User Manual for the Study Design Tool to Inform Deployment of Motus Automated Radio Telemetry Stations on Offshore Wind Turbines

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The Study Design Tool for which this User Manual was written is available at:
https://briloon.shinyapps.io/auto_radio_telemetry_Shiny_tool/

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Disclaimers

Acknowledgements

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Citation

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Background

Automated radio telemetry systems consist of radio tags (small transmitters attached to birds, bats, or insects) and stations (receivers with antennas that record signals from "tagged" organisms within detection range; Figure 1). The Motus Wildlife Tracking System[1] ('Motus') is an international collaborative research network that uses cooperative automated radio telemetry to track tagged organisms on coordinated frequencies (currently 166.380 MHz and 434 MHz in North America). Collaborators using Motus have collectively tagged tens of thousands of birds and bats and tracked their movements using an international network of automated radio telemetry stations. Motus also serves as a hub for data from thousands of receiving stations and tagged animals worldwide representing hundreds of species.

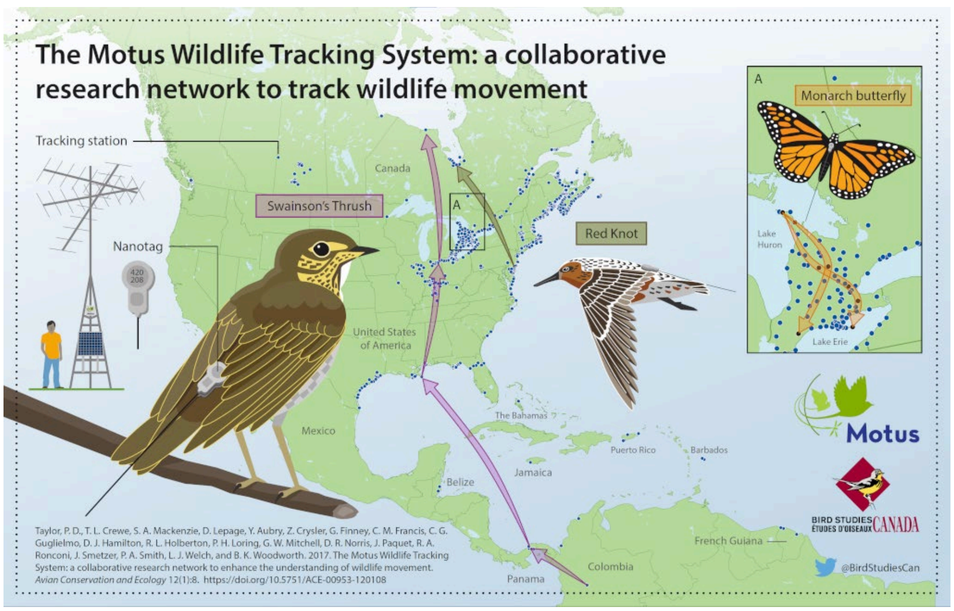

Figure 1. The Motus Wildlife Tracking System.

This user manual and the associated study design tool are part of an effort to develop standardized protocols for the use of Motus in pre- and post-construction monitoring for birds and bats at offshore wind energy projects. Detailed protocols will enable the offshore wind industry to use standardized approaches to monitor a wide range of avian and bat taxa, including threatened and endangered species, and improve our understanding of how these species use offshore environments. This effort, titled "Development of Monitoring Protocols for Automated Radio Telemetry Studies at Offshore Wind Farms[2]," includes the following components:

- Monitoring framework – strategic framework and guide for using Motus technology to monitor wildlife in relation to offshore wind energy development;

[1] https://motus.org/
[2] https://briwildlife.org/offshore-motus-guidance/

- Guidance document – detailed guidance for setting up and operating Motus stations on offshore wind turbines and buoys;
- Online study design tool – interactive tool to help arrange arrays of Motus stations to optimize site-specific study designs at offshore wind projects and map detection coverage of offshore receiving stations;
- Simulation study – modeling study using animal movement data to inform estimates of detection and uncertainty using Motus technology;
- Motus Data Framework – centralized framework and portal to coordinate data within the Motus Wildlife Tracking System from all birds and bats detected by stations on offshore wind turbines, monitoring buoys, and receiving towers along the Atlantic coast and Outer Continental Shelf (OCS).

All products from this effort are publicly available on the project webpage[3] (and at the AMBC page?). The products are intended to be living documents that are updated as new information and technology becomes available.

The free online Motus Study Design Tool was developed to help optimize site-specific study designs at offshore wind energy facilities, including the number and locations of receiving stations necessary to cover a given project area relative to factors such as the project size and configuration, key species and questions of interest, and specific Motus technology being used. Input on the design of the tool, as well as beta testing of earlier versions of the tool, were solicited from a range of offshore wind-wildlife stakeholders to help ensure its robustness and utility. A partial list of these contributors is included in Gulka et al. (2021). For detailed, standardized recommendations on the actual deployment of Motus stations on offshore structures, including reference guides, recommended station configurations for offshore wind turbines and buoys, and equipment specifications, please see "Guidance Document for Deploying Motus Automated Radio Telemetry Stations on Offshore Wind Turbines and Buoys" (Loring 2022). For additional detail on the simulation study used to inform to determine the effectiveness of nanotag receiver arrays in detecting movements of birds in and around offshore wind farms under varying designs and conditions, and with different focal species of interest... see Adams et al. (2022). A final report for this effort will be submitted to NYSERDA in September 2022 and will be available at nyserda.ny.gov/publications.

How Motus Stations Work

More information on the components, setup, and operations of Motus stations can be found in Loring 2022 guidance doc. There are also a variety of resources available on the Motus Wildlife Tracking System website[4]. It is assumed that users of the study design tool have a basic level of familiarity with the design and components of these stations.

Q: Does the detection range of receivers vary vertically vs. horizontally?

A: Yes. A Yagi antenna has a long elliptical detection pattern with the maximum detection distance directly in front of it along the horizontal direction with lower detection distance above it. Yagis also have small side and rear lobes that can detect animals at the side and rear of the antenna array. Omni antennas have patterns more like a donut. Field detection patterns of 434

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[3] https://briwildlife.org/offshore-motus-guidance/
[4] https://motus.org/resources

MHz are currently being studied by the team at the University of Rhode Island to be able to demonstrate the in-situ pattern around a receiving station using the recommended antenna setup for offshore turbine deployment.
As discussed in Loring 2022 monitoring framework, while there are pros and cons to each of these frequencies, there are several distinct advantages to using the 434 MHz frequency offshore. It should also be noted that it is possible to design stations to monitor both 166 and 434 MHz frequencies at the same time (Loring 2022 guidance doc).

Applications of Motus Technology to Inform Offshore Wind Energy Development

Applications of Motus receiving stations offshore include:

- Collecting data on small-bodied species for which other types of transmitters are not feasible options, including protected species such as Piping Plover, Red Knot, and Roseate Tern.
- Collecting coarse-scale data on occupancy, macro-avoidance, and space/habitat-use.
- Collecting fine-scale data on flight paths and flight altitudes (attainable with sufficient antenna coverage, as fine-scale location data requires that two or more receivers detect the animal simultaneously; Paton et al. 2021).
- Opportunistic monitoring of non-target species tagged by other Motus collaborators.
- Collecting data to inform collision risk models (one such model using Motus data is under development in 2022 with funding from the Bureau of Ocean Energy Management).

However, it should be noted that uses of the data requiring finer-scale resolution (e.g., that require reasonably accurate three-dimensional location estimates) may require additional technological or analytical development to be adequately addressed using Motus. In general, limitations of Motus technologies include:

- Tag detections are limited by the location and/or capabilities of the receiving station.
- Antenna coverage is affected by many factors, including antenna type and number, antenna altitude, configuration, gain, and behavior of the tagged animals (including flight height), among other factors.
- Metal or other types of objects may block tag detection. Electromagnetic interference may also reduce antenna coverage. Therefore, due to small-scale differences in the environment, each site needs ground-truthing of receiving station detection ranges.

As a result, automated radio telemetry is not a viable approach for answering fine-scale questions relating to micro-avoidance and collisions; Motus simply does not provide the three-dimensional spatial resolution required. Likewise, Motus technology is not useful for species that spend most of their time at the water's surface (such as waterfowl), as species must spend most of their time aloft in order to be adequately detected.

Identifying a clear goal for Motus studies is important, as very different scales of information are required to estimate occupancy in an area vs. assessing habitat use or flight paths. Study design – including how many stations are used and in what spatial configuration, the number and type of antennae on each station, and the frequency of antennae/tags used – all have a strong influence on the effectiveness of Motus technologies for meeting study goals. Characteristics of the focal species (e.g., how the species of interest moves through the environment, heights at which they typically fly, and whether they spend a lot of time resting on the water) should also be carefully considered.

Overview of the Tool

The study design tool is intended to assist users in designing an array of Motus receiving stations that can be deployed on the turbines of an offshore wind energy facility. The tool provides 3-D models of station detection ranges, based on user-specified station and antenna placement within a wind-farm layout, and models of tag movement through the modeled antenna array to determine the effectiveness of the array at detecting Motus transmitters moving through or around the project footprint. Varying the antenna array design allows for estimates of tag detection volume within the project area for iterated layout designs, determination of optimal layout and antenna coverage within a wind farm area, and the identification of viable study design alternatives based on changes in study objectives or other factors.

The overall goal is to develop a freely available interactive tool that provides study design guidance based on the objectives of the study and other parameters such as the bird or bat species of interest, details of the study area (including locations of turbines or other platforms), and details of the antenna array. With these and other input data, the tool produces a map of antenna coverage and data on estimated detection probability for animals moving through the area at different flight heights.

The study design tool was built using the publicly available web application Shiny[5]. A user interface (UI) allows the user to specify parameters such as species data; wind farm-specific parameters, including turbine size and spacing and size of the wind farm; Motus receiver parameters and antenna type; and study objective. Outputs include the ideal distribution and number of receiver antennas, antenna height and orientation, and other study-specific outputs.

A back-end statistical model and empirical data gathered from prior and ongoing studies (Carlson 2022?) estimating nanotag signal range based on location of animal (height, distance and angle) relative to receiver towers with different parameters and antenna types.

Tool Assumptions

The tool currently assumes that other turbines do not affect detection rates. However, we know that metal turbine structures block tag detections, and that electromagnetic interference from the turbines can reduce antenna range. Thus, tool detection ranges should be interpreted to some degree as best-case scenarios dependent upon careful placement of stations and antennas to avoid as much interference as possible (for more information, see Loring 2022 guidance doc).

Q: Are the range estimates used based on land-based tests?
A: Yes. Offshore tests are required to improve the accuracy of these range estimates.
Q: Do the detection polygons produced by the tool represent maximum detection distance?
A: Yes. Depending on what you set the sensitivity of the receiver to (min. signal strength required for detection), the detection polygon will change to reflect that.

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[5] https://shiny.rstudio.com/

Q: Can the detection polygons be output in 3D?
A: Three-dimensional mapping is not planned as part of this project, but Rob DeLuca (URI) indicated that he could share images that could be included in the tool to help users understand the results.
Q: Can the volume of air within the predicted detection polygons be estimated?
A: Not currently, as the tool would need a 3D estimate to calculate the volume. It may be possible to add.
Q: Has detection probability been modelled as a function of distance (i.e., such as it done with point data)?
A: Not yet. This is a hoped-for goal of the project.
Q: Does tag detection range vary substantially by size and/or type?
A: A single tag type has been focused on so far. Studies in 2021 are planned to test various tags. However, the main focus is on the difference between the two frequencies rather than on differences between tag types for a given a frequency.

BRI provided a demonstration of the tool via webinar on XXXXX, 2022. A recording of this webinar is available at (direct link to Youtube video).

User Manual

The current focus of the tool is modelling various positions and numbers of receivers within a turbine array to estimate detection rates of modelled animals, with the goal of informing and guiding those who are setting up such receiver arrays in the offshore environment. However, modelling the many different factors that impact receivers is challenging, and the speakers reiterated the importance of ground-truthing the detection ranges of receiving stations once they have been deployed.

Tool Inputs:
- *Study area information*. Inputs required to create the offshore wind area of interest include latitude, longitude, infrastructure size, and turbine spacing. Antennas can then be placed manually within the array. Alternatively, study areas with antenna locations can be uploaded as shapefiles. Additional data layers can also be shown on the tool's map viewer, including the existing Motus network (with data on each Motus station), and Bureau of Ocean Energy Management offshore wind lease and planning areas.
- *Antenna information*. Antenna inputs include the number of antennas, antenna direction height, frequency, and type, from which detection pattern is calculated. Receiver parameters are also important and included as well.
- *Flight height.* The tool provides detection patterns at designated flight heights identified by the user.

Tool Outputs:
- *Detection polygons,* which are visualized on the map viewer and include estimated maximum detection range and total area of coverage.
- *Optimized coverage* of a location with a predetermined number of antennas within the chosen study area. The angles of the antennas are listed so the user can recreate the study design in the field.

screenshots showing the various data screens

Review of inputs/outputs to assist with understanding how the tool can be used

Next Steps

Due to the limited number of Motus tags that can be deployed relative to wildlife populations, and the necessarily limited temporal and spatial sample that tagged animals represent, study design plays a key role to inform placement of receivers in strategic locations and thus maximize the value of tagged individuals. While the study design tool currently focuses on the placement of stations within individual wind farms, there is a clear need for coordination of study designs among offshore wind energy facilities, particularly for adjoining lease areas. Where possible, coordination of station placement across facilities will help to further optimize Motus telemetry studies to detect tagged individuals. It is strongly recommended that users collaborate and include more than a single facility's turbine locations in tool uploads, where possible, to develop coordinated study designs. Future iterations of the tool may further facilitate this type of regional-scale study design.

Updates to the Tool

Users experiencing problems with the operation of the tool should contact Andrew Gilbert at Andrew.gilbert@briwildlife.org. Updates to the tool and/or this user manual will be published at the following locations:

- https://briwildlife.org/offshore-motus-guidance/
- https://briloon.shinyapps.io/auto_radio_telemetry_Shiny_tool/

Citations

Adams 2022 simulation study

Carlson 2022 calibration data

Gulka, J., E. Adams, A. Gilbert, E. Jenkins, P. Loring, and K.A. Williams. 2021. Stakeholder Workshop: Online Study Design Tool for Informing Offshore Deployment of Automated Radio Telemetry Stations. Report for New York Energy Research and Development Authority. 11 pp. Available at https://briwildlife.org/offshore-motus-guidance/

Loring 2022 guidance document

Loring 2022 monitoring framework

Paton PWC, Cooper-Mullin, C., Kouhi, S. Loring PH, Moore J, Miller J, Potty G. 2021. Assessing movements of birds using digital VHF transmitters: A validation study. OCS Study BOEM 2021- 009. Report to U.S. Department of the Interior, Bureau of Ocean Energy Management, Stirling VA. 222 p. Available at https://espis.boem.gov/final%20reports/BOEM_2021-009.pdf.