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### **Human Factors Systems Safety - Australian Skydiving.**

This report is in response to a request received from the Sports and Recreation Section to consider Human Factors (HF) issues associated with recent accidents. To investigate whether HF principles can make a contribution to increasing the safety of the sport.

This report is divided into 3 parts

- Part 1. Introduction.  
Aims and Objectives  
History and the role of the Australian Parachute Federation.
- Part 2. Definition of Human Factors.  
Personality - Organisation and Culture.  
Safety – a cultural norm within the sport.  
A systems approach - building a Taxonomy.
- Part 3. How can HF make a contribution to the Safety outcome.  
A systems Approach – building Taxonomy  
General Observations.

## Introduction.

Sport parachuting from aircraft is a *competitive and recreational* activity, enjoyed by participants of both sexes and all ages in 118 countries. Almost any adult of reasonable health can sign up for a skydiving course or a tandem jump and more than 5.77 million jumps were made worldwide during 2002 (International Parachuting Commission, 2003).

In 1992 - 94% of known parachuting fatalities in the world happened with the jumper still having at least one good parachute on his/her back (International Parachuting Commission, 2003) It may be reasonable to assume that under such circumstances many could have been prevented. As most of the Australian cases died with equipment capable of saving their lives, this *may* suggest that the human factors issues should be critiqued and evaluated. Human Factors needs to be integrated into the safety equation. In that sense I may be able to suggest is a methodology, a different way of analysing the problem and collecting and assigning information which incorporates the human dimension.

I should comment that as a non parachute person- I have relied on technical specialist advice from colleagues in CASA.

### Aim.

The Aim of this Human Factors (HF) study is therefore to;

- To consider how the application of Human Factors principles may contribute to safety improvements.
- To contribute to the safety record of the Parachuting Community.
- To communicate and implement outcomes/recommendations throughout the Parachute community.

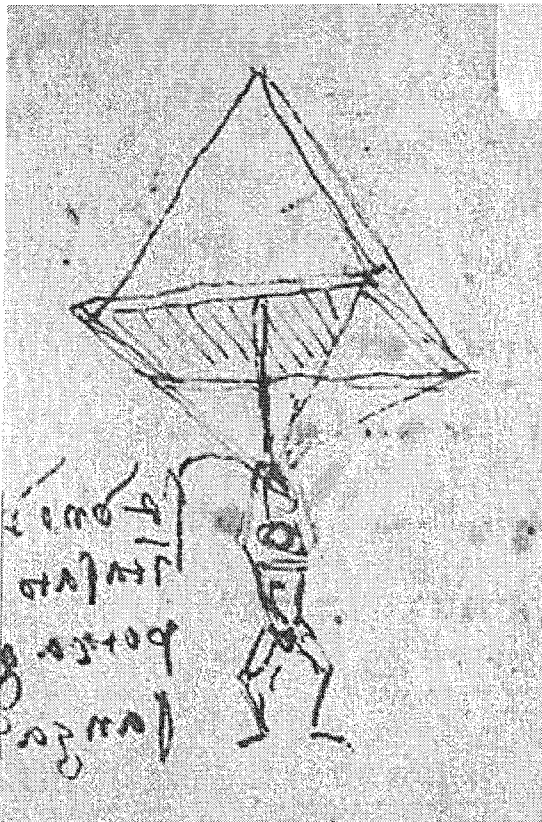
### Objectives.

- The Aims of the project will be achieved through;
- An evaluation of the culture and behaviours, which exists in the Sporting Parachuting community and which may contribute to occurrences and/or accidents.
- Gathering information (Non Technical) associated with recent parachuting accidents through discussions with CASA specialists and Industry grps
- Validate/critique such information and draw any common HF causal relationships if possible.

It is important to note that this is **not** an investigation. Such investigations are carried out by colleagues at the ATSB. This is a response to a request to provide support to our colleagues in the Parachuting community, to see if the application of HF principles can make a contribution to safety in the sport.

### **Brief History.**

*The history of parachutes dates back to medieval days. Evidence found in the*



*historical archives of Peking, China, and translated by the French monk, Vasson, indicates that parachute-like devices were used as early as the 12th Century. Stories relate that some form of parachute was used during circus-type stunts arranged to entertain guests at Chinese court ceremonials. The relation between the umbrella, known to have been invented by the Chinese, and this early device appears obvious.*

*The first known pictorial evidence of the drag principal appeared in the sketchbook of Leonardo da Vinci in 1514. The device pictured was a pyramid shaped structure by means of which, the sketch implied, a man might leap from a tower or burning building without greatly endangering his life. However, as far as is known, da Vinci did not reduce his sketch to practice.*

*Other historical Characters eg In 1595, Fausto Veranzio, a Hungarian mathematician, the experiments of the*

*Frenchman, Joseph Montgolfier, who, late in the 18th century, began to put some of the "then current" scientific findings to practical use. A contemporary of Montgolfier, Sebastian Lenormand, successfully attempted a demonstration of the parachute concept by descending with the aid of a parachute-like device from the top of the Montpelier Observatory in Paris. The first recorded emergency landing by parachute was not made until 14 July 1808 when the Polish aeronaut Jordaki Kuparento descended safely from his burning balloon over the city of Warsaw. The advent of the airplane, however, changed this situation quickly.*

*Thus, the advent of the airplane caused the launching of a series of scientific experiments to make the parachute more airworthy and led to the deployable aerodynamic decelerator of today.*

*When World War I began in 1914, very few crew members of balloons or airplanes carries parachutes. The Germans were probably the first to appreciate that a pilots or crew member's life must be saved in case of emergency, and that the parachute was the means to accomplish this.*

*An Australian pilot made the first escape by parachute from a disabled plane, on the Russian front in 1916. Three months later, another Australian pilot made a safe escape from another disabled plane. By 1917 the parachute had proven itself, and both Germans and English were equipping their air forces with these life-saving devices. By the summer of 1918, parachutes were in wide use on all fronts.*

*British, Canadian, US and Polish Parachute troops dropped into combat on 6th June 1944 – Operation Market Garden - the battle for Arnhem in Holland in advance of the massive seaborne invasion of France and later jumped into Germany during the attack at the Rhine.*

*The use of parachutes continued post WW II as a mass military transportation media. During the Korean conflict the Americans, as part of the United Nations Force, carried out a mass airborne drop in South Korea. In May 1954 the French used vast numbers of paratroops in a (heroic) attempt to relieve their besieged garrison at Dien Bien Phu in French Indo China.*

*During the 1956 Middle East crisis, British and French paratroops combined to form an airborne assault force against Egypt in an effort to capture the vital Suez Canal.*

*In 1968, in South Vietnam, the United States Army carried out an airborne attack involving 800 paratroopers to gain a positional advantage over opposing North Vietnamese forces.*

*Since the first parachute jump, the parachute has developed into not only a sophisticated military vehicle but also a sport for civilian enthusiasts. Improvements in design and functional qualities continue in a never ending challenge to meet the requirements of new aeronautical advancements.*

## **THE AUSTRALIAN PARACHUTE FEDERATION**

*Prior to 1958 either barnstorming display jumpers or military paratroops carried out all parachuting in Australia.*

*In 1958, two safety equipment workers at Williamstown Air Force Base decided to make parachute jumps outside of their working environment, just for the fun of it. Those few weekend jumps made by Jack Stevens and Allan McDonald were the birth of a sporting activity that now sees more than 70,000 first parachute jumps per year.*

*The first meeting of the Australian Parachute Federation was held on Sunday 23rd of October 1960 at the Camden Inn Hotel in New South Wales. The Department of Civil Aviation forbid parachuting except with the written permission of the Director General of Civil Aviation and so initially, the Federation was needed to negotiate a more equitable right of access to the air.*

*Within a few years it became obvious that the Federation would have to involve itself in the safety aspects of parachuting or face being regulated out of the air. Early fatal accidents were at an unacceptable level and so the Federation embarked on a program to improve safety regulation, implement safety education and instruction standards. These programs were so successful that the number of fatal accidents has decreased considerably while the number of parachute jumps made has increased 100 fold.*

*Skydiving (controlling one's body in free fall) was embraced by Australian parachutists during the sixties and soon after the first baton pass was made, Australia led the world until the end of that phase.*

*Since then Australian skydiving has continually remained at a very high standard. The introduction of the glamour skydiving events of the nineties, freestyle skydiving and skysurfing, saw Australian skydivers embrace it and immediately start winning international medals. As skydiving moves into new disciplines they will no doubt be there at the cutting edge of the sport.*

### **The Australian Parachute Federation today**

*"The Federation exists to administer and represent Australian sport parachuting; it aims to achieve these goals by promoting and maintaining a high level of safety, and by improving the standard of sport parachuting by encouraging participation and excellence in performance."*

*The Federation is located in Canberra and has volunteers at the State and local drop zone level.*

*It is affiliated with the Fédération Aéronautique Internationale (FAI) through the Australian Sport Aviation Confederation and has close links to the FAI Parachuting Commission, the Parachute Industry Association, and is contracted to carry out safety and surveillance duties for the Civil Aviation Safety Authority and assist Airservices Australia with airspace management.*

*Duties include:*

- *Promulgation of safety regulation in relation to sport parachuting;*
- *Promulgation of parachute instruction regulation and the implementation of the parachute instructor rating examination and rating system;*
- *Promulgation and implementation of a parachute rigger/packer examination and rating system;*
- *Administration of parachuting competitions at all levels;*
- *Administration of parachuting competition coaching at all levels;*
- *Promulgation and implementation of a parachute competition judges examination and rating system;*
- *Production of educational material for all areas of sport parachuting;*
- *Promotion of excellence in all sport parachuting endeavours;*

- *Promotion of sport parachuting and the correction of erroneous public impressions about sport parachuting;*
- *Supply insurance to members as directed by the APF Board.*

*An above short history taken from <http://www.apf.asn.au/ashorthistory.aspx> the Australian Parachute Federation website.*

This exercise is therefore intended to combine the efforts of the APF, their charter and CASA responsibility to assist Industry initiatives on safety.

## Part 2.

### Definition of Human Factors.

Human Factors is about people in their living and working situation; about their relationship with machines, with systems, procedures and with the environment about them; it is also about their relationship with other people.

One definition of Human Factors,

“Human Factors is concerned to optimise the relationship with people and their activities, by the systematic application of human sciences, integrated within the framework of systems engineering” Professor Edwards.

Its objectives can be seen as “effectiveness of the system”, which includes safety and efficiency and the well being of the individual. It is also about the communications and the interactions between individuals and groups.

Human Factors is multi disciplinary in nature. It draws on information from psychology to understand how people process information and make decisions. It draws on physiology to understand the sensory processes as the means of transmitting information on the world about us.

### Personality types and Culture.

In the process of preparing this report and considering the issues involved, it was suggested to me that Parachutist manifested certain behavioural traits and that those behaviour traits may have contributed to the accidents.

Without empirical data I have reservations about behavioural trait generalisations; in terms of socio economic backgrounds, participants come from the full socio economic spectrum of Australian society. Given such diversity of backgrounds it is therefore reasonable to assume that the full spectrum of behaviours will be represented.

Equally I would suggest, “drilling down” and considering the traits of those individuals who are directly involved as professionals and committed to the sport, who are experienced and competent, the same outcome may result – a wide diversity of backgrounds and motivations and therefore a wide diversity of personality types will be represented.

Given the composition and diversity of the backgrounds of participants in the sport and to then extrapolate this into some predictor of behaviours - beyond *general assumptions* - is questionable.

Therefore as a *general assumption*, it may be reasonable to suggest that participants are characterised as being - risk takers, thrill seeks he/she likes, enjoys excitement, and may be generally impulsive; an outgoing optimist, active and lively person, social, cheerful, and talkative and adventurous personality types.

*If* this general summary is reasonably accurate it may provide an insight into how people will approach the whole experience and just *may* give us an insight into the associated behaviours.



## **Safety as a cultural norm within the sport.**

Before progressing it might be useful to define the concept of culture; there are a number of definitions – one definition is “the rules and regulations which govern a society” – in short “the way we do things round here”

Why is it important to know the culture of a organisation or society? All associations and institutions have a cultural dimension which influences behaviour, and the Parachute Federation is no exception. The power and influence of culture in any organisation should never be underestimated. It is always pervasive. If the organisation has a “*safety culture*”, a *norm of behaviour*, then it is likely that it will permeate to all levels of the organisation. Equally, if safety is a peripheral issue, then it is likely it will be treated as such by all members.

To gain an insight into the cultural norms of the Federation prior to attending conference, I read the magazines and publicity materials. This provided some limited information later built on by conference attendance. Reading the Australian Skydiving Magazine and other materials, my impression is that this is a very exciting sport; it offers the ultimate experience; it places the individual in harms way; it confronts safety margins; the *risks are off set* however by quality kit, individual competence, know how and situational awareness. *(In many respects it is the ultimate educational competency experience, in the sense that it provides participants with instant competency feedback particularly if things go wrong).*

Throughout my conversations with conference participants and Federation members, the issue of safety was constantly referenced. I would also suggest this is reflected in the APF (Australian Skydiving Magazine) with each copy having section called “Safety Matters”.

From the groups I have observed at the Melbourne conference, the APF enjoys a sociological environment where robust, frank and fearless discussions on issues are the norm. In such an environment, the imposition of a system and or process which members may not be comfortable with or that have not been fully explored or tested to their satisfaction would not be acceptable.

In such a cultural environment, the probability that an individual would or could dominate the parachuting community and impose sub safety standards would seem unlikely.

This combination of individual behaviours, combined by well managed open forum discussions, I would suggest is part of the strength of this *self administered* Federation.

In summary, overlaying individual participants out going and adventurous personalities and the cultural norms of the Federation, *safety is never a peripheral activity*, it is always front of mind.

## Part 3.

### How can Human Factors make a contribution to the safety outcome?

In answer to the above question, the Human Factors perspective may see the experience or event somewhat differently.

To assist our research could I suggest a more system approach - in the sense that the event/or experience is simply a number of interacting systems all of which must link effectively and efficiently, *first time, every time*.

The parachuting experience is a system experience, dependant upon a series of holistic systems, interacting. If that is the case, the Reason framework might be useful.

Prof James Reason – Prof of Psychology from the University of Manchester in the UK - devised the Swiss cheese model (or framework) for analysing incidents and accidents. He argues that incidents/accidents are seldom, if ever, the result of *one single event*; in fact he suggests they are more likely to be the result of a *chain of events or behaviours*. In short, when the holes in the Swiss cheese slices line up, our defence mechanisms have been breached and *an incident/accident may result*.

Implicit in the framework is that systems are holistic, in that they all have a series of interlocking parts.

### A Systems Approach.

To assist the process I have therefore broken the overall experience of the jump down into four systems parts;

1. The preparation for the jump
2. The Aircraft and the Flight crew.
3. The Jump itself.
4. The landing.

This *four parts approach* provides a framework for analysis. Equally, each one of these parts will have a range of sub sections.

To enable us to consider the associated human factors matters specifically, I would suggest that the first step is to construct a *task inventory for each of the systems parts*, then to list the knowledge, skills and competencies required to perform the task, and finally the attitudes/behaviours required to ensure a safe outcome. (*I fully appreciate that much of this is already done*)

In summary, each of the systems components will therefore have four elements

- The task - including roles and responsibilities.
- The knowledge – eg the general principles/physics of parachuting.
- The associated skill and competencies which participants *must master*.
- The underpinning attitudes and behaviours essential to ensure the experience are safe and enjoyable, each time every time.

## **A Taxonomy.**

This method will provide a taxonomy, (a classification method), a framework which in turn will enable us to populate with data/information as and when we receive feedback concerning occurrences. In turn this will also enable us to associate problems/difficulties with particular parts of the four systems process - critique a system and maybe provide information about the weaknesses of a system – those areas where additional skilling, training and behaviour modifications may be necessary. This should then enable us to discriminate between technical malfunctions, operator errors and human behavioural matters.

A number of points associated with the taxonomy;

- Data and information is not the same thing. *Information*, which is useful and relevant and which can be acted upon, is the *product* of the *interpretation of data*. Good *data* followed by analysis can provide quality *information*). In this instance it will assist a better method of collecting data and therefore producing information.
- For it to be reasonably proactive this should be an ongoing activity with *occurrence* information gathered from the Drop Zone Safety Officer (DZSO), the Jump Master (JM) and the Ground Control Officer (GCO). The intended outcome of building this taxonomy is to provide the Federation and CASA with a *focus* as to where skilling/remedial actions are necessary within the overall system eg additional training may be required.
- All organisations have limited resources and it is therefore important to diagnose the point of weakness of a system and therefore focus actions/expenditures in the right place
- I appreciate populating such taxonomy may take time but this need not be complicated or difficult to compile. Completing a simple template, menu driven, will be sufficient.
- However, the process of building the framework requires inputs from participants. The framework also requires a reasonable degree of specificity, the range of associated tasks. Once we have that, we can align the person to the system *and only then* consider the appropriate relevant behaviours (Human Factors)

- Building this type of taxonomy will also enable us to factor in weighting factors. In *all* systems some parts are more important than others – eg. the consequence of non performance in this area will result in death, maiming or injury. Knowing that, will dictate the emphasis placed on acquiring knowledge, skills and the supporting behaviours. In short understanding the critical tasks/items will dictate the approach to Human Factors issues.
- If it is done well, it should provide a methodology for continuous improvement in terms of safety matters.

Given the nature of the parachuting experience, and the nature (and/or my *very* general comments about the personality traits) of the people who participate in parachuting, I would suggest it is important that participants in the sport understand *the whole system* and their functions and responsibilities within the system(s).

As I have said, Human Factors is about;

- how people interact with systems,
- processes
- with their peers and colleagues
- Tools or Kit

The human dimension is therefore as important as the Technical dimension. Understanding how people interact with their kit, their peers and within the cultural norms of their association.

### **Application of the taxonomy.**

Using the recent tragic accidents at Nagambie - as examples and applying the events to the taxonomy;

1. *It would seem that the only collocation one can conclude with certainty is one of geography. The accidents have occurred in two places - York and Nagambie. There would appear to be no other consistent causal factors. Therefore there would appear to be insufficient data to yield a general trend.*
2. *Nevertheless, having said there was no common, consistent causal factor(s), I would suggest there may be things which we can learn from the accidents. I would also suggest that the proposed taxonomy enables APF to focus in on a particular part of the system and improve it*
3. *e.g. issue 27 Aug/Sept/Oct 06 Interim Fatality Report page 45; appreciating this is only an interim report and I use it as a possible example only – it could be that instability recovery issues, combined with sensory overload with inexperienced jumpers, needs to be addressed in greater depth.*
4. *Unlike Flight simulators, where Pilots can practice recovery of a situation in a totally realistic environment, less the catastrophic result, this option is not available to the parachutist. This may therefore be an argument for greater skilling and awareness training for individual parachutists.*

From an oversight perspective dividing the parachuting experience into these four parts enables a more systematic methodology of process/systems validation. It also provides a more consistent framework for all operators and regulators to evaluate and analyse occurrences.

In summary, as I have mentioned Prof Reasons argument is that incidents – occurrences - accidents, are seldom the result of just one single event, but more likely to be the result of *a number* of events, including the human dimension, all interacting and resulting in the final occurrence. Building this taxonomy ensures that we have a methodology of gathering data, translating into useful information – (note *data and information at not the same thing*) – assigning it to that part of the system that may need to be re-evaluated and where improvements can be made both in terms of skills and competencies and also behaviour modification. In short it will provide you with a proactive safety tool.

### **Communicating findings and outcomes.**

From a communications point of view, I think it worth emphasising that we must also communicate continuously safety improvements. (*Not to incorporate our findings – information - into practical improvements into the safety equation, will simply result in our efforts remaining an academic exercise*).

From a adult education point of view, most adults contextualise information; where does this piece of information fit in relation to the *system* and assist me in what I want to achieve; how is this information going to help me achieve my goal?

It seems that for most of us, when we have a “road map of a system” our ability and motivation to learn and understand is improved significantly. It seems we (adults) are not good at working in an intellectual vacuum.

I think it worth emphasising at this stage each of the three groups I spoke to, together with my informal discussions with individuals Federation members, confirmed the extent to which the Federation members go to ensure the all participants have the necessary skills and knowledge prior to making a jump. Messages to participants are continuously re-enforced and confirmed. This is supported by a “dirt dive” which is the practice on the ground of the forthcoming event and with once again message confirmation.

### **General Observations.**

#### **Systems Safeguards**

Once again referencing Prof Reason’s framework, the APF has the added safeguard (defences) in that their own safety committee also needs to approve a change in activities, process or system.

I appreciate in making this general observation the committee makes recommendations to the board – which can equally reject such recommendation – in short a safety barrier.

## **The role of the Safety Manager for the Federation.**

Given the nature of the activity as parachuting, the role of the APF Director Safety is important. From a technical point of view not only is it important for such a person to be very competent, experienced and therefore he/she enjoy the respect of colleagues in the parachuting community, the reputation and credibility of the person communicating the safety message directly substantiates the importance of the safety message itself. *The APF is therefore very fortunate to have Graham Lee as the current Director Safety.*

## **Decision process on Safety Equipment.**

As a general observation I found attending the safety committee meeting to be very worthwhile. I would suggest the process of safety equipment evaluation may need to be re-considered. Eg the issue of buoyancy vests, life preservers was discussed. However, I was unable to establish what criteria the evaluation was being measured against – there did not appear to be any agreed criteria - workshop attendees were being asked what they thought in terms of one piece of kit relative to another.

I would suggest in the light of market demands for beach DZ's, for both tandem and individual jumpers, and the loss of life through drowning's (reference the Swedish report) a more rigours methodology of kit evaluation may be appropriate. (Criteria referencing).

## **The Economics of Skydiving v Safety.**

From a safety perspective, the economic argument overshadowing the safety requirement needs to be carefully considered. Sometimes it is worth noting that compromising safety may not only damage the reputation and business of an individual operator, it may also reflect on the safety of the overall sport and consequently reduce market demand for the activity. The Aims of the project will be achieved through;

## **Conclusion.**

From a Human Factors view point it is difficult to draw any common consistent trends in terms of behavioural modifications which may be required. There is simply insufficient data to draw such conclusions.

The Parachuting community, the Australian Federation members, are very aware of the safety imperative. This was a constant theme in discussions and debates.

In terms of CASA role in providing Industry with assistance, we have suggested a way of collecting and assigning occurrence information which may provide early recognition of a systems weaknesses and therefore enable Federation to be proactive in terms of skilling and training should that be necessary.

## **References.**

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- APF Annual Report 2005.
- Glider Accidents 1999-2001.
- Psychology and Management Cary L Cooper.
- Briefings – Reference Manual. Human Factors Cr for Pilots and Av Professionals.
- Focus Grp meetings. Could I express my appreciation for the inputs from the Melb Conference participants.

# A Systems Approach to Parachuting

To assist the process I have broken the overall experience of the jump into four systems parts:

