Diving Performance – Beyond Drag

Part 1 of 4

By Ron Evan Smith, March 2015

There are several ways to quantify diving performance. Metrics can include an achieved swimming speed at a specific RMV or metabolic rate, or an achieved depth and time interval, or other metric. In this 4 part mini-series, we will be focusing on performance metrics associated with swimming speeds and effort. Although the past decade has seen many improvemants to diver performance at depth through the introduction of rebreathers to the diving market, rebreathers achieve this performance at great cost, both in money and complexity. This means that most recreational divers will never get to exploit the benefits of these performance advantages in diving technology made possible by these rebreathers. Most divers still dive the same open circuit diving technology that we saw being used in Jacque Cousteau's underwater documentary films from the late 1960s and early 1970s.

Indeed, little has changed since then. Some might say that is a sign of a good design, that like the shark, it is so good that it does not need to evolve. However, I see a significant problem that has been patched over with stopgap measures. Furthermore, I think there are some fairly simple things that can be done to better plug the holes in the basic technology format laid out by Mr. Cousteau. My intention is to define the problem and then show that there are effective things that can be done to mitigate the situation.

This article will come in four parts. In this first part, I will define "the problem"; the performance gap that I think exists in the technology. I will show why I think it is important and why nothing has been done to solve it. In part 2, I will take a look at the engineering to get a better look at what will likely be required to solve the problem. Finally, in Parts 3 and 4, I will show some solutions that I have been working on to prime the work queue and, hopefully, get things moving in the right direction, and also cover some things that you can do now to improve your own diving performance.

The Performance Gap

Engineering a system begins with defining system requirements. In this case, we want to engineer a system for placing humans below the surface of the ocean to operate independently of the surface for a specified amount of time. If that specified amount of time is low enough and the depths below the surface are shallow enough, open circuit scuba equipment is a reasonable technology to use on the mission. For this series, I will restrict my discussion to this scope. For most divers, open circuit scuba is the limit of complexity with which they will likely engage.

Given this limited scope of ocean exploration, our first sets of requirements are to put a buddy team of divers underwater at depths not greater than 40 meters and for times not exceeding the no-decompression limits for the gas mixture being breathed (specifically, the common definition of recreational scuba diving).

The second set of requirements has to do with the fact that we are placing humans in the ocean to act independently of surface support for the duration of the dive. The ocean is a dynamic environment that is constantly changing and moving. Ocean currents commonly move at speeds beyond 2 knots. For example, the Gulf Stream has average current speeds of 3.5 knots and resides alongside the most heavily dived locations in the USA. Several popular Florida wreck dives reside at the edge of the Gulf Stream and are periodically enveloped in its currents. The humans that we want to place within this environment must be able to cope with the dynamics of this environment.

As an engineer, I would recommend that any system we design to operate independently in the open ocean needs to be able to cruise at sustained speeds of at least 3 knots and be capable of non-sustained periods of speeds at 5 or more knots. Some people may want argue about these particular values for a diver speed requirement. Some will say this is faster than needed, that they have dived for many years with much lower capability. Others may say this has too little margin and the required swimming speeds need to be higher. According to NOAA, the maximum surface currents in the Gulf Stream are 5 knots. The proposed sprint requirement has no margin to this maximum current of the Gulf Stream. However, 5 knots is a maximum surface current speed and divers typically operate below the surface and typically try to avoid maximum current conditions. For this discussion, let's just assume the requirement as I have defined it, and see what that means to scuba technology and its evolution. If our diving technology fails to meet this requirement, we will need to place increasing restrictions on how, where and when the divers are permitted to operate.

This is where the patchwork of stopgap measures come into the scene, as the system pioneered by Mr. Cousteau falls far short of these requirements. There are many stopgap measures used in the diving industry, including limiting diving activities to small time windows around local slack tides, altogether avoiding many locations with persistent strong currents, using boats to deliver divers to locations such that divers can use the anchor line to traverse the current zone and conduct the dive in the boundary layer of the sea floor (a method that is logistically analogous to overhead diving and considered technical in nature), using boats to follow the divers as they drift helplessly with the currents (requires a float line to the surface) and even in some cases using diver propulsion vehicles (DPVs) to come closer to achieving the speed requirements that I defined above.

It is worth noting that according to the most recent Tahoe Benchmark DPV tests (a large scale independent testing of DPVs from many manufacturers that was last conducted in 2011); the fastest scooters tested produced maximum speeds below 3 knots, with the single tank diver configuration. The long range cruise speed was only 1.5 knots. The fastest DPV tested, the Cuda Fury 1150, produced a maximum speed in testing of 2.9 knots. At over $7k, this DPV is likely about four times more expensive than what most recreational divers are going to spend on all their dive gear combined, let alone what they will be willing to spend on a single item purchase. Furthermore, the Cuda Fury can't easily be used if you need to get on an airliner to get to your dive destination. The large lithium ion batteries are not allowed on the plane and would need to be shipped separately by ground or by boat. For recreational diving, simply throwing more power at the problem is not an economically viable solution.

Normalization of Deviance

Things have not improved much in the past 50 years regarding swimming performance, and performance has arguably gotten worse instead of better with the normalized use of Buoyancy Compensators (BCs) and popularization of the "tech" look for dive gear. The tech look has grought an abundance of 'D' rings to harness systems that allow a diver to clip on an abundance of accessories, many of which may not actually be used on a dive. Today we can expect a strong diver with a typical recreational scuba kit to be able to maintain 1 knot and sprint at about 1.5 knots. This is a long way from my recommended minimum performance requirements of 3 knots sustained and 5 knots sprint.

Why has nothing been done to address this basic performance deficit in the last 50 years? In short, the answer is '*normalization of deviance'*. Normalization of deviance is the gradual process through which unacceptable practices or standards become acceptable. As the deviant behavior (in this case, diving in the ocean with a severe deficit in swimming performance) is repeated without catastrophic results, it becomes the social norm and is simply accepted.

The entire scuba industry has basically evolved to accommodate this large deviance from these basic system requirements. Personally, I feel that this is one of the reasons that the scuba industry is languishing economically while the sport of freediving is growing rapidly. A freediver in streamline form with a monofin can cruise at 3 knots and sprint at 5 knots. Freediving technology does a much better job of meeting the speed requirements imposed by the ocean environment. Therefore, it is a more appropriate technology to use in the ocean than is the 70's era scuba equipment. Can the technology of scuba catch up?

Freediver in streamline form with monofin, capable of efficient cruising at 3 knots.

Conclusion of Part 1

Ocean conditions are driving swimming speed requirements for divers that are well beyond the speeds that current scuba gear and diving techniques can deliver. Whereas most divers can achieve sustained speeds of about 1 knot and sprint at about 1.5 knots, the ocean conditions require speeds more along the lines of 3 knots sustained and 5 knots in a sprint. While the deviance is very large, it has become normalized within the diving culture, and as a result, little has been done to rectify the situation.

In the next installment, we will take a look at closing this performance gap. We will look at the physics of power, thrust and drag, and see if it is even possible to meet the requirements imposed by the ocean, or if there is no choice other than to continue trying to plan our dives around good ocean currents and conditions and then trying it to see of our planning was 'good enough'.

About The Author: Ron Evan Smith

Ron is the CEO and Chief Engineer at Smith Aerospace Corp. where he designs, developes and markets hydrofoil based monofins for freediving and scuba diving applications. He holds an Aeronautical & Astronautical Engineering degree from the University of Washington (B.S. 1995).

Ron is an award winning aerospace engineer and inventor with more than a decade of professional experience, specializing in fluid dynamics, control systems design, simulation development and system performance prediction.

Ron forged a passion for freediving at a young age that has only intensified over the years. He has been a certified scuba diver for over 20 years and holds several advanced diving certificates through IANTD.