



Free-swimming Diver Heating System (FDHS)

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Background: Initial Thermal Needs

- Active heating needed for long duration, cold water dives
- Thermal needs depend on insulation and activity
 - Heat delivered via closed loop “tube suit” → 
 - Heat needed in 35°F sea water:
 - ≈ 300-350W with 400 weight Thinsulate
 - ≈ 250-300W with 1.9 CLO Aerogel
 - Supply water 95-104°F
- Temperature Control
 - Activity level
 - Warmer sea water
 - Personal preference



Tube Suit



Insulation



Dry Suit

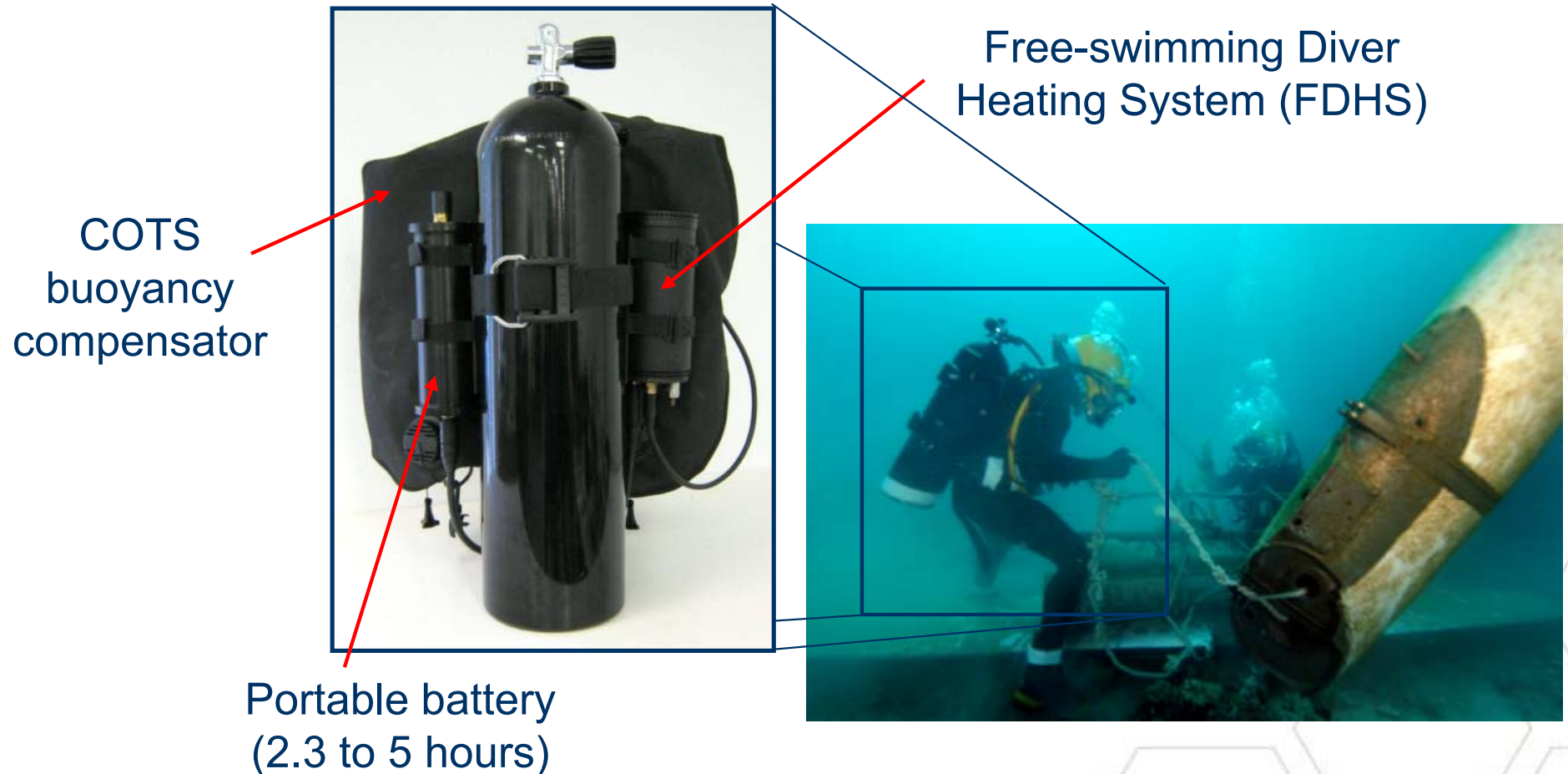
RINI Approach

- Technology: **Thermodynamic Heat Pump**
 - Extracts heat from cold sea water
 - High efficiency (1W elec. power \approx 3W heating or cooling)
- Electrically powered
 - Operates from battery or “boat” power
 - No consumables, gas venting or system recovery
- Designed to operate in dirty water
- 7 lbs (-4lbs buoyant)
- Orientation independent



Application

- Easily mounts to tank, rebreather, or BC with optional portable battery



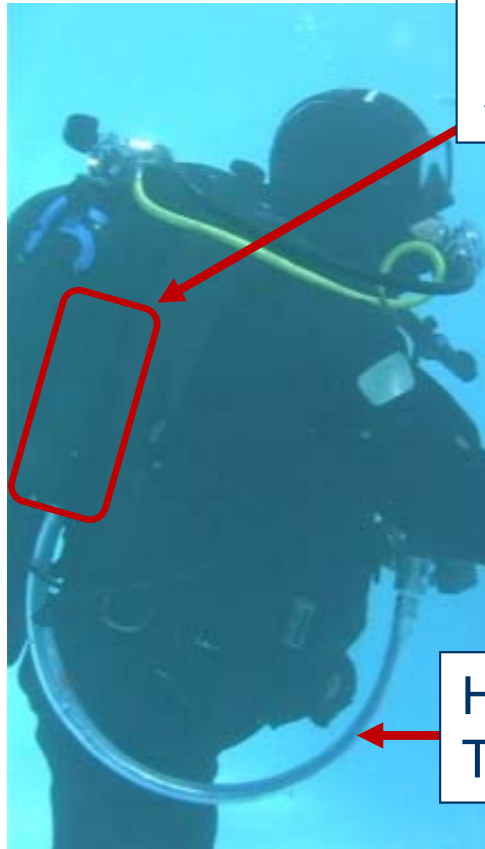
News: Heating System Submerged Testing

- Evaluation of fully submerged diver in 8ft of fresh water
 - April 4-5, Naval Surface Warfare Center – Panama City
 - Water temperature: 34°F
 - Run Time: 2 hrs 40 min (from “boat power” and portable battery)
- Accomplishments:
 - Demonstrated increased capacity
 - Up to 400W in 35°F ambient
 - Diver kept comfortable throughout test
 - Approx. 350W of heat
 - Diver arm was cool for short duration but returned
 - Swimming mobility unimpaired
 - Noise described as “low hum”
 - Evaluated in small pool



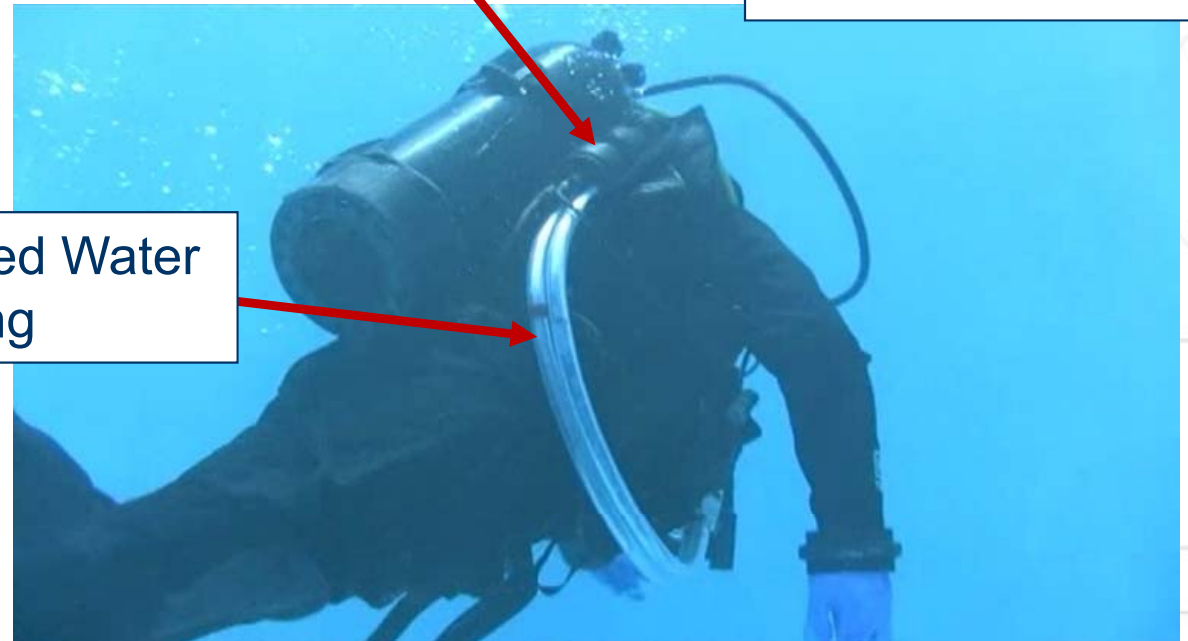
Heating System Submerged Testing

Free-swimming
Diver Heating
System (FDHS)



Dry Suit Penetrator /
Quick Disconnect

Heated Water
Tubing



BARE Dry Suit,
400 weight Thinsulate &
High Density Tube Suit

2011 Accomplishments:

- Developed thermostatic control
 - Maintains comfort (constant supply temperature $\pm 0.2^{\circ}\text{F}$)
 - Increases battery life
- Performed initial qual. tests (P-9290 & MIL-STD-810G)
 - Depth (300 FSW)
 - Cold Storage (-65°F)
 - Salt Fog
 - Decompression
 - Hot Storage (158°F)
 - Altitude
 - Shock: Drop
 - Blowing Sand
 - Fungus
- Performed redesign
 - Incorporate lessons learned
 - Improve manufacturability



Cooling System Prototype

- Built and tested Cooling System prototype
- Incorporated design lessons from Heating System
- Laboratory testing underway
 - Initial performance looks good



Cooling
Unit
3.5 x 8.5"



Cooling Unit



Heating Unit

Work Plan:

- Fully evaluate Cooling System
- Improve integration into diver ensemble
- Improve designs for durability, reliability, and manufacturability
 - Incorporate lessons learned and changes from current prototype
 - Complete next round of reliability testing
- Conduct several additional diver evaluations
- Conduct ANU diver testing
- Logistics & LRIP planning



Summary of RINI Thermal Control Systems

Steady State Conditions	Heating Unit (FDHS)	Cooling Unit (FDCS)
Specifications:		
Heat Delivered	300 W	250 W
Ambient	35°F (1.7°C)	100°F (37.8°C)
Suit Water Temp.	100°F (37.8°C)	68°F (20°C)
Power	130 W	85 W
Unit Volume	1.6 L (98 cu.in.)	1.3 L (80 cu.in.)
Unit Diameter	3.8 in	3.5 in
Unit Length	8.5 in	
Weight in Air	7 lbs	5 lbs
Buoyancy in Water	-4 lbs	-3 lbs