
CENTRAL LABORATORY OF GEODESY
MILITARY GEOGRAPHIC SERVICE
GEODESY, CARTOGRAPHY AND CADASTRE AGENCY
NATIONAL REPORT
OF BULGARIA

Ivan GEORGIEV [1], Georgi GLADKOV[2],
Plamen GABENSKI [2], Toshko TASHKOV[2],
Peter DANCHEV[2], Dimitar DIMITROV [1],
Tassi BELYASHKI[1], Tsveten BOEV [3],
Momchil MINCHEV[4]

[1] Central Laboratory of Geodesy
[2] Military Geographic Service
[3] Geodesy, Cartography and Cadastre Agency
[4] University of Mining and Geology

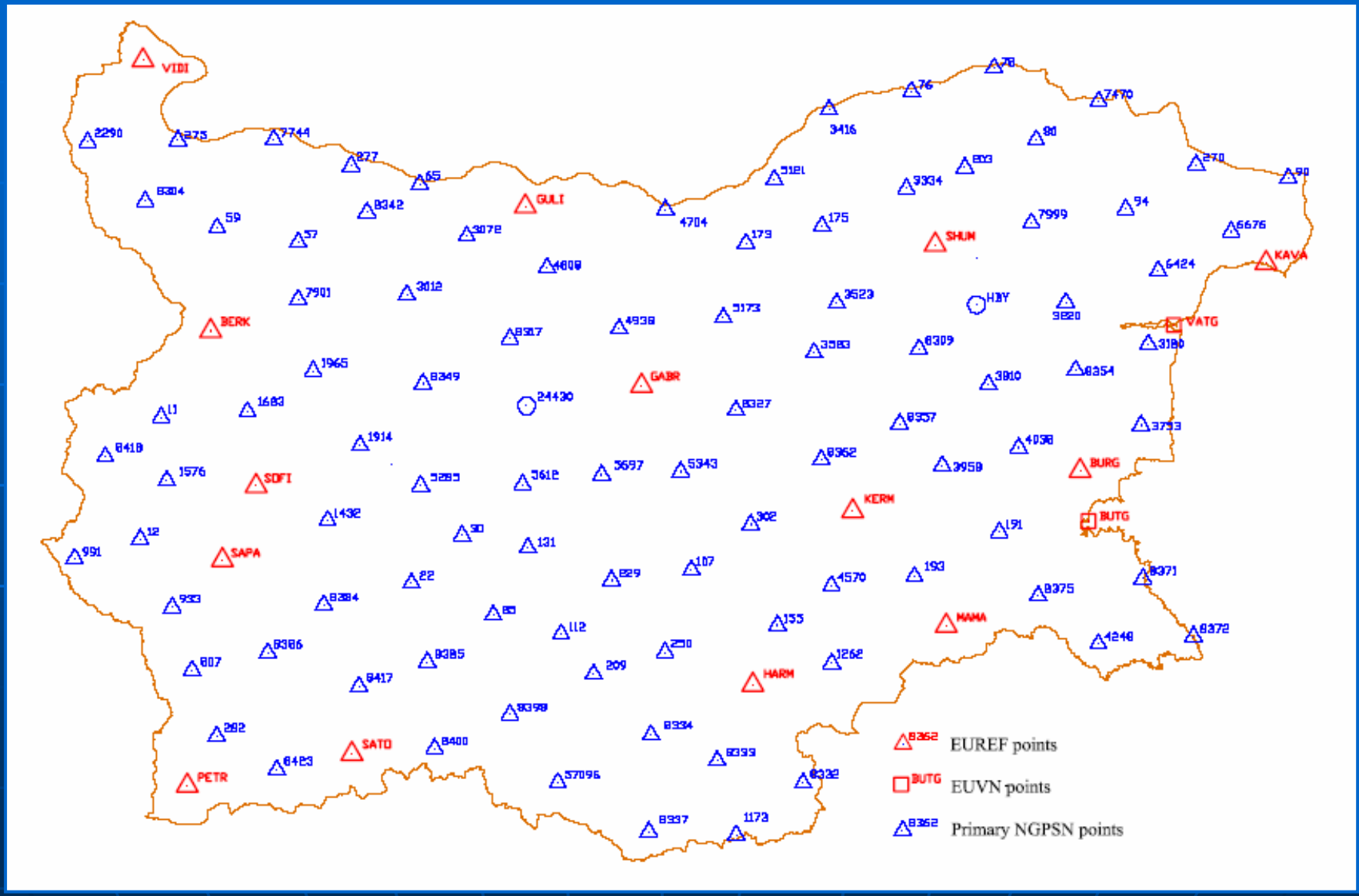
Main Activities

- Further development and maintenance of the National GPS Network
  - GPS campaign for velocity estimation of the 25 EUREF points
  - Precise levelling of all National GPS Network points
  - Gravity measurements of the 25 EUREF points
- Joining the National levelling network to EVRS
- Development of a permanent GPS array in Bulgaria
  - Deployment of permanent stations
  - GPS permanent stations data processing
- Drafting specifications

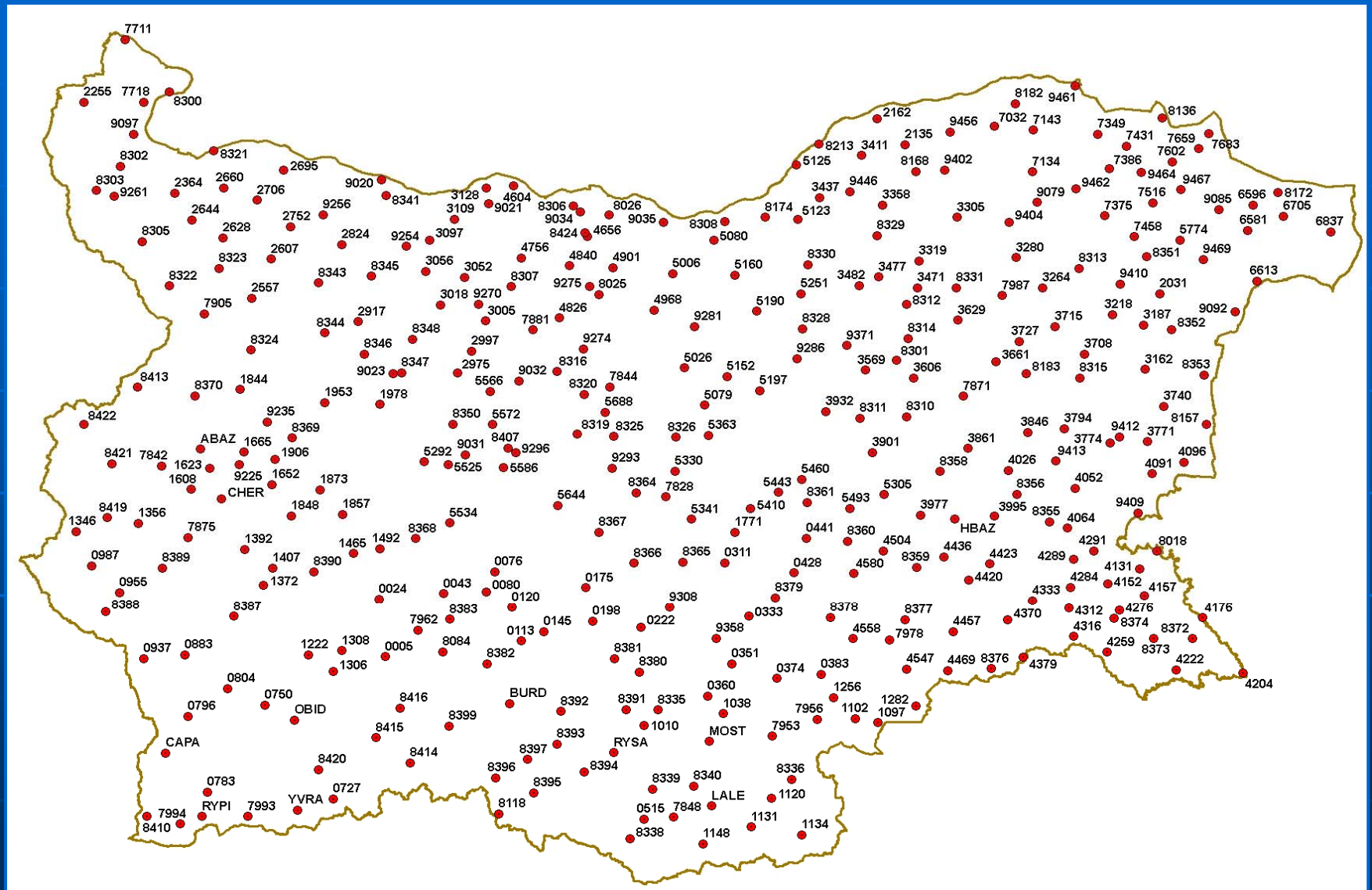
Further development and maintenance of the National GPS Network

- GPS campaign for velocity estimation of the 25 EUREF poi nts
- Precise levelling of all National GPS Network points
- Gravity measurements of the 25 EUREF points

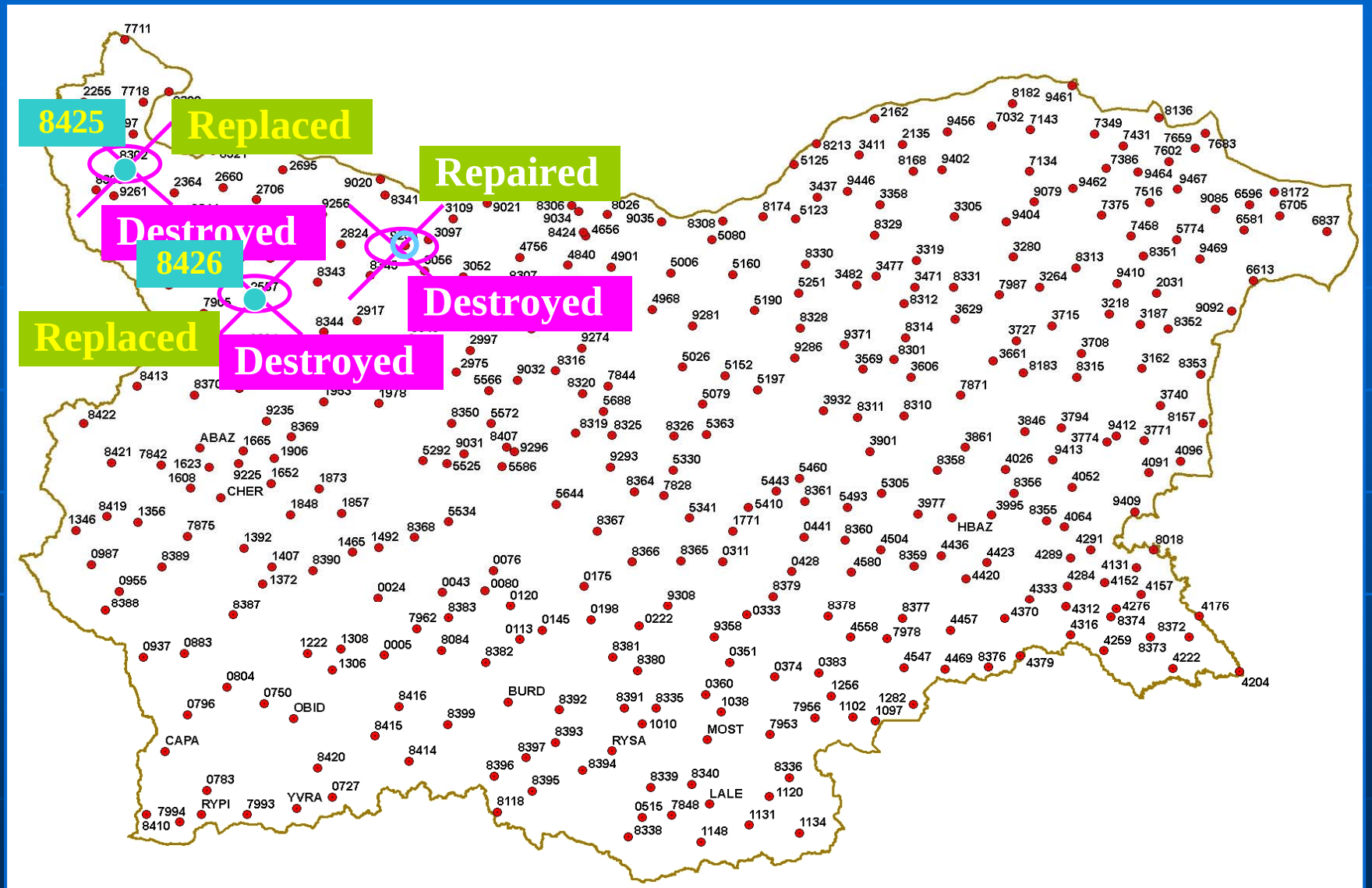
National GPS Network – Primary points

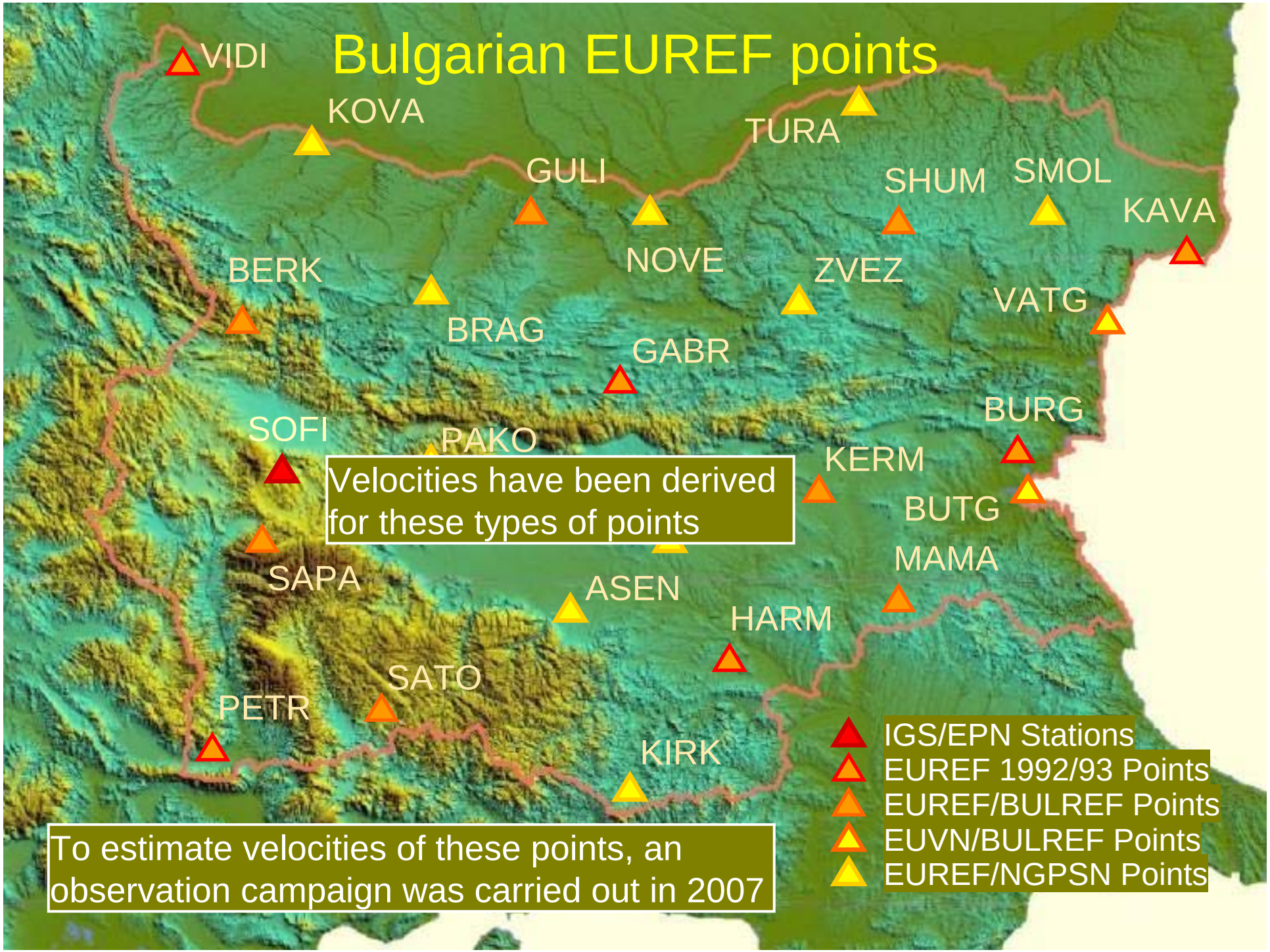


National GPS Network – Secondary points



National GPS Network Maintenance

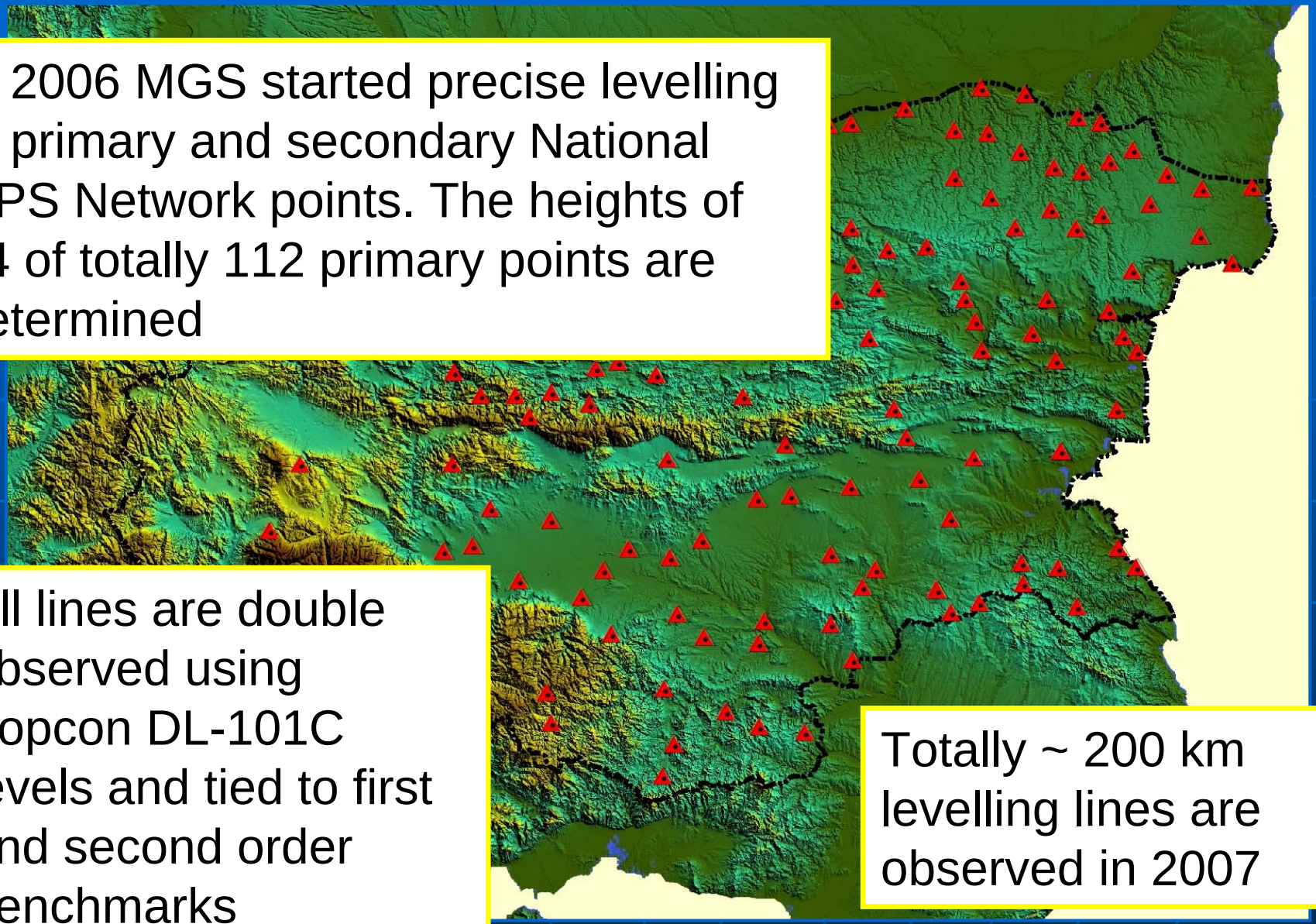



Bulgarian EUREF points
VIDI
KOVA
TURA
GULI
SHUM
SMOL
KAVA
NOVE
ZVEZ
BERK
VATG
BRAG
GABR
BURG
SOFI
PAKO
KERM
Velocities have been derived for these types of points
BUTG
MAMA
SAPA
ASEN
HARM
SATO
PETR
KIRK
IGS/EPN Stations
EUREF 1992/93 Points
EUREF/BULREF Points
EUVN/BULREF Points
EUREF/NGPSN Points
To estimate velocities of these points, an observation campaign was carried out in 2007

The 2007 GPS campaign

- Purpose
  - To obtain a second observation epoch of the 10 new EUREF points endorsed at the 2006 EUREF symposium in Riga
- Participants
  - Central Laboratory of Geodesy
  - Military Geographic Service
- Campaign details
  - Equipment: 10 Trimble receivers
  - Session length: 62 hours

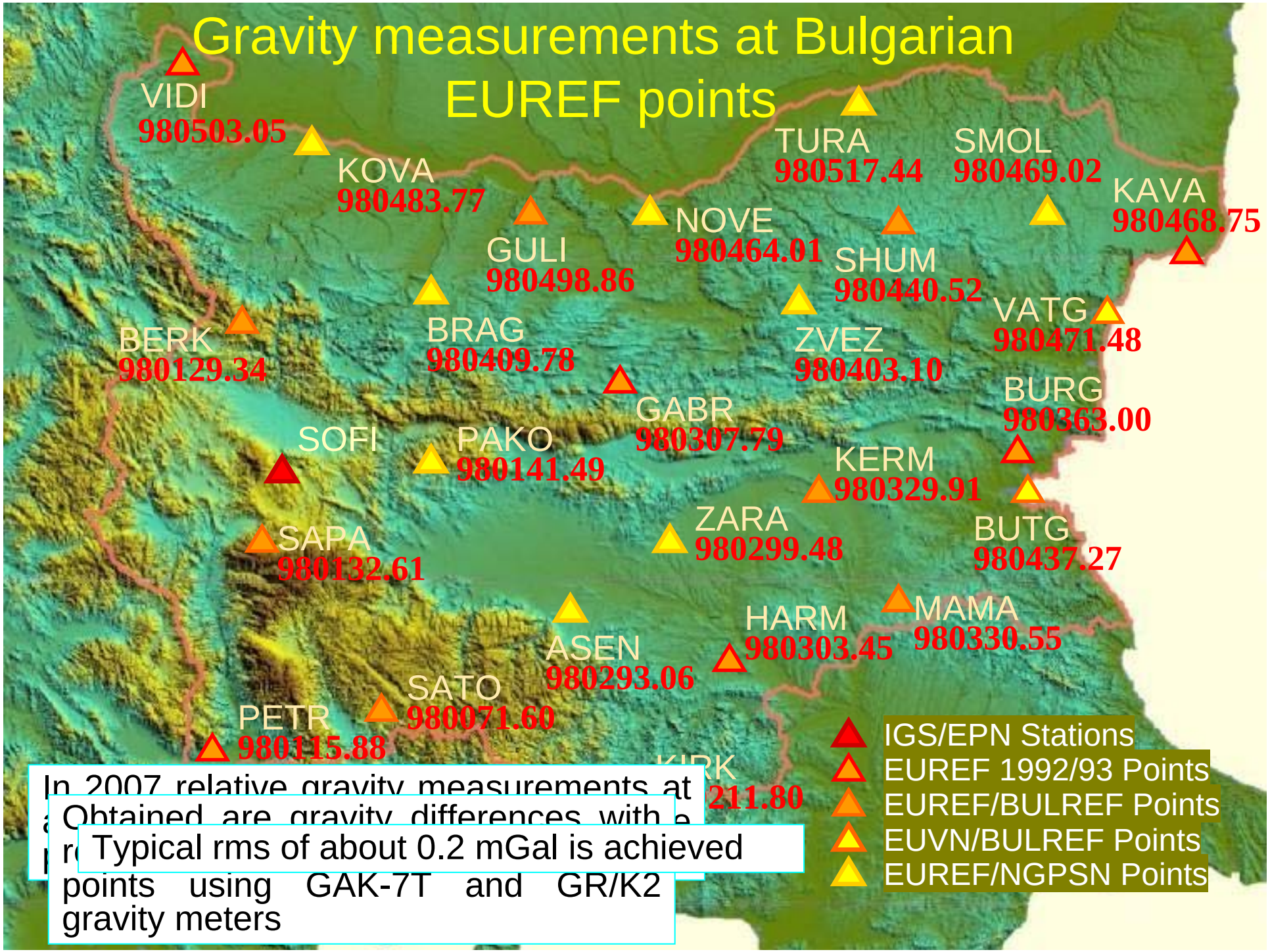
Precise levelling of NGPSN points



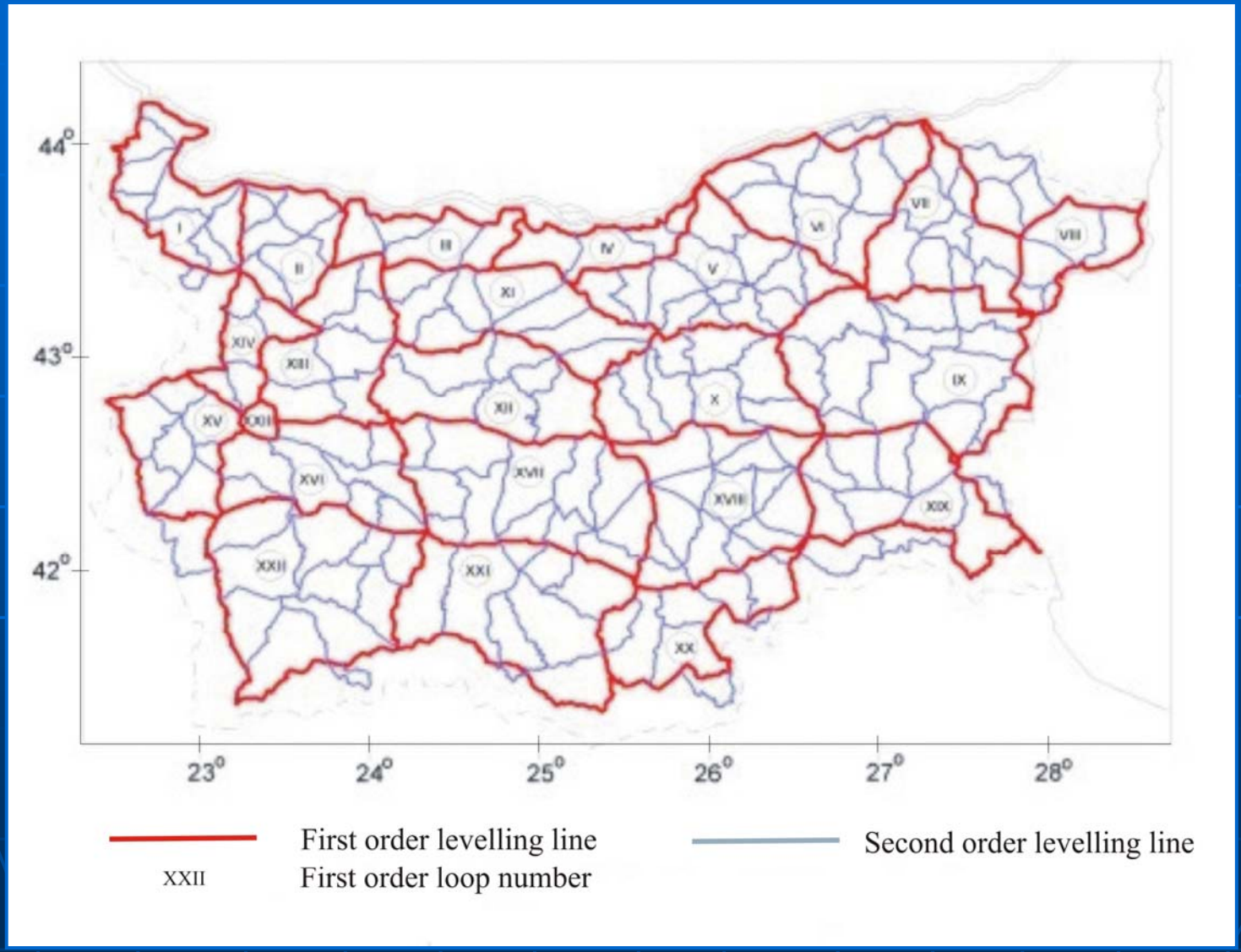
In 2006 MGS started precise levelling of primary and secondary National GPS Network points. The heights of 64 of totally 112 primary points are determined

All lines are double observed using Topcon DL-101C levels and tied to first and second order benchmarks

Totally ~ 200 km levelling lines are observed in 2007


Gravity measurements at Bulgarian EUREF points
VIDI
980503.05
KOVA
980483.77
TURA
980517.44
SMOL
980469.02
KAVA
980468.75
NOVE
980464.01
GULI
980498.86
SHUM
980440.52
VATG
980471.48
BERK
980129.34
BRAG
980409.78
ZVEZ
980403.10
BURG
980363.00
GABR
980307.79
SOFI
PAKO
980141.49
KERM
980329.91
ZARA
980299.48
BUTG
980437.27
SAPA
980132.61
HARM
980303.45
MAMA
980330.55
ASEN
980293.06
SATO
980071.60
PETR
980115.88
211.80
IGS/EPN Stations
EUREF 1992/93 Points
EUREF/BULREF Points
EUVN/BULREF Points
EUREF/NGPSN Points
In 2007 relative gravity measurements at
Obtained are gravity differences with
Typical rms of about 0.2 mGal is achieved
points using GAK-7T and GR/K2 gravity meters

Joining the National Levelling Network to EVRS



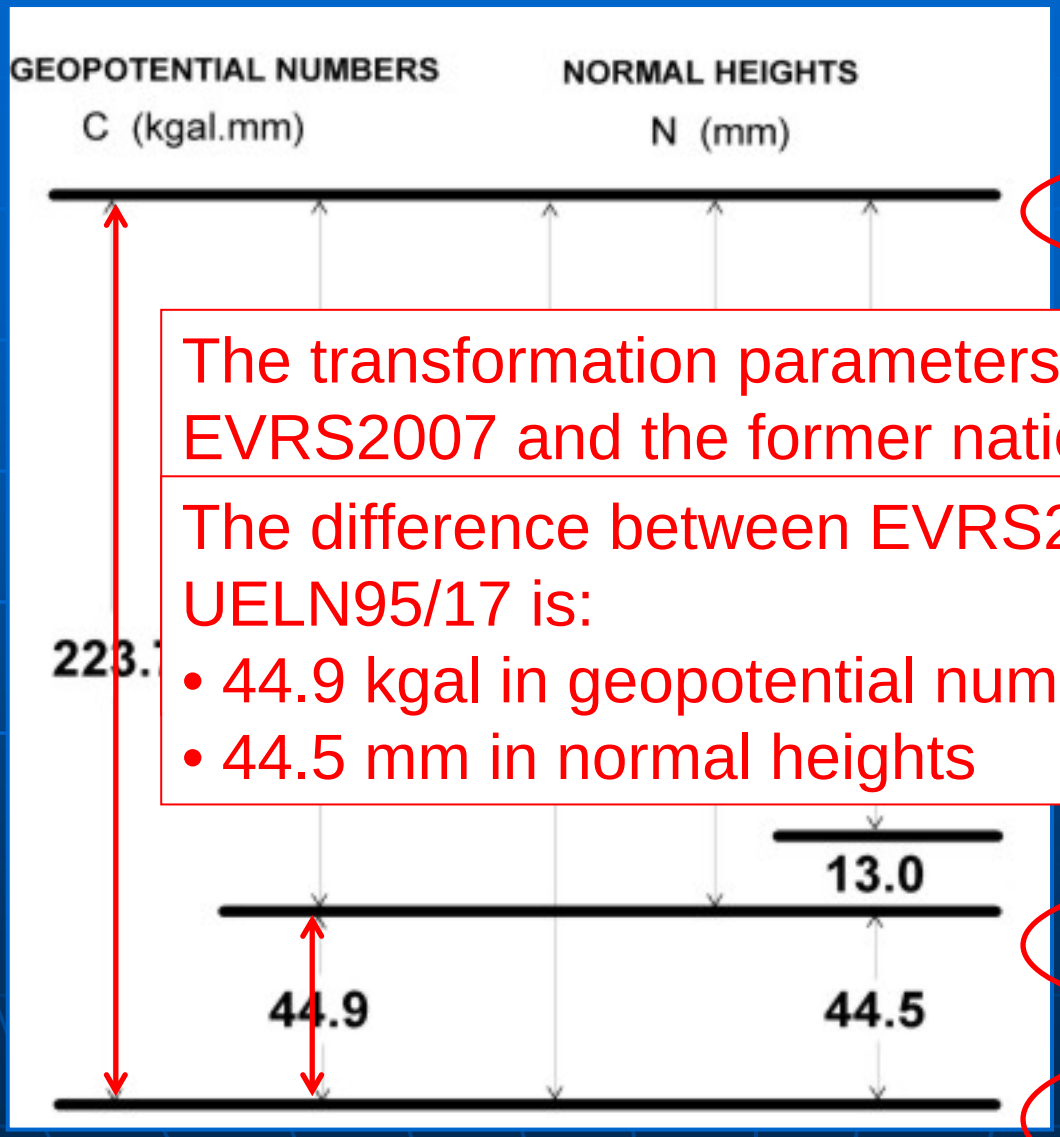
National Levelling Network
First Order

- Outlook
  - 55 levelling lines, total length 5630 km
  - 4530 levelling points, of them 330 fundamental benchmarks
  - 33 nodal points, 23 loops
  - 6 cross-border connections to Romania
- Observations
  - Last observation cycle 1974 – 1984
  - Average epoch 1979
  - Accuracy of 1 km double levelled line 0.40 mm
- Results
  - Geopotential numbers and normal heights
  - Referred to the EVRS2007 system

National Levelling Network
Second Order

- Outlook
  - 252 levelling lines, total length 8650 km
  - 6130 benchmarks
- Observations
  - Observation cycle 1983 - 1995
  - Accuracy of 1 km double levelled line 0.59 mm
- Referred to UELN-95/17
- To be recomputed
  - Constrained by 73 nodal points obtained from the First Order
  - Reference system EVRS2007

Height system intercomparison



Baltic System
Kronstadt

The transformation parameters between EVRS2007 and the former national height system

The difference between EVRS2007 and UELN95/17 is:

- 44.9 kgal in geopotential numbers
- 44.5 mm in normal heights

Black Sea

UELN95/17
Amsterdam

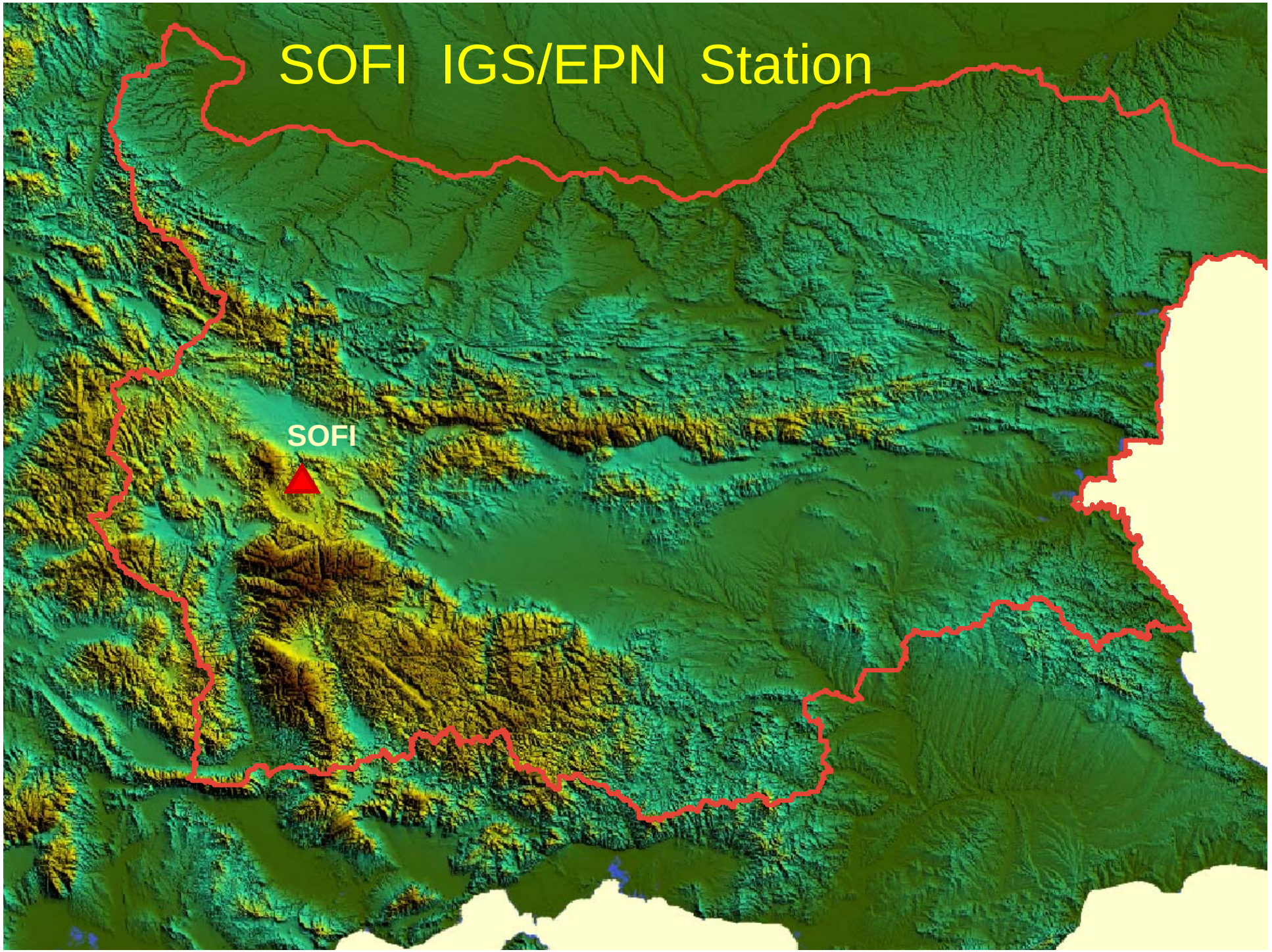
EVRS2007
13 datum points

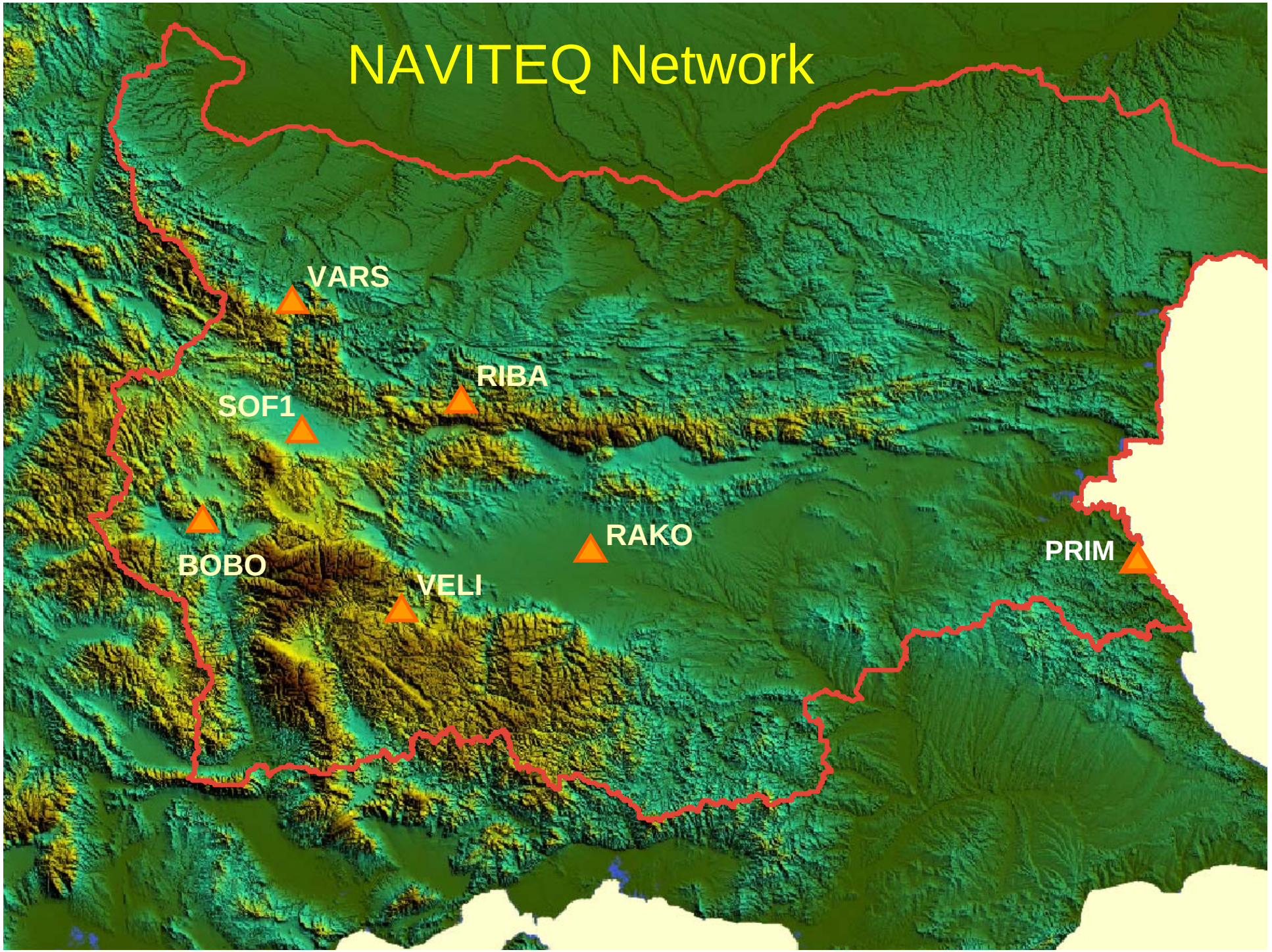
Development of a GPS Array in Bulgaria

- Deployment of permanent GPS stations
- GPS permanent stations data processing

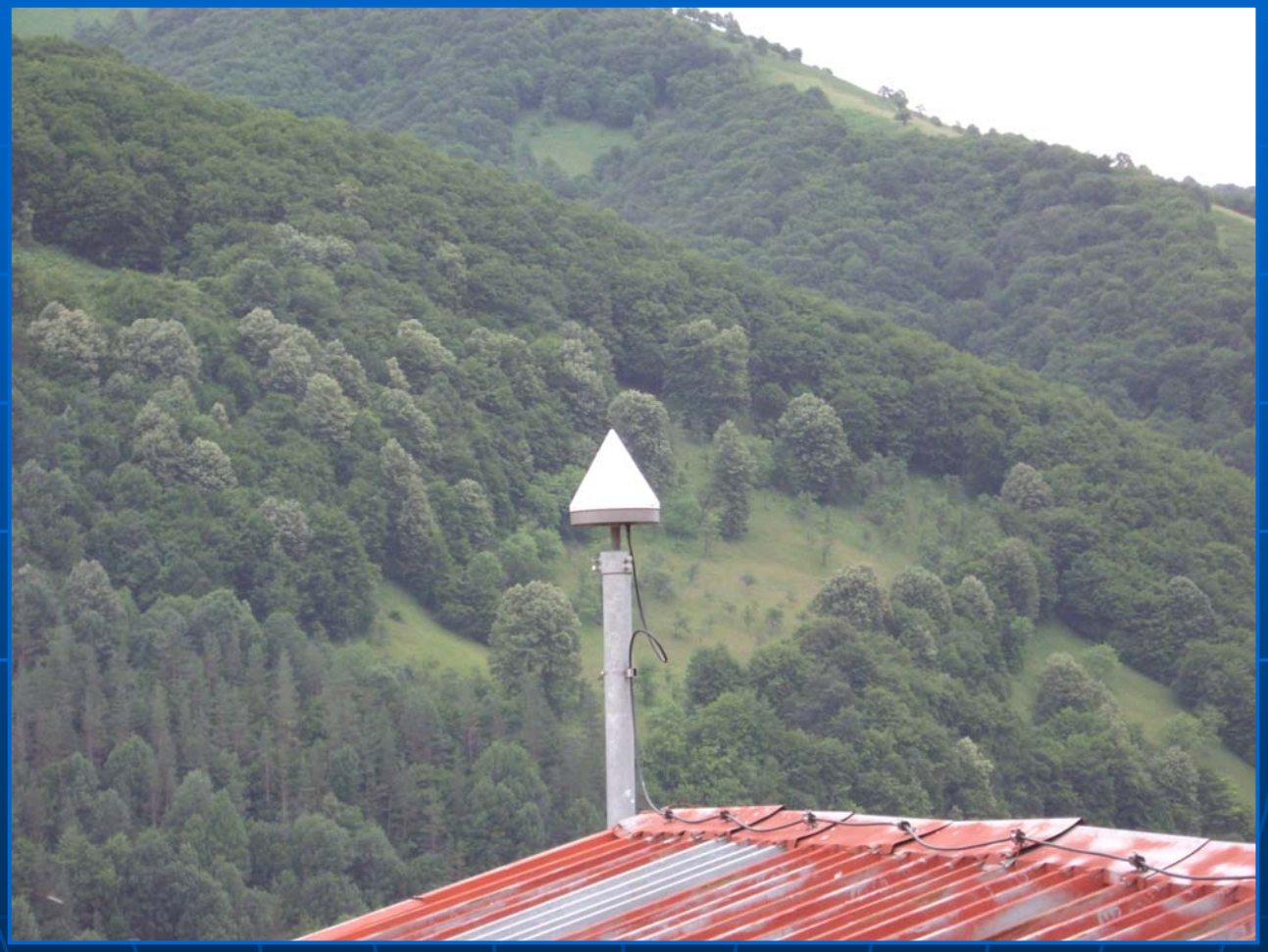
Deployment of permanent GPS stations

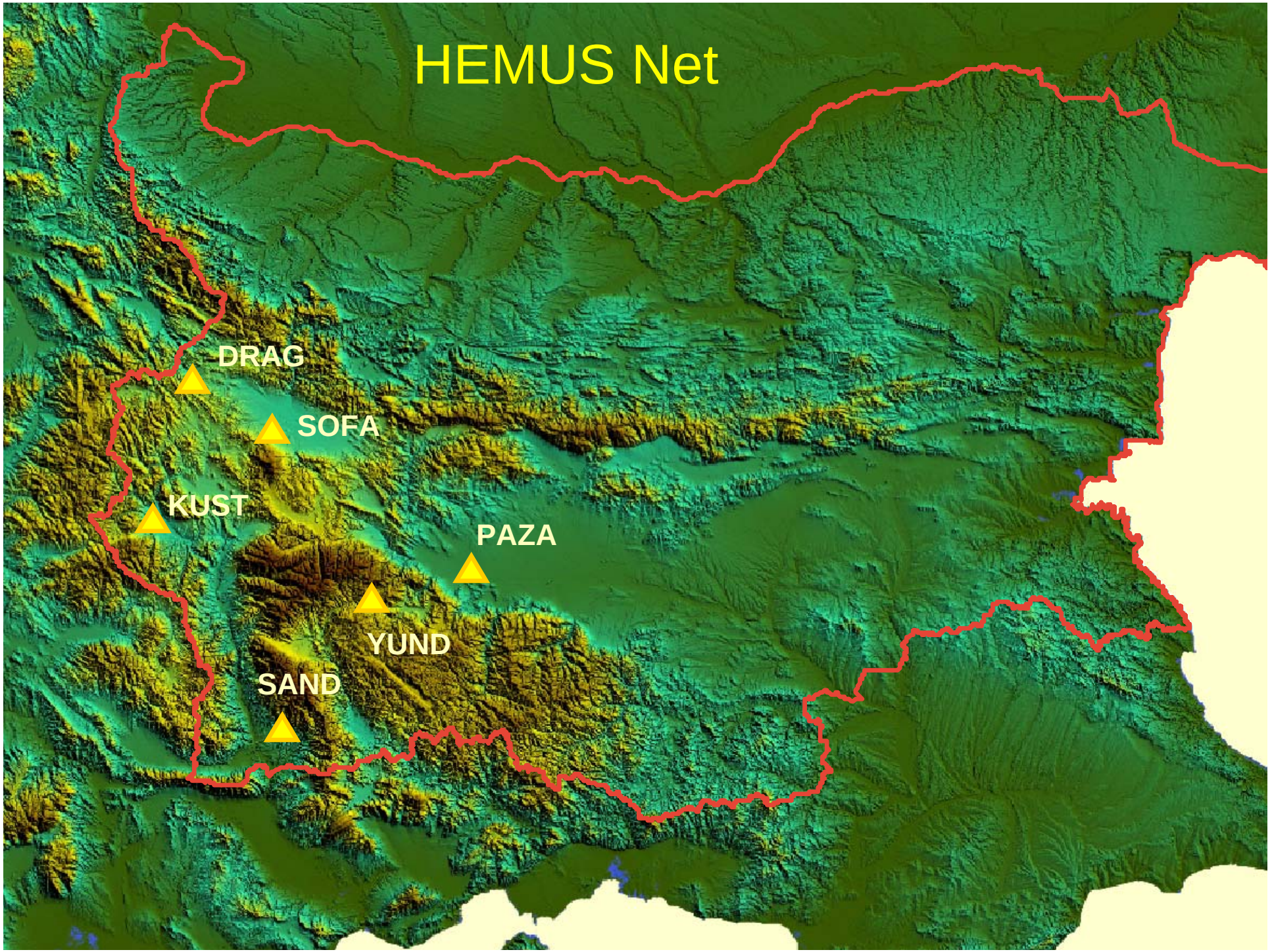
- Joint efforts of both institutions
  - Central Laboratory of Geodesy
  - Military Geographic Service
- Private companies provide 30 sec files
- At the moment, totally 17 permanent GPS/GNSS stations submit data to CLG analysis center for routine processing


SOFI IGS/EPN Station
SOFI

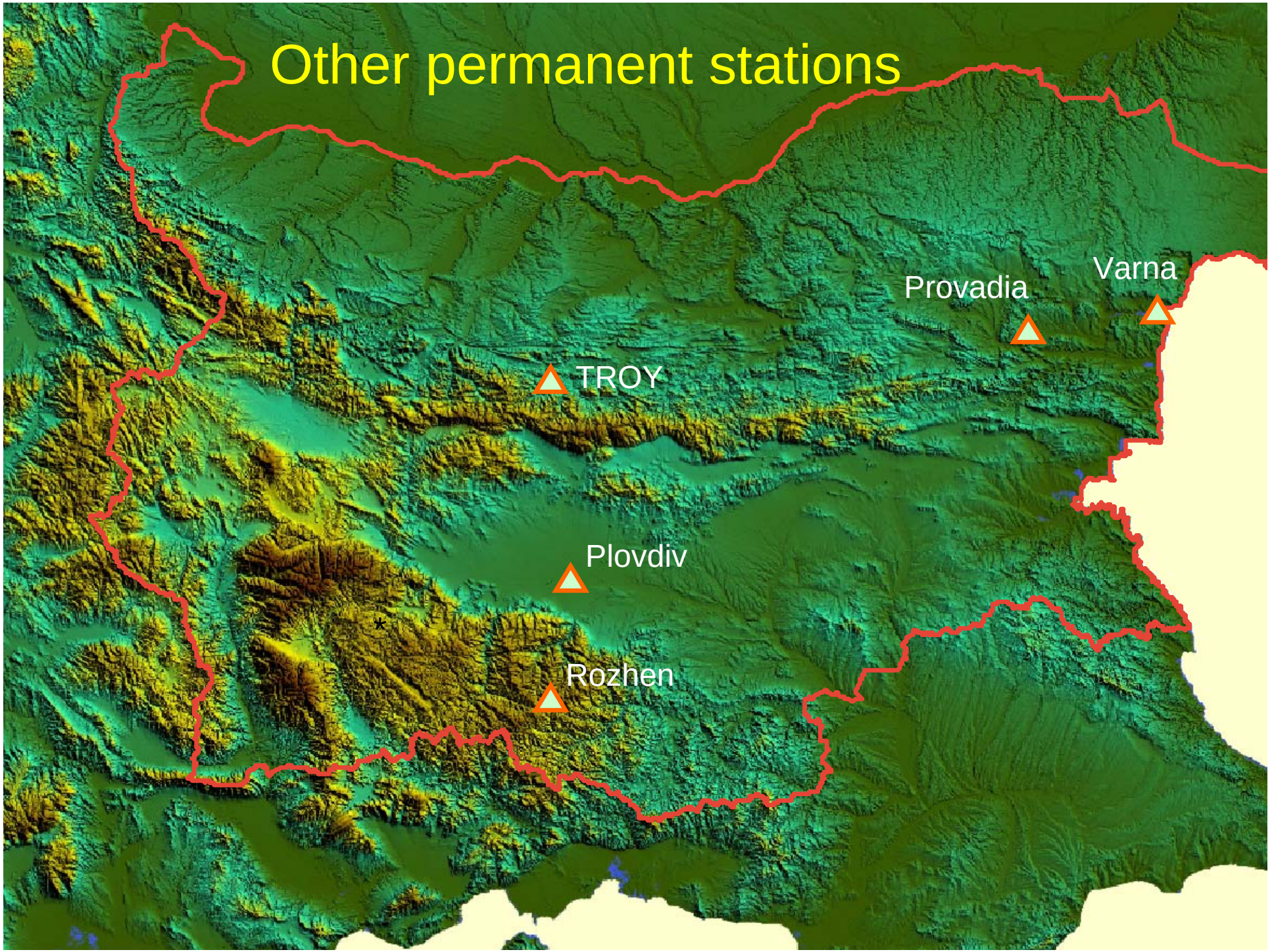

NAVITEQ Network
VARS
RIBA
SOF1
BOBO
RAKO
VELI
PRIM

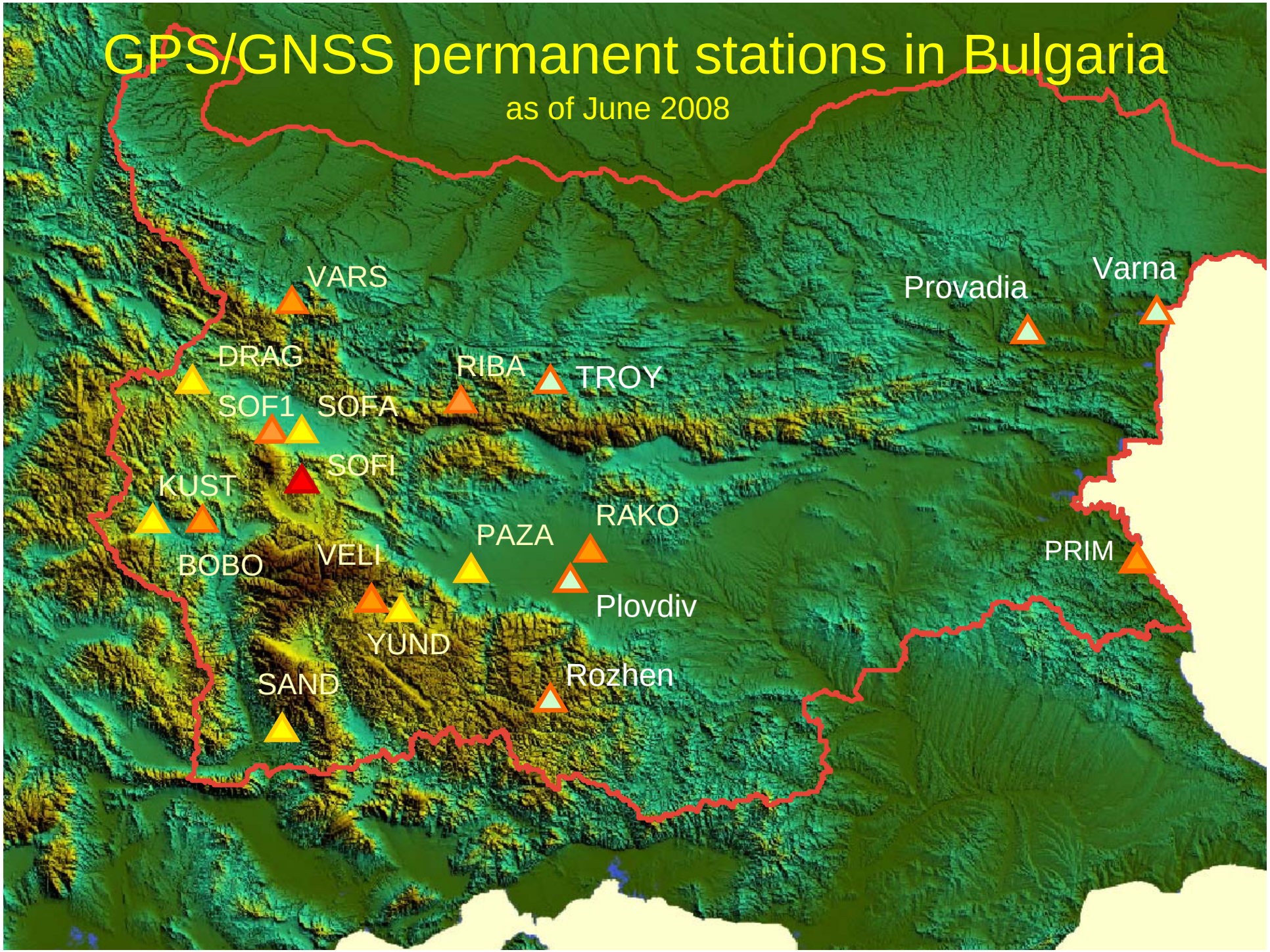
NAVITEQ Reference Station




HEMUS Net
DRAG
SOFA
KUST
PAZA
YUND
SAND

HemusNET Reference Station


Other permanent stations
Varna
Provadia
TROY
Plovdiv
Rozhen


GPS/GNSS permanent stations in Bulgaria
as of June 2008
VARS
DRAG
SOF1
SOFA
SOFI
KUST
BOBO
VELI
YUND
SAND
RIBA
TROY
PAZA
RAKO
Plovdiv
Rozhen
Provadia
Varna
PRIM

GPS permanent stations data processing

- Basics of the processing strategy
- Processing status (as of June 2008)

Basics of the processing strategy

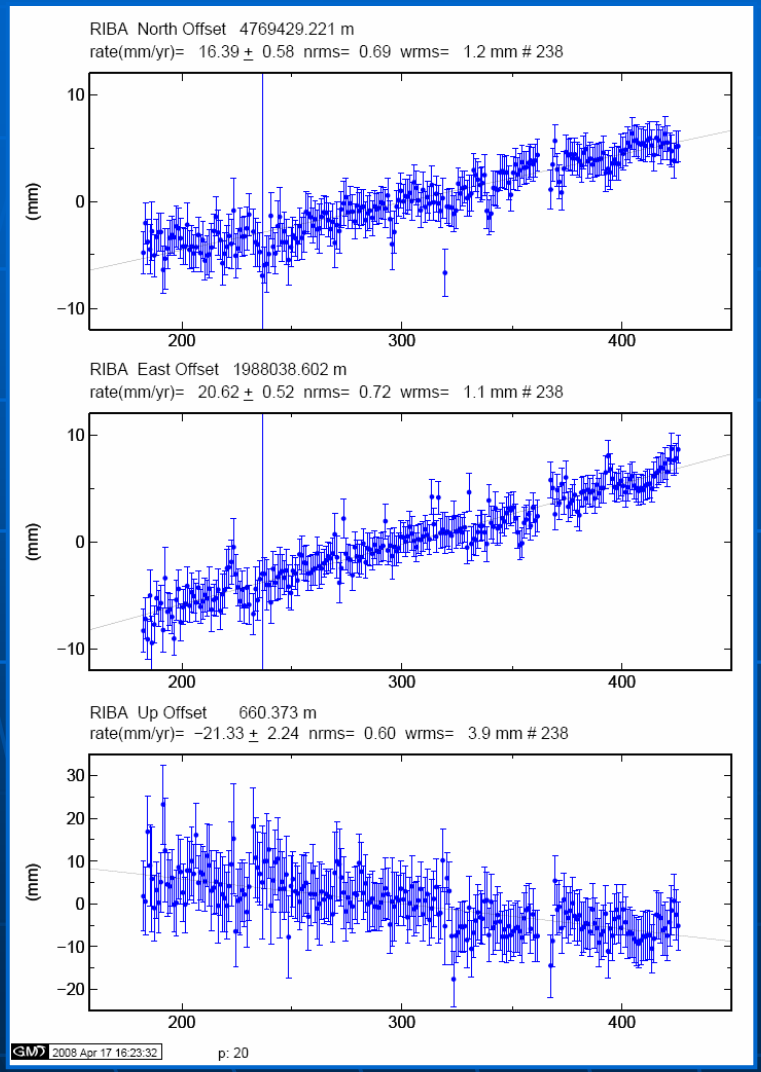
- GAMIT/GLOBK Version 10.53
- IGS satellite orbits and USNO pole coordinates
- ITRF2005 reference system
- IGS_05 absolute model of antenna phase centre variations (elevation dependent phase centre corrections)
- Observation weights depend on the height above horizon
- Loosely constrained daily solutions
- Reference frame defined at the GLOBK stage

Processing status (as of June 2008)

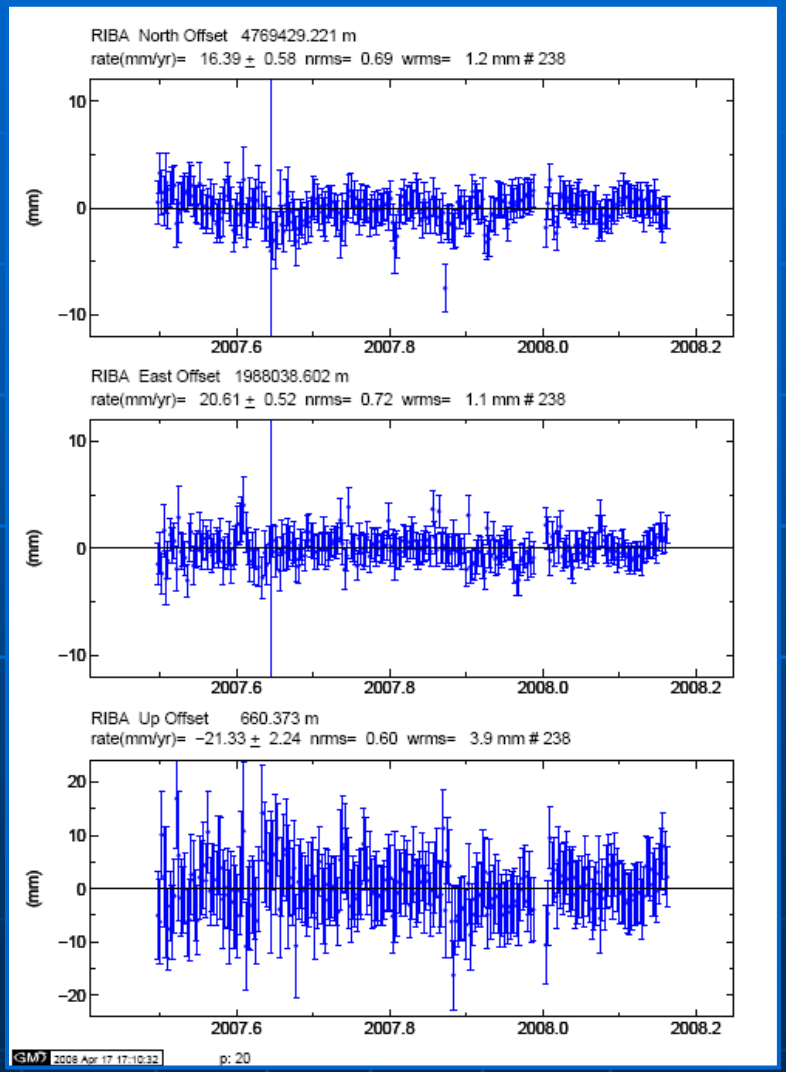
- Data available
  - Span length: 8 months
  - Sampling rate: 30 sec
- Estimated parameters
  - Station coordinates
  - Zenith delays, gradients
  - Ambiguities
- Results
  - Row time series
  - Detrended time series

NAVITEQ RIBA station

Row series

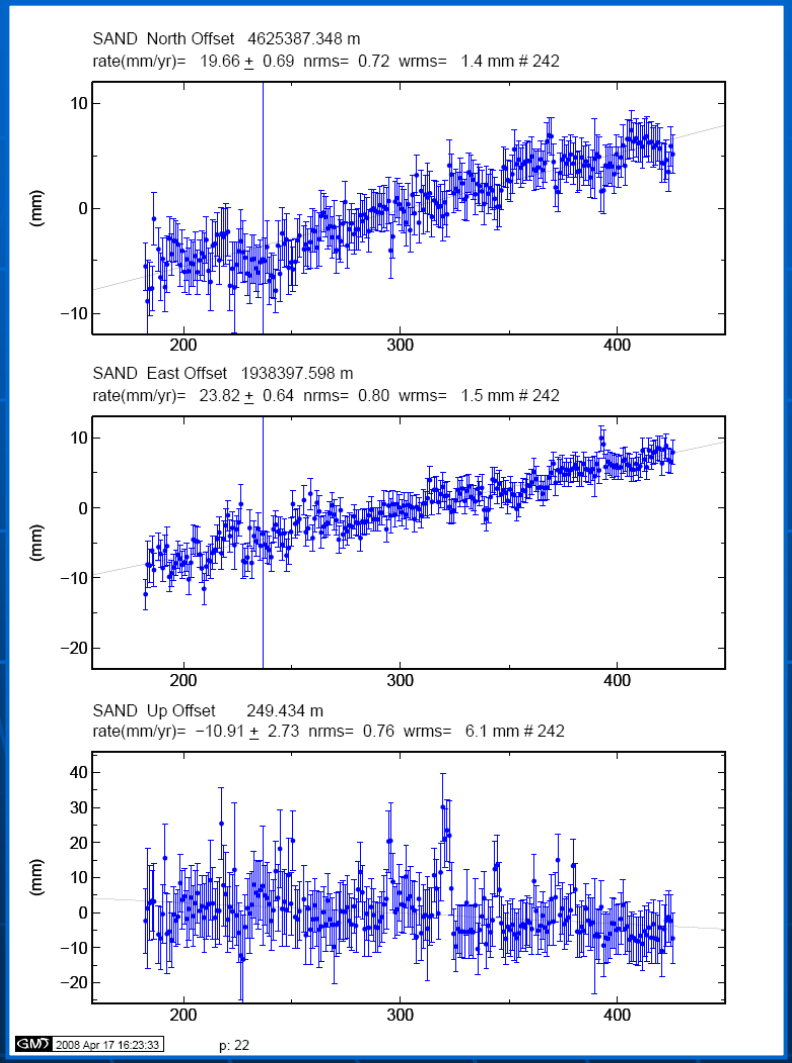


Detrended series

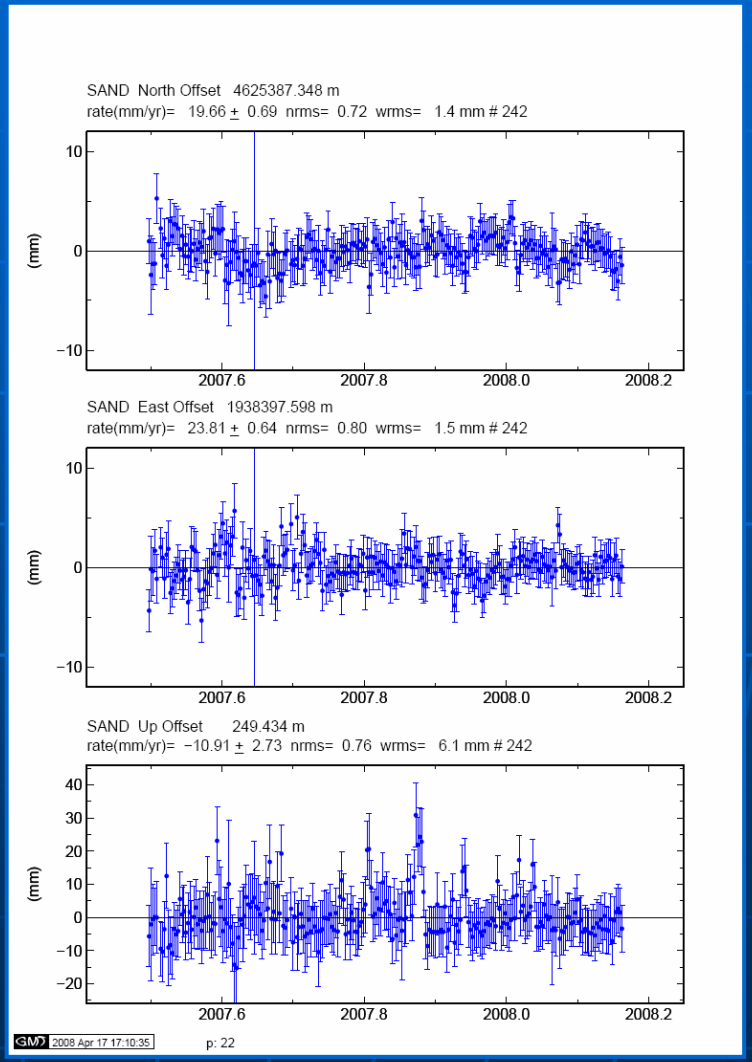


HemusNET SAND station

Row series



Detrended series



Drafting GNSS specifications

- Existing specifications, issued 1995, are out of date and not adequate to:
  - Current technology
  - GNSS status
  - Existing and developing GNSS networks and infrastructure
- Why do we need specifications
  - Institutions are responsible for national control networks, and do not provide services
  - Private companies began realization of GNSS infrastructure projects
  - Investors and contractors need specifications to define and verify project requirements
  - Service providers need it for product validation

Drafting GNSS specifications (2)

- Draft status
  - First draft completed May 2008
  - Draft revision and coordination in progress
  - Finalization due Autumn 2008

THANK YOU

FOR YOUR ATTENTION