by Steve Thompson

The digital ortho aerial photo – cornerstone of GIS/GPS mapping

GIS/GPS like any industry has its own terminology and jargon. Digital ortho photography is often mentioned related to GIS/GPS. What is a Digital ortho photo? It is an aerial photo taken of a place on the earth from an airplane or, more recently, a satellite. The photo is digital so it can be stored and displayed by a computer. These photos are the base layer upon which everything else is mapped. Digital ortho photos provide a seamless, scale correct and distortion free photo background for any mapping project, such as a water system. When utilities such as water utilities are mapped, it is usually referred to as infrastructure mapping. I would like to explain digital ortho photos in detail and how the photos relate to infrastructure mapping.

Steve Thompson
Manager GIS/GPS

Typically, infrastructure mapping would include mapping drinking water, sanitary sewer, storm sewer, natural gas, electric power, communications, and transportation networks. One part of the infrastructure that is too often overlooked is people. Without the people who keep infrastructure running, it won't last long.

There is a national/ international professional group that was named AM/FM, Automated Mapping and Facilities Management. Their new name is Geospatial Information Technology Association (GITA). Geographic Information Systems (GIS) and Global Positioning Systems (GPS) had an impact on the name change. These two technologies have revolutionized facilities mapping. The GIS is the computerized mapping and analysis system that is used to map water, wastewater, gas or other utilities on the digital ortho photos. Each set of features (meters, valves, or hydrants for example) becomes a layer in the mapping system, with the ortho photo on the bottom layer. The GPS is the computerized satellite-based location, routing, and tracking technology. We use GPS to determine the position of the water meters, valves, and hydrants, so that they can be placed in the mapping system at their proper place on the ortho photo.

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Photo basics

Now back to the digital ortho photos. I mentioned earlier that the ortho photos were seamless, scale correct, and distortion free. What does that mean exactly? The photos are seamless because they cover an entire area without gaps or overlaps. The aerial photos taken in 1991 are available for a whole city, state, or the entire United States. In Kansas we also have 2002 digital ortho photos that cover the entire state. Those gray-scale photos are tiled by quarter quad. This means the entire statewide photo is made up of individual photos that cover one-fourth of a U.S. Geological Survey 7.5 minute quadrangle map or about 3.3 miles east/west and 4.4 miles north/south on the ground. Each of these photos requires about 50 megabytes of storage space on a computer hard drive. Each quarter quad photo matches up exactly with all the photos around it so that the overall photo is seamless. For the whole state we would have approximately 6400 quarter quads or 320,000 megabytes which equals 320 gigabytes or about 500 compact discs (CDs) of data.

Photo file compression

The photos can also be combined into a single larger photo file for a whole area, for example an entire county. The only problem with the larger photo is that the file size grows so large making the file difficult to store and transfer. The larger photo file also loads onto the computer screen very slowly. To get around this problem the photo files can be compressed. Smaller files load faster. There are many compression schemes but the most popular one is called Mr. Sid Compression Format by a firm named LizardTech. With Mr. Sid compression, a single file of 300 megabytes can be created instead

of 3000 megabytes that would be required if were it not compressed.

Resolution vs. usability

Digital ortho photo files are also scale correct. Because the photo is scale correct an accurate distance can be measured directly on the photo. A north and east coordinate can also be determined for any location on the photo. Each individual digital ortho quarter quad photo is made up of millions of small cells called pixels. A pixel is the smallest displayable picture element. On a one-meter pixel resolution digital ortho photo, each pixel represents a one-meter by one-meter spot on the ground. If we zoom in to one individual pixel, we would just see a big blur on the screen, because the view is far too close. But the smaller the actual displayable pixel, the more closely we can measure distance, and the closer we can zoom in on the photo without it becoming too blurry to see anything. We can actually now purchase ortho photos down to three-inch pixel size, also called three-inch pixel resolution. With three-inch resolution, a viewer can zoom close in and see great detail over a small area. On a one-meter pixel resolution digital ortho photo we will only be able to discern objects clearly that are considerably larger than one meter by one-meter, like houses, driveways, or vehicles. But with a three-inch or six-inch pixel resolution ortho photo we will be able to clearly see curb lines, fences, people walking on a sidewalk, power poles, etc.

Storability

Of course the smaller the pixel resolution and the greater the detail, the larger the storage required to contain the photo. A three-inch pixel resolution photo versus a one-meter pixel resolution photo for the exact same area on the ground will require approximately 172 times as much storage space. So a 50 megabyte, one-meter resolution quarter quad photo file which covers approximately 3.3 by 4.4 miles on the ground will now require about 8600 megabytes at three-inch resolution. With Mr. Sid Compression that 8600 megabytes can be compressed to about 860 megabytes. So three-inch or six-inch pixel resolution photos are usually not purchased for a large area because they are more expensive, require much more disc storage space and load too slowly. KRWA is aware of at least one firm that is marketing affordable countywide ortho photos at six-inch pixel resolution.

Photo clarity

Digital ortho photos are distortion free as well. Actually the digital ortho photos are as distortion free as possible. It is impossible to remove all of the distortion but it can certainly be minimized. Because of the process used to correct the distortion in the photos, every feature, a building for instance, looks correct dimensionally in the photo and will be in the correct position

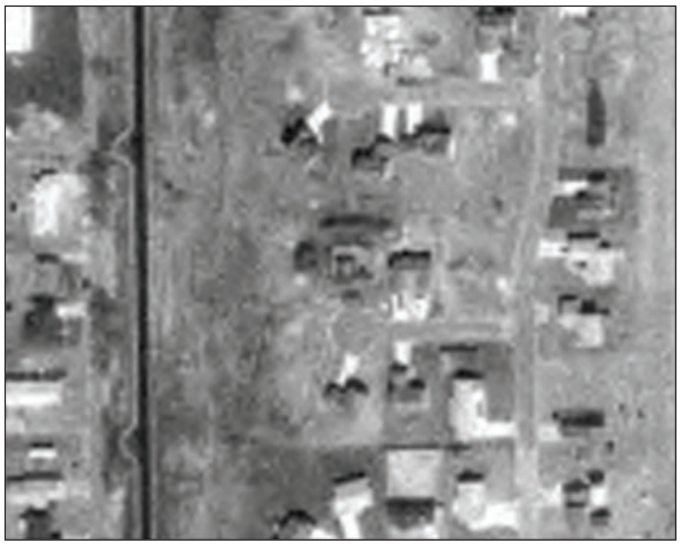


Photo A – The 1991 one-meter pixel, gray-scale, Mr. Sid compressed, digital ortho photo

Photo B – The 2000 one-foot pixel, color, Sedgwick County, Mr. Sid compressed, digital ortho photo

relative to every other building around it.

Availability and cost

Currently the 1991 gray-scale, one-meter pixel, digital ortho photos for the whole state, one file per county (200 to 300 megabytes), can be downloaded free via the Internet from the Kan. Data Access and Support Center (DASC). DASC is housed at the Kansas Geological Survey building on the University of Kansas campus. Those one-meter digital orthos were created for the entire state of Kansas at a total cost of about $4.5 million, paid for through a consortium of local, state, and federal agencies. The 2002 gray-scale, one-meter pixel, digital ortho photos for the state, tiled by quarter quad are currently available from the DASC but you have to call or email and request them on CD or DVD. The cost is $30 per DVD, one per county, or $15 per CD with several CD's required per county. The 2002 photos were created for the entire state at a cost of about $1.7 million. At the time this article was written approximately 20 counties were available for free download, one file per county. The rest of the counties are slated to be completed within three to six months.The DASC Web site is http://gisdasc.kgs.ukans.edu/; the phone number is 785/864-3965. Also at DASC, the 2003, 2004 Farm Services Administration (FSA) two-meter pixel, color digital ortho photos, can be downloaded for free. These files are one file per county (50 megabytes). The 2004 FSA photos are also available from FSA at a price. These photos are purchased annually to assist FSA in determining farm field boundaries and ag-use. Typically if a photo is one-meter pixel resolution gray scale, it will be two-meter resolution for the same file in color.

Some contract their own

Some counties have had their own digital ortho photos created by private contractors. In most cases those counties, like Saline County, have had the photos for the cities created at six-inch pixel, and the rest of the county created

Photo C – The 2002 one-meter pixel, gray scale, uncompressed TIFF format, digital ortho photo

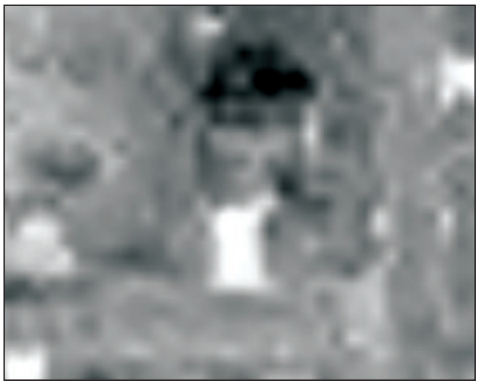
Photo D – The 2003 FSA two-meter pixel, color, Mr. Sid compressed, digital ortho photo

at a two-foot pixel gray-scale. Sedgwick County had the photos for their entire county created at one-ft. pixel, color. When KRWA maps a water system infrastructure we try to find any sources of improved photos that are available at minimal cost and use those as the base layer for the mapping project. Other groups or agencies like your county appraiser may have purchased or may be planning to purchase new photography that you may have access to.

Resolution at a glance

The two photos on the previous page and the two above illustrate differences in resolutions. These all are of the same subdivision in Valley Center, Kan., in Sedgwick County. The photos are: a) the 1991 one-meter pixel, gray-scale, Mr. Sid compressed, digital ortho photo; b) the 2000 one-foot pixel, color, Sedgwick County, Mr. Sid compressed, digital ortho photo; c) the 2002 one-meter pixel, gray scale, uncompressed TIFF format, digital ortho photo; and d) the 2003 FSA two-meter pixel, color, Mr. Sid compressed, digital ortho photo.

Through the yearly progression of the photos one can see the development occurring in the subdivision. These photos allow us to do detect changes year to year. When looking at the 1991 photo vs. the 2002 photo, the subtle difference between the resolution of the Mr. Sid compressed file vs. the uncompressed TIFF file is apparent. There will be some loss of resolution whenever a photo file is highly compressed. With the Mr. Sid compression, the photo file can be compressed to one-tenth of its previous size with very little effect on the resolution of the photo. The quality of the 2002 photo is slightly better when zoomed in to the same level. The



Far Left: Photo A – The 1991 one-meter pixel, gray-scale, Mr. Sid compressed, digital ortho photo

Left: Photo B – The 2000 one-foot pixel, color, Sedgwick County, Mr. Sid compressed, digital ortho photo

Below left: Photo C – The 2002 one-meter pixel, gray scale, uncompressed TIFF format, digital ortho photo

Below: Photo D – The 2003 FSA two-meter pixel, color, Mr. Sid compressed, digital ortho photo

2000 one-foot color photo is obviously much better than the others. The 2003 FSA photo has the least resolution, but is still clear enough for change detection; the color helps with that.

In this second set of photos on this page, we have zoomed in to two houses in the subdivision on the same photos as before. One can easily see that the Photo B, 2000 one-foot pixel, color, Sedgwick County photo is much clearer when zoomed in than the other three.

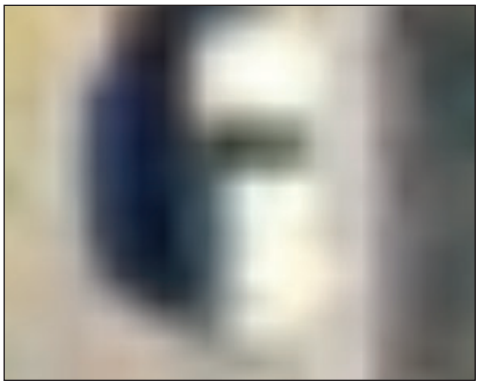
Proper registration to orientation

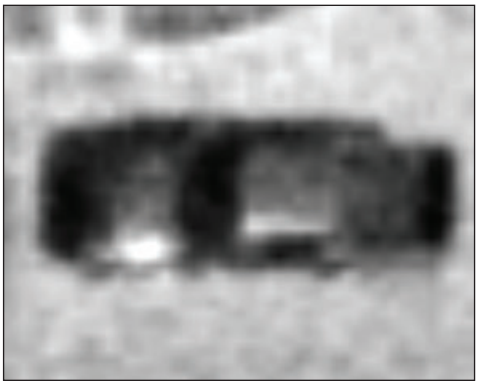
There is one caveat that we have discovered when using the digital ortho photos as a base map layer for mapping water system infrastructure. We use GPS to determine coordinates for each valve, meter, and hydrant in a water system. Those coordinates are called absolute coordinates; they identify that one spot on the earth's surface where that valve, meter, or hydrant is located. Our assumed accuracy is two to three feet. However, sometimes when we place these valve, meter, and hydrant coordinates on the photo base, they appear up to 20 to 30 feet away from where they should appear on the photo. In most cases we have found that the earlier ortho photos were not accurately registered and may be shifted or even slightly rotated. With the GPS points as a guide we can normally shift or rotate the photo base to it's proper orientation, and all of the features that we map with GPS from then on will appear in their proper place on the photo. If you have discovered problems like this with your mapping, please contact us.

In summary, digital ortho photos provide a seamless, scale-correct, and distortion free base map on which we can plot all of our valves, meters, hydrants, manholes, power poles, signs, etc.

The photos can also be used to find features previously mapped. Some of the digital ortho photos can be obtained for free or at minimal cost. New photos can created at considerable cost. KRWA would like to map your utility infrastructure for you, including water, sanitary sewer, storm sewer, natural gas, electric power, signs, etc. Please give us a call at KRWA-Mapping, 877-820-5792 or call the KRWA office at 785/336-3760.

I would also like to invite you to attend the session which we will be presenting at the KRWA conference on March 29. The presentation will be in the Hyatt Ballroom E, with seating for 350 people. The topic is of course our favorite: GIS/GPS Mapping: Applications, Accuracies, Costs and Usability. We have some new things to show you as more and more cities, counties and rural water districts move their mapping into the digital era. We hope that we can help you understand the possibilities and potential that these exciting new technologies offer.





Above: 2000 one-foot pixel, color, Mr. Sid compressed, Sedgwick County digital ortho photo. Right: Six-inch pixel, gray-scale, Mr. Sid compressed, 2002 Saline County digital ortho photo. In these two photos, notice how the six-inch pixels hold the resolution a little better than the one-foot pixels. It's apparent that the darker vehicle is a pickup.