Combining Remote Sensing Technologies

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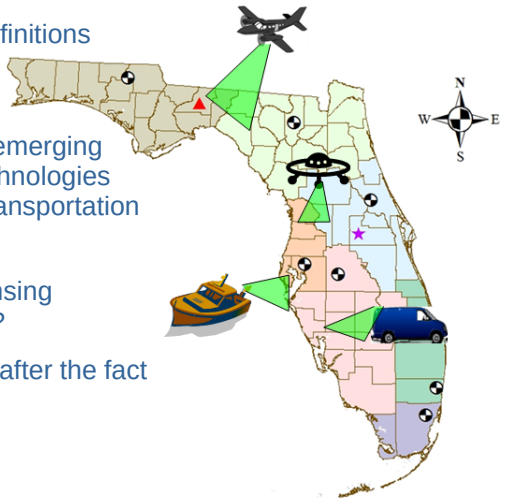
Surveying & Mapping Office

Session Objectives

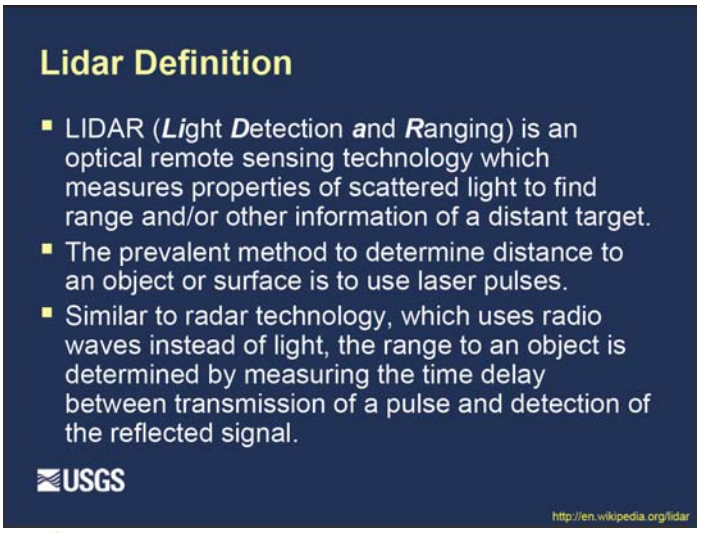
- First a couple terms and definitions
- Imagery characteristics
- A brief look at historic and emerging mobile remote sensing technologies related to 3D mapping of transportation facilities.
- What do mobile remote sensing platforms have in common?
- Combining technologies to after the fact
- Questions



Terms and Definitions

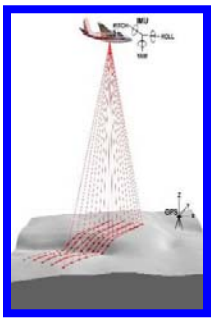
- **Photogrammetry** - The science or art of obtaining reliable measurements by photography. (Source: American Congress on Surveying and Mapping and the American Society of Civil Engineers. *Definitions of Surveying and Associated Terms*. Library of Congress Catalogue Card Number 72-76807. Washington 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 – Emits and receives
    - PASSIVE – Receives only

Light Detection And Ranging (LiDAR)

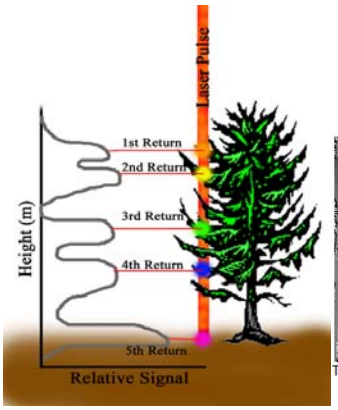


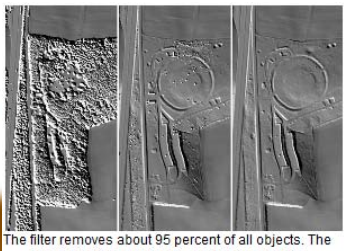
Some Pulse Laser Characteristics

- Laser pulses can penetrate forest canopy through gaps.
- Some laser pulses reach forest floor, other returns reflect from canopy and 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

2013 Design Training Expo

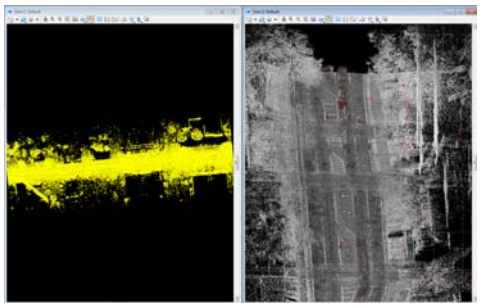
- *Imagery Characteristics*
  - *The Good*
  - *The Bad*
  - *And the Ugly*

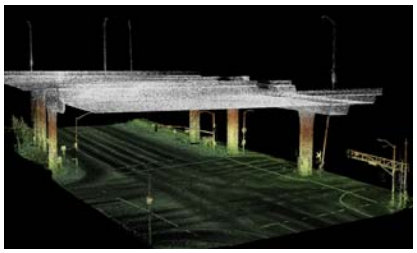
http://www.earthmagazine.org

http://www.ssi-mi.com/MobileLiDAR.html

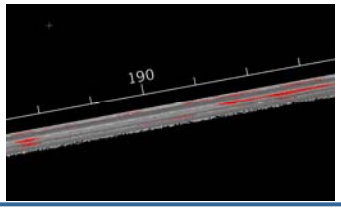
Design Training Expo

Imagery Characteristics





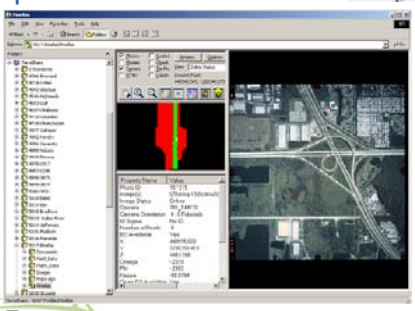
- The Good . . .



http://www.saminc.biz/project/detail/crenshaw-light-rail-mobile-mapping

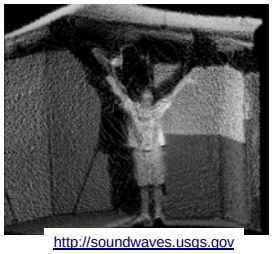
The Bad . . .

- Large File Sizes
- Special Software



And the Ugly

- Greater opportunity for misuse



http://soundwaves.usgs.gov

http://www.begadistrictnews.com.au

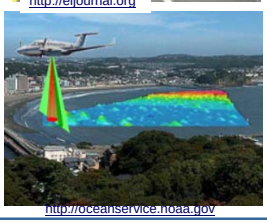
http://polargateways2008.gsfc.nasa.gov

A Brief Look at Technology

http://lidarusa.com

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

http://eijournal.org



http://oceanservice.noaa.gov

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

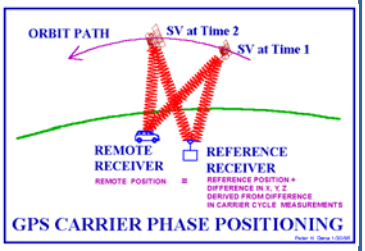
Rapidly Improving Accuracies

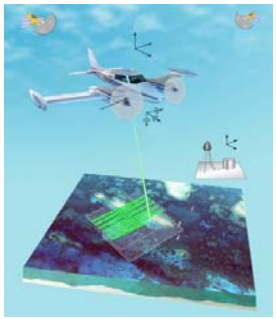
Low Altitude LiDAR Testing in District 3

Washington County SR 10	FDOT X-Sections	Difference	150kHz Roto-X	Difference	80kHz FrgSet1-X	Difference	150kHz FrgSet2-X	Difference	240kHz FrgSet3-X	Difference	400kHz FrgSet4-X
BEGIN 1	1	0	1	0	1	0	1	0	1	0	1
1562524.429 649544.226	78.304	-0.163	78.467	-0.097	78.401	0.061	78.243	0.063	78.241	-0.093	78.397
1562523.036 649548.922	78.634	-0.088	78.722	-0.015	78.649	0.202	78.432	0.156	78.478	-0.051	78.685
1562520.116 649560.522	78.959	-0.083	79.042	0.007	78.952	0.21	78.749	0.123	78.836	-0.052	79.011
1562517.459 649572.428	78.967	-0.084	79.051	-0.054	79.021	0.155	78.812	0.153	78.814	0.045	78.922
1562516.255 649576.851	78.722	-0.087	78.809	-0.007	78.729	0.059	78.663	0.034	78.688	-0.06	78.782
END											
BEGIN 2	2	0	2	0	2	0	2	0	2	0	2
1562623.897 649570.799	79.857	-0.109	79.966	-0.081	79.938	0.119	79.738	0.095	79.762	-0.051	79.908
1562622.459 649575.294	80.203	-0.061	80.264	0.002	80.201	0.16	80.043	0.091	80.112	-0.06	80.263
1562619.377 649586.984	80.587	-0.065	80.652	-0.006	80.593	0.207	80.38	0.122	80.465	-0.038	80.625
1562616.357 649598.829	80.443	-0.115	80.558	0.006	80.437	0.2	80.243	0.144	80.299	-0.026	80.469
1562615.191 649603.490	80.168	-0.146	80.314	-0.056	80.224	0.06	80.108	-0.01	80.178	-0.081	80.249
END											
BEGIN 3	3	0	3	0	3	0	3	0	3	0	3
1562722.625 649597.367	82.064	-0.099	82.163	-0.012	82.076	0.114	81.95	0.11	81.954	-0.05	82.114
1562721.847 649601.856	82.399	-0.049	82.448	0.003	82.396	0.195	82.204	0.148	82.251	-0.03	82.429
1562718.872 649613.402	82.696	-0.017	82.713	0.016	82.68	0.165	82.531	0.102	82.594	-0.014	82.71
1562715.747 649625.257	82.498	-0.062	82.56	-0.03	82.528	0.156	82.342	0.145	82.353	-0.08	82.578
1562715.168 649630.244	82.187	-0.108	82.295	-0.051	82.238	0.144	82.043	0.118	82.069	-0.029	82.216
END											

What mobile imaging systems have in common:

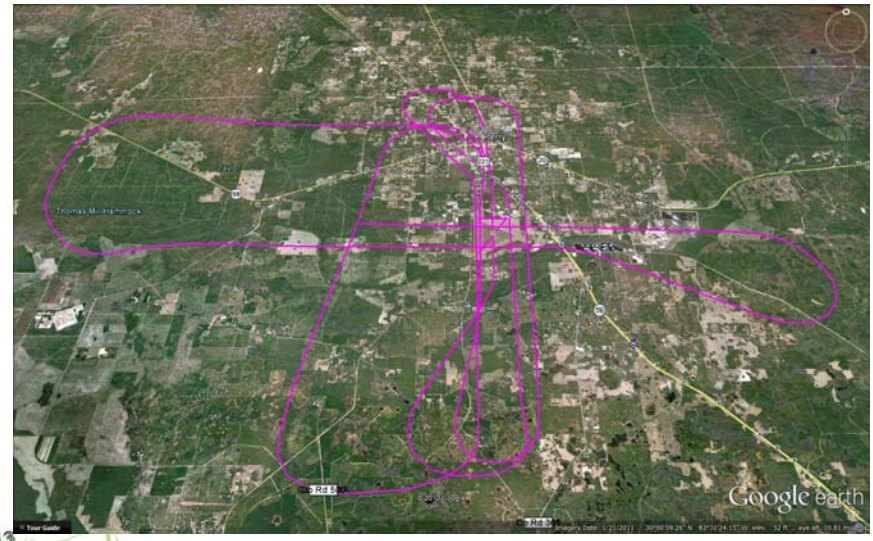
- Most Mobile Remote Sensing Systems have the following critical components in common: *Image Sensor, GPS, IMU, Base Station*
- Mobile Laser Scanning (MLS) uses a laser scanner(s) in combination with Global Navigation Satellite System (GNSS) and Inertial Measurement Unit (IMU) to produce accurate and precise geospatial data from a moving platform both in the air and on the ground.
- Traditionally the term Airborne LiDAR System (ALS) is associated with higher altitude airborne collection over a large area for surface mapping. In this document MLS from the air refers to low altitude scanning of higher accuracy from fixed wing and helicopter used for corridor projects.





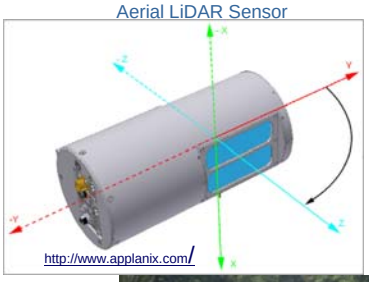
Sensor Trajectory

- SBET – Smoothed Best Estimate of Trajectory



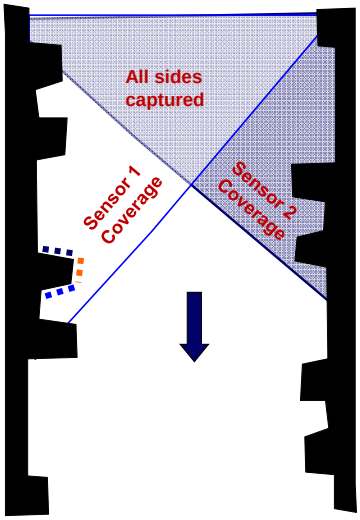
Sensor Position and Orientation

Aerial LiDAR Sensor

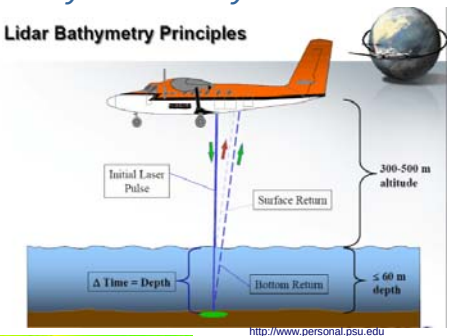


http://www.applanix.com/

http://rieglusa.wordpress.com

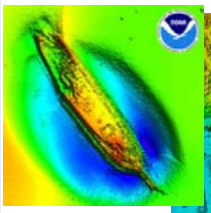


Bathymetric & Hydro Mobile LiDAR

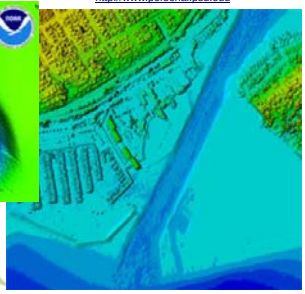


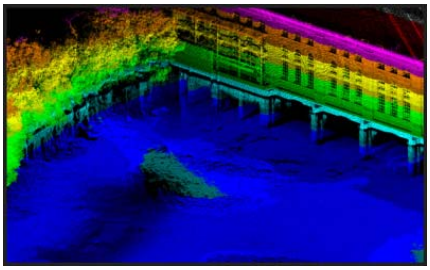
http://www.personal.psu.edu

http://www.seasllc.net



http://www.nautical charts.noaa.gov





The good old days…

http://crcgis.stockton.edu

They aren't quite dead yet.

Photogrammetry

Input

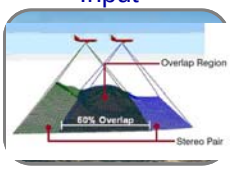
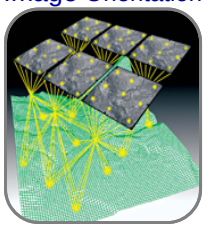
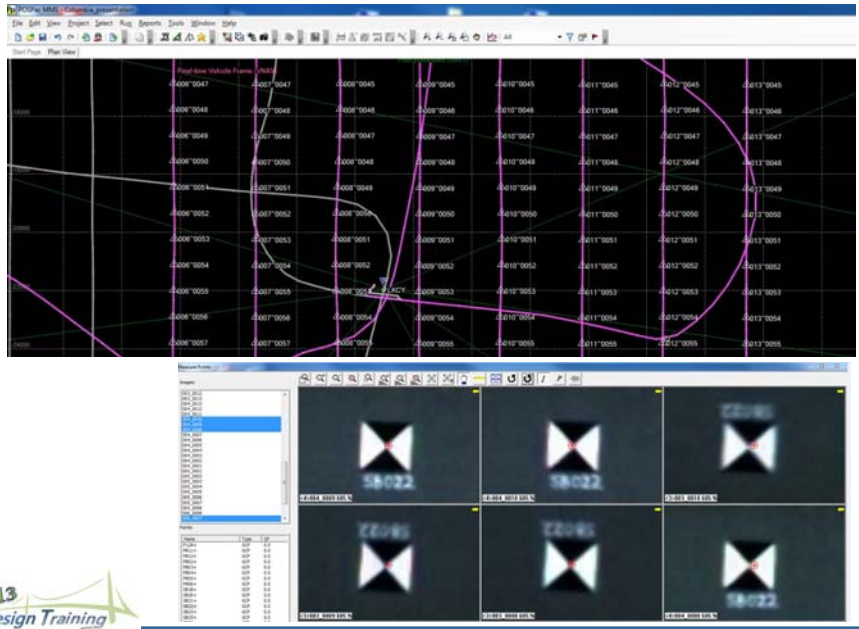


Image Orientation

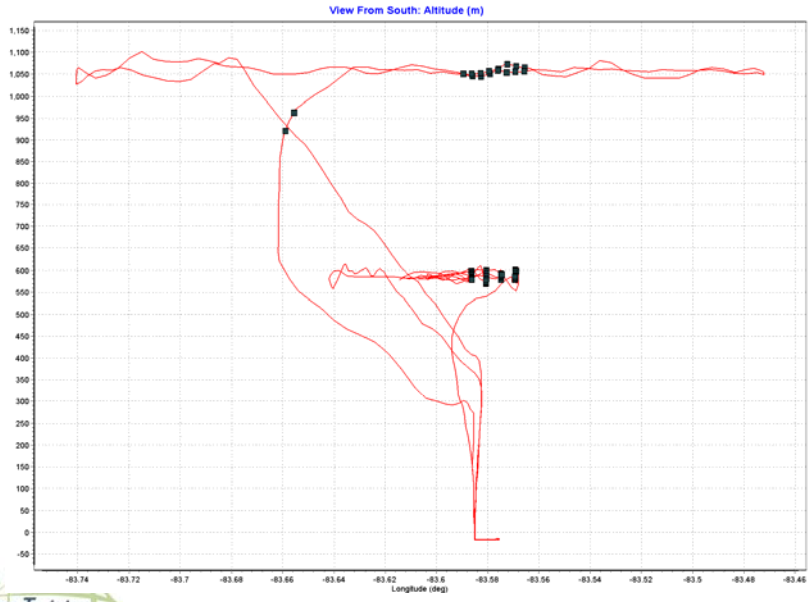


Data Exploitation

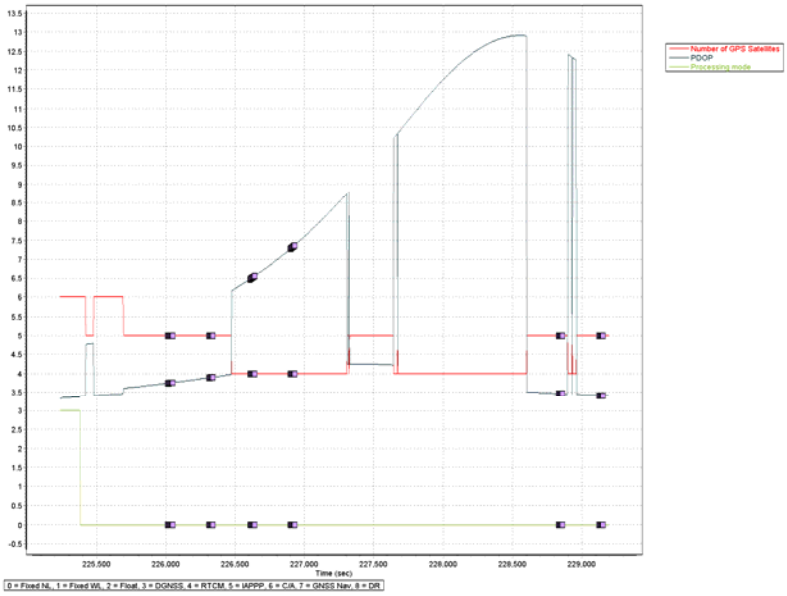
Camera Events



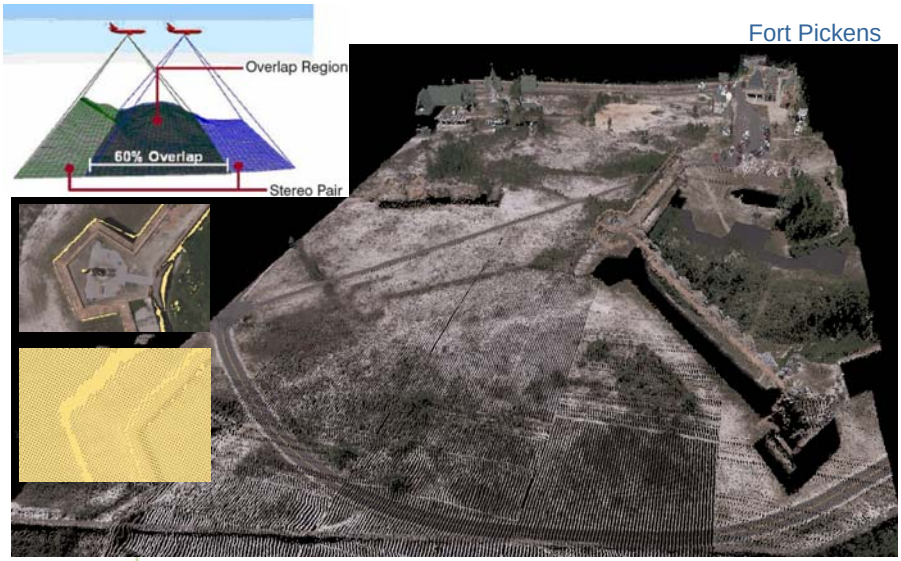
Sensor Altitude



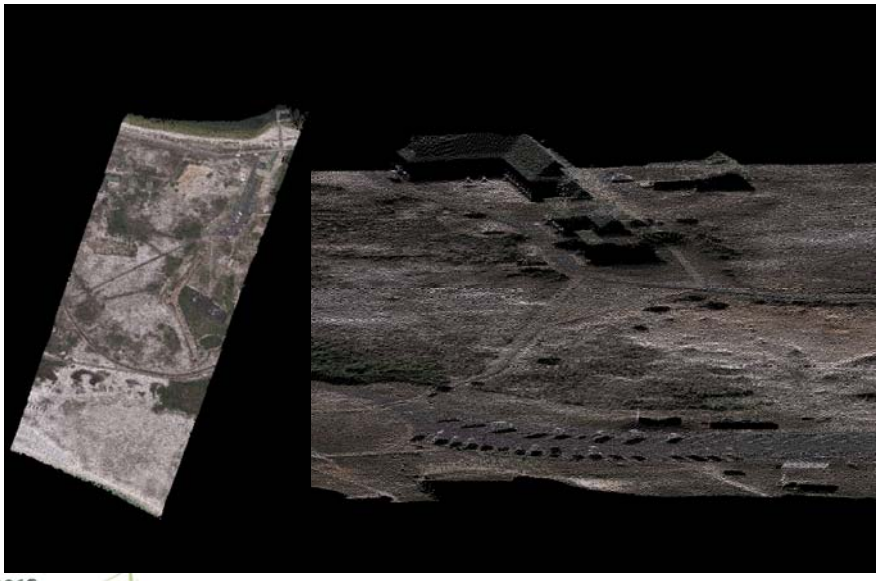
GPS Processing



Photogrammetry - Autocorrelation



Photogrammetry - Autocorrelation

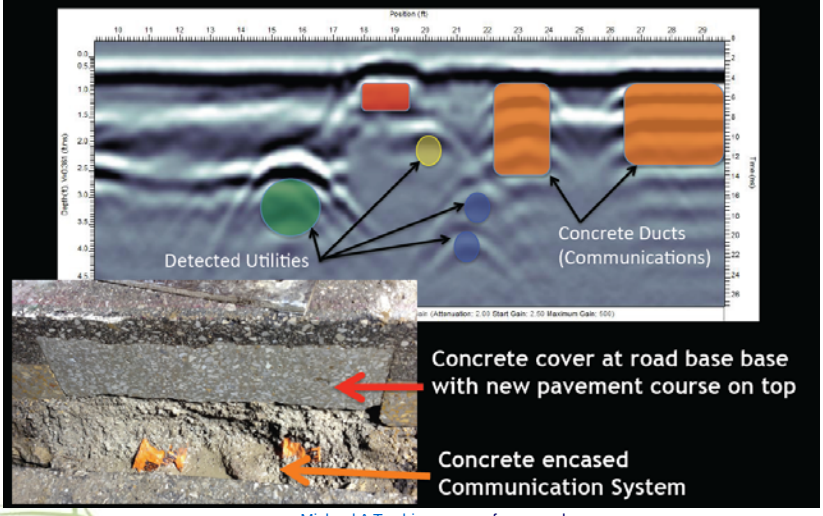


2013 Design Training Expo

Michael A Twohig – Presented at the 2013 International Mobile LiDAR Forum, Denver Colorado

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

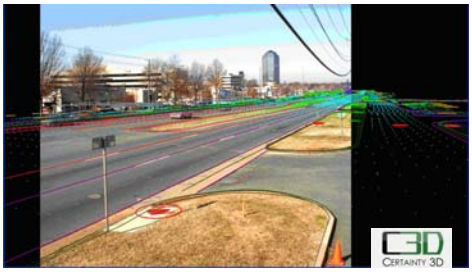


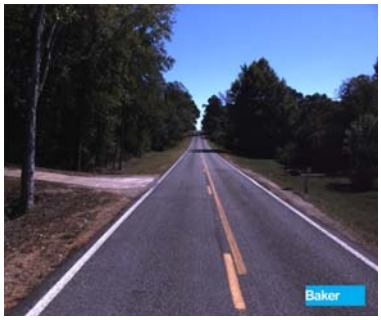
2013 Design Training Expo

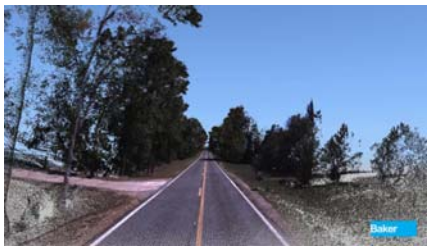
Michael A Twohig, www.surfacesearch.com

Combining Imagery with LiDAR

- Keep in Mind it may not be Independent if processed from same SBET

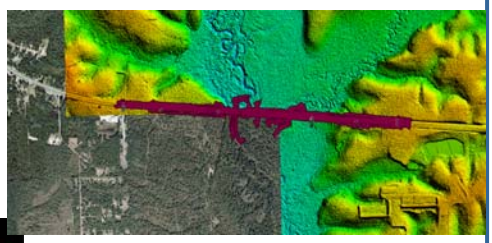


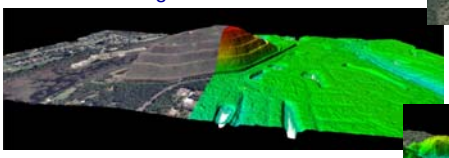


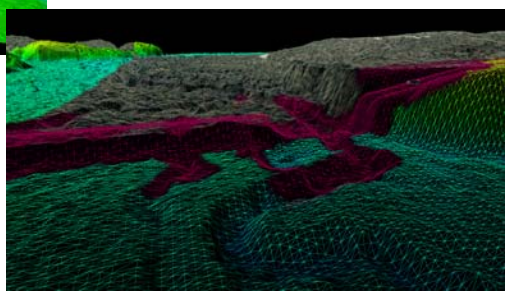


Combining Survey Image Data

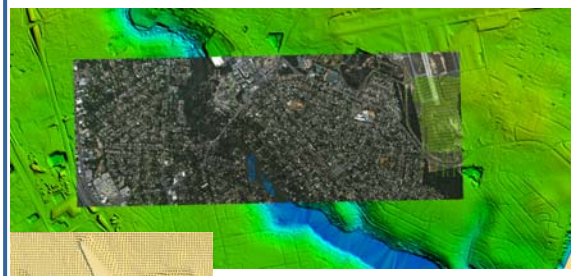
- When done right imagery from different sources can be very beneficial
  - Verify Accuracy
  - More complete Information
  - Change detection

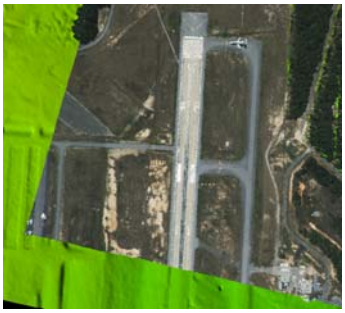




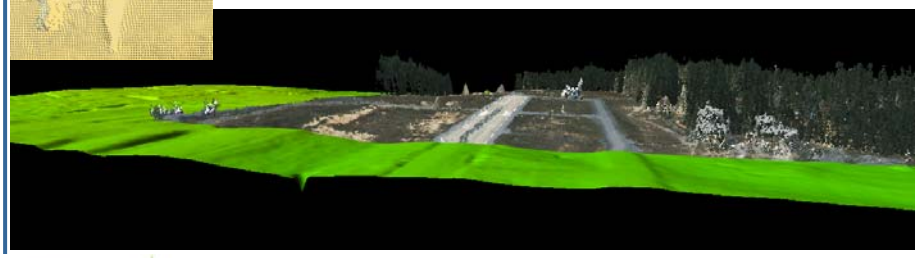


Verifying USGS DEM Surface for Orthophotography



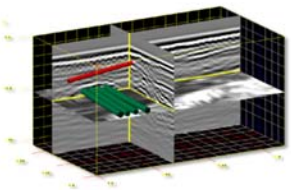


FDOT - SMO

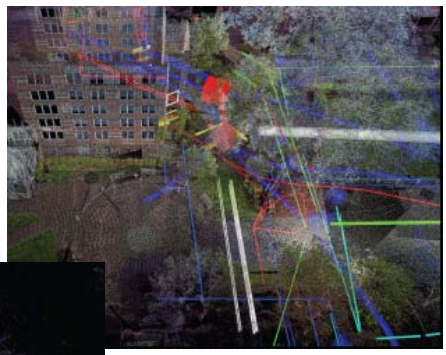


Autocorrelation from Digital Mapping Camera (DMC) Imagery

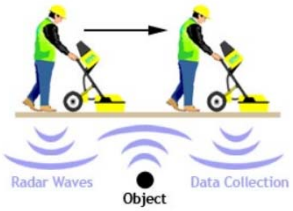
Adding Subsurface Imagery



http://www.digitalconcreteimaging.com/



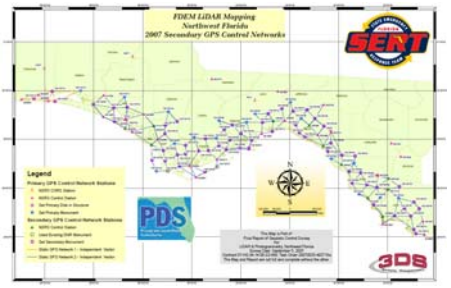
Michael A Twohig, www.surfacesearch.com



http://www.worksmartinc.net/

How do I decide if I can use it?

- ***Talk to District Survey and SMO Office***
- ***Common Datum!***
- ***Intended Use***
  - *Original Intended Use of Survey Data (Survey Report)*
  - *Current Use*
- ***Distinguishing Collection Techniques (Passive/Active)***
  - *Static*
  - *Terrestrial Mobile*
  - *Airborne*
- ***Accuracies and Point Densities***



2013 Design Training Expo

Questions?

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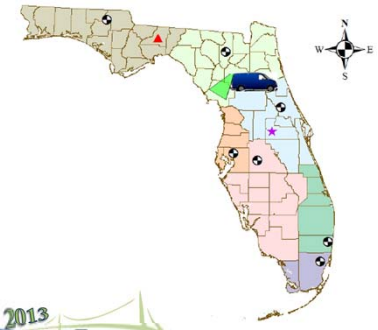

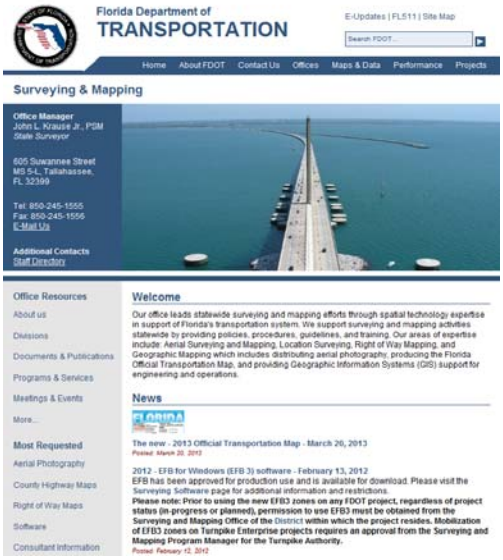

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