

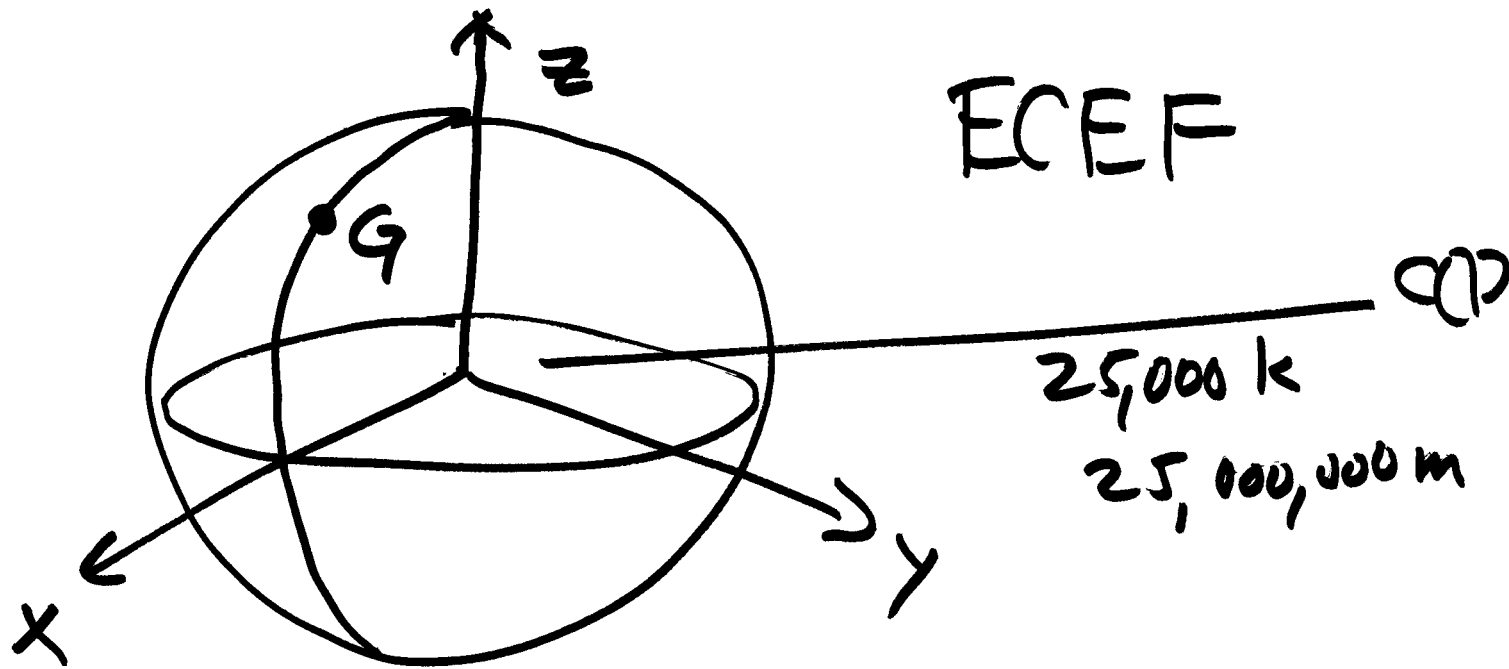
$$F = PR_{CORR} - \left[ (X_R - X_S)^2 + (Y_R - Y_S)^2 + (Z_R - Z_S)^2 \right]^{1/2} - c \cdot DT_R$$

$$PR_{CORR} : PR_{RAW} + c \cdot dt_s \quad \left[ \begin{array}{c} \text{GPS} \\ \text{Pseudorange} \\ \text{Model} \end{array} \right]$$

4 parameters  $X_R Y_R Z_R DT_R$

Recommend Km,  $\mu\text{sec}$  ( $10^{-6}\text{sec}$ )

Need unique  $DT_R$  parameter for each epoch. = time



$$\begin{bmatrix} \Delta X_R \\ \Delta Y_R \\ \Delta Z_R \\ \Delta DTR \end{bmatrix}$$

parameter  
vector

$$\Sigma \begin{bmatrix} \sigma_x^2 & & & \\ & \sigma_y^2 & & \\ & & \sigma_z^2 & \\ & & & \sigma_{DT}^2 \end{bmatrix}$$

CORS : (NGS) Continuously Operating<sup>25-3</sup>  
Reference Stations

www.ngs.noaa.gov/CORS

PRDU306a.zip

Station

name

001 · 002 · ...

day#

a : midnight → 1 am

b : 1 am - 2 am

:

x : 23 - 24

# ephemeris data

ig5 15036 .5p3 .97

r: rapid  
u: ultra  
s: final

week #

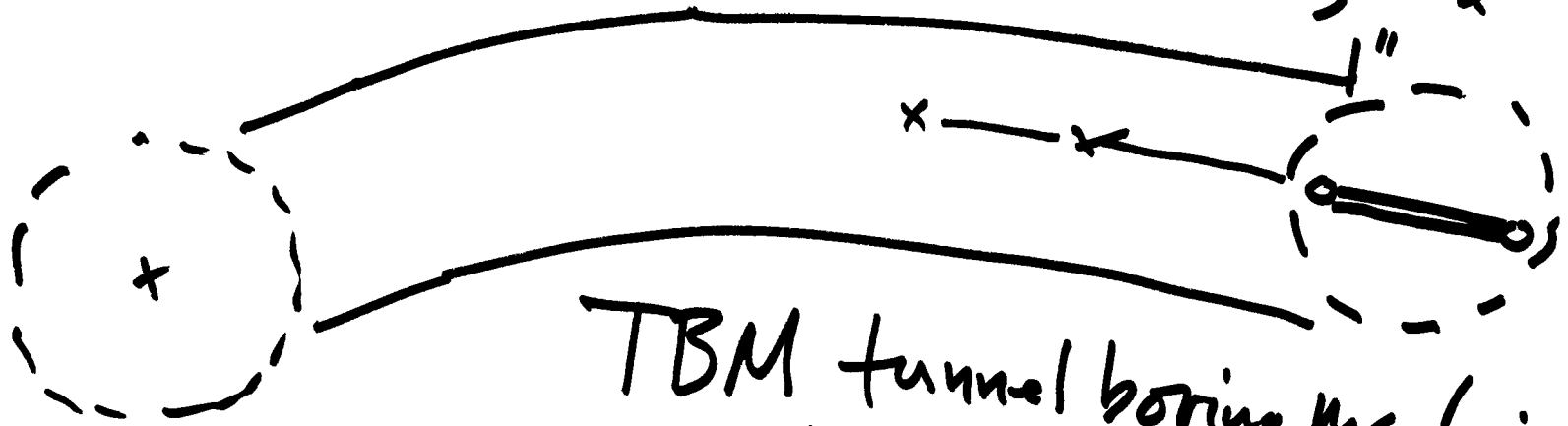
eph

day #

Sunday = 0

Sat = 6

PREANALYSIS : tunneling project



TBM tunnel boring machines  
provide direction + positions  
for TBM

short baseline  
yields poor error prop  
for azimuth extension ↴



PREANALYSIS

↑ longer baseline better if can use it

PRECISION (error ellipse) from

$$\Sigma_{\Delta\Delta}, Q_{\Delta\Delta} + \sigma_0^2, N^{-1}, \underline{\underline{BTWB}}$$

l missing

what is in B?

+ triangulation, + trilateration

traverse, ...

$$\frac{\partial F}{\partial x} \quad \frac{\partial F}{\partial y} \quad \frac{\partial F}{\partial z}$$

25-7

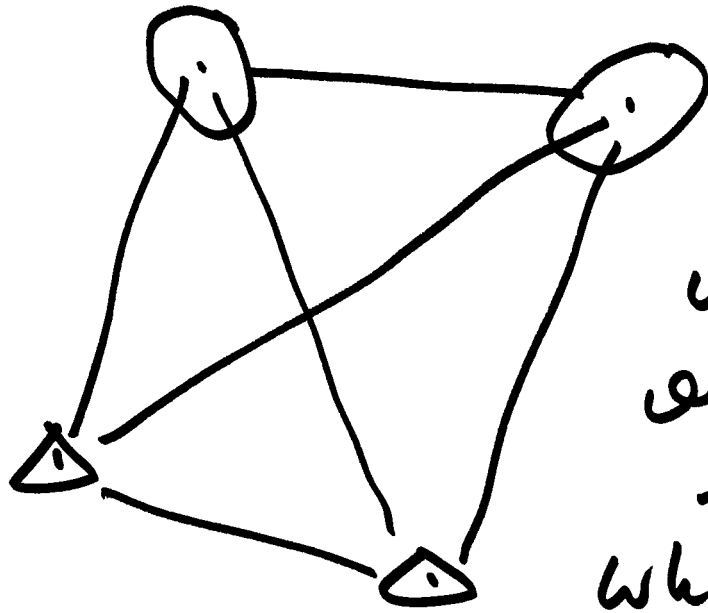
$$\frac{\partial F}{\partial p} : \frac{x_j - x_i}{D_{ij}}, \frac{x_j - x_i}{D_{ij}^2}, \text{ or something like that}$$

$$D_{ij} = \left[ (x_j - x_i)^2 + (y_j - y_i)^2 \right]^{1/2}$$

only point coordinates  
NO actual observations

$$W : \frac{\sigma_0^2}{\sigma_i^2}$$

$$N = B^T W B, \quad \bar{N}^{-1} = Q_{00}, \quad \Sigma_{00} = \sigma_0^2 Q_{00}$$



90% conf. ellipses

what if size of  
error ellipses is  
too large?  
what to do?

1. Better precision instrument  $\rightarrow W: \frac{\sigma_i}{\sigma_i^2}$
2. more redundancy (improves precision)
3. stronger network



Blunder Detection

Outlier Detection

Robust Estimation

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Specific strategies to detect blunders

IRLS

iteratively reweighted LS

L1-norm minimization

Data snooping

IRLS

- Iterate until convergence with usual weight
- modify weights based on magn. of residual (std. resid.)

~~$\sigma_v$~~   $\frac{v}{\sigma_v}$  ←

$$\sigma_v = \sum_{vv}$$

$$\Sigma_{\infty}, \Sigma_{\hat{\beta}}, \Sigma_{vv}$$