User Journey 2 - Autonomy & Piloting

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Profile

Catherine - Autonomous and Robotic Systems Engineer & Glider Pilot.

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The potential of AI tools to support Piloting:
"If you add 30 gliders, and want to deploy them all in the same place, to do the same thing. Can we do that with our current capacity? No - but we probably don't need a massive increase... piloted in roughly the same way - an easy fix.

But if somebody came along and said here are 30 more gliders, we're going to have two gliders on 15 different projects, and those projects are going to change every year, and they're all going to have different sensor configurations, we (currently) have no way to cope with that sort of scale..." . **[How Might Wes - 4, 8 & 9]**

Jobs to be done

Autonomous underwater and surface vessel operations including piloting, maintenance, troubleshooting, and fieldwork.

Vehicle preparation, maintenance, integrate new sensors, calibrate and enable new glider behaviours, mobilisation.

Pilot the long range fleet (primarily gliders and USVs, but also ALRs when necessary) as part of the team's rota. **Time away on field work (both shore-based and at sea:** Required (on occasion) to work away from home during field operations and out of hours whilst piloting. Occasional seagoing time on Natural Environment Research Council (NERC) and other ships.

Work with scientists and researchers to help design glider operations to best support their research projects. Focused on solving challenging long-term marine science problems, underpinning international and UK public policy, business and societal outcomes.

Step	Step 1	Step 2	Step 3	Step 4	Step 5	Step 6	Step 7	Step 8	Step 9	Step 10
Journey point	→ Planning and programme design	→ Preparation of sensor (Slocum Glider)	→ Slocum Glider in mission (data transmission)	→ Mission issue / incident handling	→ Satellite transfer / auxiliary data	→ Data interruption or file (error state)	→ Recovery (return to shore)	→ Post-mission data extraction	→ Data transfer to data centre	→ Data delivery to scientists
Actions **Backing quote from research**	**A request will be made through to Marine Autonomy as part of any upcoming grant application (parameters of which will have initially been discussed with the Scientist/Researcher depending on what the science requires). NMF Head of MARS / Engineering Manager Approves Technical Viability of Request. This will also need to be approved by NERC. The Principal Investigator will then submit the grant application, and once confirmation of grant funding is received - the NERC Programme portfolio is set up (portfolio requests are based on prioritisation criteria).** **Current deployments per year:** • 20–25 glider deployments • 1-3 ROV Campaigns per year • 2-10 AUV Campaigns **Battery life is always a consideration in route planning (if battery life is used in an optimal way, more data can be collected)**	**Gliders fitted with requested sensor payloads, ballasted and undergo pre-deployment testing.** **The gliders are shipped to deployment location (on ship or shore) and once configured, are then deployed at sea or at land (depending if on ship or shore deployment).** **Each glider has a digital logbook for pre-mission status and ongoing documentation.** 	**Glider pilots are available 24/7 to ensure operations. Once the glider has been depolyed (from ship or shore), Pilots currently pre-set the route and monitor it during operations to maintain optimal parameters during mission.** **Experienced pilots are always in demand, and Trainee pilots require quite a lot of support (training happens on real missions).** **The Glider begins collecting and transmitting sensor data:** • Near Real Time (data sent through satellite comms when glider is in the water, depending on the glider model, but the more widely used (Slocum) sends decimated data. • Real-time monitoring tools are active where available. • Metadata is collected but not automatically linked to the vessel metadata for sensor issue tracking. This is currently done manually.	**Example of 'typical' issue during mission:** • Glider loosing a wing • One of the payload sensors breaking / being broken **Field crew (e.g. ship-based) will intervene to retrieve, repair and re-deploy glider—even outside regular hours. The mission continues, and data transmission resumes.** *"Providing context to changes to sensors... those changes can occur rapidly, so I'm thinking about the location of a sensor... currently the logging system just logs it automatically - no context given. In the moment- you are trying to fix the problem.* *You need a system that can take complex outcomes of the problem and put it into something that 10 years down the line, can be looking at the data, and see something that doesn't seem right, and be able to match that anomaly, with what actually occurred during those few hours the problem was arising."*	**Data is streamed through satellites to the Data Centre. Satellites also record Level 0 data (terabytes per cruise - for eg: plankton bloom data at sea-level surface, mapping sea grass, carbon offsetting etc.). This is currently backed up to Liverpool servers at NOC.** **Volume: Level 1 data is sent to NOC -** 3 files per track, 40GB for each day, 3x days per campaign. **Time to process: 1:1 - Times it takes to record, time it takes to process.** *"We don't really got many people who do whats called image processing - and that's really what I'd like to get into - I need a project that's big enough...* *I think there is scope for more and better use of machine learning in all sorts of ways in what we do."*	**If an issue occurs - for example, the glider data download fails on a weekend, the Data Centre is not staffed at the time - so there is no immediate response.** *"We've been doing the project for three years, and I don't think we've had a Christmas break where something hasn't gone wrong. And as soon as it happens over Christmas break - there's not really an option to get it fixed. I don't think we can fix without funding. It is a frustration to the Customer."* *"Sometimes the notice will come through on a Wednesday, to say we're going to do the maintenance this weekend - and that's fine, we appreciate the fact that they're trying to do the maintenance on the weekend, and it's spoiling someones weekend to do the job, so it doesn't impact everyones work - but the gliders and the vehicles that are out in the water, are still out at the weekend.* ***The days when they are being deployed or recovered, are whenever the weather is best."***	**The next step is for the vessel and gliders to return to shore. The instruments are retrieved and offline data downloads initiated.** *"At the moment, from my perspective at least - I see things as very disjointed. I see NOC, the centre of excellence - generating all the control systems for Autonomous vehicles. But it's then very difficult to know - okay that group owns that asset, NOC owns a lot more assets - and then how it's all shared and planned...and then the planning side, Marine Planning through MFP, it's almost impossible to get itineraries out working between BAS, NOC and NERC.* ***Having a digital infrastructure like that that's maintained, internally within NERC is key.*** *If there is a new feature - like what we're generating - we could slot into the MFP, but currently we cannot, because it's too close source software wise. It's the difficulty of developing on closed source software."* **~ BAS Research interview**	**After each mission, the raw data is manually downloaded from each instrument.** **If the instrument was not part of the MARS / NOC Marine Equipment Pool, the relevant organisation will retrieve their own instrument, and data.** *"Because of the systems we have. Getting data off the vehicles onto IMS - Inventory Management System... all of the data on IMS we can't pull through onto C2 or BODC - we don't have an API - it would be quite game changing if we were able to do that..."* *"We would be super keen to use C2 at SAMS - for Gliders and our platforms - if it had all the tools we needed"*	**The raw data is then passed to responsible Data Centre (BODC, or other). The manual cleanup and Quality Control (QC) processes begin.** **NOTE - IN PROGRESS:** **Data model for sensor data descriptions, deployments and datasets [NOC / BGS / CEH etc in discussion, NOC IADOPT standards, Vocabularies]**	**Final datasets sent to Research Teams and Research Scientists.** **Remote Sensing Data:** **Level 2 product - server in Southampton** **40 mins per file, 14 files per day** *"Leave overnight - things always crash, go wrong - none of these are operational services... it is a dice roll"*
Goal	What is the aim / goal or purpose? Successfully scope and plan out the annual deployments based on the scientific research which has been granted funding. Ensure battery life is optimal for science / data collection required on glider route.	What is the aim / goal or purpose? Successful preparation of sensors, testing and deployment of glider in determined location.	What is the aim / goal or purpose? Enable the collection and streaming of data from glider and sensors on board (delayed mode or real time data).	What is the aim / goal or purpose? Successfully fix any issues in data transmission when they occur, and ensure this gap can be 'accounted' for / contextualised in future (as needed).	What is the aim / goal or purpose? The goal is to ensure that satellite data is delivered to researchers as quickly and as completely as possible—whether in near-real-time or delayed mode—so that it can be effectively used for scientific research.	What is the aim / goal or purpose? Correct any data transfer issues as swiftly as possible to re-connect the data flow and prevent / reduce gaps in collected data.	What is the aim / goal or purpose? Retrieve instruments and prepare / start data downloads (MARS team @ NOC)	What is the aim / goal or purpose? Successfully extract data from sensors and autonomous devices / vehicles.	What is the aim / goal or purpose? Successfully retrieve datasets collected from sensors and send to Data Centre. Pusher App (push data to Data Centre eg: BODC) Slocum recovery data - .ebd (Engineering), .sbd (Science) + Cache files CTD's - Digital package emailed (ASCII file)	What is the aim / goal or purpose? Scientists (need: processed data) • Get insights from data collected Customers (need: raw/original data) • Understanding processing steps • Understand what the data was used for initially Govt (need: link to funding) • Demonstrate value of data
Touchpoints	C2 Platform (users require UI relevant to autonomous vehicle in use) Various Spreadsheets (Excel etc) Communication (phone / conversation) Email	Glider Digital Logbook - "GlideLive" Fitting with payload (Physical) Slocum/Glider/AUV (Physical) Various Spreadsheets (Excel etc)	Data Centre Monitoring Dashboards (File formats depend on platform - BODC ERDDAP, MetOffice .covjson generated) C2 Platform	 Data Centre Monitoring Dashboards C2 Platform Microsoft Automate (Vessels) Risk - Spreadsheets (Vessels)	Sent via FTP (login / password only) ***NB** Potential security risk*	Data Centre Monitoring Dashboards C2 Platform IMS / Sharepoint / GIT (Vessels) Email - Cross-Org Comms *"Communications are only done via emails, no teams messages - it does hamper efficient comms..."*	 Slocum/Glider/AUV (Physical) SD card physically removed from the glider (eg: by MARS operator)	C2 platform (MARS) Inventory Management System / MFP (Vessels) Various Spreadsheets (Excel etc)	
Pain points	Most non-MARS users come to C2 with an existing familiarity with a specific platform type. (Original goal of C2 and some of the comms-backbone work that underpinned SoAR and MAS-DT was a aspiration to create a platform agnostic system. Now work is underway to ensure platform-dependant UI's are available in CT as the UX of the platform was not considered in the first MVP iteration: *"The last one I did in 2022 that was a sea-glider, and the whole plan was to test on the C2 interface... and I had to arrange data transfer so I could get it on my own website to pilot the glider... because I found it impossible to use the C2 tools at the time...It didn't have enough plots... I know it was on the cards to be developed..."*	None reported, but full service design study has not been carried out. **Future potential** *"We've always relied on bottle data. Taking it to the lab... we haven't got real-time biogeochemical data traditionally. Gliders are starting to help us with this, I think that is the most exciting thing in terms of observations... that can transform what we do - alongside the modelling and AI - the new observations are really powerful for us..."* • Also see ROV Core samples - HMW 61	Pilots can adjust waypoints or sampling strategies only when the platform is at the surface and has connectivity. Standard gliders currently lack AI/ML capabilities to adapt routes mid-mission (e.g., optimising data collection or battery use). **Note**: NOC is developing this autonomy for both onboard and server-side systems. Currently sensors such as CTD's and Gliders are not connected within a network. This requires pairing & matching datasets manually, which is time consuming for Scientists & Ship Crew. If fleet size increases, need for trained pilots increases - supporting piloting software (eg: AI) Demand on Experienced Pilots (planning & training, monitoring etc)	No automated flagging or context and sensor-specific metadata linkage (vessel & autonomy metadata) when failures occur. *"I know across NOC there are different things - MARS use JIRA, NOC IT have started using a new system...CPS is just starting to use a new service... ideally if we had one [joined up] that would be great."* **Current projects & future potential** Sensor metadata management open source systems (federated - linked data stores / services)	**Large volumes of data transfers is not sustainable / standardised / scalable currently** *"It's not a commercial system - it can take a long time - standard output - 10-15 minutes per data file, a data file may be 150 MB. 15 minutes of radar data - but it's not needed to (historically), when it's just 2 of you. ..."* *"It will run through the processing even if it has gaps - in the science, basically."* No formal process for archiving or standard data handling and reporting across sensors. This results in one-off systems with little reusability/scalability. Transient nature of satellite data. Data products are dated so MARS team have had to find workarounds to handle spatial data sources (when addresses of data products change over time, when it's important to the user to identify how old the data is). This introduces complexity for any analysis automation.	**Gliders do not work within 'office' hours** Disconnect between the Data Centres and the Autonomy Operations. **Note:** Gliders are partially observable systems. NOC has been working towards AI fault detection for remote systems. Currently reactive, need for optimisation, to prevent data loss occurrences. **Future potential** *"Link positional inputs from the gliders on CT, into the Ship's bridge AIS display.* *Whenever the glider surfaces, the system sends a position to the server in the lab, and that will be communicated to the AIS tracking system on the bridge - so they can see the location of vessels and surfaced gliders. As you have more and more platforms in the water in a small operational space, that situation is a lot more challenging."*	Disjointed view of autonomous vehicles nationally - unless within MEP, and logged / maintained by NOC / MARS. **Future potential** An open source, National equipment registry / dashboard to provide real-time equipment / status (and location, based on security level clearance / checks) or open source 'extension/API' of the MEP.	Disconnected systems / data silos. No shared visibility across the UK of all deployed assets unless they're part of/entered into the Marine Equipment Pool. C2/MARS, IMS / MFP (Vessels), Other systems across UK used by independent fleets / not part of MEP. Usability / UX of the C2 platform does not yet meet all user requirements (see Step 1 pain point) - backlog of features, lack of resource (UX/Development etc). **Current projects & future potential** Sensor data management platform. Cloud based / MQTT, atuomated processing, QC, infilling, UI, API etc). Source: ***CEH work - Matt Fry*** **Current projects & future potential** Stores and patterns for large gridded time series datasets. Eg: Pangeo community approaches (JASMIN, NOC + OTHER ORGS)	Future potential Leading systems for storage and management of image, video and UAV data. Standards based on RDA group, involving BAS + Others. **Current projects & future potential** Automation of QC processes, open source tools for data QC, machine learning / AI automation Source: ***CEH work - Matt Fry*** **Current projects & future potential** Mechanisms for automated publication and update of published sensor datasets into NERC data centres.	Time it takes to get insights from data *"(Speaking about MARS) We know where all the platforms are, but not consistent information from them. Even that interface (C2), it gets difficult to assimilate that information [and get insights from it]. It's time consuming to do..."* Lack of contextual ship to sensor metadata: if any gaps in data are identified in future, it's a manual, laborious process to try and understand what happened contextually – involves back tracking/ manual investigation and connecting different documents, logs etc. *"When we did the commission for the data management systems - we went out to the community and got feedback from them - and broke it down into aspects of marine data system. We had a workshop and asked them to prioritise... the underway data model came out on top, and the contextual logging events was the second - and we've spent less time on that. So if I were to spend money on, I'd spend it on that..."* Occasional failures during transfer or processing - identifiable after full transfer occurs (reactive) *"It will run through the processing even if it has gaps - in the science, basically. So that's happened on a couple of occasions. when I've had data uploaded through BODC..."*
HMW examples	10 3	31 56 60 61	4 5 6 8 9 21	45 46 14 9	37 55	4 19 30	20	7 19 23 40	43 37 39	18 11