the human diver

'counter-errorism in diving'

A Field Guide to 'If Only...'

Written for divers, instructors, dive safety officers and supervisors to maximise learning from the documentary

So that others may learn

Made possible with the support of Ashley Bugge, the dive team,

Paradigm
Human Performance Ltd

and many others. Thank you.

Contents

Overview

The documentary around Brian Bugge's death focuses on a number of aspects concerning human factors, human error, non-technical skills, psychological safety and creating a Just Culture. These are themes and concepts which have been developed over many years in aviation because of the severe consequences of things going wrong - concepts which have not been formally accepted in diver training programmes or operations.

A key point to be made is the aviation community recognised just focusing on the negative outcomes i.e. pilot/operator error, without understanding how it made sense for those involved in the task to do what they did e.g. pilots, cabin crew, air traffic control operators or mechanics, made little difference to safety. What needed to happen was to look further back and deeper into the events surrounding the 'error' or adverse event. Areas they started to look at included ineffective non-technical skills (decision-making, situation awareness, leadership and teamwork) or error-producing conditions e.g. time pressures, peer pressure, poorly thought out instructions/manuals or financial pressures and how they came about. The documentary and this workbook expose a number of these issues around Brian's death and highlights what can be done to prevent such an event from occurring again.

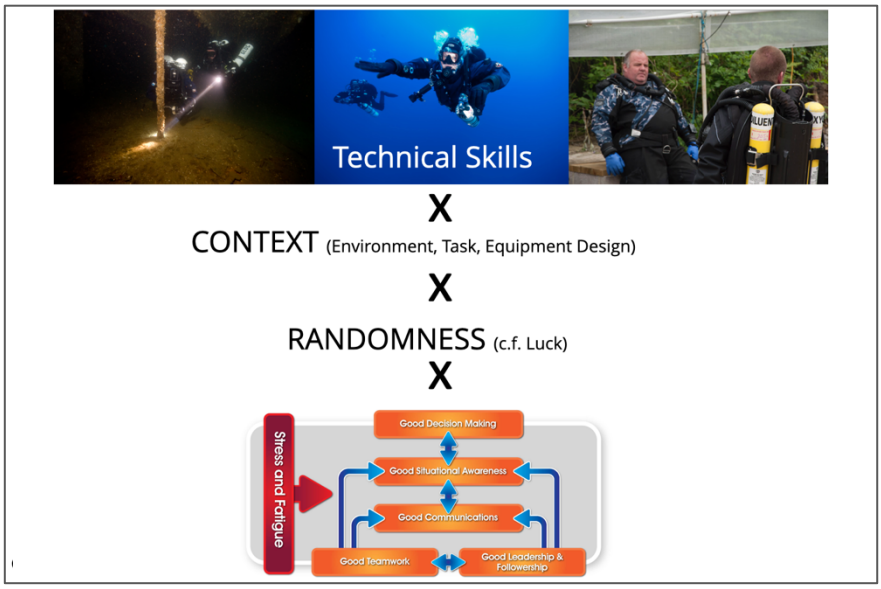
Many of the actions, errors, failures and violations demonstrated during the film will happen prior to or during many dives around the world, but they do not end in a tragedy. The difference in this case is these multiple factors came together at just the wrong time in the right place. As observers, we are also informed by hindsight bias, we know the outcome, so we know how relevant certain factors were and we look out for them. In real-time, we are not afforded this luxury. We cannot predict the future with 100% accuracy and so the need to reflect on activities is crucial if we are to improve future learning.

Human error is normal, our mental capacity is limited, we don't register everything we sense, and miscommunication is common, and yet we manage to get through life, without injury or death. We achieve this because we adapt and change. The difficulty is when we don't necessarily reflect on those deviations or adaptations, we set new internal standards, and this can lead to problems in the future when the deviations and risks we are holding in our head are overridden by the immediate task at hand and we forget the critical factors.

By examining and addressing failures across the whole system covering culture, equipment design, training, and individual performance limitations, rather than the silos created because of a focus on blame, we can make greater improvements to diving safety. But that starts from the position that we are all fallible, irrespective of experience.

Outcomes

Outcomes in diving are often thought of being primarily linked to technical skills e.g. buoyancy control, trim, propulsion, line-laying, launching a dSMB or the adherence to a training slate, but in a research paper I co-authored for surgeons, we explored a number of other different factors which are shown in the model below. Critically, these elements are not just additive in nature, but are multiplied. Therefore, if you have great technical skills, the learning culture is good, the equipment is designed well, luck is on your side, but you miss a critical piece of information (coming under non-technical skills), you can end up with a zero 'score' which leads to an accident.



Outcomes are a function of... (Casali, Lock & Cullen. 2019)

Workshop Options

Two options are available for running workshops using this guide; a simple 90-minute session which focuses on the key elements in the film, or a longer 3-4-hour workshop.

Each section of the workbook has an outline, instructions and key questions to ask the participants about their thoughts on how the section topic relates to the events of the film but also to their own diving activities. For the additional topics there is learning material for the facilitator and questions for the participants. The goal is to highlight the interdependence of these factors along with the complexity of accidents. If accidents were simple, they likely wouldn't have happened!

The problem with ‘human error’

Human error is said to be at the root cause of anywhere between 70% and 90% of accidents. The difficulty is that attributing human error to a cause is the same as saying gravity causes things to fall! It doesn’t help learning so to prevent future events because the detail is not there to understand how the event really happened. We are seduced by the power of simplicity – blame it on the last person to touch it!

Human error can be classified as *‘an unintended outcome from a planned or expected activity’*. There are different ways of viewing error.

- Error as the cause of failure: ‘This event was due to human error.’ The assumption is error is some basic category or type of human behaviour that precedes and generates a failure. It leads to variations on the myth that safety is protecting the system and stakeholders from erratic, unreliable people. “*You can’t fix stupid*”.
- Error as the failure itself, i.e. the consequences flow from an event: ‘The choice of dive location was an error.’ In this sense the term "error" simply asserts the outcome was bad producing negative consequences (e.g. caused injuries to the diver).
- Error as a process, or more precisely, departure from the "good" process. Here, the sense of error is of deviation from a standard as a model of what is good practice. The difficulty here is that there are different models of the process which should be followed: e.g., e.g. which standard is applicable, or how accurately is the standard described?

This view toward error will determine whether learning occurs. Consider how the following examples appear with each view from above. Consider the following as an example of this.

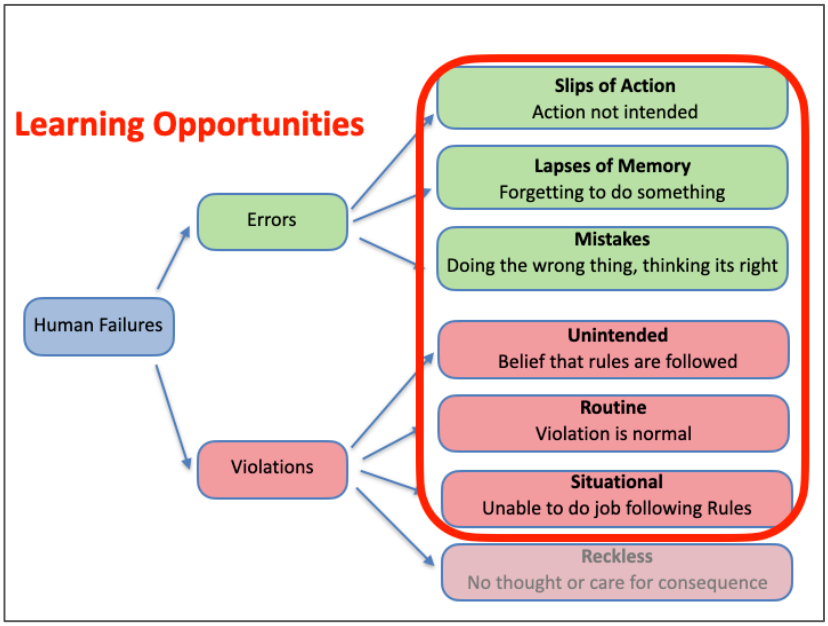
- We could have a good overall outcome (arriving back on the boat without injury), but we have made errors during the dive. This could be not monitoring gas effectively and surfacing with only just enough gas e.g. 10 bar/150 psi.
- We fail to monitor gas consumption effectively as above, but we decided the reef we were looking at was really interesting, and everything appeared fine, and so we decided to go below the minimums briefed and surface with the same amount of gas (10 bar/150 psi). This could be thought of as a violation.
- We could also have a new outcome even if we followed the same actions or made a slight deviation, for example making a navigation error in a wreck or a cave and a new room or site is discovered. This adaptation could be called innovation, or if it resulted in injury, error as the cause of failure.

In each case, we need to reflect on the activity to determine the conditions in which the ‘error’ happened because it is only by looking at the conditions that we can truly make big differences to safety and performance. If we only focus on the outcome e.g. navigation

error without looking at how and why the error happened e.g. distraction or disorientation or surfacing with a low amount of gas, we will likely make the same mistake again.

Unfortunately, when the same errors happen repeatedly but we don't have adverse outcomes e.g. surfacing with very limited breathing gas, we reset the baseline as to what is 'safe' and we erode the safety margins created through training and best practice. In diving, there are many variations of the standards which have been published, and because there is limited accountability for deviations, these deviations then become the norm. Humans drift from standards without accountability, either from a training organization or an adverse outcome. This drift from the standards occurs as we reset the baseline of 'safe' with each error without an adverse event, e.g. surfacing with less than 50 bar/500 psi of gas. Efficiency guides human behaviour. Without reflection and debriefing we erode our safety margins, ever increasing the risk that an error will result in an adverse event.

Focusing on 'human error' means we miss opportunities for learning. Note that recklessness, without thought or care for consequence, is not very prevalent in incident analysis reports. Most people don't get up in the morning and decide today is a great day to die, to get bent, to get entangled in line, or to run out of gas...



If we are to truly learn from any event, success or failure, we should look at how it made sense for the individual to do what they did. 'Errors' are often seen as 'honest' mistakes due to our inherent fallibility whereas violations are seen as 'dishonest' mistakes that should be punished. However, if we look at unintended, routine and situational violations, then we can often see the context or the environment influences the adherence to or violation of the rules. If everyone is breaking the 'rules', it is much harder to do the right thing because we are creatures of social conformance and we don't want to be different.

Summary of the events

This section provides a number of technical aspects which could not be covered in the documentary and will help those who are interested to know more about the cause of the fatality. It is easy to get sucked into looking at the technicalities without considering the wider picture. Humans have a tendency to simplify things as much as possible - this is one of our strengths and at the same time, one of our many weaknesses. By simplifying things, we can reduce the mental or cognitive overhead required to process information. Unfortunately, when it comes to learning from incidents and accidents, we have to force ourselves to not simplify our view of what happened. "We find what we are looking for."

To set the context, this custom 'course' was planned to run over 22 weeks with multiple CCR classes making up the programme so was not a 'standard' course. In addition, the students were on a mixture of Liberty and Megalodon CCRs with the instructor diving a Liberty CCR.

Below is a list of timecodes and issues which arise during the video and highlights just how many factors are present. They have been put into broad 'buckets' or topics using the following definitions which follow the Human Factors Analysis and Classification System.

Org = Organisational Factors. Resource management, organisational culture and organisational processes.
Sup = Supervisor Failures. Inadequate supervision, planned inappropriate operations, failure to correct a problem, supervisory violations.
Latent = Latent or Pre-condition for Unsafe Acts. Substandard condition of operators/divers. Substandard practices of operators/divers.
Active = Active failure on the part of the narrator or subject of the conversation, including slips, lapses, mistakes and violations.

03:36 **Org:** **Sup**: Violation of standards to be left on the bottom on their own. **Active**: Incompetent and unaware, don't know what they don't know.
04:18 **Org:** There is a culture of expecting to pass a course.
04:32 **Org:** There is a culture of cavern diving as Open Water divers. **Sup**: Dos Ojos is not a cavern suitable for Open Water divers due to the large area of overhead and limited opportunity to surface if there is an issue. As they had already booked there, committed or sunk costs make it hard to say no. **Active**: incompetent and unaware, overconfidence.
07:10 **Latent**: Personal drive/ego and self-induced pressures. Blinkered view.
07:42 **Org:** and **Sup**: Disorganised programme which caused frustration amongst the team. Trade-off between daily/work life balance and getting course dives scheduled.
08:00 **Org:** Constant changes in programme. **Sup**: Lack of clarity of tasking/programme. **Latent**: Frustrations/time pressures.
08:10 **Sup**: Leadership and management of students' expectations.
08:54 **Active**: Sunk costs and frustrations.
09:08 **Org:** Culture of "military following orders" – social norms.

09:40 **Org:** Imposed time limits which could not be adhered to. **Latent**: Self-induced time pressures and finances with risk of having to pay benefits back if the courses were not completed in time.
10:01 **Sup:** and **Latent**: Friction, frustrations, teamwork and lack of effective leadership.
10:32 **Sup:** First instructor for this dive walked away because of adherence to standards (*good leadership*) – students had not completed enough hours on the CCR prior to the course. **Sup:** Violation allowing student to start course.
10:43 **Latent:** Lack of trust in instructor/new team with new instructor. **Sup:** Need to develop effective teamwork.
12:05 **Sup:** Changed plans, again. **Latent:** frustrations within the team.
12:30 **Sup:** Leadership/managing expectations. **Latent:** Frustrations, anger and sunk costs.
13:30 **Org:** Culture of compliance and relationship with instructor – Brian worked in the dive shop through which the course was being taken through. **Sup:** Shop dynamics/leadership/self-induced pressure to get website media. **Latent:** Sunk costs.
14:51 **Latent:** Sunk costs due to time pressures.
16:17 **Latent:** Lots of changes in short period of time.
16:25 **Latent:** Frustrations over changed plans.
16:48 **Sup:** Leadership and lack of control. *"Controlled Chaos"*.
17:15 **Latent:** Thermal stress, starting self-induced time pressures.
17:50 **Org:** and **Sup:** Attitude and Leadership. (Leadership or team development processes are not taught in instructor development classes).
18:00 **Sup:** Creating effective teamwork. **Latent:** Lack of psychological safety.
18:14 **Sup:** Assumptions, lack of psychological safety.
18:32 **Sup:** Attitude to the seriousness or criticality of the situation.
18:40 **Latent:** Time pressures due to drysuit.
19:30 **Latent:** Short trip, 8 mins, time pressures.
19:30 **Org: Sup: Latent: Active:** Checklist culture, design, teaching and execution. Brian had made the same mistake two weeks before by not selecting dive mode prior to entering the water but he had not this picked up. Fortunately, the O2 was on at this time.
19:51 **Active:** Assumption a checklist started is a checklist fully completed.
20:15 **Sup:** Not managing team effectively to go at pace of slowest member. Time pressures. **Active:** CCR unit is still in surface mode when he steps off the boat.
20:26 **Sup:** Brian was first off boat before everyone was ready.
20:33 **Sup:** Not best practice to enter the water after the student when there isn't a need to be on the boat.
20:56 **Org: Sup: Active:** Cameras should not be taken on training dives, especially CCR training dives, due to task workload. Self-induced pressures to capture media.
21:15 **Active:** Rationalising previous experience for deviations on the class.
21:45 **Sup:** Induced pressures to produce media, not corrected. **Latent:** Team's inability to say no.
22:09 **Sup: Latent:** Authority gradient and assumption of knowledge on the part of the team.
22:27 **Latent:** Diffusion of responsibility, "someone will say something". **Active:** Lack of self-confidence & lack of psychological safety.
22:38 **Org: Latent:** Culture of deference to rank and to comment in private.
22:53 **Org:** Physical environment changed from expected (increased current). **Active:** Workload and impact of O2 consumption during pre-breathe.

Technical Aspects of the Rebreather Operation

The Head Up Display for the unit would be flashing two red LEDs in surface mode if the pO2 is below 0.40. However, in bright sunlight, these LEDs are not easily visible. The handsets would be vibrating but they might not be noticed above the boat noise or through Brian's drysuit with everything else going on.

Right (as you look at it) LED is lit

Both LEDs lit but in the shadow of the diver's hand

The buddy light on the back of the unit would be green as long as the pO2 was above 0.20 even though the diver's HUD would be flashing red. The buddy light is designed to be visible when the diver is horizontal in the water and the ambient light levels are much lower than surface sunlight. Ambient light makes the green LED difficult for the buddy or instructor to see while on the surface.


The red LED of the buddy light.


The green LED of the buddy light.

Extracts from the DiveSoft Rebreather System Logs

The following three pages are from the publicly released report from DiveSoft (the manufacturer of the rebreather Brian was diving). The data does not include the pO2 within the breathing loop while the unit is in surface mode (no pO2 data logging happens

here, so we can't see the loop pO2). The pre-dive sequence was carried out in accordance with the handset checks and finished at 07:12:03 and it appears the unit turns off or is shutdown at 07:25:47. At 07:35:56 the unit is turned back on and goes into surface mode. The surface mode aims to keep the pO2 at 0.4. However, Brian had been taught to turn his O2 off to preserve the gas in case it leaked on the boat ride – as such it appears his O2 cylinder was not on. So even though the solenoid would be firing, the O2 that was being consumed while breathing from the loop while getting ready, was not being replaced. At 07:49:57, the unit switched to CCR mode as it reached 1.5m depth (fail-safe mechanism). Two weeks prior, Brian had also entered the water with the CCR still in surface mode but because his O2 was on, then there was a major issue.

Terminology used in the report extracts below.

CU: Control unit of the rebreather, two interconnected computers placed inside of the rebreather head (left-hand side and right-hand side) each with its own battery, sensors, and solenoid.

Handset: Control terminal of the rebreather, two handsets are connected to the head through a cable (left- hand and right-hand, each to its CU).

HUD: Head-up display, contains 3 LEDs, each is separately controllable.

Critical Alarm: all LEDs are glowing red, text on both handsets, vibrating alarm on both handsets.

ppO2: Partial pressure of oxygen, or the fraction of oxygen in the breathing mix. Air contains 21% oxygen, or 0.21 bar, at the surface (if no oxygen is added or depleted, the ppO2 will double with every 10m of increasing depth due to increasing water pressure).

The physiological safety band of oxygen pressure for human beings is 0.16 to 1.6 bar. If the ppO2 drops below 0.16 bar, the diver will lose consciousness from hypoxia. Loss of consciousness is almost instantaneous.

SYSLOG.DSF Non-divedatalog(alsoavailableintextformatSYSLOG.CSV)
CONFIG.DCF Configuration record (also available in text format CONFIG.CSV)
00000033.DLF Dive log (also available in text format 00000033.CSV)

The events from 00000033.DLF are timestamped and are counted from the start of the dive. In the timestamp they are listed with an added time 20.5.2018 07:49:58.

Data from SYSLOG.DSF are marked with the letter S. Data from 00000033.DLF are marked with the letter L. All files are from right CU.

Brian Bugge Incident – 20 May 2018

Timeline from 2018-05-19 20:56:15 to 2018-05-21 03:12:37

2018-05-19

S	20:56:15	Switch on by the Left CU
S	20:56:22	Connection with Left Handset and Left CU established
S	20:58:26	Calibration of O2 sensors started, using 98% Oxygen
S	20:59:42	Calibration finished, timestamp from configuration 2018.05.19 20:59:42
S	21:01:24	Calibration of He sensors started
S	21:01:36	Calibration finished
S	21:07:36	Predive check started
S	21:11:34	Predive check finished
S	21:12:59	Shutdown

2018-05-20

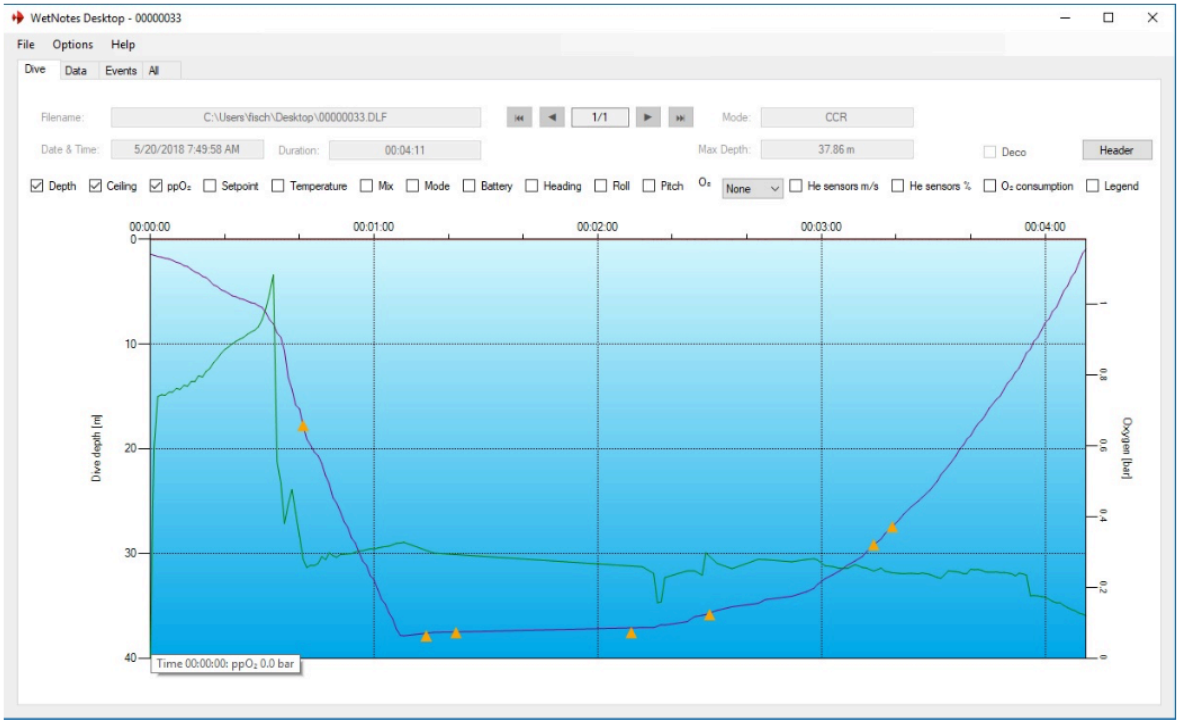
S	07:08:54	Switch on by the Right Handset (Surface mode initiated)
S	07:09:03	Connection between Right Handset and Right CU established
S	07:09:06	Connection with Left CU established
S	07:09:38	Predive check started
S	07:12:03	Predive check finished -> all tests confirmed as OK
S	07:12:09	Manual switch to CCR mode
S	07:14:32	Manual switch to Surface mode
S	07:25:47	Shutdown (probably by 10min timeout)
S	07:35:56	Switch on by the Left CU (Surface mode initiated)
S	07:36:03	Connection with Left Handset and Left CU established

S	07:49:57	Switch to CCR mode (emergency initiation of dive mode by submersion to depth greater than 1.5m)
		(The time spent in depth lower than 1.5 meters cannot be acquired from the logs, as the unit was not in dive mode)
L	07:49:58	Dive started (dive log timestamp 00:00:00)
		Last known ppO2 according to individual sensors:
		0.05bar (2.34mV), 0.04bar (1.76mV), 0.04bar (1.94mV), 0.04bar (1.82mV)
		All O2 sensors in Error state ("voltage too low" – meaning O2 readings are too low)
		Critical Alarm "ppO2 measuring lost"
L	07:49:59	Attempted O2 backup measuring (false due to air in the loop, instead of the configured diluent)
L	07:50:32	Total loss of O2 measuring, both main and backup (probably due to sea water on the sensors a flooded loop)
L	07:50:33	O2 injection, for 3 seconds (repeated every 3 to 6 seconds)
L	07:50:39	Critical Alarm "Hypoxia" (repeated every 30 seconds)
L	07:51:06	Maximum depth of 37.86m reached
L	07:52:15	Ascent to 37.09m (probably caused by the start of recovery of the diver)
L	07:54:09	Surface reached
S	22:12:22	Connection with the Left CU lost
S	22:12:27	Connection with the Left CU established (repeat 5x)
S	22:13:51	Connection with the Left CU lost (unit probably switched off by jumpers removal)

2018-05-21

S 03:01:05 Reset (power up) and an attempt at connecting with the left CU
(unsuccessful, probably due to the left battery running out)
(repeat until 03:12:37, probably due to the right battery running out)

Dive Profile



General Discussion

This section is a general one and its aim is to get your participants to think about adverse events, how they came to be and what conditions created them. Italicised text gives you some questions to guide your session.

Give them a brief overview like “Diver X was on a closed-circuit rebreather diver training course. They were with an instructor and 3 other divers on a boat and were planning to dive on a wreck in approximately 35-40m/115-135ft of water. They were using a gas mix which had breathable trimix on the surface. Diver X entered the water without their oxygen cylinder turned on, they went hypoxic shortly afterwards, passed out and sank. They were recovered from the bottom but died despite CPR being carried out.”

What are your initial thoughts about the cause of the accident? Normal responses include: checks weren’t completed, inadequacy of training, and instructor failure. Using a whiteboard or flipchart, write down their responses to refer back to.

Is someone to blame?. If so, whom?

Advise them that the video is emotional and powerful and that they shouldn’tbe surprised if they cry or feel angry. These responses are normal human reactions given the circumstances. (demonstrate trust and tell them what you experienced),

The video is 34:06. You will pause it at 25:50 once the narratives from the dive team have finished (before Gareth starts speaking).

What are your current thoughts? Have your opinions changed about how the accident happened? Have their opinions have changed about how the accident happened? Add their responses in a new colour.

Restart the video and play until the end.

What are your final thoughts about how the accident happened? Add the final comments to the whiteboard/flipchart in a third colour

Ask them to look at the factors involved. *How often do you consider the factors involved in yournormal diving operations? How many are ‘technical’ or skill-based and how many involved non-technical skills?* You can refer back to the definitions (p.4-5) and the summary of events (p.8-13) pages for guidance on the multiple factors present.

End of 90 minute session

If you want to take the conditions discussion further, consider the following table which comes from a document developed by the US Department of Energy that looks at preconditions or pre-cursors for errors. It was developed by examining thousands of

incident reports and identifying the factors that were present prior to the accident or incident.

Note, this list is not exhaustive but shows the different areas which we need to consider if we are to reduce errors and then accidents. It is slightly different to the one in the video but the concepts are generally the same. Also note just because these factors are present, it doesn't mean an accident WILL happen, it just increases the likelihood of one occurring.

The WITH Model

Work environment	**I**ndividual capability	**T**ask demands	**H**uman nature
• Distractions / Interruptions	• Unfamiliarity with task / First time	• Time pressure (in a hurry)	• Stress (limits attention)
• Changes / Departures from routine	• Lack of knowledge (faulty mental model)	• High workload (memory requirements)	• Habit patterns
• Confusing displays / Controls	• New technique not used before	• Simultaneous, multiple tasks	• Assumptions (inaccurate mental picture)
• Work-arounds	• Imprecise communication habits	• Repetitive actions / Monotony	• Complacency / Overconfidence
• Hidden system responses	• Lack of proficiency / Inexperience	• Irreversible acts	• Mind-set
• Unexpected equipment conditions	• Indistinct problem-solving skills	• Interpretation of requirements	• Inaccurate risk perception

Ask them how they would close the gap between what is supposed to happen and what really happens in their world of diving?

Other areas to consider.

Humans have a tendency to drift and our behaviour is influenced by rewards/punishment.
If we drift and there is no/limited checking of performance, and we are rewarded for quantity, what do you think happens to quality?
If we punish (e.g. negative social media posts) those who report adverse outcomes, especially those which appear to be 'irrational', what do you think happens to the learning opportunities.
If we report sub-standard behaviours to organisations but nothing is done, or appears to be done, what do you think happens to reporting? Who would you report these to as a diver?

Psychological Safety

Psychological safety and Just Culture are both concepts that are essential if diving safety is to improve. Both are often misunderstood, so this section and the next explain the concepts, identify events or conditions in which they apply, and provide tools to create and maintain them.

Psychological safety has been described by Professor Amy Edmondson as "*a shared belief that the team is safe for interpersonal risk taking*" and "*a team member will engage in subconscious decision-making, weighing up the risk of speaking up against the interpersonal climate versus the longer-term consequences of not speaking up".* It is like trust but shared amongst the team. Trust is normally 1:1, whereas psychological safety is 1:many or many:1. Psychological safety is created by leaders/instructors within the team by showing that it is ok not to know the answer, to ask curious questions, to admit their fallibility or to ask for help from the team. This allows others in the team to do the same, put their hand up and say, "I don't know, can you help me?".

In diving, this is not easy given the egos and bravado that are present. In many cultures, this open and vulnerable behaviour is not normal either, especially as those in positions of expertise or experience are held on a pedestal, making it odd or uncomfortable for leaders to express the fact that they might not have or know the answer. However, if psychological safety is created within a team, the results are amazing because teams will start to contribute, collaborate (not compete) and start to release discretionary effort (the difference between what you have to do, and what you want to do). In effect, get more done with less.

Some examples of situations where psychological safety is missing in diving are shown below.

- Wanting to undertake a class but feel you might not pass.
- Wanting to receive coaching from an instructor but feel that you will not be perfect.
- Wanting to contribute to the plan and/or schedule but feel your ideas won't be welcome or you'll appear 'stupid' amongst peers.
- Wanting to use a checklist, but feel you'll be called weak because you are using one.
- Wanting to not go into a wreck when short of gas, but feel you have to continue.
- Wanting to thumb a dive, but feel you are going to ruin it for others.

Exercise

Tell the group about a dive incident that happened recently (recent and obvious will be more effective and powerful) e.g. entanglement with a dSMB line, running low on gas, unplanned buddy separation or entering the water with gas turned off. Focus not just on the outcome, but all of the factors that led to the incident (distractions, equipment servicing, fatigue/stress), and why your decisions made sense to in the moment, even if afterwards it seemed irrational. If your group is larger than 10, break them up into groups

of 6-8 to discuss the incident and move around the room asking questions, encouraging discussion and modelling respectful, curiosity-driven questions.

Note: It must be emphasised that this is NOT a shaming activity, but rather to learn about local rationality and why performance can be variable, even for those who are really experienced. If the speakers are unable to expand on their story, try to get away from the outcome and counterfactuals (what should have been done, what could have been done).

Summary: Psychological safety is proactive in nature. It is a culture that has to be created to allow an individual to speak up within the team. The idea is to prevent adverse events from occurring by allowing people to raise concerns or highlight different, potentially better, ways of doing things. It is created by the leaders within the team or organisation by role-modelling behaviours.

Just Culture

A Just Culture has been defined as *"A culture in which front-line operators or other persons are not punished for actions, omissions or decisions taken by them that are commensurate with their experience and training, but in which gross negligence, wilful violations and destructive acts are not tolerated"* (European Aviation Regulations) or *"as an atmosphere of trust in which people are encouraged, and even rewarded, for providing essential safety-related information, but in which they are also clear about where the line must be drawn between acceptable and unacceptable behaviour."* (Professor James Reason). Importantly, it is not the same as a no-blame culture. We must take into account how and why it made sense for that person to do what they did at the time, irrespective of the apparent irrationality.

For a Just Culture to be effective, we must understand the different concepts of 'human error' and human performance variability, and what personal, environmental or social pressures created the circumstance to make the error or the violation occur or be more likely. If you remember back to the earlier section on human error, you will see that errors or violations can really only be determined after the event. Consequently, a Just Culture is required to deal reactively with adverse outcomes so that we can learn. This is compared to a psychologically-safe environment which is needed to help prevent incidents/accidents.

There are many problems with trying to bring a Just Culture into an environment like diving:

- There is a limited understanding of human error and how it occurs, which makes it easy to blame the individual without understanding the impact the context can have.
- We are hard-wired to simplify judgements when negative outcomes happen as being the fault of the individual, but when good things happen, they are down to the environment. Conversely, when something bad happens to us, we blame it on the environment, but when something good happens, it is down to our skills and judgement. This is known as the fundamental attribution error.
- We judge severe outcomes e.g. fatality or multiple fatalities more harshly than minor events, even if the causal factors are nearly the same.
- We are biased by hindsight which has two effects: we know the outcome, so can join the dots to identify how the event is going to happen, something those involved can't do, and secondly, even without knowledge of the outcome, we believe we would have identified what was going to happen at the time and so made different choices.
- The litigious society we live in makes it hard to talk about the serious incidents and accidents we have been involved in. We don't want to highlight issues with others, especially organisations, in case they decide to sue us or they aren't taken seriously.

As Professor James Reason highlighted above, the community needs to be clear where the line of acceptable behaviour is drawn. Unfortunately, as Sidney Dekker covers in his book 'Just Culture', it isn't so much as where the line is drawn, but rather who draws it. If the line

is drawn by peers who genuinely understand and acknowledge the real-world challenges faced and pressures encountered, then more learning will happen. This is because the real issues, the gaps between 'Work as Imagined' and 'Work as Done' can be aired. However, if it is lawyers, who are often looking for a single root cause, draw the line then learning will be limited as only the absolute minimum will be disclosed and that will rarely identify external pressures or challenges.

Exercise.

Consider an adverse event you've been involved with or heard of. How were the people involved treated? In person? On social media? How were your feelings influenced by the severity of the event? Do you feel differently if you think about it as a process rather than as a foregone conclusion?

Imagine time stopped right before Brian stepped off the boat. Do you think that any one person was responsible for the outcome or were there multiple factors at play? Did all of those factors exist before the clock stopped? Look at the WITH model from earlier in the workbook for more factors. *As a community how do we expose those factors without the accountability of serious or fatal accidents?*

Summary

Creating a Just Culture across the whole diving industry is not likely to be possible because of multiple legal, cultural and social differences and conflicts. Aviation has managed this at a national level through legislation in some countries, others struggle, and blame is very prevalent in these countries. In diving, there is no such legislation which protects information given for a safety investigation from being used in a litigation case. However, there is nothing to stop individuals or teams or organisations taking a different perspective. The first question shouldn't be 'who is to blame?' but rather 'how did it make sense for those involved to do what they did?' Next, don't look at where the line is drawn regarding acceptable behaviour, but rather who is drawing it.

Situation Awareness

Situation awareness is the ability to perceive data, process it into something relevant to the here and now, and then project into the future about what might happen. Situation awareness is the first step in decision-making where we collate information before determining a best course of action. The research shows the majority of incidents and accidents are due to inadequate or misdirected situation awareness, and then a valid decision is made with incorrect or invalid information. This is different to someone having the correct information and then making a flawed decision.

Our attention span is limited. While our senses can receive billions of bits of data, our brains can only deal with a much smaller amount of data and so we filter and ditch the majority of data coming in as being apparently irrelevant or unimportant. The problem is we only know what is important and/or relevant when something goes wrong and we recognise what we should have seen using hindsight.

Exercise

Ask them *what draws your attention to a scene or information*? It will likely come under the mnemonic DIPI – Dangerous, Interesting, Pleasurable or Important. If it is one of these, then we are likely to pay attention to it, if not, we dismiss it and stop paying attention. The challenge is working out how relevant these cues/clues are and that is where experience, feedback and debriefs matter – we learn through good and bad things happening to us.

There are numerous examples of critical information being missed in diving which then lead to an incident or accident: missing or incorrect dive briefing information; erroneous navigation cues like misread bearings or misidentified parts of a wreck; being too focused on photography/videography to miss an important signal; or not noticing pO2 changes via the divers' HUD and handsets.

Selective attention or inattention blindness is a recognised phenomenon whereby we don't see something that is 'obvious' (in hindsight) because we are focused on something else. We can't pay 'more' attention, we can only improve where our attention is focused.

On the boat, Brian's rebreather had both a HUD and a buddy light. It is the diver's responsibility to monitor the LEDs and the flashing sequence, but how easy is it to notice that on a bright sunlit day? When we are distracted, we miss critical information.

To show them how easy it is to miss information, show them this clip https://www.youtube.com/watch?v=v3iPrBrGSJM and pause at 01:25 when the caption 'How many changes did you spot?" is displayed. Ask them how many of the four changes they saw. Carry on playing the video.

Ask the participants why they think they missed the changes during the card trick. Fundamentally, the changes were missed because they happened off screen and the

participants' focus was on the card game. We don't necessarily track information from one scene to another and we make assumptions about the state of that information/object when we revisit the original scene. This is likely the reason Brian forgot to turn his oxygen back on and missed selecting 'dive mode' on the rebreather – his attention was somewhere else, and he had already completed the checklist on the unit only 10-15 mins beforehand. This 'forgetting' happens all the time but can have catastrophic consequences in certain circumstances. A checklist could help here, but the checklist had already been completed (07:12:03) and the flow was interrupted when the unit shutdown at 07:25. Interruptions interfere with our mental models (representations of reality) and the way we think the future will happen – this is the 'project forward' part of situation awareness. We assume a state will remain constant over a period of time e.g. dive mode vs surface mode.

Another point to make is that information can be recognised as relevant after the event. Rewind the film to 00:50 and play for the next 20 secs. Make sure the volume is up. Ask them to watch and see if they can see the changes. Then ask them if they heard something around 5 seconds into the clip which is relevant to the changes, if not, replay. The sound you can hear is the backdrop being changed. Does that noise have significance now whereas before it didn't?

If they think it would be hard to miss something obvious like a HUD or an audible alarm, show them this video which was shot from the passenger seat of a light aircraft coming into land in the Alps. The gear is not down, and there is a warning horn to alert the crew (and the passengers) this is the case, but they apparently didn't hear it.
https://www.youtube.com/watch?v=5McECUtM8fw

Now ask them to consider the significance of selective attention, task fixation, self-induced pressures on their diving and how they would manage them more effectively. Checklists will likely come up and are covered in more detail in the decision-making section next.

Summary

Our attention is finite. Just because we have sensed something it doesn't mean we have comprehended its meaning. You can't pay more attention, but you can point your attention in the right place more often. That means understanding what factors are Dangerous, Important, Pleasurable or Interesting (DIPI) to us and the team using briefs and debriefs.

Decision-making including Checklists

Decision-making has three parts – collect information, decide on an outcome, then start the execution process. The problem is many of our decisions don't happen in a conscious manner or obviously logical manner. Our decisions are heavily influenced by emotions, biases, mental shortcuts and previous experiences, which allow us to make decisions really quickly, and without much thought. Most of the time, this normally isn't an issue. However, when we undertake risky activities and nothing goes wrong, we make a mental jump that says 'what we did must have been right because the outcome was okay' without looking at how close we were to an incident or an accident. What is even worse is we can erode the safety margins or rules we have been taught, not necessarily with a huge jump which would be obvious at the time, but rather through the gradual shifting of what is 'good enough'. This is known as Normalisation of Deviance. When incidents or accidents happen, it is normally a deviation from 'normal' rather than from 'the rules'.

In the situation awareness section, it is explained that a large percentage of incidents/accidents are due to incorrect perceptions and processing of information and then making a good decision on this 'flawed' information, rather than correct information and a bad decision. One of the ways in which we can maximise the chances the information we are using is correct is to slow our thinking down by engaging our brain's 'System 2' as Daniel Kahneman called it. System 2 is the slow, methodical and logical part of our brain, compared to the fast, emotive and intuitive part of our brain called 'System 1'. System 1 operates 95-99% of the time and we can't turn it off. But we can force it to slow down.

One of the ways we can do this is by using checklists.

Ask the participants *what is the purpose of a checklist*? To help not forget things. A shopping list is a checklist, but we have to remember to take it with us. It also needs to be accessible while we walk around the aisles. It is more effective and efficient if it is laid out in the order of the store too. If we forget an item on a shopping list, it isn't too much of an issue.

Ask them *how else we can stop forgetting things which are critical*?. Somewhere in the responses should be 'practice'. But what about when you are busy and other things are on your mind? Do you always remember to execute the checklist properly when you are busy? What helps you execute it? *(Patterns and habits, with prompts from the environment)*

Discuss *what makes an effective checklist? How many items can you remember reliably?* An effective checklist is based on the user having training and experience. This allows the checklist to be concise, with 6-9 items of short prompts to jog a memory created through the training. It needs to be relevant to the operating environment. For example, a fridge-mounted shopping list is not much use on a shopping trolley, the same applies to a mobile device app for a final pre-dive checklist. If there is too much 'friction' in its use i.e. it is hard, difficult, too long or inconvenient to use, then it won't be used, and this means the diver relies on their memory which we know is fallible.

There are multiple checklists in diving and it is this lack of clarity that causes problems. For example, in rebreather diving, it is often said divers should use a checklist, but what do they mean? There are build checklists for assembling the unit, more checklists for when you are on-site e.g. the boat, shore location or cave and then another final checklist to ensure the unit is safe to dive and can support life executed just before you enter the water. These checklists are all very different tools.

Checklists in other high-risk environments have been designed with the physical operating environment in mind and the time constraints between prior and successive tasks addressed. They are also designed with known starting and ending configurations taken into account. Current rebreather build checklists nearly always assume the unit is in its component parts, but most divers don't disassemble the whole unit after each dive. Consequently, the diver enters the checklist part of the way through, or not at all and does the checks from memory. This can lead to errors which may not be detected until too late.

When the time taken to do the task is incompatible with the operating environment, then errors will be induced e.g. Brian completing the handset-based checks, but then the unit switching itself off and reverted to a different mode. Then, due to distractions, the changes (dive mode and O2 off) weren't picked up when he went to dive his CCR.

Standardisation of checks and their adherence is key if we are to be able to cross-check each other. If checks are not standard, how does one diver cross-check another? Is the check itself correct but it is missing actions you expect to be carried out or is it being done incorrectly because an action ***has*** been erroneously missed?

Finally, it is the culture of checklist adoption which causes the most problems for a number of different reasons. One of the most prevalent with skilled/experienced operators is they sometimes feel having to rely on a checklist is an afront to their technical competence. This is not just limited to diving, the following quote comes from healthcare– "*The WHO Safe Surgical Checklist has been heralded as a major innovation in medicine, but unlike a new piece of technology, the challenges to introducing changes in the safety culture in the operating theatre are significant."* (Walker, 2012)

How to make checklists more effective?

- Identify critical elements/tasks that MUST be completed and why. Putting items to be carried out in the water e.g. 'know your pO2 at all times' on a surface checklist is not useful and draws attention away from the true purpose of the checklist.
- It must consider the operating environment (both physical and time) and the implications of task flow e.g. cannot do one task without another already being completed.
- It must take into account known or consistent configuration/start states and system timeouts.
- Contain a small number of lines (6-9), otherwise break the checklist into chunks which are operational- or time-focused.
- Requires baseline competence to execute them.
- To be most effective, requires teamwork and effective communications.

Exercise

Ask the participants to *make a list all of the checklists they are supposed to use prior to and post-dive and examine them for both content (in line with the comments immediately above)* and then to *look at where the checklists fail to be effective*? *What conditions prevent them from working? What can be done to change their execution? Consider both technical and social issues when it comes to using them.*

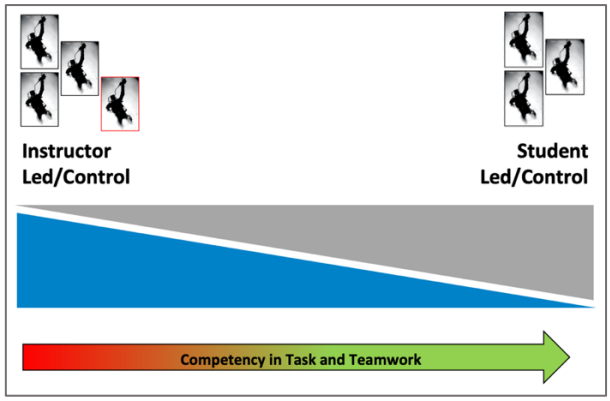
Additional Resources:

This link (https://www.thehumandiver.com/checklists) takes you to a page on the Human Diver website which has resources on checklist design and implementation. This includes a video from Professor Simon Mitchell about the utility of checklists in rebreather diving. This video also includes a demonstration of a pre-dive, buddy/crew/supervisor lead checklist, something which more dive operations are undertaking to ensure their clients are safe, especially when operating in more remote locations. Research papers on checklist design are also available on this page.

Summary

For checklists to be effective they have to take into account the prior skill-development of the user, along with the operating environment and the time constraints under which the checklist will be used. They should not be used as a tool for limiting liability nor transferring liability, rather they should be used because they make sense, not because they HAVE to be used. For checklists to be effective, they have to be designed and produced well, using published scientific literature on the topic to guide the flow and contents. Checklists in healthcare and aviation work to increase safety and reduce error not just because they have been designed well, but because operators know they are fallible and WILL make a mistake at some point.

Leadership and Followership



Leadership Interaction During Training

Every instructional training course involves at least one team, normally two. The instructional team (instructor and students) and the student team. All instructors are leaders as they have a team and goal, but how they should execute this role changes based on the maturity of the team and competence within the team. At the start of the learning process, instructors should be more autocratic and directive because the team is not necessarily clear on the goals and their roles in achieving them. As the team matures and their competence improves, the instructor is more hands-off, thereby developing the students to operate as a team on their own. If students are not exposed to team diving during training, it will take longer to develop this outside of a training environment. The skills in diving in a team are not limited to helping each other out when something goes wrong, but also about collaborating and co-operating together to create a shared mental model between them i.e. an idea about what is going to happen now and next.

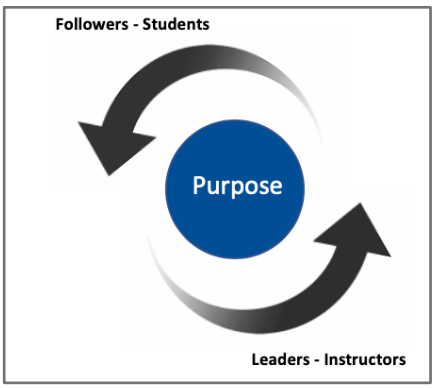
The concepts of team development and the associated dynamics are not taught in dive instructor development and yet they are key to ensuring the correct leadership and engagement style is used during training courses – these concepts are a key part of the two-day class The Human Diver provides on non-technical skills in diving. Understanding the different styles needed and being aware of their own personal preferences leads to more effective learning, thereby reducing failure rates and maximising competence.

Furthermore, how effective followers should behave within a team is also not covered in any of the training materials. The most effective followers in a team are those who are able to support their leader (instructor) in achieving the goals of the dive/project/class, at the same time as being able to challenge them in a constructive, dissenting manner. This requires the leader to create the environment whereby it is possible, even encouraged, to speak up. This isn't about being brave, because bravery is only needed when you have something to be fearful of. Take away the threat, and conversations are much easier and more effective. Create psychological safety and you can help create great followers.

Summary: Leadership is not easy and is executed in many styles. It takes time to develop and requires the correct mindset to allow reflection on weaknesses.

Teamwork

Teams are made up of individuals who are working together, interdependently and dynamically, around a shared and valued purpose or goal. In the case of a training course, the goal should be about developing skills to facilitate safe and effective diving after the course, not acquiring a piece of plastic. In the case of a dive outside the training environment, the primary purpose of the dive should be about surfacing having had a fun time without injury. The secondary purpose should be about whatever the 'goals' of the dive were e.g. photography project, observe sea life, explore a reef or shipwreck or the inside of a flooded cave system. Unfortunately, it is these secondary goals that sometimes take primacy leading to goal fixation and safety is compromised as a consequence.



Effective teams are able to brief their dives in a manner which identifies gaps in their knowledge and allows them to learn from their own and others' mistakes (by referring to incident reports/social media reports). By undertaking an effective brief, the team increases their team situation awareness and expectations of what might happen which then makes decision-making more reliable.

'Plan the dive, dive the plan' is something we hear on numerous occasions. The problem is often we don't consider what might happen if the plan changes, especially as mother nature has a different idea what the plan should have been! Furthermore, because of our inherent biases, we often don't want to change the plan because it is mentally difficult to do so: the more we are committed to it, the harder it is to change prior to or during the dive.

In addition, effective teams they will run critical, not criticising debriefs, which allow lessons to be identified (and learned) to improve their future dives. These debriefs also allow wider learning to happen if the information is shared via some form of incident/learning system or social media.

Summary: Teams don't just happen. If you put a group of people together, they will form a team, eventually. But many don't have the time to do so. Undertaking training which develops leadership, followership and teamwork has been proven to improve safety and performance in high-risk environments.

Summary

As you will have seen from the film and the discussions you have had within the workshops, incidents and accidents are rarely caused by a single, obvious error, but rather a multitude of small factors and issues which come together and reach a critical mass. In this case, the critical mass was reached when Brian stood up from the bench without his O2 valve being turned on and then stepped off the boat. Had he noticed this, he would have still likely entered the water with his rebreather in an incorrect configuration, but the fail-safely mechanisms built into the CCR would have kept him alive. Whether that would have been recognised as a learning moment is not clear, as that happened two weeks before.

To focus on this single issue alone would miss the point about taking a human factors and systems-thinking view of this incident. Right from the very outset Brian and Ashley were exposed to gaps, weaknesses and violations in the diver training system. These continued for Brian until 20 May 2018.

In the 1950's and 1960's, the aviation accident safety record wasn't great, with 'pilot error' being a prevalent cause in accident reports. However, through effective accident analysis and the examination of cockpit voice recorders/air traffic control tapes, investigators identified co-pilots, flight engineers and controllers knew something wasn't right prior to the accidents, but often they could not speak up. It wasn't 'pilot error', it was much more complicated. This is what instigated cockpit (now crew) resource management training and human factors programmes. The safety of aviation improved markedly as a consequence.

Moving to diving, following a number of high-profile cases, the UK Health and Safety Executive published a report in 2011 which contained a recommendation that Closed Circuit Rebreather divers undertake some form of human factors training due to the inherent fallibility of humans and the multiple 'hidden' ways in which rebreathers can fail. Such training should take into account decision-making, cognitive biases, checklist design, teamwork and leadership.

Since 2016, Gareth Lock and The Human Diver has been developing and delivering courses on human factors and non-technical skills in diving, taking those lessons learned from aviation, nuclear industry and healthcare and translating them into the diving domain. The goal is to improve the knowledge and practice of human factors and non-technical skills in diving (and other domains) so that we don't have another situation where someone says "If Only…"

Definitions / Glossary

This section provides a series of definitions to ensure students and facilitators understand the terms and can talk from the same informed position.

Human Error – an unintended outcome from a planned or expected activity. It can consist of slips, lapses, mistakes and violations. Errors can only be determined after the event because if we didn't intend to do something, we would have stopped it before it happened!

Slip – an unintended action where the diver/operator has done something without realising it e.g. performing an action too soon in a procedure (weight belt inside the harness instead of outside), or performing an action in the wrong direction, e.g. pressing the inflate button on the BCD instead of the deflate button.

Lapse - forgetting to do something or losing your place midway through a task. This might be forgetting to tighten the cam-band on the BCD, to close the zip on your drysuit, or not analysing your gas because you forgot.

Mistake - mistakes are decision-making failures. The two main types of mistake are rule-based mistakes and knowledge-based mistakes. They arise when we do the wrong thing, believing it to be right. Examples include poor assessment of gas consumption leading to low/out of gas, poor propulsion technique and trim leading to silting out or entering a wreck without a line. Many mistakes are down to performance shaping factors, which will be covered in a later section of this workbook.

Violation – traditionally thought of as a conscious choice to make a decision which counters an existing rule. Violations can be further broken down into routine, situational, contextual or reckless. Understanding the context provides some insight into why the rule was broken, and in many cases, it is the social, cultural or financial environment which makes it easier to break the rule than follow the rule.

Just Culture – *"A culture in which front-line operators or other persons are not punished for actions, omissions or decisions taken by them that are commensurate with their experience and training, but in which gross negligence, wilful violations and destructive acts are not tolerated"* (European Aviation Regulations: 376/2014) Note, it is not the same as a no-blame culture.

Psychological Safety – "*a shared belief that the team is safe for interpersonal risk-taking*" (Professor Amy Edmondson). This means that we mentally weigh up the potential negative (social) consequences of speaking up versus staying quiet and an adverse event occurring. If there are low levels of psychological safety, then critical information is often lost within the team and assumptions go unchallenged.

Decision-making – the process of collating information, determining the best response and executing it. Multiple models of decision-making exist but most of the information

collation and determination takes place sub-consciously or via mental shortcuts (heuristics and biases) not consciously or in the logical process that many think we apply.

Situation Awareness – the ability to sense data, process its meaning in the 'here and now', and then project into the future to determine a likely outcome. Situation awareness is the first step of decision-making. What we sense or process is often based on previous experiences and can be summed up by the acronym DIPI.

DIPI. Dangerous, important, pleasurable or interesting - something which draws our attention to it. Without an effective feedback process, we don't know what to pay attention to and may ditch apparently relevant information.

Communications – the accurate exchange of information between two or more parties so both the intent and the message are understood. Communication is not just limited to people, communication also takes place between manuals and hardware e.g. dive computers and the operators

Team - *"a group of two or more people who are working interdependently, adaptively, and dynamically toward a shared and valued goal/mission/objective"* (Eduardo Salas).

Leadership – the ability to encourage, coach, mentor and develop others to achieve goals because they want to achieve them, not because they have to.

Followership – the ability to be constructively challenging or dissenting towards the leader while supporting them to achieve both their and the team's goals.

Performance Shaping Factors – normally categorised as stress and fatigue but can also include factors relating to the workplace and its design, the individual themselves, the task design and implementation and human nature and its inherent variability.

Sunk Costs – these are the costs in terms of time, money, resource you have invested in the dive or the course that you won't get back. One of the most precious of these is time, something we can never get back. The closer you get to the goal, the more you have invested, the harder it is to say no, especially if you can rationalise the risk away that as this hasn't happened before, it will be ok to take this risk.

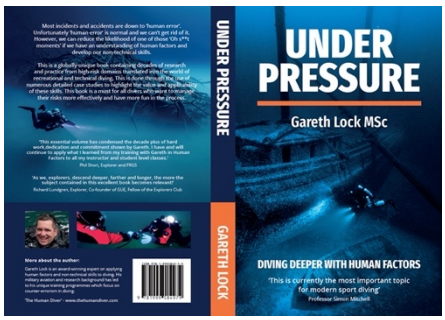
Want to know more?

The Human Diver started delivering training in human factors, non-technical skills, Just Culture and psychological safety for divers in January 2016. Since then, more than 350 divers across the globe covering recreational, technical and scientific diving have undertaken face-to-face training – this includes heads of diver training organisations, senior instructor trainers and prestigious scientific diving organisation staff. Details of this flagship course can be found https://www.thehumandiver.com/p/classroom

For those who wanted to learn something without a huge commitment, more than 1000 people have subscribed to the award-winning 'Human Factors in Diving' micro-class which is delivered in an eLearning format and lasts around 2.5 hours but has a huge amount of additional material for those who want to dig deeper. You can sign up for this course here http://www.thehumandiver.com/p/microclass

When it comes to training, there are those who want to undertake a more interactive learning activity, and so a 10-week, 15-hour webinar-based programme was developed. This course involves live webinars with student interaction and consolidation exercises. Two of these have run now with more than 50 divers graduating. There is one course scheduled for 1 June 2020 and there maybe another before the end of 2020. Details for the next course can be found here https://www.thehumandiver.com/ten-week-HF-webinar-series-june2020

In March 2019, *'Under Pressure: Diving Deeper with Human Factors'* was published. This 300+ page book takes the topics of human factors, non-technical skills and Just Culture and explains them through a mixture of theory and more than 30 case studies. It is available from multiple online sources and The Human Diver website. https://www.thehumandiver.com/underpressure



The Human Diver Limited
Malmesbury
Wiltshire
SN16 9FX

Tel: +44 7966 483832
Email: contact@humaninthesystem.co.uk