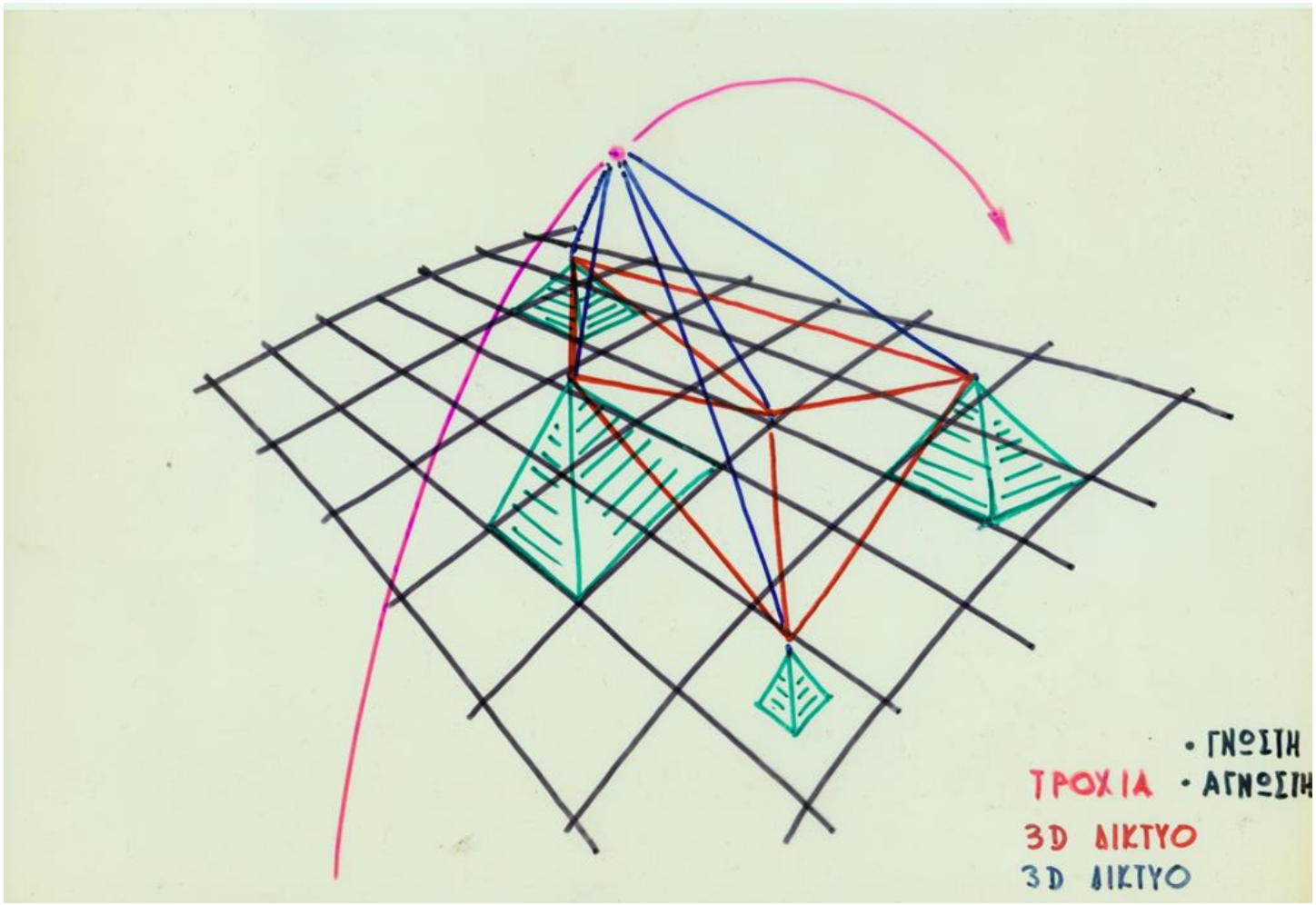
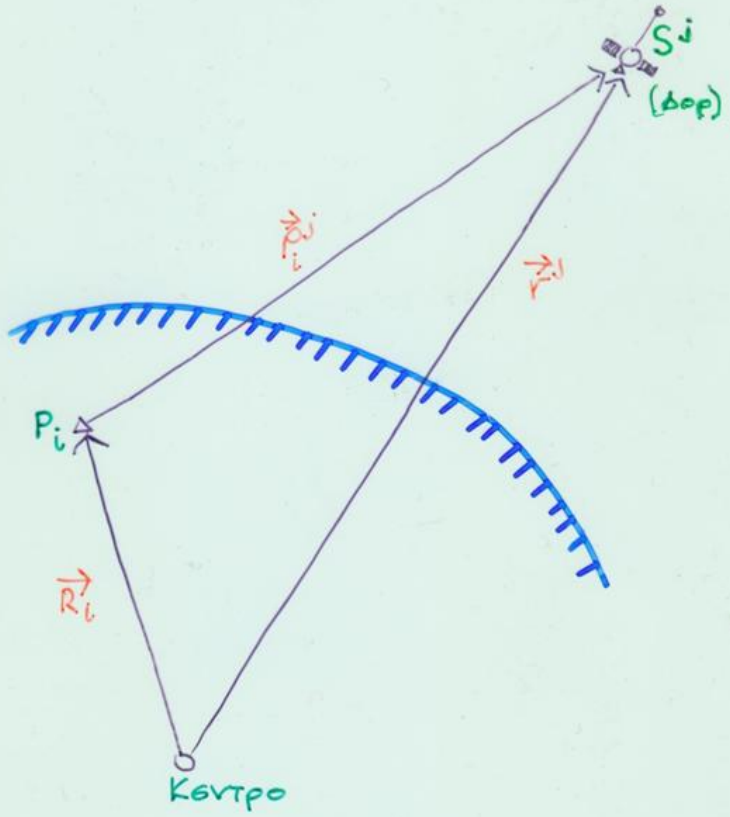
NAVSTAR - GPS

NAVIGATION
SATELLITE
TIMING
AND
RANGING

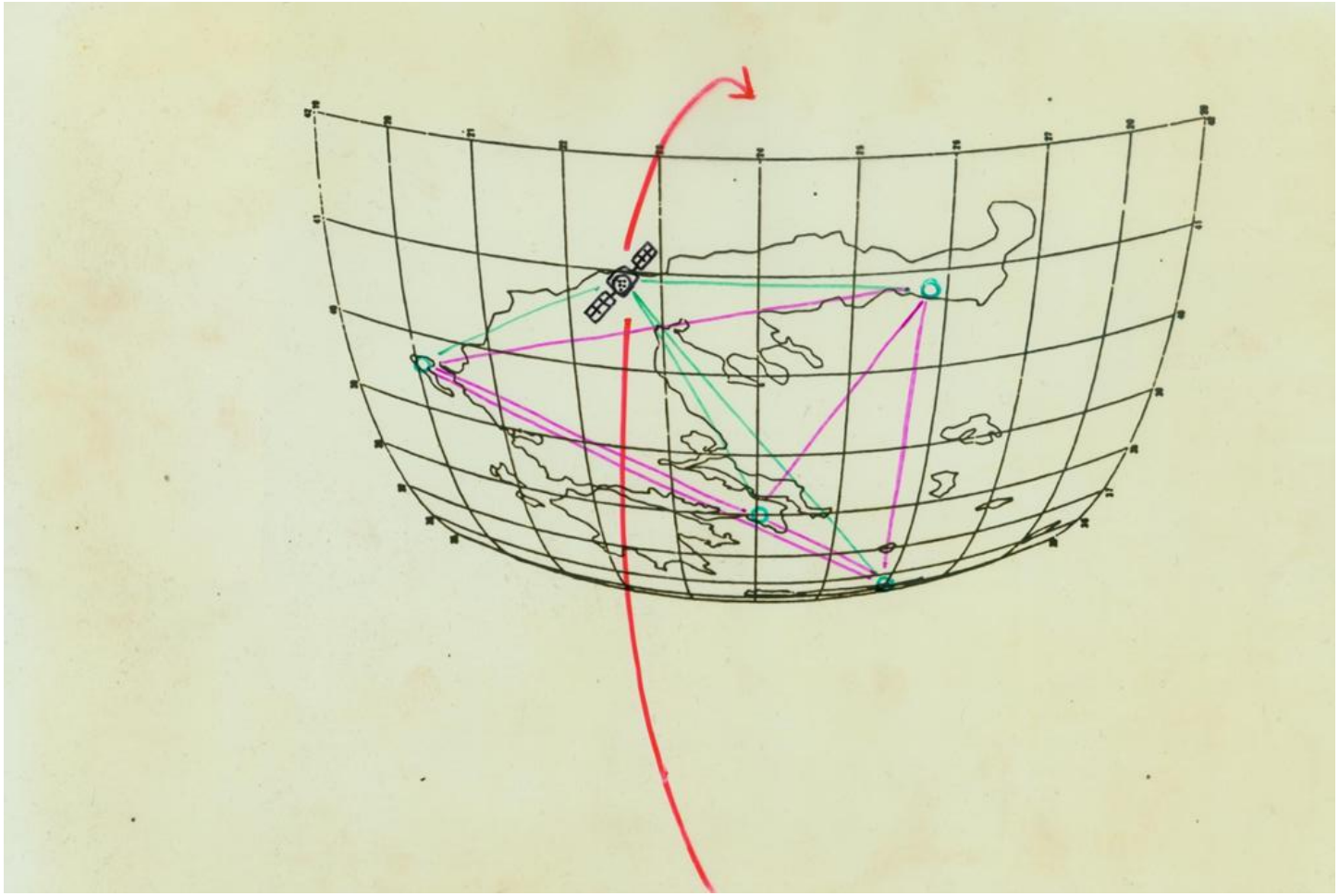
GLOBAL
POSITIONING
SYSTEM

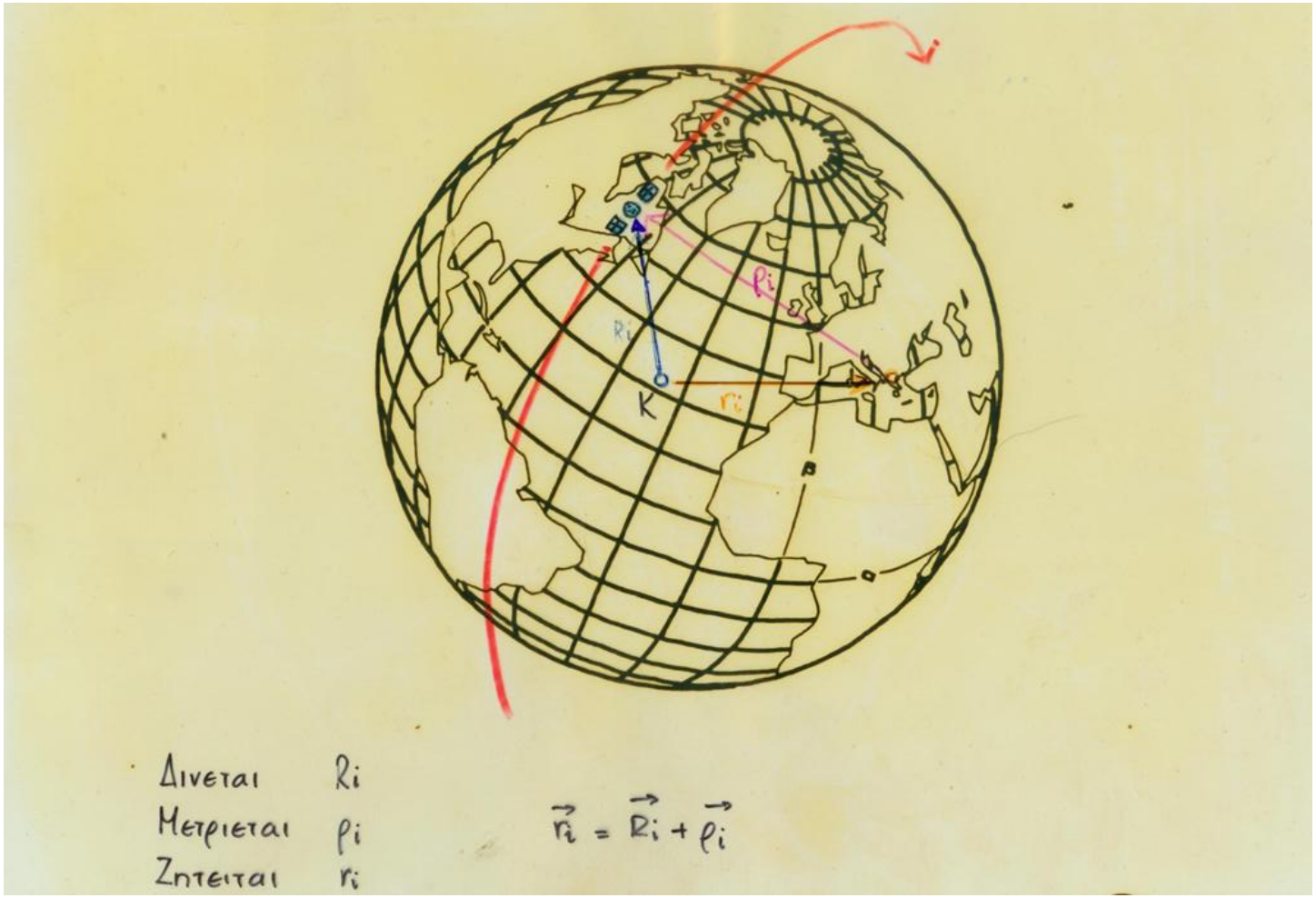

• ΓΝΩΣΤΗ
ΤΡΟΧΙΑ • ΑΓΝΩΣΤΗ
3D ΔΙΚΤΥΟ
3D ΔΙΚΤΥΟ

ΑΡΧΗ ΕΝΤΟΠΙΣΜΟΥ ΘΕΣΗΣ ΜΕ ΔΟΡΥΦΟΡΟΥΣ

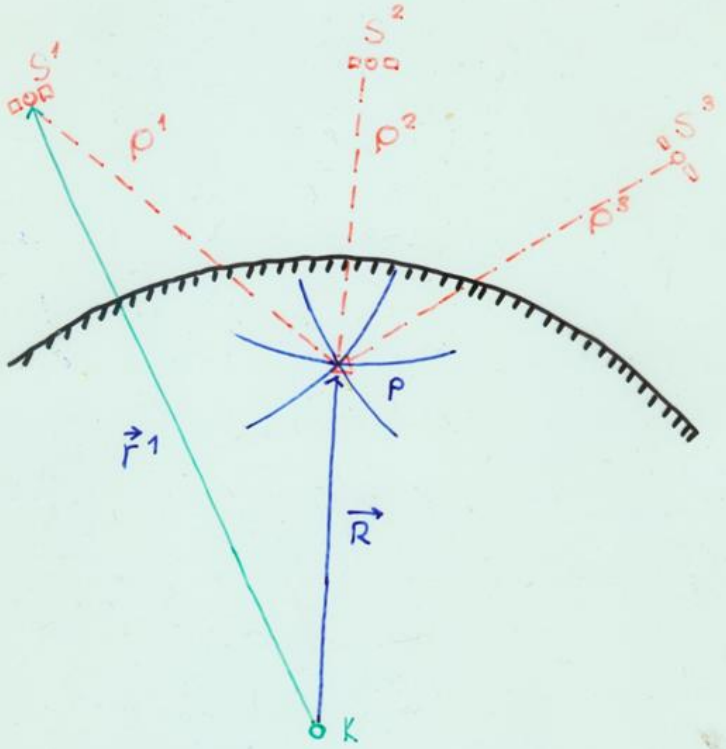


ΔΙΝΟΝΤΑΙ
ΜΕΤΡΟΥΝΤΑΙ
ΖΗΤΟΥΝΤΑΙ




i
Ri
ρi
ri
K
Δίνεται Ri
Μετριέται ρi
Ζητείται ri
$\vec{r_i} = \vec{R_i} + \vec{\rho_i}$

ΑΡΧΗ ΕΝΤΟΠΙΣΜΟΥ ΘΕΣΗΣ ΜΕ ΤΟ ΣΥΣΤΗΜΑ GPS

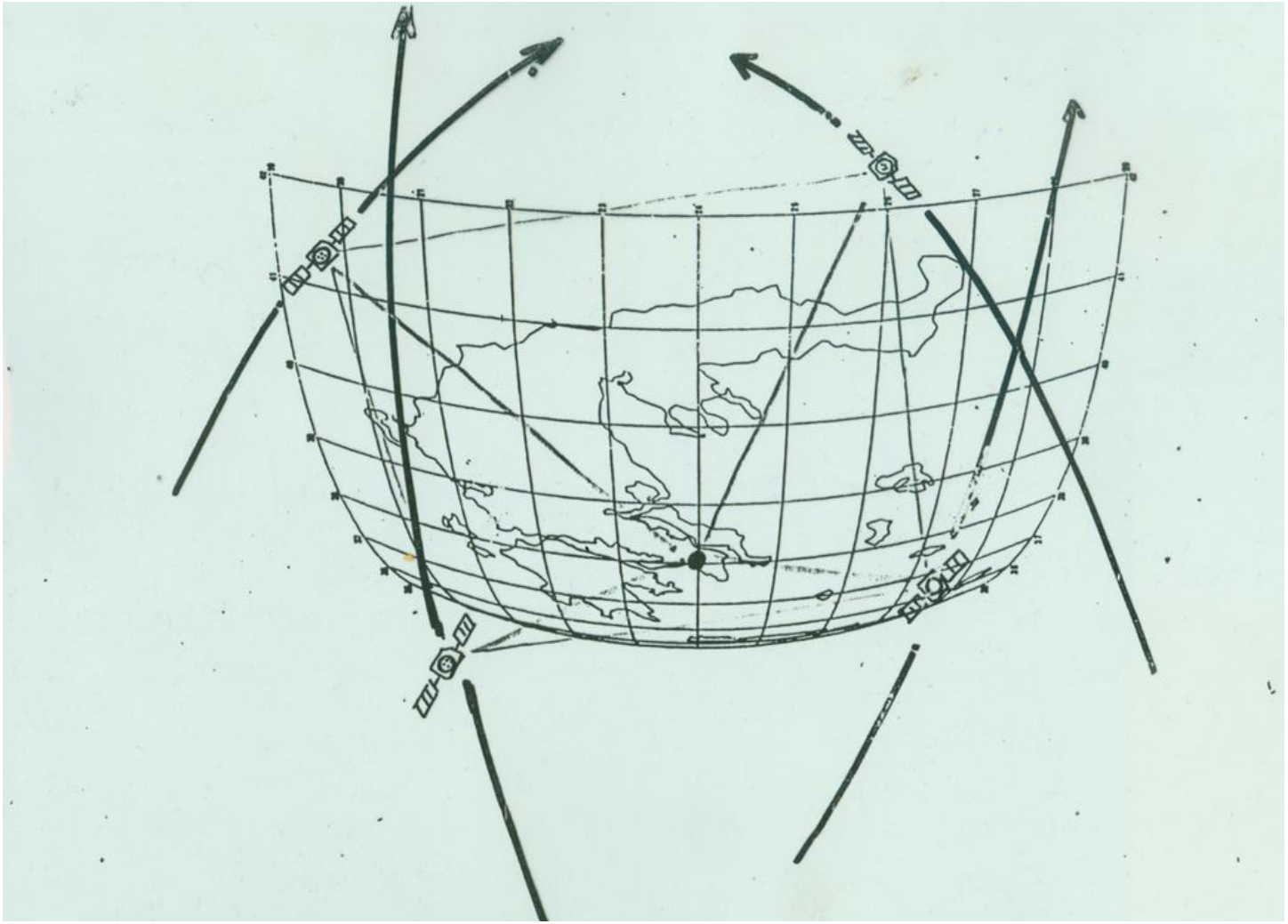


ΠΟΛΛΑΠΛΕΣ ΑΠΟΣΤΑΣΕΙΣ ΣΕ ΔΟΡΥΦΟΡΟΥΣ

ΔΙΝΟΝΤΑΙ $\vec{r}^j$ $j = 1, 2, \ldots, n$ όπου $n \geq 2$

ΜΕΤΡΟΥΝΤΑΙ $\vec{\rho}^j$ $j = 1, 2, \ldots, n$ ΤΑΥΤΟΧΡΟΝΑ

ΖΗΤΕΙΤΑΙ $\vec{R}$



OPERATIONAL NAVIGATION SPACECRAFT

LIFE
- 6-YEAR MEAN MISSION DURATION
- 7.5-YEAR DESIGN GOAL
- >10-YEAR CONSUMABLES

NAVIGATION
- HARDENED PROCESSOR PARTS
- 2 Rb + 2 Cs CLOCKS

SHUTTLE LAUNCH
- PAM-D
- 1 TO 4 NAVSTAR/SHUTTLE

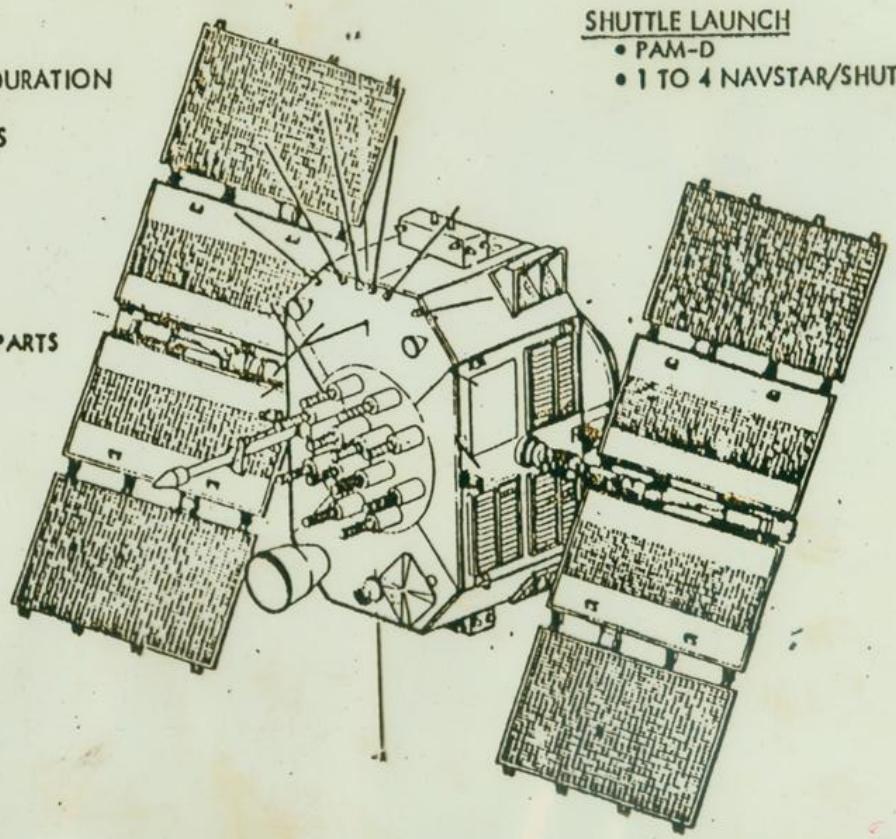
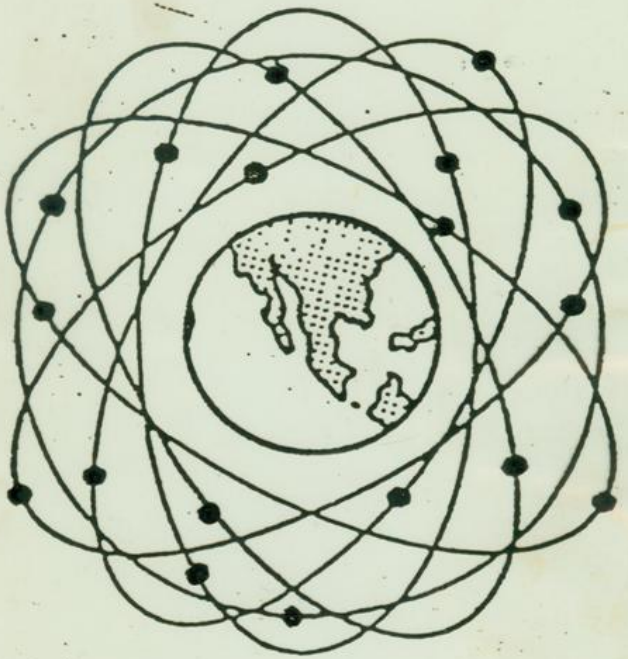


FIGURE 7: OPERATIONAL GPS SPACECRAFT

ΤΡΟΧΙΕΣ ΔΟΡΥΦΟΡΩΝ GPS



ΜΕΤΑ ΤΟ 1990

21 ΔΟΡΥΦΟΡΟΙ (+ 3 ΕΝΕΡΓΟΙ ΣΑΝ ΑΝΤΑΛΛΑΚΤΙΚΑ)

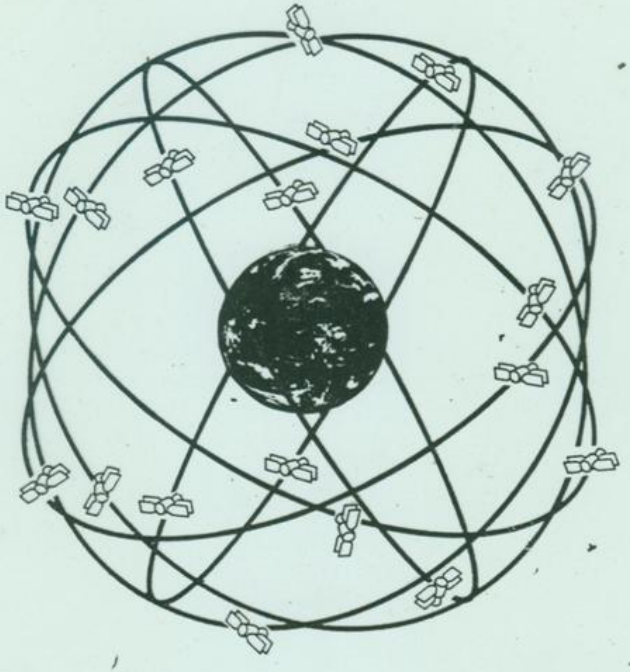
6 ΕΠΙΠΕΔΑ

ΠΛΗΡΗΣ ΚΑΛΥΨΗ

ΔΟΡΥΦΟΡΟΙ ΠΑΡΑΓΩΓΗΣ

ΥΨΟΣ 20200 ΚΜ

SATELLITE CONSTELLATION



18 SATELLITES → 21 + 3 → 32
6 ORBITAL PLANES
55° INCLINATION
20 200 KM ABOVE EARTH
12-HOUR ORBITS
5 HOURS ABOVE HORIZON

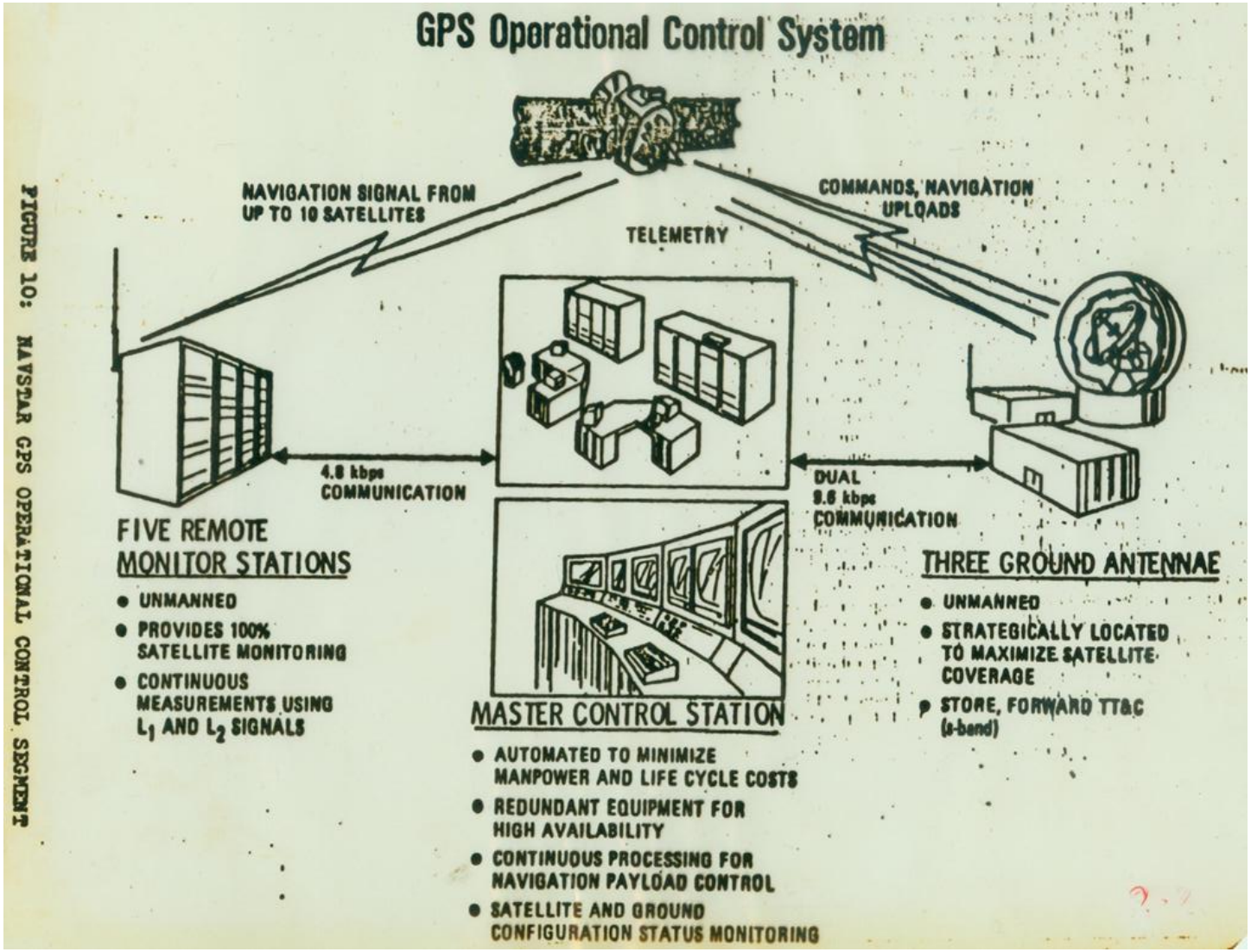
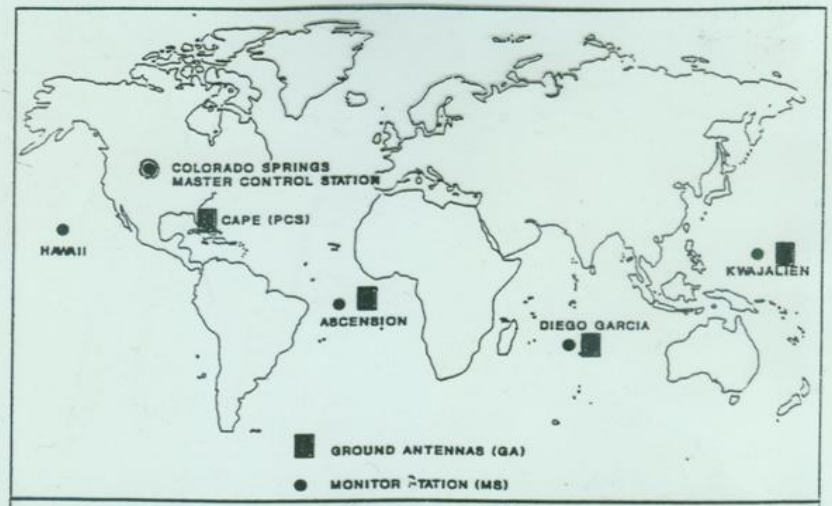


FIGURE 10: NAVSTAR GPS OPERATIONAL CONTROL SEGMENT



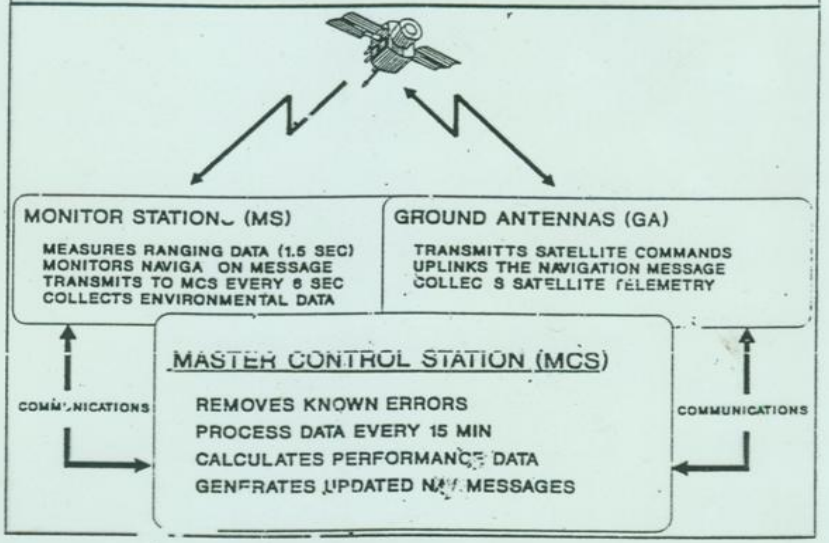


Fig. 3—Operational Control System

Table 1—SEP/CEP Navigation Solutions for the OCS Monitor Stations

Criteria	All	Colorado Springs	Ascension	Hawaii	Diego Garcia	Kwajalien
SEP (3-D)*	8.3	7.8	6.8	9.0	9.1	9.0
CEP (2-D)*	4.5	4.5	3.8	5.1	4.6	5.0
RMS PDOP	3.6	3.9	3.4	3.9	3.4	3.3

*Values in meters

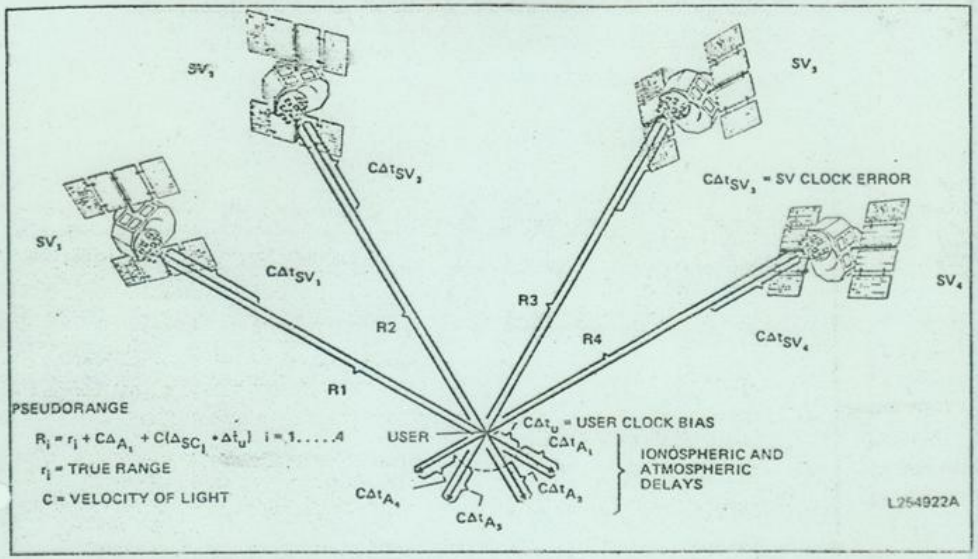


Figure 2–2. Concept of Pseudoranges and Clock Offset

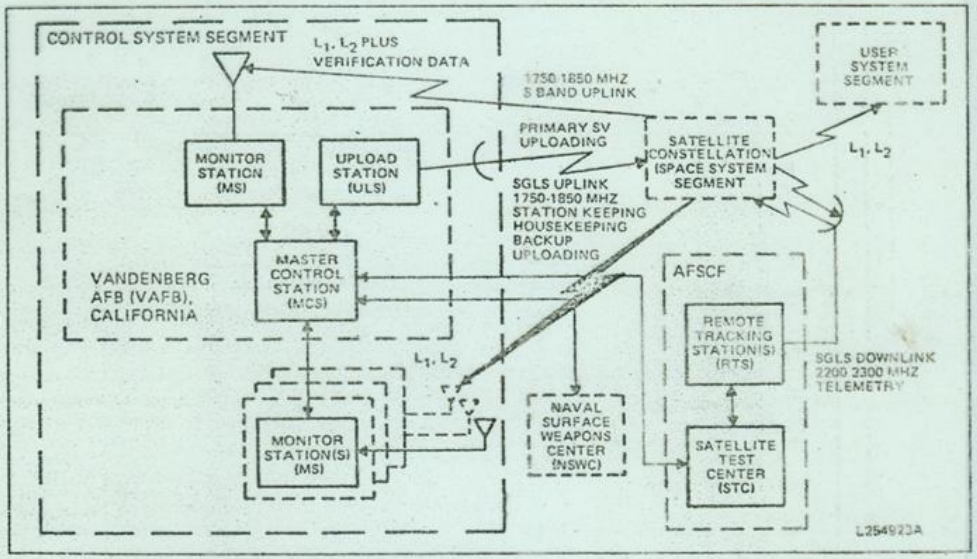
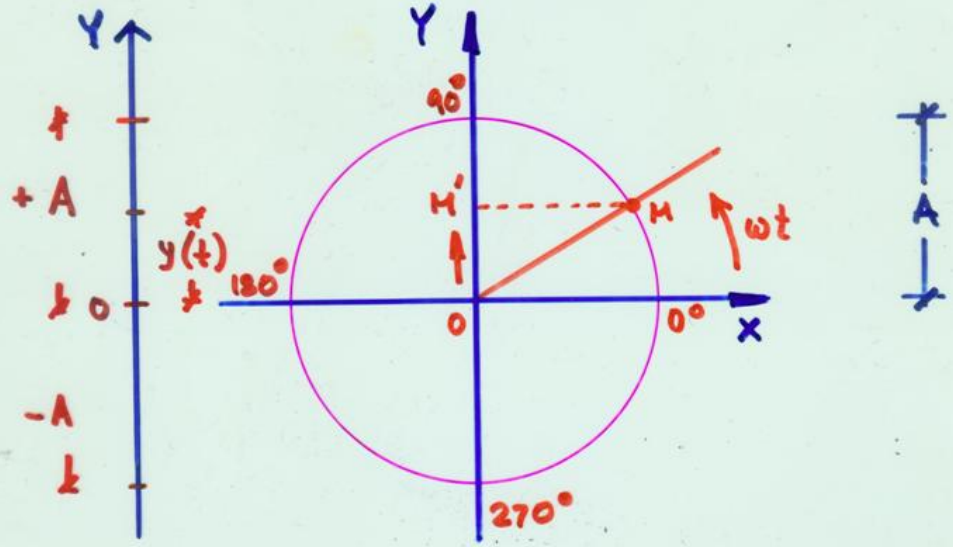


Figure 2–3. NAVSTAR GPS Block Diagram and Clock Offset

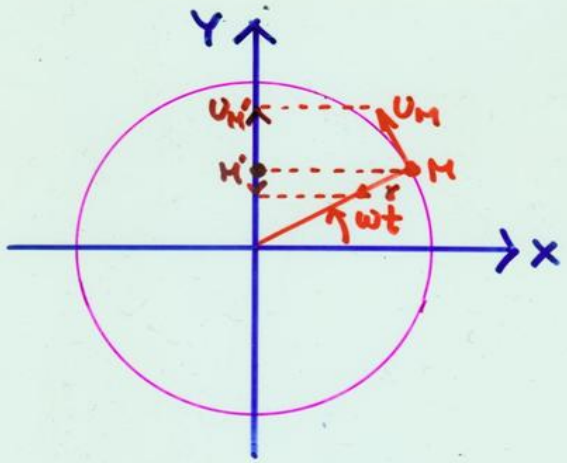


$y(t)$ = απομάκρυνση μεγίστα $\pm A$

T = περίοδος

ω = γωνιακή ταχύτητα

$f = \frac{1}{T}$ = περίοδος

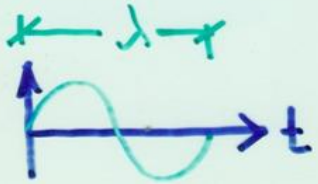


$y = A \sin \omega t$

$\omega t = (\text{γωνιακή ταχύτητα} \cdot t) = \text{φάση}$

$\omega = \frac{2\pi}{T} = 2\pi f$

$y = A \sin \omega t \qquad y = A \sin \frac{2\pi}{T} t \, [+\varphi]$



λ

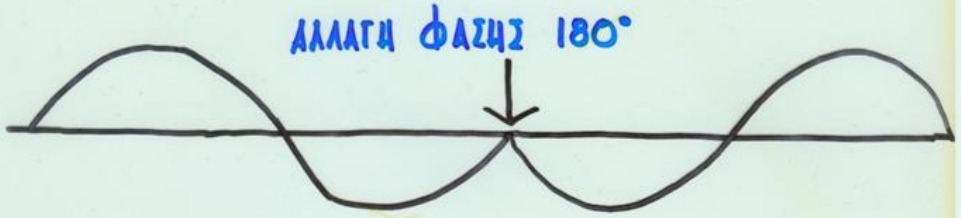
ΤΟ ΣΗΜΑ ΤΩΝ ΔΟΡΥΦΟΡΩΝ GPS

ΒΑΣΙΚΗ ΣΥΧΝΟΤΗΤΑ $f_0 = 10.23$ MHz

ΦΕΡΟΥΣΕΣ $L_1 = 154\, f_0 = 1575.42$ MHz

$L_2 = 120\, f_0 = 1227.60$ MHz

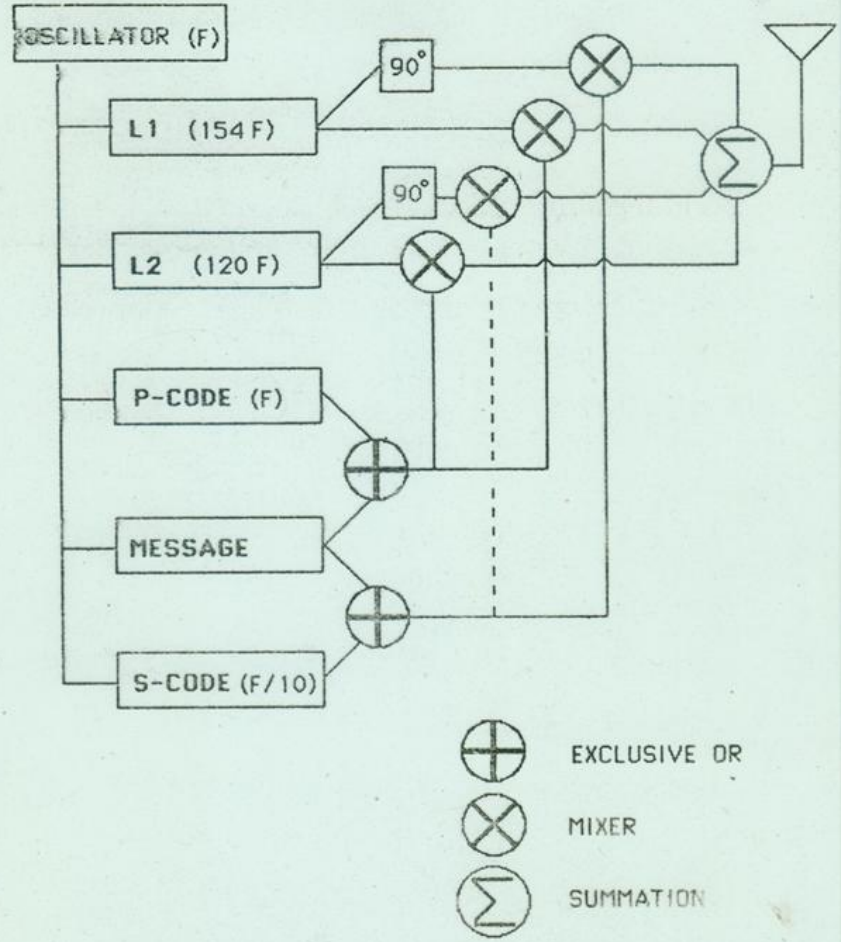
ΔΙΑΜΟΡΦΩΣΗ ΦΑΣΗΣ



1. ~~P~~ Y-CODE — ΣΕΙΡΑ ΜΗΚΟΥΣ 267 ΗΜΕΡΩΝ ΜΕ ΒΗΜΑΤΑ ±1 ΣΤΗΝ f_0 (10.23 MHz)

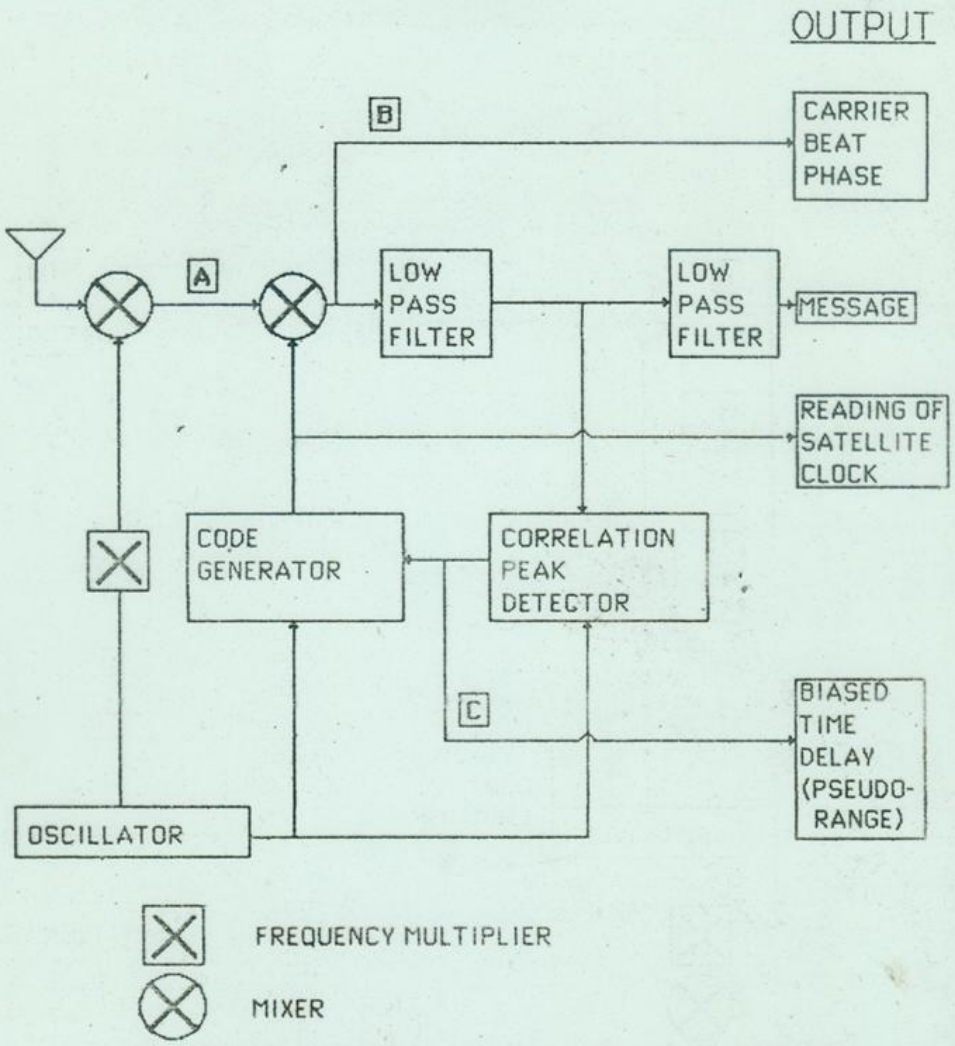
2. C/A CODE — ΣΕΙΡΑ ΜΗΚΟΥΣ 1 ms ΜΕ ΒΗΜΑΤΑ ±1 ΣΤΗΝ $f_0/10$ (1.023 MHz)

3. ΜΗΝΥΜΑ — ΣΕΙΡΑ 1500 BIT ΜΕ ΒΗΜΑΤΑ ±1 ΣΤΑ 50 bps



GPS SATELLITE SIGNALS

FIGURE 1

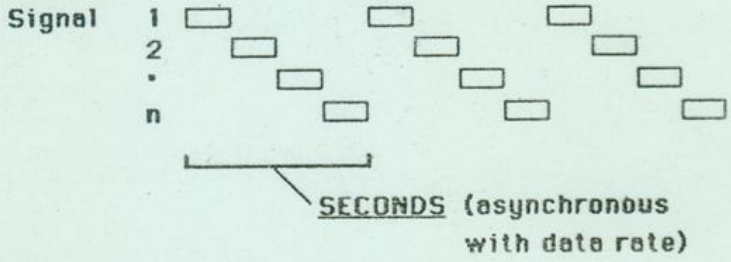


GPS CORRELATION CHANNEL

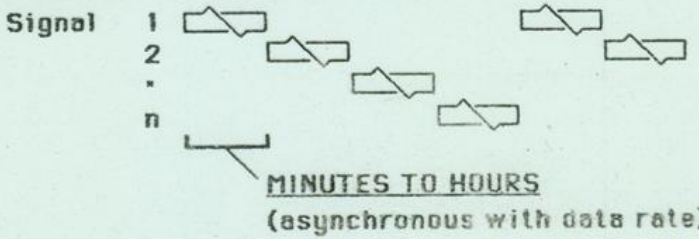
FIGURE 3

MULTIPLEXING CHANNEL

FAST SWITCHING CHANNEL



SLOW SWITCHING CHANNEL



MULTIPLEXING AND SWITCHING CHANNELS

FIGURE 4

$$c = \lambda \cdot f \qquad \lambda = \frac{c}{f}$$

$$c = 299792458\, m/\sec$$

f = 1 575 420 000 Hz λ= 0.190 m
f = 1 227 600 000 Hz λ= 0.244 m
f = 10 230 000 Hz λ= 29.31 m
f = 1 023 000 Hz λ= 293.05 m

c η ταχυτητα του φωτος
λ το μηκος κυματος
f η συχνοτητα

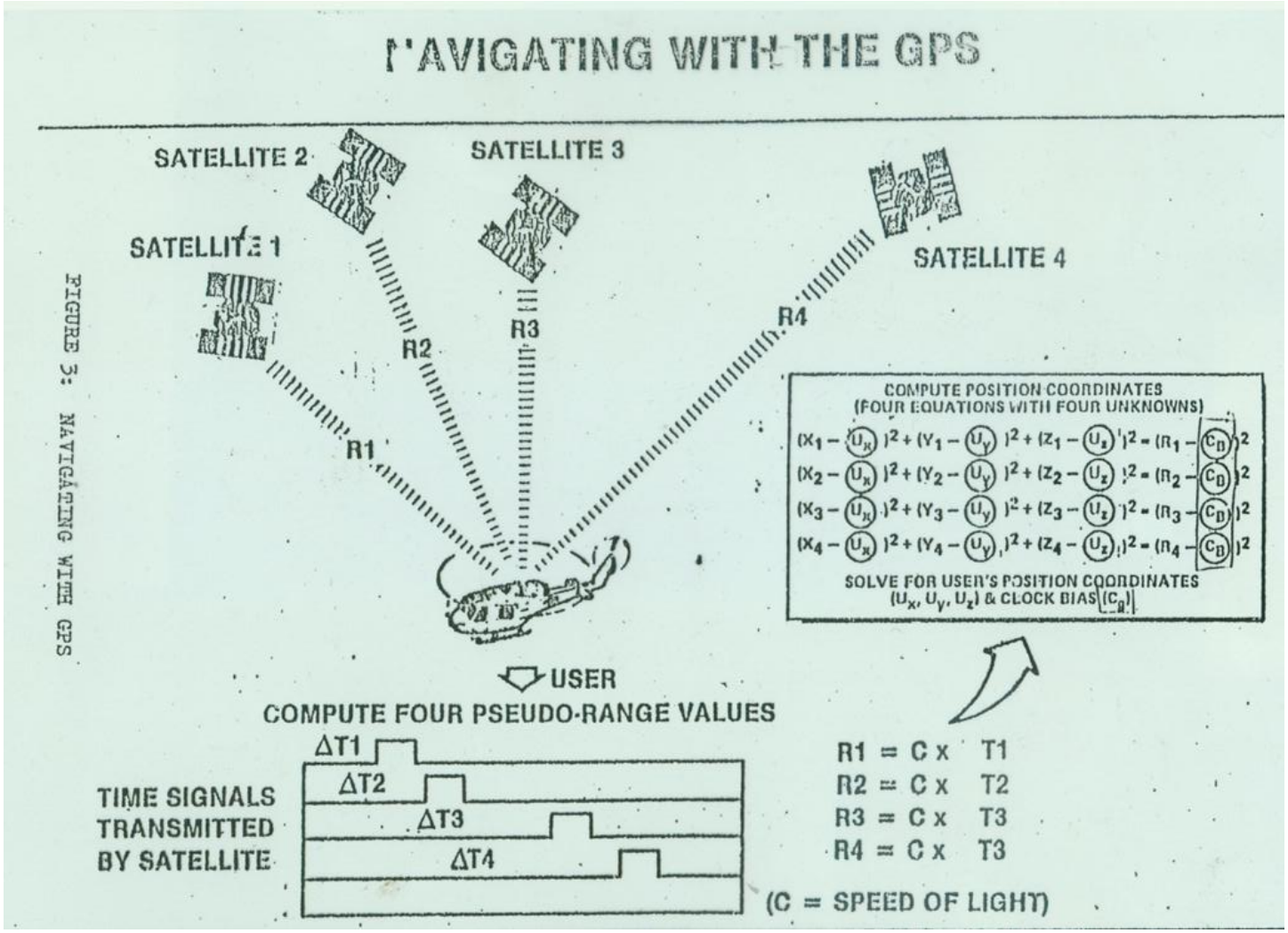
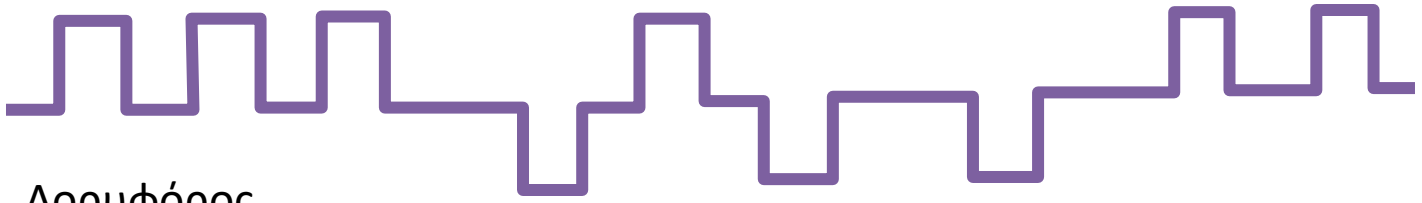
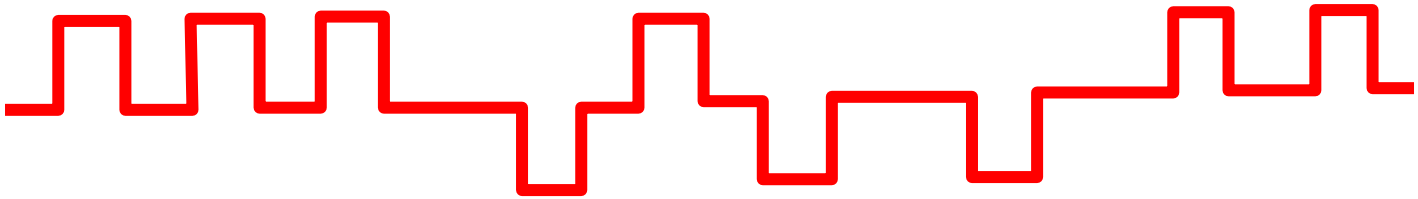


FIGURE 3: NAVIGATING WITH GPS

Μέτρηση Απόστασης

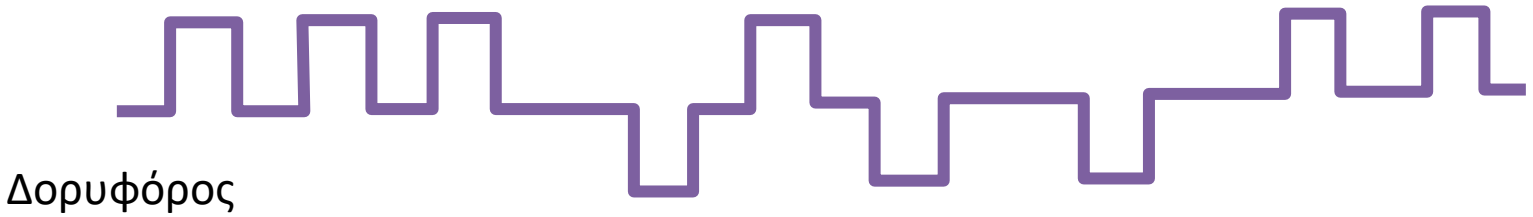


Δορυφόρος

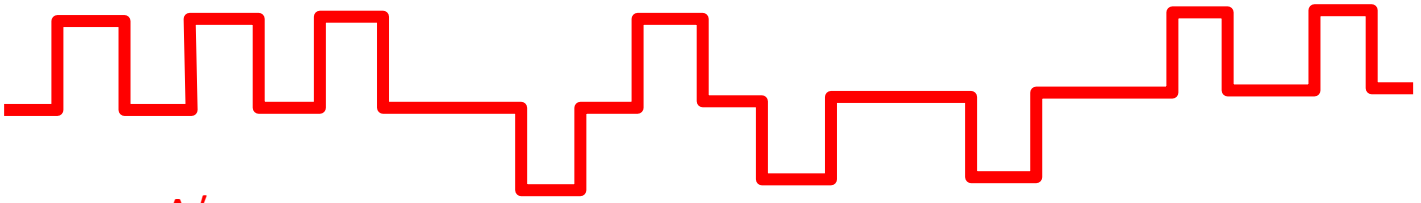


Δέκτης

Μέτρηση Απόστασης



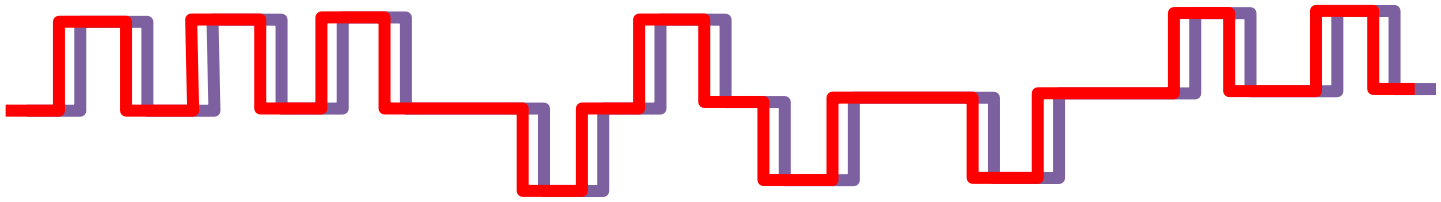
Δορυφόρος



Δέκτης

Μέτρηση Απόστασης

Δορυφόρος



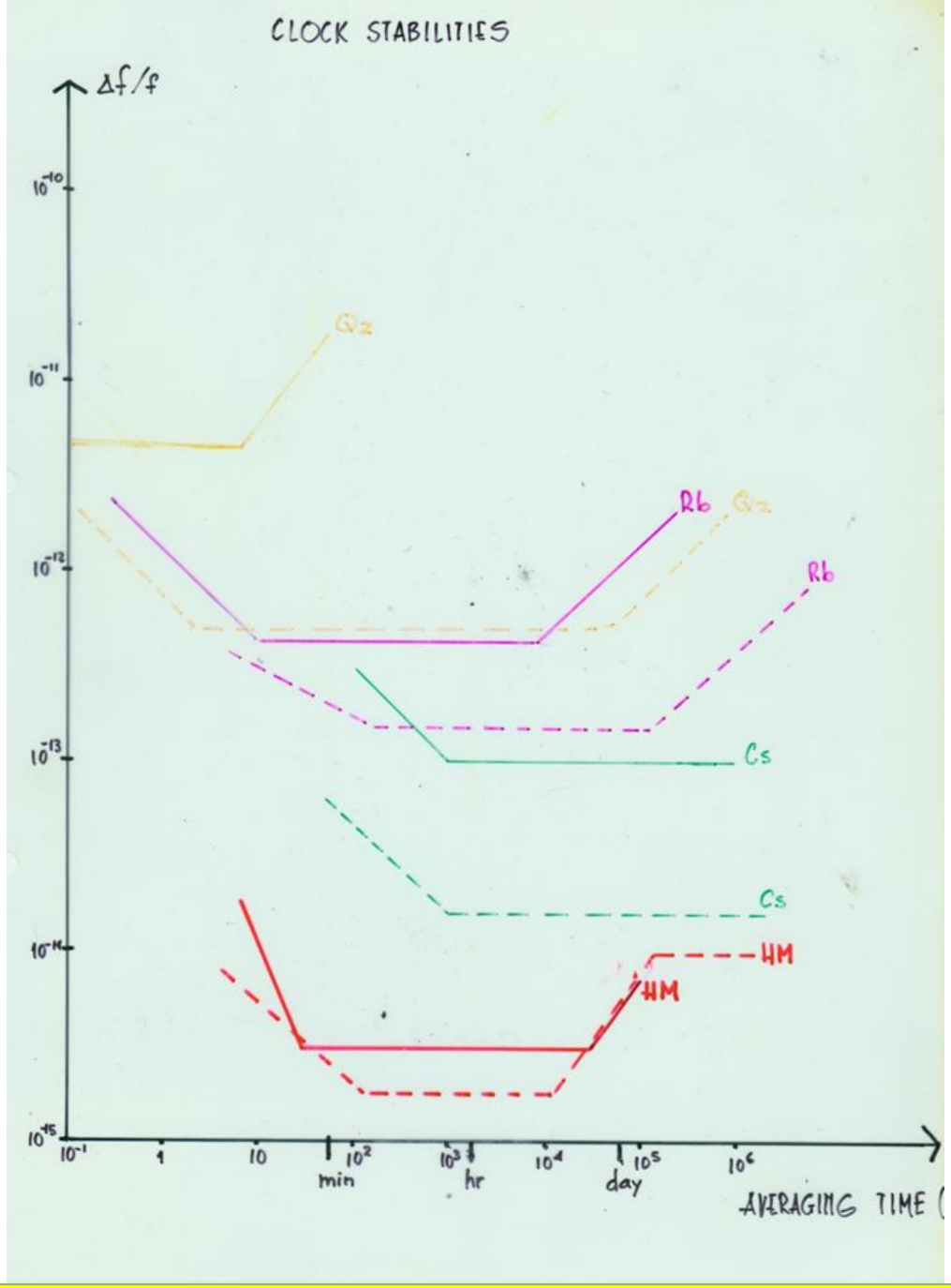
Δέκτης

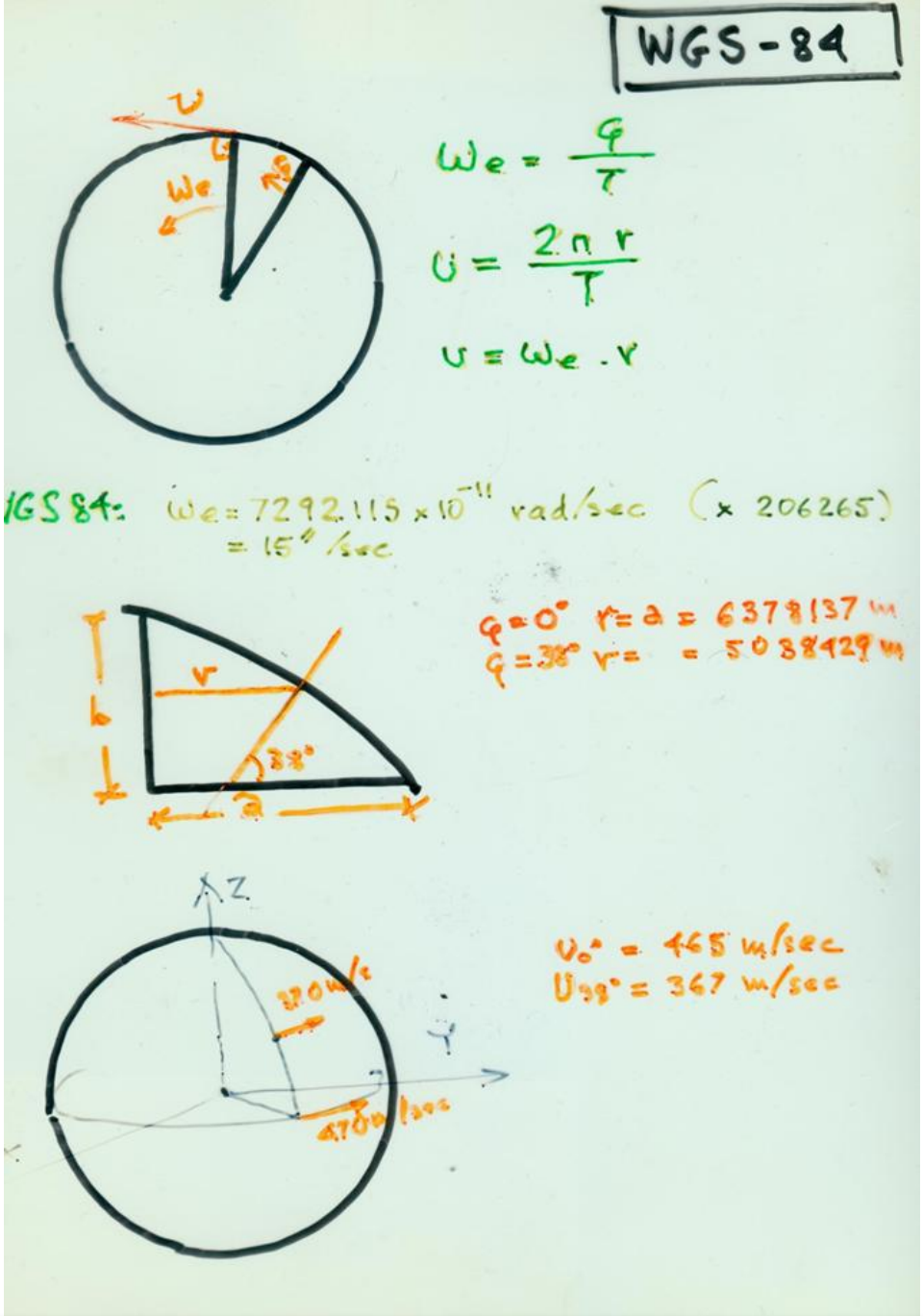
TIME!!

SPEED OF LIGHT
SATELLITES IN ORBIT
EARTH ROTATION
ACCURACY

GEODYNAMICS

REFERENCE SYSTEMS


CLOCK STABILITIES
Δf/f
10⁻¹⁰
10⁻¹¹
10⁻¹²
10⁻¹³
10⁻¹⁴
10⁻¹⁵
Qz
Rb
Qz
Rb
Cs
Cs
HM
HM
10⁻¹
1
10
10²
min
10³
hr
10⁴
10⁵
day
10⁶
AVERAGING TIME



WGS84:ω_e= 7292115x10^{11} rad/sec (x206265)=15”/sec

ϕ=0º r=a=6378137 m
ϕ=38º r= 5088429 m

Vo =465 m/sec
V_{38}=367 m/sec

GPS παραμέτρους κάθε 15 sec

Κίνηση παρατηρητή 5500 m

Κίνηση δορυφόρου 3300 m/sec x 15 s = 49500 m

22 Mm απόσταση δορυφόρου-δέκτη
300 Mm/sec = c (299792458 m/s)

0.07 sec διαδρομή σήματος από δορυφόρο προς δέκτη

Κίνηση παρατηρητή 367 m/s x 0.07 sec = 25.7 m
Κίνηση δορυφόρου 3300 m/s x 0.07 s = 231 m

‘Τοπογραφικες ‘ παρατηρησεις GPS καθε 15 sec

Κινηση παρατηρητη 5500 m
Κινηση δορυφορου 3300 m/sec x 15 sec = 49500 m

22Mm αποσταση δορυφορου-δεκτη
300Mm/sec =c

0.07 sec διαδρομη σηματος απο δορυφορο προς δεκτη

Κινηση παρατηρητη 367 m/sec x 0.07sec= 25.7 m
Κινηση δορυφορου 3300 m/sec x 0.07sec= 231 m

$$R_i^j(t) = \rho_j^j(t) + c\Delta\delta_i^j(t) + \Delta\rho_{ion} + \Delta\rho_{tropo}$$

$$R_i^j(t) = \rho_j^j(t) + c\delta^j(t) - c\delta_i(t) + \Delta\rho_{ion} + \Delta\rho_{tropo}$$

$\Delta\rho_{iono}, \Delta\rho_{tropo}$ ..μοντελα

$c\delta^j(t) = \alpha_0 + a_1(t - t_{0)} + \alpha_2(t - t_0)^2$

Measurement data is corrected for:

a) Signal transmission time
b) Atmospheric delays
c) Relativistic effects
d) Satellite clock offset
e) Group delays

$$R_i^j(t) = \rho_i^j(t) - c\delta_i(t)$$

$$\rho_i^j(t) = \sqrt{(X^j(t) - X_i)^2 + (Y^j(t) - Y_i)^2 + (Z^j(t) - Z_i)^2}$$

$$\rho_i^j(t) = \sqrt{(X^j(t) - X)^2 + (Y^j(t) - Y)^2 + (Z^j(t) - Z)^2}$$

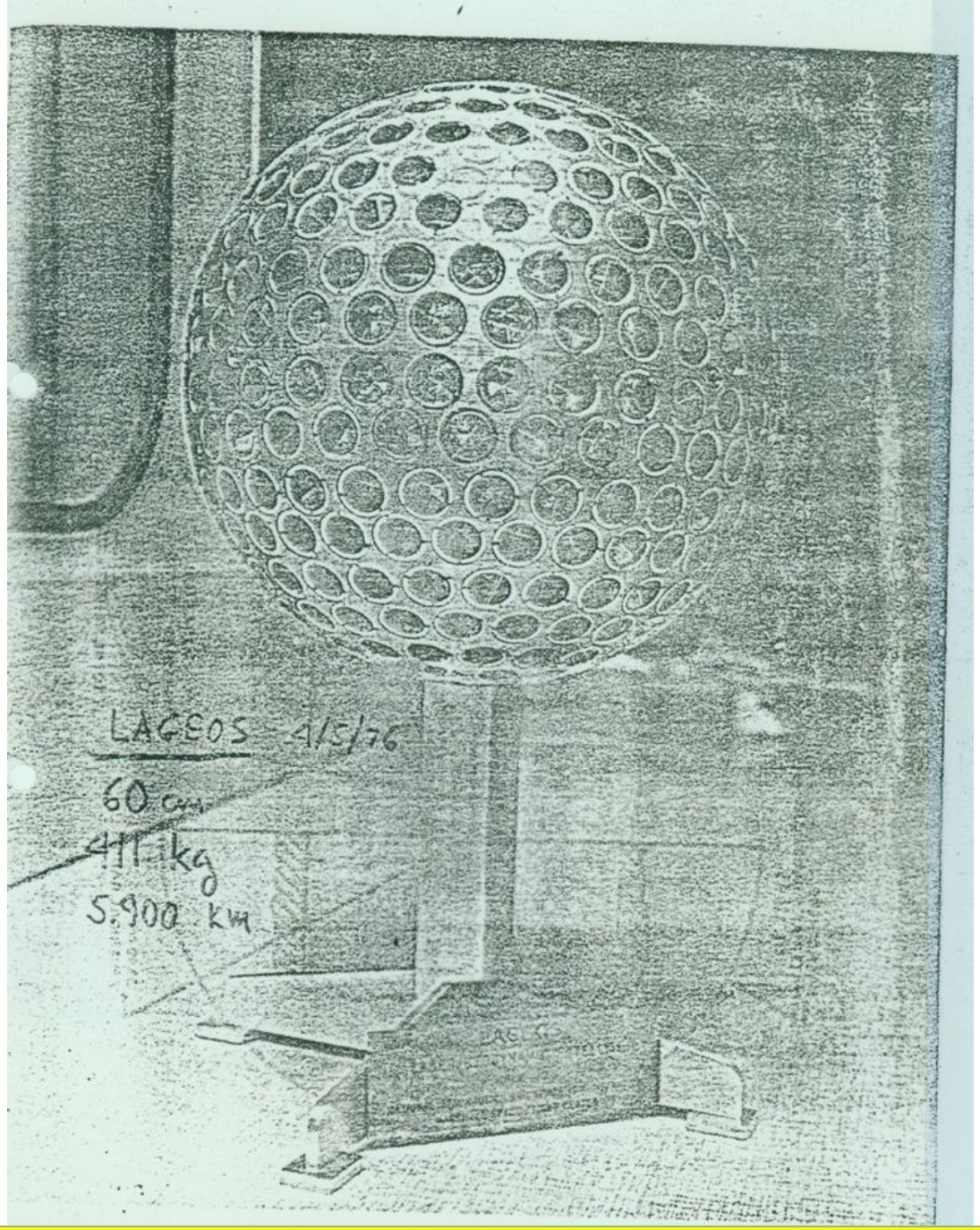
$$\overline{\rho}_i^j(t) = \sqrt{(X^j(t) - \overline{X})^2 + (Y^j(t) - \overline{Y})^2 + (Z^j(t) - \overline{Z})^2}$$

$$\hat{X} = \overline{X} + \Delta X$$

$$\hat{Y} = \overline{Y} + \Delta Y$$

$$\hat{Z} = \overline{Z} + \Delta Z$$

$$R^j = \overline{\rho}^j - \frac{X^j - \overline{X}}{\overline{\rho}}\Delta X - \frac{Y^j - \overline{Y}}{\overline{\rho}}\Delta Y - \frac{Z^j - \overline{Z}}{\overline{\rho}}\Delta Z - c\delta t$$


LAGEOS 4/5/76
60 cm
411 kg
5.900 km