Marine Composites

Webb Institute

Senior Elective

Naval Ship Design Considerations

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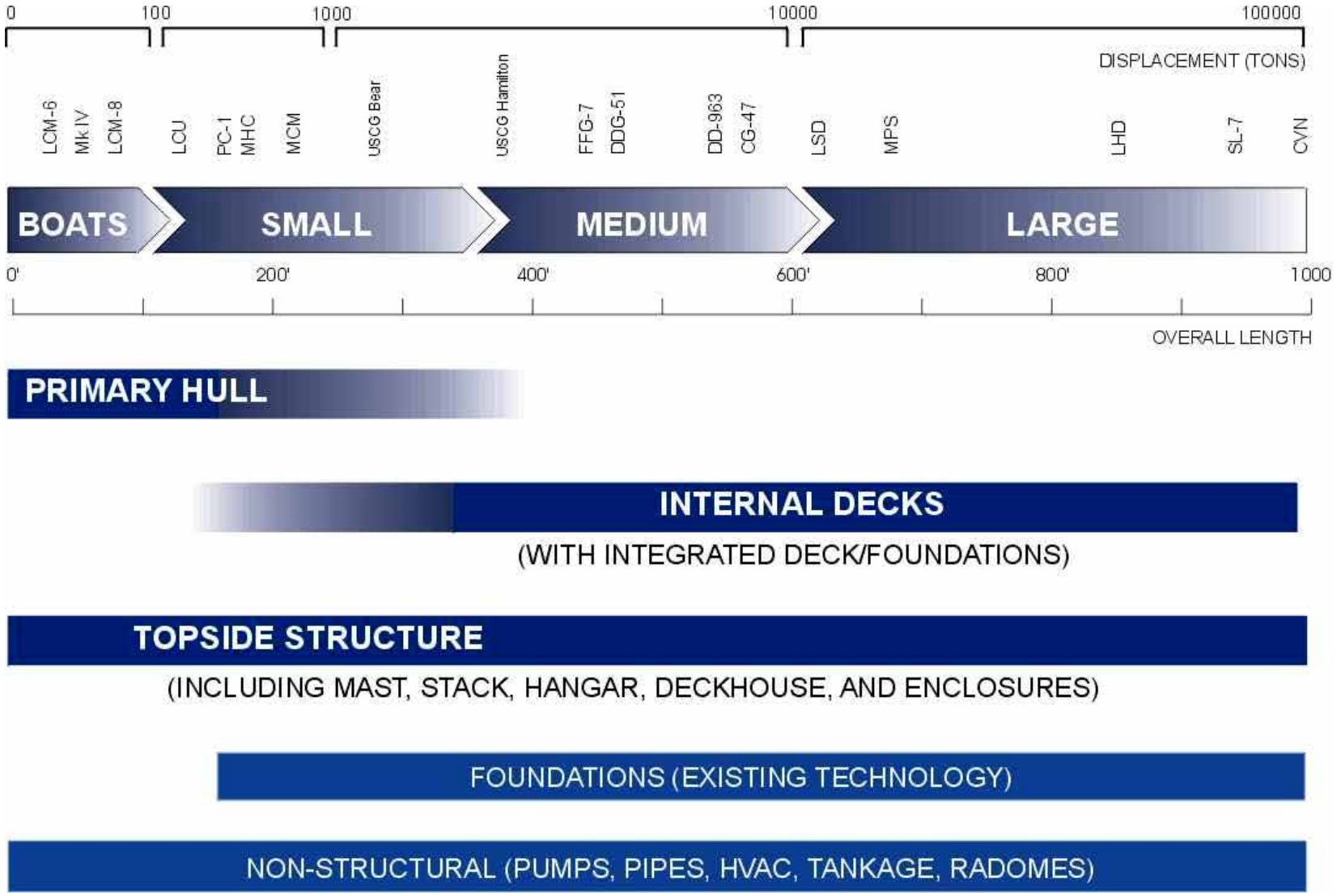
Composites Applications for Surface Combatants



G. Robert Lamb, "High-Speed, Small Naval Vessel Technology Development Plan," Carderock Division, Naval Surface Warfare Center, NSWCCD, May 2003

Early Naval Composite Ships

Twelve Lerici class ships were constructed by Intermarine SpA between 1985 and 1996.

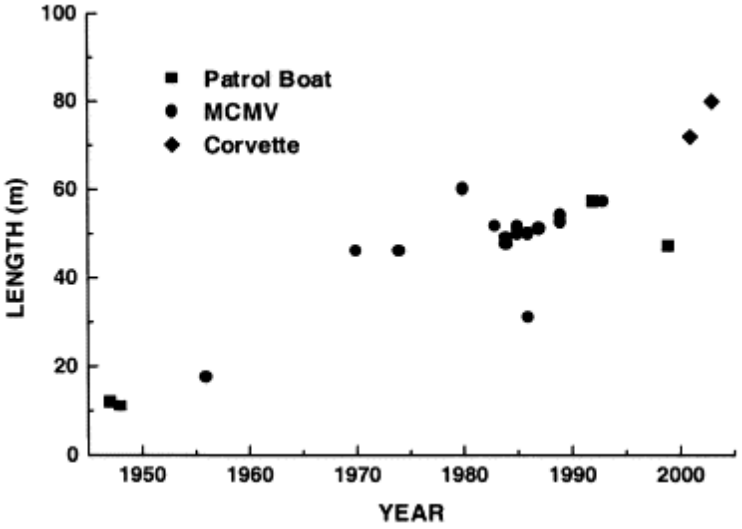
The Bay Class minehunter was commissioned by the Royal Australian Navy (RAN) in 1987

The Huon class Minehunter built for the (RAN) in 1995 is a Italian Lerici derivative.

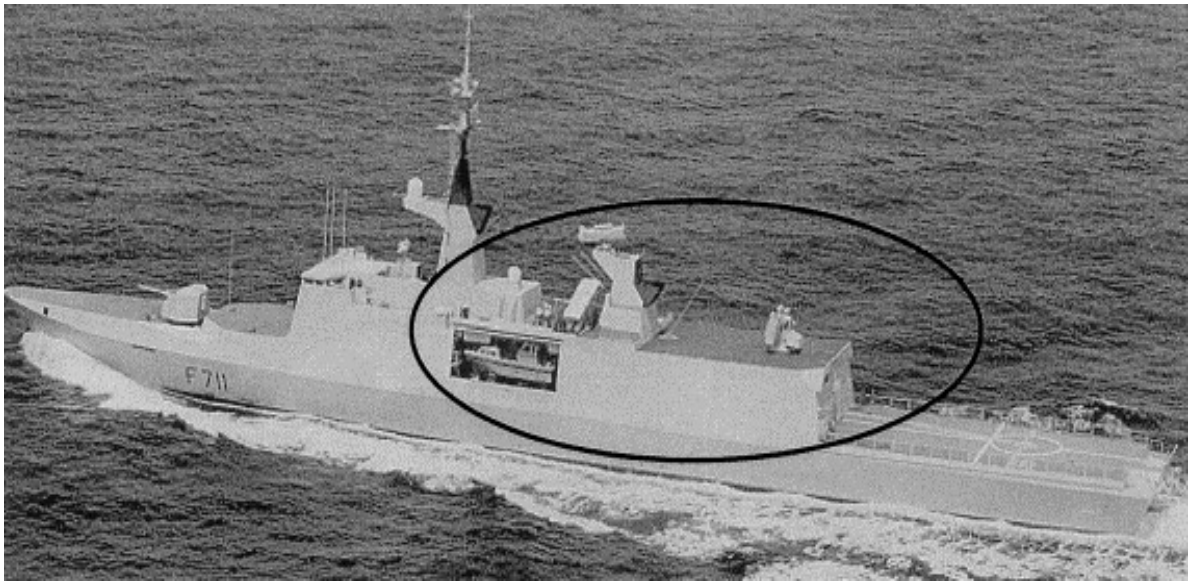
The Sandown class of minehunter was first commissioned into Royal Navy service in 1989

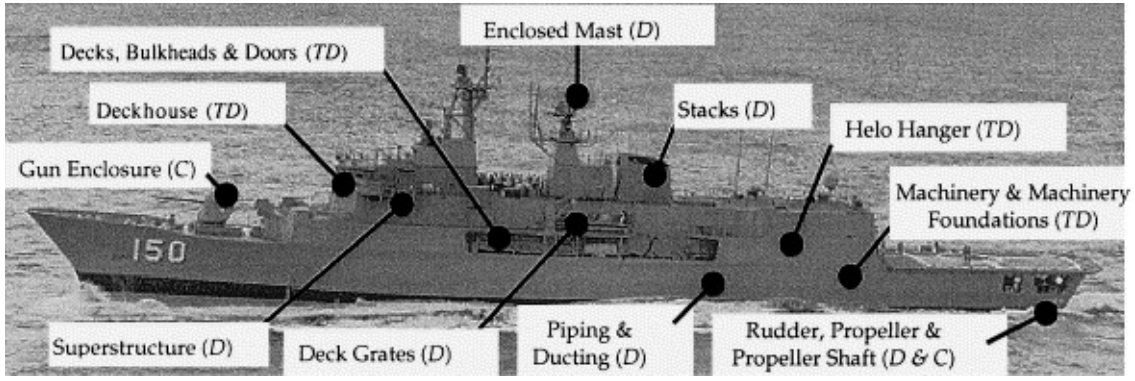
Early Naval Composite Structure

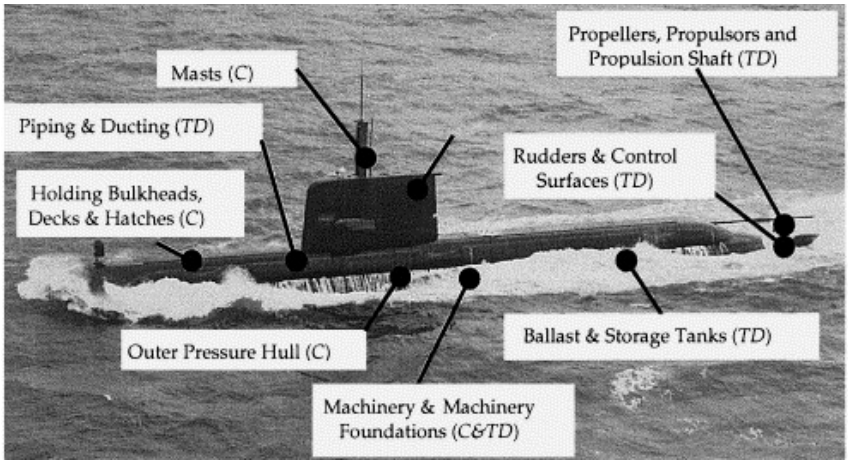
Plot of vessel length against year of construction for all-composite patrol boats, MCMV and corvettes



La Fayette frigate with the composite superstructure section

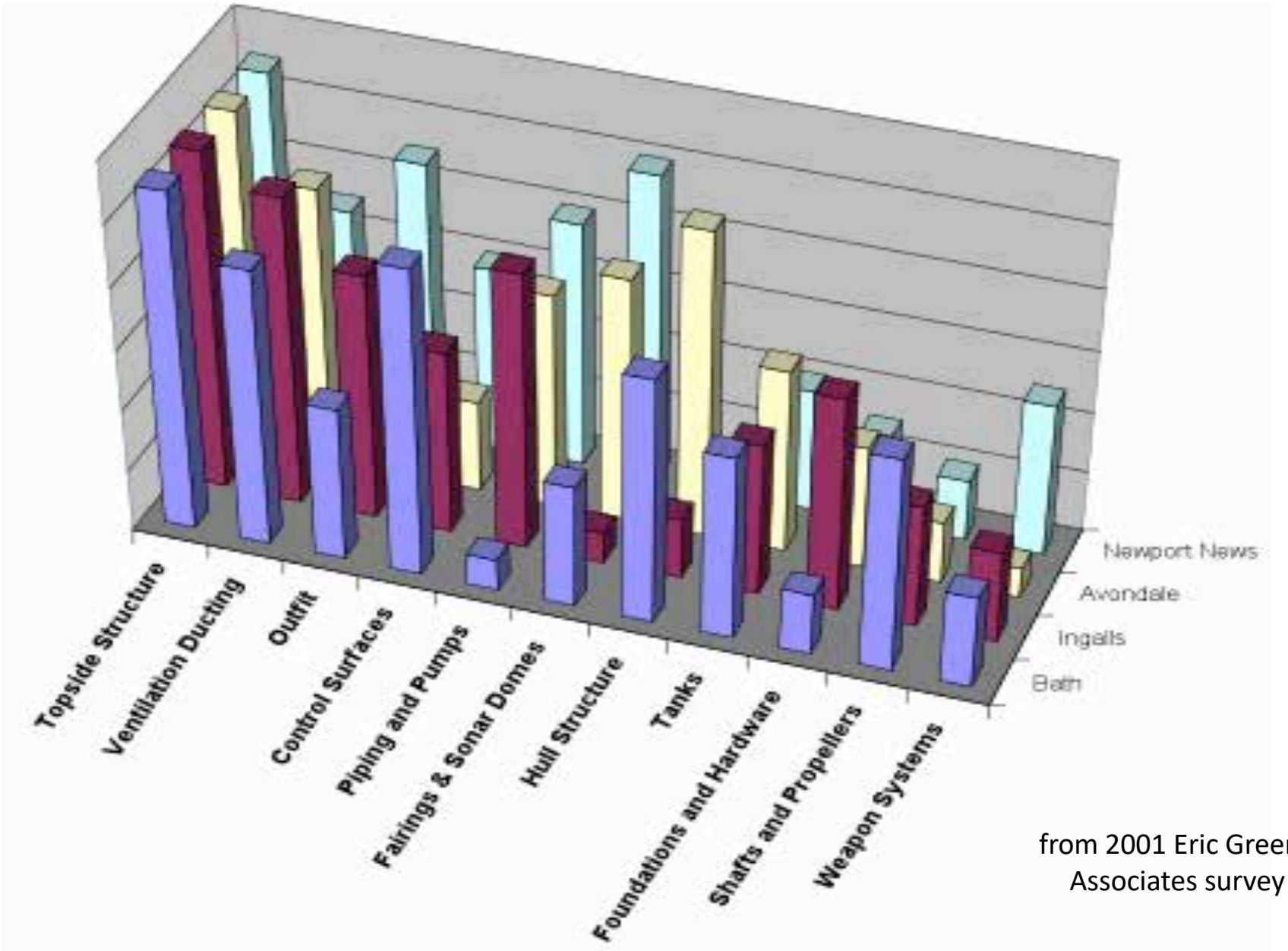






A.P Mouritza, , , E Gellertb, P Burchillb, K Challisb," Review of advanced composite structures for naval ships and submarines," Composite Structures, Volume 53, Issue 1, July 2001.

Naval Shipyard Priorities



from 2001 Eric Greene Associates survey

Scandinavian Warships

VISBY Class Corvette built by Kockums, Sweden

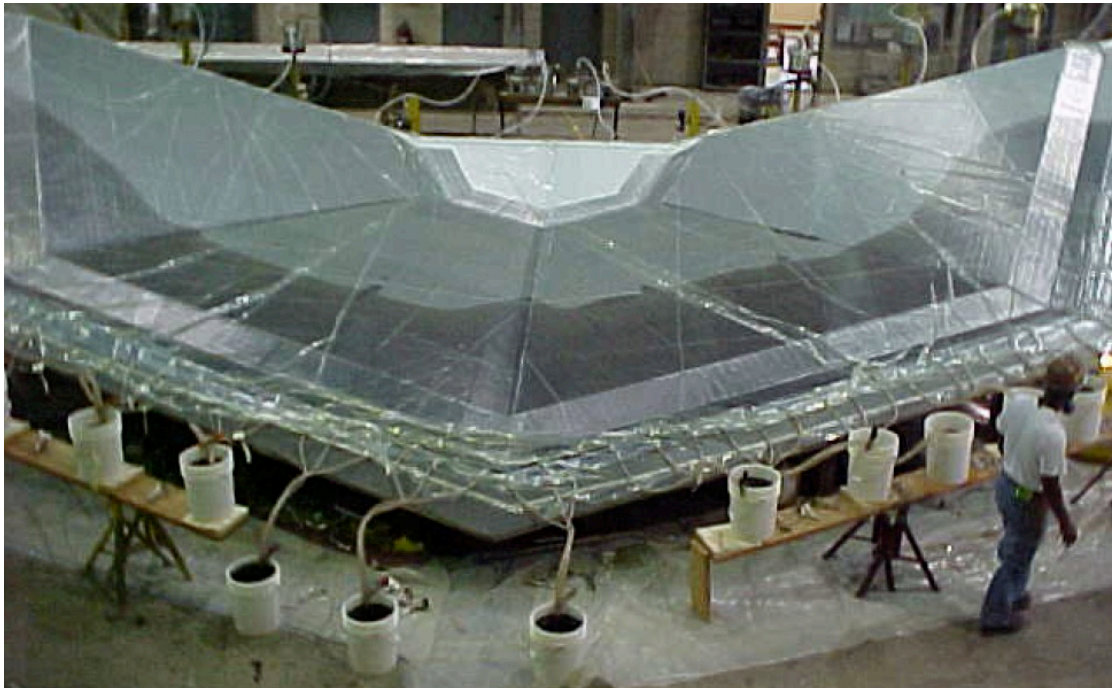
The *VISBY* displaces 600 tons (fully equipped), is 73 m overall length with a 10.4 m beam. The hull utilizes sandwich carbon fiber construction giving a quoted speed of >35 knots.

SKJOLD Fast patrol Craft built by Umoe Mandal, Norway

The ***Skjold*** represents the new breed of Fast Patrol/Missile torpedo boats Built by Umoe Mandal A/S in Norway. DIAB core materials are used throughout the vessel providing lightweight performance and low electro-magnetic signature (EMS). Rohacel foam is used where elevated temperature performance is required. ***Skjold*** ('Shield') has an air-cushioned catamaran hull (surface effect) which, with waterjet propulsion, provides high speed and maneuverability.

Composite Structures Increase Platform Performance

Composite High Speed Vessel [Rasmussen, NSWCCD]

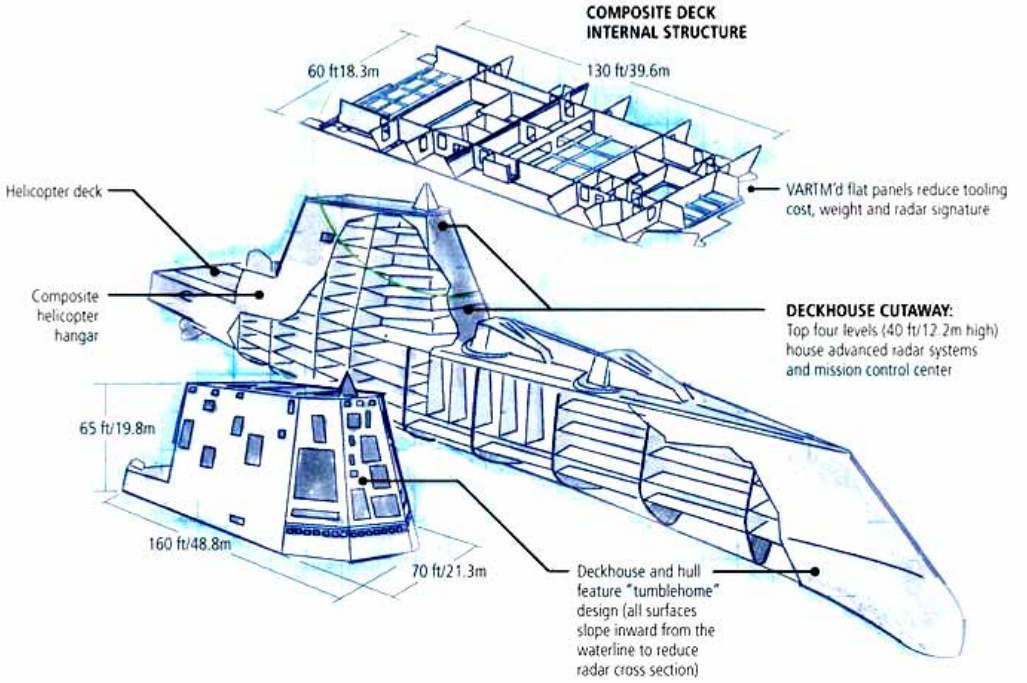


Infusion of AEM/S Panel at NGSS [Rasmussen, NSWCCD]

LPD 17 AEM/S Seam 40-foot Vertical Infusion

DDG 1000 Deckhouse

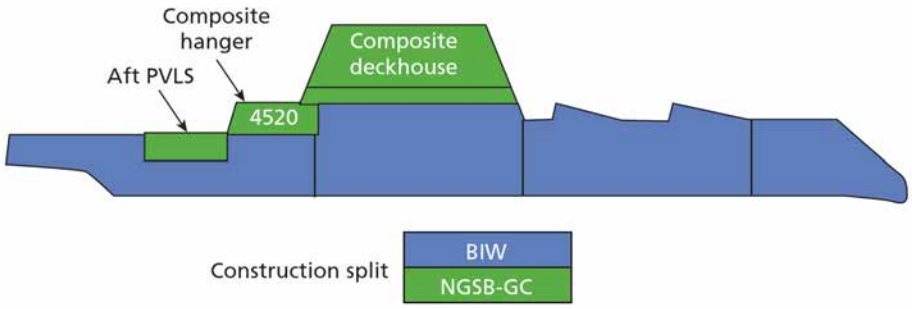
Huntington Ingalls



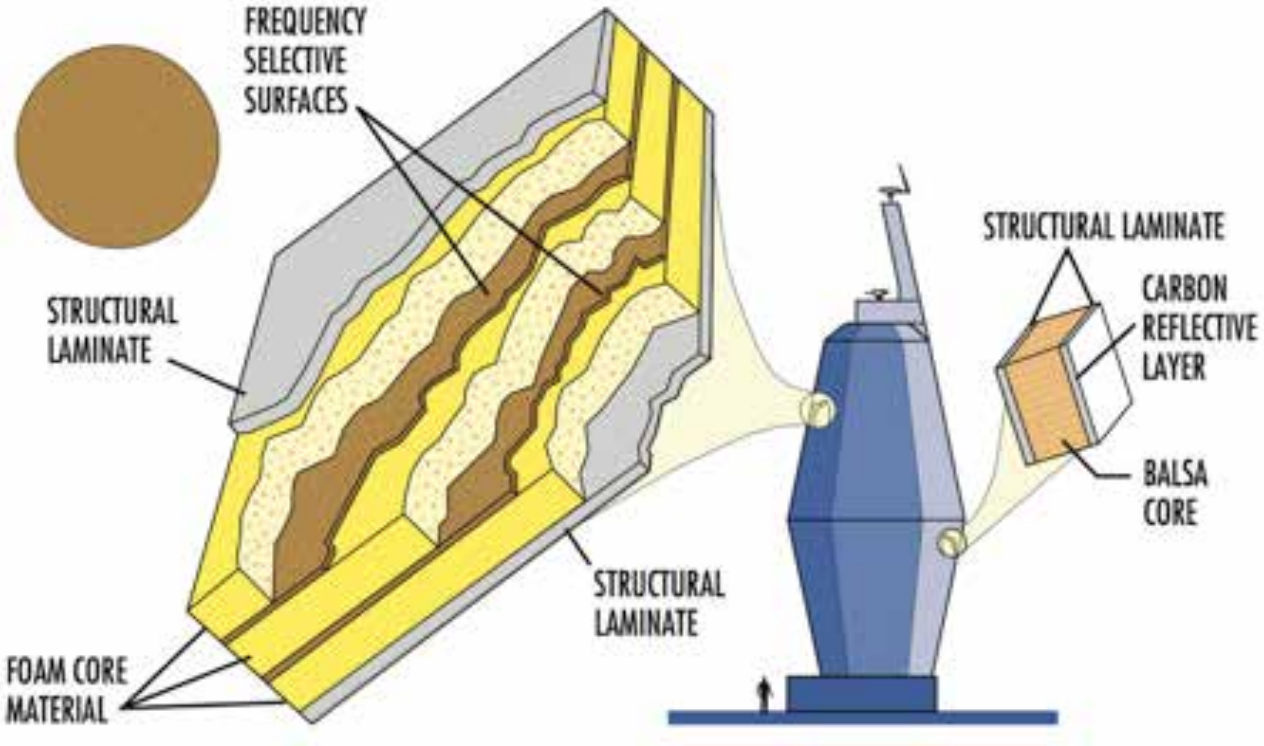
Karl Reque

The 160 ft long by 70 ft wide by 65 ft high deckhouse of the Navy's newest destroyer is a composite structure built using carbon fiber, vinylester resin and a balsa core. Use of composites will allow the Navy to reduce topside weight, platform signature and to integrate apertures into the structure.

Bath Iron Works – Ingalls DDG 1000 Shared-Build Plan



Advanced Enclosed Mast System (AEM/S)



The Navy's Advanced Enclosed Mast System (AEM/S) was developed as a method to enclose a ship's vast array of radars and sensors typically exposed on masts. The composite AEM/S structure allows routine maintenance to be performed in any weather and also reduces the ship's radar signature. The faceted nature of the AEM/S structure provides the necessary flat surfaces for mounting phased array antennas.

The above illustration shows how frequency selective surfaces are used to control what signals are transmitted through the structure. The AEM/S was fielded as an Advanced Technology Demonstrator (ATD) on the on the *USS Arthur W. Radford* (DD 968) in 1997 and endured 100-mph plus winds and an accidental ship collision. The AEM/S is now the baseline design used on the LPD-17class of ships. These installations have experienced some problems with water ingress into the balsa core in areas of bolted connections.

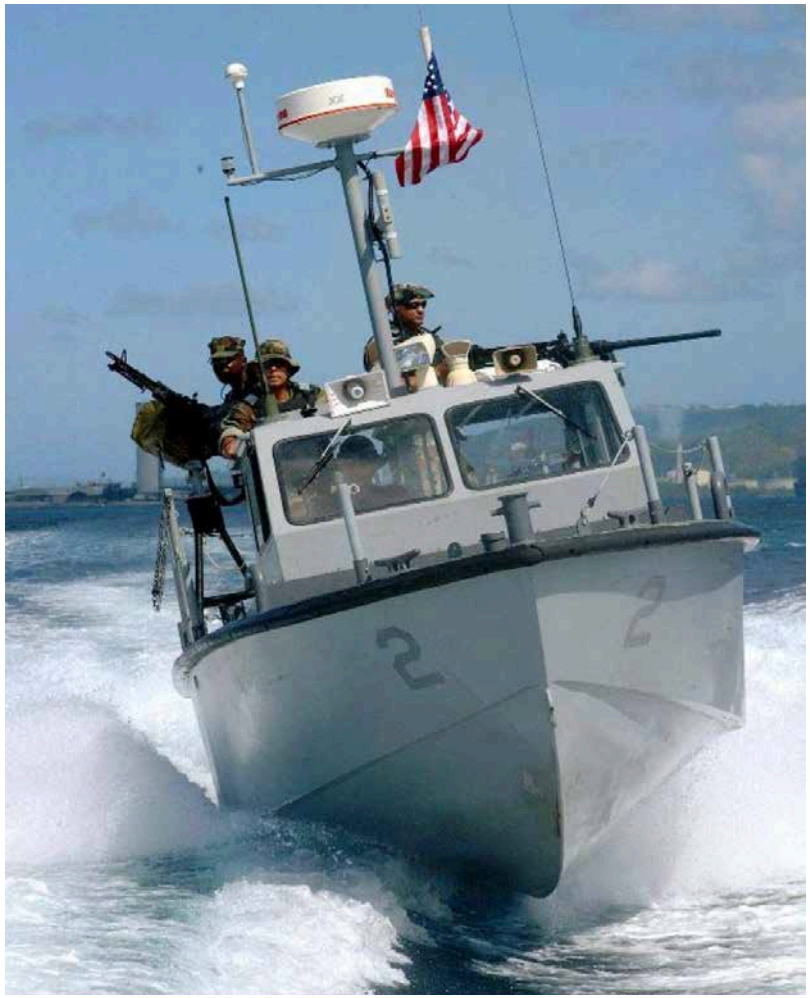
LPD-17 Advanced Enclosed Mast System

11-meter RIB

Length: 36 feet
Speed: 45 knots+
Displacement: 18,500 pounds (full load)
Number in Inventory: 72
Builder: United States Marine, New Orleans, LA
Years Manufactured: 1998 - present
Resin System: Vinyl Ester
Fiber System: E-glass & Kevlar
Core: Linear & Cross-Linked PVC
Manufacturing Process: Hand Layup, vacuum assist

Naval Boats

At sea Aboard *USS Blue Ridge* (LCC 19) Sailors Practice Deployment of Ship's Small Boats



Members of Inshore Boat Unit Seventeen (IBU 17) Patrol the Waters of Apra Harbor, Guam

Underwater Shock Testing (UNDEX)

MCM Rudder

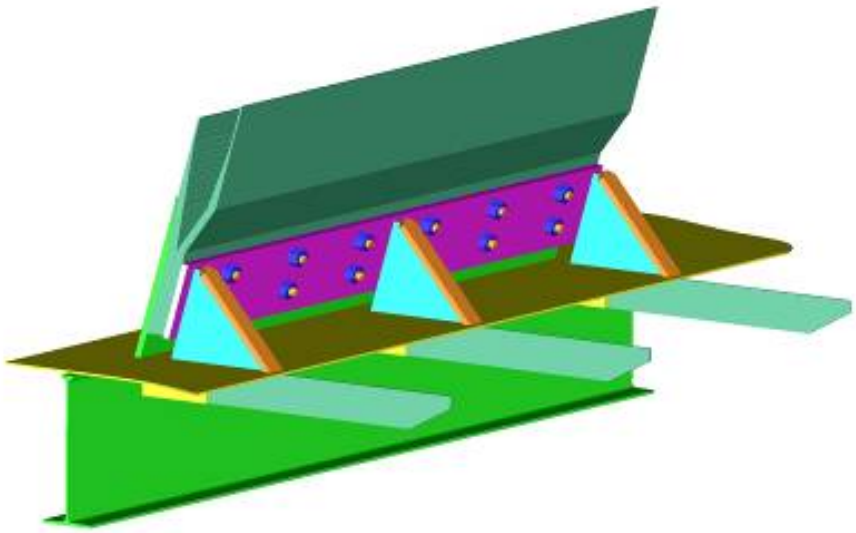
Composite MCM Rudder Built by Structural Composites Shown During Shock Trials (1997)

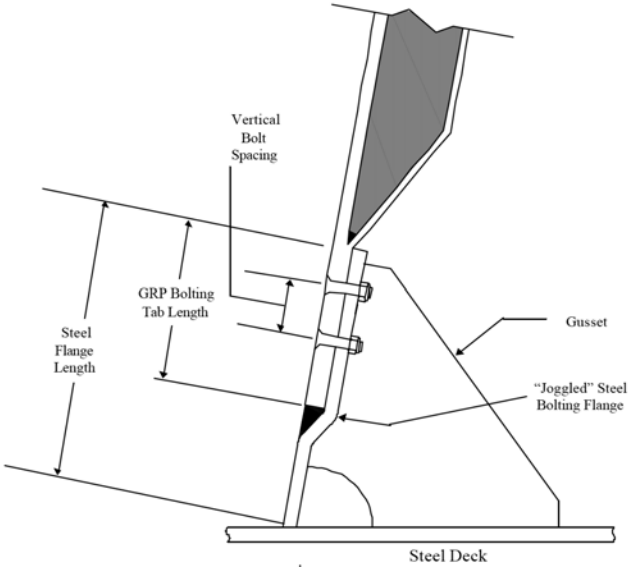
DDG 51 Rudder

DDG 51 Rudder Built by Structural Composites Shown During Shock Trials (2007)

Composite Twisted Rudder Test Article

Joining Composites to Metals





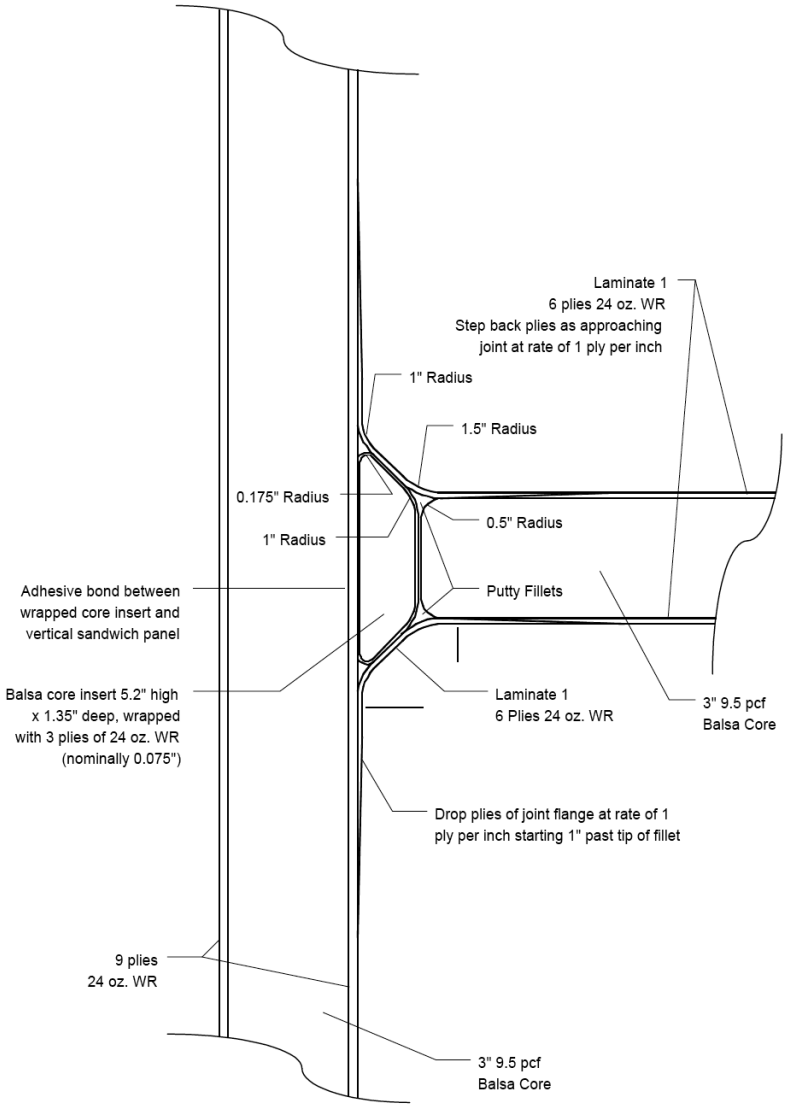
Typical Parameters for Bolted Joint Connection

Bolt spacing (vertical)	3 inches
Bolt spacing (horizontal)	3 to 4 inches
Steel flange length	9 inches
Steel flange thickness	0.5 inches
GRP bolting tab length	6 inches
Nominal weight (9” x ½” steel flange, ½” bolts spaced every 3 inches, ½” gussets spaced at 24”)	22.40 lbs. per linear foot

Composite deckhouse to steel deck joint R & D program by the ONR ManTech program

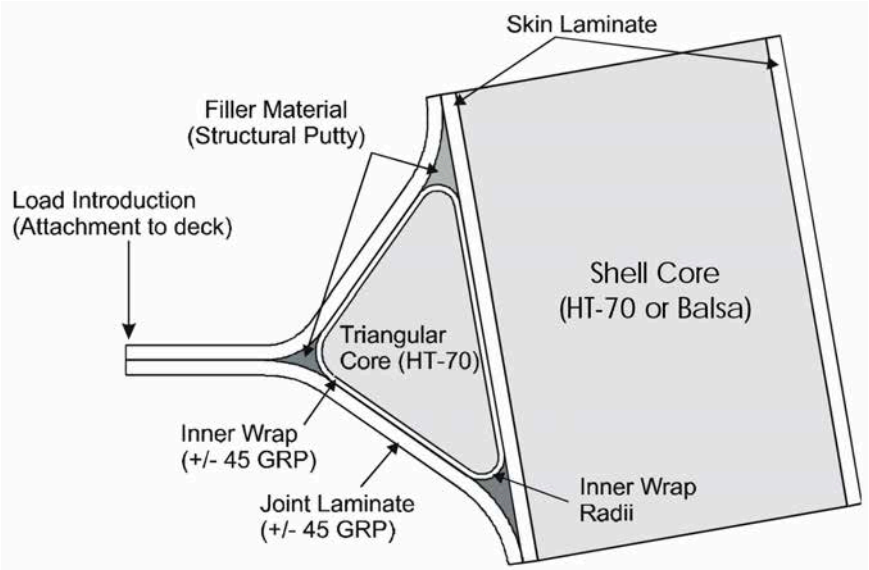
Typical Naval 'T-Joints"

Sandwich-to-Sandwich Tee Joint

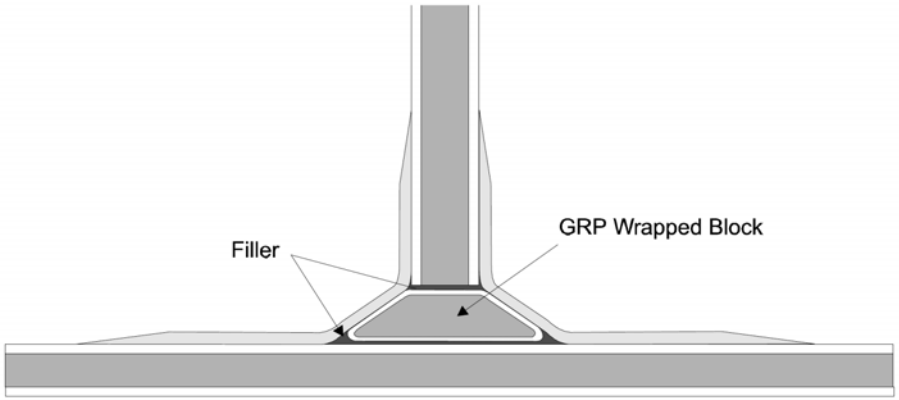


Naval Surface Warfare Center, Carderock Division

Triangle Joint Used to Attach Deck for AEM/S



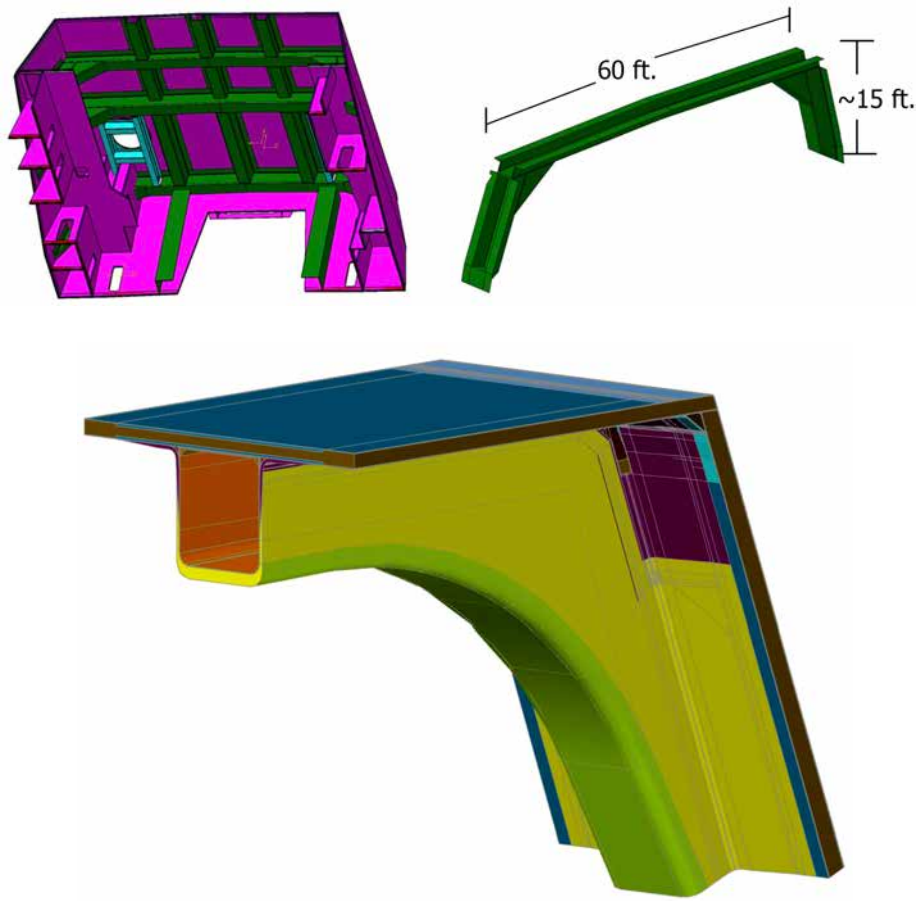
Tee with Toe-Block Added



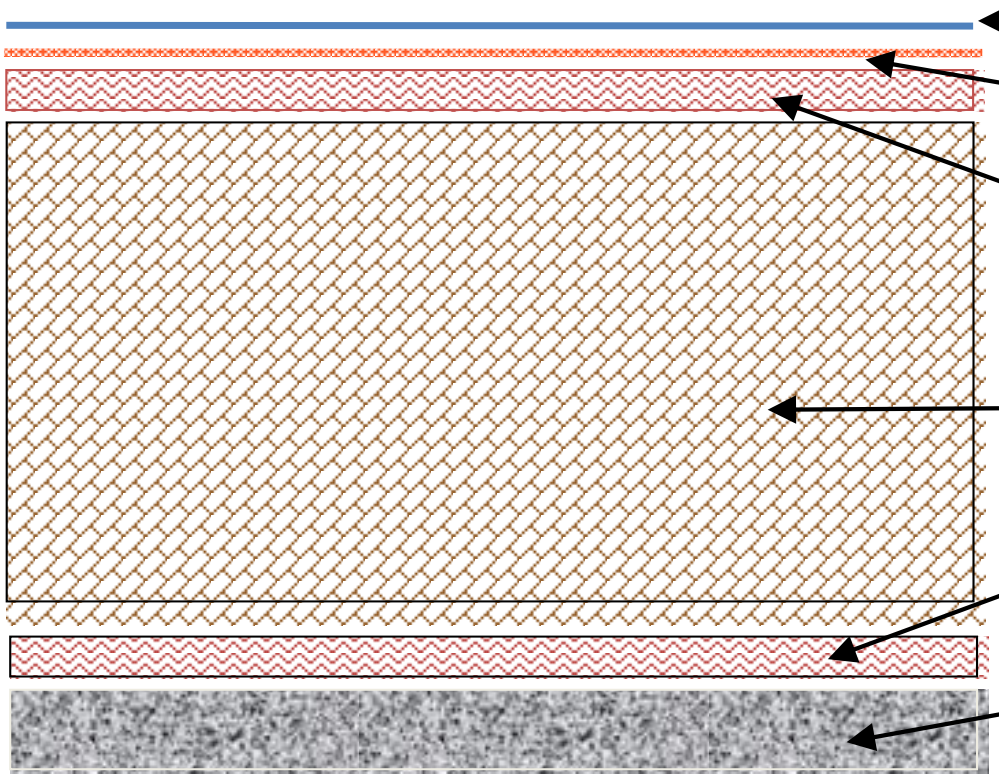
Large Scale Test Articles

Large Scale Shock Test Article Built for DDG 1000 program

Helicopter Hanger Deck Corner Gusset



Typical Naval Ship Laminate



0.030” Fiberglass

0.019” EMI Shielding

4 Plies Fiberglass
(0.050” each x 4 = 0.20” total)

3.00” D-100 End Grain Balsa
(Varies from 3.0” to 18.0”)

4 Plies Fiberglass
(0.050” each x 4 = 0.20” total)

0.60” Chartek VI
(Intumescent Fire Coating)

Ship Masts

This 27 long ton composite mast was installed on CVN 77 in 2006

John P. Hackett, "Composites Road to the Fleet—A Collaborative Success Story," Northrop Grumman, 2011

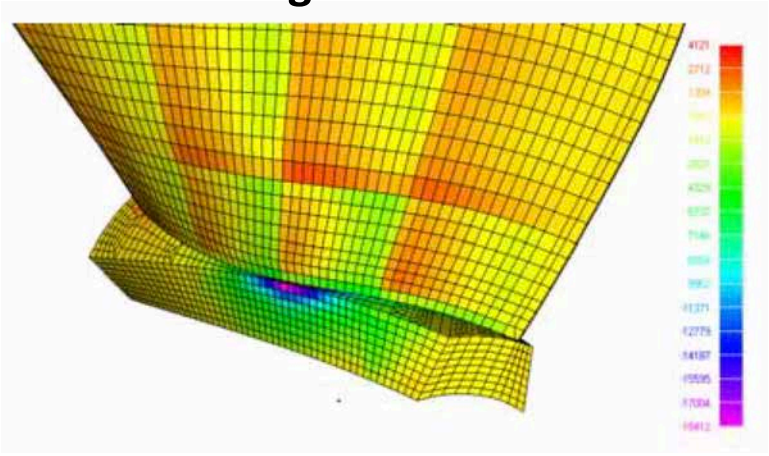
Carbon fiber mast on Norwegian Skjold class coastal corvette

Eric Greene

Yard Patrol Boat
Demonstration Propeller Blade

- Two blades were produced via VARTM technique
- Blades were 24” span x 18” chord x 1.5” thick (@ root)
- Dimensional precision evaluated using a photogrammetry technique (Max. deviation at center ~0.07” attributed to mold stiffness)
- 50X improvement in composite cavitation erosion resistance

Static Through-Thickness Shear



Composite Technology Development, Lafayette, Colorado

DDG 51 Class Composite Fairwater

Composite Demonstrators

Mark V Composite Demonstrator built by Hodgdon Yachts

Stilleto Composite Demonstrator built by M-Ship

GHOST Watercraft Prototype

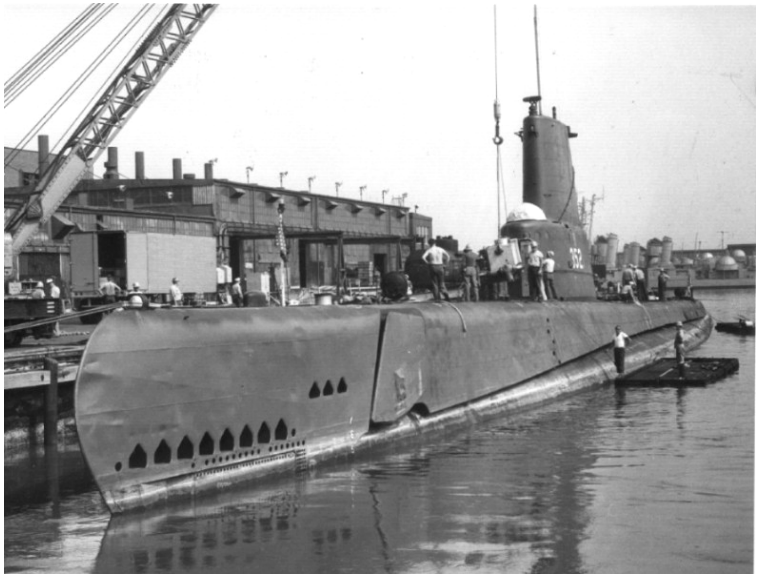
Prototype probably not composite construction – but should it be?

Gizmag

The GHOST watercraft is a small vessel that uses a combination of aircraft and boat technology to “fly” on the water using two buoyant tubular foils and a gas turbine. The boat uses supercavitation techniques that surround the tubular foils with a bubble of gas to eliminate drag.

Juliet Marine Systems, Inc., Portsmouth, NH

Historical Uses of Composites on Submarines



Fairwater on USS Halfbeak (1954 - 1965)

Light Weight Wide Aperture Array Assembly, Seemann Composites (2001 - 2005)

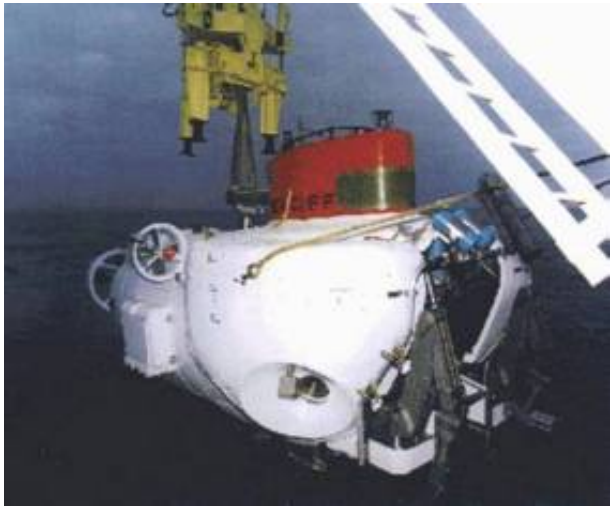
Mast Fairings (1963 - present)

Dry Deck Shelter (1982 - present)

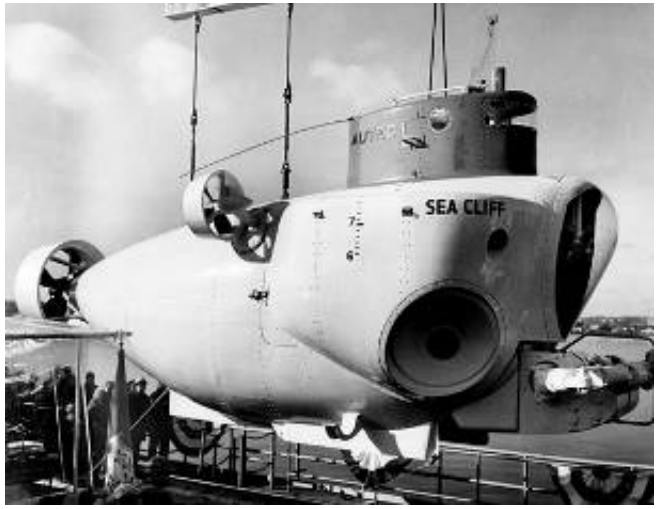
Deep Submergence Vehicles

DSRV-1 *Mystic*

The DSRV outer hull is approximately 15 meters (50 feet) long, 2.4 meters (8 feet) in diameter, and is constructed of fiberglass.



DSV-3 *Turtle*



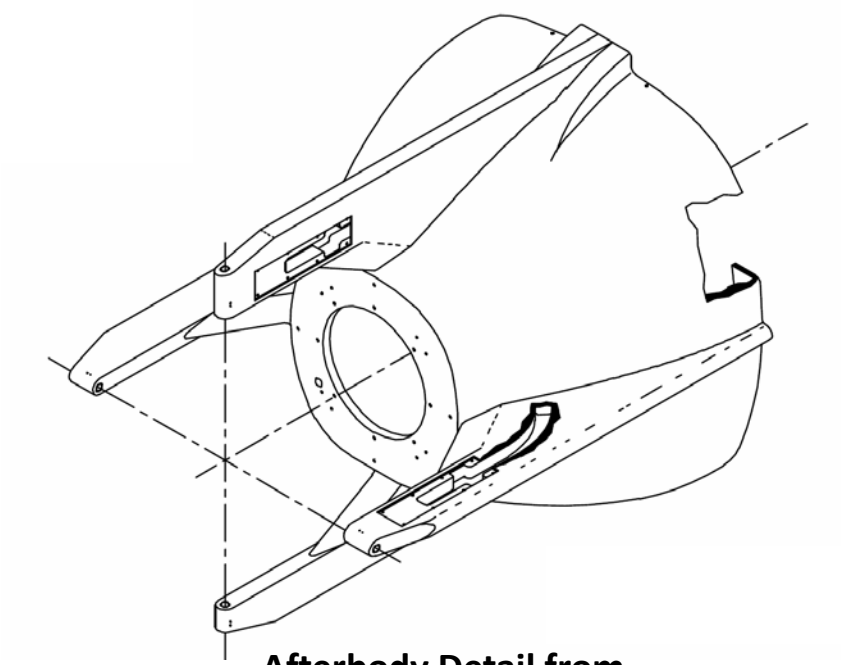
DSV-4 *Sea Cliff*

These DSVs are constructed of a fiberglass hull over the metal crew sphere

Mk 8 SEAL Delivery Vehicle System

Sandwich Laminate Consists of:

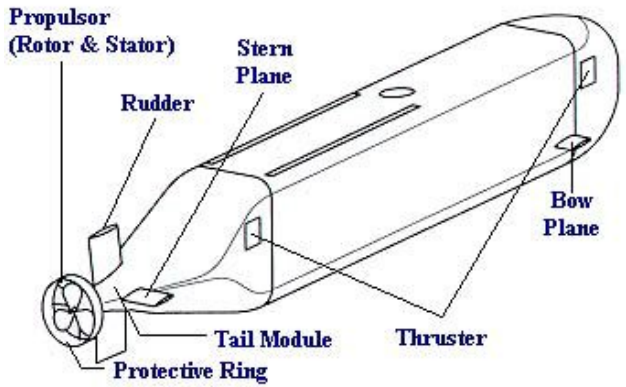
- Divinycell H80 PVC foam core
- E-glass biaxial, cloth, mat and unidirectional strand
- Interplastic Corporation CORVE8121 vinylester resin

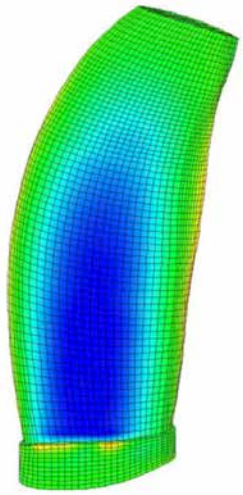


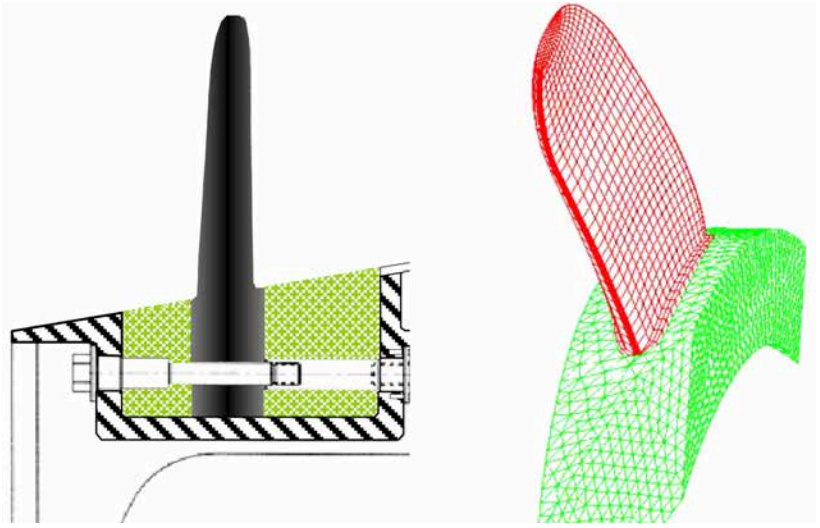
Afterbody Detail from NAVSEA Drwg 6893402

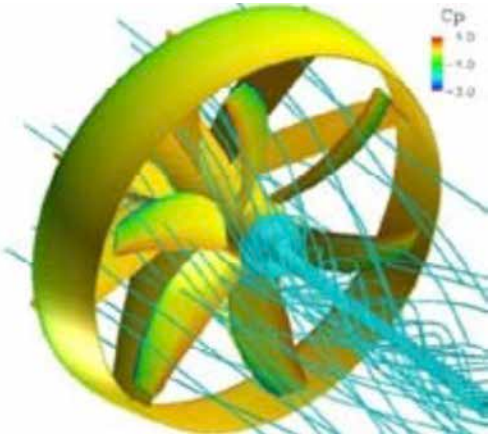
***GATOR* Class SDV showing SEAL Team and Equipment**

ASDS Composite Rotor



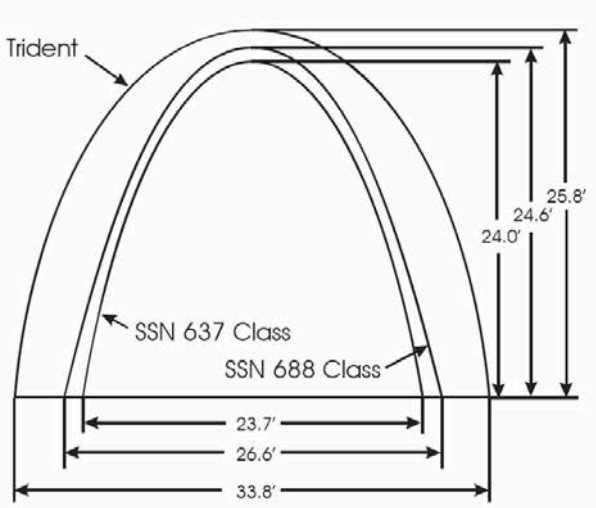






Kevin Koudela, Penn State ARL Composite Technologies

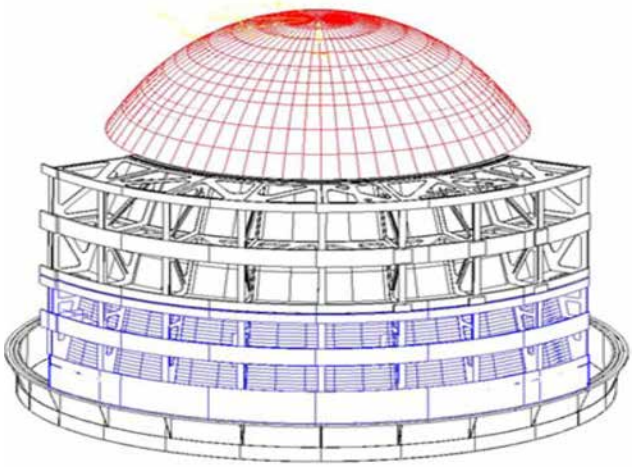
Submarine Bow Domes



	Surface Area sq-ft	Weight lbs
SSN 637 Class	1388	26,260
SSN 588 Class	1519	28,177
Trident	2282	43,700

Comparison of Submarine Bow Dome Sizes

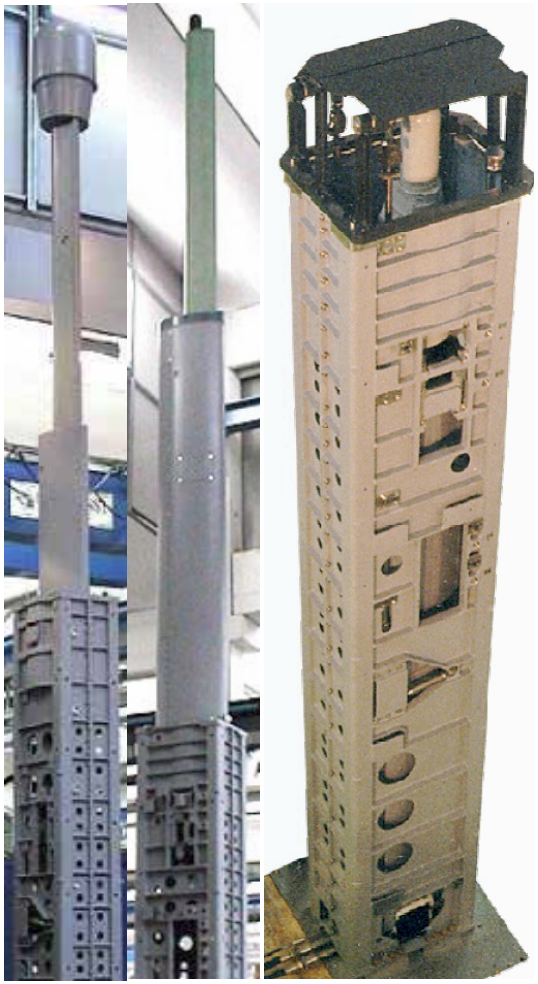
E-Glass/Epoxy Bow Dome Cured in an Autoclave

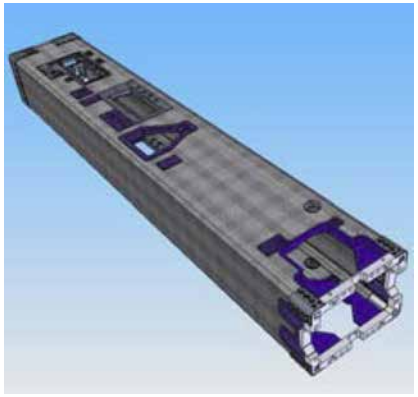


Bow Dome Laminate and Lay-up Tool Solid Model [Penn State ARL]

20’ Diameter x 50’ Length Autoclave at Hitco

Universal Modular Composite Electric Mast





- Carbon Fiber / E-glass Epoxy Sandwich
- Pultrusion Processing

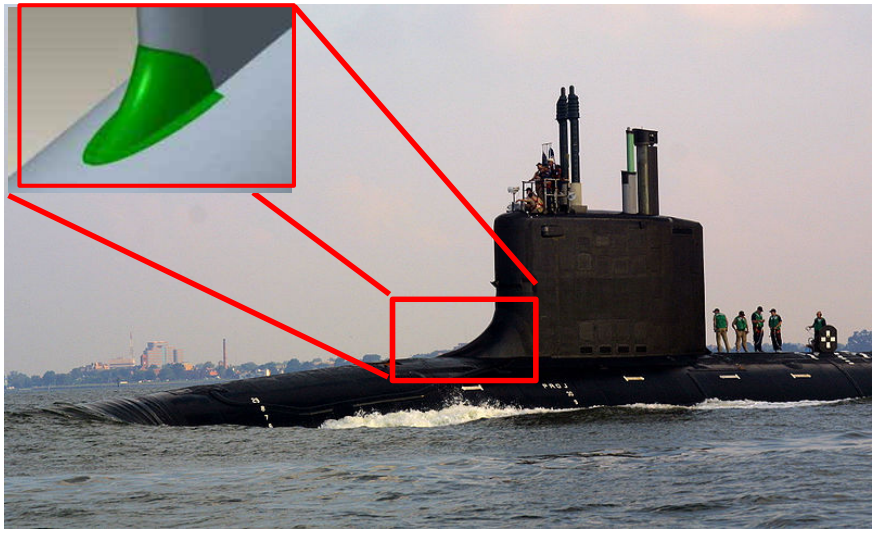
UMM Guide Trunk, KaZaK Composites, 2007

Sail and Mast Arrangement on *LOS ANGLES*-Class Sub

Submarine Sail Cusp

"Goodrich Delivers First Composite Sail Cusp for Nuclear Submarine," COMPOSITES TODAY, June 18, 2012

This composite sail cusp was built by Goodrich for the next eight Virginia Class nuclear attack submarines. The complex double curvature shape makes it suitable for composite construction.



The cusp is said to be 5,000 lbs lighter and $150,000 less expensive than the steel version, achieves a schedule reduction from 14 months to 3 months, and an estimated $20,000 savings per periodic VCS sail maintenance. [Ginger Gardiner, Composites Technology, Feb 2012]

R & D History at Ingalls Shipbuilding

Project Name	Funding Source	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
U.S.S. Pelican (MHC-53)	PMS 490	◆																			
Miscellaneous Early Small Test Articles	IRAD/CRADA/NSWC-CD	◆																			
1/2 Scale DDG 51 Mast	IRAD/CRADA/NSWC-CD [ONR(6.2)+DNA]			◆																	
Hangar Module	IRAD/CRADA/NSWC-CD [ONR(6.2)+DNA]			◆																	
1/4 Scale AEM/S System Mast	ONR ATD					◆															
Composite Platform	NSWC-CD [ONR(6.2)]							◆													
Composite Hull Section	NSWC-CD [ONR(6.2)]							◆													
Full Scale AEM/S System Mast	ONR ATD								◆												
Composite Door	IRAD								◆												
Composite RCS Test Fixtures	IRAD/CRADA									◆											
Sealift Deckhouse	MSC										◆										
Maritech Deckhouse	MARAD										◆										
LPD 17 Composite Mast	PMS 317										◆										
Integrated Topside Demonstration System (ITDS)	IRAD											◆									
DDG 51 Composite Helo Hangar	ONR											◆									
DDG 51 Remote Minehunting System (RMS) Enclosure	PMS 400												◆								
Low Observable Multi-function Stack	ONR													◆							
Joint Modular Lighterage System (JMLS)	NSWC-CD													◆							
CHSV	ONR															◆					
CVN 77 Mast	PMS 378															◆					
AESD Deckhouse	ONR ATD																◆				
DDG 1000 Test Articles (RCS, Joints, Fire and Shock)	PMS 500																◆				
DDG 1000 Deckhouse Engineering Development Model (EDM)	PMS 500																◆				
DDG 1000 Integrated Deckhouse Start Fabrication	PMS 500																				◆

Litton Buys Avondale →

← Northrop Grumman Buys Litton

John P. Hackett, "Composites Road to the Fleet—A Collaborative Success Story," Northrop Grumman, 2011