

Long-term subsidence study in the Wadden Sea Region

Bestuur

Prof. dr. Pavel Kabat (voorzitter)
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To: NAM/Shell, Steering Committee (SC), State Supervision of Mines (SSM), Advisory Group for Economic Affairs (AGE), Wadden Academy (WA)

From: B. Orlic

Date: 16 July 2014

Subject: Minutes of the Geodesy workshop held on 7 July 2014 from 10:00-16:00 at NAM in Assen

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Legend: => Action points NAM

Distribution list:

NAM/Shell:

Antony Mossop, Pieter van de Water, Jeroen Jansen, Dirk Doornhof, Ruud van Boom, Hermann Bähr, Harry Piening, Wim van der Veen, Sander Hol, Arjan van der Linden, Fons Marcelis, Pedro Zuiderwijk

SC:

Hessel Speelman, Ramon Hanssen, Patrick Baud, Robert Zimmerman, Ryszard Hejmanowski, Rune Holt, Adriaan Houtenbos, Bogdan Orlic

SSM:

Hans de Waal, Annemarie Muntendam-Bos, Rob van Lieshout

AGE:

Jaap Breunese

WA:

Klaas Deen

Attendance:

NAM/Shell: T. Mossop, W. v/d Veen, D. Doornhof, F. Kraaijeveld, O. v/d Wal, H. Piening, R. v. Eijs, R. v. Boom, H. Bähr, S. van Putten (on teleconference)

SC: R. Hanssen, A. Houtenbos, R. Hejmanowski, H. Speelman, B. Orlic

SSM: Hans Roest

UU: G. Marketos

TUD: Sami Samiel-Esfahany

Technical documents prepared by NAM and distributed to SC/SSM/AGE before the meeting:

The geodesy meeting was organized in the form of a research workshop, i.e. an informal awareness workshop. No documents were distributed before the meeting.

Response by the SC-members received after the meeting:

Written comments by one SC-member on subsidence testing.

Action points from the previous meeting (the Geodetic meeting held in January 2014 in Utrecht) relevant to this meeting:

=> NAM is requested to organize a 1-day follow-up workshop to discuss the details, and further consolidate the Geodetic research plan.

The geodesy meeting was organized as a follow-up to the previous geodetic meeting and this action point is now closed.

Meeting objective

- This research workshop, organized for Geodetic committee members and NAM researchers, was dedicated to a better understanding of the other discipline's language and concepts.

Agenda

- 10.00-10.15 Whole workflow overview (T. Mossop)
- 10.15-12.00 Geomechanical prediction workflow, covering
 - Reservoir modelling
 - Rock mechanics
 - Geomechanics
- 12.00-12.45 Lunch
- 12.45-13.45 Geodetic processing workflow (H. Bähr)
- 13.45-14.15 Testing approaches in Geodesy (B-method of testing) (R. Hanssen)
- 14.15-14.30 Coffee break
- 14.30-16.00 Further discussion on integration, statistics and other relevant topics

Meeting highlights

- **Geomechanical prediction workflow**

NAM experts explained how Geomechanical models are being created from Geological models, Reservoir models, Rock mechanics and Physics/Theory, all with their own uncertainties. These Geomechanical models are calibrated against the Geodetic data. Although the Geodetic data has its own uncertainties, it narrows down the uncertainties of the other 4 input models.

Discussion follows, regarding the interpolation of pressure measurements over the gas field and the variability in the strength of reservoir rock.

Geodetic data is typically used for calibrating the rock strength (i.e. reservoir compaction) and checking if aquifers are depleting.

Monitoring of horizontal surface deformation could provide additional data for calibrating geomechanical model.

The stability of benchmarks used for levelling plays a role in the quality of the Geodetic data and subsequent calibration of Geomechanical models. The amount of autonomous movement of the benchmarks is under discussion.

Currently, the Geomechanical model is calculated using a Monte Carlo approach (several realizations) and calibrated to the Geodetic data by minimizing the RMS value. When a Geomechanical model is calibrated against the Geodetic data, some form of statistical testing should be used, in order to state when deviations are acceptable. Formal acceptance criteria are not used in the current workflows.

- **Geodetic processing workflow**

NAM experts explained the current procedure in processing the Geodetic measurements.

When levelling technique is used, the survey registers contain the results of a free-network adjustment with only 1 (fixed) reference benchmark used as datum, adhering to the procedure as defined by SodM and Rijkswaterstaat on 18.8.2005. This makes the comparison with previous results easy for the public.

Discussion follows regarding the use of PS-InSAR technique. When comparing processing results of ascending and descending (satellite) tracks, the results don't always match. Further investigation is required.

Analysing densely sampled data from permanent GPS stations and PS-InSAR can reveal high frequency signals, such as noise or seasonal effects, which do not show in levelling data. Interpreting densely sampled data should be done with caution.

For the Waddensea monitoring, GPS survey campaigns are carried out. Within a period of 3 years, all available benchmarks are surveyed. GPS stations close by or above the same reservoir should be surveyed at the same time in order to mitigate the effect of systematic error sources. The use of multiple GPS reference stations around the relevant area, is seen as a good practice.

Currently 3 geodetic measuring techniques are used: Levelling, GNSS (GPS) and PS-InSAR. In processing, levelling and PS-InSAR data are combined.

One member of the SC explained the B-method of testing for the adjustment model with observation equations according to the 'Delft school'.

It is discussed how geodetic adjustment theory could be used for testing Geomechanical models. As part of the study, a statistics group is looking into alternative methods.

In the written comment received after the meeting from one member of the SC it is argued that in the current methodology of testing of Geomechanical model predictions against Geodetic measurements, there are more parameters than measurements. It is proposed to combat the problem by drastically reducing the number of parameters and to investigate the impact of spatio-temporal correlation in parameters.

Requests and Action points NAM

⇒ **None**

Next meetings

The next regular meeting is the 4th Steering Committee meeting that will be held on 1 and 2 December 2014 (as agreed at the 3rd Steering Committee meeting).