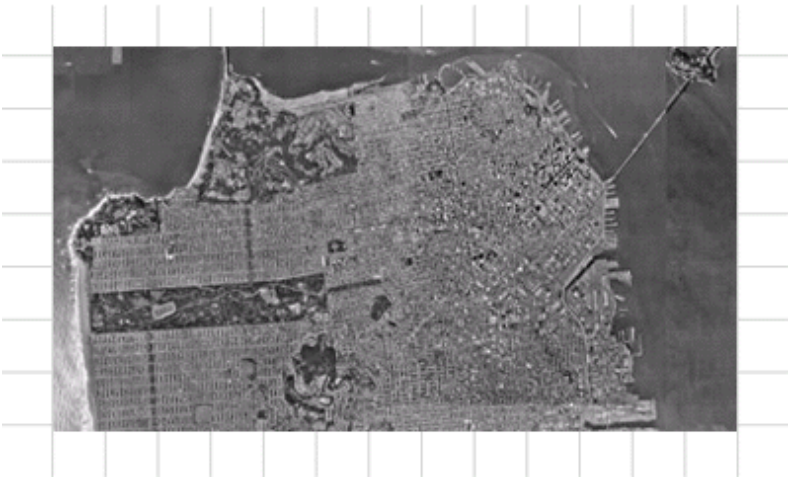
TerraServer Story

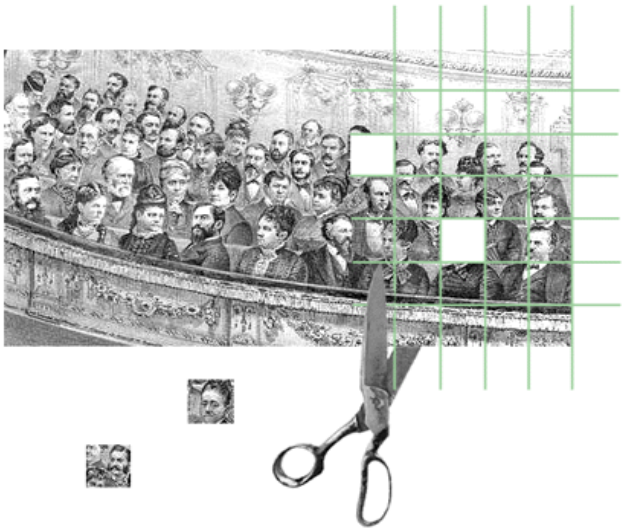


The above images covers an area approximately 8 miles across and 5 miles from north to south. The complete picture was formed by processing over twenty 50-Megabyte files. This section of the Web site explains how these very large pictures were processed so that you can view them relatively quickly over the Internet using the average home PC.

TerraServer's purpose is to provide viewers access to such vast amounts of data over slow speed telecommunication lines and simple computer designs such as PCs and web browsers. Historically, users were required to have high-end graphics workstations that had the CPU, memory, and graphics hardware capabilities to manipulate this data, as well as be close to where the data was stored. Even then, it was rare for systems to have access to much more than 50 to 100 gigabytes of image data at one time.

Our goal is to give our viewers access to "terabytes" of data (10 to 100 times more than normal access) while browsing the Internet from the comfort of their own homes. Instead of presenting images in their original large format, TerraServer divides these images into small tiles that can be retrieved over the Internet. The story that follows describes how TerraServer takes the images and cuts, inventories, and displays them on your computer.

Keeping in mind that the picture above had to be one huge picture to begin with, how does TerraServer take it apart and put it back together again to fit on your computer screen? An analogy is to imagine taking your 35m camera - with no wide-angle lens - to a large family gathering to take a group photo of everyone in attendance. Because there are too many people to fit in your camera's view finder, you would have to take several pictures in a panoramic-type view. When the film is developed, you would then take your scissors, trim the picture edges, and try to match and glue each panoramic photo into one big picture. You would also want to overlap the edges a bit in order to line up the pieces correctly as "one" scene. And it might not be a bad idea to number each individual piece so that you can easily recognize its place in the "whole" picture.



TerraServer basically does just that with its image editing, although our process is a bit more complicated, of course.

An original Russian satellite image from SPIN-2, for example, is a 40-kilometer by 160-kilometer sized photographic swath of a particular area of earth. These pieces of film are too large to scan at once, so they are scanned and overlapped as four separate 40-kilometer square images. From Russia, the four 40 X 40-kilometer sections are sent to Aerial Images/SPIN-2 in North Carolina where they are again quartered into 20-kilometer square images. Tapes containing these uncompressed 20 X 20-kilometer image files are then shipped to Microsoft for further processing and loading onto TerraServer.

The files Microsoft receives still contain too much data to be effectively downloaded over the Internet. Depending on the type of image - satellite or aerial photograph - a single image can range between 50 MB and 1,500 MB in size. The TerraServer team wrote an image processing program that takes several of these large input files at a time, computes the image's location on earth, and merges pixels from multiple files into one single photo. The *merged* images are then *cut into smaller* images and compressed in the JPEG file format so Web browsers can recognize them.

By the way, a pixel is the smallest visible unit within an image and represents a shade of color or grayscale at a a single location point on the image. An image pixel is similar in concept to a "dot" in "dots per inch" when explaining how a printer sprays ink on the printed page. A typical satellite image may be as large as 40,000 by 40,000 pixels, whereas a typical graphic on a Web page may be only 300 pixels by 100 pixels.

TerraServer's input imagery is re-sampled to the nearest power of 2 from 1 meter per pixel. USGS imagery is 1 meter per pixel. SPIN-2 input imagery is 1.56 meters per pixel and resampled to 2 meters per pixel. Imagery is edited into 200-pixel by 200-pixel tiles at all resolutions.

Keeping track of all these pieces of imagery is not as difficult as it may seem. The tiles are organized in TerraServer's database table by theme, resolution, and location. Each tile can be identified by where it was cut from in the original image by being assigned a relative X and Y tile identifier by TerraServer's tiling program. The relative position depends on whether the imagery type is from the USGS or SPIN-2.

There are unique fields that identify every image tile that is processed into the TerraServer database. These fields are:

- Theme - The image data stored on TerraServer comes from a variety of sources and vary in format, resolution, color, and projection system by data source. TerraServer indexes and names imagery by projection system, which is a mathematical system to transform or *project* earth onto a flat surface. It also indexs by the acquisition method (satellite or aerial or drawn) and source (USGS, SPIN-2). These category names are called "themes" in TerraServer. Thus, all aerial imagery we present from the USGS is one theme. All the SPIN-2 imagery is a second theme. USGS topographical maps are a third theme.

TerraServer offers seven levels of resolution for every image. Complete information on image resolution is provided in the section entitled "TerraServer Scale".

- X - Marks the tile's relative position on the X-axis within the image's "scene". The relative position starts from 0 on the "left" side of the scene.
- Y - Marks the tile's relative position on the Y-axis within the scene. The relative position starts from 0 on the "bottom" of the scene.

  A tile is uniquely indexed in a table by these X and Y tile identifiers. The X and Y integer values identify the tile's place within the whole scene of an image tile. X tiles are sequentially numbered left to right beginning with 0 across the scene. Y tiles are sequentially numbered bottom to top beginning with 0 across the scene. Within the Universal Transverse Mercator (UTM) projection system, the X,Y offset is computed from the UTM value of the bottom left pixel of the tile cut from the image.
- SceneID - The SceneID is assigned to each tile to group the X and Y values that can be displayed together on a single Web page. For USGS UTM projection data-sets, the SceneID is the UTM zone assigned to the original image a tile's pixels were extracted from. For SPIN-2 data-sets, a unique SceneID is assigned for each scene loaded per theme.

These fields uniquely identify a tile row within the TerraServer HTML table and are part of almost every URL within the TerraServer web application. An image's URL is TerraServer's version of the number you would use to identify an individual piece of your family portrait. An image's URL is its unique name and pointer to where it belongs in the whole scheme of things. It contains the X and Y values, the Scene ID ("1" for USGS, "2" for SPIN-2), the image date and size. The URL is the data in the "Address" window on Internet Explorer or the "Location" window on Netscape Navigator. It usually looks something like this:

http://terraserver.microsoft.com/image.asp?T=1&S;=10&X;=2342&Y;=10368&Z;=10&W;=1

For those of you familiar with GIS systems, the USGS X, Y, and Z values can be converted to their UTM equivalents by using the simple formulas below:

UTMX = X x TileSize x MetersPerPixel
UTMY = Y x TileSize x MetersPerPixel

To get the UTM address of the lower left hand corner of the tile represented in the URL above, the formulas would read:

X = 2342 x 200 x 1
Y = 10368 x 200 x 1

The "Z" field in the URL is the UTM zone. The Scale or "S" field indicates meters per pixel. The following table maps Scale value to Meters Per Pixel (MPP):

Scale	MPP
10	1
11	2
12	4
13	8
14	16
15	32
16	64
17	128

the resolution, X, Y, and SceneID values, TerraServer can reconstruct any portion of an original image or scene.

Click the "Next" button to find out how TerraServer's loading and cutting processes actually work.

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Microsoft Research
TerraServer Built by Microsoft Research

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