

# NMA Analysis Center 2014 Annual Report

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**Abstract** The Norwegian Mapping Authority (NMA) has been an Associate Analysis Center within the IVS since 2010. In 2014, NMA delivered its first official product to IVS. This was the contribution to ITRF2014 with 22 years of 24-hour sessions processed. In the future, NMA will continue to work towards becoming a fully Operational Analysis Center

## 1 General Information

NMA has been an Associate Analysis Center within the IVS since 2010. The analysis center is operated by the Geodetic Institute at NMA with main offices in Hønefoss, Norway. NMA is a governmental agency and the IVS activities at NMA are completely funded by the Norwegian government.

NMA aims to become a fully Operational Analysis Center and to contribute with timely session-by-session unconstrained normal equations. NMA is using the analysis software GEOSAT. GEOSAT was originally developed by Per Helge Andersen at the Norwegian Defense Research Establishment (NDRE). In the recent years, a lot of effort has been put into training a team at NMA to continue the development of GEOSAT.

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## 2 Component Description

GEOSAT was originally designed to combine information from VLBI, GNSS, and multi-satellite DORIS and SLR, one epoch at a time with the use of a Kalman filter and models that are common across the techniques. As a result, the different data types can complement each other at each epoch in the determination of all common parameters. To validate GEOSAT, a large number of VLBI sessions were processed and submitted to the IVS Combination Center at BKG for review. The main focus has been to process R1 and R4 sessions, but several other 24-hour sessions have also been tested. GEOSAT is not, in its current condition, able to process Intensive sessions.

## 3 Staff

The current team involved in the development, maintenance, and usage of GEOSAT is:

- Ann-Silje Kirkvik - VLBI
- Halfdan Pascal Kierulf - VLBI
- Åsmund Skjæveland - VLBI
- Ingrid Fausk - SLR
- Geir Arne Hjelle - DORIS, miscellaneous
- Micheal Dähnn - GNSS
- Eirik Mysen - Combination technique
- Per Helge Andersen - GEOSAT founder
- Laila Løvhøiden - Project manager

The team was considerably strengthened in 2014. Geir Arne Hjelle was employed in the beginning of 2014 and has been helping out in different parts of the project. Micheal Dähnn and Eirik Mysen have also

been assigned to the project, and the project has gotten a new project manager. In addition, Åsmund Skjæveland has been assigned to help with the routine processing of R1 and R4 sessions as NMA progresses towards becoming a fully Operational Analysis Center. Per Helge Andersen was originally planning to retire in June 2015 but has agreed to stay on until the end of 2015.

#### 4 Current Status and Activities

At the General Meeting in Shanghai in March 2014, it was shown that GEOSAT was able to produce EOP estimates comparable to the other Analysis Centers'. The test data were the R1 and R4 sessions from 2006. The results were promising and it was decided that NMA should try to contribute to ITRF2013. Later tests on 11 years (2003-2013) of R1 and R4 sessions revealed several problems that had to be fixed. In particular, the station coordinates were bad.

With all the new antennas being built there are some sites that now have two operational antennas observing in the same session. This situation had never been tested in GEOSAT before, and it turned out that the software was mixing the different monuments at the same site. The station coordinate could be off by hundreds of meters. Hobart and Hartebeesthoek were the sites that revealed this problem. Once this was fixed, there were still problems with the solution.

The station coordinates were still off by half a meter in some cases, but after some investigation it turned out that the eccentricities were not applied at all due to a software bug. This was easily fixed and the solution started to look good from NMA's point of view.

But a thorough review of the data set by Sabine Bachmann at BKG revealed that the station coordinates still were off by up to 1.5 cm for some stations. This problem was a lot harder to solve. All the station displacement models were checked and updated, but nothing improved the result. Finally, it turned out that a pre-processing algorithm was throwing away almost all the cable calibration data and the remaining cable calibration data was applied with the wrong sign. Fixing this problem finally gave comparable station coordinates.

With these fixes, most 24-hour sessions from 1994 until 2013 were analyzed and submitted to the ITRF2013 solution. Late in 2014 it was decided that

ITRF2013 should become ITRF2014, and processing of sessions from 2014 was also started.

#### 5 Future Plans

The main focus for the team members at NMA is still to learn as much as possible from Per Helge Andersen in order to have the necessary competence to sustain and develop GEOSAT themselves after his retirement. This includes both the software design and the theoretical aspects of the models and estimation technique.

After finishing the work on ITRF2014 the next step is to prepare the software and production chain in order to try submitting timely unconstrained normal equations to the IVS Combination Center. In addition, the software must be updated so that it can estimate earth orientation parameters with higher frequency than one day.