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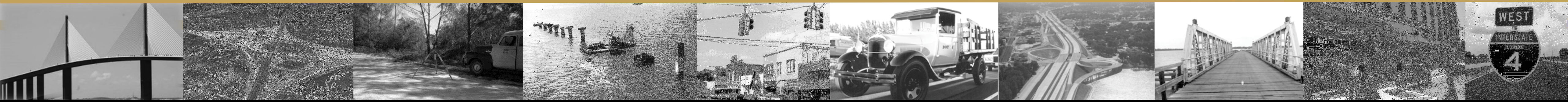
Point Clouds and Underground Imaging 101

Surveying and Mapping Office

John Krause, PSM-State Surveyor

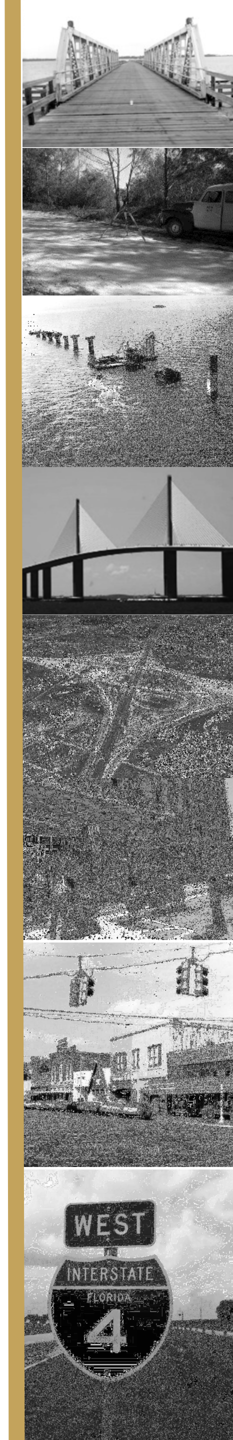


Centennial FDOT 1915 ★ 2015

Celebrating 100 Years of Innovation, Mobility and Economic Development

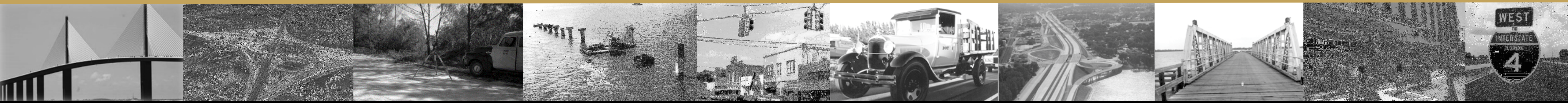
Collecting enhanced data

- Photogrammetry
- LiDAR
- Underground Imaging

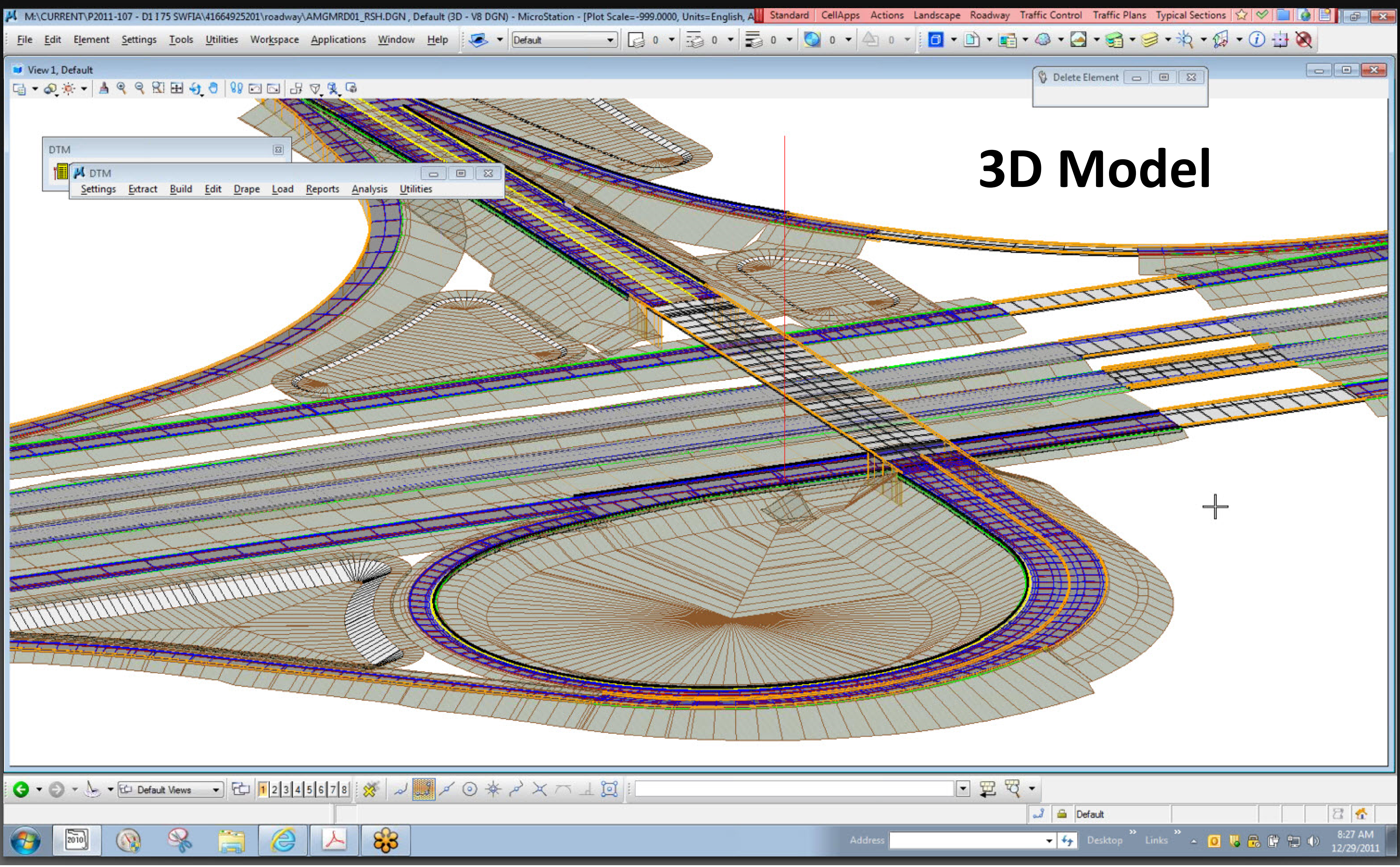


Objectives

- Why are we doing this? What we do now works…..doesn't it?
- Overview of new technologies for Design Surveys
- Benefits-leveraging better suited collection activities and data
- Discussions of when to consider using them
- Scoping
- Deliverables
- Overall discussion from the audience-We are still learning!



3D Model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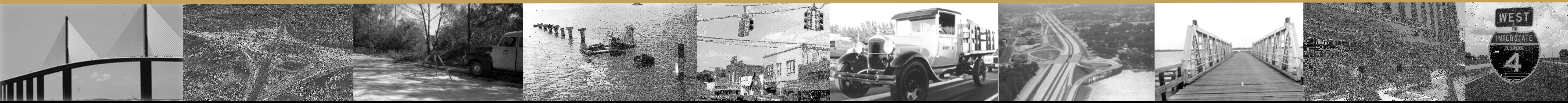
WEST
INTERSTATE
FLORIDA
4

Why is it so important to do this…..and why rush?

- Safer for surveyors and the public and it is less impact on traffic and therefore tourism and commerce..
- Opportunity to create better, (less risk) construction plans.
  - ✓ This is the over arching goal.
  - ✓ Think about Automated Machine Guidance (AMG) and Digital Construction Sites.
- We have imaging tools that will add great density to our topographic data.
- Our CAD packages can now create very accurate 3D Models.
- Opportunity to use the right surveying tool on in specific areas of the project to meet our needs.
  - ✓ "Required Density" and "Accuracy" right where we need it. Cost effective results.
- Best Practice coupled with prudent risk taking is what we get paid to do…we have available the various tools to consider in our project scoping.



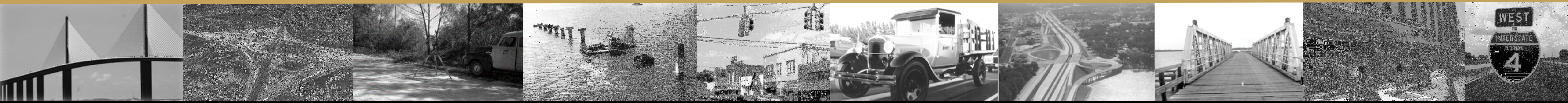
Terms and Definitions

- ***Photogrammetry*** - **The science or art of obtaining reliable measurements by photography.** (Source: American Congress on Surveying and Mapping and the American Society of Civil Engineers. *Definitions of Surveying and Associated Terms*. Library of Congress Catalogue Card Number 72-76807. Washington 1972, 1978.)

- ***Remote Sensing*** - **The process of detecting and/or monitoring the chemical or physical properties of an object without physically contacting the object.** *(Source: American Congress on Surveying and Mapping and the American Society of Civil Engineers. Definitions of Surveying and Associated Terms. Library of Congress Catalogue Card Number 72-76807. Washington 1972, 1978.*

- ***Image*** - **A pattern formed by electromagnetic radiation that approximately duplicates the pattern formed by a real object or a physical field detectable by the radiation.** This definition is more general than the usual definition because many instruments used for detection operate at other than light frequencies but in ways similar or analogous to those used for forming optical images. The kind of radiation forming an image is usually specified by adding a word that identifies the part of the spectrum involved, e.g., **radio image, infrared image, optical image, and X-ray image**. However, the terms "radar image" and "X-ray image" are used to refer to optical images of the images formed by radar or X-ray. *Source: National Geodetic Survey: Geodetic Glossary. Library of Congress Catalogue Card Number 86-61105. 1986.* http://www.ngs.noaa.gov/CORS-Proxy/Glossary/xml/NGS_Glossary.xml

  - **ACTIVE Sensor– Emits and receives**
  - **PASSIVE Sensor– Receives only**



Photogrammetry

Input

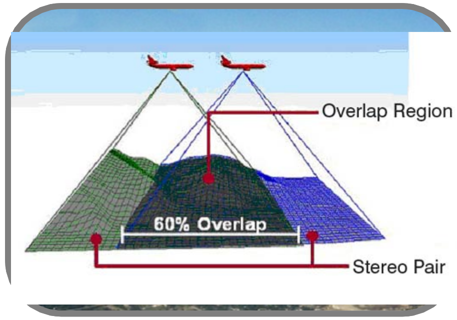
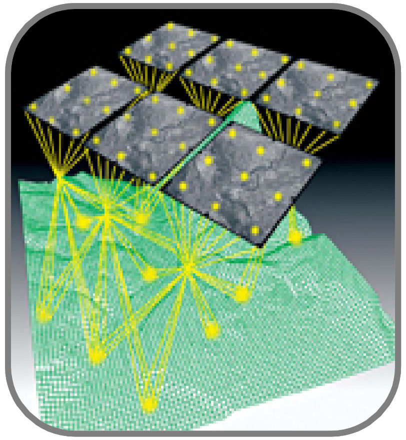
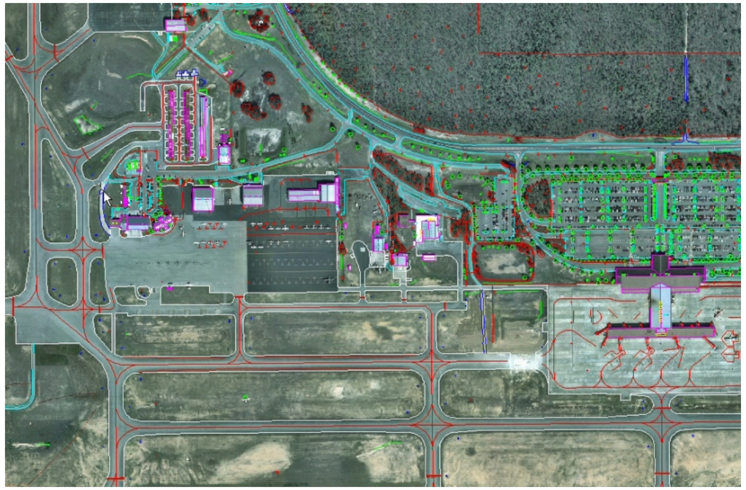
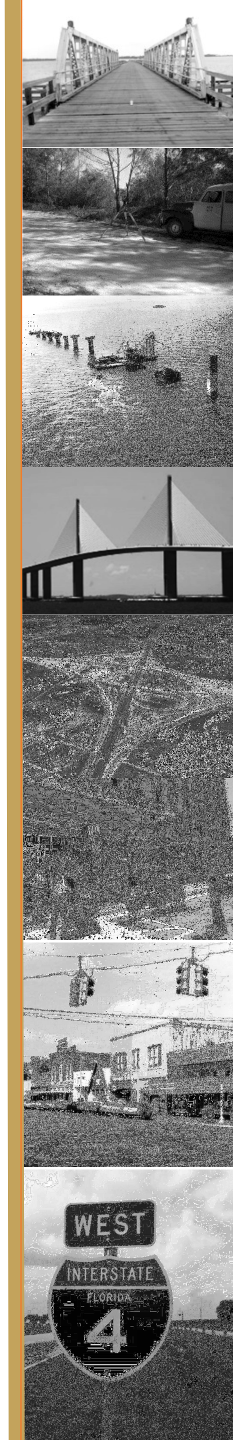


Image Orientation





Data Exploitation



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Light Detection And Ranging (LiDAR)

Lidar Definition

- LIDAR (***Li**ght **D**etection **a**nd **R**anging*) is an optical remote sensing technology which measures properties of scattered light to find range and/or other information of a distant target.
- The prevalent method to determine distance to an object or surface is to use laser pulses.
- Similar to radar technology, which uses radio waves instead of light, the range to an object is determined by measuring the time delay between transmission of a pulse and detection of the reflected signal.

USGS

http://en.wikipedia.org/lidar

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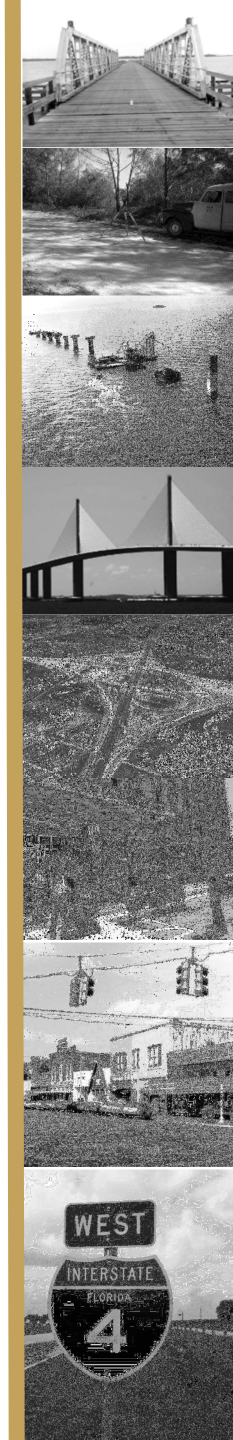

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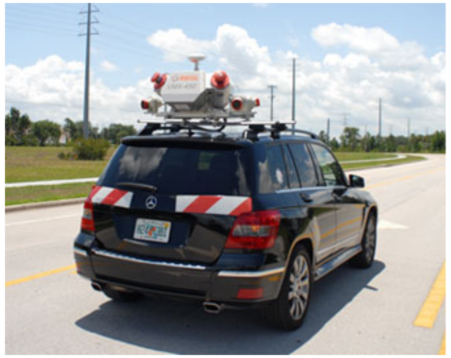
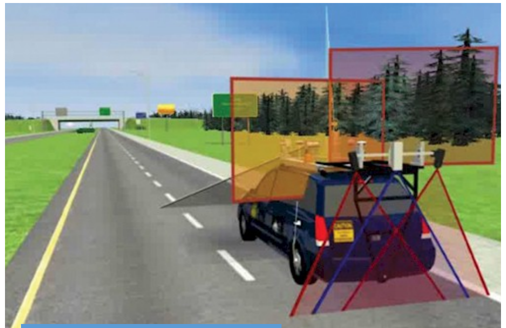
Static LiDAR

Mobile LiDAR

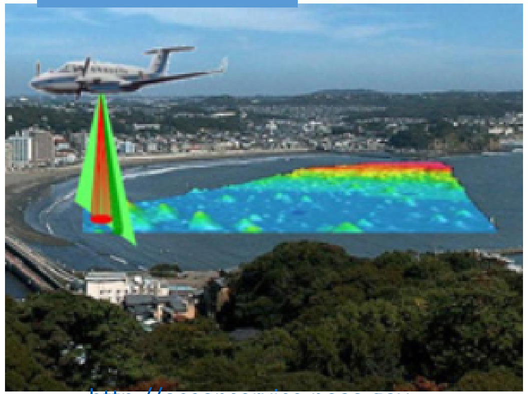
http://lidarusa.com

http://www.terraluma.net/platforms.html

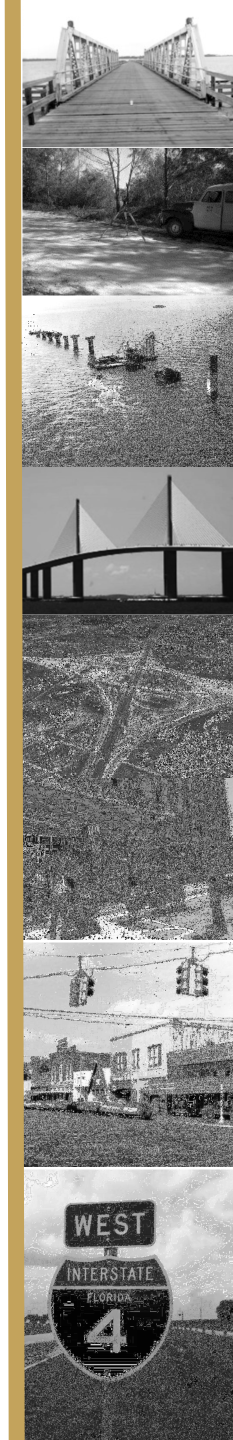




http://eijournal.org



http://oceanservice.noaa.gov



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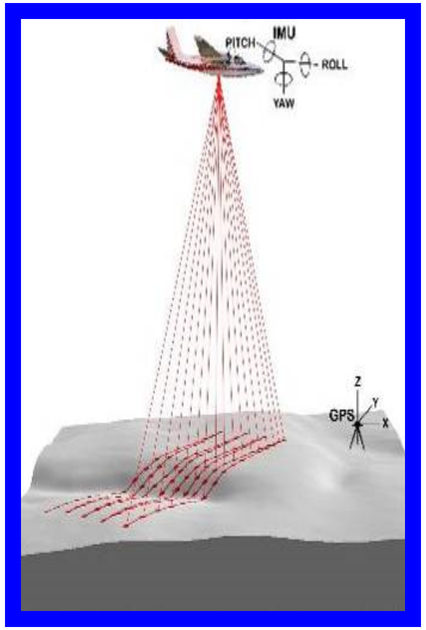
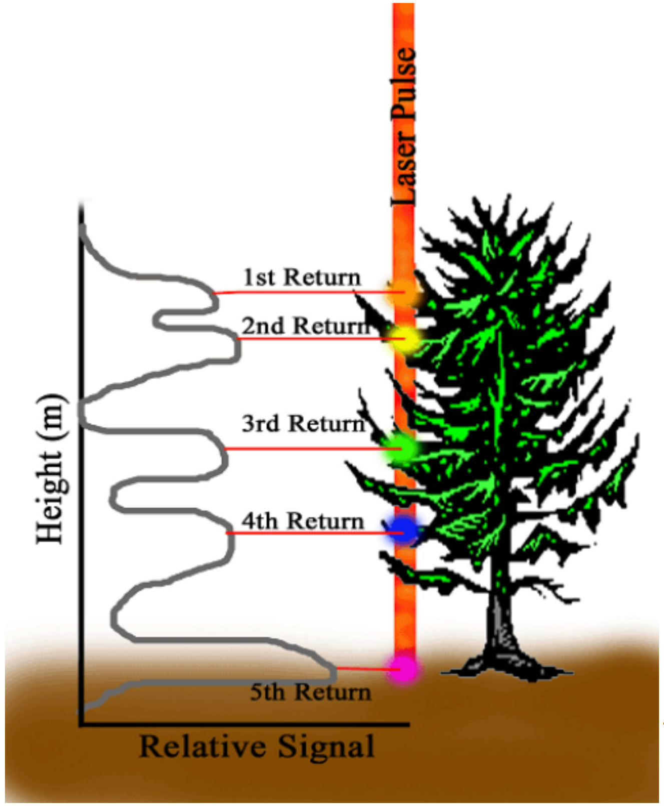
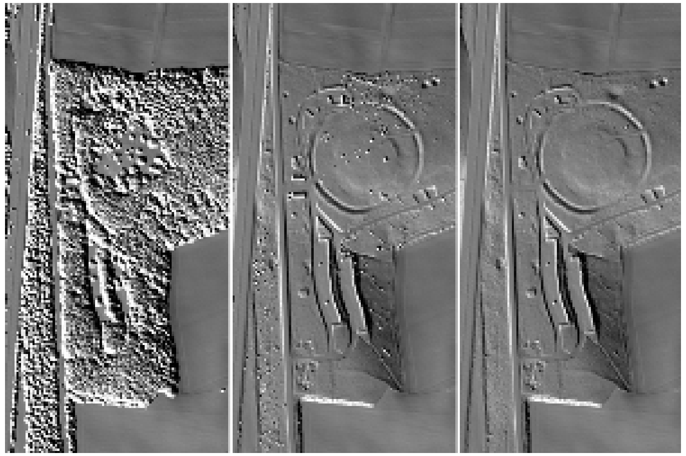
Some Pulse Laser Characteristics

- Laser pulses can penetrate forest canopy through gaps.
- Some laser pulses reach forest and water bodies floor, other returns reflect from canopy, sub-canopy vegetation.
- Recommend eye safe full wave form LiDAR for engineering projects.



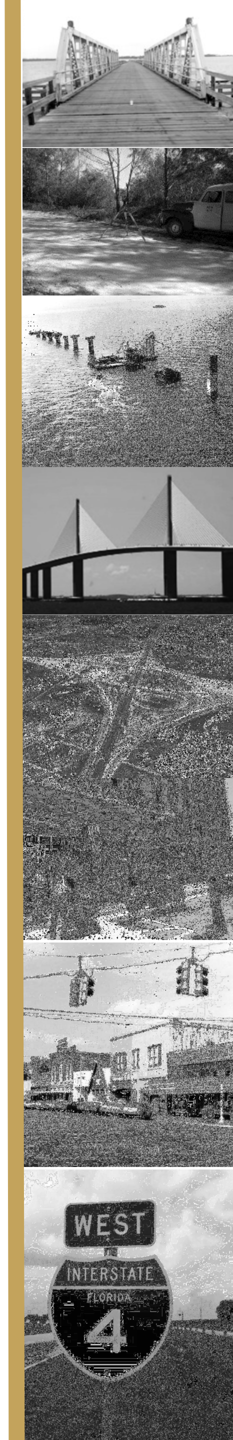
http://www.geodigital.com/





The filter removes about 95 percent of all objects. The remaining fragments are removed manually.

http://lidarcomm.com



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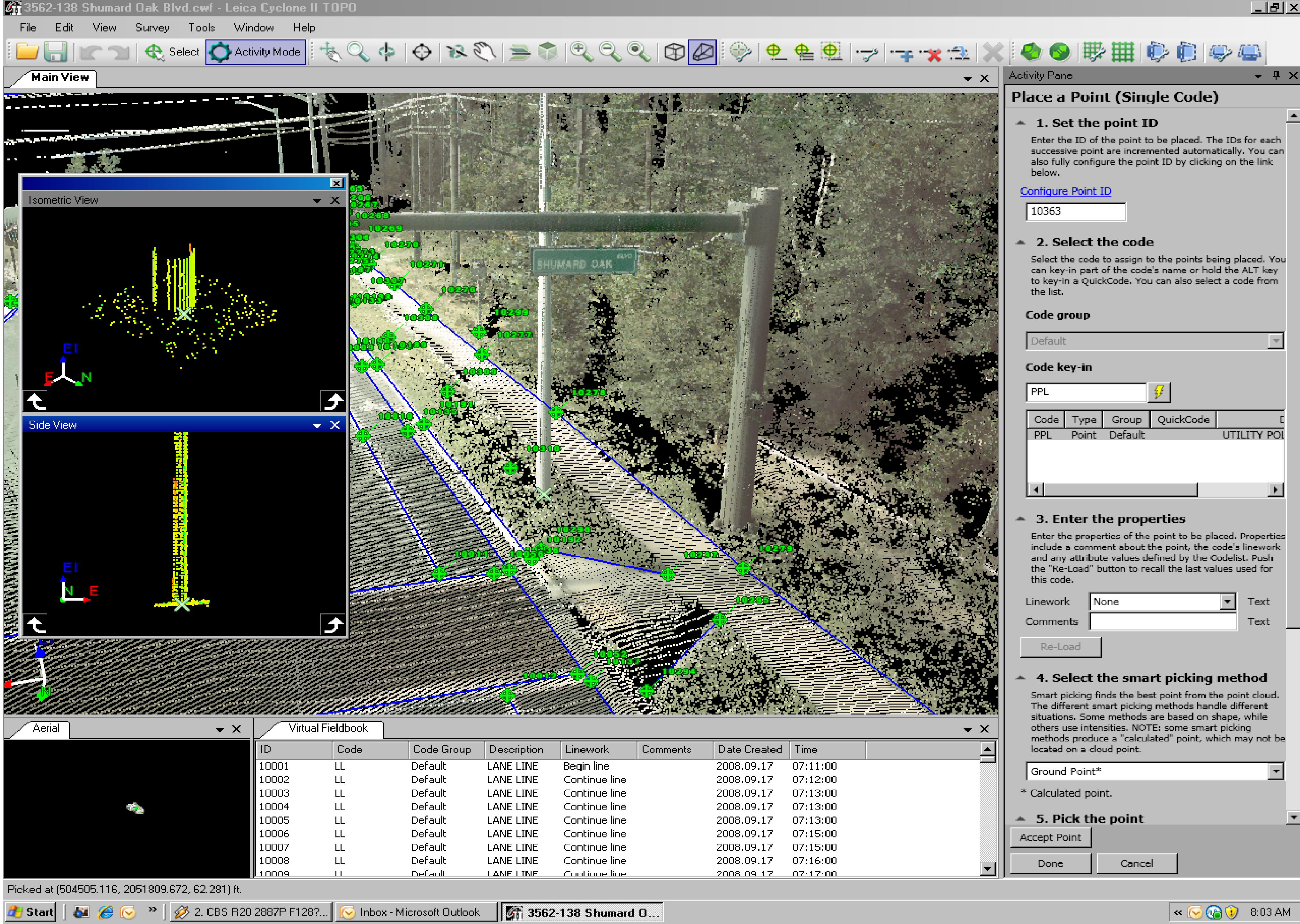

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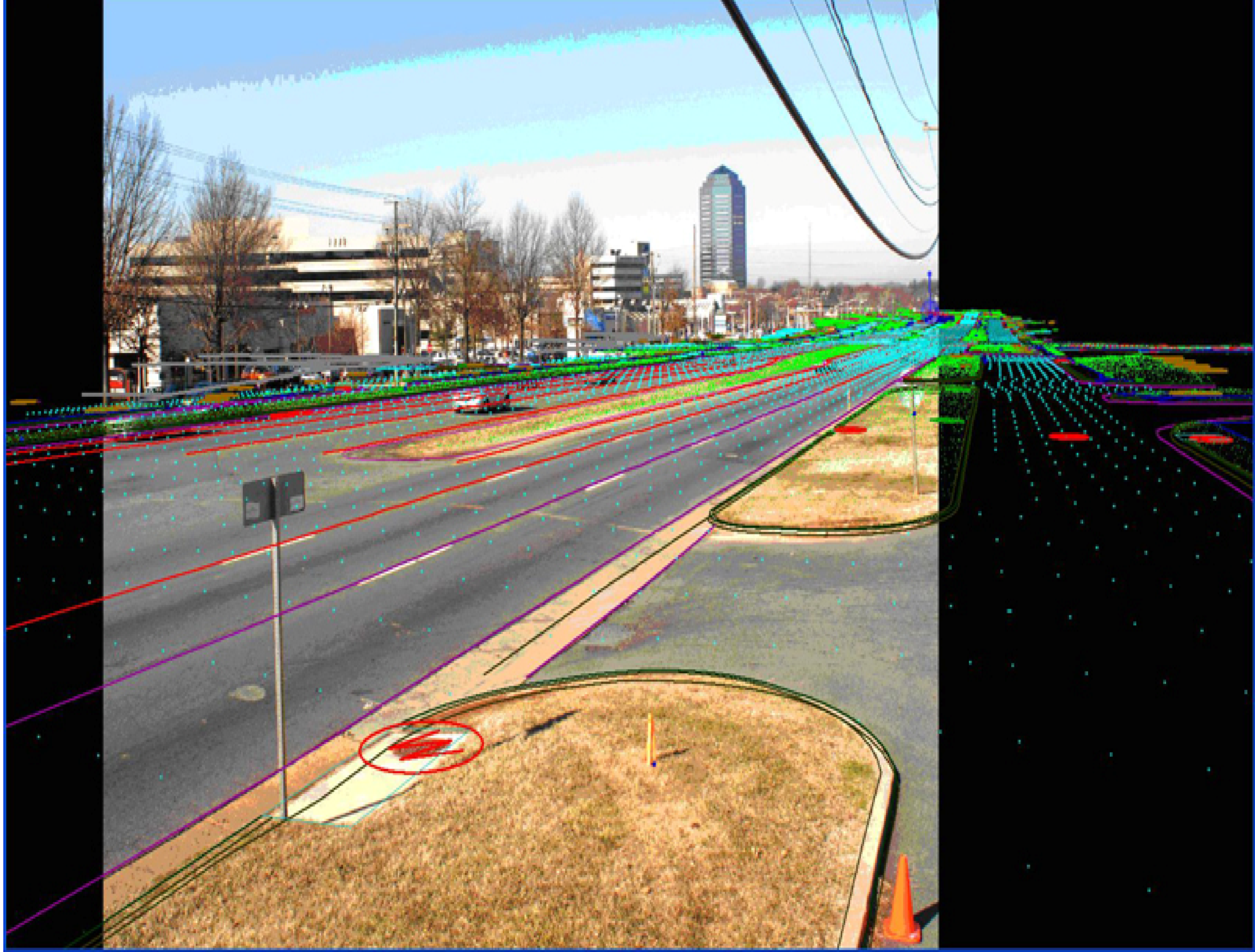

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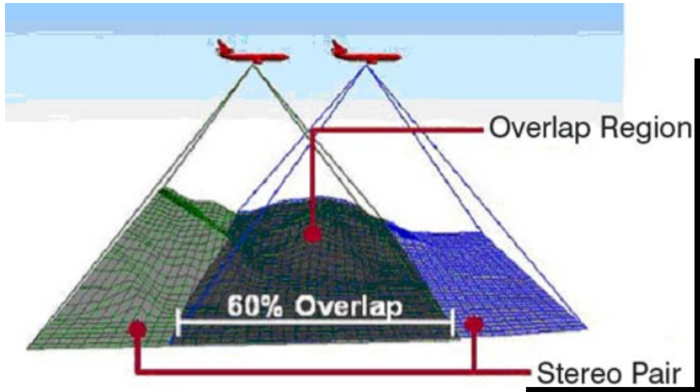
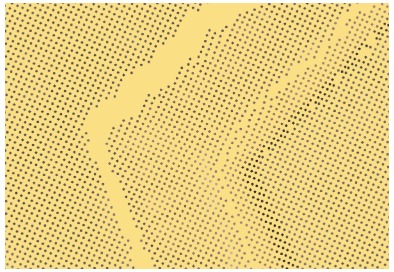
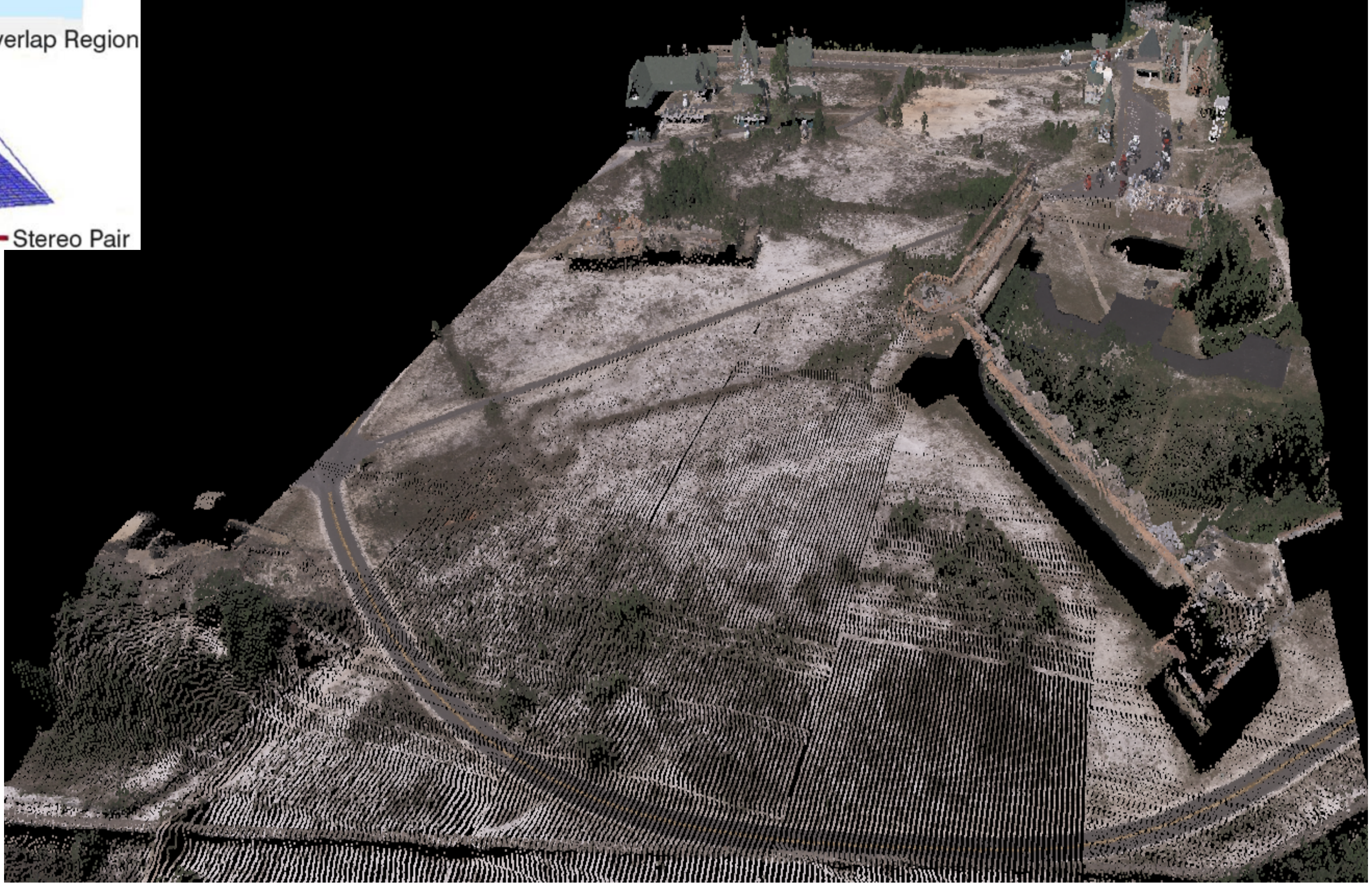
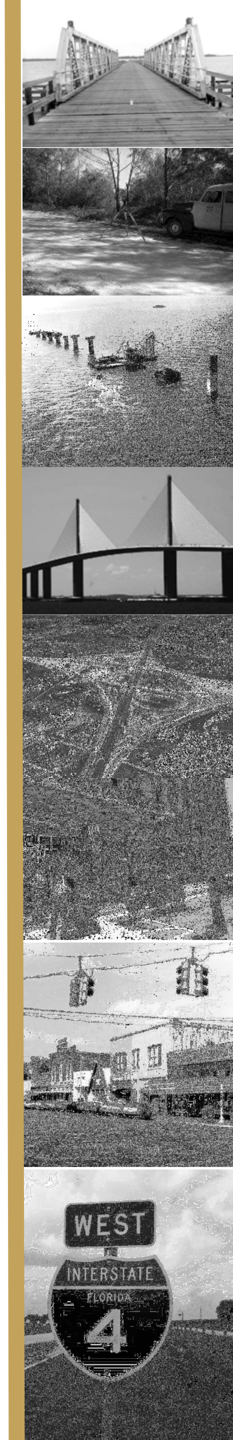
Photogrammetry - Autocorrelation





Fort Pickens





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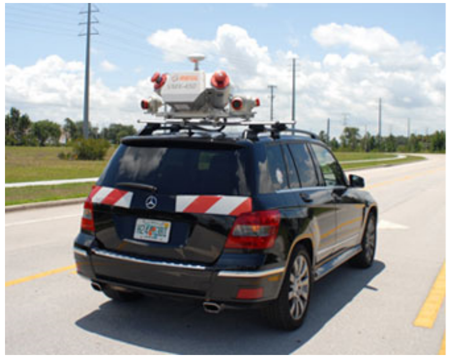
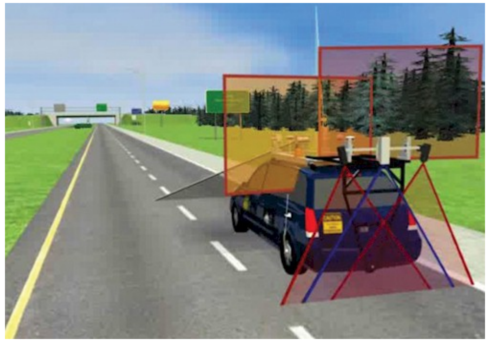
General LiDAR Survey Methods and Vertical Accuracies

- Fixed Wing Aerial LiDAR Mapping (ALS) = +/- 0.5 – 1.0 feet
- Low Altitude MLS = +/- 0.1 – 0.2 feet
- Vehicle TMLS = +/- 0.050 – 0.1 feet
- Static Laser Scanning = +/- 0.005 – 0.05 feet





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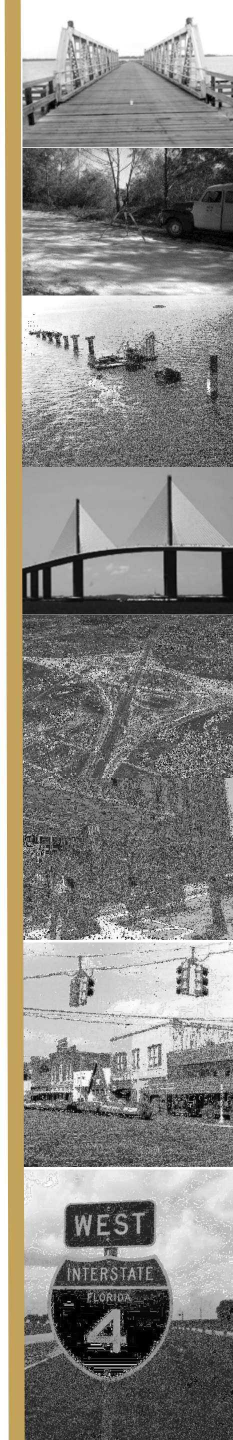

The Underground…..

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Quality Level B (Designating)

- Surface geophysical methods used to search to, trace, locate, and/or image existing utilities.

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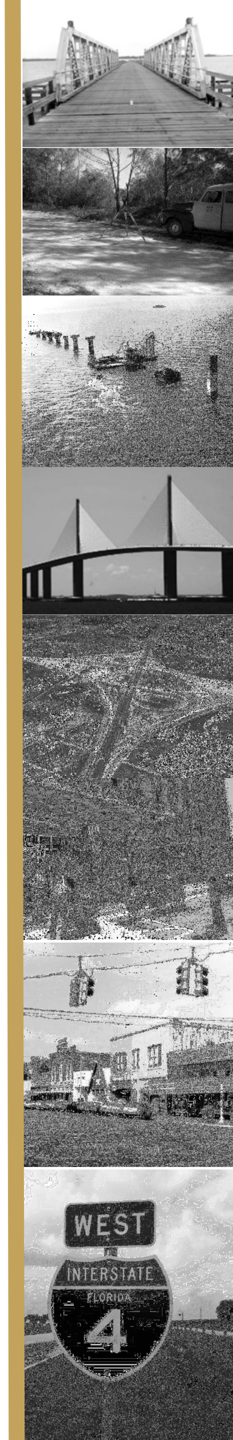
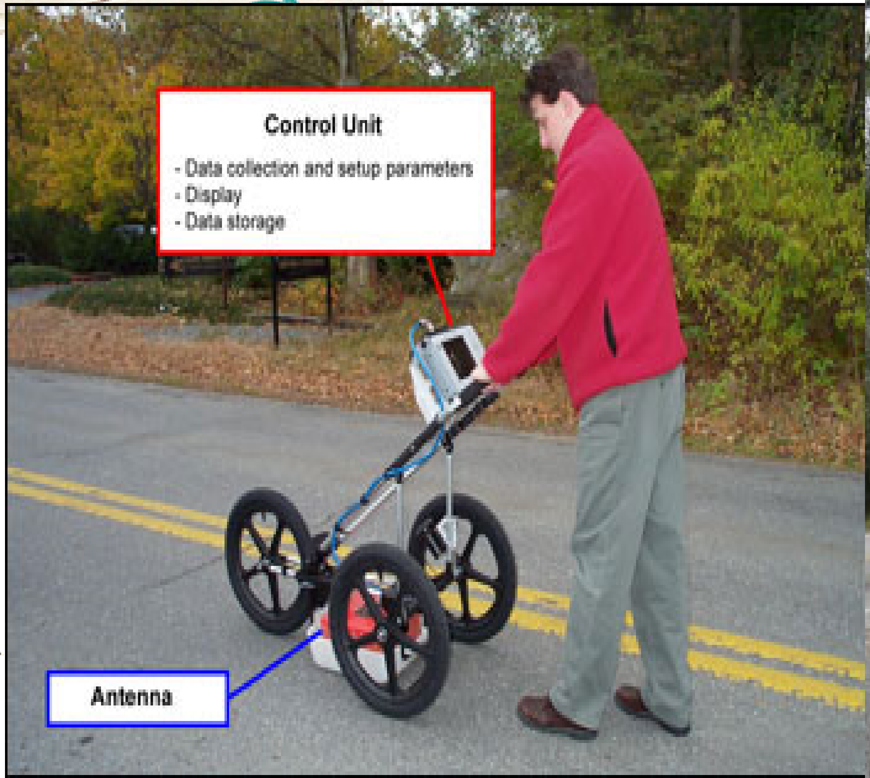
Typical 1 or 2 channel GPR

- GPR operates by using **Radio Frequency Pulses** and measuring in Time **Domain**……the time it takes the signal to travel from a transmitter and return to a receiver from reflecting off of an object. In all cases time = distance, in our case……depth.
- Frequency ranges are typically 200mhz to 1000mhz in commercial GPR.
- Frequency selection is critical to depth (limits) and resolution (detail)



One or two Channel GPR Units



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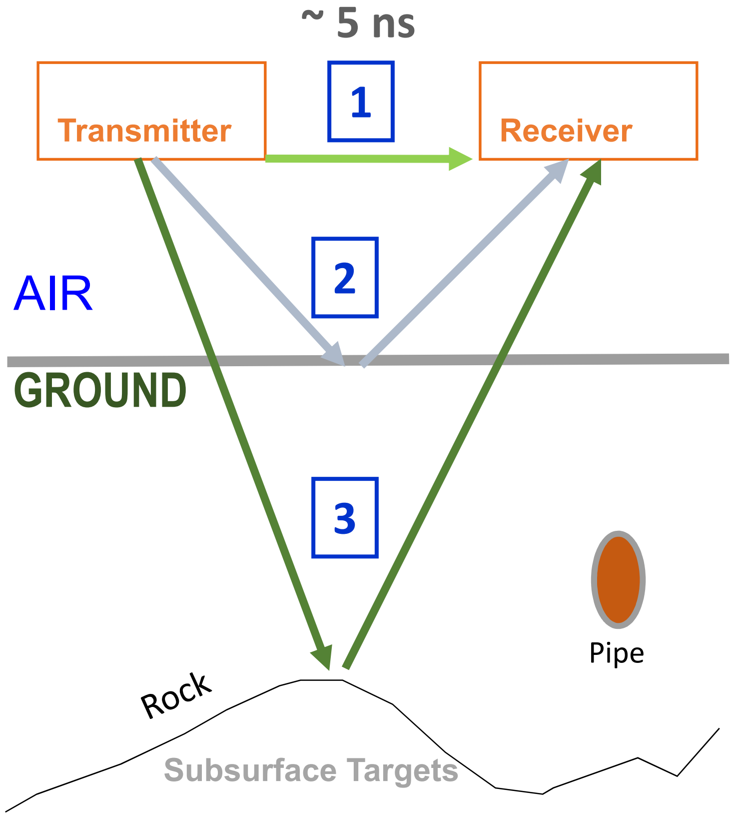
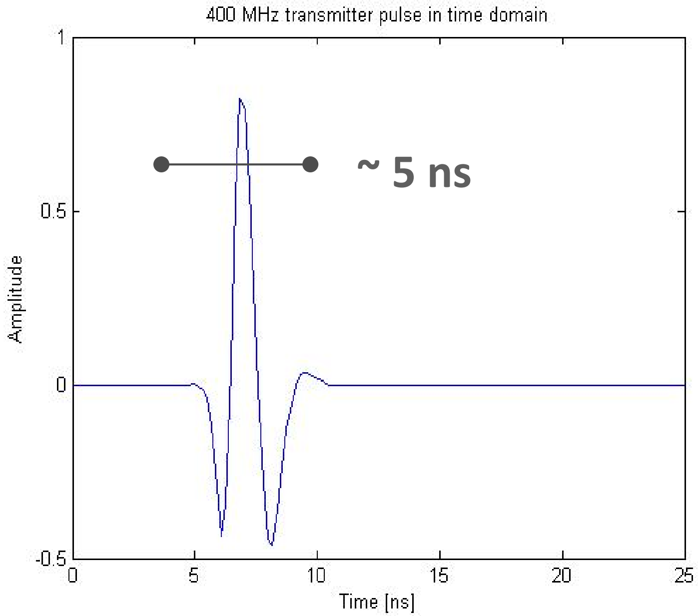
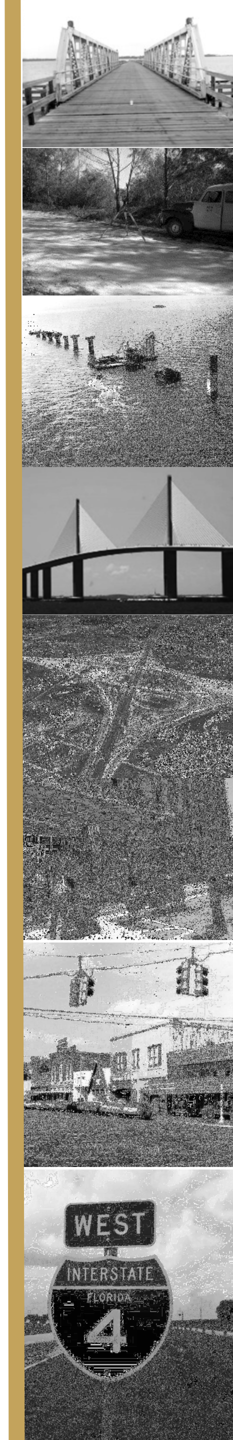
23-Jun-15

Transmitter Pulse and Wave Paths

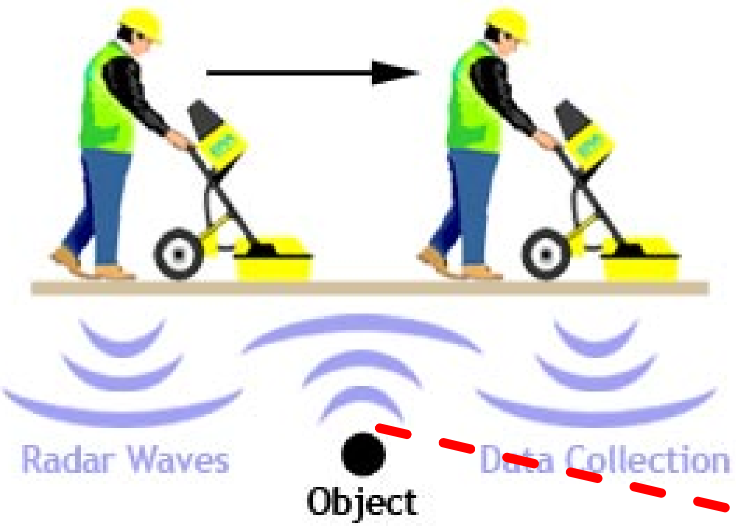




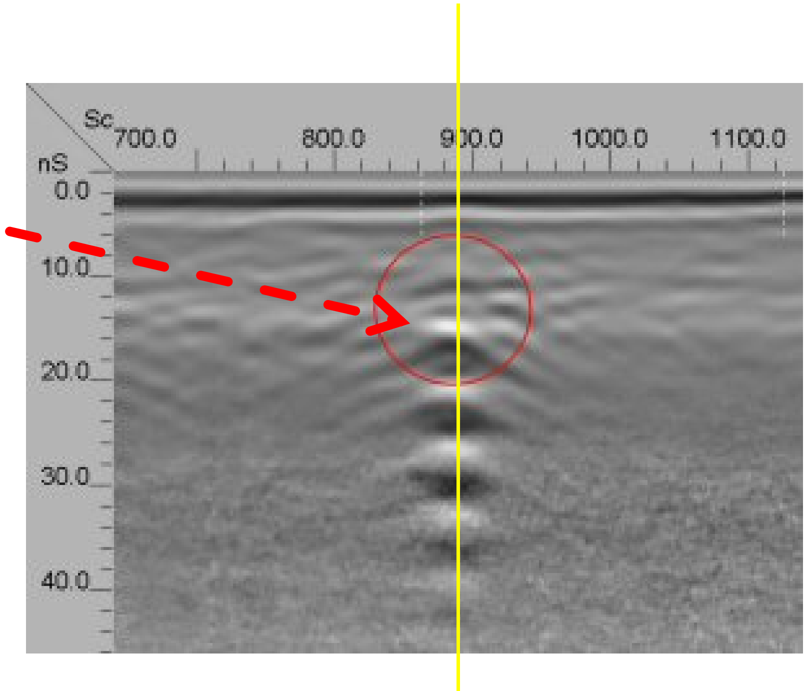
1. Direct wave from transmitter to receiver through air
2. Reflection of ground surface through air
3. Reflection of subsurface target, mainly through ground



GPR- as it moves along……………………



Mark the utility in real time with paint….



….and/or store object into data collector

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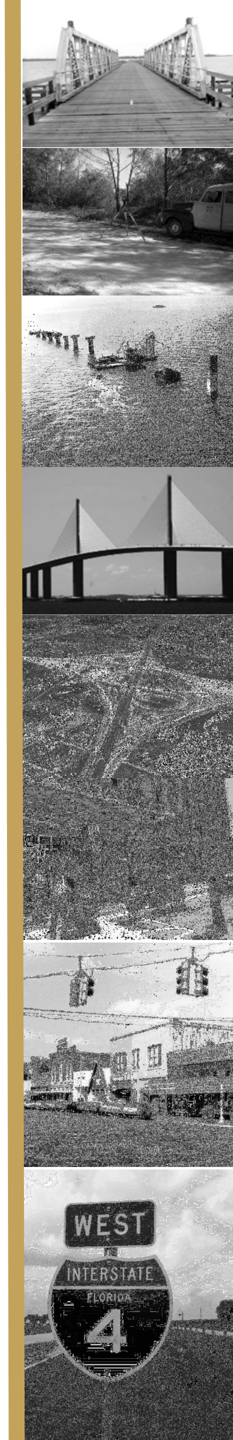
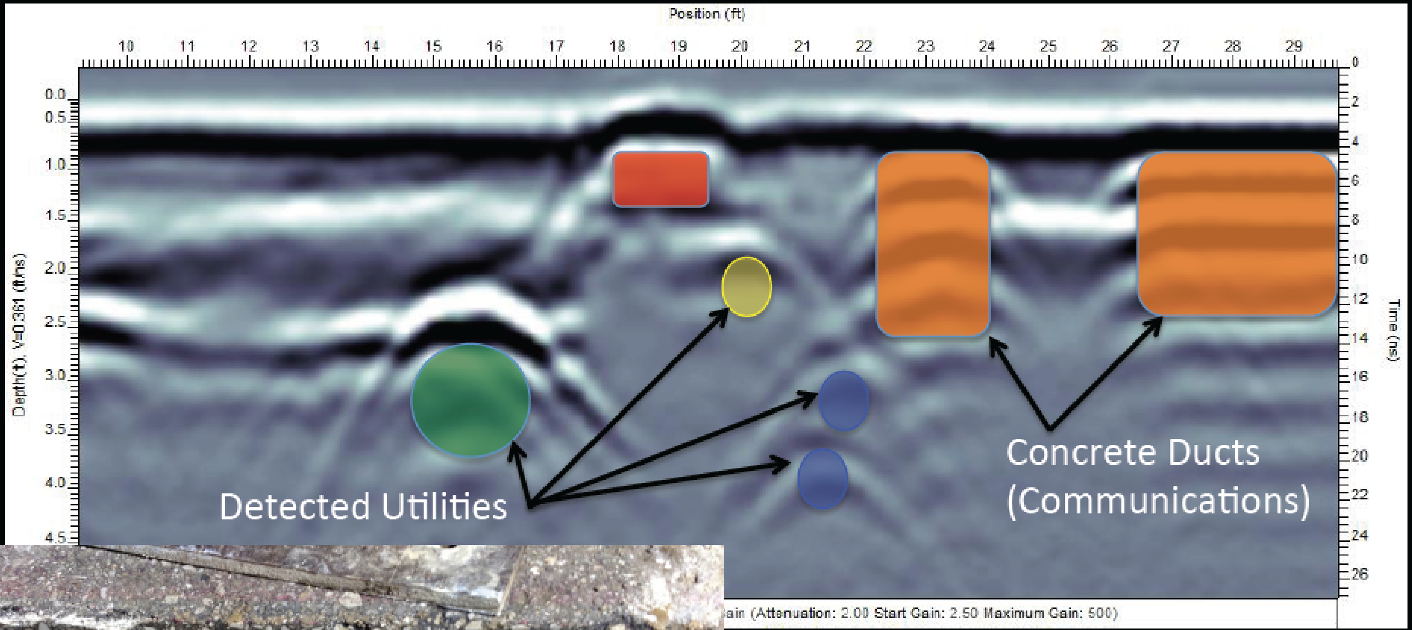


http://www.google.com/search?hl=en&site=imghp&tbm=isch&source=hp&biw=1920&bih=976&q=ground+penetrating+radar

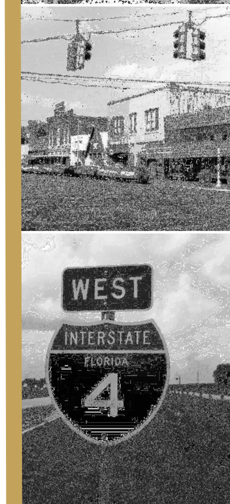
GPR Data Example

Ground Penetrating Radar used to correlate the data from hand held locators and assist with depth estimates for the 3 d Model



Concrete cover at road base base with new pavement course on top

Concrete encased Communication System



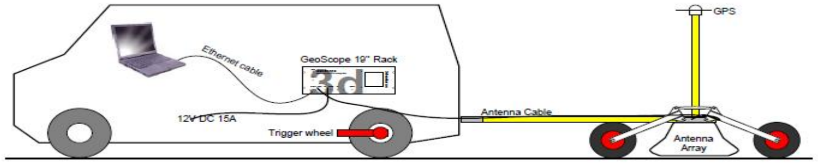
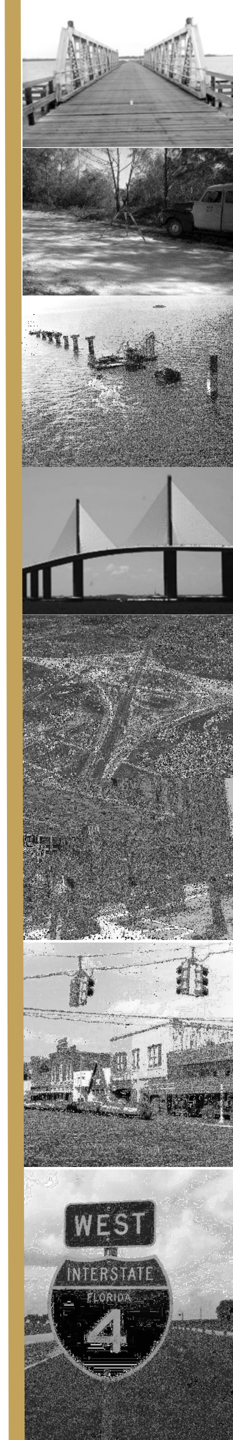
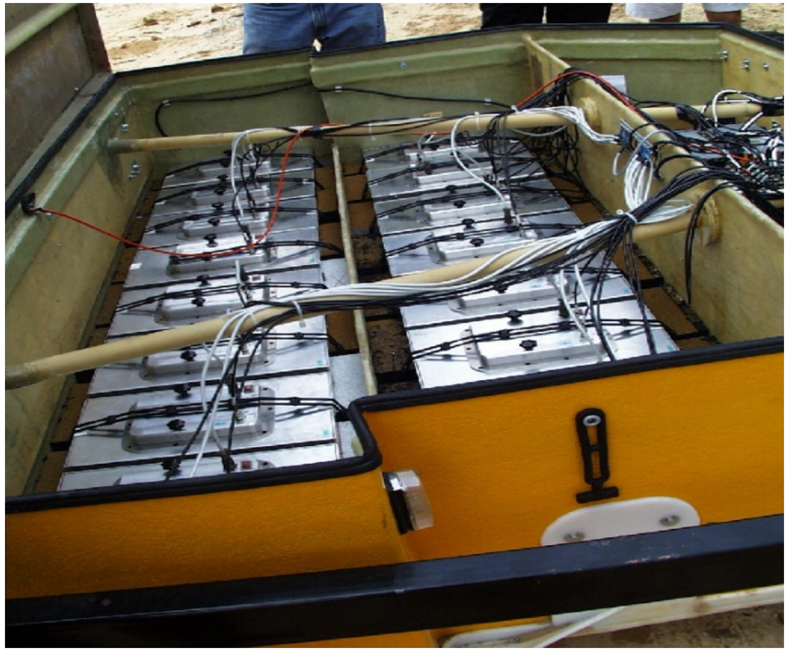


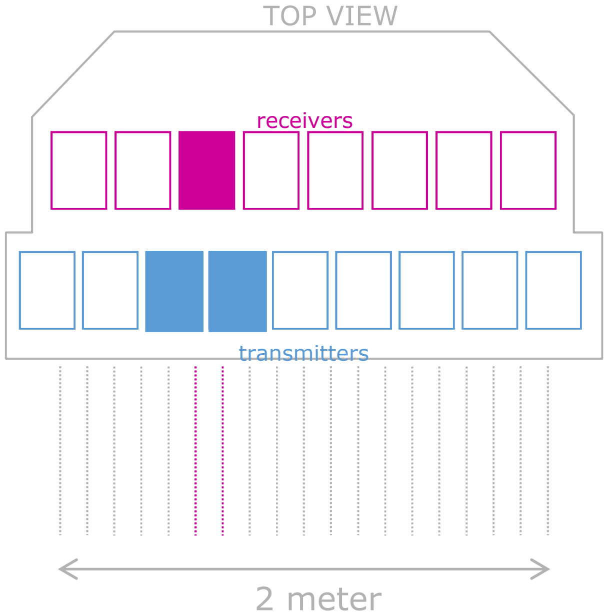
Figure 8 - Typical GPR setup with 4-wheel trailer.



Multi Channel GPR Arrays
and collection platforms

Mala Geosciences GPR Array



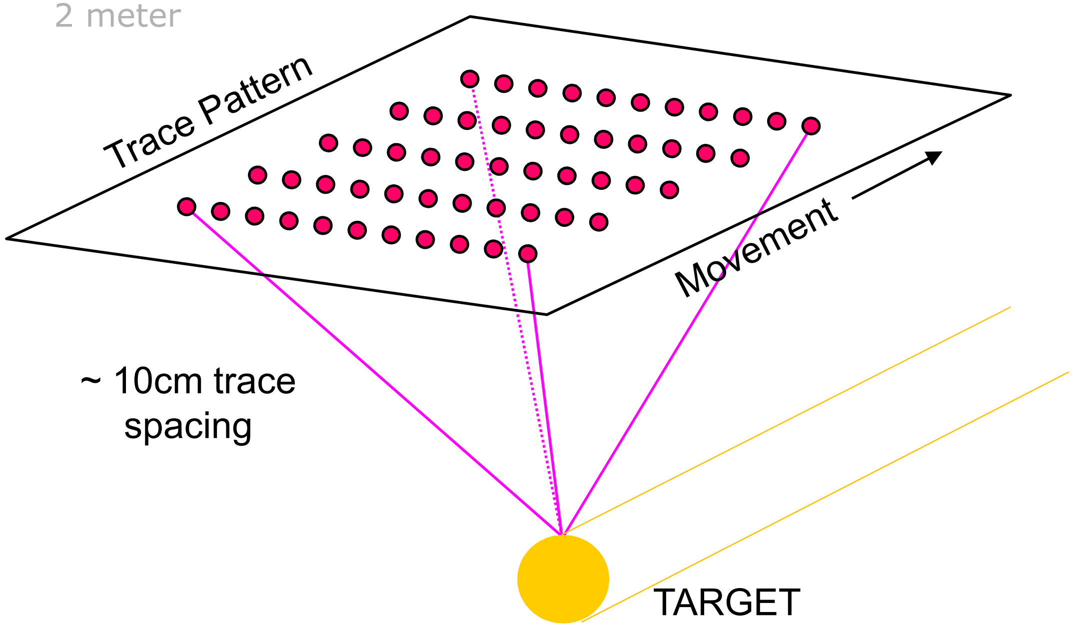


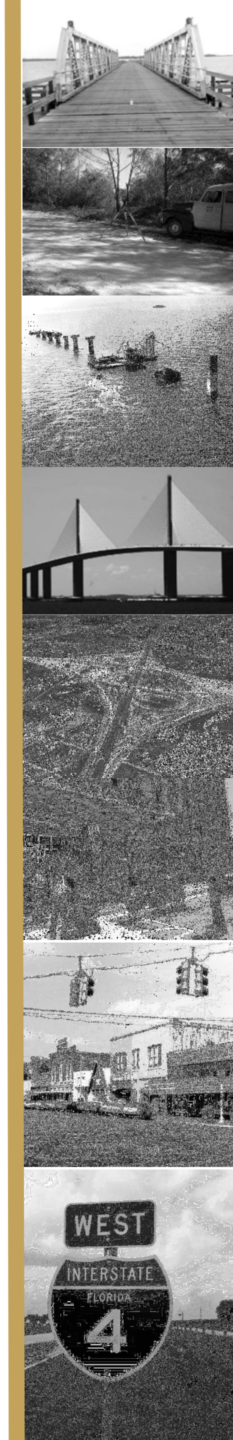
- 200 or 400 MHz

(Frequency dictates depth vs resolution)

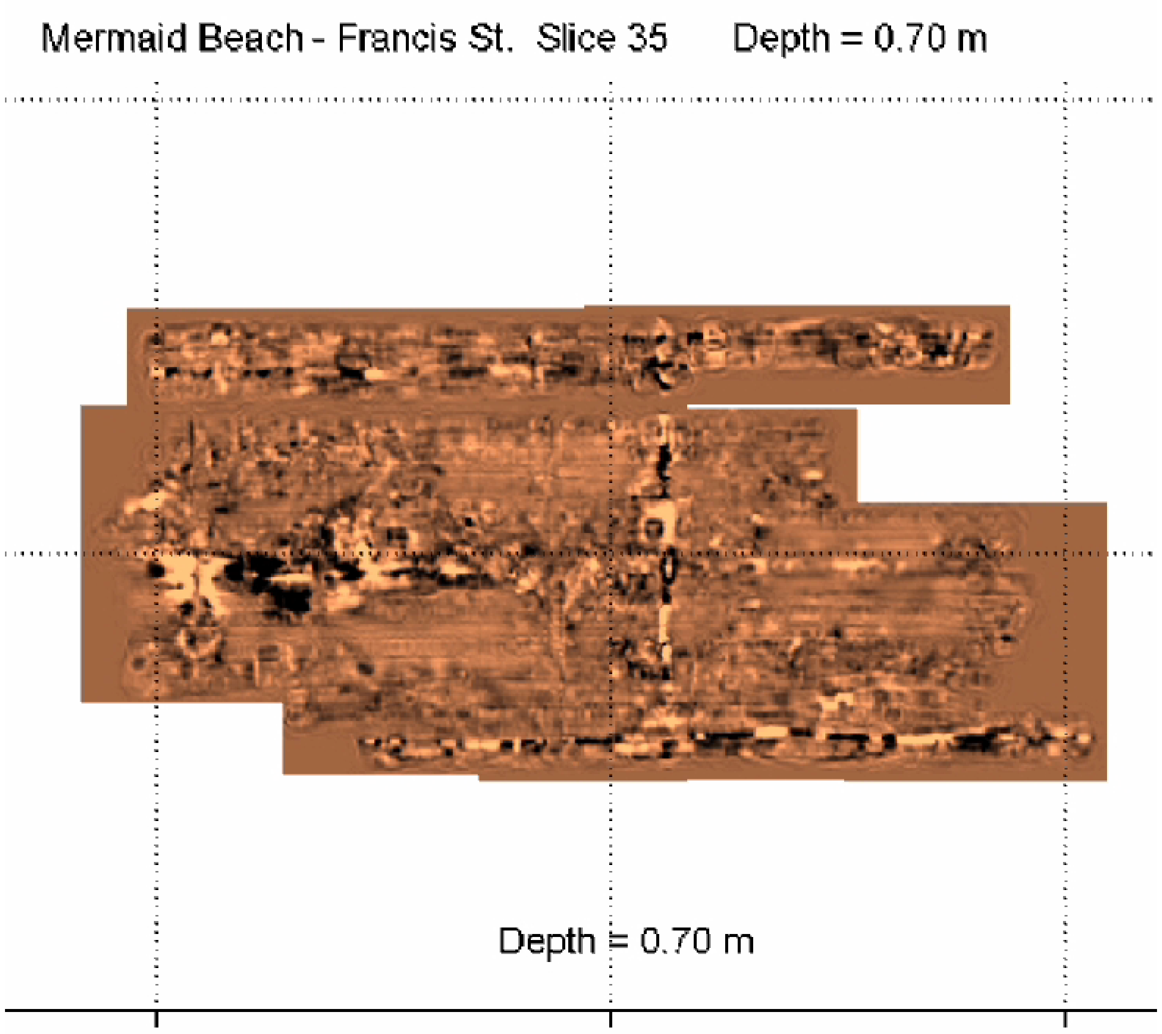
- 17 GPR antennae (9 Tx/8 Rx)
- 16 channels
- Control Box
- Trigger Wheel
- Laptop (on board vehicle)

200 MHz array





RT Imagery- QL "B+"



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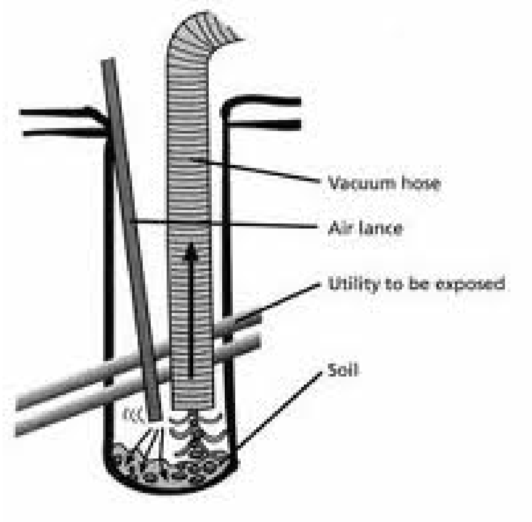
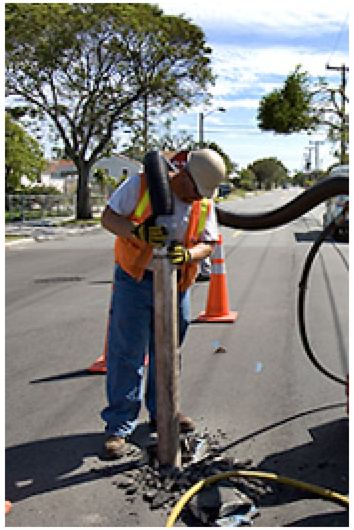
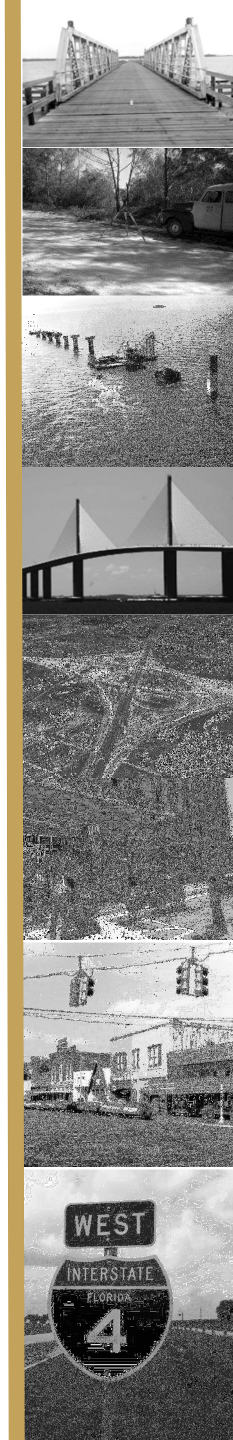
Test Holes- QL-"A"- Vacuum Excavation



Excavation either by high pressure air or water. The spoil is removed by a cyclone vacuum system.

Properly done this is non-destructive and minimally invasive.





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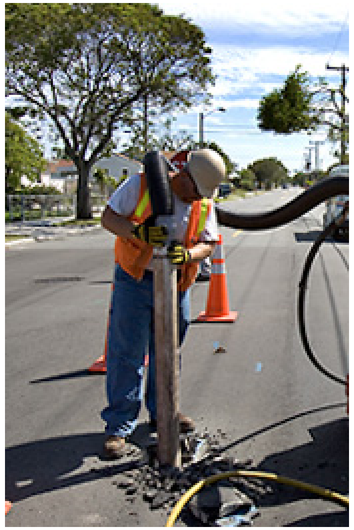
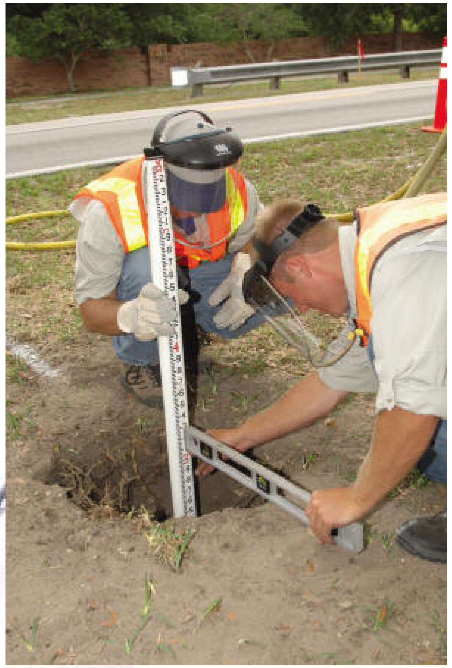
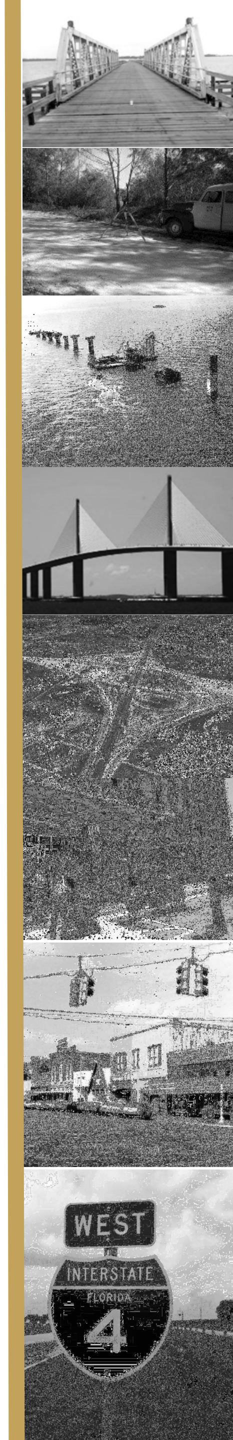
http://www.google.com/search?q=test+holes

Test Holes- QL-"A"- Vacuum Excavation







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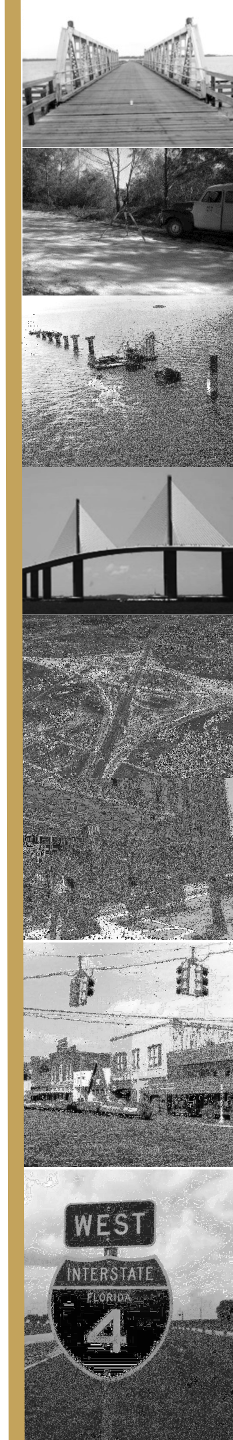
http://www.google.com/search?q=test+holes

Putting the above and below together

LiDAR and……..Imaged Utilities?

Buried Utilities…….symmetry?



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Reality

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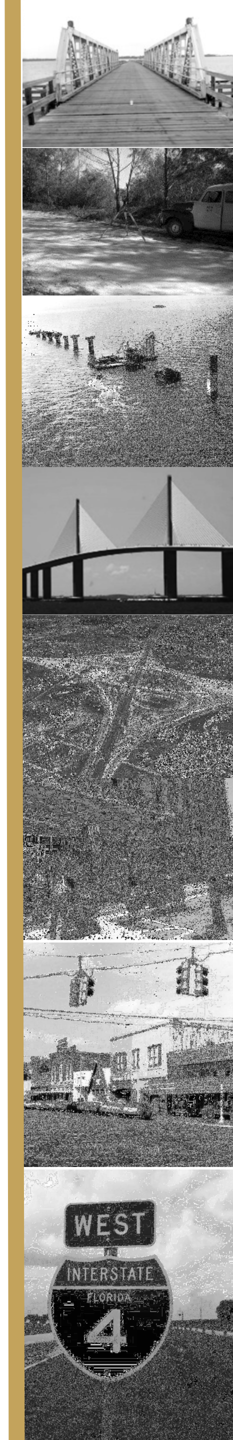

And more reality

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Technical Challenges

- All of these technologies have strengths and weaknesses based on their capabilities and the environment they are used in. Know what to use where.
- Marrying the surface and underground data so the data collector, plans producer and eventual customer understand the source and accuracy of the data. Feature based CAD will help this.
- Rapid technology development and how it impacts work flows, standards, and even terminology. Constant conversation on the next “Apple” release……….
- QA/QC with everybody on the same page. Proper expectations need to begin with specific scoping language. Less boiler plate expectations.
- Consultant vs. FDOT piece of mind. We are not expecting to help you work out the issues. Be ready explain redundant data collection methods.
- All parties need to be clear on what they need before not after.

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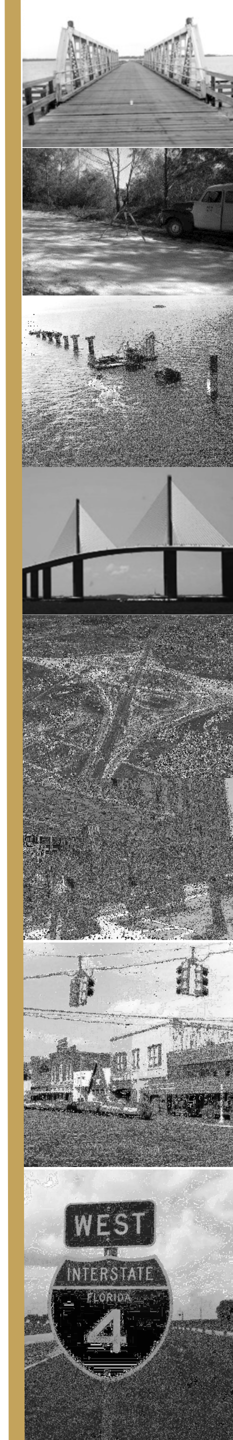

Administrative Challenges

- 3D modeling sets the expectation that all data is “created equal”
- Engineers want simplification. They are not experts in measurement but they may have “had a survey course in college”
- Perception that better or richer data is more expensive for design budgets. Mostly true right now but it is getting cheaper. The goal is a better construction plan. This we know save money in the big picture.
- Getting a seat at the table to even discuss the options.
- Lack of respect for the role we are starting to play in collecting, disseminating and managing data.
- Follow the laws and rules but don’t get caught up in trying to build a watch when what we need is to build a road and drainage system to. Use professional judgment and common sense.

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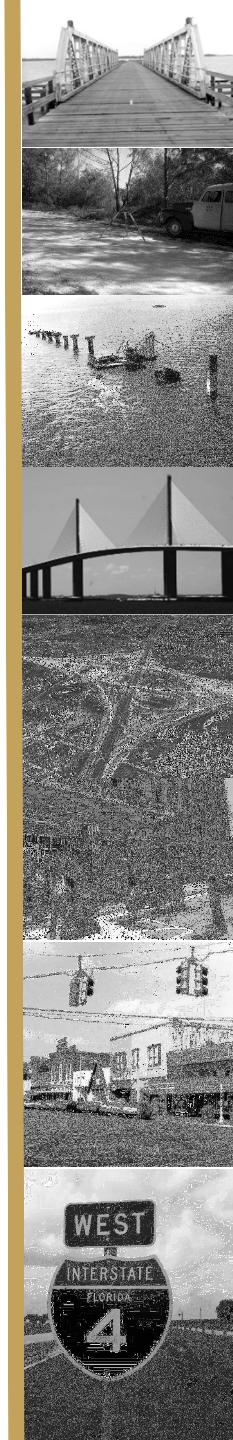

Opportunities and where do we go from here?

- Keep the pedal down because technology is getting smaller and Unmanned Aerial Systems (UAS) are coming down the tracks.
- There are more underground imaging technologies being developed, electromagnetic, acoustic. Benefits of algorithms to reduce noise and process data.
- CAD and GIS are 3D and more robust. They can handle Point Clouds and are becoming more intuitive.
- No blind trust. We need to collaborate, innovate, and find the best solution (scoping) for the project and life cycle applications of this data. (we manage the corridor well beyond the project…..GIS etc.)
- More Data certainly offer more challenges but the juice is worth the squeeze. Civil Integrated Management
- This is truly an opportunity to “transform” the way we collaborate and do business.

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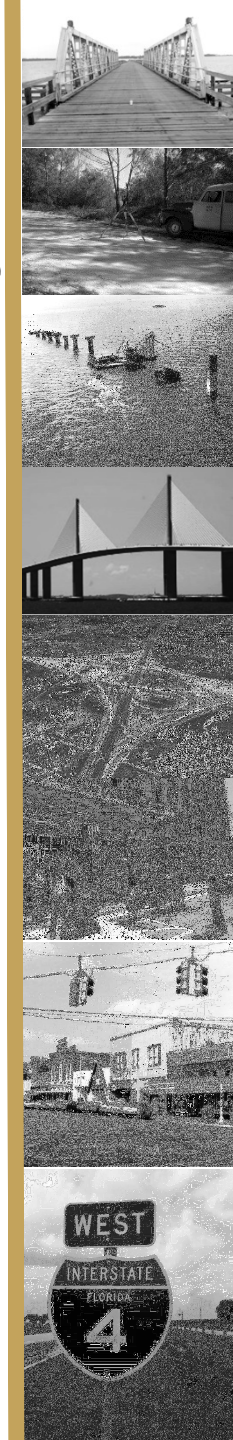


Murray Bros.
Caddy Shack
S Legacy Trail
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Golfway Dr
Golfway W Dr
Parkland Trail
9 Mile Rd
W Twincourt Trail
Subway
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World Golf
Center Pl Way
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Commerce Lake Dr
American Cul
Federation
World Commerce Pkwy
9 Mile Rd
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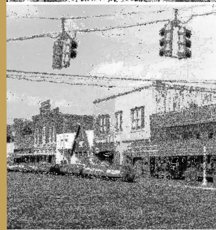
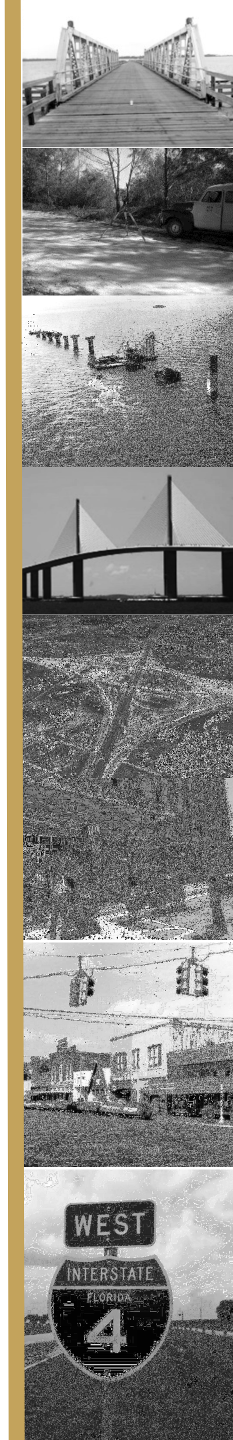



WEST
INTERSTATE
FLORIDA
4

Construction Sequencing

- http://www.vincico.com/projects/a7a04/a7a04v10.html



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