Test Report of

U.R.I. DLM ANTENNAS

By The

NAVAL UNDERSEA WARFARE CENTER
Of
Newport, Rhode Island

At

The NUWC
Fishers Island, New York One MileTest Range

March 31, 2005

Robert Vincent
Dept. Physics
University of Rhode Island
Kingston, RI 02881

The following are test results and data for the Testing of URI DLM antenna by the NUWC of Newport, RI at their Fishers Island, N.Y. one mile test range. These measurements and testing were performed on March 31, 2005 and done by NUWC personnel with URI personnel assisting in antenna assembly and installation.

The NUWC one mile range consists of a salt water pool, 50 feet in diameter with a radial system located in the pool and exceeding beyond the pool for considerable distance. This is a world class installation and the only one of its kind anywhere in the world.

The range is calibrated for the measurement of antennas in the low high frequency to low very high frequency range. All the equipment used for testing is located under the pool in an underground facility. There are no above ground buildings or structures that can affect antenna performance in anyway. Entrance to the underground facility is through a circular hatch near the pool area down a vertical ladder system. All electrical lines are located and fed to the facility through underground ducts so as not to interfere with measurements.

Data for antennas under test is relayed back to the main facility using UHF telemetry data links. All the testing and control as well as data are performed using onsite computers. A range calibration is done for each individual measurement.

Indicated data shows this to be extremely accurate and well managed facility with all equipment calibration and certification traceable back to the National Institute of Standards. The overall data error of this facility is less than 0.2db. in any one measurement.

The test equipment consist of a computer controlled generator and amplifier located inside the facility. A coax cable is run up an access pipe to the center of the pool. Here all the radial and ground system is connected central to the antenna under test mounting position. One mile from this location over salt water ocean path is located the sense and measurement equipment. This equipment is computer controlled through a bi directional UHF telemetry link. You can view the paper written by NUWC personal at http://www.amta.org/StaticFiles/PDF/amta_2002/session%2013/a2002-13-02-072.pdf

The antenna feed coax cable is characterized using a network analyzer and its loss over length for frequency is plotted. These cable loss figures are noted and applied to measurements made at the various test frequencies. They are indicated in a table below.

Cable loss numbers for NUWC antenna test:

The table below indicates coax cable loss for the cable connecting the antenna from the NUWC test set. These numbers have to be added to the measured result indicated in gain calculations. In addition, I have done a preliminary tabulation of antenna efficiency compared to the NUWC test monopole. Adding the cable loss to the antenna under test column and then dividing by the reference antenna level indicates percent of efficiency as compared to the NUWC reference monopole. The reference monopole can considered as a perfect monopole operating over a perfect ground system. NUWC calculates this reference antenna level over their calibrated one mile range.

| Frequency | Cable loss db |
|---|---|
| 3.54 MHz | 0.84db |
| 7.0 MHz | 1.20db |
| 10.1 MHz | 1.45db |
| 14 MHz | 1.73db |
| 27.5 MHz | 2.48db |

Using these numbers, the antenna gain for each type of antenna tested is listed below

| Antenna type | Gain db** |
|---|---|
| 7MHz Plano Spiral Top Hat "Super DLM" | +.06db |
| 7 MHz Capacity Top Hat DLM | -0.81db |
| 7 MHz Standard DLM #1 | -1.71db |
| 7 MHz Standard DLM #2 | -1.56db |
| 7MHz Plano Spiral Helix DLM with 3D Load Coil. | -1.91db |
| 7 MHz Flat 3D helix with Plano Load Coil | -0.43db |
| 10 MHz Standard DLM #1 | -1.14db |
| 10 MHz Standard DLM #2 | -1.37db |
| 3.5 MHz Standard DLM | -2.33db |
| 14MHz Plano Spiral Helix DLM With 3D load coil | -2.54db*** |
| 28MHz Plano Spiral Helix DLM With 3Dimensional Load coil | -4.12*** |

Note: ** These figures are compared to the NUWC reference monopole antenna.
*** These antennas are an experimental design and not optimized for maximum performance. The total height of these antenna is approximately 3-5 feet and was mounted a considerable distance above the reflected ground plane for its given height and operating frequency. Antennas of this type should be mounted higher and using elevated radial systems such as used in a ground plane antenna.

Percentage of operating antenna length as compared to a ¼ wave monopole is indicated below. .

| Antenna Type | %1/4 wave |
|---|---|
| Plano Spiral Top DLM (super DLM) | 50% |
| Top Hat DLM | <30% |
| Standard DLM | 33% |
| Plano Spiral Helix DLM | <33% |
| 3D Flat Helix DLM | approx 40% |

Bandwidth of antenna varied from a low of approx 3-5% of operating frequency for a standard 3.5 MHz DLM to approximately 15% of operating frequency for the Plano Spiral Top DLM (super DLM). The Top Hat DLM with load coil at a height of approximately 10 feet or less than 30% of a standard ¼ wave monopole was 350 KHz at an operating frequency of 7 MHz or 5%.

Indicated -3db bandwidth of each antenna is indicated below.

| Antenna type | Bandwidth noted |
|---|---|
| 7MHz Plano Spiral Top Hat "Super DLM" | 1.100 MHz |
| 7 MHz Capacity Top Hat DLM | 0.310 MHz |
| 7 MHz Standard DLM #1 | 0.160 MHz |
| 7 MHz Standard DLM #2 | 0.400 MHz** |
| 7MHz Plano Spiral Helix DLM with 3D Load Coil. | 0.180 MHz |
| 7 MHz Flat 3D helix with Plano Load Coil | 0.430Mhz |
| 10 MHz Standard DLM #1 | 0.300 MHz |
| 10 MHz Standard DLM #2 | 0.280 MHz |
| 3.5 MHz Standard DLM | 0.100 MHz |
| 14MHz Plano Spiral Helix DLM With 3D load coil | 0.200 MHz*** |
| 28MHz Plano Spiral Helix DLM With 3Dimensional Load coil | 1.000 MHz*** |

*** See note above

Summary:

Several antenna types, all using DLM technology were tested by personnel of the Naval Undersea Warfare Center at the one mile range located on Fishers Island, New York. Several of these antennas are recent developments and are still undergoing design and variations to improve performance. Several antennas tested such as the 7 MHz DLM used helix designs using variations in material. These are indicated by giving better performance in either gain or bandwidth. This information for now is held proprietary by the University of Rhode Island. Several of the antennas such as the Plano Spiral Top Hat design for 7 MHz are still under development and continuing improvement. The improvements consist of retaining the current performance while reducing size. There have been several PSTH designs developed for the 3-6 MHz frequency range but could not be tested at NUWC due to the large size of the top hat. (In some cases 10 to 12 feet in diameter and could not easily be transported to Fishers Island. In addition, none of the lower frequency antennas such as the 1.8 MHz 3 dimensional helix DLM and the 1.8 Mhz Plano spiral helix DLM's were tested. The cost and time of transporting and erecting these antennas were beyond the scope and budget constraints of this particular effort.

The antennas tested indicate excellent performance despite their small size. When you compare the performance of these antennas with a commercial antenna of like size used for mobile applications, you can see the increase in performance. Also it should be noted that the survivability of the commercial antenna operating on a low loss ground system is probably very limited and will end up destroying itself in short time. All the antennas tested have been operated with power levels exceeding 1000 watts for extended periods with no ill effects. This is probably due to their high efficiency in which a majority of the power is radiated rather than wasted in heating up the antenna and its associated components.

The majority of this development was done with limited funding and new discoveries and designs resulting in further improvements are being made all the time.

None of the VHF, UHF and microwave 2 and 3 dimensional antennas were tested at this US Naval facility. Also, there were no vertical elevation patterns or H plane measurements made. The performance of these antennas in these areas has, under actual operating conditions, indicated each of them to be superior to their full size counterparts, especially when operated on reduced and non resonant ground plane systems.