

1.0 OBJECTIVE.

- 1.1 An increasing number of marine structures are utilizing composite materials. Major structure and components can be built lighter and corrosion-resistant using composites. Upcoming projects, such as the US Navy's DD(X) Topside Structure and the USCG's Fast Response Cutter are slated to be built with composites. Additionally, the offshore oil industry is starting to build composite risers and habitability modules. Nondestructive Evaluation (NDE) techniques developed for aerospace structures are not viable for large marine structures. A state-of-the-art assessment of available NDE techniques for marine composite structures is required.

2.0 BACKGROUND.

- 2.1 Building large marine structures using composite materials for specialized applications is one of the few remaining areas of shipbuilding where the United States has remained competitive. The demand for speed and reduced manning should continue the trend towards advanced-material construction. Our analytical techniques and fabrication processes now allow us to undertake structures of ever-increasing size. What has not kept pace with marine composite technology is the ability to inspect large composite structures and assess structural integrity.

In 1990, Yoseph Bar-Cohen authored a report for the USCG R & D Center [8.1] This excellent report surveyed various NDE techniques as applied to composite panels with defects. However, Dr. Bar-Cohen worked for McDonnell Douglas when the report was done and techniques cited are still mostly used by only by the aerospace industry 20 years after his research.

Over the past two decades, the industry has moved towards laminates with higher fiber contents and higher strength materials. [8.2] Also, the industry has more "field" experience with various NDE techniques. FEA techniques have advanced to the point where we can now perform a Flaw Criticality Analysis to help us assess how large a defect is required before a composite structure fails. This helps us answer the question of how small a defect should we be looking for.

- 2.2 The US Navy has invested millions of dollars to qualify composites for use in topside structures on major surface combatants. Additionally, the Office of Naval Research is funding the design and process trials for a high speed vessel. Many of these prototype efforts never get deployed in the fleet because ship program managers simply do not have confidence in our ability to inspect and repair large composite structures. The US Coast Guard has also resisted composite construction for ship classes such as the 47-foot Motor Lifeboat, although a definite potential exists for lifecycle maintenance cost savings exist. Simply stated by one of the USCG's naval architects: with aluminum, the can easily see and repair cracked welds.

NDE techniques are required for cored composite structures as well as solid laminates. Recent investigations by Strand, et. al. [8.3] looked into reported widespread skin to core delaminations of balsa-cored boats and the resulting affect on structural performance. Destructive analysis (hole saws) are

commonly used to verify what's actually going on inside cored laminates. In order to advance the use of composite construction for military and commercial applications, cost-effective NDE methods need to be established and accepted by the industry.

3.0 REQUIREMENTS.

3.1 Scope

- 3.1.1 The Contractor shall conduct an assessment of current NDE methods for large, marine composite structures. The assessment shall survey the military, commercial and recreational industries. Sources shall include marine surveyors, manufacturers, platform owners and academia.

Concurrently, a separate assessment of flaw criticality is required to determine the lower limit size of as-built flaws or in-service damage that needs to be detected in order to ensure structural integrity.

- 3.1.2 The Contractor shall identify the most promising NDE approach that perhaps uses multiple NDE methods for large and small-scale inspection.

- 3.1.3 The Contractor shall address probability of defect detection as a function of size in the laminate.

3.2 Tasks

- 3.2.1 The Contractor shall conduct a state-of-the-art review of relevant large-scale composites NDE technology.

- 3.2.2 The Contractor shall construct laminates with defects of various sizes.

- 3.2.3 Laminates will be examined using candidate NDE techniques. Process will be videotaped.

- 3.2.4 The Contractor will provide assessment of Best Practice NDE Method(s) for Large Marine Structures.

- 3.2.5 A web site to post project results will be developed.

- 3.2.6 Produce project final report.

- 3.3 Project Timeline. See Figure 1.

4.0 GOVERNMENT FURNISHED INFORMATION.

- 4.1 Standards for the Preparation and Publication of SSC Technical Reports.

5.0 DELIVERY REQUIREMENTS. (Identify the deliverables of the project).

- 5.1 The Contractor shall provide quarterly progress reports to the Project Technical Committee, the Ship Structure Committee Executive Director, and the Contract Specialist.

- 5.2 The Contractor shall provide project update via a web site titled www.CompositeSurveyor.com. The web site shall also be used as a technology transfer medium upon project completion.

- 5.3 The Contractor shall provide a print ready master final report and an electronic copy, including the above deliverables, formatted as per the SSC Report Style Manual.

6.0 PERIOD OF PERFORMANCE.

- 6.1 Project Initiation Date: October 1, 2006.

6.2 Project Completion Date: 12 months from the date of award.

7.0 GOVERNMENT ESTIMATE. These contractor direct costs are based on previous project participation expenses.

- 7.1 Project Duration: 12 months.
- 7.2 Total Estimate: \$99,995.
- 7.3 A Cost Estimate is contained in Figure 2.

8.0 REFERENCES.

- 8.1 Yoseph Bar-Cohen, "Nondestructive Evaluation (NDE) of Fiberglass Marine Structures State-of-the-Art Review," USCG R & D Center, report no. CG-D-02-91.
- 8.2 Greene, Eric, MARINE COMPOSITES, copyright 2000.
- 8.3 Strand, Rick & O'Meara, Rich, 03 March 2005 Presentation at NSWCCD Meeting on Impact Testing

9.0 SUGGESTED CONTRACTING STRATEGY.

- 9.1 Suggested contracting strategy: Sole Source contract to Eric Greene Associates, Inc., Prime Contractor
The US Naval Academy and Structural Composites, Inc. will be utilized as subcontractors to construct and evaluate test laminates.

