

GPS
PASSIVE

DOT

24⊕

"FULL"
CONSTELLATION

RADIO SIGNAL

SPEED OF LIGHT

Atomic Clocks

TWICE
DAILY -
NOT...
GEOSYNCRONOUS

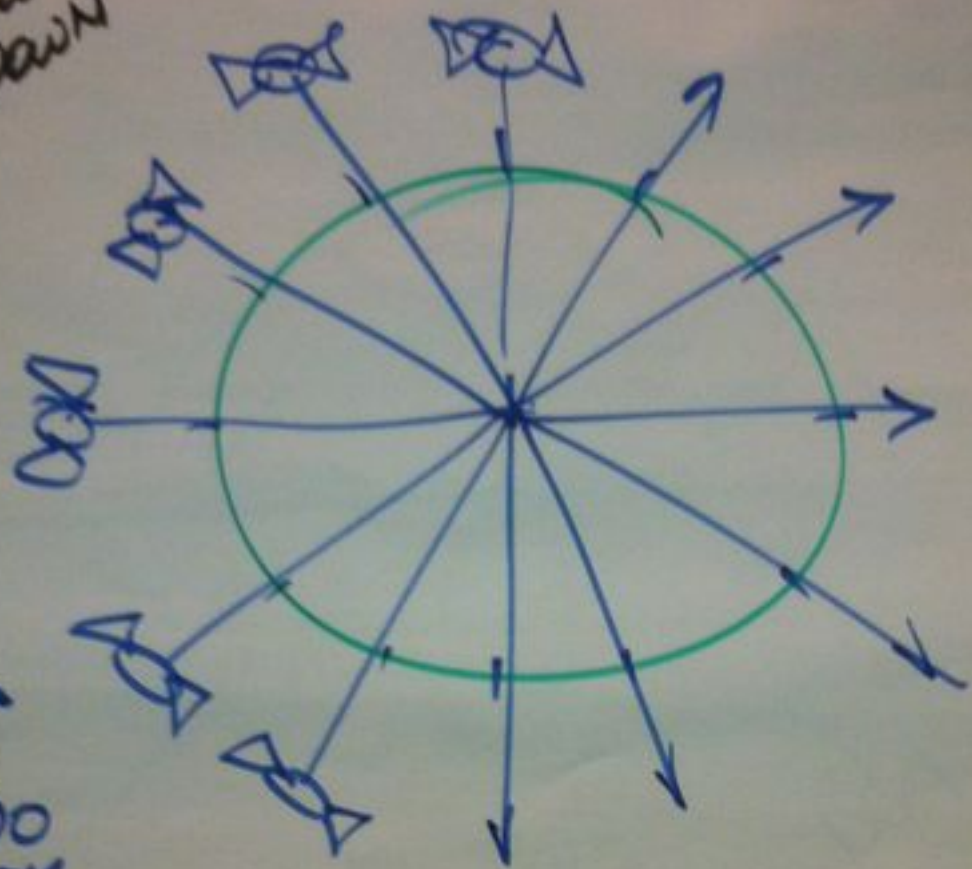
WHY?

- G - GPS
- N - GLONASS
- S - GALILEO
- S - COMPASS
- "BEIDOU"

"DGPS"

AUTONOMOUS - SINGLE RT - RELATIVE
STATIC - KIN - RTK

FRONT VIEW
LOOKING DOWN



PRN
PSEUDO
RANDOM
NOISE

ORBITAL PLANES

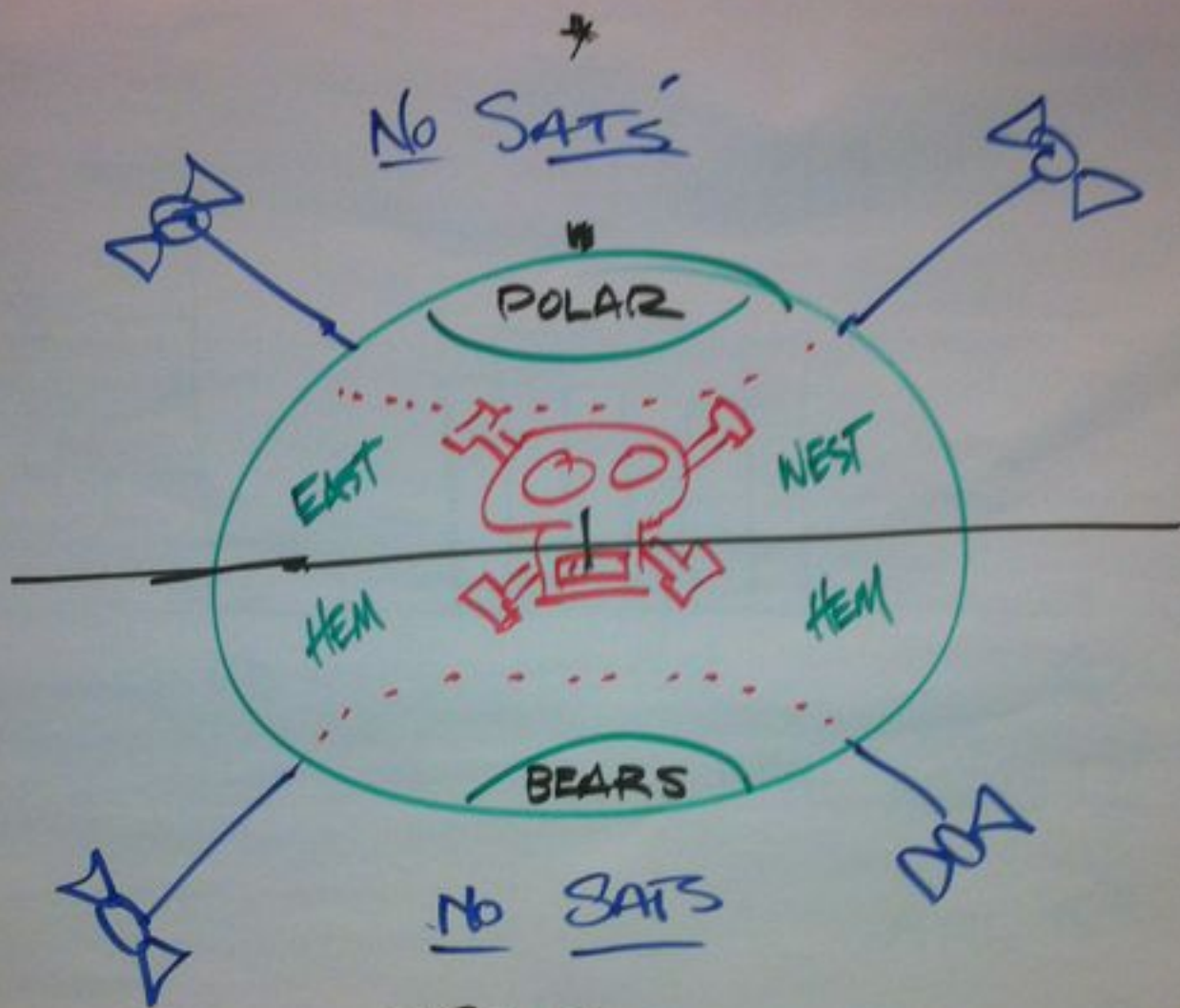
24 SATELLITES

FULL CONSTITUTION

MILITARY

SPS STANDARD CA CODE - PPS PRECISE P CODE

⊕ GLONASS ⊕ GALILEO ⊕ COMPASS



SPACE CONTROL USER } SEGMENT

MINIMUM 4

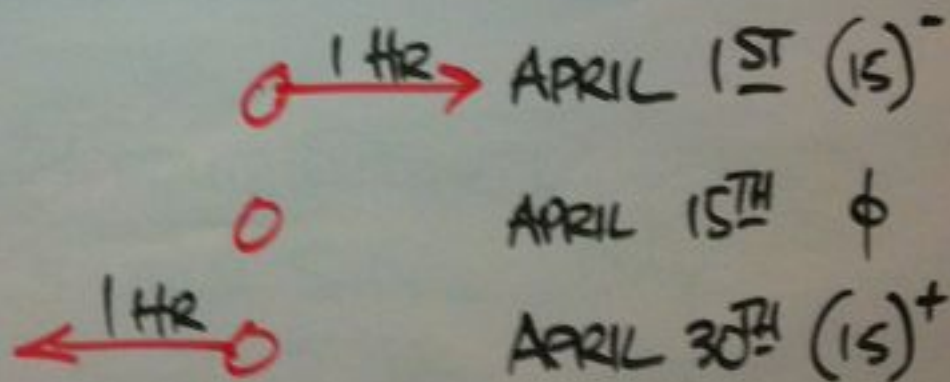
X-4-2- "TIME"



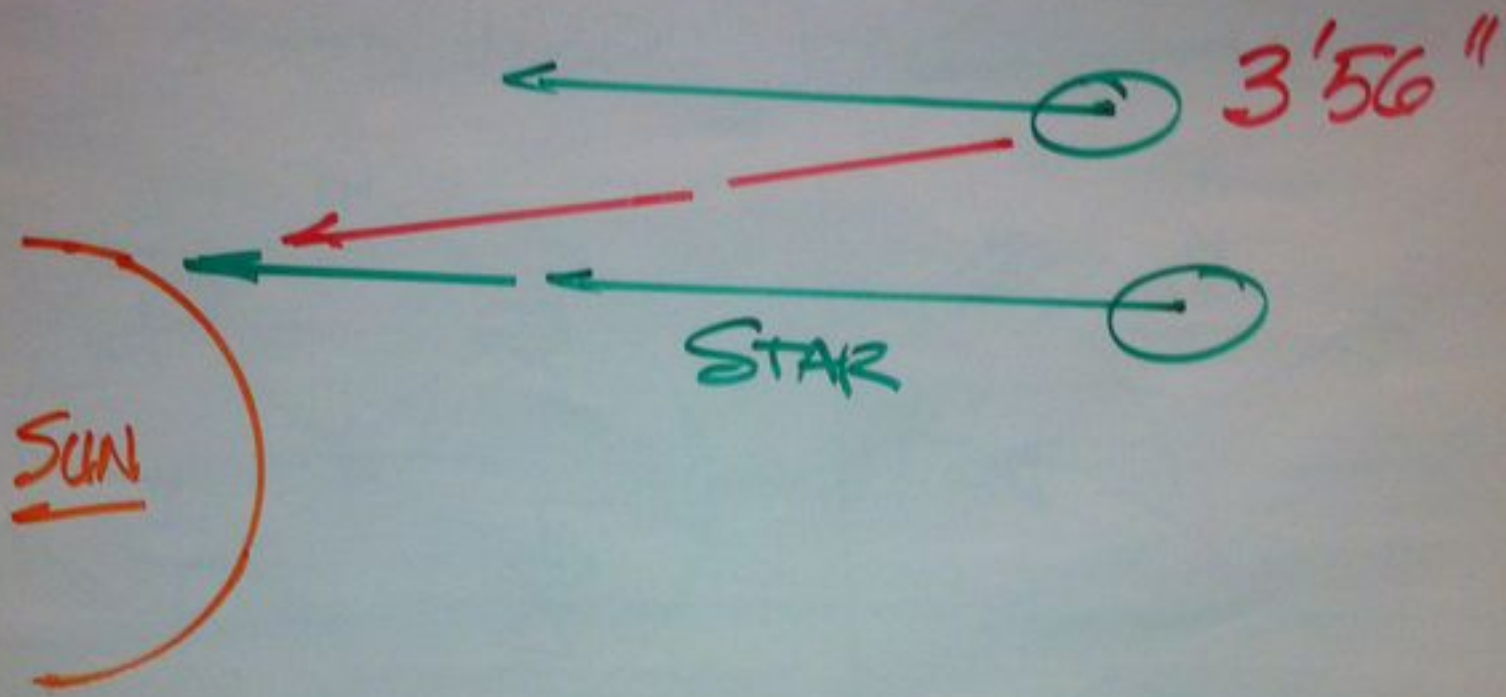
BPA
BAM
ARP

ERRORS

LOW-ORBIT - CLOCK - MULTIPATH - ANTENNA

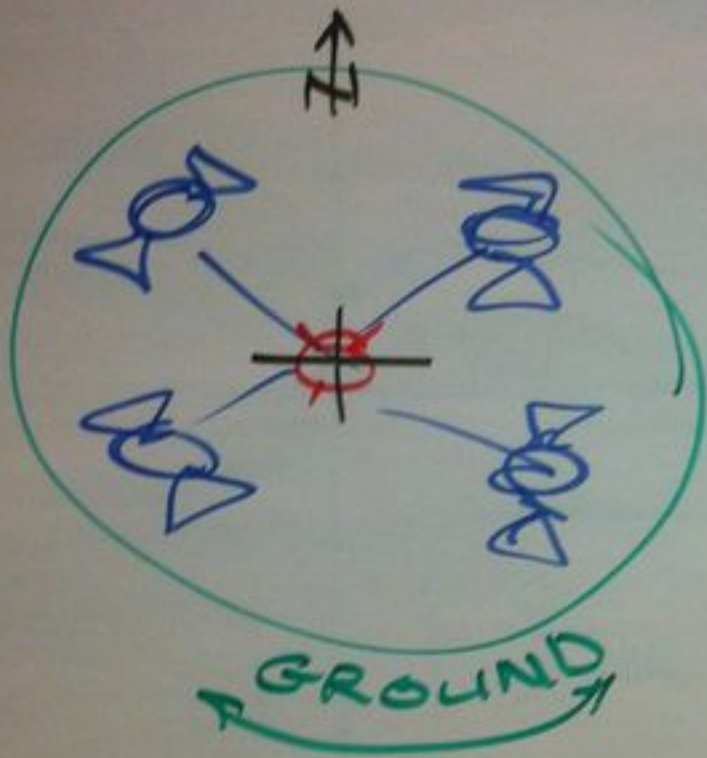


BLOCK OF SATELLITES
 BROADCAST EPHEM
 ALMANAC
 PRECISE EPHEM



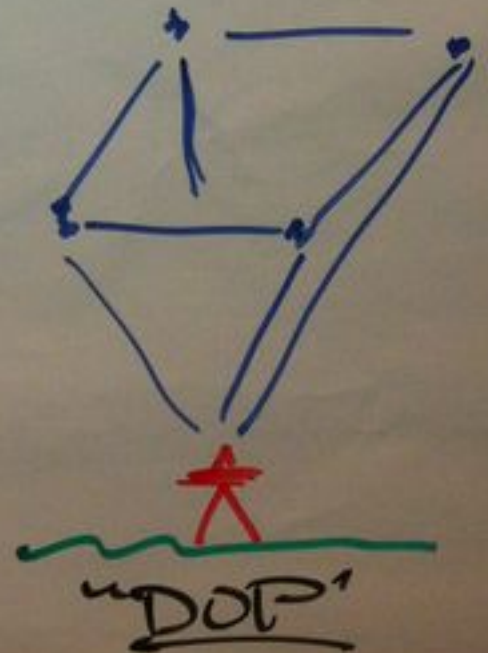
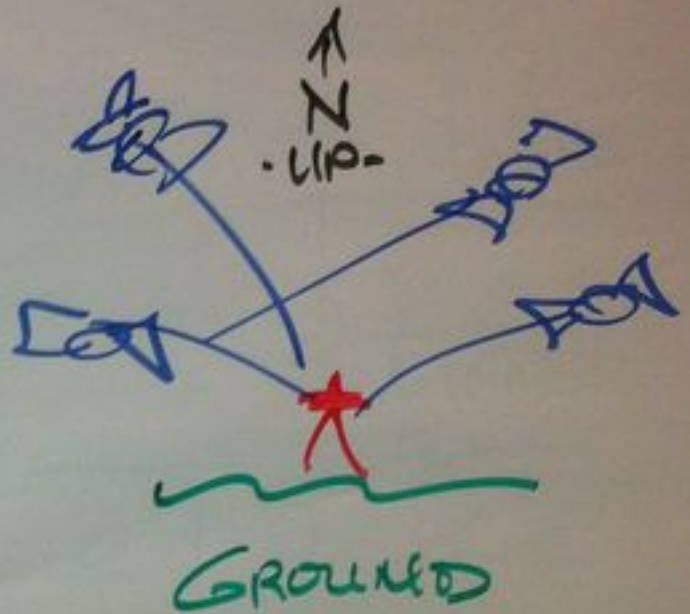
24 Hour SOLAR DAY
 - 4 min SIDER DAY
 STAR DAY

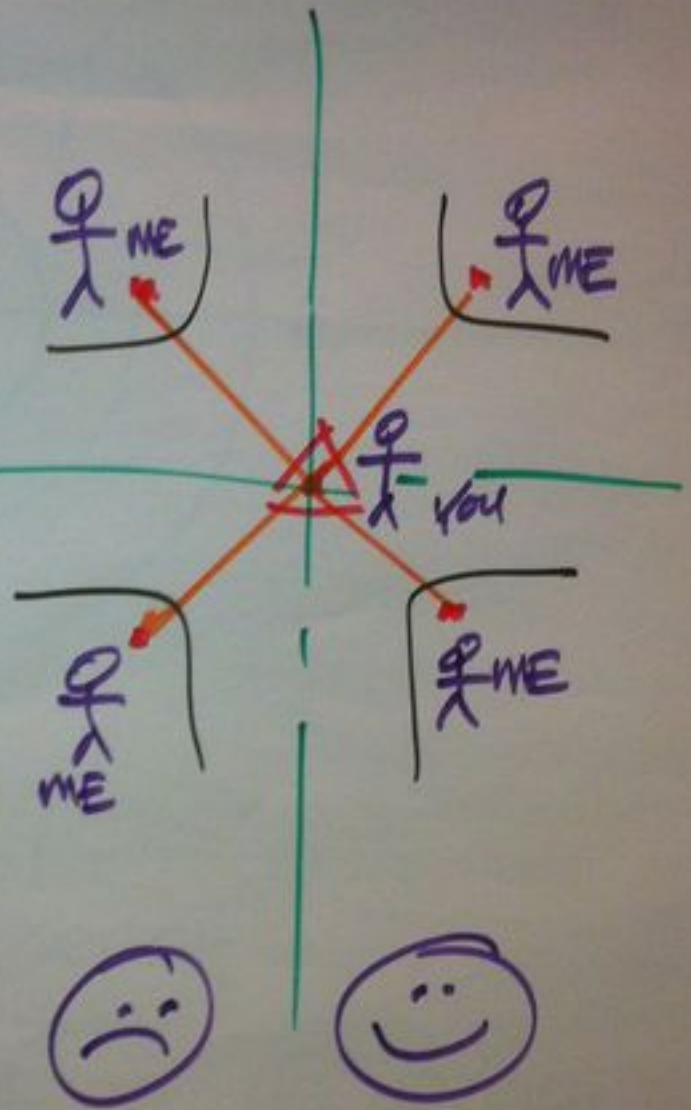
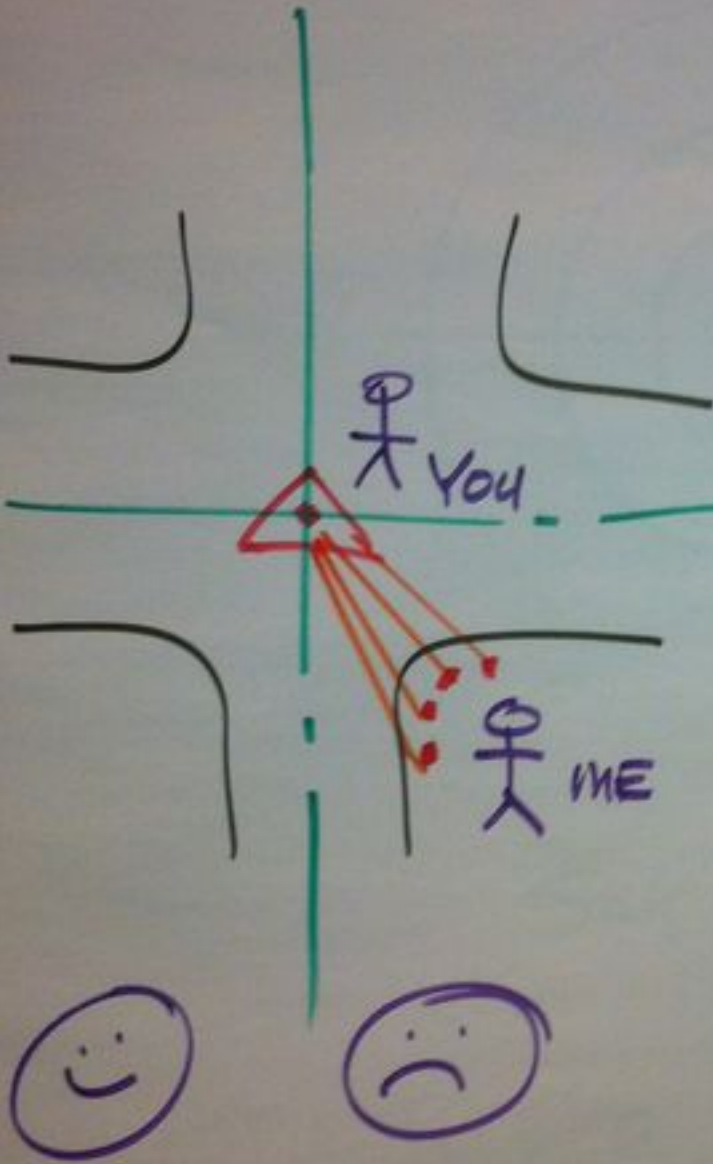
PLAN VIEW
"GOOD" HDOP

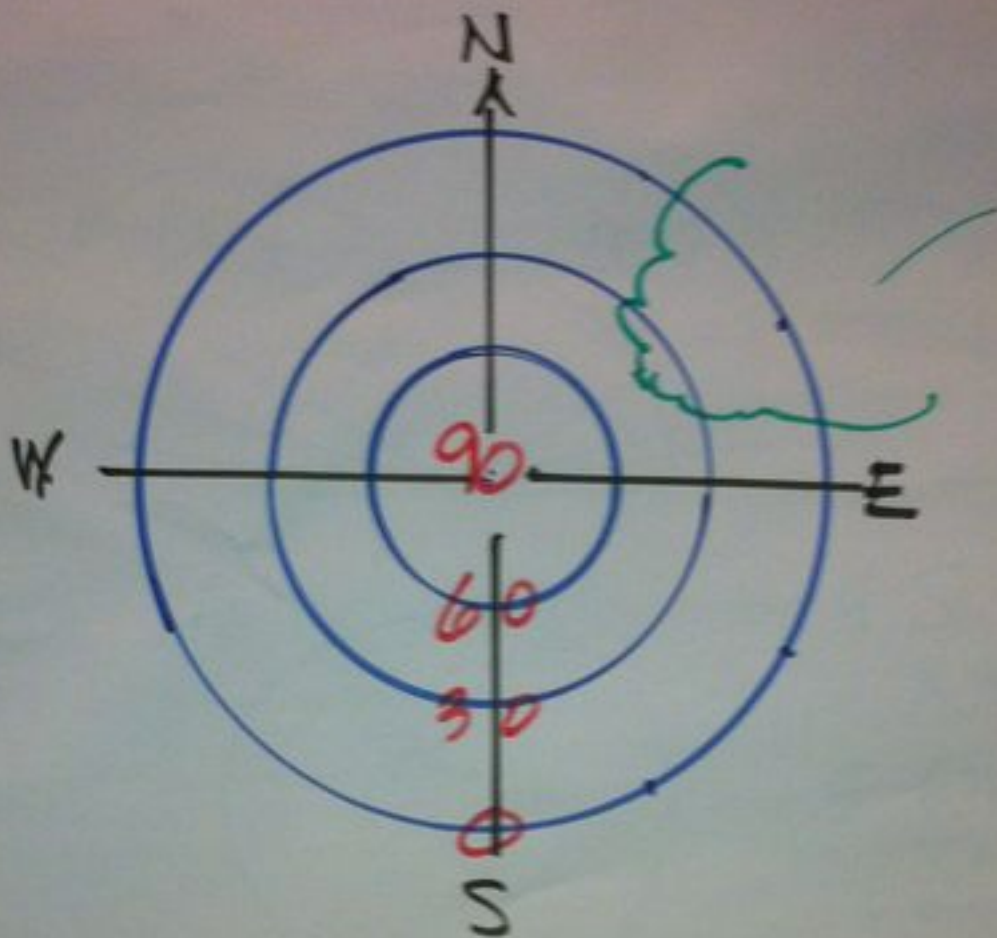


DOP
H DOP
V DOP
P DOP (3D)
E DOP (AN)

PROFILE VIEW
GOOD V DOP

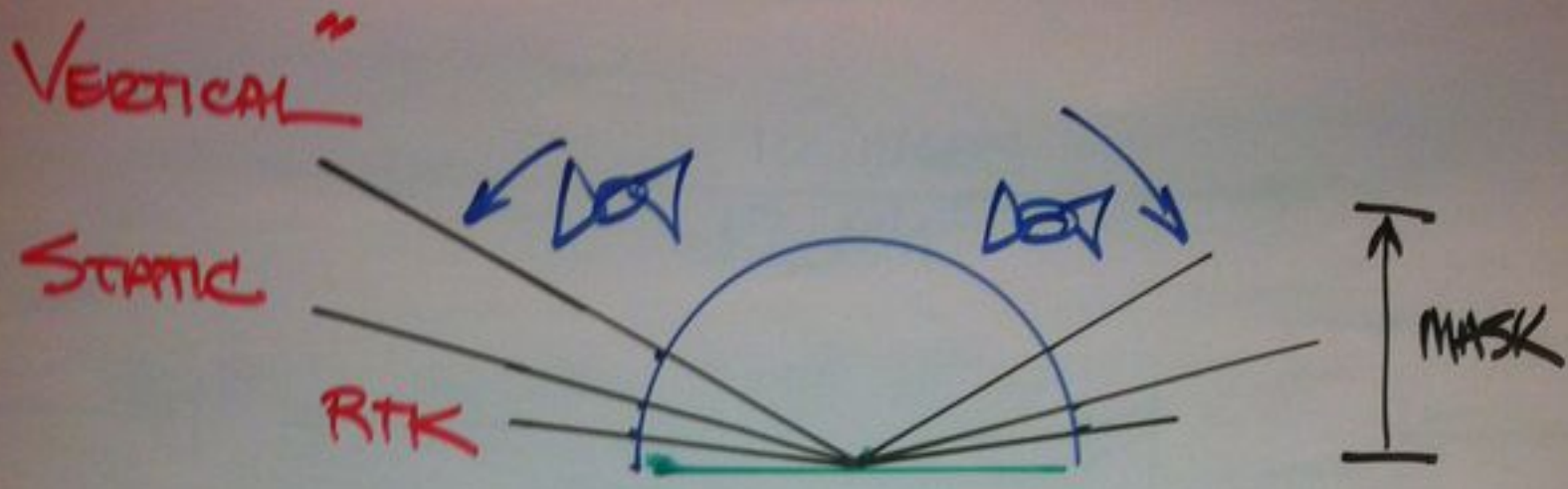






SKY PLOT
 VISI GRAPH

APPLE TREE @ 160° Az @ 40° UP/HIGH
 60-



4 SAT
 X 4 2 T
 5 RTK
 INIT



"MASK"
 HORIZON
 SATELLITE PLANNING
 MISSION PLANNING

10 MILES
17 KM

15 SEC



RTK

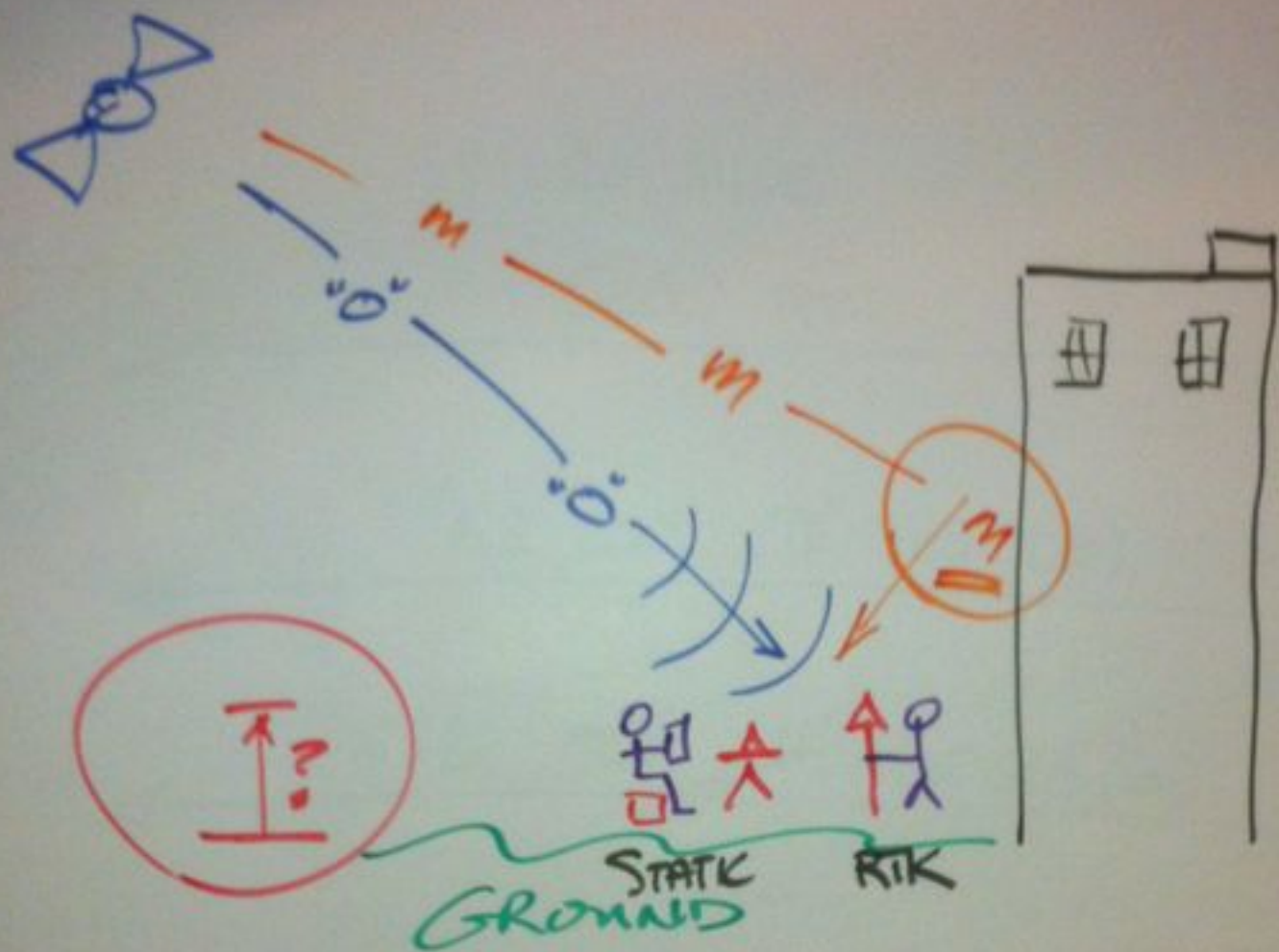
- 1.
- 2.
- 3.

15 MIN



STATIC

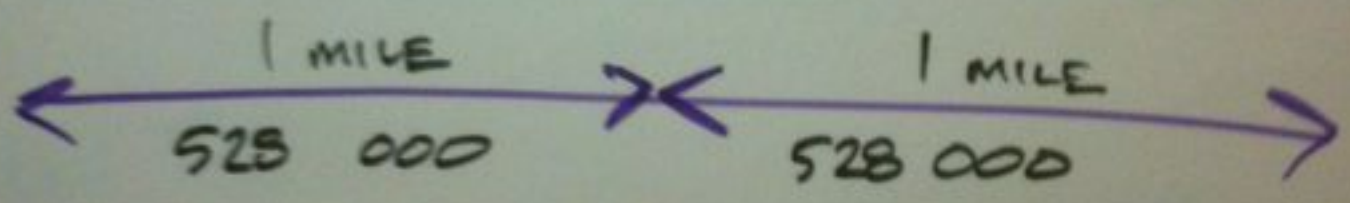
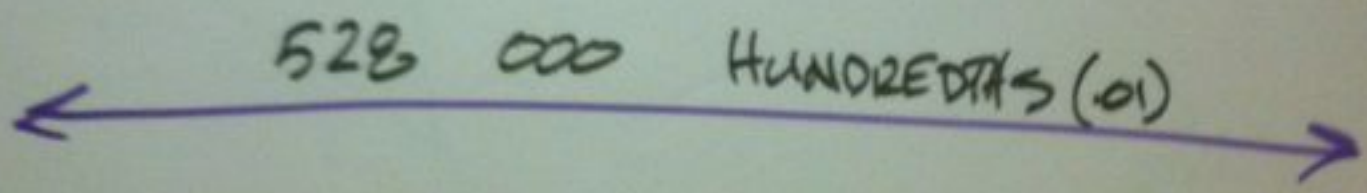
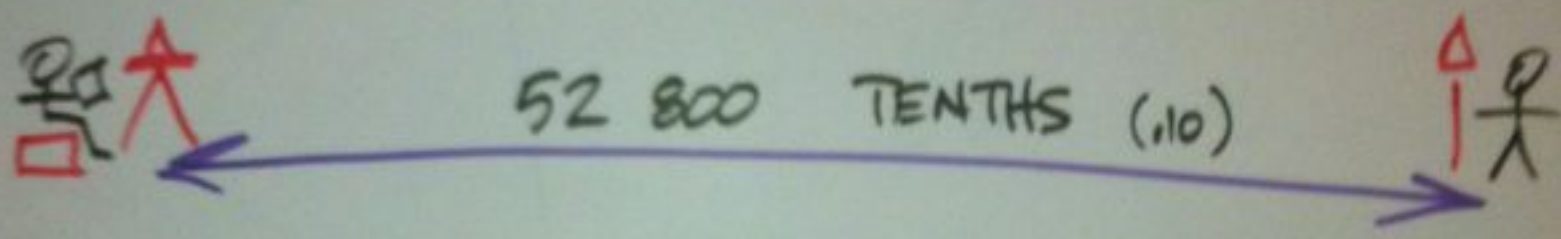
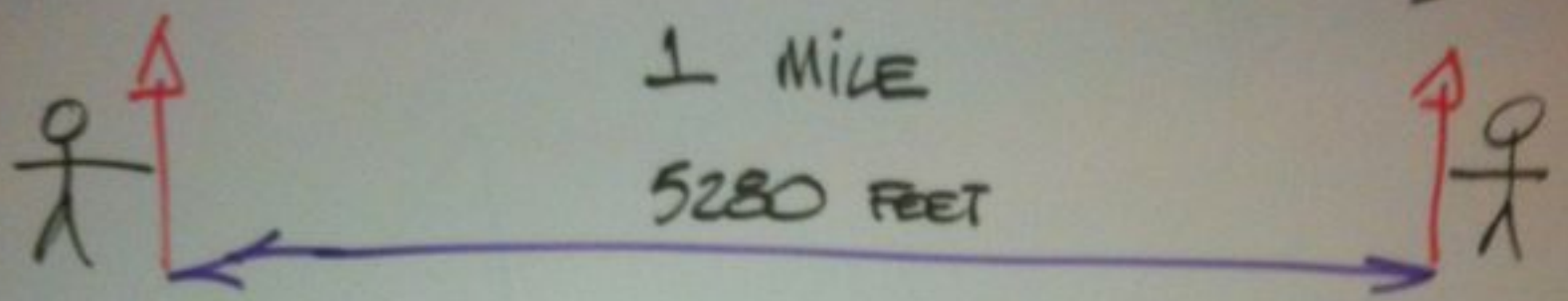
- 1.
- 2.
- 3.



LESS MULTI-PATH WITH MORE TIME
WITH MORE "DISTANCE"

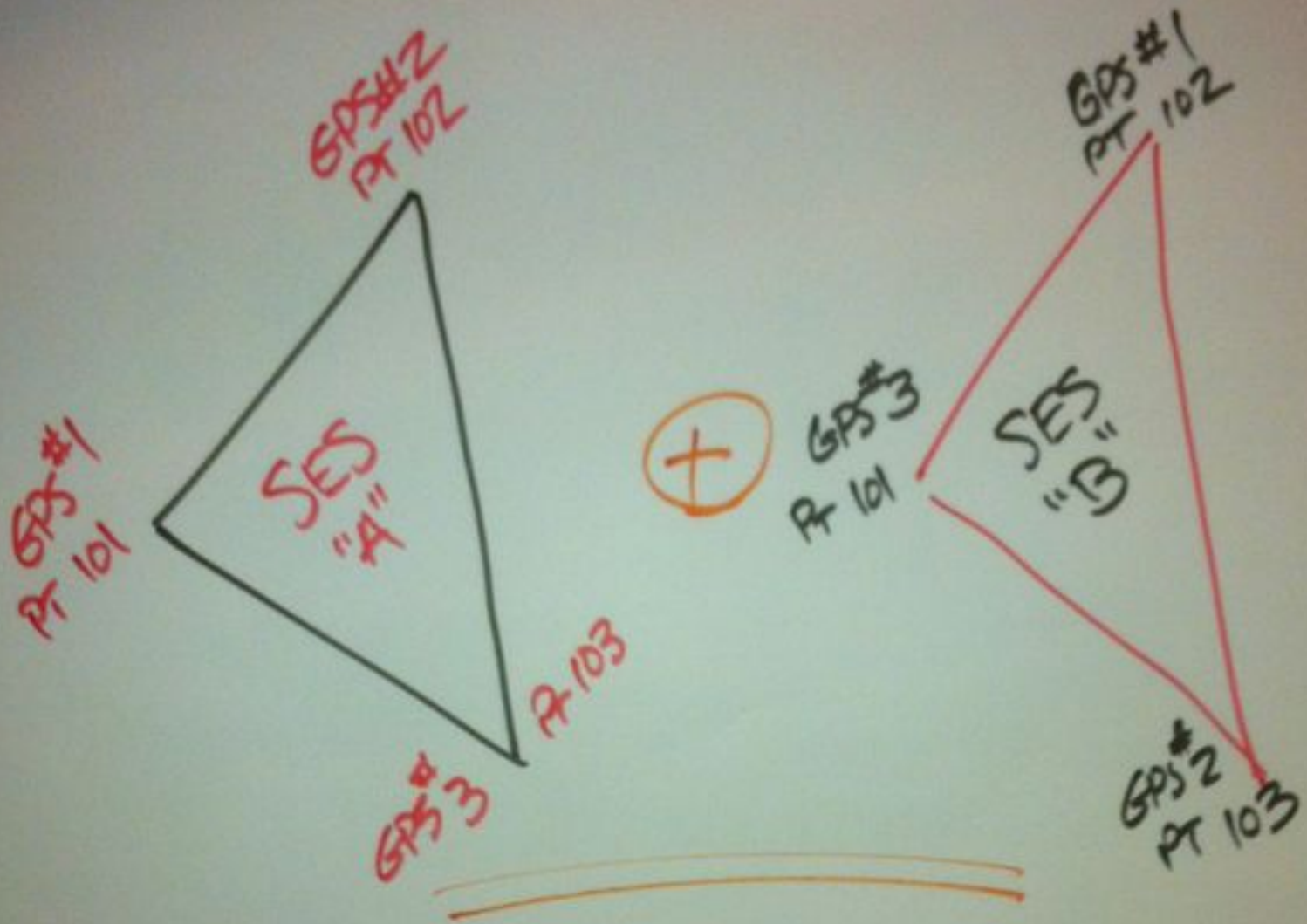
BAD ANTENNA HEIGHT AFFECTS BOTH
GPS IS 3-D VECTOR "SLOPE CHAIN"

PPM

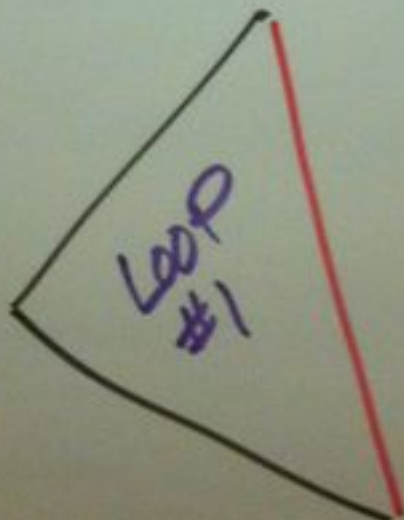


So...

1 PPM IS .01' EVERY 10000'



1. DIF TIME
2. DIF ANT.
3. DIF GPS



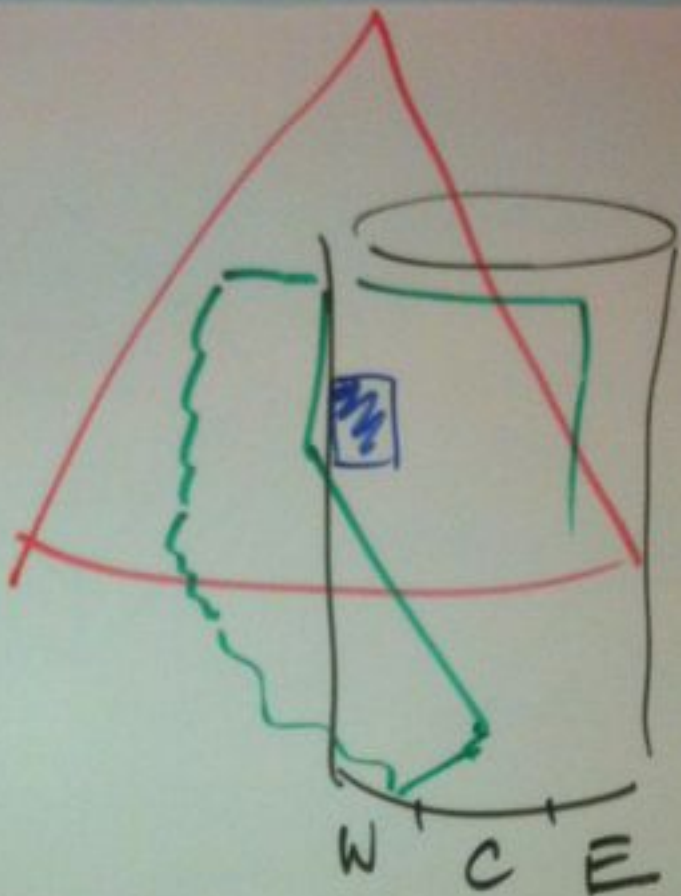
$$N = 3 \text{ GPS}$$

$$N - 1 = 2$$

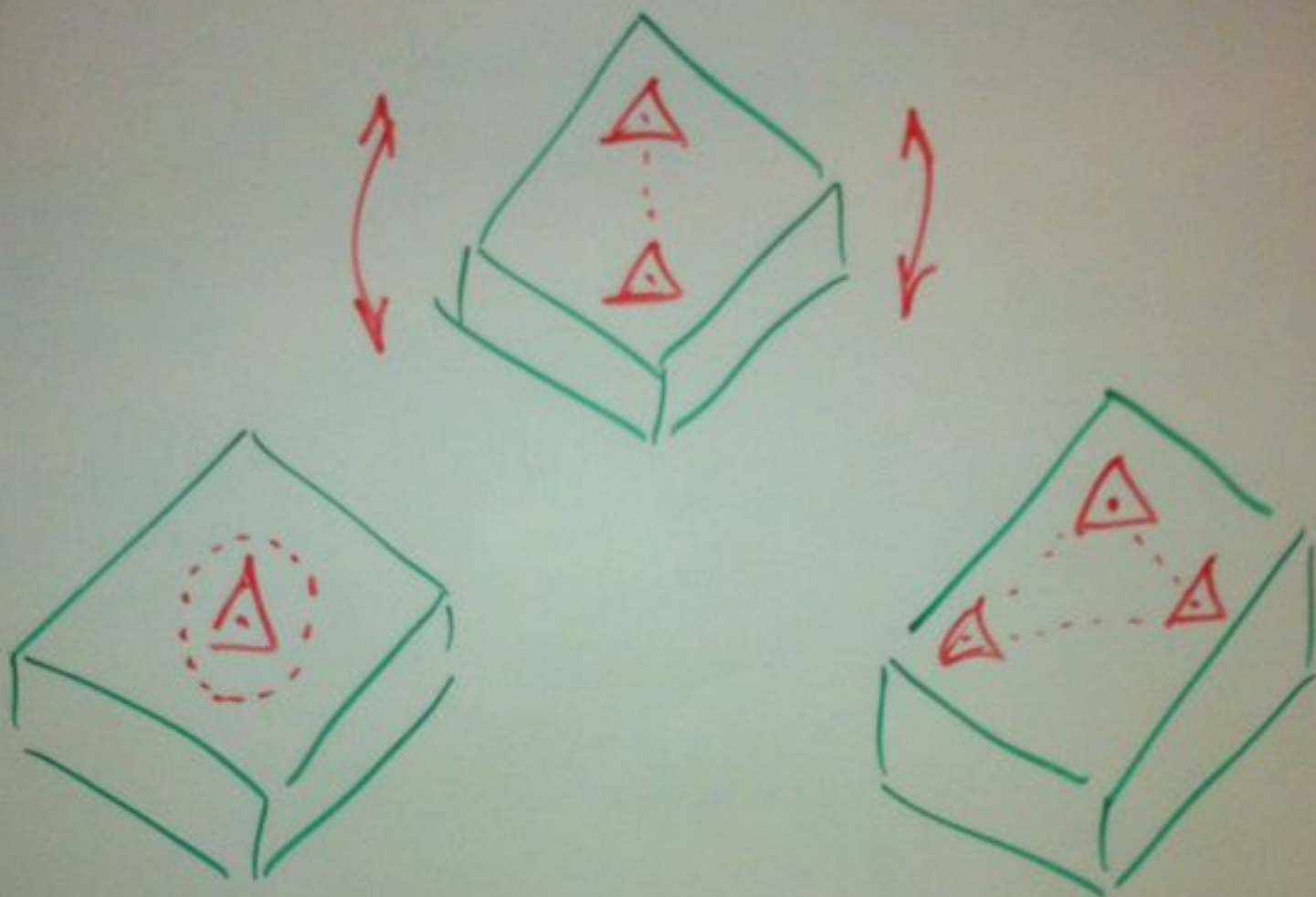
INDEPENDENT
BASE LINES



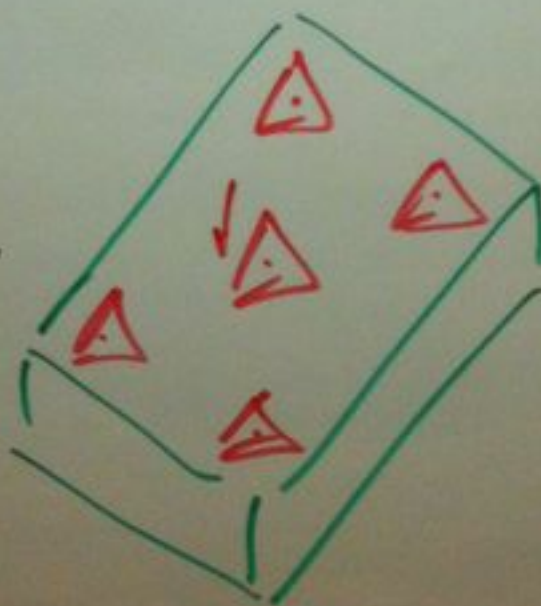
PLANE SURVEYING
 LOCAL JOB
 LOCAL
 CONTROL



PLANE SURVEYING
 "CONTROLLED DISTORTION"
 ERROR
 KNOWN PUBLISHED
 LAMBERT CA
 MERCATOR NY



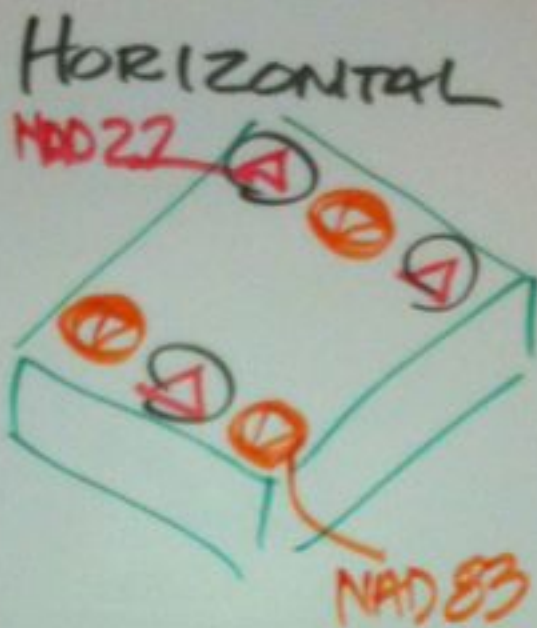
YES -
 INTERPOLATE
 NO -
 EXTRAPOLATE



3 PT
MINIMUM

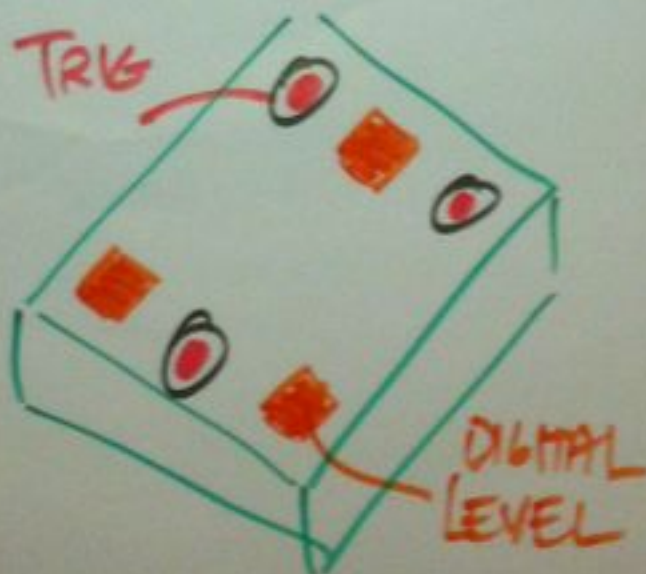
MORE IS..
BETTER
 "PHOTO
 MODEL"

APPLES
CITY
NAD 27
EPOCH
1991.35
"CLASS"
1ST



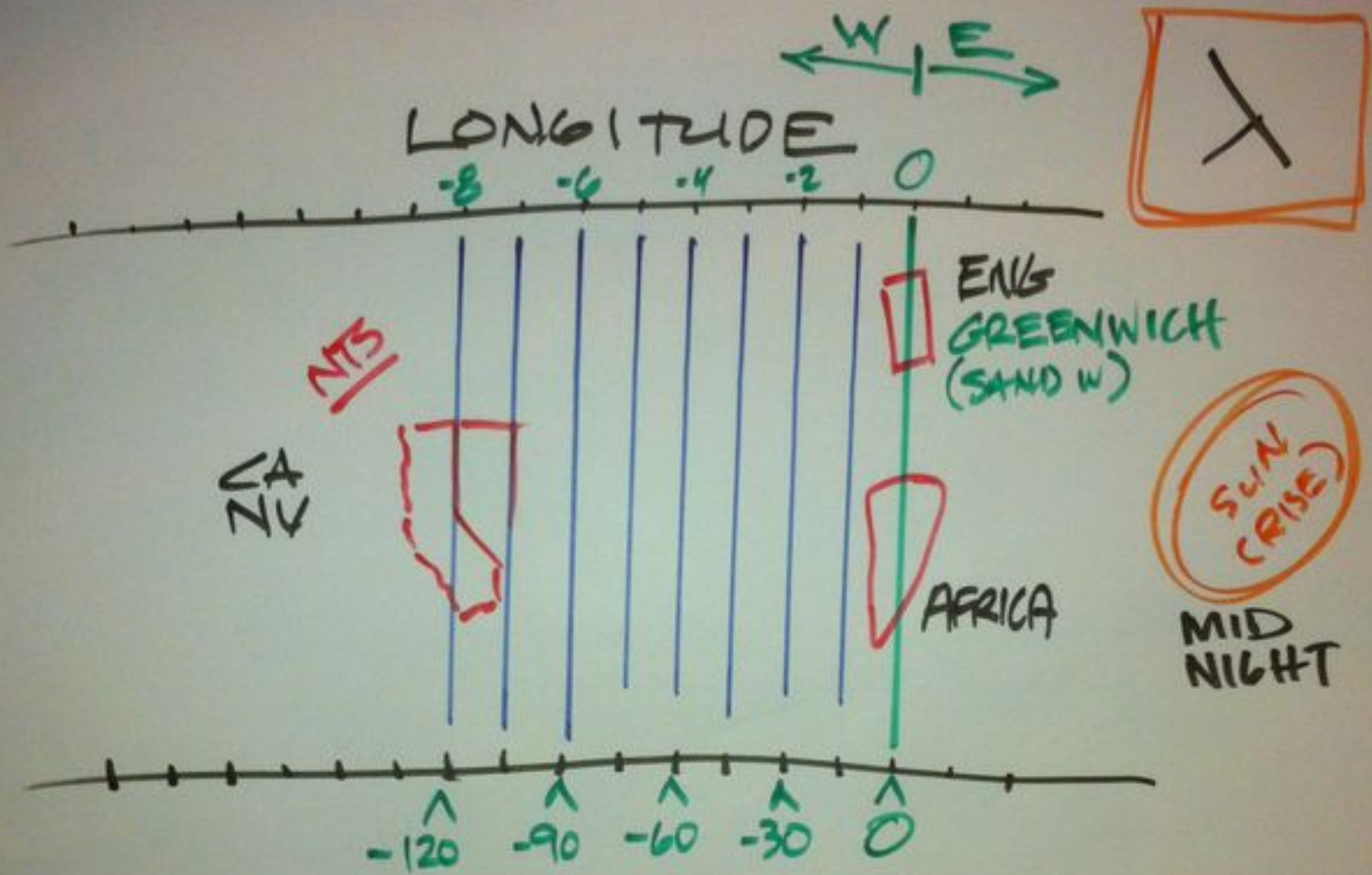
ORANGES
AGENCY
NAD 83
EPOCH
2007.00
"CLASS"
2ND

APPLES
CITY
NAD 29
ADJ. DATE
"CLASS"
GPS
TRIG



ORANGES
AGENCY
NAD 88
ADJ DATE
"CLASS"
PRECISE
LEVELS

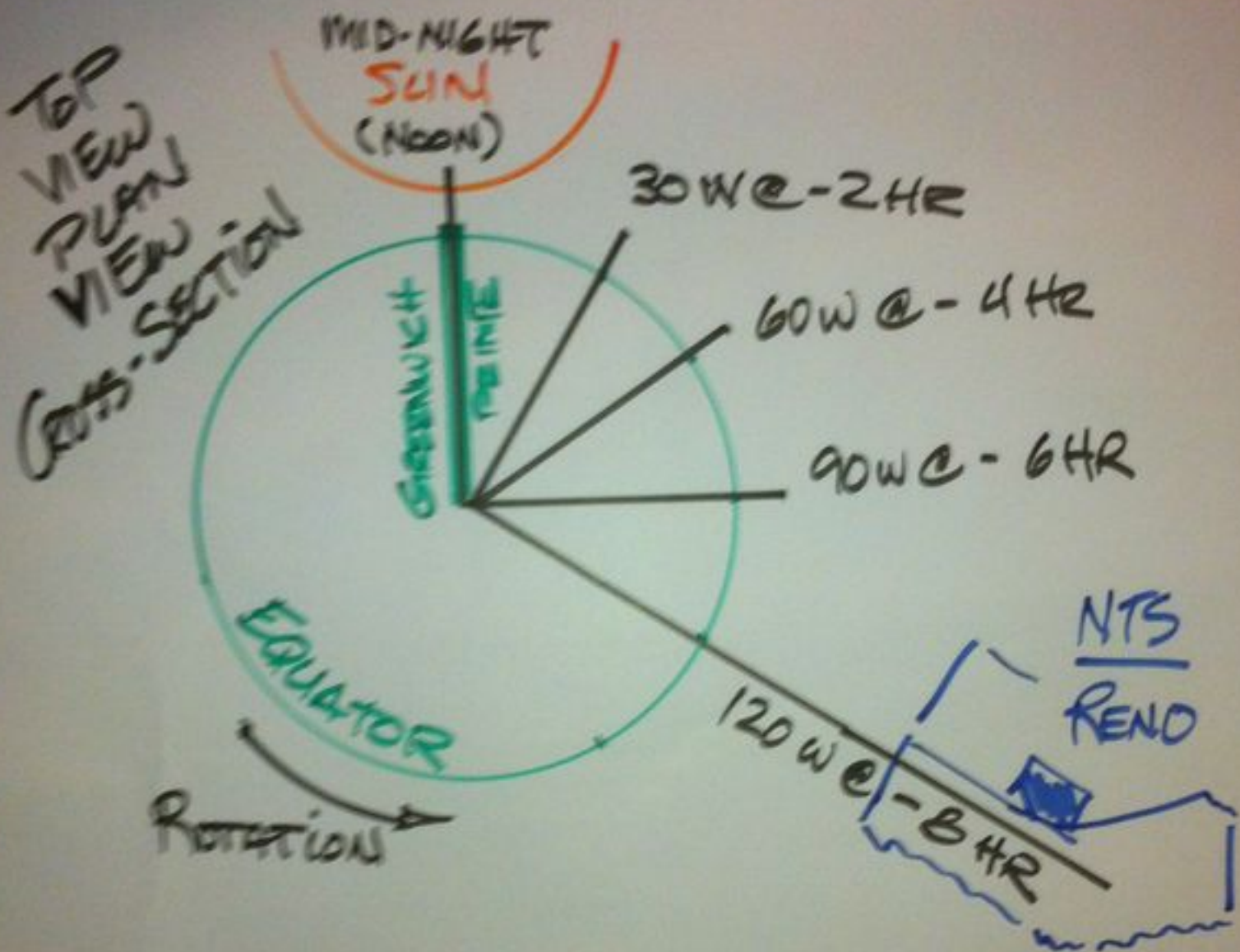
VERTICAL



120 WEST LONGITUDE

4pm

120 WEST IS	MID NIGHT	GPS
	NEW DAY	GPS
	JULIAN DAY	$\frac{1}{365}$
	DAY-TIMER	



LONGITUDE

TIME = ANGLE

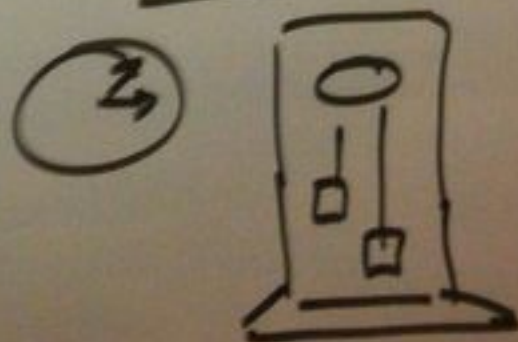
ANGLE = TIME

GREAT CIRCLES

MERIDIANS

GMT - UNIVERSAL TIME

CRONOMETER





SMALL CIRCLES

GREAT CIRCLE

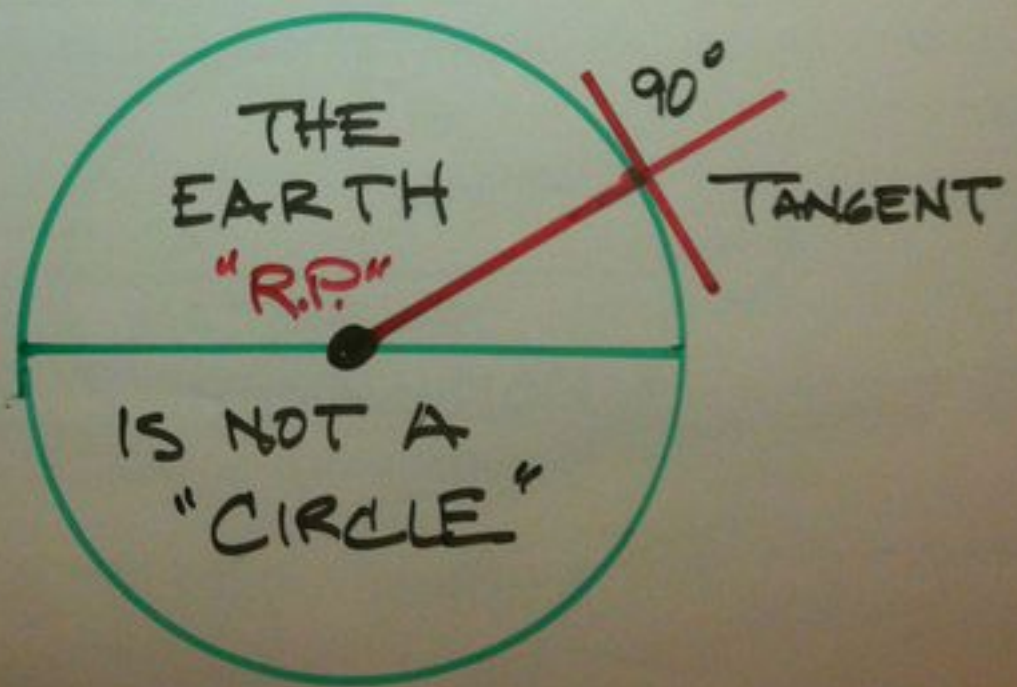
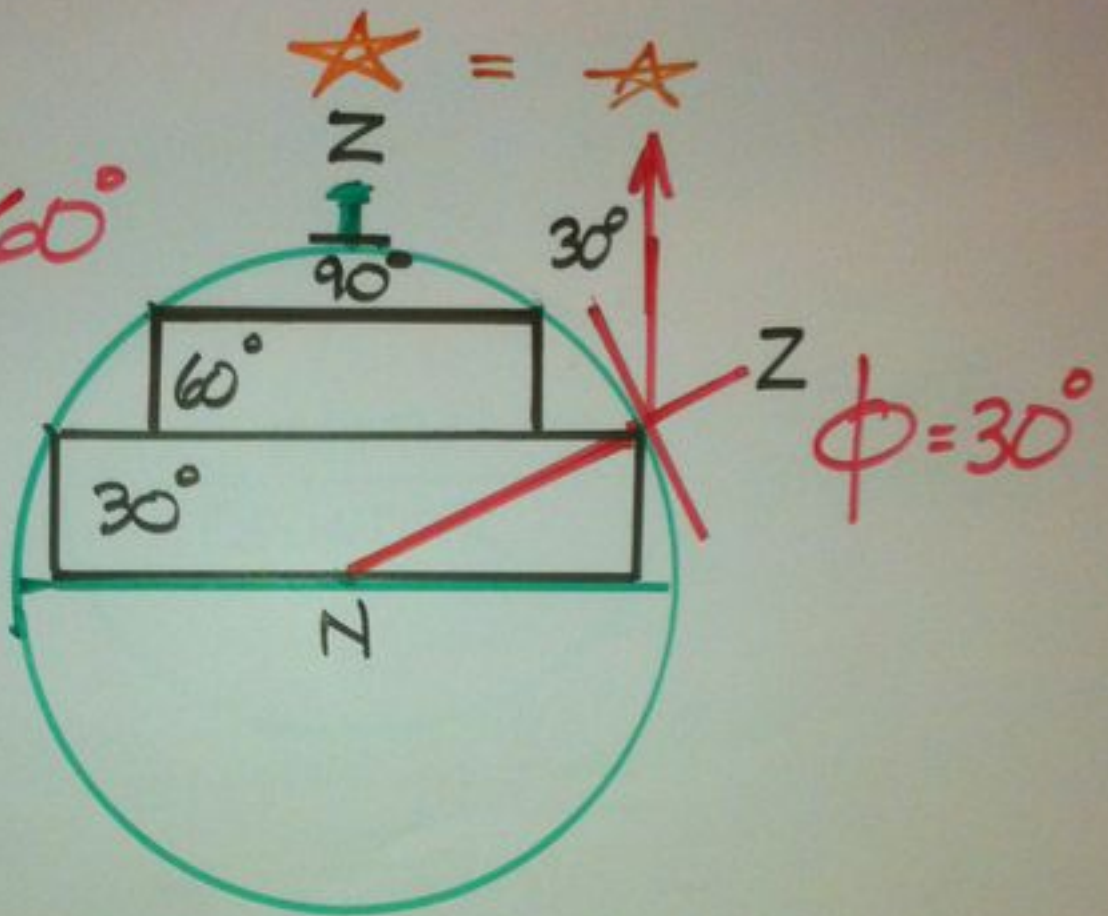


$\Delta^+ \Delta^{++}$ LONGITUDE IS
A FUNCTION OF (YOUR) LATITUDE

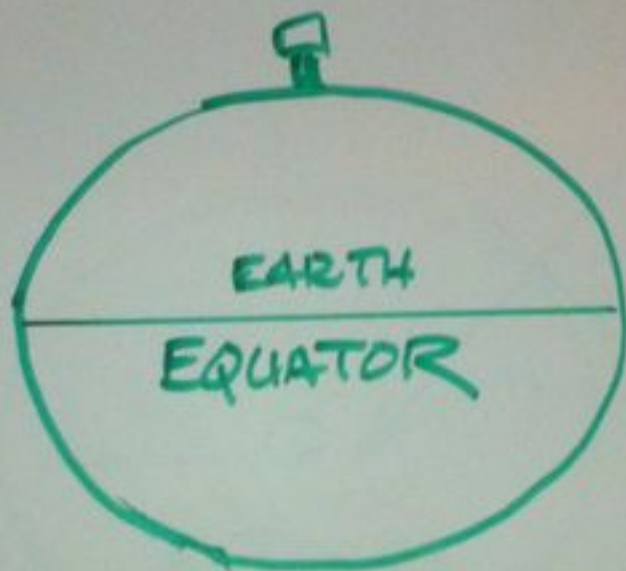


LAT $\rightarrow \phi = 60^\circ$

GREAT
CIRCLE
MERIDIAN
EQUATOR.



PHYSICAL
EARTH

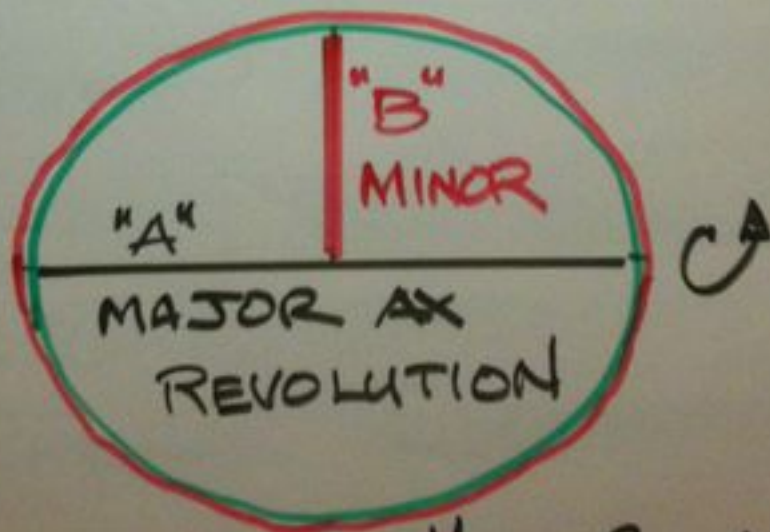


OBLATE
SPHEREOID

MATH MODEL
APPROXIMATE
↓

MATH

NAD 83
DATUM
GRS 80
ELLIPSOID



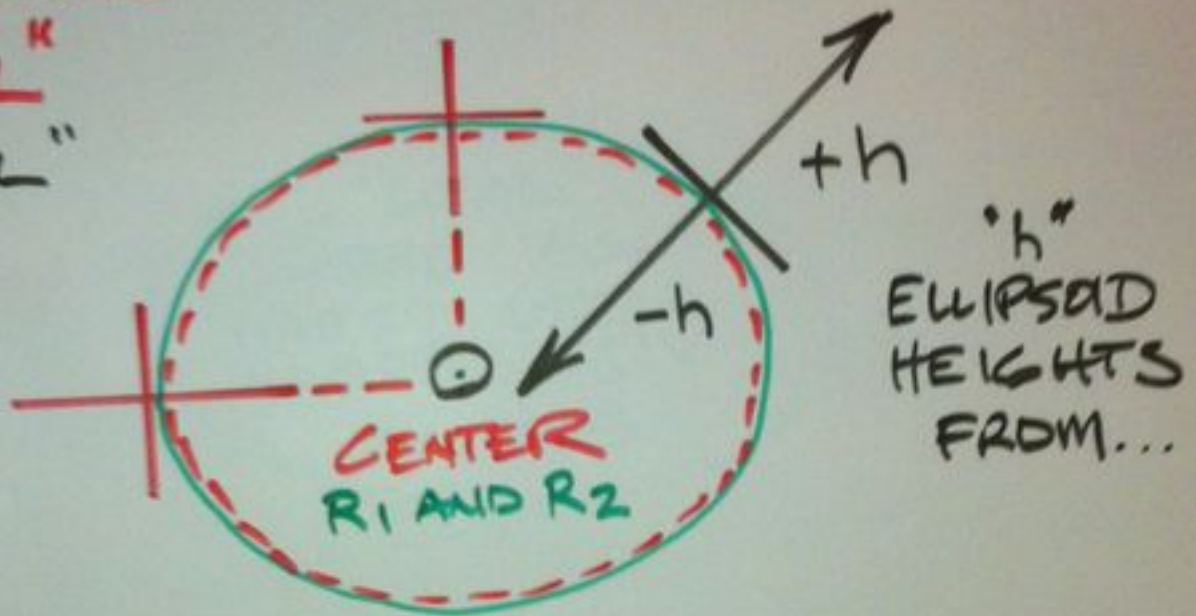
99%
SHOW
TELL

MAJOR A: 6 378 137

MINOR B: 6 356 752

RIGHT ANGLE
PERPENDICULAR
"NORMAL"
"NORMAL"

$$XYZ = \phi \lambda h$$



THE GRS 80

REFERENCE ELLIPSOID [3-D]

APPROX MATH (ONLY) MODEL OF
OBLATE SPHEREOID
PHYSICAL EARTH

MATH GEODETTIC COORDINATES
GEOGRAPHIC

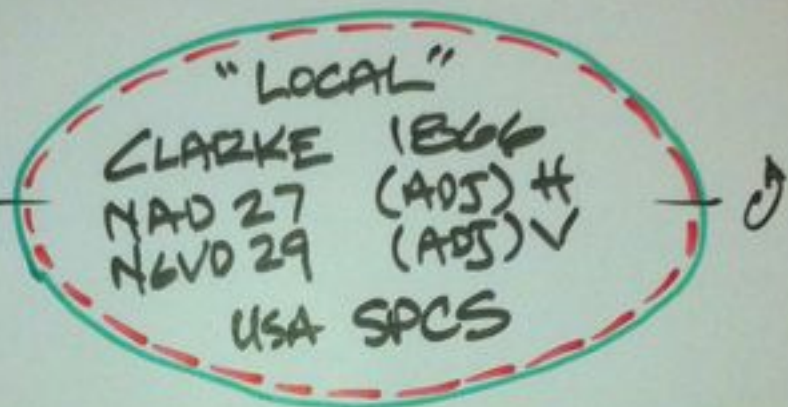
REFERENCE

ELLIPSOIDS

[3-D]

MATH

REVOLUTION
MAJOR AX



BOTH

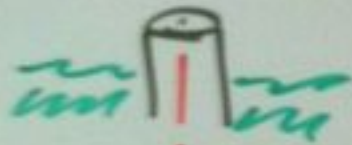
$$A_{MAJOR} = 6\ 378\ 137$$
$$B_{MINOR} = 6\ 356\ 752$$

NAD 83 $\phi \lambda h$ NEE' MAY NOT MATCH WGS 84

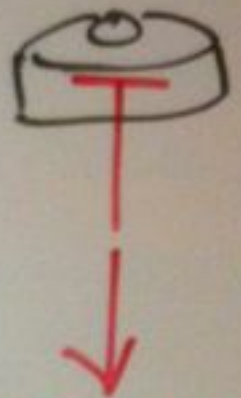
BREAK *
- HANDOUTS -



GRAVITY
LEVEL
BUBBLE



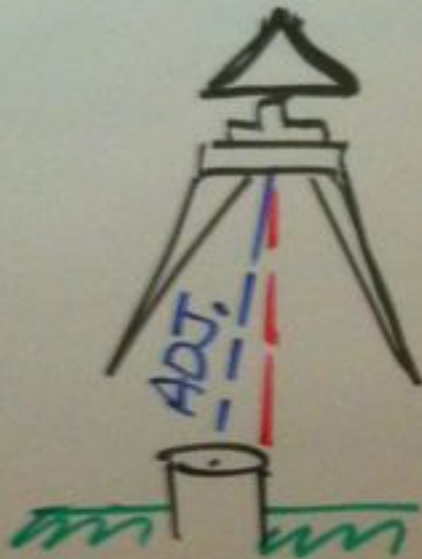
GRAVITY
PLUMB
LINE



GRAVITY
LEVEL
BUBBLE
TANGENT
PERP
RT. ANGLES



GRAVITY

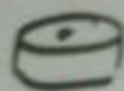


GRAVITY

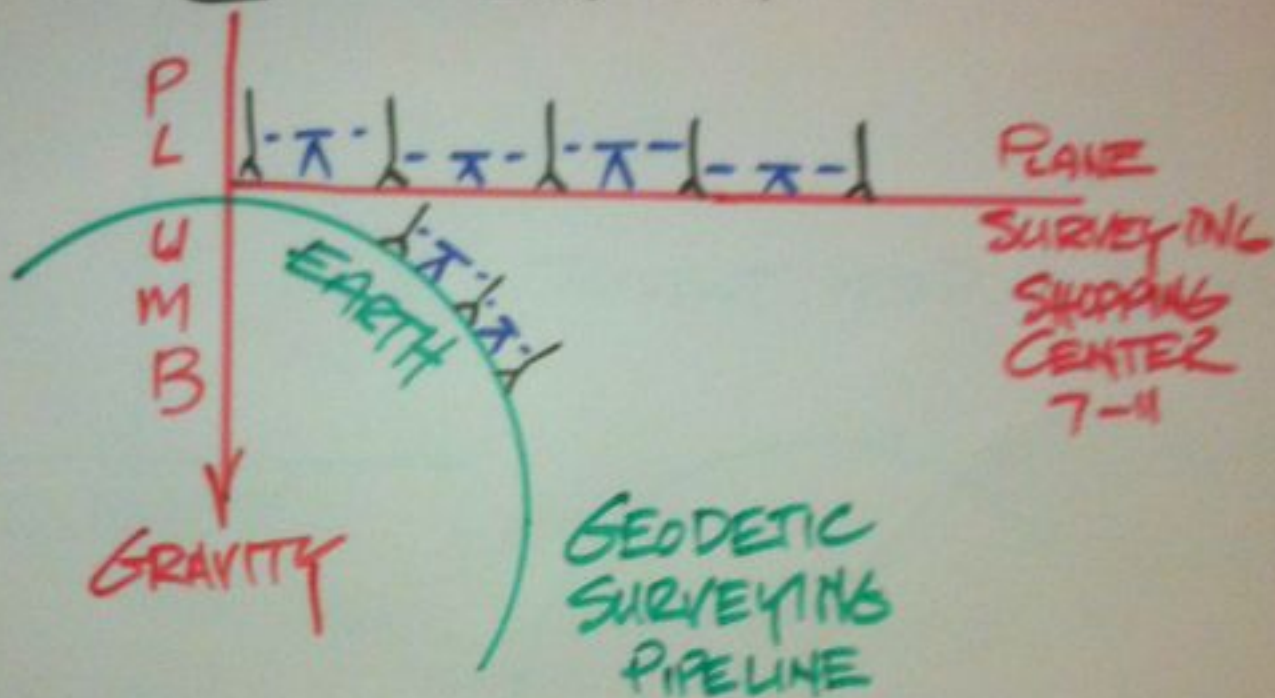
"BAD"
SET-UP #2
N UNITS ϕ
E EACH λ
EL DATUM h
ANTENNA HEIGHT

"BUBBLE"
T

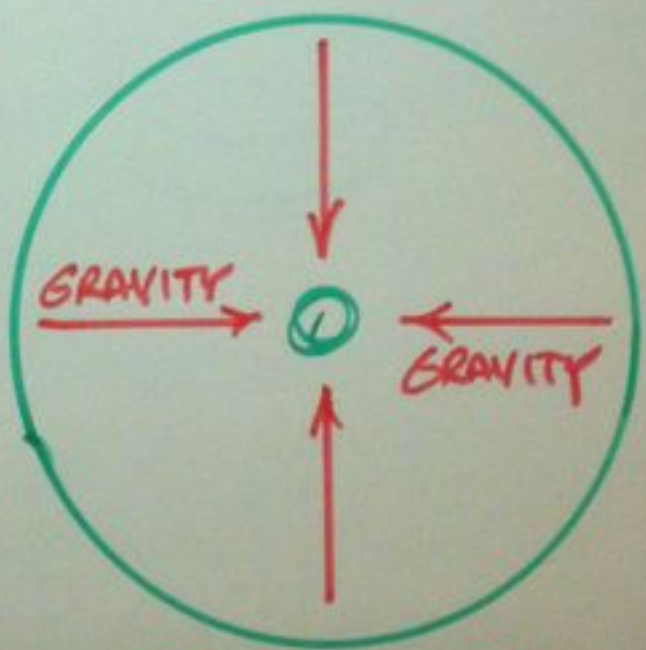
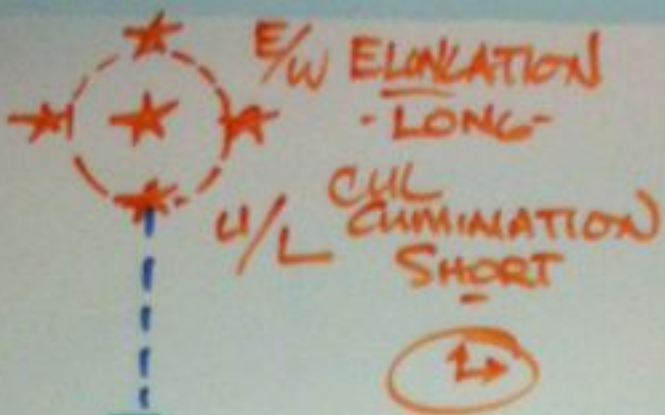
LEVEL
BUBBLE



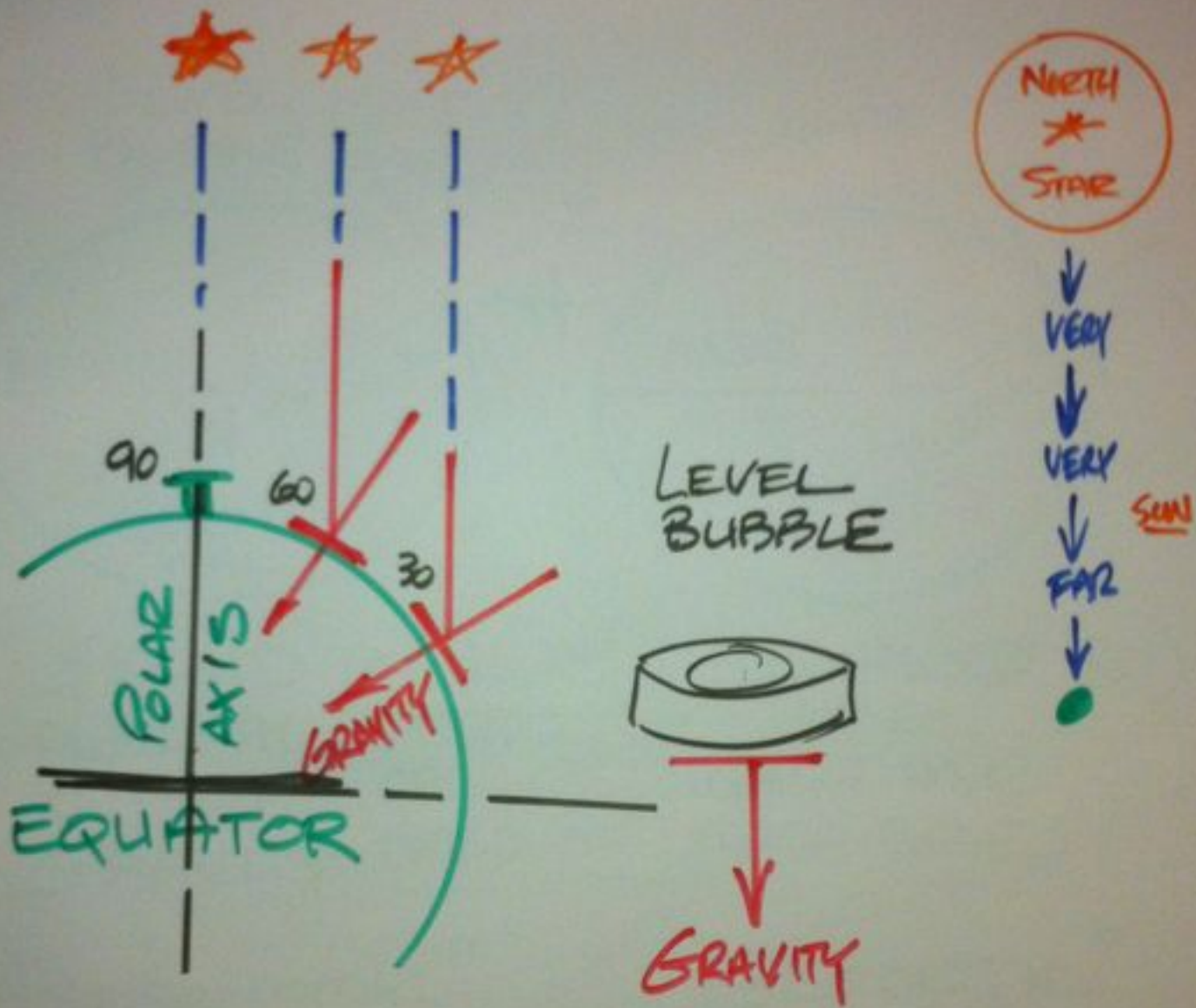
TANGENT PERP RT. ANGLE



NORTH
STAR
POLE
STAR



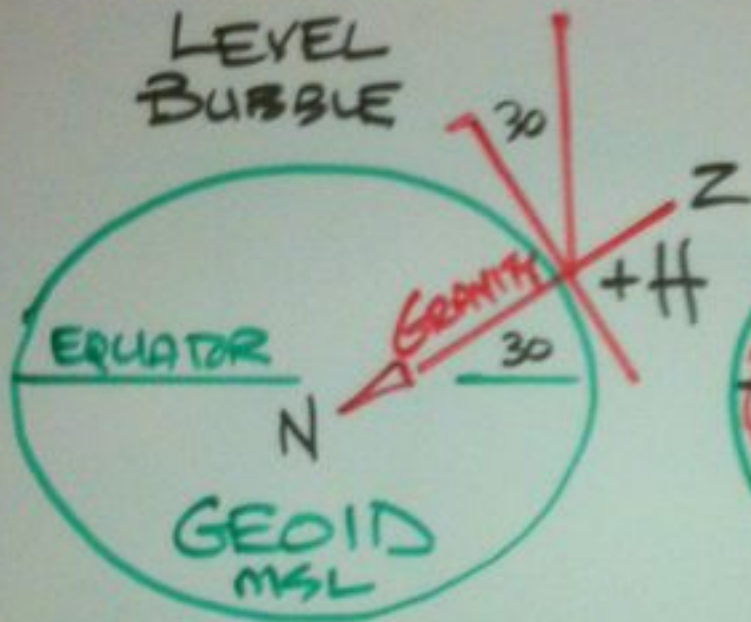
EQUATOR
CROSS SECTION
TOP VIEW



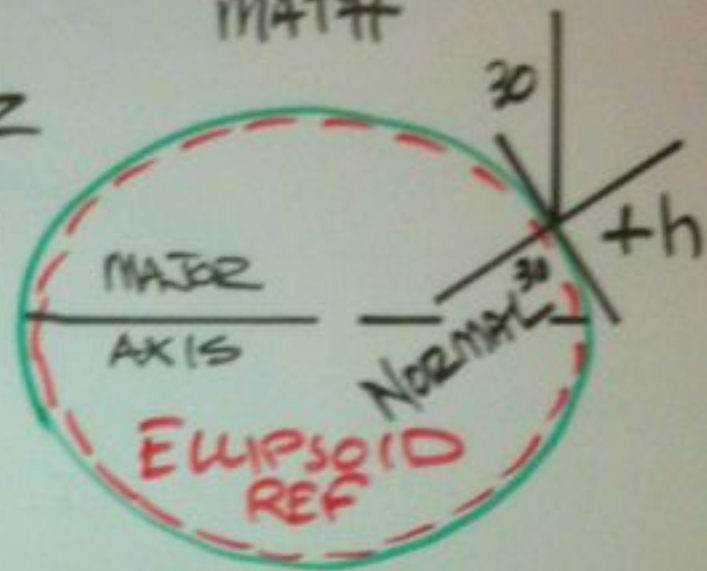
"ASTRONOMIC" $\phi \lambda \#$
 PHYSICAL (NATURAL) MEASURE
 BASED (TIED TO) ON GRAVITY

EARTH STAR

LEVEL BUBBLE



MATH



GEOID (MSL)
 NATURAL SPHEREOID
 PHYSICAL OBS
 GRAVITY BASED

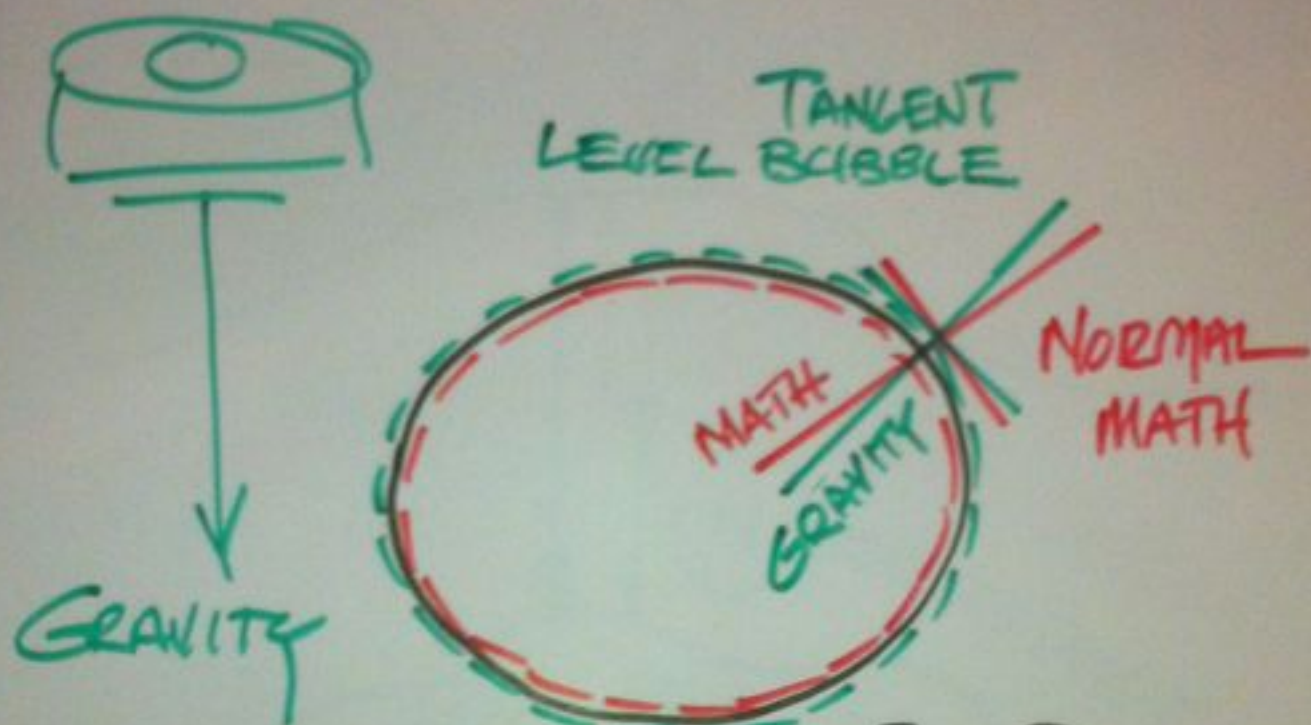
ELLIPSOID (REF)
 WGS84
 NAD27 NAD83
 MATH BASED

"ASTRONOMIC"

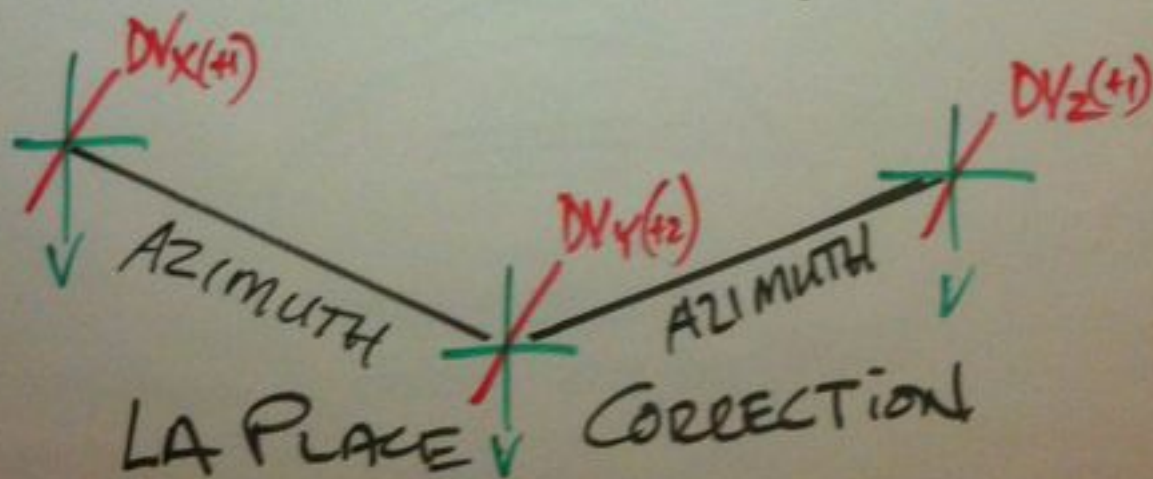
ϕ LAT
 λ LONG
 H ORTHO
 *GEOID

"GEODETIC"

ϕ LAT
 λ LONG
 h ELLIP
 *ELLIPSOID

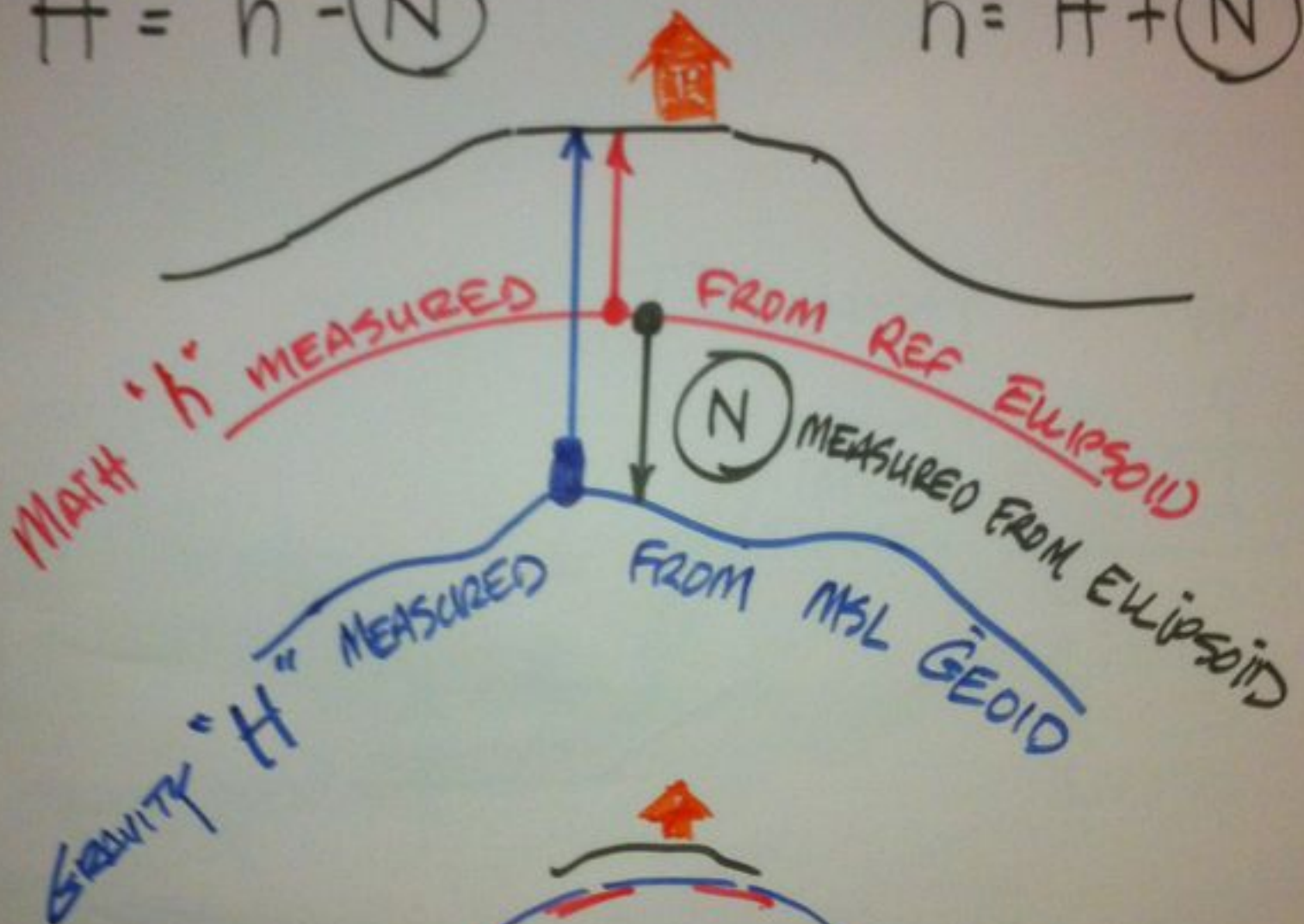


"DEFLECTION" [ANGLE]
OF THE VERTICAL
(A FEW SECONDS)



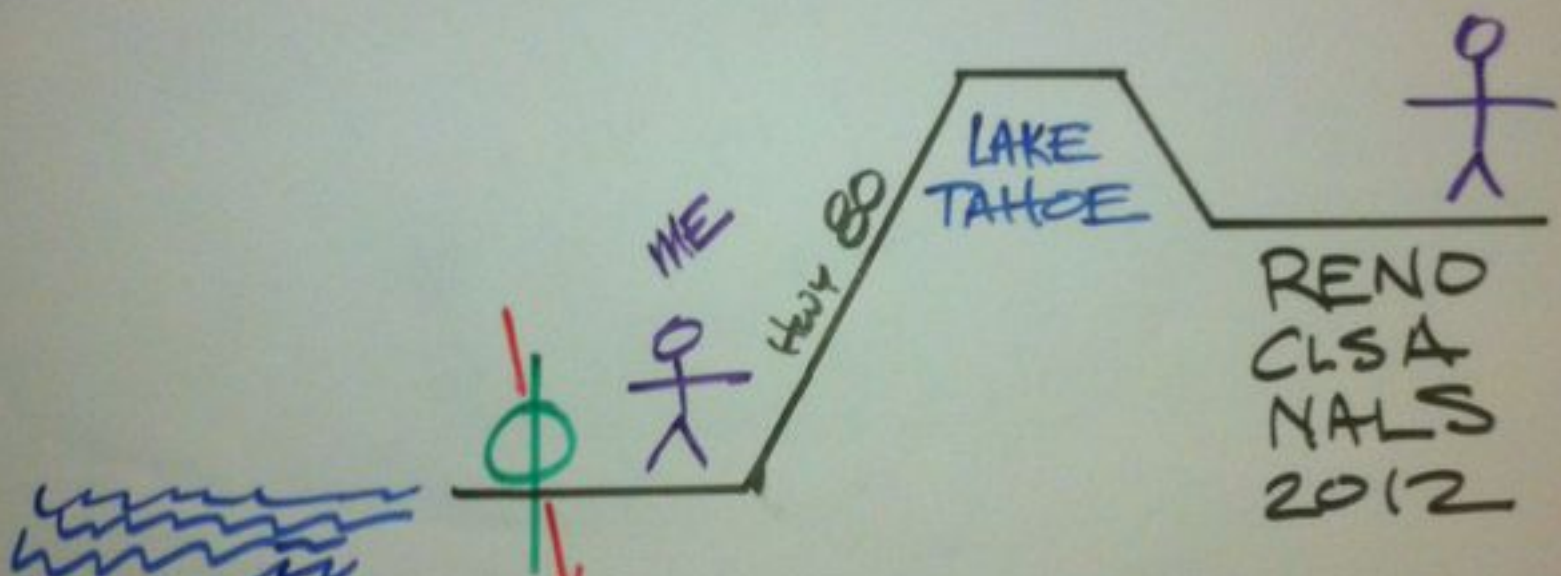
$$H = h - \textcircled{N}$$

$$h = H + \textcircled{N}$$



CHANGE
HAND OUT

TOPOGRAPHY



OCEAN
MSL
GEOID
~
~
~

SAN
DIEGO
TORREY
PINES
GOLF
COURSE

"GRAVITY"

GEOID
MEASURES
(SHOWS)
GRAVITY
EQI-POTENTIAL
(CONTOURS)

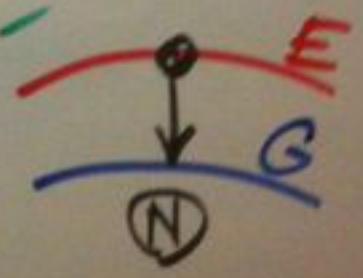
ANOMALIES

SPARKS
RENO



-78.8
-78.9
-79.0
-79.1
-79.2
-79.3

INCLINE



HANDOUT