U.S. Marine Composites
.....*think BIG*

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4TH INTERNATIONAL CONFERENCE ON

ADVANCED ENGINEERED WOOD

& HYBRID COMPOSITES

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Presentation Overview

- Capability to build large composite structures in the U.S.
  - Boat hulls and ship components
  - Aircraft structures
  - Infrastructure components

- Future opportunities
  - High performance marine vehicles
  - Marine aviation
  - Offshore wind and ocean renewable energy

- Required technology development
  - Better understanding of ocean loads
  - Improved infusion materials (reinforcements, resin & vacuum bags)
  - Non-Destructive Examination (NDE)
  - In-service structural health monitoring

U.S. Large Composite Hull Fabrication

This 160 foot composite motoryacht is typical of infused hulls produced by Christensen. The company has plans to produce a 186 foot, 500+ GT yacht will be constructed in a purpose-designed facility in Tennessee.

U.S. Large Composite Hull Fabrication

Atlas Hovercraft of Florida is introducing commercial hovercraft technology to the US. Bonded pultruded structural profiles are used to develop the large, flat surfaces.

Scandinavian High Performance Marine Vehicles

The ***VISBY*** is 73 meter Fast patrol Craft built by Kockums of Sweden. Material of construction for the hull is sandwich construction carbon fiber reinforced plastic giving a quoted speed of >35 knots.

The ***Skjold*** is Fast Patrol/Missile torpedo boats Built by Umoe Mandal. ***Skjold*** ('Shield') has an air-cushioned catamaran hull (surface effect) which, with waterjet propulsion, provides high speed and maneuverability.

Large Naval Composite Marine Structures

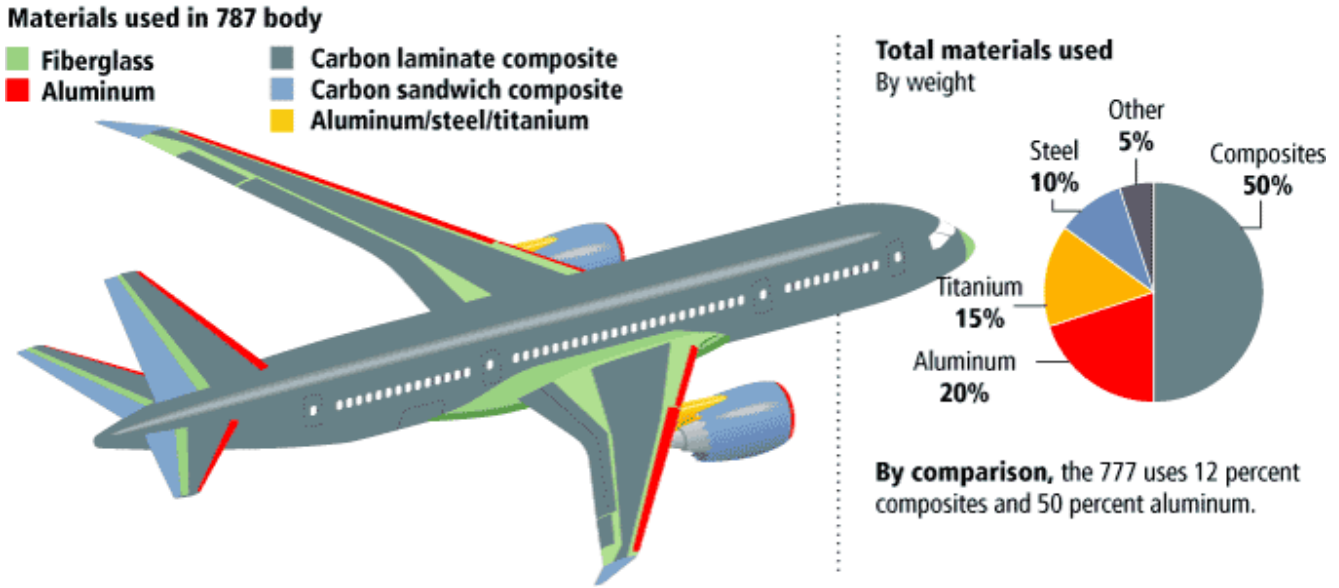
Structural Composites infused a composite rudder with complex shape for the US Navy's DDG 51 class destroyer.

Goodrich Composites fabricates submarine bow domes in autoclaves using prepreg technology

Composite Aircraft Structures

The Beechcraft Starship achieved FAA Type Certification in 1987.

Bombardier Aerospace new mid-size business jet is an all-composite design



Composite Infrastructure Components

Installation of ZellComp composite bridge decking in Bradford VT (top) and Tangier, VA (bottom)

Composite footbridge built in Scotland in 1990 (top) and large carbon fiber beams from Strongwell (bottom)

Future High Performance Marine Vehicles

Umoe Mandal (Norway) is working on this 75 meter advanced composite ship for the US Office of naval Research. This forth-generation Umoe composite ship converts from an SES to a hovercraft to transport equipment from a “Sea Base” to a beach.

Marine Aviation Vehicles

Howard Hughes' ***Spruce Goose*** was 218 feet long with a 320 foot wingspan and designed to carry 700 soldiers. At 181 tons at takeoff, the flying boat flew only about one mile in 1947.

In 1984, the Dornier company introduced an all-composite, 12 passenger amphibian transport.

Offshore Wind Energy

The SWAY technology utilizes a “downstream” turbine design with aerodynamic turbine housing and support spar.

StatoiHydro (Norway) is investing $79M to build a 2.3 MW offshore windmill. The floating wind turbine can be anchored in water depths from 120 to 700 meters.

Small Wind Energy

Quiet Revolution in the UK has manufactured this aesthetically-pleasing vertical axis wind turbine with carbon composites.

Greentenco has developed a combination wind/solar power generator for remote, rural applications.

Aeroturbine has developed a wind turbine for installation on urban rooftops.

Skystream (left) and Zephyr (right) manufacture small wind turbines for individual residences.

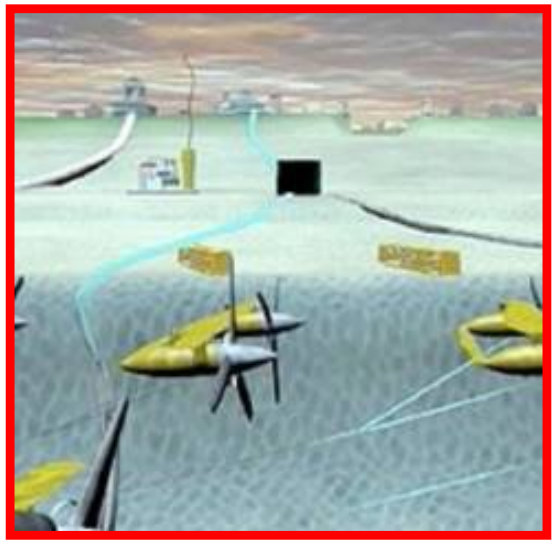
Composite Cars

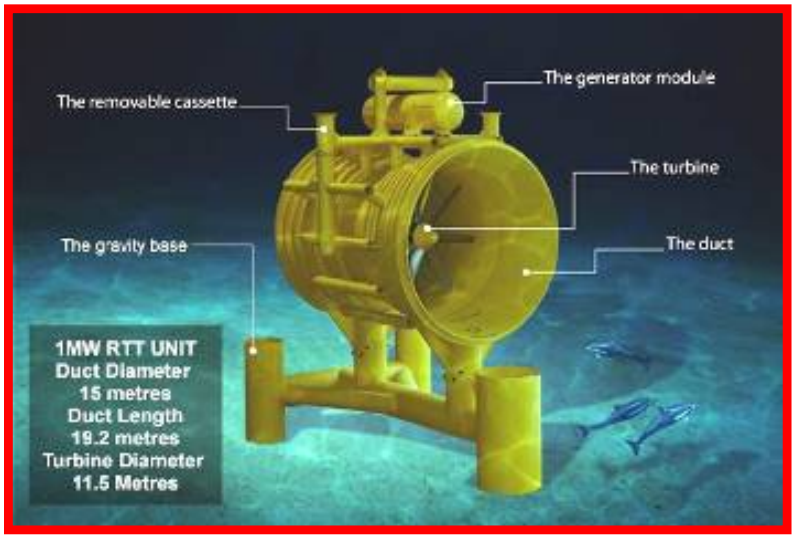
The Toyota 1/X concept car uses a carbon composite body to produce a car that weighs 1/3 of the Prius. The structure of the 1/X is designed to absorb shock and impact loads. The car is claimed to travel more than 600 miles on four gallons of fuel.

The Aptera achieves high mileage in part from its composite aerodynamic body.

Ocean Tidal Energy

Marine Current Turbines Ltd has installed a 1.2MW SeaGen tidal energy system in Ireland.





Underwater turbine farms have been proposed by Florida Atlantic University (left) and Lunar Energy (right)

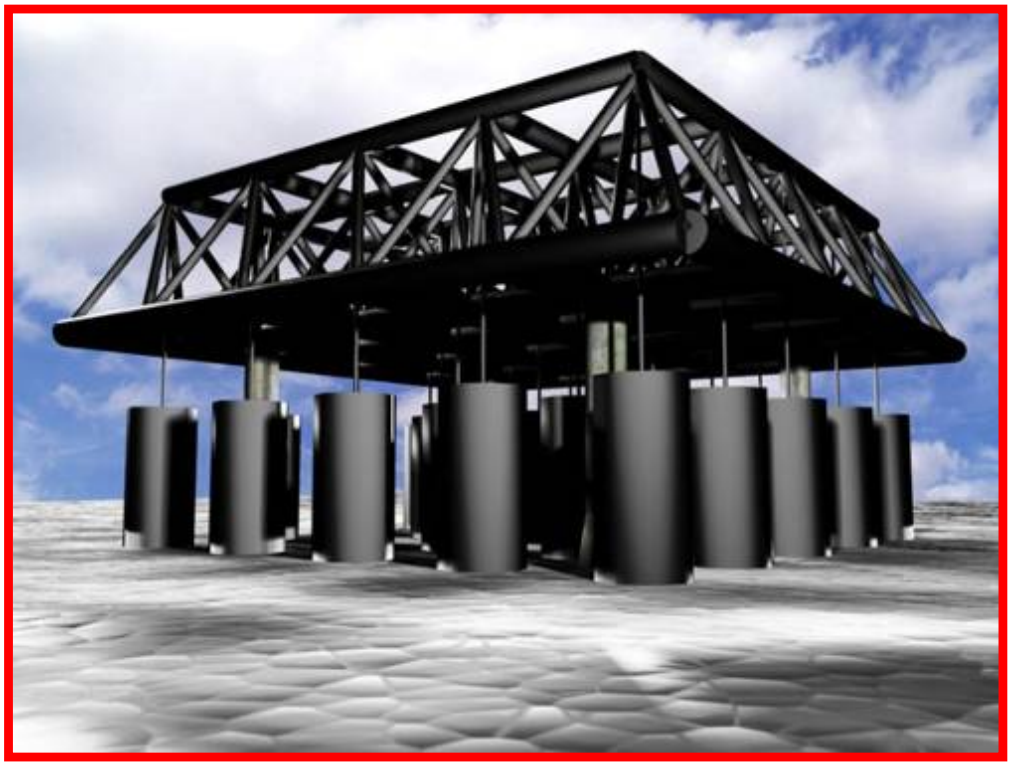
Verdant Power has tidal turbine installations in New York and Canada.

UEK Corporation has been developing a practical way to harness river, tidal and ocean currents with hydro kinetic turbines since 1981

Ocean Wave Energy

Ocean Power Technologies has installed the first PowerBuoy® system near Reedsport, Oregon.

Wavebob plans a wave-farm for the West of Ireland and has opened a North American office



The Manchester Bobber is an innovative wave energy device. With the Bobber, a floating mass rises and falls under the action of waves in the water and this causes a pulley and its shaft to oscillate.

Ocean Environment

Corrosion

Recent studies estimate the direct cost of corrosion in the United States to be nearly $300 billion dollars per year.

Extreme Waves

On the open sea, waves can commonly reach seven meters in height or even up to fifteen in extreme weather. In contrast, some reported rogue waves have exceeded thirty meters in height.

Improved Resin Infusion Materials

- Reinforcements and Flow Media
  - Infusion media now integral to many reinforcements
  - Surface infusion media is a process disposable item
  - Infusion with carbon reinforcements more problematic

- Resin Systems
  - Longer working times required for larger structures
  - Exotherm control is critical with thick structures
  - Mechanical strength of resin need to increase with structure size

- Vacuum Bags
  - Larger, seamless bag material is needed
  - More efficient leak detection methods are required

Improved Manufacturing Methods

Monocoque

- Large molds built with CAD/CAM
- Improved methods for creating fiber preforms
- Difficulties infusing very tall structures
- Improved resin flow prediction programs and real-time wet-out monitoring
- Ability for on-site fabrication of large, infrastructure projects

Modular

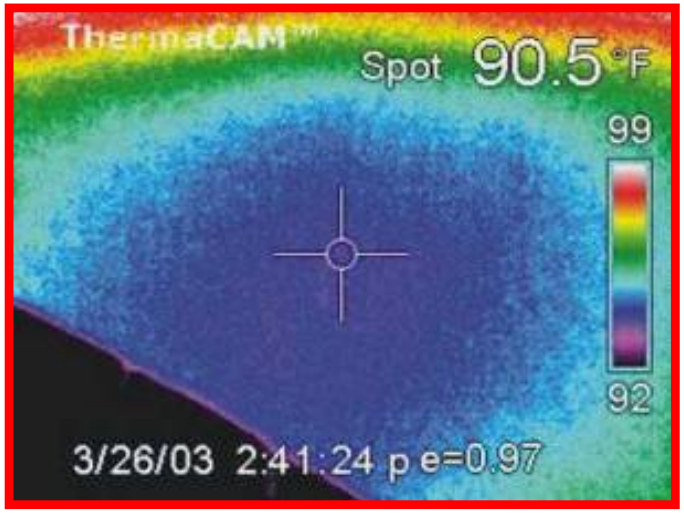
- Joints need to be as strong as base laminate
- Equipment needed to handle completed module
- Enhanced planning for outfitting required
- Internationally-accepted strength criteria would help the industry

Non Destructive Evaluation (NDE)

Moisture Meter

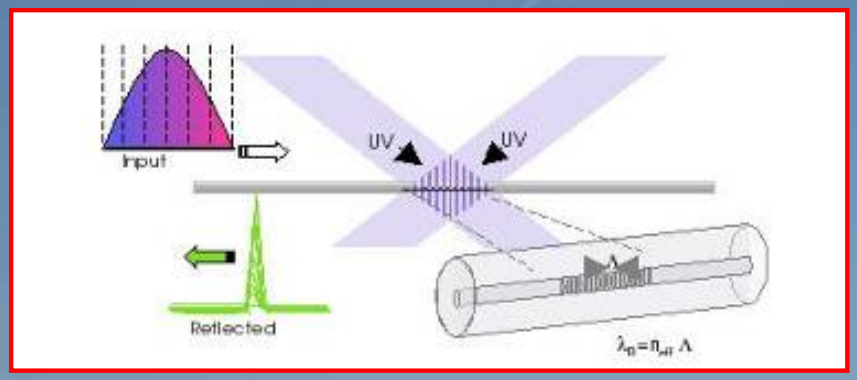
Infrared Thermal Imaging Camera

Ultrasonic Thickness Gauge



IR Image of Laminate

In-Service Structural Health Monitoring



Fiber Bragg Grating Sensing

The Path Ahead

Very High Speed Sealift
Trimaran -VHSST

Blended Wing Body Aircraft

SeaBridge – A Pentamaran
Bridge over the Sea