Minutes

27th Meeting of the North Sea Hydrographic Commission Tidal Working Group (NSHC TWG27)

4th - 5th February 2025
United Kingdom Hydrographic Office (ADMIRALTY & UKHO)
ADMIRALTY Way, Taunton, Somerset, TA1 2DN

For reference, see the NSHC TWG website.

Participants (See also Annex A)

Belgium (BE)	– Johan Verstraeten (JV)
Denmark (DK)	– Nicki Riber Andreasen (NA)
Denmark (DK)	– Kristian Villadsen Kristmar (KK)
France (FR)	– Gaël André (GA)
Germany (DE)	– Andreas Boesch (AB) (Chair)
Iceland (IS)	– Gudmundur Birkir Agnarsson (BA)
Netherlands (NL)	– Ronald Kuilman (RK)
Norway (NO)	– Aksel Voldsund (AV)
Republic of Ireland (IE)	– Sean Cullen (SC)
Sweden (SE)	– Thomas Hammarklint (TH)
United Kingdom (UK)	– Chris Jones (CJ)

Invited experts:

UKHO	– Tom Cropper (TC)
UKHO	– Simon Hampshire (SH)
BKG	– Joachim Schwabe (JS) (online, Tuesday, 13:30-14:00)
BKG	– Gunter Liebsch (GL) (online, Tuesday, 13:30-14:00)

1 Opening

1.1 Opening address

- Mr. Andreas Boesch (AB), Bundesamt für Seeschifffahrt und Hydrographie (BSH), and new Chair of the NSHC Tidal Working Group, opened the meeting at 0900 UTC and welcomed all participants (Annex A - List of Participants).
- He stated that it was good to see the group meet face to face, as was the case last year in Gothenburg for the 26th TWG meeting. He was particularly pleased that **all** NSHC nations were represented at this meeting, the first time this has happened in many years.
- Chris Jones (CJ, UK) briefed the group on the logistics for the meeting, welcoming everyone to Taunton (the first time of visiting Taunton and the UKHO for the majority of delegates).

Welcome address from UKHO National Hydrographer Rear Admiral Angus Essenhigh

- On the second day of the meeting (5 February 2025), the group was warmly welcomed by Rear Admiral Angus Essenhigh, the UK National Hydrographer and current chair of the IHO NSHC.

- He emphasised the importance of S-100; it is very near to implementation; much of the world looks to northern Europe to show willing and to get behind this development drive.
- He stressed that Hydrographic Office engagement is so important, which in turn will also get industry engaged - this is of paramount importance; as is the need to 'convince governments'.
- RAdm Essenhigh highlighted the importance of the dynamic contours in terms of safety and port operations.
- He raised the topic of collaboration, stating its importance in terms of the recognition that various nations are all at different stages of development in their "S-100 journeys", and that ideas and technical challenges should be shared in this NSHC WG.
- AB (Chair) reciprocated the Admiral's words, agreeing on the importance of the topics at hand and thanking Rear Admiral Essenhigh for taking the time to welcome and address the group.

1.2 Introduction round

- There was a round-table introduction session, where each Member State (MS) introduced themselves.
- CJ (UK) advised that two UKHO team members would attend the S-104/S-111 sessions later on the first day (see 'Invited Experts' listed above).
- The List of Participants was reviewed and accepted. See Annex A.

2 Administrative Arrangements

2.1 Appoint a secretary for the meeting

- CJ (UK) volunteered to act as Secretary for the meeting. This was greatly appreciated by the group.

2.2 Review the Program and Logistics

- AB (Chair) went through the programme of activities for the day, including the administrative arrangements.

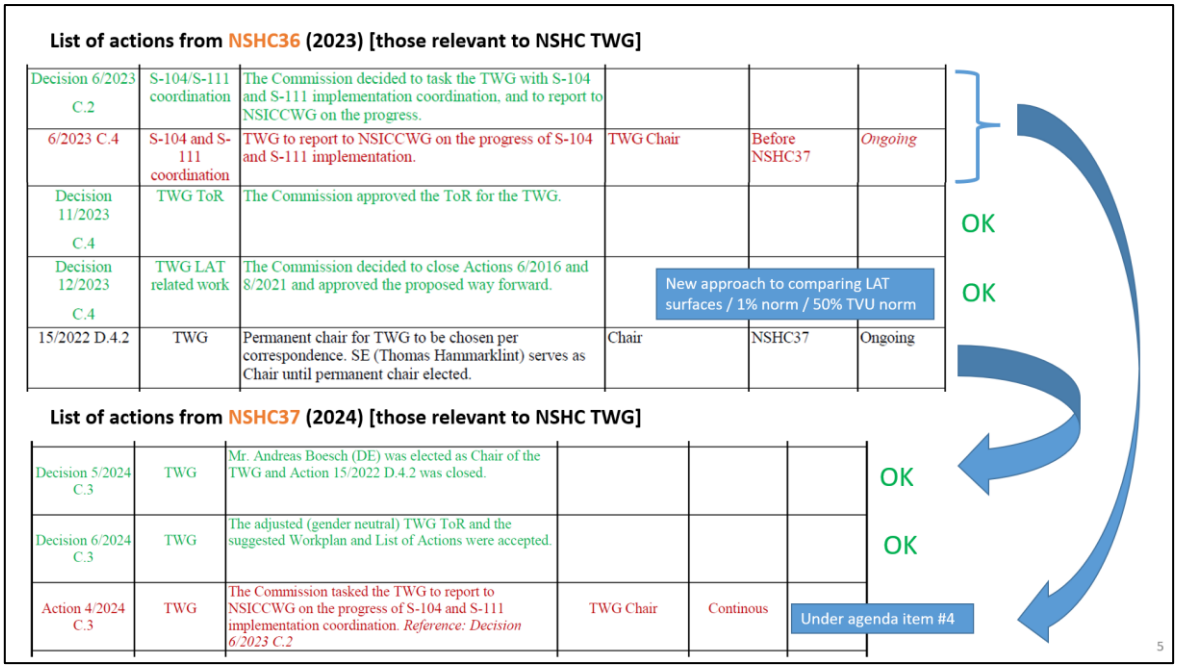
2.3 Adoption of the Agenda.

- The latest version of the agenda was displayed by AB (Chair). He commented it was built from the Work Plan, and that it is was an extensive agenda. The items may not necessarily be discussed in the order shown during the course of the meeting.
- The agenda was adopted without further amendment. See Annex B for the final agenda.

2.4 Report on activities since TWG26 (including minutes of TWG26 and NSHC37)

- AB (Chair) displayed the minutes of the last meeting (NSHC TWG26, Gothenburg), explaining the items covered as well as the actions identified by the NSHC (to be covered later in this meeting).
- No comments or issues were raised on the minutes of the previous TWG meeting.
- He covered the details of S-104 & S-111, and that TWG are tasked with the cooperation and coordination of S-104 & S-111 in the North Sea region, reporting on this to the **North Sea International Charting Co-ordination Working Group (NSICCWG).** It was noted that the NSICCWG was also meeting today (4-5 Feb 2025) in Aalborg, Denmark.
- The Chair displayed the report prepared by TH (SE) on the **Status of Implementation of S-104 & S-111 in the NSHC region**. This report discussed how the cooperation could be done, i.e. making test datasets available, exchanging software, reduce differences at boundaries.

- TH (SE) referenced the presentation he gave to NSHC as outgoing Chair of TWG (following TWG26).
- RK (NL) asked if TWG had received a report from the NICCWG? AB (Chair) explained that the reporting was one way, i.e. from TWG to NSICCWG. If we need feedback from that group, this could be requested, for example on specific guidance such as S-102 / S-104 coordination in the NSHC region.
- On 3 May 2024, TH (SE) and AB (DE) had a video call for the handover of the Chair.
- AB (Chair) mentioned he had been contacted by the NW European Shelf Operational Oceanographic System (NOOS), who expressed an interest in any common activities between NOOS and NSHC TWG. AB (Chair) has been in contact with the new NOOS Chair Annette Zijderveld and is now on the NOOS mailing list. There is a Tide, Waterlevel and Wave Working Group of NOOS, but no specific details are yet available. AB (Chair) will remain in contact with NOOS to explore possible co-operation.
  TH (SE) mentioned the BOOS involvement in BSCD2000, specifically for coordination of vertical datums, and there is an MOU, which ensures no duplication of effort.
  JV (BE) stated that BE also contributes to NOOS efforts; waves & wind and other offshore parameters – they have arrangements with local NOOS representatives already.
- AB (Chair) showed the 2023 Action Items (from NSHC36) and how they 'map across' to those actions from NSHC37 (in 2024). He explained how the actions related over these two years and what actions remain outstanding.

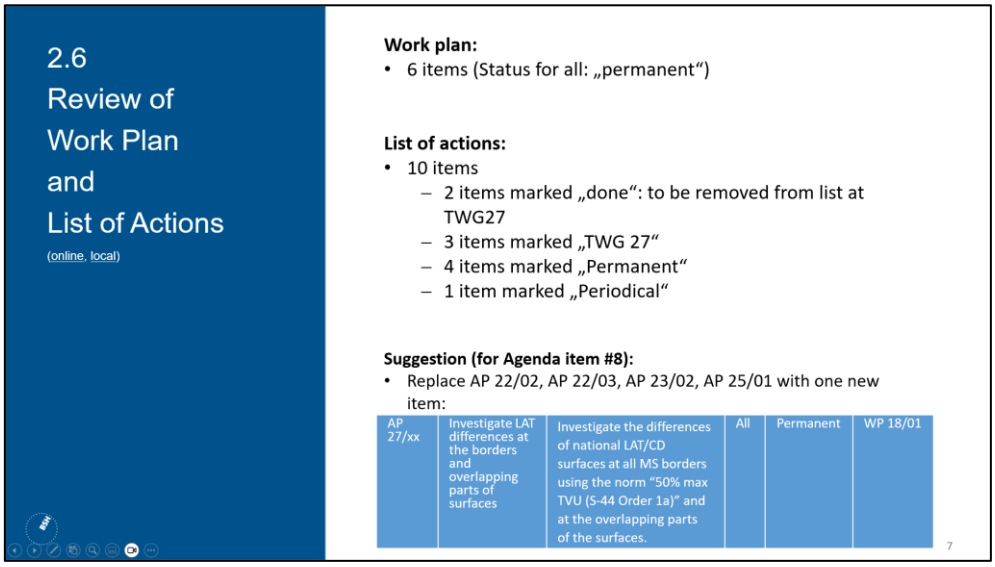


2.5 Review Terms of Reference (ToR)

- AB (Chair) displayed the ToR.
- KK (DK) raised the idea and possibility to open up the WG and invite oceanographic and meteorological institutes. The Chair agreed, and not only for the implementation of S-104 & S-111 topics. TH (SE) mentioned the wording used in BOOS, and the Chair added it to the ToR Procedures, item 3.4.
- SC (IE) mentioned the IHO EU network WG, meeting next in Cork Ireland on 21 May 2025; have engaged with EuroGOOS before and therefore should we ask the NSHC to task the NSHC TWG to more formally liaise with these bodies, such as EuroGOOS.
- See amended Terms of Reference in Annex C. Changes need to be approved by NSHC38.

2.6 Review Work Plan and List of Actions

- AB (Chair) presented the work plan on screen and explained the latest status, which items were 'done', which were 'ongoing' and which are 'permanent'.
- He also showed a breakdown 'summary' slide with a suggestion of replacing several AP's (AP22/02, AP22/03, AP23/02, AP25/01) with a new Action Item AP27/03.



3 LAT/CD/Reference Systems *[WP 16/04, WP 18/01, WP 18/02, WP 22/01]*

Several presentations were given under this Agenda item. Presentation files are available at the NSHC TWG website.

RK (NL) Presentation – LAT differences on the North Sea

- RK (NL) went through the Work Packages WP18/01, AP23/02 and AP25/01
- He displayed the various boundaries in the North Sea region and explained the difference in LAT, against the ½ TVU (the latest accepted comparison measure). He explained that if the difference in LAT between two Member States was below the ½ TVU line, it is on the safe side.
- GA (FR) commented that FR have supplied new surfaces. AB (Chair) stated that DE will supply updates in 2026.
- GA (FR) stated the latest FR data, when compared to UK, has now reduced the differences, and RK (NL) displayed the new ½ TVU results, which look much better now than was the case previously.
- With the supply of the new data sets, there is now 100% coverage with LAT/CD surfaces (along the maritime boundaries).

Discussion:

- KK (DK) asked the question about how to calculate LAT? It was recognised that there are several LAT surfaces in existence in the North Sea region; different methods of calculation.
- JV (BE) commented that BE calculated the LAT at individual tide gauge points initially, then used a hydrodynamic model to create a surface which matched at those points.
- TC (UK) – mentioned that the FES LAT model could be used as an 'independent' surface against which to compare all the national HO LAT surfaces.
  NL will add the FES LAT model as an additional surface across the whole North Sea region to the comparison statistics.

- KK (DK) mentioned the new SWOT dataset which is now much better resolution in close proximity to land than was possible with previous satellite altimetry missions.
- AV (NO) stated that NO is planning to compute point based LAT's as described by BE above. NO has separation models along the coast derived from point- based LAT calculations and collocation. For the open ocean the separation models are based on a mean sea surface derived from sattelite altimetry together with Z0 from hydrodynamic models. We are now looking into a way of combining these two models into one master model.
- GA (FR) commented that the MSL epoch is important. They first need to fix the MSL epoch in the modelling; but this needs to be periodically updated over time owing to MSL rise.

ACTION (AP27/01): Collect information how LAT /CD surfaces are calculated by the HOs and make it available to the group

GA (FR) Presentation – NEW FRENCH SURFACES TO ELLIPSOID BATHYELLI V2.2

- GA (FR) updated the group on the Shom "BathyElli" vertical transformation tool, version 2.2.
- The development used the EGG2015 Geoid *a priori*, MSS2015 from CNES, Tide model FES2014b, GNSS surveys, Tide Gauges "RAM2026".
- The development firstly computed the MSL surface (epoch 01/01/2020) with the Mean Sea Surface add trend 0.002m per year from 1993.
- He showed the uncertainty in the surface, and described the satellite tracks which were evident in the previous surface; these have now been resolved.
- Validation of the MSL; showed the "before and after", as well as the comparison against the UK VORF surfaces at specific points.
- RAM is at each tide gauge side. The comparisons showed much better agreement, and much smaller errors.
- They computed MSL to LAT using FES2014b and the RAM TG sites. The differences again are much smaller in this surface comparison.
- He showed the traditional Shom tidal zones with the specific levels of Chart Datum (CD), with the differences between CD and LAT (the differences can be up to 60cm).

Discussion:

- AB (Chair) asked which surface was sent to NL for the surface comparison work? Was it CD or LAT or both? GA (FR) confirmed it was the LAT surface.

RK (NL) Presentation – Project HydroLev

- RK (NL) presented a project in preparation of TU Delft in which a global LAT model is to be created (LAT w.r.t. MSS). The approach includes model-based hydrodynamic levelling and the use of the Global Tide and Surge Model.

RK (NL) Presentation - How HO's publish their separation models under INSPIRE

- RK (NL) described how he had been contacted by Geonovum, which is the national spatial data infrastructure executive committee in the Netherlands; they would like to know how European HO's publish their separation models under INSPIRE?
- NA (DK) advised that DK are not currently publishing their data via INSPIRE.
- AB (Chair) reported that DE are not publishing via INSPIRE; their online data consists of a text file with some metadata but not in the INSPIRE format.
- SC (IE) stated that the IHO HSWG S-44 PT is working on bringing S-44's water level standards up to date, and that this could relate to INSPIRE which is of course a European Standard.
- AV (NO) said their models are available on the National Geodata Portal, which is INSPIRE compliant (Chart datum above ellipsoid - Kartkatalogen)
- GA (FR) – only the CD surface is freely available on the Shom web portal data.shom.fr [CD to ellipsoid].

- CJ (UK) referenced the UKHO's Marine Data Portal where the VORF separation model transformations are available at cost.

Paper for Consideration by NSHC/ North Sea International Charting Co-ordination Working Group (NSICCWG): Harmonization of Sounding datum

(*related material: e-mail with attached proposal dated 05-01-2025*)

- The Chair introduced the paper and explained that the German BSH had asked NSHC TWG to comment and feedback on this paper (even though the final decision will be made in the NSHC).
- He went through the core points of the paper and reviewed the recommendations.
- The paper invoked much discussion; KK (DK) asked if this was introducing more ambiguity?
- BG (IS) – commented how can we ensure the users know what LAT or aLAT ("approximately LAT") means?
- RK (NL) – mentioned that it would make things easier.
- CJ (UK) – supports the paper.
- TH (SE) – commented that for interoperability between S-102 and S-104, these should absolutely be using the same vertical datum. It has been raised that in ECDIS today it is not obvious what the vertical datums are. In SE they of course use the BSCD2000. SE supports this paper.
- KK and NA (DK) – support the need for harmonization and the need to harmonize, just which should be the definition used? The NSICCWG will likely ask for more information.
- TH (SE) – mentioned in the past the discussion on which additional datums could be added to the list of vertical references, the list would be very long. This is better to define a general datum to avoid the different specific datums.
- GA (FR) – mentioned (as shown in his earlier presentation) that CD can differ from LAT by up to 60cm.
- The NSHC TWG understood that the NSICCWG would make the decisions on this paper. TWG did not suggest a specific value, or difference, at which aLAT is no longer appropriate, agreeing that it is difficult to define a single value for this (it can depend on local conditions as to when aLAT is no longer appropriate, signifying use of a different local vertical datum being used instead).
- It was felt that a decision in NSICCWG was appropriate, based on the well represented experience in that group.

BKG (Federal Agency for Cartography and Geodesy) Presentation - Geoid as vertical datum, MSS from altimetry)

- AB (Chair) introduced the team from BKG (**Joachim Schwabe, Gunter Liebsch)** who joined the meeting via a Teams link.
- The talk focused on the activities of the BKG related to MSS & geoid in the Baltic Sea and North Sea regions.
- The BKG provides geodata and geodetic reference information, in terms of the heights, definitions and realization of the 'zero' reference level and their connection to EVRF2019; the harmonization of heights in Europe.
- Reference was made to the BSCD2000 datum as an example of bringing together all of the disparate datums on paper charts, all with different epochs, with the primary product being the BSCD2000 height transformation grid, which is seamless and harmonized. The secondary product is the gravimetric geoid, with estimated errors of 2cm.
- The Mean Sea Surface (MSS) was derived from satellite altimetry which of course suffers from contamination of the 'footprint' in the coastal zone; later satellite altimetry missions have provided more robust data. This then provides a robust MSL from altimetry.

- They demonstrated that the MSL ranged between -20cm and +10cm in the German EEZ of the North Sea, displaying on screen the variance in MSL with respect to different geoid models.

Discussion:

- AV (NO) asked how the comparison was made between the altimetry and the geoid / real-time gauge data (as they are not referenced to the same 'zero' datum). BKG just looked at the *differences*, so did not need to first reference to the same zeroes; the geoid model shows the potential.
- KK (DK) commented on the fact there is not one common geoid model in the North Sea region and don't we need a common solution, for example the EGG15 model? A comment from the floor was that this may not be the official geoid in use in each Member State country.
- TH (SE) referenced the need to bring land and sea transition together in a seamless consolidated system, e.g. BSDC2000.
- AB (Chair) noted that the differences in the national LAT/CD surfaces are now below the specified 1/2 TVU limit at almost all points of the maritime borders (in some cases significantly below) and asked whether a common geoid model might be the next necessary step for further harmonisation.

4. Implementation of S-104/S-111 *[WP 24/01]*

AV (NO) Presentation – S-104 & S-111; Status and implementation from the Norwegian Mapping Authority Hydrographic Service (NHS)

- AV (NO) described that for S-104, the NHS will be responsible for both the data & products; distribute the existing gridded datasets. They will use contractors for the technical implementation.
- They will produce test datasets within Q2 of 2025, and operational datasets in Q4 2025.
- NHS will be offering astronomical tidal predictions and model outputs for S-104.
- For S-111 – the Norwegian Meteorological Institute will produce the actual datasets, and will also distribute the data. Again, they will use contractors for technical implementation.
- They will use the Electronic Chart Center (ECC) to assist (runs PRIMAR)
- They will use the currently best available national data; currents from the Met Office models.
- AV (NO) outlined their mission, which now builds in their commitment to developing these S-104 & S-111 datasets.
- NHS are looking at an area on the West coast of Norway just outside Haugesund; they will start with S-101, S-102, S-104, S-111, S-128, S-131. This is an interesting area, with strong currents. They will start the project this year (2025).

Discussion:

- KK (DK) asked about the Norwegian Meteorological Institute involvement, in terms of responsibility for their data; - it will be the best available data

GA (FR) Presentation – Production of S-104 & S-104

- GA (FR) gave the details of Shom's S-104 production; this covers two types of datasets; astronomical predictions and forecasts (astronomical & HYCOM 2D surge).
- 0.8 x 0.8 degree grid "UB3", S-104 will be on a 0.001 degree grid.
- For S-111, again it will be astronomical prediction & forecasts. Today they are using Atlas forecast online at data.shom.fr
  S-111 Files are produced over one week; the same for S-104
- Their S-102 gridded surface is high resolution, to enable dynamic safety contours

- GA (FR) mentioned the UKHO/Shom trial, "S-100 across the Channel" – here the plan is to test the S-101, S-102, S-104, S-111 and S-124 between as a collaboration between the two Hydrographic Offices.
- Ongoing projects: INTERREG Project HAROPA LE HAVRE. Looking to construct a global tidal model.

Discussion:

- TH (SE) asked if there was any funding from INTERREG and mentioned that SE were close to also being funded within this project.

TC (UK) Presentation – UKHO S-104/ S-111

- TC (UK) briefed on UKHO's production of S-104 & S-111 datasets.
- He detailed the pipeline from .nc files to .hdf5 files, plus the catalogue.xml, using the NWS model 1.5km grid
- The outputs of the S-104 & S-111 are available via the UKHO file share service – (the Exchange catalogue file is not yet quite correct, but this will be corrected soon) - see https://fss.admiralty.co.uk
- He mentioned the UK Port Trials that had been completed, using the SeaIQ PPU – this had been well received from pilots; the S-111 showed the shear boundaries, which confirmed the local knowledge of the pilots.
- He reported that there is still work to do on S-104; and so far the results are that there is limited evidence that using the surge model directly is better than the astronomical tide; it has been more accurate to add the surge component from the ocean models to the astronomical prediction.
- TC (UK) mentioned the open source models that had been looked at for the weather forcing and showed the 'pros and cons' of these. For example Copernicus NWS model, but also STOFS 2-D, with its unstructured grid and covering the globe, it performs as well as the NWS model.
- He concluded with mentioning that the future plan for the UKHO is to develop the spatially varying temporal uncertainty layer.

Discussion:

- TH (SE) asked about technical validation of the files, machine-to-machine; have UKHO tested the files in this way? TC (UK) responded to say that UKHO has an internal tool which automatically creates the exchange data set including the catalogue.xml file. TH (SE) mentioned that they have asked PRIMAR for help, and that a 'test ECDIS' system would be helpful. TC (UK) mentioned that UKHO trying to engage with OEM's. A comment from the group stated that Furuno is developing a test ECDIS system.
- AB (Chair) asked how it is known that the .xml file is correct? TC (UK) replied that the UKHO had 'mirrored' the NOAA approach initially, now uses a tool developed by IC-ENC.

TH (SE) Presentation – Baltic Sea e-Nav project and the Implementation of S-104/S-111 in the Baltic Sea

- TH (SE) gave an overview of the Baltic Sea Chart Datum 2000, Water level and Currents Working Group (CDWCWG). This group has grown over the years, and is made up of specialisms from oceanographers, geodesists and surveyors / hydrographers. They co-ordinate their work with many other bodies.
- TH (SE) showed the 5-year roadmap for implementation status of the Baltic Sea up to 2024, in terms of BSCD2000, S-104 & S-111, mentioning that the Baltic Sea e-Nav project is a part of the "IHO S-100 world" and also the IHO S-100 implementation timeline.
- The work of the CDWCWG has consolidated 40 different CD's into the singular BSCD2000 reference plane;

- He also stated the real-time Hydro and environmental information service which deals with the Connecting Europe project.
- TH (SE) highlighted the e-Nav Interreg project 2023-2026; there are several HO's & OEM's involved, as well as RENC; there is a 'stepped approach' for S-10x development over the timeline.
- SE will deliver test files imminently (Feb 2025) to the OEM – to develop the interoperability between S-102 & S-104. The financing of this Interreg project is extensive – 5M Euro over 3 years.
- TH (SE) mentioned the challenges in harmonization and validation of the S-100 datasets, showing a more detailed timeline of the implementation in Sweden.
- The production line for S-104 & S-111 was shown, in terms of the split in responsibility between SMHI (Production) and SMA (Distribution). TH (SE) mentioned that if you want your national Met Office to 'do it all', the IHO can "licence" this to recognise the Met Office as the official producer.
- TH (SE) went on to show the S-104 & S-111 use case examples which included the new sluice development on a major river with strong currents, 5-6 knots. See Video.

Discussion:

- NA (DK) asked about the SMHI / SMA crossover, in terms of the responsibilities and particularly the liability.
- SH (UK) asked about how the data would be consistent across borders; SE agreed that the products need to be coupled to ensure that there is consistency in all the uses.

RK (NL) Presentation – Demo of SATIS application

- RK (NL) updated the group on the S-10x production development of NLHO.
- For S-101 – they use Caris 4.1 composer
- For S-102 – they use Caris BASE Editor
- For S-104 – the use NetCDF files from hydrodynamic model, then their production tool "SATIS" to create the HDF5 via an API.
- For S-111 output is for Data Coding Format 8 [DCF=8, regular grid] creating 12 files per ENC cell per year?
- Ronald showed a demo of the SATIS application. He showed how the tool creates an S-111 or S-104 .hdf5 files from the XML catalogue file. He then showed the viewer result; one hour interval current arrows for one month (12 months in total).
- S-104 is delivered in 30 minute time steps
- Their code is freely available via Richard Flapper at NLHO, and the viewer is available via Richard Flapper's GitHub site.
- A comment was made about what, if any, involvement that IC-ENC could offer to assist in validating test datasets; how to leverage any assistance?

RK (NL) Discussion Points – Different S-111 layers and Rollout of S-100 Products

- RK (NL) raised the discussion point that NLHO wishes to publish S-111 data sets at different layers, and could this be done?
- The general consensus of the group was that it could be done. Even though the S-111 product specification is designed for surface navigation, conceptually the data could apply to more than one layer of the water column.
- There was also a discussion about "S-100" data on Inland Waters and who would be responsible for the "S-104 & S-111"-type products in those regions; i.e. S-401 is the Inland ENC Product Specification. There was some discussion on this topic; it was agreed that this would fall to IHO TWCWG (if at all) and would be tasked (if required) by HSSC, should there be a need.

- For reference, the IHO website for Inland ENC Product Specification is here; see also Inland ENC Harmonization Group.

- RK (NL) also asked two questions about the rollout of S-100 Products within Hydrographic Offices:
  1) *Do the HO's already have a S-100 roll out plan developed for home waters?*
     - DE - plan to start with the Elbe river.
     - UK - / FR – start with ports, and also the joint trial in the English Channel La Manche region
  2) *And what about in Overseas Territories? (e.g NL in Caribbean)*
     - FR have a plan to roll out in overseas region – more detail will follow from Shom in due course.

NA (DK) Presentation – National S-104 & S-111 developments; Danish Geodata Agency (DGA)

- NA (DK) reported that DK have established a national S-100 Working Group – looking at the different Phase PS's, i.e. Phase 1 Route Monitoring & Phase 2 Route Planning….as well as the Critical Framework.
- The emphasis is on developing the framework for producing S-101 & S-102
- They have a new ENC gridding scheme
- For S-104 & S-111, DGA is currently discussing with DMI to use their existing outputs, e.g. DKSS (Storm Surge Model) – this is freely available.
- NA (DK) raised some questions to the TWG:

  1) How do you ensure that the quality of the oceanographic model is suitable for navigation (liability)? [Data input, model verification, max uncertainties].
     - AB (Chair) reported that DE runs a model forecasts multiple times a day and does a manual quality check 4 times a day in order to 'correct' the forecast at the tide gauge sites.
     - TC (UK); discussed the work UK have done / theoretically plan to do. The process would be to take at least one-years' worth of model hindcast (ideally more), then compare against all observation points, use the statistics from those points, use the largest uncertainty allowed in S-104 (couldn't remember if it was 3 or 4 Standard Deviations), and this would be an attempt to provide the "safest" uncertainty layer. You could interpolate this from points for a spatially complete layer and inflate the uncertainty in e.g. complex/shoal regions without the point location coverage. By going for the largest uncertainty, these values could end up being quite large. But a typical 95% uncertainty on a 15-minute forecast implies you would go outside of these bounds once every few hours – which doesn't sound "safe". It might be worth having a temporally varying uncertainty which changes value depending on the phase of the tide. With TVU the greatest part is tidal uncertainty (TC assumption!). This method would essentially allow you to almost account for the tide uncertainty. TC happy to be challenged on this thought process/pointed at papers which describe a better approach! A lot of UK ports use 1 meter / 10% of tide value – whichever is greater, I can imagine doing all the above work and coming up at similar
     - SH (UK) advised that insurance underwriters / fleet managers would also advise on the baseline that they require their shipping fleet to safely operate at.

  2) How do we handle point-based LAT calculations vs surface based LAT calculations, i.e. multiple realizations of LAT. How do we ensure S-104 is using the correct vertical reference?
     - TC (UK) advised we would take point-based as the target/truth. As mentioned in the second bullet above, we want an "as-long-a-hindcast-run (or accumulation of forecast data) as-possible". For the model, most of these run at the height above

geoid, so the spatial layer needs a GEOID to CHART DATUM transformation (in the UK, this would be to use the Mean Dynamic Topography Layer which is usually output by forecast providers which gets you from GEOID to MSL, alongside the UK VORF separation model which transforms from MSL to CD; globally you could use the FES transformation layers instead of VORF). We can then compare the point-based mean (from observation locations) against the overlying model cell means. If the transformation layers are good, the bias will be close to 0 cm. If you have sufficient points, and there is a variable bias, again I would spatially interpolate the bias values from these points and use this as an additional transformation layer that gets added to every forecast step. If you didn't have any transformation layers, you could do this with the raw model outputs. It would probably be worth reinvestigating this layer every time a model undergoes a significant update/annually to check the bias layer is still acceptable.

Discussion: how to coordinate the implementation of S-104 Water Level and S-111 Surface Currents in the North Sea.

- NA (DK) suggested the need to share tide gauge data across borders to ensure smooth transitions from national networks. There was agreement for this in the group; not only real-time data, but predictions, and datums too.

ACTION (AP 27/02): AB (Chair) will setup a questionnaire of the status of readiness of S-104 & S-111 of NSHC Member States (MS).

- **AP 26/01:** AB (Chair) raised the topic of providing links to S-104 & S-111 datasets and testbed programs; he displayed the IHO GitHub webpage at https://iho-ohi.github.io/S100Resources; the webpage only contains the links to the data sets – the data itself has to be hosted elsewhere. **CJ (UK) to look at this GitHub webpage for S-104 & S-111 and check the links.**
- TH (SE) suggested having an overview which is based on the IHO timeline, as an S-100 roadmap for the NS area; maybe something for NSICCWG to consider?

TWG Report to North Sea International Charting Co-ordination Working Group (NSICCWG) on the progress of the implementation of S-104 and S-111

- AB (Chair) introduced the topic, which is an action requested by the NSHC (Action 4/2024 C.3)
- He stated that he will write a short report based on the presentations and discussions here at this meeting.
- The report should state that more information/co-operation on S-102 test data sets is needed, as S-104 builds upon S-102.
- In addition to test data, there are also some ongoing test trials (also across maritime boundaries). Are other initiatives needed?

Discussion:

- TC (UK) offered support in terms of modelling bias-corrected values. Where the tidal signal is significant.
- TH (SE) stated that E-nav uses a bias-correction of the forecast model data; to relate to everything to BSCD2000; they can do this at the tide gauge locations, but how to deal with it in no-data areas? When a model is upgraded, any assumptions or pre-defined bias corrections need to be re-checked and re-calculated, sometimes on a short period basis.

5. Data Rescue and Data Archaeology *[WP 24/02]*

AB (DE) Presentation – Recently discovered historic datasets

- AB (DE) described the tide gauge data recently discovered at the BSH office in Hamburg, in a bunker underneath the BSH main building
- He mentioned they had been discovered by his colleague, Anna von Gyldenfeldt, in five drawers containing tide gauge data from the 1930's
- He showed an example for Delfzijl from the year 1934/1935…there may be data from other countries. BSH will compile an inventory of the data, that will be shared with the TWG.
- The presentation generated a discussion on the importance of identifying and conserving records such as these. Projects such as the UK National Oceanography Centre (NOC) Citizen Science which helps to accurately capture such records can be used for this type of data

6. Topics contributed by the participants: Presentations & Updates

AB (DE) Presentation – National Developments

- AB (DE) gave a talk on 100 years of the German storm surge warning service.
  He outlined the history of the service which commenced in 1924; there was a press conference with the Mayor of Hamburg, a reception, a public exhibition, and a technical workshop with expert users. The exhibition displayed real-time records from a major storm surge in 1962.
- AB (DE) displayed a series of BSH websites on tides, water levels and chart datum, as well as an OpenCode GitLab – a repository for open source-code which will be added to systematically.
- He then informed the group on Germany's work to update their national Chart Datum surface which will be finalised in 2026. CD was defined at 65 tide gauge locations, using the latest LAT values, valid for 2025 (the last update was 2021). The work involved checking the 2026 values against the 2025 values, if differences are within the range +/- 5cm, these are accepted. There were some changes required. Some gauges "dry-out"; these areas use an LAT '*plus some other dependency*', based on surrounding area knowledge / characteristics.
- He then moved on to the topic of Artefacts in 2D-tidal predictions. He detailed the procedure for harmonic analysis which runs in 2 iterations: In the first run, all water level data available and all resolvable partial tides (depending on the length of the time series) from a master list of 104 partial tides are used. In the second run, a 3-sigma clipping is applied to the observations and only significant partial tides with SNR>2 are used. Thus, the number of partial tides used for predictions varies across the 2D area.
- He showed the resulting artefacts which are related to the number of partial tides used in the prediction at specific points; they display as tracks/ patterns; the challenge is: is it better to use 'too many' insignificant partial tides in the analysis, or should the structure in the predicted surface be accepted?
  TC (UK) fed back on this question– yes – you can do a harmonic prediction using say 7, 34, or 104 constituents; then look at the Mean Absolute Error (MAE) values; most of the time using too many harmonics will give a 'smoother result'.
  JV (BE) suggested that the tracks shown might be related to bathymetry.
- Finally, AB (Chair) introduced a new colleague at the BSH, Thorben Knoop, who is working on their S-104 & S-111, to develop new 2D forecasting products on tides & water levels: contact Thorben.knoop@bsh.de

AV (NO) Presentation – update on some radar related issues

- AV (NO) showed the details of some new radar gauge equipment installations and detailed the issues and challenges they faced in the project.

- He detailed the differences in the 1-minute average of 1Hz data and the effect of the filters being applied, the differences can be up to 15cm.
- The causes of the differences had a strong correlation between the wind speed indicating the issues are caused by waves (i.e. how the frequency / footprint of the surfaces are affected by waves).
- The work on this is ongoing. Independent measurements are being made using pressure sensors to compare against.
- He showed the results of the radar measurements using a pipe / stilling well; differences are still evident, probably cause by interference, but are much smaller.
- The next steps are to design more tests using more sensors; two additional radar sensors have been installed as well as two new pressure sensors at each site.
- More results should be available soon.

NA (DK) Presentation – Denmark's Depth Model, DDM v2 update

- NA (DK) started by giving the background to the DDMv1 model, in 2022/2023
- He then showed the differences between the v1 and v2 models, the higher resolution and extended coverage was evident.
- Data from other nations played a role in this new updates; EMODnet is also a repository for the outputs of this data.
- Lots of new data is being received, for example from Windfarm developments. Satellite Derived Bathymetry has also been ingested.
- He stated that crowd sourced bathymetry has been 'well controlled' as it is from a Danish research vessel.
- NA (DK) also showed the usefulness of DDMv2 in terms of data archaeology.
- DDMv2 uses a polygon-based approach (rather than cell-based) which allows for smoother demarcation of the boundary.
- See more at the IHO article https://ihr.iho.int/articles/denmarks-depth-model-version-2-0-improved-compilation-of-bathymetric-data-within-the-danish-waters/
- "DKLAT2023" is now a recognised EPSG code 10550

JV (BE) Presentation – Ongoing LAT Study / Updates current atlas for Zeebrugge / S-104 & S-111 / Data Archaeology

- JV (BE) briefed the group on the ongoing LAT study, where the University of Ghent are providing an updated LAT surface for the Belgian North Sea region.
- Moving on to the current atlas for Zeebrugge, he stated that the currents are based on ADCP measurements, with this being a 'traditional paper publication'. At high tides there is a significant eddy occurring.
  In July 2024, the largest ship to date entered Zeebrugge; the current atlas was used, as well as the vertical layer depth of the currents, which is very relevant.
- Regarding Belgium's S-100 developments, the Maritime Service Division project group has been established. The focus is on S-101 & S-102, with the first test dataset being released to IC-ENC. The timeline for S-104 & S-111 is 2026. For S-104 & S-111, there are different options – see SLIDE 9 of the presentation
  Flanders Hydraulics / RWS have joint models; there is also machine learning development.
  JV (BE) concluded stating there is a large amount of number crunching for S-104 & S-111 between the model output and the final product.

7. Any other business

7.1 Update the List of Members

- AB (Chair) displayed the contact details of the members. AV (NO) advised they will have a new location address from mid-March (but not ready yet).

7.2. Review the provisional TWG website.

- AB (Chair) displayed the current TWG website; thanks to TH (SE) for establishing this excellent website.

7.3. BSCW shared workspace: introduction, feedback, do we want to use it?

- AB (Chair) explained that over several meetings of the TWG the idea of a shared space had been mentioned and discussed; a place the group could use to share data and collaborate.
- Andreas has set up a German-hosted site for the NSHC TWG – he asked the question if the group thinks this is helpful? The group agreed that this system is helpful.
- Those members who haven't yet registered will have all received an invite.
- NA (DK) mentioned the new IHO portal to possibly host the NSHC TWG documents (but it still may not be appropriate to share some data / information there which may be 'too accessible'). AB (Chair) will check if a group for TWG can be set up in the IHO Portal and which functionality is available.

7.4 Discussion: Procedure for future TWG meetings (VTC, hybrid, face-to-face)

- AB (Chair) showed the NSHC meeting schedule, and the plan for alternate VTC / in person meeting.

DECISION: The NSHC TWG agreed to meet alternately compared to the main NSHC, i.e. when NSHC meet in person, NSHC TWG will meet via VTC, and vice-versa. This helps to limit the need for a host nation to host 2 physical meetings in one year.

8. Review the Work Plan and List of Actions and unresolved issues of this meeting

- AB (Chair) displayed the new action items (AP27/01 and AP27/02) identified during the meeting.
- As mentioned earlier in the minutes (see section 2.6), it was suggested to replace AP22/02, AP22/03, AP23/02, AP25/01 with one new item, AP27/03. The group followed this suggestion.
- AB (Chair) went through the Work Plan items and suggested edits and updates to this.
- AP26/1 was changed to Permanent.
- See amended Work Plan and List of Actions in Annex D. Changes need to be approved by NSHC38.

9. TWG Report to the 38th NSHC Conference and list of matters to be reported

- AB (Chair) commented that he will create this report (8-9 April 2025 is the date of the online NSHC meeting which he will attend).

10. Place & Date of the next meeting

- AB (Chair) reported that the next NSHC TWG meeting be a VTC meeting, provisionally planned for February 3-4 2026; this may be changed in line with the scheduled NSHC39 meeting (unknown yet).
- The length is to be decided (one day, or two half days etc).

11. Closing Remarks

- AB (Chair) expressed his gratitude to all attendees and again commented how beneficial it had been that all NSHC Member States were represented at this meeting.
- He commented that the meeting had involved a full and productive agenda, and he thanked the delegates for their engagement, commitment and contribution to all the topics and discussions.
- Re-iterating the words of Rear Admiral Essenhigh, the Chair expressed the importance of continued coordination of S-104 & S-111 in the NSHC region.
- AB (Chair) thanked CJ (UK) for the logistics and hosting at UKHO, Taunton. CJ (UK) acknowledged the kind words and again thanked all delegates for making the journey to the UK.

The meeting was closed at 1225 on 5 Feb 2025

ANNEX A

List of Participants
NSHC TWG27

4-5 February 2025
United Kingdom Hydrographic Office (ADMIRALTY & UKHO)
ADMIRALTY Way, Taunton, Somerset, TA1 2DN

Country	Organization	Name	E-mail address
Belgium	MDK	**Johan Verstraeten**	johan.verstraeten@mow.vlaanderen.be
Denmark	GST	**Nicki Riber Andreasen**	nirib@gst.dk
Denmark	GST	**Kristian Villadsen Kristmar**	krkri@gst.dk
France	SHOM	**Gaël André**	gael.andre@shom.fr
Germany	BSH	**Andreas Boesch (Chair)**	andreas.boesch@bsh.de
Iceland	ICG	**Gudmundur Birkir Agnarsson**	birkir@lhg.is
Netherlands	MINDEF	**Ronald Kuilman**	rb.kuilman@mindef.nl
Norway	NHS	**Aksel Voldsund**	Aksel.Voldsund@kartverket.no
Sweden	SMA	**Thomas Hammarklint**	thomas.hammarklint@sjofartsverket.se
Ireland	GSI	**Sean Cullen**	sean.cullen@gsi.ie
United Kingdom	UKHO	**Chris Jones**	christopher.jones@ukho.go.uk

Invited Experts

Country	Organization	Name	E-mail address
United Kingdom	UKHO	**Dr Thomas Cropper**	thomas.cropper@ukho.gov.uk
United Kingdom	UKHO	**Simon Hampshire**	Simon.hampshire@ukho.gov.uk
Germany	BKG	**Joachim Schwabe**	
Germany	BKG	**Gunter Liebsch**	

ANNEX B

Agenda
NSHC TWG27

4-5 February 2025
United Kingdom Hydrographic Office (ADMIRALTY & UKHO)
ADMIRALTY Way, Taunton, Somerset, TA1 2DN

This agenda corresponds to the actual order of the meeting.

Tuesday, 4 February 2025

09:00	Tidal Working Group meeting commence **1. Opening** 1.1 Opening address 1.2 Introduction round	 Chair, UK All
09:20	**2. Administrative Arrangements** 2.1 Appoint a secretary for the meeting 2.2 Review the Program and Logistics 2.3 Adoption of the Agenda 2.4 Report on activities since TWG26 (including minutes of TWG26 and NSHC37) 2.5 Review Terms of Reference 2.6 Review Work Plan and List of Actions	 All Chair, UK All Chair All All
10:15 - 10:35	Coffee break	
10:40	**3. LAT/CD/Reference Systems** *[WP 16/04, WP 18/01, WP 18/02, WP 22/01*] Comparison of national LAT/CD surfaces New French MSL/LAT/CD surfaces to the ellipsoid Project HydroLev (Global LAT) How HO's publish their separation models under INSPIRE (*related material: e-mail with attached presentation dated 28-01-2025)* Paper for Consideration by NSHC/NSICCWG: Harmonization of Sounding datum (*related material: e-mail with attached proposal dated 05-01-2025*)	 NL FR NL NL, All Chair, All
11:50 - 12:00	Break	
12:00	**4. Implementation of S-104/S-111** *[WP 24/01]*	

	Norway: Status and plans for S-100 implementations France: Implementation of S-104 and S-111	NO FR
12:30 - 13:30	Group photo Lunch	UK
13:30 14:10	Geoid as vertical datum, MSS from altimetry (Federal Agency for Cartography and Geodesy) [via MS Teams; 14:30 MEZ] **4. Implementation of S-104/S-111 (continued)** UK: Implementation of S-104/S-111	DE UK
14:40 - 15:00	Coffee break	
      16:40	Sweden: Baltic Sea e-Nav project and the implementation of S-104/S-111 in the Baltic Sea NLHO S-100 update / Demo of SATIS application Discussion: S-111 Layers/S-401/Rollout (*related material: e-mail with attached presentation dated 28-01-2025)* Denmark: Implementation status, S-104 and S-111 **5. Data Rescue and Data Archaeology** *[WP 24/02]* Recently discovered Historic datasets	SE NL NL, All DK DE
16:50	End of first meeting day	
19:00	Joint dinner @ Zizzi Italian Restaurant Magdalene House, Taunton, TA1 1SB	

Wednesday, 5 February 2025

09:00	**4. Implementation of S-104/S-111 (continued)** Discussion: how to coordinate the implementation of S-104 Water level and S-111 Surface Currents in the North Sea? AP 26/01: Provide links to S-104 and S-111 test datasets TWG Report to North Sea International Charting Co-ordination Working Group (NSICCWG) on the progress of the implementation of S-104 and S-111	 All All Chair
09:30	Welcome address from UKHO National Hydrographer Rear Admiral Angus Essenhigh	UK
09:40	**6. Topics contributed by the participants: Presentations & Updates**	

	Germany: National Developments	DE
10:00 - 11:00	Tour of the UKHO Archives	UK
11:00 - 11:10	Coffee break	
11:10	Decimeter difference in water level between 26 GHz and 80 GHz radars	NO
	Denmark Depth Model v2	DK
	Belgium: NHSC Tidal Working Group 27	BE
11:50	**7. Any other business** 7.1 Update the List of Members 7.2 Review the provisional TWG Website 7.3 BSCW shared workspace: introduction, feedback, do we want to use it? 7.4 Discussion: Procedure for future TWG meetings (VTC, hybrid, face-to-face)	 All All, SE All, Chair All, Chair
	8. Review the Work Plan and List of Actions and unresolved issues of this meeting	Chair
	9. TWG Report to the 38th NSHC Conference and list of matters to be reported	Chair
	10. Place and date of the next meeting	All
	11. Closing remarks	Chair
12:25	End of meeting	
12:30 - 13:30	Lunch	

ANNEX C

NSHC Tidal Working Group
Terms of Reference

Changes to be approved by NSHC38, 8-9 April 2025
As proposed by TWG27, 4-5 February 2025

1. Objective

To provide technical advice and promote co-ordination on tidal issues especially within the North Sea Hydrographic Commission (NSHC).

2. Authority

The Tidal Working Group (TWG) is a subsidiary of the NSHC and its work plan is subject to NSHC approval. Subject to approval by NSHC the TWG is especially involved with the regional interpretation and implementation of tidal issues as identified by Tides, Water Level and Currents Working Group (TWCWG).

3. Procedures

a. The TWG should:

1. work according to the agreed NSHC work plan
2. monitor and report the progress of the work plan
3. propose new work plan items for consideration by the NSHC.
4. invite meteorological, oceanographic and geodetic experts to the working group as contributors as appropriate.

To support the identification of new work plan items deemed relevant for the NSHC, the TWG should:

5. liaise with relevant Hydrographic Services and Standards Committee (HSSC) working groups, such as TWCWG.
6. Exchange views and experiences concerning tidal issues like unifying vertical datum, analysis, modelling and related issues like sea level rise and surge.
7. Coordinate the implementation of S-104 Water Level and S-111 Surface Currents and report on the progress to NSICCWG.

b. The TWG will conduct its business mainly by correspondence. Meetings and workshops should be scheduled as deemed necessary for the accomplishment of the work plan.

4. Composition and Chair

1. The TWG shall comprise representatives of the NSHC Member State and expert contributors if applicable.
2. Decisions should generally be made by consensus, if a majority is required each Member State has one vote.
3. External contributors can contribute to the work plan but are not entitled to vote.
4. The Chair will be nominated by the TWG and approved by the NSHC Conference.
5. The Chair should monitor and report on the work plan to the NSHC.

ANNEX D

NSHC Tidal Working Group
Work Plan and List of Actions

Changes to be approved by NSHC 38, 8-9 April 2025
As proposed by TWG27, 4-5 February 2025

Work Plan

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 ERS	Exchange between HO's on operational methodologies for ellipsoidal referenced surveying 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
WP 24/01	Regional cooperation and coordination of the implementation of S-104 Water Level and S-111 Surface Currents	Coordinate the implementation of S-104 Water Level and S-111 Surface Currents and report on the progress to NSICCWG. Make available S-104 and/or S-111 test datasets which could be compared at national boundaries in the North Sea region, investigate and collaborate on resolving any differences.	All	Permanent
WP 24/02	Data Rescue and Data Archaeology	Exchange between HO's on details and methods used in the rescue of national / international archive tidal & water level datasets, for the purposes of climate change studies, tsunami research and any such activity requiring access to these important assets	All	Permanent

List of Actions

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~~	~~Done~~	~~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~~ closed, merged into new 27/03	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~~ closed, merged into new 27/03	WP 18/01
AP 22/05	Ensure common European LAT surface adoption	Follow the developments of European initiatives e.g. EMODnet on new LAT	All	Permanent	WP 22/01
AP 23/02	Investigate all LAT differences at the borders and overlapping parts of surfaces using the redefined Norm	Investigate the differences at all MS borders (and overlapping parts of surfaces) between national LAT reference surfaces	All	~~Permanent~~ closed, merged into new 27/03	WP 22/01
AP 24/01	UK and FR to supply 'CD to Ellipsoid' separation values along their common boundary to NL to investigate if this improves the result in any way	Charted depths in this region are reduced to 'CD', which is ***approximately*** LAT. Therefor it is important to ensure the correct surfaces are being compared with each other, then used in the 1% norm calculation (or other suitable method as decided by TWG)	FR, UK, NL	~~TWG27 Feb 2025~~done	WP 18/01

~~AP 24/04~~	~~Elect a permanent Chair of NSHC TWG~~	~~As directed by NSHC; the Chair should expect to be in place for a 5-year minimum term~~	~~All~~	~~Done~~	~~2024-04-10 Approved at NSHC37~~
AP 25/01	Investigate LAT differences at overlapping parts of surfaces	Each member state should supply LAT surfaces for an as large as possible area of the North Sea to NL who will compare the surfaces	All	~~TWG27 Feb 2025~~ closed, merged into new 27/03	WP 18/01
AP 26/01	Provide links to S-104 and S-111 test datasets	Link to existing IHO website, which already coordinates this. https://iho-ohi.github.io/S100Resources	All	~~TWG27 Feb 2025~~Permanent	WP 24/01
AP 27/01	Exchange information on LAT / CD calculation and implementation	Collect information on how LAT /CD surfaces are calculated by the HOs and make it available to the group	Chair	Permanent	WP 18/01
AP 27/02	Coordinate implementation of S-104/S-111	Conduct questionnaire on implementation status of S-104/S-111	Chair	TWG28	WP 24/01
AP 27/03	Investigate LAT differences at the borders and overlapping parts of surfaces	Investigate the differences of national LAT/CD surfaces at all MS borders using the norm “50% max TVU (S-44 Order 1a)” and at the overlapping parts of the surfaces.	NL, All	Permanent	WP 18/01