FIG 2018 ISTANBUL

XXVI FIG CONGRESS

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Multi-constellation GNNS baseline solutions – a perspective from the user's and developer's point of view

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Outline:

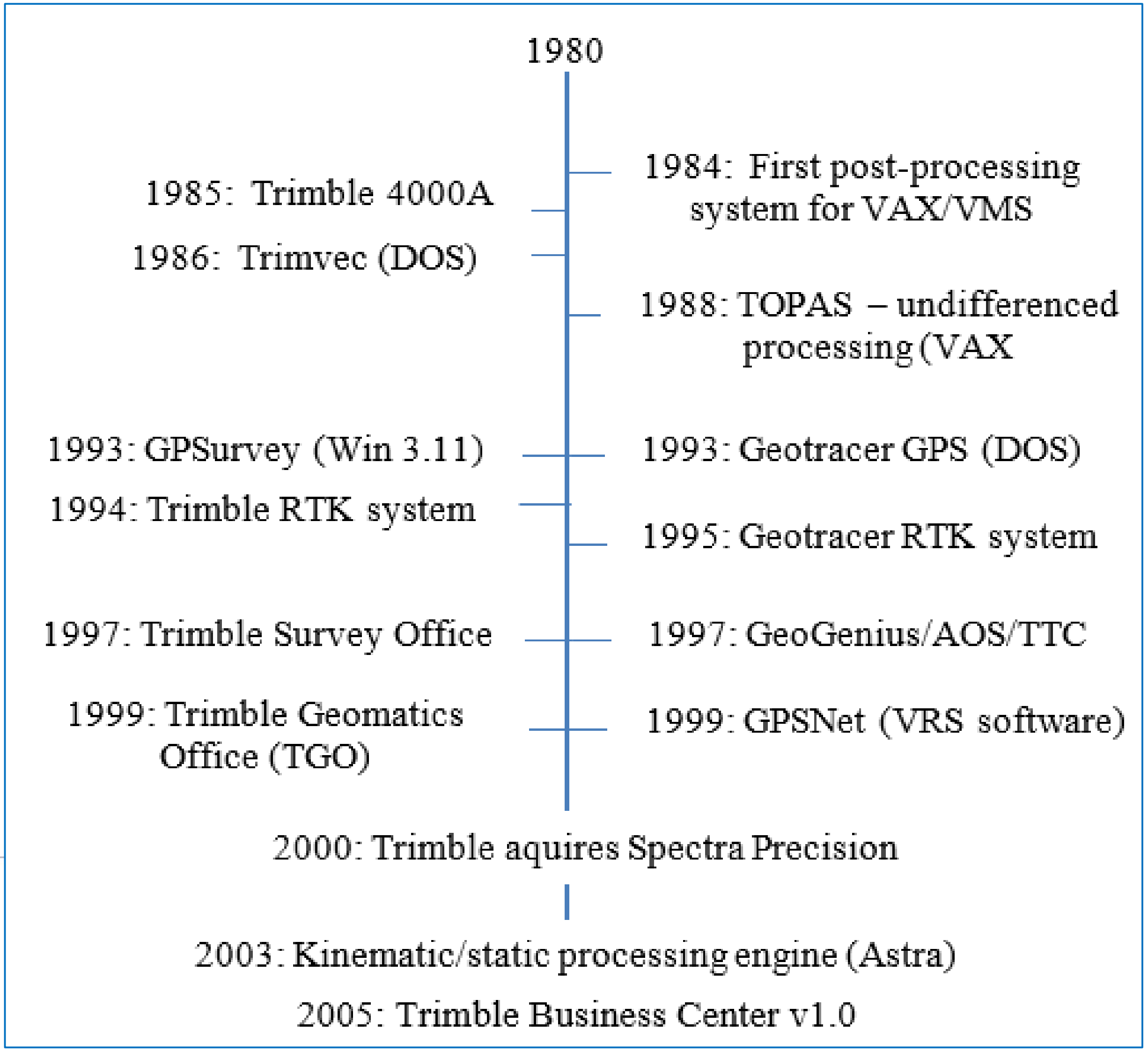
- Introduction
- Post-Processing baselines SW evolution
- TBC v4.00 – New Generation of Static Baseline Processing
- CROPOS
- Baseline processing with GPS-only, GLONASS-only and combined GPS+GLONASS data using CROPOS
- Subnetwork baseline processing using Galileo data combination
- Conclusions

Introduction:

- The first GPS receiver was purchased in 1989
- Faculty of Geodesy introduced a satellite geodesy (GPS) in the curriculum since 1996
- Since the beginning, Trimble's HW and SW solutions were used for static and kinematic (post-processing) applications
- SW: GPSurvey → Trimble Geomatics Office (TGO) → Trimble Business Center (TBC)
- PP SW evolution
- Example of Multi-constellation GNSS baseline solutions (GPS, GLONASS, Galileo)

Software Evolution in Trimble

- Long history in surveying software
  - GPSurvey (TrimNet)
  - TGO
  - Terramodel
  - VRSNet
  - TBC
- Focus on the entire system solution



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Post-Processing baselines SW evolution

- TBC v1.0 (2005): L1 Postprocessing Module
- TBC v1.11 (2007): Session editor, Time-based view, Internet download
- TBC v2.00 (2008): Optical (total station and level) data support
- TBC v2.11 (2009): .T02 format
- TBC v2.40 (2010): Multiple frequency (L1/L2/L5) baseline processing
- TBC v2.60 (2011): Multi-core CPUs by processing independent baselines
- TBC v2.80 (2012): Support for QZSS

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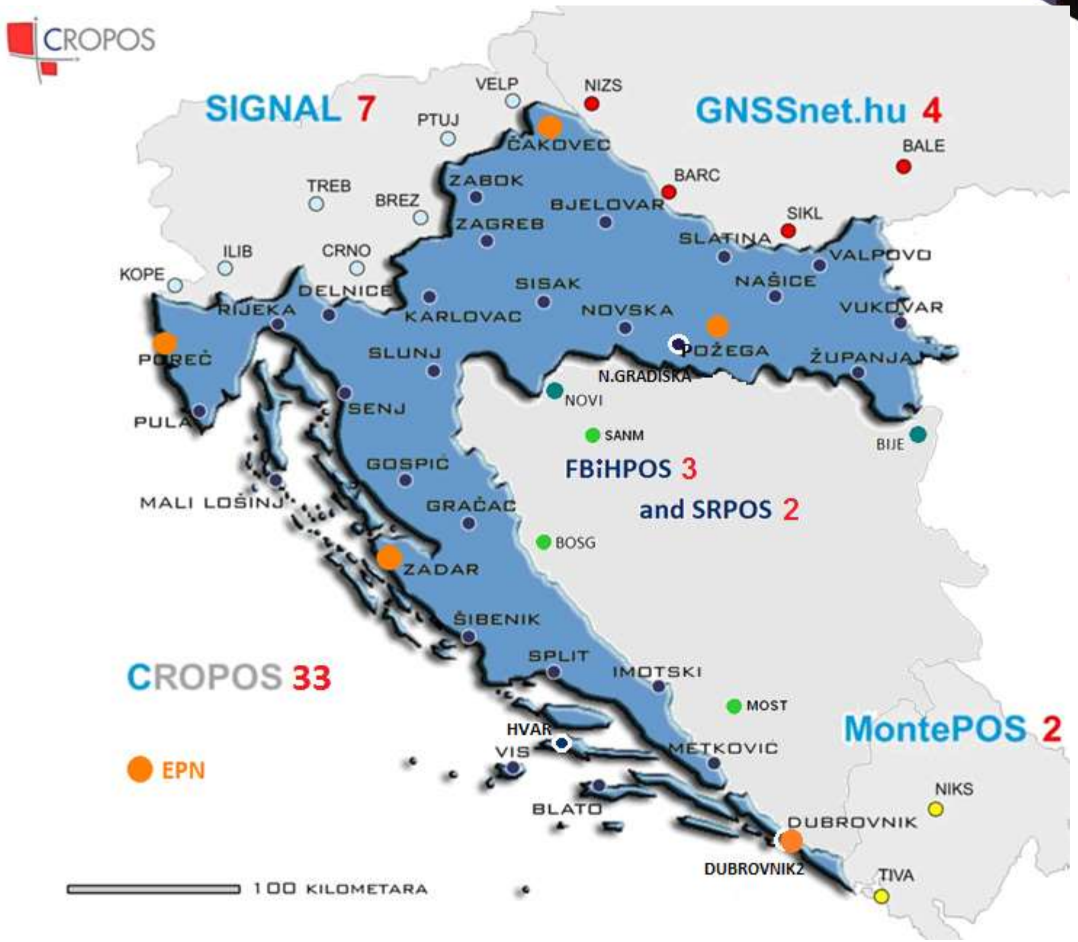
Post-Processing baselines SW evolution

- TBC v3.00 (2013): 64-bit version, UAS support
- TBC v3.20 (2014): RINEX Galileo Ephemeris
- TBC v3.50 (2015): Support GNSS independent constellation processes (PP/PPK), including BeiDou only, GLONASS only, and BeiDou + GLONASS only
- TBC v4.00 (2017):
  - Automatic dynamic parameters Support for Differential Code Biases (DCB) for satellites via the Internet Downloads
  - Support for Earth Orientation/Rotation Parameter (EOP) models

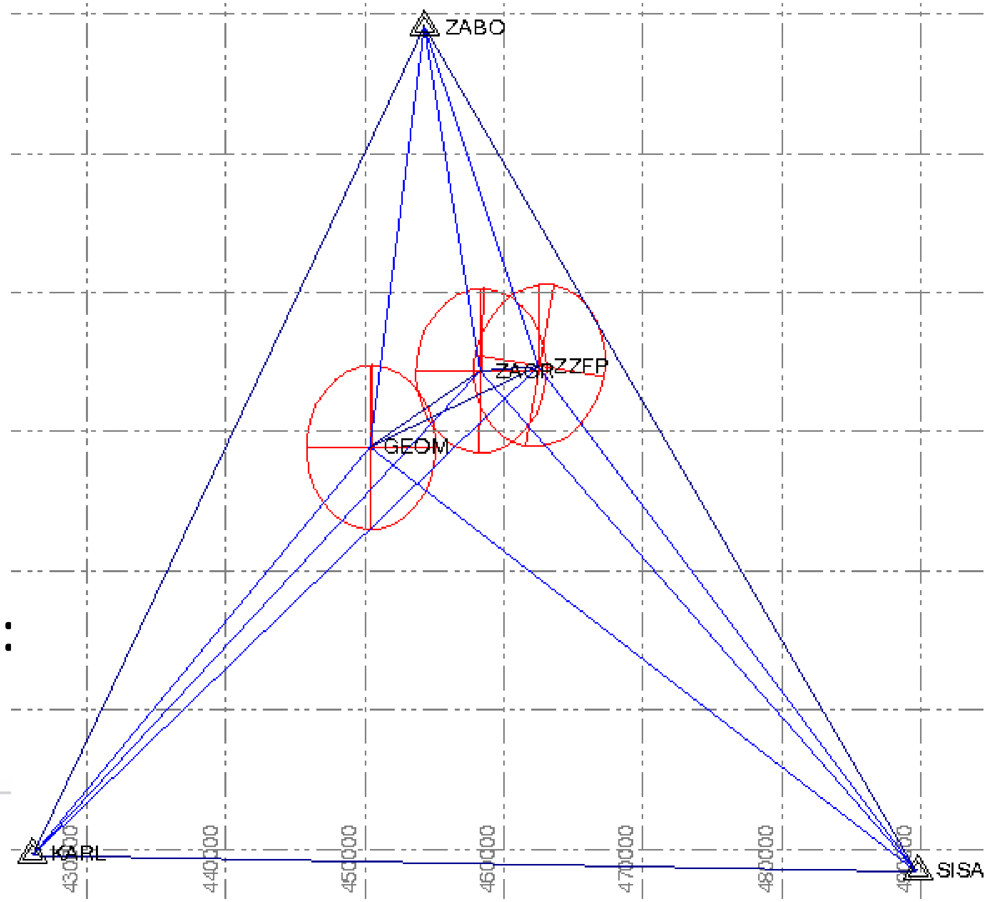
CROatian Positioning System (CROPOS):

- 33 national GNSS stations + 18 GNSS stations from neighbouring networks
- ~ 70 km
- Estab. in 12/2008, ETRF2000 (R05), e=2008.83
- DPS, Highly Precise Positiong Service (HPPS); Geodetic Precise Positiong Service (GPPS)
- CROPOS is based on Trimble's solutions: NetR5, Zephy Geodetic 2 wRadome, Trimble Pivot Web, VRS concept
- Currenty CROPOS supports GPS and GLONASS observations



Baseline procesing with GPS-only, GLONASS-only and combined GPS+GLONASS data using CROPOS GPPS:

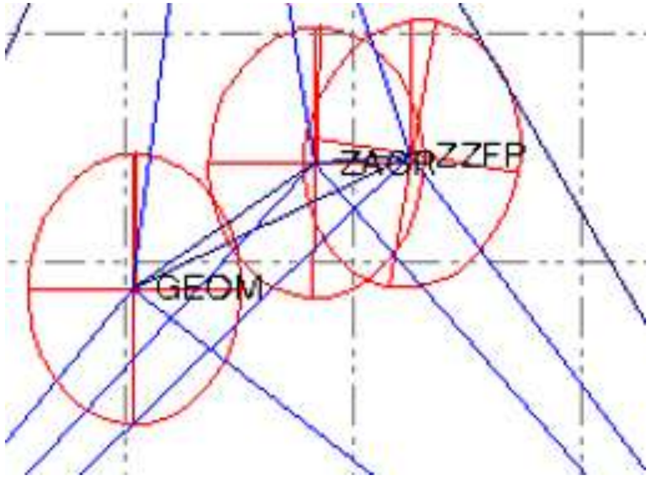
- CORSes: ZABO, KARL, SISA, ZAGR
- 35 hours, 5 sec logging interval
- IGS Final Precise Ephemeris (GPS & GLONASS)
- IGS Final EOP
- ETRF 2000 (R05), e = 2008.83 → ITRF2014, e = 2017.33
- Two additional stations: GEOM (NetR9) & ZZZF (R10)
- TBC v4.00
- Baseline processing with 3 different data combinations: GPS-only, GLONASS-only, GPS+GLONASS



Baseline procesing with GPS-only, GLONASS-only and combined GPS+GLONASS data using CROPOS GPPS:

- homogenous accuracy (a= 8-9 mm; b=6-7 mm; σh=27-30 mm)
- CORS ZAGR coordinates comparison: 'Measured-Reference'

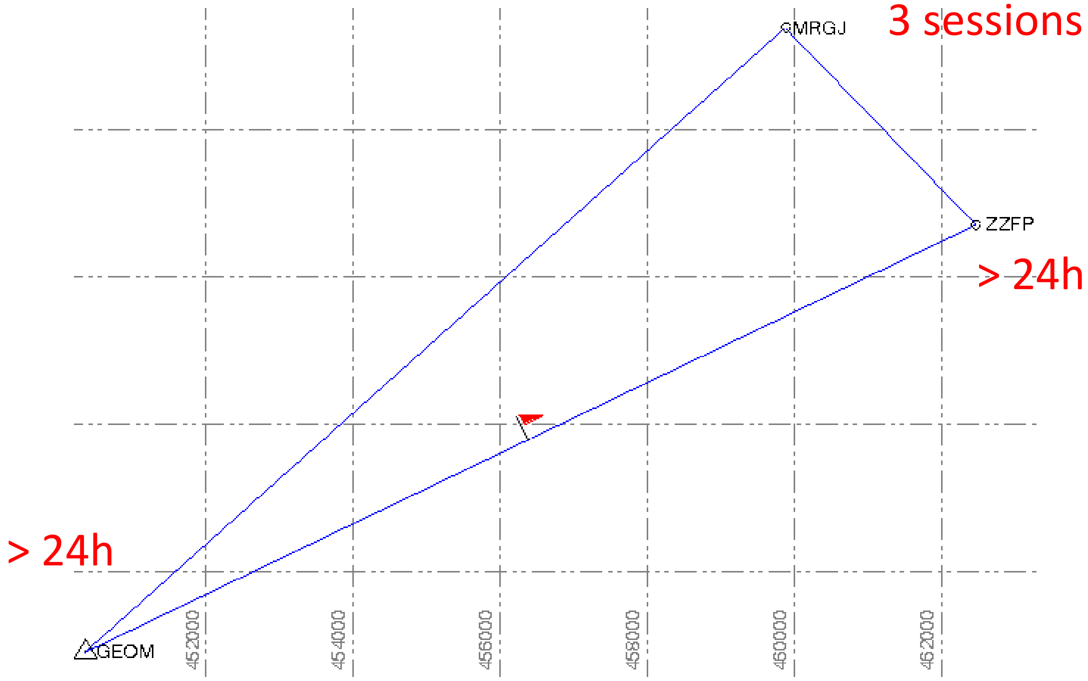
Combination	ΔE [m]	ΔN [m]	Δh [m]	σE [m]	σN [m]	σh [m]	2D [m]	3D [m]
GPS only	-0.002	0.008	0.005	0.005	0.007	0.027	0.008	0.009
GLONASS only	0.001	0.008	0.001	0.006	0.006	0.032	0.008	0.008
GPS+GLONASS	-0.001	0.008	0.004	0.005	0.006	0.027	0.008	0.009

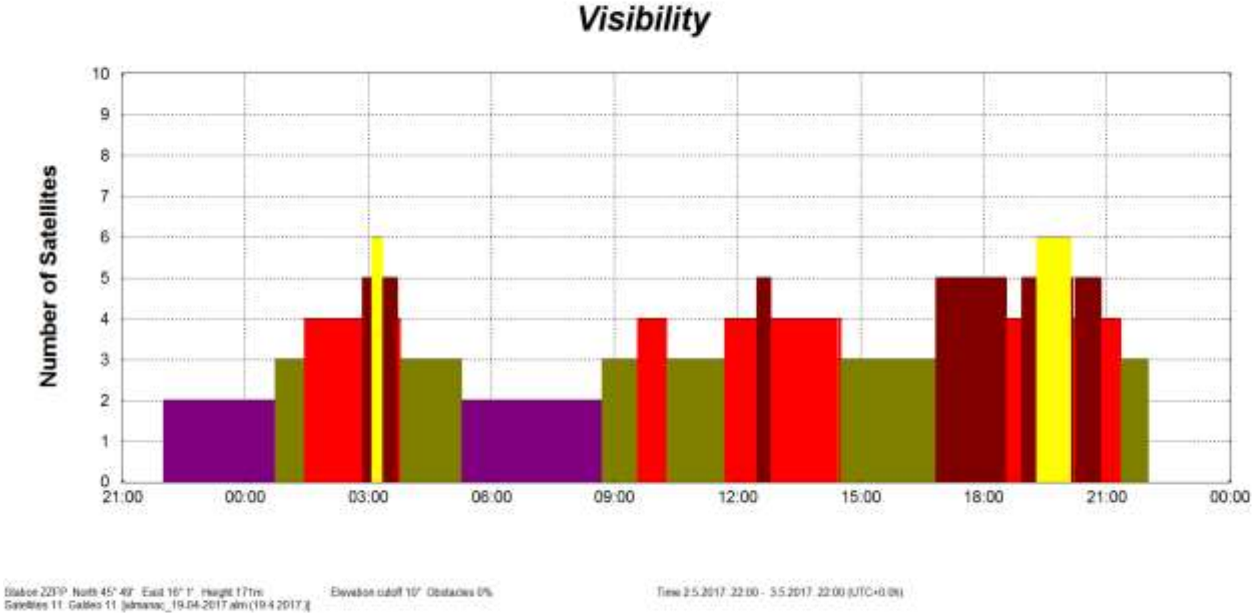


- all combinations have led to (2D) and (3D) spatial deviation < 1 cm
- GPS+GLONASS combination declared as the most reliable
- Coordinate precision of stations GEOM and ZZFP was assessed from the coordinate differences: GPS-GLONASS; GPS-(GPS & GLONASS); GLONASS – (GPS & GLONASS)
- GPS+GLONASS combination was pointed out as the most reliable

Subnetwork baseline processing using Galileo data combinations:

- GEOM (NetR9), ZZFP (R10), MRGJ (R10)

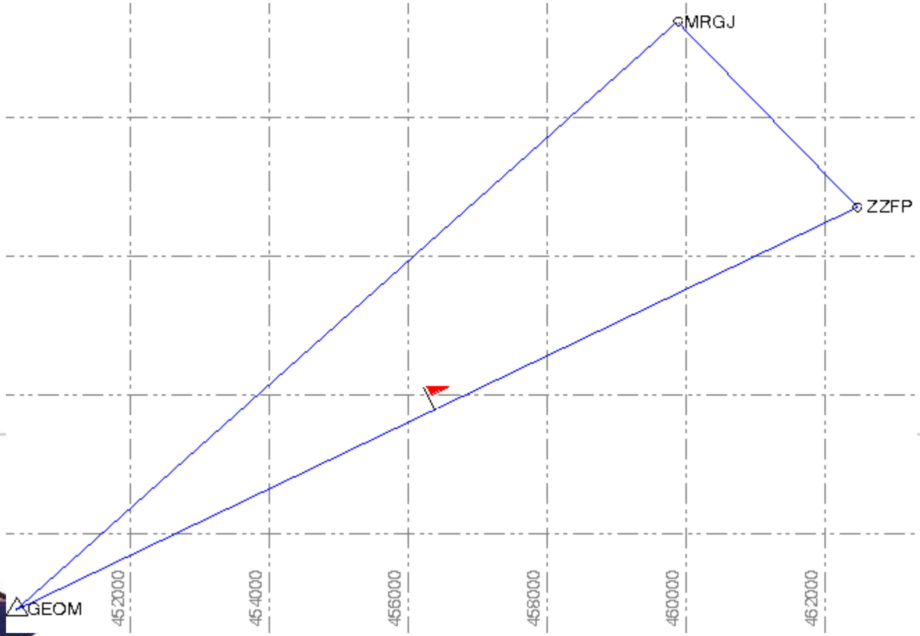


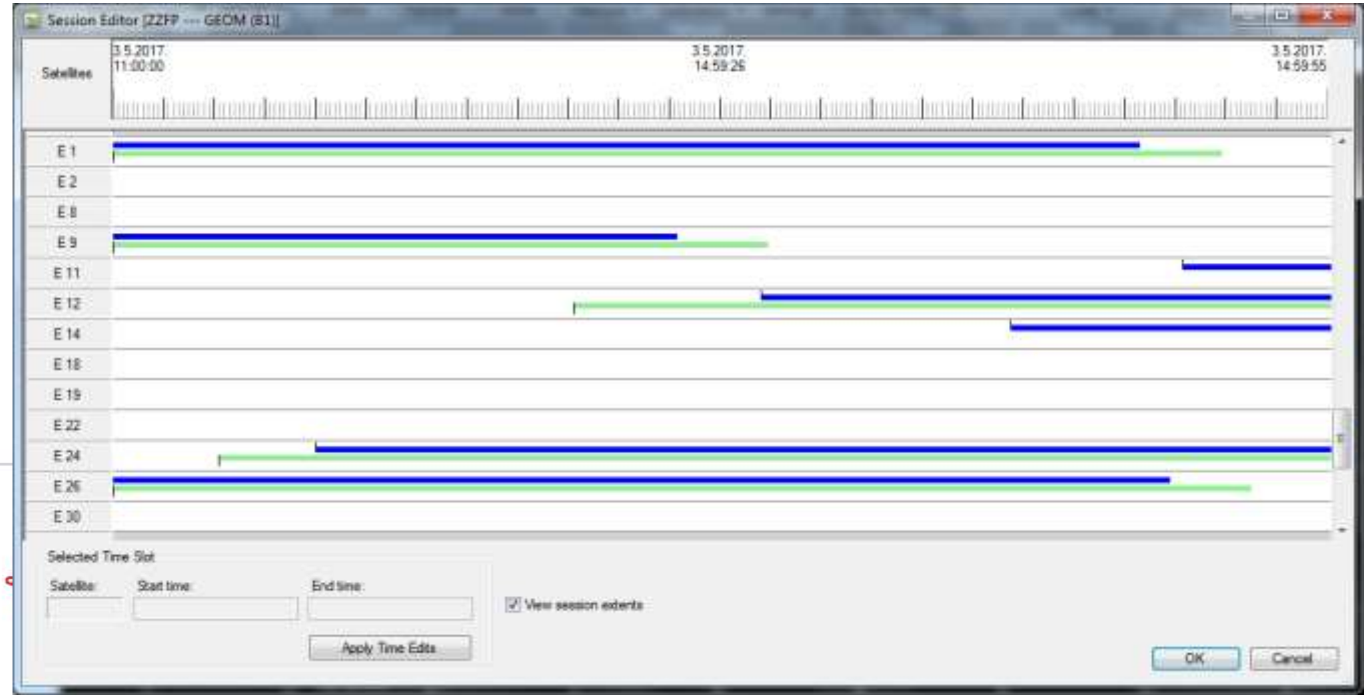


Time window	PDOP range (min-max)	Number of SV	Duration (minutes)
01:26 – 03:45 UTC	2.98 – 582.64	4, 5, 6	140
11:41 – 14:25 UTC	7.37 – 828.78	4, 5	165
16:50 – 20:51 UTC	1.96 – 137.33	4, 5, 6	242

Subnetwork baseline processing using Galileo data combinations:

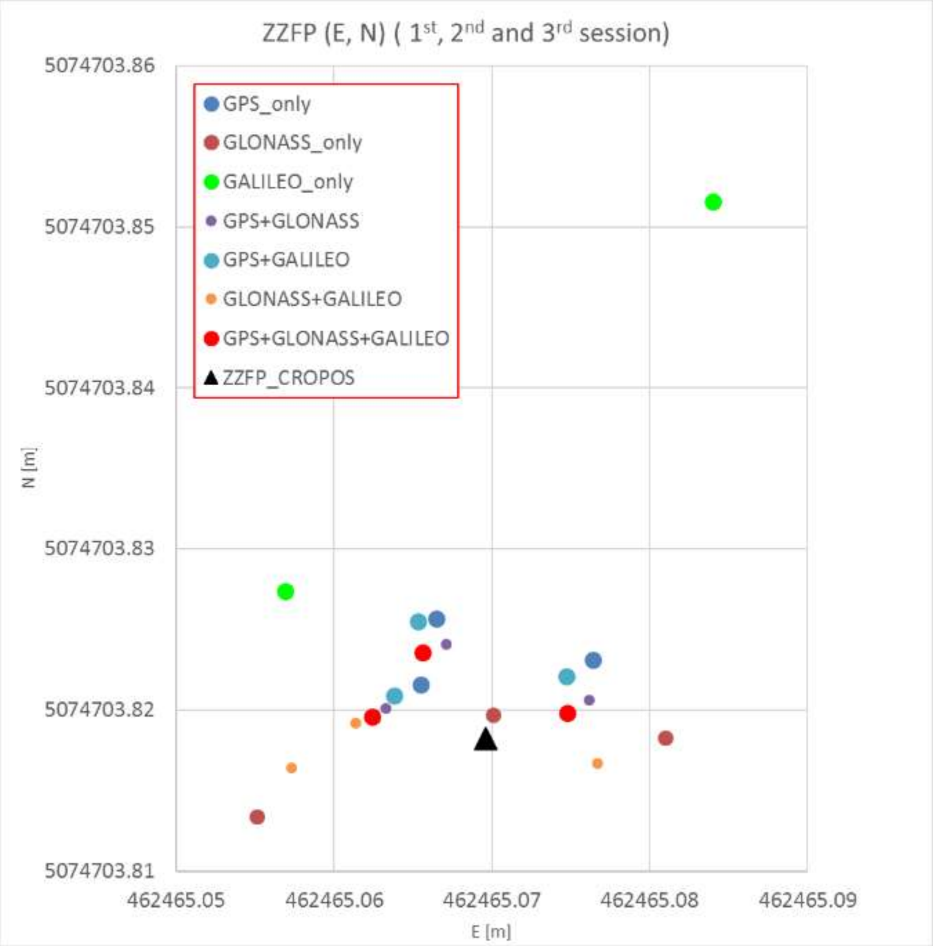
- 3 sessions, 7 different data combinations (GPS-only, GPS & GLO, GPS & GLO &GAL, GPS & GAL, GLO-only, GLO & GAL, GAL-only) → 21 project
- Minimally constrained adjustment with GEOM station being fixed
- All baselines were obtained with FIXED solution with one exception: GEOM → ZZFP (2nd session)

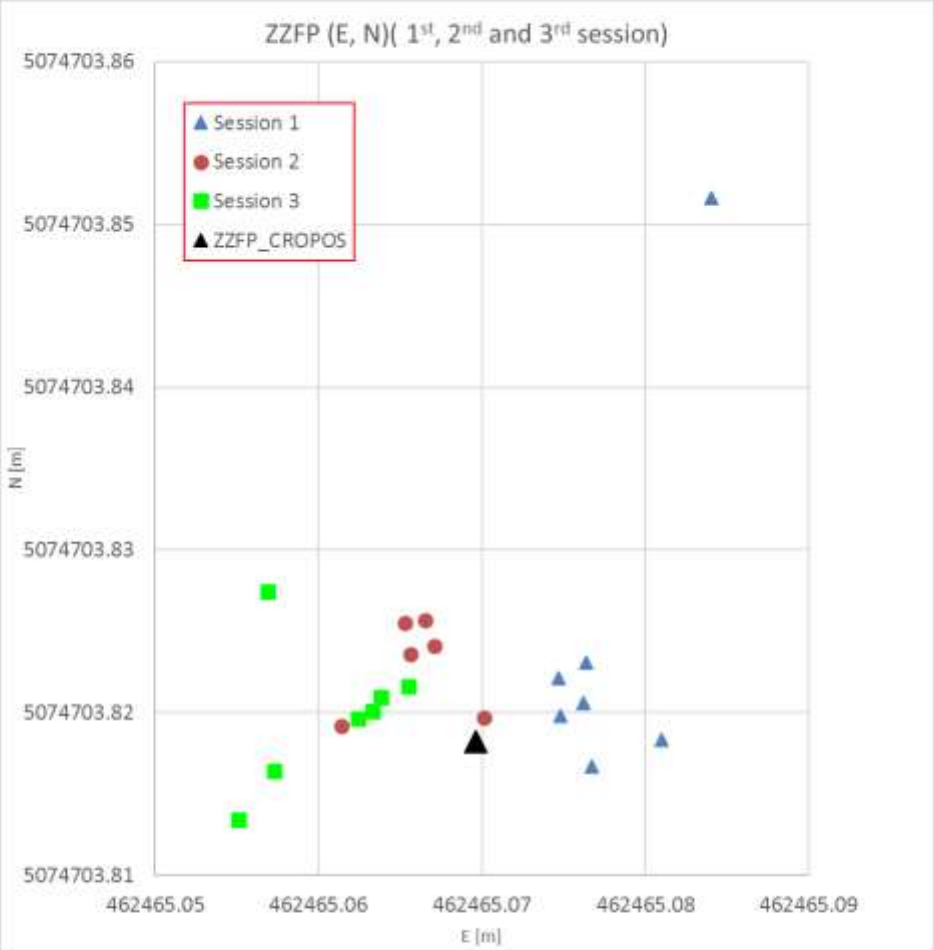




Subnetwork baseline processing using Galileo data combinations:

- Coordinates of the station ZZFP obtained with different data combinations were compared to the reference (GPS & GLONASS)





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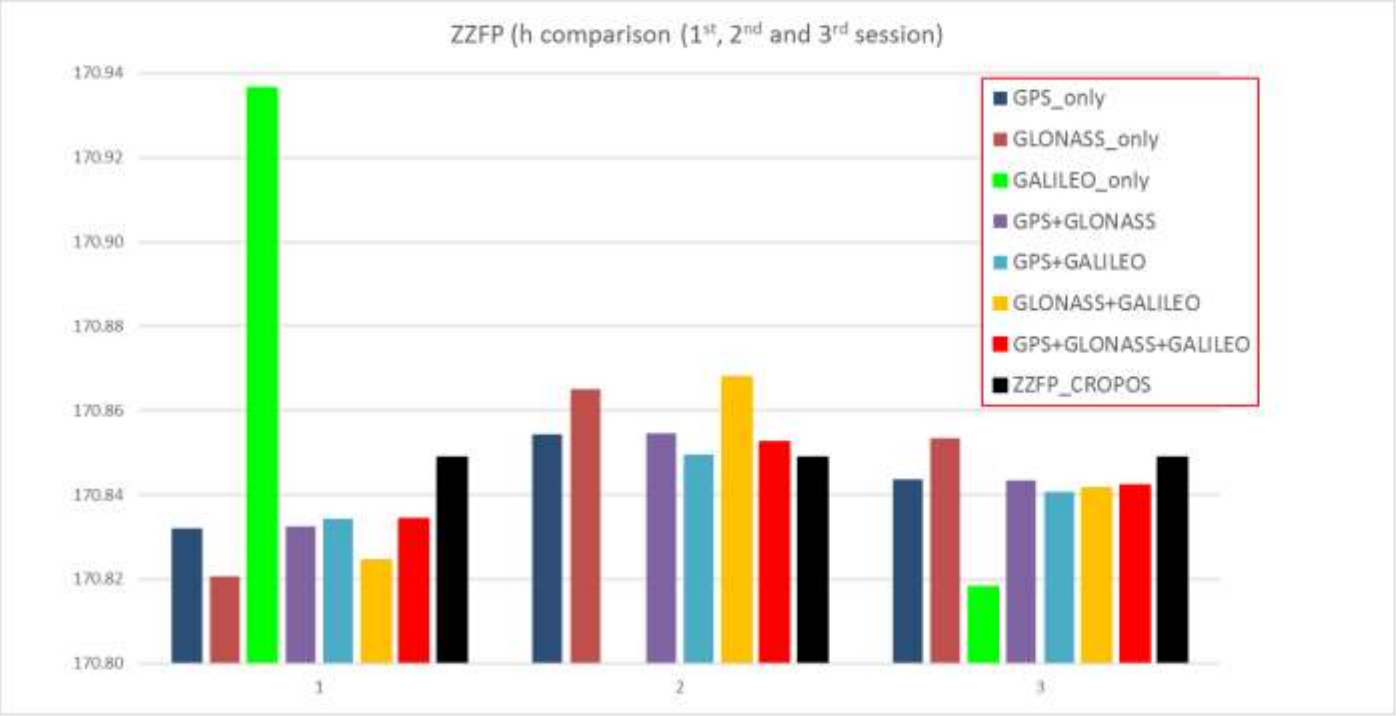

- Heights obtained from the combination (GPS+GLONASS+Galileo) have shown the smallest sum of departures from the reference value
- 3rd session being the longest in duration with better satellite visibility showed overall best results

CONCLUSION:

- Difference between reference coordinates of CORS ZAGR and those calculated in TBC v4.00 have shown to be at sub-cm level proving great potential
- Subnetwork featuring 3 stations were occupied by Galileo-enabled GNSS receivers leading to a 7-combination solutions
- Since Galileo constellation hasn’t been fully deployed, mission planning has shown to be an essential step in reaching a FIXED baseline solution
- By approaching the FOC, Galileo satellites are expected to provide an improvement in terms of availability, accuracy and reliability of coordinates determination

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