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PERCEPTIONS OF RISKY FLIGHT BEHAVIOR AMONG AIR FORCE PILOTS[1]

PERCEÇÃO DOS PILOTOS DA FORÇA AÉREA PARA OS COMPORTAMENTOS DE RISCO NO VOO

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Abstract

The aeronautics sector has witnessed a marked evolution, with a significant reduction in the number of accidents. Nevertheless, studying this topic continues to be crucial since most accidents are caused by human error, which includes pilots' perception errors. The Air Force (PoAF), much like the rest of the aviation industry, sees flight safety as a critical issue and makes serious efforts to address it by striving to foster a safety culture and provide world class training to its pilots. To that end, this study used a sample of 103 officer pilots (53.7% of the universe) to analyse risk perception and flight safety behaviour among Air Force pilots. The study used a deductive reasoning methodology, a quantitative research strategy and a case study design. The data were gathered using two questionnaires, which the author translated into Portuguese and adapted to the Air Force context. The results revealed that, in spite of the differences in the means observed in groups with different operational experiences, Air Force pilots generally assess risk in an appropriate, homogenous manner, and have a positive (self-) confidence and safety orientation.

Keywords: Perception, Risk, Safety Behaviour / Attitude, Aviation.

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[1] Article adapted from the individual research work carried out in the 2018/2019 Field Grade Officers Course (2nd edition). The defence took place in July 2019 at the Military University Institute.

Resumo

O sector aeronáutico tem protagonizado uma acentuada evolução, com assinalável redução na taxa de acidentes, continuando, ainda assim, a afigurar-se crucial o estudo desta matéria, considerando que grande parte das causas dos acidentes estão relacionadas com falha humana, como seja erro de perceção dos pilotos.Esta temática reveste-se de extrema importância para a Força Aérea (FA) que, sintónica com a demais indústria aeronáutica, encara esta problemática com grande seriedade, apostando na promoção de uma cultura de segurança e na formação, de excelência, ministrada aos seus pilotos. Pelo referido, foi objetivo deste estudo analisar a perceção de risco e o comportamento de segurança em voo dos pilotos da FA, numaamostra de 103 oficiais pilotos aviadores (53,7% do universo).Baseado numa metodologia de raciocínio dedutivo, alicerçada numa estratégia de investigação quantitativa e num desenho de pesquisa de estudo de caso, os dados foram recolhidos através de dois questionários, traduzidos para português e adaptados para o contexto da FA pelo autor. Os resultados revelaram que, apesar das diferenças de médias verificadas entre grupos com diferentes experiências operacionais, a generalidade dos pilotos da FA avalia o risco de forma homogénea e ajustada, e denota uma positiva (auto)confiança e orientação para a segurança.

Palavras-chave: *Perceção, Risco, Comportamento/atitude de Segurança, Aviação.*

1. Introduction

Safety is one of the most important aspects of aviation. Since the early 20th century, progress in aircraft design has been accompanied by new ideas and regulations that aim to make aviation safer (Stahl, 2016).

Despite the fact that this progress has almost always been reactive – and, unfortunately, usually attained at the cost of the lives of the victims of aviation accidents – its existence is undeniable and its positive impact on safety is reflected in the assertion that flying is the safest means of transportation (Janic, 2000, p.7).

Between 2000 and 2012, the aviation sector saw a significant improvement (42%) in the accident rate (Herman, 2012, p.1), which has since fallen to half (ICAO, 2019) and is now at the lowest ever (Herman, 2012, p.1). This encouraging decline stems from the manifestly positive way aviation regulators have responded to the challenge of further improving the safety of an industry that was already remarkably safe (Shappell, Detwiler, Holcomb, Hackworth, Boquet, & Wiegmann, 2006, p.5). However, this decline is still cause for concern as 70% to 80% of aviation accidents are caused, at least in part, by human error, which includes perception errors by the pilots (Wiegmann, & Shappell, 2003, p.4).

Risk is ubiquitous (Hunter, 2002, p.4) and a part of all human activities (Luhmann, 1993, p.28; Wiener, & Rogers, 2002, p.4). Naturally, some activities entail greater risks than others. This is the case of aviation, wherepilots substantially underestimate these risks, despite the fact that everyone is aware of them (O'Hare, 1990, cited in Hunter, 2002. p.4). Underestimating risks (much like overestimating them) will invariably result in various types of hazards (Ji, Yang, Li, Xu, & He, 2018, p.2), which are an important factor in aviation accidents (Hunter, 2002, p. 6; Ji, You, Lan, & Yang, 2011, p.2).

Therefore, correct risk perception entails not only making accurate assessments about the environment (external dimension), but also about one's personal capacities (internal dimension) (Hunter, 2002, p.6). It is by combining these two dimensions (external and internal) that pilots make decisions about the safety of the aircraft, and incorrect assessments about either of these two factors lead to poor decision making (Hunter, 2002, p.4) or even to inaction because if pilots are not aware of a risk, they cannot take measures to avoid or mitigate it, which can ultimately lead to aviation accidents (You, Ji, & Han, 2013, pp.2-3). Risk perception is thus an antecedent of behaviour (C.P.Fachada, orientation meeting, 8 March 2019), and there is an influence relationship between the risk perceived by pilots and their (subsequent) behaviour during flight, that is, between pilots' perceptions (internal and external) and the way they fly the aircraft.

Furthermore, there is a direct relationship between risk perception and safety attitudes, that is, accurate risk perception is directly proportional to safety attitudes (Ji et al., 2011, p.6). Safety attitude is defined as something that is (previously) learned, which influences the way a person will (predictably) think or behave (Wilkening, 1973 cited in Joseph, Verma, & Chandana, 2012, p.3).

Naturally, both the Air Force (PoAF) and its pilots are aware of these issues and devote considerable efforts to ensuring flight safety and building a safety and accident prevention structure (RFA 330-1, 1999), with good results so far (Marado, 2017, pp. 2-15). Nevertheless, accidents still continue to happen, and every effort must be made to reduce or (ideally) eliminate them.

Bearing in mind that the relationship between safety training and safety behaviours has been confirmed by several studies (Jamal, 2008, p.42; Mukherjee, Overman, Leviton, &Hilyer, 2000, p.1), the PoAF has understandably invested in courses that cover such topics, such as the Crew Resource Management (CRM) course and the Flight Safety Course (FSC). However, behaviours have multiple causes, so it is necessary to analyse other variables associated with safety behaviour among pilots (DRDC,2010, p.27), such as the accumulation of flight hours / experience (which is associated with heightened risk perception and safety attitude).

The topic of this study – *Perceptions of risky flight behaviour among Air Force pilots* – is both current and highly relevant to aviation in general and to the PoAF in particular, as the organization can use the study's findings to improve its flight safety policies.

This study focuses on risk perception and flight safety behaviour among Air Force pilots, and the study is delimited (Santos, & Lima, 2016):

– In terms of time, to the present day;

– In terms of space, to military pilots assigned to an Air Unit;

– In terms of content, to risk perception and flight safety behaviour among Air Force Pilots.

The general objective (**GO**) of this study is *To analyse risk perception and flight safety behaviour among PoAF pilots*, and its specific objectives (**SO**) are:

SO1: To assess risk perception among PoAF pilots;

SO2: To analyse flight safety behaviour among PoAF pilots.

These objectives are contained in the research question (**RQ**), *How do PoAF pilots perceive risk and what are their flight safety behaviours?*

2. Theoretical and conceptual framework

This chapter contains the literature review, the key concepts and the analysis model.

2.1. State-of-the-art and key concepts

This section will present the key concepts of the theoretical framework on which this study is based.

2.1.1. Risk perception

The etymology of the word risk is uncertain and the term is often used with different meanings in different contexts (Luhmann, 1993, pp.9-10).

Although the concept of risk has been widely studied from various perspectives (Drinkwater, 2014, p.24; Slovic, & Weber, 2002, p.3), researchers have yet to agree on a definition (Renn, 1998, p.3).

Moreover, the concept was created by human beings to help them cope with life's dangers and uncertainties (Slovic, & Weber, 2002, p.5). These uncertainties stem from human beings' manifest inability to accurately predict their future (Wiener,& Rogers, 2002, p.4). It is the reason why all definitions of risk refer to something that might happen, that is, to a future probability (Drinkwater, 2014, p.24).

Therefore, risk is operationalized both as the likelihood that a human action or event will affect something that a person cherishes (Renn, 1998, p.3) and as the result of the combination of two factors, probability and the harm caused by exposure to a particular situation or activity (Wiener,& Rogers, 2002, p.4).

In the context of aviation, Hunter (2002, p.4) defines risk as the possibility of loss of life or injury (that is, it includes both the possibility and the severity of given hazard), that is, the likelihood of a situation leading to losses (RFA 25-1, 2008). In other words, the possibility of a negative consequence (such as the reduction of a safety margin) in result of a threat (Joseph,& Reddy, 2013, p.2).

Despite these multiple definitions (Renn, 1998, p.3), most authors tend to distinguish between reality and probability, linking risk to the probability that an undesirable event may occur as a result of human action or natural causes.

In regards to **risk perception** – a topic that has interested researchers for several decades – there are several definitions of the concept in the literature (Sjöberg, 2000, p.1).

Although they take different approaches (Hunter, 2002, p. 6; Ji et al., 2011, p. 2; Joseph, Verma, & Chandana, 2012, p.2; Pauley, O'Hare, & Wiggins, 2008, 2), most authors agree that risk perception is an essentially cognitive activity. In other words, recognising the risk inherent to a situation involves not only pilot's perception of the situation but also of his or her ability to deal with it, since only an accurate assessment of these two components will result in correct risk perception (Hunter, 2002, p.6; Ji et al., 2011, p.2; Joseph et al., 2012, p.2).

Although the present study focuses on risk perception among pilots (on a personal level), in the aeronautical context, and specifically in the Air Force, the impact of individuality (i.e. a variability that refers to the fact that risk perception is dependent on personal features) is reduced by the use of risk management tools such as forms/checklists of events/occurrences. Once these forms are filled-out, they are used to estimate the risk associated with a given mission (this estimation is done by the organization, not the pilot).

Returning, then, to individuality, three models were devised to study the complex nature of this phenomenon: the axiomatic model; the sociocultural model; and the psychometric model (Weber, 2001, p.1). The latter is the most influential and cited of the three (Drinkwater, 2014, p.39; Rundmo, & Norfjaern, 2017, p.1) and will be the model used in this investigation.

Slovic (1978, p.2) and Slovic and Weber (2002, p.2) explain that the psychometric model consists of developing a "taxonomy for hazards" that can be used to understand and predict responses to risk. The model's rationale is that risk is subjectively defined by a person and thus can be influenced by a wide range of social, psychological, institutional and cultural factors (Slovic, 2000, p.4). Therefore, this approach involves quantifying risk factors and using them to make predictions and warn people and society to the dangers they are facing (Slovic, 2000, p.4; Slovic, & Weber, 2002, p.8).

Since risk perception is subjective (as mentioned above), correctly assessing risk involves the use of specific scales, which, in the case of aviation – bearing in mind that pilots, due to their knowledge/experience, tend to assess risk differently –, involves the use of questionnaires that describe/assess aviation-related situations (Hunter, 2002, p.7).

Risk perception, more specifically risk assessment, is thus a critical tool in aviation (Ji et al., 2018, p.5; You et al., 2013, p.2), which serves to identify hazardous flight situations and provide feedback on the way pilots process information, which in turn contributes to increased flight safety.

Ji et al. (2018, p.2) observed that pilots involved in fewer accidents/incidents were precisely those who had a more accurate risk perception. Therefore, flight experience is an important predictor of incidents/accidents (Ji et al., 2018, p.5). In the present study, flight experience is operationalized as the knowledge a pilot accumulates throughout his or her career, specifically the training they received (undergraduate pilot training, i.e., in the final phase of the flight course, and any complementary training courses they attended already on active duty, such as the flight safety course), the number of flight hours logged, the operational qualifications they acquired, and the type of missions they perform.

2.1.2. Flight safety behaviour

In aviation, flight **behaviour** in normal operating conditions (that is, on flights where no incidents/accidents occur, *cfr.* Wong, Pitfield, Caves, & Appleyard, 2006, p.1) is defined as the set of actions taken by the pilot during the operation of the aircraft. This includes all concrete actions associated with piloting, such as any time the pilot interacts with the aircraft – by using the controls or any other system –, as well as non-technical actions such as communicating and collaborating with the crew, decision making, workload management and general situational awareness (You et al ., 2013, p.1).

Risk perception (Drinkwater, 2014, p.19; Drinkwater, & Molesworth, 2010, p.2; Hunter, 2006, p.9) and attitude (among other factors) are antecedents or predictors of behaviour, especially flight safety behaviour, or, in other words, risky flight behaviour.

Furthermore, and in addition to the points already addressed, risk perception can be explained by the fact that any situation in which the risk is perceived as being too high will tend to cause people individually or society in general to change their behaviour until the risk is deemed acceptable or even removed (Klinke, & Renn, 2002, p.1; Machin, & Sanky, 2008, p.2).

In one of its many definitions (Åberg, 1999, p.1), **attitude** is operationalized as an enduring organization of motivational, emotional, and cognitive processes related to a specific aspect of a person's universe (Krech, & Crutchfield, 1948, p.152). In other words, it is the result of what a person thinks and feels about a particular object or thing, which may vary in the short/long term, and which influences the way he or she behaves (Drinkwater, 2014, p.54).

In this context, attitude is an antecedent not only of behaviour (as noted above) but also of perception and processing (Albarracín, Sunderrajan, Lohmann, Chan, & Jiang, 2018, p.29; Fazio, 1989, p.2 (Schwarz,& Bohner, 2001, p.2; Sjolber, 2000, p.9).

With regards to the association between **behaviour** and **safety**, which is defined as an action to mitigate risk, safety behaviour is achieved by striving to eliminate hazards, preventing an event from occurring, and/or preparing against negative outcomes (Hollnagel, 2008, p.1).

In the case of aviation, achieving this goal has and will continue to entail combining efforts in various areas, such as advances in aircraft technology, more comprehensive accident investigations, better air traffic control services, advances in pilot training and the fact that increasingly more attention is given to personal factors during training (Hunter, 2002, p.25; Oster Jr., Strong, & Zorn, 2013, pp.1-2).

2.2. Analysis Model

Table 1 contains the analysis model that served as a guide for this investigation.

Table 1 – Conceptual map

<table>
<tr><th>General Objective</th><td colspan="5">To analyse risk perceptions and flight safety behaviour among PoAF pilots.</td></tr>
<tr><th rowspan="2">Specific Objectives</th><th>Research Question</th><td colspan="4">Ho do PoAF pilots perceive risk and what are their flight safety behaviours?</td></tr>
<tr><th>Subsidiary Quastions</th><th>Concepts</th><th>Dimensions</th><th>Indicators</th><th>Data collection techniques</th></tr>
<tr><td rowspan="6">SO1
To asses risk perception among Air Force Pilots</td><td rowspan="6">SQ1
How do PoAF pilots perceive risk?</td><td rowspan="6">Risk perception</td><td>Demanding Operations</td><td>Q7, Q8, Q9, Q10, Q13, Q21, Q23</td><td rowspan="6">Questionnaire survey</td></tr>
<tr><td>Regular Operations</td><td>Q1, Q3, Q5, Q14, Q23, Q26</td></tr>
<tr><td>Driving</td><td>Q11, Q17, Q20</td></tr>
<tr><td>Altitude of Flight</td><td>Q4, Q15, Q24</td></tr>
<tr><td>Trivial Activity</td><td>Q12, Q16, Q25</td></tr>
<tr><td>Serious Safety Failure</td><td>Q18, Q19</td></tr>
<tr><td rowspan="3">SO2
To analyse flight safety behaviour among PoAF pilots</td><td rowspan="3">SQ2
Qhat are the flight safety behaviours of PoAF pilots?</td><td rowspan="3">Flight safety behaviour</td><td rowspan="3">Safety attitudes in aviation</td><td>Self-confidence (Q6, Q7, Q8, Q10)</td><td rowspan="3">Questionnaire survey</td></tr>
<tr><td>Risk orientation (Q3, Q5, Q11)</td></tr>
<tr><td>Safety orientation (Q17, Q19, Q20)</td></tr>
</table>

3. Methodology and methods

This chapter describes the methodology and methods used in this study.

3.1. Methodology

The methodology includes the following phases:

– An exploratory phase during which the literature review was carried out, the RQ and SQ were formulated, and the concept map was conceptualised;

– An analytical phase, which consisted of collecting, analysing, and presenting data;

– A conclusive phase, which consisted of discussing the findings and drawing conclusions from them, as well as listing the study's contributions to knowledge, limitations, suggestions for future studies and recommendations.

The study uses deductive reasoning, which involves moving "[...] from the general to the specific, that is, making deductions using a theoretical basis to discover a specific fact" (Santos,& Lima, 2016, p. 21), and is supported by a quantitative research strategy and a case study research design.

3.2. Method

This subchapter describes the participants, the procedure, the data collection instruments, and the data processing techniques.

3.2.1. Participants and procedure

Participants. The sample analysed during the pre-test phase consisted of 4 Officer Pilots (Captains) attending the 2018/2019 Field Grade Officers Course, with different types of training (specific training: 3 participants completed their undergraduate pilot training in the United States of America and 1 in Portugal; complementary training: 3 participants attended the CRM course and 1 attended the FSC), different flight experiences (all participants were assigned to different squadrons: Fighters, Helicopters, Cargo/Patrol and Instruction), and all had logged from 1000FH-1500FH flight hours (FH) . During the test phase (Table 2), the sample consisted of 103 Officer Pilots serving in different Air Force Air Units (53.6% of N=192). The majority of participants hold the rank of Captain (74.8%), have completed their specific training (undergraduate pilot training) in Portugal (53.4%), as well as their complementary training (CRM course, 75.7%), have logged from [1500FH, 2000FH [(24.3%), and are assigned to Cargo / Patrol Squadrons (40.8%).

Table 2 – Descriptive analysis of the sample

Variable		n
Category		
Field-grade Officers		8
Captains		77
Lieutenants		18
Undergraduate Pilot Training (country of completion)		
U.S.A		33
Brazil		15
Portugal		55
Complementary Training		
CRM	Yes	78
	No	25
CSV	Yes	39
	No	64
Flight Hours		
< 500HV		14
[500HV, 1000HV[		21
[1000HV, 1500HV[		22
[1500HV, 2000HV[		25
≥ 2000HV		21
Missions type / Squadron		
Fighters		**16**
	201	8
	301	8
Instruction		**18**
	101	11
	802	7
Cargo / Patrol		**42**
	501	8
	502	19
	504	6
	601	9
Helicopters		**27**
	552	8
	751	19

Source: SIAGFA, Operations Module (data on 10 April 2019).

Procedure. After obtaining authorisation, the measuring instrument was chosen and a questionnaire was prepared using Google Forms. Participants were sent a link to the questionnaire via WhatsApp both in the pre-test phase (March 2019) and in the test phase (April 2019). Before filling out the questionnaire, participants were informed about its purpose and were assured of the anonymity and confidentiality of their answers, as they would only be used for statistical purposes.

3.2.2. Data collection instruments

The questionnaire consisted of three parts. The first served to collect demographic data. The second was designed to assess risk perception using Hunter's Risk Perception

Scale, translated into Portuguese by the author[2] (2002, pp. 9-12). The scale consists of 26 brief descriptions of situations or activities with different associated risk levels, scored on a 10-point Likert scale (1 = Low risk and 10 = High risk). The third aimed to assess aviation safety attitudes using a Portuguese translation of Hunter's Aviation Safety Attitude Scale (2005, pp. 5-7), which contains 20 statements about aviation and about how pilots appraise their own capacities, scored on a 5-point Likert scale (1 = Strongly disagree and 5 = Strongly agree).

3.2.3. Data processing techniques

The qualitative analyses were carried out using the software *Statistical Package for Social Sciences* (SPSS 23.0).

4. Data presentation and discussion of results

This chapter contains the data analysis and the answer to the RQ and the SQ.

4.1. Risk perception among Air Force Pilots

4.1.1. Psychometric properties of the scale

Exploratory factor analysis (EFA) and reliability study. Two EFA with varimax rotation were carried out. The first limited the number of factors to 5F (as in the original instrument), which explained 66.6% of the total variance. The second EFA was carried out without limiting the number of factors (Table 3), which resulted in 6F that accounted for 71.3% of the total variance, with Cronbach's Alphas that ranged from 0.700 to 0.892, considered reasonable to good according to the classification provided by Hill and Hill (2002, p.149)[3]. This factor analysis was further confirmed by a KMO of 0.845 (classified as good according to Kaiser, 1974, p.35 and Hill,& Hill, 2002, p.275) and a Bartlett's Test for Sphericity with a significant Chi-square ($\chi 2 = 1482.438$, $p<0.0001$).

[2] These two scales were adapted using the procedure devised by Fachada (2015, p.43), which involved first, translating the scales from English to current and fluent Portuguese. The translation was done by the author of this study (who is a proficient speaker of the language). The first version was revised by two different people (an officer pilot who was a potential respondent (with an advanced level of English, as stated above) and an English lecturer at the Air Force Academy. The two revisions were then compared. This semi-final version was analysed by two PoAF pilots who filled-out the questionnaire. After completing it, each added any suggestions they deemed relevant. The final version was then pre-tested.

Note: The "proficiency" level reflects the criteria of the Defense Language Institute of the US Department of Defense and of the Standard Language Proficiency (SLP) 3-4 level as defined by NATO, which assesses "listening", "speaking", "reading" and "writing".

[3] Cronbach's alpha coefficient is considered: reasonable from [0.7 , 0.8 [, good from [0.8 , 0.9 [and excellent if ≥ 0.9 (Hill & Hill, 2002, p.149).

Table 3 – Exploratory factor analysis and Cronbach's Alpha coefficient in RP

Factor	Item	*Factor loading*					
		1	2	3	4	5	6
Demanding Operations (DemOps) (α=0.892)	1.7_Fly in clear air at 6500 feet between two thunderstorms about 25 miles apart.	.676					
	1.8_Take a two-hour sightseeing flight over an area of wooded valleys and hills, at 3000 above ground level.	.531					
	1.9_During the daytime, take a cross-country flight in which you land with 30 min of fuel remaining.	.866					
	1.10_Make a traffic pattern so that you end up turning for final with about a 45 degree bank.	.522					
	1.13_During the daytime, take a cross-country flight in which you land with over an hour of fuel remaining.	.581					
	1.21_At night, take a cross-country flight in which you land with 30 min of fuel remaining.	.742					
	1.22_Take a two-hour sightseeing flight over an area of wooded valleys and hills, at 1000 above ground level.	.593					
Regular Operations (RegOps) (α=0.892)	1.1_During the daytime, fly from your local airport to another airport about 150 miles away, in clear weather, in a well-maintained aircraft.		.651				
	1.3_Make a two-hour cross country flight with friends, after checking your weight and balance.		.706				
	1.5_At night, take a cross-country flight in which you land with over an hour of fuel remaining..		.689				
	1.14_During the daytime, fly from your local airport to another airport about 150 miles away, in a well-maintained aircraft, when the weather is marginal VFR (3 miles visibility and 2000 foot overcast).		.668				
	1.23_At night, fly from your local airport to another airport about 150 miles away, in clear weather, in a well-maintained aircraft.		.642				
	1.26_At night, fly from your local airport to another airport about 150 miles away, in a well-maintained aircraft, when the weather is marginal VFR (3 miles visibility and 2000 foot overcast).		.511				
Driving (Drive) (α=0,854)	1.11_Drive your car on a freeway near your home at night, at 65 MPH in moderate traffic.			.811			
	1.17_Drive your car on a freeway near your home, during the day, at 65 MPH in moderate traffic, during heavy rain.			.739			
	1.20_Drive your car on a freeway near your home during the day, at 65 MPH in moderate traffic.			.725			
Altitude of Flight (AltFlight) (α=0,841)	1.4_Fly across a large lake or inlet at 500 feet above ground level.				.742		
	1.15_Fly across a large lake or inlet at 1500 feet above ground level.				.829		
	1.24_Fly across a large lake or inlet at 3500 feet above ground level.				.833		
Trivial Activity (TrivAct) (α=0,723)	1.12_Take a two-hour flight in a jet aircraft on a major US air carrier.					.693	
	1.16_Make a traffic pattern so that you end up turning for final with about a 30 degree bank.					.627	
	1.25_Ride an elevator from the ground floor to the 25th floor of an office building					.745	
Serious Safety Failure (SSafeFail) (α=0,700)	1.18_Start a light aircraft with a dead battery by hand-propping it.						.817
	1.19_Make a two-hour cross country flight with friends, without checking your weight and balance.						.803

Source: Hunter (2002, pp. 9-12).

4.1.2. Descriptive and inductive analyses

Given the good fit of the statistical parameters described above, the factor structure chosen for the present study is 6F. The scores for each factor correspond to the average scores attributed by respondents (Table 4): high risk (SSafeFail$_{M=8.36;SD=1.57}$); medium risk (DemOps$_{M=4.84;SD=1.59}$; Drive$_{M=4.64;SD=1.65}$); usually low risk / low risk (RegOps$_{M=3.86;SD=1.27}$; AltFlight$_{M=3.48;SD=1.52}$; TrivAct$_{M=2.24;SD=1.01}$).

Table 4 – Descriptive statistics and correlations of the studied variables in RP

			M	SD	1	2	3	4	5	6	7	8	9	10	11
1. Rank															
Training	Spec.	2. PT			-.369**										
	Comp	3. CRM			**-.669****	.394									
		4. CSV			-.357**	.096	.016								
5. FH					**.691****	-.469**	**-.635****	-.213*							
6. MT					-.008	.182	.068	.030	.111						
Risk Perception		7. DemOps	4.84	1.59	-.040	.262**	.042	.017	-.100	.106					
		8. RegOp	3.86	1.27	.085	.117	-.121	-.040	-.019	.018	**.632****				
		9. Drive	4.64	1.65	.030	.217*	-.099	.023	.050	.080	**.558****	.419**			
		10. AltFlight	3.48	1.52	-.063	.165	-.016	.192	-.021	-.123	**.581****	**.522****	.342**		
		11. TrivAct	2.24	1.01	.125	.103	-.074	.072	.181	.182	.424**	.463**	.488**	.376**	
		12. SSafeFail	8.36	1.57	.008	.010	-.074	-.068	-.014	-.014	.430**	.329**	.384**	.225*	.213*

Cohorts codification: Rank (1=Lieut, 2=Cap, 3=FieldOf); PT (1=USA, 2=Brazil, 3=Portugal); CRM (1=Yes, 2=No); CSV (1=Yes, 2=No); FH (1=< 500, 2=[500 , 1000[, 3=[1000 , 1500[, 4=[1500 , 2000[, 5=> 2000); MT (1=Inst, 2=Fight, 3=Cargo/Patrol, 4=Helo).
**Significant correlations at 0.01 level; *Significant correlations at 0.05 level.

Table 4 also shows statistically significant correlations between:

– Having completed the CRM complementary course and both rank (r = -. 669; p <0.01) and FH (r = .635; p <0.01);

– FH and rank (r = .691; p <0.01);

– DemOps and: RegOps (r = .632; p <0.01), AltFlight(r = .581; p <0.01) and Drive (r = .558; p <0.01);

– RegOps and: AltFlight(r=.522; p <0.01) and TrivAct (r=.463; p <0.01);

– Drive and TrivAct (r=.488; p <0.01).

Differences in means (t-Student / ANOVAS / Kruskal-Wallis / Mann-Whitney).

With regards to complementary training (FSC and CRM), as Table 5 shows, a statistically significant difference was observed between the mean values obtained by FSC and AltFlight(t=-1.965, p<0.01). Having completed the FSC was considered "a safeguard/ beneficial" that improves pilots' risk perception.

Table 5 – Difference in the means of RP sorted by complementary training in CSV

Factor	Group	n	M	SD	Student t-test		Homoscedasticity	
					t	*p*	Levene	*p*
DemOps	Yes	39	4.81	1,55	-0.167	0.868	0.025	n.s.
	No	64	4.86	1,63				
RegOps	Yes	39	3.93	1,33	0.403	0.688	1.094	n.s.
	No	64	3.82	1,24				
Drive	Yes	39	4.60	1,57	-0.234	0.816	0.874	n.s.
	No	64	4.68	1,71				
AltFlight	Yes	39	**3.11**	1,46	**-1.965**	**	0.047	n.s.
	No	64	**3.71**	1,52				
TrivAct	Yes	39	2.15	1,11	-0.723	0.472	1.178	n.s.
	No	64	2.29	0,95				
SSafeFail	Yes	39	8.50	1,44	0.685	0.495	0.412	n.s.
	No	64	8.28	1,65				

Note: In order to confirm the homoscedasticity requirement. The p value associated with the Levene test should be n.s. (≥ 0.05).
** $p < 0.01$.

The results shown on Table 6, complemented by the *Post Hoc* test results reveal statistically significant differences between the mean values obtained for different types of missions:

– Fighters (M=3.50; SD=1.28) and Cargo / Patrol (M=5.59; SD=1.49) regarding the DemOps factor (F=8.877; p<0.0001), *Post Hoc p* <0.0001;

– Fighters (M=3.73; SD=1.38) and Cargo / Patrol (M=5.04; SD=1.46) regarding the Drive factor (F=2.562; p<0.05), *Post Hoc p* <0.05;

– Fighters (M=3.73; SD=1.38) and Cargo / Patrol (M=5.04; SD=1.46) regarding the Drive factor (F=2.562; p<0.05), *Post Hoc p* <0.05.

Table 6 – Difference in the means of RP sorted by mission type

Fator	Grupo	n	M	SD	Mín.	Máx.	ANOVA		Homoscedasticity	
							F	*p*	Levene	*p*
DemOps	Instruction	18	4.72	1.27	1.83	7.00	**8.877**	****	0.539	n.s.
	Fighters	16	**3.50**	1.28	1.50	5.67				
	Cargo / Patrol	42	**5.59**	1.49	2.83	8.67				
	Helicopters	27	4.55	1.53	1.00	8.17				
RegOps	Instruction	18	4.18	1.10	2.50	6.17	1.536	0.210	0.402	n.s.
	Fighters	16	3.34	1.29	1.33	5.50				
	Cargo / Patrol	42	3.80	1.28	1.17	6.50				
	Helicopters	27	4.06	1.31	1.33	6.50				
Drive	Instruction	18	4.63	1.84	1.67	8.33	**2.562**	*	0.706	n.s.
	Fighters	16	**3.73**	1.38	2.00	6.00				
	Cargo / Patrol	42	**5.04**	1.46	2.00	7.67				
	Helicopters	27	4.59	1.81	1.33	8.00				
AltFlight	Instruction	18	3.83	1.36	1.67	6.00	1.764	0.159	0.135	n.s.
	Fighters	16	3.17	1.40	1.67	6.67				
	Cargo / Patrol	42	3.74	1.51	1.33	7.67				
	Helicopters	27	3.04	1.63	1.00	7.67				
TrivAct	Instruction	18	2.13	0.94	1.00	4.00	**3.677**	*	1.617	n.s.
	Fighters	16	**1.54**	0.62	1.00	2.67				
	Cargo / Patrol	42	**2.44**	1.10	1.00	5.33				
	Helicopters	27	2.40	0.96	1.00	5.00				

SSafeFail	Instruction	18	8.50	1.77	3.50	10.00	1.876	0.139	1.983	n.s.
	Fighters	16	7.75	1.38	6.00	10.00				
	Cargo / Patrol	42	8.71	1.24	3.50	10.00				
	Helicopters	27	8.09	1.89	2.50	10.00				

Note: In order to confirm the homoscedasticity requirement. The p value associated with the Levene test should be n.s. (≥ 0.05).
* $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$; **** $p < 0.0001$

To better understand these data, it had to be ascertained if the place where respondents completed their undergraduate pilot training (TIR) was acting like an extraneous variable in regards to the DemOps, Drive, and TrivAct factors. The analysis of the data revealed that, while there were differences in the means obtained by TIR within each of the four groups (type of mission), those differences were not statistically significant. That is, regardless of where the pilots assigned to each type of mission completed their TIR, on average, their risk perception when performing demanding operations, driving and engaging in trivial activities is similar. Therefore, training can be treated as a homogeneous group common to fighters, cargo/patrol, helicopters and instruction pilots.

Finally, as with CRM, no statistically significant differences were found in the mean values associated with rank and flight hours.

4.1.3. Brief overview and answer to SQ1

Based on this analysis, the answer to SQ1 – *How do PoAF pilots perceive risk?* – is that pilots tend to perceive the following situations as: high risk, Serious Safety Failures (e.g. "Start a light aircraft with a dead battery by hand-propping it" and / or "Make a two-hour cross country flight with friends, without checking your weight and balance"); medium risk, Demanding Operations ("At night, take a cross-country flight in which you land with 30 min of fuel remaining"), and; usually low risk to low risk, Driving, Regular Operations ("During the daytime, fly from your local airport to another airport about 150 miles away, in clear weather, in a well-maintained aircraft."), Altitude of Flight ("Fly across a large lake or inlet at 500 feet above ground level.") and Trivial Activity ("Ride an elevator from the ground floor to the 25th floor of an office building").

Based on the findings by Klinke and Renn (2002, p.1) and Machin and Sanky (2008, p.2) which are described above, it can be deduced that in high risk (and possibly medium risk) situations, pilots will tend to monitor / manage / change their attitude and behaviour to reduce or remove the likelihood of that risk occurring.

Furthermore, a positive association was found between having completed the CRM course and both rank and FH. This relationship was to be expected, at least in theory, because longer service terms are likely to be reflected in higher ranks, which implies more complementary training and FH.

On the other hand, having completed complementary training such as the CRM and / or the FSC, as well as having logged more FH, does not significantly correlate to risk perception among pilots, except for a single case in which the FSC was described as a "safeguard/beneficial" factor that improved risk perception in the item altitude of flight, which as described as flying across a large lake or inlet at 500, 1500 and 3500 feet above ground level. A superficial and abusive interpretation of these data (which indicate a non-correlation) would seem to disprove the need for a flight safety doctrine, which, among other activities, incudes the provision of safety courses / training such as the ones already mentioned (CRM / FSC). However, risk is only one of the topics covered in this type of courses, so this would be a rather limiting interpretation. Moreover, this absence of a correlation can be explained by the fact that pilots are already very familiar with the issue, which is covered extensively since basic training. This positively shapes their risk attitudes, and consequently their risk perception and behaviours (as confirmed by Albarracín, Sunderrajan, Lohmann, Chan, & Jiang, 2018, p.29; Marado, 2017, p.2.15; Sjolber, 2000, p.9). Furthermore, and especially in the case of the FSC, these results can be interpreted as proof that the Air Force's safety and accident prevention system is working as it should, since it requires that its most direct actors (i.e. the officers who attended the course) raise the awareness of other service members to these issues.

Still with regards to how Air Force pilots perceive risk, fighter pilots tend to rate the types of flight / activities listed under Demanding Operations, Trivial Activity and Driving as less risky than Cargo / Patrol pilots. This is not an indication of any differences in courage, but perhaps – since no statistically significant differenceswere found in each of the four missions between the mean values obtained by the pilots who completed their TIR in the US, Brazil and Portugal, which allows for the groups to be treated as a homogeneous "whole" – to the type of flight: the aircraft operated by these pilots (F-16) was designed to manoeuvre at much higher speeds, attitudes and bank angles than Cargo/Patrol aircraft; a significant part of fighter operations requires pilots to perform manoeuvres that exploit the F-16's extensive flight envelope, while most Cargo/Patrol operations arecarried out at straight and level flight or using attitudes and bank angles below 30º. That is, to a kind of habituation effect, which is reflected in accumulated knowledge. The knowledge/perception of what each pilot considers a "safe" flight envelope.

Finally, these differences in perception are not observed in flight activities classified as high-risk, regarding which most pilots tend to make similar assessments.

4.2. Flight safety behaviour among PoAF pilots

4.2.1. Psychometric properties of the scale

Exploratory factor analysis (EFA) and reliability study. An EFA with varimax rotation was carried out, which resulted in 3F (similar to the original version of the instrument) that accounted for 62.8% of the total variance, with Cronbach's Alphas that ranged from 0.520 to 0.783 (Table 7), considered unacceptable to reasonable according to the classification by Hill and Hill (2002, p.149)[4]. This EFA of the factors SelfConf and SafeOrient is further confirmed by a KMO of 0.682 (which is considered mediocre by Kaiser, 1974, p.35 and Hill, & Hill, 2002, p.275, but acceptable according to other researchers such as Carvalho, 2013, p. 27, e Lordelo, Hongyu, Borja, & Porsani, 2018, pp. 62-63[5]) and a Bartlett's Test for Sphericity with a significant Chi-square ($\chi 2=281.779$, $p<0.0001$).

Table 7 – Exploratory factor analysis and Cronbach's Alpha coefficient in ASA

Factor	Item	Factor loading		
		1	2	3
Self Confidence (SelfConf) (α=0.783)	2.6_I am very skillful on controls.	.753		
	2.7_I know aviation procedures very well.	.791		
	2.8_I deal with stress very well.	.792		
	2.10_I have a thorough knowledge of my aircraft.	.748		
Safety Orientation (SafeOrient) (α=0.709)	2.3_I am a very careful pilot.		.857	
	2.5_I am a very capable pilot.		.577	
	2.11_I am a very cautious pilot.		.882	
Risk Orientation (RiskOrient) (α=0.520)	2.17_If you don't push yourself and the aircraft a little, you'll never know what you could do.			.775
	1.4_Sometimes you just have to depend on luck to get you through.			.645
	2.20_Speed is more important than accuracy during an emergency.			.716

Source: Hunter (2005. pp. 5-7).

4.2.2. Descriptive and inductive analyses

Given the good fit of the statistical parameters described above (specifically, SelfConf and SafeOrient), the factor structure chosen for the present study is 3F (with some reservations regarding the alpha values obtained by RiskOrient).

As Table 8 shows, on a scale in which the intermediate point is "3" - "Neither agree nor disagree", the factors that obtained "agree" scores were: SafeOrient (M=3.90;SD=0.49) and SelfConf (M=3.83;SD=0.49), and the factor that obtained "disagree" scores was RiskOrient (M=1.88;SD=0.62).

[4] Cronbach's alpha coefficient is considered: unacceptable if ≤0.6, weak from [0.6 , 0.7[, reasonable from [0.7 , 0.8 [, good from [0.8 , 0.9 [and excellent if ≥ 0.9 (Hill,& Hill, 2002, p.149).
[5] This procedure (determining the suitability of the coefficient) is recommended by the most researchers and served to validate the two factors (SelfConf and SafeOrient) for further analysis.

Table 8 – Descriptive statistics and correlations of the studied variables in ASA

			M	SD	1	2	3	4	5	6	7	8
		1. Rank										
Training	Spec.	2. PT			-.369**							
Training	Comp.	3. CRM			**-.669****	.394						
Training	Comp.	4. CSV			-.357**	.096	.016					
		5. FH			**.691****	-.469**	**-.635****	-.213*				
		6. MT			-.008	.182	.068	.030	.111			
Aviation Safety Attitude		7. SelfConf	3.83	0,49	.215*	-.129	-.202*	-.028	.311**	.156		
Aviation Safety Attitude		8. SafeOrient	3.90	0,49	.067	-.158	.086	-.106	.102	-.223*	.361**	
Aviation Safety Attitude		9. RiskOrient	1.88	0,62	-.050	.176	.076	.072	-.021	.255**	.134	-.092

Cohorts codification: Rank (1=Lieut, 2=Cap, 3=FieldOf); PT (1=USA, 2=Brazil, 3=Portugal); CRM (1=Yes, 2=No); CSV (1=Yes, 2=No); FH (1=< 500, 2=[500 , 1000[, 3=[1000 , 1500[, 4=[1500 , 2000[, 5=> 2000); MT (1=Inst, 2=Fight, 3=Cargo/Patrol, 4=Helo).

**Significant correlations at 0.01 level; *Significant correlations at 0.05 level.

Still in regards to Table 8 (after removing the values marked in grey, which were analysed in the previous sub-chapter), the highest (albeit with values close to .3) and most statistically significant correlation was found in the relationship between SafeOrient and SelfConf (r=.361; p<0.01).

Differences in means (t-Student / ANOVAS / Kruskal-Wallis / Mann-Whitney).

The results shown on Table 9, complemented by the results of the *Post Hoc* tests ($p<0.01$), reveal statistically significant differences (F=4.636, $p<0.01$) between the mean SelfConf scores obtained by the groups <500 (M=3.48;SD=0.41) and [1000, 1500[(M=4.05;SD=0.52).

Table 9 – Difference in the means of ASA sorted by FH

Factor	Group	n	M	SD	Min.	Max.	ANOVA F	ANOVA *p*	Homoscedasticity Levene	Homoscedasticity *p*
SelfConf	<500	14	**3.48**	0.41	3.00	4.00	**4.636**	**	0.641	n.s.
	[500, 1000[	21	3.64	0.47	2.75	4.50				
	[1000, 1500[	42	**4.05**	0.52	3.00	5.00				
	[1500, 2000[	25	3.90	0.49	3.00	5.00				
	>2000	21	3.96	0.37	3.25	4.75				
SafeOrient	<500	14	3.76	0.40	2.67	4.33	0.360	0.836	0.854	n.s.
	[500, 1000[	21	3.89	0.40	3.33	5.00				
	[1000, 1500[	22	3.91	0.64	2.00	5.00				
	[1500, 2000[	25	3.95	0.44	3.00	5.00				
	>2000	21	3.94	0.52	2.67	5.00				
RiskOrient	<500	14	1.76	0.65	1.00	3.33	0.701	0.593	0.976	n.s.
	[500, 1000[	21	2.05	0.58	1.00	3.67				
	[1000, 1500[	22	1.88	0.75	1.00	3.67				
	[1500, 2000[	25	1.77	0.51	1.00	2.67				
	>2000	21	1.90	0.62	1.00	3.00				

Note: In order to confirm the homoscedasticity requirement. The p value associated with the Levene test should be n.s. (≥ 0.05).

** $p< 0.01$.

The results in Table 10, complemented by the results of the *Post Hoc* test, reveal statistically significant differences between the mean values obtained by each type of mission:

– In regards to SelfConf (F=2.919; $p<0.05$), *Post Hoc* $p<0.05$; Instruction (M=4.03;SD=0.44) and Cargo / Patrol (M=3.68;SD=0.47).

– In regards to RiskOrient (F=3.318; $p<0.05$), *Post Hoc* $p< 0.05$; Fighters (M=1.63;SD=0.57) and Helicopters (M=2.16;SD=0.68).

Table 10 – Difference in the means of ASA sorted by mission type

Factor	Group	n	M	SD	Min.	Max.	ANOVA		Homoscedasticity	
							F	*p*	Levene	*p*
SelfConf	Instruction	18	**4.03**	0.44	3.25	5.00	**2.919**	*	0.516	n.s.
	Fighters	16	3.97	0.52	3.25	5.00				
	Cargo / Patrol	42	**3.68**	0.47	2.75	4.50				
	Helicopters	27	3.87	0.50	3.00	5.00				
SafeOrient	Instruction	18	4.04	0.38	3.33	5.00	2.072	0.109	1.436	n.s.
	Fighters	16	4.08	0.39	3.33	5.00				
	Cargo / Patrol	42	3.86	0.48	3.00	5.00				
	Helicopters	27	3.77	0.58	2.00	4.67				
RiskOrient	Instruction	18	174	0.68	1.00	3.67	**3.318**	*	0.364	n.s.
	Fighters	16	**1.63**	0.57	1.00	3.00				
	Cargo / Patrol	42	1.85	0.51	1.00	3.00				
	Helicopters	27	**2.16**	0.68	1.00	3.67				

Note: In order to confirm the homoscedasticity requirement. The p value associated with the Levene test should be n.s. (≥ 0.05).
* $p< 0.05$.

As with risk perception, a comparative intragroup study sorted by "type of mission" was carried to better understand these data, isolating the effects of the undergraduate pilot training variable on the SelfConf factor. (Note: while the mean values obtained by RiskOrient were significantly different, the low alpha value obtained by this factor precludes it from being studied further). Again, the analysis of the data revealed that, while there were differences in the means obtained by TIR within each of the four groups (type of mission), those differences were not statistically significant. This confirms what had already been suggested by the factors related to risk perception, that regardless of where pilots (sorted by mission type) completed their TIR, they tend to have similar levels of self-confidence regarding flight safety attitudes and flight behaviour, which allows for training to be treated as a homogeneous group for fighters, cargo/patrolling, helicopters and instruction.

This analysis did not reveal any statistically significant differences associated with rank and complementary training (CRM and FSC).

4.2.3. Brief overview and answer to SQ2

Based on this analysis, the answer to SQ2 – *What are the flight safety behaviours of PoAF pilots?* – is that the sample analysed was generally safety-oriented (e.g. "I am a very careful pilot" and "I am a very cautious pilot") and had a positive, rational and prudent (self-) confidence (not to be mistaken for overconfidence), as demonstrated by their critical and moderate assessment (i.e. values in the range of 3-4 on a scale where 5 is the maximum) of items associated with overconfidence (and therefore negatively associated with safety, e.g. "I am very skillful on controls" and "I deal with stress very well"). The respondents are also attentive / cautious / aware, as well as prudent and careful in the way they perceive risk situations (e.g. as indicated by their negative answers to questions such as "Speed is more important than accuracy during an emergency" and "If you don't push yourself and the aircraft a little, you'll never know what you could do").

Therefore, it can be inferred that self-confidence positively correlates to safety orientation.

Another factor that influences flight safety attitude and flight behaviour among Air Force pilots is FH, as pilots with more logged FH (e.g. between 1.000FH and 1.500FH) obtained higher mean scores in (self-)confidence that pilots with 500FH or less (although the latter also obtained positive scores). This can be explained by the gains in terms of knowledge and confidence that greater familiarity with a particular task tends to entail, and suggests to some degree that flight experience is an important predictor of flight behaviour, which has an impact on the occurrence of incidents / accidents (Ji et al., 2018, p.5).

On average, pilots assigned to instruction squadrons also scored higher in (self-) confidence than pilots assigned to cargo/patrol squadrons (who also obtained positive scores). This could be explained by differences in career/status progression as well as by the effects of accumulated experience described above (e.g. Ji et al., 2018, p.5). More specifically, pilots in instruction squadrons begin working as pilot instructors the moment they complete their training, which entails, among other responsibilities, that they are immediately given command of an aircraft, whereas pilots in cargo / patrol squadrons will only have that opportunity later in their careers.

Finally, while there were differences in the means obtained by rank and complementary training (CRM / FSC) in regards to flight safety attitude and flight behaviour, these differences were not statistically significant.

4.3. Risk perceptions and flight safety behaviour among Air Force Pilots

4.3.1. Correlation Analysis (PR and ASA)

The values in Table 11 (after removing the values marked in grey, which were analysed in the two previous sub-chapters) show that the highest and most statistically significant correlation was obtained by the relationship between RiskOrient and SSafeFail (r=.409; p<0.01). That is, people who are more risk-oriented (i.e. more willing to accept higher levels of risk) tend to attribute a lower level of risk to activities associated with Serious Security Failures.

Table 11 – Correlations of the studied variables (RP and ASA)

		1	2	3	4	5	6	7	8
Risk Perception	1. DemOps								
	2. RegOps	**.632****							
	3. Drive	**.558****	.419**						
	4. AltFlight	**.518****	**.522****	.342**					
	5. TrivAct	.424**	.463**	.488**	.376**				
	6. SSafeFail	.430**	.329**	.348**	.225*	.213*			
Aviation Safety Attitude	7. SelfConf	-.242*	-.151	-.106	-.063	-.120	-.224*		
	8. SafeOrient	-.165	-.166	-.042	-.063	-.106	-.022	.361**	
	9. RiskOrient	-.115	-.120	-.072	-.098	-.002	**-.409****	.134	-.092

**Significant correlations at 0.01 level; *Significant correlations at 0.05 level.

4.3.2. Brief overview and answer to the RQ

Based on the above analysis and discussion, the answer to the RQ – *How do PoAF pilots perceive risk and what are their flight safety behaviours?* – is that, while there are differences in how these pilots perceive risk, as well as in their flight safety attitude and behaviour, there is a certain homogeneity in how they assess high-risk situations such as Serious Safety Failure(s) (e.g. "Start a light aircraft with a dead battery by hand-propping it") and in how they adopt a "demeanour" of caution, attention, prudence and prevention. In other words, respondents show appropriate levels of awareness in regards to directing, confronting, managing and/or attempting to resolve/mitigate risk (e.g. "Speed is more important than accuracy during an emergency").

Other features that appear to be somewhat homogenous are, on the one hand, a demeanour that shows a well-adjusted, thoughtful, cautious and positive (self-)confidence (e.g. "I have a thorough knowledge of my aircraft") and safety orientation (e.g. "I am a very cautious pilot"). On the other hand, rank, the number of flight hours logged, the place of completion of undergraduate pilot training and having completed complementary training (CRM) play a less significant role. This tendency was also confirmed in regards to the FSC, except for a single situation in which it was described as a "safeguard / beneficial" factor that improved risk perception related to the altitude of flight factor, which is described as flying across a large lake or inlet at 500, 1500 and 3500 feet above ground level.

A superficial interpretation of this may lead one to think that this contradicts the need for flight safety training, in which one of the lessons learned is that experience and awareness-raising / training on these issues are "safety-friendly" activities (in the context of aviation). However, such an interpretation would be abusive because, while the differences exist, as stated above, they are not statistically significant. Furthermore, with regard to the relevance of complementary training (CRM / FSC), it would be rather limiting to assess these courses only by the results obtained in this area since they focus on vast range of topics that are just as important as flight safety. On the other hand, with regard to the FSC, these results can be interpreted as proof that the Air Force's safety and accident prevention structure is working as it should, that is, the fact that having completed the FSC did not lead to any significant differences was to be expected because these courses require that their most direct actors (i.e. the officers who attended the course) raise the awareness of their peers to these issues. Moreover, the results could also indicate a possible effect of good "acculturation" to the safety culture enforced in the squadrons. Another possible explanation is that pilots are already very familiar with the topic, which is covered extensively and appropriately (as this study shows) since basic training, which positively shaped their risk orientation and safety attitudes and behaviours.

More specifically, in terms of risk perception – and with the exception of high risks flight activities classified as Serious Safety Failures, as mentioned above – Air Force pilots tend to perceive the following activities (among others) as medium risk: "Make a traffic pattern so that you end up turning for final with about a 45 degree bank" and "During the daytime, take a cross-country flight in which you land with 30 min of fuel remaining" (Demanding Operations); and "Drive your car on a freeway near your home, during the day, at 65 MPH in moderate traffic, during heavy rain" (Driving). The following activities were considered low-risk, or usually low risk: "At night, fly from your local airport to another airport about 150 miles away, in clear weather, in a well-maintained aircraft" and "Make a two-hour cross country flight with friends, after checking your weight and balance" (Regular Operations); "Fly across a large lake or inlet at 500 feet above ground level" and "Fly across a large lake or inlet at 3500 feet above ground level" (Altitude of Flight); "Make a traffic pattern so that you end up turning for final with about a 30 degree bank" (Trivial Activity).

Still regarding the manner in which Air Force pilots perceive risk, fighter pilots tend to rate situations classified as Demanding Operations, Trivial Activity and Driving as less risky than Cargo / Patrol pilots. These differences could be related to both type of flight and a kind of habituation effect, which is reflected in accumulated knowledge and influences what pilots consider a (safe) flight envelope. Due to the profile of their missions and the performance of their aircraft, Fighter pilots are regularly exposed to very high attitudes, speeds and bank angles, while Cargo/Patrol pilots, as a result of their aircraft's more limited flight envelope, carry out most of their operations at straight and level flight or using attitudes and bank angles below 30º.

Regarding flight safety attitude and behaviour, pilots who logged more FH, especially those who logged from 1000FH-1500FH, scored higher in self-confidence (although not overconfidence) than pilots who logged 500FH or less (whose self-confidence scores were also positive). This can be explained by the simple fact that the longer people perform a task, the more familiar they are with it and the better they perform it.

Finally, self-confidence – in which all pilots obtained positive scores – is higher on average among Instruction pilots than among Cargo/Patrol pilots. This could relate to the fact that these two Air Units are quite different in terms of assignments and qualifications (even more than career progress). One example of this is that pilots in Instruction Squadrons begin working as instruction pilots the moment they complete their training, and are immediately given command of an aircraft, among other responsibilities, whereas Cargo/Patrol pilots will only become Aircraft Commanders, with all that the position entails, later in their career.

5. Conclusions

Since its birth in the early twentieth century, the aviation industry has seen tremendous growth. However, at the same time, a long hard battle for the safety of crew and passengers was being fought. The advances in the analysis and investigation of aviation accidents, combined with important advances in aircraft technology and reliability and the increase in regulation and standardisation of procedures, as well as the significant improvement in air traffic control systems, have increased the safety of air transport to the point that it is now admittedly the safest mode of transport in the world.

However, these achievements do not mean that safety has ceased being a concern. Today, increasing safety is still crucial and the challenge of making aviation even safer remains high, as it is becoming increasingly difficult to improve an already excellent performance. However, upon deeper analysis, this positive record reveals that although the accident rate continues to decline, human factors remain one of the major causes of accidents, and thus warrant further study.

Errare humanum est is a fact of human nature, and thus it is unlikely that error will ever be completely eliminated. Nevertheless, there have been significant efforts to minimise aviation errors, especially through a number of measures taken over the last decades. One of those measures is the training given to pilots. Pilot training has undergone major changes and improvements which aimed to close gaps associated with teamwork, decision making and safety behaviour, among other factors. These measures also include crew management training, the use of better simulators that can recreate a broad range of flight situations, or investing in actions to provide education and foster awareness about issues related to flight safety.

Bearing in mind all the investments made and the significant improvements that have been achieved, it would be reasonable to expect human error to have decreased even more significantly, even to near negligible levels. However, this has not happened so far. One explanation for this rests precisely in how pilots perceive the situations they must deal with on a daily basis and how they adjust their behaviour according to their perceptions (that is, how accurately they assess the relationship between external requests and their personal resources/capabilities). Risk is closely linked to aviation, however, not all pilots perceive the risk associated with a specific event exactly the same way. This variation in inter-pilot perceptions is influenced by how they interpret external and internal variables.

Therefore, considering that the Air Force is aligned with the rest of the aeronautics industry with regards to the focus on safety, and that Air Force pilots are naturally aware of this (and thus the decisions they make while flying an aircraft are affected by these phenomena), it is urgent to study this issue in order to identify factors that are positively associated with flight safety.

This IRP examined risk perceptions and flight safety behaviour among Air Force pilots, and was delimited in terms of: time, to the current day; space, to Officer Pilots assigned to an Air Unit; and content, to risk perception and flight safety behaviour among pilots.

The work was guided by the following RQ: *How do PoAF pilots perceive risk and what are their flight safety behaviours?*

The study was carried out in three phases (exploratory, analytical, and conclusive) and the methodology used combined deductive reasoning, a quantitative research strategy with qualitative elements, and a case study research design.

The present document consists of five chapters: the introduction, the theoretical and conceptual framework (which includes the literature review, the key concepts and the analysis model), the methodology and methods, the data analysis and discussion of the findings, and the conclusions.

SO1, *To assess risk perceptions among Air Force Pilots*, was achieved by answering SQ1, and was operationalised by delivering a questionnaire to 103 PILAV officers from various Air Force Units. The data were subject to quantitative analysis, revealing that this group tended to assess the following risk situations in a similar way: high risk, serious safety failure(s) (e.g. "Start a light aircraft with a dead battery by hand-propping it" and/or "Make a two-hour cross country flight with friends, without checking your weight and balance"); medium risk, demanding operations (e.g. "Make a traffic pattern so that you end up turning for final with about a 45 degree bank" and / or "At night, take a cross-country flight in which you land with 30 min of fuel remaining"), and "Drive your car on a freeway near your home, during the day, at 65 MPH in moderate traffic, during heavy rain"; usually low risk / low risk, regular operations (e.g. "During the daytime, fly from your local airport to another airport about 150 miles away, in clear weather, in a well-maintained aircraft" and / or "Make a two-hour cross country flight with friends, after checking your weight and balance"), altitude of flight (e.g. "Fly across a large lake or inlet at 500 feet above ground level.") and trivial activity ("Take a two-hour flight in a jet aircraft on a major US air carrier").

Despite the fact that safety training has been proved to be effective, no statistically significant correlations were found between complementary flight safety training (CRM and / or FSC) and risk perception, except for a single situation in which the FSC was described as a "safeguard / beneficial" factor that improved risk perception associated with altitude of flight. This seems to suggest that the relevance of these courses is overstated. However, this would not be an accurate interpretation because it would limit the value of these courses to their effects on risk perception. Considering the broad range of themes / areas addressed in these training courses, this would be a rather limiting interpretation. These results may, however, be explained by the fact that risk perception is a topic already explored in depth during pilot basic training (*ab initio* training, considered a strong and appropriate shaper of attitudes / behaviours). In the case of the FSC, this could even confirm that the Air Force's accident prevention system is working as it should, according to the underlying philosophy of this type of training (i.e. officers who attend the course are responsible for raising awareness of their peers to these issues). They may also stem from the integration of new pilots in environments (squadrons) with a good safety climate, that is, who encourage pilots to assimilate these concepts and attitudes.

As for the way Air Force pilots perceive risk, the study revealed that fighter pilots see activities classified as Demanding Operations, Trivial Activity and Driving as less risky than Cargo / Patrol pilots. This could be linked to a habituation effect to their mission type. In other words, to the different flight envelopes of the aircraft used by Fighter pilots and Cargo / Patrol pilots.

Finally, most pilots assessed risk in a similar way when asked about activities classified as high risk.

With regards to SO2, *To analyse flight safety behaviour among PoAF pilots*, the answer to its SQ was obtained by delivering a questionnaire to the sample described above. The data were subject to quantitative analysis, which revealed that the sample obtained positive scores in (self-) confidence and safety orientation (two correlated variables), caution, and risk awareness. In terms of (appropriate) self-confidence, the most experienced pilots (those who logged between 1000FH and 1500FH) scored higher in appropriate confidence than pilots who logged 500FH or less). This could be due to their greater flight experience, as well as to the significant differences in the means obtained by Instruction pilots and Cargo / Patrol pilots. This could be explained by the fact that the first group are assigned command of their aircraft shortly after completing their training, with all the complexity and rigour that implies, whereas the latter group will only experience this opportunity much later in their careers.

With regards to flight safety attitude and flight behaviour, it is worth noting that no statistically significant differences associated with rank, training and complementary training (CRM / CSV) were found.

As for the GO, *To analyse risk perceptions and flight safety behaviour among PoAF pilots*, the answer to the RQ is that, despite the differences in risk perception, flight safety attitude and flight safety behaviour, respondents assessed the situations classified as high risk in a similar way and showed an appropriate level of awareness in risk orientation. The participants also obtained positive, weighted and homogeneous results / mean scores in (self-) confidence and safety orientation.

As for the influence of rank, place of completion of undergraduate pilot training, and attendance of the CRM course on risk perception, no statistically significant correlations to risk perception, flight safety attitude and flight safety behaviour were found. As for the other sociodemographic variables, the only exceptions were the relationship between FH and safety (which is associated with greater self-confidence, although not with overconfidence, probably stemming from their greater flight experience) and the fact that attending the FSC improved risk perceptions in the factor Altitude of Flight (e.g. "Fly across a large lake or inlet at 500 feet above ground level"). On the one hand, it might not be advisable to assess the effectiveness of these complementary training courses only by their effects on these variables, as the contents cover a broad range of topics related to flight safety; on the other, especially in the case of the FSC, these results should be interpreted as positive and a confirmation that the Air Force safety structure is working as it should (one of its policies is encouraging service members who attended the courses to foster awareness to safety issues among their peers).

With regards to this study's *contributions to knowledge*, once the Organization is aware of its findings, it can use them to optimise its flight safety policies. The study found that, in general, despite the differences between groups with different backgrounds and operational experiences, pilots assess risk in an appropriate and homogeneous manner and tend to be confident and safety-oriented in the performance of their duties. Another contribution is the translation into Portuguese and validation for the Air Force context of two scales which are widely used to measure the topics analysed here.

The main *limitation* of this study – which did not significantly limit the benefits that can be drawn from its findings – is that the situations described in the questionnaires are too general because they are designed for a wide range of audiences. Therefore, these measuring instruments do not fit the context of the Air Force perfectly. This limitation was minimised by conducting a pre-test study to identify and remove the items that did not fit the Portuguese military aeronautical reality.

Future studies on this topic should use a questionnaire that has been further adapted to the context of the Air Force and / to the normal flight envelopes of the aircraft used by the various groups (Instruction, Fighters, Cargo / Patrol and Helicopters). This adaptation must, of course, respect the underlying logic of the existing questions. For example, in the demanding operations / risk perception section, a specific change that can be made is to the "45 degree" in the question "Make a traffic pattern so that you end up turning for final with about a 45 degree bank", which is adequate to Cargo / Patrol operations. When assessing Instruction and Fighter pilots, this value should be 60 degrees. It would also be of interest to examine if the good results obtained by Air Force pilots in regards to safety-related issues are a result of their basic training (regardless of where they completed their undergraduate pilot training) or of a support and acculturation system within the Air Force Units. In other words, to control the possible effect of acculturation to a flight squadron (external variable), since no significant differences in regards to undergraduate pilot training were found in this study. This could be done by conducting a longitudinal study that assesses the sample at two different times: the first, immediately after they complete their training, and the second, after they have been assigned to a flight squadron for two / three years.

Finally, as a *practical recommendation,* the Air Force should continue and, if possible, reinforce its continuous improvement policies both in regards to the already excellent training it provides its pilots and in promoting a safety culture across all levels of the organization.

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