

GeoSAR and PurVIEW: A New Solution for Efficient and Accurate Large-Area Topographic Mapping

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SUMMARY

This paper provides an overview of GeoSAR and ESRI's PurVIEW for ArcGIS®; introduces the Fugro Toolbar and the 3D GeoSAR data used in PurVIEW; and discusses the development of GeoSAR topographic line map (TLM) data using PurVIEW.

GeoSAR is an airborne dual-band interferometric synthetic aperture radar (IFSAR) system capable of producing 288 square kilometers of high resolution data per minute. These data are well suited for developing useful Geographic Information System (GIS) tools such as digital elevation models (DEMs), orthorectified images (ORIs) and TLMs. Dual-band GeoSAR data have been effectively used in determining cultural, geologic and vegetative structures and other common land use mapping characteristics. GeoSAR's fast collection rate and excellent data quality make it especially well-suited for large-area topographic line mapping.

PurVIEW is a powerful stereoscopic image viewing and feature extraction extension for ESRI ArcGIS, the world's leading GIS technology. Fugro EarthData worked with ESRI Canada to develop compatibility between PurVIEW and GeoSAR. The collaboration has already produced important interface and display advancements that optimize workflows for large-area TLM.

PurVIEW displays dual-band GeoSAR in 3D and captures TLM features directly to a geodatabase. The database provides storage and dissemination of the (unified) GeoSAR image, elevation and feature data. As a result, Fugro EarthData analysts are now able to more easily work with GeoSAR and share geo-spatial data. The combination of GeoSAR and PurVIEW will improve the development of faster and more effective TLMs.

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1. BACKGROUND

Fugro EarthData and ESRI Canada have a strategic partnership and global distribution agreement to deliver PurVIEW worldwide. Fugro EarthData operates GeoSAR, a dual-band IFSAR. PurVIEW is an integrated image display and viewing plug-in software application that incorporates stereoscopic viewing capabilities for the ESRI ArcGIS Desktop. PurVIEW requires no specialized training, making it easy to classify GeoSAR X- and P-band data into geo-spatial features. GeoSAR combined with PurVIEW creates a highly effective system for developing large-area topographic maps.

1.1 Fugro EarthData's GeoSAR System

GeoSAR is a dual-sided, dual-frequency IFSAR mapping system. The system is integrated onto a Gulfstream II business jet and is wholly owned by Fugro EarthData, Incorporated, located in Frederick, Maryland USA. GeoSAR is capable of collecting data from 13 kilometers above ground level at an airspeed of over 400 knots, yielding a net collection rate of 288 square kilometers per minute. The SAR operates at two frequencies simultaneously: X-band with a center frequency of 9700MHz, and P-band with a center frequency of 350MHZ.



Figure 1: Fugro EarthData's GeoSAR. A purpose-built Gulfstream II business jet serves as the collection platform for X- and P-band IFSAR data.

The system is designed to produce high accuracy digital elevation models (DEM) and orthorectified images (ORI) in both radar bands simultaneously. Image and DEM quality are excellent and are independent of cloud cover and sun illumination, yielding nearly all-weather

collection capability. GeoSAR is a commercialization of IFSAR technology developed by NASA's Jet Propulsion Laboratory. Fugro EarthData has been commercially operating the GeoSAR aircraft since 2002, generating large cover area maps worldwide.

1.2 PurVIEW Software

PurVIEW is a stereoscopic tool tightly integrated with ESRI ArcGIS Desktop technology that enables 3D visualization and data capture. The software is developed by I.S.M. International Systemap Corporation. and marketed through ESRI Canada.

PurVIEW transforms ESRI ArcGIS Desktop into a precise stereo-viewing environment with access to a wide range of models, scripts and tools. The software recognizes and can simultaneously use multiple data inputs, including standardized products, non-standard data sets, and mission-specific data; and features are extracted directly from orthorectified 3D imagery and deposited into a geodatabase. PurVIEW greatly simplifies the process of extracting and displaying features, thus reducing the cost of editing data.

1.3 Fugro EarthData and PurVIEW

Recently, Fugro EarthData worked in partnership with I.S.M. and ESRI Canada to modify PurVIEW to more easily support large-area topographic map production using GeoSAR data. By simplifying the management of large spatial datasets, PurVIEW allows for easier interpretation of GeoSAR's elevation and image data. Central to this capability is the development of the Fugro Toolbar and associated tools and workflows to create wide-area 3D GeoSAR images for the attribution of features.

In January 2010, these relationships resulted in a strategic partnership between Fugro EarthData and ESRI Canada, and a global distribution agreement for PurVIEW that will allow Fugro EarthData to distribute PurVIEW worldwide.

1.3.1 The Fugro Toolbar

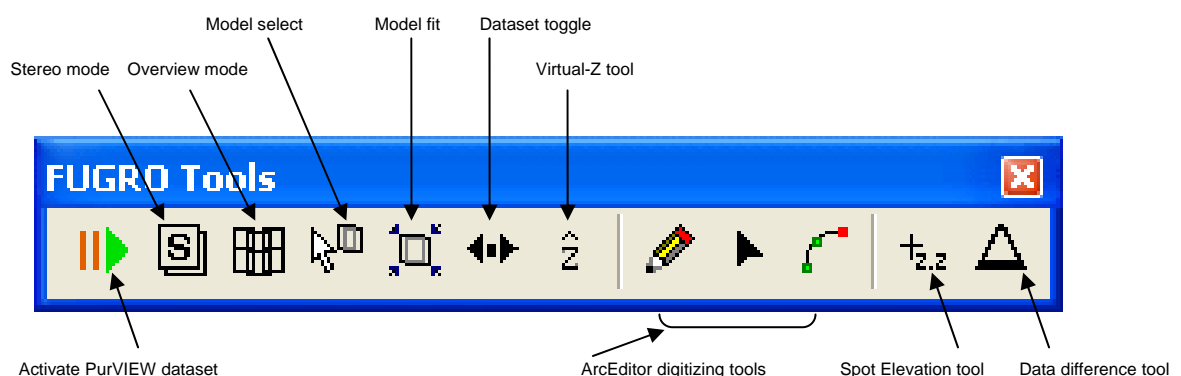


Figure 2: The Fugro Toolbar. The toolbar contains a composition of selected standard PurVIEW tools, standard ArcGIS ArcEditor tools, and custom ArcGIS/PurVIEW tools targeted at Fugro EarthData Incorporated applications.

The Fugro Toolbar supports the digitizing and query of features directly from GeoSAR data, and it provides ready access to important tools, including on-the-fly synthetic stereo display, automatic 2D feature draping, a terrain tracking stereo cursor, and a data difference display. Ongoing development will continue to increase the functionality and add features specific to other Fugro collection systems. Currently, the Fugro Toolbar is available only with concurrent production of GeoSAR radar data.

1.3.2 GeoSAR Dual-band Stereoscope Image Display

GeoSAR's X-band reflects off the first surfaces of vegetation, buildings, and bare earth, delivering images that are rich in surface detail. GeoSAR's P-band penetrates dense foliage, showing details hidden beneath the vegetation. PurVIEW enables feature extraction simultaneously using data from both radar bands, and users can easily switch between coregistered stereo pairs.

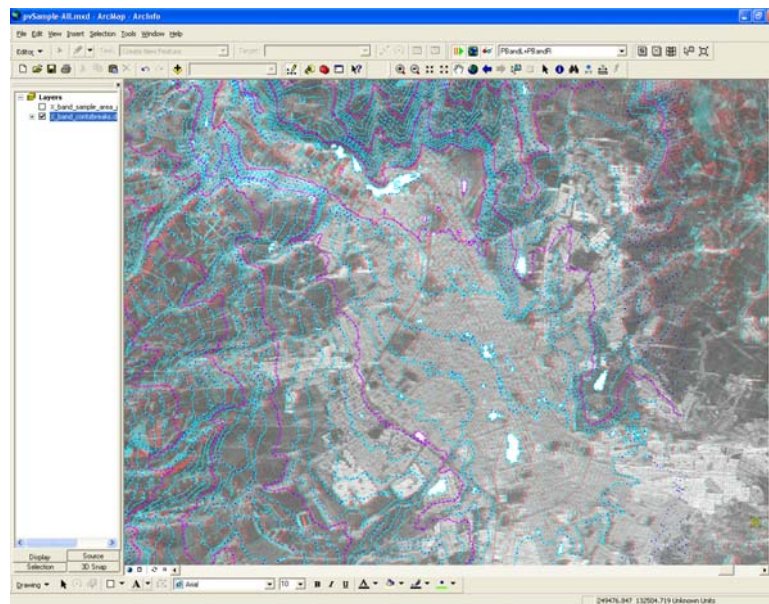


Figure 3: Anaglyphic 3D GeoSAR P-band image with feature data. This example shows a typical P-band orthorectified stereo pair rendered as a red/blue anaglyph. The image has been overlaid with features extracted with, or displayed, by ESRI's PurVIEW software

PurVIEW's 3D stereoscope display fuses the image and elevation data of GeoSAR's two radar bands, enabling the visualization of geodata in three dimensions from multiple editing

viewpoints. Significantly, PurVIEW can display in real time GeoSAR’s X-band surface, and P-band surface and subsurface layers draped over a GeoSAR DEM, which greatly improves radar interpretation. Additionally, vector data and other features can also be displayed simultaneously with radar data.

2. TOPOGRAPHIC MAP PRODUCTION

Obtaining consistent, comprehensive TLM datasets can be an arduous task; traditional map production technologies and common GIS practices can comprise hundreds of steps that require multiple data type conversions. ESRI ArcGIS Desktop with PurVIEW streamlines this process, enabling the stereo viewing and feature extraction of GeoSAR TLM data from directly within a 3D environment. Using PurVIEW to view stereoscopic GeoSAR TLM data models means that Fugro EarthData’s analysts are able to efficiently capture and attribute linework and polygons directly to an industry standard geodatabase—greatly expediting the production of large-area topographic maps.

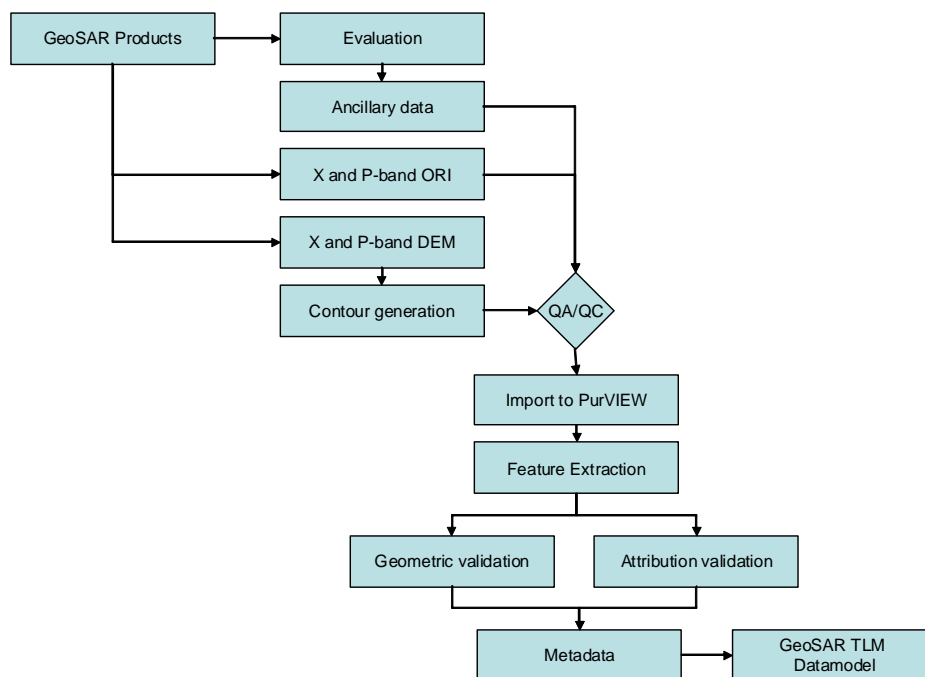


Figure 4: GeoSAR PurVIEW TLM flowchart. The flowchart illustrates the major steps required to produce a GeoSAR TLM geodatabase from radar data using ESRI’s ArcGIS Desktop and PurVIEW software.

Like all editing environments, PurVIEW works best when coupled with good geodatabase design. Accordingly, Fugro EarthData first works with the customer to craft a GeoSAR TLM geodata model. This model is a geodatabase that encapsulates the feature data and product specifications that guide Fugro EarthData’s analysts in the decomposition of GeoSAR data. The geodatabase structure reflects the TLM extraction rules and process control guidelines,

the data dictionary and data models, and the metadata standards and quality metrics that will comprise the work package.

The geodatabase is made accessible (on-demand, enterprise-wide) by ESRI's ArcGIS Server's geodata management and service framework. Generating GeoSAR TLM geodata then relies on extraction rules and radargrammetry techniques that are very similar to traditional photogrammetry.

2.1 GeoSAR / PurVIEW TLM radargrammetry

First, a GeoSAR X- or P-band DEM is overlaid with a GeoSAR X- or P-band ORI to derive a stereo pair image set. This stereo pair is then loaded into the PurVIEW 3D editing environment and TLM features are extracted.

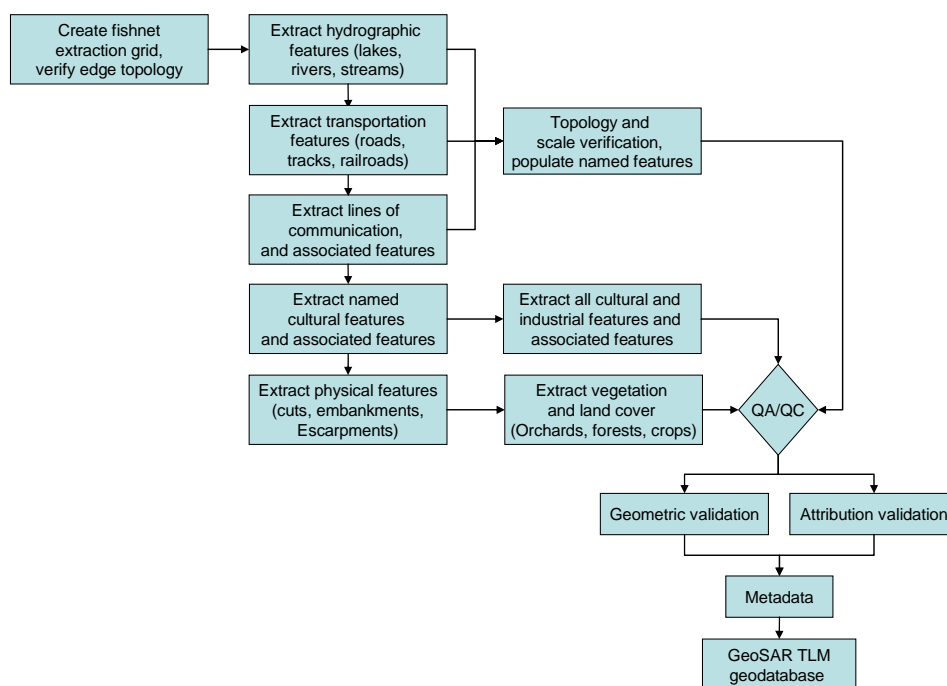


Figure 5: GeoSAR TLM feature extraction. The flowchart focuses on some important feature extraction steps in creating a GeoSAR TLM dataset.

GeoSAR TLM features are then compiled using a unified geodatabase with stereo imagery, contours, and feature tables generated from project specifications, as well as ancillary aerial or satellite photography, LIDAR data or other standard data types. These ancillary data are used as interpretation, classification, and compilation guides. Features are generally extracted by theme, with specialty production teams assigned to certain themes.

These themes may include:

- Administrative boundaries
- Drainage/hydrography
- Industrial facilities
- Obstacles
- Physiography
- Population
- Slope and surface configuration
- Soils and surface materials
- Transportation
- Utilities
- Vegetation

The final product is a fully-populated GeoSAR TLM geodatabase that is complete with both X- and P-band DEMs, ORIs, any other derived raster products, the extracted TLM data, and all of the ancillary data. PurVIEW is then used for the QA/QC process to verify these data. Features are checked against both radar bands to test for correct attribution, monotonicity, placement, elevation, and other important characteristics. Fugro EarthData is ISO9000 registered and employs ISO9001:2000 standards for quality control, process improvement, and for assuring codes of practice.

2.2 GeoSAR TLM geodatabase finishing

After primary collection with PurVIEW is accomplished, the GeoSAR TLM geodatabase is made ready for delivery using a robust finishing process. Fugro analysts perform continuity validation using topology tools that diagnose and fix most common problems in network features such waterways, roads or power lines. Hydrographic features are compiled and merged. Proper names and/or numbers are attributed to features. Contours are produced from both the of GeoSAR's X- and P-band DEMs. Lastly, the compiled features are checked for position and scale consistency with the rest of the GeoSAR TLM geodatabase. Generally, Fugro EarthData adheres to USGS mapping standards for 1:24,000 and 1:50,000 mapping scales.

Lastly, PurVIEW serves as a viewer, query, and analysis engine for the completed GeoSAR TLM data. Geodatabase queries can be executed on feature codes or any common attribute. Using ESRI's ArcGIS service framework, GeoSAR TLM geodata are co-registered to a common projection, ellipsoid, and datum, and displayed together on the fly. Accuracies obtained are comparable to photogrammetrically compiled geospatial data.

CONCLUSION

This paper introduced Fugro EarthData's GeoSAR, a dual-band IFSAR system, in the context of large-area topographic mapping. GeoSAR's image and elevation data are useful for numerous TLM applications, including natural resource management, economic development, infrastructure planning, national security, and disaster preparedness. Interpreting GeoSAR and sharing feature data using a common interface and a database is critical for efficient TLM production.

PurVIEW is a GIS-integrated 3D stereoscopic mapping tool that can be used for image interpretation and feature extraction. Using PurVIEW, GeoSAR analysts compile large-area TLMs using precise orthorectified radar image mosaics and DEMs. The feature data are extracted directly into a geodatabase where it is compiled and incorporated into GIS applications. The tool's accuracy is equal to or superior to that of photogrammetrically compiled TLM data.

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