TLS Parameters, Workflows and Field Methods

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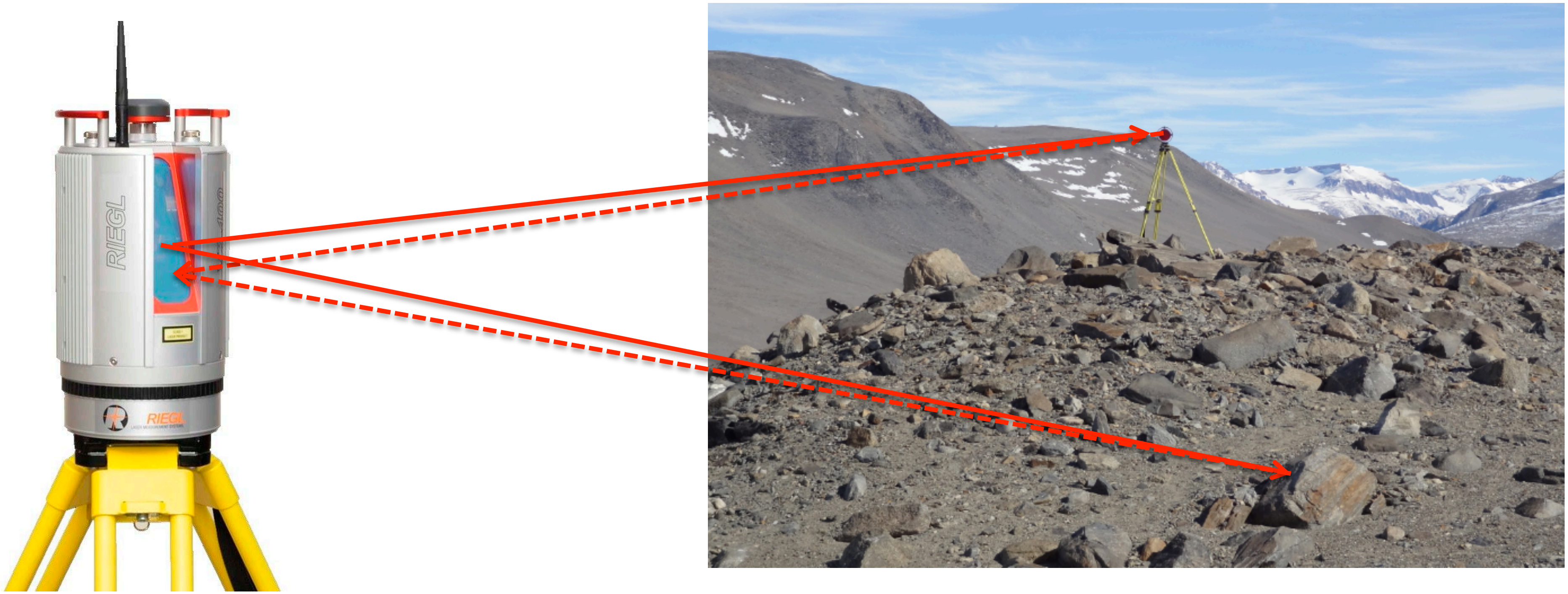
How a Lidar instrument works (Recap)

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

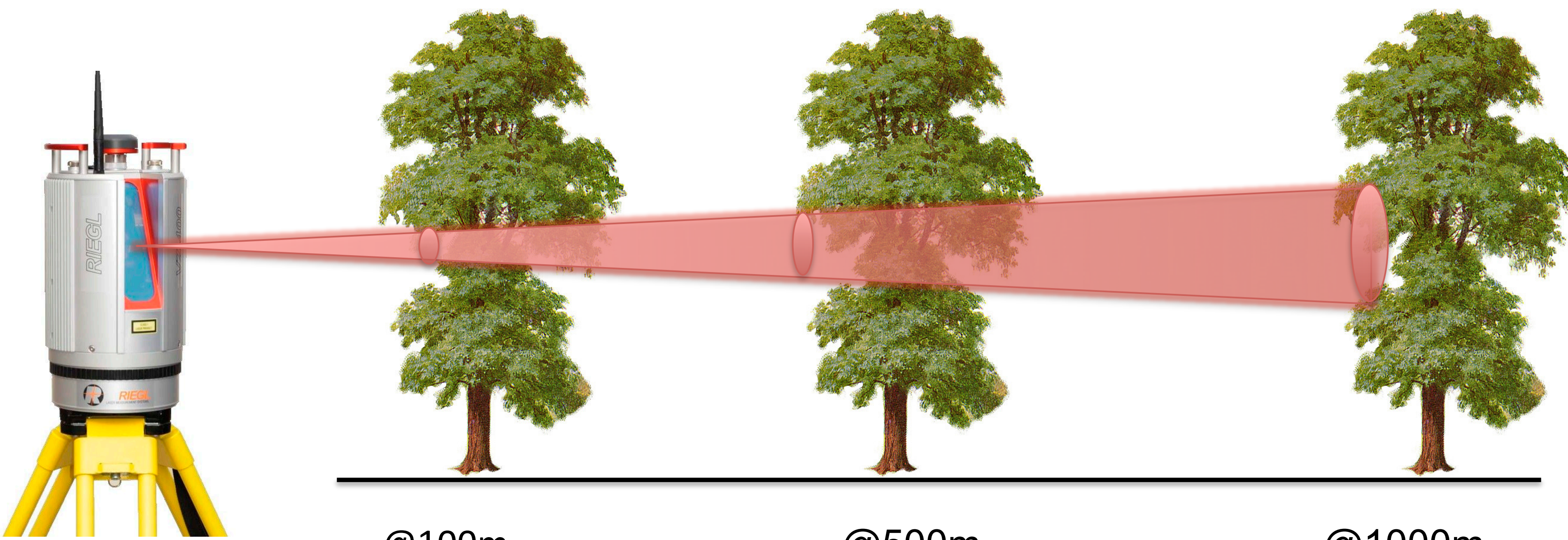


TLS Instrument and Survey Parameters

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

Beam Divergence

Df = (Divergence * d) + Di

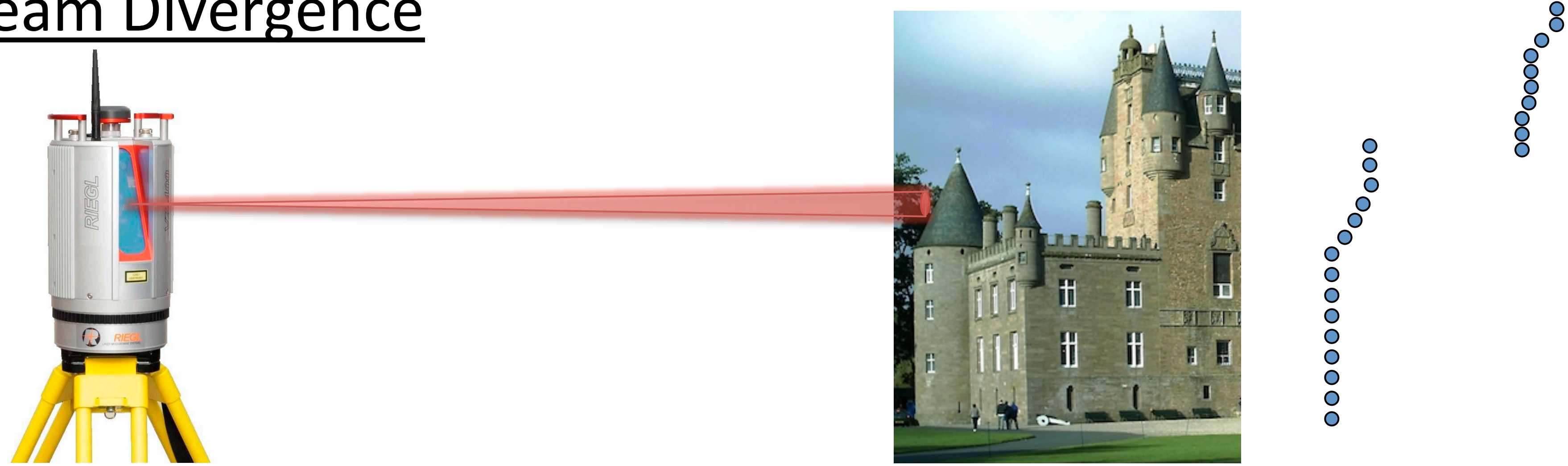


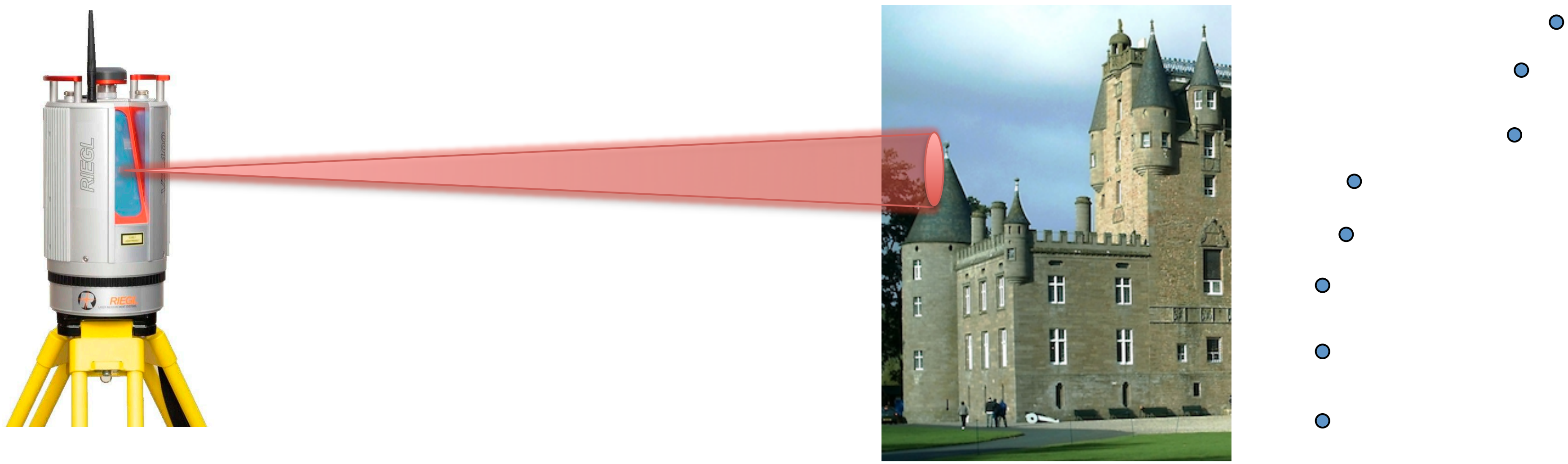
@100m,
Df = 36mm

@500m,
Df = 180mm

@1000m,
Df = 360mm!

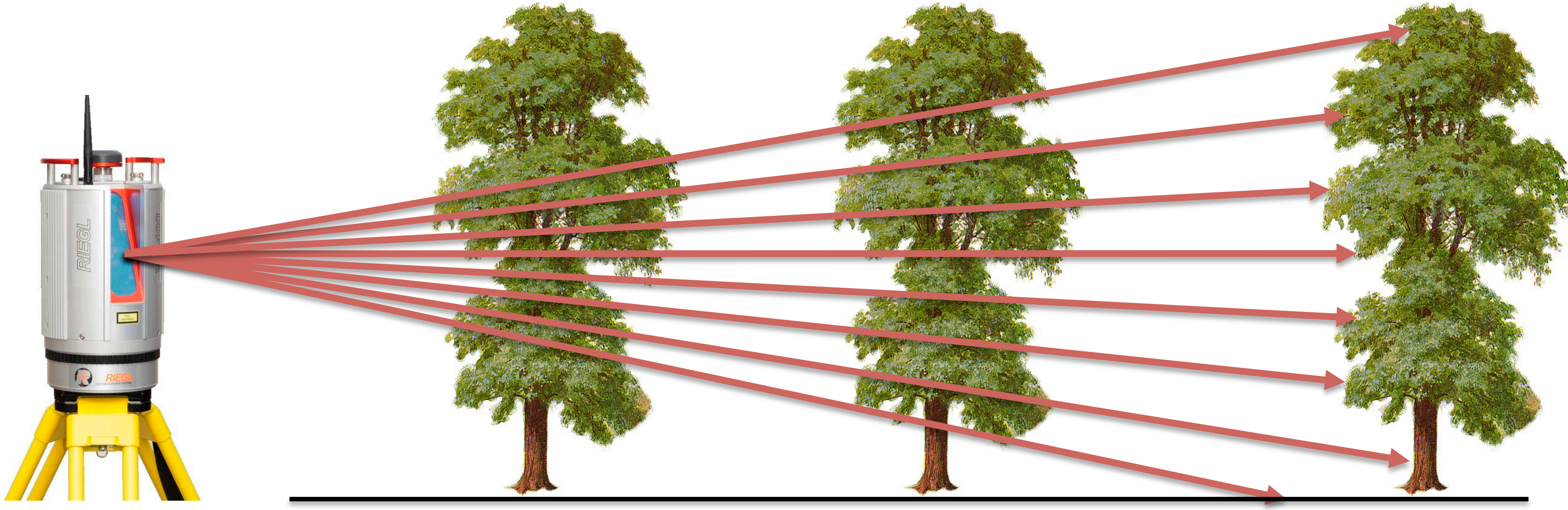
Beam Divergence



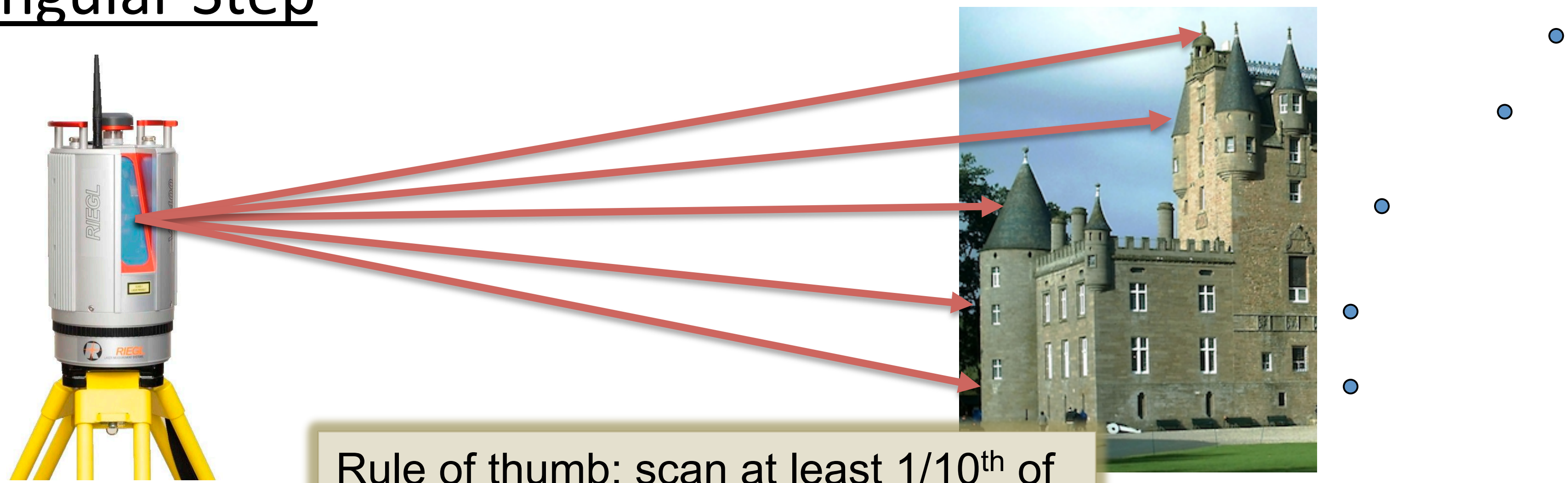


Angular Step

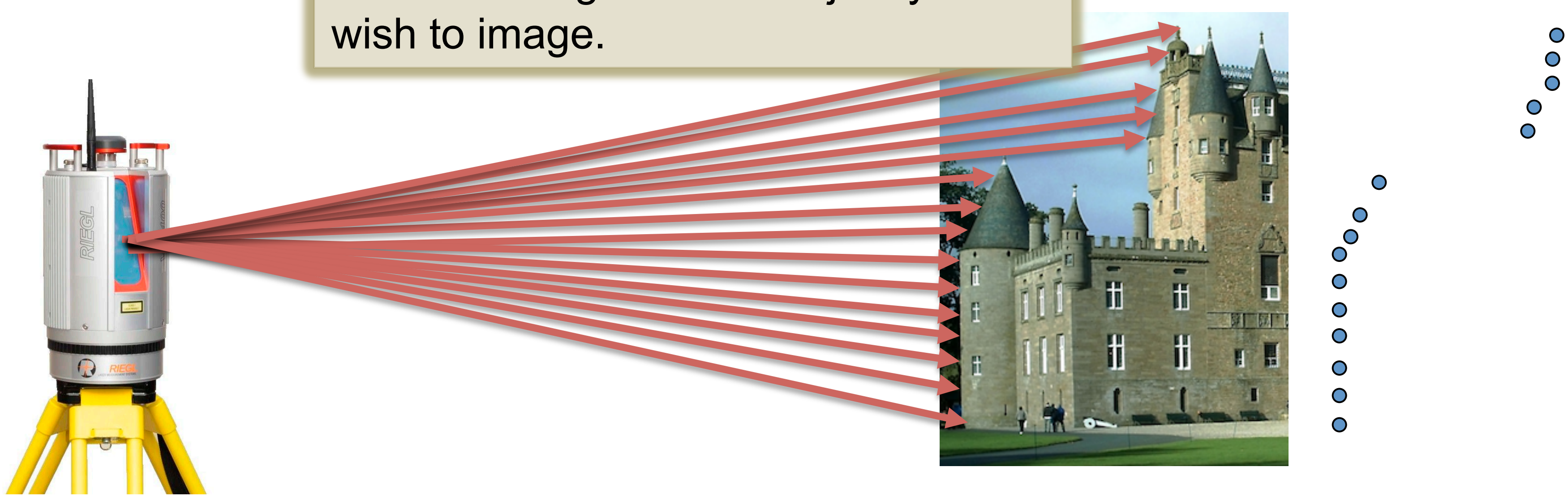
Spacing = d(m)*TAN(step)

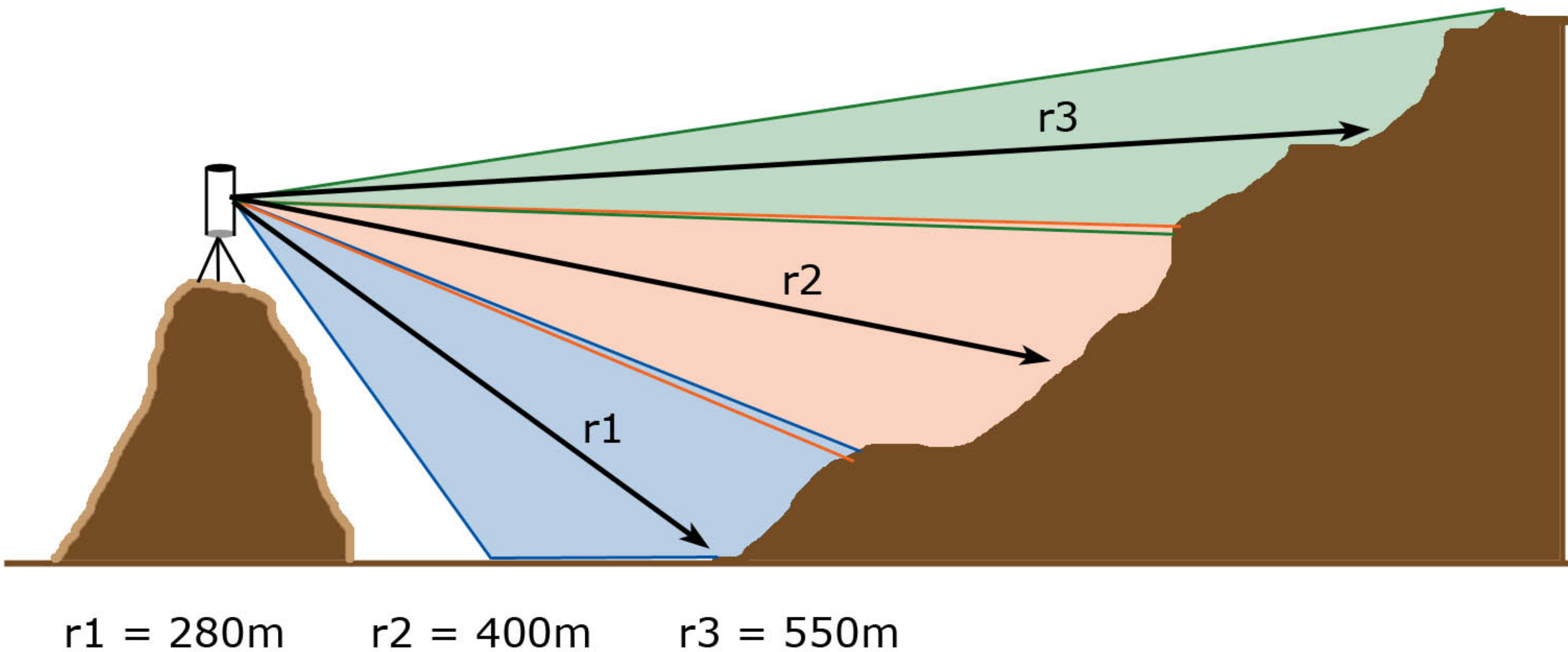


Angular Step



Rule of thumb: scan at least 1/10th 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.

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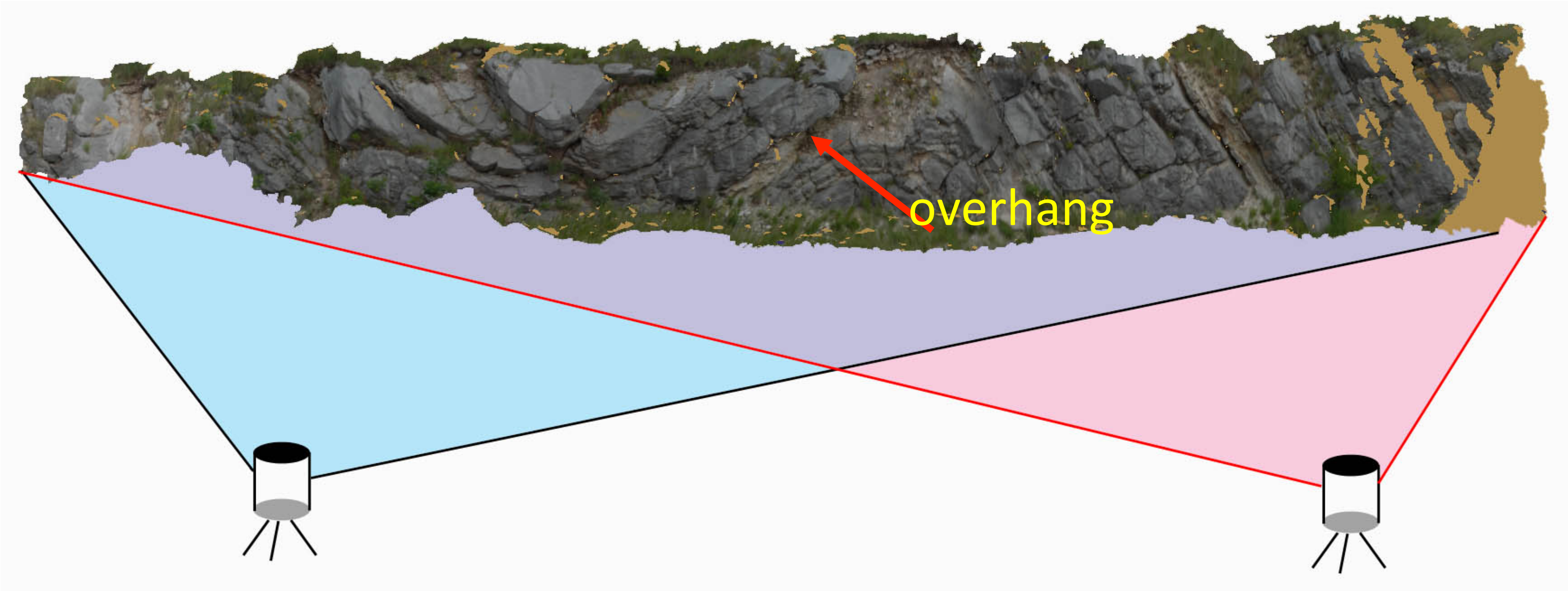


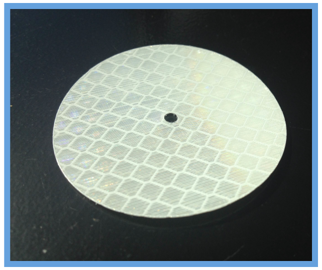
Scan Positions

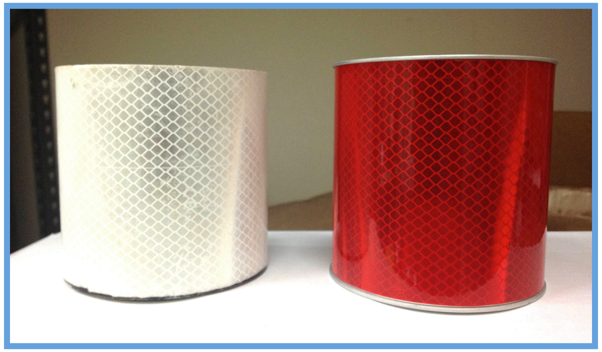
Choose scan positions to minimize occluded (shadowed or hidden) geometries.

TLS Instrument and Survey Parameters

Targets

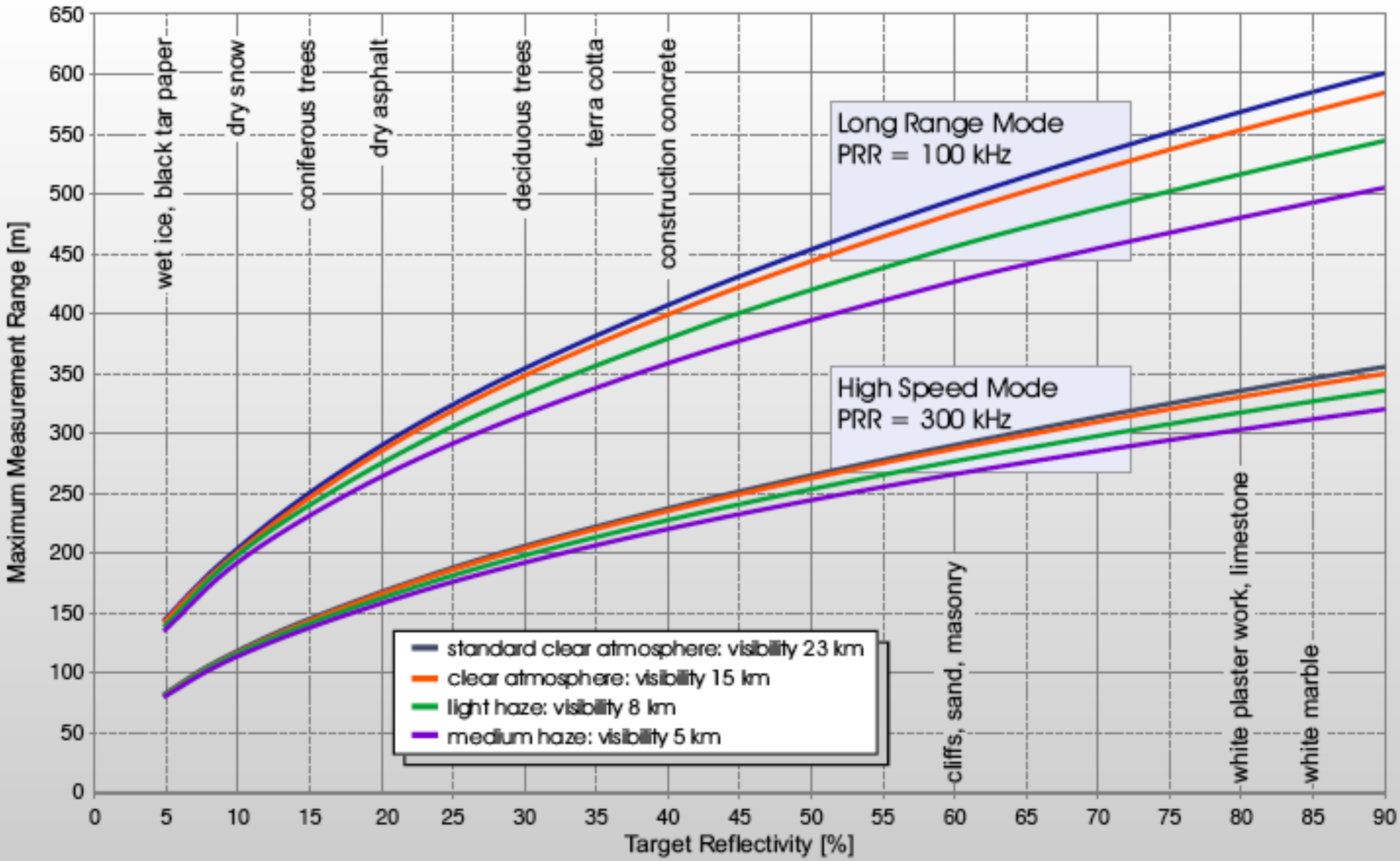
- Reflective objects that serve as reference points for scans.
- Same targets must be common between scan positions.
- Use at least 5 reference targets to register scan positions (the more the better).
- Different shapes and colors serve different functions





(images not to scale)

Riegl VZ400 Maximum measurement range as function of target material



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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

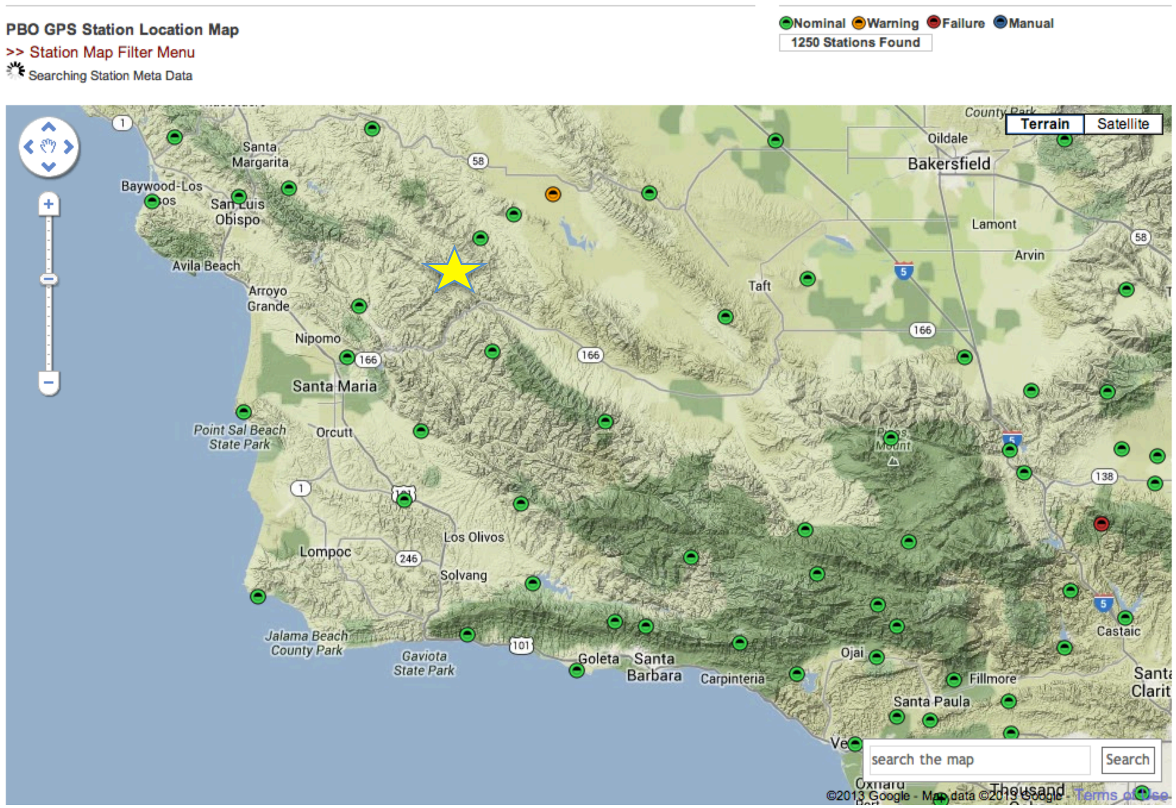
- Make a copy of the data collected in the field. Keep the original project(s) in a safe place. Post process using the copy of the project.

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.

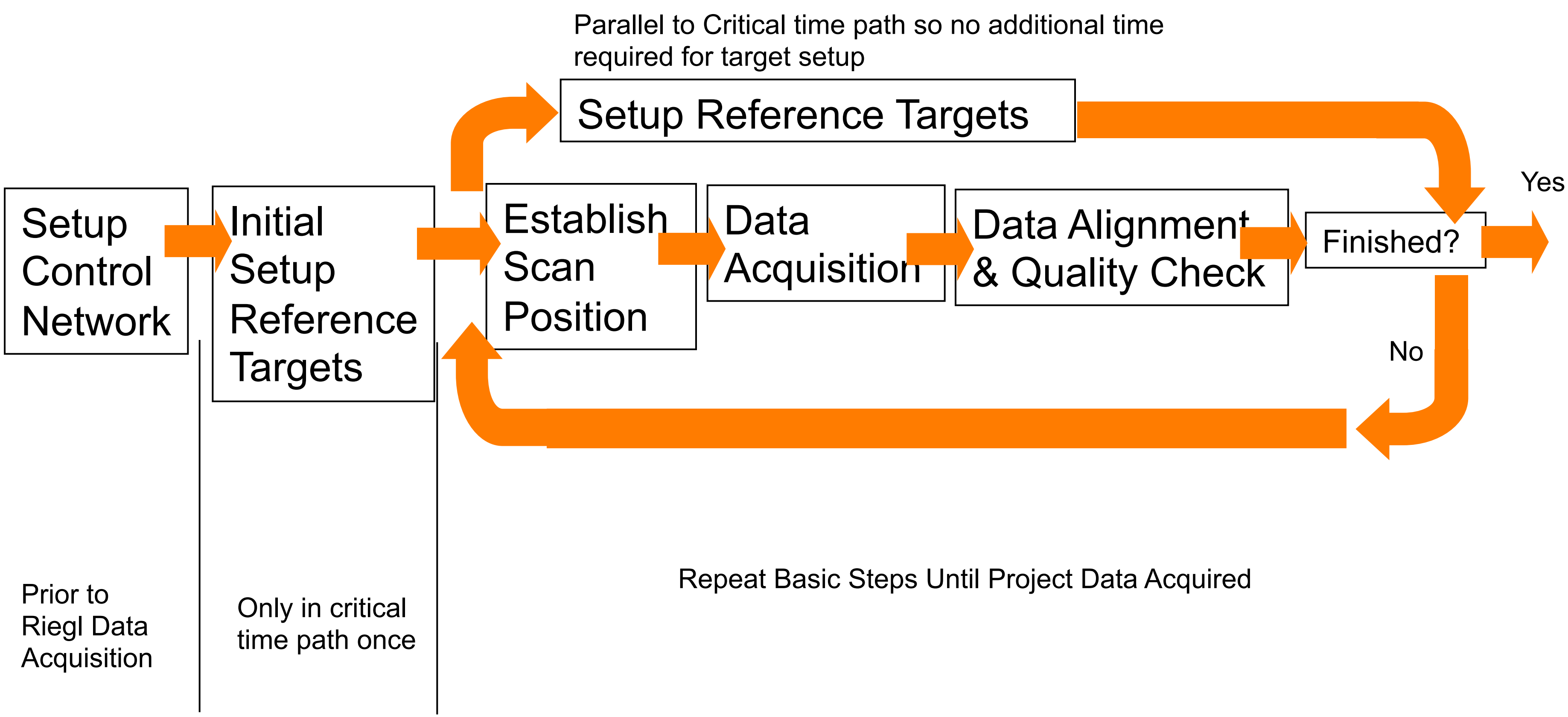
At the field site

- 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.

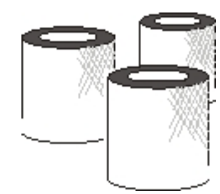
Riegl System Work Flow Overview



Basic Field Kit

Checklist:

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



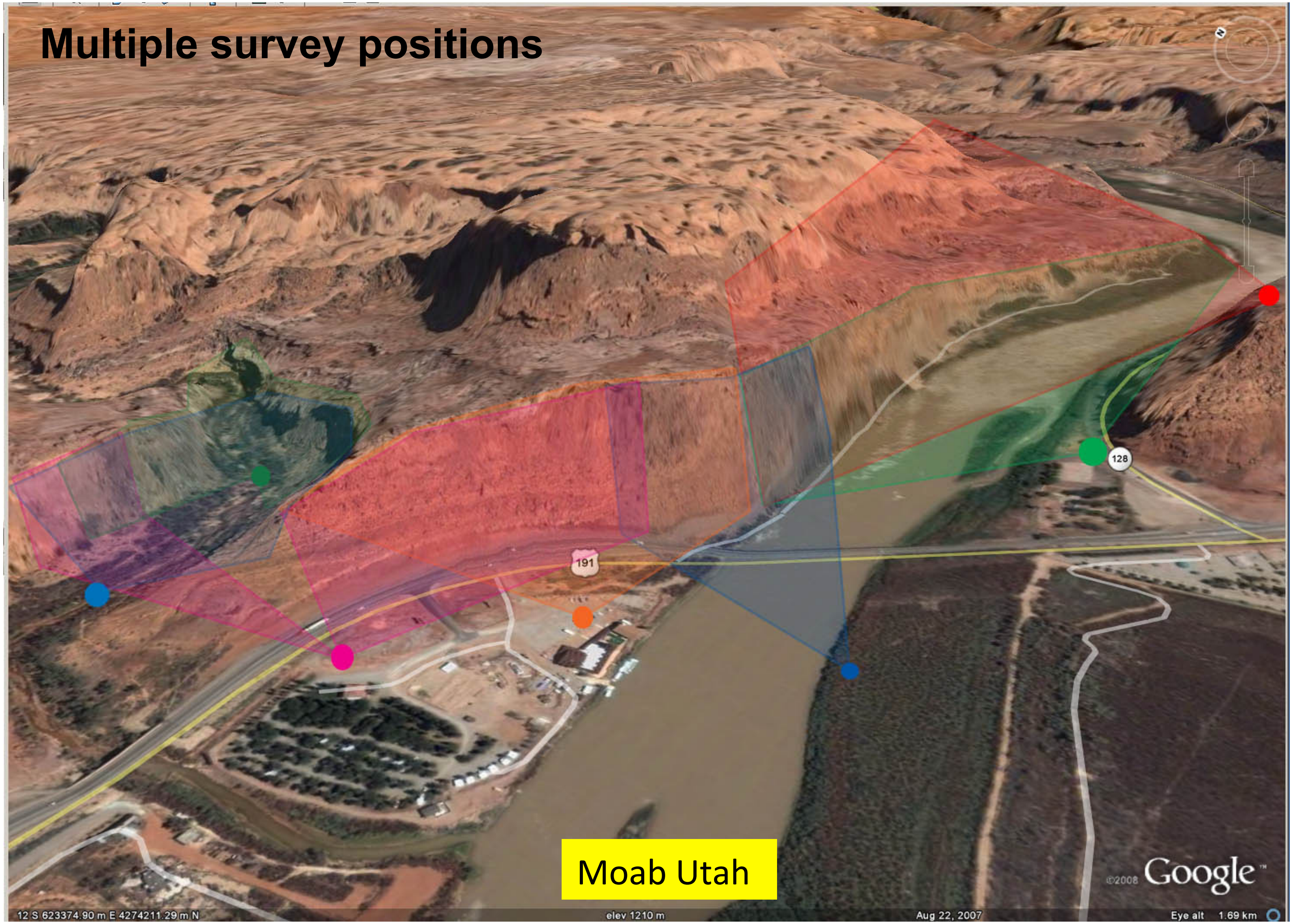
300 lbs!!

ield Kit

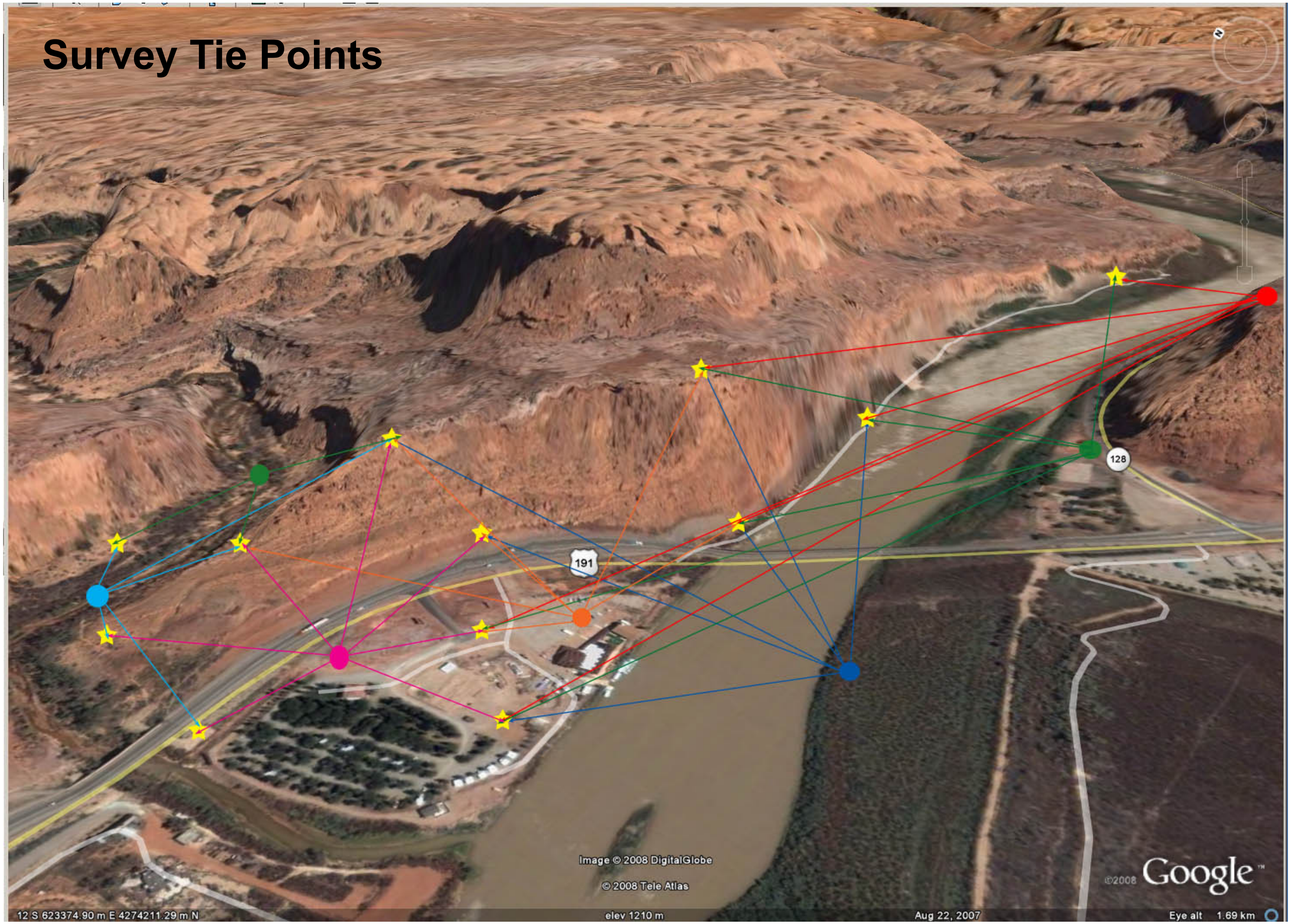
Standard tie point workflow

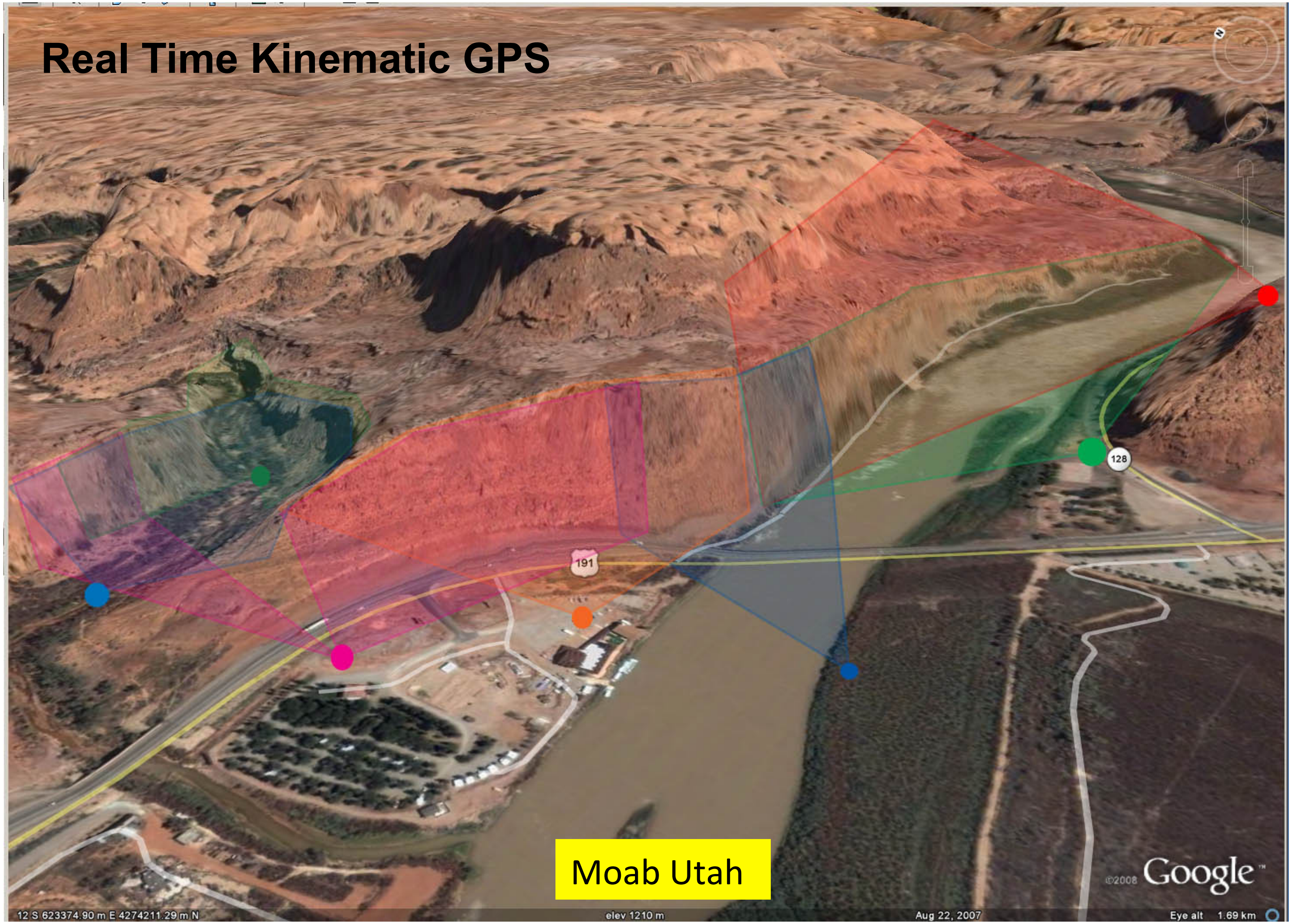
- Reminders – use at least 5 targets. That is, every scan position should see at least 5 targets, every target should be seen by at least 2 scan positions.
- The more targets common to all scan positions, the better

TLS Survey Workflow


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

Survey Tie Points




Real Time Kinematic GPS
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©2008 Google
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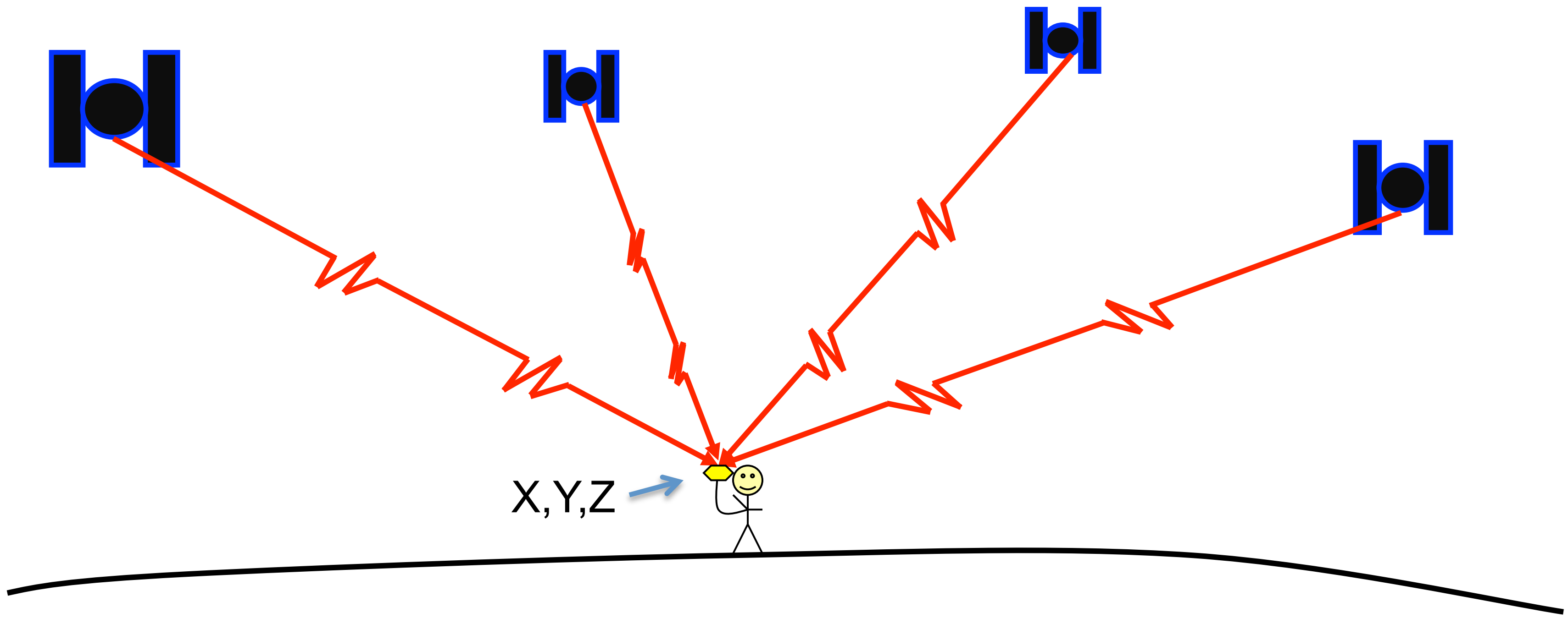
- Constellation of 31 satellites which each house an atomic clock.
- Precise time information is sent to a receiver on earth.
- A minimum of 4 satellites in sky view is needed to obtain a coordinate.

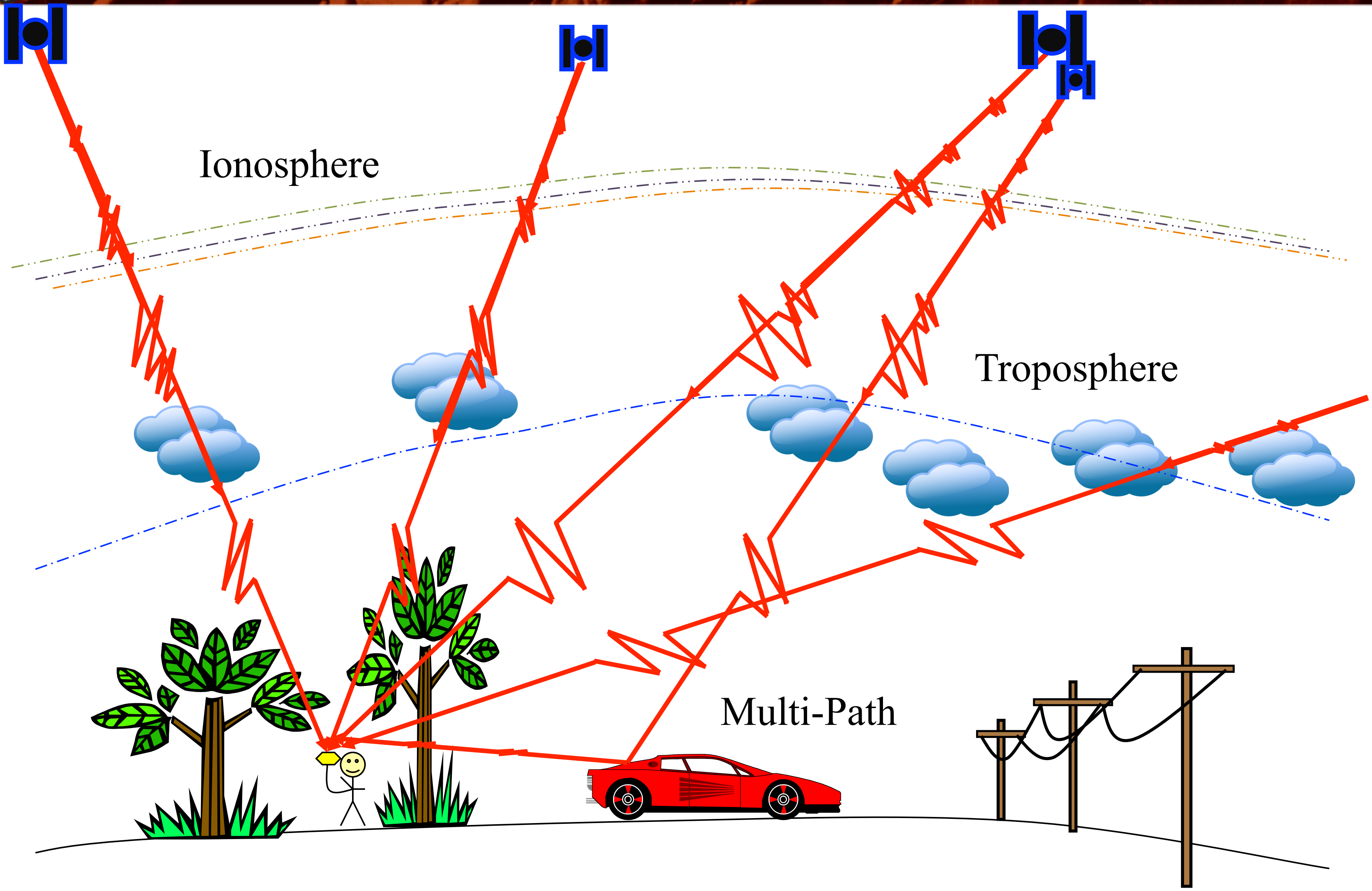


Differential GPS

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.

GPS Errors



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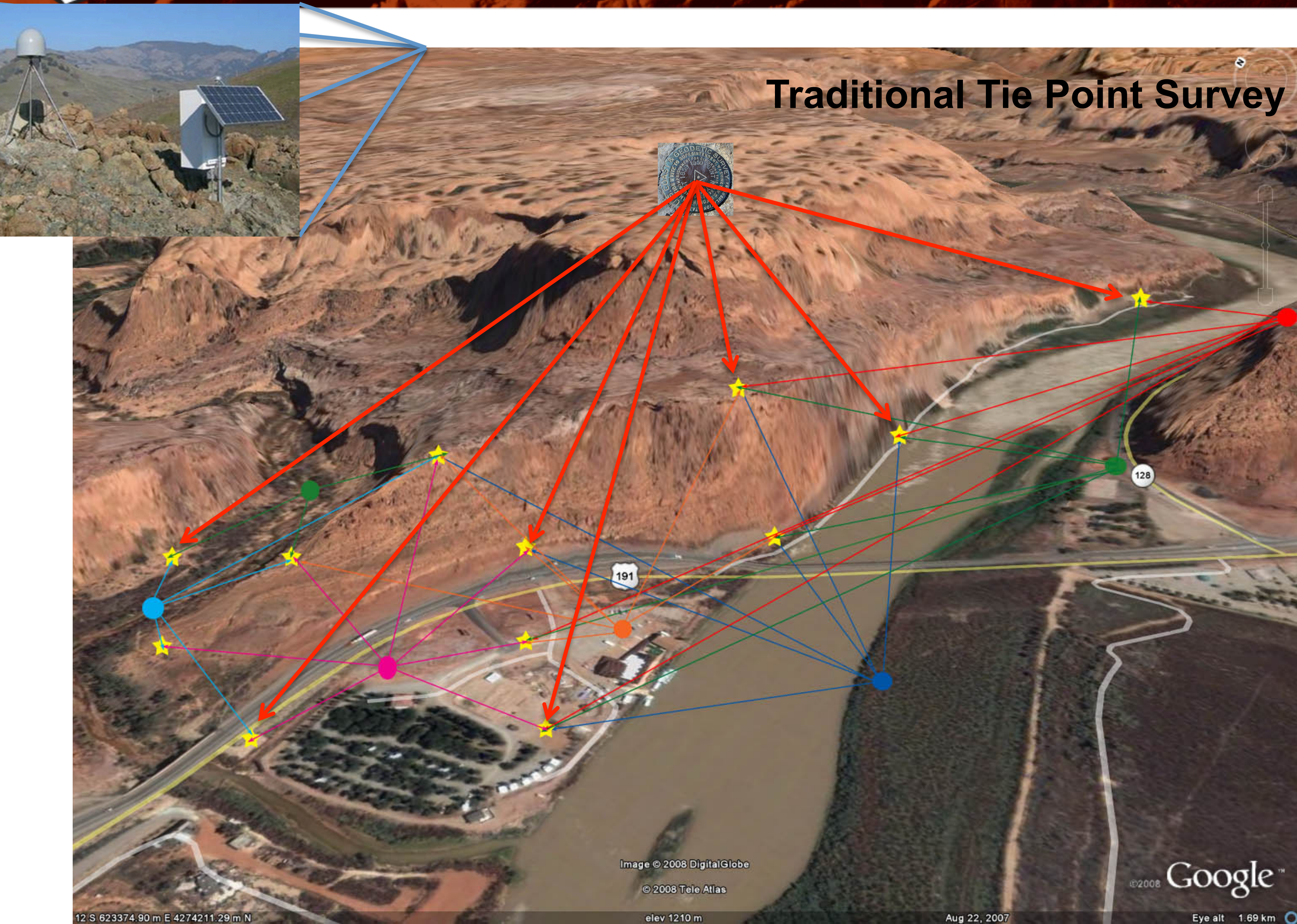
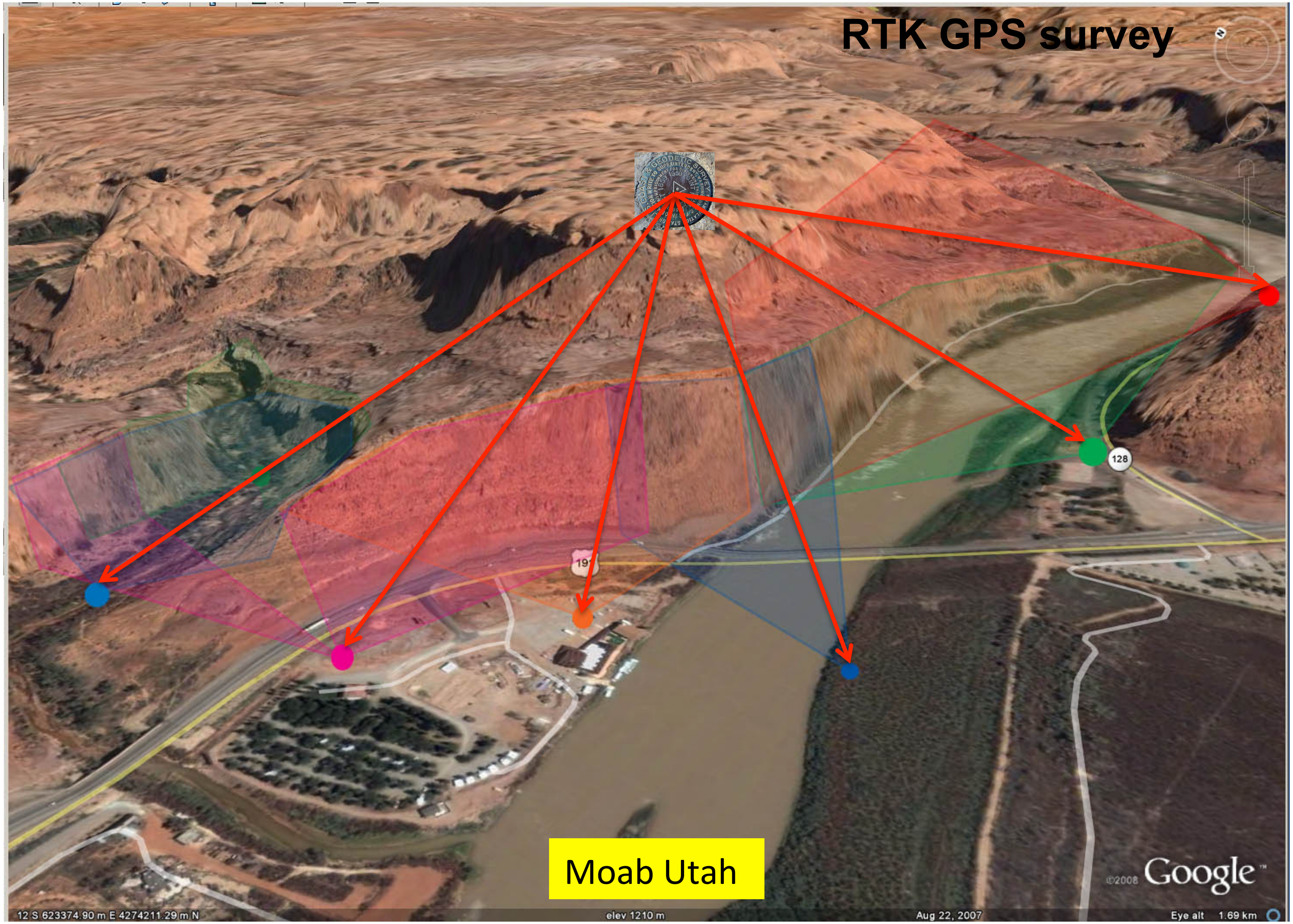
Adding GPS to a TLS survey



Adding GPS to a TLS survey



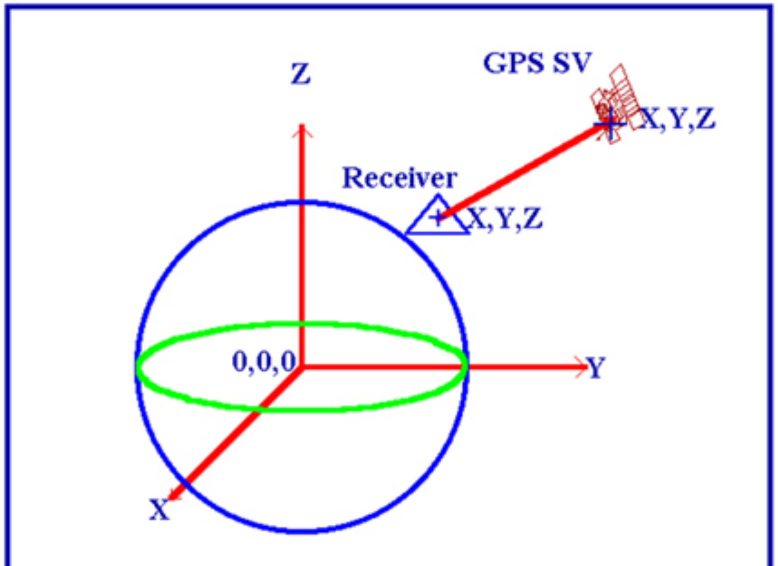
Understanding coordinate systems - GPS

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

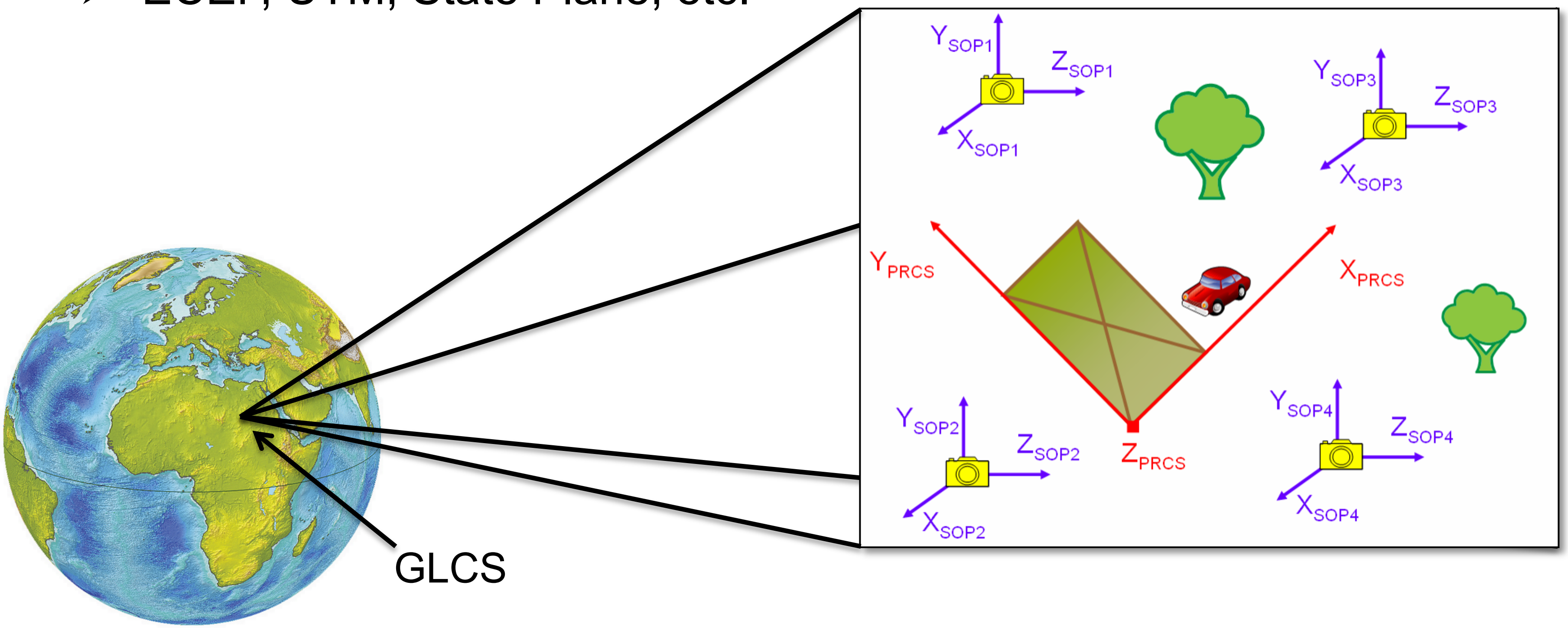
Earth Centered Earth Fixed (ECEF)



Earth Centered, Earth Fixed X, Y, Z

Understanding coordinate systems - TLS

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

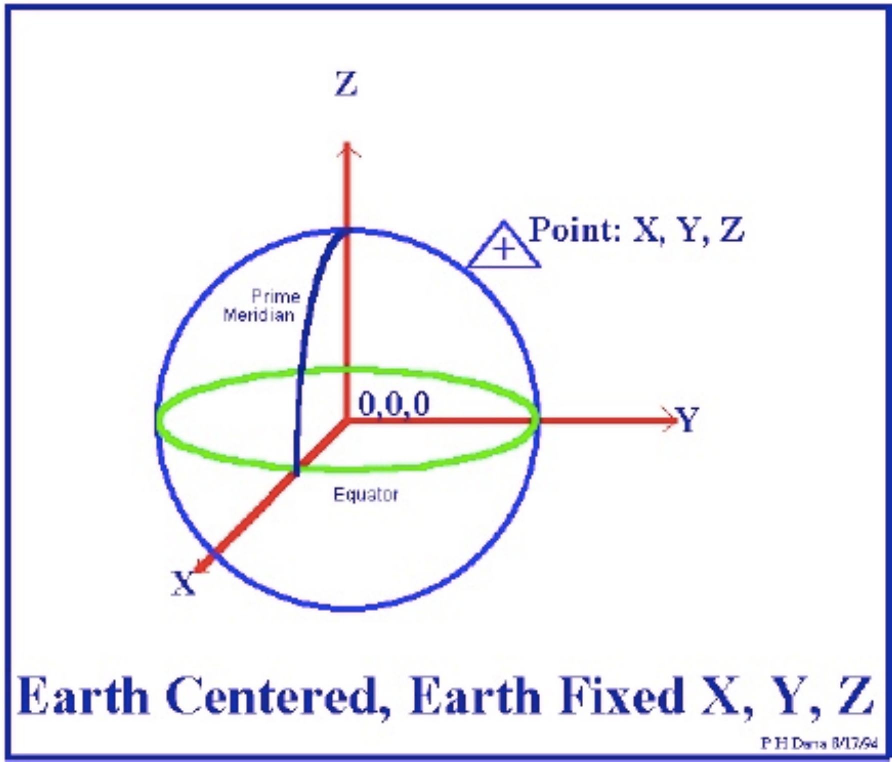


Understanding coordinate systems - GPS

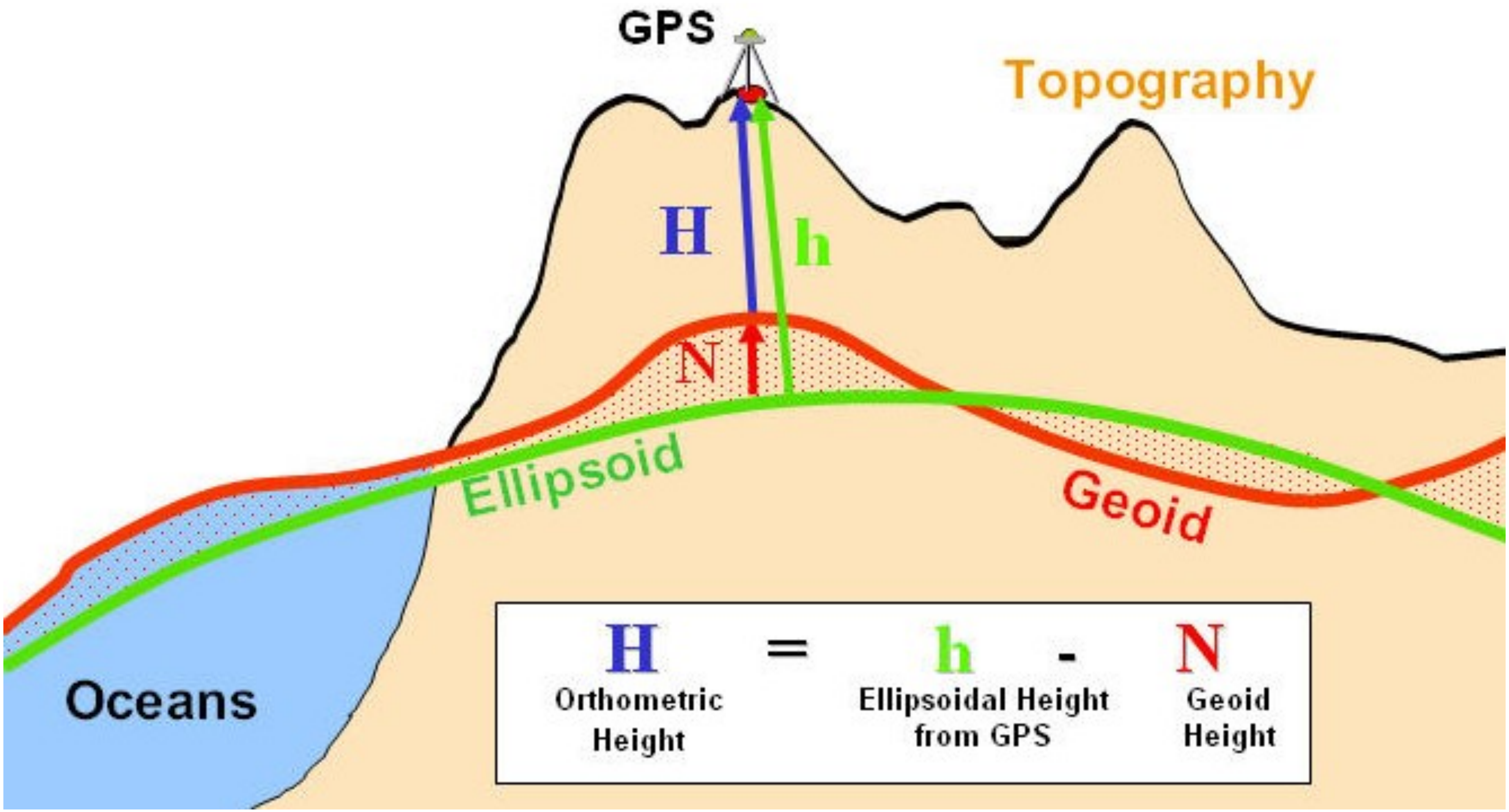
TLS data often handled in Earth Centered, Earth Fixed coordinates.

- 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



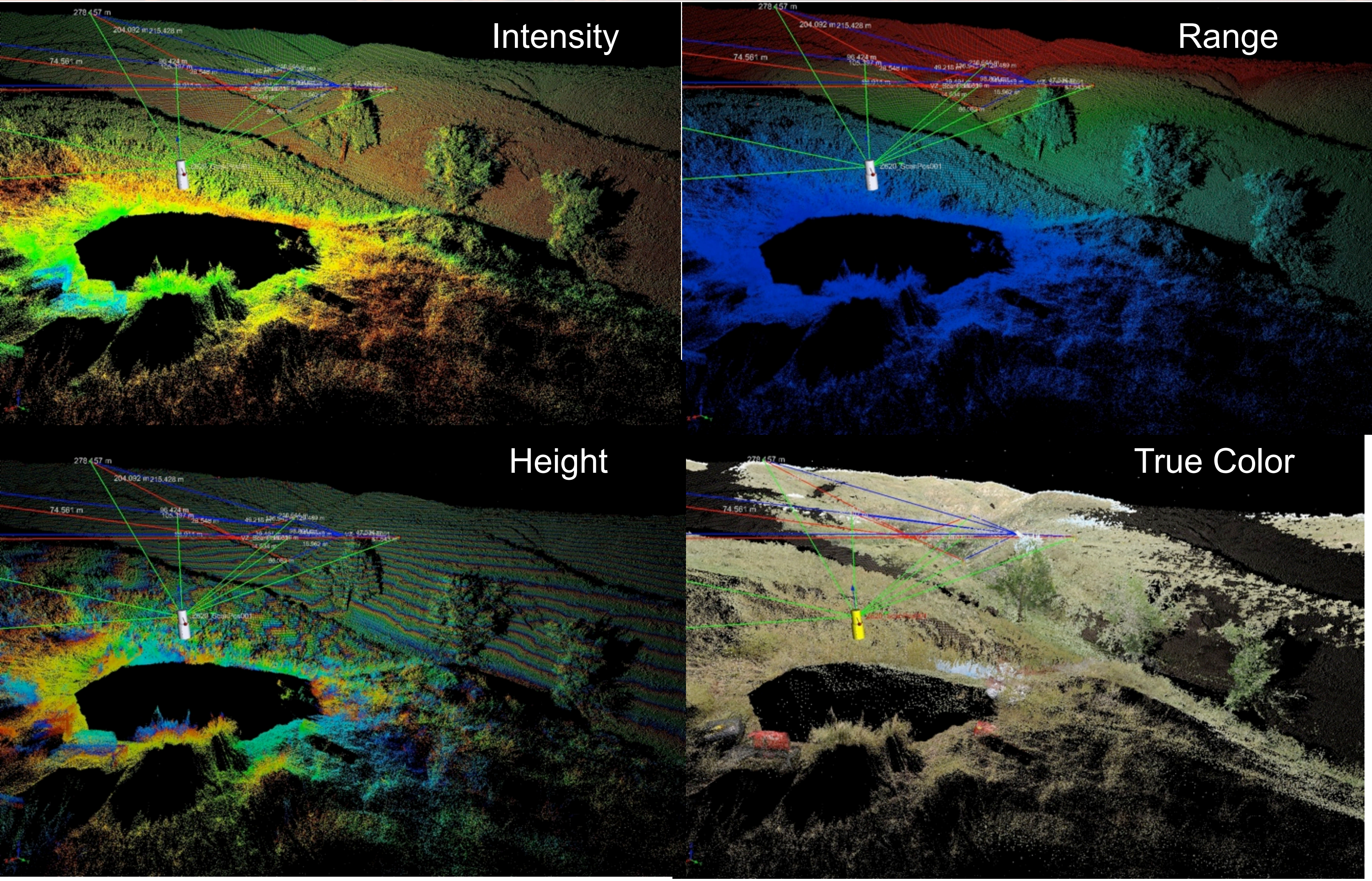
After data collection is complete…

- 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 (Chris and Carlos will cover these).
- 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.

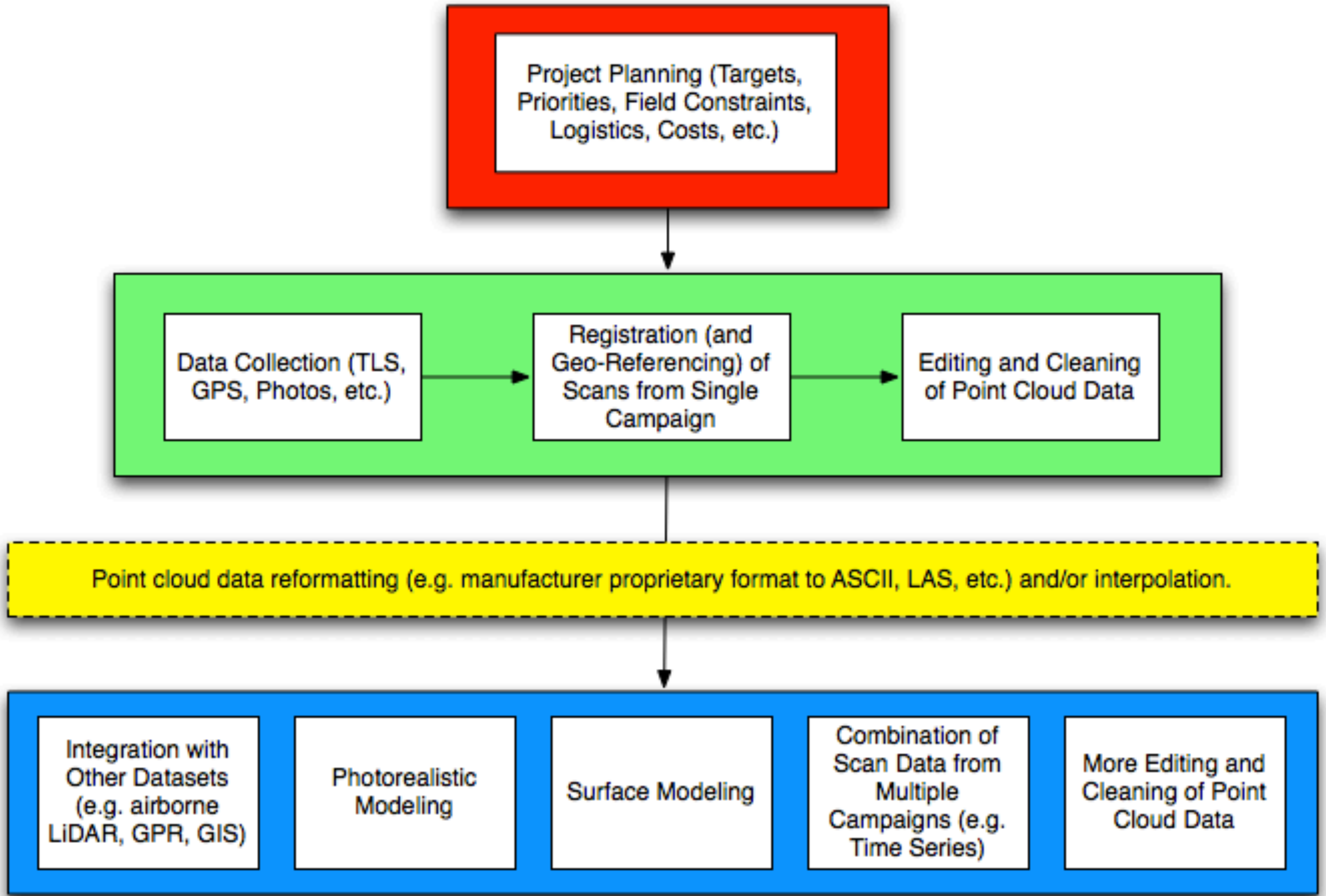
TLS Data



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.

Summary


Project Planning (Targets, Priorities, Field Constraints, Logistics, Costs, etc.)
Data Collection (TLS, GPS, Photos, etc.)
Registration (and Geo-Referencing) of Scans from Single Campaign
Editing and Cleaning of Point Cloud Data
Point cloud data reformatting (e.g. manufacturer proprietary format to ASCII, LAS, etc.) and/or interpolation.
Integration with Other Datasets (e.g. airborne LiDAR, GPR, GIS)
Photorealistic Modeling
Surface Modeling
Combination of Scan Data from Multiple Campaigns (e.g. Time Series)
More Editing and Cleaning of Point Cloud Data