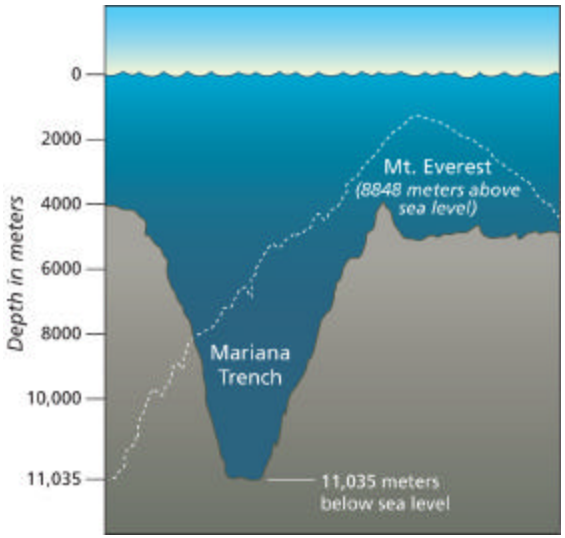
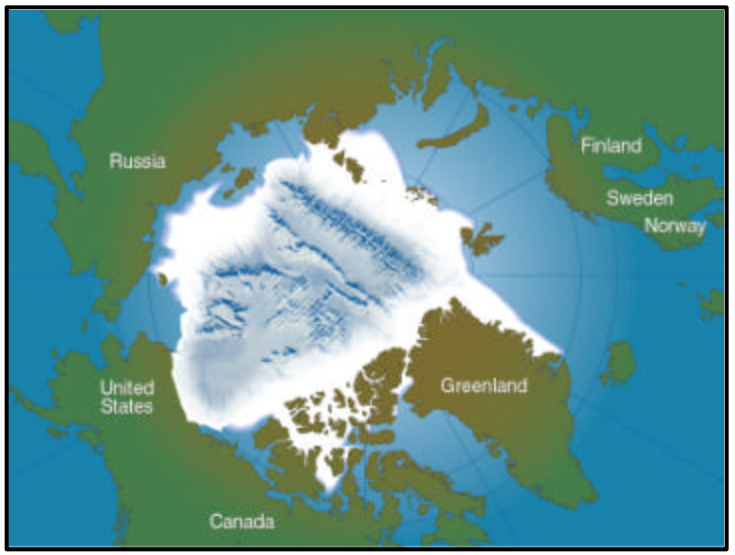
Exploring the Abyss
A Hybrid Vehicle for Working in the Deepest Ocean

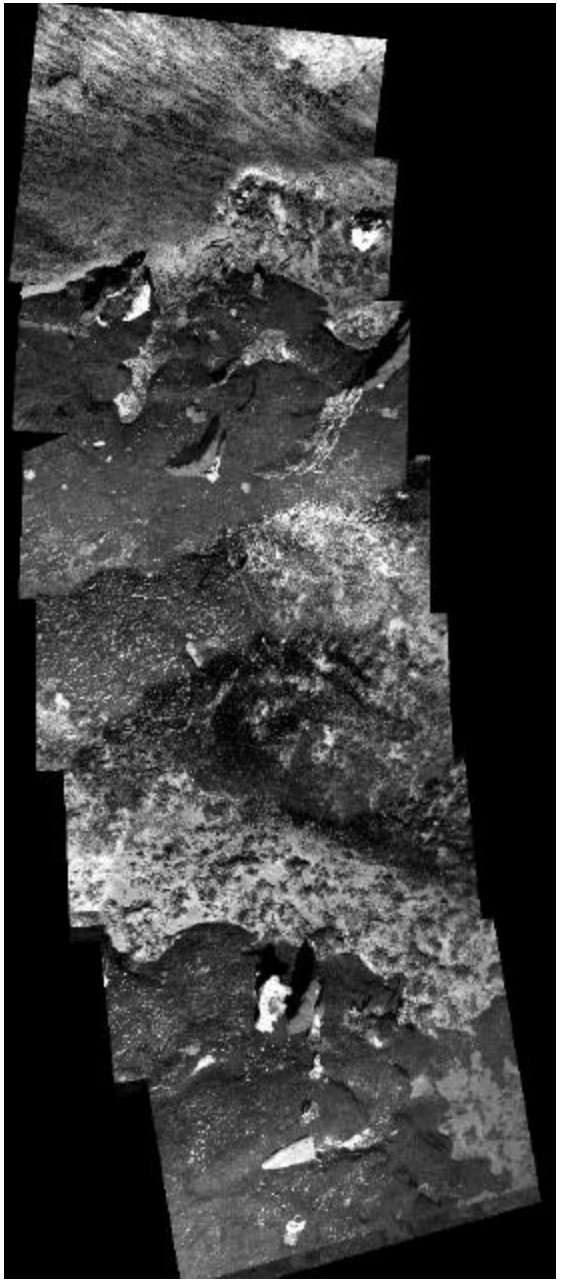
What Does an HROV Do?

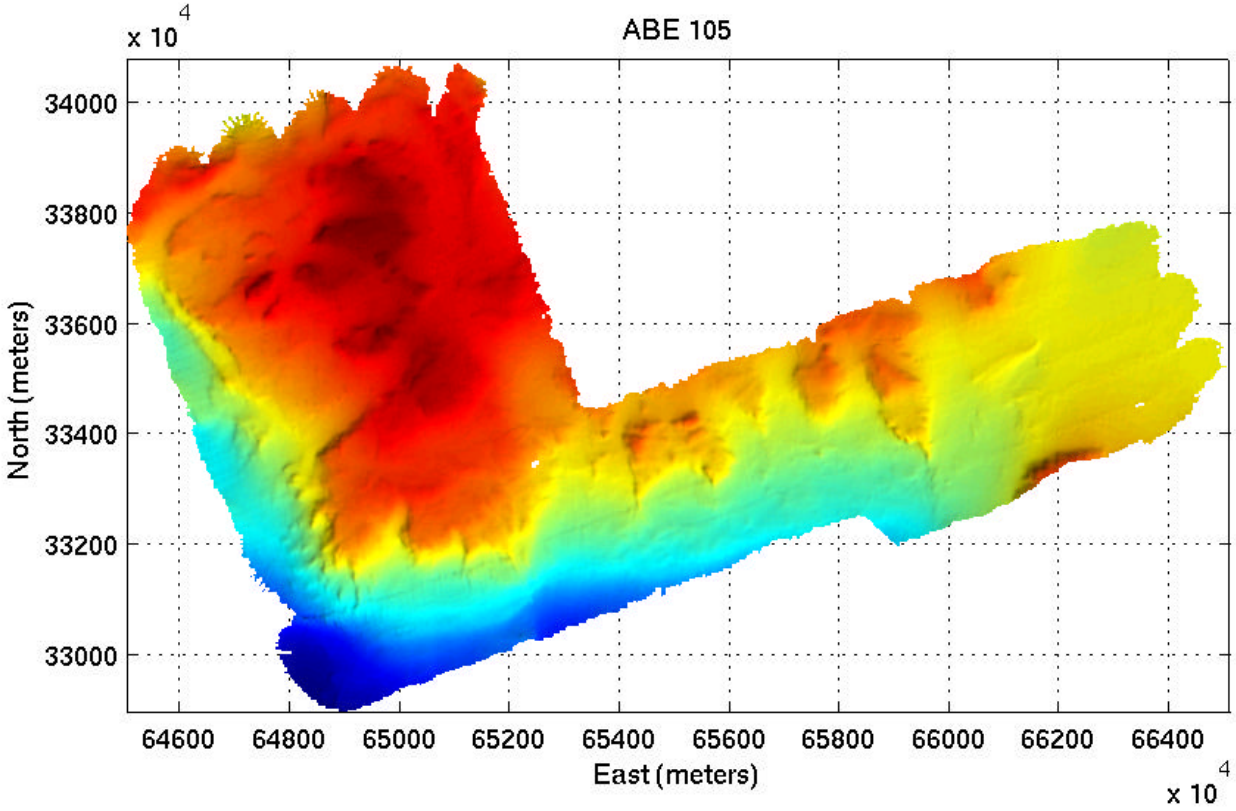
- Through use of new materials and techniques, HROV will achieve access to the deepest and most remote regions of the ocean





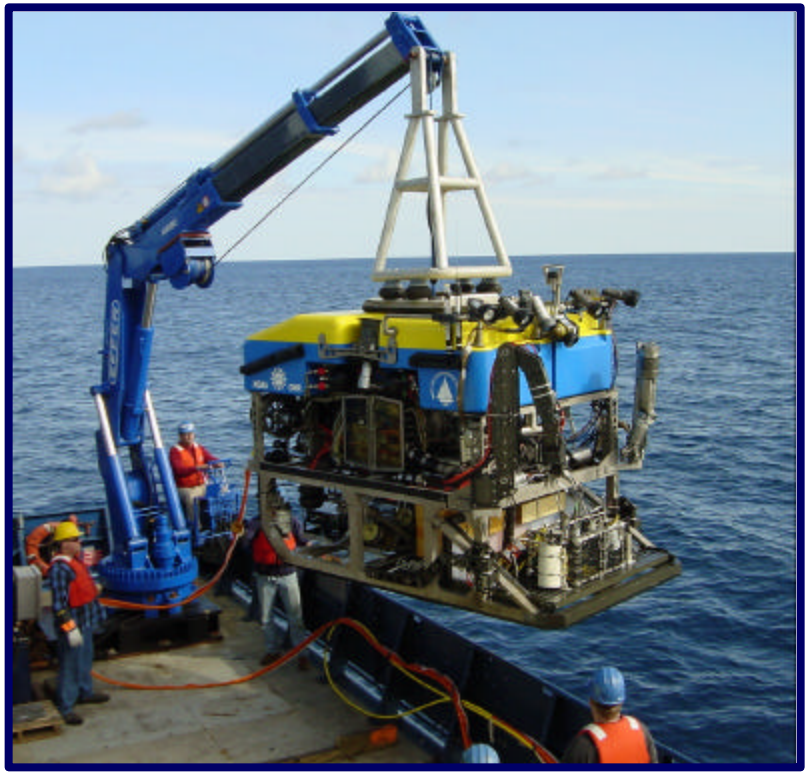
Autonomous Benthic Explorer (*ABE*)





Jason Operations

- 250 lbs. of payload, with 300 lb. tool sled
- Highly flexible science interfaces
- Two spatially correspondent master-slave manipulators
- High efficiency electrical propulsion with large capacity auxiliary hydraulic supply



- 500 lbs. of thrust in each axis
- Large telescoping sample drawer with two side mounted swing arms
- Proven operations to 6,500 meters (deepest diving operational ROV worldwide)
- Heavy lift capability 1.5 ton at maximum operational depth

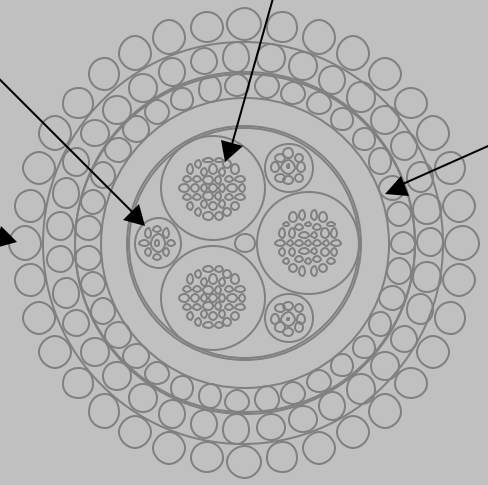
Electro-Optic Armored Umbilical

Power conductor (3)
#11 AWG, Hard-drawn copper

Optic Waveguide (3)
Fiber: 8.3/125/250SMF

Cable Core Jacket
HDPE .422 dia.

Armoring
3 Layers GEIPS
17mm (.680 inch) dia.



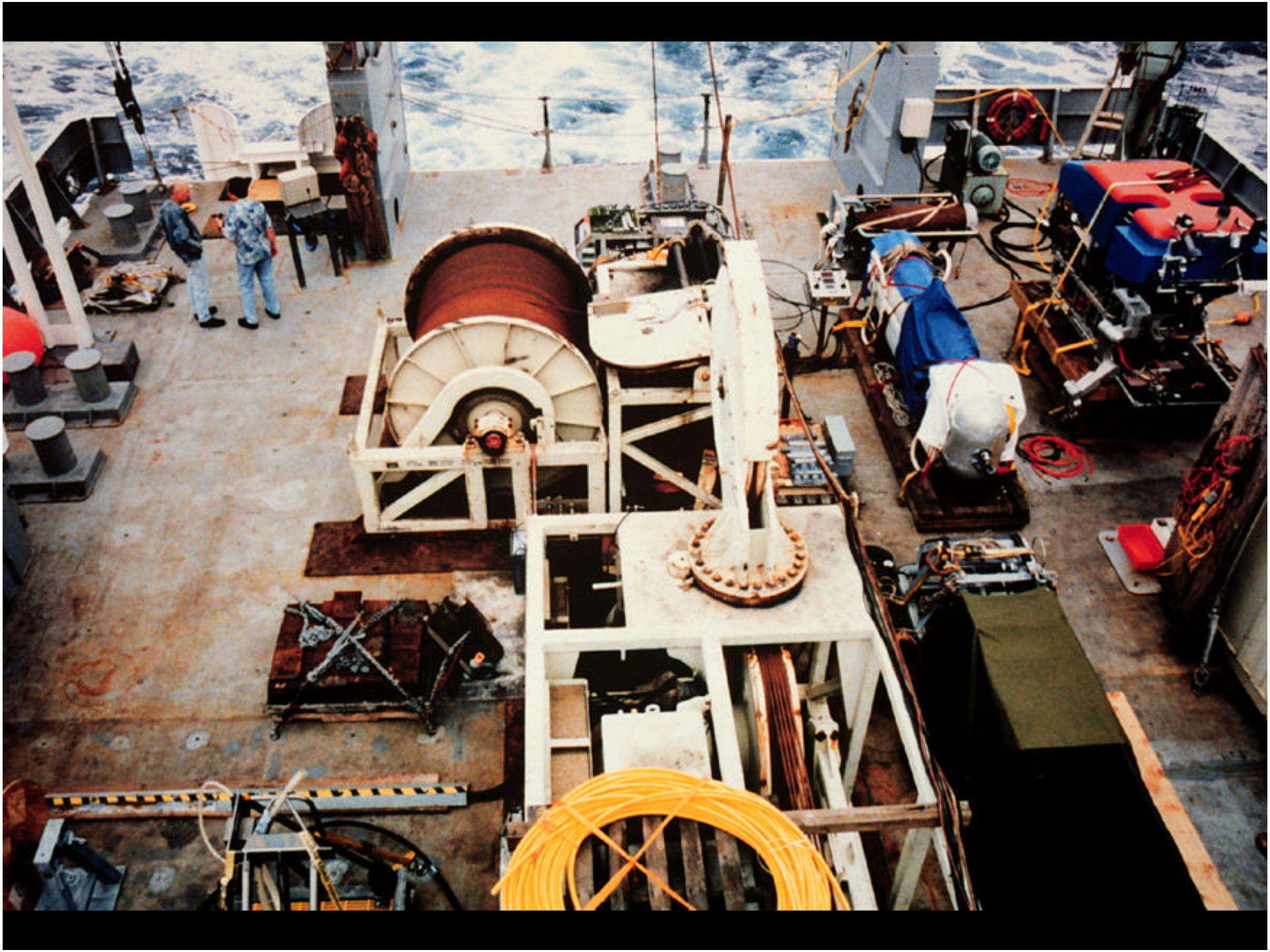
Manufactured by:

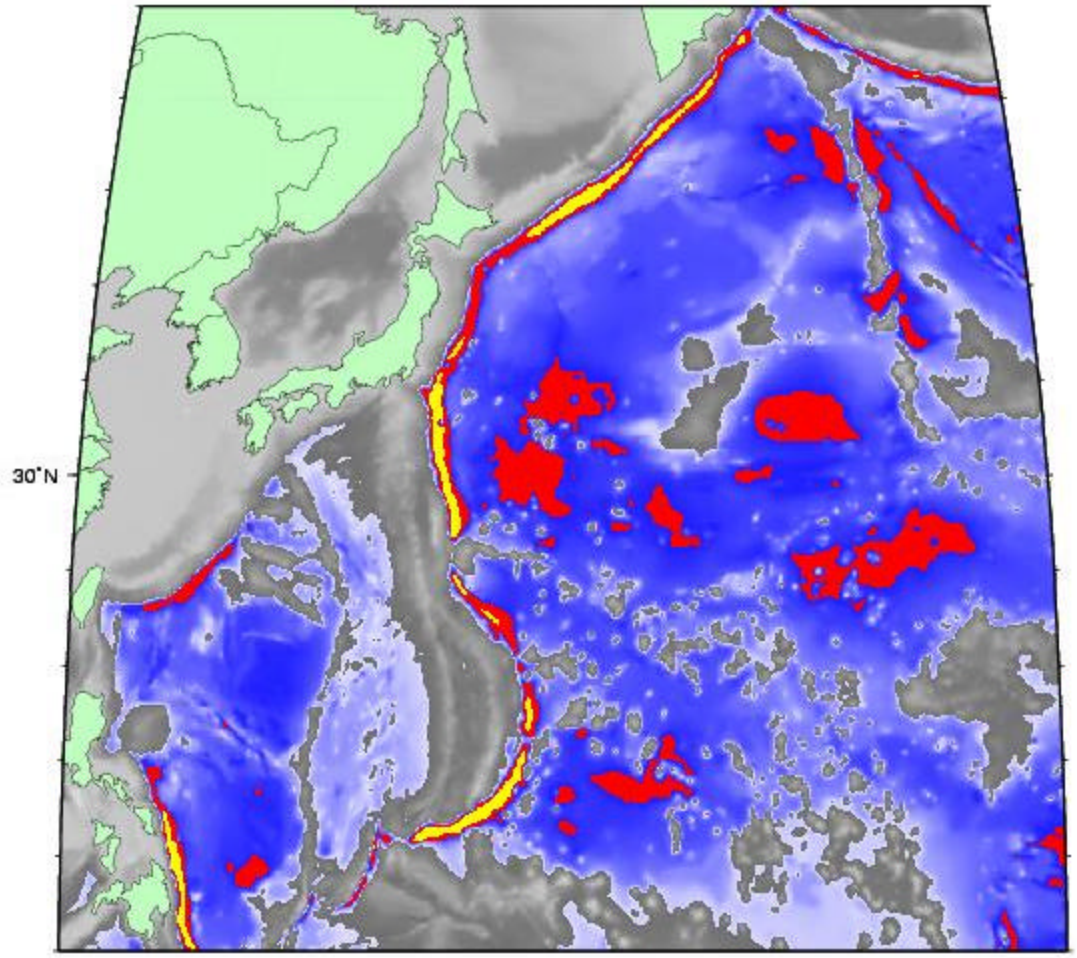
The Rochester Corp.

Culpeper VA.

PHYSICAL

Length		10,000 m	32,800 ft
Wt. in Air	1,112 kg/km	747 lb/kft	
Wt. in Seawater		905 kg/km	608 lb/kft
Breaking Strength, Free End		205 kN	46,000 lbf
Recommended Bend Radius		61 cm	24 inches
dc Resistance		4.9 3/km	1.5 3/kft
Optic Attenuation		.7 dB/km	.21 dB/kft





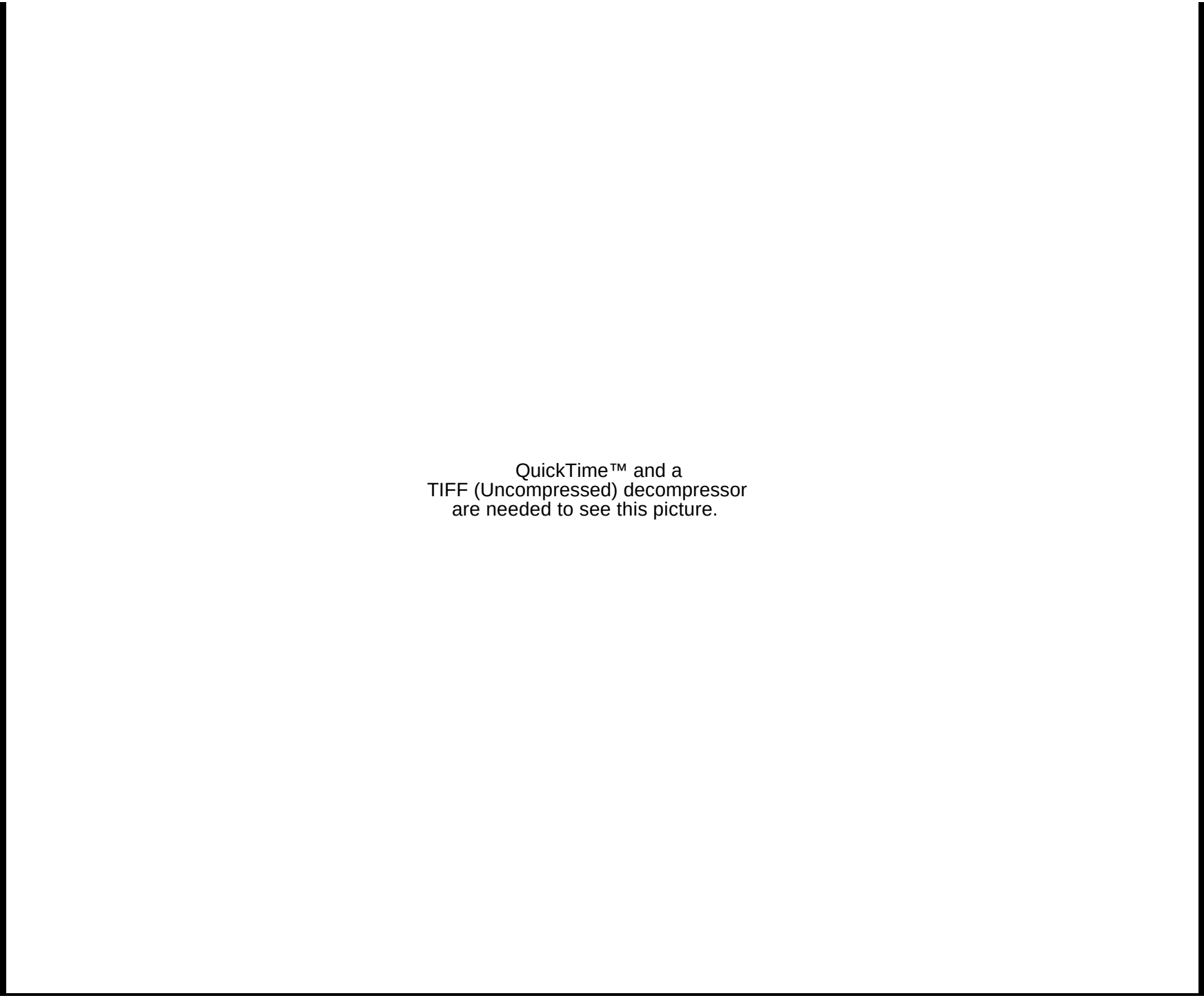
Global Ocean depth chart

Robinson projection

-10000 -7000 -6000 -4500 0


KAIKO


QuickTime™ and a
TIFF (LZW) decompressor
are needed to see this picture.


QuickTime™ and a
TIFF (Uncompressed) decompressor
are needed to see this picture.

Going to 11,000 Meters is a Significant Technical Challenge

- Ambient Pressure is 16,000 pounds per square inch -- previous visits have used conventional technology for key structural components, resulting in large, heavy systems
- Traditional solutions of supplying power from the surface support vessel adds huge physical overhead because of the cable winch and overboard equipment must support 7 miles of cable over the side.

Where Might HROV Go?

- **Event Response -** Light weight “fly-away”
- **Under Ice Operations** - Large horizontal excursions
- **Margins -** Trenches
- **Marginal Environments -** High latitudes
- **Service and support of Observatories**
- **Public Outreach** - Explore the unknown

What is an HROV?

- A **Hybrid** cross between an AUV and a ROV in a single package
  - AUV for Mapping
  - ROV for Close inspection and manipulation
- New class of vehicle intended to explore the harshest ocean environments though the innovative application of new techniques and materials
- New Class of vehicle intended to offer a more cost effective solution for survey/mapping and direct interaction

QuickTime™ and a TIFF (Uncompressed) decompressor are needed to see this picture.

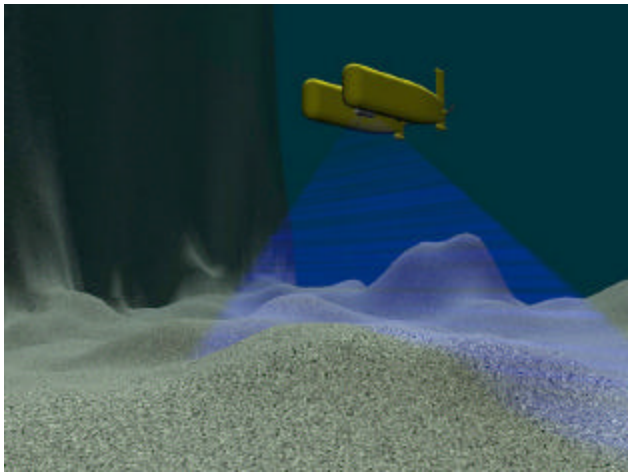
AUV Mode

QuickTime™ and a TIFF (Uncompressed) decompressor are needed to see this picture.

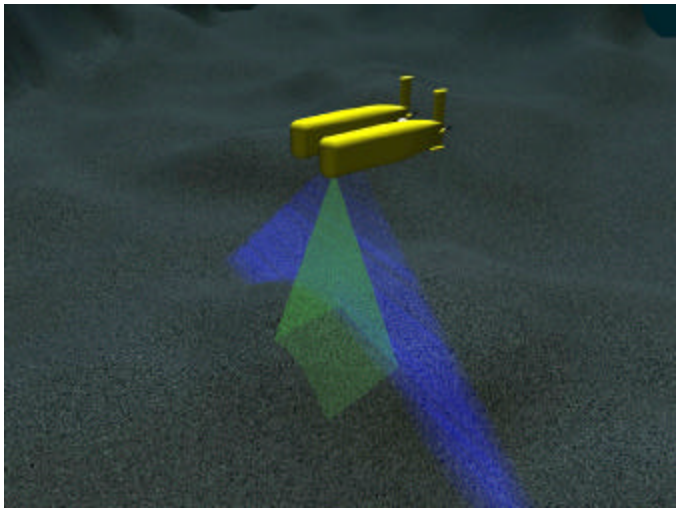
ROV Mode

AUV Mode of Operation

High altitude (50M) sonar mapping

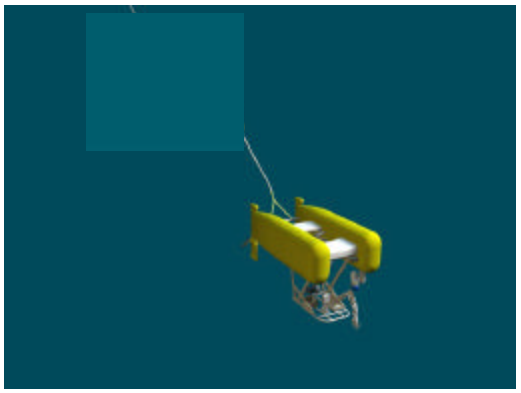


low altitude (10M) digital photograph collection

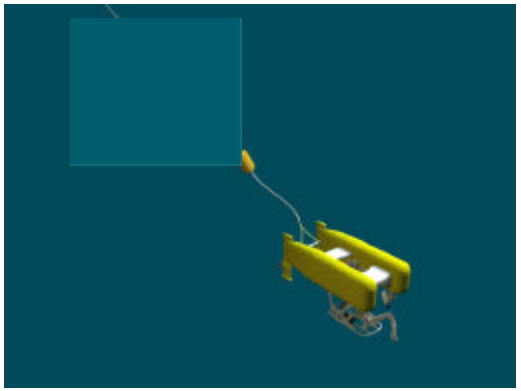


ROV Mode of Operation

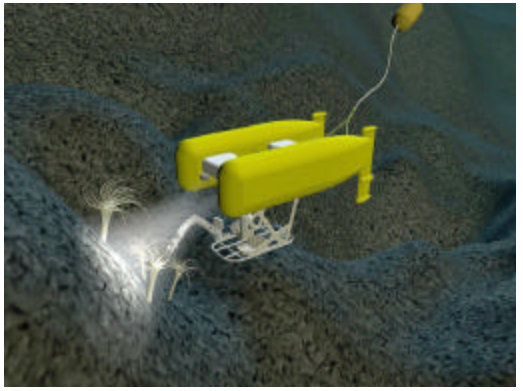
Descent with Depressor and Armored Cable



Release from Depressor Micro-fiber tether payout

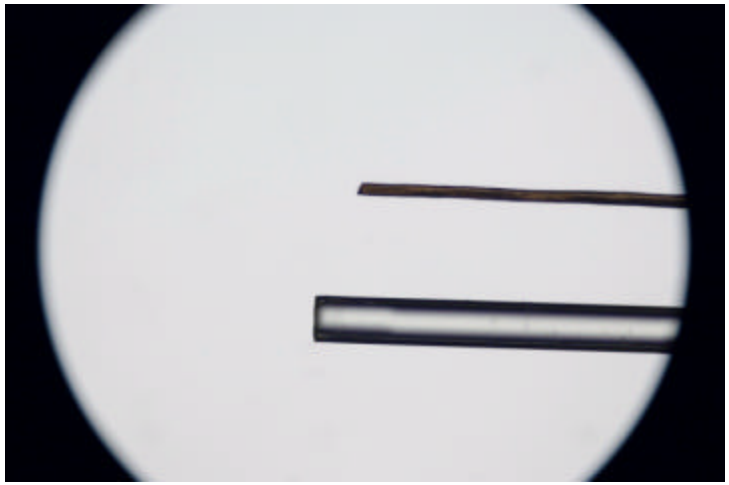


On Bottom collecting samples



Fiber Optic Micro Cable

- **Size: 0.010 inch diameter, 8lb RBS**
- **Each Canister contains 20km of fiber**
- **20 KM of fiber weights .7 pounds in water.**
- **Tested to 20,000 psi with no optical attenuation.**



Summary of Vehicle Mission Profiles

AUV

- Survey speed of up to 3 knots
- 70 KM of coverage (sonar)
- Lower altitude photo coverage at slower speed increases mission duration

ROV

- 4 sample sites (typical)
- Up to 7 KM of transits
- Projected bottom time of 8 hours
- Each sample site assumes high resolution imaging and sample collection

HROV Sampling Capabilities

? Push coring

? Heat-flow probe

? Geotechnical/Geochemical sensors –pore pressure in sediments

? Rock sampling/drilling

?Biological sampling – small suction samplers, nets and “bio boxes”

• Water sampling

Ceramic Floatation

- Traditional syntactic foam for 11,000 meters has a S.G of .68
- 3.5 inch dia. alumina ceramic spheres have a S.G of .37
- Collapse pressure in excess of 30,000 psi (close to a 2X safety factor for HROV)

Main Housings

Mechanical Characteristics

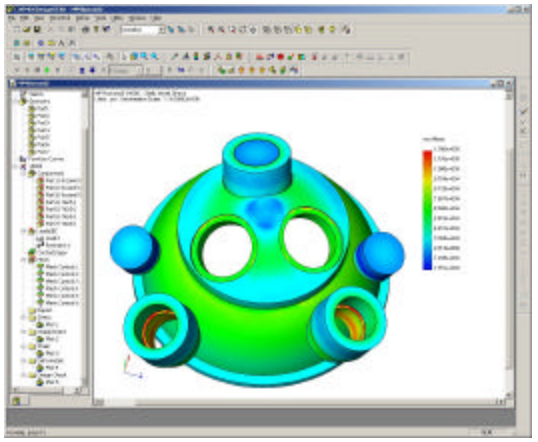
•Alumina Ceramic/Grade 5 titanium construction based on SPAWAR design guidelines

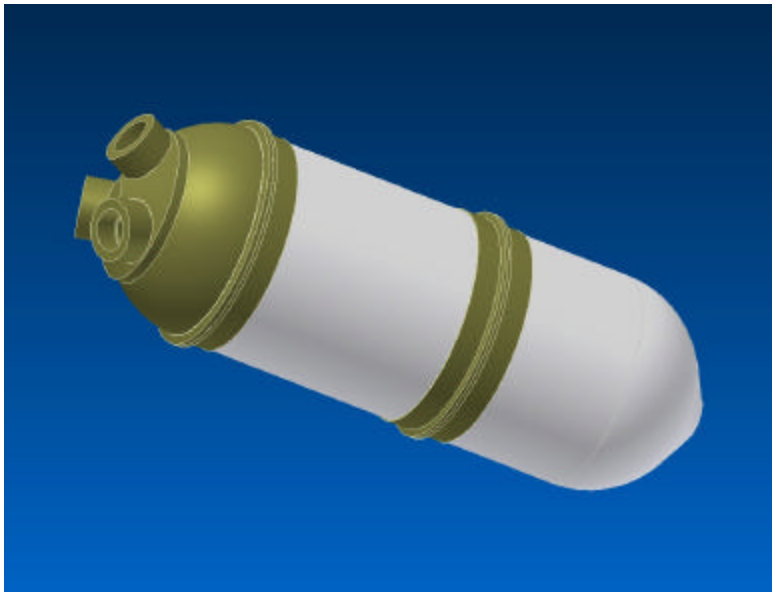
• 4 Housings - 2 for batteries and 2 for electronics

•135 lbs buoyant in water

• Comparable Ti vessel: 300 lbs air weight and 80 lbs negative in water, yielding a savings of 215 pounds.

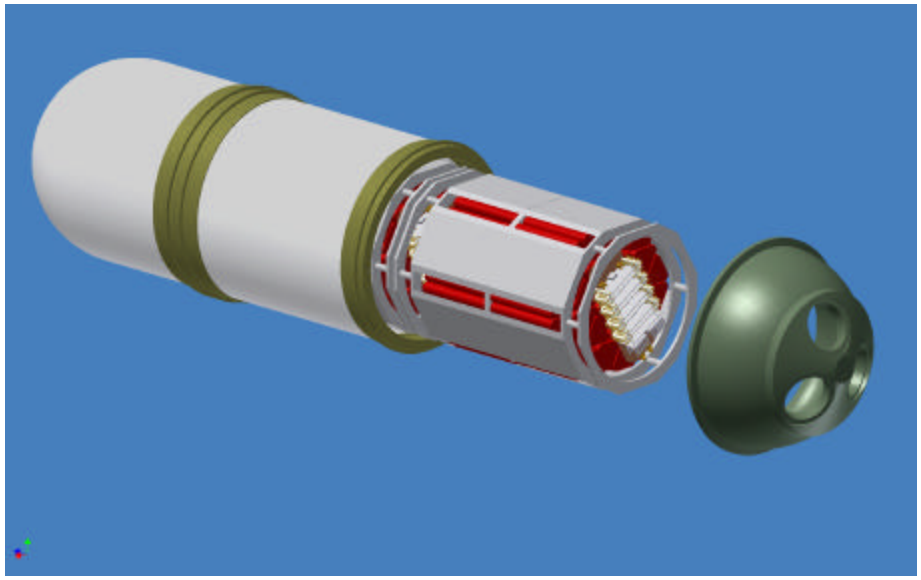
• Total in-water weight savings of approximately 730 lbs!

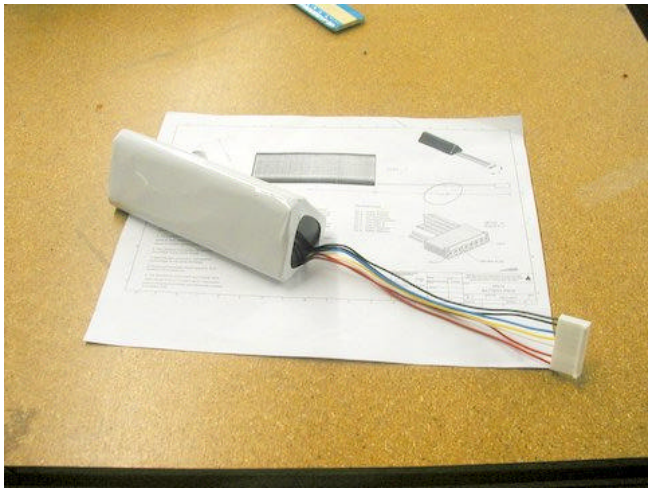




Lithium Ion Batteries

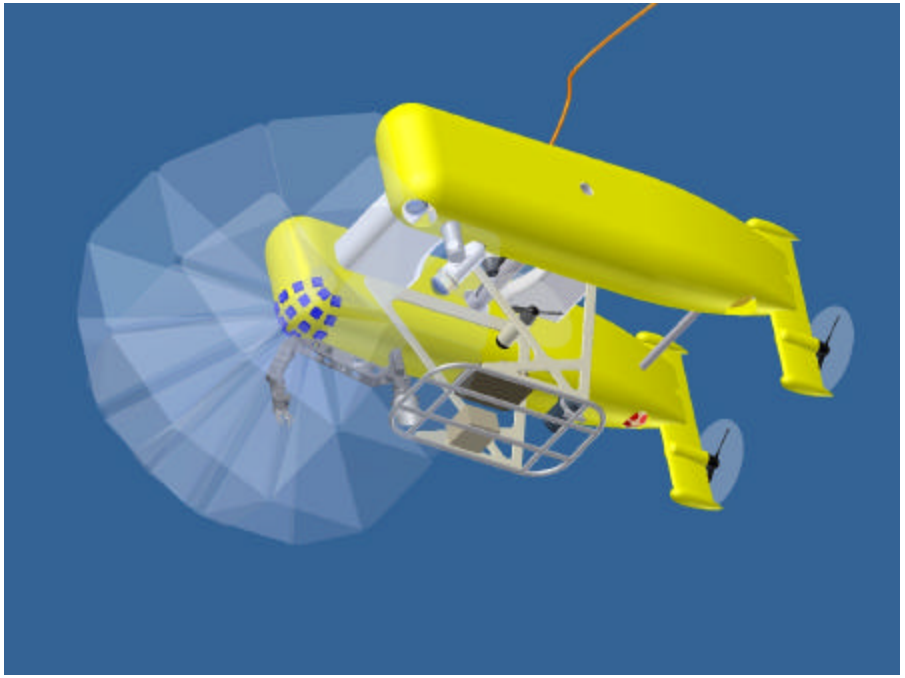
- 18 KWh total capacity
- 50 volt buss, 3KW charge/discharge
- 270 lbs weight
- Formal hazard analysis complete with external review
- First article battery in house undergoing test prior to U.N. testing





LED Lighting Characteristics

- Ability to strobe
- High electrical to optical conversion efficiency
- Pressure tolerant design
- Ability to create a spatially flat illumination field to match the camera field of view
- Discrete color for best “effective transmission” through water



Summary

- This is a unique, high risk project to develop new technology allowing cost effective access to unexplored areas of the ocean
- HROV technology will have important implications and feed forward into other oceanographic systems
  - Micro-fiber tether
  - Ceramics
  - High capacity energy storage
  - Efficient (autonomous) manipulation
  - Integrated lighting and imaging systems
- Exploration of the final 4,500 meters of the ocean and under ice environments **will** result in new discoveries