Real-Time GNSS - EUREF-IP

Georg Weber, BKG

Status  Network, coverage, contributors
White Paper  Real-time GNSS in routine EPN operations
Tools  BNC, Windows Mobile client
Products  RTNET, real-time orbits & clocks
Real-time IGS  Call for Participation
Next  Standardization & Tools
Priorities

• Upgrade EPN stations to real-time
• Integrate them into DGPS/RTK networks
  – They are the best real-time monitored long-term available reference stations.
  – This ensures real-time access to a consistent ETRS89 realization European-wide.
  – It allows an easy real-time data exchange between adjacent networks for offering seamless services.
  – It enables the generation of new products like real-time clock and ionospheric corrections supporting PPP.
Contributors to www.euref-ip.net

1. AGH University of Science and Technology - Poland (2)
2. Agricultural University of Wroclaw - Poland (1)
3. Agriculture Institute University of Milano - Italy (1)
4. Bucharest Technical University of Civil Engineering - Romania (1)
5. Budapest University of Technology and Economics - Hungary (2)
6. Bundesamt fuer Eich- und Vermessungswesen - Austria (2)
7. Czech Technical University CVUT - Czech Republic (1)
8. DIST Universita di Cagliari - Italy (1)
9. European Space Agency - Europe (1)
10. FOMI Satellite Geodetic Observatory - Hungary (1)
11. Fachhochschule Bochum - Germany (1)
12. Federal Agency for Cartography and Geodesy - Germany (17)
13. Finnish Geodetic Institute - Finland (3)
14. GOP Research Institute of Geodesy Topography and Cartographie - Czech Republic (1)
15. Geodetic Institute University Warszawa - Poland (1)
16. Geodetic and Cartographic Institute - Slovakia (1)
17. Institut Cartografic de Catalunya - Spain (2)
18. Institut Geographique National - France (1)
19. Institute of Geodesy and Geodetic Astronomy Warsaw University of Technology - Poland (1)
20. Instituto Nazionale di Ricerca Metrologica I.N.R.I.M. - Italy (1)
21. L'equipe du reseau Banian - New Caledonia (2)
22. NERC Space Geodesy Facility - United Kingdom (1)
23. National Geographic Information Institute - Korea (1)
24. Natural Resources - Canada (9)
25. National Land Survey - Sweden (3)
26. Papageorge Reference Network - U.S.A. (1)
27. Royal Observatory - Belgium (1)
28. Scripps Orbit and Permanent Array Center - U.S.A. (1)
29. Solucoes em Posicionamento Global SPG - Brazil (1)
30. National Land Survey - Sweden (3)
31. Technical University Prague - Czech Republic (2)
32. Technical University Delft - The Netherlands (1)
33. Technical University Milano - Italy (1)
34. Instituto Geografico National - Spain (15)
35. Instituto Geografico Portugues - Portugal (1)
36. Instituto Geografico National - Spain (15)
37. University of New Brunswick - Canada (2)
38. University Rome La Sapienza - Italy (1)
39. VUGTK Geodetic Observatory Peceny - Czech Republic (1)

Total: 94 Streams

Contributors to www.igs-ip.net

1. Addis Abeba University - Ethiopia (2)
2. Agenzia Spaziale Italiana - Italy (1)
3. Brazilian Institute of Geography and Statistics - Brazil (1)
4. Agriculture Institute University of Milano - Italy (1)
5. Astronomical Institute University of Milano - Italy (1)
6. Astrophysics and Space Science Institute - Korea (2)
7. Brazilian Institute of Geography and Statistics - Brazil (1)
8. Clark Fortune McDonald & Associates - New Zealand (2)
9. DIST Universita di Cagliari - Italy (1)
10. Department of Sustainability and Environment Victoria - Australia (1)
11. European Space Operations Centre - Germany (3)
12. FOMI Satellite Geodetic Observatory - Hungary (1)
13. Federal Agency for Cartography and Geodesy - Germany (20)
14. Federal Agency for Cartography and Geodesy - Germany (20)
15. Florida International University Miami - U.S.A. (1)
16. GOP Research Institute of Geodesy Topography and Cartographie - Czech Republic (1)
17. GPS Solutions Inc. - U.S.A. (1)
18. Geodetic Institute University Warszawa - Poland (1)
19. Geoinformatics Center Asian Institute of Technology - Thailand (1)
20. Geoscience Australia - Australia (23)
21. lnstitut Geodetik i Kartografii Warszawie - Poland (1)
22. Istituto Nazionale di Ricerca Metrologica I.N.R.I.M. - Italy (1)
23. Lantmaeteriverket - Sweden (1)
24.九州アジア日本地図情報機器研究所 - Japan (1)
25. Mecinca Topografia GPS - Venezuela (1)
26. NASA Stennis Space Center - U.S.A. (1)
27. National Geographic Information Institute - Korea (1)
28. National Geographic Information Institute - Korea (1)
29. National Land Survey - Sweden (3)
30. Natural Resources - Canada (9)
31. Naval Observatory - U.S.A. (1)
32. Point Inc. - Canada (2)
33. Puget Sound Reference Network - U.S.A. (1)
34. Regional Centre for Mapping of Resources for Development - Kenya (1)
35. Royal Observatory - Belgium (1)
36. Scripps Orbit and Permanent Array Center - U.S.A. (1)
37. Solucoes em Posicionamento Global SPG - Brazil (1)
38. Standard Instrument Corporation - Taiwan (1)
39. Survey Research Institute HARAM SRI - Egypt (1)
40. Surveys and Mapping - South Africa (2)
41. SwissTopo - Switzerland (1)
42. Technical University Prague - Czech Republic (4)
43. Universidade Estadual Paulista UNESP/FCT - Brazil (4)
44. Universidade da Baira Interior UBI/CGUL/IDL - Portugal (1)
45. University New South Wales - Australia (1)
46. University Padova - Italy (2)
47. University of New Brunswick - Canada (2)

Total: 116 Streams
Real-time GNSS in Routine EPN Operations

• White Paper available from:

• Turn EUREF-IP Pilot Project into routine service

• Guidelines developed for
  – Reference stations
  – NTRIP Broadcasters
  – High-rate RINEX Data Centers
  – Role of EPN Central Bureau
Streams from different casters
Supports different formats
Synchronised stream output
High-rate Rinex

Tools: BNC
Real-time orbits from IGS plus clocks from EPN

To do:
- Check improvement in Double Difference Clock Corrections
- PPP tests
Double Difference Clock Corrections: Discrepancies

IGS Final Clocks vs. Broadcast and RTNET Clocks

\[
\begin{align*}
\text{RMS} &= \pm \sqrt{\frac{\sum_{k=1}^{m-1} \sum_{i=1}^{n-1} \sum_{j=i+1}^{n} \left[ \left( c_k(t_j) - c_k(t_i) \right) - \left( c_{mE}(t_j) - c_{mE}(t_i) \right) \right]_{\text{SOURCE}_1} - \left[ \left( c_k(t_j) - c_k(t_i) \right) - \left( c_{mE}(t_j) - c_{mE}(t_i) \right) \right]_{\text{SOURCE}_2}^2} {\frac{(m-1) \times n \times (n-1)}{2}}}
\end{align*}
\]

- \( c \) = Satellite clock correction
- \( t \) = Epoch
- \( i,j \) = Index for epochs
- \( k \) = Index for satellites
- \( mE \) = Index for satellite with max. elevation
- \( m \) = Number of satellites
- \( n \) = Number of epochs

SOURCE = Source of clocks
30sec Double Difference Clock Corrections between SVN10 and SVNmaxElev

- IGSFinal - RTNET, \( \text{rms} = +0.057\text{ns} \)
- IGSFinal - Broadcast, \( \text{rms} = +0.116\text{ns} \)
PPP Test

Thin lines: Broadcast clocks
Thick lines: Real-time clocks

Reaching ~10cm accuracy level after ~10min
1. **Real-time IGS Pilot Project**
   1.1 Background
   1.2 Goals and Objectives
   1.3 Organizational Aspects
   1.4 Project Committee

2. **Call for Participation**
   2.1 Real-time Tracking Stations
   2.2 Real-time Data Centers
   2.3 Real-time Analysis Centers
   2.4 Real-time Associate Analysis Centers
   2.5 Real-time Analysis Center Coordinator
   2.6 Real-time Network Management and Monitoring
   2.7 Real-time Users

3. **Instructions for Submitting Proposals**
   3.1 Proposal Form
IGS: „SOC/UDP“ vs. EUREF: „RTCM/NTRIP“

• Handling GLONASS and GALILEO should be a must. Consequently, extending today’s pure GPS “SOC/UDP” solution would be a necessity.

• However, all modern GPS+GLO Internet-ready receivers already support “RTCM/NTRIP”. How can station operators be convinced to run an extra “SOC/UDP” Linux PC on the site if what’s needed is already integrated in the receiver?

• Suggestion: closely cooperate with RTCM to develop RTCM v3 and NTRIP v2 in a way that it fully satisfies our needs.
New RTCM Working Group: State Space  
Chaired by G. Wuebbena

- **Final goal**: Concepts and Messages for all types of accuracy

- **Step 1**: Dual frequency Real-time PPP  
  - Message(s) for precise orbits and satellite clocks

- **Step 2**: Single frequency Real-time PPP  
  - Development of VTEC ionospheric messages

- **Step 3**: RTK-PPP  
  - STEC, troposphere, delays, carrier phase ambiguity (maintain integer nature)
New RTCM Working Group: Extension of RTCM v3 to...

- Overcome the current limitation of handling only one code per frequency
  - Current problem: L2C
  - Future problems: L5 and GALILEO

- Develop new RTCM v3 format which allows to transport any observation becoming available
Plans: Precise Point Positioning

Laptop/PDA solution for 10cm real-time European-wide till standards adapted and SW integrated by vendors
Potential Topics for Discussion

• Data policy, stream providers & users
• Protecting commercial interests
• Standardization, formats and protocols
• Limited resources, availability & reliability
• Software tools, Open Source
• Etc.