LATVIJAS UNIVERSITATE

Engineering process of SLR for LEO orbiters

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Institute of Geodesy and Geoinformation,

Rigas GeoMetrs SIA

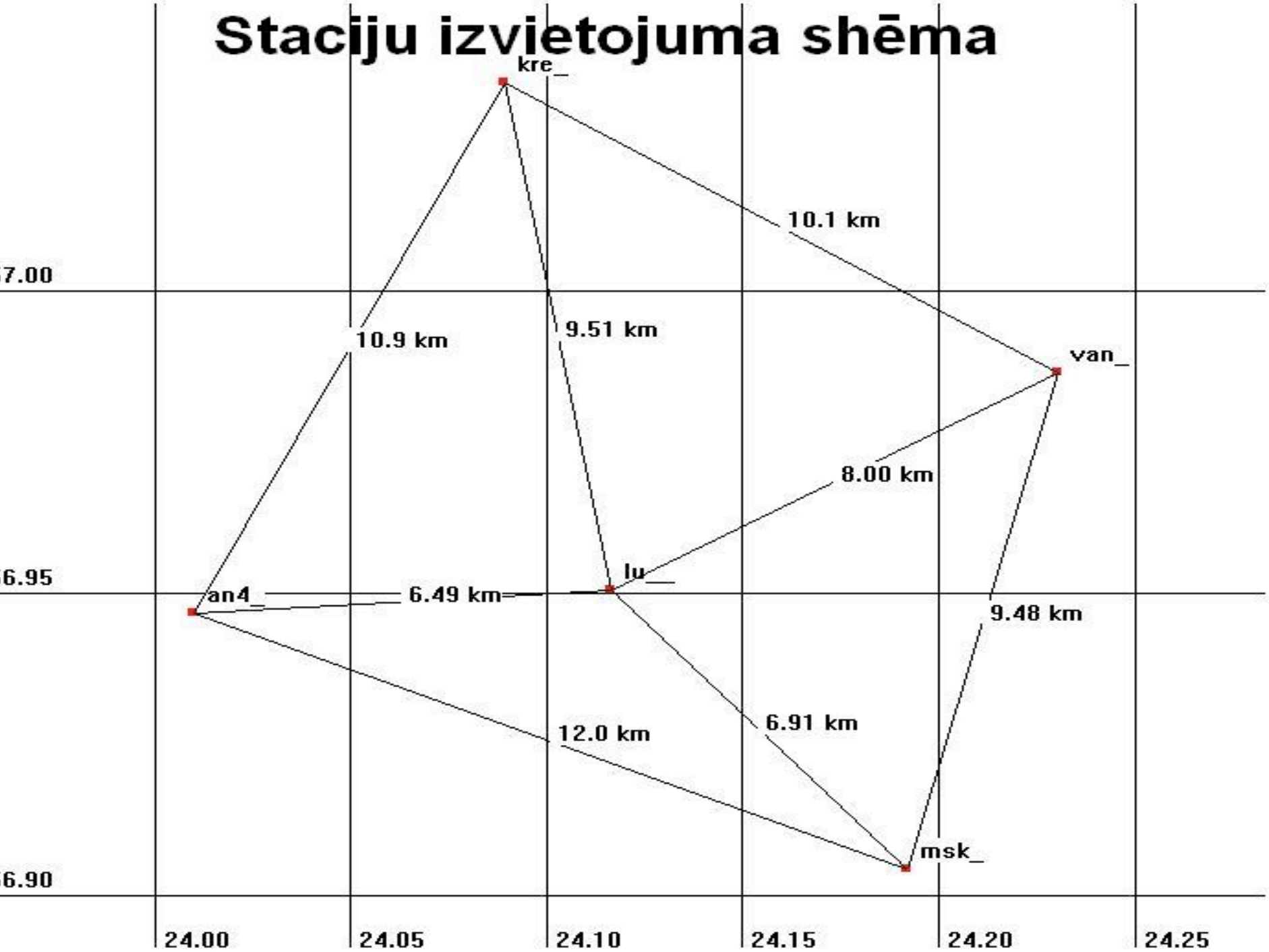
Overview

- Introduction
- New SLR for LEO satellites (and LAGEOS)
- GNSS network EUPOS-RIGA
- Next steps
- Stars

Three groups

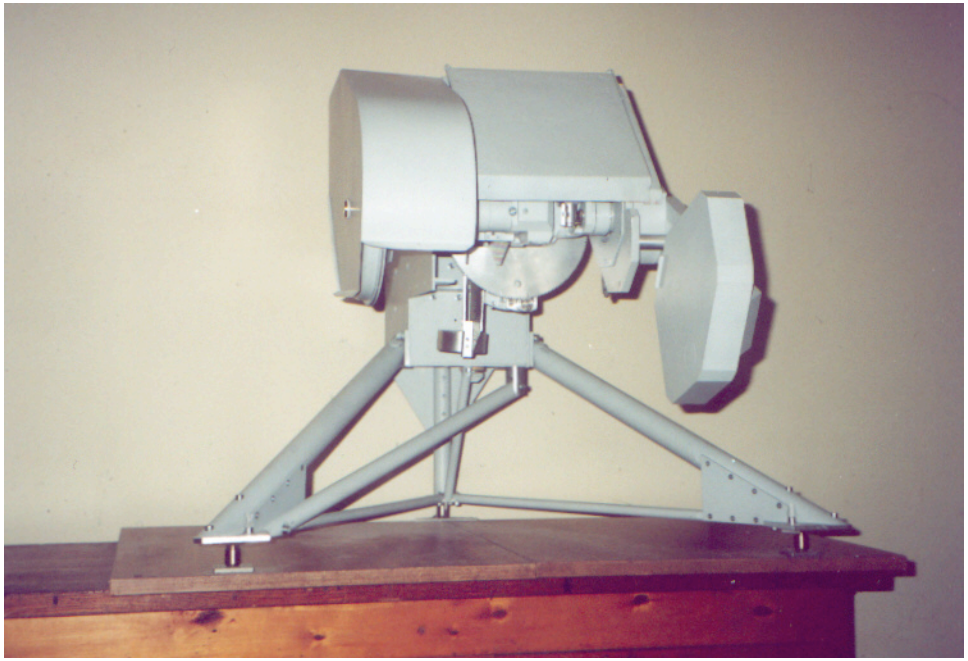
- Institute of Electronics and Computer Science (Y.Artjuh and colleagues)
- Institute of Astronomy (K.Lapushka, K.Salmins, M.Abele)
- Institute of Geodesy and Geoinformation (M.Abele, J.Balodis, A.Rubans, A.Zarinsjh,....)

Staciju izvietojuma shēma

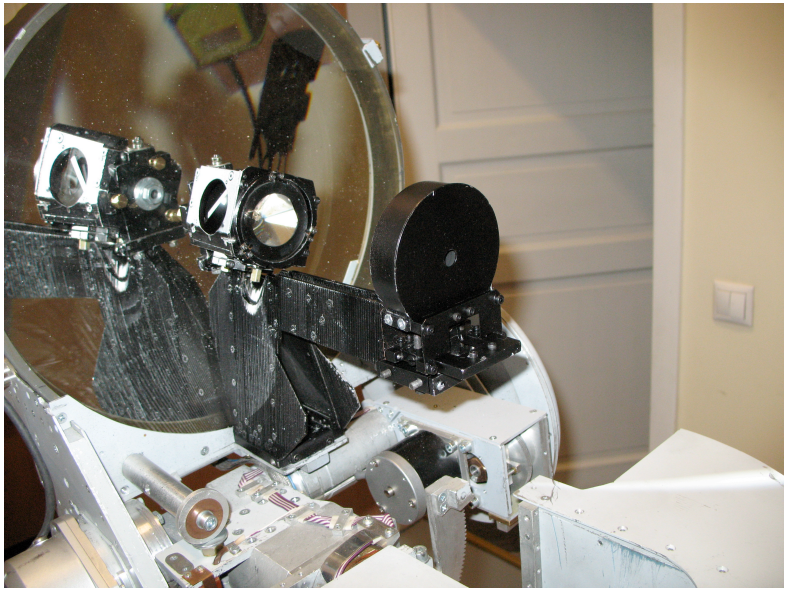


SLR for LEO Satellites

SLR for LEO Satellites

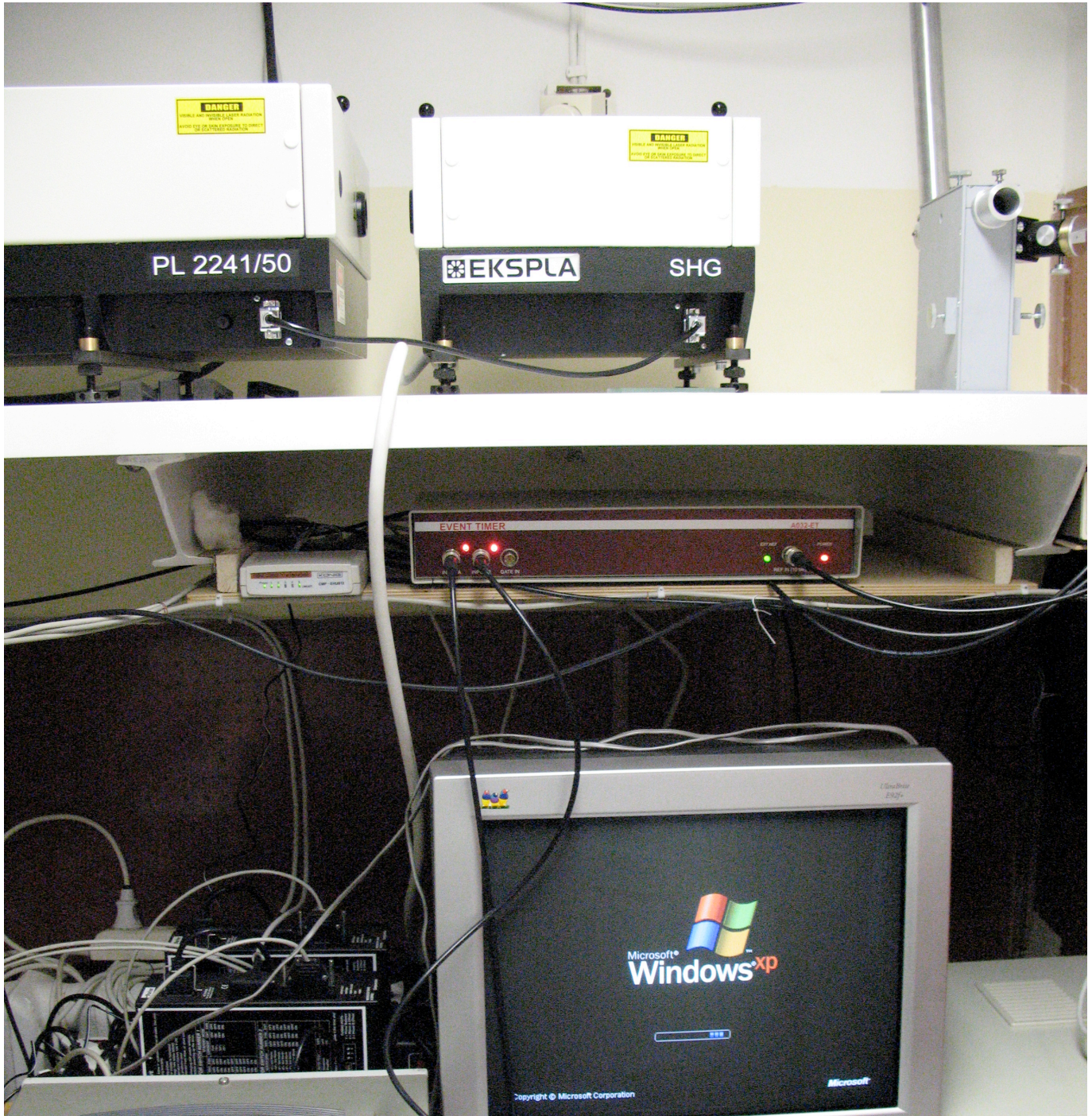



SOKKIA

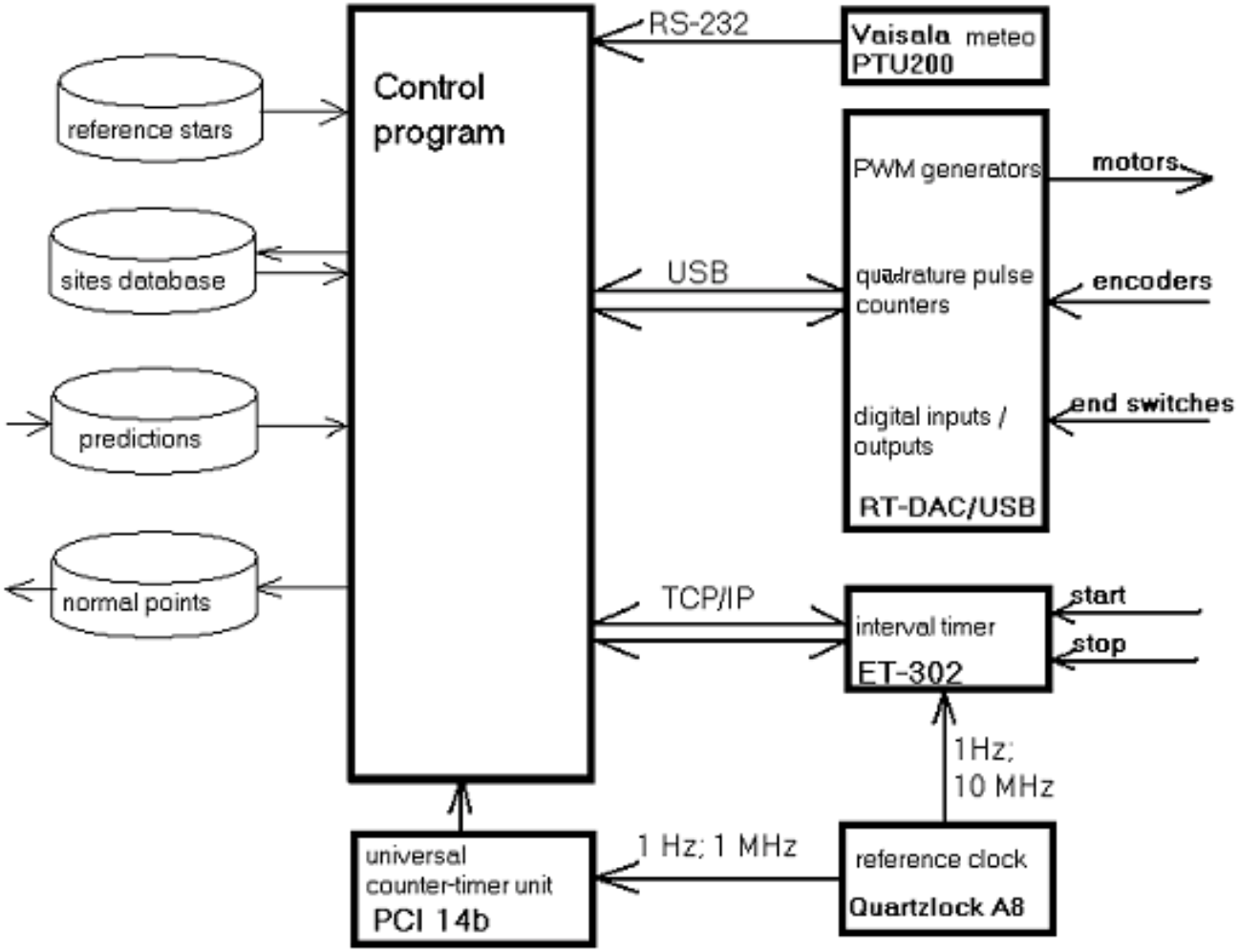


Ekspla Laser PL2241 532 nm

Pulse length ~ 30 psec
Energy 18 mJ +- 4%
Repetition rate 50 Hz


DANGER
PL 2241/50
DANGER
EKSPLA
SHG
EVENT TIMER
Microsoft
Windows xp
Copyright © Microsoft Corporation
Microsoft


EKSPLA
PL 2241/50
TOSHIBA


reference stars
sites database
predictions
normal points
Control program
RS-232
Vaisala meteo PTU200
PWM generators
motors
USB
quadrature pulse counters
encoders
digital inputs / outputs
end switches
RT-DAC/USB
TCP/IP
interval timer
ET-302
start
stop
1Hz; 10 MHz
universal counter-timer unit
PCI 14b
1 Hz; 1 MHz
reference clock
Quartzlock A8

Mount control hardware

- Compumotor S57-51P stepper motors,
- Heidenhain RON 200 incremental encoders: 72” divisions; interpolated to 0.7” per division,
- InTeCo RT-DAC USB data acquisition and contrunit:
  - - PWM ǵenerators (2.4 Hz ... 156 kHz),
  - – quadrature pulse counters,
  - – digital inputs/outputs for servo sensors
  - – timer-counters for position time acquisition.
- QuartzLock A8-B GPS-disciplined quartz frequency Standard,
- ET-302 event timer,
- Vaisala PTU200 meteo station.

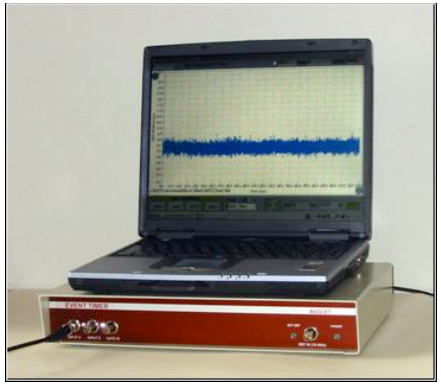
About Event Timer A032-ET

The A032-ET is the latest commercially available model of Riga event timers

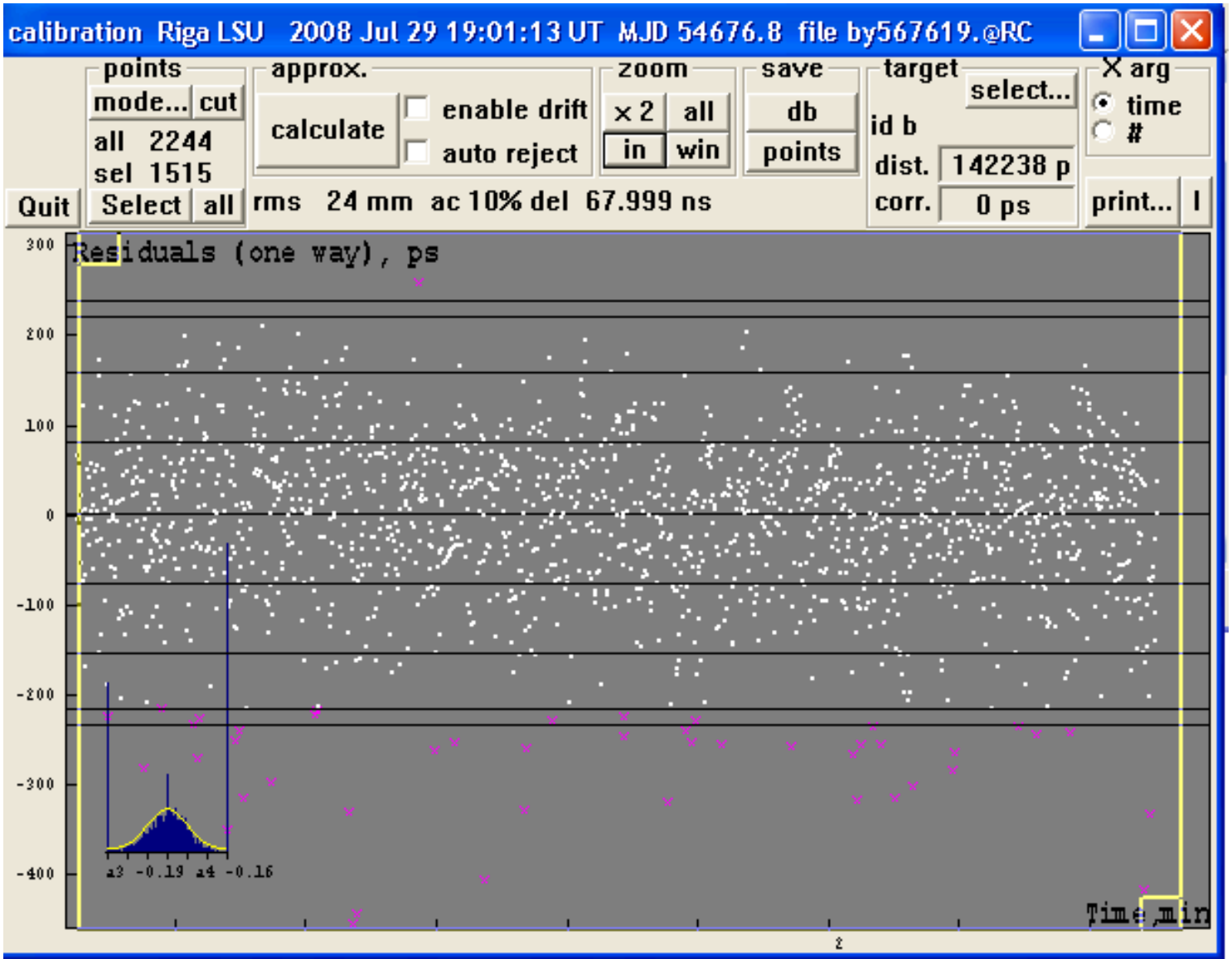
Event timers used in ILRS laser network. (Data are taken from http://ilrs.gsfc.nasa.gov/)

Manufacturer	Model	Resol. [Ps]	Jitter [Ps]	Linearity [Ps]	Stability [Ps/K]	Stability [Ps/hour]	Max. rep. rate [Hz]	Max. TOF
PESO	PET4/TIGO	1.2	3.5	3	<0.3	<0.5	>100	N/A
EOS	MRCS V.4	2	10	1	N/A	1	1000	N/A
HTSI	MLRO	0.5	<2	N/A	N/A	0.5	2000	N/A
IECS	A032-ET	1	7-9	<1	<0.5	N/A	10,000	1.5 hr

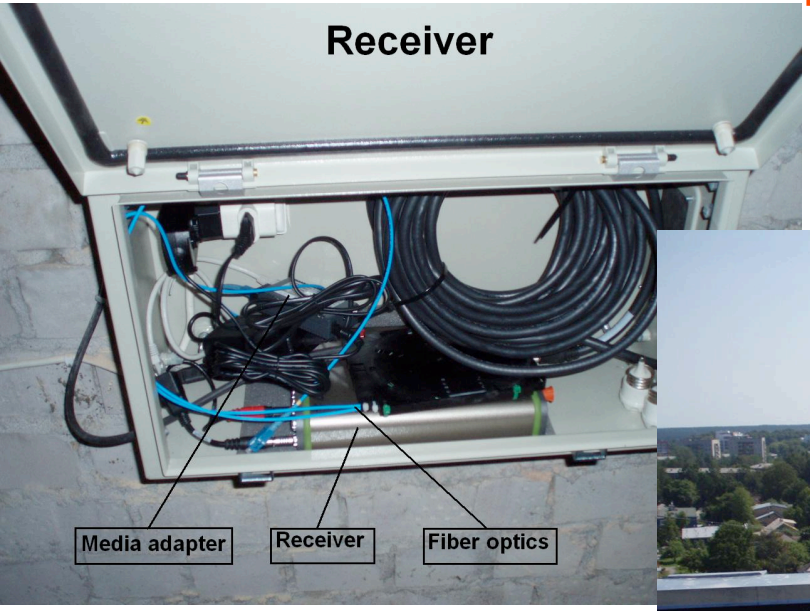
Currently the A032-ET is recognized within ILRS community as the best in term of price/performance ratio. During last few years 18 units of the Riga Event Timer A032-ET have been delivered to Japan, Switzerland, China, Spain, Austria, Latvia, Germany and Finland for use in the ILRS laser network.

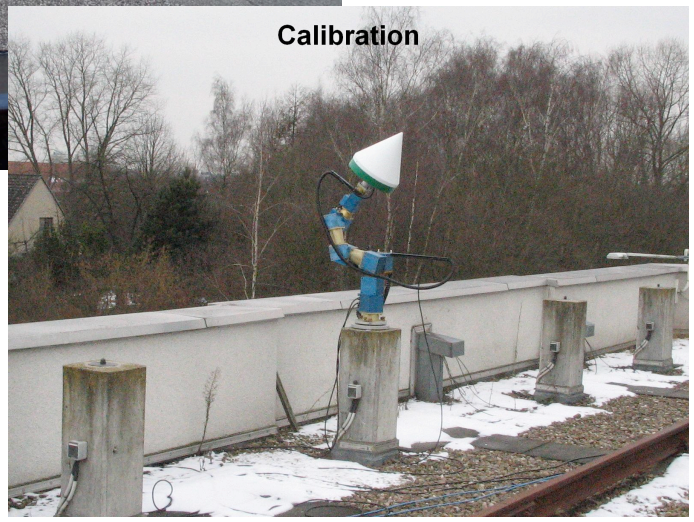


Calibration

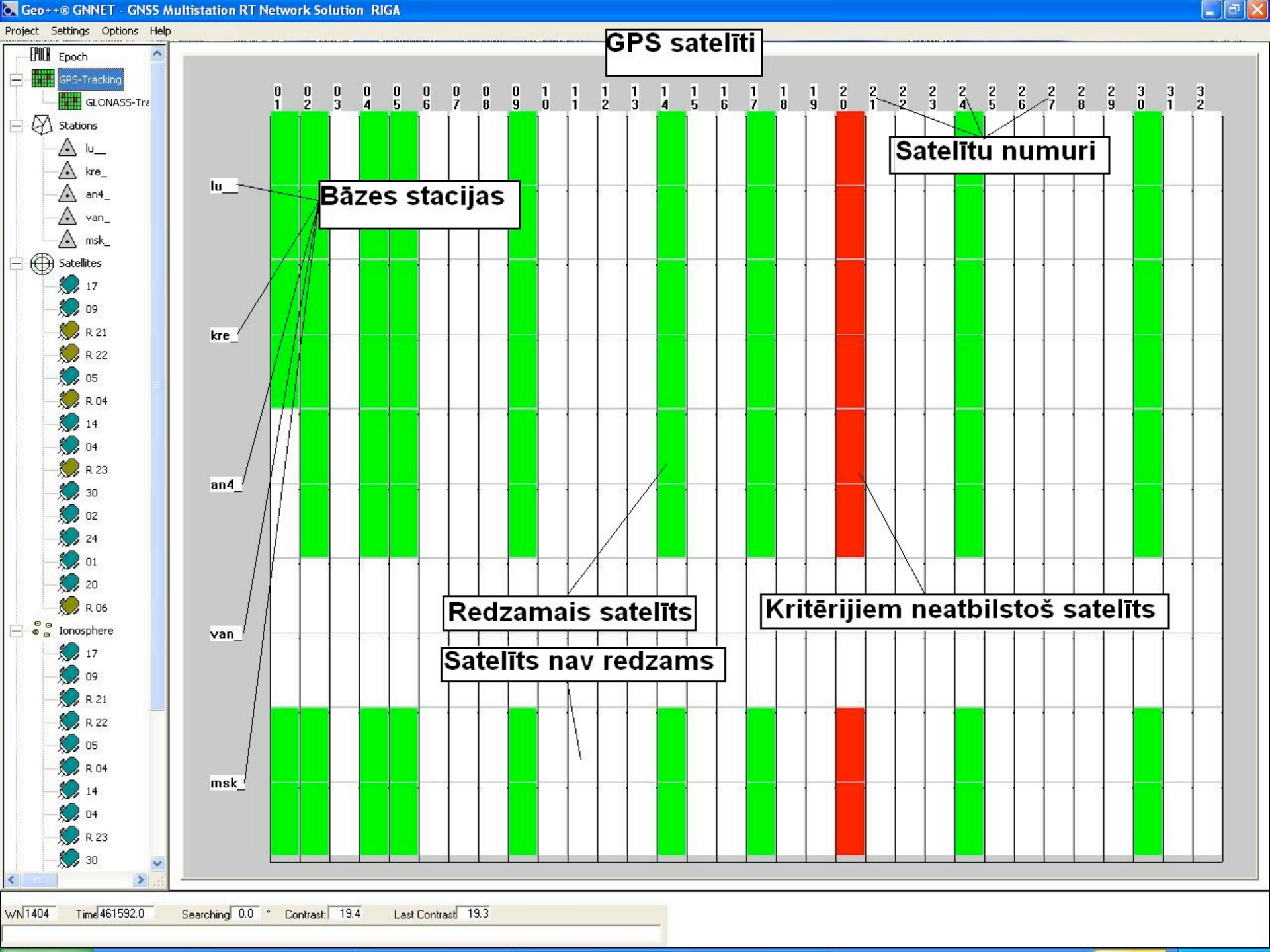


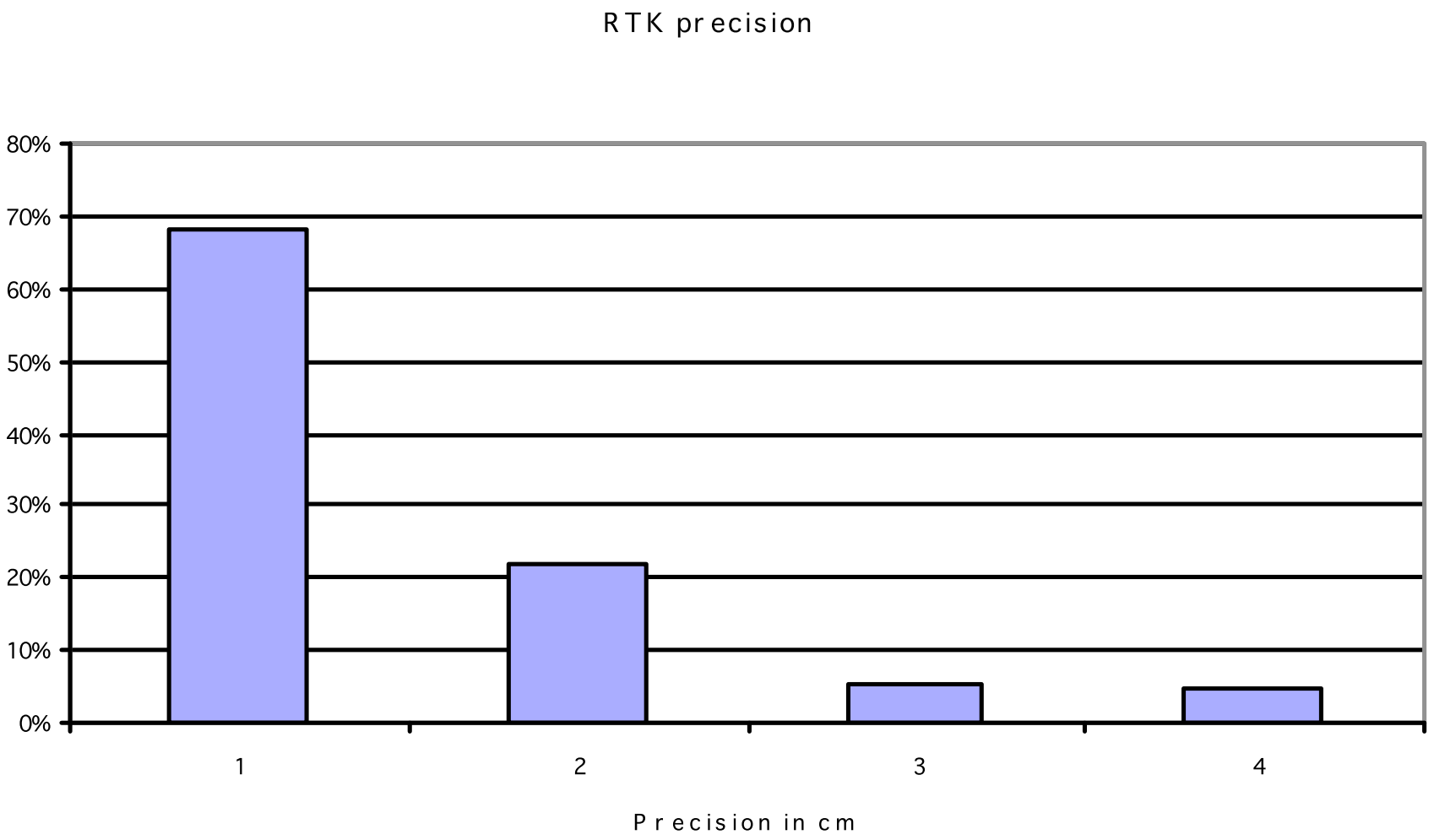
Equipment



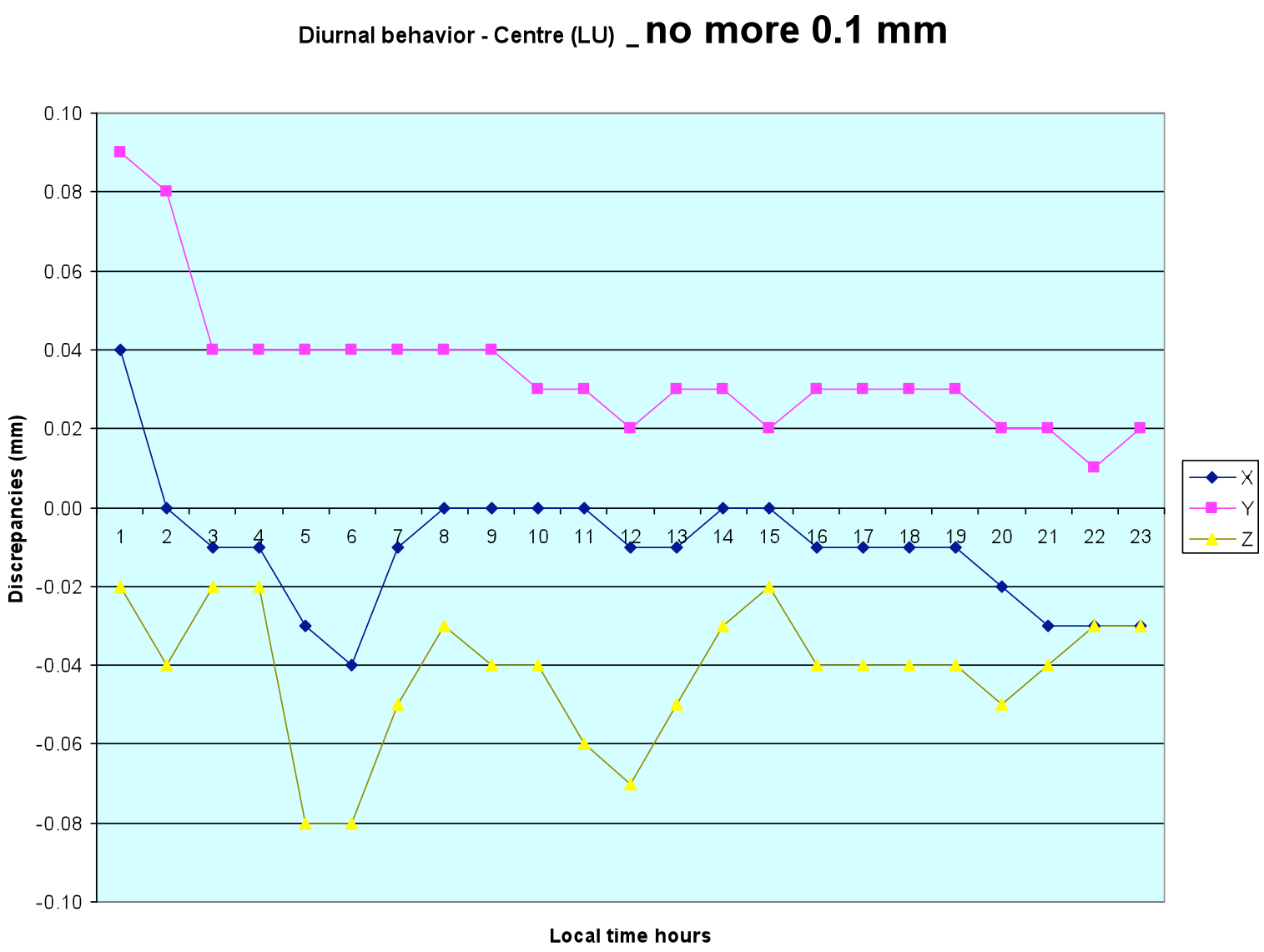


EUPOS® RIGA
European Position Determination System

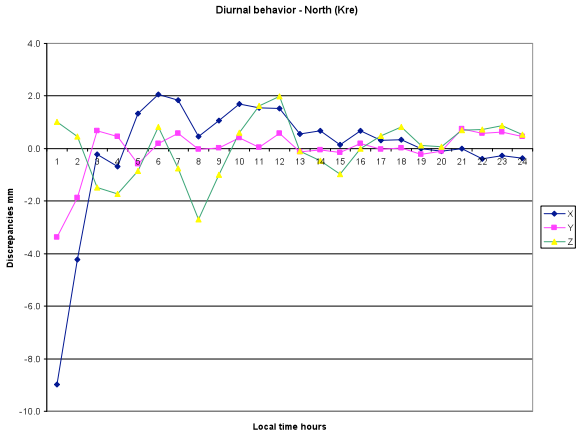

Geo++® GNNET - GNSS Multistation RT Network Solution RIGA
Project
Settings
Options
Help
Epoch
GPS-Tracking
GLONASS-Tra
Stations
lu__
kre_
an4_
van_
msk_
Satellites
17
09
R 21
R 22
05
R 04
14
04
R 23
30
02
24
01
20
R 06
Ionosphere
17
09
R 21
R 22
05
R 04
14
04
R 23
30
GPS satelīti
Satelītu numuri
Bāzes stacijas
lu__
kre_
an4_
van_
msk_
Redzamais satelīts
Satelīts nav redzams
Kritērijiem neatbilstoš satelīts
WN 1404
Time 461592.0
Searching 0.0
Contrast: 19.4
Last Contrast 19.3

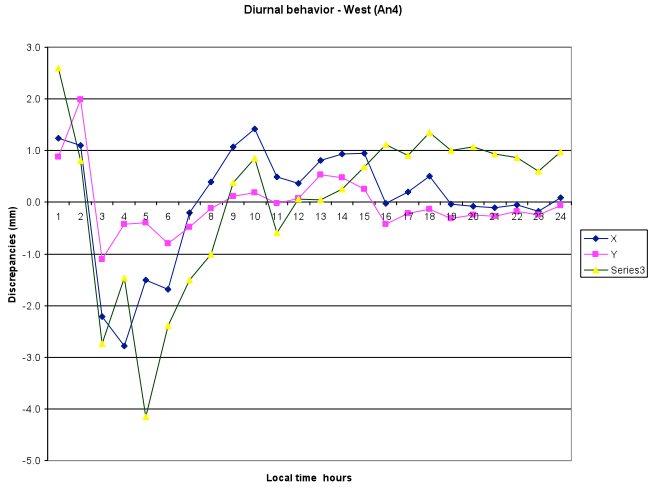

RTK precision
80%
70%
60%
50%
40%
30%
20%
10%
0%
1
2
3
4
Precision in cm

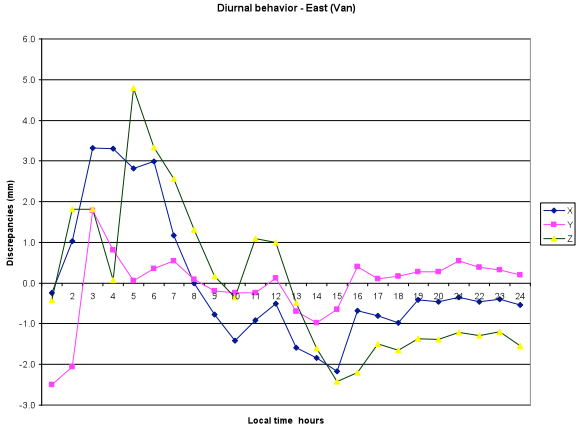
EUPOS-RIGA bāzes stacija Lu

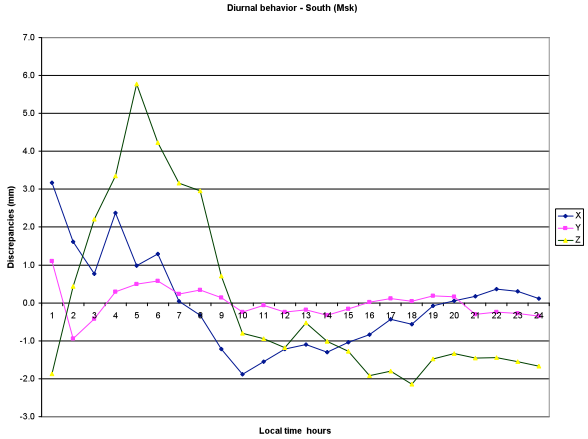

Diurnal behavior - Centre (LU) _ no more 0.1 mm
0.10
0.08
0.06
0.04
0.02
0.00
-0.02
-0.04
-0.06
-0.08
-0.10
Discrepancies (mm)
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23
Local time hours
X
Y
Z

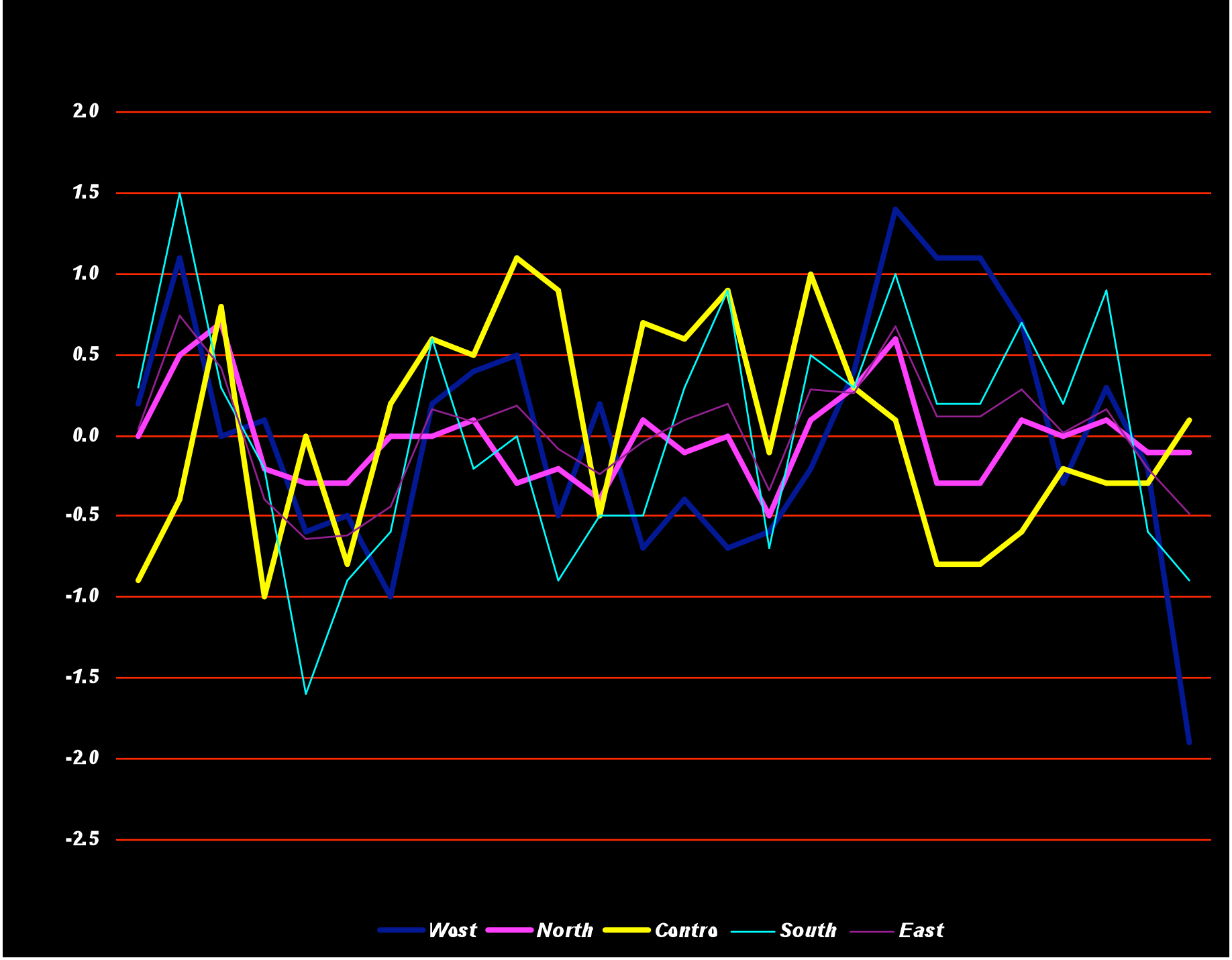
Base station antena

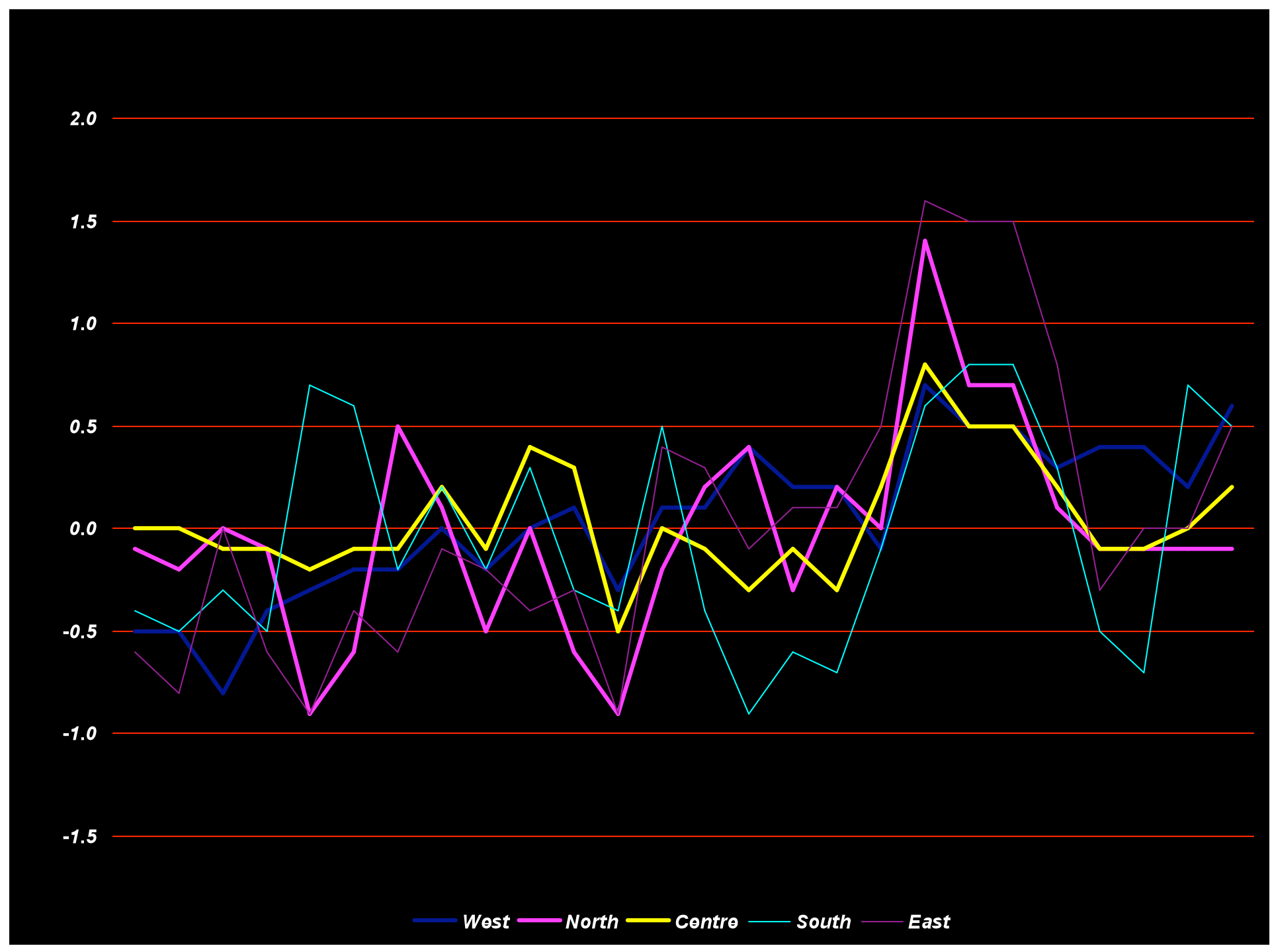

Diurnal behavior - North (Kre)
Discrepancies mm
Local time hours
X
Y
Z

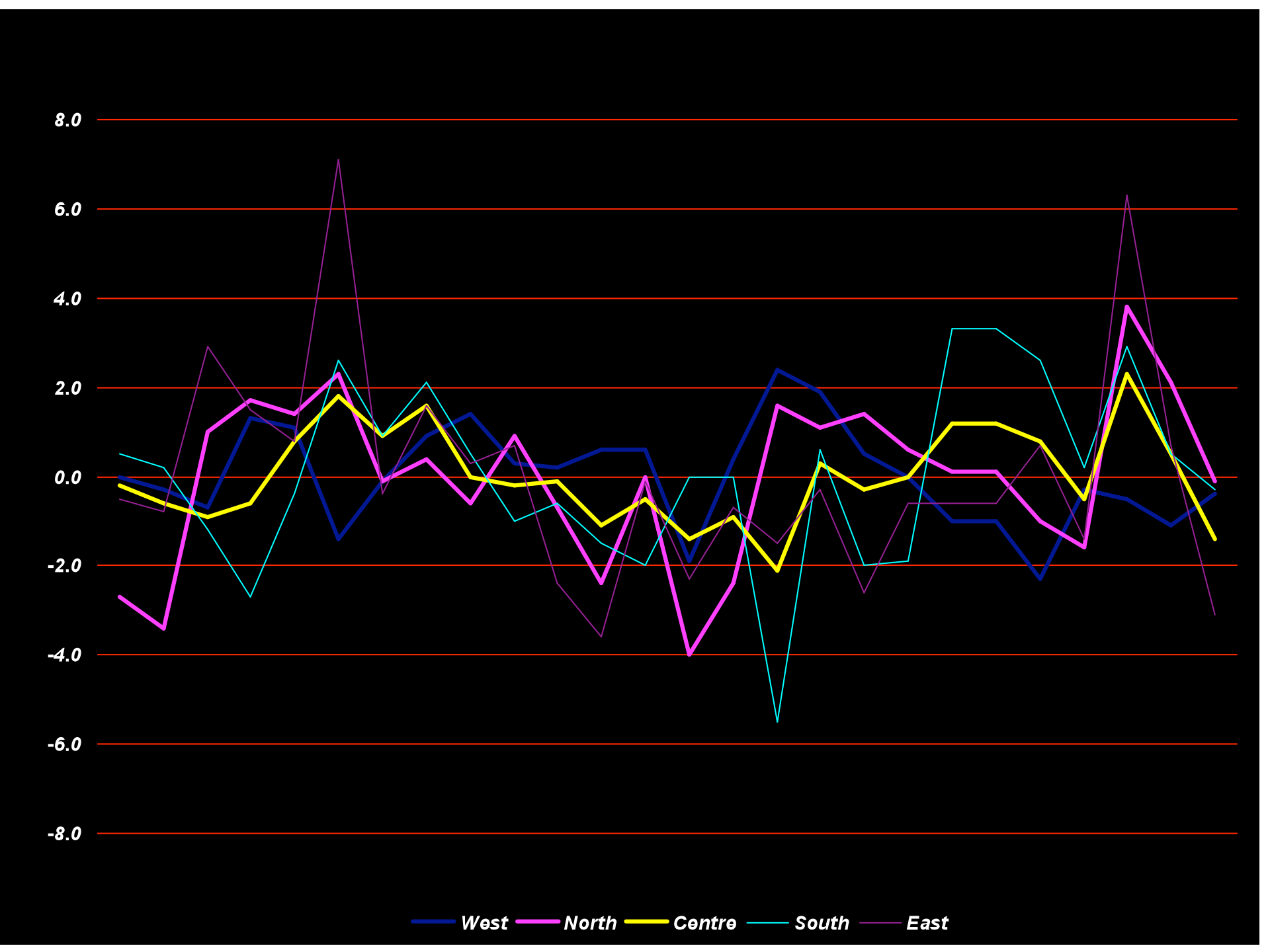

Diurnal behavior - West (An4)
Discrepancies (mm)
Local time hours
X
Y
Series3


Diurnal behavior - East (Van)
Discrepancies (mm)
Local time hours
X
Y
Z


Diurnal behavior - South (Msk)
Discrepancies (mm)
Local time hours
X
Y
Z


2.0
1.5
1.0
0.5
0.0
-0.5
-1.0
-1.5
-2.0
-2.5
West
North
Contro
South
East


2.0
1.5
1.0
0.5
0.0
-0.5
-1.0
-1.5
West
North
Centre
South
East

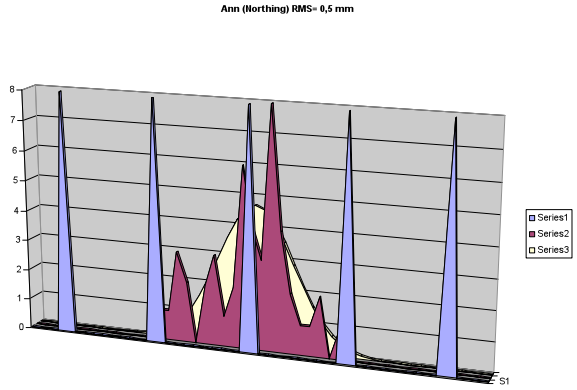

8.0
6.0
4.0
2.0
0.0
-2.0
-4.0
-6.0
-8.0
West
North
Centre
South
East

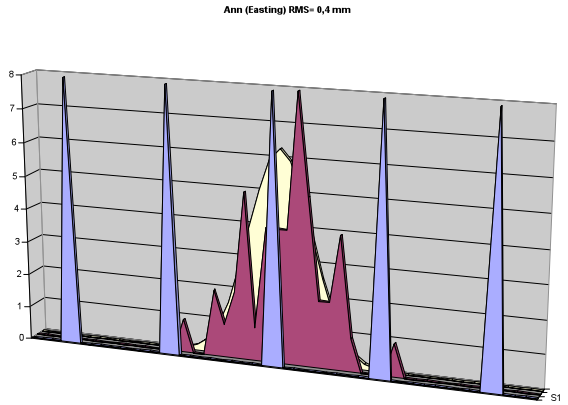
Precision analyses mm 2008,g, 1,janv,- 28,febr,

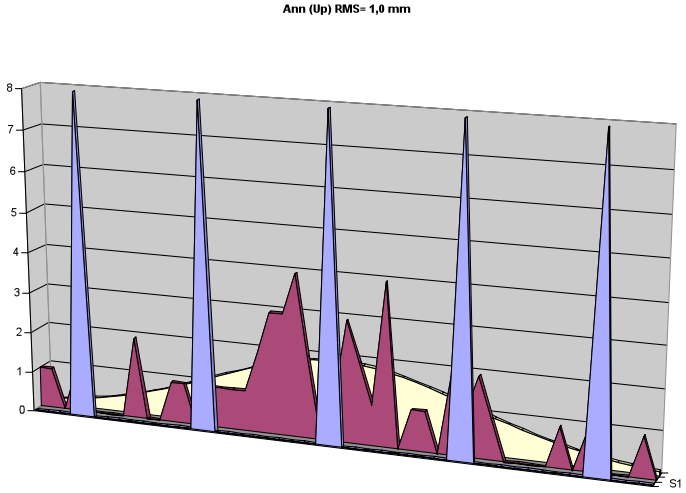
- Base station RIGA-1884 (IGS, EPN)

#	St,	X	Y	H
1	Ann	0,5	0,4	1.0
2	Kre	0,9	0,5	2.0
3	Lu	0,3	0,4	1.0
4	Msk	0,9	0,6	2.3
5	Van	0,8	0,8	2.2

Ann

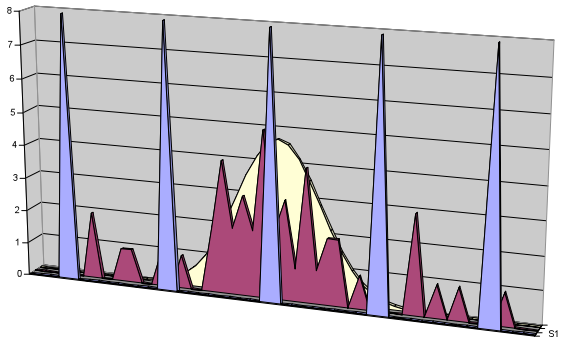

Ann (Northing) RMS= 0,5 mm
8
7
6
5
4
3
2
1
0
Series1
Series2
Series3
S1


Ann (Easting) RMS= 0,4 mm
8
7
6
5
4
3
2
1
0
S1

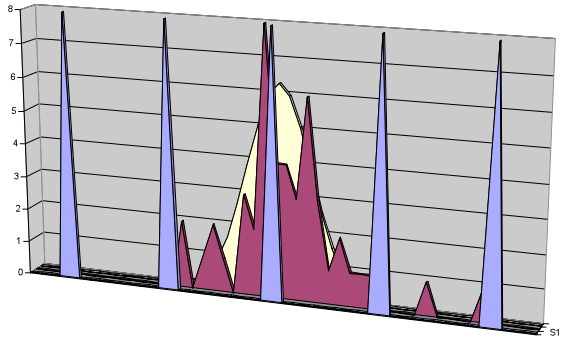

Ann (Up) RMS= 1,0 mm
8
7
6
5
4
3
2
1
0
S1

Kre

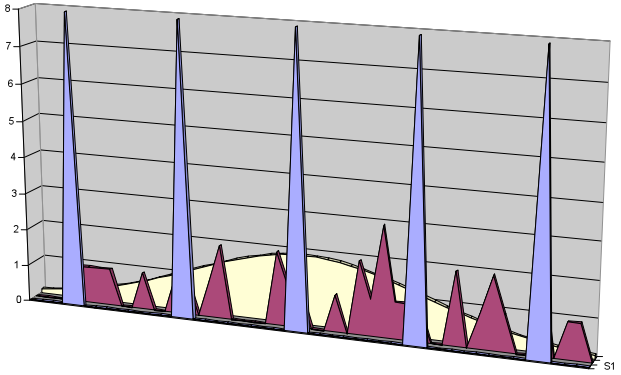
Kre (Northing) RMS= 0,9 mm



Kre (Easting) RMS= 0,5 MM

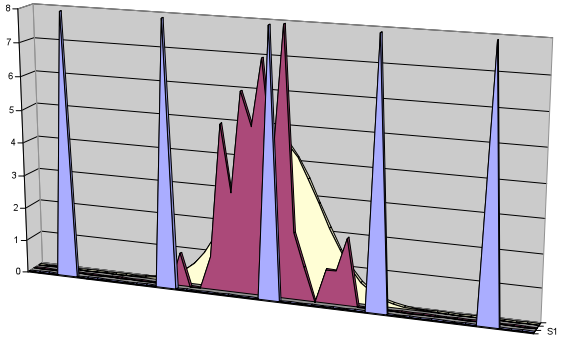


Kre (Up) RMS= 2,0 mm

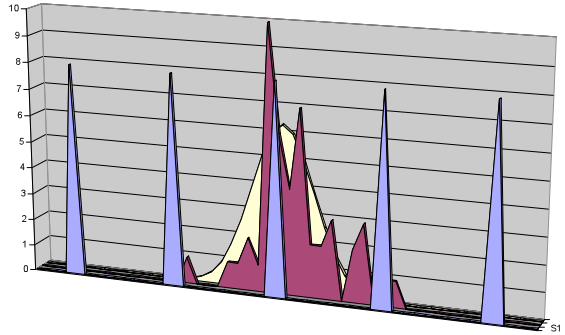


Lu

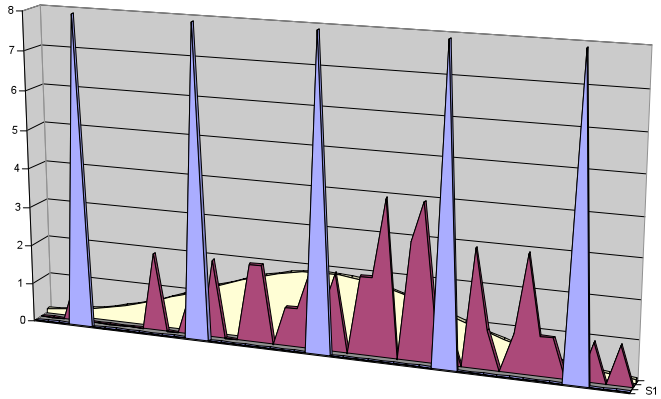
Lu (Northing) RMS= 0,3 mm



Lu (Easting) RMS= 0,4 mm

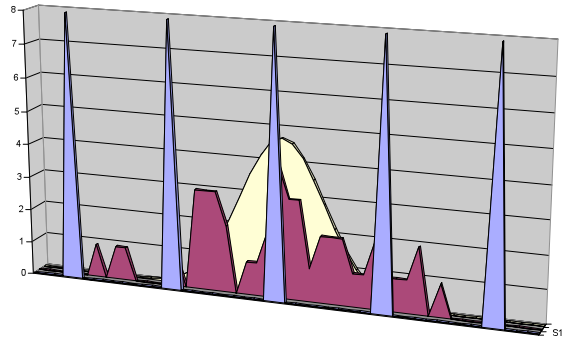


Lu (Up) RMS= 1,0 mm

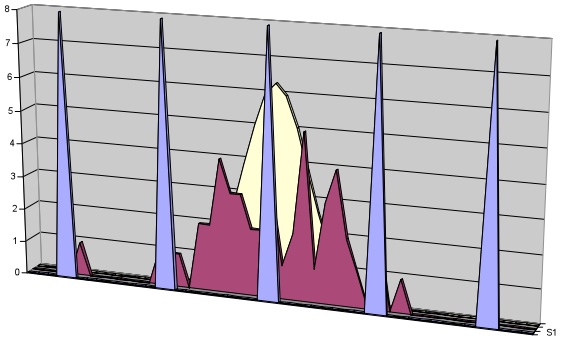


Msk

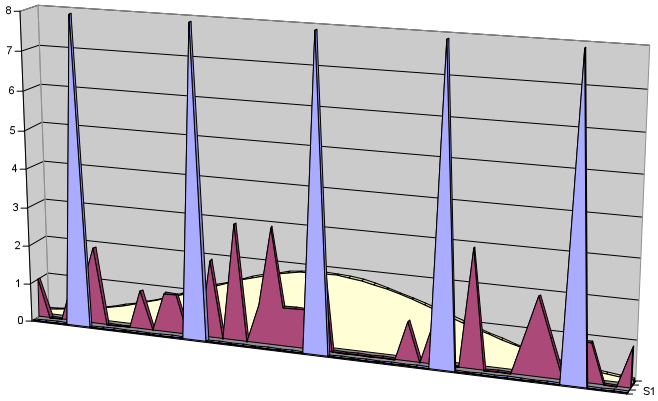
Msk (Northing) RMS= 0,9 mm



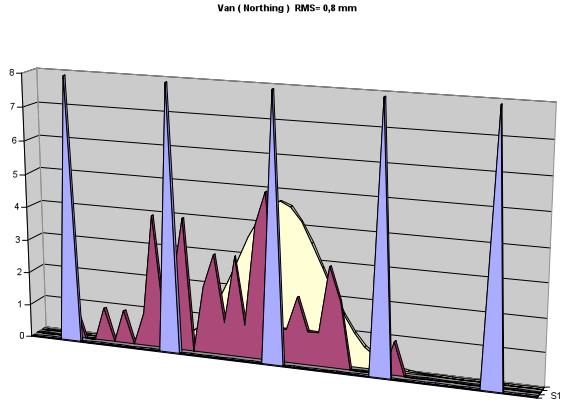
Msk (Easting) RMS= 0,6 mm

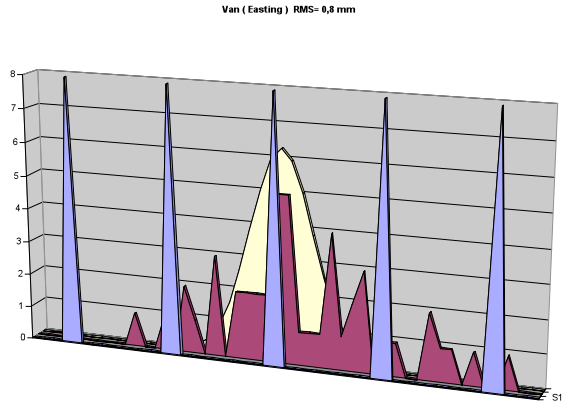


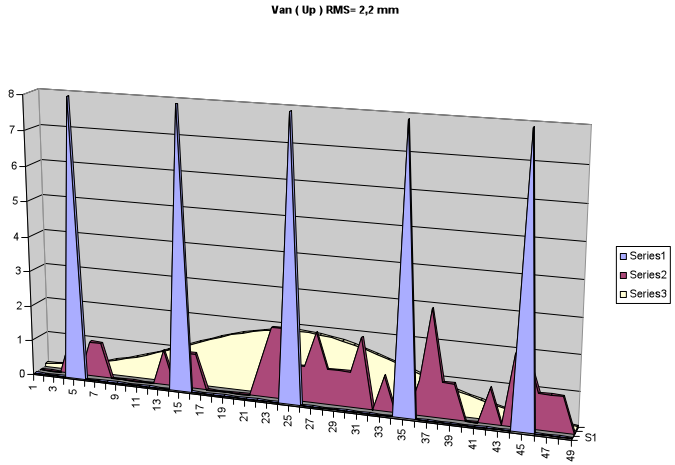
Msk (Up) RMS= 2,3 mm



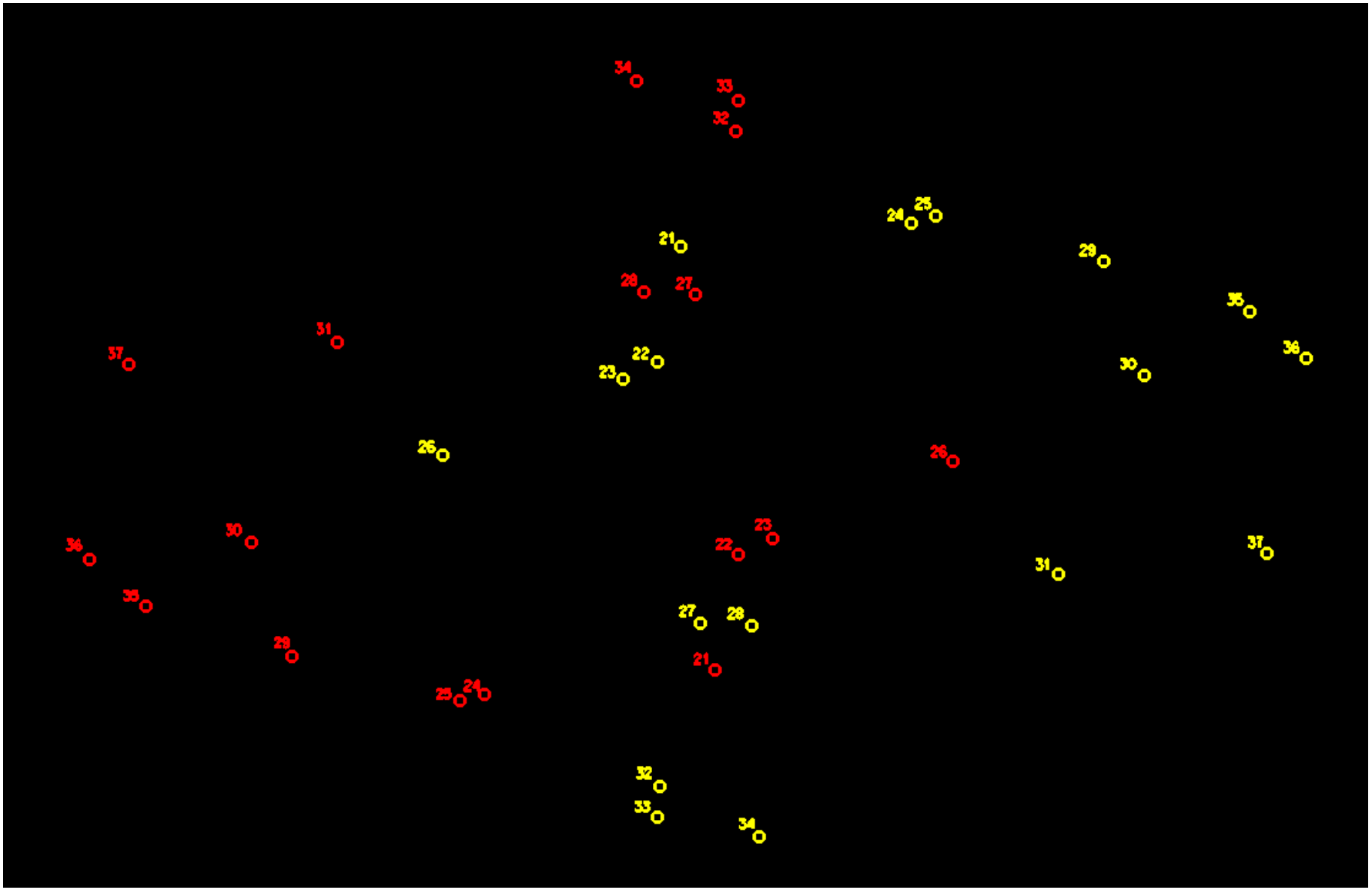
Van


Van (Northing) RMS= 0,8 mm
8
7
6
5
4
3
2
1
0
S1


Van (Easting) RMS= 0,8 mm
8
7
6
5
4
3
2
1
0
S1


Van (Up) RMS= 2,2 mm
8
7
6
5
4
3
2
1
0
1
3
5
7
9
11
13
15
17
19
21
23
25
27
29
31
33
35
37
39
41
43
45
47
49
S1
Series1
Series2
Series3

Next steps


34
33
32
24
25
21
29
28
27
35
31
37
22
23
36
30
26
26
23
30
36
22
37
31
35
27
28
29
21
25
24
32
33
34

Star identification

$$C = \varphi(P)$$

$$\left.\begin{aligned} \xi_i &= M\cos\tilde{a}\, x_s + M\sin\tilde{a}\, y_s + e \\ \eta_i &= M\cos\tilde{a}\, y_s - Msim\tilde{a}\, x_s + f \end{aligned}\right\}$$

$$i = \varphi(s), i \in C, s \in P$$

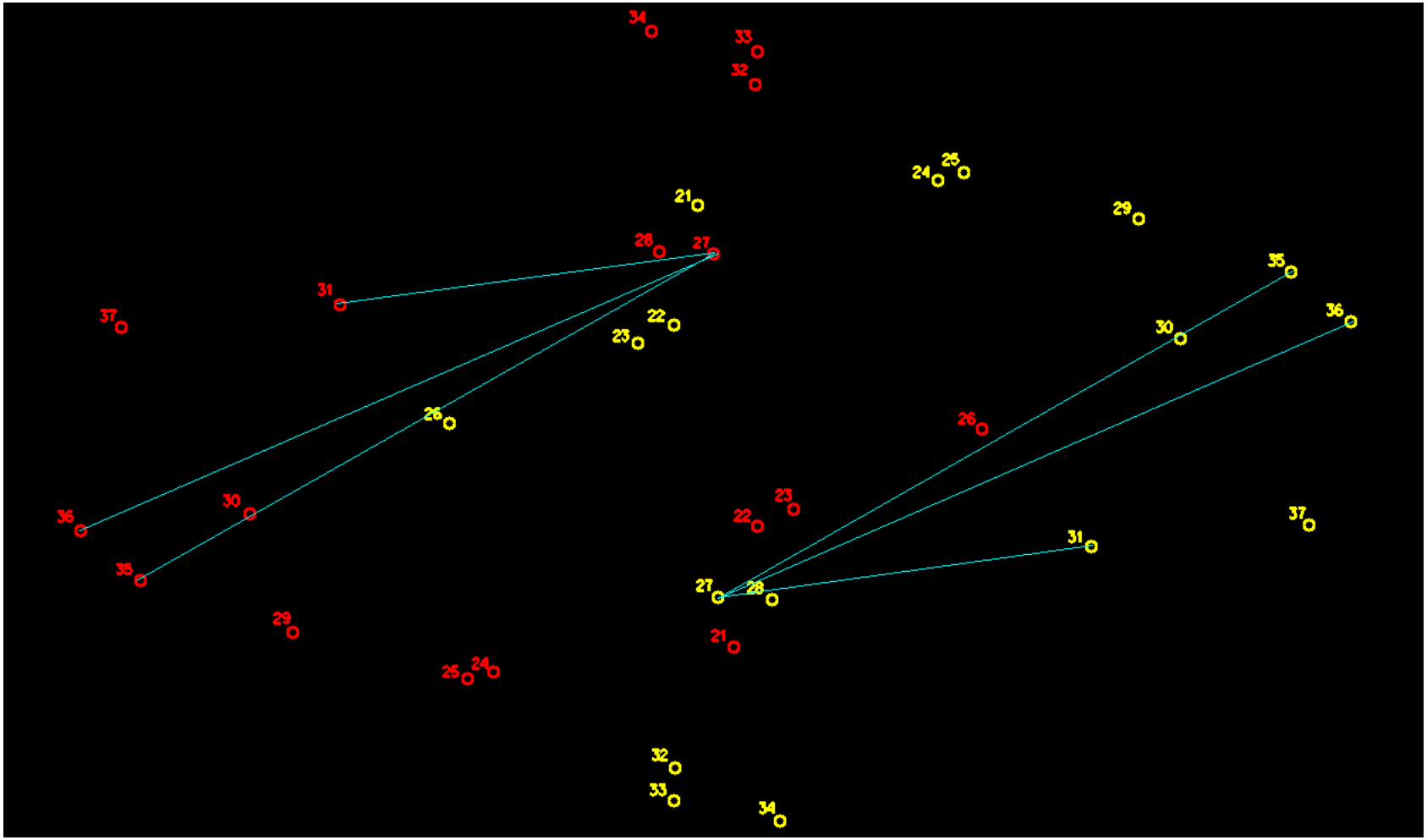
$$\varphi^{-1}(i) \in \cap\left(\left\{s,t\right\}: \exists j\left(\frac{d(i,j)}{d(s,t)} = M \,\&\, \alpha(i,j) - \alpha(s,t) = \tilde{a}\right)\right) = \left\{s : \exists t \exists j\left(\frac{d(i,j)}{d(s,t)} = M \,\&\, \alpha(i,j) - \alpha(s,t) = \tilde{a}\right)\right\}$$

$$\forall s \quad \exists i \qquad i = \varphi(s)$$

$$\frac{d(\varphi(s),\varphi(t))}{d(s,t)} = M,$$

$$\alpha(\varphi(s),\varphi(t)) - \alpha(s,t) = \tilde{a}.$$

Vectors of identified stars

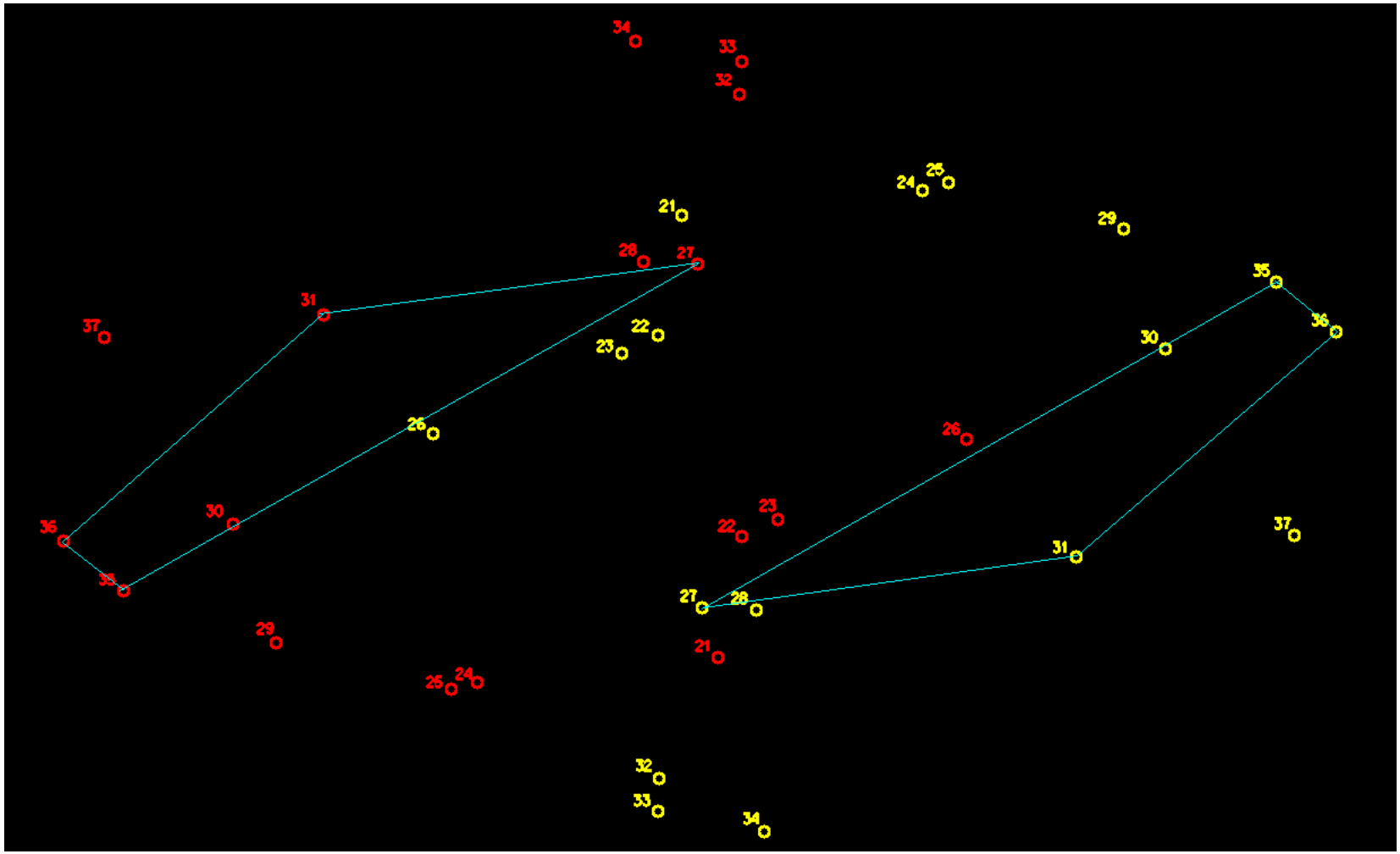


$$W_i := \left\{ w \in W_i' : \sigma_{iw} = \max\left\{ \sigma_{iw'} : w' \in W_i' \right\} \geq r_2 \right\},$$

$$\sigma_{iw'} := \left| \left\{ w'' \in W_i' : \beta_{iw''} = \beta_{iw'} \right\} \right|$$

$$i = \varphi(s_i),$$
$$w[1] = \varphi(t).$$

Identified stars




Thank you