Buying Optical Satellite Imagery?

The Top 10 Things to Consider

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A little more than a decade ago, the only satellite imagery most people saw was a weather map on a TV broadcast. That changed with the launch of IKONOS in 1998, when the world’s first commercial high-resolution Earth imaging satellite returned stunning images from around the globe. From more than 400 miles in space, the striking details of Egypt’s Great Pyramids and San Francisco’s Golden Gate Bridge suddenly came alive, inspiring a host of uses for the imagery.

The golden age of high-resolution optical satellite imagery continues as users worldwide tap into this information-rich data for a host of commercial projects and research studies. All satellite imagery, however, is not created equal. A growing number of sensors and sources can make choosing the right imagery for your project seem like a daunting task. This article sheds light on some of the most important considerations when ordering and using optical satellite imagery.

1. Resolution

It’s the first number we look at and the one that grabs the headlines. Resolution, however, can refer to multiple parameters. For example, temporal resolution measures how frequently a satellite can image a target. But more commonly spatial resolution is used to describe the level of detail. An image with 1-meter spatial resolution, where each pixel represents a ground distance of 1 meter x 1 meter, has higher resolution—is more detailed—than a 5-meter resolution image, where each pixel represents a ground distance of 5 meters x 5 meters. The native ground sample distance (GSD) of images varies based on collection geometry, but images are subsequently re-sampled to a uniform resolution.

Zoomed out far enough, high- and medium-resolution imagery looks the same. The difference becomes apparent when zooming in closer, as the high-resolution imagery—typically 1 meter or less—will display greater feature detail and show smaller features. Although digital imagery doesn’t have an inherent scale, higher spatial resolution will support viewing/plotting at a larger scale (see accompanying table, page 13).

Resolution selection often is driven by size of the area of interest (AOI). Due to cost and technical considerations, high-resolution imagery usually is selected for AOIs smaller than 500 square kilometers, whereas medium-resolution imagery can offer a cost savings for AOIs 500 square kilometers and larger. Besides higher cost, disadvantages of high-resolution imagery include larger file size (there’s an exponential relationship between resolution and file size) and smaller swath width—the width across a single scene/strip of imagery.

2. Spatial Accuracy

Although there’s typically some level of correlation between spatial resolution and accuracy there are notable exceptions. For example, compared with DigitalGlobe’s Quickbird satellite, the company’s WorldView-1 and WorldView-2 satellites offer only a moderate enhancement to spatial resolution, but because they employ new technology they achieve significantly improved native accuracy. Most satellite imagery is delivered georeferenced or geocorrected, but not orthorectified, which is a process that improves absolute accuracy by correcting for terrain displacement. Therefore, the accuracies listed in the table are exclusive of terrain displacement, which is significant in areas of high relief. Typically, horizontal accuracy is expressed as CE90 (Circular Error 90 percent), but it may also be expressed as RMSE (Root Mean Square Error) or as a scale. For example, to comply with U.S. national map accuracy standards for 1:12,000 scale, an orthorectified image would need to achieve 10-meter CE90 accuracy.

3. Off-Nadir Angle/Elevation Angle

In practice, collecting an image at nadir, i.e., looking straight down at the target, doesn’t happen with high-resolution satellite imagery, satellite sensors always shoot at an angle. This agility improves imaging revisit times and, with some satellites, enables stereo collection for 3-D elevation modeling.

Satellite operators may report this either as “elevation angle,” where 90 degrees is looking straight down, or “off-nadir angle,” where 0 degrees would be looking straight down. A typical minimum is an elevation angle of 60 degrees, which is a 30-degree off-nadir angle. A high elevation angle (lower off-nadir angle) is often desirable, especially in areas of high relief or tall buildings to maximize what’s known as the building-lean effect.

4. Sun Elevation

Sun elevation is the angle of the sun above the horizon. Imagery collected with low sun elevation angles may contain data that are too dark to be usable. A typical minimum sun elevation angle is 30 degrees, but adhering to this requirement means that northern latitudes above 35 degrees will...
have black-out periods during the winter months when imagery with an acceptable sun elevation angle can’t be collected.

Decreasing the minimum required sun elevation angle to 15 degrees means that only northern latitudes above 50 degrees will have a black-out period, even a 90-degree sun angle is low for many applications. For example, increased shaded areas are problematic for classification and stereo projects.

Changes in sun elevation angle cause variations in the illumination conditions under which imagery is acquired. This will be more pronounced in high-relief areas and areas with taller objects, such as trees and buildings, where low sun elevation angles mean longer shadows will be cast.

For some of the affected land masses, these black-out periods correspond to months with snow cover, making new clouds during these times less desirable. In areas such as Alaska, where sun angle and snow cover limit the window for optimal imaging, optical satellites currently are unable to meet the high demand for imagery.

Vector extraction from imagery allows roads, hydrology, and other features to be mapped faster and less expensively than traditional ground surveys to create new maps or update/correct existing maps. The resulting accurate, up-to-date base data then is used to support applications such as Internet mapping, portals and handheld Global Positioning System devices.

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Because high-resolution imaging satellites are able to shoot off nadir, their revisit times—ability to repeat coverage of an area in a few days or less—employing multiple high-resolution satellites on the same AOI means that intraday collects are theoretically possible. However, in the real world, clouds and competition for satellite time are significant obstacles. A satellite’s collection capacity is determined by its swath width (see table), agility to point and shoot at multiple targets or capture multiple swaths at once. Large area mapping, high-zoom pass, onboard storage and downlink capacities. Pléiades 1, GeoEye-1, WorldView-1 and WorldView-2, and other satellites offer significantly improved collection capacities than their predecessors, while the older satellites, such as Ikonos and QuickBird, may have better available capacity to collect an AOI in regions where the newer satellites have demand backlogs. A satellite such as Pléiades 1, which doesn’t have a U.S. government backing, may also be able to offer an AOI at a cost. Tasking two or more satellites for the same AOI improves the ability for imagery to be captured. For example, DigitalGlobe offers constellation order fulfillment (COF) where QuickBird and WorldView-2 can be tasked to acquire the same AOI with no cost uplift. RapidEye further leverages the constellations by employing a system of five identical satellites to facilitate global and regional-scale mapp- ing and saturating coverage of areas with persistent cloud cover. When placing a new collect order, a feasibility assessment typically will be run to estimate the turn-around time. The feasibility takes into account potential cloud cover for the region and competition for satellite time in the area. Because collection queues can change daily and cloud cover is uncontrollable, feasibility estimates only, guaranteed collection times. Most satellite operators offer priority tasking for an additional charge. Areas that have both high demand for imagery and persistent cloud cover are challenging to collect regardless of the time and are likely to require lengthy turn-around times.

### Cloud Cover

Typical cloud-cover guarantee with new collections is 15 per- cent or less within the project AOI. Some satellite operators offer an improved cloud-cover guarantee for a cost uplift or the ability to choose a small cloud-free target area that must have zero cloud cover. This option is well suited for infrastructure sites such as airports, mines, and oil and gas installations. Typically, if the satellite op- erator supports this feature, each collect order that meets specifications during the estimated collection window can be charged. With archived imagery, a reduced-reso- lution preview graphic can be reviewed ahead of time, although it may be difficult to detect small clouds or haze.

### Delivery Method

Traditional delivery methods have been FTP, DVD and external hard drive. As FTP capabilities have improved and the cost of external hard drives has come down, DVDs are used less frequently. Before ordering a large area with DVD delivery, it’s worthwhile to consider the time required to upload from DVD to hard drive vs. the extra cost of delivery on external hard drive. Heavy imagery users also will benefit from an up-grade to USB 3.0.

Leveraging Professional Guidance

Although these basic parameters dealing with ideal imagery collection scenarios, real-world cost and turn-around time constraints often mean imagery users will need to consider available imagery. For example, in a high cloud cover/high task- ing competition area such as Indonesia, the best option may be to use a less than optimal archived image because a new collect likely would require a lengthy turn-around time and not come back entirely cloud-free.

In such instances, an experienced geodata professional can help users understand the acceptable trade-offs for a proposed project. Working with an independent data company, often called value-added resellers (VARs) or channel partners, can help ensure the optimal imagery solution for your specific project.

A specialized data company can source DEMs and ground control as needed and can offer custom processing and flexible delivery options. For example, imagery can be ortho-output as a 16-bit pan plus MS for users with more advanced remote sensing software and three-band, 8-bit pan-sharpened mosaics with con- tour adjustment, or GeoTIFF and wavelet compressed formats for users with digital computer-aided drafting (CAD), geographic information system (GIS) and graphics software applications. In areas where the selection of archived imagery with superior native accuracy can be used as control to improve the ortho accuracy of imagery with lower native accuracy, a value-added vendor can combine imagery from multiple sensors into the same mosaic. In addition, products can be processed to complement each other. For example, higher resolution imagery with superior native accuracy can be used as control to improve the accuracy of medium-resolution images covering larger areas.

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### Additional Options

Along with the leading commercial optical satellite imag- ery products, many additional optical imagery solutions exist. Where available, aerial photography can be an alternative to high-resolution satellite imagery. Agriculture projects that may require large area collection in a short time window will benefit from the large swath width of satellites such as DEOS-1 or AWIFS. CBERS data should be considered for any project in South America where medium-resolution imagery is required. The Japanese satellite ALOS no longer is collecting new imagery, but archived imagery collected during its five-year lifespan is available at moderate cost. The range of imaging satellites is too numerous to list, but includes options such as KOMPSAT, EROS, FORMOSAT, the IRS constellation, Resourcesat and Cartosat, among other sensors. In some regions, LandSat and low-cost ASTER imagery can facilitate projects where commercial imagery may be cost-prohibitive, both LandSat and ASTER’s SPOT Image products offer extensive historical imagery archives.