Human Factors & Decision Making in Diving

Freely Adapted from Aeronautical Decision Making

By Fabio Sardone

I am a diver since I was 14 and a pilot since I was 16.At time of writing I am 49 so I have gained a little bit of experience in a couple of fields in which people are faced with an unnatural environment for man and require good handling of stress, situational awareness and skills to successfully carry out activities.

I recently upgraded from Open Circuit hypoxic Trimix to a Closed Circuit Rebreather. I was already convinced that divers' training was too light on Human factors and Decision making, but,moving to CCR, the analysis of literature and accidents I carried out to try to understand the safety of operating a CCR, convinced me this area needed even more attention in CCR training that in Tech OC training. I have, in fact, learned (reference Rebreather Forum 3) that most of the accidents are due to human factors and especially due to a faulty decision making process. This strikes a stunning resemblance with aviation accidents where the human factors are the cause of the majority of preventable accidents. While in Aviation there is a lot of training and discussion about Decision Making in diving there is little to no training in Diving Decision Making (DDM). Here, I will attempt to mutate what I have learned in the aviation decision-making process to diving in an effort to improve rebreather diving safety.

GENERALITY

Divers who are involved in accidents generally know what went wrong (even more so those reading about the accident). Very often, the diver was aware of the possible hazards when the decision led to the wrong course of action was made. In the interest of expediency, cost savings, self-gratification, or other, often irrelevant factors, the incorrect course of action was chosen. This cycle of decisions began in the planning stage with decisions made on how much gas was necessary, how much bailout, the dive profile, the diving conditions, accepting the maintenance status of the equipment. This cycle continues throughout the dive with decisions made on depth, penetration, adherence to plan and when to start ascent. Each dive is a sequence of choices with certain milestones in the sequence that require particular determination and discretion.

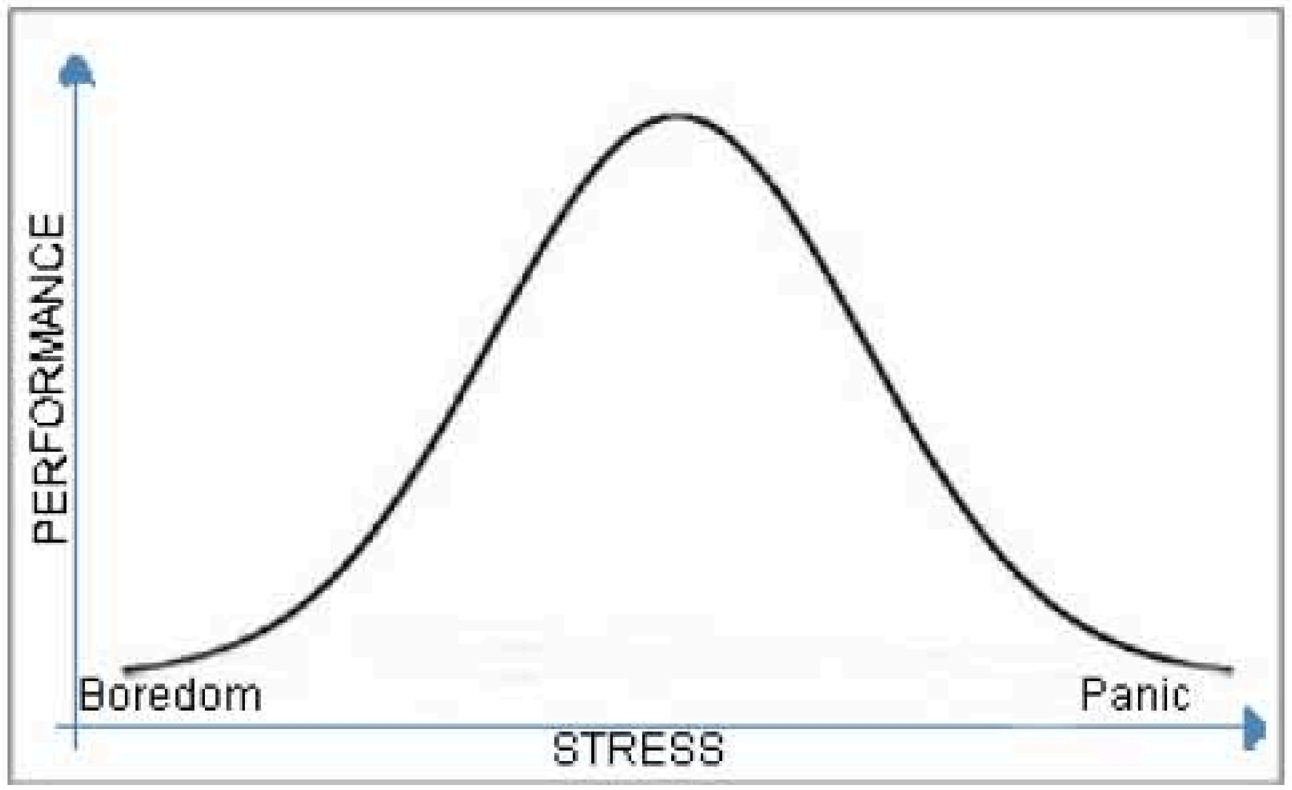
While the simple task of diving is mainly a physical one, learning to handle complex situation underwater,possibly, with failing equipment, lost deco gasses, or entrapment in overhead environment, requires experience and a solid thought process. DDM might help reduce the long and sometimes painful process of learning how to make good judgment decisions based upon experience alone. While it is true that simple errors of equipment operation are seldom serious, mistakes in judgment can be fatal, especially in CCR diving.

STRESS AND DIVING

What is stress? Stress is a term used to describe the body's nonspecific response to demands placed on it, whether these demands are pleasant or unpleasant in nature. The demands on a diver can range from entrapment on overhead environment to a lost wallet. Correctly executing required tasks (before and during dive) is diver's responsibility and it is necessary to survive the dive. Therefore, a healthy diver should perform at his/her optimum level and make decisions to the best of his/her ability. Numerous physical and psychological conditions in a diver's personal and professional life, as well as the nature of dive itself, can hamper this ability. Even though a diver might (while he/she should!) hold a medical *'fitness to dive'* certificate, the decision whether the diver is fit to dive is strictly his/hers.

HOW MUCH STRESS IS IN YOUR LIFE?

You may face major stressors such as a loss of income, serious illness, death of a family member, change in residence, or birth of a baby, plus a multitude of comparatively minor positive and negative stressors. These major and minor stressors have a cumulative effect that constitutes your total stress-adaption capability, which can vary from year to year. When we exceed this level, stress overload may lead to poor health or illness.



IS STRESS BAD?

Stress is a response to a set of circumstances that induces a change in aperson's current physiological and/or psychological patterns of functioning forcing him to adapt to these changes. Stress is an inevitable and necessary part of life that adds motivation to life and heightens a individual's response to meet any challenge. In fact, performance of a task will generally improve with the onset of stress, but will peak and then begin to degrade rapidly as stress levels exceed a individual's adaptive abilities to handle the situation.

HANDLING STRESS IN DIVING

Accidents often occur when diving task requirements exceed a diver's capabilities. **A superior diver uses superior judgment to avoid situations, which might call for use of superior skills.** The difference between diver capabilities and task requirements is the margin of safety.

a. Stress is insidious. Stress has a gradual and cumulative effect that develops slowly, so slowly that stress can be well established before becoming apparent. An individual may think that he/she is handling everything quite well, when in fact there are subtle signs that he/she is beyond his/her ability to respond appropriately.

b. Stress is cumulative. A generalized stress reaction can develop as a result of accumulatedstress. There is a limit to a diver's adaptive nature. This limit, the stress tolerance level, is based on a diver's ability to cope with the situation. If the number or intensity of the stressors becomes too great, the diver is susceptible to an environmental overload. At this point, a diver's performance begins to decline and judgment deteriorates.

PERSONAL CHECKLIST

One essential decision point before a dive is whether to go dive in the first place. Establishing a checklist of basic principles that cannot be compromised is one first and fundamental step in making this initial decision and avoiding then a dangerous path with decision leading to compromising safety lately in the dive. This personal checklist should include the fundamental tenets applicable to every dive. Once a diver decides what not to do, the decision on what needs to be done becomes clearer. Consider the following "nevers" as factors that contribute significantly to unsafe dive:

a. **Dive while under the influence of alcohol or drugs, including applicable prescription drugs,** is a never. Several drinks of an alcoholic beverage will influence thought and reaction for approximately 24 hours, while heavy drinking will have lingering effects for up to 36 hours or longer with the addition of dehydration on decompression. Effects from the use of marijuana remain in the system for at least a week. The concept should be obvious that safety is measurably compromised within those time periods. The side effects and duration of all prescription drugs are well documented and available from a local pharmacist, the family physician, a drug addiction agency, or the Surgeon General. Most of the time recreational diving happens during time off, weekends, vacations where people like to relax and maybe drink a bit more, these activities do not match.

b. **Diving with a known medical deficiency.** This is never expedient, while it could be legal certainly could bring dire consequences in a non-permissive environment like underwater.

c. **Diving outside the certified equipment limits** (scrubber duration, sensor expiry dates, depth, gas density). Beyond that, you are in the wilderness and all discoveries could be unhappy experiences.

d. **Diving beyond diver certification/knowledge/experience.** Certification (properly done) means you have experienced the environment in a benign situation under supervision. Divers, before the whole certification paradigm had been put in place, used to build experience with other divers until they felt they had built the necessary experience. You do not know what you do not know. Instructors will provide the training for the diving you are certified to perform. Going beyond those limits or, in general the limits of your experience and knowledge, might bring you in unknown territory both in term of knowledge or motor skills/abilities, which in turn might have serious consequences. Divers might not even understand what they are risking because the do not understand the demands a failure might put on them, do not know the proper response action to an issue or they are unknowingly lacking a piece of critical equipment.If no failures happen they might be able to enjoy great diving, but if they have to cope with a failure they might be beyond their capability to handle the required drill to safely return to surface unharmed. In this circumstances multiple dives with no mishap will reinforce the idea of being able to dive beyond recognized limits and inducing further increase in risk factors: time, depth or overhead penetration just to name a few. This is called normalization of deviance and it would require an article of its own. A very notorious case happened in summer 2015 of a diver (Doc Deep) that experienced several extreme dives (outside recognized limits) without consequences, which kept enforcing the idea that was ok to keep pushing until the fatal one (a world record attempt).

e. **Diving with less than the required minimum gas reserves** (bailout)/failing to plan gas consumption correctly/underestimate own SAC rate. Always have something suitable to breathe is key to survive a dive!

f. **Casual neglect of any applicable checklist** is never justified. A checklist may be larger or smaller; however, certain standards should be established for all dives so that the first decision point is whether or not to begin the dive. This can be the toughest decision. . Diving accident statistics show that divers should be conducting pre-dive checklists on themselves as well as their equipment (CCR).


CAMP

The **I'M SAFE** checklist

1. **I**llness. Do I have any symptoms?
2. **M**edication. Have I been taking prescription or over-the-counter drugs?
3. **S**tress. Am I under psychological pressure from the job? Do I have money, health, or family problems?
4. **A**lcohol. Have I been drinking within 8 hours? Within 24 hours?
5. **F**atigue. Am I tired and not adequately rested?
6. **E**ating/Drinking. Have I eaten and drank enough of the proper foods/water to keep adequately nourished/hydrated during the dive?

Diver impairment contributes to many more accidents than failures of equipment. This version of the "I'M SAFE" personal checklist (See box above) contains all of the most common categories of diver impairment and can easily be committed to memory.

THE DECIDE MODEL
A good tool to use in making good decisions is the Decide Model (see Box).

The Decide Model, comprised of a six step process, is intended to provide the diver with a logical way of approaching decision making. The six elements of the Decide Modelrepresent a continuous loop decision process whichcan be used to assist a diver in the decision makingprocess when he/she is faced with a change in asituation that requires a judgment. This Decide Model is primarily focused on the intellectual component,but can have an impact on the motivationalcomponent of judgment as well. If anindividual practicesthe Decide Model in all decision making, itsuse can become very natural and could result inbetter decisions being made under all types of situations.

The DECIDE model	DECIDE Model Example
1. **D**etect. The decision maker detects the fact that change has occurred.	1. Detect: I am using more gas then expected (this detection presuppose a plan and monitoring the discrepancy between this plan and the actual execution of the dive)
2. **E**stimate. The decision maker estimates the need to counter or react to the change.	2. Estimate: the excess gas I am using was in reserve in case I lost my first deco gas or for my buddy, therefore I need to act
3. **C**hoose. The decision maker chooses a desirable outcome (in terms of success).	3. Choose options: I can go shallower on the wreck rather then visiting to lower parts or I need to end early my dive
4. **I**dentify. The decision maker identifies actions that could successfully control the change.	4. Identify: Best course of action and signal decision to buddy
S. **D**o. The decision maker takes the necessary action.	5. Do: go shallower or abort the dive
6. **E**valuate. The decision maker evaluates the effect(s) of his action countering the change.	6. Evaluate new gas consumption and repeat process

DIVERS' ATTITUDE

Let me repeat: Divers who are involved in accidents generally know what went wrong. Very often, the diver was aware of the possible hazards when he made the decision that led to the wrong course of action. Often in case of fatal accident the diving community recognizes the faulty decisions or the safety rules violation originating the accidents, nevertheless divers are committing the same mistakes over and over (diving sensors beyond dates, overusing scrubber, using non appropriate absorbing materials, wrongly assembling equipment by skipping checklists usage).The box illustrates some recognized dangerous attitude, which lead to faulty decision-making process resulting in less than optimal selection of a course of action. Also in diving, since the field is unregulated or loosely regulated, divers tend to believe that following rules is not really compulsory. While this might be true in term of legal compulsion to follow those, most of the time in dangerous activities, rules (or guidelines) are written in the blood of those who discovered the need of doing things in a certain way in the worst possible way: by loosing their life. Let's make a few points about rules and following them in the diving world.

a. A diver does not have to be a phenomenal one to be prone to disregard the rules that would assure a safe dive. However, a diver should be an emotionally stable person who can accept the fact that he/she is not in possession of all facts or skills for all situations and be willing to accept the recommendations of those who specialize in evaluating, assessing, and defining diving procedures.

b. Reaching a consensus on all matters within the diving community is difficult, if not impossible. The absence of a strong regulatory body makes rule adherence essentially voluntary. Even though the rules and procedures are designed to serve most of the people most of the time, a diver can always argue for different ways of doing things. The immature, emotionally unbalanced diver has strong tendencies to satisfy a personal need regardless of the consequences.

Dangerous Attitudes

a. **Antiauthority** (don't tell me!). This attitude is found in people who do not like anyone telling them what to do. In a sense they are saying no one can tell me what to do. They may be resentful of having someone tell them what to do or may regard rules, regulations, limits and procedures as silly or unnecessary.

b. **Impulsivity** (do something quickly!) is the attitude of people who frequently feel the need to do something-anything-immediately. They do not stop to think about what they are about to do, they do not select the best alternative, and they do the first thing that comes to mind.

c. **Invulnerability** (it won't happen to me). Many people feel that accidents happen to others, but never to them. They know accidents can happen, and they know that anyone can be affected. They never really feel or believe that they will be personally involved. People who think this way are more likely to take chances and increase risk.

d. **Macho** (I can do it). People who are always trying to prove that they are better than anyone else are thinking I can do it - I'll show them. People with this type of attitude will try to prove themselves by taking risks in order to impress others. While this pattern is thought to be a male characteristic, women are equally susceptible.

e. **Resignation** (what's the use?). People who think what's the use? Do not see themselves as being able to make a great deal of difference in what happens to them. When things go well, the person is apt to think that's good-luck. When things go badly, the diver may feel that someone is out to get me, or attribute it to bad luck. The diver will leave the action to others, for better or worse.

c. Some divers break rules simply for the immediate gratification of some emotional need. Even though they may know that this emotional need is not considered a healthy habit (e.g., smoking, speeding, overeating).

d. Existing rules would go a long way to remedy the accident rate; however, personality traits that cause irrational behavior also make divers prone to disregard the rules that would assure safe diving.

HAZARDOUS ATTITUDE	ANTIDOTE
Antiauthority: Don't tell me	Follow the rules. They are usually right
Impulsivity: Do something quickly	Not So Fast. Think First
Invulnerability: It won't happen to me	It could happen to me
Macho: I can do it.	Taking chances is foolish
Resignation: What's the use	I'm not helpless. I can make a difference

e. When a diver exhibits one or more of the five hazardous attitudes or irrational behavior, that diver may also be exposing any emotional weaknesses in his/her personality. While this should be a clear hint to the diving instructor to advice the student or even deny certification, it also constitutes an alarm bell for a diver himself.

RISK MANAGEMENT

Risk is the combination of the **P**robability of an event happening and the **D**amage that occurrence can cause. The product of this 2 factor is called the PxD evaluation of risk. Probability goes from zero to one. Zero the event cannot happen, one means it will happen for sure. The damage goes from nil to death (or maybe multiple deaths). Therefore we do not really care about the amount of damage an event that has zero probability to happen will cause. Also we do not care about the probability of an event that does not cause any damage. In the first case it cannot happen in the second we do not care if it does. We need to work on limiting damage of events that can happen or to lower their probability. Or both. This is the essence in risk management.

Before working on mitigation measure (lowering damage) or prevention measure (lowering probability) we need to identify the risk areas. There are 4 risk elements involved in diving: The Diver, the Equipment, the Environment, the External Pressures.These can be committed to memory with the DEEP acronym:

a. **D**iver: consider factors like fitness to dive, training, experience, recent experience, fatigue, mental state, etc.

b. **E**quipment: right kind and amount, maintenance status, suitability for intended use.

c. **E**nvironment: day vs night dive, low visibility, overhead environment, depth, current, water temperature, sea state.

d. external **P**ressures: peer pressure, motivation to execute a dive (establishing personal depth records is never a good idea), finding ourselves in a boat with others and finding out the condition are bad and nobody wants to be the first to call off the dive, etc.

An example of an analytical methodology is represented in the following table. This method is not a substitute of good judgment but is a way to guide the attention to possible trouble areas. Also and foremost will help focus diver's attention to the combination of factors, which one at the time might not represent an issue but all together, since stress is cumulative, might represent an issue when faced with the need to cope with all at the same time.

The evaluation items and the scores are based on personal experience of the author, the table is only intended to be an example of the methodology and might be too complex for day to day diving, but spending a little time during the planning stages might provide insight on the safety level of the intended dive. It might be a good way to manage risk on live aboard, dive clubs and dive operator and provides a way to show that you applied due diligence in marshaling a dive.

CONCLUSIONS

Diving is an activity taking place in hostile environment which does not sustain human life, therefore survival is heavily dependent upon correct use of equipment (which is to be considered life support equipment) good decision making and skills.

Safety is a mind set, opting for the safer course of action rather than the preferred one, taking no shortcuts in training and maintenance, requires good mental discipline and strong will to adhere to principles.

This paper's objective was to show to the diving community some (or most) of the methods in use in aviation, which has been pioneering, within flying safety in the disciplines of accident analysis risk management and decision making.

These tools together with strong formal training and recurrent training have brought down incident rates in aviation, especially human factors related. My hope is that, one day, the same reduction of fatal incidents could be achieved in diving, maybe making life insurance for tech divers available/affordable.

REFERENCES

US Department of Transportation – Federal Aviation Administration – Advisory Circular AC 60-22 dated 13 December 1991

Irvin N Gleim – Garret W. Gleim – Pilot Handbook – Gleim Publications 9th Edition – Study Unit 6: Aeromedical Factors and Aeronautical Decision Making

	DIVING RISK MANAGEMENT MATRIX						
	Risk Level	1	2	3	4	5	Rating
	Diver						
1	Experience (Related to the planned dive)	Expert (more than 200)	Good Experience (more than 100)	Practitioner (more than 50)	Trained (more than 10)	Untrained	
2	Recent diving experience (90 Days)	More than 50	24 to 49	10 to 23	1 to 9	no dives	
3	Emotional Condition	Excellent	Good	Average	Poor	Unacceptable	
	Equipment						
4	Air Reserves	Exceed Requirements		Meet Requirements		None	
5	Redundancy	All equipment redundant (I have a backup for everything and I know where it is and how to use it)	Only critical Equipment is redundant	I have some backups but no redundancy (i.e. octopus on single first stage)	I have all I need and no more	I am missing some bits, but I never use them anyway	
6	Maintenance staus	Excellent	Good	Close to expiration	Will be expired by the time I finish diving	Something expired or beyond usage dates	
7	Experience with this equipment (CCR v/s OC or usage of a DPV ... etc)	Expert (intimately familiar with all equipment and used in multiple recent dives	Good Experience but little recent experience/usage or recurrent training (drills)	Trained but little or remote experience and no recurrent training/drills ever performed	Only trained but no usage or drill performed after initial training	No training	
	Environment						
8	Planned Depth	Well within experience and recent experience	Well within experience	Near or at certification limits	Near or at certification limit with little experience	Exceeds certification limits	
9	Water Temperature	Confortable	Cold but I have enough protection to stay warm during entire dive (included deco)	Cold but I will be ok, maybe a bit hand and feet cold during deco	Very cold and I will need to move during deco to stay warm	Insufficient thermal protection: I doubt I can stay warm today	
10	Visibility	High I have no doubt I can see my buddy if we separate and can navigate only by visual references	Fair I have to stai close and better know how to use/have a compass	Low (less than 3m 10 ft) and familiar and equipped with/for conditions	Possible brown out/silt out and I am familiar and equipped	Possible brown out and unfamiliar untrained unequipped	
11	Overehead (only if trained)	No overhead whatsoever	Penetration of a single wide open ambient with no additional connection with others	The cavern zone	Cave/wreck	Untrained for overhead	
12	Surface support	Full, competent and equipped	Suitable for the need	Some available	None required	Required but not available	
13	Decompression	None	Some	One gas change	Long and with multiple gas changes or rebreather	Loss of any gas might result in need to abbreviate deco or insufficient bailout	
	Pressures						
14	Alternate Dive available	There is plenty of dive sites to see: if the planned one is unavailable I will dive another			This is my last chance to dive this site	I have to dive here today	
15	Peer pressure	None	Well planned and within experience but onsite conditions worst than expected		I am uneasy with this site/conditions, but everybody wants to dive here	Come along you will be ok: we dove this site in worst conditions	
16	Expedition Pressure	We already dove all the sites of this trip and achieved all objectives	There are a few dives to complete objectives but well on schedule and confident to complete	We on a tight schedule to complete the objectives	We will not complete all the objectives of the trip	We have to make this dive otherwise we will have wasted this trip	
	Additional/personal factors						
						Total Risk rating ->	
	Risk is within normal parameter. Diving is inherently risky. Do not take unnecessary risk and adhere to you personal limits in order to stay within your training and experience						16-32
	Elevated Risk. Dedicate extra time to review contingency plans, available gas, surface support and site conditions. Delay or replan the dive. Be extra careful with those around you and their mental status (signs of stress, voiced concerns) and competency equipment of surface support. Be very careful not to violate any personal limit and ensure your team mates do the same.						33-55
	High Risk. Any 5 should be reason to abort the dive: these are already in a 'never do that area'. Dedicate extra time for planning and review contingency plans, consider a team review and consult a more experienced diver if available (maybe discuss your plans with your instructor). Examine methods to reduce the risk to the extent possible. Consider making training dives before executing this plan. Split dive objectives in multiple dives.						56 and above. Any 5