

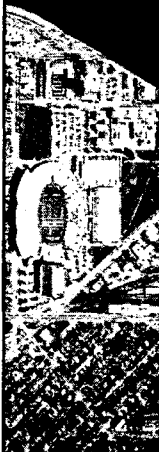


## Photogrammetric and Remote Sensing Technology for the GIS Community

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September 26, 2003

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## Biographical Information

Dr. Frank L. Scarpace received his Ph.D. in the field of Physics from the University of Wisconsin-Madison. He is a Full Professor in the Department of Civil and Environmental Engineering and the Nelson Institute for Environmental Studies at the University of Wisconsin-Madison. Professor Scarpace has been teaching and conducting research in the fields of Remote Sensing, Image Processing and Digital Photogrammetry since 1972. Professor Scarpace teaches all of the advanced courses in remote sensing, image processing, algorithm development, and digital photogrammetry within the mapping science field at the University of Wisconsin-Madison.

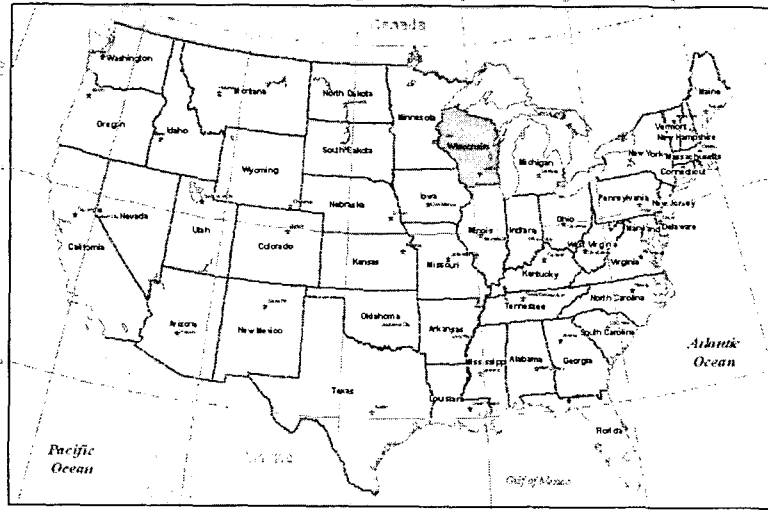


He has over 150 published articles and papers, and has been the Principal or Co-Investigator on more than 56 research grants. Current research includes use of neural networks and fuzzy logic for image classification, developing methods of geometrically correcting multi-spectral scanners, and integration of LIDAR and image data for improved DEM production. Dr. Scarpace is the author of numerous software programs involving image processing and digital photogrammetry. In addition to his University appointment, Dr. Scarpace is president of a small software company, Image Processing Software, Inc. IPS markets OrthoMapper™ and SurfaceMapper™, digital photogrammetric software programs.

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# The State of Wisconsin



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## Outline



- ✘ **What's New in Photogrammetry?**
- ✘ **Photogrammetric Technology for the GIS User**
  - ◆ Orthophoto Technology
  - ◆ Digital Elevation Models
- ✘ **Next Generation Satellite Imagery**
  - ◆ IKONOS
  - ◆ QuickBird
  - ◆ MODIS
- ✘ **Integrating these technologies into GIS Applications**

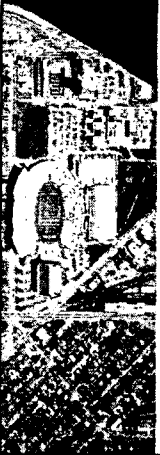
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## What's New in Photogrammetry?

- ✘ **Photogrammetry is the science of using measurements on aerial or satellite imagery to determine the size and/or location of features on the earth.**
- ✘ **The mathematics used within Photogrammetry have been well understood for over 50 years.**
- ✘ **New software tools allow the GIS professional to use these technologies.**

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## Map Products from Photogrammetry

- ✘ **Orthophotos**
  - ◆ **Image maps which have a constant scale that are derived from aerial images or satellite imagery with coordinates associated with each element.**
- ✘ **DEMs**
  - ◆ **Digital Elevation Model – An array of points in a regular horizontal grid that have X, Y, and Z coordinates assigned to each point.**

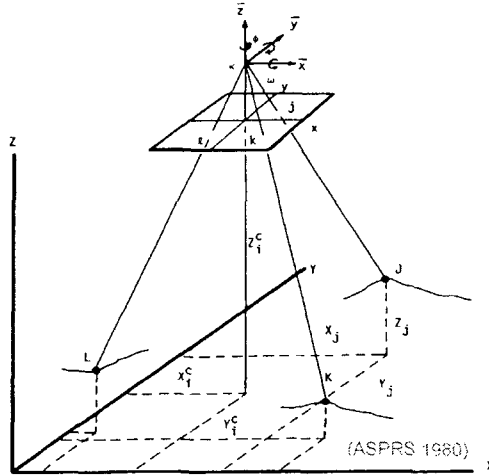
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# Orientation

To create orthophotos or DEMs, an aerial image must first be oriented.

Determining the orientation for an aerial image has been a difficult task.

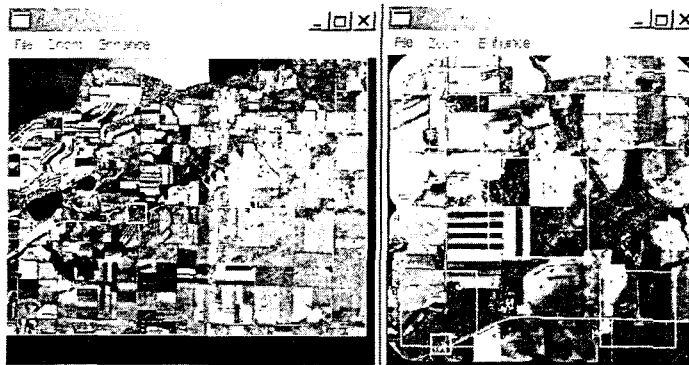


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# Orientation (Cont'd)

Tools exist to just point and click to orient an image.



Reference orthophoto

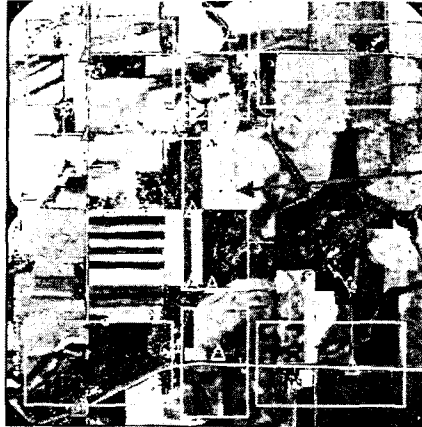
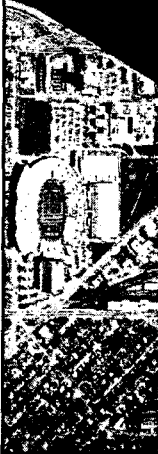
Aerial image to be oriented

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## Orientation (Cont'd)

✦ Tools exist to automatically put in tie points so orthophoto mosaics can easily be created.



Tie Points

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## Orthophoto

The necessary ingredients to produce an orthophoto are:

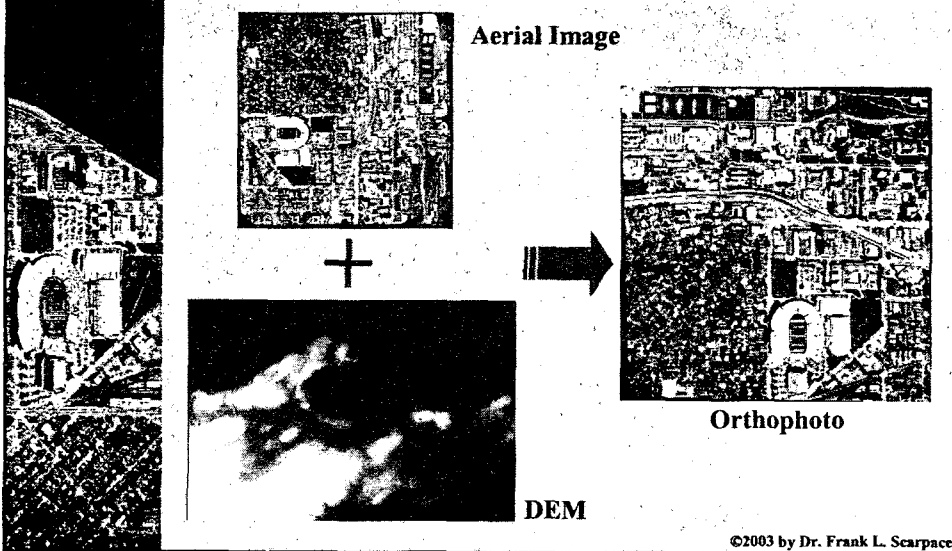
- ◆ An Oriented Image
- ◆ A Digital Elevation Model (DEM)



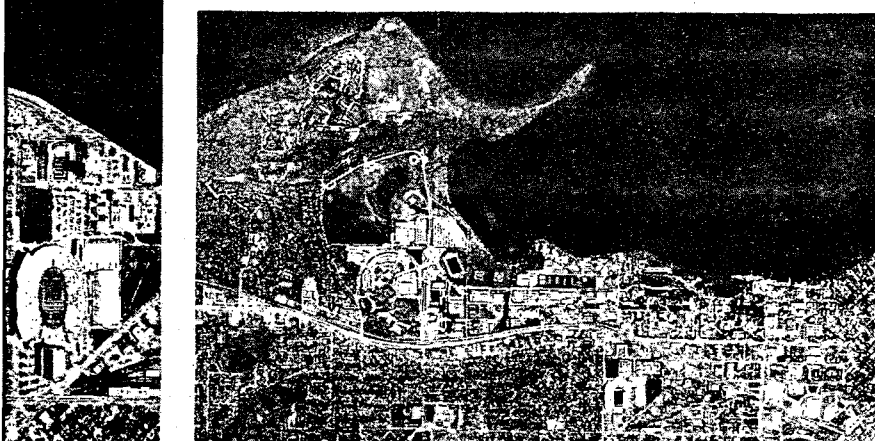
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## Orthophoto (Cont'd)



## Orthophoto Mosaic



UW Campus mosaic constructed from 80 individual aerial images.

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## Digital Elevation Models

### ✧ Softcopy Technology

- ✧ Aerial or Satellite Imagery
- ✧ Relatively inexpensive
- ✧ Very accurate

### ✧ LIDAR

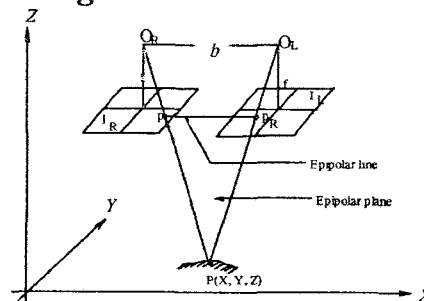
- ✧ Pulsing Laser
- ✧ Relatively fast
- ✧ Less accurate

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## Softcopy Photogrammetry

### ✧ Automatically measuring elevations from aerial images



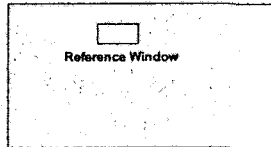
### ✧ Geometry involved to determine elevations using photogrammetric techniques.

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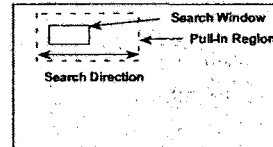
## Automated Softcopy Approach

Left Image



*Reference Image*

Right Image



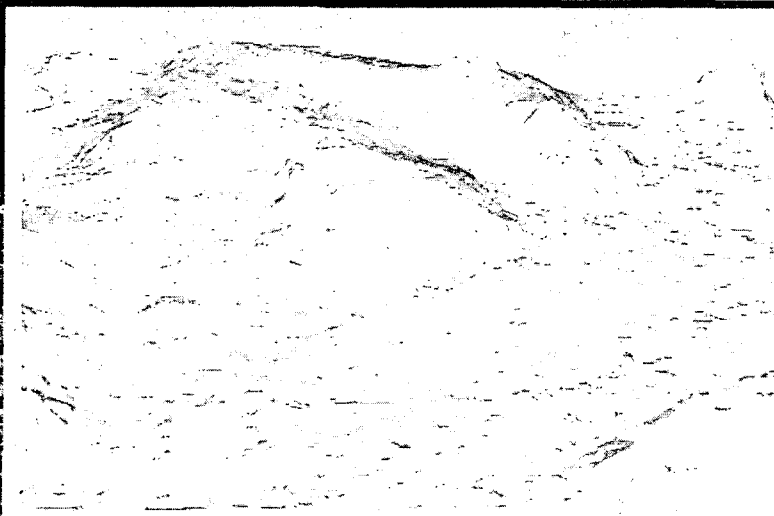
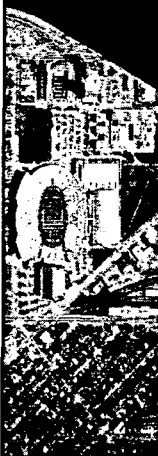
*Searching Image*

- ✦ **Softcopy approach tries to determine the corresponding points in a stereo model automatically by using image matching techniques. If corresponding points are known, elevations can be calculated.**

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## Automated Collection of Elevations

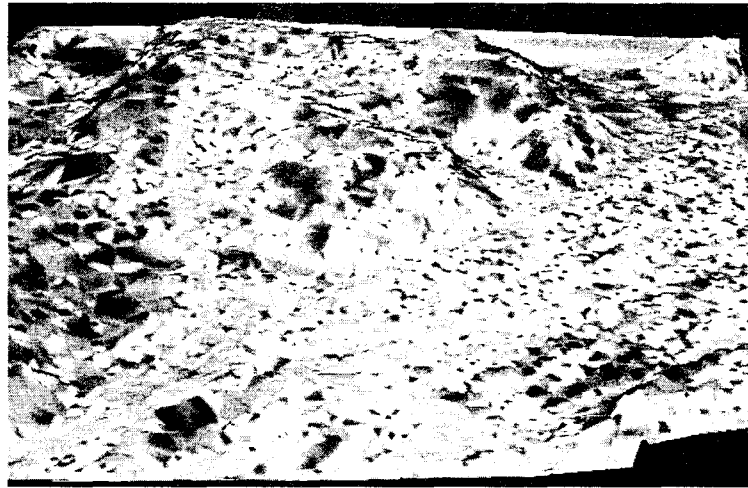


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## Correlation Coefficients for the Matching Algorithm



Correlations between 0.5 and 0.9

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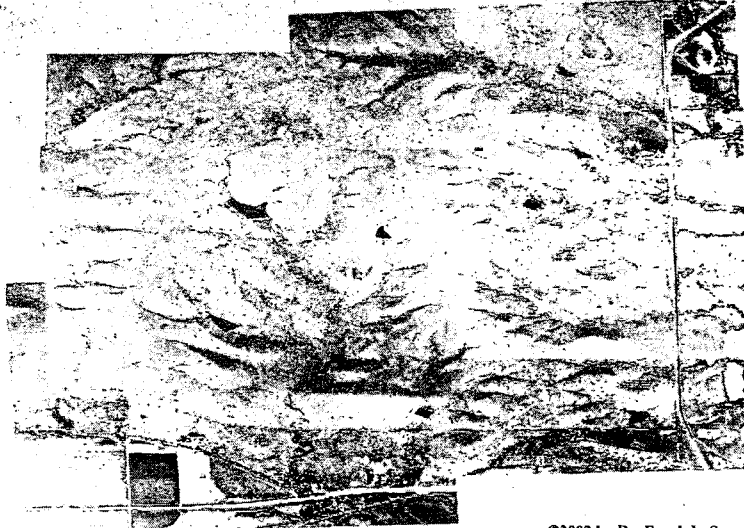
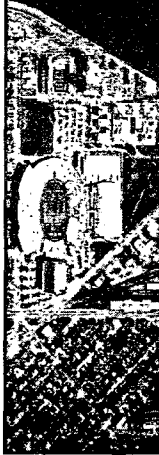
## Creating Precise DEMs

- ✘ Softcopy technology can create precise DEMs.
- ✘ Limiting factor is the editing time.
- ✘ Editing time can be minimized by using an existing DEM as a first approximation.

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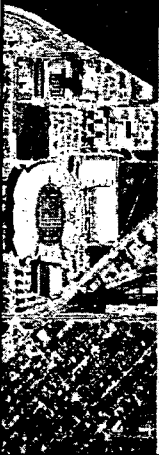
## Mosaic of Tallgrass Prairie Area



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## 30 meter resolution DEM



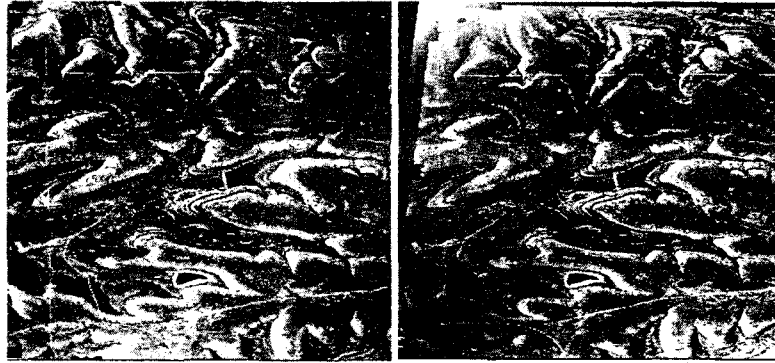
✱ Available for the USA from USGS for free



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## Images from one stereo pair used to derive elevations



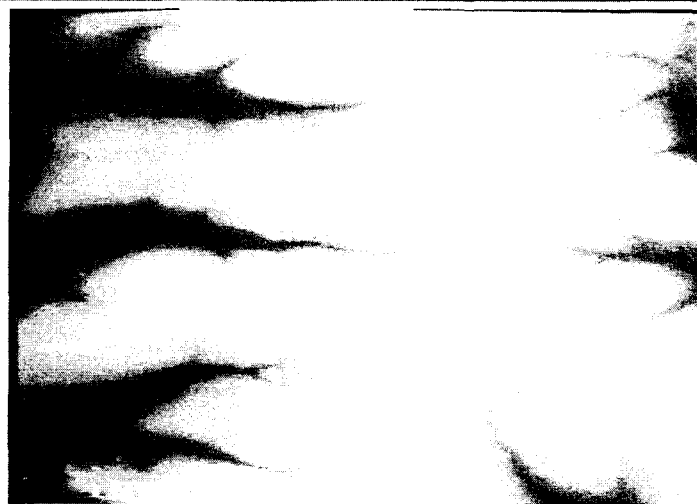
Left Image

Right Image

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## 2 meter DEM made using Softcopy technology with minimal editing



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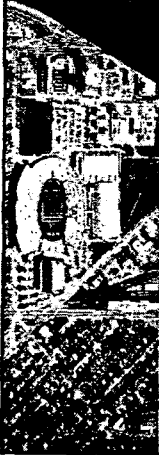
# LIDAR Technology

## ✧ LIDAR (Light Detection And Ranging)

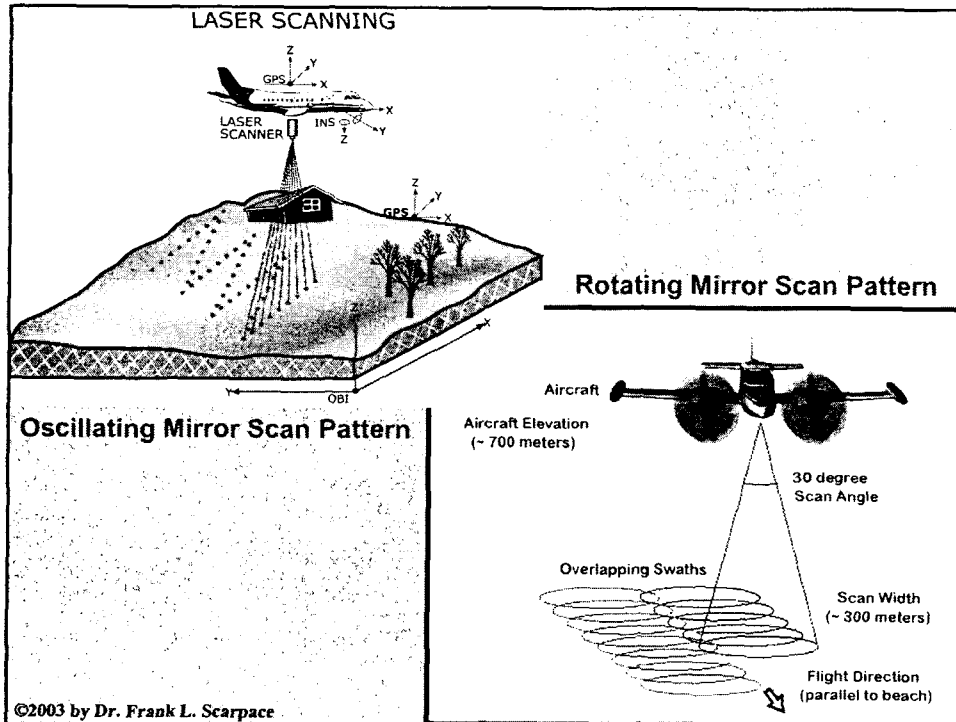
- ◆ 25 Year Old Technology
- ◆ Became Cost Effective Very Recently

## ✧ System Components

- ◆ Laser Scanner, GPS, IMU
- ◆ Robust Computer Support
- ◆ Requires Calibration

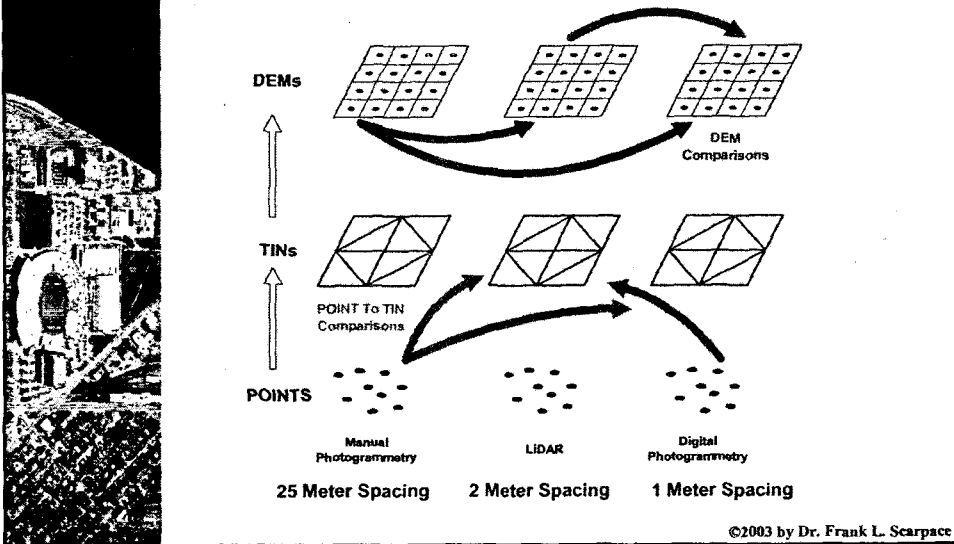


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## Comparison Between Methods



## Traditional Photogrammetry



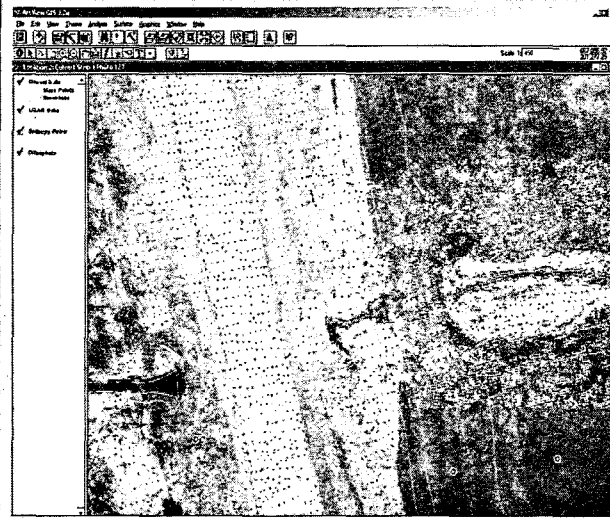
**Points and Breaklines are measured by experienced operators.**

**This is the standard other technologies must meet.**

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## A Comparison between LIDAR, Softcopy and Manually derived Elevations



Red is  
LIDAR

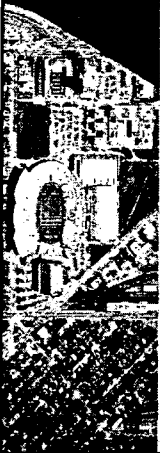
Grey is  
Softcopy

White is  
Manual

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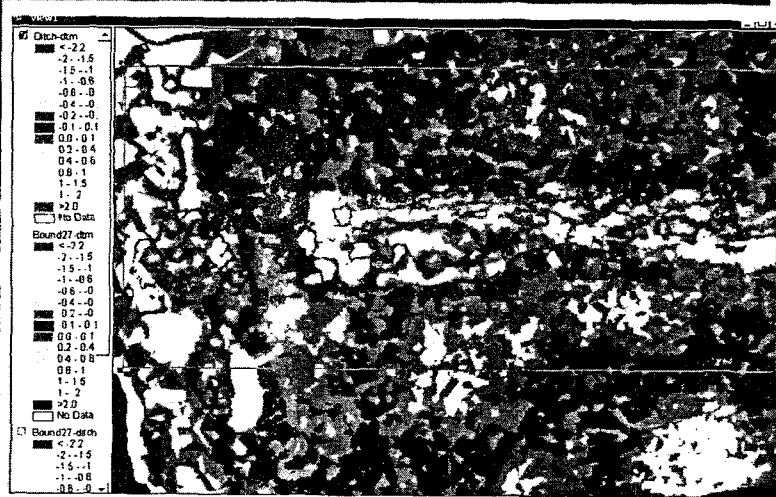
## Gully Differences between LIDAR and Manual DEMs



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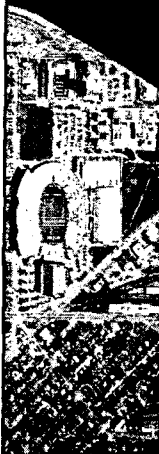
## Gully Differences between Manual and Softcopy DEMs



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## Technique Comparisons



	Standard Deviation Differences	RMS Differences
Softcopy & Manual	20 cm	23 cm
LIDAR & Manual	43 cm	43 cm

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## Next Generation Satellite Imagery

- ✦ **IKONOS Satellite Imagery**
  - ◆ 4 meter multi-spectral (4 bands)
  - ◆ 1 meter panchromatic
- ✦ **QuickBird Satellite Imagery**
  - ◆ 2.5 meter multi-spectral (4 bands)
  - ◆ 0.6 meter panchromatic
- ✦ **DMSP**
  - ◆ Defense Mapping Satellite Program
- ✦ **MODIS**
  - ◆ 36 Bands
  - ◆ 250m, 500m, and 1000m resolution



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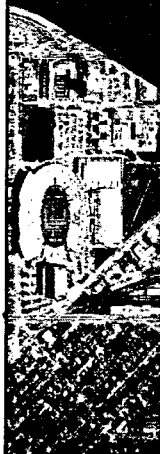


## IKONOS



4 meter  
multi-  
spectral  
imagery

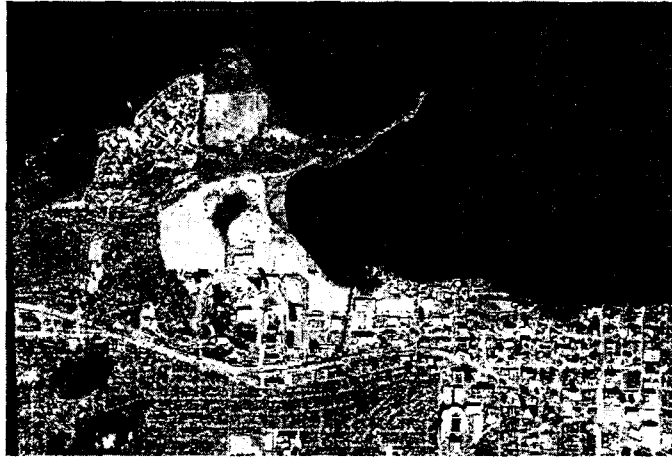
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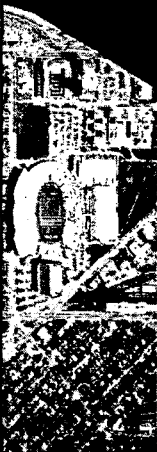


## IKONOS (Cont'd)

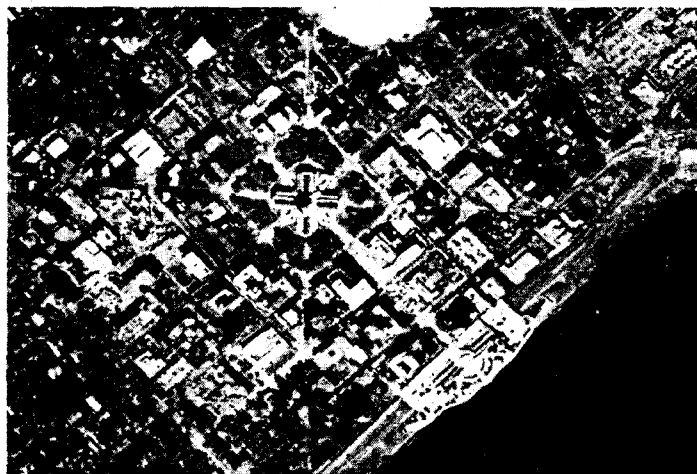


1 meter resolution panchromatic imagery

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## QuickBird

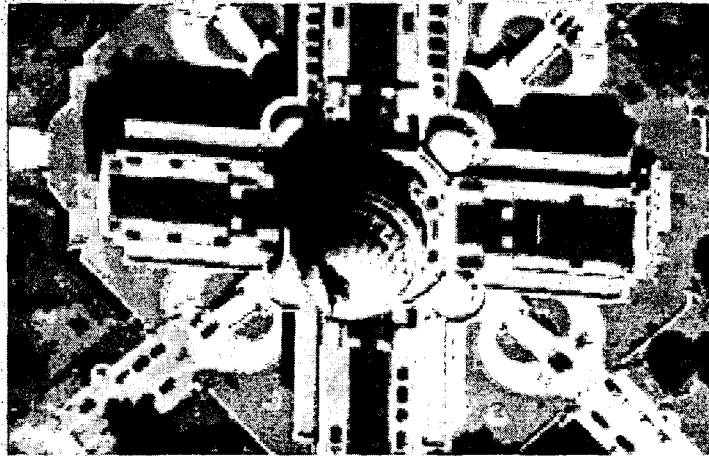


Multi-spectral – 2.5 meter resolution imagery

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## QuickBird (Cont'd)

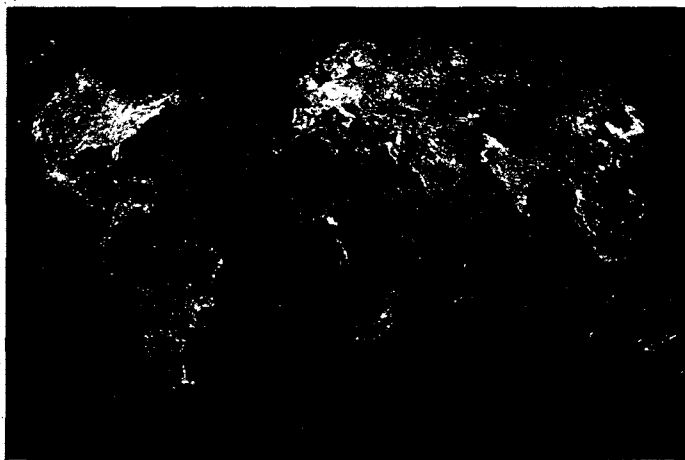


Panchromatic imagery – 0.6 meter resolution

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## A View of the World at Night



1996-1997 Imagery from DMSP

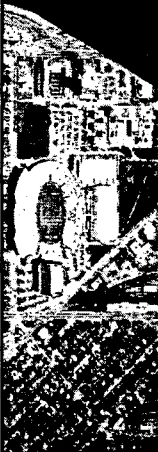
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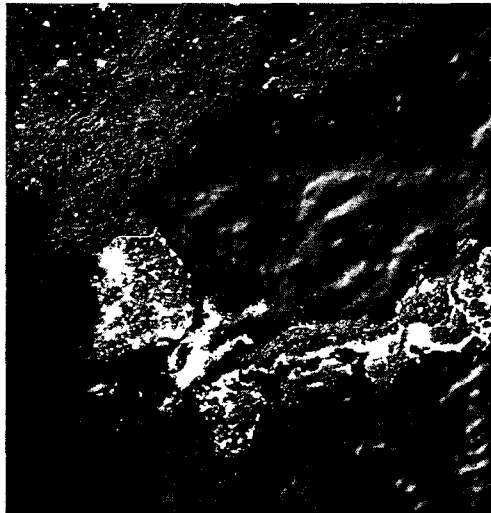
## The Korean Peninsula Area



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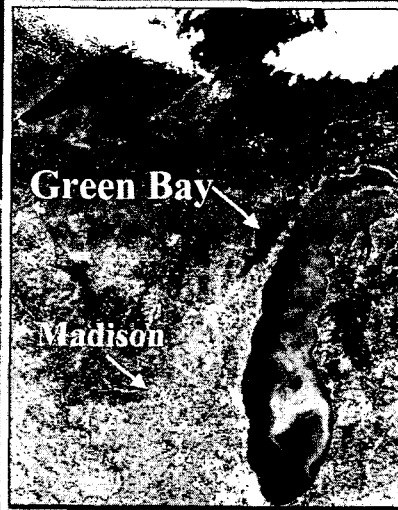
## Map with DMSP Overlay



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## MODIS Imagery: Sept. 3, 2002



Terra: 12:10 PM

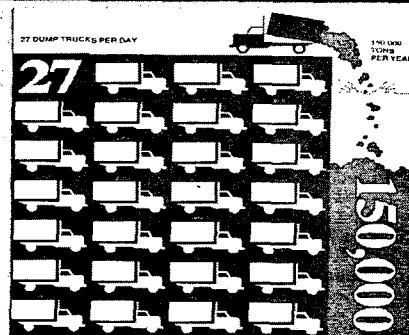


Aqua: 1:45 PM

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## Sediment Transport into Green Bay



- ✦ Sediment load = 150,000 Tons/yr
- ✦ Equivalent to 27 dump trucks per day, each carrying 15 tons
- ✦ Cost of dredging GB Navigation Channel = \$8.4 million/year
- ✦ Phosphorus & sediment are major problems in Green Bay

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## Monitoring sites in Green Bay



Raw MODIS image  
(bands 1, 4, 3):  
13 July 2001



Seasonal mean SDT map,  
based on 15 dates of MODIS  
imagery from July thru  
September, 2001.

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## Water quality in Green Bay: summer 2001 (July thru Sept)

Enhanced true-color MODIS images: bands 1 (red), 4 (green), and 3 (blue) 40 km



Chlorophyll-a concentration, derived from MODIS data

0 12 25 38 50+ (mg/m<sup>3</sup>)



Total suspended solids, derived from MODIS data

0 6 12 18 25+ (mg/L)



Water clarity (Secchi disk transparency), derived from MODIS data:

<0.25 1 2 3 4+ (m)



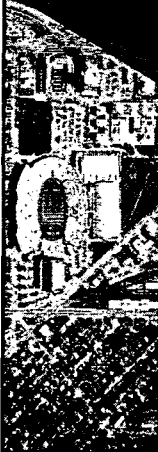
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## Integration with GIS applications

✱ Mapping land use / land cover change in watersheds and riparian zones

◆ Upper Yahara Watershed



1967

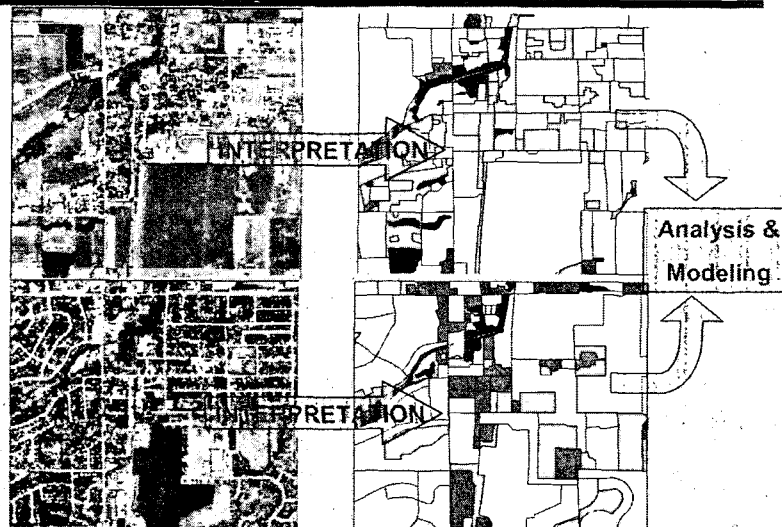


1996

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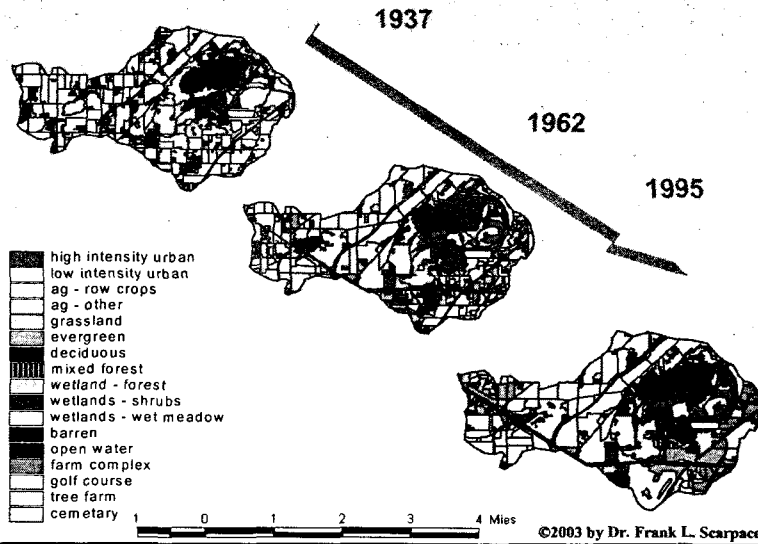
## From interpretation to analysis in a GIS



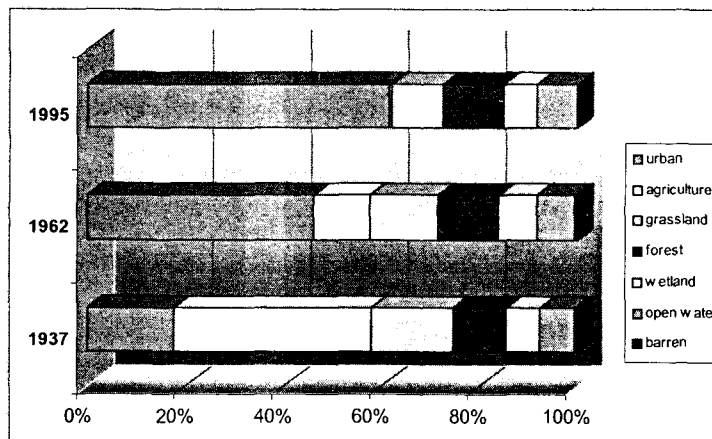
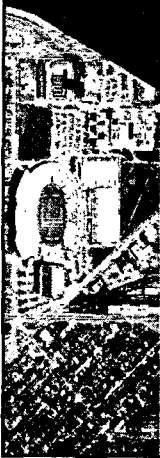
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# Lake Wingra Watershed



# Lake Wingra Watershed (Cont'd)



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## Conclusions

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- ✦ **Photogrammetric technology is now ready to be easily used by the GIS community.**
- ✦ **LIDAR technology is an emerging cost-effective tool for all except the most demanding applications.**
- ✦ **New generation satellite imagery can now be easily integrated into GIS analysis.**

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## Acknowledgements

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- ✦ **The Korean Society for Geo-Spatial Information Systems**
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- ✦ **Professor Kyehyun Kim**

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## Time for Questions...

