

Form 442 Question 4: Government Project Description

Applicant's Name (company): Woods Hole Oceanographic Institution

File No.: 0062-EX-CM-2018

Contact: Dr. Anthony Kirincich (akirincich@whoi.edu)

The investigator, Kirincich, has multiple awards from the **Directorate for Geosciences** of the **National Science Foundation** that involve observing the surface circulation of the coastal ocean using HF radar technology:

- (1) An Interdisciplinary Research in Hazards and Disasters (Hazards SEES) project titled: "Uncovering the Hidden Skeleton of Environmental Flows: Advanced Lagrangian Methods for Hazard Prediction, Mitigation, and Response." MIT is the lead institution on this project (Prime Award No. EAR-1520825) with WHOI/Kirincich a sub-awardee of MIT.
- (2) A collaborative research project from the Physical Oceanographic section of Geosciences titled: "Resolving complex coastal flows via advances in high-frequency radar" (OCE-1657896). Kirincich is a co-PI with Washburn from UCSB.

Form 442 Question 6: Description of Research Project

Applicant's Name (company): Woods Hole Oceanographic Institution

File No.: 0062-EX-CM-2018

Contact: Dr. Anthony Kirincich (akirincich@whoi.edu)

Part A: A description of the nature of the research project being conducted.

The investigator, Kirincich, is a physical oceanographer that uses HF radar technology to sense surface circulation of the coastal ocean. Kirincich has multiple awards from the Directorate for Geosciences of the National Science Foundation (described in Question 4) that involve observing the surface circulation of the coastal ocean using HF radar technology. The present license request would allow work to proceed on two main fronts:

- (1) Collection of surface current data in support of an Interdisciplinary Research in Hazards and Disasters (Hazards SEES) project examining the role of Lagrangian Coherent Structures for Oceanic and atmospheric hazard assessment, modeling, and prediction. MIT is the lead institution on this project and WHOI/Kirincich is a sub-awardee.
- (2) Advanced research on surface current extraction methods from HF radar data sets. This work will use the data from the 8-receive channel UH-built systems to evaluate and/or develop direction-finding algorithms to increase the resolution and accuracy of surface current extractions.

Additionally, Kirincich is developing extraction algorithms for surface wind speed and directions from the backscattered power of the HF radar systems. This research will continue using the proposed license.

Part B: A showing that the communications facilities requested are necessary for the research project involved.

First, the bandwidth of 16.1-16.2 MHz is an approved bandwidth for HF radar transmissions for use in observing the coastal ocean as defined within the recent ITU WRC-2012 definitions.

The goals of both projects will be satisfied using the proposed facility, operated at 16.1-16.2 MHz, for the following reasons:

1. Project 1 requires surface current data at ranges of 80 km and resolutions of ~1.5 km, which is within the capabilities of HF radars operating at frequencies of 16 MHz. This combination of range and resolution is not available at other frequency bands approved for HF radar surface currents (25 or 13 MHz).

2. Preliminary tests have shown that background noise at 13 MHz in the region would prevent data collection at accuracies sufficient for Project 1 to achieve its observational goals.
3. Project 2 requires the use of the multi-channel University of Hawai'i-built system. As planned, the project will test the combination of a simplified 8-element array in two different configurations along with MUSIC processing techniques to provide cost-effective, high spatial resolution sampling. Two separate tests will be made, deploying the receive array in both a traditional ULA as well as a compact circular array pattern. Preliminary work using existing systems in the region, with transmit frequencies of 25 MHz, have shown that second order scattering from the ocean surface is an important aspect of this research. Operating at a lower frequency (16MHz) will allow us to make direct comparisons of the effects of the second order noise on the surface current extractions.
4. Kirincich is developing extraction algorithms for surface wind speed and directions from the backscattered power of the HF radar systems. In previously published work (Kirincich, 2016, *J. Atmos. Oceanic Technol.*) Kirincich suggested that accuracies of the wind speed extractions could be lowered by using the observations of multiple frequencies of HF radar. This hypothesis can be tested using the results from a 16 MHz system in combination with the results of existing systems in the region operating at 25 or 5 MHz.

Part C: A Showing that existing communications facilities are inadequate.

As described above, existing HF radar systems in the region, operating for surface current extractions, use transmit frequencies of 25 or 5 MHz. The combinations of ranges, range resolution, Doppler frequency resolution, and noise properties are inadequate to achieve the goals of all three research aims described here.

It should be noted that the requested bandwidth is an approved bandwidth for ocean observations established in the WRC-2012 results. Additionally, a search of other experimental licenses within the region, shown below using 16-16.5 MHz as the search criteria, finds no other existing licenses for 16.1-16.2 within a 100 km radius

Search Criteria: Frequency Range = 16 MHz through 16.5 MHz, Computed Box Based on Point/Radius: Center = 41° 21' 0" N 70° 40' 0" W, Radius = 200 Kilometers
Currently Licensed and Pending Facilities

OET Experimental Licensing System Database							
Call Sign: WF2XMP	File Number: 0224-EX-ML-2015	Licensee: Rockwell Collins, Inc.	FRN: 0004383329	Issue Date: 11/30/2015	Expiration: 06/01/2017	Radio Service: XD	Status: Granted
Site Address: 1370 Quogue Riverhead Road, Flanders		State: NY	County: SUFFOLK	Fixed Coordinates: 40° 52' 54" N 72° 38' 15" W Distance from Center: 173.5 Kilometers Azimuth from Center: 253.1°			
Frequency: 16160.00000000 - 17450.00000000 K							
Call Sign: W12XER	File Number: 0014-EX-CM-2017	Licensee: Skycast Services LLC	FRN: 0025141839	Issue Date: 03/02/2017	Expiration: 03/01/2018	Radio Service: XT	Status: Granted
Site Address: 95 Lidge Drive		State: NY	County: SUFFOLK	Fixed Coordinates: 40° 50' 32" N 73° 2' 21" W Distance from Center: 207.1 Kilometers* Azimuth from Center: 254.9°			
Frequency: 16.20000000 - 16.36000000 M							
Site Address: 1370 Quogue Riverhead Road		State: NY	County: SUFFOLK	Fixed Coordinates: 40° 52' 53" N 72° 38' 14" W Distance from Center: 173.5 Kilometers Azimuth from Center: 253.1°		Mobile Coordinates: 40° 52' 53" N, 72° 38' 14" W Distance from Center: 173.5 Kilometers Azimuth from Center: 253.1°	
Frequency: 16.20000000 - 16.36000000 M							
Call Sign: WH2XCI	File Number: 0027-EX-CM-2016	Licensee: The MITRE Corporation	FRN: 0023375751	Issue Date: 12/06/2016	Expiration: 10/01/2018	Radio Service: XD	Status: Granted
Site Address: 202 Burlington Road		State: MA	County: MIDDLESEX	Fixed Coordinates: 42° 30' 12" N 71° 14' 12" W Distance from Center: 136.5 Kilometers Azimuth from Center: 340.0°		Mobile Coordinates: 42° 30' 12" N, 71° 14' 13" W Distance from Center: 136.5 Kilometers Azimuth from Center: 340.0°	
Frequency: 16000.00000000 - 17900.00000000 K 16000.00000000 - 19995.00000000 K							