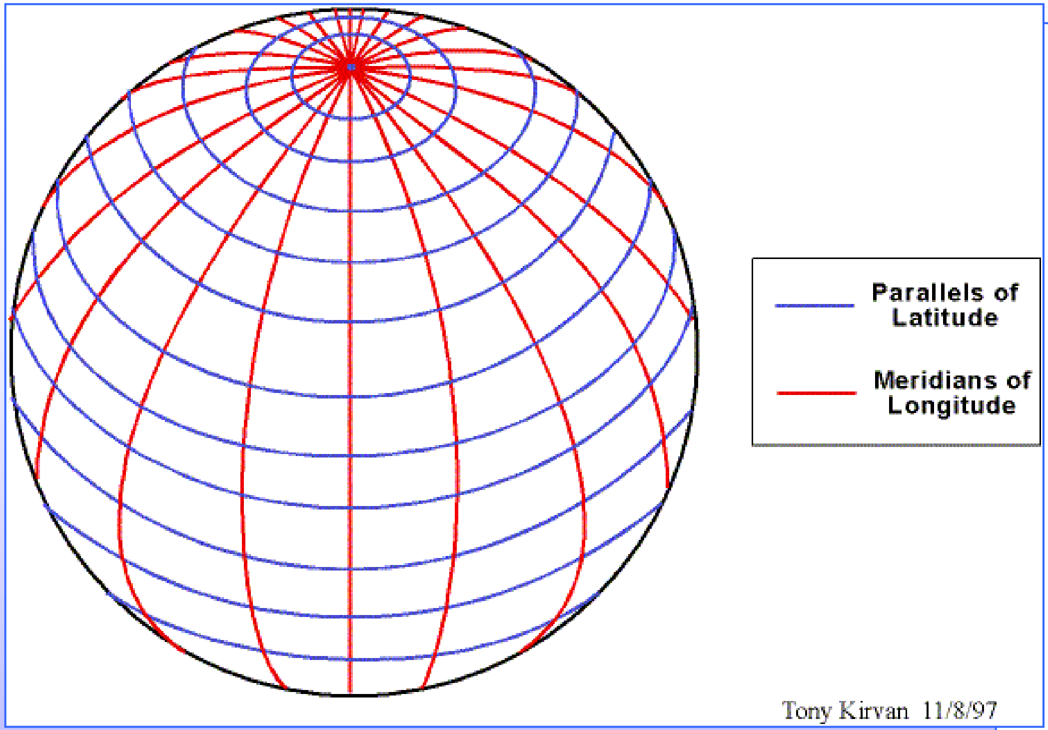
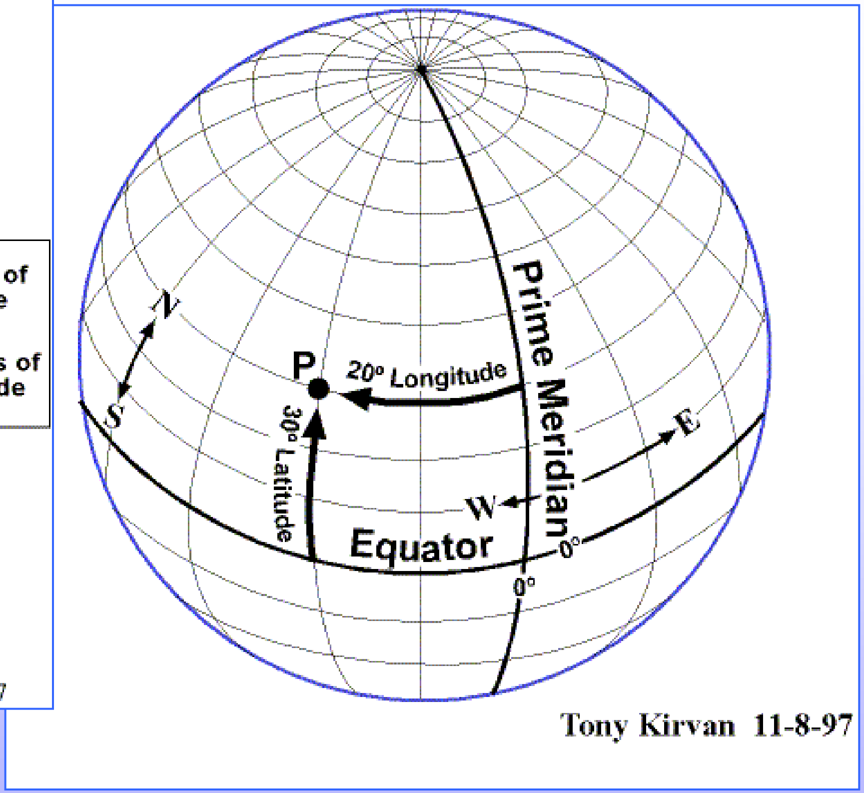
Geometria di un satellite

- Sfera Celeste
- Sistemi di Coordinate
- Studio Eclissi
- Geometria Terra / Satellite

SMAD Chapter 5
p. 95

Sfera Celeste 1/2





azimuth (longitudine ℓ)

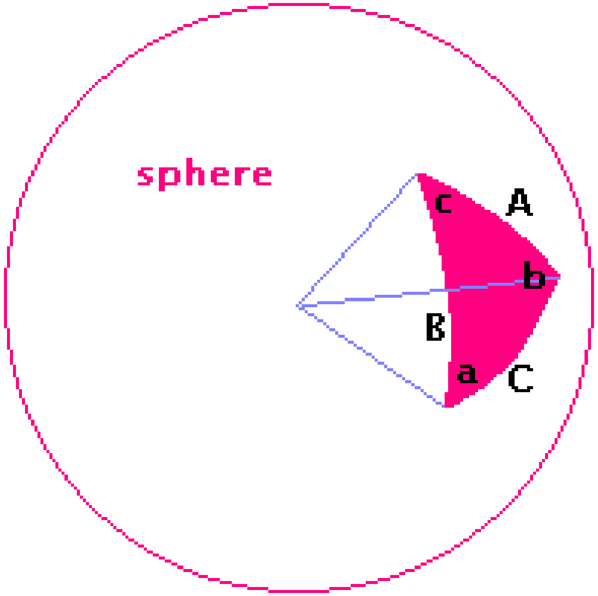
elevazione (latitudine λ)

$$x = \cos \ell \cos \lambda$$

$$y = \sin \ell \cos \lambda$$

$$z = \sin \lambda$$

Sfera Celeste 2/2



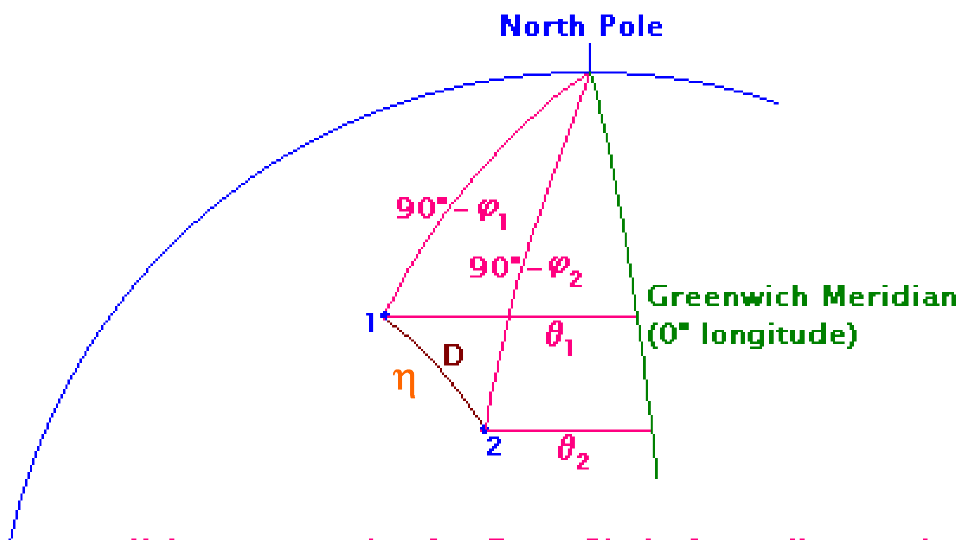
A spherical triangle consists of Great Circle Arcs, extending from the sphere's center, forming Great Circle Angles. Relations among arcs and angles are:

$$\cos(A) = \cos(B)\cos(C) + \sin(B)\sin(C)\cos(a)$$

$$\cos(a) = -\cos(b)\cos(c) + \sin(b)\sin(c)\cos(A)$$

$$\sin(A)/\sin(a) = \sin(B)/\sin(b) = \sin(C)/\sin(c)$$

SMAD Appendix D
Table D-3 p. 907



φ_1, φ_2 elevazione

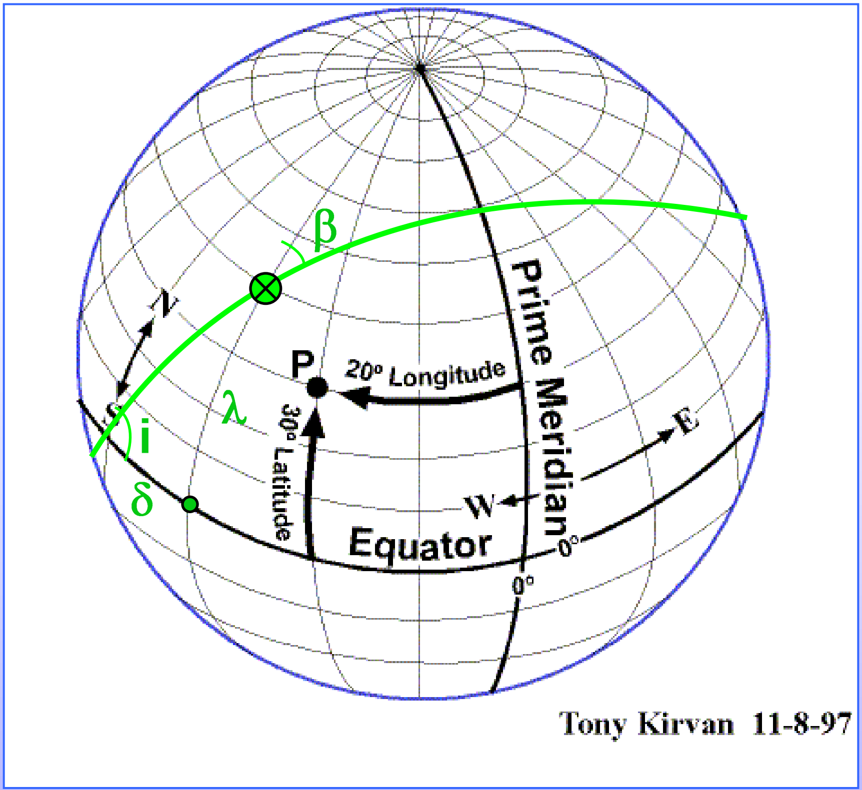
θ_1, θ_2 azimuth

Using an equation for Great Circle Arcs, distance between 1 & 2 is estimated as:

$$\cos(\eta) = \cos(90^o - \varphi_1)\cos(90^o - \varphi_2) + \sin(90^o - \varphi_1)\sin(90^o - \varphi_2)\cos(\theta_1 - \theta_2)$$

$$D = 2\pi R_t/(2\pi)\,\mathrm{acos}(\sin(\varphi_1)\sin(\varphi_2) + \cos(\varphi_1)\cos(\varphi_2)\cos(\theta_1 - \theta_2))$$

Finestre di Lancio



$\lambda > i$?

$\lambda = i$?

$\lambda < i$?

SMAD Appendix D Table D-1 p. 905 riga 4 col. 3

SMAD Appendix D Table D-1 p. 905 riga 5 col. 3

$$\sin\beta = \cos i / \cos\lambda$$

$$\cos\delta = \cos\beta / \sin i$$

$$LST = \Omega + \delta$$

$$LST = \Omega + 180^o - \delta$$

SMAD chapter 6.4
p. 153-155

$$v_{sud} = - v_o \cos\gamma \cos\beta_L$$

$$v_{est} = v_o \cos\gamma \sin\beta_L - v_\lambda$$

$$v_r = v_o \sin\gamma \quad (v_z)$$

$$v_\lambda = 464.5 \cos\lambda \text{ m/s}$$

β azimuth di lancio

γ angolo traiettoria volo al *burn-out*

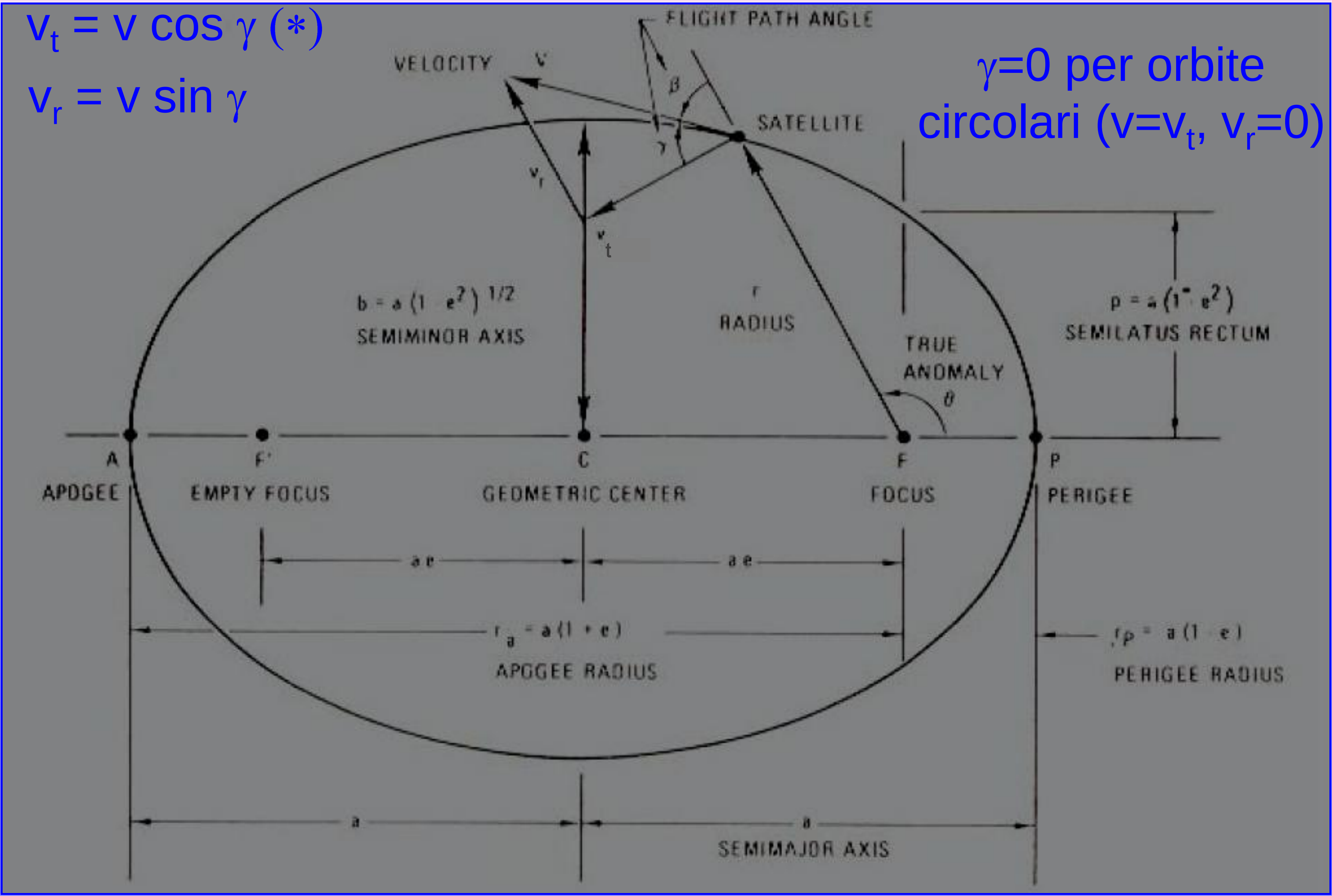
(vedi ultima trasparenza su orbite)

Parametri Ellisse

$v_t = v \cos \gamma$ (*)

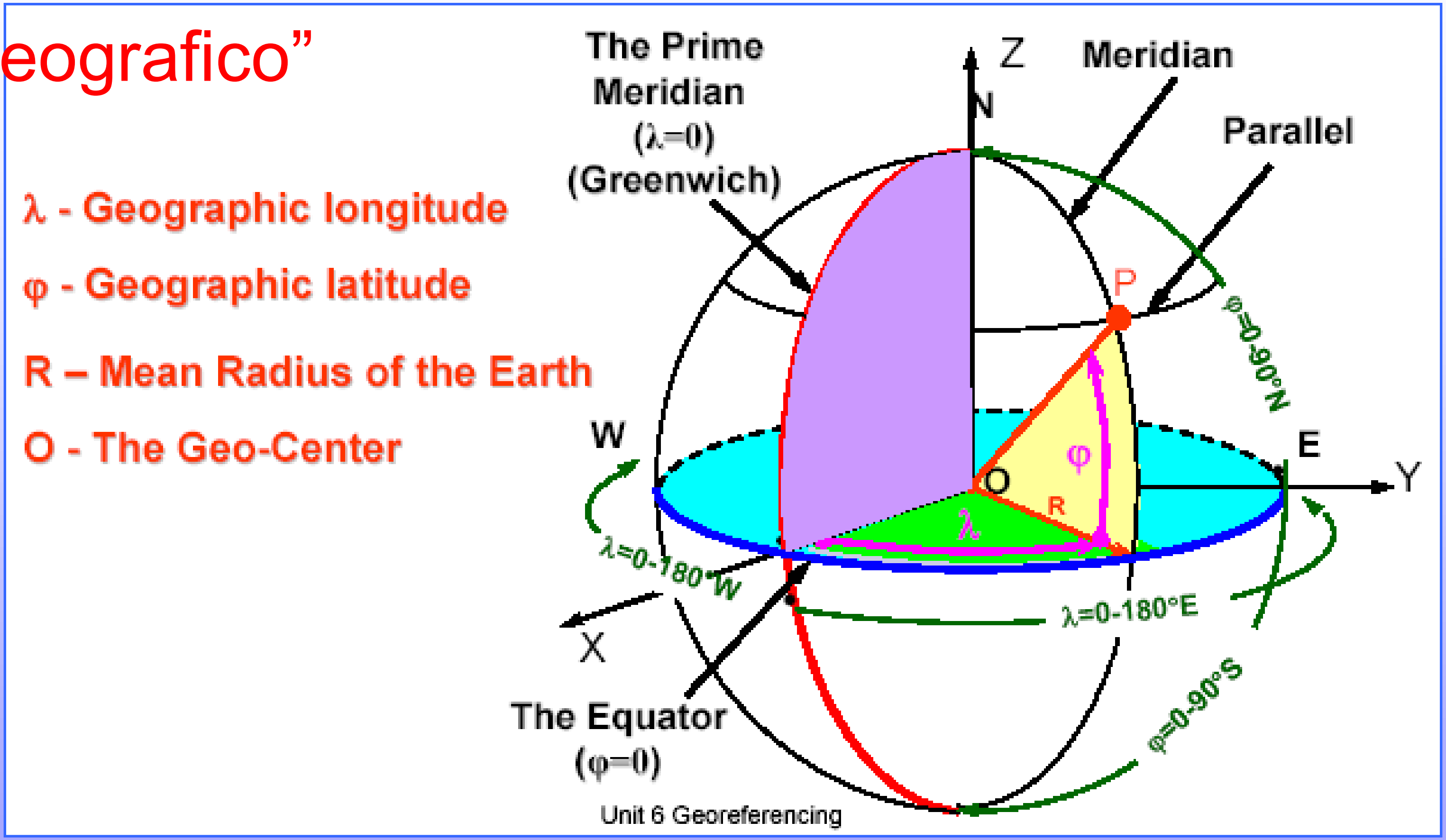
$v_r = v \sin \gamma$

$\gamma=0$ per orbite circolari ($v=v_t$, $v_r=0$)



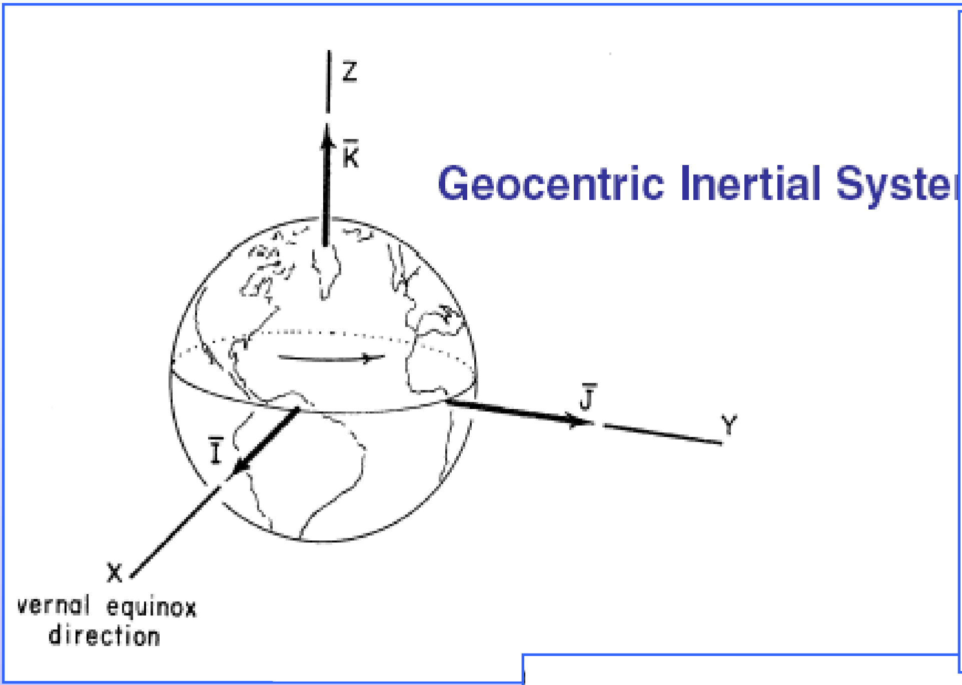
Sistemi di Coordinate 1/3

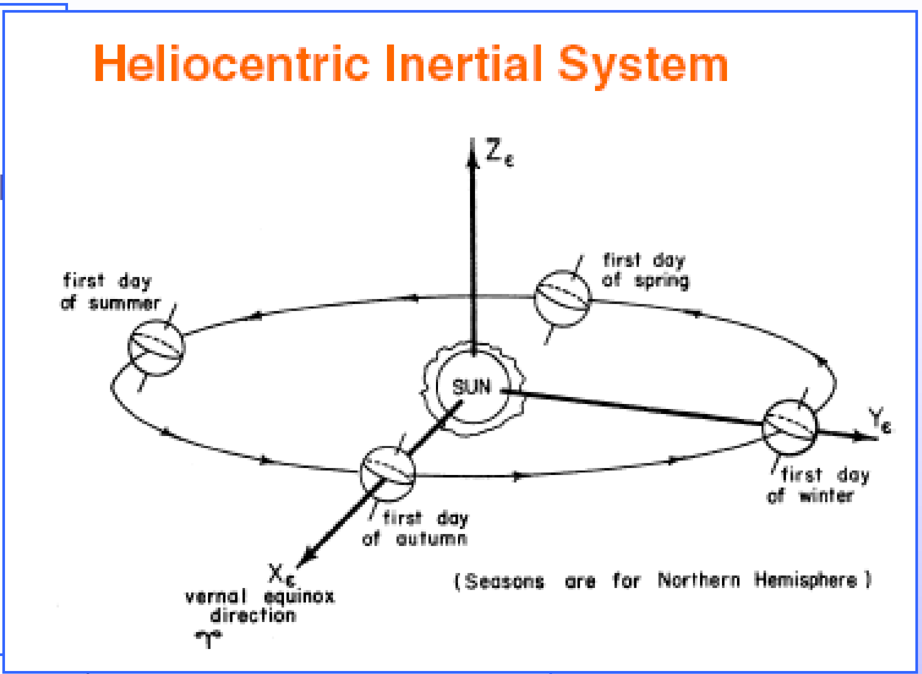
Sistema Geocentrico "Geografico"

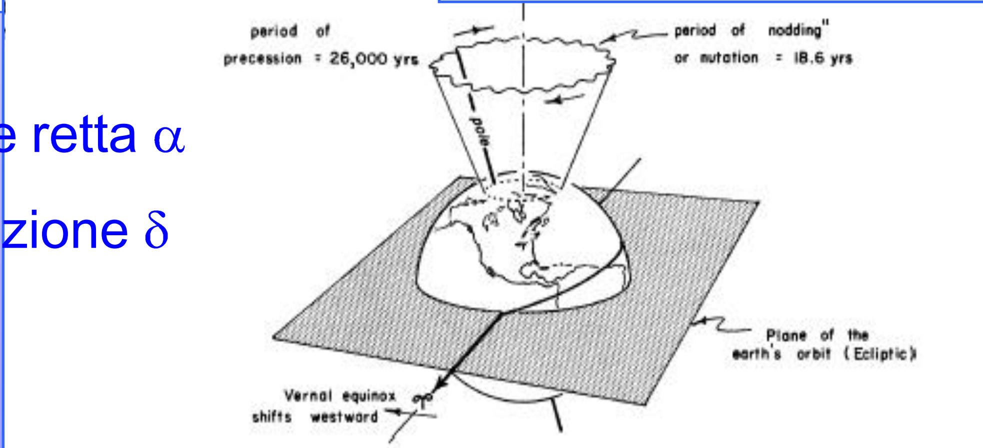


Attenzione all'indicazione lat/long !

Sistemi di Coordinate 2/3







50.2786" westerly drift of the Vernal Equinox per year

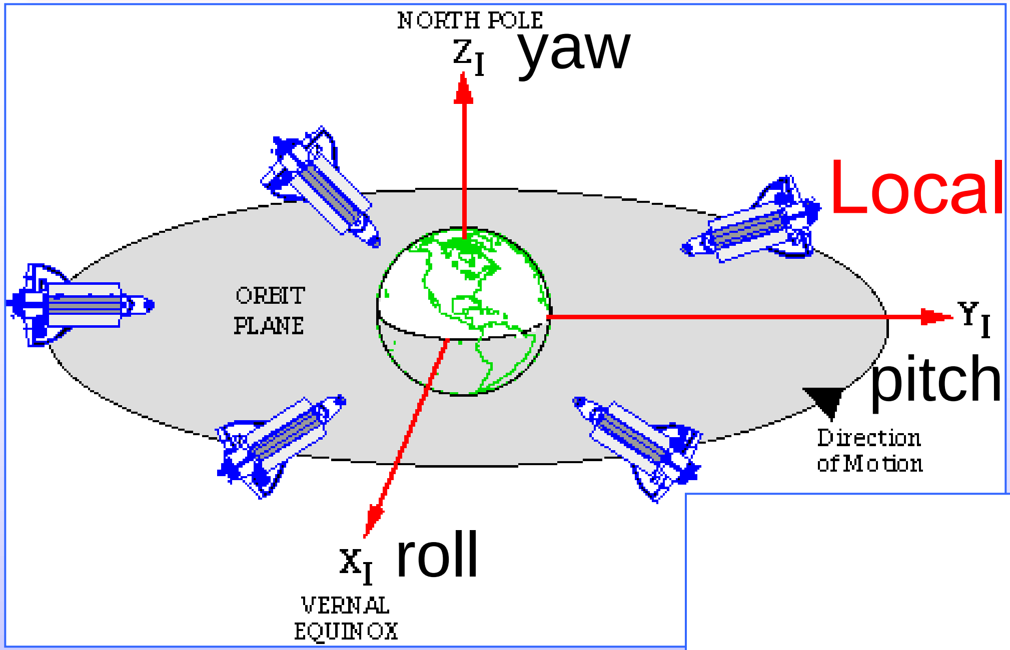
azimuth = ascensione retta α

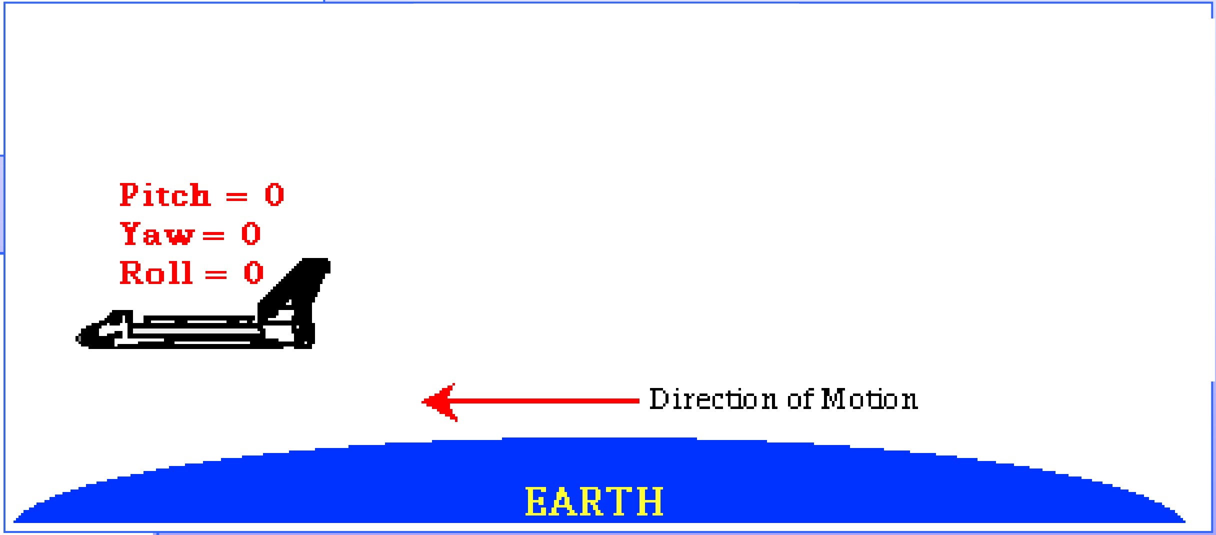
elevazione = declinazione δ

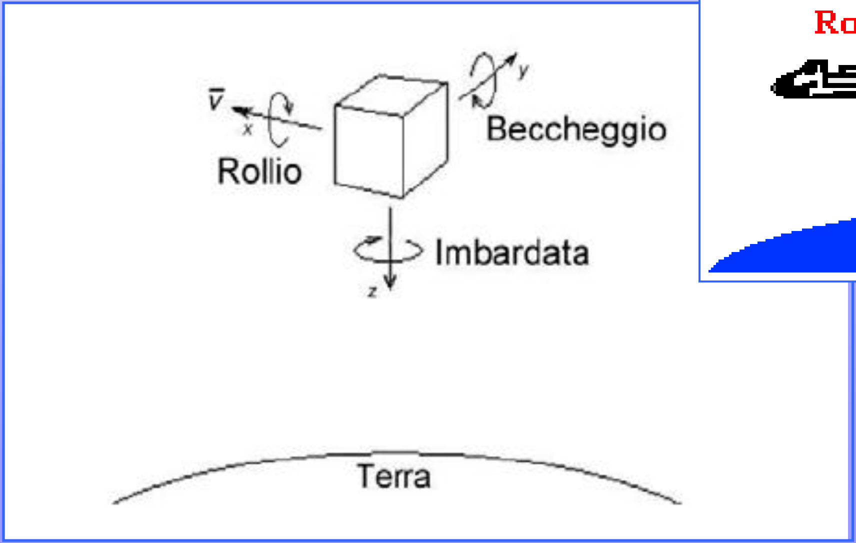
Sistemi di Coordinate 3/3

LVLH

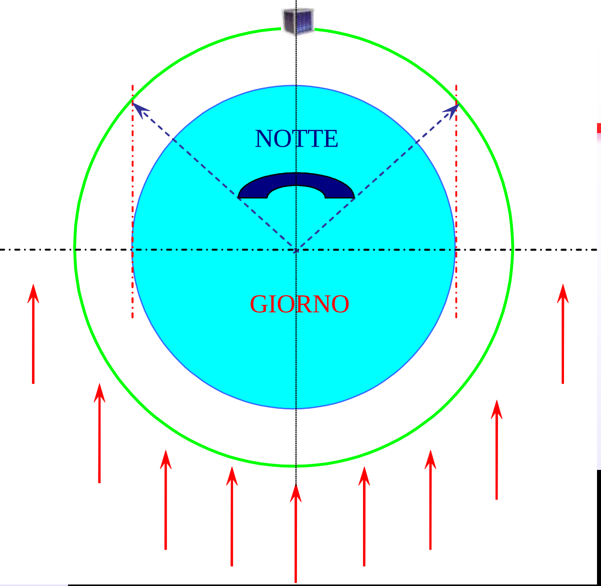
Local Vertical – Local Horizontal



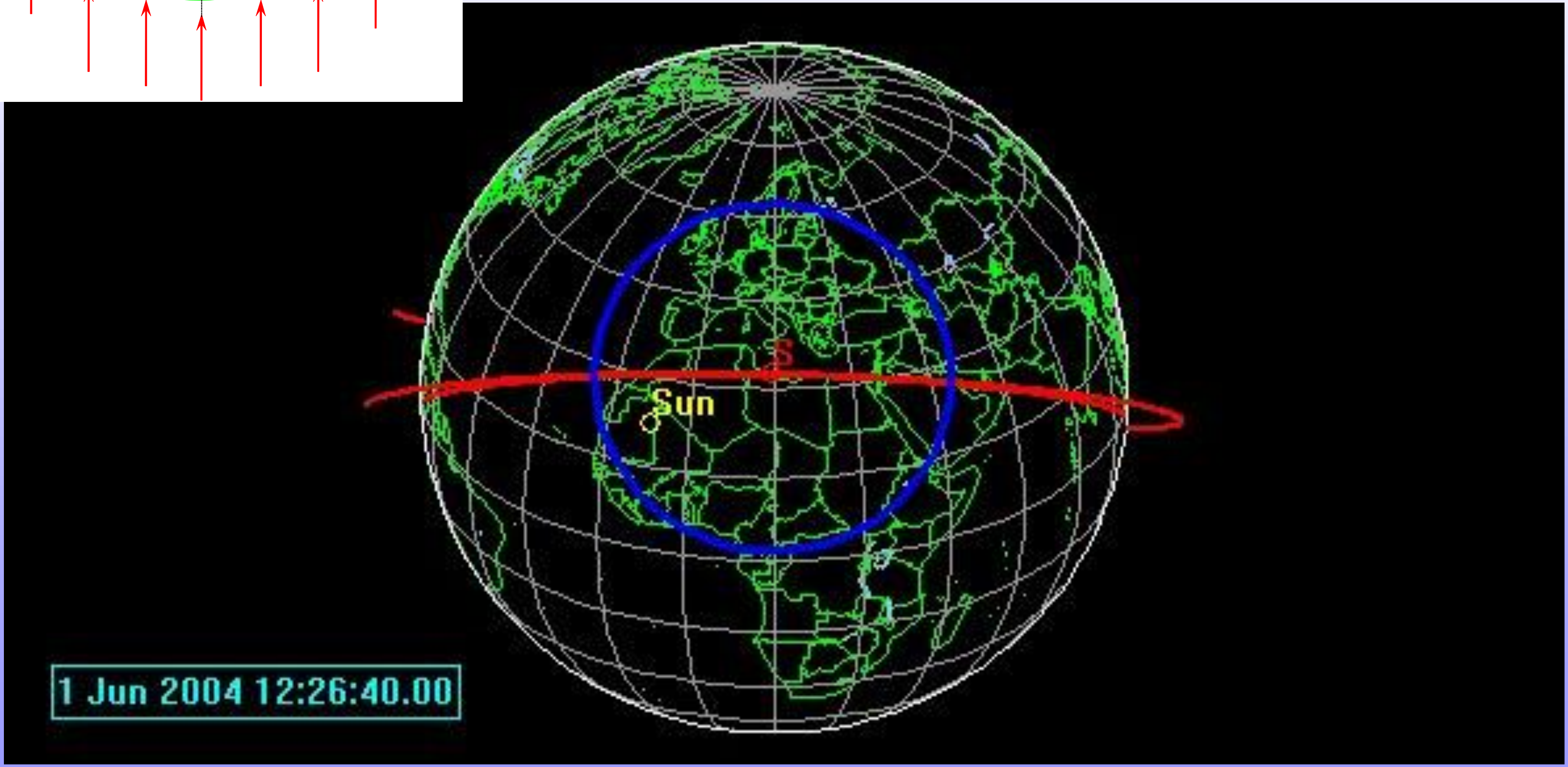




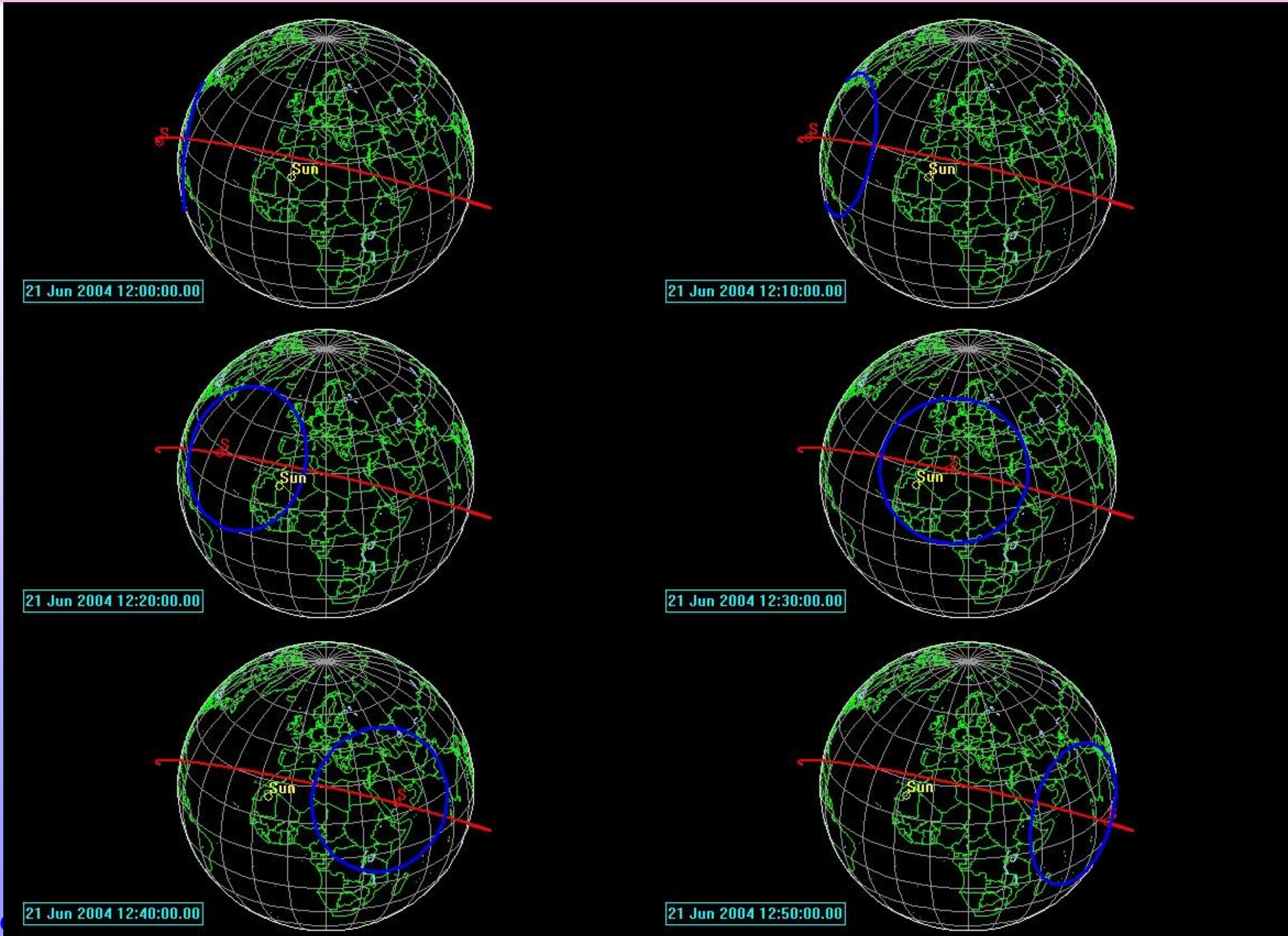
Studio Eclissi 1/3



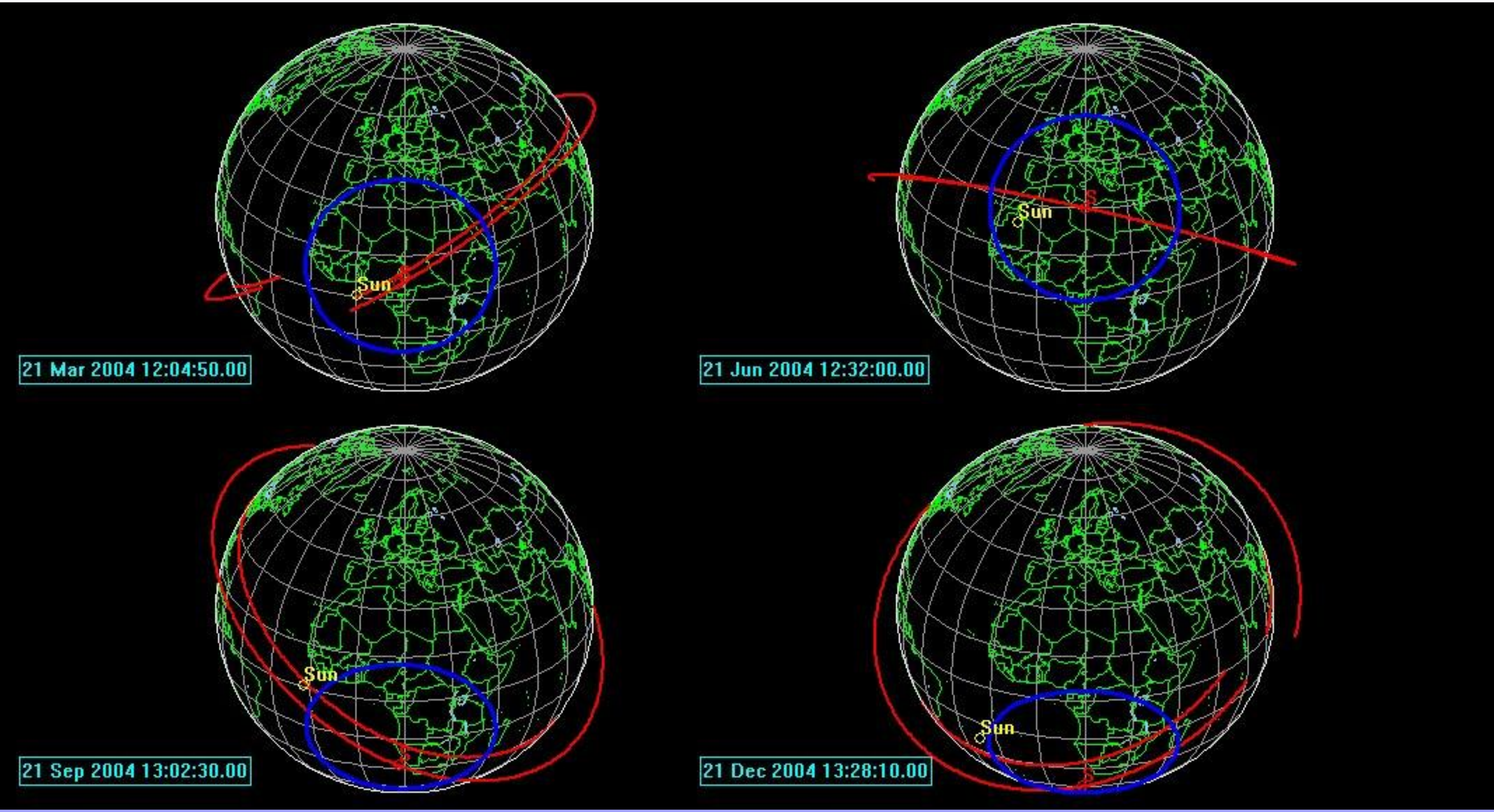
h = 1000 km, i = 32°



Studio Eclissi 2/3

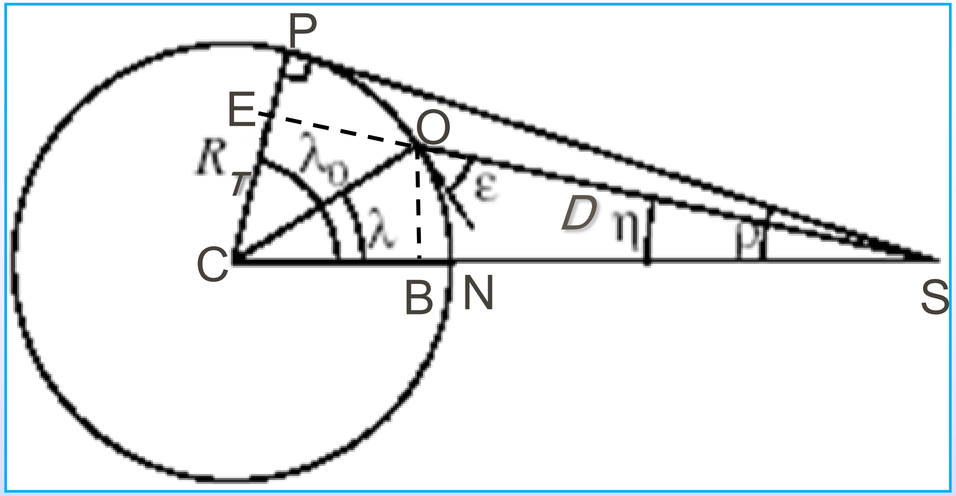


Studio Eclissi 3/3



SMAD chapter 5.1
Example 1, 2 e 3
p. 105-110

Geometria Terra / Satellite



ρ raggio angolare Terra

η angolo di nadir

ε elevazione

λ angolo centrale Terra

SMAD chapter 5.2
fig 5-13 p. 110-113

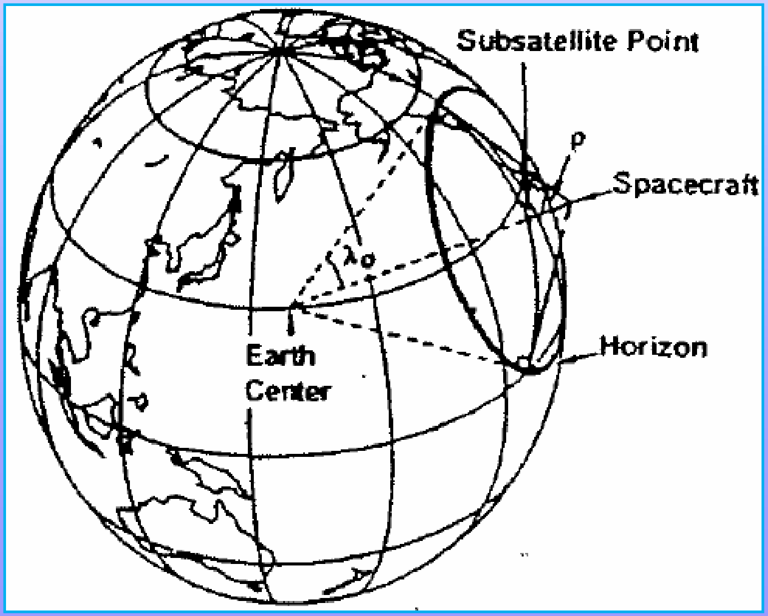
$\sin\rho = \cos\lambda_0 = R_T/R = R_T / (R_T+h)$

$\sin\eta = \cos\varepsilon \sin\rho$

$\lambda = \pi/2 - \eta - \varepsilon$

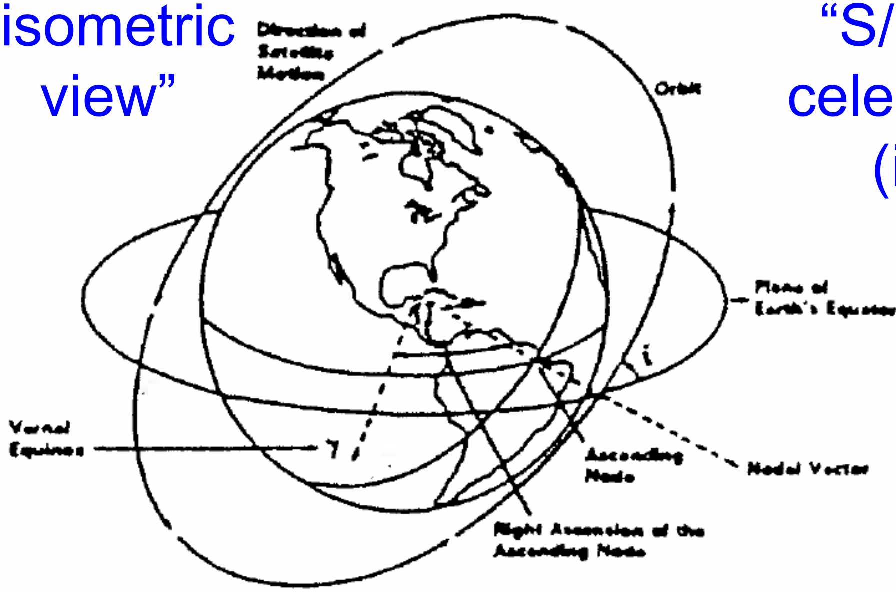
$\mathrm{tg}\,\eta = \sin\rho \sin\lambda / (1 - \sin\rho \cos\lambda)$

$D = R_T \sin\lambda / \sin\eta$

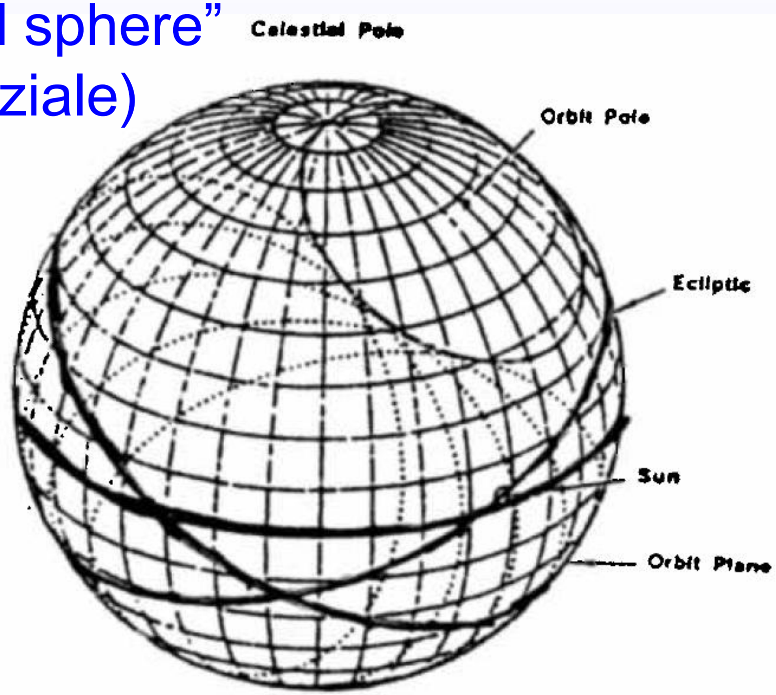


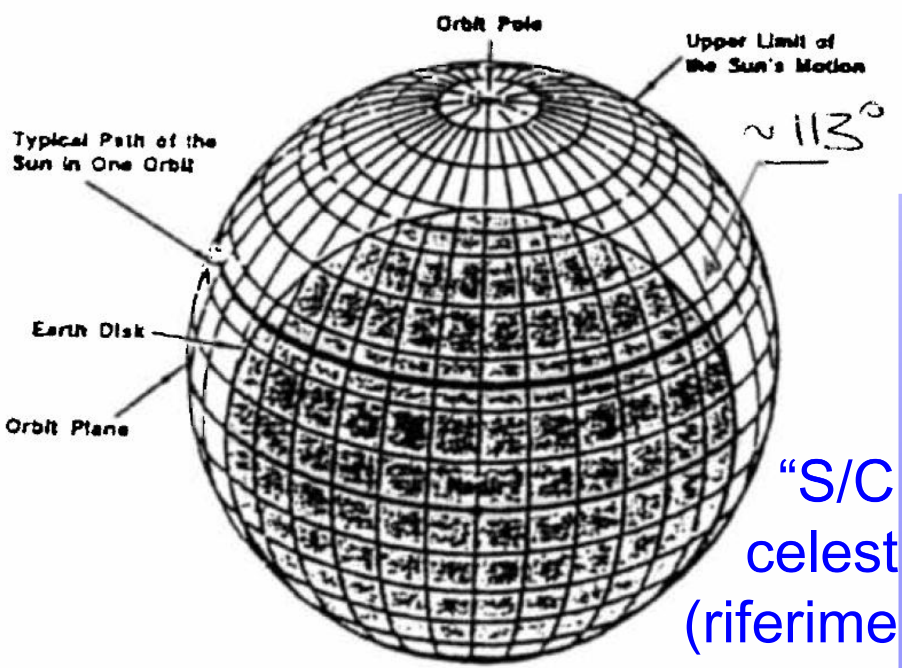
Geometria di un satellite 1/3

"isometric view"



"S/C centered celestial sphere" (inerziale)



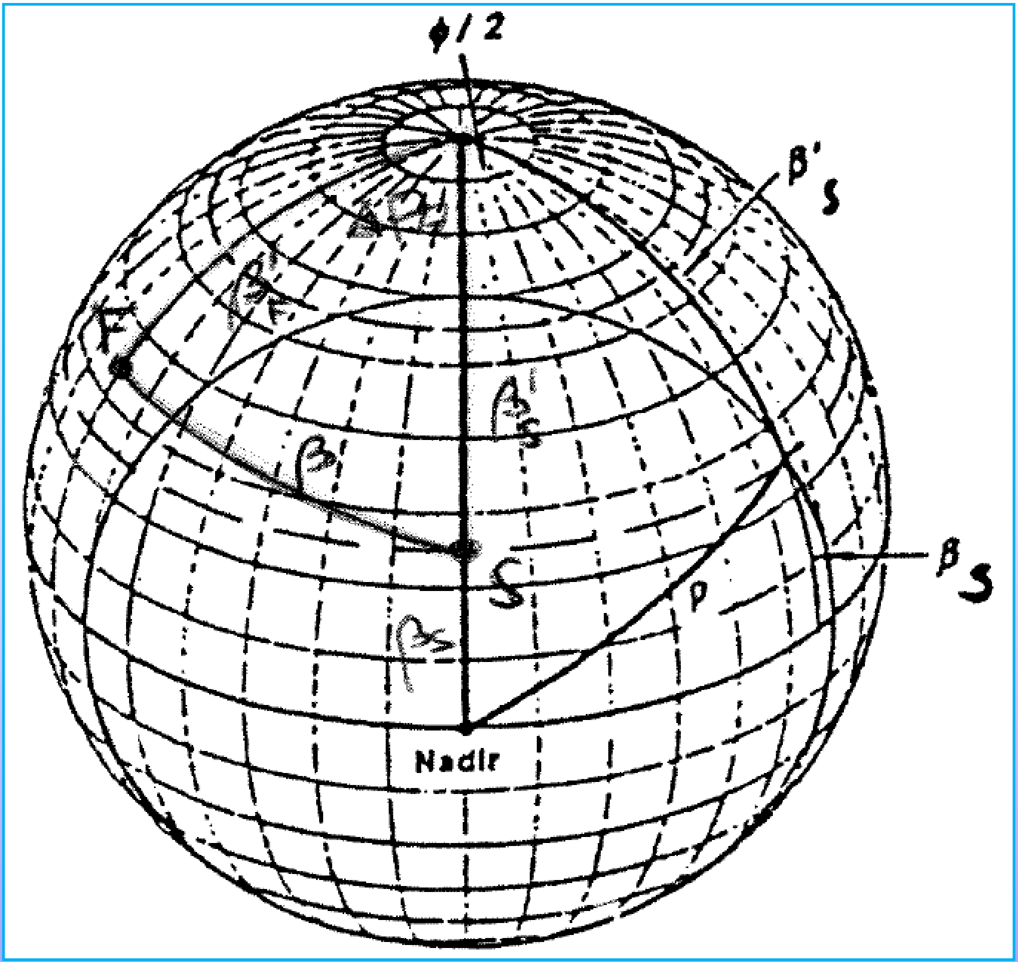


"S/C centered celestial sphere" (riferimento terrestre)

h = 1000 km, i = 32° $\Rightarrow$

τ = 105 min, ρ = 60°

Geometria di un satellite 2/3



β_s = 25° ⇒ Φ/2 =56.5°

Durata fase notturna (eclisse): max e min

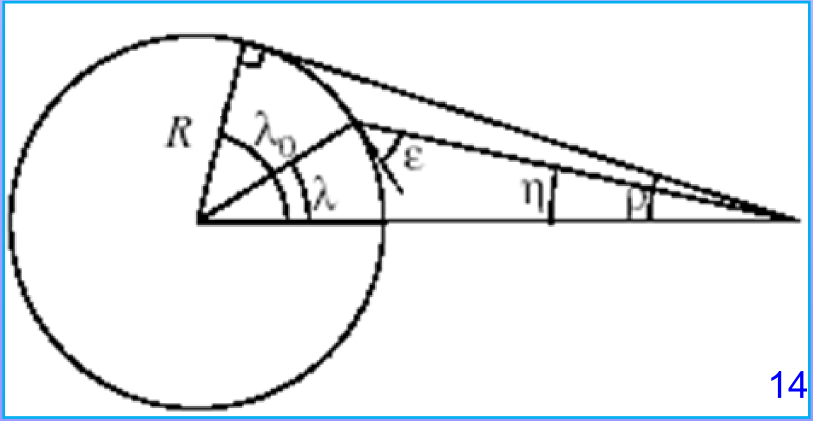
β_s : max e min

β_F = 35°, Az_o= 75°

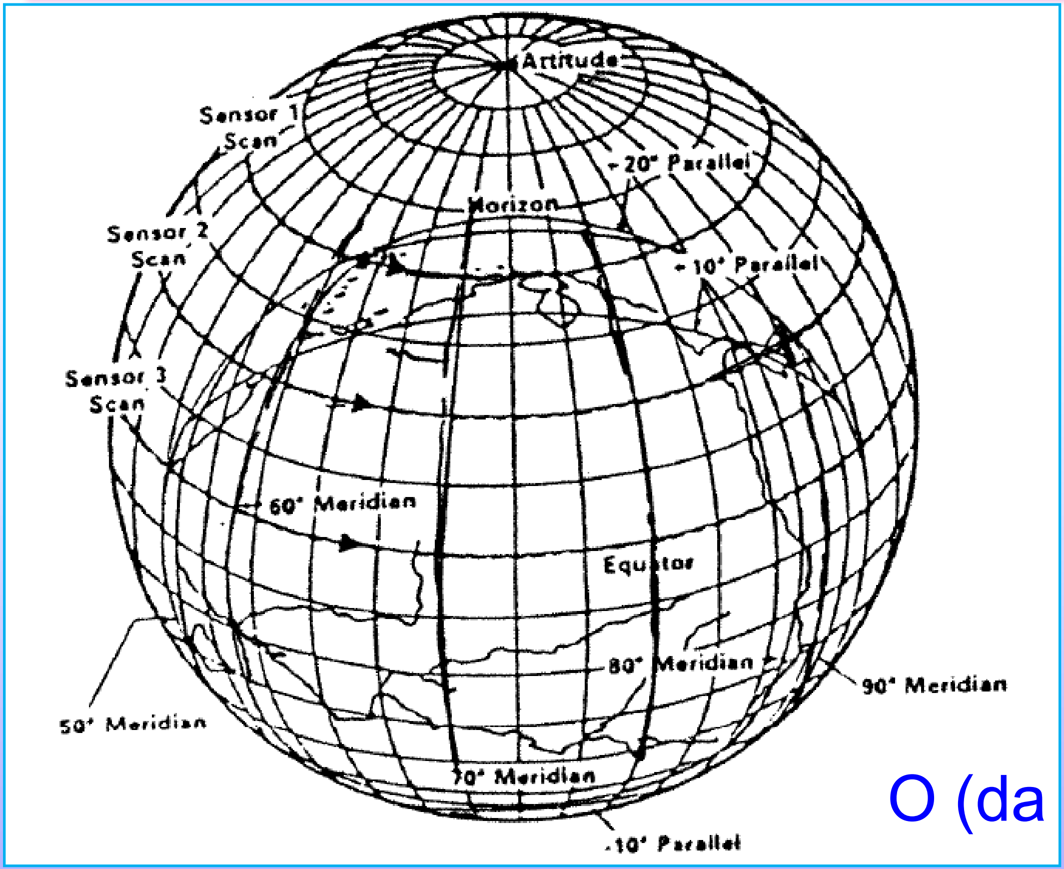
A = 0.5 m^2 ⇒

- "eclisse": Az = Az_o Φ/2

- "dietro": β = π/2



Geometria di un satellite 3/3



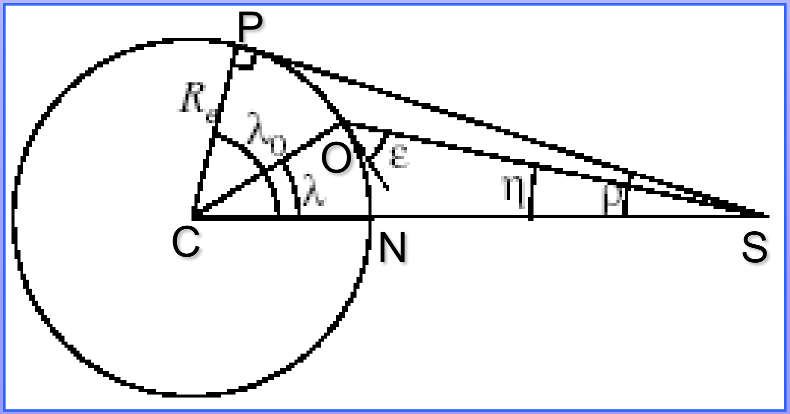
$l_o = 200^o$, $\lambda_o = 22^o$

$l_N = 185^o$, $\lambda_N = 10^o$

$\Rightarrow$

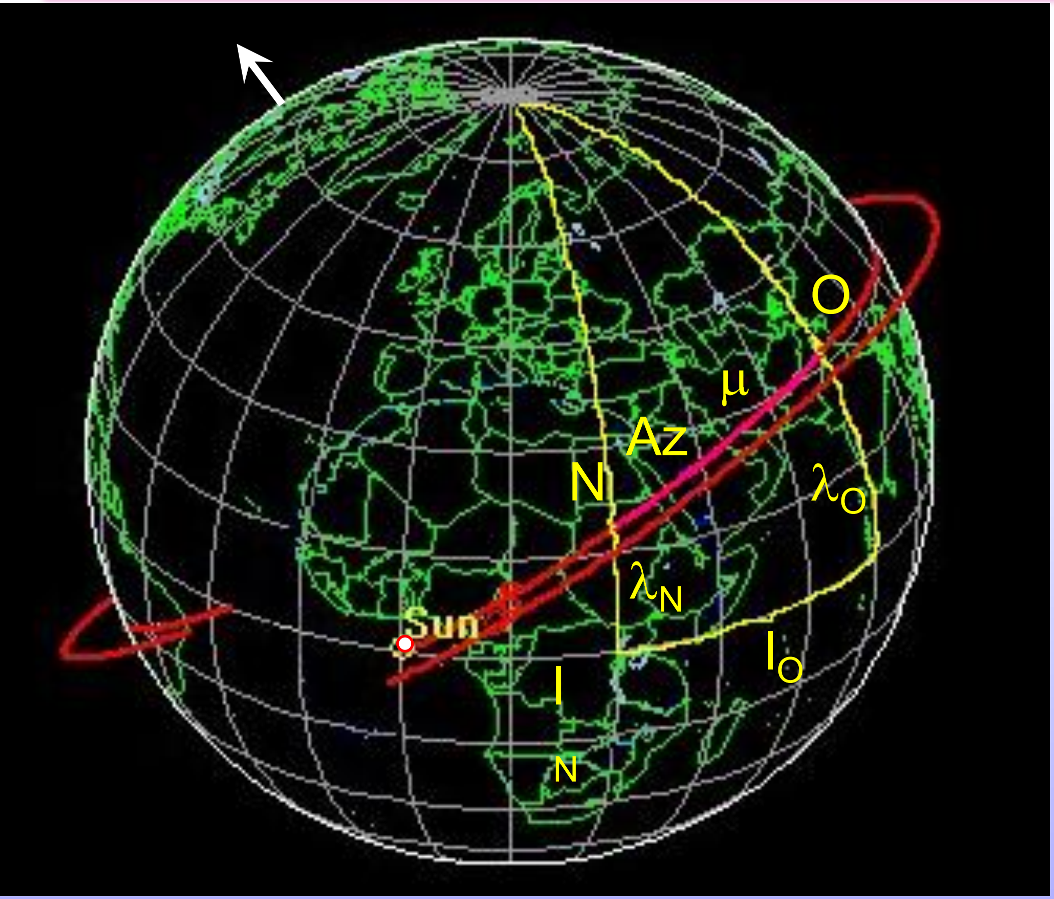
$\rho = 59.8^o$, $\lambda_0 = 30.2^o$,
$D_{max} = 3709$ km

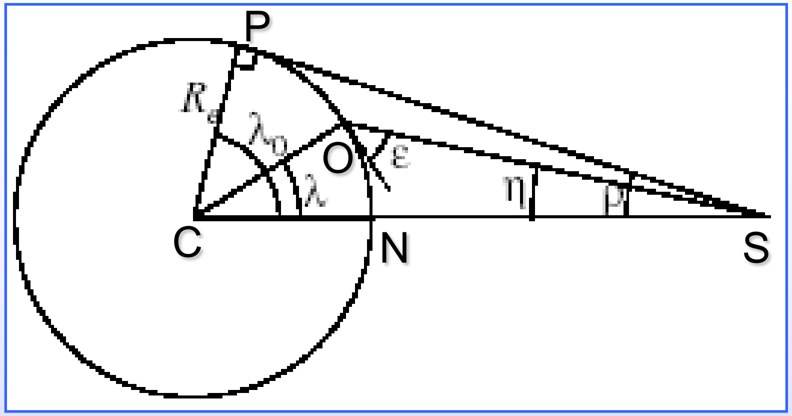
O (da N)
- $\lambda = 18.7^o$ (swath width)
- $Az = 48.3^o$



O (da satellite)
- $\eta = 56.8^o$ (ε=14.5°)
- D = 2444 km

Passaggio sopra la stazione 1/2





Meglio: geometria vista dal satellite!
Nota: quella segnata non è un'orbita del satellite ma un cerchio max che passa per O e N

N = Sub Satellite Point
O = Punto qls Terra!!!

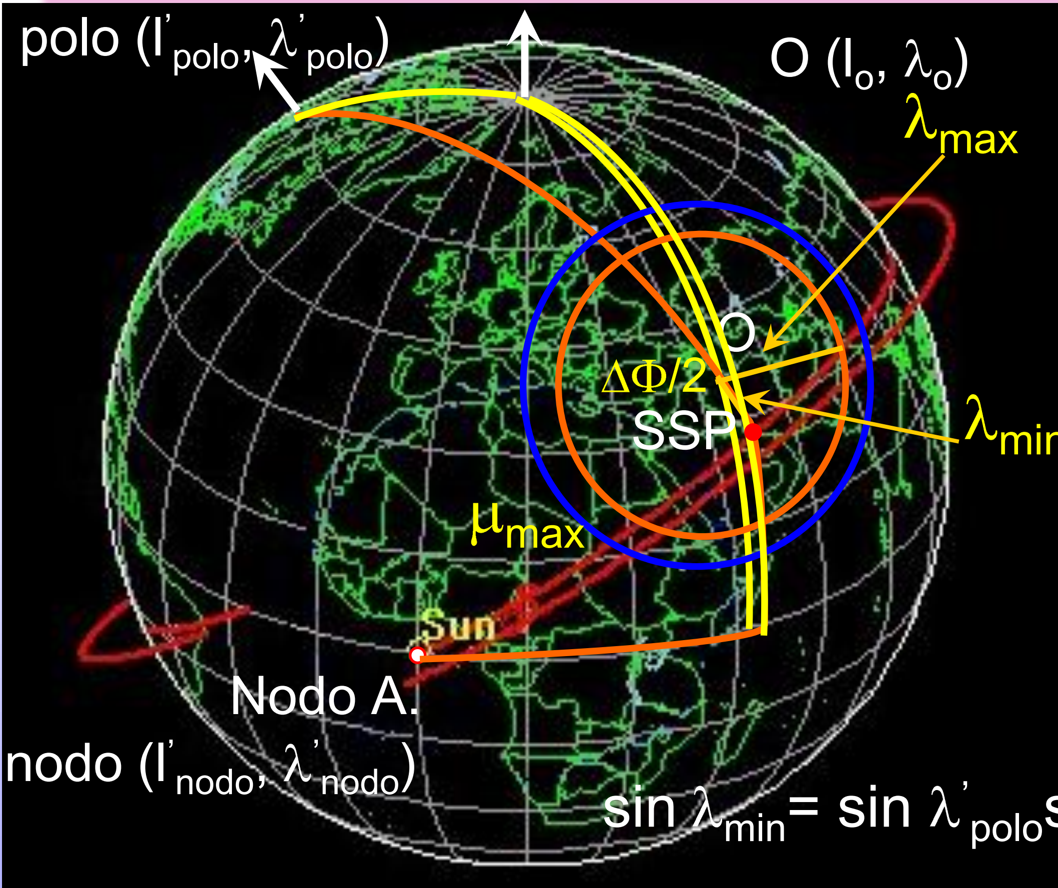
$$\cos\mu = \sin\lambda_N \sin\lambda_O + \cos\lambda_N \cos\lambda_O \cos(l_O - l_N) \quad \Rightarrow \eta$$

$$\sin\lambda_O = \sin\lambda_N \cos\mu + \cos\lambda_N \sin\mu \cos Az \qquad (\mu \equiv \lambda)$$

$$\cos \mathbf{Az} = (\sin\lambda_O - \sin\lambda_N \cos\mu) / \cos\lambda_N \sin\mu$$

SMAD chapter 5.2
fig 5-12 p. 112

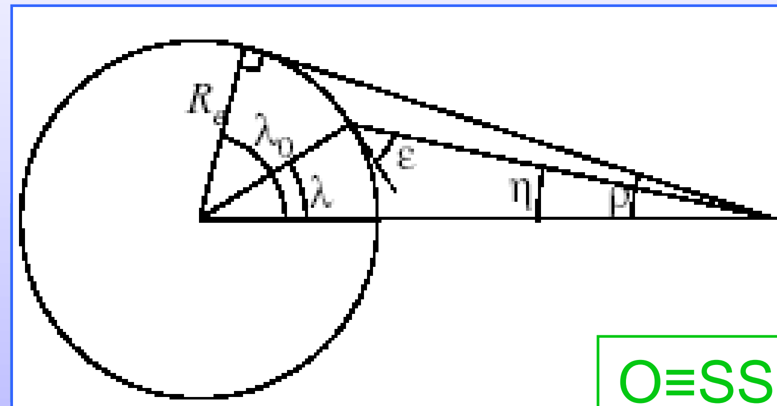
Passaggio sopra la stazione 2/2



$\sin \eta_{max} = \cos \varepsilon_{min} \sin \rho$

$\lambda_{max} = \pi/2 - \eta_{max} - \varepsilon_{min}$

$D_{max} = R_T \sin \lambda_{max} / \sin \eta_{max}$



O≡SSP

$\sin \lambda_{min} = \sin \lambda'_{polo} \sin \lambda_o + \cos \lambda'_{polo} \cos \lambda_o \cos(l_o - l'_{polo})$

$\tan \eta_{min} = \sin \rho \sin \lambda_{min} / (1 - \sin \rho \cos \lambda_{min})$

SMAD chapter 5.3.1
fig 5-17 p. 118-121

$\varepsilon_{max} = \pi/2 - \eta_{min} - \lambda_{min}$

$R_T \sin \lambda_{min} = D_{min} \sin \eta_{min}$

$\omega_{max} = \dot{\theta}_{max} = v_{sat} / D_{min}$

$\cos \Delta\Phi/2 = \tan \lambda_{min} / \tan \lambda_{max}$

$T = \tau/180^o \, \mathrm{acos}(\cos \lambda_{max} / \cos \lambda_{min})$