

Marketing vs Engineering: what happens when the engineering budgets of safety critical products are diverted to marketing.

Introduction

Rebreathers are life support systems, sold in their thousands to members of the public.

Some companies have approached the market by producing the best engineered product that they can, others have diverted the budget needed to do that into marketing. This paper reveals some of the things that have occurred behind the scenes and why sound engineering is the only good business option, as well as the only option for ethical companies.

Objectives

Deep Life created this document to encourage good practice in safety critical products and to help parties carrying out due diligence to recognise the warning signs. It uses “how **not** to do it” examples from the sports rebreather industry as source material.

Unfortunately in the Sports Rebreather segment of the dive industry, some companies take an opposite approach to that one would expect. Their practices are identified so all stakeholders can recognise them for what they are and make further enquiry about the functional safety status of their equipment. The short-cut signs have much wider implication than the examples from this specific industry sector: they can be identified in other sectors where malpractice occurs.

The companies in these examples design and manufacture rebreathers. These are safety-critical life-support systems used by divers: the rebreather removes the carbon dioxide exhaled by a person and replenishes the oxygen. Failure to perform either of those functions will generally result in a mortality. In particular, a lack of oxygen is not detectable by human physiology: hypoxia loss of consciousness suddenly and without warning. Beside the carbon dioxide and oxygen hazards, many other hazards exist within rebreathers which require mitigation in their design, including avoiding floods, caustic solutions from the scrubber, pressurised gas hazards, faulty decompression calculations etc.

Consequently, professional rebreather design is an expensive business. It ranks alongside other safety-critical electronics that manage systems that are inherently dangerous and unstable, from avionics down. Professional design is methodical, painstaking and SLOWER than for a non-safety application. This gives rise to the alternative, and much more lucrative option: just cut out the “professional” bit of this picture, and just let anyone design a rebreather, without any training, engineering knowledge or QA at all.

What follows may seem tongue in cheek, and is written in that style, but in fact is a compilation of true life stories of what happened when some companies used amateurs and salesmen as an alternative to competent engineers. It is written in the second person addressing a CEO of a business that did just that. The light narrative presents very weighty and serious issues in a readable manner.

Deep Life is totally opposed to the views or practices behind these examples: it does not condone them in any way. Other professional companies involved in military and commercial rebreathers share in condemnation of the bad practices listed here. However all the practices here occur, products are sold incorporating those practices and thousands of members of the public use those products.

Basic questions

Why did a dive equipment company allow one of their salesmen, we shall call him "Nick", to design their rebreather electronics and software, when they knew Nick had never been to any engineering college or university, never trained as an engineer or programmer, never worked as an engineer before, had never been trained in any aspect of Functional Safety, and was in fact thoroughly

incompetent¹? Nick never knew how much he did not know. He did not know about brownout circuits, watchdog timers, or even battery contact designs: elementary things for a trained engineer. As a result, his rebreather controllers would hang, or reset, or power off. Underwater.

A thousand rebreathers designed by Nick were sold. When the company that sold them discovered that the rebreather displays could just hang (showing perfectly normal oxygen levels, while the oxygen is in fact falling to lethal levels), what did they do? That when the temperature changes, the oxygen levels would be completely wrong? That the oxygen injector and exhaust valve would be so badly positioned in the breathing loop that the oxygen injected did not actually get to the diver in the event the diver ascends quickly? In fact, the product is a serial killer, whether by intent, incompetence or mismanagement, the result is the same: Nick's slaughter² is comparable to that of Harold Shipman³. The CEO of the dive company was the Project Manager for that rebreather, which means the trail leads right to his desk. There are a lot of dead people, cut down in their prime, families left behind, lives ruined. What are the reactions and responses when these facts are discovered?

Answers in the Marketing Budget world

We will now take a narrative, from the position of a CEO of a company in just the position above. This is easier to read than a dull list of dates, actions, responses. It conveys the ego-driven, profit driven, environment that sustains this situation even today.

CEOs are leaders, and a leader must keep his cool in a crisis. The CEO is told, "Real leaders get better in a crisis!" If rebreather manufacturers have to pay out for mistakes in design then there would be no money to be made, so no employment, and no feeding chain of instructors and industry⁴. That feeding chain is going to help you in your hour of need.

You are not the first to be in this predicament of using amateurs, so we have managed to compile some well tried and tested advice based on the historic actions of several sport rebreather manufacturers when the fatal accidents start to mount. This is a step-by-step approach that has enabled those manufacturers to avoid the need to compensate victims, and protect their businesses. Any deaths on your products can even be good for trade by making others appear the bad guys⁵.

When times are tough, remember most divers who are still alive have never had a rebreather controller hang on them underwater, and cannot believe such a thing can happen. They especially can't believe it could happen when they look at the invoiced cost of their rebreather, almost ten thousand pounds once training and supplies are included. If even divers don't expect it, then coroners and judges more easily fooled: they use Apple gadgets or the like designed by professional engineers; these gadgets have trained people to think that even a phone or tablet always works, so surely a rebreather for underwater life support use MUST be okay. Now it turns out that an astonishing proportion of your rebreathers are involved in fatal accidents. What do you do?

We divide up the advice into three sections: Preparation, Defending your business from claims following the accidents, and Dealing with the experts.

¹ This is not an exaggeration, unfortunately. None of the examples here are. Every example given here are events that happened between 1995 and 2012, more than once.

² See the accident list published on www.deeplife.co.uk/accident.php

³ Harold Shipman is one of the most prolific serial killers in recent history. This study shows that iCrimes though can easily surpass him, with a trail much harder to follow.

⁴ This is false of course: the most widely-used products today are a lot safer and in general use because manufacturers were obliged to make them safer as a result of product liability cases, leading to more instructors and a bigger industry. Cars, planes, trains, toys, children's equipment, processed food, kitchen equipment, sanitary fittings ... many examples can be given.

⁵ Corporate use of "The Dictator's Handbook: Why Bad Behaviour is Almost Always Good Politics", Bruce Bueno de Mesquita, Alastair Smith, Jul 2012, ISBN 978-1610391849

Preparation

1. Keep an open mind on ethics⁶. The divers are dead and you can't bring them back. If you asked a guy with the technical qualifications of a Fish Packer do heart surgery on members of the public, yes that is murder: but if all you did was let someone with the same qualifications of that Packer be a project leader, or develop circuits, write some programs for oxygen control and sell it then there is no specific law against that, so it must be all right. Manufacturers don't need to worry, as they acted within the law.
2. Consumer protection Jobsworths are so apathetic there is no need not to worry about anyone forcing you as a manufacturer to ever do a recall even after you found out about those "interesting features" in Nick's or Packer's design: they will defend jobs and that defends you. If they ever have the audacity to want to test your product following a fatality or near miss, supply them with a new unit with the faults rectified and don't mention the improvement – it is internal so they won't notice. In fact, if anyone notices the improvement, charge them for the upgrade!
3. There is dirt in your cupboards so you need to engage the grubbiest lawyer you can find: the guys who defend the tobacco industry are the best! Engage a dirty player and train him up. Be careful though, incidents when you give him a free loan rebreather and free dive training do not improve the situation so use the fixed versions of the rebreather – don't reissue those early models.
4. Honest to truth, lawyers define "truth" totally differently to scientists and engineers: in law "truth" is what your lawyer proves it to be, and evidence that can be set aside becomes like evidence that does not exist, i.e. the true facts become legally "false", replaced with what evidence you get accepted. In the legal world opposites work – use the methods that follow often enough to refute the information, then your defence will become the legally adopted "true fact" no matter how absurd that may be.
5. Destroy the "bad" evidence! This is much easier than you may think. First, make sure your electronic controllers do not log anything that might be used against you like oxygen levels and if you can, use controllers that erase the logs after a while. We assume you used proprietary software so the complete contents of logs can't be downloaded by independent investigators. Second, get the equipment examined by one of your men: they can ring the local police after an accident and offer their services. It is easy for them to then break the rebreather down so a professional analysis is later pointless; throw out the carbon dioxide absorbent and oxygen cells. Don't use a video while this is being done, or put the video where the view is poor. Remember, no evidence = no facts = no case in law!
6. Experts have tools to simulate the dive profile and plot out awkward things like the oxygen levels that could be incriminating. To counter this, you need some contradictory evidence to introduce doubt. For example, a simulation from half experts that have bugs in them or make absurd assumptions. You have to work on this early. Give out some freebies to people in government labs or medics and they may write it up as a paper: just fix the known design bugs on any rebreathers that are sent to them first. Issue steady contracts to those labs, - look for the Jobsworths: once a H&S, medic, consumer standards or QA Jobsworth gives you a report saying something is OK, they will just blindside anybody that says anything else, and you can quote them!

⁶ **The examples catalogue malpractices to encourage the opposite, to enable better decisions and effective due diligence, to avoid investment risks in mergers and acquisitions. Deep Life totally oppose the practices listed, as do its clients, and rejects the views and attitudes of companies operating these malpractices. However ALL the examples given here occur in parts of the sports rebreather industry.**

7. When you spot a medic that posts onto forum or presents only to recreational diving conferences, sponsor them! A free rebreather or some parts. It is astonishing how little you need to win some people over, how cheaply they sell their souls, and how hard they will then work to undermine anyone who stands up against you. Any with fragile egos will warm to you, and use their position (even though it is irrelevant to rebreathers or diving), to troll competitors and those who asks questions.
8. Get rumours going on your sales, that your sales numbers are five, ten or twenty times more than they are. This makes your statistics look better, and make you look stronger than you really are. Instead of one in 17 of your rebreathers being involved in a fatal accident, it can be one in 300 or even more. The key to succeed in this is do not use simple serial numbering, then it is very hard to verify what the real numbers are. It helps especially that for every rebreather you sell, ten wishful divers do the training course for at least one of the many training stages you offer – it makes the number of users you have look huge if you quote the total number of courses attended. We will come back to the importance of this later.

Defending your business from claims following fatal accidents

1. Your lawyer in his opening comments needs to explain to the court that the wife left behind “cannot quite reconcile events with the person they knew”. Use precisely those words. This stains the people who are emotionally connected, as being not able to handle “the truth” as you define it and if you are fortunate, it may remove them from the picture – remember they are women⁷, who judges know are emotional types anyway.
2. Emphasise the rebreather was modified: almost every rebreather has some modification, even if it is adding a line cutter to the harness or a different harness or cylinders, whatever. It does not matter what the modification is, it can be linked in someway, and that will start the judge thinking the diver is to blame. The judge does not know a line cutter from a scrubber cartridge, or cartridge from a cylinder. If there is a second dive computer, even better, as the profiles and plots are going to be different, so you can cast doubt on any logs that are produced: if the plots point the finger, get an “Expert” to wipe the “wrong” log early on – see “Preparation”.
3. For the court cases, find out if the diver’s family are going to be supported by any Expert Witnesses, and if so make sure you use the section on “Experts” before the case begins. Ensure enough of your contractors examine the equipment so you have statistical ammunition when that battle begins.
4. Create noise. If there is enough noise, the judge or coroner will not be able to distinguish relevant facts from “facts” that you just made up. This is a really good tactic: innocents who believe anything are much more common than you would think! Good examples of noise are:
 - a. Point out how badly the diver looks after his unit (of course, the diver did look after the rebreather, but after it has been left flooded with salt water in the police station and government labs for a few weeks, there will be lots of photos of corrosion to prove the point). There may even be some wires corroded right through! Get an expert to say that happened prior to the dive!
 - b. If the diver used a better absorbent, blame the absorbent. Even if the diver has used DiveSorb when you as a manufacturer make a margin on selling 797, then that must be to blame even if the sorb was fresh and the fatal dive lasted only a few minutes. You know, Divesorb lasts longer when you test it – Divesorb is a good product, better than the

⁷ The overwhelming majority of rebreather divers are men, so when they die, the person persuing any legal case is their wife. The sexist bias to legal defence described does occur.

scrubber granules you sell, but there is just not enough reseller's margin on it to recommend it; this is too technical for judges to understand so you are fine. The fact the diver used Divesorb, means he did not use your recommended product, so blame the accident on the diver's "error". Obviously to do this you can't have published comparison data of the same absorbent tested in your rebreather, so its better if you don't publish any test data in any detail. Don't worry, other than the professional rebreather companies, that's pretty much the norm so the users will expect no data in the user manuals and not go looking for detailed scrubber duration test data and plots.

- c. Was the diver seen to do his pre-dive checks? If not, then he must not have switched the rebreather on so the diver clearly is to blame for the accident. If he was seen to do it, was there a signed and verified dated checklist? If there was, then was it the list you published in an obscure corner of your forum – no, so the diver must have used the “wrong” procedure!
- d. Heart attack: very hard to prove, or disprove. Most dead rebreather divers are 40yrs+ so will have some arterial blockage. Get the guy dug up and autopsied again: the more he has decomposed, the more the options in conclusion. In most developing countries, morgues are not refrigerated, and a lot of diving is in warm waters overseas. This is business; don't let a few maggots get in the way, especially if his loved ones gets the photos of their hero being mutilated in an autopsy it will put them off suing you. As a manufacturer, you have a legal right to get an autopsy, or a second autopsy, on divers who die on your equipment.
- e. If the heart attack does not stack up the coroner will probably just rule it a drowning as long as you didn't sell your rebreather with a gag strap fitted to keep the airway dry. The authorities are only after the cause of death, not the root cause (the cause of the cause of death). They have a lot of cases to handle, and don't want complicated accidents on their desk.
- f. Focus on poor dive practice. Hardly any dives are done to the letter of the book, and even if the diver did that, there are enough different dive training agencies all with different procedures you can just choose another book. Anything the diver has done that differs from what a training agency would advise a beginner can be cited as a diver mistake. Enough diver mistakes, and the case is won. It does not matter that none have any bearing on the accident – judges and juries won't work that out. Start with, how close was the buddy?
- g. What training did he have on your specific unit? Require lots of specialised training, expensive training. Most divers won't do those courses, especially if they have been diving for years and have done near identical courses on other rebreathers. This means that in court, when the diver has not done all of the courses in a certified manner, then he must be to blame for any accidents. Courts can take more notice of that, than the fact Nick's rebreather controllers hang or reset from time to time, with one less user each time it occurs. Seeing two tiny black dots on a battery means nothing to the public, but the idea of someone using complex equipment without training is just unthinkable, unless the person is a diver of course.
- h. Research the history of the diver. There must be something he did wrong in the past or posted about, that explains his 'bizarre' behaviour on the day. If he has not done anything wrong, make something he has done that is unusual, appear wrong!
- i. Suggest subtly to the claimant that they need to include XYZ component manufacturer in their claim. Oxygen sensor manufacturers are a great target as many evils can be blamed on these innocents. Of course all sensors fail at some point, juries won't know that you as the manufacturer should have taken this into account when designing your rebreather and

its software should test the sensor and to do something safe if the sensor is faulty – they don't know that - they just see the failure and that is it – the sensor manufacturer gets the blame. If XYZ is big, they will have in-house lawyers who can run the defence for you, saving you a packet of money. XYZ may even be dumb enough to pay off the claimant (sorry, the term is "make a settlement out of court without accepting liability"). Life gets better every day, for those that still have life that is.

- j. If you can make your own oxygen sensors so low quality that users opt to use premium high quality sensors from another supplier, you have a get out-of-jail-free card as this instantly cause for suspicion and the obvious reason for the fatality that's not your fault. Your cheap sensors also make you more money, because they are a consumable! Quality companies like Aii offer ruggedised sensors for rebreathers, but don't use those rugged sensors for your own products: rebrand the cheap sensors meant for land use, so you can claim they are not fit for purpose and therefore again, any accident is not your fault.
5. Sue the victim's family and take everything you can. This might seem a bit harsh, taking the widow's house, wages and bank account, child allowance and all that, but there is precedent of it having been done successfully by a rebreather company even though it was definitely a rebreather design fault that killed her hubby. This frightens off other possible claimants really well, so when the rebreather design was to blame for their husband's or father's demise this tactic will just stop others dead, if you excuse the irony.
6. Dive forums and social media are also really good at persuading others not to sue, as it is a horrible thing that the victims' family wants to investigate what went wrong. There are lots of trolls out there just aching for an excuse and a widow is a prime target: what these trolls say can be so shocking that it takes a strong lady to persist. If you don't believe people would be this low just Google some of the rebreather accidents on the diving forums.
7. Sue the claimant's lawyers: this has been done, and again it frightens off claimants from the other cases that come up. At least, it makes decent lawyers harder to find.
8. Cite your CE approval, even if it is a dodgy one. Even if it is from the Italian agency RINA, nobody will know just what that means. If it's a valid certificate but not worth the paper its written on, don't worry, no court will ask an auditor if they have any Functional Safety qualifications, or even if they verified anything that you as manufacturer submitted to them – this sort of stuff is far too technical for a judge to know or understand. If it is CE marked, it must be safe, even if the standard used is one you wrote yourself. This is a really good defence in Europe as you only need to meet the letter of the law and not the intent - that greatly cuts down the risk of any legal retribution for your actions.
9. Do not offer any information on almost identical accidents that have occurred, idiot! If anyone publishes a list of the accidents, attack them until it is withdrawn or use misinformation to discredit it. Claim it has errors: you never need to say what the errors are - just "errors". Even if there is less than 1% of error, even if whether it is an error or not is disputed, an error is an error, and on that basis the whole database of accident data can be binned in the minds of your users and you can prevent the jury seeing any of it.
10. Make sure you have medics and/or some popular recreational dive industry 'experts' in your pocket (loaning free rebreathers works well here, or just give them a contract), to proclaim that this is a unique fatality or better that not enough evidence exists to come to any conclusion for the reason behind the cause of the cause of the fatality.
11. Do not tell the coroner how many rebreathers you have sold: that is commercial information and some smart-alec will work out at least one in 20 is involved in a fatal accident – that does not sound good. Definitely does not sound good to anyone, so do not let it be known. Attack anyone who lets that slip.

12. If interviewed in the USA in a process called “Discovery”, get training on how to answer questions without incriminating yourself.

Experts, what experts?

The fly in the ointment is if an expert is called in that knows his stuff, but there are ways to deal with that, which work:

1. Most experts on rebreathers are connected with a manufacturer in some way, after all, it is a specialised field. Perhaps the widow’s lawyer has traced the money flow, and worked out the bias being in your favour with the dealers you arranged to examine the rebreather involved in the accident. But that works both ways: if money is not involved, then either the widow’s expert is an amateur (and amateur experts don’t count), or he is involved with a competitor so has a conflict of interest so your lawyer can discount him for that. If the widow’s expert got his expertise on your rebreather, then lean on him. He must have got his expertise from somewhere. If he was used to support you in the past, then he is to blame if the rebreather is not right, so press that man harder! It is surprising how otherwise decent people will change their point of view if it implicates them.
2. Have your lawyer write to the coroner or judge, explaining the witness you can’t lean on is “on a crusade” – use those exact words. He must be “on a crusade” if you can’t lean on him. Claim he has some other dubious interest – if he has not, then set him up with one! Try to get him excluded before he gets onto the witness stand. Once again social media and diving forums are great for this, you can have your supporters write all sorts of myths and as they are in print, they must be true. Especially if there are enough of them.
3. If you managed to write to a previous coroner claiming the expert was on a crusade, and the coroner commented on that, then quote the coroner’s comment as proof! Legal quotes don’t have to be in context: lawyers will demand Yes or No answers, and if the expert tries to put anything in context, that will go against him as a witness because he won’t be answering questions directly – he will be deemed an unreliable witness. Push the context to the limit to make the expert look unreliable!
4. If the expert witness causing you trouble is too clean so there is nothing juicy you can dig up, then get your lawyer to create a web site in a territory where slander laws don’t exist to cite whatever “information” you decide to put on there as proof. Remember in law, repeat it enough and it can become “true”. Magazines you advertise in can do the same. Dive forums need advertising and hate legal letters, so get the expert banned if he objects: you can still post about him, but he can’t reply – good heh? Judges use Google, and you know how to get hits on Google, right?
5. Call in those rain-checks. Invite your friends to be witnesses, to get the problem expert’s independent view reduced to a small minority. Once he is below 10% in number of experts, then he is out!
6. If an expert witness knows too much, pay your lawyer to form an industry association to fight him. That organisation can also set you up to ignore that pesky CE standard: remember consensus is fact in law and you can then cover your actions by calling them ‘improvements’ in rebreather safety. Less spent on testing is more in your pocket and punters don’t need to know about testing of your product.
7. Threaten to sue the widow’s expert witness. It puts off 99%: less than 1% of people will put their ethics and principles ahead of their reputation and money. That 1% though can a right pain, and suing those guys can be a really bad move as it doubles their chance of winning, so don’t actually sue witnesses, just threaten to. Let the weak succumb! By the way, don’t sue the rich ones: that can get quite expensive, and if you can’t afford the final tab, then you lose.

8. He must be in the industry to be an expert, so get the industry to attack him. The dive industry is small enough, that if he is a business, that is going to hurt his pocket. There are so many egos out there, who have spent thousands on your rebreather, they just love it. Send a few emails out to the big names, put them into conference presentations and you are away. Be careful though because the wiser punters know this is an interesting one to watch for as it can quietly reveal who they might want to buy from next or who has an agenda that may not be in the diver's interest.
9. Again, expect the widow's expert to look at accident stats, so you must multiply your sales figures by at least 5 or 10 when speaking about them, and refuse to issue them to courts unless ordered to, as they are commercially sensitive (if people know how few were sold, and how many accidents there are, or how they are clustered around specific revisions of the product, that would not be good for business, so definitely, commercially sensitive). Nobody will notice a factor of 5 to 10 increase in sales, but it makes things look so much safer.
10. If the expert has a strong Functional Safety background, you are in for trouble, but all is not lost. Just give the other lawyers enough doubt, that they stop him demonstrating the problem in the court. Whatever you do, you do not want a real expert to demonstrate the faults in court! Without a demo it is just words against words, and you can afford to pay to have more words.
11. Seriously, have you tried to kill the expert? Remember, you have the perfect alibi. Your actions killed the diver so why not kill the expert? Get him to dive one of the units with that special code or scrubber and get him underwater. This sounds crazy, but it has been done.
12. If (11) failed, get a supporter to put invites out onto web forum to shoot him at a show! Death threats definitely puts the weaker experts off. Only do this in the Good Old US of A, the Land of the Free – it will get you arrested in the UK. This has been done quite a few times (the threats, no actual shootings yet – but there is still time), and there were no repercussions so long as the poster abandoned his plans to visit Europe or the UK afterwards.

Insure against the Downside

You may hear of an element of lawyers who work on the basis that the more trouble you are in, the more money you have to pay them, the more money you pay them, then amazingly, the more trouble you are in. Don't let this get you down because they will save you at the end of the day: they can recognise a business that is going to be a long-term repeat customer. Lawyers are very commercial people: you can learn something from them – remember, keeping customers coming back means keeping them alive, and that means they won't suck the lifeblood from you on the first case.

This concept of repeat customers is not really true in your business: you may not need to invest in a functionally safe product as that's not commercially viable with your sports business model, because after all, the average rebreather diver only dives your product for 2.6 years before moving on. For some it can make no commercial sense to look at divers as repeat customers: just keep the costs down, price up and make the product look good. But remember, lawyers like repeat business.

When the Investors Came

When the investors arrived to buy the company, the accounts stood up, and some well known names acted as references. The deal almost went through, then the meaning of skeletons was explained by engineers hired by the investors.

The deal was off. The investors were not comfortable with buying a company where one in 17 products had been involved in a fatal accident, where the ethics were those described above, where technical incompetence protected by good marketing was the order of the day.

If only, professional safety engineers had been used from the outset. If only, the management had even one person with a moral compass. If only, so many of those users had not died on the company's rebreathers. If only, ... Note, even in this "if only" list, the consequences of the company's failings on others has not been considered.

This bottom line means that diverting funds from engineering to marketing and legal costs, can sustain your business at a subsistence level - where you earn money to eat, to pay the rent and your car, but the investment you make with the time in your business is wasted, because at the end of the day, you cannot sell it for what it would be worth.

Engineering focused rebreather companies have none of the problems listed above. They may take much longer to grow sales, but eventually they will overtake, and their business will worth enough to retire on.

The bottom line that hiring an amateur hobbist to design the electronics, software and mechanics of a life support system is a grave mistake. All the grief, the lies, the slander, it brings may be reflected on as you move towards the end of your own life on your earthly course, while watching the engineering group expand with their better products, far safer record that their endeavours create. There is no short cut to a well engineered product, and by attempting to use marketing to virtualise that product, is a rough road with a dead end.

Back to the Ethical Side of the Fence

We live in a world where there has been enormous social improvement over the past 150 years. Good housing, safe working conditions, access to education, health, freedom from communicable disease, the abolition of slavery, and freedoms, even the freedom to travel and enjoy life, all are part of the transformation – at least in the Western World. These huge social improvements were not free; they took time, effort and their advocates were opposed vigorously. The champions of these advances endured ridicule, shame and trials before their victories were won.

Safety of the products we buy is one of those transformations. It is not complete, as evidenced by the hundreds of divers who have died in the past two decades from hypoxia, hyperoxia, hypocapnia, caustic floods and "heart attacks" on rebreathers, divers who probably would not have died had Functional Safety standards such as IEC 61508 been applied.

This may seem a satirical piece, and is written in that style to make its points. Unfortunately all of the tactics listed here have been used by companies that have chosen to take the amateur design route in life support systems. There is even a lawyer who works for the sports companies with the worst record who runs a web site slandering expert witnesses to try and prevent others standing forward, and to damage them generally. Some events were too shocking for us to relate. In the sports rebreather sector amateur designers are a majority – very different from military rebreathers which are generally designed by large professional teams. This contract gave us a lot of material to choose from in developing this paper.

The Deep Life Group companies producing rebreathers, including Open Safety Equipment Ltd, does not use any of the above tactics and pays the price: derision by those opposed to Functional Safety, or those who make just lip service to safety. Deep Life live very differently to those amateur companies. We embrace ISO 26000 – Social Responsibility, as well as being certified to ISO 9001 - QA, ISO 14001 Health, Safety and Environment, and IEC 61508 – Functional Safety. We maintain this level of compliance as part of our overheads. We published detailed engineering reports of wide value to the industry: these are downloaded hundreds of times a month, and in some cases, thousands of times a month.

Deep Life Group employs only fully qualified engineers, and has done since day one. Moving to the ethics, we ensure all monitors and dive computers produced by our customers log everything, never

self-erase logs, all meet IEC 61508 and all are serial numbered sequentially. We use professional factories to build our products, not a garden shed or garage. CNC machined Delrin parts might look really good but ever asked yourself why they are not used underwater by any military or commercial diving company?

Our customers have proven they can sell recreational rebreathers for a reasonable profit and still be competitive: these meet fully the CE EN 14143:2003 standard for rebreathers and IEC EN 61508 - the “Gold standard” in Functional Safety – something no other piece of dive equipment does nor ever has. What this means is that the honest route must have been viable all along and there is no excuse for taking shortcuts in Functional Safety design.

As a manufacturer, when making the decisions relating to a new product, you need to decide whether you want to lead the life traced out here? As a user, do you really want to pay for those short-cuts? The price of a small short-cut in safety-critical systems can be the ultimate price anyone can pay. No amount of black campaigning by the sports rebreather industry can cover up these basic facts: if rebreathers are not designed and built to comply with all relevant safety standards, then they pose a serious and avoidable risk to their users, with all the consequences that entails. Following a certified Functional Safety route, is the only route to minimise those risks. It also adds value to your company in an exit, and in many cases is a prerequisite for a successful investment. The more common the unethical route, then the higher the premium is for high quality companies.

Declaration of Conflicts of Interest

1. Deep Life designs rebreathers, dive computers and other products for companies that require fully certified products, to IEC EN 61508, designed with ISO 9001 and 14001 processes.
2. Our primary business is commercial diving, emergency and military rebreathers and breathing gas monitoring, but we also produce sports rebreathers.
3. We have a commercial interest in finding customers that place a value on safe products, and therefore an interest in promoting best practice.
4. We have declined contracts with companies that advocate the bad practices described in this paper, and shall continue to do so.
5. We enjoy working with ethical partners, clients and suppliers, and hope that they become the majority as the social transform from dangerous goods on general sale, to safe products, continues.
6. We work from the outset to maximize the value of our client’s companies when it comes the time for their trade sale, IPO or exit, identifying and protecting intellectual property, and ensuring a detailed documented path is in place at every stage.

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From a background in safety engineering, the author is a serial entrepreneur and technologist who has founded and developed 11 company groups (over 50 individual companies), of which 9 groups been taken through to successful exits (one good IPO, six trade sales, and two MBOs), with a further MBO that was initially unsuccessful but was turned around by Deep Life to form the basis of a profitable trade sale of a public company in 2007. Deep Life is the 11th Group in this series, working with clients to build value in their companies and achieve the maximum investor value, with innovative products, fully certified, embodying well protected intellectual property. The UK trading company in the Group is Open Safety Equipment Ltd.

The process adopted in the trade sales involves sale of the business to a trade partner growing a strong brand, transferring the technology and intellectual property to the buyer, then voluntarily

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liquidating the technology companies within the business group: this approach minimises the due diligence costs associated with bounding all legal risks.