

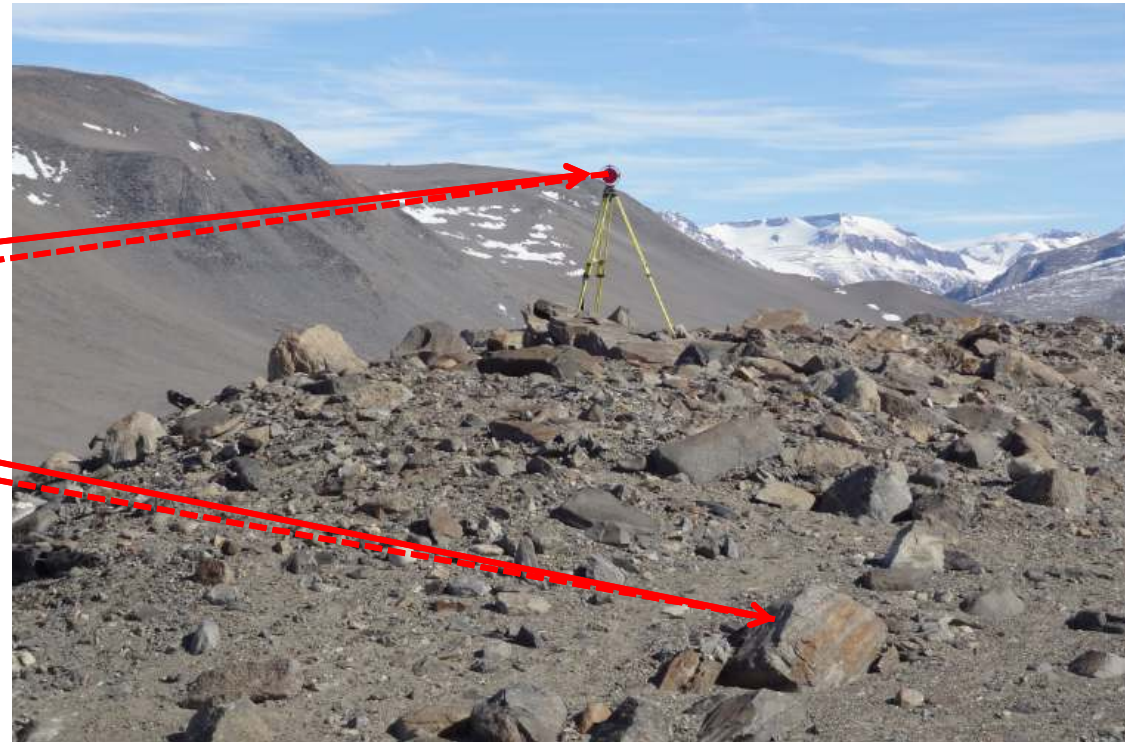
# TLS Parameters, Workflows and Field Methods

Marianne Okal, UNAVCO

June 20<sup>th</sup>, 2014

## How a Lidar instrument works (Recap)

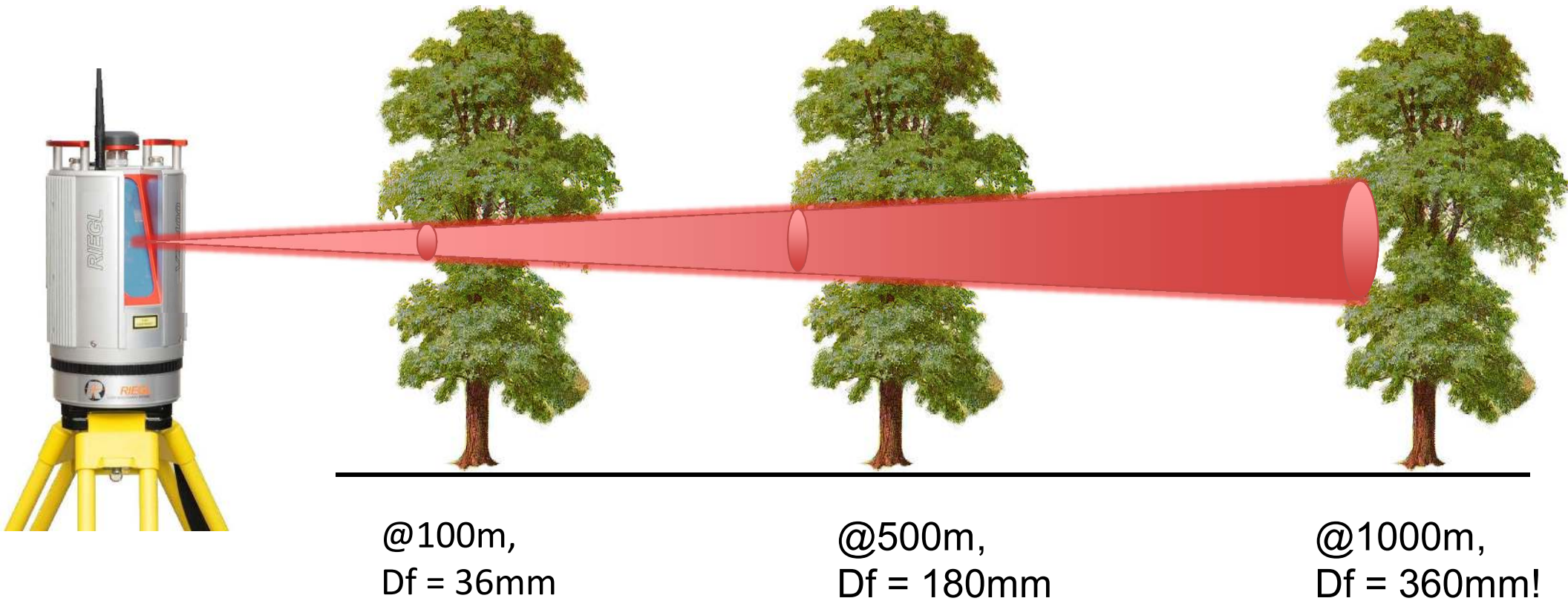
- Transmits laser signals and measures the reflected light to create 3D point clouds.
- Wavelength is usually in the infrared ( $\sim 1550\text{nm}$ ) or green ( $532\text{nm}$ ) spectrum



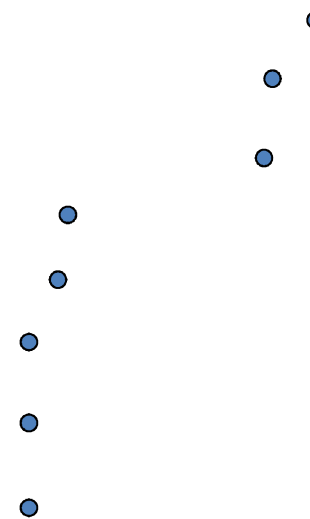
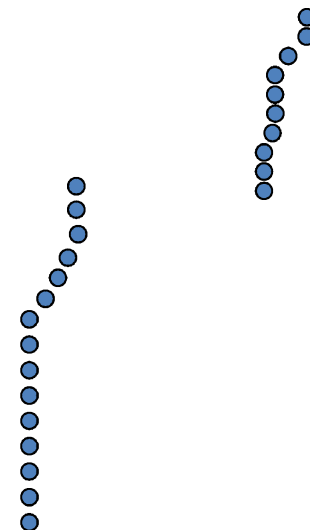
- Spot size (range, divergence)
- Spot spacing (range, angular resolution)
- Spot density (range, angle, number of setups)
- Angle of incidence (spot shape, intensity, range)
- Edge effects
- Registration
- Targets
- First return, last return, “other”
- Shadows, Field of View
- Scan object characteristics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

## Beam Divergence

$$D_f = (\text{Divergence} * d) + D_i$$

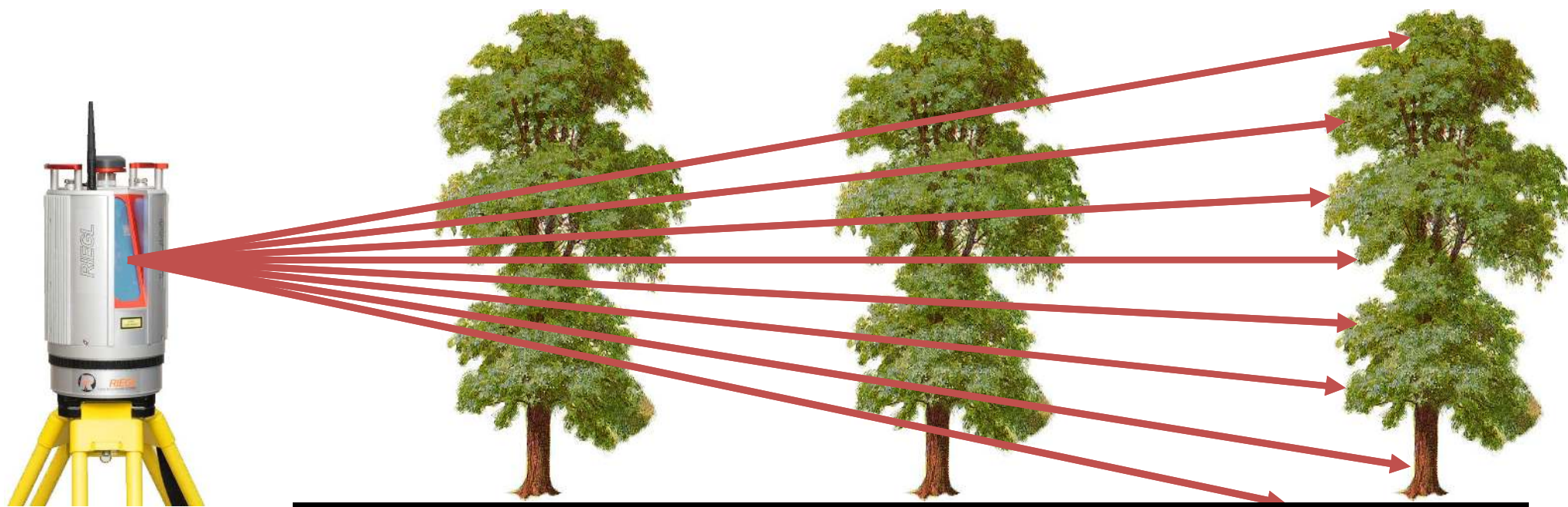


# Beam Divergence

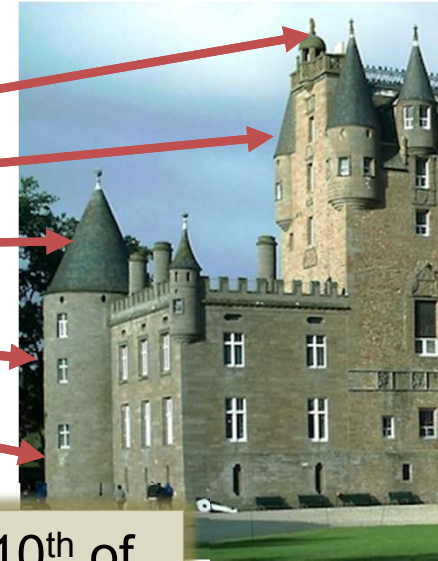


## Angular Step

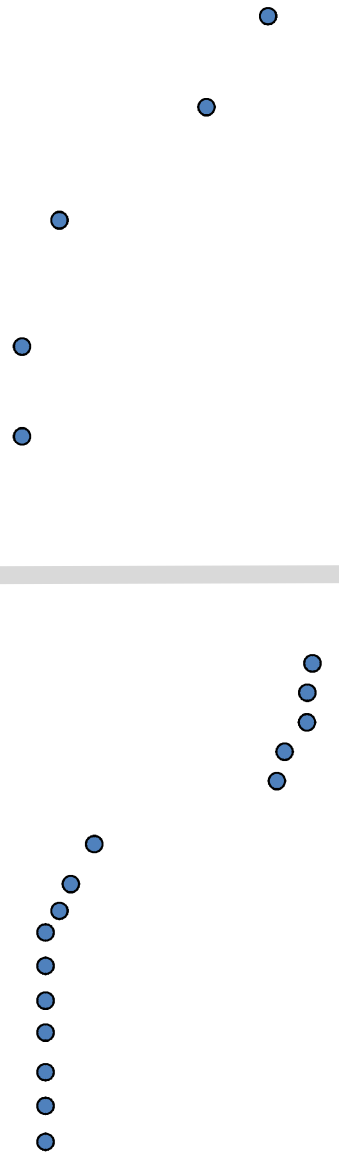
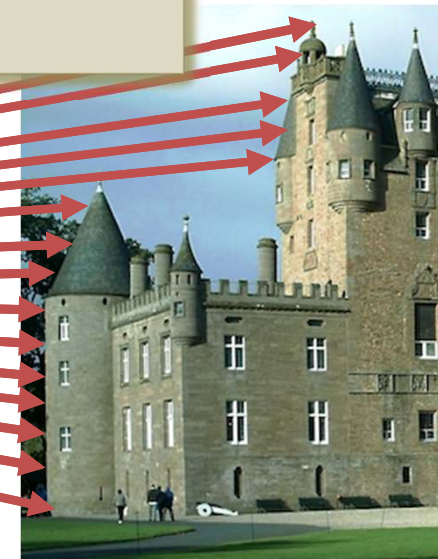
$$\text{Spacing} = d(\text{m}) * \text{TAN}(\text{step})$$

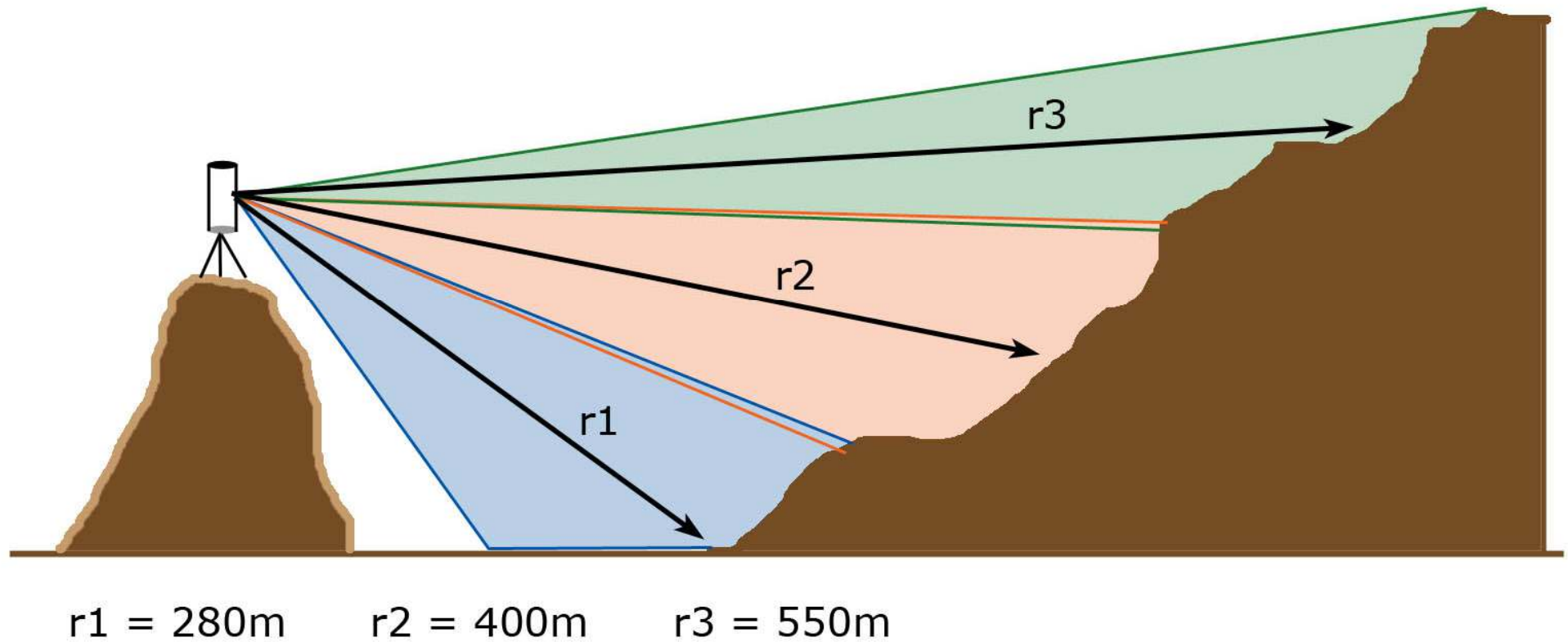


## Angular Step



Rule of thumb: scan at least  $1/10^{\text{th}}$  of the “wavelength” of the object you wish to image.

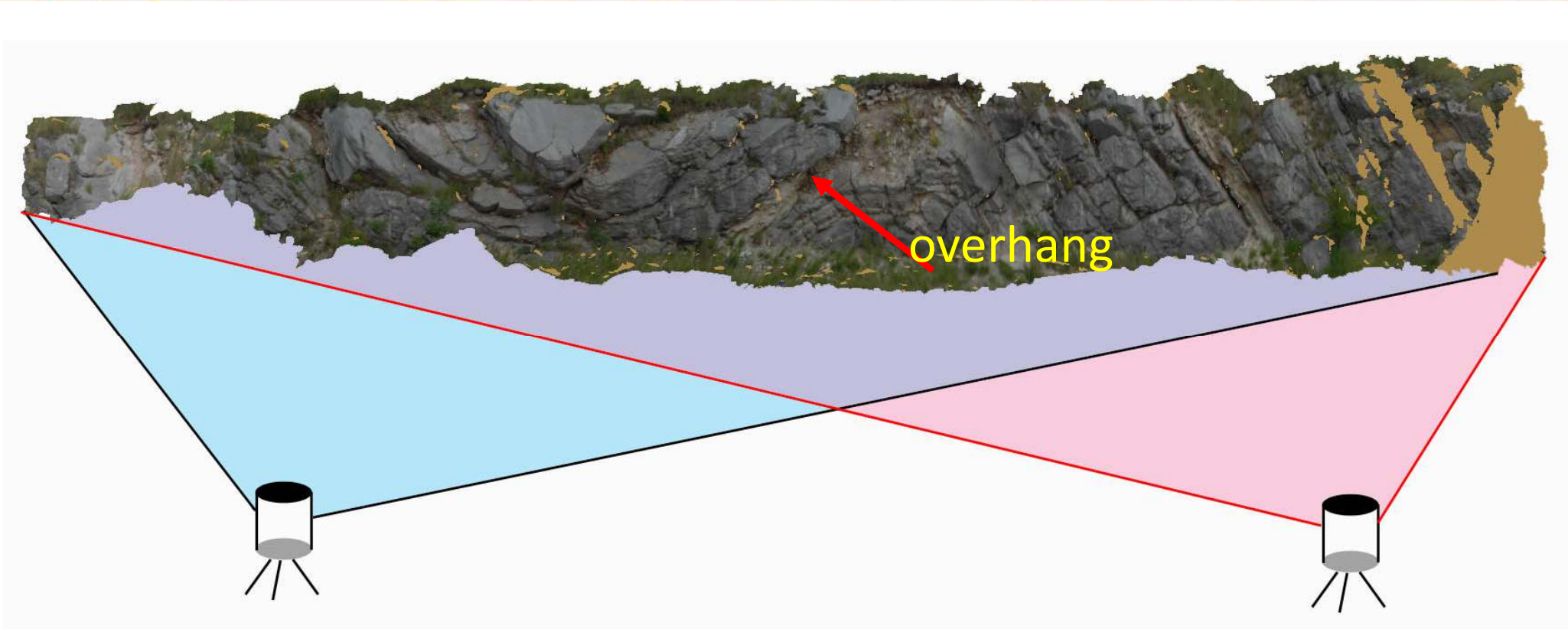




## Shot Spacing / Sample Density

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



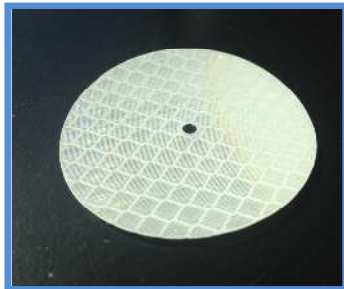


## Scan Positions

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

Targets

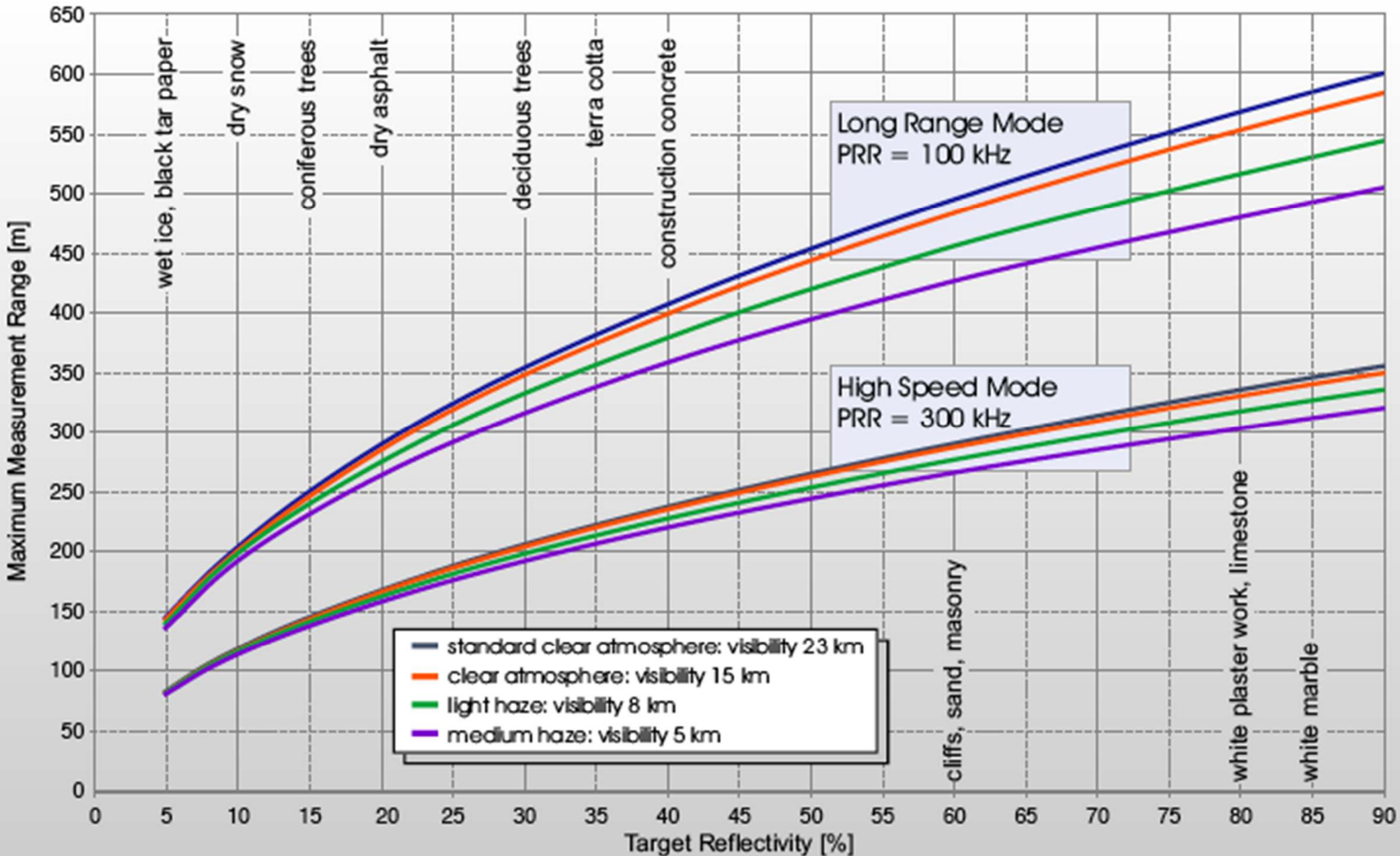
- Reflective objects that serve as reference points for scans.
- Same targets must be common between scan positions.
- Use at least 5 reference targets to register scan positions (the more the better).
- Different shapes and colors serve different functions



(images not to scale)

# TLS Instrument and Survey Parameters

## Riegl VZ400 Maximum measurement range as function of target material



- 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
- Registration
- Targets
- First return, last return, “other”
- Shadows, Field of View
- Scan object characteristics (albedo, color, texture)
- Area of Interest

## 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

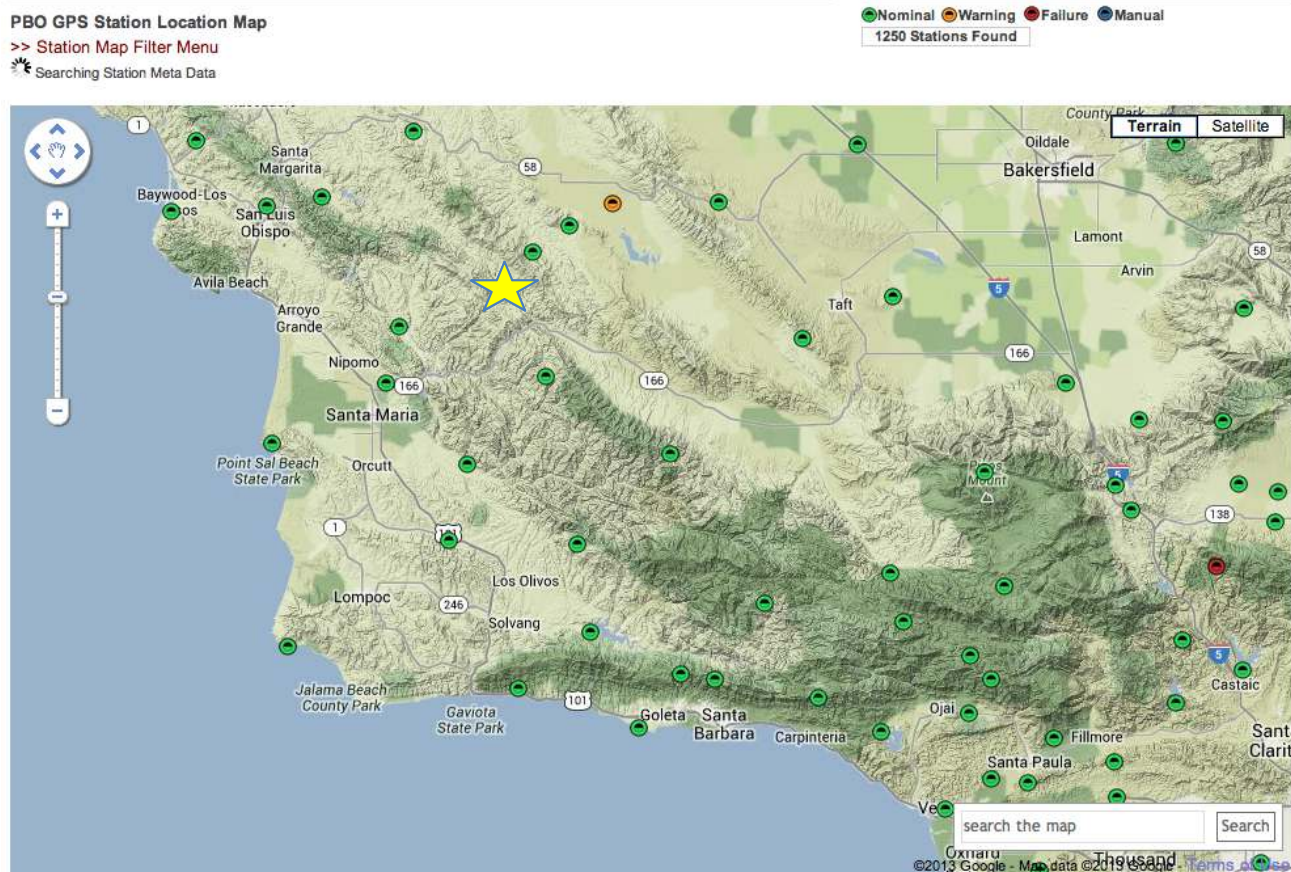
- Make a copy of the data collected in the field. Keep the original project(s) in a safe place. Post process using the copy of the project.

## Metadata

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

## Before heading out into the field

- GPS network – identify base stations, benchmarks and **make sure they are operational!**



- Understand field site, anticipate challenges you may encounter (complex landscape, is power available in evenings, etc.)
- Give equipment a test run.

## At the field site

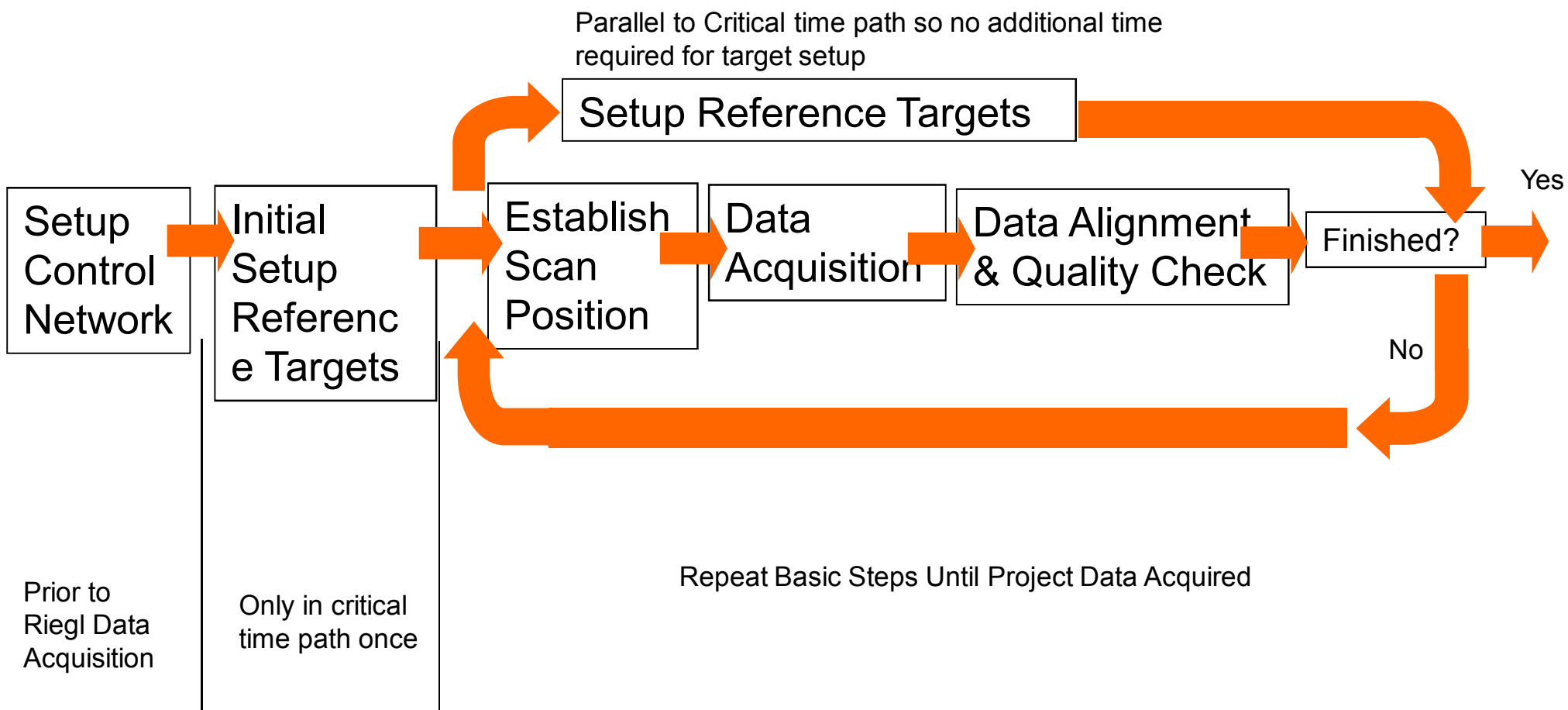
- Take a **walk around the field site** before setting anything up. Identify scan positions, target positions and your GPS base station.
- Set up targets and start GPS data collection. This will take 1-2 hours.

### Only now are you ready to start scanning!

- Scan Position 1
  - 360-deg Panorama scan + Image acquisition if desired.
  - Target finescan
  - Area of interest finescan
- Scan Position 2 and beyond
  - Same as Scan Position 1, but after the target finescan you will find corresponding points with previous scans and co-register scan positions.



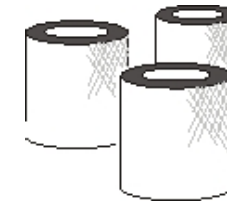
# Riegl System Work Flow Overview





## Checklist:

- Scanner
- Power supply
- Laptop
- Scanner tripod
- Reflector tripods
- Flat and Cylindrical Reflectors
- GPS receivers
- Safety gear
- Permit



**300 lbs!!**



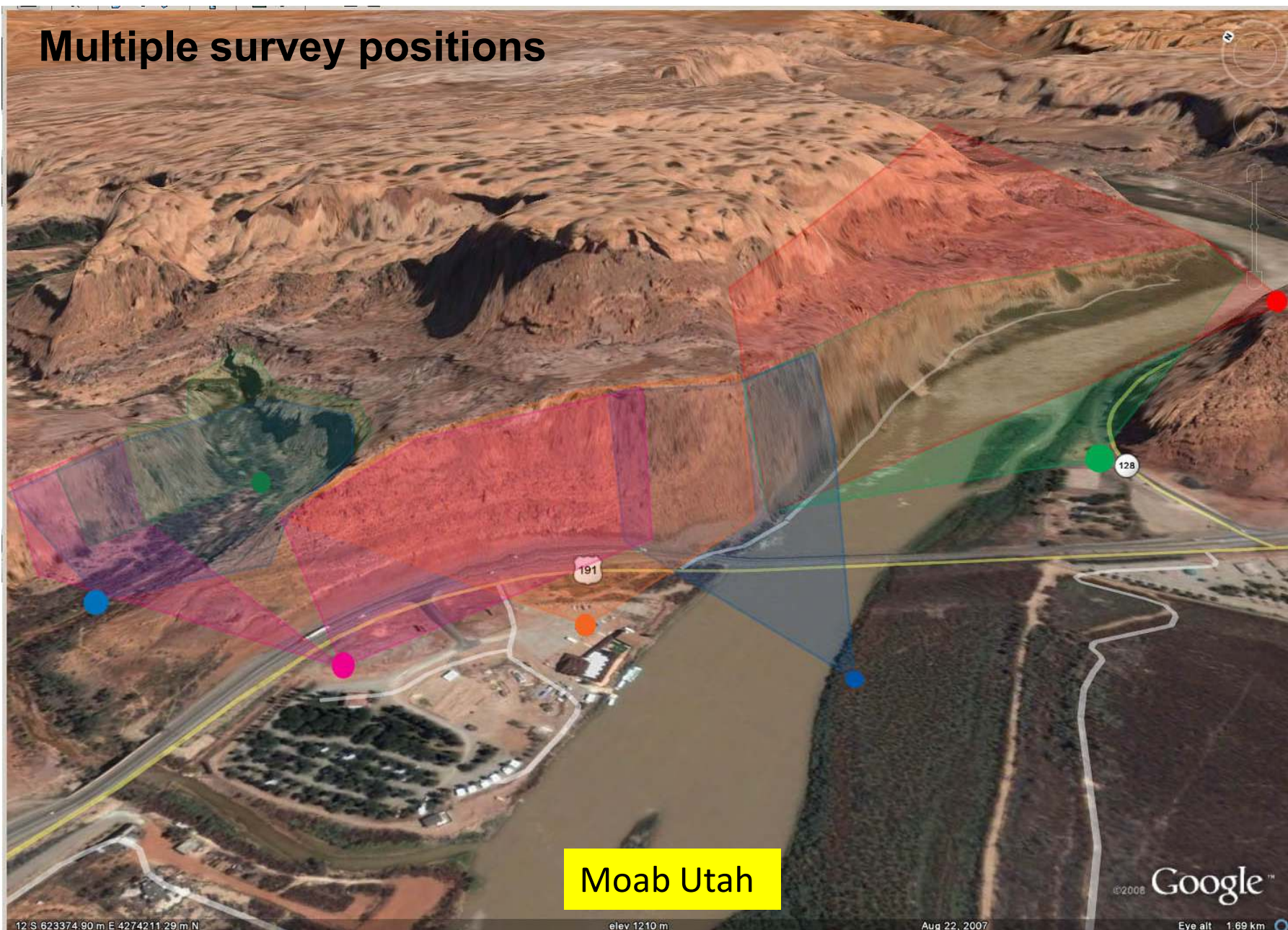
Standard tie point workflow

- Reminders – use at least 5 targets. That is, every scan position should see at least 5 targets, every target should be seen by at least 2 scan positions.
- The more targets common to all scan positions, the better

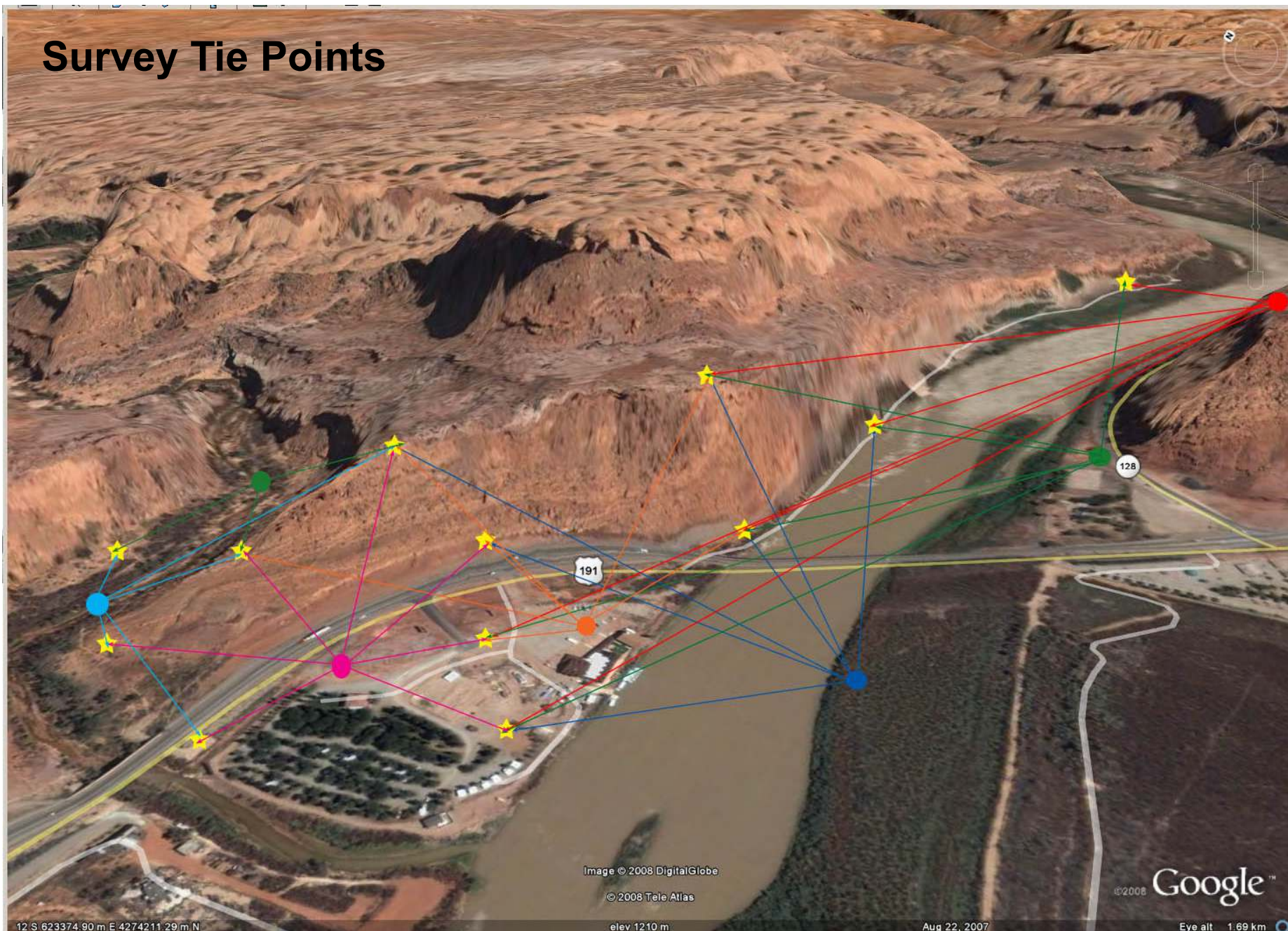




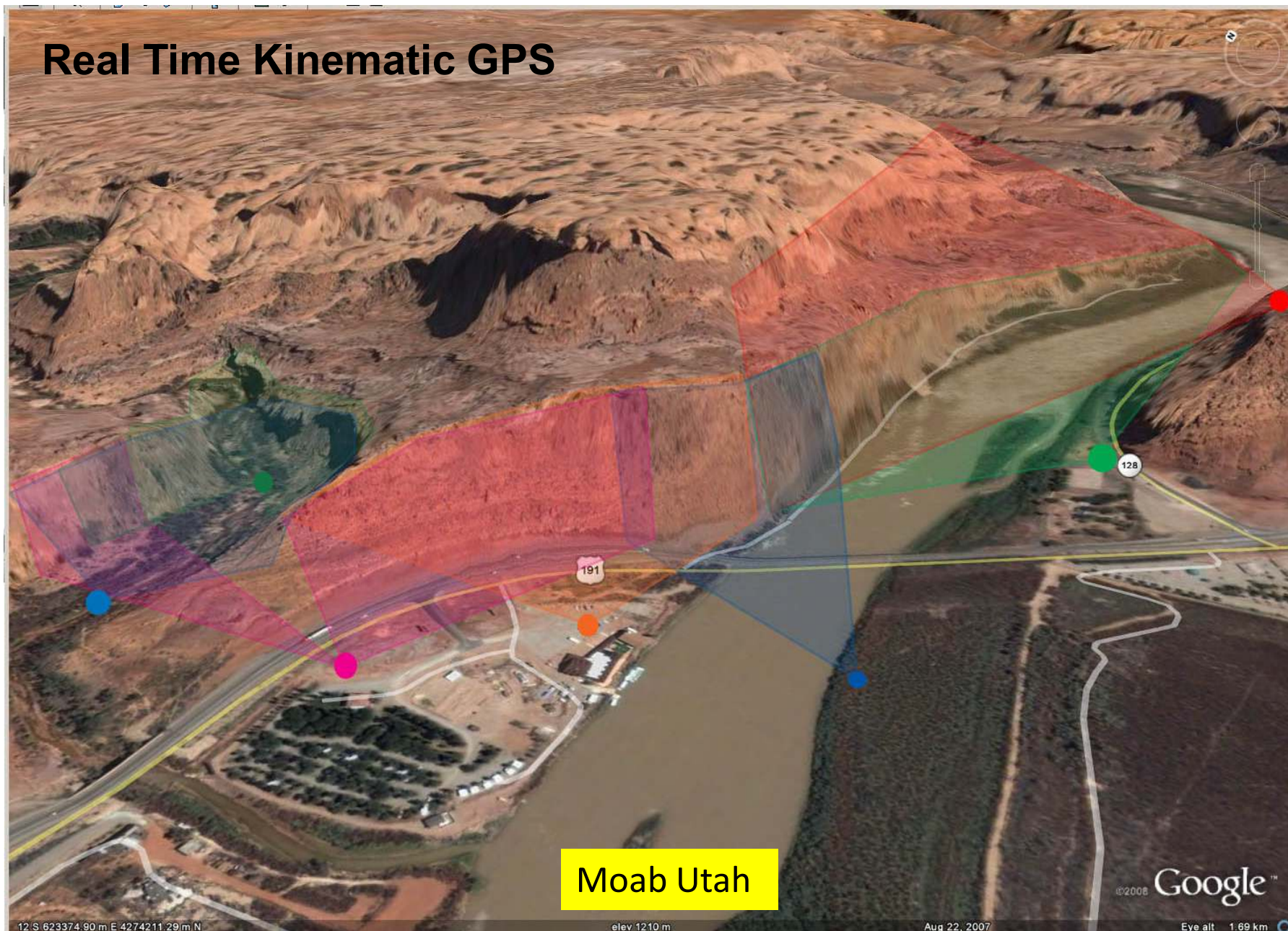
Multiple survey positions



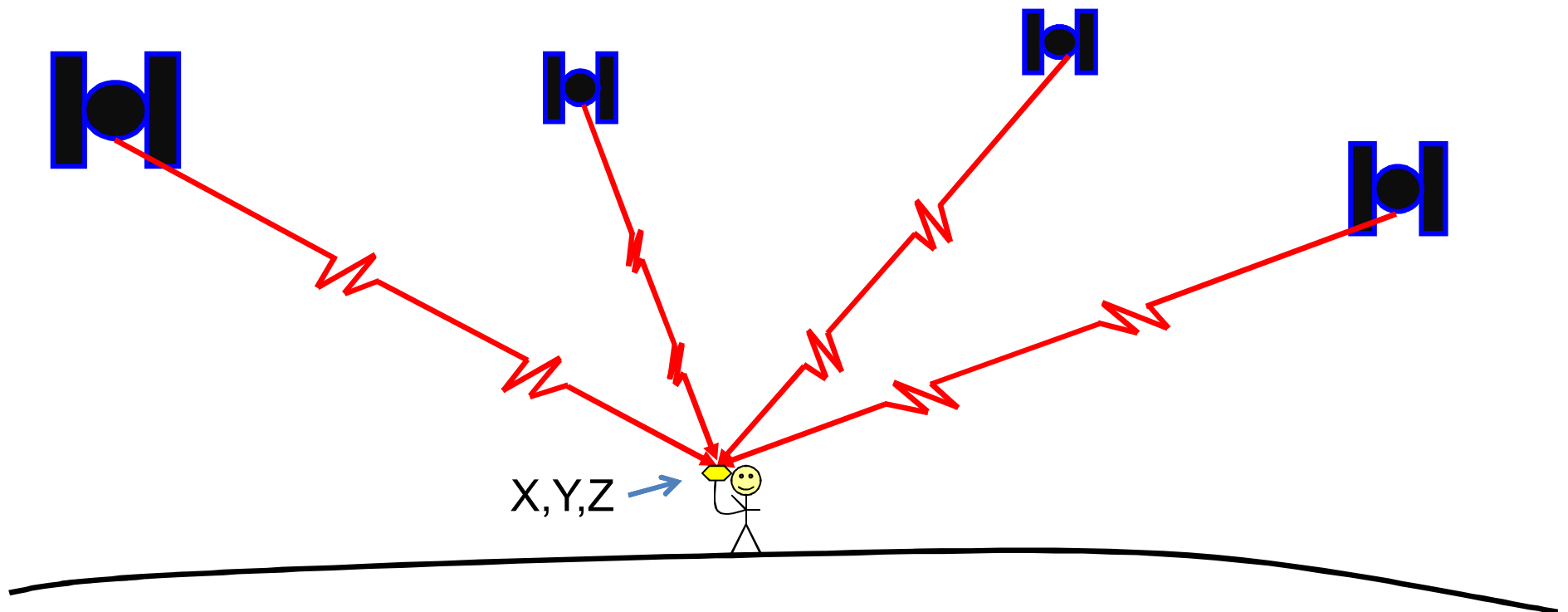
# Survey Tie Points



# Real Time Kinematic GPS



- Constellation of 31 satellites which each house an atomic clock.
- Precise time information is sent to a receiver on earth.
- A minimum of 4 satellites in sky view is needed to obtain a coordinate.

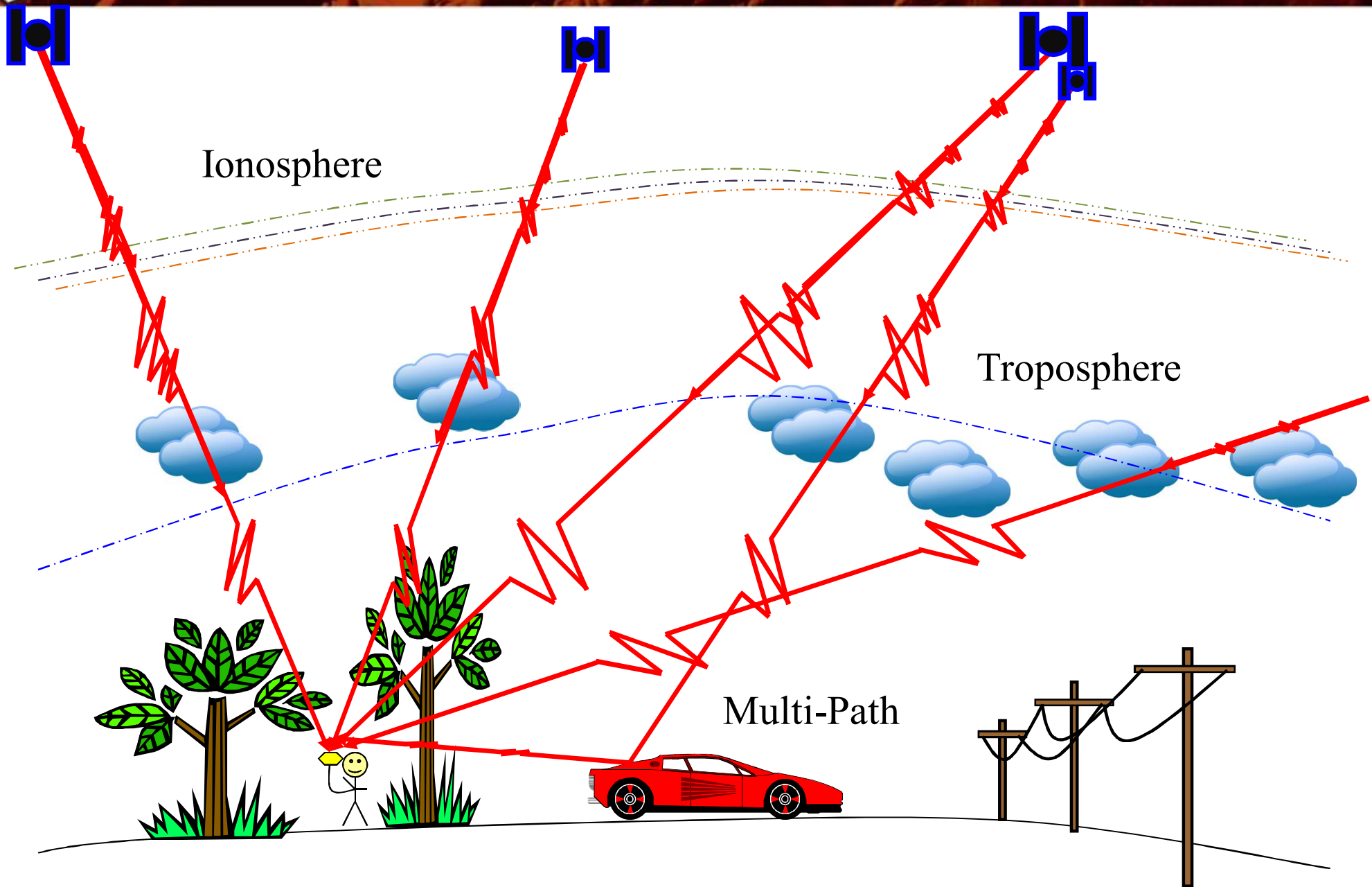




Uses known reference points (base stations) on the Earth to provide corrections for unknown points.



- Advantage is cm to sub-cm precision!
- Base station and unknown points must share same occupation time
- Base stations and unknown points must “see” same errors (same sky view). Practical limit is 100km.
- Vertical precision will always be ~2x less precise than horizontal precision.





### Traditional Tie Point Survey

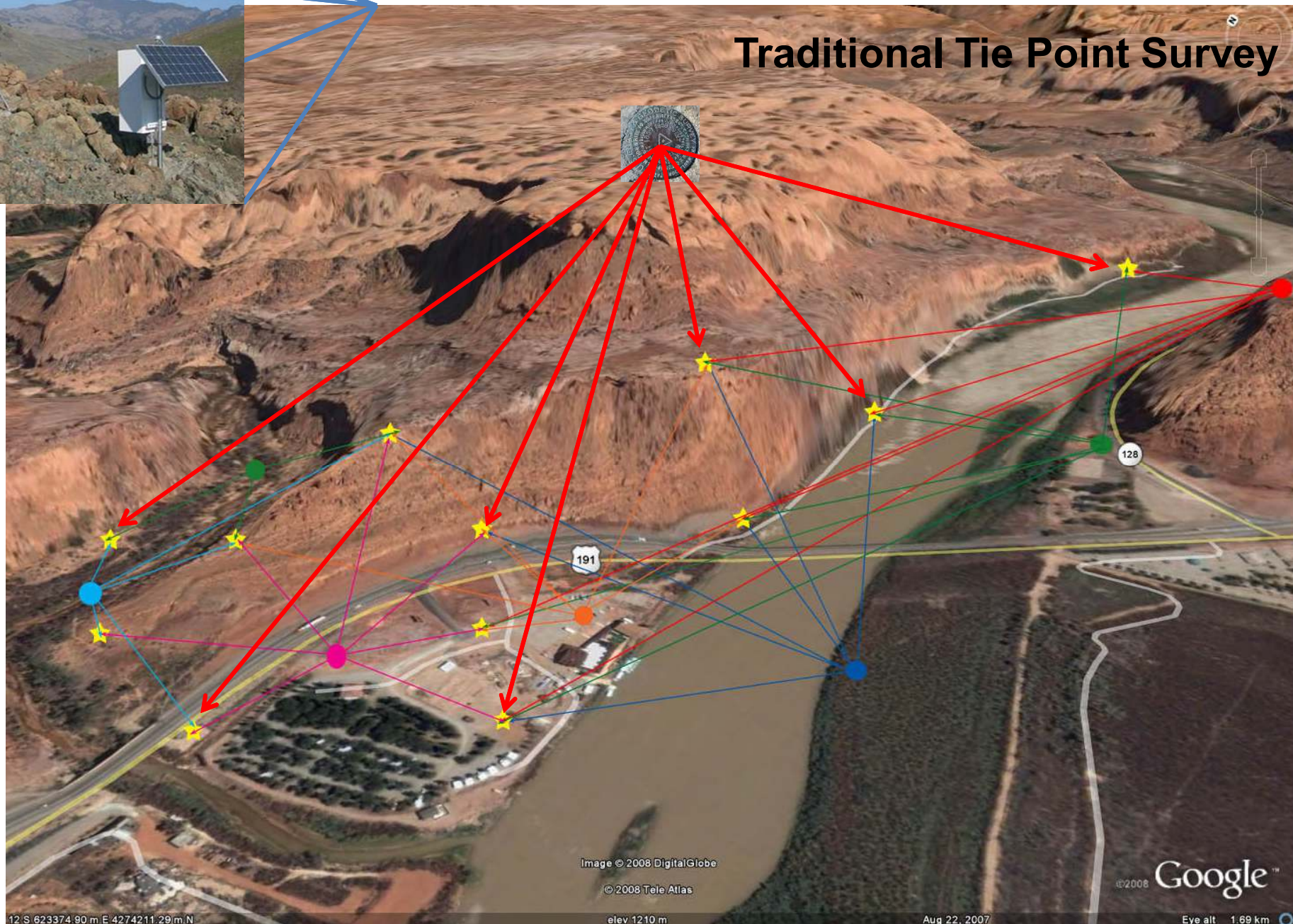
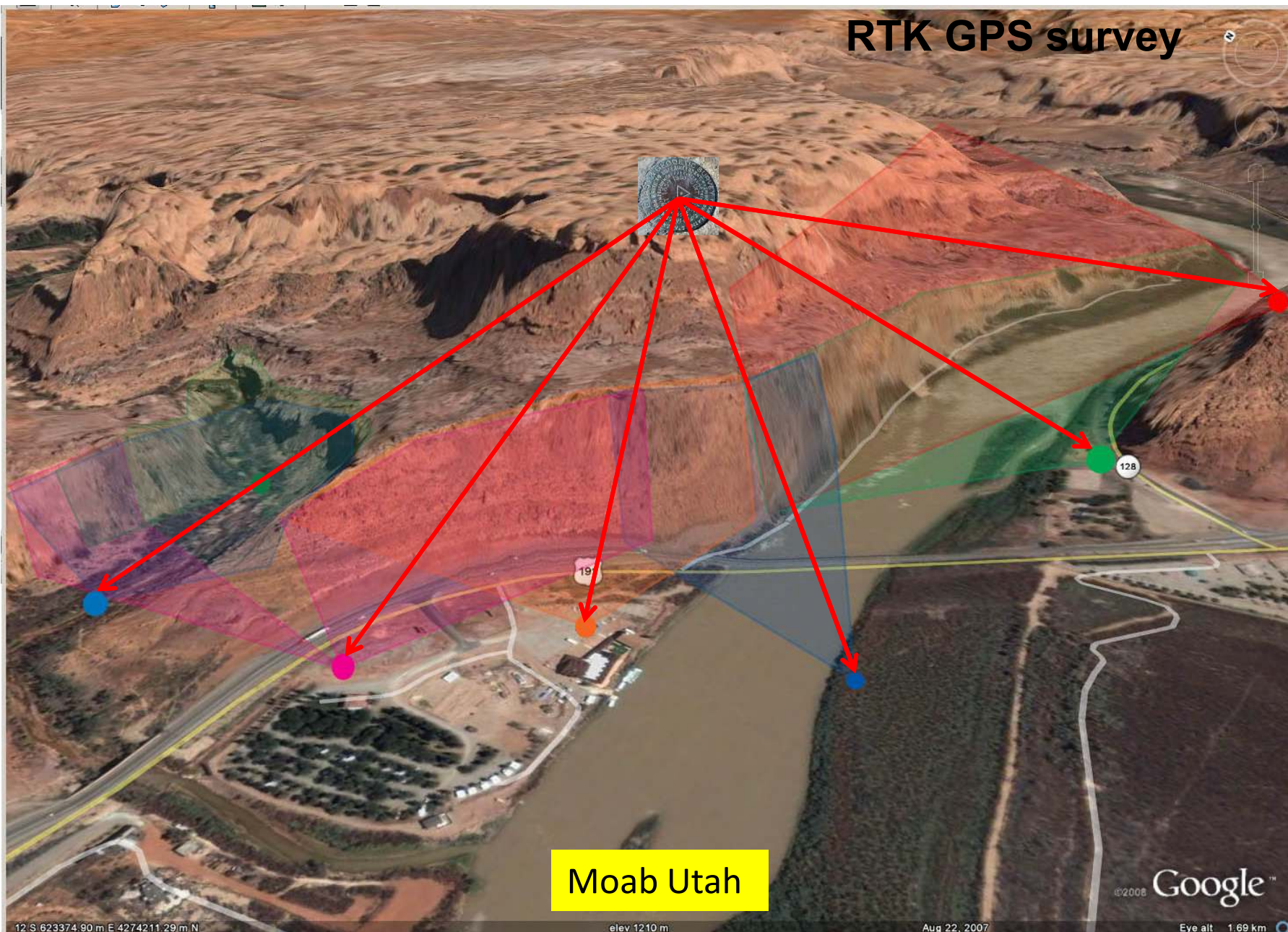


Image © 2008 DigitalGlobe

© 2008 Tele Atlas

©2008 Google™

# Adding GPS to a TLS survey



RTK GPS survey

Moab Utah

Google

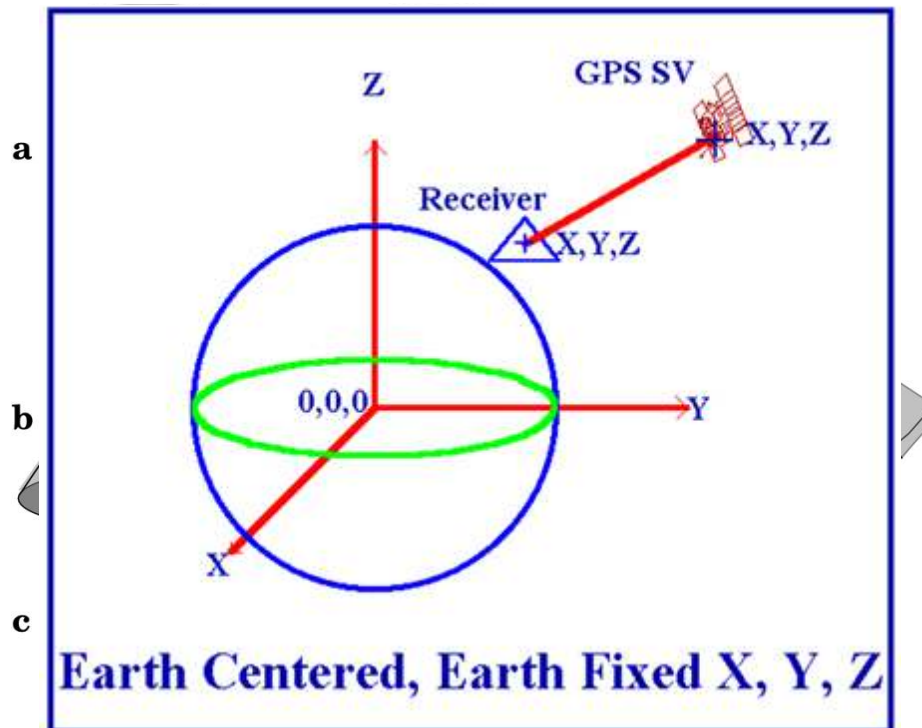
# Understanding coordinate systems - GPS

Point ID	Northing	Easting	Elevation	Latitude	Longitude	Ellip. Height	X (ECEF)	Y (ECEF)	Z (ECEF)
BF - UTD1	1370462.012	577608.894	94.429	-77.72225	162.27091	40.108	-1296058.157	414350.03	-6210455.012
BF - UTD2	1370484.93	577645.326	78.213	-77.72203	162.27239	23.892	-1296088.759	414322.955	-6210433.867
BF - UTD3	1370451.914	577632.2	92.861	-77.72233	162.27192	38.539	-1296056.922	414324.606	-6210455.347
BF - UTD4	1370446.605	577618.498	95.796	-77.72238	162.27135	41.474	-1296047.793	414335.745	-6210459.505
BF - UTD5	1370480.558	577607.267	97.233	-77.72208	162.2708	42.912	-1296075.07	414358.23	-6210453.832

Projected values (ex. UTM)

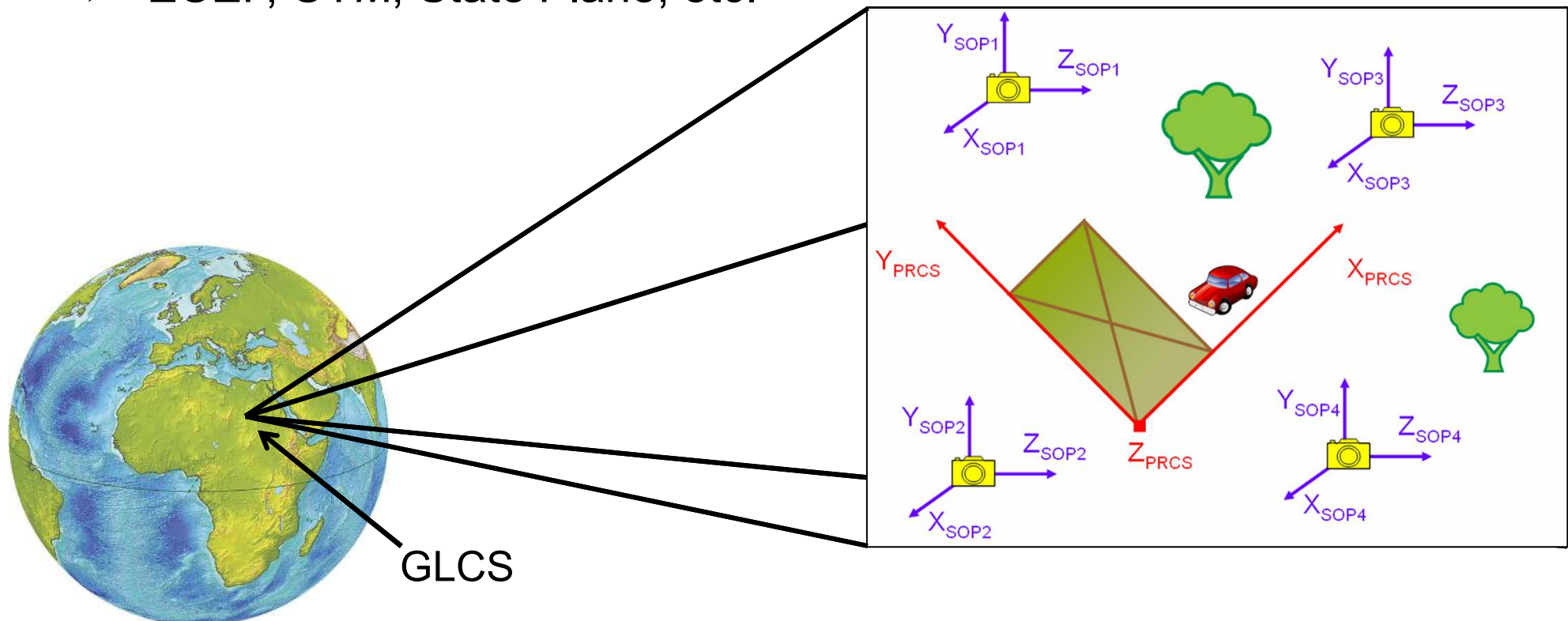
Spherical coordinates

Earth Centered Earth Fixed (ECEF)



# Understanding coordinate systems - TLS

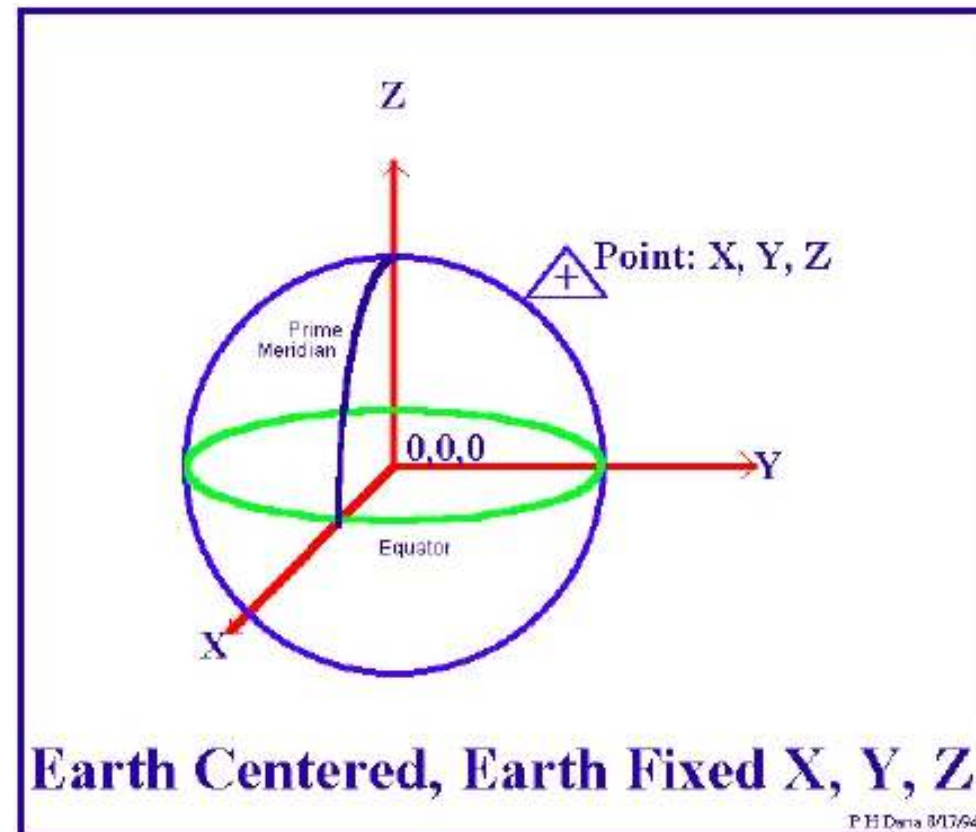
- **SOCS** – Scanner Own Coordinate System
  - Each scan position has origin at scanner location
- **PRCS** – PProject Coordinate System
  - Local coordinate system for entire project
- **GLCS** – GLocal Coordinate System
  - ECEF, UTM, State Plane, etc.



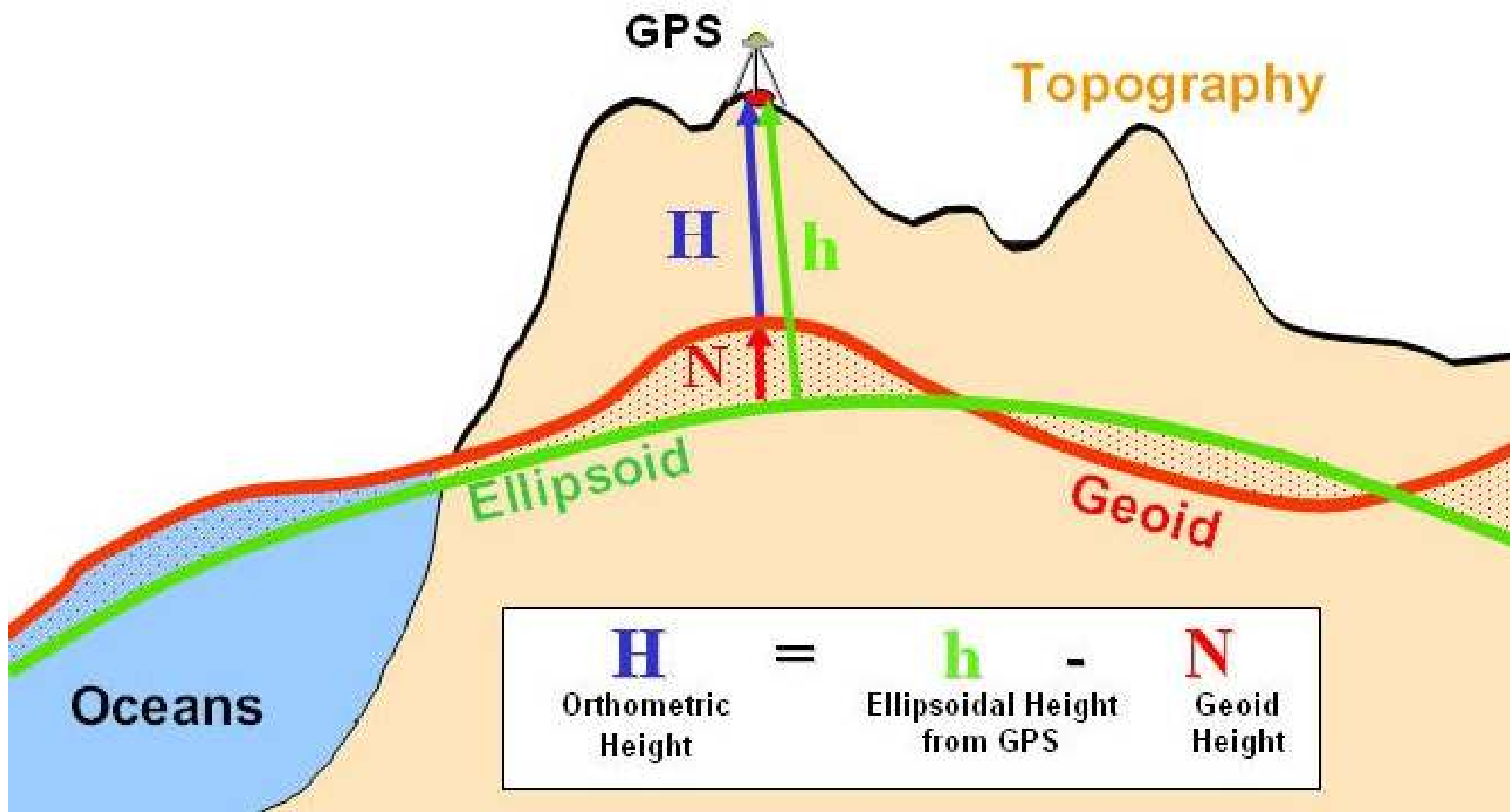
# Understanding coordinate systems - GPS

TLS data often handled 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...



# Understanding coordinate systems - GPS



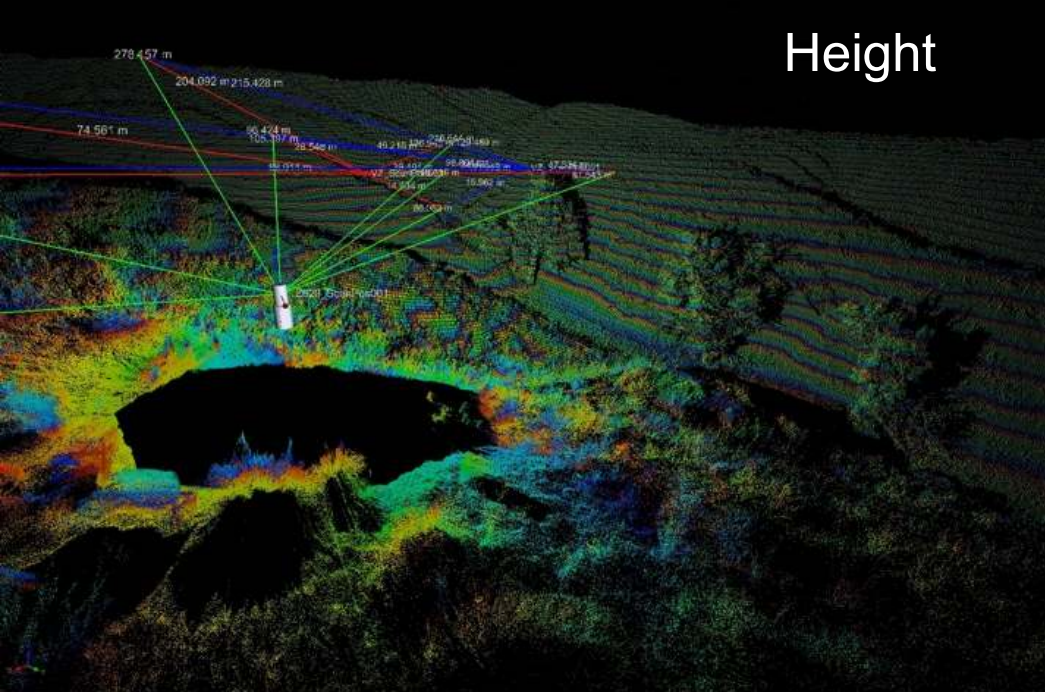
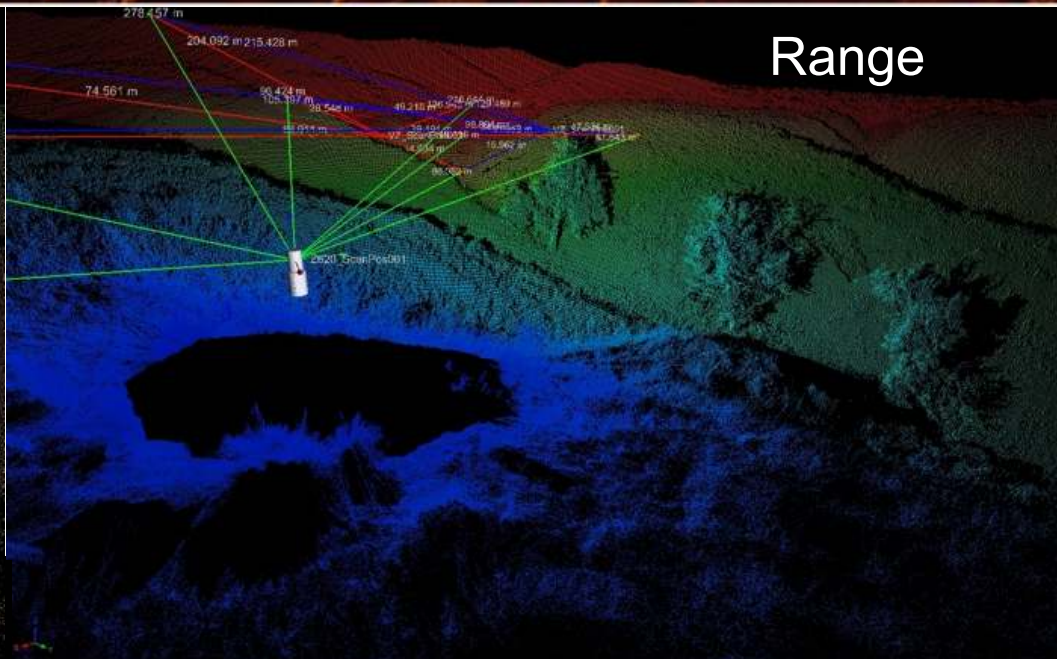
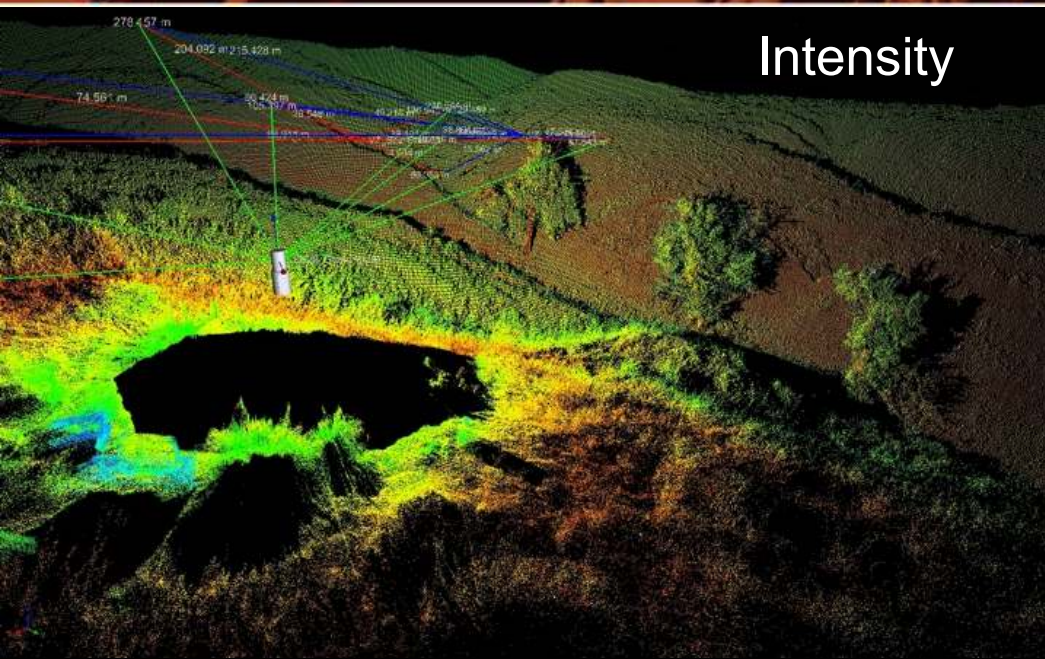


***After data collection is complete...***

- The bulk of the work begins...not a joke! Data processing will be the most time consuming (and hardest) portion of the project.
- Archive your raw data set/project ASAP – multiple copies.
- Re-register all scans to get best fit (especially important for larger field areas).
- Archive final project and create metadata.
- Create higher order datasets.
- Export data to appropriate format.

## 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
- Typically ASCII XYZ + attributes or LAS
  - E57 = New standard under development, minimal adoption
- UNAVCO ***standard deliverable*** = merged, aligned, georeferenced point cloud in ASCII or LAS format.



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.

