

Rebreather Technology: There is a Market, but Can Anyone Deliver?

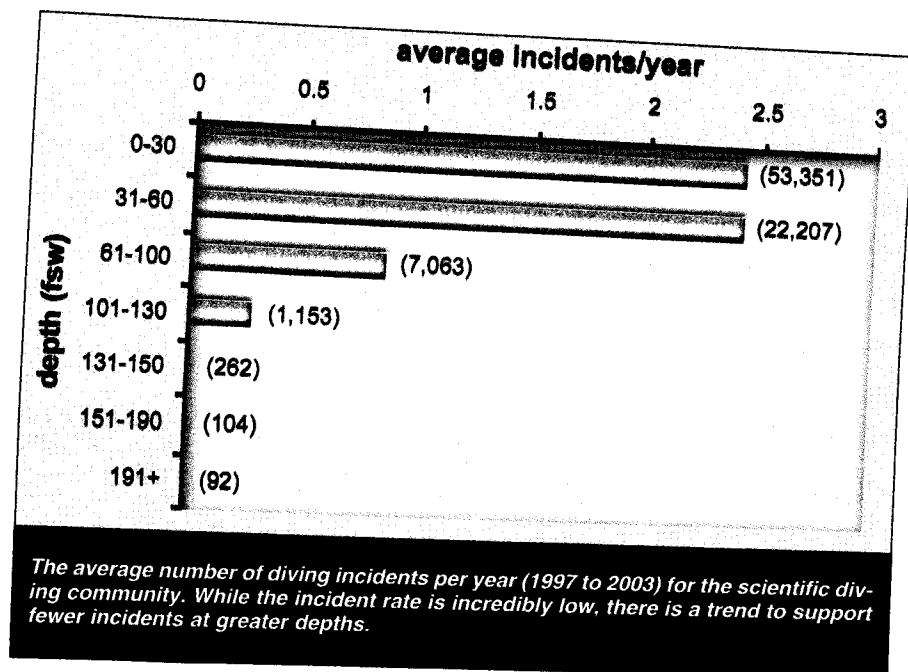
The Industry Now has an Opportunity to Turn this Technology Into its Most Strategic Asset

By Michael Lombardi
Marine Scientist and Consultant

The closed-circuit rebreather (CCR) has traditionally been regarded as the simplest and safest underwater life-support system ever conceived. That statement should surely catch your attention, as it is the antithesis of what has been wrongfully engrained for over a century.

Rebreathers pre-date the open-circuit, self-contained underwater breathing apparatus (SCUBA), having roots dating back to 1879, when Henry Fleuss was among the first to develop a closed-circuit oxygen rebreather in an attempt to offer divers freedom to explore. Half a century later, still predating Jacques Cousteau's aqualung, Dr. Christian Lambertson evolved the oxygen rebreather to make it suitable for military use. Ultimately, it has taken nearly 60 years for evolutions of this technology to find the beginnings of a market opportunity within the public sector.

Today, there lies incredible controversy within the diving industry regarding applications of rebreather technologies. While the advantages—physiological benefits, reduced cost, and recycling gas—is clear and has been demonstrated, the technologies' stream application and utility have yet to be fully realized and appreciated. Throughout the 1990s, and into the 21st century, small cells and independent developers have produced rebreather technologies suitable for underwater work. These have placed divers at depths greater than 500 feet and for durations exceeding eight hours (all independent of direct



surface support. This technology is the future of exploration and, in time, could save the underwater industry billions of dollars in highly advanced manned intervention of our oceans. However, several obstacles exist, especially while pursuing application of this technology in a professional capacity.

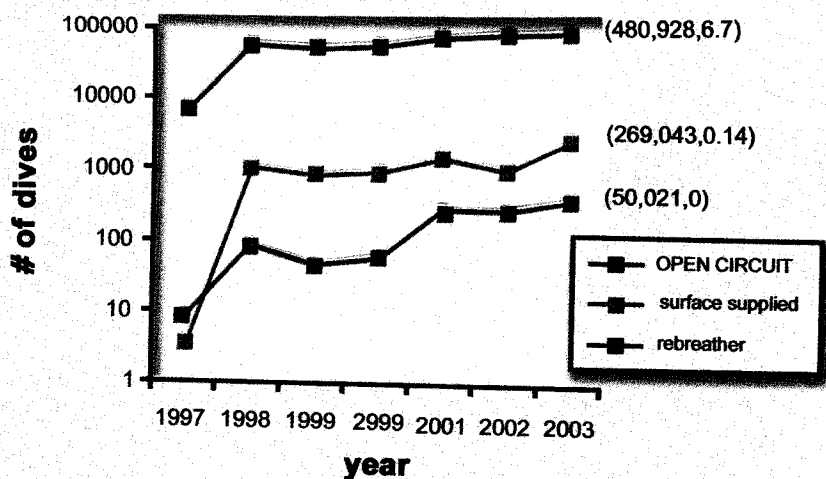
It will take a consortium of technology developers, academics, industrial powerhouses, creative interpretation and the drafting of new standards to demonstrate this next step.

Technology Overview

What is a rebreather? CCRs are a highly advanced personal underwater life-support system that is used instead of more conventional open-circuit SCUBA. CCRs recycle the diver's exhalations, therefore, recovering

valuable gas that is lost as bubbles in open-circuit techniques. The complications are clear—there needs to be a method of removing poisonous carbon dioxide, as well as a method for maintaining a life-sustaining amount of oxygen as the body metabolizes the oxygen in the bag. These limits were not easily overcome in the late 1800s and early 1900s, hence the continued development of surface-supplied gas systems and, eventually, the SCUBA that we know today. However, rebreather technology resurfaced during the 1940s and 1950s for stealth military operations, and again with significant modifications in the 1960s and 1970s as electronically controlled systems were born.

A new breed of innovation is likely to sweep across the marketplace in this century. The concept of this technolo-



The number of dives per diving mode for the period 1997 to 2003. All three modes support an expanding scientific diving community, and rebreather utilization seems to be on the rise.

gy pre-dates SCUBA for a reason: it is logically and mechanically simple. The evolution of related necessary innovations was just a bit slow (from scrubbers to sensors), hence the fear that has overridden the industry. Research and development is still only in its infancy, and we are still at the beginnings of a much-needed revolution of the industry.

Advantages. The advantages of using closed-circuit rebreathers stem from the physical and physiological benefits of recirculating the breathing gas. These advantages include extended duration (three to four hours typically, but up to 12 hours' dive time); extended depth (theoretically up to, and exceeding, 2,000 feet of seawater); non-acoustic and often non-mag-

netic; virtually unlimited gas supply, carried on the diver's back, thus reducing gas management/task-loading; increased redundancy (since several new bailout contingencies can be acted upon); bubble-free operation increases the quality of animal interactions for scientific applications and for underwater photography/videography; a constant partial pressure of oxygen poses a significant physiological advantage for decompression safety and recycling gas reduces the cost of dive operations, especially deep operations in need of special/custom mixed-gases.

Disadvantages. While there is likely an arguable disadvantage for every listed advantage, the disadvantages most often discussed are cost and complexity. The cost of these systems can range from \$5,000 to over \$20,000. However, the cost and value should not be confused, as just a few weeks of extensive mixed-gas operations can easily justify the expense of this asset and offer a competitive advantage in the marketplace. These units are driven by computers, and if this means complex, then so be it. However, as we plunge into the 21st century, we are hard-pressed to

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"The advantages of using closed-circuit rebreathers stem from the physical and physiological benefits of recirculating the breathing gas."

accomplish much of anything with technical merit without the assistance of computers. Technology will only improve, as will reliability and humans' confidence in applying this incredible tool. The key is training. Rebreathers are no more complex in principle than open-circuit SCUBA. If this generation is to be a proponent of perpetuating rebreather stewardship, new training philosophies need to be developed and implemented from day one. This holds true industry-wide, from recreational divers to the off-shore community. Rebreather diving is not difficult, and we do not need to relearn how to dive, we just need to rethink how we dive.

State of the Market

The current rebreather market is quite small. Less than a dozen companies are out there, and those that are produce units with varying features and performance levels ranging in quality from those with large runs and excellent customer support, to those with a less-than-desirable garage style. The technical recreational market makes up over 90 percent of the market, accounting for less than a few thousand units sold annually. The military marketplace is not huge; however, success is found by offering a high-quality, high-dollar product over an extended contract. Both recreational and military markets will be left out of this discussion, as they have already found success, yet the truest and still unrealized potential exists in the commercial and scientific market segments.

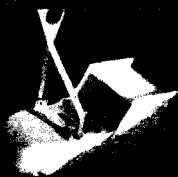
Commercial Diving. Current Occupational Safety and Health Administration (OSHA) diving regulations require commercial divers to use a surface-supplied breathing gas supply via an umbilical. The gas supply is generated by a compressor and requires a number of topside personnel to tend to the diver. In this configuration, gas is expended as exhaust bubbles, much like open-circuit SCUBA. For deeper excursions, gas reclamation systems have been employed which filter and recompress exhaust gas with 60 to 70 percent efficiency. When a mixture other than air is used for deep offshore

commercial diving, such as helium-oxygen or neon-oxygen, expendable gas may cost upwards of \$1,000 per hour, due to the high work of breathing and high volume of gas necessary to be delivered under ambient pressure. CCRs recycle gas at 100 percent

efficiency and, because they are self-contained, offer a virtually unlimited gas supply at a cost of only \$20 to \$30, regardless of depth or work of breathing.

Other markets for this technology are evolving in the commercial sector. Port and harbor security, for example, has demonstrated the need to thoroughly inspect our coastal harbors and waterways. Several sensors and analytical instruments have been developed; however, there will forever be a need for the dexterity and reaction

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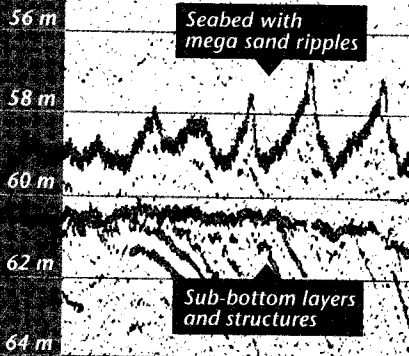
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Scientific Diving. The scientific community is beginning to address the appropriateness of CCRs for regular working operations. In January 2003, the National Oceanic and Atmospheric Administration (NOAA) released its Diving Program Strategic Plan 2003-2008: *Charting a New Course for the NOAA Diving Program*. This plan lists several priorities, including the adoption of new technology. Following this, the NOAA-National Undersea Research Program formed a rebreather committee, which has recently drafted a set of CCR specifications for an acceptable scientific diving unit. The scientific community appears to be rapidly progressing on this front and will continue to do so considering its exceptional safety record with new deep and mixed-gas activities. However, it has become evident that the standing obstacle is the actual existence of a rebreather unit that meets 100 percent compliance for proposed standards, further offering incentives for small developers to meet the compliance factors.

Entering the Market. Just one, although most significant, obstacle in realizing successful market penetration is defining the size of the market itself. Numerous companies have gone belly-up while committing to intensive, although much-needed, research and development efforts. Several critical technologies evolved from these, yet the company never realized profitability in the marketplace. This is one reason for all of the garage-built units.

The reality is that the scientific diving market will probably open up first, within the next five years, yet this is likely to only include 30 to 50 total units over five years across private firms, academia and government research organizations. For a small company to realize success here, the set of manufacturing standards must be met first, requiring a degree of research and development. For such a small market, and no guarantee of securing any exclusivity over this market, such a unit would likely sell for upwards of \$30,000, making it difficult, if not impossible, to spark customer interest as the value previously discussed has yet to be realized and is difficult to model. For larger companies, the research and development



Researcher Marc Slattery (University of Mississippi) works through a comprehensive pre-dive checklist for a scientific rebreather dive.

component is still required, but with too high of a risk considering the minimal payoff.

The commercial diving sector will slowly integrate this technology as it becomes more appropriate on a project-specific basis. However, there is no forecastable market, as there are yet to be any proposed or adopted standard operational protocols. Adopting any of the existing rebreathers to meet the needs of the commercial industry is certainly possible, however, until there is demonstrable benefit in straying from tried-and-true surface supplied systems, it is unlikely that a major market will open anytime soon.

In both cases, issues facing a small company are International Organization for Standardization compliance (or equivalent), the expense of product liability insurance, sound training programs and third-party testing/evaluation. Garage-built companies are unlikely to meet any of these criteria, and as the costs to enter the marketplace exceed reasonable private investment potential (considering the return), it is unlikely that the needs of scientific and commercial diving will be met anytime soon without government subsidy via institutional investment or a small business innovation research award. Further, the purchaser and end-user are likely to be very unsatisfied with the lack of timely cus-

"The mainstream utility of rebreathers for professional diving will inevitably encourage cross-collaboration and lead to new life in the sea programs."

tomer support and lack of insurance on the product, thus shifting much of the liability to the end-user or the project, which would not have acceptable operational standards in place to begin with. It is a vicious cycle.

The Future

While the advantages are clear in a professional diving venue, the obvious hurdles include the industry adopting a set of operational guidelines and standards that are cross-compatible with every unit appropriate for commercial use, addressing product liability insurances and compiling an adequate supply of pre-mainstream data to justify safe operation in a working capacity.

In the early 1980s, the American Academy of Underwater Sciences (AAUS) was born to grant scientific divers exemption from OSHA commercial diving regulations. Since that time, there has been a clear distinction between the definitions of these activities. This can largely be linked to the mode of diving utilized for each. A brief review of each organization will reveal that the AAUS offers more flexibility in pursuing application of advanced technologies. However, do not discount the interest of the commercial sector. The access granted to our oceans with this technology is unsurpassed. It is feasible to make untethered, surface-to-surface excursions exceeding 500 feet of seawater, approaching the continental shelf. When coupled with saturation technologies, both science and industry will increase their access to our oceans considerably. There again exists a gray area between scientific and industrial objectives, as each exploration will lead to potential new business opportunities. The mainstream utility of rebreathers for professional diving will inevitably encourage cross-col-

laboration and lead to new life in the sea programs.

Conclusions

With the benefits being clear for every market segment, it is more than appropriate to begin to thoroughly address operational, training and safe-

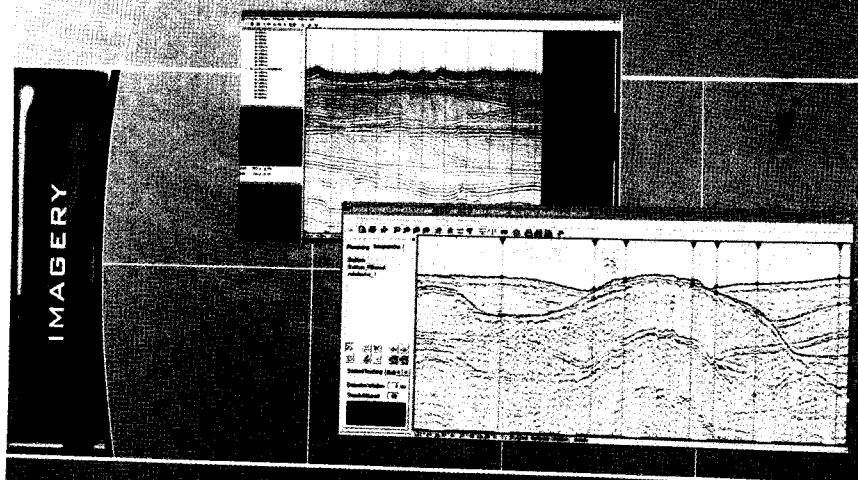
ty guidelines for implementing CCRs into existing operations.

As we move forward in developing these standards, there is an opportunity to raise the bar in training programs, thus laying the foundation for a positive track record of safety. This will, in fact, prove to open industry-wide acceptance for this technology and further establish a platform for program development. /st/

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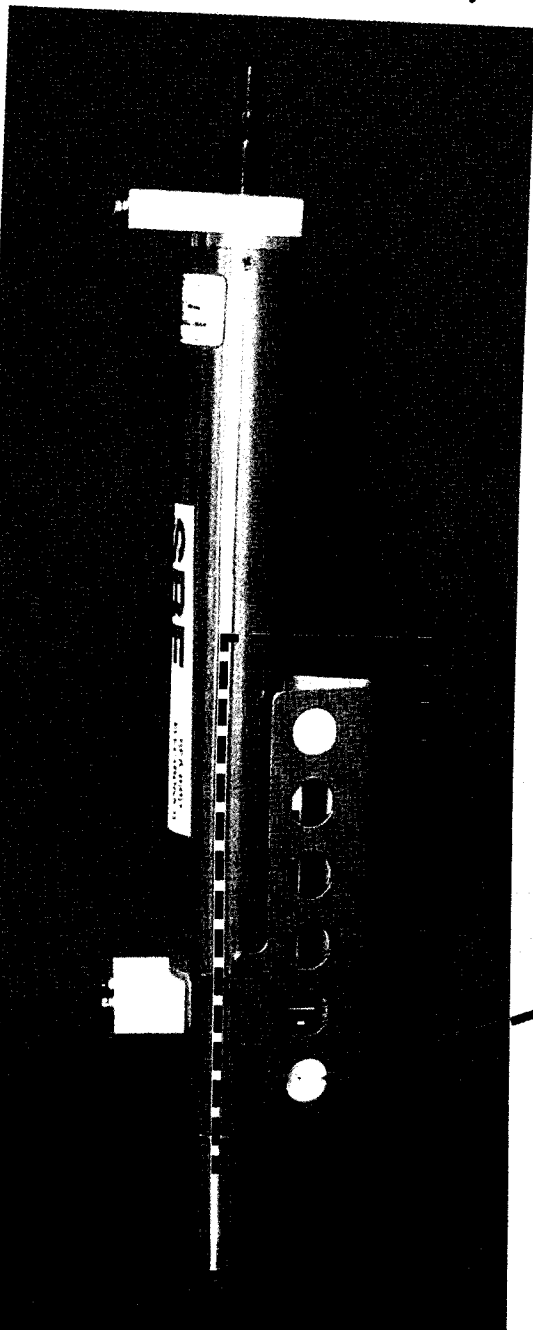
Michael Lombardi is an active independent dive instructor and has held various leadership roles in institutional dive programs, including assistant teaching and working as dive supervisor for the University of New Hampshire, interim diving safety officer for NOAA's Caribbean Marine Research Center and dive supervisor for commercial and scientific projects under the auspices of the U.S. Army Corps of Engineers.

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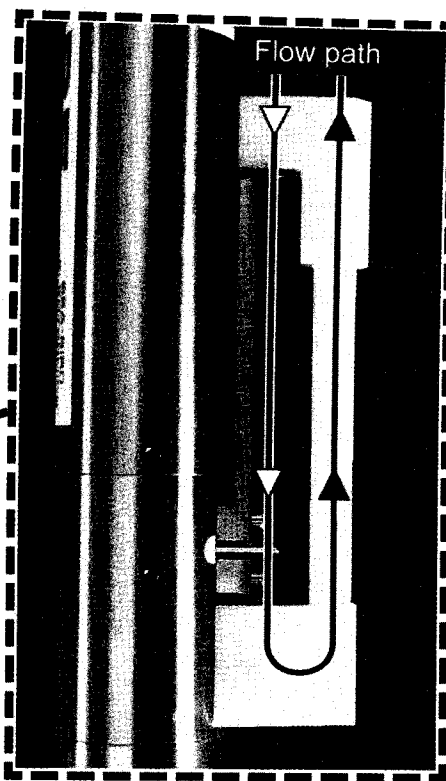
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