

Automatic determination of vertical deflection components from GPS and zenithal star observations

Jacek Kudrys

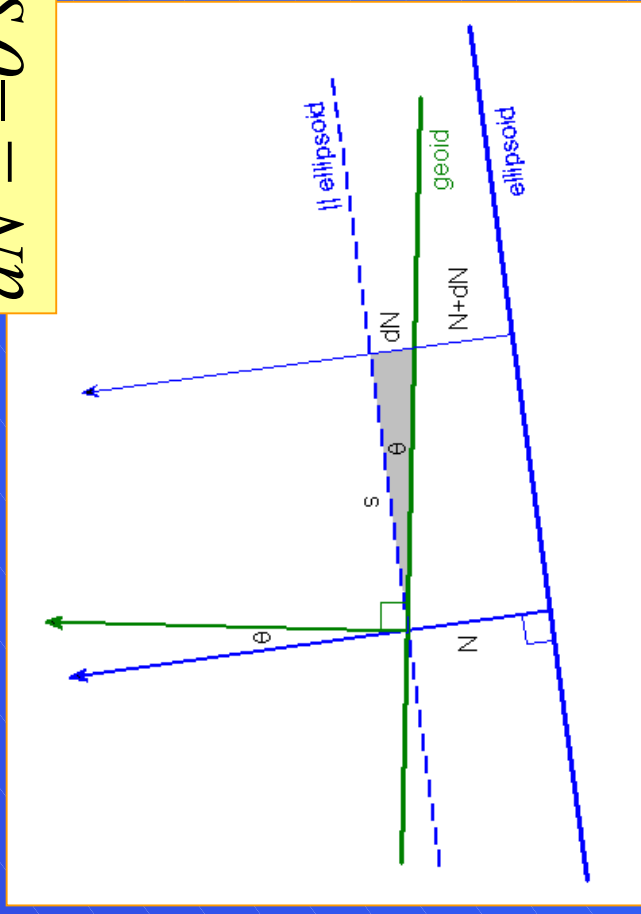
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Astro-geodetic vertical deflection

- astronomic coordinates Φ, Λ
- geodetic coordinates φ, λ
- vertical deflection
- geoid determination

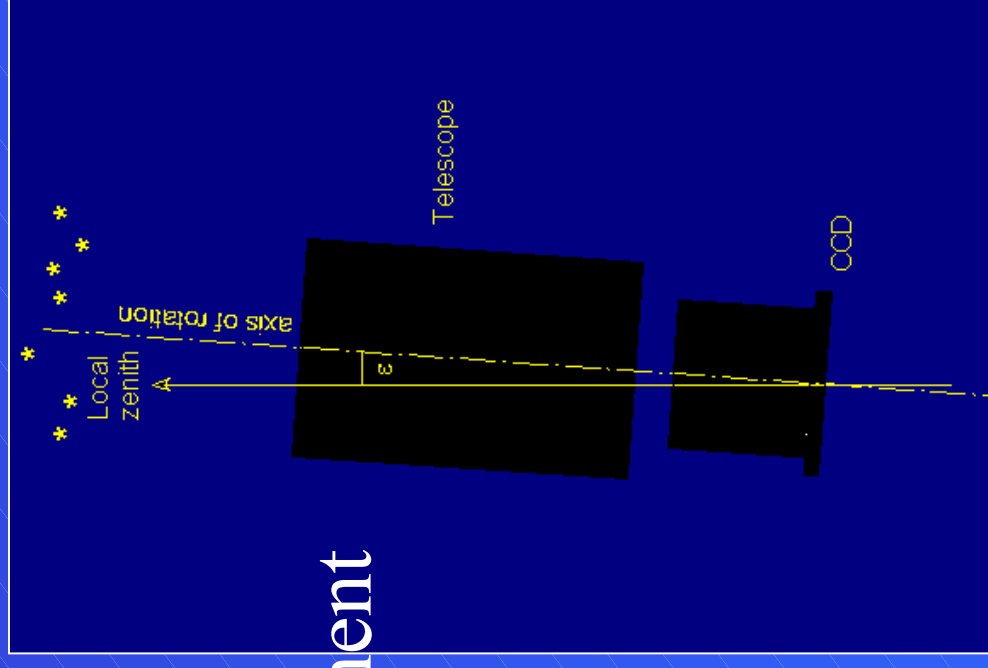
$$\begin{aligned}\xi &= \Phi - \varphi \\ \eta &= (1 - \lambda) \cos \Phi \\ \theta &= \xi \cos \Lambda + \eta \sin \Lambda\end{aligned}$$

$$dN = -\theta s$$

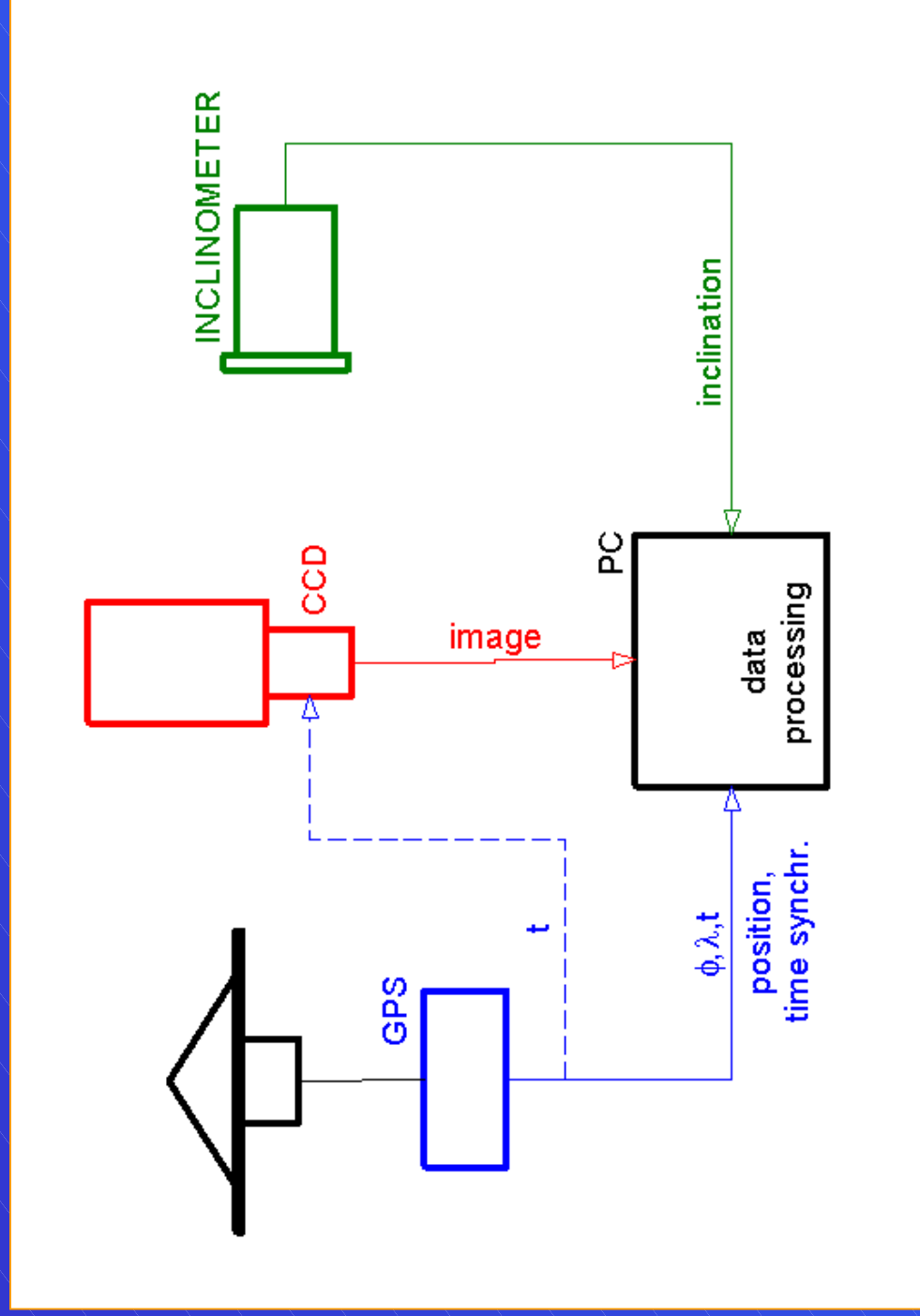


System principle

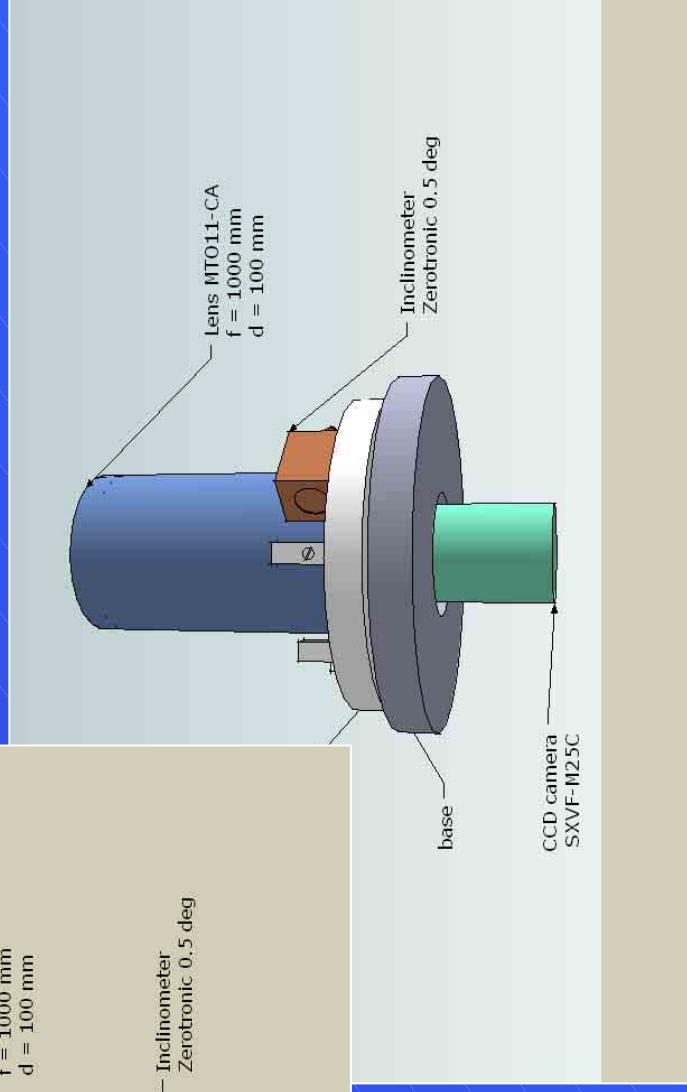
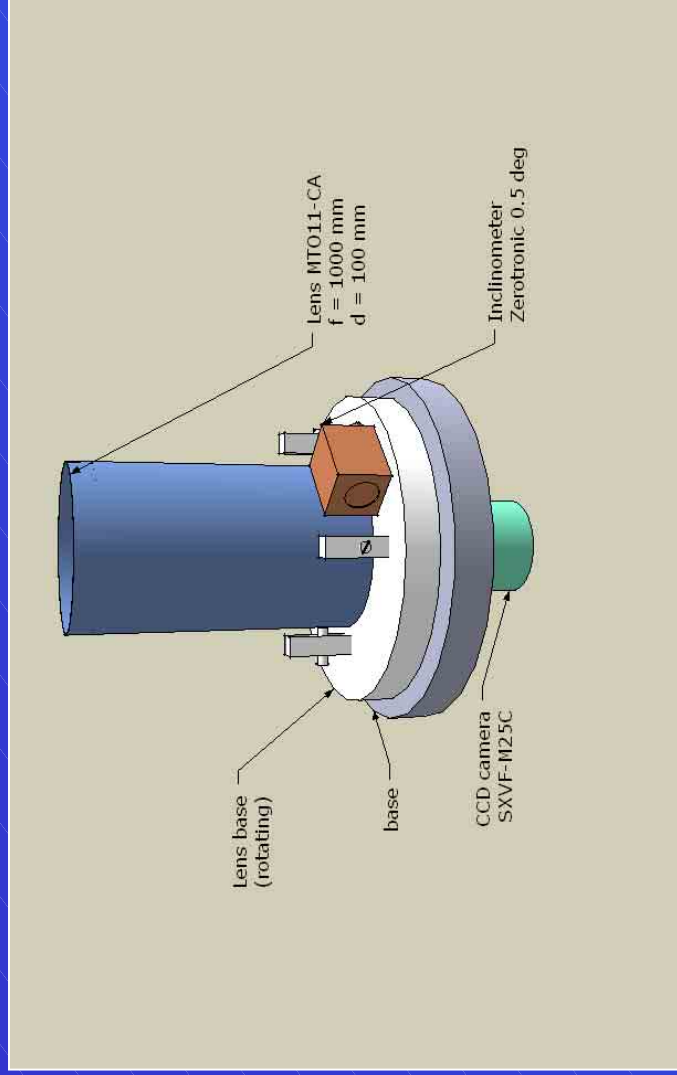
- GPS timing and positioning
- CCD star imaging
- precise inclination measurement



System diagram



Apparatus #1



CCD camera + MTO-11CA lens

Starlight Xpress SXVF-M25C

- 16 bit
- $7.8\text{ }\mu\text{m} \times 7.8\text{ }\mu\text{m}$
- 3024×2016 pixels
- 1 pix = 1.63”

MTO-11CA

- 1000 mm focal length
- 100 mm aperture
- FOV 82’ x 54’



CCD + MTO – sample image



Apparatus #2



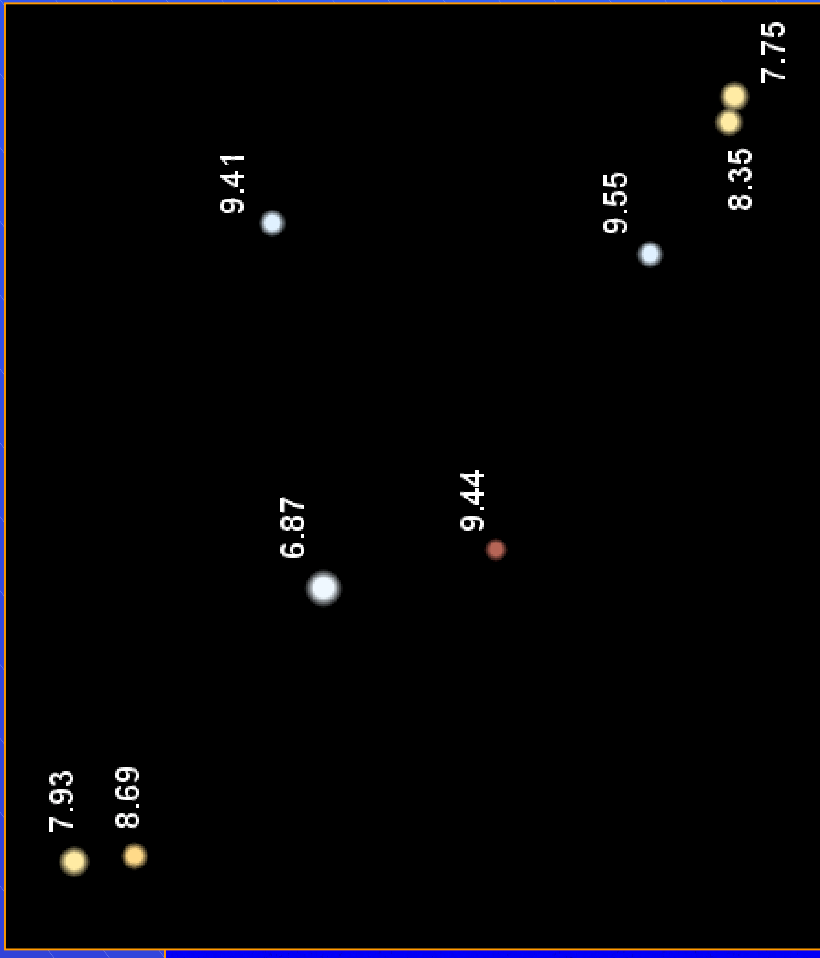
PZL-100

Zerotronic

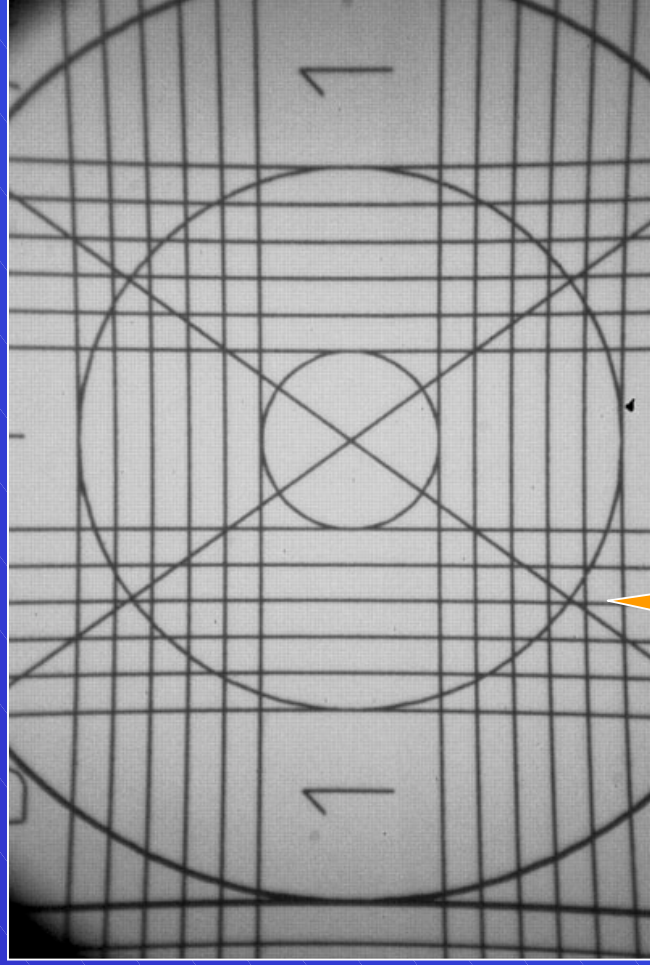
CCD

eyepiece projection

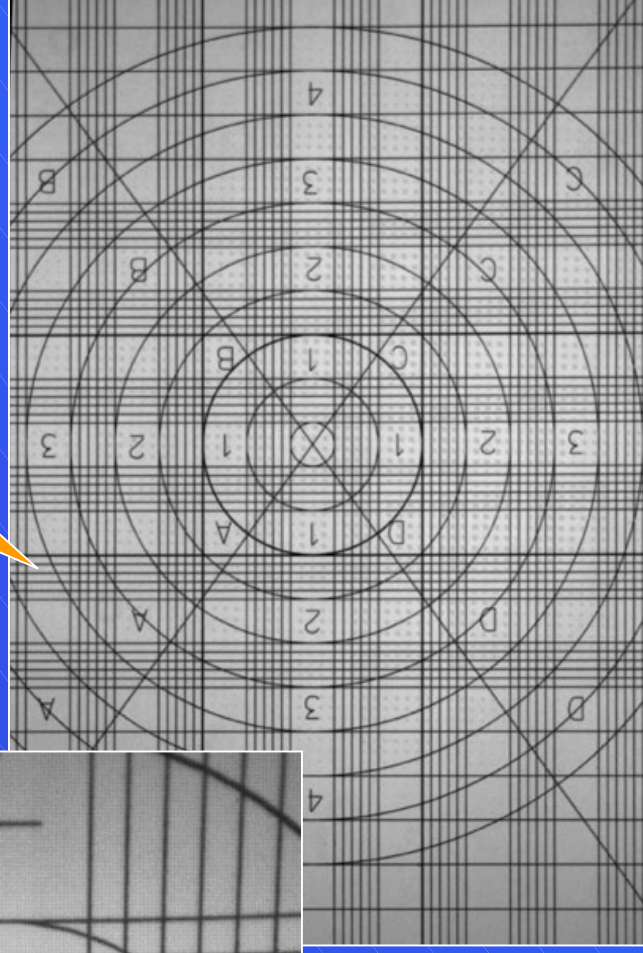
Sample image – CCD + PZL-100



Lenses - distortions

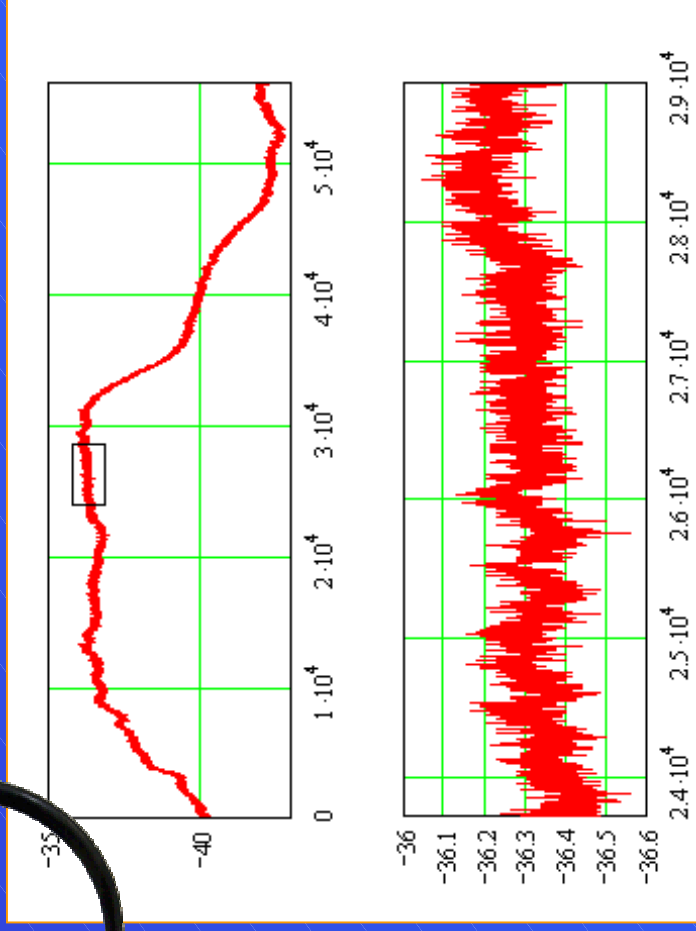
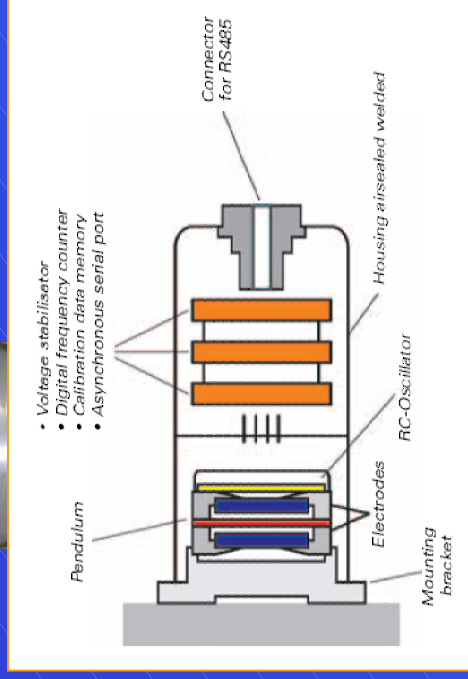
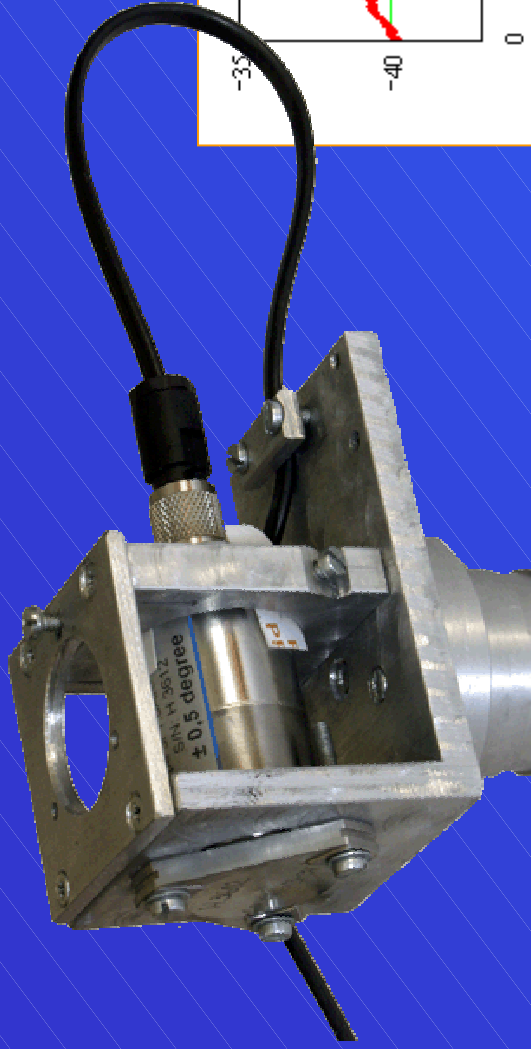


MTO-11CA



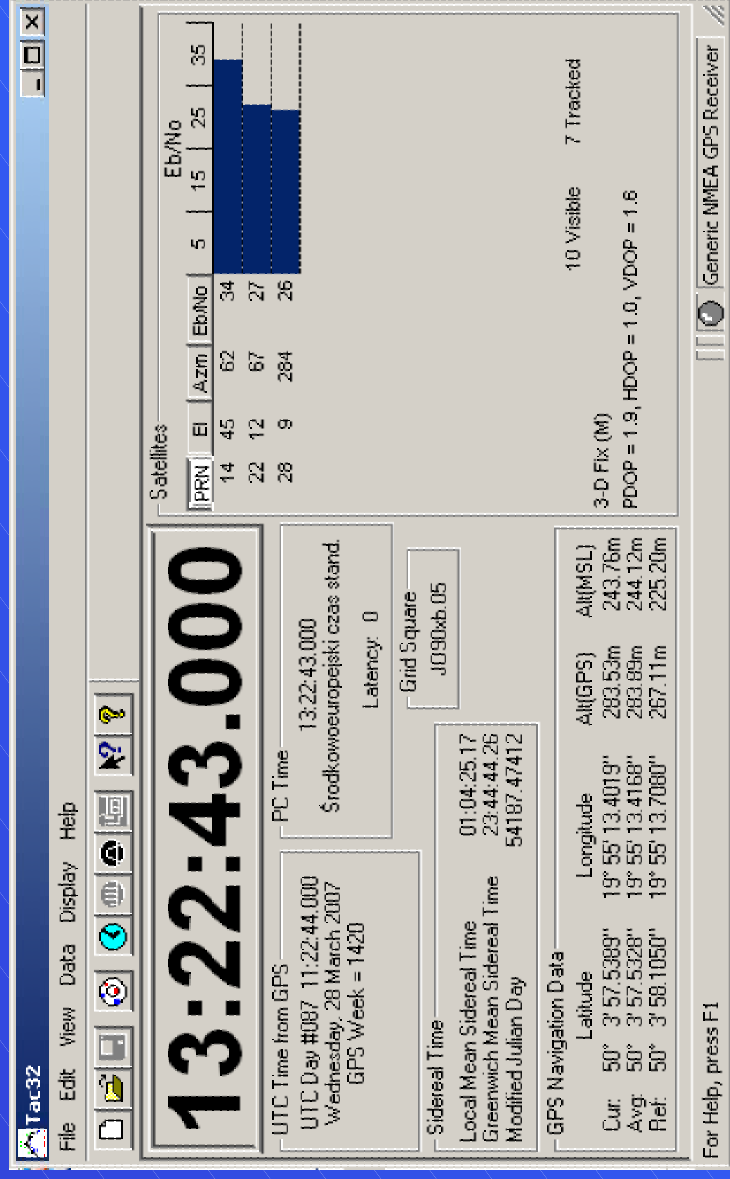
PZL-100

Zerotronic - Inclinometer

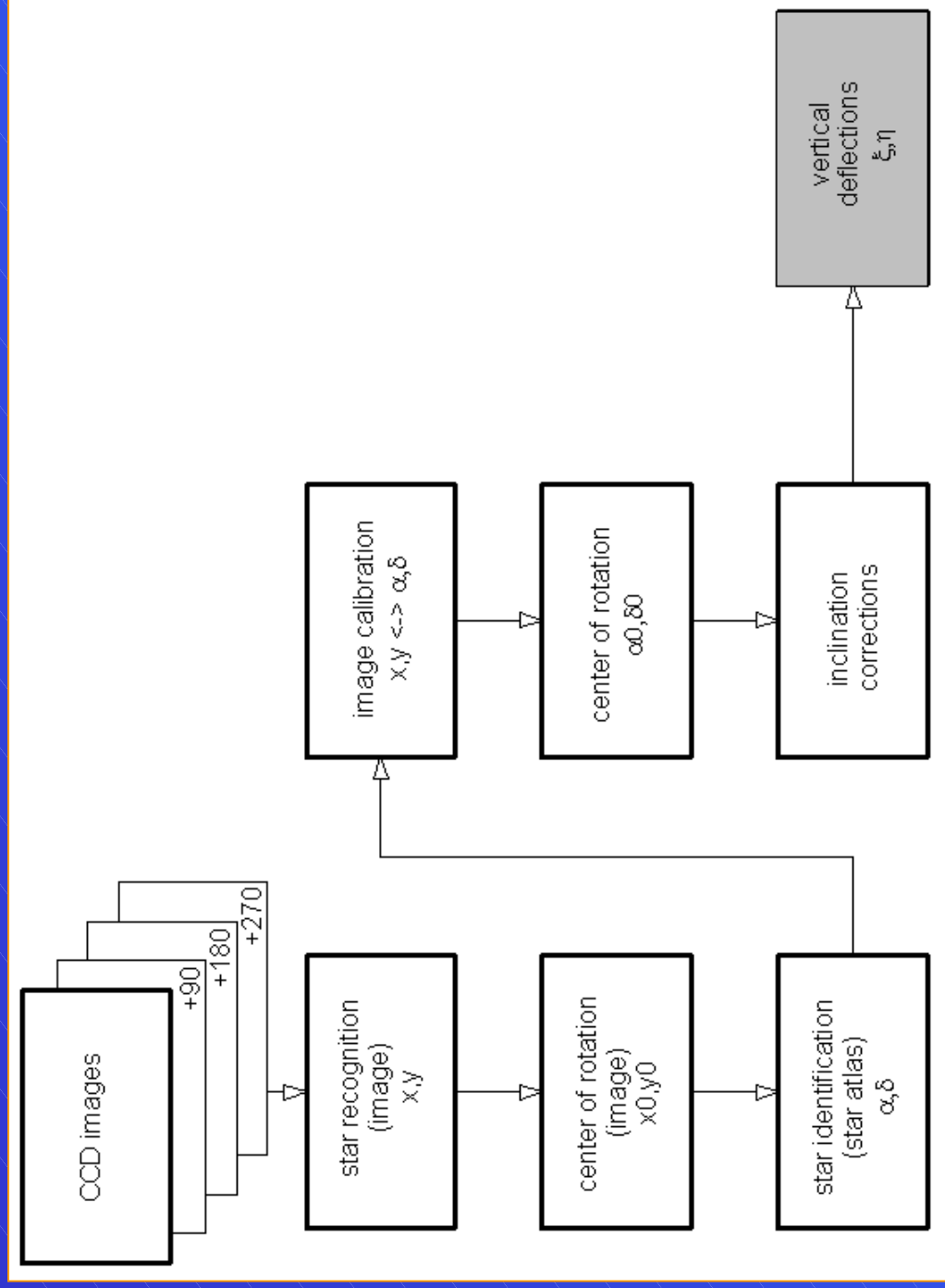


GPS time synchronization

- NMEA messages
- 1PPS synchronization
- ~10 ms



Data processing



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PZL-100

typical geodetic