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August 5, 2016

Dr. Robert Headrick
ONR Code: 332
Office of Naval Research
875 North Randolph Street
Arlington, VA 22203-1995

Dear Dr. Headrick,

Attached please find the progress report for ONR Contract N00014-14-C-0230 for the period of January 20, 2016 to April 19, 2016.

James C. Preisig
President, JPAnalytics LLC

CC: DCMA Boston
DTIC
Director, NRL

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Progress Report #8

Coupled Research in Ocean Acoustics and Signal Processing for the Next Generation of Underwater Acoustic Communication Systems

Principal Investigator's Name:	Dr. James Preisig
Period Covered By Report:	1/20/2016 to 4/19/2016
Report Date:	8/5/2016
Contract Number:	N00014-14-C-0230
Firm Name and Address:	JPAnalytics LLC 638 Brick Kiln Road Falmouth, MA 02540 jpreisig@jpanalytics.com (508) 566-0236
Program Officer:	Dr. Robert Headrick ONR Code: 322 Office of Naval Research 875 North Randolph St. Arlington, VA 22203-1995 Robert.Headrick@navy.mil
Security Classification:	Unclassified
Distribution Statement:	Approved for public release. Distribution is unlimited.
Total Contract Amount:	$595,731
Costs Incurred This Period:	$31,756.66
Costs Incurred To Date:	$312,923.55
Estimated Costs To Complete:	$282,807.45

1. **Description:** Technical work this period has spanned two areas. The first of these is VHF Acoustics. During this time period, the Principle Investigator worked with Dr. Grant Deane at the Scripps Institution of Oceanography to conduct a second VHF acoustics wave tank experiment. Using experience from the first full experiment conducted in October 2015, Dr. Deane designed and fabricated a new array mounting mechanism that was able to maintain stability to on the order of millimeters in the tank with wind speeds up to 16 meters per second. The data from the experiment was all quality checked and found to be of very high quality. Quality check results are discussed more fully in the Results and Recommendations section of this report. Numerous insights were gained from the analysis and are described more fully in the Results and Recommendations section of this report. In parallel, the Principle Investigator continued to work with vendors to develop a new field deployable system for collecting VHF acoustic data in a wide range of environments. This work falls under Research Task 2 from Section 2.2 of the Technical Approach and Justification.

   The second area of work involved the continued development and convergence analysis of new methods of applying reduced-dimensional inference algorithms to improve the performance of or reduce the computational complexity of coherent equalizer adaptation algorithms. This is joint work with MIT/WHOI Joint Program Student, Atulya Yellepeddi and is motivated by the desire to exploit lower dimensional structures in acoustic communications data, specifically frequency domain transformations of received communications signals, to achieve the specified improvements. The work this quarter focused on the continued development and analysis of an Expectation Maximization (EM) based technique that exploits a proposed graph structure of the data to improve performance. This work falls under Research Task 3 from Section 2.2 of the Technical Approach and Justification.

2. **Major Accomplishments this Period:** The successful SIO tank experiment without any significant motion of the array mounting mechanism was a major accomplishment during this time period.

3. **Results and Recommendations:**

   The March 2016 VHF acoustic wave tank experiment was conducted for two primary reasons. The first was to redo the tests of October 2015 but with an array mounting mechanism which remains stable (i.e., no vibration) at the wind speeds used in the experiment. The second purpose was to conduct the tests up to higher wind speeds to determine of the apparent plateauing of some quantitative signal characteristics with increasing wind speed at the upper limit of the usable wind speed of 7 m/s was indeed occurring or was an artifact of the experimental conditions. Thus, in the second experiment (March 2016) a new array mounting mechanism was used and the tests used wind speeds of up to 16 m/s.

Preliminary analysis and quality checking of the data indicates that both purposes were achieved. Figure 1 shows the measured channel scattering function of the direct (approximately 0.02 ms delay) and the first surface bound (starting at approximately 0.065 ms delay) arrivals. The scattering functions clearly show that the Doppler Spread of the direct arrival remains small as the wind speed increases. This clearly indicates that the array mounting mechanism is remaining stable throughout the range of tested wind speeds. The asymmetry of the channel scattering function at the higher wind speeds that was observed in the first experiment is clearly still present.

Figure 2 shows the calculated Doppler shift (mean of the Doppler profile) and spread (standard deviation of the Doppler profile). The results whos that the Doppler shift of the direct arrival is essentially zero and the spread remains stable at approximately 2.5 Hz with only a small rise at higher wind speeds. This indicates that the mounting mechanism does indeed remain reasonably stable as predicted from the observation of the scattering functions. The asymmetry of the scattering function as quantified by the mean Doppler shift appears to plateau at about - 5 Hz above about 7 m/s wind speed while the Doppler spread quantified by the standard deviation of the Doppler profile continues to increase with up to the maximum wind speed used of 16 m/s. The detailed analysis of the data from this experiment will be conducted over the next 12 months.

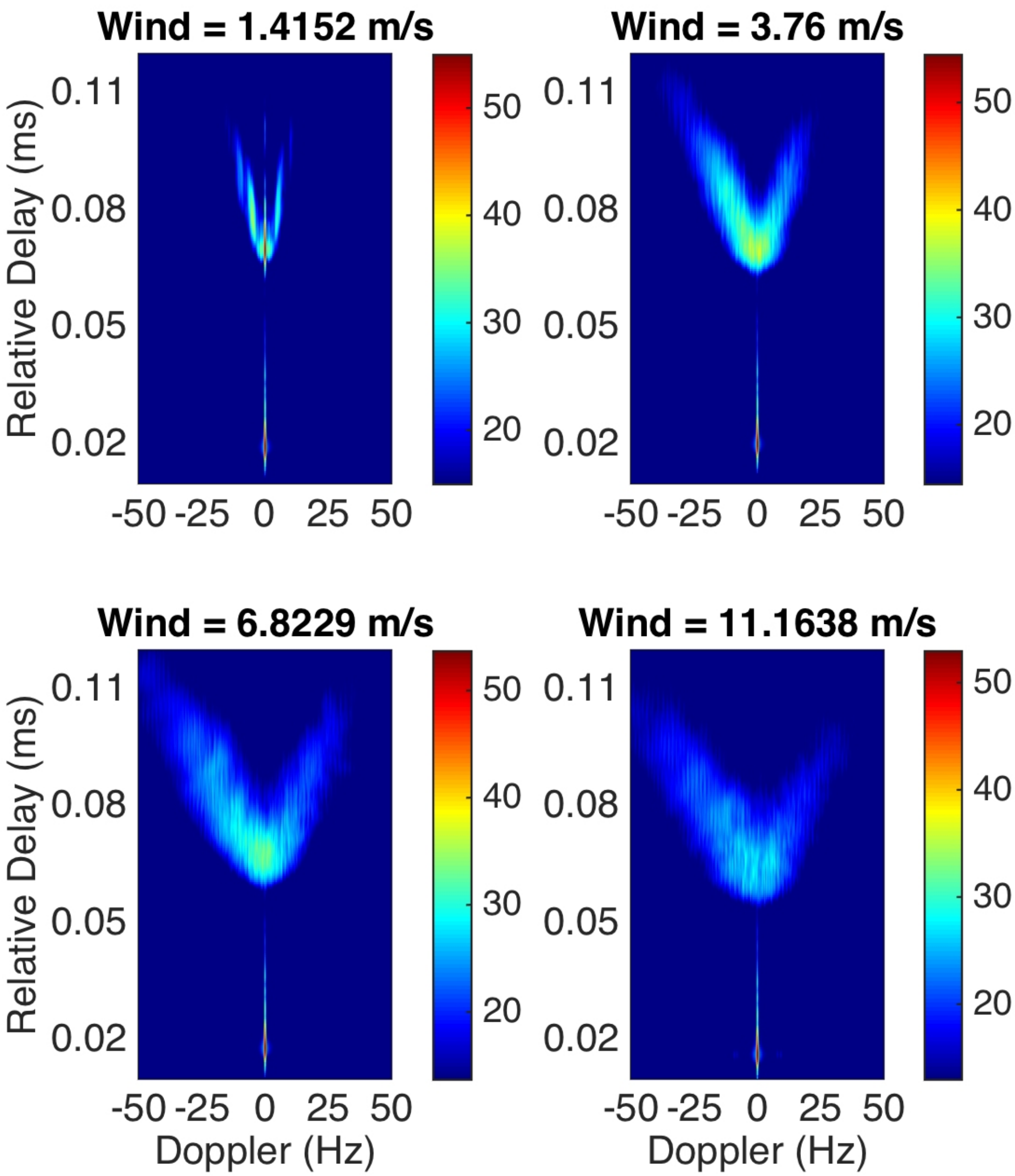

Figure 1: Sample Channel Scattering Functions for Different Wind Speeds

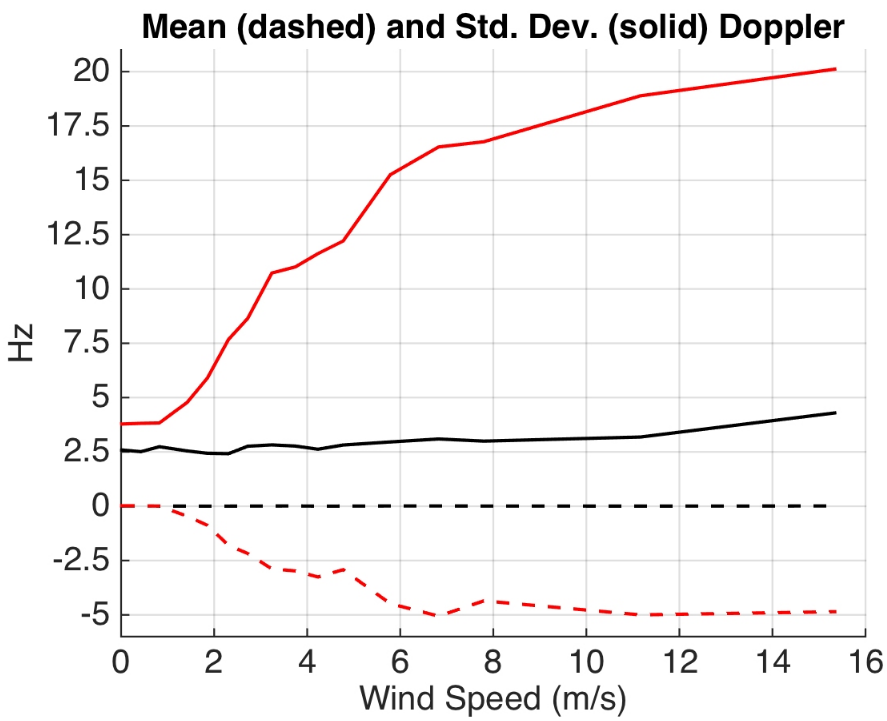

Figure 2: Doppler Shift (dashed lines) and Spread (solid lines) of the Direct (Black) and First Surface Bounce (Red) Arrivals

4. **Publications and Presentations:** None during this period.