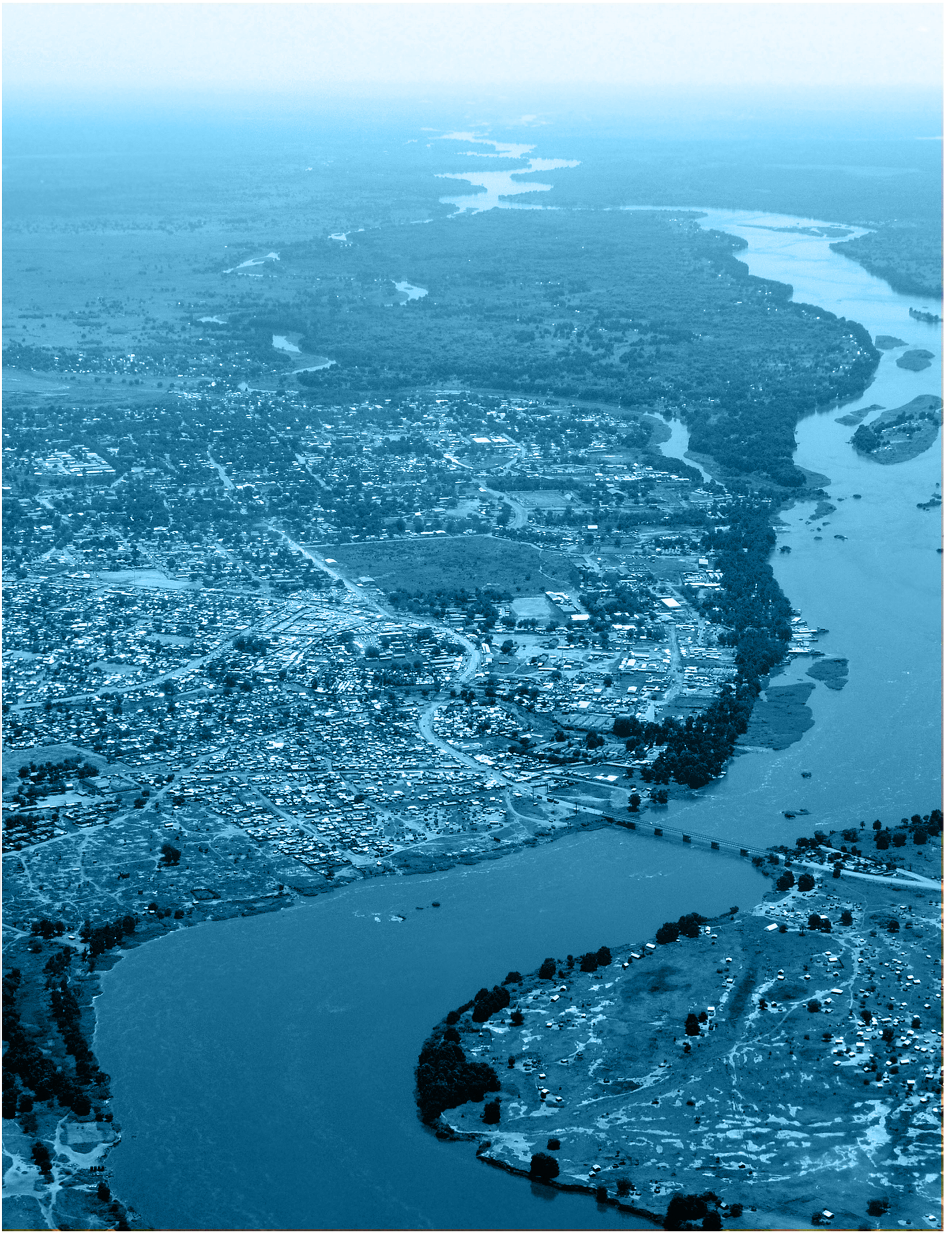
⑦ Compute a smoothed solution for your synthetic aperture radar (SAR) // SAR motion compensation requires the exact line-of-sight displacement of the radar antenna to be measured during an aperture window with the least amount of high frequency error possible. SAR Tools has been provided to remove the effects of filter resets during the SAR aperture windows.

Integrated tools and new techniques from one complete solution

POSPac MMS represents an easy step in airborne data post-processing with integrated functionality for today's professionals using Applanix' integrated inertial/GNSS technology. Take advantage of the new powerful tools and techniques designed to provide complete processing solutions from mission startup to project completion. POSPac is environmentally friendly too. Able to fly sharp turns, it increases fuel efficiency and decreases environmental effects.



POSPac AVProject



AIRBORNE LAND MARINE

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