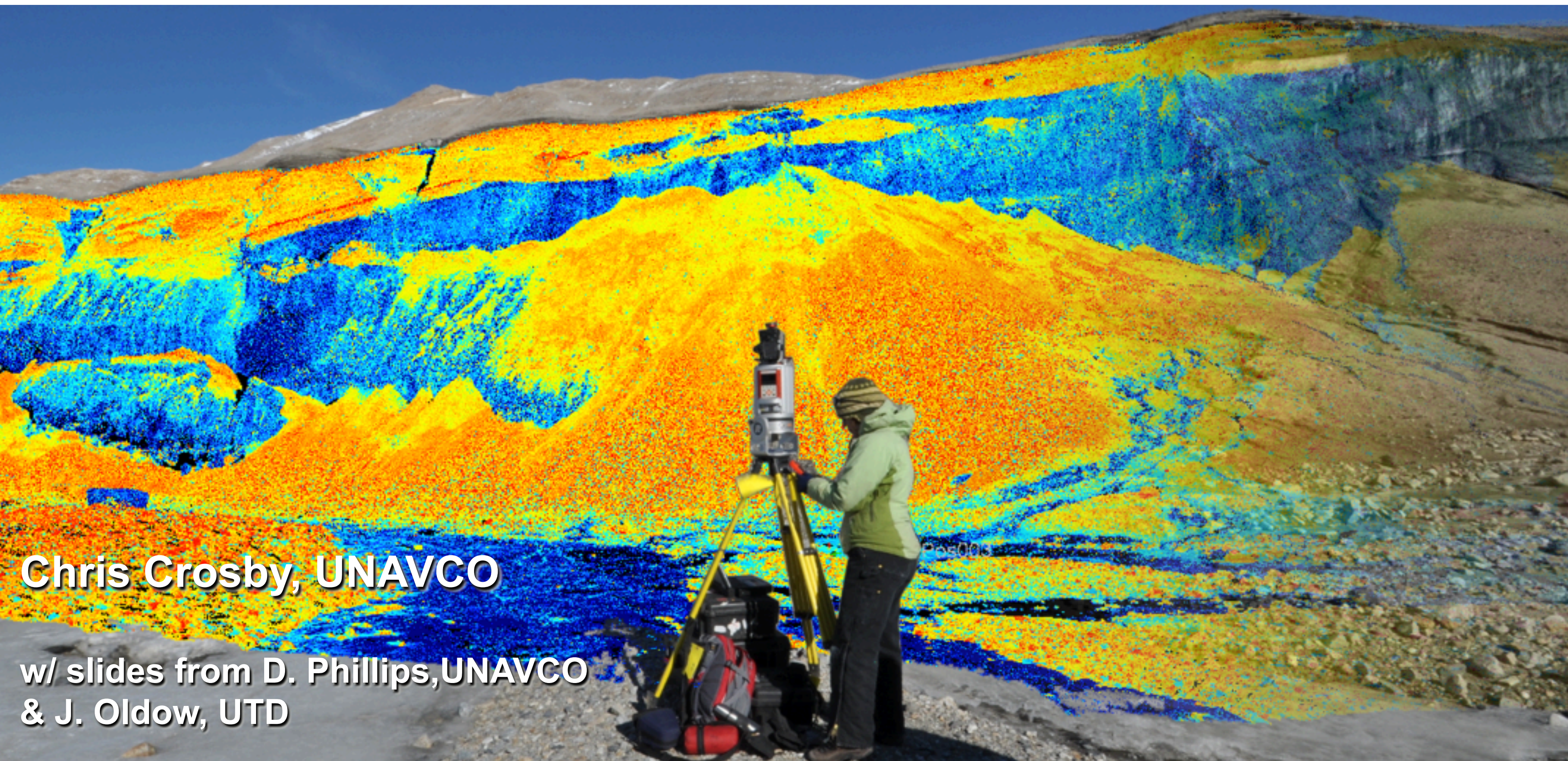
Terrestrial Laser Scanning Principles



Chris Crosby, UNAVCO

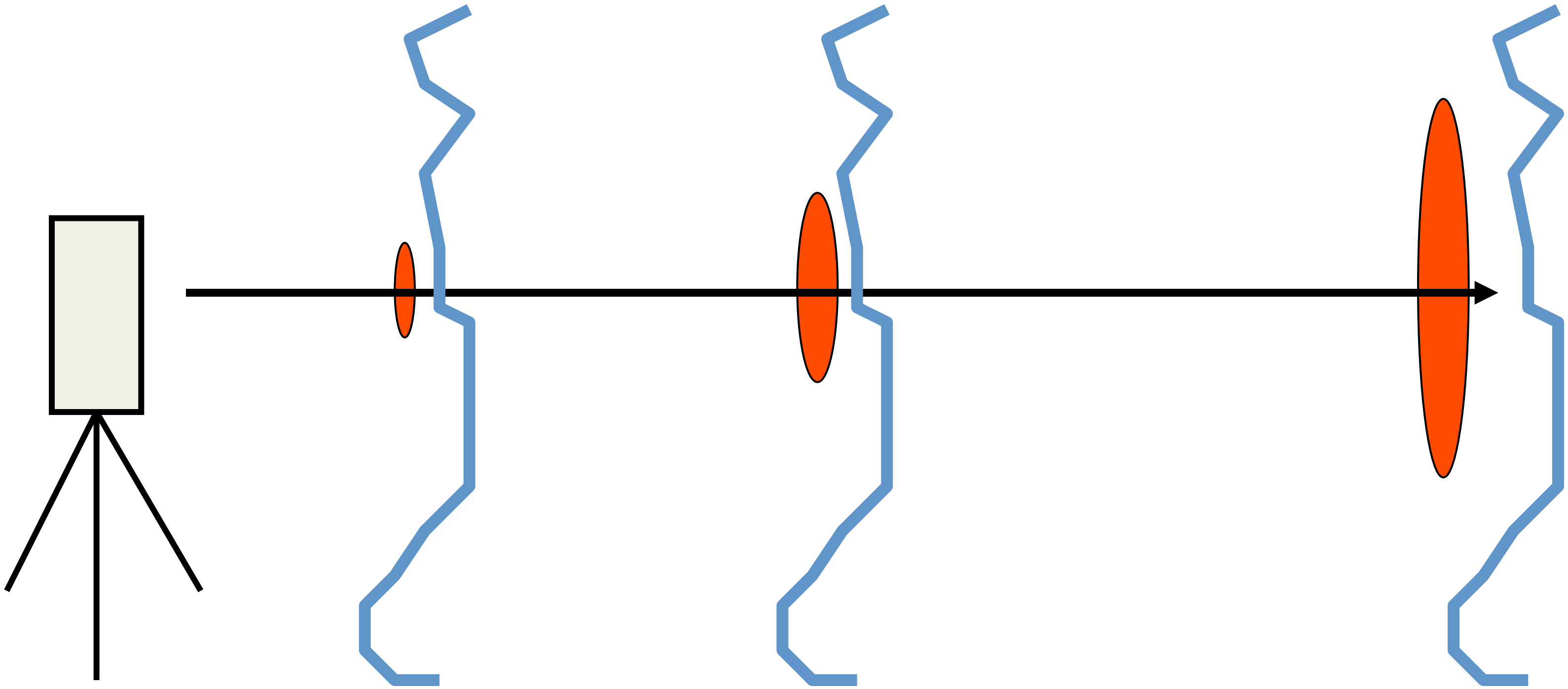
w/ slides from D. Phillips,UNAVCO
& J. Oldow, UTD

TLS Instrument and Survey Parameters

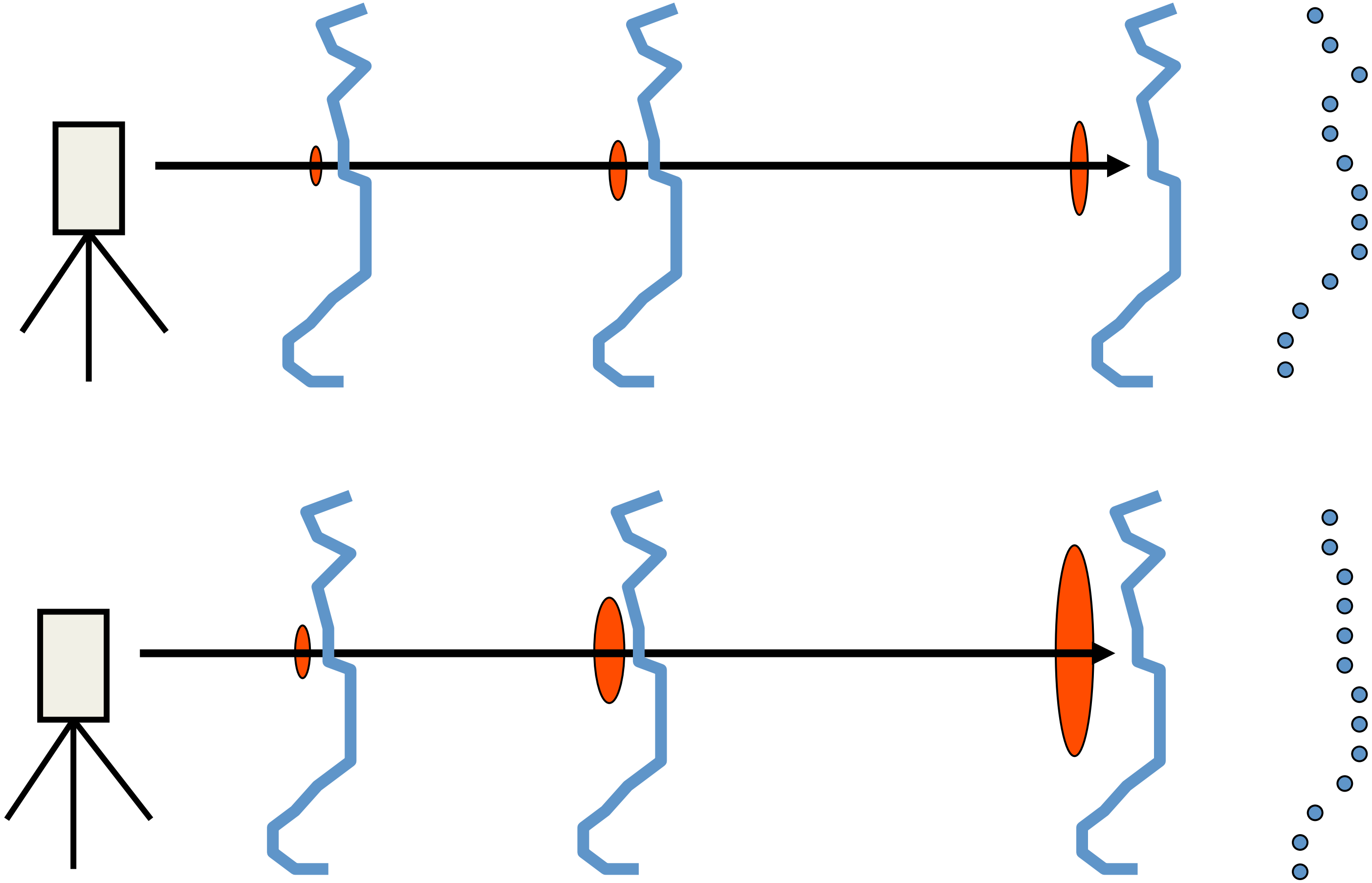
- Spot size (range, divergence)
- Spot spacing (range, angular resolution)
- Spot density (range, angle, number of setups)
- Angle of incidence (spot shape, intensity, range)
- Edge effects
- First return, last return, “other”
- Shadows
- Scan object characteristics (albedo, color, texture)
- Field of View
- Points Per Second

Beam Divergence

Df = (Divergence * d) + Di

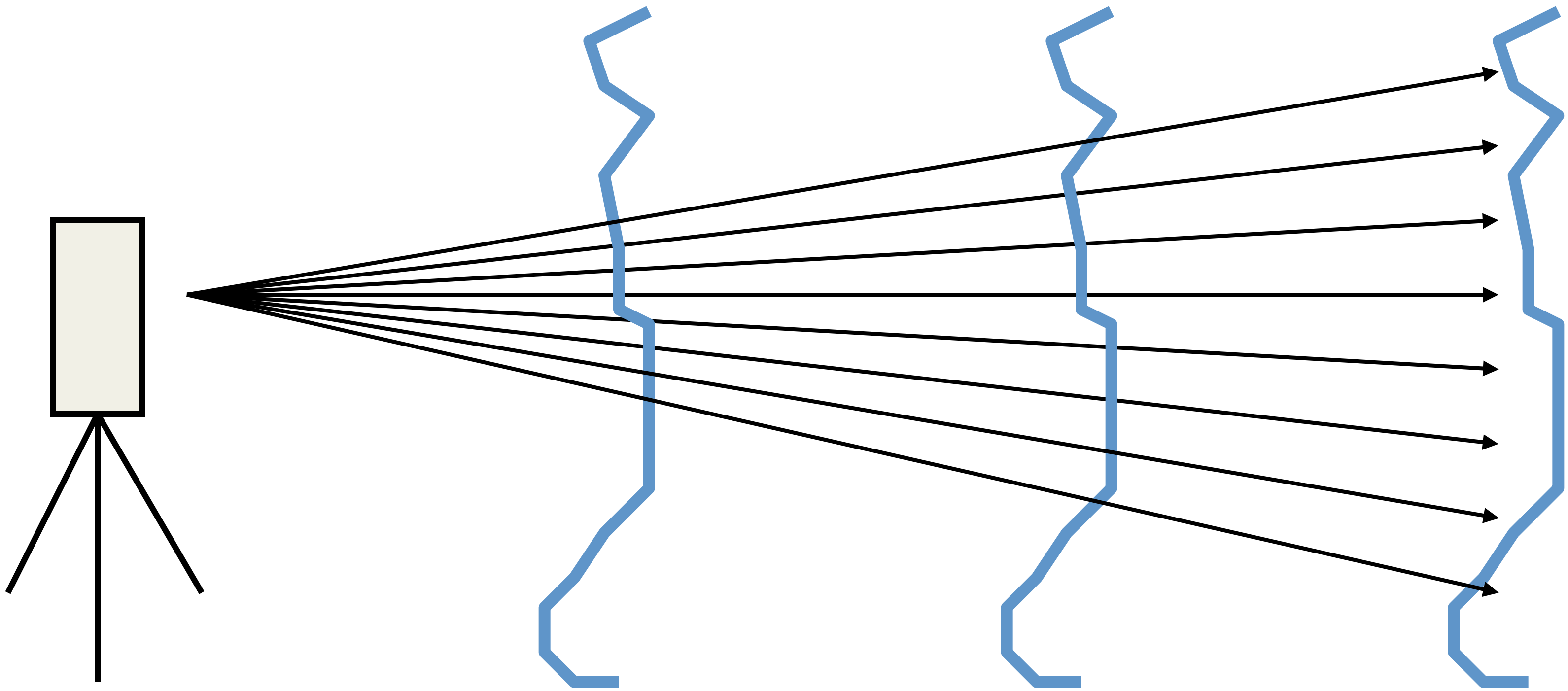


Beam Divergence

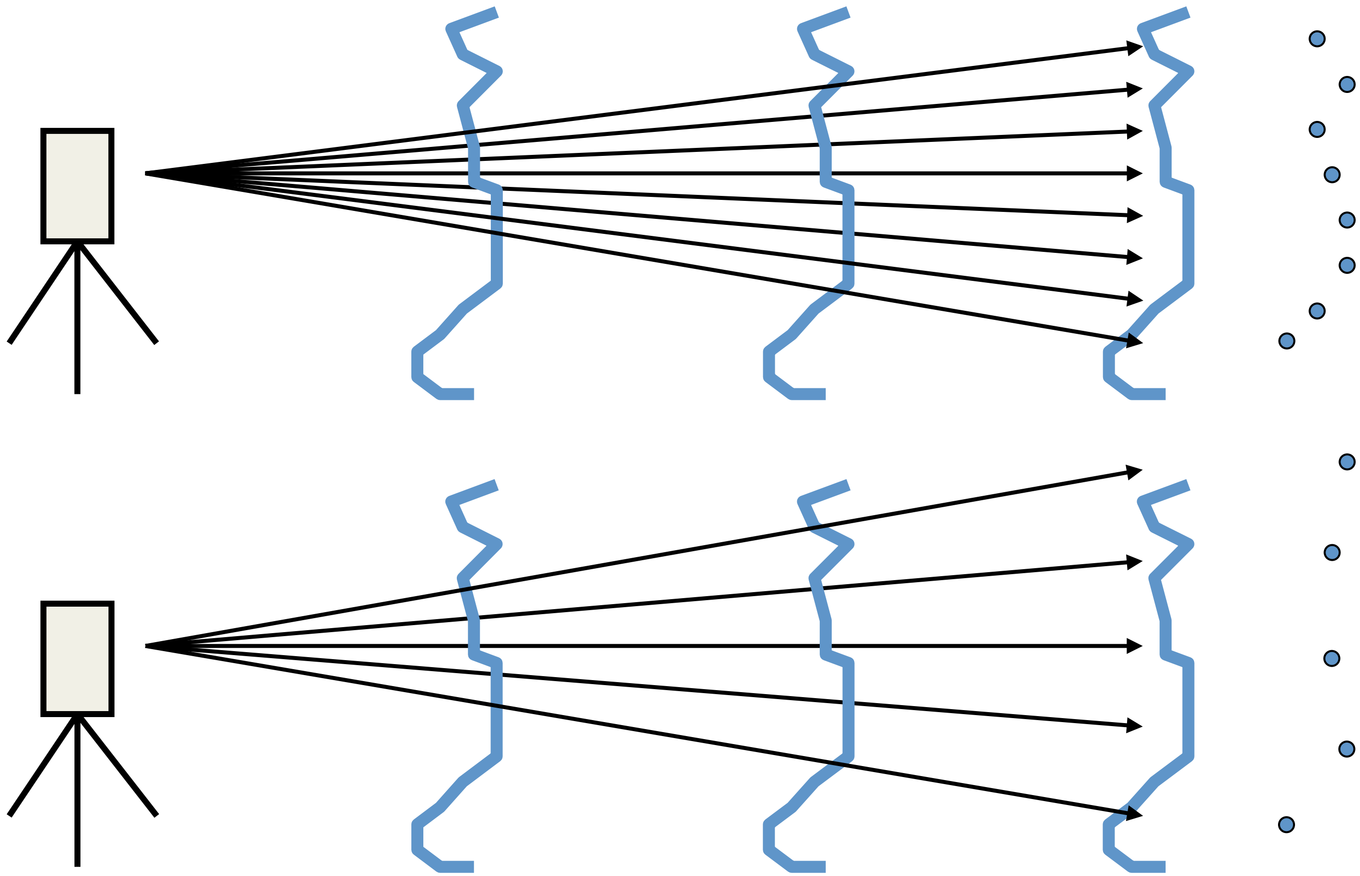


Angular Step

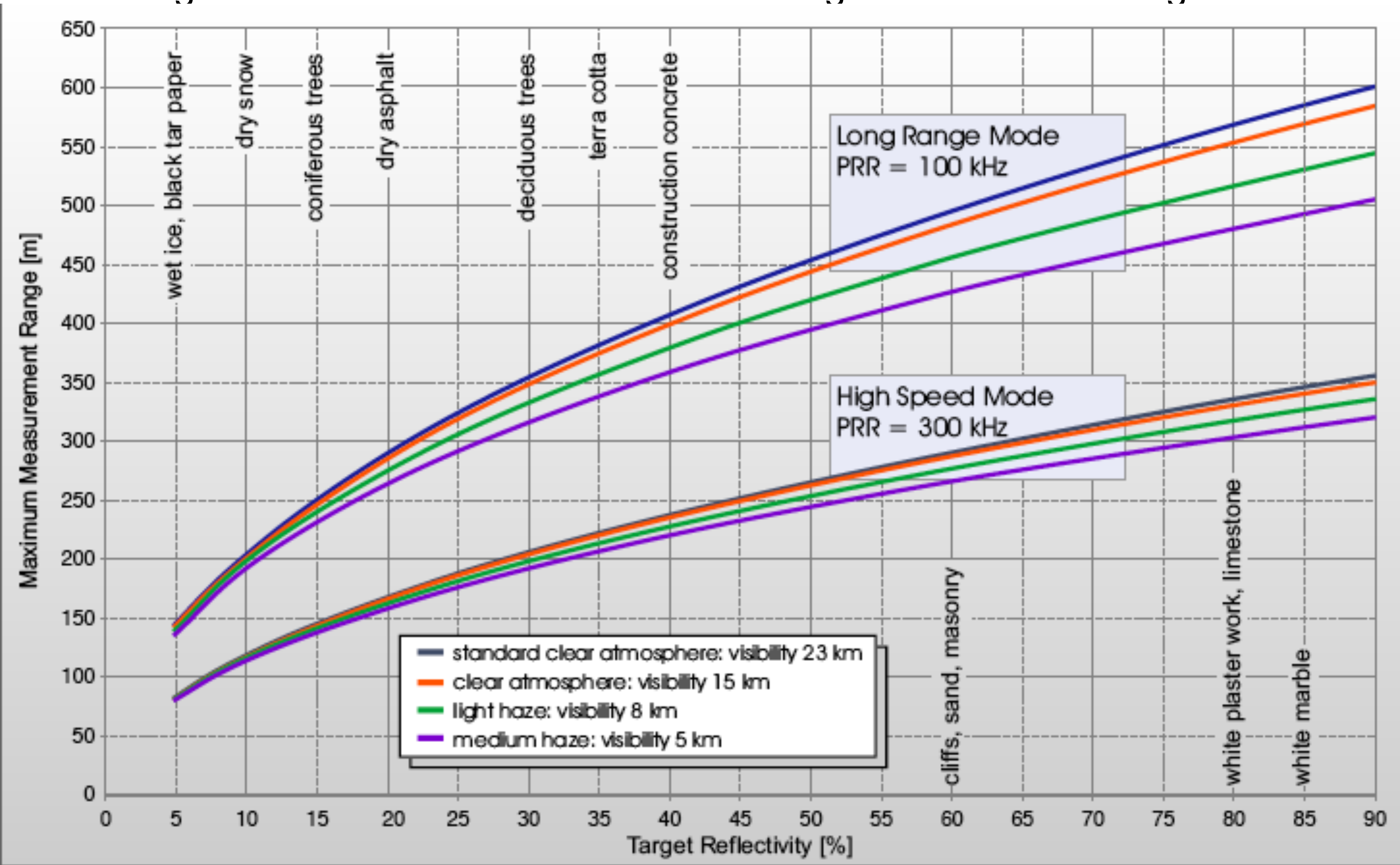
Spacing = d(m)*TAN(step)

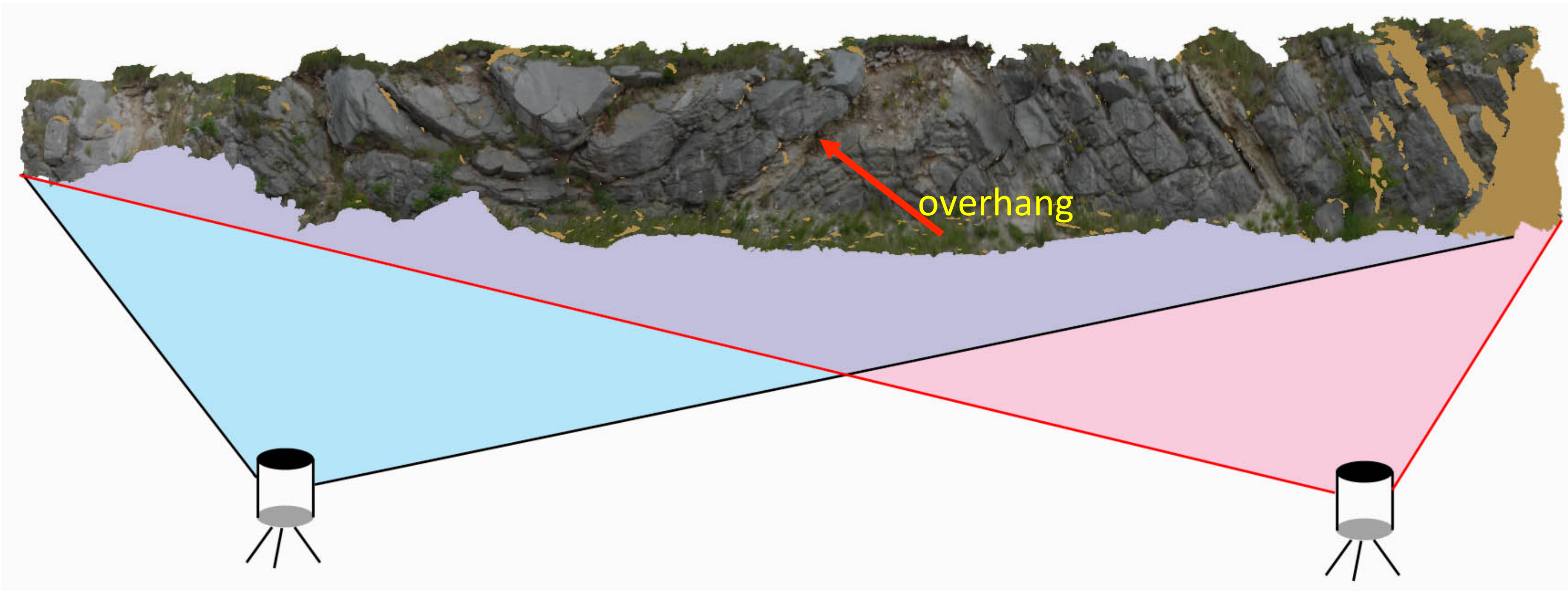


Angular Step



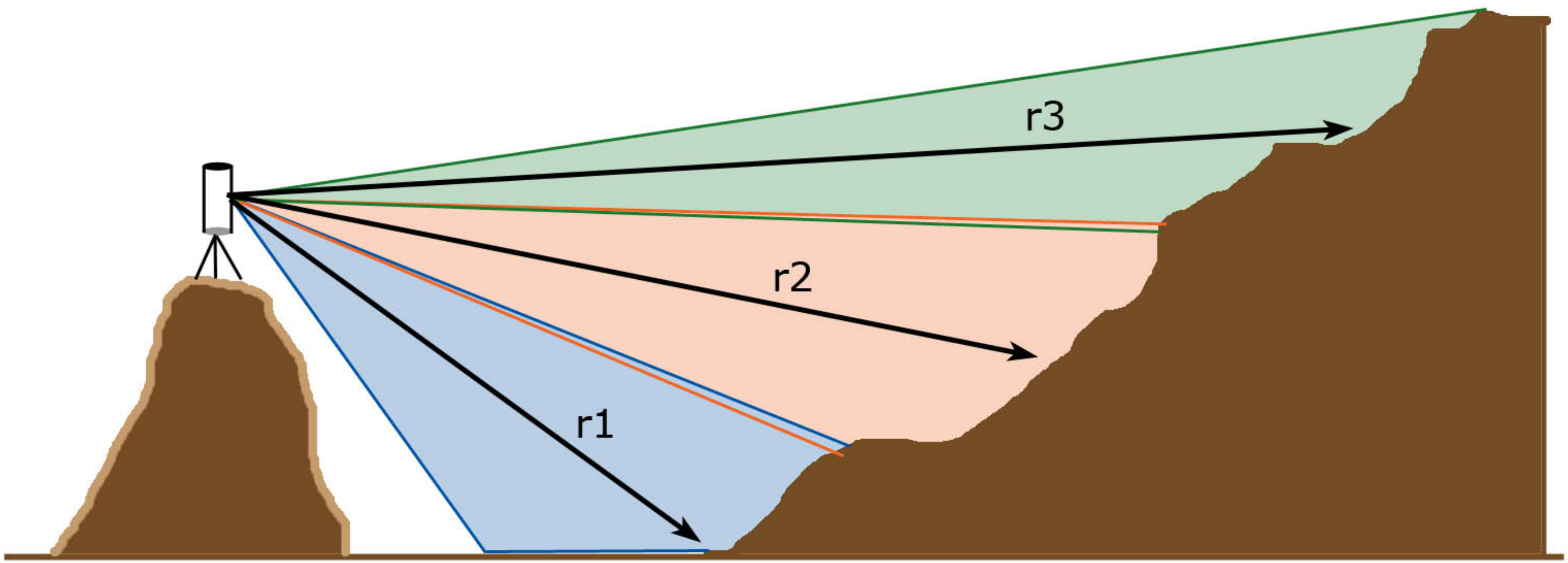
- Riegl VZ400 Maximum measurement range as function of target material





Scan Positions

Choose scan positions to minimize occluded (shadowed or hidden) geometries.



r1 = 280m   r2 = 400m   r3 = 550m

Shot Spacing / Sample Density

- Shot spacing varies as a function of range to target.
- Choose angular scan resolution to optimize sample density.

Standard tie point workflow (e.g., Riegl RiScan Pro)

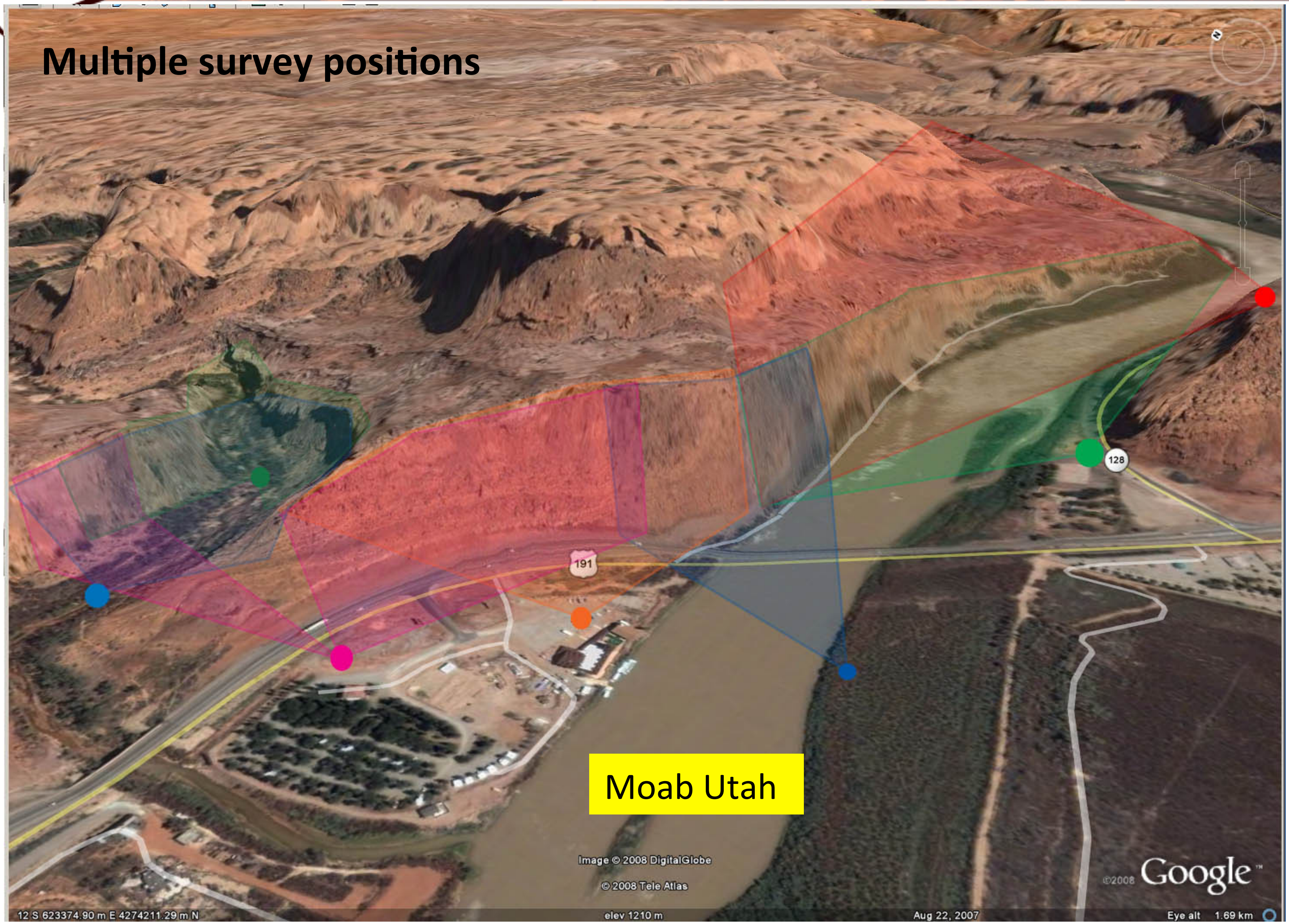
- Use at least 5 reference targets to register scan positions (the more the better).
- Same targets must be common between scan positions.
- The more targets common to all scan positions, the better

In the field

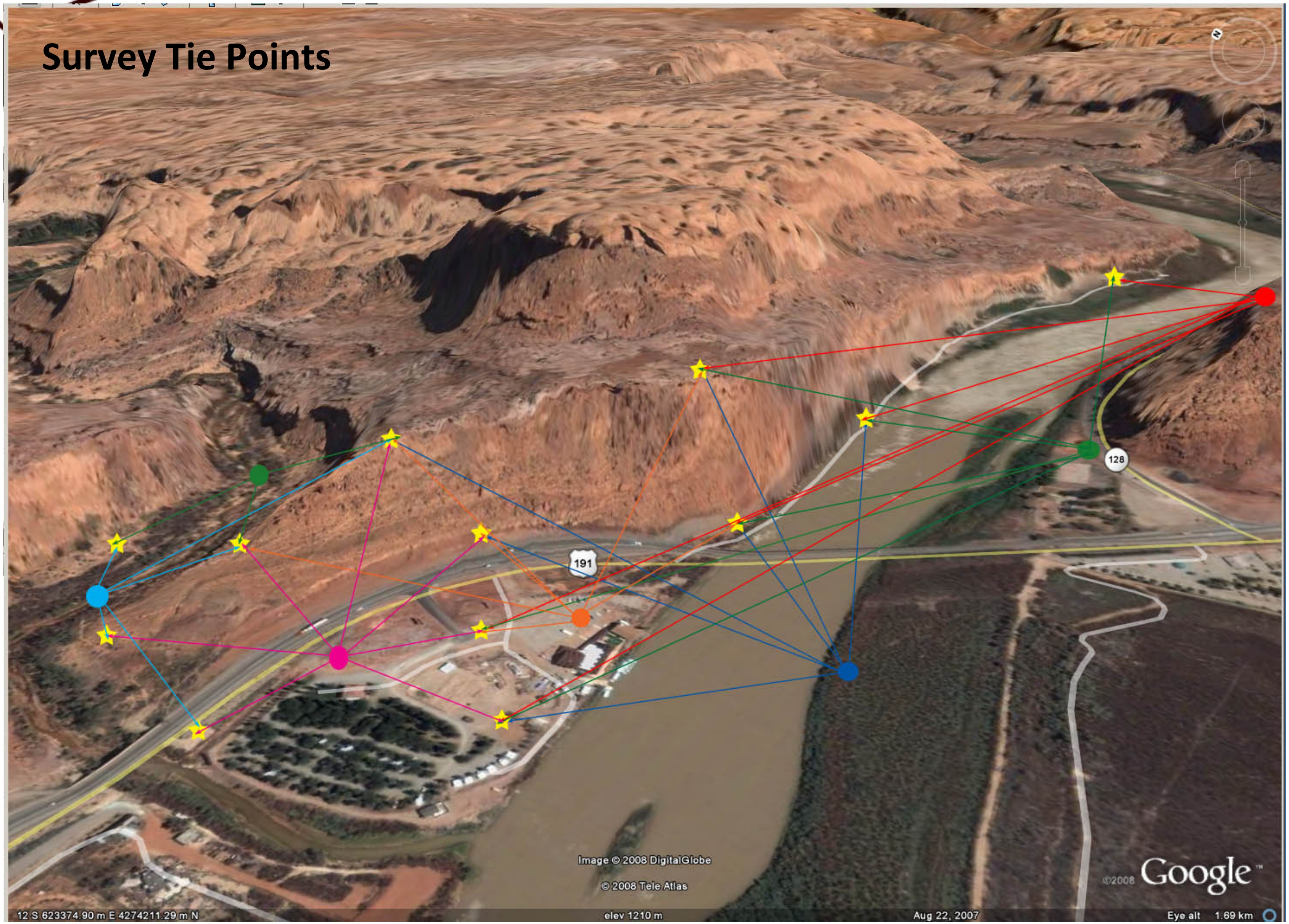
- Determine scan locations, target locations and GPS locations.
- Set up targets and GPS.
- Scan position 1
  - 360-deg "panorama" scan + Image acquisition if desired.
  - Target fine scan.
  - Area of interest scan + Image acquisition if desired.
- Scan positions 2 +
  - Same as above but then find corresponding points and co-register scan positions.

TLS Instrument and Survey Parameters

Moab, Utah survey site


Multiple survey positions
191
128
Moab Utah
Image © 2008 DigitalGlobe
© 2008 Tele Atlas
©2008 Google
12 S 623374.90 m E 4274211.29 m N
elev 1210 m
Aug 22, 2007
Eye alt 1.69 km

TLS Instrument and Survey Parameters



Remember…

- **Resolution vs. Areal Coverage**...only so much time available! Let the science be your guide.
- **In general, a greater number of short range setups is preferable to a few number of long range setups.** This may be limited by access constraints.
- **Scan from “strong” angles, minimize LiDAR “shadows”.**
- **Longer range shots = larger spot size, less angular resolution, less intense return.**
- **Scan with a spot spacing at least 1/10 the wavelength you want to characterize.**
- **Atmospheric affects**
  - Rain, fog, wet surfaces are major problems.
  - Don’t shoot into the sun.
  - Don’t let machine overheat.
- **Treat the equipment gently...it’s finely calibrated and EXPENSIVE!**
- **The data are only as good as your setup!!!**

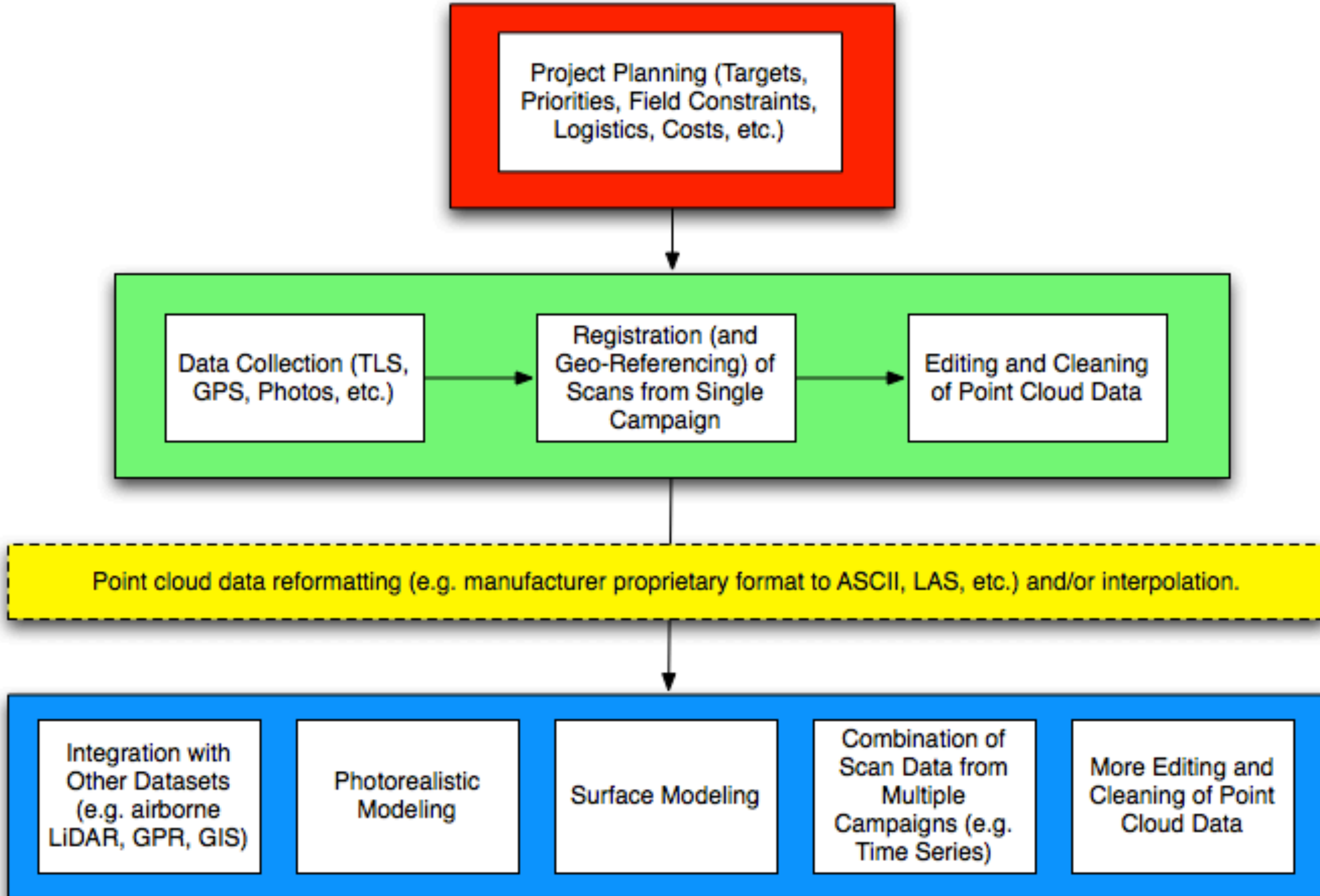
Data volume can be a problem:

- Technology outpaces most software for data processing & management.

- *Just because you can, doesn't mean you should*

- Science application should define data collection.

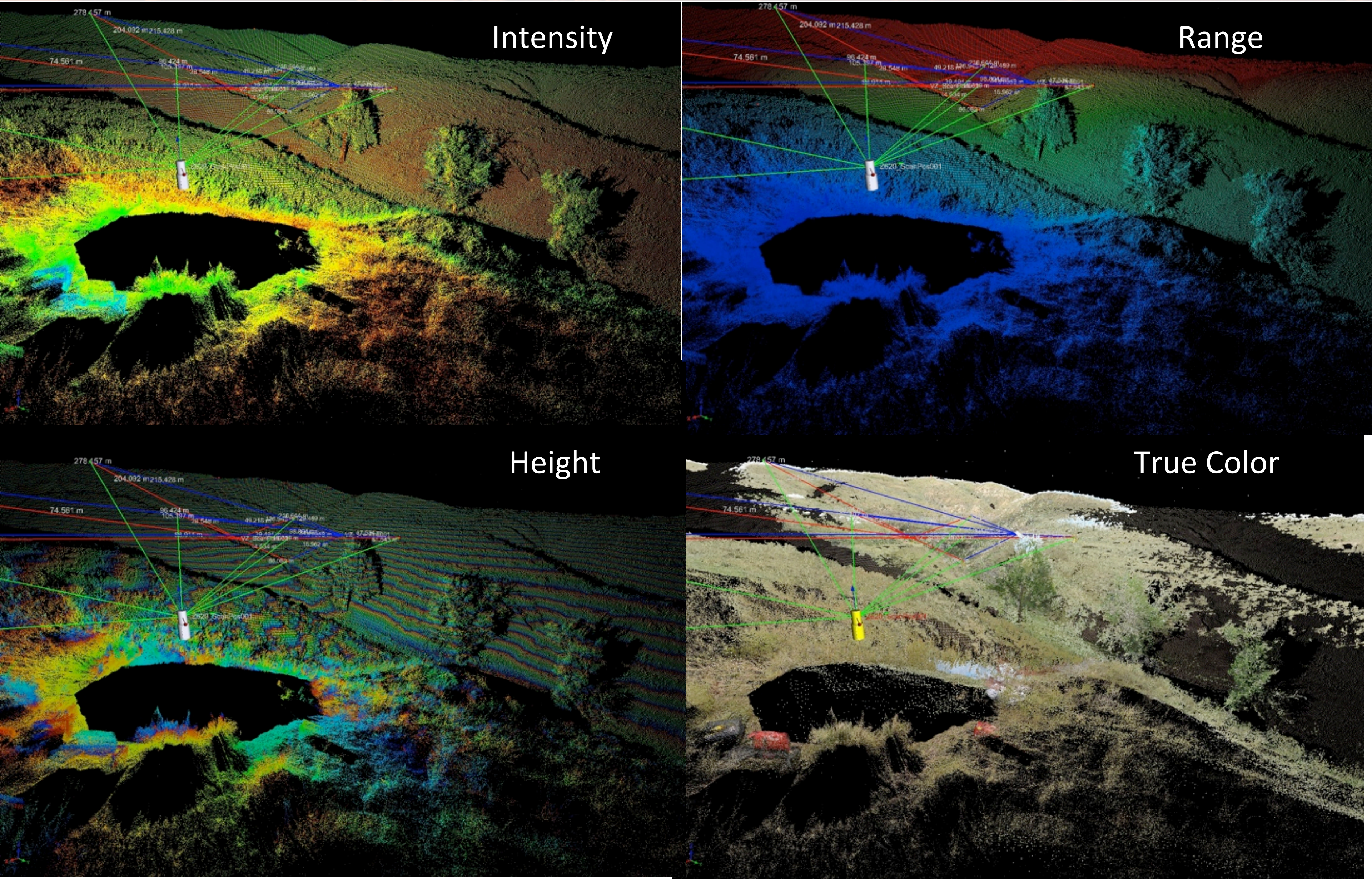
TLS Workflow Overview



Point Cloud

- 3D "point cloud" of discrete locations derived from range and orientation of scanner for each laser pulse.
- XYZ position in cartesian coordinates plus associated point attributes: intensity, RGB, etc.
- 3D point clouds are the basis for subsequent analysis and used to create CAD or GIS models
- UNAVCO ***standard deliverable*** = merged, aligned, georeferenced point cloud in ASCII or LAS format.

TLS Data

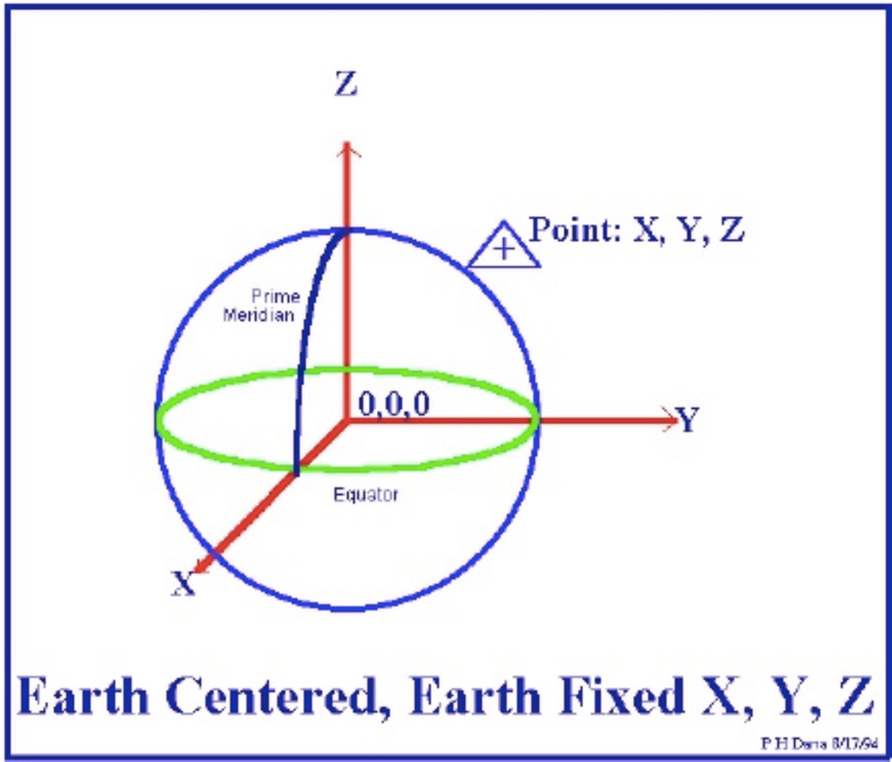


A note on coordinate systems:

- Three types of coordinate systems used in TLS:
  - Scanner coordinates (Riegl = “SCS”)
  - Project coordinates (“PRCS”)
  - Global Coordinates (GLCS)
- Remember the scanner thinks only in **angles and distances**
- Initially, all scans are independent w/ measurements relative to position of the scanner.
- Tie points link scans together = project coordinates (PRCS)
- Independent GPS information allows georeferencing of data (GLCS)

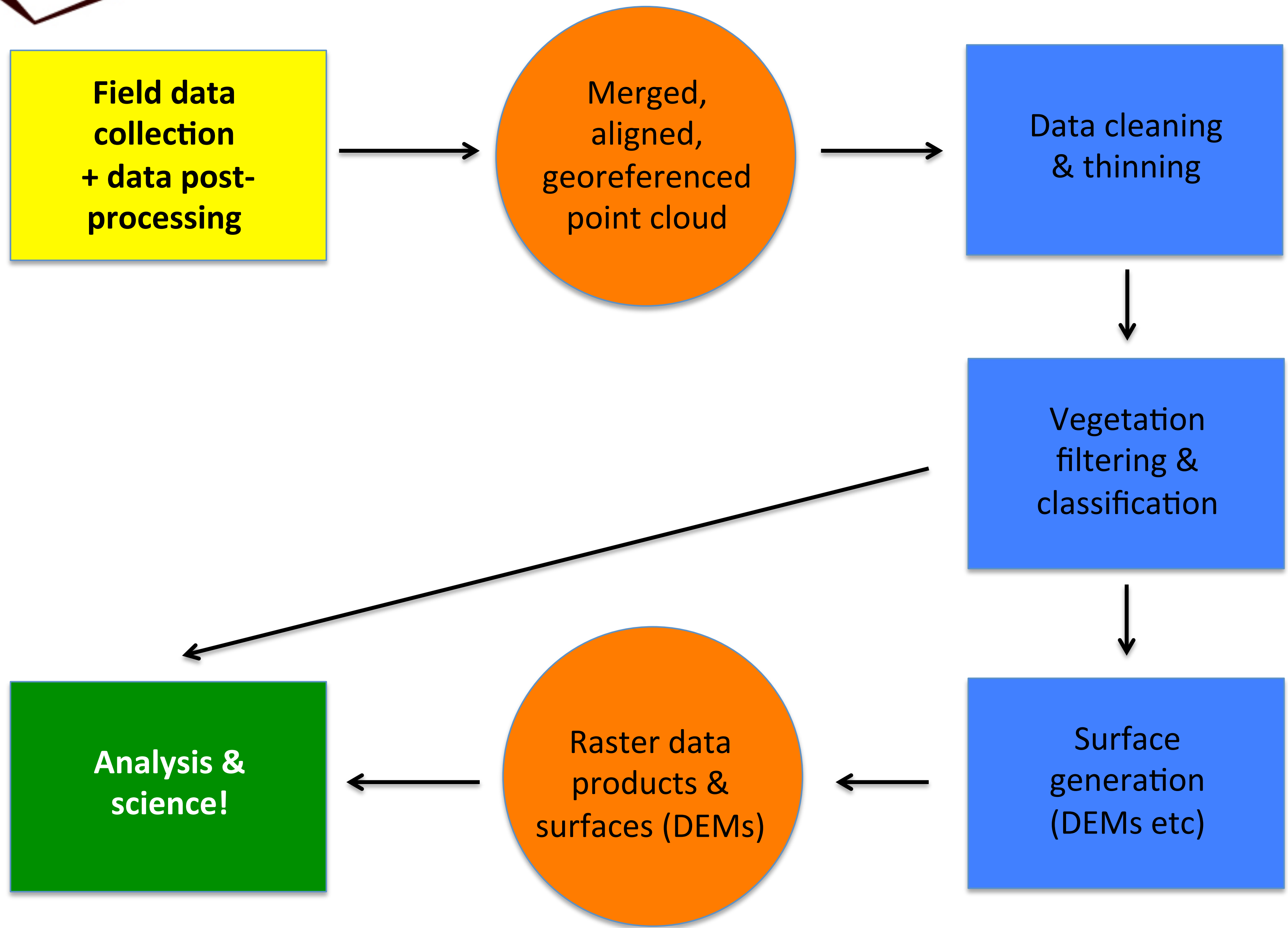
TLS data often delivered in Earth Centered, Earth Fixed coordinates.

- Origin = center of mass of the Earth.
- Three right-handed orthogonal axis X, Y, Z. Units = meters.
- The Z axis coincides with the Earth's rotation axis.
- The (X,Y) plane coincides with the equatorial plane.
- The (X,Z) plane contains the Earth's rotation axis and the prime meridian.



- Preferred by geodesy community
- Not GIS friendly! Requires transformations into 2D cartesian (e.g., UTM).
- Application of data matters
- Beware vertical datums…

TLS Processing Workflow – Overview



Project Planning

- Choose instrument based on capabilities and science/data goals.
- Schedule based on instrument availability, science requirements, environmental factors.
- Use Google Earth, field site photos, etc. to establish preliminary locations for scan positions, control targets, registration targets, etc.

Instrument calibration & data collection

Post-processing & Analysis

- Make a copy of the data collected in the field. Keep the original project(s) in a safe place. Post process using the copy of the project.

Metadata

- Project summary document.
- GPS data (raw files, rinex files, antenna heights, log sheets, etc.).
- Field photos.
- Google Earth files, etc.

Yesterday it worked
Today it is not working
Windows is like that

Out of memory.
We wish to hold the whole sky,
But we never will.

Windows has crashed.
I am the Blue Screen of Death.
No one hears your screams.

A crash reduces
your expensive computer
to a simple stone.

Serious error.
All data have disappeared
Screen. Mind. Both are blank.

A file that big?
It might be very useful.
But now it is gone.

ABORTED effort:
Close all that you have.
You ask way too much.

To have no errors
Would be life without meaning
No struggle, no joy

Chaos reigns within.
REFLECT, REPENT, REBOOT.
Order shall return.