Mapping Matters

Your Questions Answered

The layman's perspective on technical theory and practical applications of mapping and GIS

By Qassim A. Abdullah, Ph.D., PLS, CP

Q: What advantages can radar sensor (IFSAR) add to the GIS industry?

Anonymous, Frederick, Maryland

Dr. Abdullah: Only a small portion of the community of GIS data users are familiar with the geo-spatial data currently produced from SAR systems and there is little known about the potential of this great technology for the mapping industry. This is mainly due to the close association of such products with the coarse accuracy of space imaging radar programs such as SIR-B and SIR-C that produced the SRTM elevation data over the world in the past two decades. Airborne radar imaging sensors are proven to be a viable means for providing unmatched capabilities for geo-spatial data under certain circumstances. Before I continue further in my introduction, I will provide a short yet informative description of the SAR imaging technology. The term "SAR" which stands for "Synthetic Aperture Radar" is a quite recent technique for digital terrain imaging and modeling and it differs from all methods used for optical sensors as it presents many advantages for GIS applications such as global coverage, all weather capabilities, and high spatial accuracy.

Another term closely associated with SAR is "Radar Interferometry", which involves coherently combining radar measurements made by two or more antennas displaced by a relatively small distance. Radar Interferometry resembles the photogrammetric modeling of the SAR data. Interferometry is the study of interference patterns created by combining two sets of radar signals. In examining a puddle of water with a film of oil on it, you will probably notice bands of color on the surface. These bands of color are caused by light rays bouncing off the smooth surfaces of the oil and underlying water, making interference patterns. When two interferometric radar data sets are combined the first product made is called an "interferogram" (also called a fringe map). A fringe map looks similar to those bands of color you see in a film of oil that I mentioned above.

The two space-based programs publicly funded and lunched by the U.S. government, SIR-B and SIR-C, set the foundation for all subsequent imaging radar. The Shuttle Radar Topography Mission (SRTM) obtained elevation data on a near-global scale to generate the most complete high-resolution digital topographic database of Earth. SRTM consisted of a specially modified radar system that flew onboard the Space Shuttle Endeavour during an 11-day mission in February of 2000. SRTM is an international project spearheaded by the National Geospatial-Intelligence Agency (NGA) and the National Aeronautics and Space Administration (NASA). You are using SRTM data each time you use "Google Earth" or similar internet tools to explore many parts of the world in 3D.

The exciting discussions on radar-generated elevation data are yet to come with the introduction of the airborne-based systems. The first generation of such a system was developed in 1996 in the United States of America by the Environmental Research Institute of Michigan (ERIM) and NASA's Jet Propulsion Laboratory (JPL). The Defense Advanced Research Projects Agency (DARPA) had originally funded the system under an innovative program for developing new remote sensing technology for government and commercial applications. It is referred to as the "InterFerometric Synthetic Aperture Radar for terrain Elevation (IFSARE)" system. The IFSARE (now referred to as "STAR-3i") system, which is an X-band only system, is now owned and operated by Intermap Technologies Inc. of Englewood, Colorado, USA.

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The second generation of this type of system is called "GeoSAR" and was developed by a consortium consisting of the California Department of Conservation, Calgis Inc., and JPL, with funding provided by DARPA. The GeoSAR system, which is a dual X-band and P-band IFSAR system, is now owned and operated by Fugro EarthData, Inc. of Frederick, Maryland, USA. Both STAR-3i and GeoSAR are flown on board a Lear Jet and G2 Gulf Stream, respectively, and collect data from an altitude of 40,000 ft. or more. The two systems bridge the gap between the space-based and the airborne systems in terms of cost and attainable accuracy. Space-borne sensors, such as the IFSAR used in the SRTM program, provided global coverage but with lower spatial accuracy (vertical accuracy of 16 m as RMSE) while the airborne-based lidar system can provide sub decimeter vertical accuracy but with limited coverage capability.

Both airborne IFSAR systems are capable of providing products accurate to sub-pixel both in vertical and planimetric and can cover vast stretches of land in a timely manner. Both X-band and P-band on board these airborne systems provide all weather capability. While the X-band imaging capability is effective in open and lower density foliage, the P-band products expand the window of opportunity for using such systems in vegetated areas where forest canopy challenges the X-band capability in penetrating dense foliage such as that found

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continued from page 1099

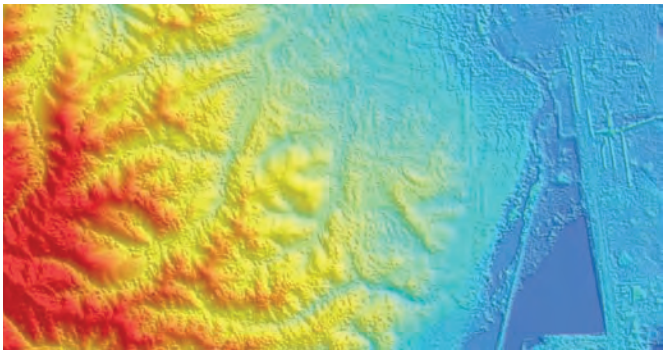

Figure 1. High resolution IFSAR X-band DSM from STAR-3i (Image courtesy of InterMap Technologies)

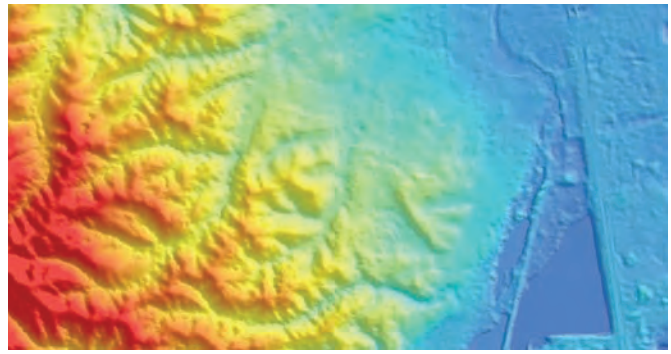

Figure 2. High resolution IFSAR X-band bare earth DEM for the same area (Image courtesy of InterMap Technologies)

Figure 3. Three meters X-band data of Pipeline Terminus in Covenas, Columbia (Image courtesy of Fugro EarthData)

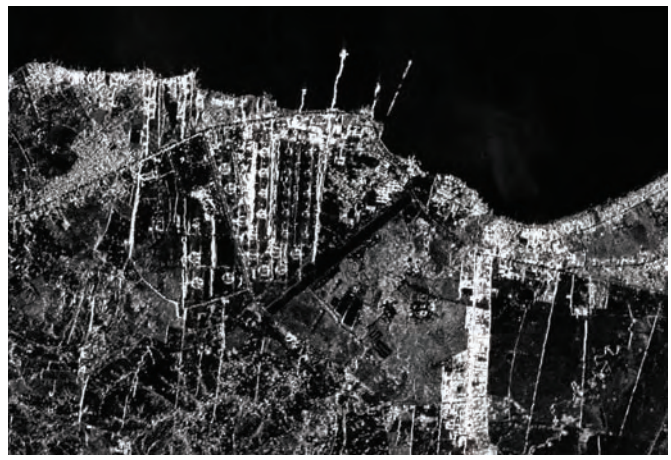

Figure 4. Five meters P-band data of the same area (Image courtesy of Fugro EarthData)

in many tropical regions around the world. The latter capability is very effective and noticeable when one compares details of under forest canopy infrastructure between X-band and P-band products in areas of South America where the canopy is very dense for the X-band to penetrate.

the magnitude imagery (ortho rectified MAG) are used to extract and update existing maps and to analyze under canopy and forest floor details (see Figures 3 & 4). Gradually, the geospatial community will realize the advantage and the potential of such sensors and will be able to utilize such technology for medium and large scale projects.

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It is worth mentioning that both systems simultaneously produce quality radar intensity images that are similar to lidar intensity images and posses the same geometric quality as the elevation data in term of horizontal accuracy. The intensity or magnitude ortho rectified imagery are very useful in depicting features that are necessary to update existing maps, especially since the resolution (GSD) of some of these products is about 1.25 meters. Users of STAR-3i and GeoSAR data are using both P-band and X-band stereo mates alternatively to collect feature in open or forested terrain. The elevation models from both systems, which are usually collected over vast areas such as country- or state-wide coverage, possess high quality vertical accuracy of sub-meter to 5 meters depending on flying parameters and post-processing efforts. Such elevation data are used to update many countries elevation data sets, ortho-rectifying high resolution space color imagery, and the generation of high quality 3D modeling (see Figures 1 & 2). while

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