

# Watershed Sciences 4930 & 6920 GEOGRAPHIC INFORMATION SYSTEMS

WEEK Five

## TERRESTRIAL LASER SCANNING (AKA GROUND BASED LIDAR)

Joe Wheaton



## PURPOSE OF TODAY'S DEMONSTRATION

- Introduce you to TLS
- Demystify TLS & LiDaR



## TODAY'S PLAN...

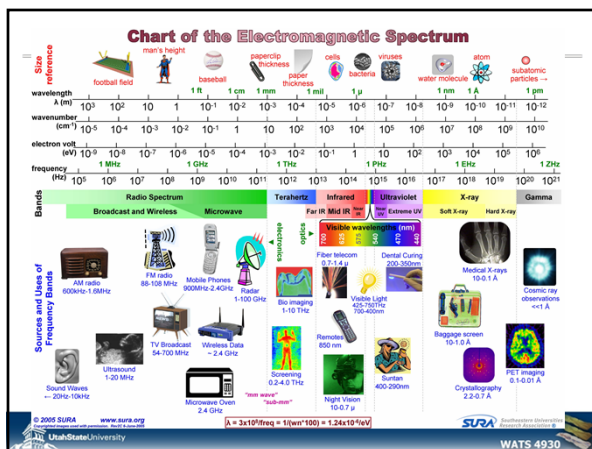
- I. What is TLS?
- II. Let's see this thing in action
- III. What can be done with it?
- IV. Is this the future?



## ACTIVE AND PASSIVE REMOTE SENSING

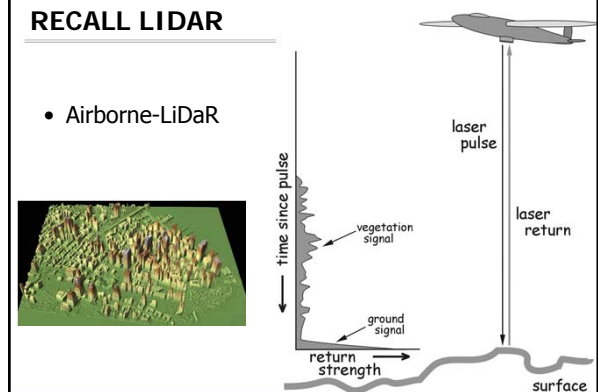


Visible light Copyright © 2006 Pearson Prentice Hall, Inc. Radar Copyright © 2006 Pearson Prentice Hall, Inc.



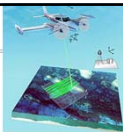
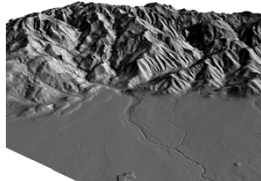
## RECALL LIDAR

- Airborne-LiDaR



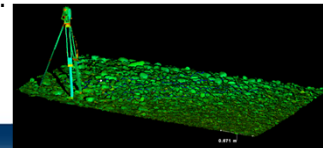
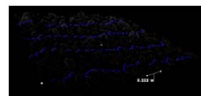
## WHAT IS TLS?

- LiDaR from the ground...
- Terrestrial Laser Scanner (a.k.a. ground-based LiDaR)



## SORT OF LIKE A TOTAL STATION...

- Normal total station needs a reflector target...
- Reflectorless, just looks for a return off any surface
- TLS, like reflectorless... on speed.



## RECALL TOTAL STATION SURVEYING



## FIRE THE SMART ONE...

- Who's the smarter one?



Who's on the dumb end of a stick now...

## A GUN AND A ROD...



- Gun shoots and record
- Prism on rod reflects

- Technically an example of active remote sensing...

## TS CALCULATES - DISTANCES

Slope Distance is Calculated:

- Gun shoots beam
- Beam reflected back off prism
- Time is recorded
- Based on speed of light, slope distance is calculated

$$(SD = t \cdot V_{Light})$$



## THE PRISM or REFLECTOR (WHAT IS SHOT)

They go on top of the pole...

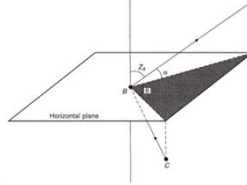
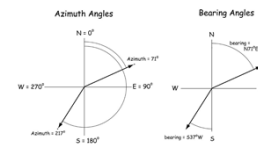
- Standard unidirectional prism
- Fancy, 360° prism
- Multiple prisms (for long distances)
- Nothing (reflectorless)

Allows: a) lower intensity laser, b) greater distances, c) non ambiguous returns



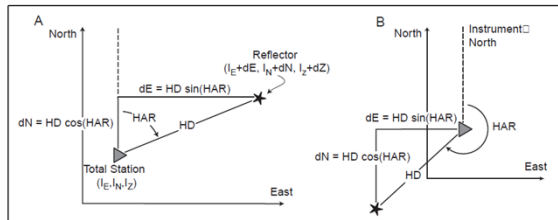
## TS MEASURES - ANGLES

- Measures horizontal angles (azimuths or bearings)
- Measures vertical angles (zenith)



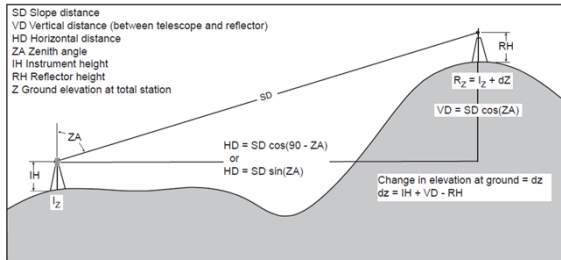
- Can only do this relative to a horizontal plane
- Horizontal plane exists because instrument is 'leveled'

## TOTAL STATION SURVEYING – HORIZONTAL DEFINITIONS



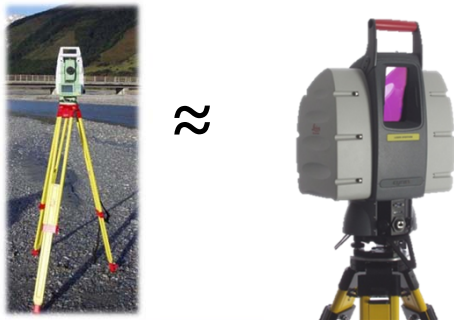
- This diagram shows how you get your x & y coordinate values at each surveyed point...

## TOTAL STATION SURVEYING – VERTICAL DEFINITIONS



- This diagram shows how you get the z coordinate  $R_z$  of the point you want to survey

## SO A TLS IS LIKE A REFLECTORLESS TOTAL STATION... ON METH



## DIFFERENT INSTRUMENTS & SOFTWARE

Different instruments help address different scales of questions (same technology)

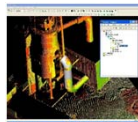
### Leica

- Shorter range (up to 300 m)
- Higher Resolution Accuracy (2-5 mm)



### Riegl

- Longer range (up to 2 or 8 km)
- Lower Resolution & Accuracy (10 mm)



## LOTS OF OPTIONS OUT THERE



Trimble GX



Optech ILRIS-3D



Leica ScanStation C10



Riegl VZ



Leica HDS4400

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## RADIOHEAD – HOUSE OF CARDS

- No cameras or lights used....
- Just a Terrestrial Laser Scanner

Radiohead - House of Cards



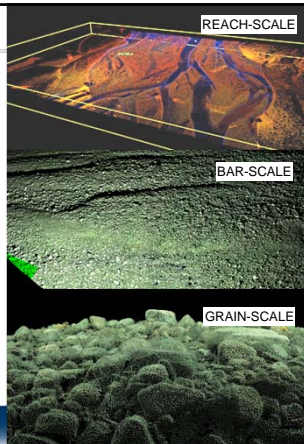
## SOME APPLICATIONS ALREADY IN USE:

- Quantifying 3D-Structure of Wildlife habitat
- Mapping forests fuels for fire modeling
- Quantifying forest growth rates to estimate above ground carbon sequestration
- Calculating growth rates
- Mapping stratigraphy and structural geology
- Lichenometry
- Complex hydraulics in bedrock rivers
- Quantifying form drag & flow resistance from complex morphologies and vegetation
- Calculating surface roughness
- Morphological Sediment budgeting

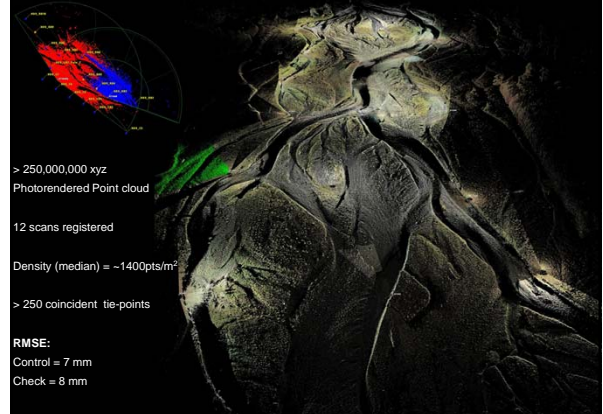


## TLS SCALE-FREE?

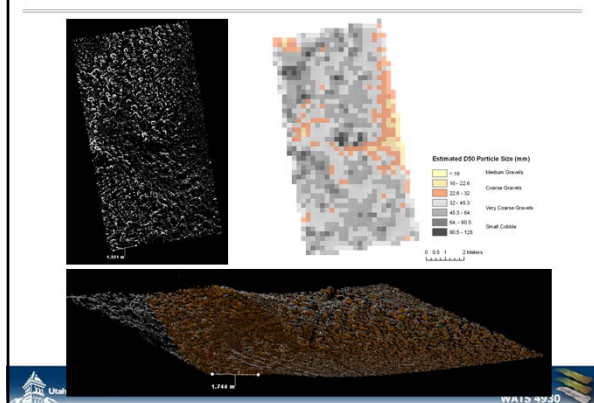
- High sampling rate enables landform recording at scales from the grain up to the reach in one single, integrated dataset
- Captures everything (three orders of magnitude more data)



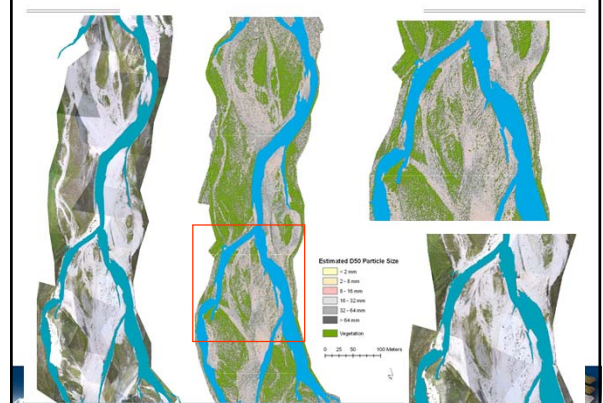
## Registered Feshie 2007 Scans



## MAPPING PARTICLE GRAIN SIZES



## REACH SCALE GSD MAP: RIVER FESHIE 2007



## CHARACTERIZING HYDRAULIC HABITAT

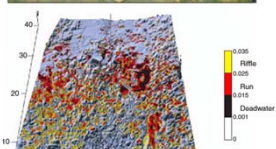
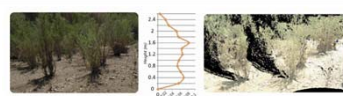
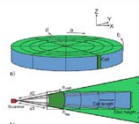


Plate 1.7 Spatial distribution of biotope types for the reach shown in Figure 1.6 defined by laser scan water surface roughness measurement (Large & Heritage, 2007).

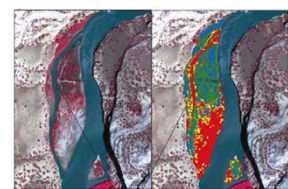
From Large & Heritage (2007)

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## CHARACTERIZING VEGETATED ROUGHNESS



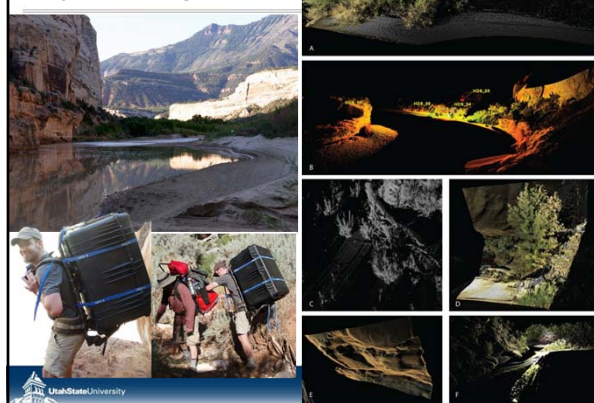
- Relate projected area (frontal area drag) from TLS to Airborne LiDaR
- Map roughness spatially over much larger areas...



From Manners et al. (In Prep)

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## A CHALLENGE...



## ONE SMALL PROBLEM...

- NearIR LiDaR does not penetrate the water surface



Plate 7.2 Surface and photo of the point bar study site at the River South Tyne at Lambley.

## WATER SURFACE TOPOGRAPHY



## COASTAL CLIFF EROSION

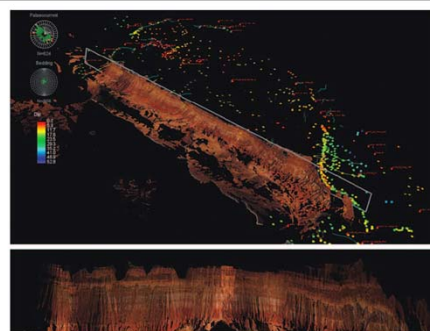


Plate 11.3 Projection plane view of the southwest face of the Nukhul syncline outcrop [see Figures 11.5–11.7 with a four times vertical exaggeration. Note the presence of a subtle anticline structure visible in the projection plane. This feature is not easily visible in the field, and is only clearly visible in vertically exaggerated data. The feature is also visible in the contour map in Figure 11.4.



## TRACKING INDIVIDUAL FAILURE EVENTS

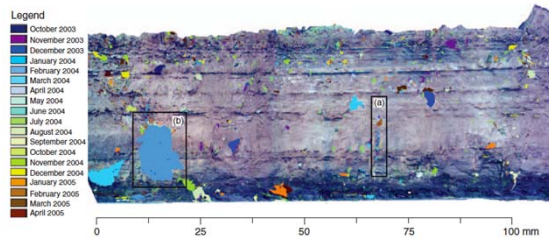


Plate 15.3 Orthoimage of the Red Nabbs headland overlaid with a shapefile locating the spatial extent and position of changes recorded over the monitoring period. The headland was relatively stable throughout the monitored period with concentrations of change on vertical steps in the cliff face (Inset a) and towards the seaward edge of the site where the largest failure occurred (Inset b).

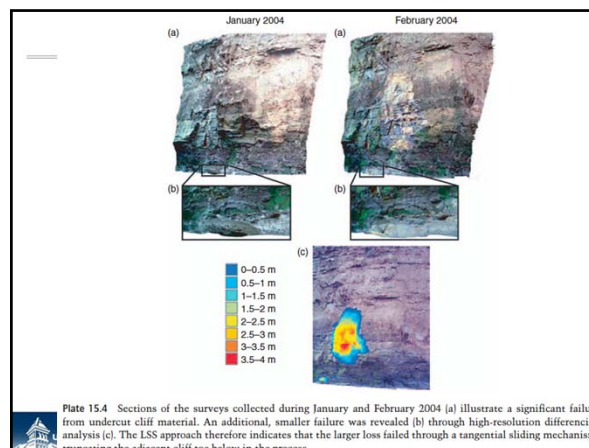
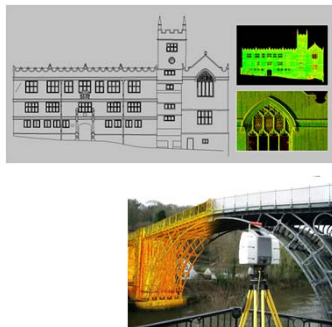


Plate 15.4 Sections of the surveys collected during January and February 2004 (a) illustrate a significant failure from undercut cliff material. An additional, smaller failure was revealed (b) through high-resolution differencing analysis (c). The LSS approach therefore indicates that the larger loss failed through a tangential sliding mechanism, repeating the adjacent cliff face below in the process.

## OTHER APPLICATIONS

- Architectural
- Pipe-networks
- Animation industry
- Crime-scene/accident inventory
- Archeology
- Heritage Scanning
- Civil Infrastructure



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## FUNDAMENTAL CHANGE IN PROBLEM

- From an era of being fundamentally data poor to being data rich
- Too much data can be just as bad as the real world...

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## SOME WEBSITES...

### Groups:

- ISPRS: [http://www.isprs.org/technical\\_commissions/wgic\\_5.aspx](http://www.isprs.org/technical_commissions/wgic_5.aspx)
- Laser Scanning Forum: <http://www.laserscanning.org.uk/>

### Projects:

- Rees Scan: <http://www.reesscan.org>
- Guang Zheng's Forestry Research: <http://staff.washington.edu/guangz/Forest%20inventory%20characterization%20from%20GDL.htm>

### Manufacturers

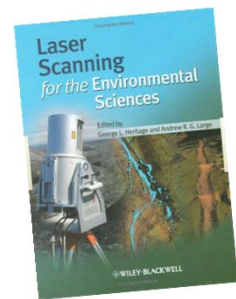
- Leica: <http://hds.leica-geosystems.com>
- Riegl: <http://www.riegl.com/>
- Trimble: <http://www.trimble.com/trimblegx.shtml>
- Optech: <http://www.optech.ca/i3dhome.htm>



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## GOOD BOOK ON TLS

- Laser Scanning for the Environmental Sciences
- Most of text online:
  - <http://www3.interscience.wiley.com/cgi-bin/bookhome/122380460>



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