

22nd NSHC Tidal Working Group meeting minutes

Ostend, Belgium
25 – 26 October 2017

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Abbreviations used in this document

EVRS	European Vertical Reference System
IHO	International Hydrographic Organization
MDK	Flemish Hydrography (Maritieme Dienstverlening en Kust)
NHS	Norwegian Hydrographic Service (Kartverket sjødivisjonen)
NLHO	Royal Netherlands Navy Hydrographic Office (Dienst der Hydrografie)
NSHC	North Sea Hydrographic Commission
SHOM	French Naval Hydrographic and Oceanographic Service (Service hydrographique et océanographique de la marine)
TWG	Tidal Working Group
TWCWG	Tides, Water Level and Currents Working Group
UKHO	United Kingdom Hydrographic Office

Other abbreviations are written out when first used.

Location

Agency for Maritime and Coastal Services, Ostend, Belgium

Participants

Karolyn Hondeghem	MDK	Belgium
Hans Poppe	MDK	Belgium
Gwénaële JAN	SHOM	France
Andreas Boesch	BSH	Germany
Ronald Kuilman	NLHO	Netherlands
Aksel Voldsund	NHS	Norway

Opening

The chair, Karolyn Hondeghem (BE), gave a welcome speech to the participants and thanked them for taking time out of their busy schedules to prepare presentations and attend the meeting. She especially welcomed the new German member Andreas Boesch and asked him to thank his predecessor Patrick Goffinet for the many years of contributions and cooperation. The opening ended with each member introducing themselves giving a short overview of their tasks. During the opening, the member list was passed around and updated (see ANNEX A).

Adoption of the Agenda

The agenda was adopted (see ANNEX B).

Adoption of the Minutes of the 21st NSHC TWG Meeting

The Minutes were adopted.

Status of the Action Points from the 21st NSHC TWG Meeting

The work plan and action points of the 21st NSHC TWG Meeting were discussed. The results can be found in the tables below.

Work Plan NSHC Tidal Working Group: (Mar 2016)					
Item Number (TWG/Item)	Objective (Why/Priority)	Task Description (What/How)	HO Involved	Status	Discussion Result
WP 16/04	Enable GNSS-based tidal reduction and the connection with the vertical datum on land	Follow developments on geoid, MSL and LAT computations for the North Sea area	All	Permanent, see also WP18/01	To be discussed at agenda item: <i>Explain and reduce differences in reference surfaces at the international boundaries</i>
WP 18/01	Improve North Sea wide realization of reference	Explain and reduce differences in reference	All	Permanent	To be discussed at agenda item: <i>Explain and reduce differences in reference surfaces at the international</i>

	surfaces	surfaces at the international boundaries			<i>boundaries</i>
WP 18/02	Improve methodologies for GNSS surveys	Exchange between HO's on operational methodologies for GNSS based surveys	All	Permanent	To be discussed at agenda item: <i>Developments GNSS Based Surveys</i>

Item Number (TWG/Item)	Objective (Why/Priority)	Task Description (What/How)	HO Involved	Status	Corresponding Work Plan Item	Discussion Result
AP 18/01	Explain differences in realizations of LAT	Exchange on bilateral basis between involved HO's to investigate further the origin of observed differences at the boundaries between national reference surfaces	All	Permanent	WP 18/01	To be discussed at agenda item: <i>Explain and reduce differences in reference surfaces at the international boundaries</i>
AP 19/03	Make an overview over existing separation and hydrodynamic models, including metadata	Each member state sends the information to UKHO	All, UK	July 2015	WP 18/01	UKHO coordinates. The chair will send a mail to Chris Jones asking him to send mails to all members requesting the data needed to complete this AP.
AP 20/01	Improve North Sea wide realization of reference surfaces	Redo the work done in 2010 using the latest references from the Member States	NL, All	Closed	WP 18/01	removed
AP 20/02	Show insight in the status at all bilateral boundaries	Create a matrix showing the status at all boundaries wrt Chart Datum, LAT, MSL and ellipsoidal boundaries	NL, All	Closed	WP 18/01	removed

AP 20/03	Better capitalize the work done by the NSHC TWG	Use the webportal for NSHC TWG on the IHO website	UK, All	Closed	None	removed
AP 20/04	Gain insight the connection between EVRS and chart datum	Create overview of connection between EVRS and Chart Datum	NL, All	Dec 2016	WP 16/04	To be discussed at agenda item: <i>Open Discussions AP 20/04 "Gain insight in connection between EVRS en chart datum" needed?</i>
AP 21/01	Investigate the differences at the BE-FR border between national LAT reference surfaces	Investigate all LAT differences at the border of more than 1 percent (LAT difference/depth)	BE, FR	Dec 2016	WP 18/01	To be discussed at agenda item: <i>Explain and reduce differences in reference surfaces at the international boundaries</i>
AP 21/02	Investigate the differences at the BE-NL border between national LAT reference surfaces	Investigate all LAT differences at the border of more than 1 percent (LAT difference/depth)	BE, NL	Dec 2016	WP 18/01	To be discussed at agenda item: <i>Explain and reduce differences in reference surfaces at the international boundaries</i>
AP 21/03	Investigate the differences at the DK-DE border between national LAT reference surfaces	Investigate all LAT differences at the border of more than 1 percent (LAT difference/depth)	DK, DE	Dec 2016	WP 18/01	To be discussed at agenda item: <i>Explain and reduce differences in reference surfaces at the international boundaries</i>
AP 21/04	Investigate the differences at the DK, NO border between national LAT reference	Investigate all LAT differences at the border of more than 1 percent (LAT difference/depth)	DK, NO	Dec 2016	WP 18/01	To be discussed at agenda item: <i>Explain and reduce differences in reference surfaces at the</i>

	surfaces					<i>international boundaries</i>
AP 21/05	Investigate the differences at the FR-UK border between national LAT reference surfaces	Investigate all LAT differences at the border of more than 1 percent (LAT difference/depth)	FR, UK	Dec 2016	WP 18/01	To be discussed at agenda item: <i>Explain and reduce differences in reference surfaces at the international boundaries</i>
AP 21/06	Investigate the differences at the DE-NL border between national LAT reference surfaces	Investigate all LAT differences at the border of more than 1 percent (LAT difference/depth)	DE, NL	Dec 2016	WP 18/01	To be discussed at agenda item: <i>Explain and reduce differences in reference surfaces at the international boundaries</i>
AP 21/07	Investigate the differences at the NO-UK border between national LAT reference surfaces	Investigate all LAT differences at the border of more than 1 percent (LAT difference/depth)	NO, UK	Dec 2016	WP 18/01	To be discussed at agenda item: <i>Explain and reduce differences in reference surfaces at the international boundaries</i>
AP 21/08	Investigate the differences at the NO-SWE border between national LAT reference surfaces	Investigate all LAT differences at the border of more than 1 percent (LAT difference/depth)	NO, SE	Dec 2016	WP 18/01	To be discussed at agenda item: <i>Explain and reduce differences in reference surfaces at the international boundaries</i>

Adoption of the Minutes of the 32nd NSHC Conference

The Minutes were adopted.

Participant Presentations

GNSS Buoy and Damped and Undamped Tides

Hans Poppe (BE) gave a two part presentation.

- In the first part various GNSS buoys (both commercially available and self-made) and their pros and cons were described. MDK chose the Triaxys hydrolevel buoy for its campaigns as it is commercially available, well tested with many good results, and provides real time GNSS corrections. Its main cons are its high price and difficulty to measure in high current situations.

In a campaign around Zeebrugge, the results of the Triaxys buoy were compared to the measurements acquired from a radar system. After removal of the many spikes in the GNSS buoy data, the conclusions were drawn that the noise increases with the tide, that an accuracy of 10cm after post processing or of 20cm in real time is attainable, and that the buoy had trouble measuring in high current situations where it was completely immersed. It was decided to adapt the buoy by placing it inside a donut of additional floats. The data of subsequent campaigns showed less spikes, but a sine wave on the difference of measurements made by the buoy and a radar system approximately 30km from the coast. This difference still needs to be studied and explained, and the buoy still needs to be adjusted to try to achieve accuracies better than 10cm after processing.

- In the second part various tidal measurement techniques were discussed such as floating gauge in a stilling well and radar with and without stilling well. MDK is in the process of renewing its tidal measurement stations. In doing so it is testing these various techniques by placing both in each location and comparing the results. Some conclusions of the tests are:
 - Radar based sensors are expensive but require less maintenance and are better suited for undamped measurements but are black-box sensors.
 - Stilling wells require much maintenance as sediment clogs the tube.
 - Initial results with radar are promising.

Discussions and comments:

- All participants will share information on radar tide gauges
- Gwénaële JAN (FR) sent a link to a paper from Spain on *Overlapping sea level time series measured using different technologies: an example from the REDMAR Spanish network* (B. Pérez et al. 2014 Nat. Hazards Earth Syst. Sci., 14, 589–610, 2014).
- Gwénaële JAN (FR) provided a Spanish report on solutions for sediment problem in stilling wells
- Further study needs to be done to determine the non-tidal influences in measurements performed without a stilling well. At sea this should not be a problem. Aksel Voldsund (NO) noted that when you average the data over 1 minute no wave component is present.
- Aksel Voldsund (NO) commented that his floating gauges with stilling wells do not require an excessive amount of maintenance as they only need to go 1 time every 3 years. He also stated that shortening of the teeth of the gear minimized slipping of the cable and that NO uses level switches at well-defined heights in the stilling well whereby any slipping of the cable can easily be detected. The level switch is assumed switched only if it remains switched for at least one minute.
- Coastal tide gauges deployed by Shom are radar gauges. Gwénaële JAN (FR) asked if it would be possible to obtain tide gauge data from Belgium. BE answered that we

operate under a completely open data policy and that the data can be downloaded directly from the website: <https://meetnetvlaamsebanken.be/> after creating an account. Webservices are also available. An api document will become available on the same site. If anyone would like a copy before it is available on the site, please send a mail.

New Mean Tide Curves in Development for Tide Tables

Andreas Boesch (DE) gave a presentation on the German project that aims at the development of new mean tide curves for the tide tables to improve the provided tidal information. The analysis technique is based on the harmonic representation of inequalities (HROI) and 1 minute tide gauge data for almost 19 years. Currently curves are given for spring and neap tide and are stretched to fit mean tidal value which are updated every year but the curves shape stays the same. Using the harmonic representation of inequalities the curves are calculated using the collected tidal data providing full curve tidal predictions. Initial comparison of the stretched curves and the calculated curves is 5-30cm depending on the station.

Discussions and comments:

- Hans Poppe (BE) stated that curves are normally not completely sin or cos due to bottom friction but that averaging causes loss of this effect. For this reason, BE stopped this method of determining the tidal curve.
- Aksel Voldund (NO) asked why normal harmonic analysis was not used. Andreas Boesch (DE) answered that shallow water means we need lots of tidal constituents and HROI needs less computing power. With a reasonable number of long term constituents, this method provides better results especially in the rivers. Aksel Voldund (NO) said to use all constituents and to remove those that are not significant.
- Ronald Kuilman (NL) asked if there are international standards for producing tide tables from IHO. Gwénaële JAN (FR) thinks probably not in an official version as a recommendation format but raised the current IHO action in TWCWG on this topic: Standards for Digital Tide and Tidal Current Tables (v1.1). A copy of the draft version can be obtained from Gwénaële JAN (FR). The question was raised whether or not this was needed. The group decided that it was not, but rather the responsibility of each country but that the information on how this was done must be shared.
- Gwénaële JAN (FR) asked what the accuracy of the resulting curves is and if there is no problem in rivers and harbors due to nonlinear condition. Aksel Voldund (NO) stated that the quality of tidal prediction is difficult to test as the weather is unknown at the time of the prediction. He mentioned the need for a unified definition of accuracy of tide. Perhaps something along the lines of: "prediction is tide, weather is the rest".
- The use of harmonic representation of inequalities for the calculation of LAT surfaces was mentioned.
- The use of altimetry if no tidal information is available was discussed. To be efficient new data is needed as the current data is very coarse (500m footprint for one track) and the repeatability is questionable.

Accomplishments of the TWCWG

Gwénaële Jan (FR) gave a three part presentation.

- In the first part the main accomplishments of the TWCWG were outlined. These included:

- Work on the product specification for surface currents (S-111) and water level (S-104)
 - A first test dataset has been uploaded to help finalize the dynamics information to include in navigation products for surface currents.
 - The S-111 product specification file structure is almost final.
 - A S-111 validator tool should be available soon from Canada (2018).
 - The S-104 product specification is in draft.

In the future it will be important to motivate shareholders to share tools for S-111 encoding and additional data sets should be included.

- In 2017 an English course on the basics of hydrography and tides has been developed in cooperation with SAN and placed on the IHO website. Other levels will also be developed. The courses will also be translated into other languages.
- Exchange Harmonic constants/predictions.
- Determine ellipsoidal height of MSL.
- Share methods to calculate chart datum.
- In the second part an initiative to improve the French LAT surface was discussed. This initiative is to try to estimate the marine geoid impact on MSL and other reference surfaces. The sea land link problem should be solved by using the GRS80 ellipsoid as a common reference. Litto3D should produce a continuous land-sea altimetric digital model of the coastal fringe. The problems with altimetry data at the coast could partially be solved by adding tide gauges. The impact of the geoid on the SMH derived from altimetry and GPS should be recomputed with the new geoid derived from new gravity data in the coastal area (SurfRef CNES /Shom project).
- In the third part data rescue from old paper tidal data was thrown into the group. SHOM digitalizes many documents and would like to make an international dedicated program to increase digitalization. The benefits of digitizing this old data are to preserve historical data, to improve knowledge on trends, and to identify and study extremes. Any country interested in participating in creating inventory should contact corine.lochet@shom.fr.

Issues:

- The problem with digitization of paper data is that the human hand is best at this point.
- With historical data, sometimes the information on reference level is lost. If so, this data is useless.
- What is accuracy of this old data?

These 3 issues for data rescue were acknowledged, but the general opinion is that there is still a wealth of information to be found in this data.

Making a common reference frame in the Søre Sunnmøre area in Norway and Visualization of the sea level

Aksel Voldsund (NO) gave a presentation on 3 projects in the Søre Sunnmøre area which was chosen due to the availability of freely distributable data:

- The first project, the common reference frame project, aims at determining the relationship between the Quasi Geoid Model, the MSS, the LAT surface, and the reference ellipsoid (EUREF89) along the whole coast. The fieldwork, working area, and calculation techniques were

discussed and some preliminary results were shown. The error estimates of the calculated surfaces are currently being worked on. To study some of the questions raised during the project, a second phase will be started where the used methods will be tested in an area where the dynamic topography is expected to be more significant, hydrodynamic modelling will be used to investigate the SST, and satellite altimetry will be used to close the gap between this project's MSS and the open ocean MSS based on traditional satellite altimetry carried out by DTU.

- In the second project, Green Laser Søre Sunnmøre (GlaSS), the aim is to fill the data gap in existing maps and navigational charts through airborne green and red laser with good coverage down to 3 meters below CD. The initial results seem good with the exception of missing data in areas with kelp or a dark seafloor.
- The third project, building a sea level visualization tool, aims at developing a sea level visualization tool which couples the future sea level rise, the tidal levels, and the extreme levels connected to storm surges with land uplift and detailed terrain models. This tool should visualize the consequences of current and future storm surges in order to spread knowledge about sea level change and the risks connected to it. The consequences for infrastructure and buildings are based on information from the cadaster. In a further phase, transects will be added to visualize depth.

Discussions and comments:

second project:

- Gwénaële JAN (FR) asked to receive some cost information from Aksel Voldsund (NO).

third project:

- Gwénaële JAN (FR) asked if the tool is open for use. Aksel Voldsund (NO) stated that the methods used are public and that he will share them.
- Gwénaële JAN (FR) raised the interest in knowing the strategies of the Member States of the NSHC-TWG regarding placing flood information online (for example estimations derived from model output). Aksel Voldsund (NO) said that this discussion was had in Norway and that it was decided that it should be ok to publish this if the aim is to inform the public and to help in future planning.
- Aksel Voldsund (NO) said that he would send a link to the tool when it came online at the end of the year.

Explain and reduce differences in reference surfaces at the international boundaries (WP 16-04, WP18-01)

Ronald Kuilman (NL) gave a presentation on the progress made on WP 16-04 and WP18-01 (see ANNEX E). First the 2017 status of the LAT differences at all boundaries was discussed (see ANNEX D). The difference is presumed insignificant if $\frac{\text{difference}}{\text{depth}} < 1\%$ along the whole boundary.

Discussions and comments:

- At the FR-BE border, there is a small area where there is no French data (see figure 1). Gwénaële JAN (FR) mentioned that there was a lack of validated GNSS survey data in that area (FR-LAT here was computed in 2009, 2015). It would probably become available next

year at which time she will send it to Ronald Kuilman (NL) for inclusion in the difference calculation.

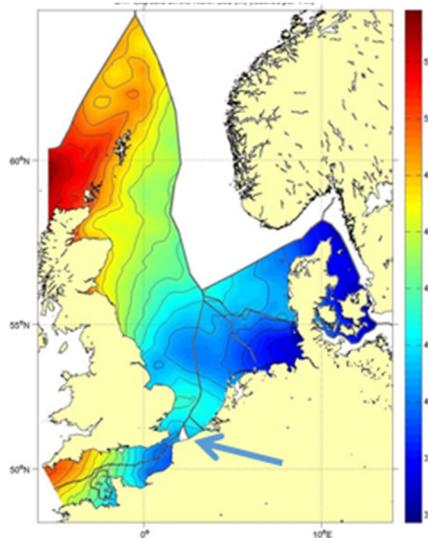


Figure 1: From R. Kuilman talk (at NSHC 2017, slide 8): the blue arrow points to the lack of data

- For Norway, higher resolution data was supplied and the calculation was redone for the matrix in ANNEX D. LAT was calculated using the Danish MSS and modeled tides.
- For Germany, two different LAT models with two different granularities and with overlap is used.
- For Belgium, Hans will send the LAT to ellipsoid model to Ronald Kuilman (NL). It will also be placed on <http://www.afdelingkust.be/nl/andere-publicaties> for downloading.
- For the Netherlands, a new LAT model will be obtained from the NEVREF project. Ronald Kuilman (NL) will recalculate the $\frac{\text{difference}}{\text{depth}}$ values at all borders.
- Higher resolution data made the $\frac{\text{difference}}{\text{depth}}$ decrease greatly and made the change along the boundary more stable.
- The calculations show that the $\frac{\text{difference}}{\text{depth}}$ value becomes bigger at small depths. The group discussed whether or not these differences are acceptable as ships cannot sail there anyway. The group agreed that we need to understand the differences and the goal of the Work Plan item before moving ahead. The group decided to:
 - share information on how each country built their respective LAT surface as studying the used steps and bathymetry could pinpoint possible issues. For the bathymetry for example differences could be explained by sand banks differing on both sides of the border (in space or in time), whether the bathymetry is singlebeam or multibeam, and so forth. The question was raised whether it was possible for all members to share this information. The group proposed to introduce a new action point (AP 22/01) to compare the surfaces given this new information (see ANNEX E).
 - ask NSHC what the goal of the Work Plan item is: is it to obtain a seamless LAT surface for charting (for safe shipping) or for modelling as for charting the observed differences are acceptable, but for studying they are not? Is it necessary to have a seamless surface as we also have a jump at land-sea boundaries TAW-LAT?

Only with this information can a substantiated decision be made.

- The group proposed to introduce a new periodical action point (AP 22/02) to update the matrix in ANNEX D.
- Aksel Voldsund (NO) asked if chart datum should be included in the matrix, and if not, opted to remove 2*: *differences on a common boundary, not checked, different CD* and to introduce 1*: *no LAT surface available*. Hans Poppe (BE) stated that the matrix should make a comparison of chart datum rather than LAT as this is the reference frame that is officially used. He stated that an explanatory note could always be added if the responsible hydrographic office uses a margin or approximate LAT as chart datum.
- Aksel Voldsund (NO) proposed to introduce a new permanent action point (AP 22/03) to make error estimates in LAT surfaces.
- The group discussed the effectiveness of the arbitrarily chosen 1% norm:
 - Hans Poppe (BE) noted that the norm is too strict near the coast and should be dependent on the uncertainty of the used bathymetry. If uncertainty of the bathymetry is 5% for example, how can the difference across the border be smaller than 1%.
 - Gwénaële JAN (FR) asked what each country uses as accepted error on hydrography in coastal area. France uses the 1dm IHO standard. Gwénaële JAN (FR) raised 2 questions (ref. FR talk, slide 10): Near the borders, should we compare :
 - The bathymetry (end 2017) injected in the LAT computations?
 - The number of in situ observations used for reference surfaces computation?
 - Andreas Boesch (DE) proposed to link the 1% norm to something practical such as the IHO standard for hydrographic surveys (S44 table). Most surveys are 1A.

The group proposed to introduce a new action point (AP 22/04) to decide how the norm should be redefined before the next TWG meeting and to then make an according proposition to NSHC for acceptance.

- The group discussed how frequently chart datum should be recalculated. Hans Poppe (BE) commented that chart datum should be stable in time to compare surveys. Aksel Voldsund (NO) replied that due to changing conditions (for example land uplift) it is necessary for Norway to recalculate chart datum for each new data set as chart datum is relative to MSL, and MSL changes with changing conditions. How can chart datum then be fixed? Gwénaële JAN (FR) replied that in France, if the change is smaller than 50cm chart datum is not changed. Aksel Voldsund (NO) thought this was too large, but France highlighted the consequence of a CD change (in terms of paper charts needing to be changed, workload, marine paper chart portfolio). France checks chart datum regularly, but changes it only if the difference is greater than 50cm (in most cases, the CD difference is smaller than 10cm). Aksel Voldsund (NO) asked whether the whole surface was updated if certain points differ more than 50cm. Gwénaële JAN (FR) replied that changes are done in a consistent manner to insure chart coherence.

Open Discussions

Opinions on the EMODNET European Vertical Datum publication

Opinions on NEVREF

The general opinion of the group is that each country should maintain their own vertical datum, and that this should be THE reference used by all subcontractors. All other versions are interesting for studying the own reference and should be used to improve it and to investigate why there are

differences and where they come from. The chair will recommend to the NSHC to ensure that the EMODNET LAT surface that is being developed, and all other initiatives, are marked as unofficial, not chart datum, and not for navigational purposes. Each member of the group should enforce this within their respective countries.

The group proposed to introduce a new work plan item (WP 22/01) to follow the developments of European initiatives on new LAT surfaces and a new action point (AP 22/05) to follow the developments of European initiatives on new LAT surfaces.

AP 20/04 “Gain insight in connection between EVRS and chart datum” needed?

The general opinion of the group is that this action point is interesting and should be maintained. Ronald Kuilman (NL) will send a mail to all member states requesting them to send him an overview of connection between EVRS and Chart Datum.

Does the TWG want to keep a private page on the www.nshc.pro site? If so, it should remain up to date. What do we want to put on this page? Do all publications have to go via Chris Jones (UK) or should this be a task of the chairing country?

The general opinion of the group is that it is important to maintain this private page, but that it should be kept up to date with all minutes, reports, and presentations of the group. In order to simplify the process of uploading information, it was decided that this should be a task of the chairing country rather of Chris Jones (UK). The chair Karolyn Hondeghem (BE) will contact the webmaster (Bernd Vahrenkamp (DE)) and upload all presentations and the minutes of the 22nd TWG meeting once the minutes have been adopted. The names and information of all members will also be added.

Opening

The chair, Karolyn Hondeghem (BE), welcomed the participants to the second day of the 22nd NSHC TWG meeting.

Tidal Developments: actual, expected, or considered

- Measurements
- Digital Tide Tables
- Website Predictions

Each participant gave a brief overview of their country’s current state of tidal measurements.

- Aksel Voldsund (NO) showed pictures of the level switch system used by Norway to monitor the slipping of the chain and showed the website.
- Gwénaële JAN (FR) discussed the use of HF radar for measuring surface current.
- Gwénaële JAN (FR) proposed that all members could send her an inventory of their countries tide gauges and current meters in order to create a North Sea wide inventory.
- Andreas Boesch (DE) stated that Germany has a network of 140 federal and state tide gauges along the North Sea providing minute data that can be consulted at <http://pegelonline.wsv.de>, but that some of these tide gauges will be shut down in the near future due to personnel and budget problems. He mentioned that new tide gauges may be added around the islands as this could provide interesting information. Gwénaële JAN (FR) suggested that it would be interesting, from a modeling point of view, to put

these on both sides of the island. Germany does not provide tide tables in digital format, but on www.bsh.de, 7-day tidal forecasts can be found.

- Hans Poppe (BE) showed the website <https://meetnetvlaamsebanken.be/> and the webshop <https://hydrowinkel.afdelingkust.be/> where the Belgian publications can be bought. Some can also be downloaded via <http://www.afdelingkust.be/nl/publicaties>. On the <http://www.kustweerbericht.be/nl/home.asp> site 3-day tidal forecasts can be found. Also the Stormvloedwaarschuwing application, which warns key officials of coming storms, was described.
- Gwénaële JAN (FR) stated that France provides a 7-day tidal forecast for all harbors via the Shom site although surge is not included as this is via French Met office. An example was displayed during the meeting: <http://maree.shom.fr>.
- Ronald Kuilman (NL) said that he had no new developments as this is the responsibility of Rijkswaterstaat.

Discussions and comments:

- The group discussed how far in advance should tide model predictions should be placed on the net. The general opinion was 4 days with uncertainty values like the Met Office.

Developments in LAT - Geoid conversion

Each participant gave a brief overview of their country's developments in the LAT - Geoid conversion.

- Ronald Kuilman (NL) discussed the NEVREF project. The results should be available in 2018.
- Aksel Voldsund (NO) referred to his presentation on the common reference frame model project which will give results, first for a small part of the coast, and in a next phase along the whole coast.
- Hans Poppe (BE) stated that MSL is recalculated yearly and that a new study has been started to find an unequivocal connection between the geoid, the ellipsoid, and various reference / reduction surfaces at sea and in the intertidal area. The LAT-MSL matrix can be downloaded from <http://www.afdelingkust.be/nl/andere-publicaties>. Others will also become available at the same location in the near future.
- Andreas Boesch (DE) stated that Germany published the conversion matrix last year and that an update can be expected in 4 to 5 years.
- Gwénaële JAN (FR) stated that for France, the conversion matrix between marine surfaces of reference can be downloaded from the data.shom.fr site.

Developments GNSS Based Surveys (WP18-02)

Each participant gave a brief overview of their country's developments on GNSS Based Surveys.

- Andreas Boesch (DE) stated that Germany uses GNSS when available. When not, further offshore, old fashion methods based on co-tidal, co-range charts are used. Precise Point Positioning (PPP) techniques are also being tested.
- Gwénaële JAN (FR) stated that France is testing a PPP technique with GINS software to avoid the connection to a GNSS fixed point on land. The results are very promising.
- Ronald Kuilman (NL) stated that the Netherlands measures with respect to the ellipsoid since 2016, and in 2018 will stop with backup techniques as they are satisfied with the results.

- Aksel Voldsund (NO) stated that Norway still uses old fashion methods, but that a new project will be started in 2018 to update the process and look at certain issues with high current situations.
- Hans Poppe (BE) stated that Belgium uses LAT to ellipsoid with RTK corrections on ship.

Open Discussion

To what extent are the specification of requirements for sea level measurements formalized? Experiences? Available documentation?

Aksel Voldsund (NO) asked the group for any experience and available documentation regarding how to specify requirements for sea level measurements as the split between data collectors and data owners in Norway in increasing, producing a need for good formal specifications. Each participant gave an overview of their experience:

- Hans Poppe (BE) stated that the subcontractor checks the level of the tide gauges with a GPS unit, and that the NGI does a levelling measurement twice a year. A subcontractor also quality checks the data and makes comparisons to other stations. Aksel Voldsund (NO) asked if the requirements were different depending on the expected use of the data (climate change studies, navigation, ...). Hans Poppe (BE) answered that Belgium always tries to provide the same accuracy of the data irrelevant of the expected use. Aksel Voldsund (NO) asked if it is not overkill to always produce the most accurate data and if there are numbers available as to which accuracy and stability must be achieved. Hans Poppe (BE) answered no.
- Ronald Kuilman (NL) said that this is the responsibility of Rijkswaterstaat, and that he would ask them to send the specification of the requirements to Aksel Voldsund (NO).
- Gwénaële JAN (FR) will try to get information from the team responsible for the measurements and will forward it to Aksel Voldsund (NO).
- Andreas Boesch (DE) stated that they are not the data owners, but customers, and that Aksel Voldsund (NO) should send the question to the German data owners.

How should the time evolution in reference frames (MSL, LAT, ...) be handled. Should MSL be referred to a reference datum? Does this datum need to be the same as the reference datum of the Quasi Geoid Model used in the reference frame? Do any of the member states extrapolate the change in MSL so that e.g. MSL(2017) could be calculated? How is the challenge by transforming from the mean over a period of e.g. 4 months to MSL handled within the different countries?

Aksel Voldsund (NO) showed some data and asked the group how to translate 4 month tide gauge data to a 19 year average. He asked if the mean over the period should be used, the mean of the coastal station, ... Aksel Voldsund (NO) stated that the comparison of the 4 month running mean between 2 permanent stations gives an idea of the error on the data which can help to determine the error on a temporary station. 4 months was chosen to include seasonal variations. He commented that different land uplift over 17 years between 2 stations would change MSL significantly so that MSL should be referenced to a date to be able to see effects in time.

Discussions and comments:

- Gwénaële JAN (FR) stated that France references MSL to a time period (ex: 1993-2009, etc.), but that the change in MSL over time is generally small for reference surface computation application. MSL is changed if the variation compared to the previous

computation becomes significant or if new validated data can feed the MSL computation. Note: This consideration is different if the sea level change over a long time period is studied.

- Aksel Voldsund (NO) stated that models are discreet and questioned whether they should estimate the trends and then use it for years. He asked whether other countries extrapolated MSL to get today's MSL?
 - Hans Poppe (BE) stated that in the harbor MSL doesn't change a lot and that Belgium does not extrapolate as the trend is exponential, not linear. He added that the situation for Belgium is different than for Norway as we do not have land uplift.
 - Gwénaële JAN (FR) stated that in France, old data gets corrected via linear regression and trends, and that the used method depends on the need and the data available in the research department. Official products do not get updated with each recalculation as the change is normally small and an update is expensive.
- Aksel Voldsund (NO) asked Hans Poppe (BE) if the year running average of Belgium jumps around a lot? Hans Poppe (BE) answered that there is a small year-to-year variation, sometimes denoting a rise and sometimes a fall, but that, if one looks over multiple years, a rising trend of MSL is seen. Gwénaële JAN (FR) stated that France provides MSL anomalies, and leaves it up to the users to determine what they do with them.

Current atlas - accuracy? only surface current? what is the depth of "surface current"? is current provided in real time or only as predictions? how many and which values are provided in the current atlas?

Each participant gave a brief overview of their country's practices with respect to currents.

- Hans Poppe (BE) said that Belgium is developing a digital version. The application will be downloadable from the website and will be based on a depth integrated tidal and current hydrodynamic model based on Delft3D. The published current atlas goes to 10m depth. In the digital version, the user will be able to change the depth as needed. Uncertainties not published.
- Andreas Boesch (DE) said that for Germany, the current is based on a hydrodynamic model. Germany has a new printed current atlas with a grid of 900m and to a depth of 5m. An online version is available at <https://www.geoseaportal.de/mapapps/?lang=en>. The accuracy of the model has been verified at some points with observations, but only a small number of observations are available.
- Aksel Voldsund (NO) said that his department is not responsible for currents.
- Ronald Kuilman (NL) said that for the Netherlands calculations are based on the Deltaris 2D Dutch continental shelf model v6. One value is provided for whole water column. A new current atlas will be available in 2020. Uncertainties not published.
- Gwénaële JAN (FR) noted that uncertainties are not often provided online due to the open issue of how these should be computed. Gwénaële JAN (FR) noted the importance of bathymetry when comparing tidal current ellipses. France publishes a tidal current atlas with hourly currents for neap tide and spring tide. Time reference is high tide.

Draft report of the NSHC-TWG for the 33rd NSHC conference (27-28 March 2018 Ostend)

The draft report will be made by Karolyn Hondeghem (BE) and sent to the members.

Any Other Business

All participants will send their presentation to the chair, Karolyn Hondeghem (BE), to be placed on the group site <http://nshc.pro/>.

Review of Work Plan Points

The group reviewed the Work Plan Points as can be found in ANNEX E.

16/04	remains open
18/01	remains open
18/02	remains open
22/01	New

Review of Action Points

The group reviewed the Action Points as can be found in ANNEX E.

18/01	remains open
19/03	remains open - chair will contact Chris Jones
20/01	removed
20/02	removed
20/03	removed
20/04	remains open - Ronald Kuilman will send mail requested needed information
21/01	remains open – LAT needed from France in small area, tide information needed from Belgium
21/02	remains open – the used bathymetry should be compared, new LAT surface will become available
21/03	remains open – close to the coast 1% norm not achieved => the used bathymetry should be compared; saw pattern is due to low resolution in the German data
21/04	remains open – NO will send mail to DK to discuss
21/05	remains open – FR will send mail to UK to discuss
21/06	remains open – new information available => NL will redo the calculation and update the matrix
21/07	remains open – NO will send mail to UK to discuss
21/08	To Be Closed – SWE does not used LAT. NO will send mail to SWE to discuss
22/01	new
22/02	new
22/03	new
22/04	new
22/05	new

Date and Venue of the 23rd NSHC TWG

The 23rd NSHC TWG meeting should be held in Iceland, but as Iceland does not attend the meetings, the group wonders if they will be willing to chair. The chair, Karolyn Hondeghem (BE), will send a mail to Hilmar Helgason (ICE) to check if Iceland is willing to host the next meeting. If not, the next in line

is Sweden, but then the TWG meetings will be out of faze with the NSHC meetings. The next meeting should be held at least 6 weeks prior to the NSHC meeting.

Closing Remarks

The chair, Karolyn Hondeghem (BE), thanked everyone for their attendance at and contribution to the meeting and wished everyone a safe journey home.

ANNEX A: Member List

COUNTRY	NAME AND ADDRESS	TELEPHONE & e-mail
BELGIUM	Hans Poppe MDK afdeling kust Vrijhavenstraat 3 8400 Oostende BELGIUM	Tel: 32 /(0)59.55.42.62 e-mail: Hans.poppe@mow.vlaanderen.be
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UNITED KINGDOM	Chris Jones The U.K. Hydrographic Office Admiralty way Taunton, Somerset, TAI 2DN UNITED KINGDOM	Tel: +44 (0) 1823 337900 ext. 3504 e-mail: Christopher.jones@ukho.gov.uk

ANNEX B: Agenda

Tuesday 24/10/2017

20:00 - 21:00	Welcome Drink – Belgian Beer Tasting: https://www.cafebotteltje.be	
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Wednesday 25/10/2017

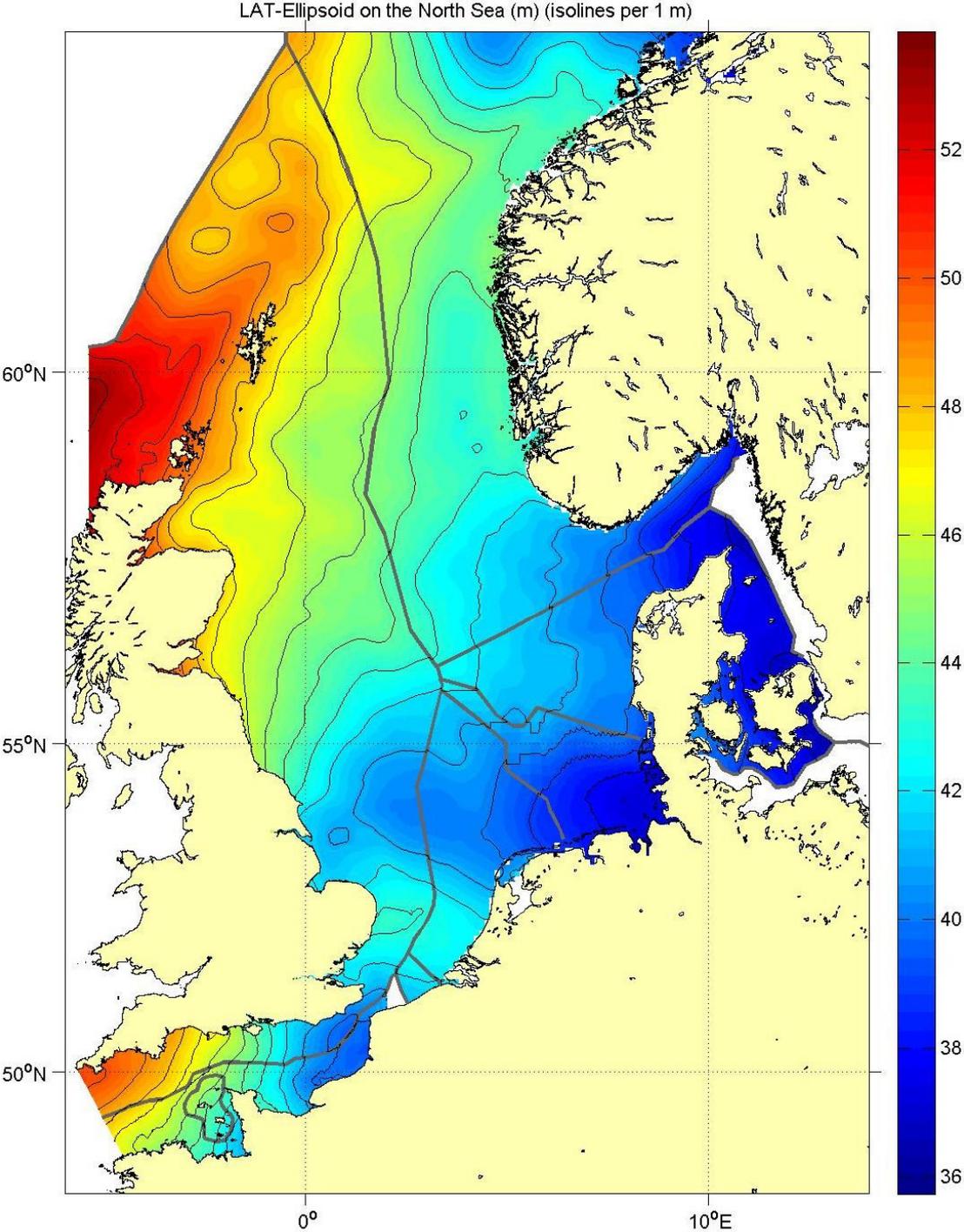
09:00 - 9:30	Opening <ul style="list-style-type: none"> ➤ Welkom ➤ Introduction Round 	Chairman
9:30 - 9:45	Adoption of the Agenda	All
9:45 - 10:15	Adoption of the Minutes of the 21 st NSHC TWG Meeting	All
10:15 - 10:30	Status of the Action Points from the 21 st NSHC TWG Meeting	All
10:30 - 10:45	Adoption of the Minutes of the 32 nd NSHC Conference	All
10:45 - 11:00	Coffee Break	
11:00 - 12:30	Participant Presentations <ul style="list-style-type: none"> ➤ GNSS Buoy and Damped and Undamped Tides (approx. 45 min.) ➤ New Mean Tide Curves in Development for Tide Tables (approx. 20 min.) ➤ Accomplishments of the TWCWG (approx. 25 min.) 	BE - Hans Poppe DE - Andreas Boesch FR - Gwénaële Jan
12:30 - 13:30	Lunch	
13:30 - 13:45	Making a common reference frame in the Søre Sunnmøre area in Norway and Visualization of the sea level	NO - Aksel Voldsund
13:45 - 15:45	Explain and reduce differences in reference surfaces at the international boundaries (WP 16-04, WP18-01) <ul style="list-style-type: none"> ➤ Update comparison vertical reference surfaces ➤ 1% norm - LAT Border Difference/Depth ➤ Discussion 1% norm ➤ AP 21/01 - AP 21/08 ➤ Missing data on FR-BE border? 	All NL - Ronald Kuilman NL - Ronald Kuilman
15:45 -	Open Discussions <ul style="list-style-type: none"> ➤ Opinions on the EMODNET European Vertical Datum publication ➤ Opinions on NEVREF ➤ AP 20/04 “Gain insight in connection between EVRS en chart datum” needed? ➤ Does the TWG want to keep a private page on the www.nshc.pro site? If so, it should remain up to date. What do we want to put on this page? Do all publications have to go via Chris Jones (UK) or should this be a task of the chairing country? 	All
19:30	Dinner http://www.oceanoostende.be/nl/	

Thursday 26/10/2017

09:00 - 9:15	Opening	Chairman
9:15 - 9:35	Tidal Developments: actual, expected, or considered <ul style="list-style-type: none"> ➤ Measurements 	All

	<ul style="list-style-type: none"> ➤ Digital Tide Tables ➤ Website Predictions 	
9:35 - 9:55	Developments in LAT - Geoid conversion	All
9:55 - 10:15	Developments GNSS Based Surveys (WP18-02)	All
10:15 - 11:15	<p>Open Discussion</p> <ul style="list-style-type: none"> ➤ To what extent are the specification of requirements for sea level measurements formalized? Experiences? Available documentation? ➤ How should the time evolution in reference frames (MSL, LAT, ...) be handled. Should MSL be referred to a reference datum? Does this datum need to be the same as the reference datum of the Quasi Geoid Model used in the reference frame? Do any of the member states extrapolate the change in MSL so that e.g. MSL(2017) could be calculated? How is the challenge by transforming from the mean over a period of e.g. 4 months to MSL handled within the different countries? ➤ Current atlas - accuracy? only surface current? what is the depth of "surface current"? is current provided in real time or only as predictions? how many and which values are provided in the current atlas? 	All
11:15 - 11:20	Draft report of the NSHC-TWG for the 33 rd NSHC conference (27-28 March 2018 Ostend)	Chairman
11:20 - 11:30	Any Other Business	All
11:30 - 12:00	Review of Action Points	All
12:00 - 12:15	Date and Venue of the 23 rd NSHC TWG	All
12:15 - 12:30	Closing Remarks	Chairman
12:30	Lunch	

ANNEX C: LAT-Ellipsoid on the North Sea (October 2017)



ANNEX D: Status differences at all boundaries with respect to LAT
(NSHC TWG Oct 2017)

	BE	DK	FR	GE	NL	NO	UK	SW	IC
BE									
DK	1								
FR	2	1							
GE	1	4	1						
NL	4	1	1	4					
NO	1	2*	1	1	1				
UK	3	3	4	3	3	2*			
SW	1	2*	1	1	1	2*	1		
IC	1	1	1	1	1	1	1	1	

Legend:

- 1: no common LAT boundary
- 2: differences on a common boundary but not checked
- 2*: differences on a common boundary, not checked, different CD
- 3: differences on a common boundary checked to be not significant
- 4: differences on a common boundary checked to need to be reduced

ANNEX E: Updated Work Plan and Action Points of the 22nd NSHC TWG Meeting

The work plan and action points of the 22nd NSHC TWG Meeting can be found in the tables below.

Item Number (TWG/Item)	Objective (Why/Priority)	Task Description (What/How)	HO Involved	Status
WP 16/04	Enable GNSS-based tidal reduction and the connection with the vertical datum on land	Follow developments on geoid, MSL and LAT computations for the North Sea area	All	Permanent, see also WP18/01
WP 18/01	Improve North Sea wide realization of reference surfaces	Explain and reduce differences in reference surfaces at the international boundaries	All	Permanent
WP 18/02	Improve methodologies for GNSS surveys	Exchange between HO's on operational methodologies for GNSS based surveys	All	Permanent
WP 22/01	Ensure common European LAT surface adoption.	Follow the developments of European initiatives on new LAT surfaces.	All	Permanent

Item Number (TWG/Item)	Objective (Why/Priority)	Task Description (What/How)	HO Involved	Status	Corresponding Work Plan Item
AP 18/01	Explain differences in realizations of LAT	Exchange on bilateral basis between involved HO's to investigate further the origin of observed differences at the boundaries between national reference surfaces	All	Permanent	WP 18/01
AP 19/03	Make an overview over existing separation and hydrodynamic models, including metadata	Each member state sends the information to UKHO	All, UK	July 2015	WP 18/01
AP 20/04	Gain insight the connection between EVRS and chart datum	Create overview of connection between EVRS and Chart Datum	NL, All	Dec 2018	WP 16/04

AP 21/01	Investigate the differences at the BE-FR border between national LAT reference surfaces	Investigate all LAT differences at the border of more than 1 percent (LAT difference/depth)	BE, FR	Dec 2018	WP 18/01
AP 21/02	Investigate the differences at the BE-NL border between national LAT reference surfaces	Investigate all LAT differences at the border of more than 1 percent (LAT difference/depth)	BE, NL	Dec 2018	WP 18/01
AP 21/03	Investigate the differences at the DK-DE border between national LAT reference surfaces	Investigate all LAT differences at the border of more than 1 percent (LAT difference/depth)	DK, DE	Dec 2018	WP 18/01
AP 21/04	Investigate the differences at the DK, NO border between national LAT reference surfaces	Investigate all LAT differences at the border of more than 1 percent (LAT difference/depth)	DK, NO	Dec 2018	WP 18/01
AP 21/05	Investigate the differences at the FR-UK border between national LAT reference surfaces	Investigate all LAT differences at the border of more than 1 percent (LAT difference/depth)	FR, UK	Dec 2018	WP 18/01
AP 21/06	Investigate the differences at the DE-NL border between national LAT reference surfaces	Investigate all LAT differences at the border of more than 1 percent (LAT difference/depth)	DE, NL	Dec 2018	WP 18/01
AP 21/07	Investigate the differences at the NO-UK border between national LAT reference surfaces	Investigate all LAT differences at the border of more than 1 percent (LAT difference/depth)	NO, UK	Dec 2018	WP 18/01
AP 21/08	Investigate the differences at the NO-SWE border between national LAT reference surfaces	Investigate all LAT differences at the border of more than 1 percent (LAT difference/depth)	NO, SE	Dec 2018	WP 18/01

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AP 22/01	Investigate the differences in national LAT reference surfaces at all borders.	Each member state should supply information on how their LAT surface was built to NL who will analyse this information and compare the surfaces.	NL, All	Dec 2018	WP 18/01
AP 22/02	Investigate the differences in national LAT reference surfaces at all borders.	Each member state should supply all LAT updates to NL who will update the LAT differences matrix accordingly.	NL, All	Periodical	WP 18/01
AP 22/03	Investigate the differences in national LAT reference surfaces at all borders.	Make error estimates in LAT surfaces.	All	Permanent	WP 18/01
AP 22/04	Explain the differences in national LAT reference surfaces at all borders.	Decide how the arbitrary 1% norm should be redefined to be linked to something practical before the next TWG meeting and make an according proposition to NSHC for acceptance.	All	Dec 2018	WP 18/01
AP 22/05	Ensure common European LAT surface adoption.	Follow the developments of European initiatives on new LAT surfaces.	NL	Permanent	WP 22/01