Summary of Workshop: Cabling and Platform Development for High-Flow Marine Sites (part of the Pathway Program)

January 10, 2020

Prepared by:

Marine Renewables Canada

Prepared for:

Offshore Energy Research Association (OERA)
Fundy Ocean Research Center for Energy (FORCE)

Summary of Workshop: Cabling and Platform Development for High-Flow Marine Sites (part of the Pathway Program)

1.0 BACKGROUND

The Offshore Energy Research Association (OERA) has a mandate to enable sustainable development of Nova Scotia's energy resources by facilitating and funding collaborative research and development. It has supported numerous tidal energy R&D projects over the years and is now leading the Pathway Program in collaboration with the Fundy Ocean Research Centre for Energy (FORCE) with funding from Natural Resources Canada (NRCan) and Nova Scotia Department of Energy and Mines (DEM) – a coordinated R&D program that will define, test and validate Environmental Effects Monitoring (EEM) solutions for the instream tidal energy industry that can meet regulatory requirements. The program will increase the understanding of impacts from instream tidal energy projects in the Bay of Fundy and improve the understanding of fish and marine mammal interaction with instream tidal energy devices. The program will also improve data processing and analyses, so that results can be reported to regulators and disseminated to the public in a timely manner.

The main objectives of the Program are to i) define a DFO-approved solution for the tidal energy industry, ii) apply machine learning to data analysis to reduce reporting time and compliance costs, iii) minimize initial capital costs to developers, iv) develop regional capability to manage, process, analyze and report EEM data, and v) develop intellectual property that regional companies can exploit commercially in multiple marine industries, both regionally and globally.

To conduct this program successfully, OERA and FORCE are assessing different types of monitoring technology that can gather adequate data to inform regulatory requirements. To complete this assessment effectively, OERA and FORCE are consulting with experts through several workshops to gather information on how the technology may be able to work effectively in high-flow environments to gather required monitoring data.

The first workshop under the Pathway Program was focused on "Cabling and Platform Development for High-Flow Marine Sites." The Pathway Program contracted Marine Renewables Canada (MRC) to assist in leading workshop development, delivery and information-gathering. This summary report is the outcome of the workshop discussion and insights gathered during the workshop held on December 10, 2019.

2.0 WORKSHOP FOCUS

Instream tidal energy turbine projects, specifically in Nova Scotia but also elsewhere in the world, have an obligation to the local community and to regulatory bodies to provide environmental monitoring of their projects to ensure that there is no undue harm to marine animals or permanent alteration to habitat. This is critically important in ecologically sensitive and historically significant areas like the Bay of Fundy.

Project developers have been working to address the monitoring requirements at the FORCE test site in the Bay of Fundy with limited success to date. Previous bottom-mounted turbine projects in the Minas Passage have tried mounting sensors directly onto the turbines and/or on the support bases for the turbines and identified some unique challenges. For example, when a component or cable failed, the monitoring ceased for specific instrument as the turbine/base could not be recovered for repair a monitoring sensor, given the substantial marine operation required for recovery. Further, installation errors and misalignments prevented monitoring from occurring because it was not possible to modify the configuration or monitored area after the turbine was deployed. Additionally, vibrations and noise from the generator tend to be picked up by the monitoring sensors, creating noise in the data, and hampering the analysis. Finally, incorporating sensors into a turbine design after it has been finalized can be challenging, making mounting mechanisms post-fabrication less than ideal.

FORCE has experience using autonomous and cabled sensor platforms for data collection at the FORCE test site. However, autonomous systems have limited data storage and battery capacity that limits the available time for monitoring without a minor marine operation for recovery, data card swap and battery recharge/replacement.

At various instream tidal energy sites around the world, there has been substantial work to develop an integrated cabled monitoring platform that can successfully monitor interactions of marine animals with tidal turbines. Most notable efforts include the Adaptable Monitoring Package (AMP) developed at the University of Washington, the Flow, Water Column and Benthic Ecology (FLOWBEC) through a team in Scotland, and the Fundy Advanced Sensor Technology (FAST) Environmental Monitoring System (EMS) at FORCE.

From the work done to date, sensors can be attached to a monitoring platform and data can be collected. However, at the FORCE test site in the Bay of Fundy, an integrated monitoring platform has not yet been successfully deployed near a turbine that has collected meaningful environmental effects data. The Pathway Program is identifying the right sensors for the FORCE site and various turbine technologies. The next steps are ensuring that those sensors can work together as an integrated sensor suite on a platform and can properly manage the data that is collected from those sensors. The Pathway Program intends to tether the integrated monitoring platform back to shore with a power and data cable, given the proximity of the test site to shore. This may not be practical at all tidal sites. Where impractical, power and data management may have to be addressed differently.

The intent of the first workshop was to address some key questions related to sensor integration and data management.

Assumptions:

1. Subsea platform will be cabled to shore for power and data
    a. Two conductor cable (double existing capacity and allows redundancy)
    b. 600V cable
    c. 4 core, single mode fibre op connection
    d. dual armoured shielding

2. The following monitoring equipment must be mounted: echosounder, PAM, imaging sonar
    a. 2 Oceansonics icListen hydrophones with 2 Arm Smart Cable
    b. Kongsberg Simrad WBT Tube Echosounder
    c. Tritech Gemini 720 sonar
    d. ADCP (Nortek Signature 500)
    e. Subsea camera (model to be confirmed)
    f. Kongsberg OE10-104 medium duty pan & tilt unit
    g. RBR duo RS 232 CT device

3. The platform must be deployed within 10 m of the designated location and must be oriented in such a manner that the sonar faces the swept area of the turbine.

4. Redundancy on the platform is limited to the second hydrophone

5. Full data redundancy exists in the cable

6. In the event of sensor failure, the decision will be made to recovery the platform early or leave in place, depending on the failure

7. The platform must remain deployed and collecting data for a threshold of 60 days, with an objective of 90 days

Requirements/ Points of Discussion

1. What is the right approach for redundancy on a cabled platform?
2. What is the best way to interface with and integrate all sensors and components?
3. How do we easily control the sampling frequency?
4. How do we set duty cycles appropriately to avoid interference among devices?
5. What sort of “software backbone” has been found useful on other projects and why?
6. What is the right approach for data transfer and storage?
7. What is the right approach to grouping or sectioning the data into manageable segments for processing and analysis given a cabled platform?

3.0 WORKSHOP FORMAT

The Cabling and Platform Development for High-Flow Marine Sites workshop was held on December 10, 2020 and was facilitated by Kes Morton of Pisces Research Project Management Inc.. Experts and industry representatives with knowledge/experience of monitoring platforms (particularly for high-flow tidal energy sites), data integration and analysis, and tidal energy development (Pathway Program partners) were invited to attend. Participants were provided with a backgrounder document and agenda in advance of the event that outlined the problem statement, objective, and desired outcomes:

> **Problem Statement:** What is the best way to integrate the Pathway Project sensor suite onto a subsea monitoring platform and most effectively manage the data received via the cabled connection.
>
> **Objective:** Explore and further define the best methods for sensor integration and data management of an environmental monitoring platform at the FORCE site.
>
> **Desired outcomes:**
> 1. Agreement on needs/requirements of integration module.
> 2. Data management plan framework
> 3. Data processing and analysis requirements identified

The workshop included brief presentations on key issues pertinent to the topic, followed by discussion from all participants. The workshop participants were:

- Jean-François Bousquet – Dalhousie University
- Robert Drinnan - Ocean Sonics
- Luiz Faria - OERA
- Dan Hasselman – FORCE
- James Joslin – University of Washington
- Tom Knox – MacArtney
- Jennifer LaPlante – DeepSense
- Marius Lengkeek - Ocean Networks Canada
- Andrew Lowery - MaRDO Consulting
- Alisdair Mclean - OERA
- John Moloney – JASCO Applied Sciences
- Kes Morton – Pisces Research Project Management Inc. (facilitator)
- Ross O'Flaherty – Strum Engineering Associates
- Adrian Round - Ocean Networks Canada
- Donald Sinclair - EMEC
- Surinder Singh – Dalhousie University
- Sarah Thomas - DP Energy
- Amanda White – Marine Renewables Canada (workshop organizer)
- Benjamin Williamson – University of Aberdeen/University of Highlands and Islands
- Tony Wright – FORCE

The next section provides a summary of the input gathered and key points and/or questions raised.

4.0 SUMMARY OF DISCUSSION

4.1 Introduction to workshop

In-stream tidal energy projects have received approvals and funding that require them to meet specific milestones. In particular, some developers' funding and investment is at risk if regulatory requirements are not met with sufficient data on the impacts of turbines to marine animals. The development of in-stream tidal energy faces a significant barrier when it comes to monitoring effects on marine life. Regulators such as Fisheries and Oceans Canada (DFO) do not have an approved solution for monitoring the fish-turbine interaction in the near field (100 meters). Therefore, they do not have the ability to trust the data and evaluate it – or speak with confidence to the public about the development and operations of tidal energy projects.

OERA and FORCE have been working on identifying potential solutions to the monitoring challenge. A joint proposal was developed and received $2 million of support from Nova Scotia Department of Energy and Mines and Natural Resources Canada (NRCan). The funding goes towards the Pathway Program – a joint project between academia, industry and developers to solve the problem. The Program includes three streams:

- Global Assessment – Examine and understand the global state of the science on environmental monitoring for instream tidal energy.
- Data Management – Establish an understanding and solution for how to manage the mass amount of data – and report results to DFO in timely fashion (quarterly basis)
- Field Trials – Test different technology that can be used with a platform including echo sounders, imaging sonars, passive acoustics, etc.

The collective goal is to define a monitoring solution, acceptable by DFO, that will allow developers to get their authorization from regulators quicker and with less risk. DFO will be liaising with the project team throughout the work being conducted.

Workshop problem statement & objective

The project team is targeting a spring demonstration deployment (i.e middle of March) to demonstrate that sensors will work on a platform via a cabled solution and capture data at a critical time (spring migration). Tidal energy developers are working with OERA, FORCE, and local industry to select the platform, cabling specifications, and appropriate sensors. The spring deployment will be a "brute force" solution – taking raw sensors and attaching them to the platform which will be connected with a cable running back to shore. The focus of workshop discussion will be to develop a good understanding and general consensus on the direction needed to enhance the platform and improve it for the next deployment in September 2020.

4.2 Experience with instream tidal energy monitoring solutions

- **Adaptable Monitoring Package (AMP) (University of Washington & Marine Institute)**

The University of Washington has been working on the AMP for the last eight years with the impetus being the deployment of two turbines in the Puget Sound and monitoring requirements. The initial concept was to attach instruments on an arm attached to a turbine, allowing one cable to be used for the turbine and instruments. However, this design evolved to meet the needs of the project – the system would need to be deployed and recovered on a regular basis and therefore a separate gravity bottom mounted platform was developed that could be deployed independently of the turbine.

The platform had over two years of in-water deployments with the system operating, allowing for issues such as corrosion, bio-fouling and data processing to be ironed out.

The current AMP has an ADCP, four hydrophones, two different sonars (Gemini, BlueView) acoustical camera, split beam echo-sounder, and two optical cameras. Development of the system progressed in three generations – putting all instruments in a single body, connection software and allowing for smart control, and real-time data processing for management and reducing data load (target detection and tracking).

The AMP has been deployed at PNNL Marine Science Lab (2017), Oregon Wave test site (AutoAMP), Hawaii (focus on wave energy integration), and Sequim.

- **FLOWBEC**

FLOWBEC was developed in 2010 in Scotland as a project aimed at identifying the physical conditions influencing the behaviour of fish, their predators, and benthic communities using developments in high resolution physical modelling and state of the art observation systems. The objective of FLOWBEC was to collect continuous data and to measure the flow and turbulence driving the behaviour, and therefore establish predictability of animal behaviour.

FLOWBEC is a completely self-contained platform with the ability to carry out baseline measurement or be deployed next to a turbine without the need for cable interfaces. It was developed with 66 kWh of modular and flexible onboard batteries, data processing and data storage. The sensors used on FLOWBEC are multi-beam echo sounder, ADCP, ADV, camera, and hydrophones. Software was developed to process different data streams and a deployment and recovery methodology was established. The biggest challenge has been working with developers' interface to bring data to shore.

- **Key discussion points and take-aways:**
    - **Integration:** Sensors on the same platform need to be synchronized and interface with each other (allow for "crosstalk"). This can be accomplished using a pinged scheduler in the system – sensors can also be pinged individually without interfering with each other. Having one instrument control throughout allows one sensor to trigger another. The AMP converts native data to fibre by connecting all sensors to a single bottle that uses

an umbilical back to shore. It is crucial to work with instruments having different capabilities in order to get the full picture (monitoring).

- ***There is a "crucial step" with integration and data processing, which is iterative and needs to be tuned in-situ.***

    - **Data management and bandwidth capacity:** From the AMP experience, a fibre option connection to shore was in place using a gigabyte of bandwidth with all different instruments running continuously and streaming data back to shore. This approach saves data in ringer buffers – essentially saving the last minute of data at any given time. It allows one to continuously look at both sonar images and optical imagery for marine life (i.e. fish, kelp, etc.). The system in place automated to acquire and write data to disc (previous 30 seconds and following 30 seconds). Depending on the site characteristics and how well algorithms are tuned, terabytes can be reduced to a few gigabytes a day.

      The AMP does not require a multiple gigabyte per second link to support requirements. This is only needed if there is a need for multiple camera sets. Under the current system, information is gathered at 10 frames per second and that is fast enough to do the data processing required. Projects having faster requirements (15-20 frames per second) would experience challenges.

- ***Tuning of algorithms is key step for both organizations to reduce data storage burden.***

    - **Practicality of autonomous systems:** An autonomous system is not a requirement of the platform being developed through the Pathway Program and there are concerns that one would not have the ability required to live stream data to meet regulatory requirements in a meaningful timeframe.

      Experience at University of Washington has demonstrated that battery and wave powered autonomous systems have allowed sensors to be operational for over 84% of the deployment, specifically due to the use of the wave power.

      FLOWBEC was designed with a self-contained platform that could be serviced independently and a cabled platform to get real-time feedback that relied on a lower bandwidth. FLOWBEC recorded continuously and when trying to focus on long-duration monitoring, automation is necessary.

- ***Autonomous systems are possible but not required or necessarily desirable for the Pathway Program.***

        - **Platform position and floating vs. bottom-mounted turbines:** Pan & tilt devices could be used to change orientation of instruments (sonar), but other platforms/observation systems (ONC, FAST, AMP, FLOWBEC) have noted that these have high failure rates.

To address different types of turbines that may be used at the FORCE site, having flexibility of changing field view of instruments is valuable. For the initial spring deployment, it may be useful to try different deployment methods for getting a good field view and determine how different backgrounds affect data quality.

- ***Pan & tilt will have issues and failures – not something that can be relied on.***

4.3 Integration Module Definition

Instruments identified to be used on the platform must be integrated in a way that optimizes performance. It is recognized that all instruments cannot all be on simultaneously and a key requirement will be identifying which ones interfere with each other or are synergistic and how to manage that.

- **Managing interference between instruments**
  - Ocean Networks Canada (ONC) pings every instrument every 10 seconds and turns off all other instruments that they are not pinging as they would interfere. To address challenges with acoustic interference on active ADCPs and other sounders, ONC uses a software solution that has proven successful.
  - FLOWBEC focuses on the same target using multiple instruments in order to measure behaviour, movement, etc. Pinging in 10 second intervals creates a risk that the target may be missed. Therefore, they interleave pings.
  - One common controller can be used to synchronize all instruments. While the spring “brute force” deployment of the platform will only have full manual control (with automation implemented in phase 2 or 3), there is an option of adding trigger lines to each of the acoustic instruments via the common controller. This allows the development of software that has synchronized control of the different instruments, creating the option to select either manual or trigger.

- ***It is imperative to have a system that can individually turn on instruments and power cycle individual instruments from shore***

- ***Cross-talk from multi-beam, ADCP, multi sensor, and hydrophones can be processed and filtered out, however some other types of instruments present challenges. Building hardware capabilities before deployment that can be controlled to trigger those instruments with a temporal offset delay between them helps to address the cross-talk problem.***

  - To avoid a hydrophone picking up echosounder transmissions, one could choose not record, duty cycle, or filter it out in processing. There is duty cycling to avoid interference and there is duty cycling (longer than 10 seconds).

  - Characterizing instruments and how they ramp up and their synchronization is important, as sometimes it takes an instrument awhile to get a ping out.

  - ***Pre-deployment testing is necessary – tank testing in particular, can assist with characterizing the instruments.***

- **Managing interference between instruments and marine life:** It is important to keep in mind that these systems and instrumentation can change behaviour of animals which needs to be minimized as much as possible. Two instruments that can affect animal behaviour are echo sounders and camera lights. In the US, there are regulations on how long an echo sounder can be active – they cannot run the 38 kilohertz split beam continuously unless there is a marine observer on shore monitoring for marine life (such as seals) nearby. The AMP used a 200 kilohertz echo sounder as it is outside the range of hearing for seals and safe to use.

  - ***The echo sounder being used for the spring platform deployment at FORCE should be evaluated to determine if it will interfere with marine animals being studied.***

- **Capability of cabling for the platform**
  The initial platform deployment at FORCE will have a common controller that will control a bank of converters. High voltage DC will be sent to the platform which can accept 200-400 volts. Onshore, each port can be manually isolated and therefore, cabling does not limit integration of instrumentation, nor any live tuning of the instrumentation.

  - ***Current design of the cabling does not limit integration of instrumentation, nor any live tuning of the instrumentation.***

- **Data processing:** Continuous monitoring (rather than interval/sporadic) is the direction for the spring platform deployment at FORCE. The AMP transmitted all data to shore and processed onshore. With a self-contained model, such as FLOWBEC, data is stored onboard and data processing happens as needed. FLOWBEC originally processed data in real-time in-situ but now transmits the data. Processing after allows the data to be processed a few times with the option of using different algorithms.

  For the spring deployment it makes sense to get as much data as possible and bring it to shore for processing. In the future, if autonomous deployments are a possibility, onboard processing systems would need to be explored. Having data on hand allows for it to be processed multiple times and to trying configuring algorithms to fine tune data processing.

  - ***For the spring deployment it makes sense to get as much data as possible and bring it to shore for processing.***

- **Influence of tidal cycle**
  The tidal cycle does have an impact on active acoustic devices and on flowing ices for passive acoustics. It may be advisable to change the instrument setting depending on the tidal cycle, but this depends on whether auto-intensity functions are being used versus fixed intensity. FLOWBEC uses adaptive algorithms to deal with flow noise and is willing to share

  ➢ ***Tidal cycle will affect the data quality. Current standard is to deal with this after data collection, and this may affect future deployment plans.***

4.4 Data Management

The spring platform system will be deployed for 60-90 days, gathering a lot of data – a plan to manage and process this data is required. Following is the estimate of how much data will be acquired:

- Hydrophones – 130 gigs per hydrophone per day (continuously)
- Echosounder – 1.4 gigs per day (10 sec ping once an hour)
- Sonar – 150 gigs per day (continuously)
- ADCP – not a significant volume of data

The AMP approach to managing a lot of data gathered was to target a timeframe, talk to the regulator, review the product specifications, and decide how much data is a reasonable amount to collect and store. Based on that determination, data can be duty cycled to a more reasonable amount (ex. collect 2 minutes of data every 15 minutes).

- **Data storage:** Currently, data from the platform will be transported onshore and collected at FORCE. However, the bandwidth at FORCE cannot handle the amount of data that will be gathered. Determination needs to go towards a more permanent solution for where data is stored. This may not be an issue for a 3 month deployment, but will be for a 15-year project.

  Potential options and solutions include:
    - At a university with real-time back-up/secure storage.
    - "Storinator" a technology developed by a Nova Scotia company that was designed for this type of application. (cost approx. $35k)
    - Develop processing algorithms and tune instruments for the initial deployment to ensure that a lot of data isn't gathered that won't be used.
    - Real-time processing an automation allows for large volumes of data to be managed.

  ➢ ***A data storage solution is required beyond the initial testing***

4.5 Data Processing & Analysis Needs

The spring deployment of the platform requires expertise, materials and human resources to analyze the data in the texting phase so that instruments can be tuned properly. Researchers with the capacity will need to be engaged effectively.

- **Software options for target detection and tracking**
  The AMP and FLOWBEC systems do not use the built-in software as it doesn't allow for proper tuning and doesn't give the best results. Both groups have written their own algorithms with improvements made monthly. Both groups are happy to collaborate on the Pathway program's development of their own algorithms.

- **Source data for algorithms**
  FLOWBEC and the AMP integrated and automated an echo sounder and multibeam sonar for source data. The echo sounder discriminates between ecological targets and physical sources. Multibeam sonar is used for target tracking, movement and behaviour. An ADCP can also be used to determine if a target is moving with the current or against it.

  - ***FORCE will likely need to develop their own algorithms during the spring deployment (with assistance from FLOWBEC and AMP) as algorithms are context dependent and need to be tuned in situ***

- **Automation for hydrophones**
  The AMP and FLOWBEC systems use an open source platform, Pamguard, that addresses most needs with automatic detection.

- **Processing analysis tools**
  Post-processing of data can be very time-consuming manually and is very subjective. The analysis aspect of it needs to be focused on answering the right questions once you have the post-process data – this can vary. The Pathway Program will need to concentrate on the questions that need to be answered – beyond blindly collecting data.

  - ***Data analysis must be planned from the questions needing to be answered. The Pathway program is focussed on 3 metrics for both fish and marine mammals:***
    - ***Abundance***
    - ***Frequency***
    - ***Distribution within the water column***

- **Human resources/expertise to manage/analyze data**
  It will likely be a challenge to identify and secure the expertise to assist with processing, analyzing and managing the data collected from the platform. FORCE has some internal capacity for manual post-processing of hydro-acoustic data and will be exploring options for analysis of the hydro-acoustic data. AMP identified that it was extremely difficult to handle the volume of data after it had been collected instead of as it was being collected.

  DeepSense has been working with FORCE on a project – automating acoustic processing of data (Ecoview). As DeepSense will have human resource capacity (students and post-docs joining), it may have capacity to assist with this aspect of the Pathway Program.

- ***There is an immediate need for expertise to develop and tune algorithms in preparation for and during the spring deployment.***

- ***There is a need for human resources both during and immediately following the spring deployment for data management and analysis.***

5.0 Next Steps

The Cabling and Platform Development for High-Flow Marine Sites workshop achieved a productive discussion with experts and industry, identifying key areas for consideration as OERA and FORCE move forward with the Pathway Program.

As part of the Pathway Program, there will be additional workshops held that focus on other key aspects of the program.