Preserving & Geospatially Enabling
Historical Data of the Missouri River

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The US Army Corps of Engineers presented a project to digitally preserve historic images and maps of the Missouri River for the National Archives.

U.S. Army Corps of Engineers – Kansas City

- Aerial Photography Film (10,000 exposures)
  - 1940’s Oblique Images
  - 1980’s – 1990’s (Near) Vertical
- Paper Hard Copy (93 maps)
  - “Map of the Missouri River from its Mouth to Three Forks, Montana”
  - 1879 and 1894
  - Sheets and Index Maps
Project Scope

- Scanned film, photography and maps to preserve them in digital format (10,916)

- Developed Index of Images and Maps for Retrieval and Query
  - Metadata

- Georeference and Spatially Enable
  - 1879 Maps Sheets (34)
  - 1894 Maps Sheets (90)
  - 1990’s Aerial Images (4,419)
Spatial Enabling Process

• To maintain cost efficiency for the client a process was developed to georeference and transform the maps without using the traditional orthographic imagery development process.

• Through the transformation process the images were aligned spatially to their “best fit” in a relative location.

• Control points were selected using publicly available NAIP imagery from 2006 and 2007 (through sources such as DASC).

• Control point locations were selected to provide a low RSME and to be a more “permanently” identifiable location for future review.

• Each image was transformed individually with control being placed per image and map.
Definitions

- **Transformation** – The process of converting the coordinates of a map or an image from one system to another, typically by shifting, rotating, scaling, skewing or projecting them.

- **Affine Transformation** – A geometric transformation that scales, rotates, skews, and/or translates images or coordinates between any two Euclidian spaces. It is commonly used in GIS to transform maps between coordinate systems. In an affine transformation, parallel lines remain parallel, the midpoint of a line segment remains a midpoint, and all points on a straight line remain on a straight line.

- **Rectification** – The process of applying a mathematical transformation to an image so that the result is a planimetric image.
• **Photogrammetry** – The science of making reliable measurements of physical objects and the environment by measuring and plotting electromagnetic radiation data from aerial photographs and remote sensing systems against land features identified in ground control surveys, generally in order to produce planimetric, topographic, and contour maps.

• **Planimetric** – Two-dimensional; showing no relief.

• **Planimetric Shift** – Deviations in the horizontal positions of features in an aerial photograph caused by differences in elevation. Planimetric shift causes changes in scale throughout the photograph.
Accuracy and Impediments

• The spatial accuracy was expected to be within 100’ in proximity, while maintaining the integrity of the selected control points and the features within the imagery.

• Due to a number of factors:
  – photo conditions,
  – flight dynamics,
  – camera orientation,
  – radiometric distortion, and
  – relief displacement

none of the photos or maps were a “true” fit, therefore creating a variable scale across the image.

• The transformation process and the varying scale of the original image fit the image to maintain a relative spatial accuracy in location and adjustment.
Limitations of the Photography

• Relief Displacement

• Tilt or Orientation of the Sensor

• Radiometric Distortion

• Photographic Scale – varies over the image regarding the planimetric shift due to relief displacement and the tilt of the sensor
Relief Displacement

- Displacement is the radial distance between where an object appears in an image to where it actually should be according to a planimetric coordinate system. Relief Displacement is caused by changes in the distance between the ground and the camera as the plane flies over the ground. The nadir point is always free of any relief displacement.
Tilted Aerial Photograph

- True Vertical Air Photograph
  - Nadir is centered
  - Image is at nadir plane

- Tilted Aerial Photograph
  - Nadir is offset
  - Image is oblique to the nadir plane
Common Imagery Base for Control

  – Missouri
  – Kansas
  – Nebraska
  – South Dakota
  – North Dakota
  – Montana
Procedure

• Determine Control Points That Would be Present in Aerial Photography and Maps from 1873-1894

• Control Points May Vary in Their Coincidence
  – Analyst Selection
  – Image Distortions/Visibility
  – Radiometric Distortions
  – Relief Displacement
Georeferencing Control Point Locations
1879 Map Sheet Index overlay on Index Map
1993 Flood Crest – Flight Line Junction
Atchison, KS - 1993 Flood Crest
1993 Flood Crest overlay on NAIP
1986 Imagery Overlay on NAIP
1993 Flood Crest overlay on NAIP
1993 Flood Crest – Control/Transformation
Anticipated Outcomes

• The anticipated outcome of the transformation process is a spatially relative image that captures the river at the moment of exposure.

• The images are able to be compared to current imagery databases, such as NAIP, through sources like DASC.

• The spatial index and metadata allow for retrieval of the images through database and spatial query.
Findings

• Each image was individually rectified using control points clearly identifiable on the ground, in current imagery primary control sources and in the archived imagery.

• The primary impediment to success for this task of the project was to locate points identifiable during the crest that continued to be quality control points in the 2007 imagery due to the amount of change.
• In most cases keeping the error matrices low was significant to maintaining the integrity of the image rectification.

• By using high quality control points locations they provided contribution to successful adjustment for each images and providing a more highly precise georeferenced solution.

• ESRI ArcGIS was used to catalog and evaluate the spatial precision of the georeferenced imagery when compared to the control sources.
• An additional challenge was due to the imagery collection flight dynamics where many images were outside typical stereographic collection parameters resulting in many non-linear or square images varying their spatial geometry of the control points.
Through the development of this historic geodatabase, the lifecycle of the Missouri River is depicted through the ebb of the post-flood imagery to the flow of the great flood of 1993 crest.
Questions & Answers
Thank You!!