# TECH 21, LLC

# SBIR 04-221
# PHASE II

# FINAL REPORT

SBIR N04-221

# TABLE OF CONTENTS

SBIR PHASE II - N04-221

# TABLE OF FIGURES – MAIN REPORT

PAGE

# INDEX TO PHASE II REPORT ATTACHMENTS

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**TECH 21, LLC SBIR 04-221**
**PHASE II**

**Acoustic / Thermal Insulation / Condensation Control / Fire Protection**
**Conformal Coating System Phase II SBIR, Topic #: NO4-221**

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**Phase II Report Submittal**
**October 15, 2012**

**Signature (Corporate Officer), Morris I. Meyer: ____________________**

## 1.0 EXECUTIVE SUMMARY

The objective of Phase II of this SBIR 04-221was to develop spray-on materials that provided significant acoustic and non-acoustic advantages over materials currently utilized by the Navy such as Navy Standard Damping Tile (MIL-PRF-23653C) or fibrous insulation. The materials developed provide significant advantages in terms of acoustic performance, thermal performance, installation time, weight and maintenance – all providing a high return on investment, better asset protection, and lower total cost of ownership. As part of Phase II, the concepts developed during Phase I were used to finalize spray-on materials for either enhanced damping (SR-1000) , thermal properties and condensation control (TEMP-COAT). These two spray-on materials can be applied independently or layered for combined acoustic/thermal effectiveness. All three of the materials were tested both in Certified Independent Laboratories and on CVN-69. These tests provide proof of concept and performance. This SBIR leveraged acoustic modeling capabilities developed under SBIR 98-092 in terms of predicting acoustic effectiveness and optimizing areas for treatment. The materials also have been certified under SOLAS – IMO Regulations which qualify them fully as safe for use passing all testing for fire, smoke and toxicity. In addition, the Phase II process ratified the products and manufacturing necessary for U.S. Coast Guard and Lloyd's Register Approvals.

TECH 21 and its Team have shown that the products involved will produce lower cost, safer, insulation systems. The noise control innovation along with the significant improvements in the TEMP-COAT insulation and condensation control product offers the Navy and Commercial entities several greatly improved choices in the construction and refurbishment of vessels of all types and sizes. Results of our testing and shipboard evaluation by Noise Control Engineering (NCE) has shown that on complete bulkhead applications SR-1000 can produce reductions of 10 dB and possibly greater. In order to produce this, the thickness of the product required will depend on the thickness of the bulkhead material. As part of this report, the findings clearly show the benefit of this water based environmentally friendly product, SR-1000.

The shipboard testing of TEMP-COAT was performed to validate the thermal benefits of the product along with the approval already in place for condensation control. TEMP-COAT performs well for condensation because it is a thermal insulation creating a barrier between two surfaces. This very safe and revolutionary product serves to insulate any medium operating between -80*F and +350*F with a guarantee of thermal conductivity and condensation control. All required testing was performed by Intertech Labs and V-Tech Labs for redevelopment of the product to meet complete IMO Standards as well as the Navy requirements. Development and testing created a product which equals or surpasses the Navy requirements and standards. Being a thermal product, it is capable of replacing blankets, foam and other forms of lagging which hides corrosion, are very expensive traps condensation and prevents reasonable and frequent inspections. Added benefits include ease of repairs and reduction in insect and rodent filth and hiding places. TEMP-COAT was first applied on Navy Vessels in 1994. The improvements made under this SBIR bring the products in total conformity with current International requirements for use and safety aboard all military and commercial vessels.

Tests on the Fire Barrier product are still ongoing as a part of this SBIR. Our objective is to produce a light weight, thin film product that can withstand 1760*F for a minimum period of one hour. It is being tested under the IMO A-754 better known as the A-60 test rules, by Certified Labs. The product is low smoke and is classified as a “pyro-tumid” product because of the hardness of its shell formed in the burning process. We are continuing to pursue the development of this product due to the need for such a liquid applied waterborne product by the Navy and all types of commercial entities.

TECH 21 Conformal Spray-on materials also offer inherent installation advantages over 12” x 12” tiles that are glued or pinned in place; thus, installation costs would be lower for the spray-on material and the thermal, corrosion and anti-condensation benefits will provide Reduced Total Ownership Cost to the Navy, reduced on board time spent by War fighter and a savings the American Taxpayer. There is also a better chance that spray-on products will be installed correctly. Damping tile is often misapplied by using small pieces or not getting good adhesion on curved surfaces or underside of deck-heads leading to corrosion and condensation. This causes the rust and corrosion that deteriorate shipboard structure.

These materials show good promise for improved damping and therefore reduced structure-borne noise transmission. Standard acoustic insulation materials will still be needed to provide increased absorption and airborne transmission loss. The spray-on damping and thermal anti-sweat treatment will be easily applied around the pins used to impale the insulation materials, unlike the placement of damping tile around the pins spaced 12 inches on center" and eliminate the pins and their weight. As predicted by theory, and proven during the NAVSEA approved Jericho Shipbuilder Designers Acoustic Testing Tool indicated that weight savings of 25% could be had over conventional acoustic tile insulation. These materials show good promise for improved damping and therefore reduced structure-borne noise transmission. Standard acoustic insulation materials will still be needed in some areas to provide increased absorption and airborne transmission loss. The TECH 21conformal spray-on damping and thermal condensation control coating treatment can eliminate the need for hard non pliable acoustic tiles with the existing 4.5 pounds/sq ft. In addition, allow the discontinuation of lagging or blankets, plus the elimination of the fastener pins weight and the labor to weld them to the hull.

Over the past 10 years our Team has evaluated the acoustic and thermal properties of the Temp-Coat aboard many US Navy ships (USS Roosevelt, USS Monterey, USS Cape St. George, USS Bonhomme Richard etc). Our acoustic team NCE has reached a determination after extensive testing employing the referenced SBIR Acoustic Testing Methodology, which employs air encapsulated in ceramic micro-spheres, could provide a reasonable degree of acoustic sound damping capability. A sizeable array of ceramic micro-spheres were tested by our team, in accordance to Navy SBIR test criteria, to determine that they would continue to perform equal to or greater than the current NAVSEA approved product(s) prior to submission to Noise Control Engineering, Inc (NCE) for testing. NCE developed the current NAVSEA approved US Navy Acoustic modeling software program (JERICHO), NCE for NAVSEA Acoustics Directorate".

## 2.0 INTRODUCTION

Under Phase I Tech 21 was charged with determining the benefits of a liquid applied sound damping material for use on Navy Ships. The issues at hand included dB Reduction, care of the war fighter, weight, maintenance, effectiveness, ease of application, cleanliness, ease of repair and many other issues.

In obtaining the right to participate in PHASE II, TECH 21 realized the importance of total Ship and Crew harmonization ant offered to pursue a blending of liquid applied products capable of transforming the ships interior into a safer, quieter, cleaner environment. The result of the offering covered major issues that affect ship assets, crew and operations. Our theory is that if, where feasible, coatings could be used to take the place of conventional insulations for sound (noise), heat and cold issues, condensation issues and fire protection, the ship configuration would become safer, easier to inspect, easier to maintain and create a better environment for the war fighter.

The substantial results and findings of the PHASE I pursuit were blended with the discovery process as stated above for PHASE II. Testing and studies were required to determine how various liquid applied products could work together to perform separate or combined tasks. Continuous testing of the individual products by Certified Labs did yield productive proof of the benefits of each individual product. Testing of the individual products for other than noise control did produce products that were not only true to their purpose but also turned them in to very safe products for shipboard use as the testing shows.

Our team was chosen in consideration of their past participation in the development of water born products with a decisive twist. That is, developing base latexes that could meet the criteria for use in developing products that had a purpose other than paint. The latex is simply the binder chosen for its ability to bind, elongate and tough enough to support the individual products purpose. These very different liquid products needed to be developed to this highest degree with the following requirements in mind. Low to no VOC's, no carcinogens, safe to use wet or dry and reaching a desirable effect to the highest known degree for such a product. In turn, tests were performed at each level for performance, compatibility with the other products being developed and their strategic use.

Much thought was given to the product use and benefits of each use. The places and types of implementation on war ships and marine constructibles are innumerable and impossible to list. As a point of interest, sales and distribution of the products (excluding FB-520 fire protective coating) have tripled since development under the PHASE II SBIR.

Each product was chosen and developed under comparative scrutiny by testing and collecting information on previous attempts to produce the very best product. Certified Testing was begun to eliminate issues in development. This is a trial and error process. The final products were selected and enhanced to achieve the very best results for Navy and Maritime use.

The final products chosen for this endeavor are reviewed below as:

**SELECTED PRODUCTS**

3.1 SR-1000 - Noise Damping Liquid Latex Coating
3.2 TEMP-COAT 101 - Thermal Barrier Liquid Latex Coating
3.3 TEMP-COAT 101 – Condensation Control Liquid Latex Coating
3.4 FB-520 (FB-521) - Pyro-Tumid Liquid Latex Protective Fire Barrier Coating

## 3.0 TEST AND EXPLANATIONS BY PRODUCT SELECTED

## 3.1 NOISE ATTINUATION AND DAMPING TESTING AND BENEFITS

Following extensive Independent Lab testing and with guidance from NCE, the final damping testing was performed by Noise Control Engineering on the USS Eisenhower. Preparation and application of the products were performed by TECH 21. The application and test protocols took place between mid February and early May 2012. Following many tests on variations of sound damping products, one final choice was tested and the results and findings are as follows:

Report 2012-008

# Verification of Acoustic Treatment Effectiveness on CVN68 Class Aircraft Carriers

## SBIR Topic No. N04-221 Phase II.5 Final Report

October 11, 2012

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# TABLE OF CONTENTS

## LIST OF TABLES AND FIGURES

# LIST OF TABLES AND FIGURES (cont.)

# 0.0 Executive Summary

Experimental data has shown that the installation of TECH21 Silent-R damping material on several compartments on the Gallery deck of the CVN69 has resulted in approximately a 5 dB reduction in noise levels. This has been demonstrated by comparing measurements taken in August 2011 prior to treatment with data acquired in April 2012. This is a significant reduction when viewed in relation to the allowable exposure times established by the Navy. For levels of 95 dBA, which were observed in the staterooms for which measurements were taken, the allowable exposure limit is 71 minutes. A reduction of noise levels by 5 dB results in an increase by a factor of 2.4 in allowable exposure time, to 169 minutes.

This reduction was observed despite the inability to completely treat the full spaces because of constraints due to ships schedule. Internal compartment items such as bunks, cabinets and wallpaper, which were attached to the bulkheads, were not able to be removed for installation of the damping material and as a result, full coverage was not able to be accomplished. In addition to this limitation, the inability to add additional treatment to the existing insulation on the flight deck underside, which is significant contributor to overall noise levels, further hindered the ability to achieve the targeted 7 dB reduction for this demonstration of material effectiveness. However, the validation of the damping treatment characteristics in the Designer Noise™ software developed by Noise Control Engineering, Inc., was accomplished as a result of this testing effort, and exercise of the model for the compartments treated shows that a reduction in noise levels of 7-10 dB can be achieved with full bulkhead treatment and additional overhead treatment.

# 1.0 Introduction

## 1.1 Objective

During Phase I and Phase II efforts of this SBIR, TECH21 has developed a product that has shown to exhibit, in controlled laboratory conditions, very good vibration attenuation and sound absorption characteristics while being lighter than traditional noise attenuation treatments. This material has also exhibited very good thermal and fire characteristics and shows the promise of being multifunctional, thus, if effective, can significantly reduce the cost and weight and achieve better results than current insulation and noise reduction treatments. The primary objective of this Phase II.5 effort was to verify the damping effectiveness for an in-situ condition by installing the treatment in a small number of high noise spaces on the 03 level of the CVN69, and measuring the treated vs. untreated noise and vibration levels during flight operations. If effective, this phase of the SBIR effort would result in a ship change document (SCD) for the immediate, permanent installation of the material in high noise areas.

A secondary objective of this Phase II.5 effort was to incorporate characteristics of the damping material, which will have been verified from the measurements taken during flight operations, into Noise Control Engineering's Designer Noise™ software. This software has been developed and validated under direct contract from ONR and from another SBIR effort. This software will then be used to develop optimized installation plans to be incorporated into the SCD, which minimize the weight and maximize the effectiveness of the noise reduction treatment.

## 1.2 Business Case and Operational Need

Modern weapon systems, particularly those existing on aircraft carriers, expose naval personnel to extremely high levels of noise for prolonged periods of time. The Veterans Administration currently pays in excess of $1.2B dollars annually to veterans as a direct result of noise induced hearing loss (NIHL) disabilities. This cost is likely to continue to rise in the future with the deployment of weapons systems with even higher expected source levels. NIHL related issues have the direct effect of decreasing the quality of life of those affected, and in addition to this, increasing warfighter down-time, decreasing productivity and effectiveness (thus survivability) and losing good workers through medical disqualifications. The development of an effective damping treatment, which can be applied to high noise areas and reduce the overall noise exposure of the ship's force can help to reverse these undesirable trends.

Existing acoustic damping tiles are heavy, outgas toxic fumes when exposed to heat, and offer no thermal protection per a Naval Audit Service report. As an alternative to these existing treatments, TECH21 developed a product that has shown to exhibit, in controlled laboratory conditions, very good vibration attenuation and sound absorption characteristics while being lighter than traditional noise attenuation treatments. This material has also exhibited very good thermal and fire characteristics and shows the promise of being multifunctional, thus, if effective, can significantly reduce the cost and weight and achieve better results than current insulation and noise reduction treatments.

## 1.3 Benefit to the Navy

NIHL related issues have the direct effect of decreasing the quality of life of those affected. In addition to this, warfighter down-time increases, productivity decreases and good workers are lost through medical disqualifications. A successful proof of damping treatment effectiveness, which clears the way for immediate deployment, will reverse these trends by reducing noise levels thus resulting in increasing warfighter effectiveness and thus survivability, reduction of incidents of medical disqualification due to NIHL, and an overall increase in the quality of life for those warfighters serving in these high noise environments. This will also result in decreased costs due to having to train replacements for personnel lost as a direct result of NIHL issues.

# 2.0 Test Setup

## 2.1 Overview

The CVN class of aircraft carriers is literally a floating city that houses nearly 6,000 people and often will launch hundreds of high performance, very loud aircraft on any given day. The Gallery Deck, which is the level directly under the flight deck, is "home" for many of crew and officers and contains many of the working offices and spaces, as well as a significant number of berthing compartments and a mess area. For this reason, it was the focus of this noise reduction evaluation. Not only are noise levels aboard aircraft carriers high, but they have been increasing over time and are expected to increase further with the deployment of advanced aircraft such as the Joint Strike Fighter (JSF). Reference 1 details work that was performed by Yankaskas and Shaw in the late 1990's. Figure 1 shows a comparison of noise levels for catapult 2 launches on the Gallery Deck in the vicinity of catapult and jet blast deflector (JBD) #2 which were measured by Yankaskas in September 2000 on the USS Theodore Roosevelt (CVN71) and those measured in April 2012 on the USS Dwight D. Eisenhower (CVN69). As can be seen, there has been a substantial increase in noise levels at similar locations. This figure also shows an estimation of the areas that exceed 85 dBA, showing approximately an increase of 45% in the area of excess noise levels just in the vicinity of catapult 2. It can be assumed that comparable increases would be measured for the other 3 catapults. Levels as high as 105 dBA were measured in passageways and staterooms. To put these levels in perspective, the US Navy now uses an 85 dBA criteria with a 3 dB exchange rate which means that the 8 hour exposure limit is 85 dBA and for each 3 dB, that time is reduced by half. For a level of 105 dBA, the allowable exposure time per 8 hours is 4.75 minutes. Assuming that launching aircraft on the catapult are at full power for 35 seconds before launch, after 8 launches, someone in that space would exceed their 8 hour noise exposure limit!

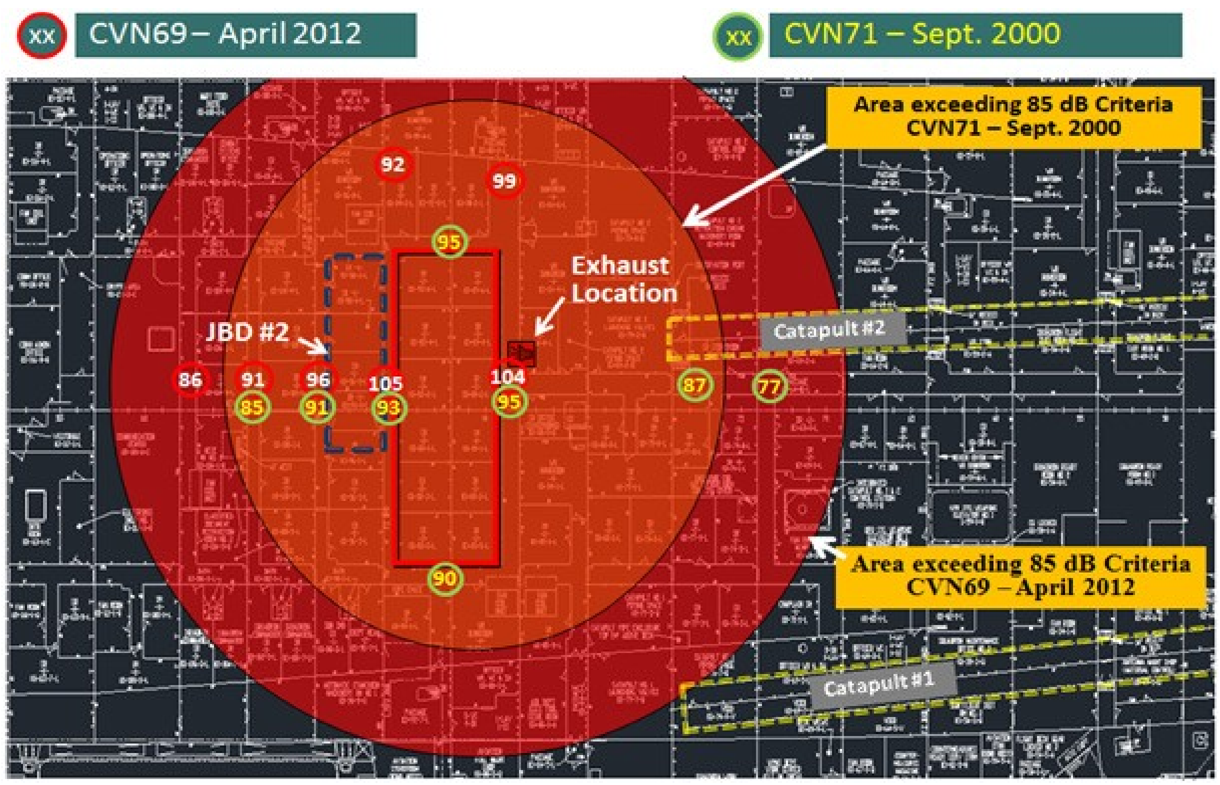



Figure 1. Measured noise levels on gallery deck showing increasing trend for catapult 2 launches.

Three "VIP" staterooms were treated with "Silent Running (Silent-R)" damping material manufactured by Temp-Coat Products of La Place, LA. Figures 2 and 3 show the location of these staterooms relative to catapult 2. Silent-R is a spray-on material that has exhibited excellent damping properties while being lighter than traditional damping materials. The material also exhibits thermal and condensation properties and has the potential for being multi-functional. Structural and joiner bulkheads were treated with this material and an ambitious measurement program was carried out to verify the effectiveness of the material and also to validate the characteristics of the material that have been incorporated by Designer Noise™, acoustical modeling software developed by Noise Control Engineering, Inc. Measurements taken will also further validate the ability to use Designer Noise™ for the CVN class of ships.


Figure 2. Location relative to flight deck operations of damping treatment and measurement location focus

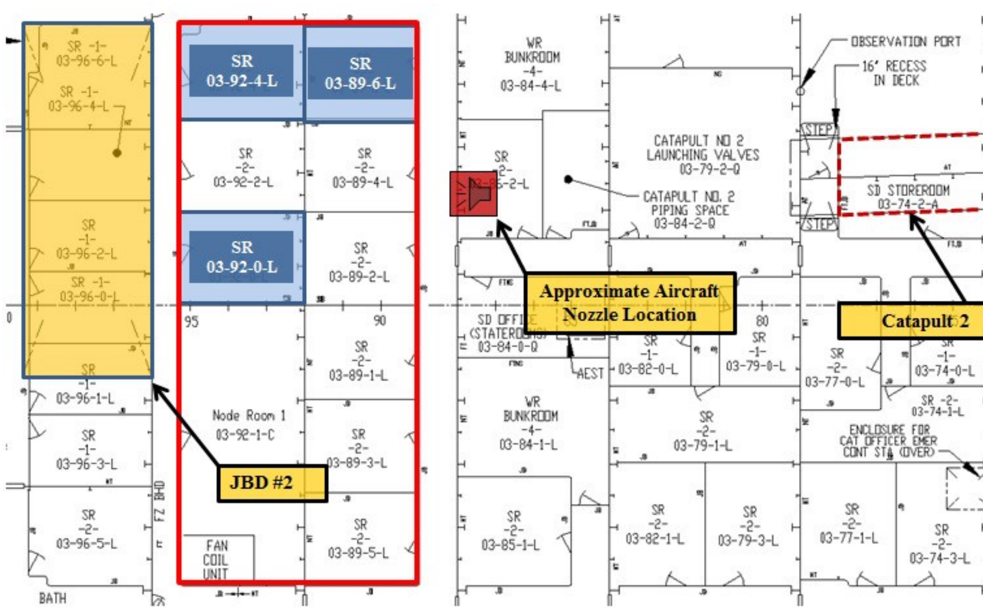



Figure 3. Location of Treated Staterooms in relation to JBD2, Noise Source and Catapult 2

## 2.2 Measurement Test Plan

A very aggressive test program was carried out on the USS Dwight D. Eisenhower (CVN69) to obtain data during flight operations and validate the effectiveness of the Tech21 Silent-R damping material. Microphones and accelerometers were installed at 107 locations and during the period of 2-April through 5-April 2012, data was acquired for 81 launch events resulting in over 8600 measurements. One of those events was a continuous time recording lasting over 18 minutes taken on the final day before coming back into port when aircraft where launched very rapidly. During this event, 17 launches were recorded which brings the total number of launches recorded to 98. Data was also acquired using a portable acoustic array in order to determine the paths of acoustical energy into the compartments. Figures 4 though 13 show typical installations of the measurement transducers. Validation of measurements indicates that all data channels were operational. Upon removal of accelerometers from installations, it was noticed that a few had become loose, but it is believed that over 98% of the data is valid. The flight deck footprint covered by this measurement effort is estimated to be approximately 21%. The flight deck area is calculated to be approximately 4.6 acres and the measurement footprint was estimated to be approximately .95 acres.

Due to the large channel distribution footprint, two distributed data acquisition systems from LMS (Leuvan Measurement Systems) were used in order to minimize cable length and the need to run wires from transducers back to measurement system. Each data acquisition system consisted of a master unit and a slave unit. The slave units were connected to the master via a fiber optic cable and so that all channels of data within the system were synchronized. The measurements were grouped into four “zones” with the data from each zone going into a unit of the data acquisition system. Each master unit was connected to a control computer via an ethernet cable that was on a separate intranet and hub, not connected in any way to ship internet. Both control computers were located in the data acquisition “command” center in SR 03-84-4-L. The master unit of the first system was located in SR 03-92-4-L and the slave unit located in 03-49-3-Q. For the second system, the master unit was located in SR 03-100-7-L and the slave in 03-118-5-Q. Data acquisition on both systems were started simultaneously for each measurement event.

Data was also acquired during carrier qualifications during the period of 15-August through 18-August 2011 prior to installation of damping treatment. A portable hand-held device was used to take acoustical and vibration measurements and the acoustic array was also employed. A complete list of the measurement locations and the log of data acquired for both the August 2011 and April 2012 tests are given in Appendices A through C. Raw time data traces were stored for all the events listed. For a significant subset of events, narrowband and 1/3 octave band spectra were calculated and stored and used for the analysis. Additional processing can be performed on any of the events to obtain spectra or any other time domain or frequency domain calculation.


Figure 4. Microphone installation in passageway

Figure 5. Microphone installation in stateroom

Figure 6. Accelerometer installation on flight deck underside


Figure 7. Accelerometer installation on structural bulkhead


Figure 8. Accelerometer installation on joiner bulkhead

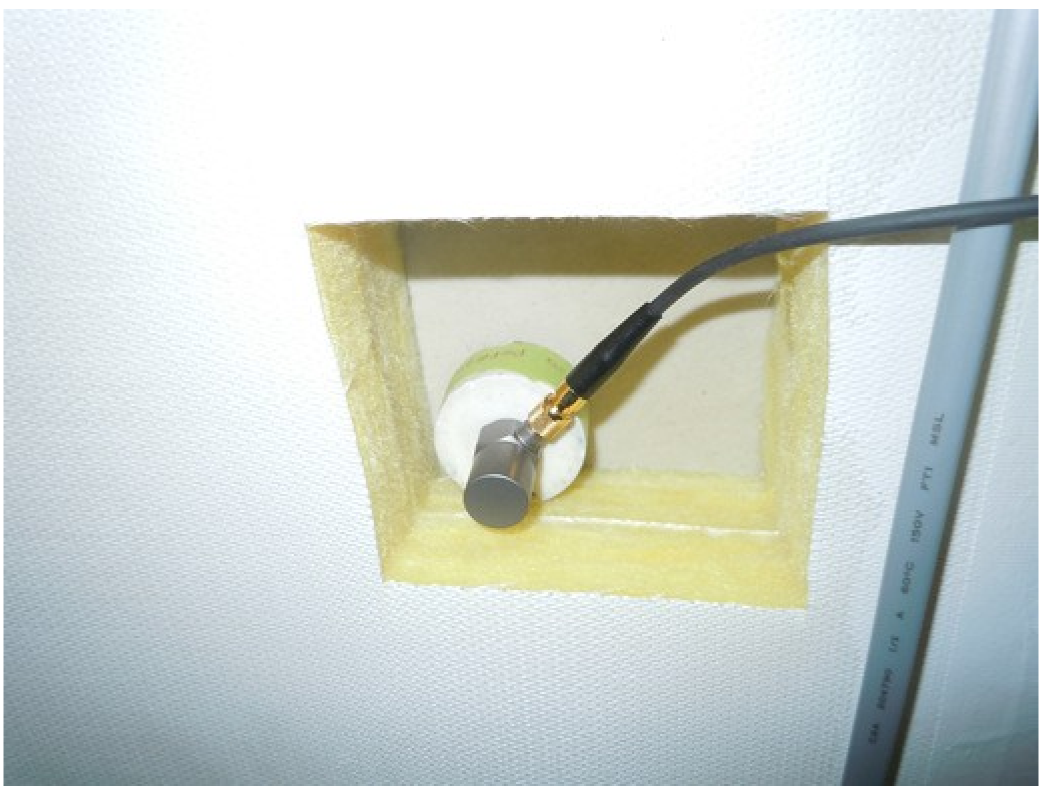


Figure 9. Accelerometer installation on catapult trough

Figure 10. Microphone and accelerometer installation in maintenance office

Figure 11. Microphone installation on flight deck envelope

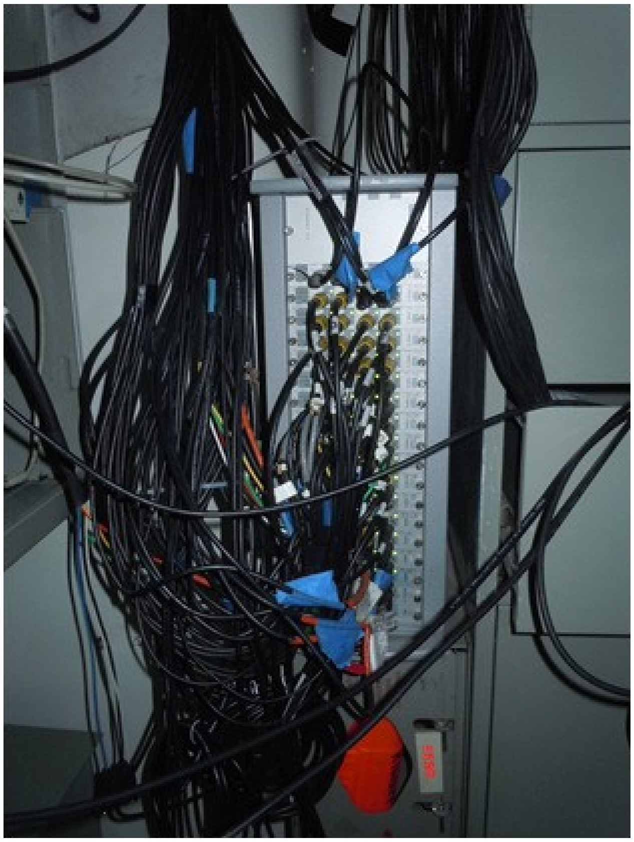


Figure 12. LMS 64-channel data acquisition system master unit located in SR 03-92-4-L

Figure 13. LMS spherical acoustic array used to determine “hot spot” locations where acoustical energy is entering compartments

## 2.2 Damping Treatment Installation

Table 1 shows a summary of the damping treatment and respective weights of the treatment that was installed. In order to be effective, the thickness of the damping material should be equal to at least ½ the thickness of the structure to which it is being applied. For structural bulkheads, a thickness of 3 mm (120 mils) was applied and for the joiner bulkheads a thickness of 1.5 mm (60 mils) was applied. In spaces 03-49-3-Q and 03-49-5-Q, the catapult trough was also treated with damping material but before the damping treatment is applied, a layer of thermal treatment was applied which reduced temperatures sufficiently for the damping treatment to be applied. This thermal treatment is applied in the same manner as the damping treatment and also had a thickness of approximately 3 mm. Weights are calculated based on a weight of .39 lb/ft$^2$ per 1 mm thickness of material.

Table 1. Treatment Plan for SilentRunning Damping Treatment (Does not take into account weight savings from any material removed from ship and replaced by SilentRunning)

| Space | Dimensions (ft) | | # of Bulkheads | Square Footage (ft$^2$) | Coating Thickness (mm) | Dry Film Weight (lbs) |
|---|---|---|---|---|---|---|
| | Height | Width | | | | |
| | | | | | | |
| SR-03-89-6-L | 8.5 | 14 | 2 | 238 | 1.5 | 139.23 |
| | 8.5 | 10 | 1 | 85 | 3 | 99.45 |
| | 8.5 | 10 | 1 | 85 | 1.5 | 49.725 |
| | | | | | | |
| SR-03-92-4-L | 8.5 | 14 | 2 | 238 | 1.5 | 139.23 |
| | 8.5 | 10 | 1 | 85 | 3 | 99.45 |
| | 8.5 | 10 | 1 | 85 | 1.5 | 49.725 |
| | | | | | | |
| SR-03-92-0-L | 8.5 | 14 | 1 | 119 | 3 | 139.23 |
| | 8.5 | 10 | 1 | 85 | 3 | 99.45 |
| | 8.5 | 14 | 1 | 119 | 1.5 | 69.615 |
| | 8.5 | 10 | 1 | 85 | 1.5 | 49.725 |
| | | | | | | |
| 03-49-3-Q | 8.5 | 16 | 1 | 136 | 3 | 159.12 |
| | 8.5 | 11 | 2 | 187 | 3 | 218.79 |
| | | | | | | |
| Catapult Trough | | | | | | |
| 03-49-5-Q | 5 | 16 | 1 | 80 | 3 | 93.6 |
| 03-49-3-Q | 5 | 16 | 1 | 80 | 3 | 93.6 |
| Totals | | | | 1767 | | 1546.74 |

Figure 14. Damping installation on structural bulkhead.

Figure 15. Damping installation on catapult trough

# 3.0 Data Analysis

## 3.1 Discussion of Source Levels

Since a comaprison of the treated vs. untreated spaces occurred a number of months apart and under different conditions, the first step in comparing the noise levels is a verification of the source levels. Figures 14 & 15 show a comparison of levels measured at the flight deck envelope during April 2012 test with measurements taken at comparable locations on flight deck with hand-held directional microphone in August 2011. As can be seen, the flight deck data taken in the April 2012 test shows consistently higher levels by approximately 6 dB. Figures 16 & 17 show comparisons of noise levels measured in the passageways near the ship centerline just aft of BHD 88 and just forward of BHD 96 for launches from catapult 2. These measurements also show consistently higher levels of 4-5 dB for the April test vs. the August test. Figures 18 & 19 show comparisons of structural vibration levels measured on the flight deck underside and on BHD 96 near the ship centerline for a catapult 2 launch. Vibration levels for the April 2012 test are also consistently higher than levels measured in August 2011 which would be consistent with the higher noise levels measured near those same locations.

## 3.2 Damping Treatment Effectiveness

Figure 20 shows the average noise reduction in the staterooms that were treated with damping material. In calculating the effectiveness of the damping treatment, any differences in the source levels, as identified in Section 3.1, needs to be taken into account. The following equation was used:

$$\Delta Lp = Lp(before) - Lp(after) + \Delta L(source) \qquad \text{where}$$

ΔLp = total noise or vibration reduction after treatment
Lp(before) = noise or vibration levels measured before damping treatment applied
Lp(after) = noise or vibration levels measured after damping treatment applied
ΔL(source) = difference between source level measurements

A consistent noise reduction of 5 dB was observed in the compartments where damping treatment was applied, which takes into account the higher source levels measured during the April test. This is a significant result when viewed in relation to the effect on exposure times. Using the same calculation as described in Section 2.1 we see that:

1. For levels of 95 dBA, (and during launch, levels exceeded 95 dBA in all staterooms measured), the allowed exposure limit is 71 minutes. By reducing noise levels by 5 dB, this results in an increase by a factor of 2.4 in allowable exposure time, to 169 minutes.

An examination of the spectrum shape in Figure 20 indicates that the part of spectrum between 315 Hz and 2500 Hz controls the overall dB(A) noise level. We can see an increase in the noise reduction above 2000 Hz for SR 03-92-4-L because additional overhead insulation in the form of a temporary dropped noise-reduction ceiling was installed on the stateroom 03-92-4-L overhead (1.5 lb/ft$^2$ lead vinyl an 2" thick fiberglass layer) to examine the effect of energy being transmitted from the overhead. The greater noise reduction at high frequencies is a result of these efforts, but this treatment did not seem to significantly effect the overall dBA level.

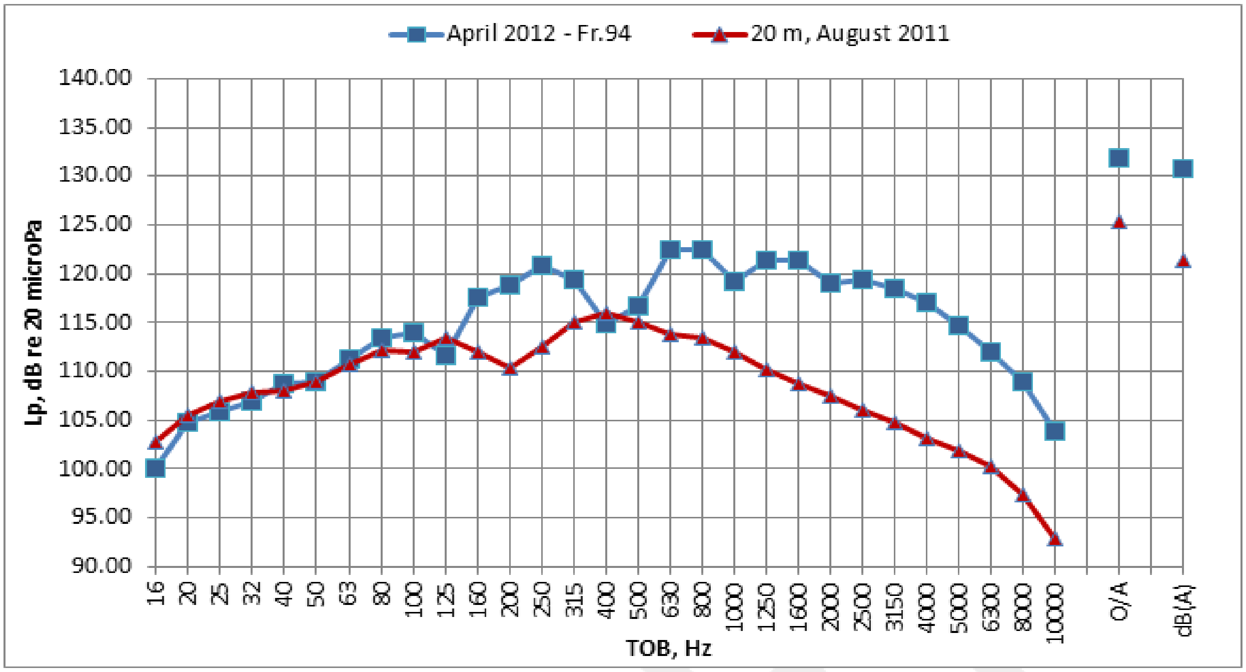



Figure 16. Comparison of noise levels between April 2012 and August 2011 tests on flight deck and flight deck envelope at 25 meter distance from source for CAT 1 launch of F18 C/D.

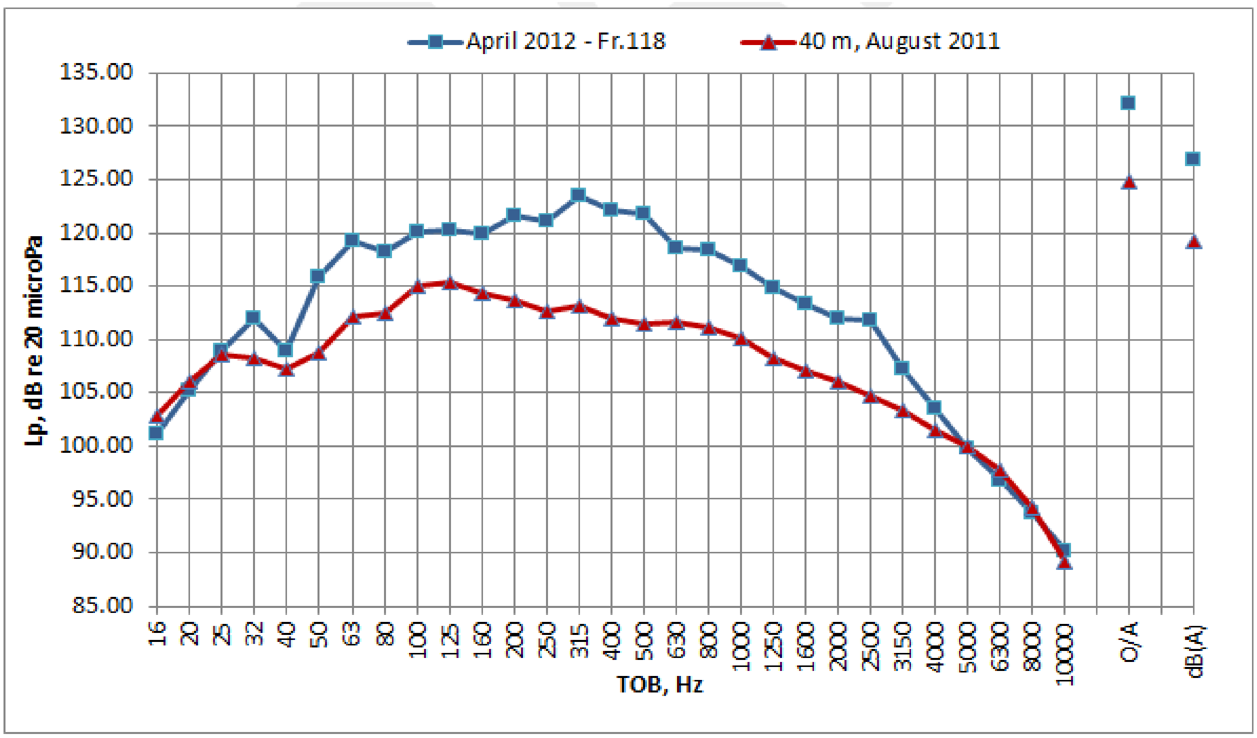



Figure 17. Comparison of noise levels between April 2012 and August 2011 tests on flight deck and flight deck envelope at 40 meter distance from source for CAT 1 launch of F18 C/D.

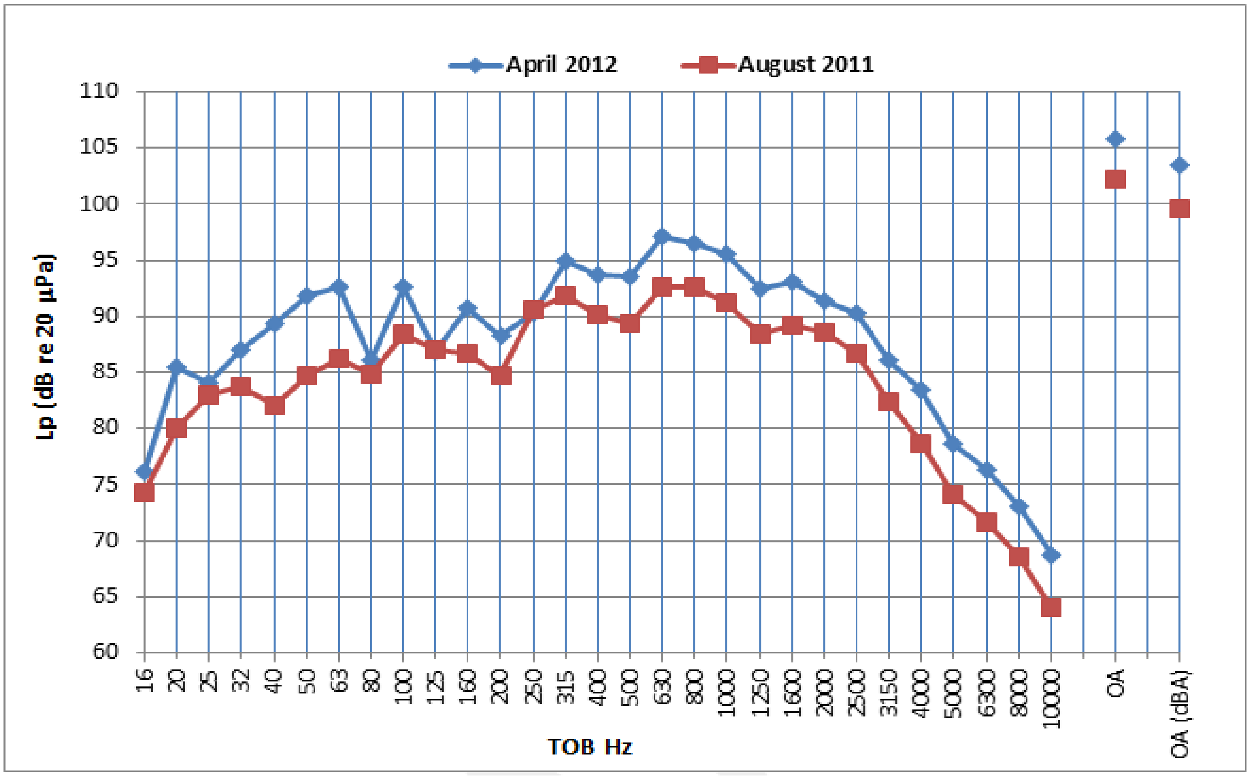



Figure 18. Comparison of noise levels measured in passageway AFT of BHD 88 near ship CL for Cat 2 Launch of F18 C/D - April 2012 vs. August 2011 test.

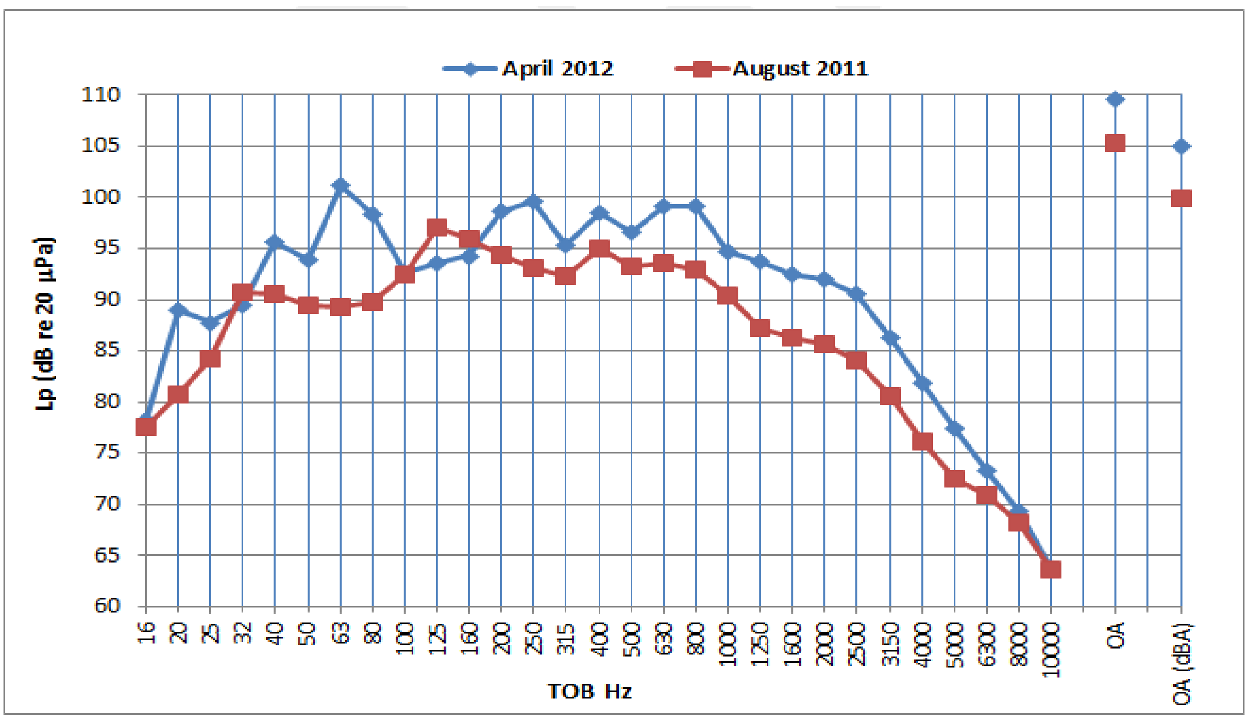



Figure 19. Comparison of noise levels measured in passageway FWD of BHD 96 near ship CL for Cat 2 launch of F18 C/D – April 2012 vs. August 2011.

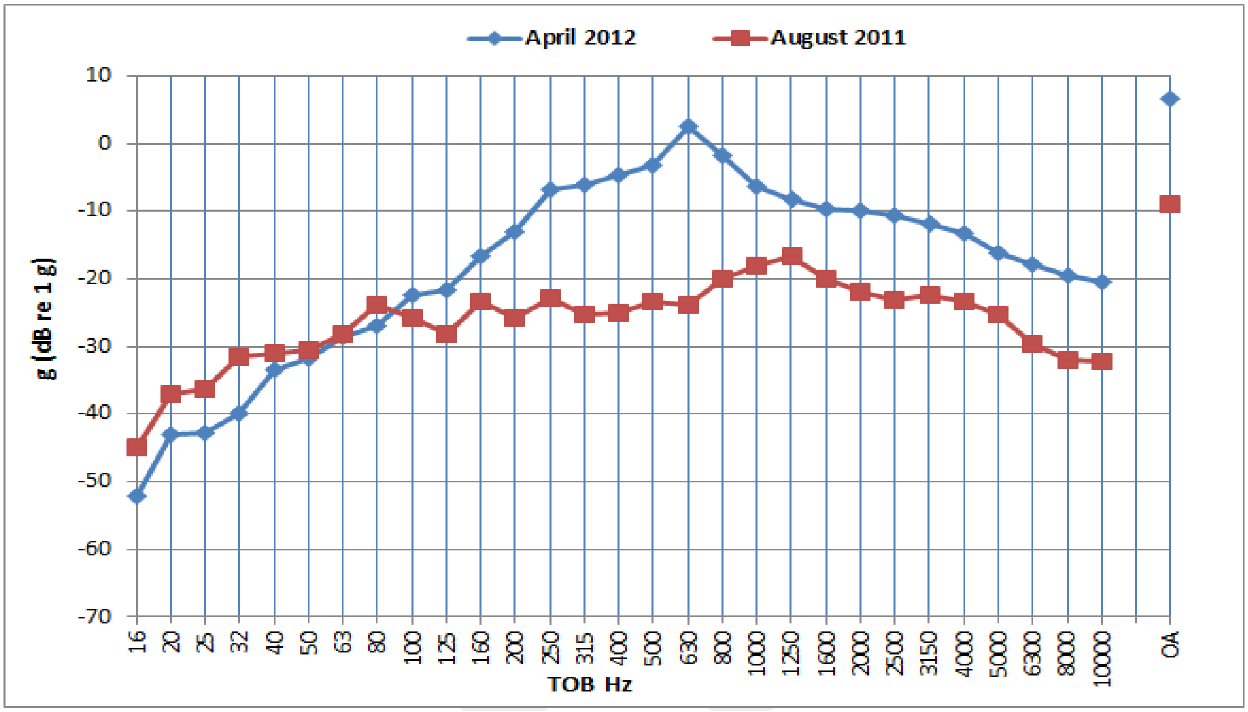



Figure 20. Comparison of vibration levels measured on flight deck underside in passageway FWD of BHD 96 near ship CL for CAT 2 launch of F18 C/D - April 2012 vs. Aug 2011 test.

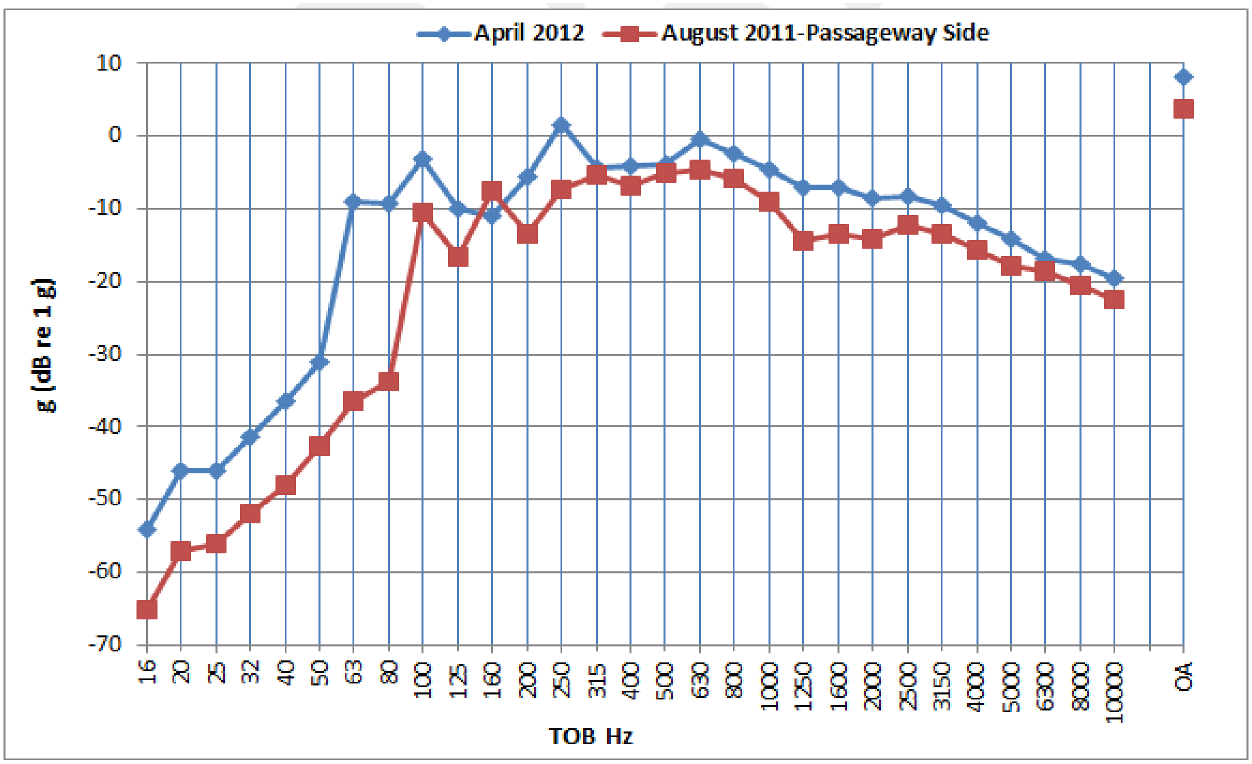



Figure 21. Comparison of vibration levels measured on BHD 96 in passageway near ship CL for CAT 2 launch of F18 C/D - April 2012 vs. Aug 2011 test.

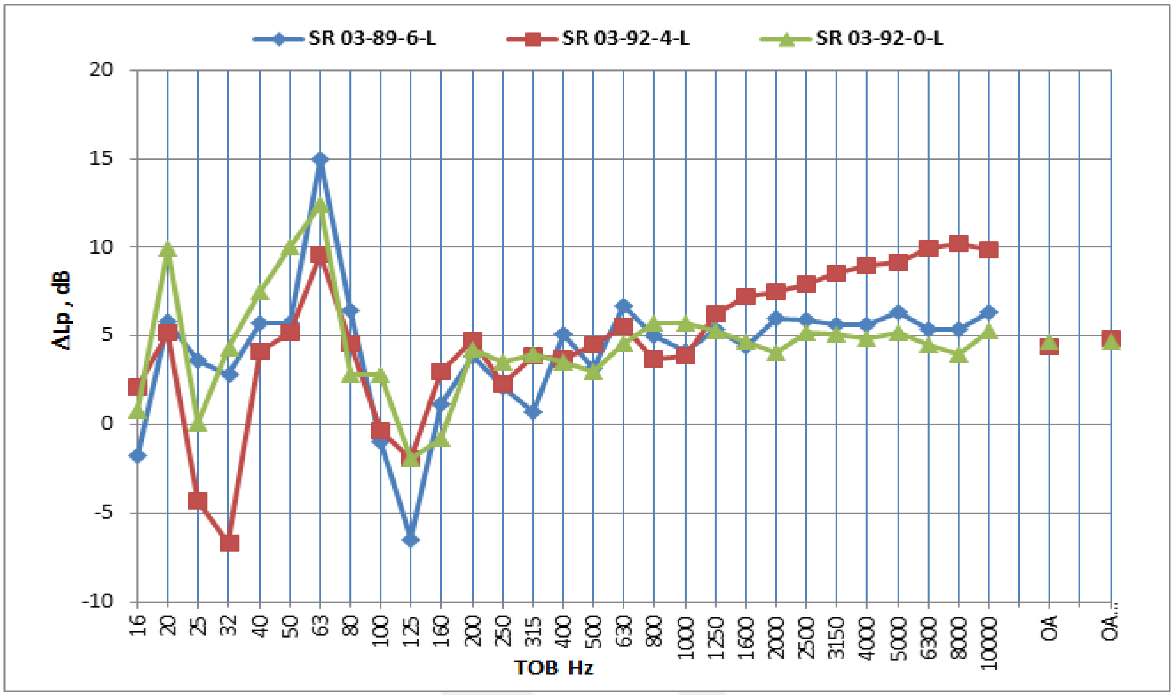



Figure 22. Average noise reduction in treated staterooms.

Vibration levels before and after treatment on the structural and the joiner bulkheads were also examined. Figure 23 shows average vibration reduction after 3 mm thick damping spray was applied to the structural bulkheads and 1.5 mm to the joiner bulkheads, as a difference between data taken on August 2011 and April 2012.

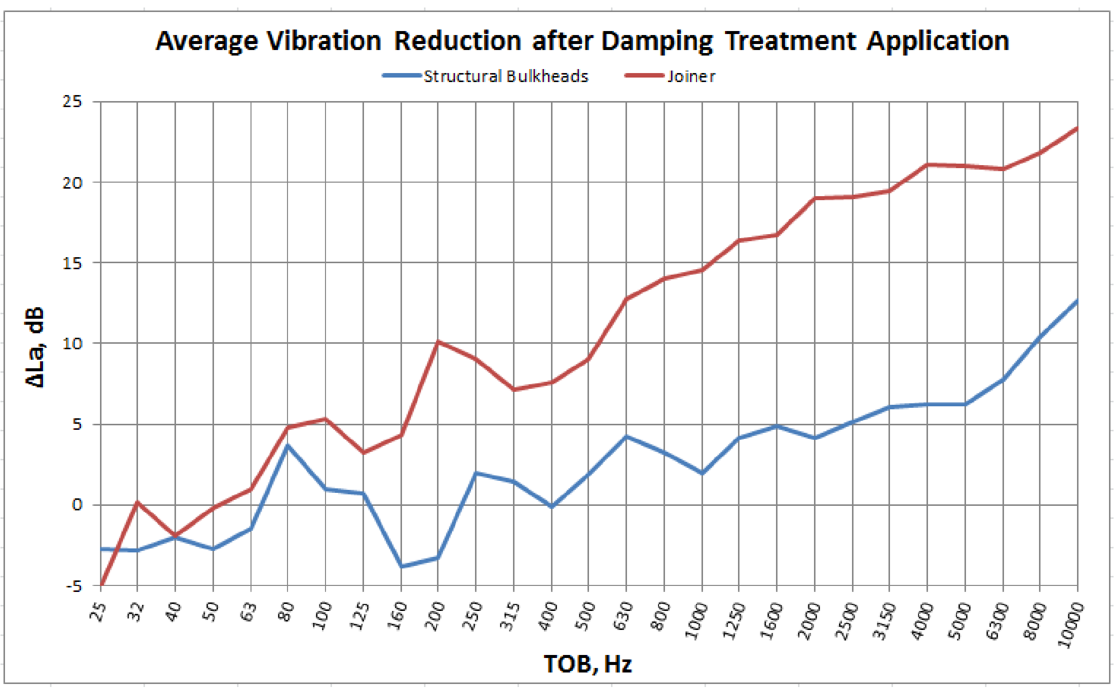
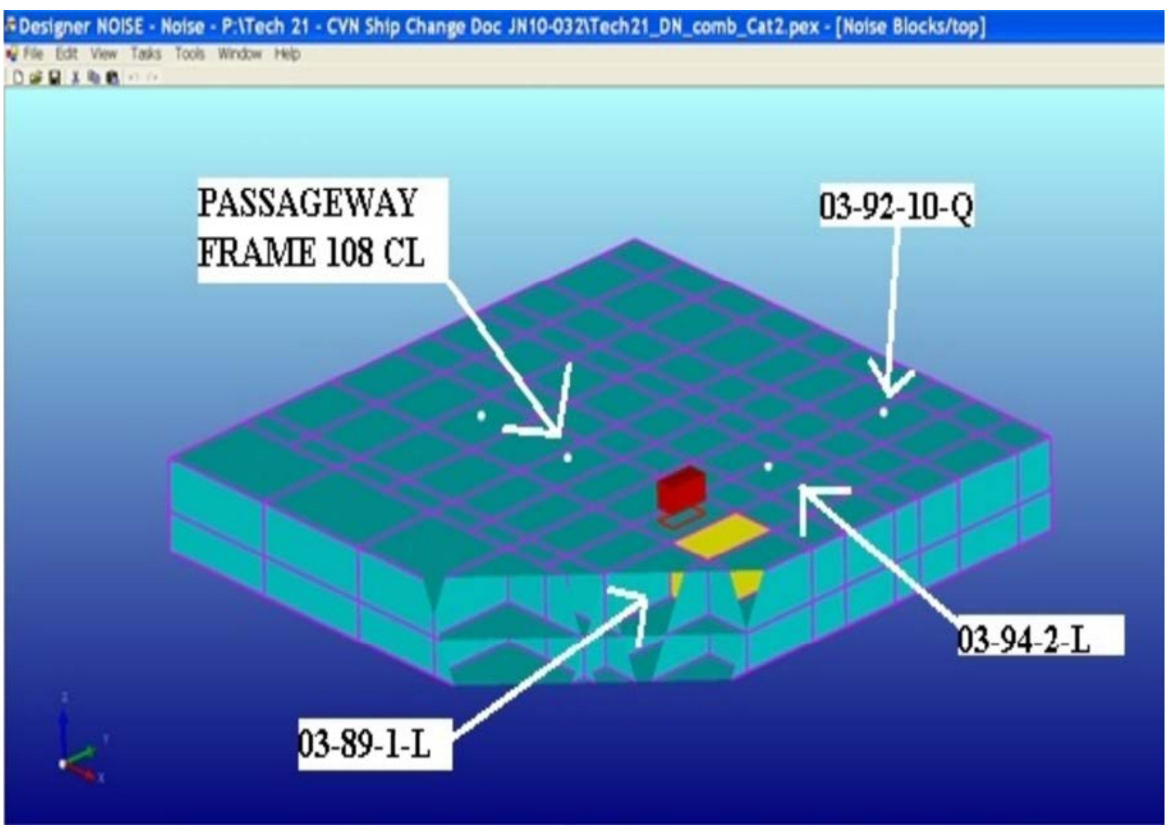



Figure 23. Average vibration reduction of bulkheads in treated staterooms.

## 3.3 Designer NOISE™ Predictions and Comparison to Measurements

A model of the areas around catapult 2 shown in Figure 24 was developed using the Designer Noise™ acoustical prediction software that was initially developed under an SBIR and is being further advanced under a direct contract to ONR. The validation of this software for the prediction of noise levels in treated spaces will enable models to be developed that will help in optimizing the treatment scheme for effectiveness, cost and weight. The model was exercised using measured inputs that were obtained during the testing program. Figures 25 through 28 show comparisons of the model predictions with measured data for four locations on the ship. As can be seen, although there are some deviations in the individual octave bands, the predicted levels were within 3 dB of the measured levels.

The verified model can now be used to predict the effectiveness of various treatment schemes and to optimize the treatment in order to maximize the effectiveness in reducing noise levels and also to minimize the cost and weight penalty of the treatment. One of the most important factors is the radiation efficiency of the various surfaces and how much of a contribution the vibration of each surface has to the overall noise levels. Thicker plates will radiate more efficiently and generally have more of an effect on the overall noise levels. Based on the verified transfer functions and radiation coefficients in the model, a plot, shown in Figure 29, of the relative contributions of each surface to the overall noise levels in a typical compartment is shown. As can be seen, as expected, the structural bulkheads and flight deck underside contribute the most to the overall noise levels.



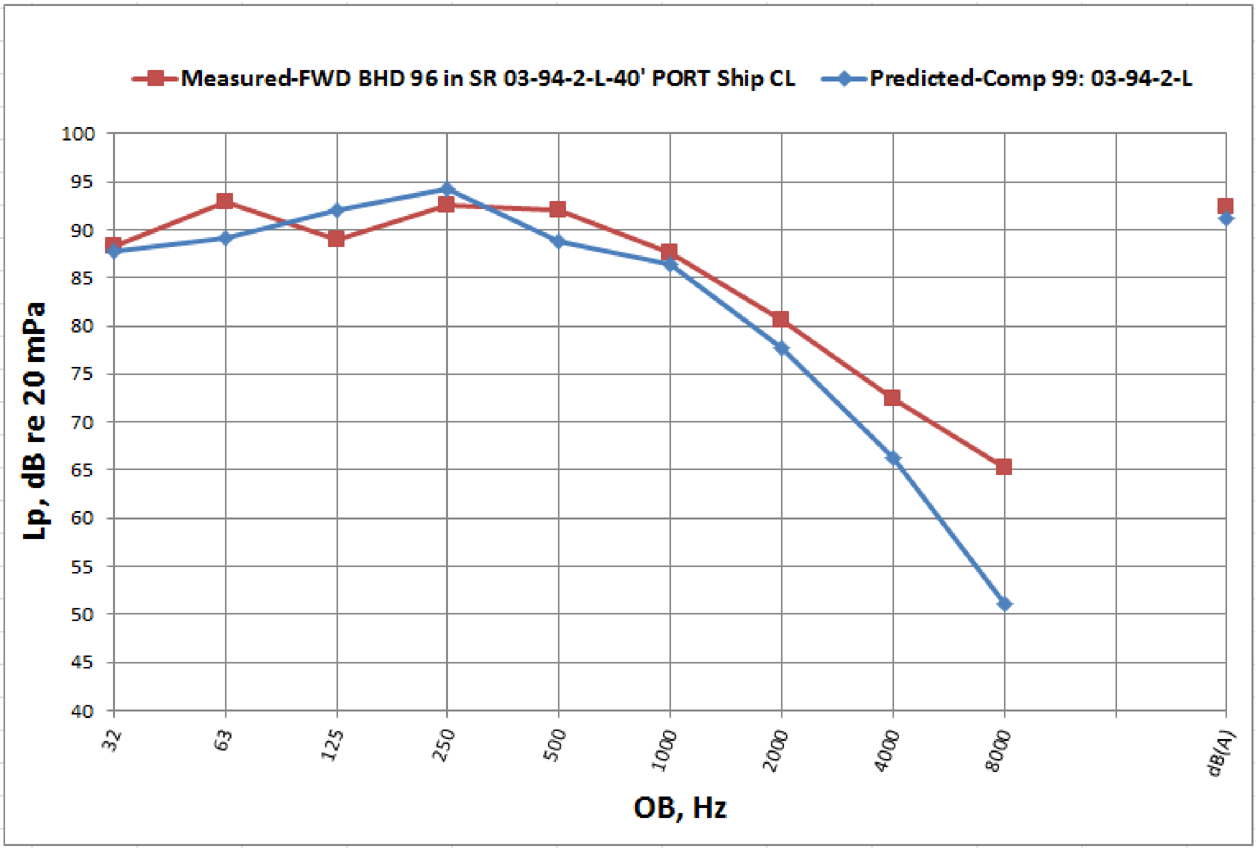



Figure 25. Measured vs. Predicted for Cat 2 Launch - 03-94-2-L.

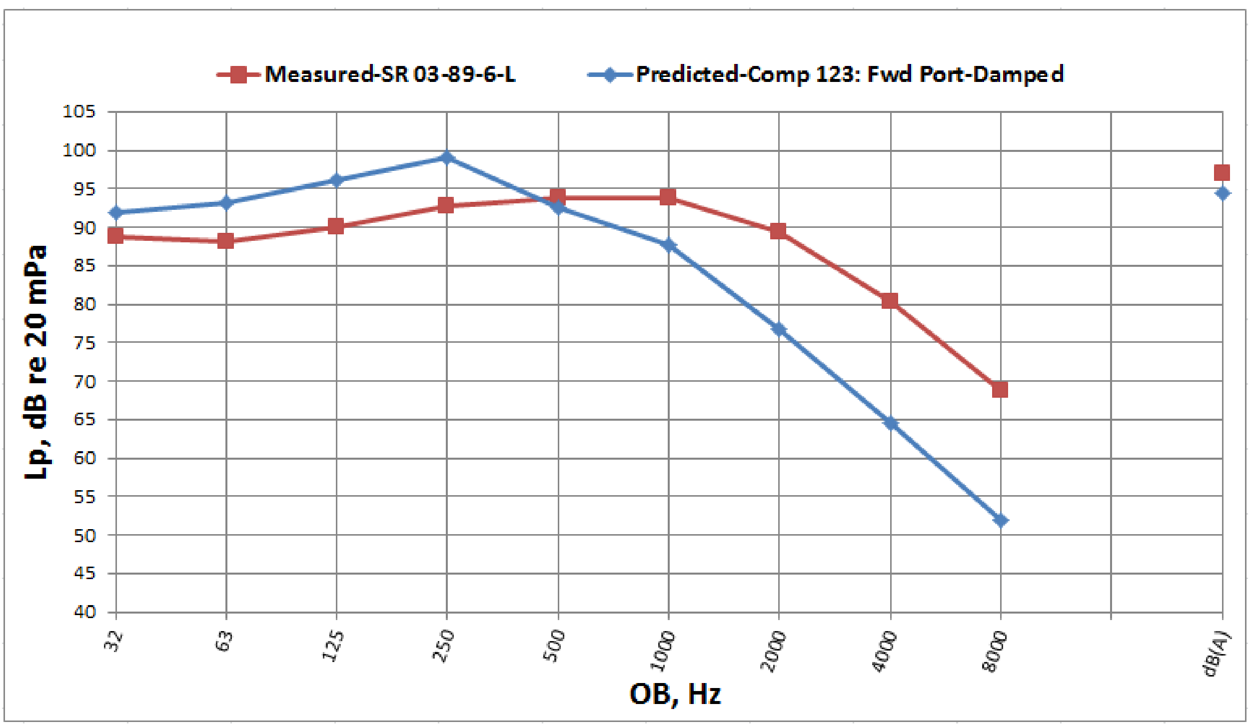



Figure 26. Measured vs. Predicted for Cat 2 Launch - 03-89-6-L.

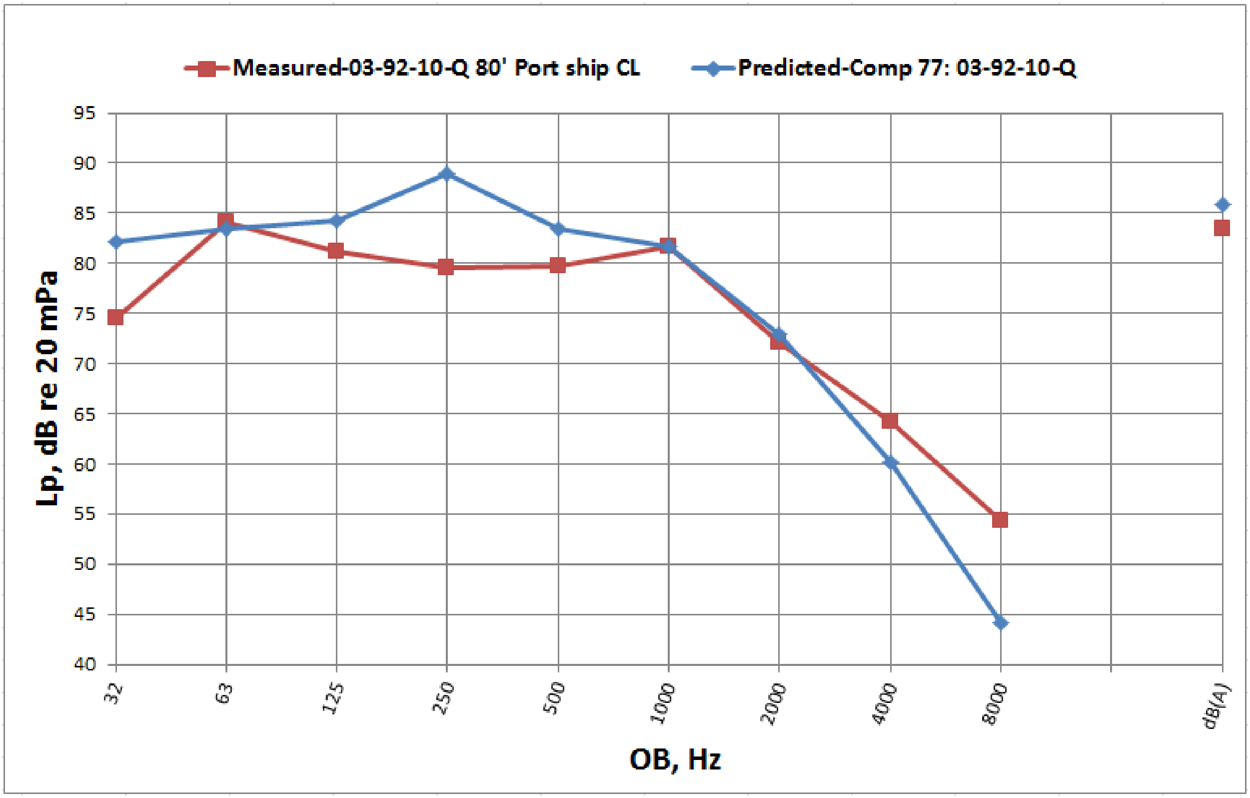



Figure 27. Measured vs. Predicted for Cat 2 Launch - 03-92-10-L.

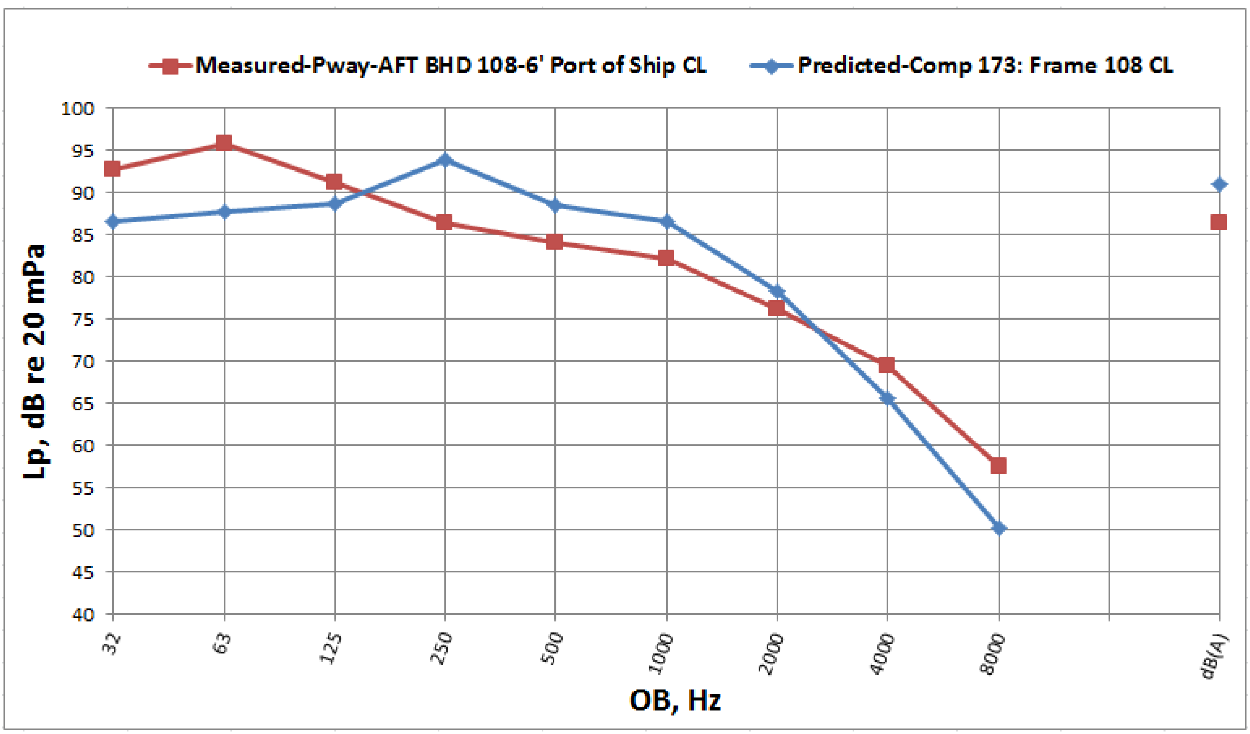



Figure 28. Measured vs. Predicted for Cat 2 Launch - PWAY 108 Fwd Fr 108 Ship CL.

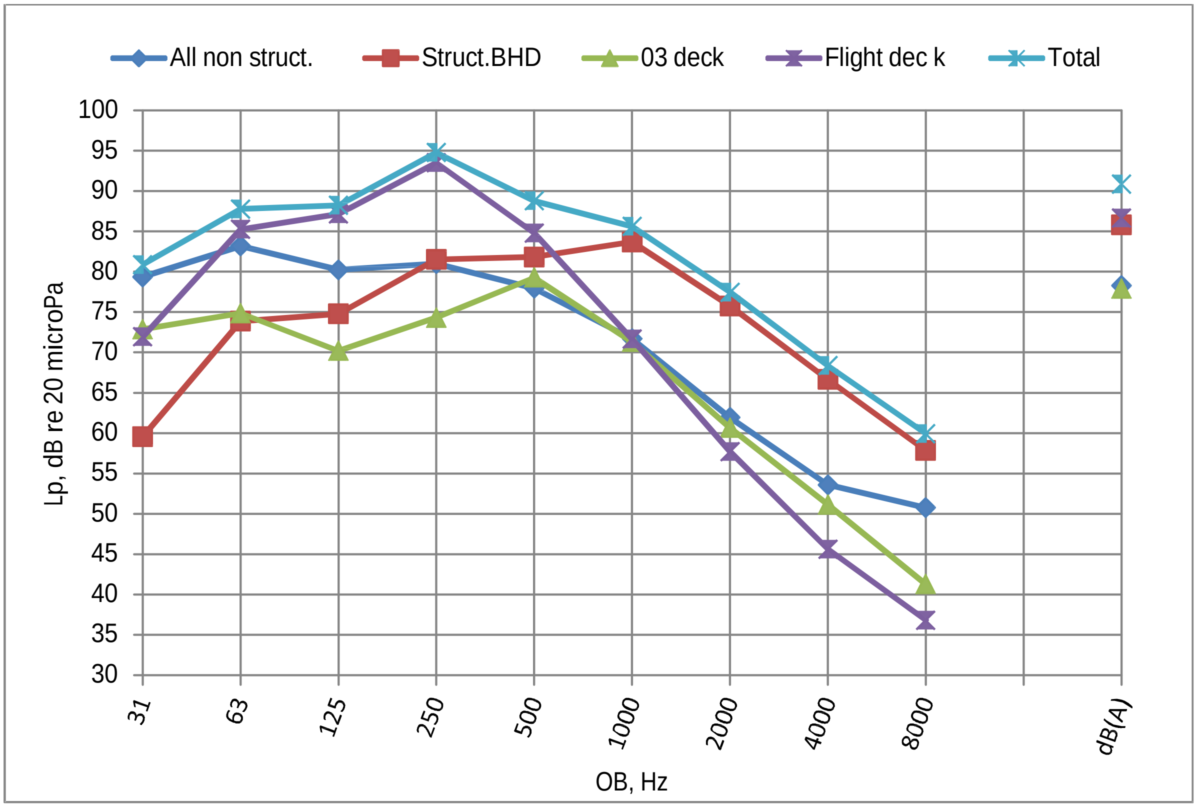



Figure 29. Relative contribution of compartment surfaces to overall noise levels

In the higher frequencies, the overall level is controlled by the radiation from the structural bulkheads. This agrees with the results of measurements taken with the acoustical array. Once vibration levels of the structural bulkheads are reduced by application of the damping treatment, the overhead radiation will dominate the noise levels and further reduction will only be possible by treating this surface. After this treatment, deck vibrations will become important. Based on preliminary Designer Noise$^{TM}$ predictions, Table 2 shows the total expected reduction in dB on overall noise levels for a tiered treatment approach. As predicted and verified by testing, the application of damping treatment conservatively will reduce noise levels by 5 dB. Subsequent application of additional or more effective noise reduction treatments on the flight deck underside can add another 3 dB of noise reduction. The contributions from the deck will then become important and further reductions will only be possible with deck treatments and the possible addition of another layer of material on the overhead with a higher transmission losses. This will be able to increase the overall noise reduction to approximately 12-15 dB.

Table 2. Noise reduction treatment options and expected effectiveness

| Option number | Required noise Reduction, dB | Treatment description |
|---|---|---|
| *I* | 5 | 1. Damping spray 3-4 mm thick on the structural bulkheads<br>2. Damping spray 1 mm thick on the joiner bulkheads |
| *II* | 8 | Option I+<br>2" thick additional fiberglass layer on the overhead |
| *III* | 12 | Option II+<br>1. 2" thick fiberglass layer on the structural bulkhead<br>2. Floating floor (3 mm thick steel plating+2" thick fiberglass |
| *IV* | 15 | Option III+<br>Additional joiner panel on the overhead |
| *V* | 19 | Option I + Modular cabin with a floating floor. |

## 3.3 Acoustic Array Measurement Results

A spherical microphone array, as was shown in Figure 13, was employed in selected spaces to augment traditional measurement methods. The microphone array uses acoustic holography and focalization techniques to identify areas where acoustical energy in entering the compartments. Results from the array were also used to help verify the model predictions and identify primary acoustical energy paths. Figure 30 shows the results of an array measurement in SR 03-96-0-L averaged over the frequency range of 800-2500 Hz which dominates the overall A-weighted noise levels. As can be seen, the structural bulkhead is the main source of acoustical energy into this compartment. Figures 31 and 32 show array plots from compartment 03-92-4-L taken before treatment during the August 2011 test and after treatment during the April 2012 test. As can be seen, the hot spots were significantly reduced by the damping treatment and the only hot spot seen in the April 2012 data is coming from an open vent leading out to the passageway.

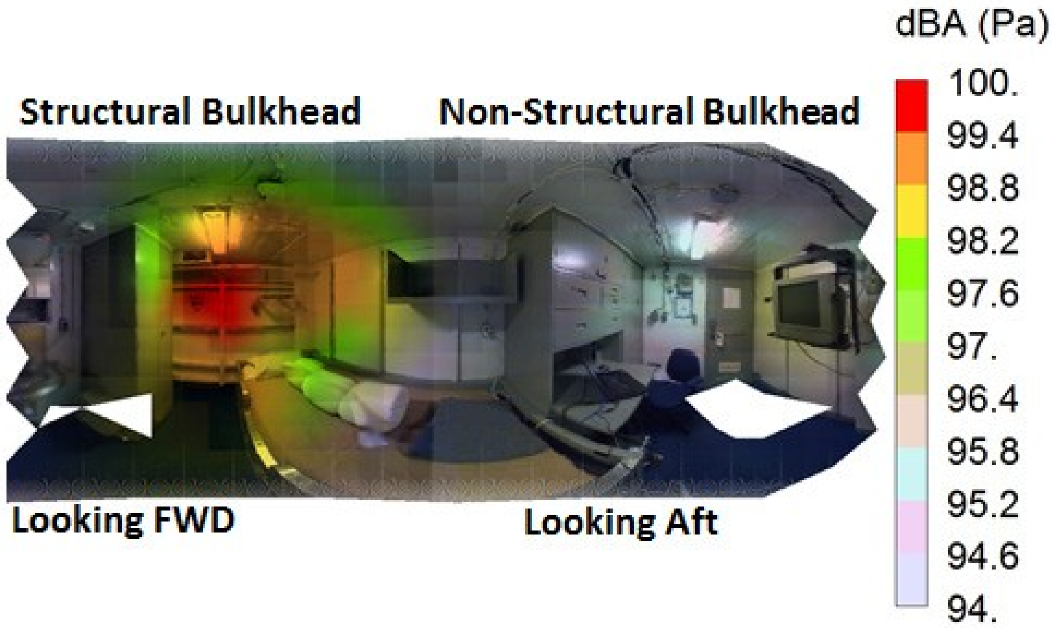



Figure 30. Acoustic array plot of SR 03-96-0-L from August 2011 test


Figure 31. Acoustic array plot of SR 03-92-4-L from August 2011 test

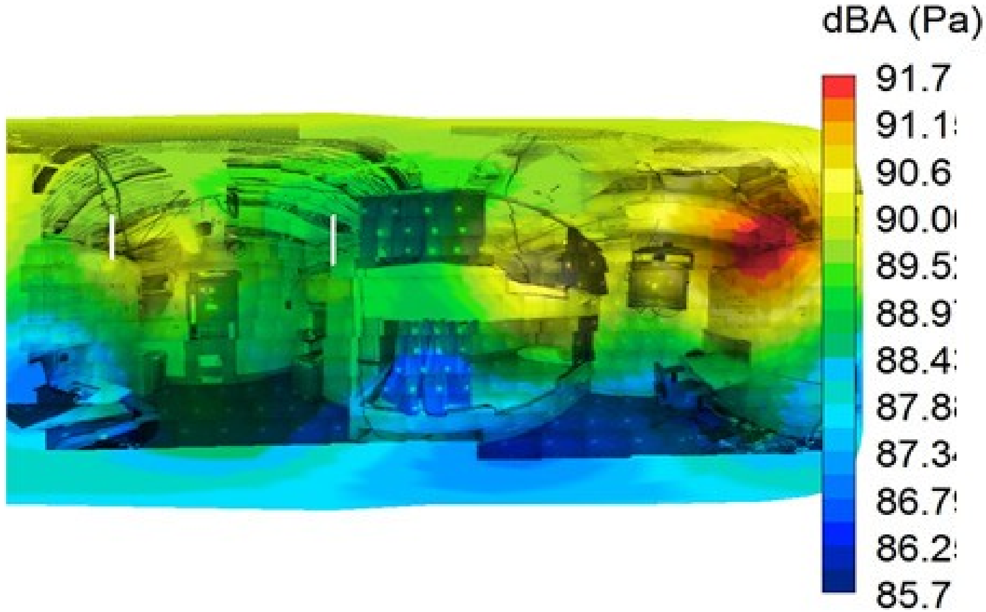



Figure 32. Acoustic array plot of SR 03-92-4-L after damping treatment - April 2021 test

## 4.0 Summary and Conclusions

The primary objective of the Phase II.5 scope of work was to verify the damping effectiveness of the Tech21 Silent-R material for an in-situ condition by installing treatment in a small number of high noise spaces on the 03 level of the CVN69, and measuring the treated vs. untreated noise and vibration levels during flight operations. Additionally, a secondary objective of this Phase II.5 effort was to incorporate material characteristics of the damping material into the Designer NOISE™ acoustical prediction software in order to validate the modeling techniques which then can be used, if the damping treatment proved effective, to develop optimized installation plans which minimize the weight and maximize the effectiveness of the noise reduction treatment. Both objectives have been met and the following is a summary and resultant conclusions that can be drawn from this work:

1. Extensive measurements were performed on the USS Dwight D. Eisenhower (CVN69) in which:
    a. aircraft source levels were quantified and acoustic transmission paths into compartments on the gallery deck were identified
    b. the relative contribution of a compartments surfaces to the overall noise levels were determined and used to further verify Designer NOISE™ predictions
    c. advanced techniques for noise diagnostics using a spherical acoustic array on an aircraft carrier were demonstrated

2. Designer NOISE™ accurately predicts noise for this difficult environment and can be used for the complete design and optimization of noise reduction treatment aboard aircraft carriers

3. The Silent-R spray damping treatment has been shown to be effective in reducing noise levels in treated compartments by 5 dB. This noise reduction was seen without complete coverage of all bulkheads due to inability of ships force to remove bunks and lockers from the bulkheads due to time an resource contraints. With full coverage, noise reductions of up to 7 dB are feasible from damping treatment.

4. Will a full optimization implementation which includes additional or different treatment of the flight deck underside and treatment of the deck surfaces, reductions of 15-20 dB should be achievable. Trade-off studies of noise reduction vs. weight and cost must be performed.

## 5.0 Next Steps

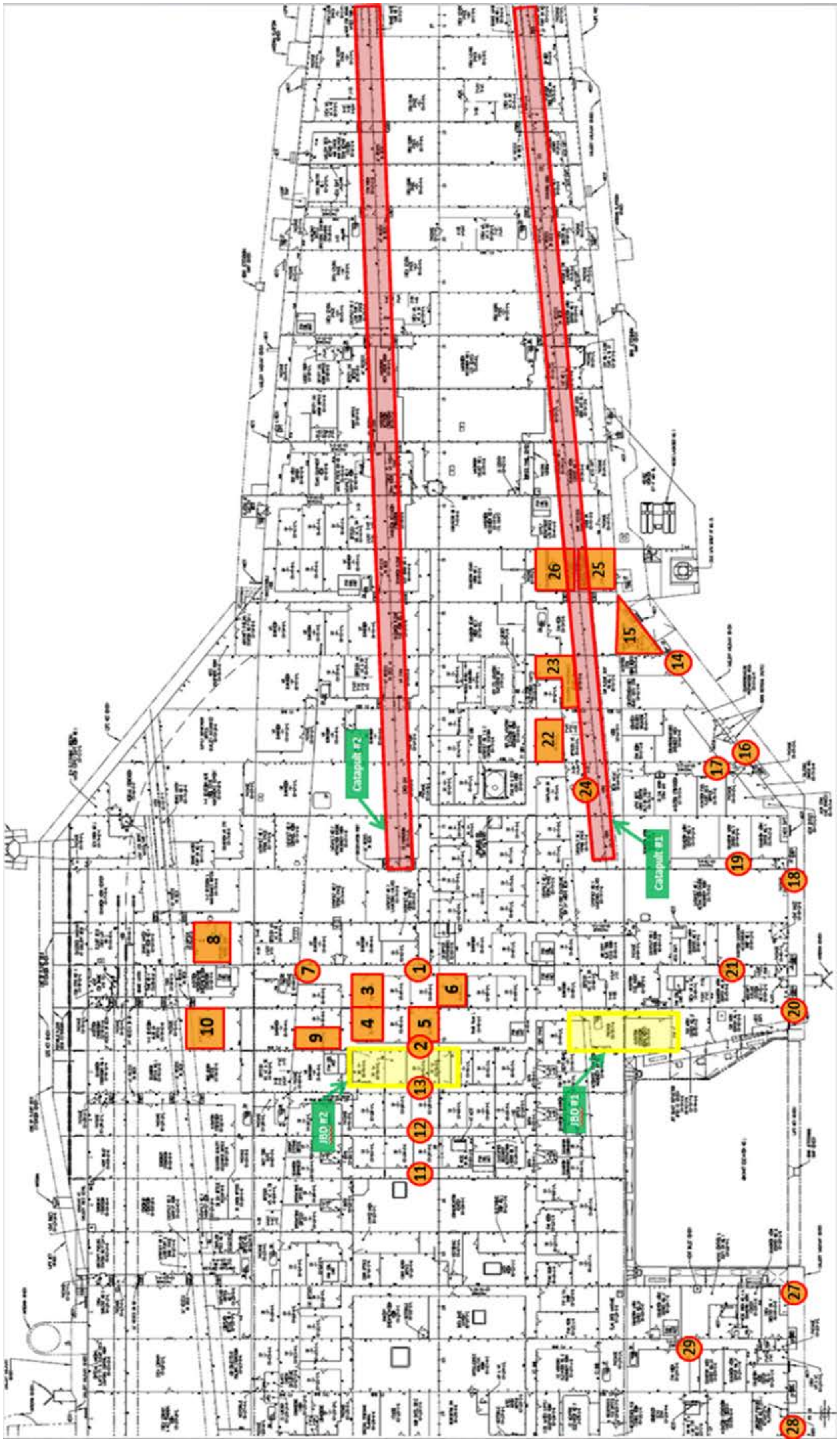
1. Determine priority spaces to be treated and target noise levels for these spaces. These spaces must be determined by PEO Carriers.
2. Design the optimized treatment using the Designer NOISE™ software for these spaces
3. Generate SCD for implementation to the fleet

# Appendix A: Measurement Locations for April 2012 Test

| Table 2. Channelization Sheet from CVN69 Test - April 2012 | | | | |
|---|---|---|---|---|
| **Compartment** | **Transducer Type** | **Location Description** | **Point Number/LMS** | **Diagram Location** |
| Passageway just aft of Bulkhead 88 approximately 6' port of ship CL | accelerometer | on Bulkhead | 1 | 1 |
| | microphone | in passageway | 2 | |
| | accelerometer | flight deck underside | 3 | |
| Passageway just fwd of Bulkhead 96 approximately 6' port of ship CL | accelerometer | on Bulkhead | 4 | 2 |
| | microphone | in passageway | 5 | |
| | accelerometer | flight deck underside | 6 | |
| SR 03-89-6-L | accelerometer | fwd Bulkhead-joiner | 7 | 3 |
| | accelerometer | fwd Bulkhead-joiner | 8 | |
| | accelerometer | port bulkhead-joiner | 9 | |
| | accelerometer | port bulkhead-joiner | 10 | |
| | accelerometer | stbd bulkhead-joiner | 11 | |
| | accelerometer | stbd bulkhead-joiner | 12 | |
| | accelerometer | aft bulkhead - FR 92 | 13 | |
| | accelerometer | deck | 14 | |
| | accelerometer | deck | 15 | |
| | accelerometer | flight deck underside | 16 | |
| | accelerometer | flight deck underside | 17 | |
| | microphone | hangng from overhead | 18 | |
| SR 03-92-4-L | accelerometer | fwd bulkhead - Fr 92 | 19 | 4 |
| | accelerometer | port bulkhead-joiner | 20 | |
| | accelerometer | port bulkhead-joiner | 21 | |
| | accelerometer | stbd bulkhead-joiner | 22 | |
| | accelerometer | stbd bulkhead-joiner | 23 | |
| | accelerometer | aft bulkhead-joiner | 24 | |
| | accelerometer | aft bulkhead-joiner | 25 | |
| | accelerometer | deck | 26 | |
| | accelerometer | deck | 27 | |
| | accelerometer | flight deck underside | 28 | |
| | accelerometer | flight deck underside | 29 | |
| | microphone | hangng from overhead | 30 | |
| SR 03-92-0-L | accelerometer | fwd bulkhead - Fr 92 | 31 | 5 |
| | accelerometer | port bulkhead-joiner | 32 | |
| | accelerometer | port bulkhead-joiner | 33 | |
| | accelerometer | stbd bulkhead-joiner | 34 | |
| | accelerometer | deck | 35 | |
| | accelerometer | flight deck underside | 36 | |
| | microphone | hangng from overhead | 37 | |

| Table 2. Channelization Sheet from CVN69 Test - April 2012 | | | | |
|---|---|---|---|---|
| **Compartment** | **Transducer Type** | **Location Description** | **Point Number/LMS** | **Diagram Location** |
| SR 03-89-1-L | accelerometer | port bulkhead-joiner | 40 | 6 |
| | accelerometer | port bulkhead-joiner | 41 | |
| | accelerometer | stbd bulkhead-joiner | 42 | |
| | accelerometer | stbd bulkhead-joiner | 43 | |
| | accelerometer | aft bulkhead - FR 92 | 44 | |
| | accelerometer | deck | 45 | |
| | accelerometer | deck | 46 | |
| | accelerometer | flight deck underside | 47 | |
| | accelerometer | flight deck underside | 48 | |
| | microphone | hangng from overhead | 49 | |
| Passageway just aft of Bulkhead 88 approximately 40' port of ship CL | accelerometer | on Bulkhead | 50 | 7 |
| | microphone | in passageway | 51 | |
| | accelerometer | flight deck underside | 52 | |
| Just fwd of Bulkhead 88 approximately 80' port of ship CL in Security Admin Training Office 03-84-12-Q | accelerometer | on Bulkhead | 53 | 8 |
| | microphone | in compartment | 54 | |
| | accelerometer | flight deck underside | 55 | |
| Just fwd of Bulkhead 96 approximately 40' port of ship CL - in SR 03-94-2-L | accelerometer | on Bulkhead | 56 | 9 |
| | microphone | in compartment | 57 | |
| | accelerometer | flight deck underside | 58 | |
| Just fwd of Bulkhead 96 approximately 80' port of ship CL - in V-3 Hanger Deck Division Office 03-92-10-Q | accelerometer | on Bulkhead | 59 | 10 |
| | microphone | in compartment | 60 | |
| | accelerometer | flight deck underside | 61 | |
| Passageway just fwd of Bulkhead 108 approximately 6' port of ship CL | accelerometer | on Bulkhead | 62 | 11 |
| | microphone | in passageway | 63 | |
| | accelerometer | flight deck underside | 64 | |
| Passageway just fwd of Bulkhead 104 approximately 6' port of ship CL | accelerometer | on Bulkhead | 65 | 12 |
| | microphone | in passageway | 66 | |
| | accelerometer | flight deck underside | 67 | |
| Passageway just fwd of Bulkhead 100 approximately 6' port of ship CL | accelerometer | on Bulkhead | 68 | 13 |
| | microphone | in passageway | 69 | |
| | accelerometer | flight deck underside | 70 | |
| Flight Deck envelope - STBD side approx. frame 59 | microphone | Deck Edge-Outside | 71 | 14 |
| | microphone | Inside 03-54-5-A Flt Deck Gear Locker | 72 | 15 |
| | accelerometer | Inside 03-54-5-A Flt Deck Gear Locker | 73 | |

| Table 2. Channelization Sheet from CVN69 Test - April 2012 | | | | |
|---|---|---|---|---|
| **Compartment** | **Transducer Type** | **Location Description** | **Point Number/LMS** | **Diagram Location** |
| Flight Deck envelope - STBD side approx. frame 69 | microphone | Deck Edge-Outside | 74 | 16 |
| | microphone | Microphone in passageway 03-69-11-L | 75 | 17 |
| | accelerometer | Flight deck underside in passageway 03-69-11-L | 76 | |
| Flight Deck envelope - STBD side approx. frame 79 | microphone | Deck Edge-Outside | 77 | 18 |
| | microphone | Microphone in passageway 03-78-1-L | 78 | 19 |
| | accelerometer | Flight deck underside in passageway 03-78-1-L | 79 | |
| Flight Deck envelope - STBD side approx. frame 94 | microphone | Deck Edge-Outside | 80 | 20 |
| | microphone | Microphone in passageway 03-84-11-L | 81 | 21 |
| | accelerometer | Flight deck underside in passageway 03-84-11-L | 82 | |
| | accelerometer | Bulkhead 88 in passageway 03-84-11-L | 83 | |
| SR 03-65-1-L | accelerometer | fwd bulkhead - joiner | 84 | 22 |
| | accelerometer | port bulkhead-joiner | 85 | |
| | accelerometer | aft bulkhead-frame 69 | 86 | |
| | accelerometer | stbd bulkhead-joiner | 87 | |
| | accelerometer | deck | 88 | |
| | accelerometer | flight deck underside | 89 | |
| | microphone | hangng from overhead | 90 | |
| Squadron Maint. Office 03-59-3-Q | accelerometer | catapult trough | 91 | 23 |
| Officer WR and Shower 03-69-5-L | accelerometer | catapult trough | 92 | 24 |
| Antenna Maintenenace Shop 03-49-5-Q | accelerometer | fwd bulkhead - fr 49 | 93 | 25 |
| | accelerometer | bulkhead under cat trough | 94 | |
| | accelerometer | rear bulkhead - joiner | 95 | |
| | accelerometer | stbd bulkhead - joiner | 96 | |
| | accelerometer | deck | 97 | |
| | accelerometer | flight deck underside | 98 | |
| | accelerometer | catapult trough | 99 | |
| | microphone | hanging from overhead | 100 | |
| | | extra cable | | |
| Squadron Maintenenace Office 03-49-3-Q | accelerometer | catapult trough | 101 | 26 |
| | microphone | hangng from overhead | 102 | |
| Flight Deck Envelope Frame 118 | microphone | Flight deck envelope | 103 | 27 |
| Flight Deck Envelope Frame 133 | microphone | Flight deck envelope | 104 | 28 |
| Passageway between frame 122-129 03-122-1-L | accelerometer | on Bulkhead | 105 | 29 |
| | microphone | in passageway | 106 | |
| | accelerometer | flight deck underside | 107 | |


Catapult #2
Catapult #1
JBD #2
JBD #1
1
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3
4
5
6
7
8
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# Appendix B: Data Logs from CVN 69 Testing - April 2-5 2012

**Table 1. Data Logs from CVN 69 Testing - April 2-5 2012**

| NCE Run # | Date | Time Off Deck | Catapult # | Aircraft Type | Notes |
|---|---|---|---|---|---|
| 2 | 4/2/2012 | 17:32 | 1 | F18E | |
| 3 | 4/2/2012 | 17:33 | 4 | F18 | |
| 4 | 4/2/2012 | 17:34 | 4 | F18 | 0-15 sec [Cat 4] |
| 4 | 4/2/2012 | 17:35 | 1 | F18 | 15-30 sec [Cat 1] |
| 5 | 4/2/2012 | 20:30 | 2 | F18E | |
| 6 | 4/2/2012 | 20:37 | 2 | F18 | |
| 7 | 4/2/2012 | 20:39 | 1 | F18 | |
| 1 | 4/3/2012 | 12:00 | 2 | F18 | |
| 2 | 4/3/2012 | | | | Did not launch |
| 3 | 4/3/2012 | 12:04 | 3 | F18 | Run 3 -> 0-8 sec {2+3 full pwr}, 8 sec |
| 3 | 4/3/2012 | 12:06 | 2 | F18 | {3 launch}, 8-23 sec {cat 2} |
| 4 | 4/3/2012 | 12:13 | 2 | F18E | steady state only - no launch capture |
| 5 | 4/3/2012 | 12:22 | 2 | F18E | |
| 6 | 4/3/2012 | 13:00 | 3 | F18E | Wet Rhino, Afterburner 0-12 sec |
| 6 | 4/3/2012 | 13:00 | 2 | F18E | 13-38 sec |
| 7 | 4/3/2012 | 13:04 | 2 | F18 | |
| 8 | 4/3/2012 | 13:08 | 2 | F18 | |
| 9 | 4/3/2012 | 13:15 | 2 | F18 | |
| 10 | 4/3/2012 | 14:30 | 2 | C-2 | |
| 11 | 4/3/2012 | 14:37 | 2 | F18 | |
| 12 | 4/3/2012 | 14:40 | 2 | F18E | |
| 13 | 4/3/2012 | 16:03 | 2 | F18 | |
| 14 | 4/3/2012 | 16:06 | 2 | F18 | |
| 15 | 4/3/2012 | 16:09 | 2 | F18 | |
| 16 | 4/3/2012 | 16:11 | 2 | F18E | |
| 17 | 4/3/2012 | 17:32 | 2 | F18 | |
| 18 | 4/3/2012 | 17:35 | 2 | F18 | |
| 19 | 4/3/2012 | 17:37 | 1 | F18 | |
| 19 | 4/3/2012 | 17:38 | 3 | F18E | |
| 20 | 4/3/2012 | 17:38 | 2 | F18 | steady state only - no launch capture |
| 21 | 4/3/2012 | 19:00 | 1 | F18E | 0-12 sec |
| 21 | 4/3/2012 | 19:00 | 3 | F18E | 8-16 sec |
| 22 | 4/3/2012 | 19:04 | 1 | F18 | steady state only - no launch capture |
| 23 | 4/3/2012 | 19:06 | 1 | F18 | |
| 24 | 4/3/2012 | 19:10 | 1 | F18 | |
| 25 | 4/3/2012 | 20:35 | 1 | F18E | |
| 26 | 4/3/2012 | 20:39 | 1 | F18E | |
| 27 | 4/3/2012 | 20:43 | 3 | F18E | Wet Rhino, Afterburner |
| 28 | 4/3/2012 | 20:45 | 1 | F18 | |
| 29 | 4/3/2012 | 20:48 | 1 | F18 | |
| 30 | 4/3/2012 | 20:52 | 1 | F18E | |

| Table 1. Data Logs from CVN 69 Testing - April 2-5 2012 | | | | | |
|---|---|---|---|---|---|
| NCE Run # | Date | Time Off Deck | Catapult # | Aircraft Type | Notes |
| 31 | 4/4/2012 | 13:00 | 3 | F18E | Wet Rhino, Afterburner |
| 32 | 4/4/2012 | 13:00 | 1 | F18E | |
| 33 | 4/4/2012 | 13:03 | 4 | F18E | |
| 34 | 4/4/2012 | 13:03 | 1 | EA-6B | |
| 35 | 4/4/2012 | 13:05 | 3 | F18 | |
| 36 | 4/4/2012 | 13:06 | 4 | F18 | |
| 37 | 4/4/2012 | 13:08 | 4 | F18 | |
| 38 | 4/4/2012 | 13:10 | 1 | F18 | |
| 39 | 4/4/2012 | 13:12 | 1 | F18E | |
| 40 | 4/4/2012 | 14:32 | 2 | F18E | |
| 41 | 4/4/2012 | 14:32 | 3 | F18E | |
| 42 | 4/4/2012 | 14:34 | 4 | F18E | |
| 43 | 4/4/2012 | 14:35 | 2 | F18E | |
| 44 | 4/4/2012 | 14:36 | 4 | F18 | |
| 45 | 4/4/2012 | 14:39 | 1 | F18 | |
| 46 | 4/4/2012 | 15:01 | 1 | F18 | |
| 47 | 4/4/2012 | 16:00 | 2 | F18E | |
| 48 | 4/4/2012 | 16:03 | 2 | F18E | |
| 49 | 4/4/2012 | 16:05 | 1 | F18E | |
| 50 | 4/4/2012 | 16:06 | 2 | F18E | |
| 51 | 4/4/2012 | 17:30 | 1 | F18 | |
| 52 | 4/4/2012 | 17:31 | 4 | F18E | |
| 53 | 4/4/2012 | 17:33 | 1 | F18E | |
| 54 | 4/4/2012 | 17:34 | 3 | EA-6B | |
| 55 | 4/4/2012 | 17:35 | 4 | F18 | Run 55-> 0-3 sec {4+1 full pwr}, 3 sec {4 launch}, 3-20 sec {cat 1} |
| 55 | 4/4/2012 | 17:37 | 1 | F18 | |
| 56 | 4/4/2012 | 17:42 | 1 | F18 | |
| 57 | 4/4/2012 | 19:00 | 1 | F18E | |
| 58 | 4/4/2012 | 19:02 | 4 | F18 | |
| 59 | 4/4/2012 | 19:04 | 1 | F18 | |
| 60 | 4/4/2012 | 19:06 | 1 | F18E | |
| 61 | 4/4/2012 | 19:08 | 4 | F18E | |
| 62 | 4/4/2012 | 19:07 | 3 | F18E | |
| 63 | 4/4/2012 | 19:10 | 4 | F18 | |
| 64 | 4/4/2012 | 19:08 | 1 | E-2 | |
| 65 | 4/4/2012 | 19:09 | 3 | F18 | |
| 66 | 4/4/2012 | 19:10 | 4 | F18 | Cat 1&4 at Full Power, Cat 4 launch @ 11 sec, Cat 1 only 11->21 sec |
| 66 | 4/4/2012 | 19:12 | 1 | F18 | |
| 67 | 4/4/2012 | 20:30 | 3 | F18E | |

| Table 1. Data Logs from CVN 69 Testing - April 2-5 2012 | | | | | |
|---|---|---|---|---|---|
| NCE Run # | Date | Time Off Deck | Catapult # | Aircraft Type | Notes |
| 71 | 4/4/2012 | 20:33 | 3 | F18E | |
| 72 | 4/4/2012 | 20:34 | 4 | F18 | |
| 73 | 4/4/2012 | 20:35 | 1 | F18E | |
| 74 | 4/4/2012 | 20:37 | 3 | F18 | |
| 75 | 4/4/2012 | 20:38 | 1 | F18 | |
| 76 | 4/4/2012 | 20:42 | 1 | F18 | |
| 77 | 4/4/2012 | 21:00 | 3 | F18E | Wet Rhino - afterburner |
| | | | | | |
| 78 | 4/5/2012 | 9:33 | 1 | F18E | |
| 79 | 4/5/2012 | 9:34 | 2 | F18E | Run 79 -> [10 -> 33 sec] |
| 79 | 4/5/2012 | 9:35 | 1 | EA-6B | Run 79 -> [117 -> 145 sec] |
| 79 | 4/5/2012 | 9:35 | 3 | F18E | Run 79 -> [145 -> 153 sec] |
| 79 | 4/5/2012 | 9:36 | 2 | F18 | Run 79 -> [185 -> 213 sec] |
| 79 | 4/5/2012 | 9:36 | 4 | F18 | Run 79 -> [213 -> 225 sec] |
| 79 | 4/5/2012 | 9:37 | 1 | F18E | Run 79 -> [290 -> 305 sec] |
| 79 | 4/5/2012 | 9:38 | 3 | F18 | Run 79 -> [335 -> 362 sec] |
| 79 | 4/5/2012 | 9:39 | 2 | F18 | Run 79 -> [360 -> 386 sec] |
| 79 | 4/5/2012 | 9:39 | 4 | F18E | Run 79 -> [400 -> 430 sec] |
| 79 | 4/5/2012 | 9:41 | 1 | F18E | Run 79 -> [525 -> 544 sec] |
| 79 | 4/5/2012 | 9:42 | 2 | F18 | Run 79 -> [549 -> 565 sec] |
| 79 | 4/5/2012 | 9:44 | 3 | F18E | Run 79 -> [635 -> 670 sec] |
| 79 | 4/5/2012 | 9:45 | 4 | F18E | Run 79 -> [734 -> 758 sec] |
| 79 | 4/5/2012 | 9:48 | 3 | F18E | Run 79 -> [893 -> 920 sec] |
| 80 | 4/5/2012 | 9:52 | 4 | F18E | |
| 81 | 4/5/2012 | 9:55 | 1 | F18E | Run 81 -> 0-14 sec |
| 81 | 4/5/2012 | 9:55 | 2 | F18E | Run 81 -> 15-42 sec |
| Data from Array Microphones | | | | | |
| 0 | 4/5/2012 | | 3 | | Pri-Fly |
| 1 | 4/5/2012 | | 1 | | Pri-Fly |
| 2 | 4/5/2012 | | 1 | | Pri-Fly |
| 1430 | 4/5/2012 | | 2 | | Pri-Fly |
| 1430-1 | 4/5/2012 | | 4 | | Pri-Fly |
| 1430-2 | 4/5/2012 | | 1 | | Pri-Fly |
| 1430-3 | 4/5/2012 | | Retrieval-3 wire | | Pri-Fly |
| 1430-4 | 4/5/2012 | | Retrieval-3 wire | | Pri-Fly |
| 1430-5 | 4/5/2012 | | Retrieval-bolter | | Pri-Fly |
| 1430-6 | 4/5/2012 | | Tower Flyby | | Pri-Fly |

# Appendix C: Data Logs from CVN 69 Testing - Microphones Only - August 2011

| Table 3. Data Logs from CVN 69 Testing - Microphones Only - August 2011 | | | | | |
|---|---|---|---|---|---|
| NCE Run # | Date | Time Off Deck | Catapult # | Aircraft Type | Notes and Measurement Locations |
| NI Hand-Held | | | | | |
| 4 | 8/15/2012 | 16:56 | 1 | F18 | Flight Deck Control - 04 Level in Island |
| 5 | 8/15/2012 | 17:00 | Touch & Go | F18 | Flight Deck Control - 04 Level in Island |
| 6 | 8/15/2012 | 17:01 | Landing | F18 | Flight Deck Control - 04 Level in Island |
| 7 | 8/15/2012 | 15:01 | Touch & Go | F18E | Flight Deck Control - 04 Level in Island |
| 8 | 8/15/2012 | 15:03 | Touch & Go | F18E | Flight Deck Control - 04 Level in Island |
| 9 | 8/15/2012 | 15:04 | Landing | F18 | Flight Deck Control - 04 Level in Island |
| 12 | 8/15/2012 | 15:14 | Flyby | F18 | Flight Deck Control - 04 Level in Island |
| 13 | 8/15/2012 | 15:15 | Touch & Go | F18 | Flight Deck Control - 04 Level in Island |
| 14 | 8/15/2012 | 15:16 | Touch & Go | F18E | Flight Deck Control - 04 Level in Island |
| 15 | 8/15/2012 | 15:18 | Touch & Go | F18 | Flight Deck Control - 04 Level in Island |
| 16 | 8/15/2012 | 15:20 | Landing | F18E | Flight Deck Control - 04 Level in Island |
| Data from Array Microphones | | | | | |
| 0 | 8/16/2012 | 15:14 | Cat 1 | ? | SR 03-89-6-L |
| 1 | 8/16/2012 | 15:16 | Cat 1 | ? | SR 03-89-6-L |
| 2 | 8/16/2012 | 15:27 | Cat 2 | ? | SR 03-89-6-L |
| 3 | 8/16/2012 | 17:12 | Cat 2 | ? | SR 03-89-6-L |
| 4 | 8/16/2012 | 17:15 | Cat 2 | ? | SR 03-89-6-L |
| 0 | 8/16/2012 | 16:36 | Cat 2 | F18 | SR 03-92-4-L |
| 1 | 8/16/2012 | 16:42 | Cat 2 | F18 | SR 03-92-4-L |
| 2 | 8/16/2012 | 16:48 | Cat 2 | F18 | SR 03-92-4-L |
| 0 | 8/16/2012 | 19:25 | Cat 1 | F18E | SR 03-92-0-L |
| 1 | 8/16/2012 | 19:26 | Cat 2 | F18 | SR 03-92-0-L |
| 2 | 8/16/2012 | 23:37 | Cat 1 | F18E | SR 03-92-0-L |
| 3 | 8/16/2012 | 23:39 | Cat 2 | F18 | SR 03-92-0-L |
| 4 | 8/16/2012 | 23:48 | Cat 1 | F18E | SR 03-92-0-L |
| 5 | 8/16/2012 | 23:55 | Cat 2 | F18 | SR 03-92-0-L |
| 0 | 8/17/2012 | 17:04 | Cat 1 | F18 | SR 03-96-0-L |
| 1 | 8/17/2012 | 17:05 | Cat 2 | F18 | SR 03-96-0-L |
| 2 | 8/17/2012 | 17:09 | Cat 1 | F18 | SR 03-96-0-L |
| 3 | 8/17/2012 | 17:12 | Cat 2 | F18 | SR 03-96-0-L |
| 4 | 8/17/2012 | 17:17 | Cat 2 | F18 | SR 03-96-0-L |
| 5 | 8/17/2012 | 17:19 | Cat 2 | F18 | SR 03-96-0-L |
| 0 | 8/17/2012 | 14:10 | Cat 1 | F18E | SR 03-64-1-L |
| 1 | 8/17/2012 | 14:14 | Cat 1 | F18E | SR 03-64-1-L |
| 2 | 8/17/2012 | 14:16 | Cat 1 | F18E | SR 03-64-1-L |
| 3 | 8/17/2012 | 14:19 | Cat 1 | F18E | SR 03-64-1-L |
| 4 | 8/17/2012 | 14:53 | Cat 2 | F18 | SR 03-64-1-L |
| 5 | 8/17/2012 | 14:56 | Cat 2 | F18 | SR 03-64-1-L |
| 6 | 8/17/2012 | 14:58 | Cat 1 | F18E | SR 03-64-1-L |
| 0 | 8/17/2012 | 16:13 | Cat 2 | F18E | Squad Maint. Office - 03-49-3-Q |
| 1 | 8/17/2012 | 16:14 | Cat 1 | F18E | Squad Maint. Office - 03-49-3-Q |

| Table 3. Data Logs from CVN 69 Testing - Microphones Only - August 2011 | | | | | |
|---|---|---|---|---|---|
| NCE Run # | Date | Time Off Deck | Catapult # | Aircraft Type | Notes and Measurement Locations |
| 2 | 8/17/2012 | 16:15 | Cat 2 | F18 | Squad Maint. Office - 03-49-3-Q |
| 3 | 8/17/2012 | 16:17 | Cat 1 | F18E | Squad Maint. Office - 03-49-3-Q |
| 4 | 8/17/2012 | 16:20 | Cat 1 | F18 | Squad Maint. Office - 03-49-3-Q |
| 5 | 8/17/2012 | 16:22 | Cat 1 | F18E | Squad Maint. Office - 03-49-3-Q |
| 6 | 8/17/2012 | 16:25 | Cat 2 | F18 | Squad Maint. Office - 03-49-3-Q |
| NI Hand-Held | | | | | |
| 1 | 8/17/2012 | 21:21 | waterbrake Impulse | | Forward Space 03-K-1-A |
| 2 | 8/17/2012 | 22:10 | Background | | Medical Space 2-120-1-Q - Under HVAC Fan |
| 3 | 8/17/2012 | 22:12 | Background | | Medical Space 2-120-1-Q - HVAC Vent |
| 4 | 8/17/2012 | 22:15 | Background | | Medical Space Patient Lobby 2-89-1-L - Under HVAC Vent |
| 5 | 8/17/2012 | 22:16 | Background | | Medical Space Patient Lobby 2-89-1-L - Under HVAC Return |
| 6 | 8/17/2012 | 22:23 | Background | | Fwd Battle Dress Station 2-89-1-L Bkgd |
| 7 | 8/17/2012 | 22:27 | Cat 1 | | Fwd Battle Dress Station 2-89-1-L Cat1 Launch |
| 9 | 8/17/2012 | 23:43 | Cat 2 | F18E | Battle Dress Station 04-166-3 |
| 10 | 8/17/2012 | 23:46 | Touch & Go | F18 | Battle Dress Station 04-166-3 |
| 11 | 8/17/2012 | 23:48 | Retrieval | F18E | Battle Dress Station 04-166-3 - Missed Wire |
| 12 | 8/17/2012 | 23:49 | Retrieval | F18 | Battle Dress Station 04-166-3 |
| 13 | 8/17/2012 | 23:50 | Retrieval | F18 | Battle Dress Station 04-166-3 |
| 14 | 8/17/2012 | 23:51 | Touch & Go | F18E | Battle Dress Station 04-166-3 |
| 15 | 8/17/2012 | 23:53 | Cat 2 | F18E | Battle Dress Station 04-166-3 |
| 16 | 8/17/2012 | 23:56 | Cat 1 | F18 | Battle Dress Station 04-166-3 |
| Shotgun Mic Hand Held-Flight Deck | | | | | |
| 1 | 8/17/2011 | 14:03 | Cat 1 | F18 | Shotgun Microphone Position 1 - 20 meter at 50 degrees port of Cat 1 |
| 2 | 8/17/2011 | 14:08 | Cat 1 | F18 | Shotgun Microphone Position 2 - 20 meter at 10 degrees port of Cat 1 |
| 4 | 8/17/2011 | 14:12 | Cat 1 | F18 | Shotgun Microphone Position 3 - 40 meter at 10 degrees port of Cat 1 |
| Set 44-Run 1 | 8/17/2011 | 14:48 | Cat 1 | F18 | Shotgun Microphone Position 4 - 65 meter at 10 degrees port of Cat 1 |
| Set 44-Run 3 | 8/17/2011 | 14:51 | Cat 2 | F18E | Shotgun Microphone Position 4 - 65 meter at 10 degrees port of Cat 1 |

| Table 3. Data Logs from CVN 69 Testing - Microphones Only - August 2011 | | | | | |
|---|---|---|---|---|---|
| NCE Run # | Date | Time Off Deck | Catapult # | Aircraft Type | Notes and Measurement Locations |
| NI Hand-Held | | | | | |
| 1 | 8/18/2011 | 13:59 | Cat 1 | F18 | Pri-Fly - by Window |
| 2 | 8/18/2011 | 14:02 | Cat 1 | F18 | Pri-Fly - by Window |
| 3 | 8/18/2011 | 14:08 | Cat 2 | F18 | Pri-Fly - by Window |
| 4 | 8/18/2011 | 14:15 | Touch & Go | F18 | 010 Level Starboard Bridge Wing Facng Port |
| 5 | 8/18/2011 | 14:17 | Retrieval | F18 | 010 Level Starboard Bridge Wing Facng Port |
| 6 | 8/18/2011 | 14:20 | Cat 1 | F18 | 010 Level Starboard Bridge Wing Facng Port |
| 7 | 8/18/2011 | 14:34 | Cat 2 | F18 | Pri-Fly - by Window |
| 9 | 8/18/2011 | 15:11 | Cat 1 | F18E | Central Passageway Fr. 88 |
| 10 | 8/18/2011 | 15:12 | Cat 2 | F18 | Central Passageway Fr. 88 |
| 11 | 8/18/2011 | 15:14 | Cat 1 | F18E | Central Passageway Fr. 79 |
| 12 | 8/18/2011 | 15:24 | Cat 1 | F18E | Central Passageway Fr. 69 |
| 13 | 8/18/2011 | 15:28 | Cat 1 | F18 | STDB Passageway Fr. 69 |
| 14 | 8/18/2011 | 15:31 | Cat 1 | F18 | STDB Passageway Fr. 79 |
| 15 | 8/18/2011 | 15:34 | Cat 1 | F18 | STDB Passageway Fr. 88 |
| 16 | 8/18/2011 | 15:37 | Cat 1 | F18E | STDB Passageway Fr. 96 |
| 17 | 8/18/2011 | 15:40 | Cat 1 | F18E | STDB Passageway Fr. 104 |
| 18 | 8/18/2011 | 15:42 | Cat 1 | F18 | STDB Passageway Fr. 108 |
| 19 | 8/18/2011 | 15:45 | Cat 1 | F18 | STDB Passageway Fr. 114 |
| 20 | 8/18/2011 | 15:50 | Cat 2 | F18 | Central Passageway Fr. 79 |
| 22 | 8/18/2011 | 15:56 | Cat 1 | F18 | Central Passageway Fr. 69 |
| 23 | 8/18/2011 | 15:59 | Cat 2 | F18 | Central Passageway Fr. 59 |
| 24 | 8/18/2011 | 16:07 | Cat 1 | F18 | Port Passageway Fr. 88 |
| 25 | 8/18/2011 | 16:11 | Cat 2 | F18E | Port Passageway Fr. 79 |
| 26 | 8/18/2011 | 16:13 | Cat 2 | F18E | Port Passageway Fr. 69 |
| 27 | 8/18/2011 | 16:16 | Cat 2 | F18E | Port Passageway Fr. 96 |
| 28 | 8/18/2011 | 16:19 | Cat 2 | F18 | Port Passageway Fr. 100 |
| 29 | 8/18/2011 | 16:21 | Cat 2 | F18 | Gym - Frame 84 |

SBIR PHASE II, N 04-221
SOUND AND NOISE ABATEMENT CONTROL TESTS
LIST OF TESTING PERFORMED (PARTIAL)
Note: listing is of passed tests and significant
Milestones, not all testing is included.
Final Sound testing Report is in the body of Report
Oberst Beam Test – Noise Control Eng.
Oberst Beam Test – Noise Control Eng.
Oberst Beam Test – Noise Control Eng.
ASTM 03359 Cross Hatch Adhesion – LTB Engineering
ASTM E756 Viscoelastic Properties – Roush Anatol Div.
ASTM E1461-01 Thermal Diffusivity – Center for Composites
IMO A653 (16) Part 5 Fire – Intertek Lab
IMO A653 Part 2 Smoke and Toxicity – Intertek Labs
ASTM E-84 Surface Burning Characteristics – Southwest Labs

## 3.2 THERMAL CONTROL STUDIES AND BENEFITS

The U. S. Navy and Commercial interests have employed TEMP-COAT as an insulation and a condensation barrier since 1994. This SBIR created the opportunity for TECH 21 to reassess the product and make certain changes to assure the product is completely compliant with all International SOLAS – IMO regulations. All testing involved for the product centered around the safety and capability of TEMP-COAT to withstand the rigors of shipboard interior-exterior use.

TEMP-COAT was first purchased for use on a Navy Vessel in 1994 by Ingalls Shipyard, Pascagoula, MS. The product was used to replace vermiculite paint which was difficult to install, gave a very rough textured finish, encouraged rust because it was an *absorptive* product causing corrosion and it was difficult to maintain. There is also much evidence that vermiculite may contain asbestos. The product was developed on the basis that it would absorb moisture until temperatures changed and then would expel the moisture. This action draws moist salt air into the coating creating the possibility of a rust and corrosion event. The product could not be top coated or it would not perform. Traditional lagging insulation systems allow moisture to form between the insulation and the metal substrate allowing CUI(Corrosion Under Insulation) to develop. TEMP-COAT is a thermal barrier creating a baffle between two temperatures controlling the surface thermally. The surface is smooth, pliable and can also be top coated to ships specifications and colors. The product is better for maintenance and control of rust and corrosion.

*Figure 1*
*Corrosion Under Insulation (CUI): Corrosion under conventional lagging system on the USS Crommelin*
*Photo Courtesy of US Navy*

The U.S. Navy first gave approval to TEMP-COAT via an on-board study under the NONDEVELOPMENTAL ITEM PROGRAM (NDI) IN June of 2001. U. S Coast Guard was the second military entity to approve TEMP-COAT in June 2007. The Navy ran onboard testing through the various ship builders for several years culminating with the approval from FTSCPAC in January 2001. Continued studies and a one year physical test on a Navy vessel gained an approval from COMNAVSEASYSCOM in March 2003. The published approval acknowledged the product as a condensation control coating with no credence to its insulating ability. The reason for this decision is unbeknown to us.

Much earlier, a recommendation was given to the product via a BATH IRON WORKS Engineering Report (General Dynamics) dated August 31,1999 performed under N00024-92-2805 and titled SSS 68-082. This report states *"Test results general supported manufacturer's claims regarding thermal conductivity, and faired acceptably with regards to adhesion and chemical compatibility."* * TEMP-COAT is an Insulation which creates a thin barrier between two different thermal surfaces. This action allows the product to do an excellent job of stopping condensation as it insulates. Today permission to use TEMP-COAT as an insulation is given on a case by case basis. Should the product be approved and published as an insulation, it would then be of great benefit to all Navy Vessels.

LITTON

INGALLS SHIPBUILDING

Memorandum

To: Jim Willis

FILE NO: x-17-018

Date: September 9, 1998

FROM: M.G. McLeod

PHONE: 4436

Re; Anti - Sweat and Spray - on Insulation

LHD-6 was experiencing extreme condensation problems because of excessive heat and humidity. The Anti - Sweat coating system failed and water from sweating bulkheads and ventilation systems became a serious problem. The Anti – Sweat system Ingalls Paint Department applies will not stand this type of weather conditions.

A vendor was contracted by the U.S. Navy and the Program office by the name of Randy Lorio d.b.a. (Temp - Coat Inc.) (see Attached) to stop the excessive sweating in the following spaces: 03-61-I-Q (the ramp from main deck to flight deck) on the bulk head and in the overhead with a result of all sweating stopped and a very good satin smooth appearance, 01-71-2-L (Medical Processing) & 01-81-6-L (Clinical Lab) on the Vent Duct sweating and dripping on Medical equipment with a result of all condensation stopped and temperature in the compartment balancing out. Note: By applying Temp-Coat the adjoining spaces also stopped sweating and the humidity level stabilized.

You need to pursue this product for other programs in way of Anti - Sweat and spray - on Insulation,

M.G. McLeod
Supt. Joiner/Insulation

*Figure 2*
*Memorandum from Ingalls Shipbuilding concerning success of installations of TEMP-COAT 101.*

To use TEMP-COAT spray applied coating as an insulation on Navy Vessels would remove excessive weight, stop unwanted rust and corrosion, allow for ease of inspection, stop mold and mildew and significantly reduce maintenance and installation costs. Features of the product are designed with general maritime use in mind. TEMP-COAT is easily repaired with brush, roller or a small air assisted siphon type spray gun designed for that purpose. The product is tested to a 63% elongation therefore it moves with the surface of the metal disallowing cracks and spider webbing. This important feature won it a 47,000 gallon job on the Huey P. Long Bridge in Jefferson, LA. A ten year study showed that it held up extremely well in comparison to conventional hard Industrial paints which were subject to stress, cracking and crazing as the steel expanded and contracted. In doing so, it alleviates or allows for detection of rust and corrosion long before they become a huge problem. Ease of inspection is created by the lack of coverings or failed paint. When a rust stain is detected, it can be repaired immediately reducing the risk of expensive repairs and maintenance.

TEMP-COAT has been put through a complete bank of tests in compliance with the requirements of the SBIR.

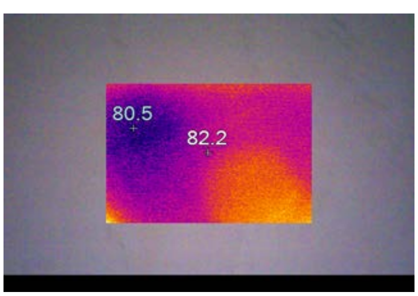
**SBIR PHASE II, N 04-221**
**LIST OF TESTING PERFORMED (PARTIAL)**

Note: listing is of passed tests and significant
Milestones, not all testing is included.
IMO A653 (16) Part 5 Fire – VTEC Labs
IMO A653 Part 2 Smoke and Toxicity – VETEC Labs
IMO A653 (16) Part 5 Fire – Intertek Labs
IMO A 653 Part 2 Smoke and Toxicity – Intertek Labs
ASTM E 162-02a Surface Flammability – Southwest Labs
ASTM E 662 Optical Density Smoke – Southwest Labs
ASTM D2369, D4017 & D1475 – VOC's American Research
ASTM D3359 Adhesion – Dallas Labs
ASTM D638 Tensile Strength – Dallas Labs
ASTM B117 Salt Fog – Dallas Labs
ASTM D752 Density @ 24*C – Dallas Labs
ASTM D2369 Total Solids – Dallas Labs
ASTM G53, UV-A 2000 Hours – Dallas ALabs
EPA Method 24 VOC's lb/gal <0.01 – Dallas Labs
Chemical Resistivity – 4 Acidic Mediums – Dallas Labs
ASTM D3359 Adhesion to 3 Sub straights – Dallas Labs
ASTM E 84 – UL 723 Surface Burning Char. –Southwest Labs
Navy Safety and Survivability – Acoustic Study

The primary purpose of the TEMP-COAT testing on the USS Eisenhower (CVN-69) was to show the thermal benefits of the product. The information gathered came primarily from the Steam Catapult Trough which displayed an outside temperature of 109.0*F before it was coated and the thermal difference of 82.2*F following installation of the coating. This represents a 24.5% decrease in thermal pass through on this project. The greater the difference in temperatures, the better the product works for heat or cold.

## Thermal Advantages of the TEMP-COAT System


Un-coated section of the steam catapult trough
- Temperature of steel plate is 109°F
- Thermal Transfer entering ship envelope can escape into interior of vessel at damages area of lagging
- Allows potential for condensation to develop




Coated section of the steam catapult trough
- Temperature of steel plate is 82.2°F
- Adheres directly to substrate blocking thermal transfer from entering the ship envelope
- Allows the ability to significantly curb or stop condensation aiding the fight against Corrosion Under Insulation

*Figure 3*
*Ship board testing of TEMP-COAT 101 applied to the steam catapult of USS Eisenhower*

Over the years many Naval vessels and other private ships have used this coating for insulation purposes including steam lines, cryogenics, boilers, overheads, bulkheads, decks, refrigeration equipment, piping and the like. TEMP-COAT would be very useful in many ways as an insulation. It is also very easy to train ships force to apply the product while on cruise.

*Figure 4*
*Commercial Application of Silent Running aboard pleasure yacht to reduce structure borne noise.*
*Photo Courtesy of Fashion Yachts*

*Figure 5*
*Application of TEMP-COAT 101 Insulation Coating on hot oil tank for personnel protection and energy savings aboard the RFA Fort George*
*Photo Courtesy of British Navy*

*Figure 6*
*Commercial Application of Silent Running and TEMP-COAT to aluminum super-structure to reduce structure borne noise and control thermal loads.*
*Photo Courtesy of TEMP-COAT Brand Products*

*Figure 7*
*Commercial Application of TEMP-COAT 101 to stop condensation issues and associated mold growth aboard car carrier Asian Spirit.*
*Photo Courtesy of Nissan Fleet Operations*

Following completion of the required testing under SOLAS IMO A.653 Part 5 (smoke and toxicity) and A.653 Part 2 (Fire) the product became qualified for use in vessels throughout the International maritime community. This opened the door for receipt of a Lloyd's Register Approval and the ongoing pursuit of a DNV approval as well as a Japanese Approval. The SBIR has opened the door to commercialization of this as well as the noise control product.

Commercial entities and Engineering groups have found that liquid applied insulation serves a like purpose to conventional insulation with many advantages. During the course of this SBIR BAE published an article that indicates private shipbuilders agree. The same applies to the Royal British Navy who is beginning to apply TEMP-COAT to its vessels and researching the use of the product on Submarines.

## 3.3 CONDENSATION CONTROL STUDIES AND BENEFITS

Ever since a moratorium was placed on asbestos in the 1980's Insulation has been a quandary for all types of construction including the ship building industry. Primarily by habit from years ago, lagging or blanket type material has been used to insulate and supposedly control condensation. The question is, do these products, along with products like vermiculite paint partially control condensation and hide the culprit and allow it to destroy the object by hiding the problem. Over the years we have had the opportunity to install condensation control liquid latex products on innumerable vessels and offshore platforms. This being done, quite often, to assist in the control of condensation and to prevent hiding the issue.

Condensation control liquid applied insulation offers the best of both worlds. The thickness can be varied to control different degrees of condensation and thermal issues while giving constant access to visual inspection on more frequent basis coupled with immediate repairs. Where a combination of problems exist, the ceramic insulation can be applied to the hull, bulkhead or other surfaces and the lagging can be pinned over it to induce noise control. Latex thermal control offers two solutions in one. It is also a permanent one time installation with nominal work to repair a surface is damaged.

Condensation control was not tested aboard the Eisenhower however, hundreds of vessels from Disney Cruise Lines to Nissan Car Carriers to Ferries, Navy Ships and U.S. Coast Guard vessels have been using the product for years.

Condensation is a very difficult problem to solve. Unlike Thermal protection, it involves temperature's, location, humidity, air movement, pressure and in the case of piping, it involves fluid or gas under pressure. The thermal / condensation control product chosen for this study has proven to provide control under all of these circumstances depending upon the amount of product is installed to cure the problem. In the case of the U.S Navy approval, it was granted based on a 60 mil thickness ( 1.5 mm) for general ships surfaces. As we write today several shipyards are applying TEMP-COAT on Navy Ship air movement duct work to solve the problem and to stop the ducts from rotting out under conventional mass insulation.

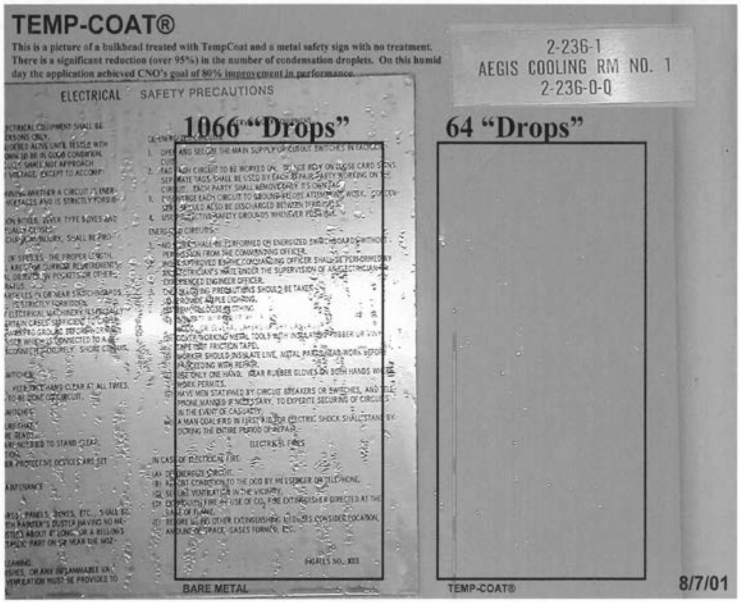



*Figure 8*
*Condensation Control: Test area performed on the USS Aegis. Coated bulkhead not condensation vs. uncoated wall plate.*

Weight is another factor in the use of a thermal control coating vs. lagging or pinned foam. We have had several opportunities to remove lagging after two years of use and weigh the lagging against the manufacturers delivered weight. In several instances the lagging weighed twice as much as it did when it was installed due to the infiltration of humidity and moisture. The weight of the coating does not change. Much more, it weighs less than 5 pounds per gallon in the container and as dry film a Navy Study confirms that it DFT weighs is 4.2 Ounces per Square Foot at a 99.5 mil thickness.

WEIGHT COMPARISON BY PRODUCT TYPE

OBJECTIVE: Design of system that will dampen noise, stop condensation, & provide thermal control

| Product Type | Installation Procedure | SQ.FT Weight: OZ | Thickness | Product | Ship |
|---|---|---|---|---|---|
| Part A (Noise | | 9.6 | 60 mils | dB Reduction | All |
| Part B | Spray | 2.4 | 60 mils | Condensation, Thermal | All |
| Part A+Part B | Spray | 12 | 120 mils | dB Reduction, Condensation | All |
| Vs. EAR Tile Typical | | | | | |
| DT 3/8 EAR Tile Typical | Cut to fit/Glue | 39 | 3/8" | DB Reduction Only | ****Machinery Spaces |
| DT 1/2 EAR Tile Typical | Cut to fit/Glue | 64.5 | 1/2" | DB Reduction Only | ****Machinery |

* Thermal Coating has shown the ability to provide 4dB reduction for absorbtion

****Due to our gassing toxicity of smoke in a potential fire, this product cannot be used in crew quarters spaces according to the NAVSEA Shipbuilding General Specification.

System not compared to lagging weights in above data as lagging is not used for structural damping

*Figure 9*
*Weight Comparison by Product Type*

## 3.4 FIRE BARRIER COATING FB-520 (FB-521) STUDY AND BENEFITS

Considerable efforts over the years have been made to produce a light weight, thin film thermal barrier. TECH 21 has worked on this concept for over 10 years with continual progress. This PHASE II SBIR has allowed us to take our progress and thinking to an entirely new level in creating a smoke free or (reduced, non-toxic, safe smoke) formulation that will be light weight and can be applied in a thin film criteria. This study is continuing with the hopes of completing the project during 2013. Thus far we have produced a product that will withstand the A-754 test bed for 44 minutes before failure. The changed and new formulation is expected to provide adequate results for a passing A-60 Test if not better.

The original formula for FB-520 was conducted on the USS Ex-Shadwell stationed in Mobile Bay, AL in 2001. Upon completion Dr. Fred Williams suggested that we try the product on the Port side of the Shadwell which is a submarine capsule. In trying for several years after our first test, funding was not available for continuance. We did, however, coat a number of areas of the vessel for Dr. Williams to protect fire fighting equipment.

*Figure 10*
*Small Scale A60 Fire Test*

All testing performed on has been by certified labs. In areas where adhesion was constant, the product met the criteria set under IMO FTP Code 53/23/Add1 using the A-60 or 60 minute burn platform. New formulations are still being tested under the SBIR for completion of this product and testing with the intent of success during year 2013.

There have been many issues of fire at sea that this product would have made the difference in limiting catastrophic events. We have had inquires from the Army and numerous Companies and Countries searching for a thin film fire protection that would pass the A-60 tests. This product will be excellent for commercialization and we intend to see it through. Thanks to the SBIR we have been given this opportunity.

## 4.0 CONCUSION

Currently the Navy uses various forms of insulations that have become history. Most insulations, cover steel and aluminum but attach poorly allowing moisture and humidity to form behind and inside of the mass structure of these products. Once moisture of any kind infiltrates the fibers or the pours of these materials, the probability of damage or corrosion is greatly heightened.
The primary areas affected are those which sustain temperatures below 250*F. At these temperatures, condensation will occur. With Fiberglass, wool, calcite perform coverings, open cell foam and "*suck-em-up*" products such as vermiculite paint, once moisture enters the product, thermal properties are significantly diminished. As thermal conditions change inside and outside of the vessel, expectations are heightened that create increased chances of Corrosion Under Insulation (CUI) and the growth of mold and feces left behind by insects and rodents alike. Salt becomes a significant issue as well as it becomes trapped between the insulation and the metal surface. These natural occurrences cause increased maintenance. In short, if the added protective converging is not completely adhering to the metal surface there is a certainty that a problem will begin and develop and worsen at that point. Corrosion and unwanted circumstances will occur. A change in logic to protect the asset while solving other needs must be realized in order to accomplish what the Navy wishes to do. With coatings as a great part of the solution, the inspection and maintenance issues are greatly diminished as well.

It is so that all surfaces need different type of treatments for noise and asset protection. However, if a coating with light weight thermal properties or noise damping coatings properties is added to the design features, much of the problem can be eliminated. This action will reduce many of the problems the ships and the crew face today. It has been learned in using these coatings in Industry, maritime and fixed offshore assets that Insulation coatings significantly reduces total cost of ownership. In many cases, in the private sector, we are installing a combination of coatings in addition to legging in order to build or convert a vessel to a better and longer lasting object. Grasping the need for total protection in construction and refurbishment is the missing link.

## 4.1 EXPECTATIONS

- ☐ Easier Maintenance And Repair / Immediate Visual Inspection. Reduced maintenance and repair cost. Can be covered with Ships required top coatings.
- ☐ Specifically engineered for use on non-porous surfaces such as metals, fiberglass, plastics, piping etc. in ships. Plus Noise and Thermal control on other surfaces.
- ☐ Sound reduction coating for use in military & commercial ships and other equipment.
- ☐ The advanced noise & vibration damping polymer is ideal for marine applications.
- ☐ Current formulations include nonflammable, non-toxic, rust-resistant and antifungal.
- ☐ Environmentally friendly. Independent Lab tested by Purdue University Thermo-Physical Labs, Boeing Aircraft Sound Labs, Intertech Labs, VTech Labs, SouthWest Labs and others.
- ☐ Complies with IMO A.653 (16) Flame Spread Test and IMO A.653 Part 2 Smoke and Toxicity for U.S. and Foreign Commercial and Military Sales.
- ☐ Anticipated noise reduction from 7 to 10 dB with dramatic reduction of noise and vibration damping depending on application and amount used
- ☐ Aids deployment of Crew Endurance Management (CEM) by reducing risk

factors related to noisy environment such as found on air capable ships with vertical takeoff and landing Harrier (93dB flight deck environments) and soon Joint Strike Fighters with 150dB+ flight deck noise environment.

- ☐ Thermally Insulate downdraft from the V-22 and Joint Strike Fighter to reduce the possibility of smoke generation in the overhead spaces located directly below the flight deck.
- ☐ Fully compliant in every State and Internationally; Ultra-low VOC's
- ☐ Anticipate acoustic reduction factors equivalent to many conventional damping materials with significant weight and bulk reduction

## 5.0 SUMMARY

Extreme efforts have been made by the Navy and the shipbuilder to meet the requirements for longevity and preservation of the Navy Ship. This begins with sound construction, proper outfitting, updated warfare technology, a more intelligent well trained crew and a coating protection system that has been used for over 30 years. Building the ideal vessel is so important to our Nations future. It would seem that new technologies in coatings and preservation would have a place in making the life full life expectancy a reality. Giving due consideration to these new concepts will cause preservation and help prevent noise depravation for the war fighter.

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