

The Product Pipeline of BAE Systems for Photogrammetry and Remote Sensing

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ABSTRACT

The capabilities in the 2013 release of SOCET GXP® enable BAE Systems' customers to transition from SOCET SET® for their photogrammetric needs. This advance comes 23 years after SOCET SET was introduced to the market and 11 years after the SOCET GXP project began. The availability of SOCET SET's photogrammetric rigor and versatility in a new setting, offering enhanced ease of use and productivity, however, is only one aspect. SOCET GXP's strengths in simpler image analysis, which led to its early and widespread success amongst defense customers, allow the product to be useful in other market segments. Moreover, though SOCET GXP is not designed to be a remote sensing package, it incorporates a worthwhile range of multispectral and hyperspectral capabilities, while more functionality for synthetic aperture radar data is being developed. BAE Systems' product line is broader than this: GXP Explorer®, a relatively new product for catalog, search and discovery, began in an effort to solve the analyst's burden of spending more time looking for data than exploiting it, but has grown to include extensive capabilities, for example links to SOCET GXP and mobile applications. SOCET GXP and GXP Explorer, therefore, meet the requirements of many customers worldwide, but the picture is bigger. GXP Explorer uses a server and Web browser model, which is central to BAE Systems' path to the future. Frequently used capabilities, such as streaming images, triangulation and orthorectification, will be provided in the form of Web services, which new browser-based products will consume: plans include video products, SOCET GXP online and a browser-based workstation for all-source intelligence analysts. After some short historical notes and context, the current products are briefly presented and the plans for the future are explained.

1. SOCET SET: TOOLS IN A PARADIGM SHIFT

Seasoned attendees at the Photogrammetric Week may recall the analog and analytical eras of photogrammetry, summarized by, for example, McGlone (2013). The current, digital era was given birth by the requirement of the U.S. defense forces to switch from traditional film sensors to more convenient digital ones, and to create products and geographic information from these new images. Associated research programs in the 1980s developed digital photogrammetric workstations, which formed the basis of commercial offerings early in the next decade. SOCET SET, launched in 1990, was one such debutant (Helava, 1991). Spurred by capable and enthusiastically marketed rivals, SOCET SET grew in capabilities and matured, becoming a workhorse for mapping in 80 countries, by military, government non-defense, commercial and educational users (Walker, 2007). Mathematical models for sensors other than the U.S. government ones that were first to be exploited, automated processes such as triangulation and terrain generation, and interfaces to third-party solutions for feature collection and editing were among the incremental developments that cemented the appeal of the product in the mapping world outside the Department of Defense.

SOCET SET is in its autumn years. Few new features are being added, but customers continue to be supported, as are those of VITec®, the other legacy product of BAE Systems Geospatial eXploitation Products® business area (GXP®). New releases of SOCET SET tend to reflect developments in the platform on which it runs or in some third-party component: v5.6, launched in 2012, for example, included compatibility with Esri® ArcGIS® 10.

2. SOCET GXP: A NEW CONCEPT

A thorough review of the market early this century resulted in a concept destined to guide BAE Systems' development directions for more than a decade. It was decided to combine the strengths of the legacy products (the image manipulation and processing of VITec and the geometric rigor and photogrammetry of SOCET SET) into a brand new offering designed to be more intuitive and straightforward in use than its predecessors. The result was SOCET GXP, which pursued these goals while taking on a characteristic appearance attributable to the use of the Microsoft Office® Fluent user interface and a viewer called Multiport®, divided into panels that could, for example, contain geometrically related images, monoscopic or stereo.

2.1. SOCET GXP for image analysis

Early versions of SOCET GXP focused on comparatively simple, attractive, yet hard to develop tools for military image analysts, who constituted the largest market segment: from snail trails and simple comparisons of images through annotations and distance measurements to PowerPoint® products, a vast functionality was developed. Certain capabilities, such as Auto Align and Ortho-On-the-Fly, while designed to facilitate comfortable viewing of multiple images, include considerable embedded photogrammetry.

These image analysis tools remain the backbone of the product and the key to many large customers. While much of these users' work is based on panchromatic imagery, they make increasing use of multispectral and hyperspectral sources. SOCET GXP's range of capabilities has proved useful to many customers, from very simple image statistics, histogram manipulations and scatter plots to a selection of tools for pan-sharpening, of which Ehlers Fusion is the most recently added, components analyses and unsupervised and supervised classifications. The Multiport may be used to show the results of up to 16 algorithms operating on the same image, all panning and updating in real-time as the user moves within the image.

Numerous military experts and observers have written extensively in recent years of the deluge of video imagery that has drowned military image analysts. The need to view and analyze this efficiently has been a top priority and BAE Systems has invested heavily in SOCET GXP's video capabilities, which include viewing with DVR-type controls, measurement, exploitation of single frames, annotation and many more.

2.2. Photogrammetry in SOCET GXP

Similarly, a range of monoscopic tools for measuring buildings depends on accurate underlying sensor models and bare-earth elevations. The traditional SOCET SET customer base was smaller, so was addressed later and it was 2012 before sufficient photogrammetric capabilities were in the product to enable the bulk of these users to transition. The user interface and the design of the product simplified learning and training. SOCET GXP was more than a routine rewrite, however. A new triangulation capability was developed for frame images, in contrast to SOCET SET's, in which frame images were treated just like any other image sources. At the same time, the range of sensor models continued to grow and exceeds 50: among the recent additions are Pléiades, SPOT 6 and LiDAR. Landsat 8 is scheduled for late 2013.

Considerable work was done to enhance the well documented capability for automatic generation of digital surface and elevation models from multiple images, Next Generation Automatic Terrain Extraction (NGATE). This included improved accuracy around high buildings and greater felicity

with oblique imagery. A new capability was added, Automatic Feature Extraction, where elevation data was used to identify and remove buildings and nearby trees from surface models. These developments continue and the current focus is on implementing the algorithms on general purpose graphics processing units (GPGPUs), certainly the least expensive route to high performance in modern workstation computing. NGATE pioneered the matching of every pixel; the resulting very dense elevation data sets, together with the growth of LiDAR since the mid-1990s, have given rise to extensive capabilities for displaying and manipulating large point clouds. Ongoing work includes refinement of LiDAR equivalents to the photogrammetric process of automatic point matching: once the algorithms to find corresponding points in multiple LiDAR strips are optimized, the sensor models already developed for LiDAR can be fully implemented.

Work is almost complete on the automatic registration of video imagery based on frame-to-frame and frame-to-reference matching and the use of a Kalman filter continuously to update sensor model parameters (Taylor and Settergren, 2012). Recent developments include the use of a Fourier-based matching called Enhanced Phase Correlation, developed by another group in BAE Systems for a specific customer, in harness with ORB (Rublee et al., 2011), a matcher from the SIFT family.

The current version is SOCET GXP v4.1 and the very last photogrammetric capabilities will be added in the autumn of 2013: datums, ellipsoids and coordinate systems for mapping extraterrestrial bodies such as the Moon and Mars; generation of reference imagery in certain U.S. government formats; and the ClearFlite[®] functionality for mapping obstructions near airfields.

2.3. Third-party components

Both SOCET SET and SOCET GXP are able to offer solutions to a wider range of customers through the addition of third-party components. Perhaps best known are links to ArcGIS: SOCET GXP has a more sophisticated connection – SOCET for ArcGIS – to the geodatabase through ArcMap[®] than SOCET SET and, in addition, a more direct interface using ArcEngine[®]. For multispectral and hyperspectral imagery, BAE Systems has integrated iCee[™] atmospheric correction – and is currently working on SHORZAN littoral and riverine analysis – from the boutique defense contractor, Applied Analysis. A relationship with Stellacore has engendered OrthoVistaXtreme, a very high performance derivative of the renowned software for mosaicking and radiometric balancing. The plan is to offer this in both standalone and fully integrated variants. Also integrated is Safe Software FME[®], which can be invoked by simple buttons on the SOCET GXP ribbon to generate output in 3D PDF or OpenFlight format. TerraGo[®] capabilities, moreover, enable output in GeoPDF[®] or 3D GeoPDF format. Currently, BAE Systems is working with Dr. Kruck and Co. and with Cardinal Systems to interface SOCET GXP to BINGO and VrOne[®] respectively, to satisfy customers for whom these are critical components. The interface to Google Earth is well established and has proved enormously popular.

3. GXP XPLORER[®]: A DEPARTURE FROM TRADITION

Thus VITec and SOCET SET continue in support mode and SOCET GXP meets the image analysis, photogrammetry and mapping needs of thousands of customers. Yet these are now but part of a much larger product palette. VITec and SOCET SET have always had a capability called Visual Coverage Tool, to catalog and show the footprints of imagery and maps on local drives. This has been rewritten for SOCET GXP and has much higher performance. The need for cataloging, search and discovery, however, goes far deeper. Here again, military requirements have flowed into the commercial software product. A contract to replace various U.S. government libraries,

containing images and derived products used by U.S. and allied forces worldwide, highlighted a need for complex, high performance searches of holdings on local and remote drives, connected by not only local area networks but also the Internet. Recognizing that it will never again be possible to have all data in the one place, yet it will be critical to find and use it very fast, BAE Systems created GXP Xplorer to meet this need: a crawler continuously examines the drives and places extensive metadata about each holding – imagery, video, maps, elevation data, features, or even Microsoft Office or other unstructured files – in a catalog. Controlled by various permissions, users can view this catalog alone, or it can be “federated” with other catalogs. Once data is found for a particular task, it can be moved to the place of use or exploited in place. Searches can be designed according to data type, time of acquisition and various other criteria; they can be stored for future use. TerraGo’s Geosemble product is offered as an option, interfaced to GXP Xplorer to enable Internet information to be sought and listed on a particular place. BAE Systems is currently adding the capability to extract coordinates from text files automatically.

Importantly, GXP Xplorer represents a paradigm shift for BAE Systems. In contrast to SOCET GXP, GXP Xplorer is not a heavy client running on a high-performance workstation. It is a server-based application, accessed via a thin, browser-based client. Two consequences of this have become pillars in BAE Systems’ plans for the future. Firstly, this structure facilitates the development of mobile apps running on iOS or Android devices. The GXP Mobile app enables a user to search the catalog remotely and download an image or a chip thereof for use in the field. This will be the first of many apps that the company will offer. Secondly, the browser-based approach has led naturally to WebView, a very simple image viewing and manipulation tool that is rapidly acquiring more capabilities as customer responses are taken into account. Desktop customers also benefit and SOCET GXP v4.1 includes the GXP Connector to GXP Xplorer, so that SOCET GXP customers can carry out GXP Xplorer searches from the Multiport then load the data that is found for further analysis in the desktop applications.

The release of GXP Xplorer v2.1 provides numerous new capabilities such that the product will appeal to several market segments beyond defense.

4. PRODUCTS IN PREPARATION

The much enlarged product range envisaged in the near- and medium-term by no means excludes traditional customers. This section concentrates on predominantly new, rather than incremental developments.

4.1. Processing of synthetic aperture radar data

Work has begun on capabilities to process synthetic aperture radar (SAR) data. BAE Systems has several groups of SAR experts whose developments can be molded into commercial products. The results are planned to include one group of standard SAR capabilities that will be available to all customers and a second group tuned specifically to the needs of U.S. government customers.

4.2. New directions for video

The video capabilities mentioned above represent a considerable investment over several years. To enable more customers to access these, they will be released in a separate, economical product in 2014, GXP Video Analysis for Desktop. Only those capabilities specifically required to work with video imagery will be included and the larger customer base that will result is certain to demand

further functionality, which will then be placed under development. In echelon with this, GXP Video Analysis for Server will be developed and released in a similar timeframe, enabling video to be archived in a central place, then streamed, multiplexed, reformatted and so on.

4.3. Browser-based products

Recent developments in military intelligence have stressed the overwhelming importance of all-source analysis. Imagery intelligence (IMINT) is one component; others include signals intelligence (SIGINT) and human intelligence (HUMINT). In parallel with this trend to multiple data sources is the growth of activity-based intelligence (ABI), where the focus is on discerning and analyzing patterns of activity and relationships (Biltgen and Tomes, 2010). BAE Systems is developing an all-source, browser-based workstation.

Reference was made earlier to WebView, a simple, browser-based image analysis tool available in conjunction with GXP Xplorer. This will be expanded as quickly as possible into a product that will include, in the browser-based format, many of the important capabilities of SOCET GXP.

5. THE IMPORTANCE OF SERVICES

Web services are pervasive and, naturally, take a central role in BAE Systems' plans. Currently, SOCET GXP consumes Open Geospatial Consortium (OGC[®])-compliant Web services and this type of data is increasing in importance throughout the product. Certain capabilities have been packaged as Web services in solutions tailored for particular customers, such as data reformatting and orthorectification. Work is underway to provide a bundle adjustment service to Esri so that ArcGIS desktop customers and ArcGIS Online customers, including Portal customers, can perform tasks ranging from registration of a few historical images to a modern reference source up to large block adjustments. BAE Systems' own client-server approach has necessitated the development of a pixel server to stream images efficiently from their archival location to browser-based and desktop clients, catering for all the formats that BAE Systems products use and reflecting the need for maximum speed.

This trend, combined with the experience gained from working with SOCET SET for more than 20 years and SOCET GXP for more than 10, has resulted in a clear picture. All the products depend on certain core capabilities that can be made available in the form of services. In addition to those already mentioned, other examples are automatic point matching, including special approaches suited to imagery from small UAVs with little or poor metadata; automatic elevation generation and automatic feature extraction; OrthoVistaXtreme mosaicking and balancing; and many more of a utilitarian variety, underlying other operations, for example computation of reduced resolution data sets to enable imagery to be viewed and manipulated at different zoom levels. As these core capabilities are identified and reconfigured as services, the products invoking them become simpler, more robust and quicker to develop. Moreover, many of these services can become products in their own right, enabling existing and new customers to build applications suited to their own requirements.

6. SUMMARY

This staccato summary of the products of BAE Systems GXP has illustrated that 2013 is a turning point, a bend in the product pipeline. Like SOCET SET, SOCET GXP was developed initially to

suit military customers, but as it grew and matured it became suited to other market segments. Indeed, the combination of modernity, ease-of-use, image analysis, remote sensing, photogrammetry and GIS-connectivity all within a single product offers many advantages. Relationships with third-party partners are a significant part of many customer solutions. The launch of SOCET GXP v4.1 in 2013 marks the presence of sufficient photogrammetric capabilities for customers to transition from SOCET SET.

This transition and the eventual departure of SOCET SET are epochal *per se*, but are accompanied by further change. BAE Systems' product range is growing fast. SAR components are in planning as well as new desktop and server products for video. Customer requirements for cataloging, search and discovery fomented a massive investment in GXP Xplorer. This can be accessed via the GXP Connector in SOCET GXP and has its own WebView image analysis capability. Whereas SOCET GXP is a traditional desktop application, GXP Xplorer and WebView are browser-based and rely on a server. New products in this format currently in work include an all-source workstation and the evolution of WebView into SOCET GXP online.

Working on these products has crystallized the vision. Clearly, certain bodies of functionality will be used by more than one of the products. The key to the future lies in identifying these and repackaging them as Web services, to be used by the various products, which can be brought to market more rapidly as a result, and also sold in their own right, thus broadening the customer base. BAE Systems, therefore, is changing direction and the result will be a better alignment with multiple market segments.

7. REFERENCES

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