Free Diver Heating System
(Personal Heating for Divers)

Business Opportunity:
U.S. Navy divers often operate in extremely cold water conditions and have limited means of staying warm during long exposures. Similarly commercial salvage divers and industrial diving operations often occur in cold water environments and could benefit from a diver heating solution. RINI Technologies' (RINI) Free-swimming Diver Heating System (FDHS) offers a compact and efficient heating technology for military and commercial divers operating in cold water environments.

RINI has primarily focused the FDHS technology for use by free-swimming divers in the Navy Special Operations Command (SOCOM) and Navy Special Warfare Command (SPECWAR). These Navy divers must operate in extremely cold conditions which can induce cold stress which in turn impairs diver performance, shortens dive duration and creates health risks to divers. A secondary focus of RINI's FDHS technology will include other armed services branches as well as commercial, industrial and recreational diving markets.

RINI is looking for our first military customer (production orders) and the subcomponent manufacturing partners we need to successfully fill and manage these orders. In addition, RINI is willing to entertain licensing opportunities for additional applications and markets.

Company Background:
RINI is a privately held, for-profit S corporation. Headquartered in a 12,000 square foot facility in Oviedo, Florida, Dr. Dan Rini founded the company in 2000, and it currently staffs 16 full time and 5 contract employees. The company has a nine year history of winning competitive research contracts (over 35 awards) from government customers including the Army Natick Soldier Center, AFRL, ONR, and DARPA.

The Company's laboratory is equipped with several fully automated data acquisition systems, high voltage power supplies, chillers, thermal test chambers, life and reliability test stations for systems and components, and other equipment needed to conduct research and development in the thermal management field. The on-site machine shop facility houses several CNC milling machines, lathes, grinders, and manual equipment; enabling precision machining capabilities. This fully capable on-site facility allows for rapid fabrication of custom prototype parts and the flexibility to make rapid design changes facilitating parametric design tests to be conducted.

Industry Problem:
Deep submersion operations performed by free-swimming divers often expose them to extreme cold conditions. Currently, the Navy has limited means of heating personnel during exposure to such conditions. This deficiency can induce cold stress which in turn impairs diver performance, shortens dive duration and can lead to health risks such as hypothermia. The issue is usually experienced during cold water dives are first felt in the diver's extremities such as hands and feet. The Navy has a good understanding of what level of heating is needed to maintain core body temperatures, and requires a solution that has a low profile, small volume, power efficient, resistant to corrosive saltwater and operates for the duration of a typical Navy dive. RINI has successfully been able to achieve the initial requirements identified by the Navy specification for a man mounted diver heating system.

Technology:
The FDHS is a miniature heat pump system that circulates warm water through a tube suit worn by the diver. The heat pump process is extremely efficient where for every 1 Watt of system electrical power will "pump" 3 Watts of heat from the sea water to the divers' body, unlike electrical heating type systems which require 1 watt of system power and only produce 1 watt of heat. This positive aspect of heat pumping technology is especially significant when considering portable applications where batteries must be carried in addition to the heating unit itself. Every component within the system was custom designed by RINI in order to meet the size, weight and efficiency requirements. Examples being a custom developed small positive displacement rotary compressor; an evaporator, water pump and condenser assembly designed to meet the heat transfer requirements while tightly integrated together.

Advantages and Differentiating Features:
The current FDHS system is a non-tethered, stand alone system that will be clipped to the diver and will warm the individual in sea water conditions as low as 1°C. The unit will provide 300 Watts of heating by circulating 35°C water through the diver tube suit in a 3.5" diameter 1.5 Liter package. The unit consumes 110 Watts of power and weighs 4.1 lbs in air and -2.0 lbs under water.

Stage of Development:
The first FDHS lab prototype will be complete in December 2009. A Phase III NAVY SBIR program is slated for the last quarter of FY09 and will focus on advancing the Technology Readiness Level (TRL) of the hardware to TRL-7 through a complete set of qualification and environmental testing that mimic operational conditions. During this period a manufacturing program will begin to develop a production plan and build low rate "production ready" runs. RINI intends to transition the FDHS technology to a Program of Record by 2011 with the first LRIP production order two years from now.

Competing Technologies:
Thermal protection for divers has been accomplished through a variety of methods that include passive or active heating approaches. The passive solutions involve wet or dry suits which are intended to "insulate" the diver from the cold water, however these suits alone are insufficient to maintain the diver core temperature at adequate levels for long durations when operating in sea water conditions <10°C. ***Aerogel – passive garments*** are worn as a supplemental liner for dry suits and provide reasonable thermal protection in cold environments but limit the mobility of the diver. The ***Thermal Electric Heater prototype*** is comprised of a large backpack that weighs 28 lbs in air and is worn by the diver that contains power, pumping and heating for a water system that circulate warm water to heat the diver. The ***Hydrogen Catalytic Heating*** approach involves a hydrogen reaction with oxygen to create the heating capacity for a circulating water loop that is supplied to the diver via an umbilical cord from the main catalytic heating system. This approach is currently not feasible for free swimming divers as the umbilical tether constrains diver mobility. The ***Resistive Heating Device*** supplies heat to the diver through electrical resistors embedded throughout the dive suit. Although this method is effective at maintaining the diver core temperature, the major obstacle facing these electric heating suits is the relative power inefficiency; for every 1 Watt heat to the diver it requires 1 Watt of electric power. Conversely, for RINI's FDHS for every 1 Watt of electric power provided the system "pumps" 3 Watts of heat from the sea water to the divers' body.

Benefits:
In cold water environments situations where diver thermal protection is necessary, the FDHS provides both physiological and cognitive benefits by maintaining a stable diver body temperature and minimizing the cold stress that can impair performance and mobility. The FDHS will increase mission times and provide the commander extended capabilities when planning missions.

Intellectual Property:
RINI Technologies is implementing an IP strategy to secure patents that cover the diver heating configuration, the general heat pump system design, the subcomponents within the system and any key elements that give the system an advantage. At present RINI's miniature vapor compression and heat pump technology components have been issued two U.S. patents and have five pending patents. The company also has three patents for laser & electronics cooling, with three other related patents pending in the US.