Concepts of Creating a Geodetic Adjustment

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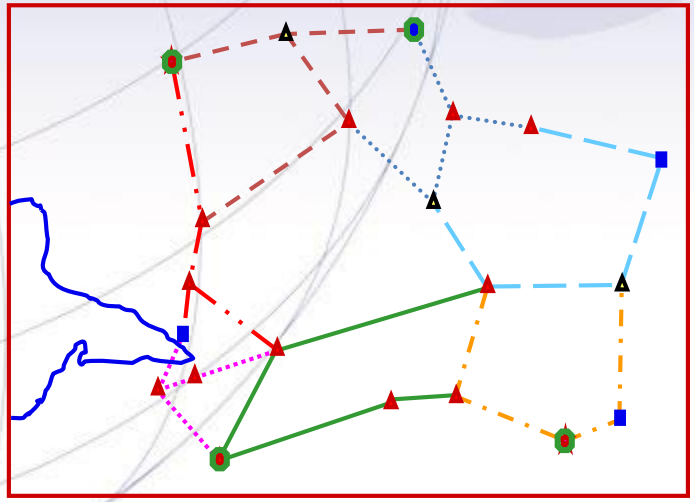
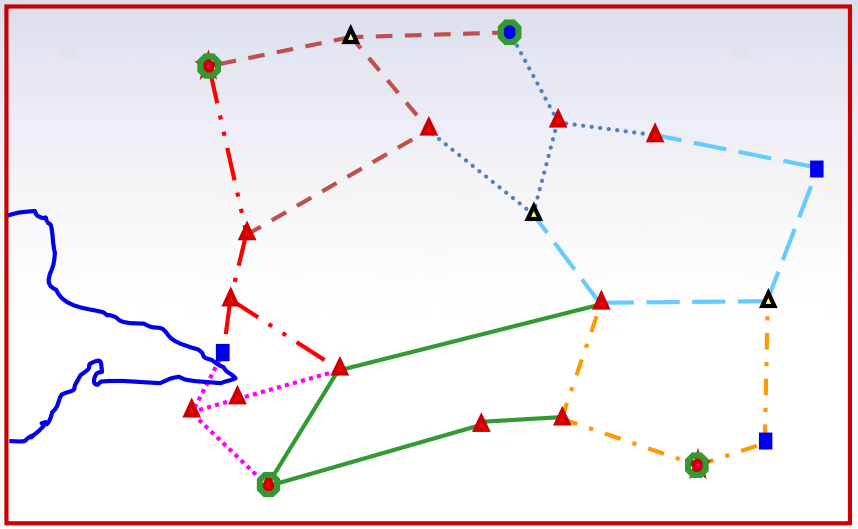
Topics To Be Discussed



- GPS Project
  - Guidelines
    - Lay out
  - Observations
  - Data Processing
  - Analysis of Base Lines
  - Adjustments

Guidelines GPS Project



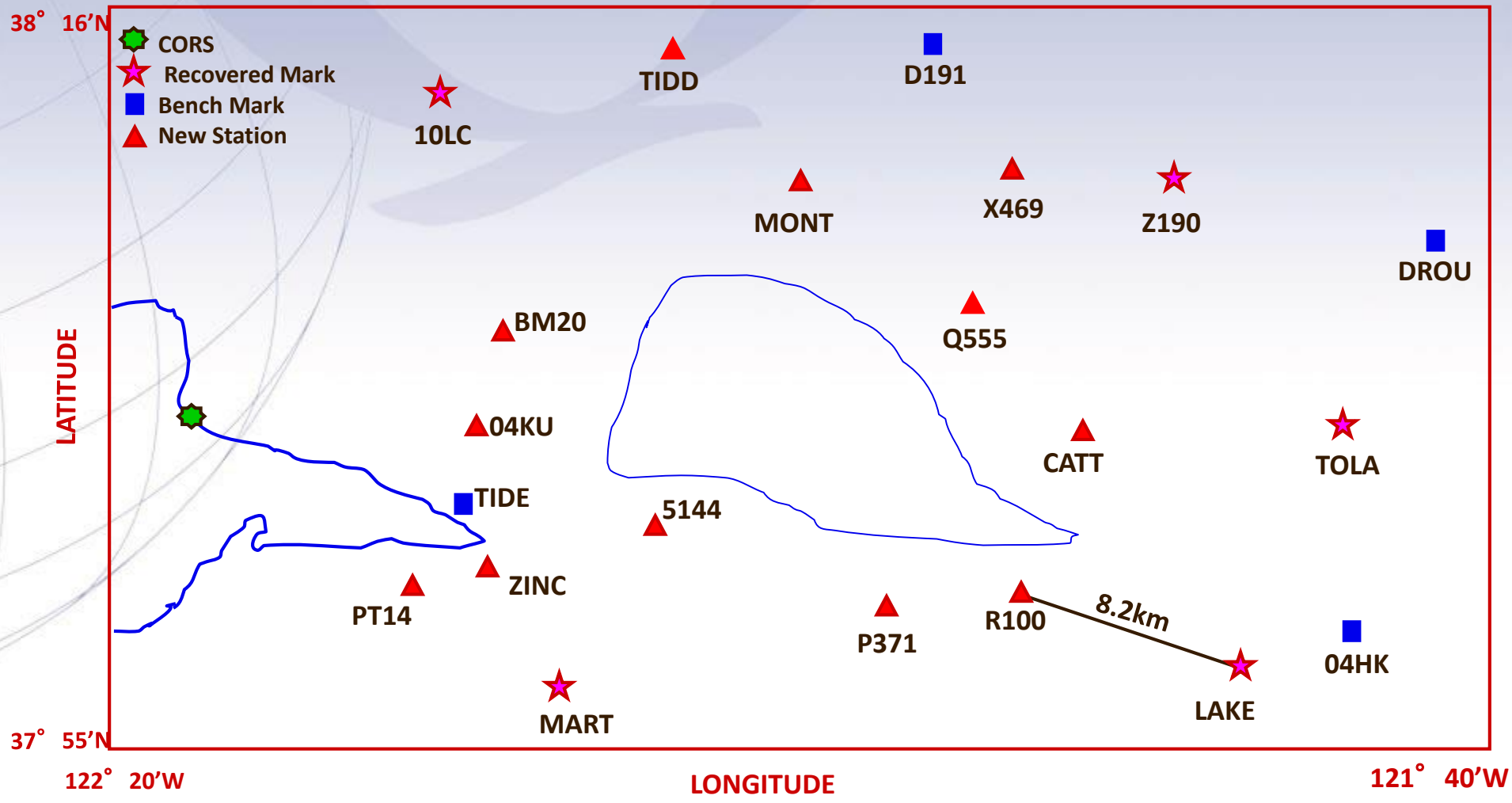
- **Must repeat base lines**
  - ➢ **Different days**
  - ➢ **Different times of day**
    - **Detect, remove, reduce effects due to multipath and having almost the same satellite geometry**

PROJECT INFORMATION

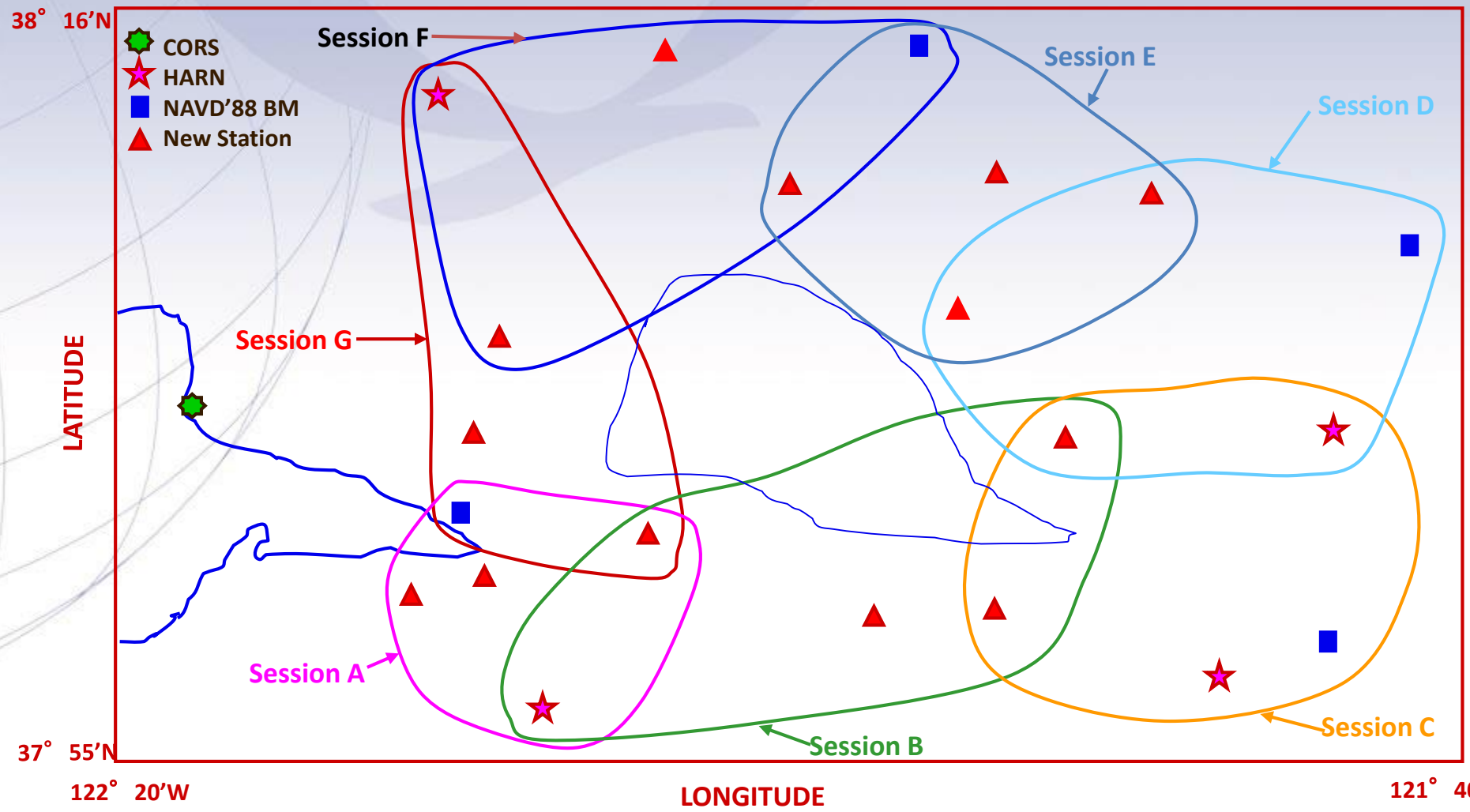
- **Area: East San Francisco Bay Project**
  - **Latitude 37° 50" N to 38° 10" N**
  - **Longitude 121° 45" W to 122° 25" W**
- **Receivers Available: 5**
- **Standards: 1 cm Horizontal , 2/3 cm Vertical**

STATION SELECTION & RECONNAISSANCE

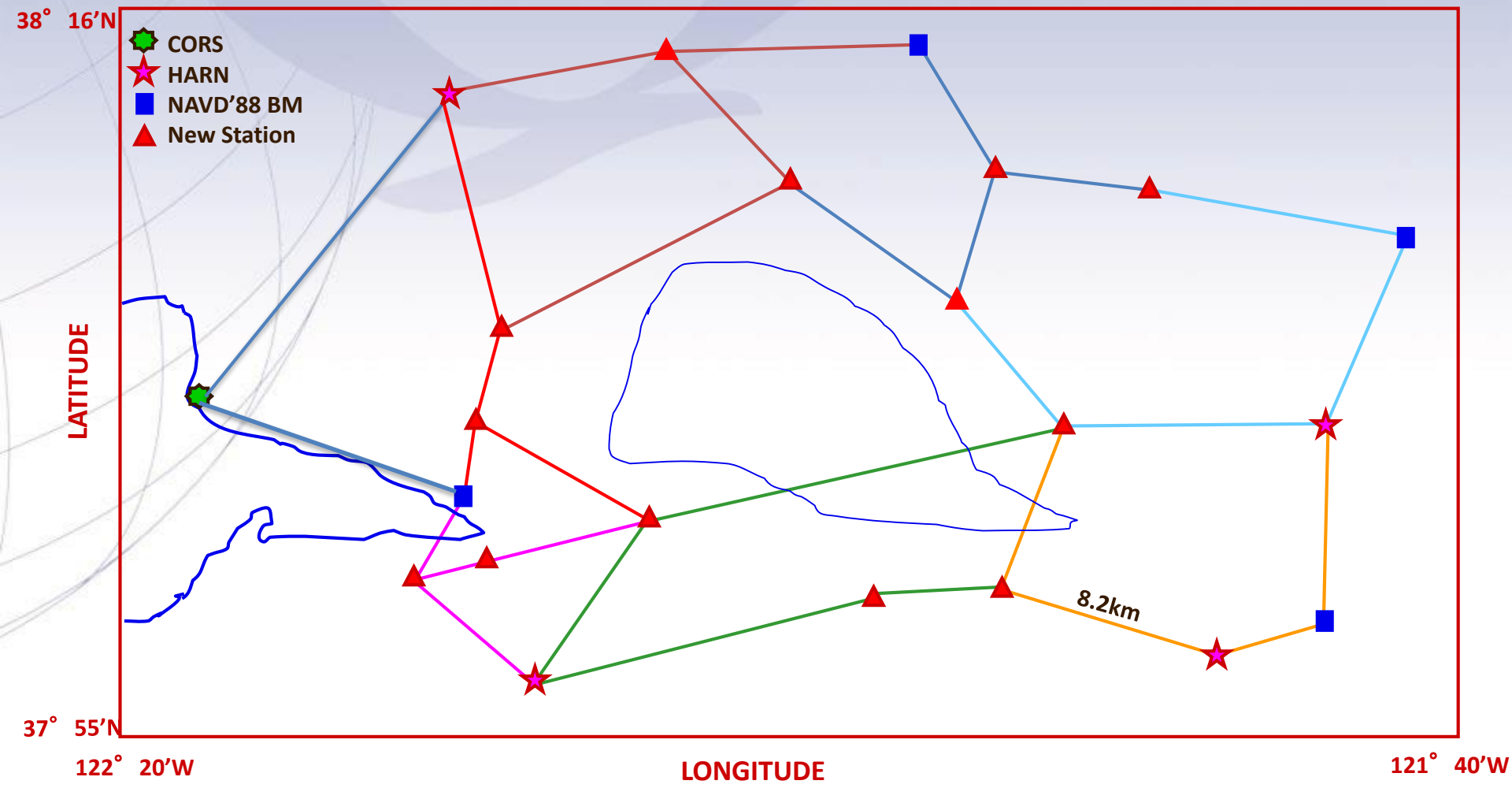
- **Find accurate connections to control stations in The National Spatial Reference System (NSRS)**
  - NGS or IGS approved CORS
  - Known Local Network Stations
  - Bench Marks (good Orthometric Heights)
- **NGS Database and data sheets**
- **Identify GPS-usable stations**



GPS-USABLE STATIONS



OBSERVATION SESSIONS



INDEPENDENT BASE LINES

OBSERVATION SCHEDULE

Day	Session		Start Time	Stop Time
1	A		8:00 AM	8:45 AM
1	B		9:15 AM	10:00 AM
1	C		10:30 AM	11:15 AM
1	D		11:45 AM	12:30 PM
1	E		1:00 PM	1:45 PM
1	F		2:15 PM	3:00 PM
1	G		3:30 PM	4:15 PM
2	D		8:00 AM	8:45 AM
2	E		9:15 AM	10:00 AM
2	F		10:30 AM	11:15 AM
2	G		11:45 AM	12:30 PM
2	A		1:00 PM	1:45 PM
2	B		2:15 PM	3:00 PM
2	C		3:30 PM	4:15 PM

GPS RECEIVER REQUIREMENTS

- **Receiver dual-frequency (full wavelength L2)**
- **Calibrated Dual Frequency GPS Antenna (preferably with ground plane)**
- **Fixed-height tripods are preferred.**

H.I. DETERMINATION

- **It is crucial to determine antenna heights accurately**
  - **Record heights to 0.1 mm or 0.001 feet.**

- **You need to know the height above the monument to the Antenna Reference Point, usually the base of the pre-amplifier.**

H.I. MEASUREMENT

B-3. Antenna Height Measurement:

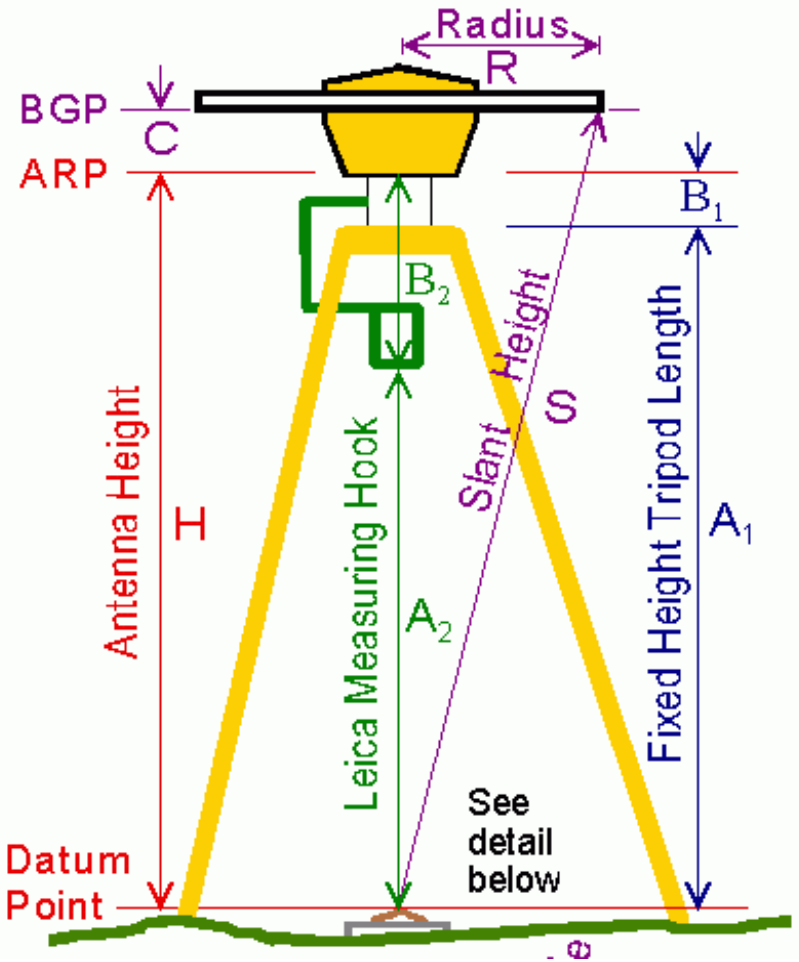
[antenna specifications] [top] [home]

The proper recordation of antenna height is critical. The Antenna Height used at NGS is the vertical distance between the station datum point and the Antenna Reference Point (ARP). Observers must carefully measure and check this height, and record and describe all measurements and antenna constants. Record all values to 0.0001 meters or 0.001 foot. All measurement computations must be checked and initialed by another person.

Fixed-height tripods simplify the measurement of antenna height **(H)**. The calibrated tripod height **(A)** should be checked with a quick measurement. Ensure that the antenna mates securely with the tripod head, and that any gap **(B)** between the tripod head and ARP is measured and included. The antenna height can then be computed from the following equation:

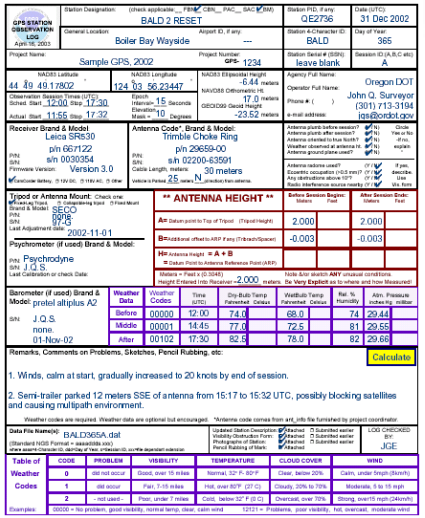
Antenna Height *H= (A + B) - Q*

NOTE: Leica antennas use a measuring hook to determine the vertical distance between the mark and antenna. Record the measured distance from the mark to the hook as A, and the offset from the hook to the ARP as B.



FIELD OBSERVATIONS

- **Observation logs**
  - Record station and observer information
  - Record complete receiver/antenna manufacturer, model part number, and serial numbers
  - Start and stop times
  - Record height of antenna
  - Record unusual conditions



GPS STATION OBSERVATION LOG — April 16, 2003

Station Designation: BALD 2 RESET			Station PID, if any: QE2736	Date (UTC): 31 Dec 2002
General Location: Boiler Bay Wayside	Airport ID, if any: ---		Station 4-Character ID: BALD	Day of Year: 365
Project Name: Sample GPS, 2002	Project Number: GPS- 1234		Station Serial # (SSN): leave blank	Session ID (A,B,C etc): A
NAD83 Latitude: 44 39 49.17802	NAD83 Longitude: 124 03 56.23447	NAD83 Ellipsoidal Height: -6.44 meters	Agency Full Name: Oregon DOT	
Observation Session Times (UTC): Sched. Start 12:00 Stop 17:30; Actual Start 11:55 Stop 17:32	Epoch Interval= 15 Seconds; Mask = 10 Degrees	NAVD88 Orthometric Ht: 17.0 meters; GEOID99 Geoid Height: -23.52 meters	Operator Full Name: John Q. Surveyor; Phone # ( ) (301) 713-3194; e-mail address: jqs@ordot.gov	
Receiver Brand & Model: Leica SR530; P/N p/n 667122; S/N s/n 0030354; Firmware Version: Version 3.0; Include Battery: ☑ 12V DC ☐ 115V AC ☐ Other	Antenna Code*, Brand & Model: Trimble Choke Ring; P/N p/n 29659-00; S/N s/n 02200-63591; Cable Length, meters: 30 meters; Vehicle is Parked: 25 meters N (direction) from antenna.		Antenna mount before session? ☑ Y ☐ N; Antenna plumb after session? ☑ Y ☐ N; Antenna oriented to true North? ☑ Y ☐ N; Weather observed at antenna Ht. ☑ Y ☐ N; Antenna ground plane used? ☐ Y ☑ N; Antenna radome used? ☑ Y ☐ N; Eccentric occupation (>0.5 mm)? ☐ Y ☑ N; Any obstructions above 10°? ☐ Y ☑ N; Radio interference source nearby ☐ Y ☑ N	Circle Yes or No; if no, explain. If yes, describe. Use Misc. form.
Tripod or Antenna Mount: Check one: ☑ Fixed Leg Tripod ☐ Collapsing/Swing Tripod ☐ Fixed Mount; Brand & Model: SECO; P/N 9743; S/N; Last Adjustment date: 2002-11-01	** ANTENNA HEIGHT **: A= Datum point to Top of Tripod (Tripod Height) 2.000 / 2.000; B= Additional offset to ARP if any (Tribrach/Spacer) -0.003 / -0.003; HI= Antenna Height = A + B; = Datum Point to Antenna Reference Point (ARP)		Before Session Begins: Meters / Feet	After Session Ends: Meters / Feet
Psychrometer (if used) Brand & Model: Psychrodyne; P/N; S/N J.Q.S.; Last Calibration or check Date:	Meters = Feet x (0.3048); Height if Tilted into Receiver = 2.000 meters		Note A/or sketch ANY unusual conditions. Be Very Explicit as to where and how Measured!	

Barometer (if used) Brand & Model: protel altiplus A2	Weather Data	Weather Codes	Time (UTC)	Dry-Bulb Temp Fahrenheit	Dry-Bulb Temp Celsius	Wet-Bulb Temp Fahrenheit	Wet-Bulb Temp Celsius	Rel. % Humidity	Abs. Pressure inches Hg. millibar
S/N J.Q.S. none. 01-Nov-02	Before	00000	12:00	74.0		68.0		74	29.44
	Middle	00001	14:45	77.0		72.5		81	29.55
	After	00102	17:30	82.5		78.0		82	29.66

Remarks, Comments on Problems, Sketches, Pencil Rubbing, etc: Calculate

1. Winds, calm at start, gradually increased to 20 knots by end of session.

2. Semi-trailer parked 12 meters SSE of antenna from 15:17 to 15:32 UTC, possibly blocking satellites and causing multipath environment.

Weather codes are required. Weather data are optional but encouraged. *Antenna code comes from ant_info file furnished by project coordinator.

Data File Name(s): BALD365A.dat (Standard NGS Format = aaaadddx.xxo); Updated Station Description ☑ Attached ☐ Submitted earlier; Visibility Obstruction Form: ☑ Attached ☐ Submitted earlier; Photographs of Station: ☑ Attached ☐ Submitted earlier; Pencil Rubbing of Mark: ☑ Attached ☐ Submitted earlier; LOG CHECKED BY: JQS

Table of Weather Codes	CODE	PROBLEM	VISIBILITY	TEMPERATURE	CLOUD COVER	WIND
	0	did not occur	Good, over 15 miles	Normal, 32° F- 80°F	Clear, below 20%	Calm, under 5mph (8km/h)
	1	did occur	Fair, 7-15 miles	Hot, over 80°F (27 C)	Cloudy, 20% to 70%	Moderate, 5 to 15 mph
	2	- not used -	Poor, under 7 miles	Cold, below 32° F (0 C)	Overcast, over 70%	Strong, over15 mph (24km/h)

Examples: 00000 = No problem, good visibility, normal temp, clear, calm wind 12121 = Problems, poor visibility, hot, overcast, moderate wind

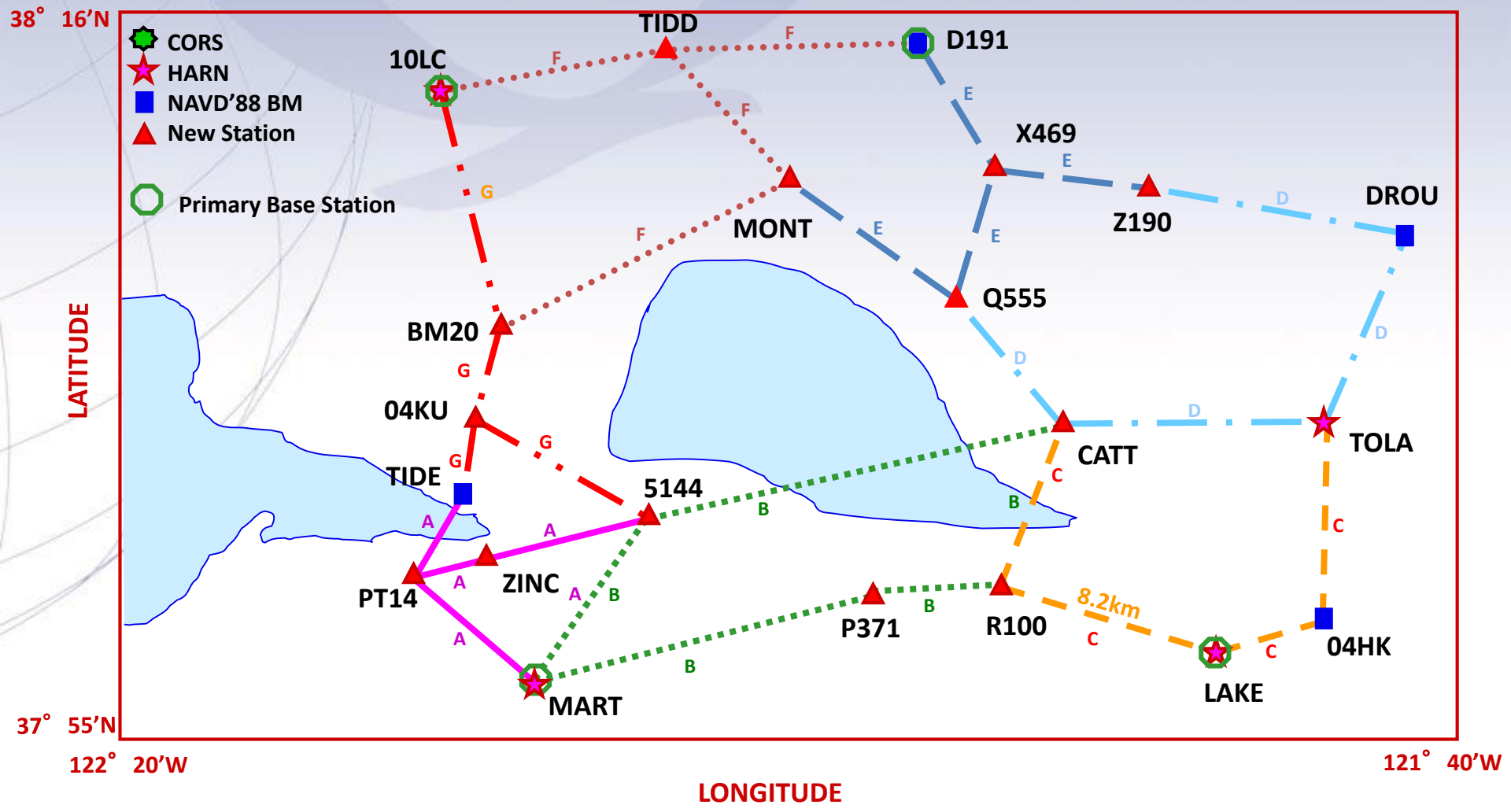
- **Obtain a clear station photograph**
  - Close-up photo of mark
  - Horizon view

Vector Processing Controls

- **Elevation Mask - 15 degrees**
- **Ephemeris - Precise**
- **Iono Corrections - All baselines ≥ than 5 km.**
- **Fix Integers**
  - **Baselines ≤ 5km: L1 fixed solution**
  - **Baselines ≥ 5 km: Iono free (L3) solution**

Analysis of the Data Processing

- Fixed solutions / low RMS (<1.5cm)
- Repeatability of measurements
- Analysis of loop misclosures
- Be aware that repeatability and loop misclosures do not disclose all problems



Repeat Base Lines

Repeat Vector Analysis

From Station	To Station	Session	dh Meters	Diff cm	Dist Meters	RMS	Solution Type
BM20	04KU	078G	45.974*		3628	0.016	L1 float double
		077G	46.004	-3.0		0.017	L1 fixed double
		076G	46.009	-3.5		0.015	L1 fixed double
ZINC	PT14	078A	15.397		3173	0.006	L1 fixed double
		077A	15.400	0.3		0.006	L1 fixed double
		076A	15.408	1.1		0.006	L1 fixed double
TIDE	04KU	078G	43.680		3133	0.022	L1 fixed double
		077G	43.654*	2.6		0.024	L1 fixed double
		076G	43.607*	7.3		0.020	L1 fixed double
PT14	TIDE	078A	-54.703*		3765	0.047	L1 fixed double
		077A	-55.031	-32.8		0.022	L1 fixed double
		076A	-55.007*	-30.4		0.019	L1 fixed double
04KU	5144	078G	28.939		7250	0.014	Iono free fixed
		077G	28.947	-0.8		0.014	Iono free fixed
		076G	28.940	-0.1		0.020	Iono free fixed
5144	ZINC	078A	-33.045		6167	0.011	Iono free fixed
		077A	-33.051	-0.6		0.009	Iono free fixed
		076A	-33.063	-1.8		0.013	Iono free fixed

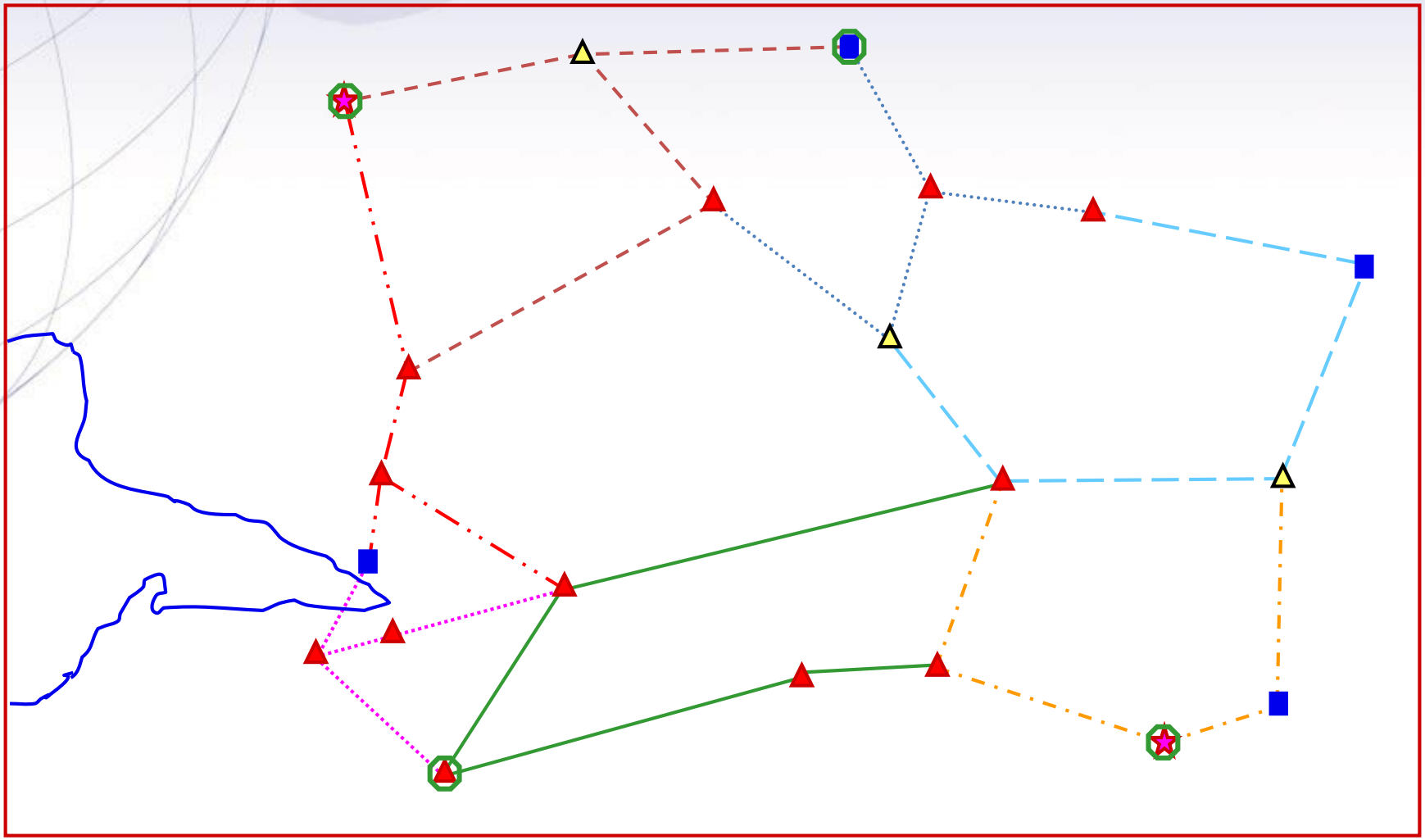
*NOTE - Reprocess all vectors which have difference greater than 2 cm.

Repeat Vector Analysis After Re-Processing

From Station	To Station	Session	dh Meters	Diff cm	Dist Meters	RMS	Solution Type
BM20	04KU	076G	46.009		3628	0.015	L1 fixed double
		077G	46.004	0.5		0.017	L1 fixed double
		078G	46.007	0.2		0.015	L1 fixed double
ZINC	PT14	078A	15.397		3173	0.006	L1 fixed double
		077A	15.400	0.3		0.006	L1 fixed double
		076A	15.408	1.1		0.006	L1 fixed double
TIDE	04KU	078G	43.680	Reject	3133	0.022	L1 fixed double
		077G	43.654	2.6		0.024	L1 fixed double
		076G	43.658	2.2		0.020	L1 fixed double
PT14	TIDE	077A	-55.031		3765	0.022	L1 fixed double
		078A	-55.027	0.4		0.023	L1 fixed double
		076A	-55.019	1.2		0.018	L1 fixed double
04KU	5144	078G	28.939		7250	0.014	Iono free fixed
		077G	28.947	-0.8		0.014	Iono free fixed
		076G	28.940	-0.1		0.020	Iono free fixed
5144	ZINC	078A	-33.045		6167	0.011	Iono free fixed
		077A	-33.051	-0.6		0.009	Iono free fixed
		076A	-33.063	-1.8		0.013	Iono free fixed

*NOTE - Reprocessed vectors which had differences greater than 2 cm.

Adjustment Guidelines



Least Squares Adjustments

- The adjustment minimizes the effects of random errors
- A least squares adjustment computes a single network solution, even with redundant vectors
- Least squares will highlight blunders and large errors
- It will provide estimates on the precision of the coordinates for the stations

Horizontal Adjustments

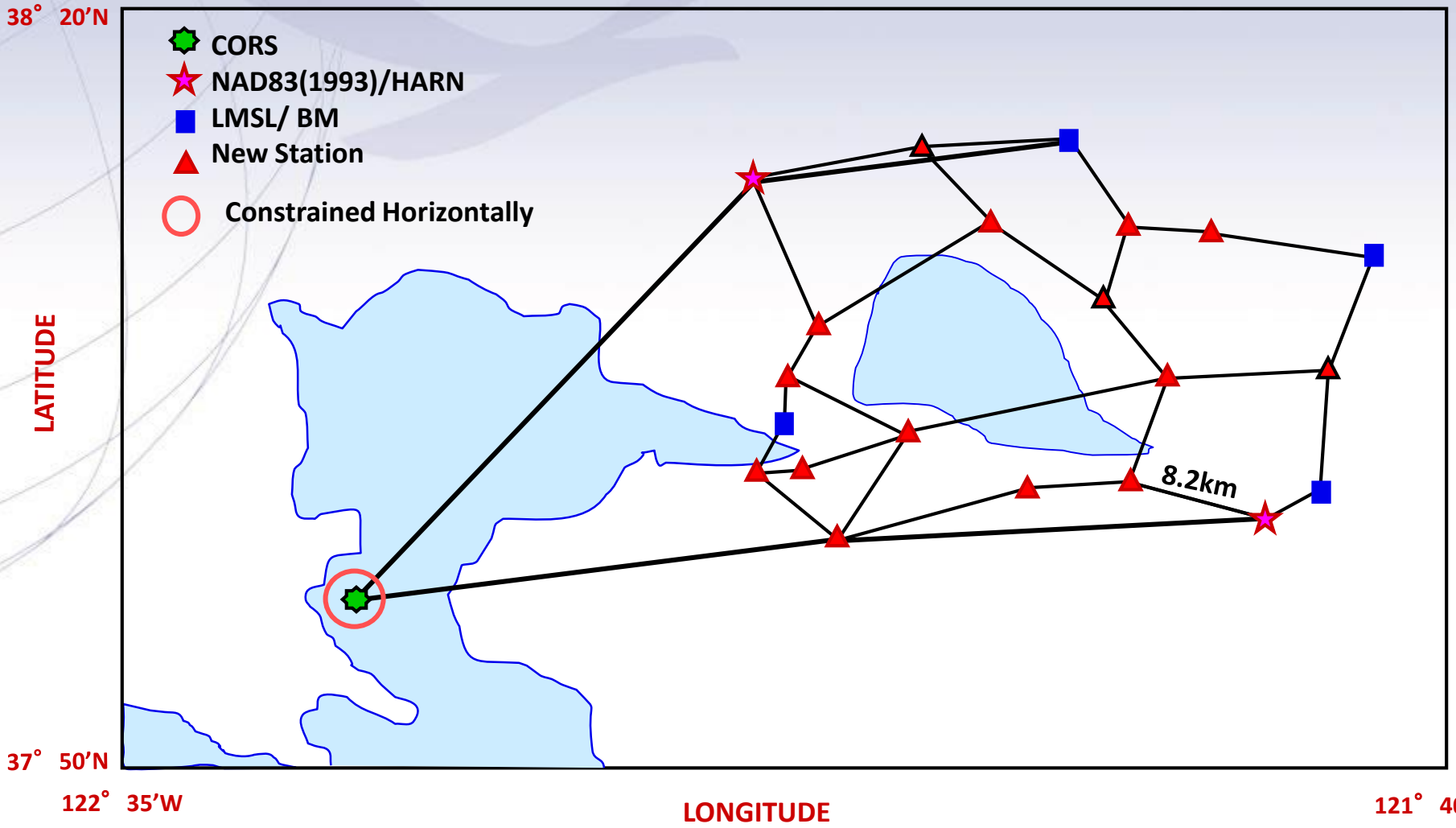
Horizontal Adjustment

(Latitude, Longitude, Ellipsoid Heights)

- **Minimum Constrained [One fixed station]**
  - Fix latitude, longitude and ellipsoid height at one station
  - Resolve all blunders and large residuals
  - Determine which Control and known station coordinates should be fixed
- **Constrained [All suitable stations fixed]**
  - Fix latitude, longitude, and ellipsoid heights at Control and known Stations
  - Make sure the constraints did not distort the project

NOTE - Geoid model NOT applied at this time

Free Horizontal Adjustment

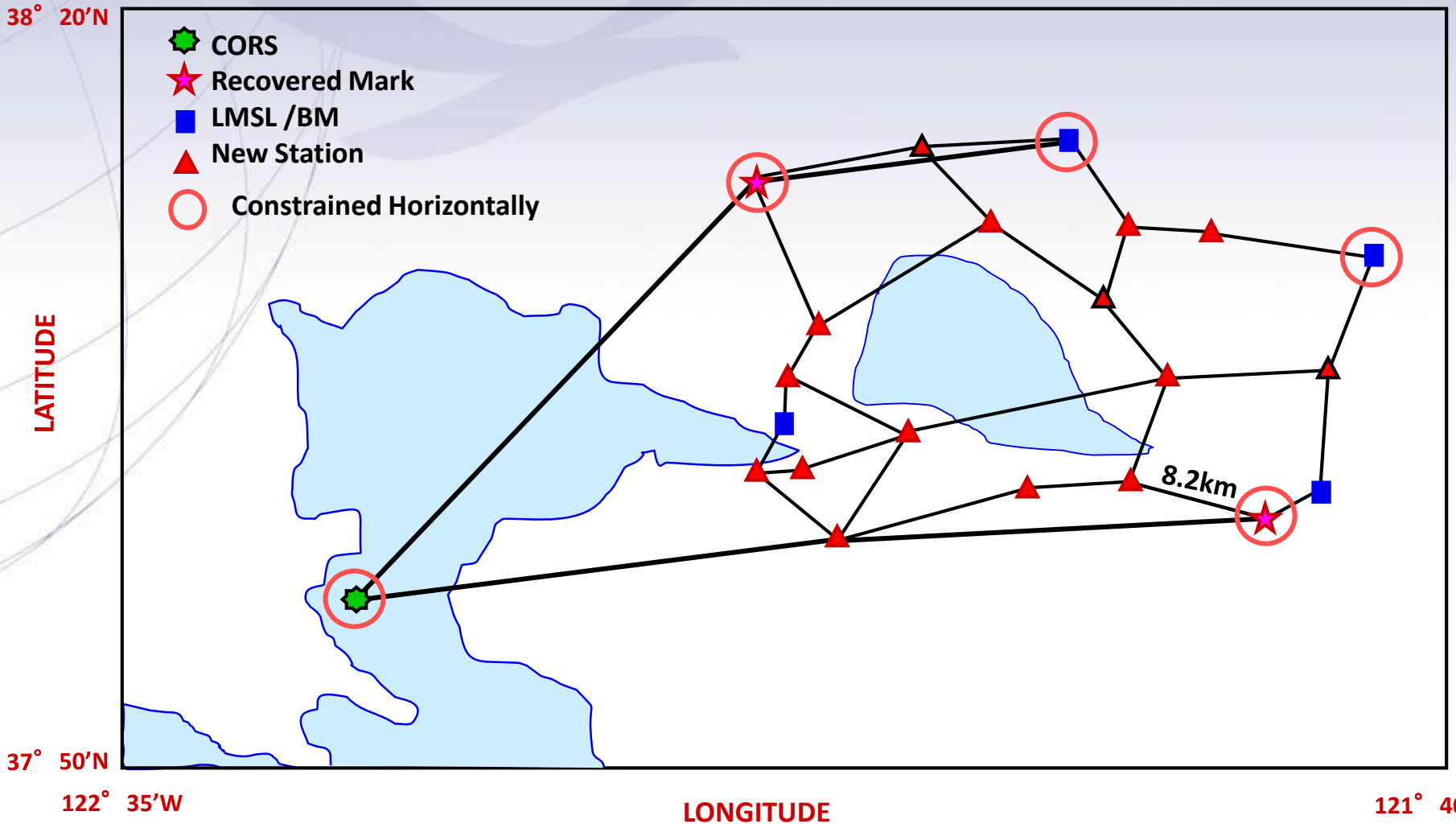


One Control horizontal

latitude, longitude, and ellipsoid heights

No LSML orthometric heights constrained at this time

Constrained Horizontal Adjustment



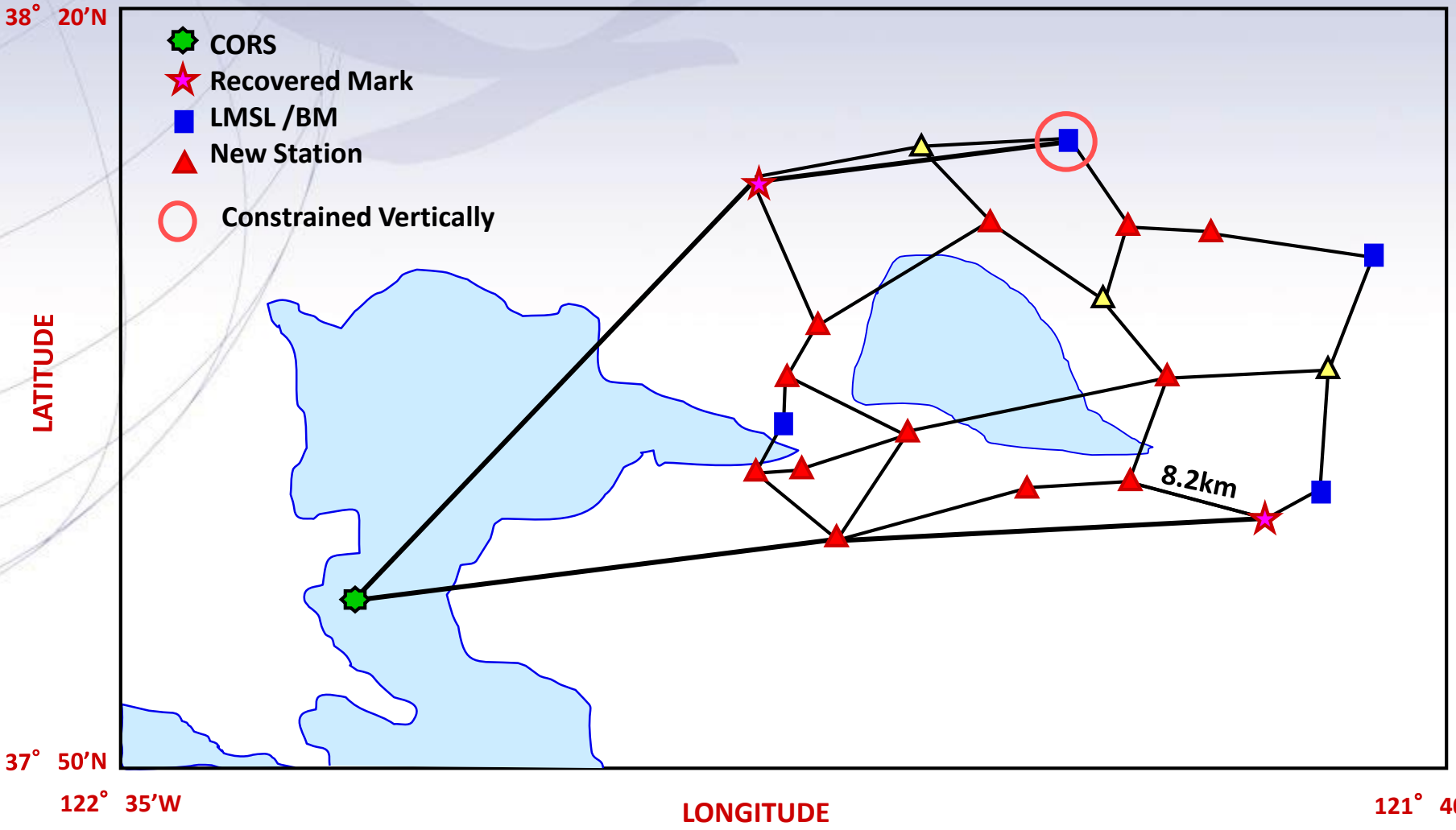
Existing Control horizontal
latitude, longitude, and ellipsoid heights
No LSML orthometric heights constrained at this time

Vertical Adjustment

3-D Vertical Adjustment (Orthometric Heights)

- Apply the Latest Geoid Model
- Minimum Constrained [One fixed station]
  - Fix latitude, longitude, and orthometric height at one station
  - Resolve all blunders and large residuals
  - Compare orthometric heights from adjustment with published bench marks
  - Determine which bench marks should be fixed
- Constrained [All suitable orthometric heights fixed]
  - Fix latitude, longitude at one station
  - Fix orthometric heights at all suitable stations
  - Make sure the constraints did not distort the project

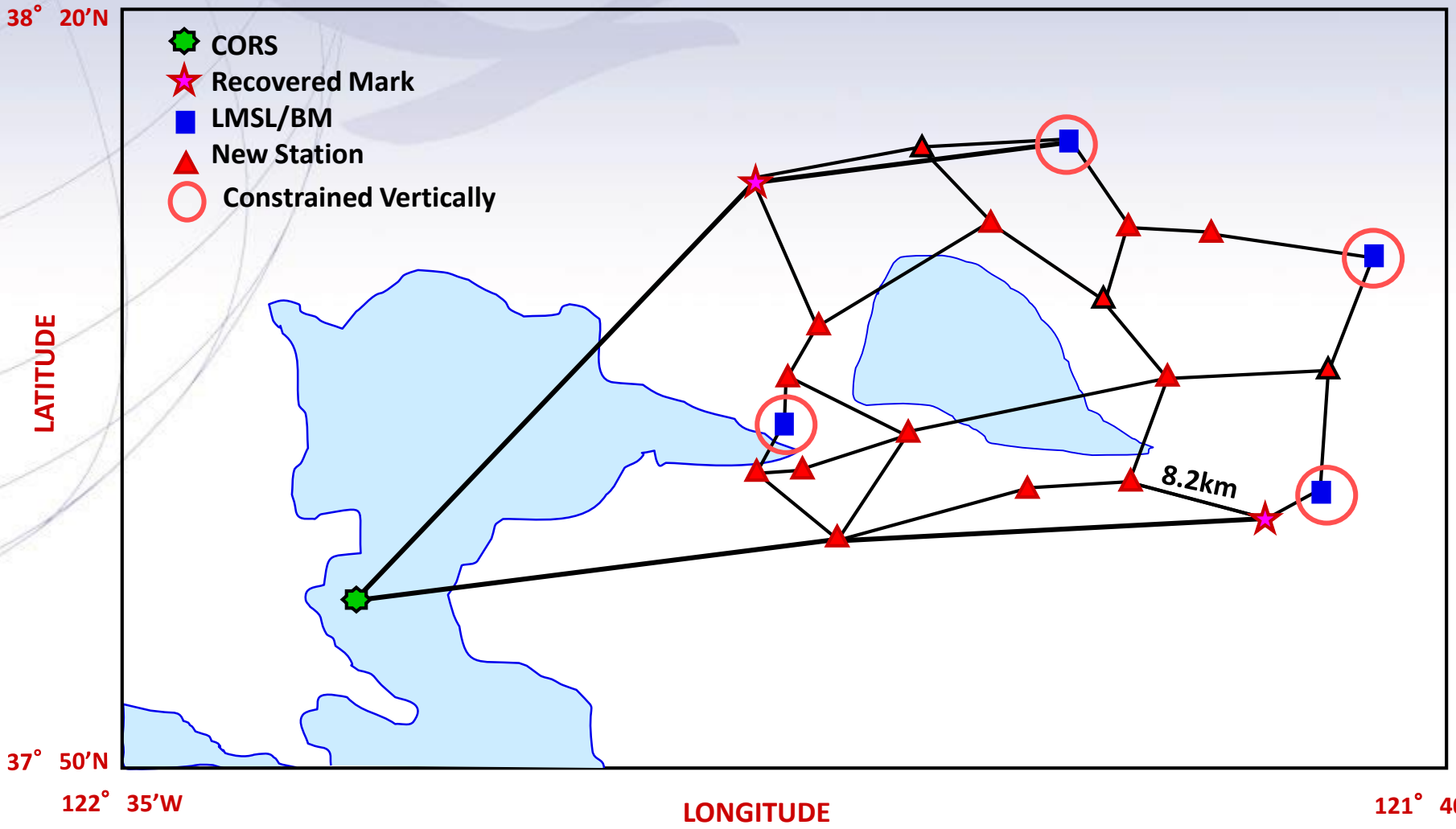
Minimally Constrained Vertical Adjustment



1 horizontal latitude and longitude

1 Local Mean Sea Level (LMSL) orthometric heights

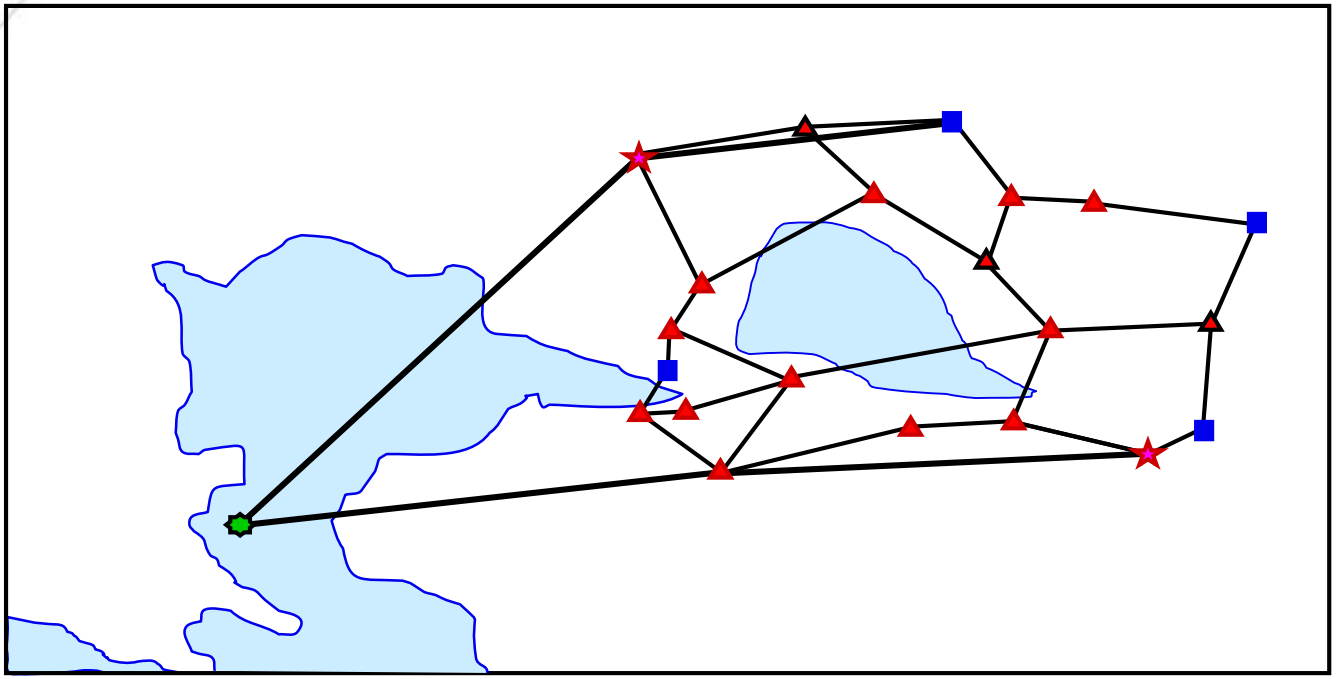
Constrained Vertical Adjustment



1 horizontal latitude and longitude
All valid orthometric heights fixed

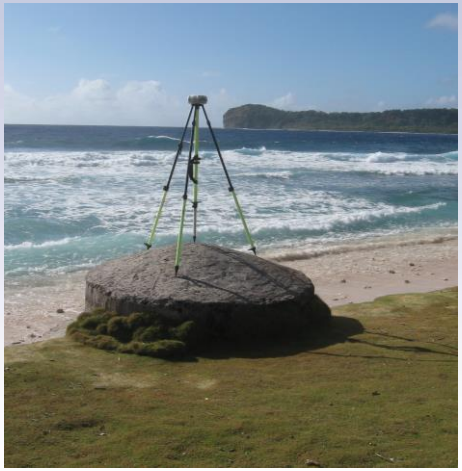
Final Products

- **Horizontal Constrained Adjustment (Latitude, Longitude, and Ellipsoid Heights)**
- **3D Vertical Constrained Adjustment (Orthometric Heights)**



Summary

- Mistakes and systematic errors must be removed before the adjustment
- A least squares adjustment handles random errors and provides a single solution
- The Minimally Constrained adjustment checks the internal consistency of the network
- The Constrained adjustment checks the existing control and references the network to the datum
- The vertical adjustment estimates GPS-derived Orthometric heights



Mahalo - Questions ????