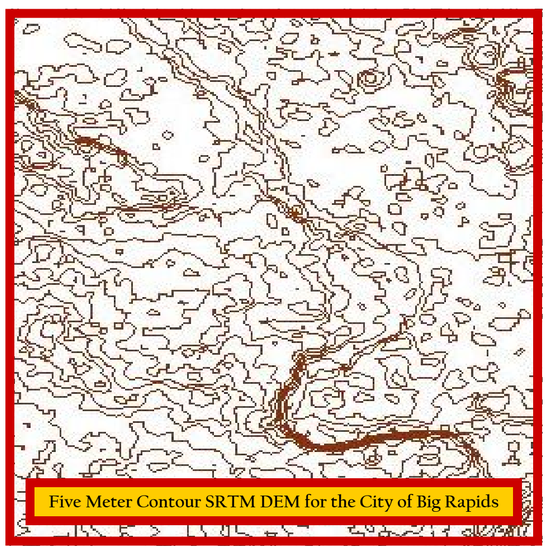
ORTHOPHOTOGRAPHY

Utilizing Low Resolution Digital Elevation Models

Inputs for Orthophotography



Five Meter Contour SRTM DEM for the City of Big Rapids

Digital Elevation Model

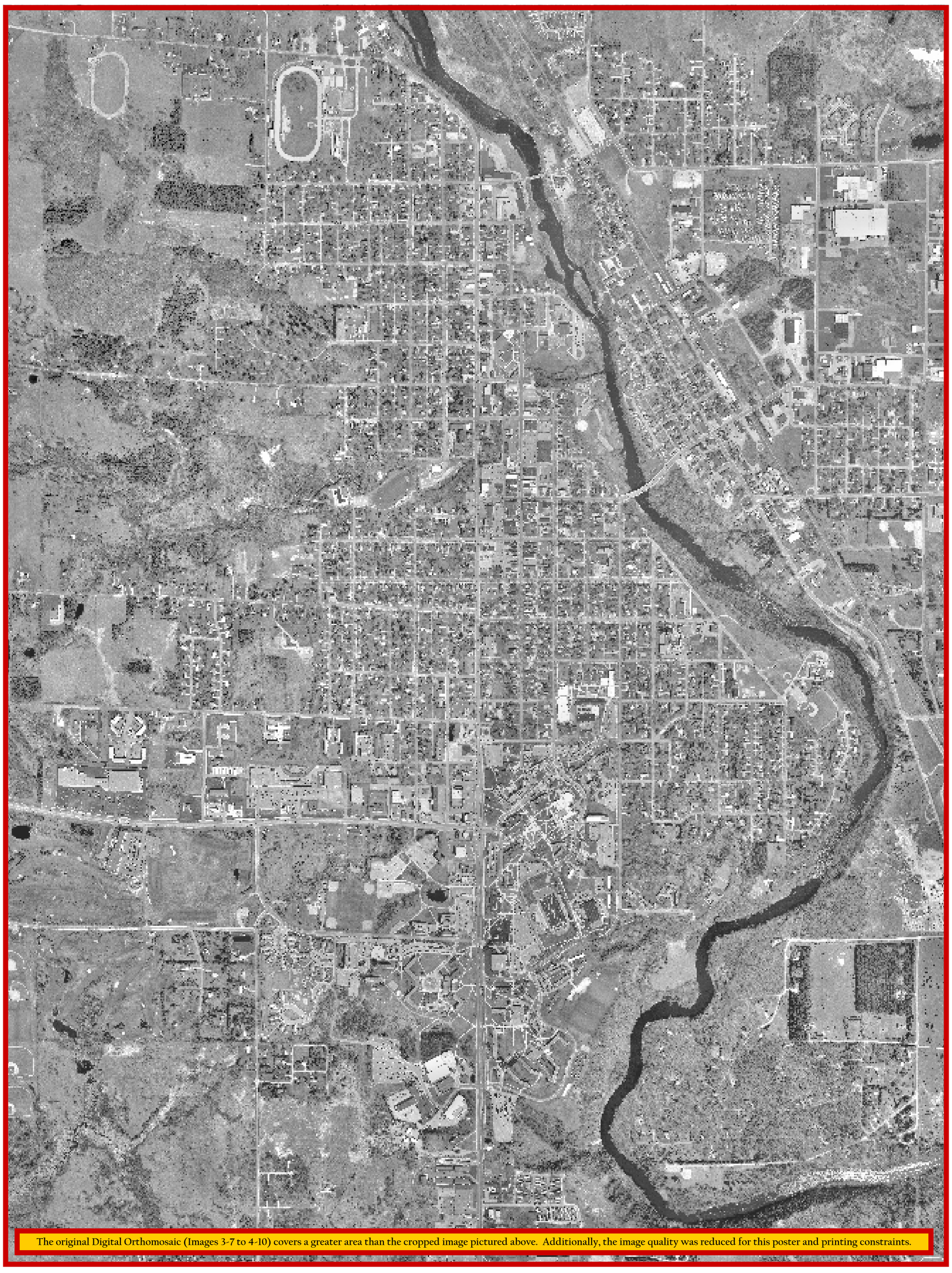
A Digital Elevation Model (DEM) is any digital representation of a surface. It normally consists of a file of elevation points, measured either systematically at equally spaced intervals, raster DEM's, or in an irregular pattern. DEM collection methods include: land surveying techniques using a Total-Station or the Global Positioning System (GPS), photogrammetric method using aerial photographs or satellite images, active sensors such as laser (LIDAR) and radar measurements (IFSAR, SRTM), and from existing data such as contour maps. Two datasets for many engineering and mapping applications that where utilized in the presented example are freely available in the United States are the National Elevation Dataset (NED) and the Shuttle Radar Topography Mission (SRTM). The DEM is used to differentially correct imagery that is distorted by terrain relief displacement.

	NED	SRTM
Source Data	Maps/Photos	Radar
Source Resolution	1" x 1" (-30m)	1" x 1" (-30m)
Source Dates	1925-1999	February, 2000
Surface Type	Bare Earth	First Return
Horizontal	NAD83, NAD27 (Alaska)	WGS84
Vertical	NAVD88, NAVD29 (Alaska)	WGS84, EGM96
Published RMSE	7m	10m

Digital Scanned Image (3-6), Not Included in Orthomosaic

Digital Photography

Digital photography is imagery either captured by a digital sensor or physical (diapositive, negative, etc.) image that is scanned into a digital format. Imaging sensors (film and digital) are typically located on airplane and satellite platforms. Once the imagery is in a digital format it is ready to be corrected for tilt and terrain relief displacement. The images for this example were acquired by airplane in April of 2004 and then were scanned into the TIFF format.



The original Digital Orthomosaic (Images 3-7 to 4-10) covers a greater area than the cropped image pictured above. Additionally, the image quality was reduced for this poster and printing constraints.

Orthorectification

The orthographic projection of the image allows it to be interpreted as a conformal map with a uniform scale. In the orthorectification process every pixel (x,y) is linked to a DEM cell value using the exterior orientation parameters (i.e., exposure station coordinates and sensors rotational parameters) through the collinearity condition, called differential rectification. Additional aspects that must be compensated for in the process that are beyond the scope of this poster include absolute/exterior orientation using ground control or rotation and positioning sensors and the correction of the sensors interior orientation.

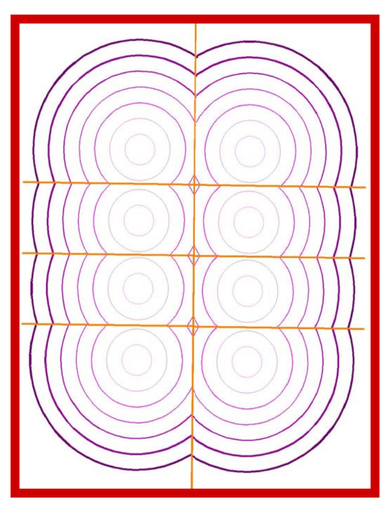
GIS Feature Layers created from Orthophoto (4-7)

Orthophotographs

Pictured to the right is the orthophotograph (3-10) used to test the quality for the block of images. The accuracy of the DEM is proportionally related to the accuracy of the orthophotograhs generated. Additionally, the horizontal uncertainty of orthophotography increases with respect to radial distance from the center (right).

Orthomosaics

Mosaicing adjacent images for an optimal product, assuming uncertainty increases with radial distance, would be so that cut-lines for individual images are nearer nadir points. In the orthomosaic generated (above) a cost function weighting the radial distance with additional variables was used to determine the location for cut-lines used to trim adjacent orthophotos. Since orthomosaics are composed of orthophotos their respective uncertainty is similar except for overlapping areas where it is significantly reduced (lower-right).



Summery

SRTM (RMSE=2.097m) data has slightly better fundamental accuracy than the NED (2.944m) data but may not represent the terrain properly and include shifts because the SRTM data is a Digital Surface Model while NED data is a Digital Terrain Model measuring ground topography. SRTM data is current which is an important advantage providing a proper model that can be used for many applications, even for updating the NED.

Moreover, the use of these datasets as soft data to be fused with sparse data with higher accuracy (hard data) or any additional elevation data, to obtain an improved surfaces and hence computations made from the surface. Truth comes through observation, and a better more reliable truth can come from multiple observations. Individually each DEM can provide results sufficient for a variety of applications, but when datasets are fused properly improvements can be measured in both the DEM and all products computed from it including orthophotography.

Benefits of Utilizing National Digital Elevation Models

- Accurate
- Cost Effective
- Can be Automated
- Products are Conformal Maps
- Feature Extraction or Base Map for GIS
- Consistency between Orthophotos
- 200% Increase in Mapped Area
  (Approximant area remaining outside the stereo/neat model for a single image)
- A Picture is Worth a Thousand Words
  (Actually more, due to the inclusion of spatial and temporal attributes)

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