



Marine Facilities Advisory Board
Tuesday 15th November 2022

Participating

Professor Carol Robinson (UEA), Chair (CR)
Adrian Baker (Dstl) (AB)
Leigh Storey, NERC (LS)
Dr Maaten Furlong, NOC (MF)
Dr Louise Darroch, NOC (LD)
Dr Jörg Bialas (GEOMAR) (JB)
Colin Day (NOC) (CD)
Professor Mike Elliott (Hull) (ME)
Dr Kate Hendry (BAS) (KH)
Dr Jo Hopkins (NOC) (JH)
Professor Kerry Howell (Plymouth University) (KHo)
Professor Mark Moore (University of Southampton) (MM)
Dr Chris McGonigle (Ulster University) (CM)
Helen Oldridge (NOC) (HO)
Dr Matthew Palmer (NOC) (MP)
Dr Alex Phillips (NOC) (AP)
Dr Natalie Powney (NERC) (NP)
Dr Tim Smyth (PML) (TS)

Secretary: Jackie Pearson, NOC (JP)

Welcome

CR welcomed LS to the meeting in his new role, also LD who would be representing Ian Moores and MF in his new role as Head of National Marine Facilities. Apologies were noted from Dr Ian Moores (BODC), Emma Defew/Mark James (MASTS), Julie Pringle-Stewart (NOC), Dr Mike Webb (NERC) and Dr Eleanor Darlington (NOC).

1. Actions from April 2022

1.1 Action 1. Infographic action will pass to MF for completion by Spring 2023 meeting. **Action 1: MF**

Action 2. Invite Dr Suzanne MacLachlan to Spring MFAB. **Action: JP**

Action 3. LD hasn't been in contact with TS as we are still working on the Python packages but will contact once happy with progress. Carry forward.
Action: LD

Action 4. MP agreed to update at that agenda point.

Action 6. HO advised that the priority order within the seismic suite has been established and costed. Without a large injection of funding, there is an

advantage to adopting a staged approach, e.g. make purchases year by year but in this instance, incremental changes would still need to be trialled. CR mentioned that CPEB had been asked if front loading the funding to avoid some of the trials/cruises was possible, however, if front-loading is used, this could cause problems later if problems arise and the money has been used.

NP advised that CPEB had been asked if further funding could be made available but this is not possible. Also, regarding theoretical front loading, although NERC could help, this may increase risk. There is a NERC meeting planned for 1 December, in case discussions are needed around this. Are there any further questions for NERC, given that there is no further funding available this financial year? NP advised that she can ask about the front-loading issue but would appreciate some advice about whether this meeting is still needed. HO responded that an item today is around capital priorities so it was agreed to come back to this. CR noted the need to decide whether the December meeting should go ahead.

NP asked whether the equipment to be procured is still the best, given the NZOC/autonomy direction of travel? Thus, once we have procured in a few years' time, will this still be the best geophysical equipment to buy, given the changing environment around Net Zero? HO replied there is an agenda item that will cover this but noted that at the moment, there is a Bluepulse version by Sercel; their air guns have a reduced environmental impact. Sercel has done some modelling around this but feedback from the WG indicated that the reduced amplitude of the signal would reduce the efficacy of what they need to achieve. NMF will go through this again to make sure all in order.

Action 7. Although we didn't manage community-wide survey, we did get feedback from users over the last 15 years which will be discussed later.

Action 8. Cover later.

Action 9. Next TRM to be published in spring. Update later.

Action 14. Complete by end of year. Carry forward action: **CR and JP**

AoB. Raise awareness of cruise opportunities. ED not present so invite update at the next MFAB. **Action: JP**

2. Update on the Net Zero Oceanographic Capability programme – Leigh Storey

2.1 Helpful documents include NOAA's Oceanic and Atmospheric Research Strategy which, for example, considers what shifts in funding may mean for NZOC and the integration required to make NZOC work. The MoD's Integrated Operating Concept 2021 is useful to help think about the shift in strategic culture in the way we will conduct science in the future.

2.2 A lot of sensors are needed and the sensors we have, need to be miniaturised. We need to think about capabilities including Saildrone; there needs to be more

integration with big programmes like Argo. Future technologies may include uncrewed aerial vehicles and solar-powered vehicles.

- 2.3 LS noted that NZOC would require a different procurement strategy than that previously employed by NERC or centres and would be more strategic. He highlighted a useful series of discussions hosted by NOAA recently that engaged with industry on R&D risks associated with autonomous capability. LS also flagged that cyber-security would also be a key area of activity for NZOC.
- 2.4 NZOC is hosting a workshop in November which will consider how future in-situ capability, digital strategy and digital twins might link up and what activity might be required to enable that.
- 2.5 'Capability' refers to equipment that goes into the water which must be linked to satellites and floats etc. Aim to get traditional and novel data sets. There is the potential to increase spatial and temporal cover. Accessibility to capability for users is underpinned by the cloud-based NMF planning web site. We are looking at how to link this to autonomous capability and think about how, for example, we might align this with digital twins. Qualified and experienced people are needed. There is also the risk this won't work. How do we integrate satellite data in ways that are sensible, quick, easy and helpful to users?
- 2.6 Re: the draft NZOC Governance Programme, LS hopes to be able to share details of the membership of its Science Advisory Group and Board around Christmas time. There will also be a coordinating committee and there has been big effort to increase diversity and encourage early or mid-career researchers. Programme director is NOC's Dr Kristian Thaller.
- 2.7 AB asked how the carbon emitted will be measured? LS advised that currently, we measure the carbon output of NERC's three research ships. Any reduction of the use of these vessels will reduce overall carbon footprint, however, this will need to be done sensibly. Understanding the carbon footprint of, for example, a glider is complex. We need to measure this to demonstrate that we are meeting UKRI's requirements.
- 2.8 LD asked if scope to look at sensors other than those being deployed in the ocean. e.g. coastal sensors, as being part of Net Zero? LS advised to look at Work Package five report – summary talks about scaling up the integration of sensors, work with industry, engage with researchers, bring in technologies from other areas. There is another future acronym – NZARC - Net Zero Aerial Research Capability and NZOC will engage with NZARC.
- 2.9 KH asked if there has been movement on getting the Work Package reports published? LS will chase but advised KH that it can be shared now with colleagues. **Action 18: LS**

Suggestions in the comments

CR: *Masters student project? Sustainability / energy faculty here might be interested in supervising something?*

AB: Assessing the carbon budget for all these things objectively might be quite a project. I can see that an MSc project might be able to look at aspects - e.g. whole life carbon budget of a glider - but pulling it all together is quite a task.

CR: agreed Adrian - I was thinking an MSc project would be a small part of this e.g. as you say of one glider but it could be a start that fits into a larger project.

3. Technology Roadmap

3.1 NMEP updates – Helen Oldridge

- Seismics – nothing procured yet but have continued the work to refurbish the seismic firing and data acquisition system.
- Scanfish – requires trials which may happen in 2023.
- Vertical Microstructure Profiler suite – we now have enough equipment to deploy a 2000 and 6000 vehicle suite on both vessels concurrently, in line with requests.
- pCO₂ installation and commissioning will take place in 2023.
- Liquid nitrogen compressor replacement – now no need to send a technician with this which works towards the NZOC goal.
- The Cal Lab was ISO certified in April 2022 so if you want any equipment calibrated, please contact us.
- Ship's IT network upgrades refit will take place in 2023. This is a big piece of work and will need a lot resource and preparation. Will turn ship from small network into something akin to a large office building.

3.2 Marine Autonomous and Robotics Systems - Alex Phillips

3.2.1 On the Marine Autonomous and Robotics Systems (MARS) front Autosub 5, which replaced Autosub6000, has been through her final trials (DY152) and delivered its first science, supporting NOC's Dr Veerle Huvenne and CLASS cruise (JC237). The AUV is now on its way to the Pacific to support two expeditions in the first half of 2023. We are now receiving Autonomous Deployment Form (ADF) and Ship time and Marine Equipment (SME) requests for this vehicle, for under ice capability.

3.3 Gliders – Alex Phillips

3.3.1 Initial trials conducted in Mallorca in 2022 with a 'Backseat' computer which allows us to build additional autonomy on the vehicle and enable it to work more smartly. Lab on Chip sensors will be integrated into the Slocum gliders and sensors have also just arrived. We have secured funding for 'glider under ice' activity and will trial this in open water in 2023 and conduct ice work in 2024 and will be looking at glider navigation under ice.

3.3.2 We are looking at the C2 piloting, planning a trial in 2023 and will look at the next evolution of how we pilot gliders using automated algorithms. In 2022 there have been five deployments of ALR. We have worked on the OCEANIDS sensors project (DY149) and with the University of Southampton (UoS) and Chelsea Technologies on the primary productivity sensors project. We have worked with the University of Southampton (DY152) on the Biocam

camera system and have completed the NERC-funded INSITE deployment.

3.3.3 MF added that the ALR has shown its capabilities but is not yet in the NMEP so at the moment, comes with a significant financial 'Pay As You Go' cost. We had hoped to get it into the NMEP during the review of the NC-large-scale research infrastructure (NC-LRI) funding but are waiting on a final decision from NERC. The ALR will not be in the NMEP for at least a year so it is difficult for the community to access because of the costs which have to be included in applications. NP added that if this cost is included within the proposal, it can need an additional £150K so is expensive. If ship time costs are a funding line in the grant proposal, then to afford it, other costs would need to be reduced to remain below the financial limit of the grant, but if it's a 'Pushing the Frontiers of Environment Science' Research grant, these don't require ship time costs included, however, this remains expensive for NERC.

3.3.4 MP talked about the cost of the application process and asked whether that additional charge applied in full to each year of a proposal. This also seems to depend on who else is using the equipment in a given year, so there are uncertainties here. CR commented that MFAB supports the ALR going into the NMEP, however, NERC is delaying this so is there anything we can do to shorten this time frame? MFAB is welcome to approach NERC through NP who confirmed that there is the NC LRI mid-term review at the moment which included a bid by NOC to increase the amount of funding received so that this (ALR and technicians) could be moved into the NMEP. NP explained that NERC's NC budgets are fixed so if one line is increased, another will be affected. There will be feedback on this to MF in the new year, however, no funding lines will change until 2024. MF added that currently, NOC underwrites the staff costs (and upkeep) for the ALR. NP added that costs depend on the number of deployments each year. We (NP and MF) should discuss as we need to streamline this process. CR recommended including this as an agenda item for the Spring MFAB. **Action 19: JP**

3.3.5 CR suggested increasing agenda slots for items to include 15 to 20 minutes discussion time. **Action 20: JP**

3.3.6 TS mentioned the IT upgrade in 2023 and said it would be good to have wider consultation because this will impact those who use real-time feeds of data. This upgrade is an important milestone so it would be good to have a view of the architecture. HO advised this is in the design process and would have something to share next week. HO added that this issue had originated from around IMO compliance issues. **Action 21: HO**

3.4 Towed Undulators – Helen Oldridge

3.4.1 SeaSoar's unique selling point is the scale of its weight and speed of survey. The Moving Vessel Profiler has completed CTD profiles on hydrographic cruises, is quick to deploy and recover and has been used to fill in gaps in surveys. Scanfish is surface-focused and the quality of its instrument suite is identical to the CTD frame and rosette. Although we didn't complete a community survey, we got feedback from those who use these items

frequently and this was generally positive.

3.5 Capital Priorities – Helen Oldridge

- 3.5.1 We will focus either on restoration of the seismic suite or look at projects that have an NZOC application.
- 3.5.2 JH talked about the towed vehicles. Gliders may replace some of this capability in the future. If you remove Scanfish from the equation as this has just been upgraded, is there going to be an exercise to prioritise between SeaSoar and the Moving Vessel Profiler (MVP) to help guide the list as a first step? HO explained that from feedback and discussion within NMF, the preference would be to keep SeaSoar. CR asked if there is a need to go to a wider community to confirm this but HO advised it is appropriate to retire the MVP. HO asked if MFAB is supportive of this retirement.
- 3.5.3 TS: Initially we looked at how many times these items had been used. It is good NMF has approached the user community, however, these responses could have been expected. Should we go back to the usage statistics to justify the decision? JB spoke about eddies and zero oxygen areas, fast moving bodies of water which need a fast-moving surface vessel to search for these and follow them. JB doubts this can be done with a remote vehicle. This would be a reason to check this information. There is a reason probably to always keep at least one of these.
- 3.5.4 CR asked if we keep and upgrade the SeaSoar, would that cover all that we need? HO advised 'no' but it leaves the fewest gaps, acknowledging that we have a finite amount of money. CR is concerned about the possibility of applicants, who may have already submitted a proposal, expecting the MVP to be in the NMEP.
- 3.5.5 NP referred to the options and asked if there is a cut-off point? For example, NMF will fund X amount - where do you draw a line? HO advised this depends on the year. NMF receives £1.5M for NC capital. We can keep items and not retire them as this doesn't cost anything so we simply look at what funding is available for that particular year. *LS added in chat that the £1.5M has stayed the same since 2013.*
- 3.5.6 NP referred to a request for a towed undulator and there is evidence that none have been used for the last eight years. If there is one request to use it, should we pay for this? On the chance that it won't be used for a further eight years, in view of the limited capital funding? There are several items needed for the seismic kit which also need to be part of the prioritisation exercise.
- 3.5.7 TS assumed that it costs money to keep things on the shelf, especially when needed after a long time of it not being used. If we keep the MVP, the re-start up time could be considerable and expensive. HO: The restart time for the MVP could be up to two years and could cost £1m. JB added that if you have equipment that is not used often, is this operated by any other institutes in Europe? Would this be worth finding out, for collaboration? HO agreed this is

a good point and advised that one European institution did have a SeaSoar and would need to find out. **Action 22: HO**

Comments in the chat:

- MP: *There may also be other UK users, e.g. Cefas, MSS, AFBI
I know Cefas have owned and used a Scanfish in the past*
- LS: *Some sort of co-ordinating group (MSCC Research Vessel Working Group)
would be useful.*
- TS: *The Swedish have just purchased an MVP <https://www.offshore-energy.biz/aml-oceanographic-delivers-mvp-for-new-swedish-research-vessel/>*

3.5.8 HO asked if MFAB agrees to restore SeaSoar and put the MVP to the bottom of the list, pending retirement, should NMF continue with the seismics programme upgrade or focus on items that have a more direct NZOC flavour? Add as agenda item for the Spring MFAB. **Action 23: JP**

4. Sensors – Helen Oldridge

4.1 We are creating an NMEP catalogue on NOC web site which will be completed within a year. LD seeking funding for a sensor Persistent Identifier (PID) registry within UKRI. PIDs enhance efficiency of data processing.

5. Data Working Group – Louise Darroch

- 5.1 This is about perfecting near real-time pipelines on ship underway data, getting that information into Application Programming Interface (API) which enables the building of applications. This is aimed towards continuous ocean monitoring. NMF has been perfecting metadata and data stores on the ships and is looking to do near real-time data transfer from ships to shore.
- 5.2 On the British Oceanographic Data Centre (BODC) side, we have the NRT system which enables us to take data from a static store with underway data and sensor metadata and pass this through the system. We have the data API and want to perfect getting this into a metadata API too. The example shown of sensor metadata has a user interface and an API which consumes Java Script Object Notification (JSON) information into code, giving a historical timeline about the sensors on the ship. LD showed an example of Environmental Research Division's Data Access Program (ERRDAP). In this case, data can be downloaded in any data format needed.
- 5.3 Delayed mode – we are working from the stores provided by NMF on the ship. This is enriched with sensor information e.g. locations etc. We aim to build a processing app in Python so that scientists can process this data on the ship in a more useable form. BODC is working to perfect getting delayed mode data that will then be put into repositories at BODC and then synchronise this with our APIs. The Network Common Data Form (NETCDF) format is enriched and has information about each of the sensors being used and this can be applied back to the data streams and this can be adapted from

underway and use it for other types of data on the ship so can move to getting near real-time data on, for example, CTDs. LD concluded by showing some details about the Ocean Processing Python package.

- 5.4 KH: brilliant and exactly the way forward as we move to a more autonomous future. This sort of project is also needed for data streams coming from other pieces of kit, the autonomous and robotic fleet and there remains the problem of image and video data. Is MFAB the right place to raise this? The data management side of things has hugely lagged behind and is a key part of the NZOC aims. This is a fantastic initiative so well done.
- 5.5 LD: much of these points will be addressed through digital twins. We are looking at high volume data, potentially using facilities like NERC's JASMIN store. Also may move toward more scalable storage that would help make these sorts of pipelines more efficient so this is on our radar.
- 5.6 CR: we should emphasise this in the minutes and thank Louise and the Working Group. This is an amazing start. MF added NOC is looking at this both through the OCEANIDS1 programme, where we did ingestion for the gliders, and also OCEANIDS2. We are working with BODC to try to streamline this pipeline. We are aware about the problem with images because of the large size of these files. CR asked that it be noted that MFAB thinks this is a great initiative and is happy to help in any way that we can.
- 5.7 KH regarding images, with the implementation of AI, it has become apparent what a problem this is as there are no established standards around data coming off the ROV. It's good to highlight the importance of this, especially when we consider this in the context of AI.

6. **Ships Underway Working Group – Helen Oldridge**

- 6.1 We are working to define the service levels for the underway system and are focusing on standardising the metadata first.
- 6.2 SURFMET: We are replacing old sensors with new and expanding to include essential ocean variables. The second wave height sensors were installed last year. Service levels will be defined as part of the refurbishment.
- 6.3 PCO₂ commissioning intended for 2023; will be a body of work around data streaming.
- 6.4 The wave radar kit is not new but provides a reference set. The WaMoS doesn't have a wave height sensor so now we are trying to optimise what we have and create data products from it.
- 6.5 TS referred to the Surfmet (Surface Water and Meteorological monitoring system) package and asked how much convergence there is between NMF Ship Scientific Systems (SSS) and BAS instrumentation and ship architecture in terms of IT? HO answered that we are both working from RVDAS so the acquisition system is the same. The network infrastructure has been modelled

using the same prerequisites as the Sir *David Attenborough* and are built with the same intention.

7. Seismics Update – Helen Oldridge

- 7.1 The priorities within the upgrade of the seismics suite have been established by the working group and we are now thinking about funding. An update will be expected in the Spring. The Seismics WG will meet monthly and initially included Tim Minshull and Tim Henstock. We now invite by exception and will continue to meet once a month. Could this meeting information also go to JP to track? **Action 24: HO**
- 7.2 CR commented that it would be useful to have the MFAB meeting before the next CPEB meeting. Talk to Nicki Lewis about this. Next CPEB will be in early April so have next MFAB in March 2023. CPEB had commented they hadn't seen progress because of being out of sync. **Action 25: JP**

8. Review of the MAS Working Group – Matthew Palmer

- 8.1 The group hasn't met since the first meeting in January; the July meeting didn't happen. There is now a new working group under the NOCA and Challenger called the Upscaling Autonomy WG, involving LS, CR and Professor Mark Inall (NOCA Chair). As there was some overlap between the MAS WG and the Upscaling WG, it was decided to postpone further meetings until the UAWG group met in October. MP is leaving NOC to join PML in December. MF and MP feel the MAS Working Group should provide advice to MFAB. MF added that in the new year, we will think about what the MARS Chief Scientist's role will be. This has, therefore, paused for now but will be spun up again in the new year. The UAWG will run for a year or so. CR thanked MP for initiating the WG and wished him well in his new role. MP apologised for communication issues around the delays and agreed to update the group. MP nominated Dr Alex Phillips as the new contact. **Action 26: MP**
- 8.2 Email MF at end of January to check progress and include a paragraph update about the October UAWG meeting for MFAB so that there is understanding that these two groups have separate terms of reference and don't overlap. It would be good for the UAWG minutes either in entirety or a paragraph to go into these MFAB minutes [see below]. There will be a meeting of the MAS working group before April. **Actions 27: JP**

9. MFAB membership call update – Jackie Pearson

- 9.1 The recent call was to appoint five new members. Responses had been slower than last time so members were asked to think about colleagues who might be interested. Those finishing their term include Mike Elliot, Kerry Howell (who offered to extend her term, if needed), Nick Wright, Clara Mano (who asked to step down) and Mark Moore.
- 9.2 The Board needs to consider the geographic, demographic distribution of members and disciplinary distribution. ECRs are welcome as we need

applicants who are thinking about writing proposals in the next three years. CD suggested that some of the challenge in recruiting members may relate to the fact that a lot of colleagues are now stepping back from roles like this.

10. Revised capital expenditure form – Jackie Pearson

10.1 JP thanked the Board for helping with development of the new version of the form. Microsoft Forms won't let external contacts submit statements of support but we have a work around. JP has suggested an autumn 2023 call, announcing in June 2022 with a closing date for the end of December 2023 (NP suggested that a dead-line of mid-December 2023 might be better). The review will be conducted at the Spring 2024 meeting. CR asked the group to note the new form and asked JP to put something out to the community to let them know this is coming. Currently, the information about this is out of date on the website so we need to let the community know that this call will be announced next year. CR also asked that this is also added to Challenger Wave, as well as the article about MFAB. **Actions 28: JP**

11. Article about MFAB for Challenger Wave – Jackie Pearson

11.1 Add text about opportunities to apply to the Board in this article. **Action 29 JP**

Any Other Business

- CR mentioned the new members starting at the next meeting and asked if there are funds to enable a face to face meeting in Spring 2023. JP advised that this was anticipated.
- Can we give Mark Inall and Ed Hill a deadline about the new Chair.
- CR asked for the minutes a.s.a.p.
- LS encouraged the group to contact him about NZOC.

Actions

#	Action	Who	Status
1	Infographic action will pass to MF for completion by Spring 2023 meeting.	MF	
2	Invite Dr Suzanne MacLachlan to next meeting	JP	Will invite to the next MFAB as the first meeting of the Rock Store Working Group happens on 25 th April
3	LD to contact TS once happy with progress on the Python packages.	LD	
4	Complete update of MFAB ToRs by end of year.	CR/JP	Complete and included as a paper for information. There are no acronyms and the paper now reflects

			sustainability/NZOC goals.
AoB	Raise awareness of cruise opportunities. ED not present so invite update at the next MFAB.	ED	ED scheduled to speak today.
18	Chase publication of NZOC Work Package reports	LS	LS to update
19	NP and MF to discuss funding for the ALR to try to streamline the process. Add as agenda item for the Spring MFAB.	JP	Completed.
20	Increase agenda slots to include 15 to 20 minutes discussion time.	JP	Have extended slots to include time for questions.
21	IT upgrade for 2023 - wider consultation important. Currently in the design process. Share available documentation when possible.	HO	HO to update
22	Establish if other institutes in Europe also operate towed vehicles.	HO	HO to update
23	Discussion about whether NMF should continue with the seismics programme upgrade or focus on items that have a more direct NZOC flavour? Add agenda item for Spring MFAB.	JP	Completed
24	Provide information from Seismics WG meetings to JP to track.	HO	On-going.
25	Arrange next MFAB in March 2023.	JP	Done
26	Update MAS working group on current status.	MP	Ask AP to advise.
27	Email MF end of Jan to check progress and include a paragraph update about the October UAWG meeting for MFAB. Include UAWG minutes either in entirety or a paragraph for these MFAB minutes.	JP	Completed and a section from the Oct 2022 UAWG minutes has been added to the November 2022 minutes.
28	Update information about capital call on MFAB web-site and include information about this, as well as MFAB in Challenger Wave.	JP	Pending.
29	Ensure Challenger Wave article about MFAB includes some information about opportunities to become members of the Board.	JP	Information about MFAB membership has been circulated across the community and a piece has been posted onto the MFAB web site about opportunities to join the Board.

Extract from the Upscaling Autonomy Working Group October 2022 Minutes

Working Group Tasks

- 3.1 MI suggested three on-line seminars, possibly all the same, to capture as many participants as possible, then issue a questionnaire, then a round table, then

produce a report. There will be some support from NZOC (Kristian Thaller) and maybe some NOC COMMS input to support this. This activity is about hybrid autonomous infrastructure. This activity is not about science programmes but how an upscaled infrastructure would work in the UK.

Engaging with the community

- Short series (two or three) of 60 min webinars explaining the possibility of a new UK Infrastructure that combines autonomy with vessels and moorings. With autonomy as the up-scaled element, but not the only element. These online seminars will be repeats and open to whole community. Aim to include a 10 min NERC perspective from Leigh Storey and that we share between us a UAWG presence at each event.
 - A questionnaire to the community, ahead of a round table discussion. The questionnaire will be crafted to draw comment on what we think are the important challenges to upscaling, seek additional challenges, and allows us to present a range of possible future options/shapes for a new infrastructure for discussion.
 - A 'roundtable' (virtual) open to the community over two to three hours, to include short overview presentations (potentially Leigh Storey, Mark Inall, Ed Hill) followed by breakouts to be facilitated by members of this WG. The purpose will be to explore questionnaire Qs, and to get thoughts on the 'models' of possible future scenarios that we will have drawn up. A jamboard might be useful here.
- 3.2 MP advised that there are other things on-going in NERC UKRI at the moment. e.g. The digital twin aspirations and there are some activities that you can't do with ships but can with autonomy. Is there discussion around how these initiatives might dove-tail? We also need to consider the critical issue of data management. MI suggested that this needs to be directed to Leigh Storey.
- 3.3 MI then asked who should be invited? All of NOCA which includes BODC? All of Challenger? This WG won't be the only group involved in this. KH: The digital infrastructure aspect (data archiving, cloud) is critical to any upscaling of autonomy so if we are thinking about who to invite, we should include digital infrastructure colleagues - not just BODC, but also DASSH. MEDIN is the network which contains BODC and DASSH etc. **Action: MI/JP**
- 3.4 AP explained that the WG also needs to note that there are other threads of work going on with NZOC so recommends a chat with LS to think about how these link together to avoid duplication. LS and Kristian Thaller are supporting this work: [NZOC Digital Workshop | noc-events.co.uk](https://noc-events.co.uk)
- 3.7 MP added that upscaling in terms of multi-disciplinary could mean getting more images and more information about temperature, for example, but we also need to make this accessible for those who haven't already considered autonomy. RH commented that ECRs will be using the system.
- 3.8 MI: In announcing this, we should advise that we are consulting on how £200M

infrastructure will be developed and this will a long-term 'disruptive' vision. CR: Looking at the wording in the call: "*we are looking to a future strategy where we are interdisciplinary – we are multi-disciplinary and therefore we need engagement from all the disciplines*". This is an exciting and amazing opportunity and word it to be as inclusive as possible. MI thanked CR for reminding the group about this.

- 3.9 AP commented that the NZOC programme struggled because it started with a blank piece of paper so there's a concern that if we have workshops without setting out potential ways forward, that this may not progress. Instead, start with maybe three or four straw persons which can be challenged rather than start with a blank piece of paper. MI: agreed so the questionnaire will offer three or four potentials and then invite feedback. We could construct a variety of models and must maintain a fully open and multidisciplinary approach. Suggest giving respondents one month to reply in advance of a workshop and that future meetings to be one hour, monthly. Next meeting to be canvassed for January 2022. **Action: JP**

Summary of the key challenges

1. Autonomy alone is no solution: Hybrid. Vessels plus moored sensors plus autonomy
2. Operational concept of swarm. Change of NERC mindset needed to support 'operational' idea (NZOC blurs these lines).
3. Where is interface between science user and engineering developer and technical operator?
4. Sensors and water samplers. More are needed.
5. Access/democratization to/of data
6. Geography vs topics⁽¹⁾ vs disciplines - prioritisation of rapid demand change
7. Barriers: sparsity; cost; sensors
8. Links to digital infrastructures.

⁽¹⁾ Topics – meaning strategic 'directed' research programmes - e.g. Highlight Topics or NC science or NERC strategic programmes like SSB etc.