ΠΑΝΤΕΙΟΝ ΠΑΝΕΠΙΣΤΗΜΙΟ ΚΟΙΝΩΝΙΚΩΝ ΚΑΙ ΠΟΛΙΤΙΚΩΝ ΕΠΙΣΤΗΜΩΝ
ΤΜΗΜΑ ΟΙΚΟΝΟΜΙΚΗΣ & ΠΕΡΙΦΕΡΕΙΑΚΗΣ ΑΝΑΠΤΥΞΗΣ

PANTEION UNIVERSITY OF SOCIAL AND POLITICAL SCIENCES
DEPARTMENT OF ECONOMIC & REGIONAL DEVELOPMENT

Master in Applied Economics and Business Administration

Preventing Human Errors and enhancing Resilience through C.R.M.

DISSERTATION

Nickolaos Vrouvas

ATHENS, 2019

Three member committee

Dr. Theodosios Palaskas, Supervising Professor

Dr. Chrysostomos Stoforos, Associate Professor

Dr. Stavros Degiannakis, Associate Professor

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

ABSTRACT

Crew Resource Management (CRM) showed up for first time in 70s in a NASA's workshop. Its purpose was to guarantee the flight efficiency and safety. That would be achieved by using all the available resources, software, hardware and the human factor. Until today, it is considered the most fruitful method of training which aims at the reduction of human errors. Because of its great importance for the aviation industry, CRM is adopted by civil and military aviation as well.

From the beginning of its introduction until today CRM has been constantly being improved and updated, following the vast growth of aviation industry. For example, resilience in aviation was recently developed as part of CRM. This thesis aim to make suggestions towards the mitigation of human errors and the improvement of resilience in aviation. The basis of this research is the CRM which is considered as the countermeasure against in-flight threats. At the same time, a wider meaning of this thesis will be revealed. As this dissertation targets in the optimization of Human Factors, the conclusions emerged after research may have a wider implementation. What is essential for aviation industry in order to be efficient and safe, does not differ from the target of every other business. Besides, some of the targets of CRM is to enhance leadership, teamwork, threat- error management and decision making which are equally important for every firm.

To achieve the required objectives this thesis is divided in two parts. The theoretical and the research. The theoretical is separated in three discrete sections, analysing the CRM, the Human Errors in aviation and the Resilience. Following the theory, methodology and fieldwork research are presented in the second part. A special questionnaire constructed exclusively for the major issues of this thesis is the primary mean of conducting this research. The conclusions-recommendations stated in the last chapters arise in a combination between theory and the questionnaire's findings.

Introduction

1.1 Principal Questions and Importance

In the last decades, travelling with aircrafts has turned into one of the main means of transport. The implementations of aviation industry in humanity are numerous. Some of the most important are, transporting passengers via civilian airlines, carrying products via cargo airlines, business flights and even firefighting missions or air patrols. Moreover, civilian flights share the skies with military aircrafts which are characterized as state aircrafts and their missions are equally numerous. Air Force's major objectives contain combat missions as well as flights oriented towards social contribution. For instance, aerial deliveries via transport aircrafts, aero medical flights, humanitarian aiding and even search and rescue missions.

Nevertheless, aviation industry speaking in terms of military or civil flights, aims at the reduction of accidents. Flight safety is the number one priority of the aviation community. This is achieved by modern and sophisticated aircrafts as well as with highly qualified and trained pilots. However, human factor as it will be revealed in the next lines of this dissertation, still troubles the scientific field. Human errors may occur from every aviator individually or as an outcome of poor cooperation between the crew members. Last generation's aircrafts capable of transporting as many as eight hundred passengers, require multi crew personnel in order to guarantee the flight safety. The code of communication between crew members, the cooperation, the reactions in case of an emergency and even the ability for an effective decision making, are some of the sub categories contained in CRM.

Despite the fact that CRM has been gradually developed through the years, human errors are not alleviated. For argument's sake, the 80% factor, as it will be analyzed in the following chapters, reveals the importance of human factors in an accident. CRM on the other hand investigates human errors by analyzing and dividing them in sub categories. In deeper analysis, through CRM many models have been developed such as the famous Swiss cheese, in order to interpret the nature of human errors. In the last line of defense, CRM educates positive crew attitudes and how to deal with threats which may emerge during flight operations.

Through the years CRM keeps growing, upgrades and imposes the respective legislation to the aviation community. Despite the improvements that have been made over the last decades, it seems that still there are more to learn and improve in aviation. Besides, the relationship between CRM and aviation's industry is bidirectional. CRM will constantly make improvements as long as accidents still happen. For example, Resilience in aviation has been developed through the last years introducing the most updated version of CRM. An incident which took place in USA at 2009, revealed that pilots must be prepared to deal even with the most extreme and unexpected scenarios. Since then, Resilience was incorporated in CRM and new training methods came up.

The most significant part in aviation industry, as already revealed, is the Human Factor. CRM and its sub categories aim at the mitigation of human errors and the development of an effective code of communication between crew members to ensure flight safety even in the most critical phases of a flight. In this dissertation, a theoretical part analyses and examines these critical concepts of the aviation community along with actual incidents and historical overview. In the second part, the most critical points of the theoretical part are examined through a questionnaire constructed exclusively for this research. Pilots of both civil and military aviation are requested to answer a sequence of questions regarding CRM, Human errors and Resilience. The results, are finally compared with the theory, revealing useful information for the professionalism and operating attitude of modern pilots.

The main questions are summarized in the three main pylons of this dissertation. The questions are divided among those regarding purely CRM, Human errors in aviation and the Resilience. A thorough analysis of the question's selection is formulated in the second part (Methodology and Fieldwork research). Regarding CRM, it is investigated the level of pilots' satisfaction from their respective training and how this might contribute to the mitigation of making mistakes. Moreover, it is investigated a potential difference in the implication of CRM principles between an airline and the Air Force. In the following section, the major questions regarding Human errors are revealed. Therein, it is examined the pilot's need to encounter more scenarios during their training in flight simulators, the importance for them to be supported by a willing and friendly organization, the compliance with standard procedures and finally their attitudes when given some critical scenarios. Last but not least, Resilience is investigated. Through the questionnaire it is examined the relation between CRM and resilience, the level of pilot's preparation (technically and psychologically) when dealing with a situation in distress and their critical thinking regarding the standard checklists.

The importance of this study is summarized in multi-layered results. For the aviation industry, useful conclusions have been emerged concerning the modern CRM. By examining the level of knowledge, satisfaction from training and self-confidence, suggestions have been made towards improvement of CRM. As stated in the beginning, CRM decisively contributes in flight safety. The combination between theory and research will uncover useful results which may decrease even more the human errors. For example, recommendations will be made regarding the operating procedures, the standardization, as well as the handling of an emergency situation. Equally important are the conclusions regarding the preparation of pilots' for the ‘'unexpected''. This aspect is oriented towards the improvement of training and the cultivation of positive attitudes.

Nevertheless, the importance of this dissertation has a wider meaning. Searching the literature review during the ‘'building'' of the theoretical part, it was clarified that the greater part of the CRM's bibliography was not purely customized for aviation. Contrariwise, many data were pumped from other fields than aviation such as business administration. Moreover, many examples were found from other specialities such as surgeons or constructors. In general, the phrase ‘'sharp end of a business'' was repeatedly mentioned for those working in critical positions of businesses. In this thesis, it is also examined the need of the employee to be supported by a friendly and willing organization. In conclusion, the human factor either in aviation or in any kind of firm, still plays a key role in safety and success. The code of communication between employees, the training, the effort for mitigation of errors and the effective confrontation of extreme scenarios are common concerns of every business. Therefore, despite that this dissertation is entitled by a specialized core, its importance and enforcement have a wider field of interest.

1.2 Thesis Organization

The structure of this thesis consists of two parts, the theoretical and the research. Following the required instructions, the aim was firstly to familiarize the reader with the subject via the analysis of the three main pylons of this dissertation and then procced to the research. Initially Literature Review was stated. On that part a quick presentation of the subject has been made as well as the motivation which triggered the commencement of this paper. In the main body of the theoretical part, CRM, Human Errors and Resilience were divided in three separate chapters in the respective row. More precisely, CRM is firstly analysed as the main thematic section. The analysis includes, the definition, the evolution and the training methods that CRM is instructed. Consequently, human errors in aviation are explained. On that section, at first a division of errors has been made into specific categories. Afterwards, it is investigated the way according to which errors can be mitigated through CRM and Threat and Error Management. In fact, this investigation is used as an interface between chapters as well, maintaining a sequence sense. Last but not least for the theoretical part, Resilience is presented. Following the previous techniques, its explanation with theoretical definitions found in the appropriate bibliography is initially written. Due to the great importance for the aviation industry and for this dissertation, a real life event is presented in the last lines of the respective chapter.

The second part consists of the research. This part strictly follows the construction of the theoretical part. In plain terms, the questionnaire was divided in three main sections according to the theory's sequence. This procedure is thoroughly explained in the Methodology along with further information regarding the set-up of the questions. Having completed the general framework of the methodology, the questionnaire is elaborated in a separate section. Therein, the selection of every individual question is justified. Moreover, it is clarified the type of the desired analysis which will be made in the following sections. Results are presented after being analyzed via SPSS. Brief comments escort them along with respective tables. Afterwards, the findings are summarized and annotated accordingly. This sub-chapter aids in the transition to conclusions-recommendations. The final suggestions emerge from a sweet balance between theory and research closing the final curtain of this dissertation.

Literature Review

Since the aviation industry began to expand, there were many issues that caused accidents. These accidents sometimes resulted to minor injuries and some others to fatal disasters (e.g. the deadliest accident in aviation ever happened-Tenerife accident, where two enormous B-747 jumbo crashed on the ground killing 583 humans as depicted in Figure 1.1.1). The evolution of civil aviation required modern and multicrew aircrafts to be constructed in order to transport passengers, goods and ensure people's safety. Until that time, the aircrafts were primarily used as fighting machines flown by just one pilot. The need for bigger aircrafts however, required more crewmembers due to the greater complexity of their systems and for the care of the passengers being aboard. By increasing the crew in the modern aircrafts, more mistakes by the flight crews could be recorded in the Flight Data Recorders of the aircrafts after the occurrence of an event. Therefore, researchers concluded that many accidents have been caused due to the failure of the crew to respond promptly in the ''status'' in which they find themselves. This was a pioneering conclusion because until then it was believed that almost all the accidents happened because of technical failure of the aircraft's systems or pilot's error in critical phases of the flight, such as the takeoff and landing. In addition, it was proved that more than 80% of the accidents were caused by human error, as it will be analyzed in the next chapters. The interesting part however, is that the human factor must be considered as an element of the wider environment. In fact, human has the most important role, because he must counteract and coordinate all the factors of the environment an airplane is operated (e.g. weather, technology, ground personnel, and emergencies). These observations led the researchers to the conclusion that there was a dire need for an adoption of a common code used between the members of a flight crew, in order to moderate the number of aviation accidents. This code was named C.R.M.-Crew Resource Management and until today it's a crucial factor for the civil and military aviation. In overall, Crew Resource Management –"is the effective use of all available resources for flight crew personnel to assure a safe and efficient operation, reducing error, avoiding stress and increasing efficiency" (Flight Safety Foundation [FSF], 2000). By implementing the CRM first into the cockpit between pilots and then between all crew members and ground personnel, it is given an emphasis in teamwork. Last but not least, researchers found out that a defective teamwork may affect the decision making, leading to a wrong decision and finally to a serious incident.

Furthermore, CRM primary includes the cognitive and interpersonal skills of the pilot rather than the technical skills required to fly a modern aircraft. Interpersonal skills are defined skills like communication, the way of acting during a teamwork and an appropriate cooperation. All these skills included in the CRM have one basic target; the aviation safety. This can be achieved by a professional acting of the crewmembers during a distress phase of the flight and resulting to a successful decision making. In other words, CRM may be explained as a management process which combines all the available resources, equipment and personnel in the most optimum way, in order to ensure safety and efficiency for every flight.

A very interesting aspect of CRM is that ‘’it is not designed to change someone’s personality’’ (Helm Reich, R. L. Foushee, H. C. Benson, R. & Russini, W, 1986). On the contrary, its target is to enhance the team work and to give instructions for a proper team coordination and human behavior by means of training, knowledge and background. This aspect has much in common with the modern psycho management that implements in the modern business in environment’s and its principles. Moreover, a good team work requires a proper communication between the members of the team. That is the reason besides, Communication along with Decision Making consist the core of an effective CRM. In particular, information must, when requested, be given accurately and kindly in order to exist the Decision Making. Otherwise, deficient and inaccurate communication may be the beginning in subsequent mistakes that may lead to a fatal disaster as it will be thoroughly analyzed in the next chapters.

Apart from Communication and Decision Making, Team Building is another crucial aspect of CRM which is also implemented in the modern psycho management. This cluster of skills includes leadership and team management. Modern aircrafts, because of their huge dimensions (e.g. Airbus A380 with max seating capacity of 853 persons [Airbus, 2019]) require a flawless cooperation of the crew. CRM records the behavior of every person individually in the team. Since every person is different, CRM instructs crew members on how to adapt to the team, optimize their performance and how to deal with situations when distressed. In another point of view, the target of CRM is to reduce problems that may arise in the team’s coordination (Jensen, R. S., 1995). A good leader in order to achieve the optimum performance level by the crew must coordinate properly and distribute equal amounts of workload.

According to the legislation (ICAO Annex 6 Part 1 Chapter 9), every operator of a multicrew aircraft must implement theoretical and practical sessions via flight simulators of CRM knowledge to new entry pilots. In fact, CRM training consists of a complete integral part of training because of its importance. During the daily operations, flight crews must respect and implement the CRM rules, from the pre-flight phase and the briefing procedure, until the complement of the flight, when the aircraft is parked in its' base. It should be noted that EASA studies on the Safety Risk Management have also revealed the paramount importance of CRM in Commercial Air Transport. This importance is due to the fact that modern pilots rely too much on the highly automated systems of the aircraft, which in a thorough analysis may result to a serious threat by confusing them. Communication and monitoring through CRM process control the psychological and cognitive reactions resulting in the prevention of a disaster (European Union Aviation Safety Agency [EASA], 2017).

Figure 2.1 Tenerife Disaster

Source: https://owlcation.com/humanities/tenerifedisaster

2.1 CRM evolution

The observations of accidents during the past decades have revealed interesting results about the human factor in an accident. More precisely, researchers ascertained that accidents and incidents occurred, were initially caused by a problematic team work (communication-coordination) rather than the technical skills, also known as ‘’stick and rudder’’ skills. Thus, CRM stands for Cockpit Resource Management because it mainly emphasized the pilot’s cooperation. The application however to other members counteracting in the safety of the flight, such as cabin crew and ground personnel finally renamed it to Crew Resource Management (Helm Reich, R.L, Merritt, A. C. & Wilhelm, J. A., 1999). According to the statement of the National Research Council in 1989, the target was to optimize human performance, while in the same time reduce the possibility of human error. That target could only be achieved by taking into consideration methods of social sciences, psychology and engineering. The need for invention of CRM formally began in 1979 by the National Aeronautics and Space Administration sponsoring a research team named Resource Management on the Flight deck. Nevertheless as mentioned above, the great number of accidents occurred during the evolution of flight, led eventually the researchers to enact a frame which would ensure safe and controlled flights. For that reason, a brief report of the evolution of aviation science is imperative.

The first men who won the gravity were the Wright brothers- Wilbur and Orville. The first flight took place in Dec. 14th 1903 and lasted 4 sec with a speed of 16.6 knots and climbing 112 feet above ground level. Four anew attempts to fly were made in Dec. 17th. That day the last flight lasted 59 sec. and the aircraft climbed 852 feet over the ground (Gray F.C., 2002). It was just a beginning of an era that in the next few years would achieve a rapid development in the military and civil aviation.

Although aircraft was still in its infancy, during the burst of the World War I it played a key role during battles and pointed out ace pilots such as the ‘’Red

Barron’’ (Walter von Richtofen, [History Editors, 2009]). Aircrafts were primarily used for military purposes. To be precise, planes were constructed for carrying heavy bombs and ammunition. During this period, the most important factor of plane crashes’ was the engine failure. It was that period of time where a successful take off was characterized a tossing of a coin (Spangler, S.M., 2002). Another major factor was that pilots couldn’t stand the high G loads resulting to the phenomenon of an out of control flight because the pilots had passed out. In the next years anti-G suits were used to prevent blood flowing to human limbs during high G sustain phases protecting the pilots from passing out. During World War II, there was a wide range of military aircrafts such as fighter, bombers (divided in light, medium and heavy), tactical reconnaissance-observation and photo aircrafts, as well as seaplanes. Similarly to WW1, airplanes had a major role in the progress of the war contributing to thousands of battles. Nevertheless, the evolution in aerodynamics didn't conform to the reduction of fatal incidents. The interesting part yet was that flight simulator was extensively used in order to familiarize pilots in flying under instrument meteorological conditions because most of the flights were conducted under visual conditions. The device which used for that purpose was named Link Trainer also known as Blue Box and was invented by E.A. Link in 1929 (Valverde, H. H., 1968).

By the decade of 1950, commercial and military aviation entered a flowering era. On the one hand, aircrafts were at last fast and capable of cruising hundreds of miles. On the other hand, the technological progress came together with an increase in fatal accidents. These accidents were provoked by technical issues, but the major purpose was the pilot error. A contributory factor towards the development of CRM, was the invention of CVR's (Cockpit Voice Recorders). By using CVR's into the cockpits named as ''black boxes'' the communication between pilots, as well as their inputs to the aircraft's systems were explicitly recorded. Therefore, when an accident occurred, the main concern of the investigators was to find and decode the CVR data. In most of the cases so, it was concluded that accidents didn't occur due to technical malfunction but due to pilot errors, latterly named as ''human factors''. These errors were associated with a problematic communication in the cockpit, failures of interpersonal skills, poor decision making and leadership. Moreover, by monitoring the communication between crew members it was evident that captains had an authoritarian role and at the same time the rest crew was lacking of assertiveness. Finally, investigations came out with the conclusion that CVR's couldn't reveal other significant human factors, such as fatigue, vigilance, situational awareness and ability for an effective decision making (Civil Aviation Authority, 2014).

An accident in the commercial aviation occurred in 1978 (United Airlines) concluding in a disaster crash, is believed to have highlighted the need for a change. To be more accurate, a malfunction in the aircraft's systems was not properly treated due to poor communication between the captain and the co-pilot. Subsequently, the pilots lost situational awareness, run out of fuel and the flight had a fatal ending. Since then, aviation industry in order to survive, equipped the aircrafts with enhanced warning systems which alert pilots for an imminent disaster. Moreover, the practice of the warning systems in the flight simulator helped pilots to manage their mistakes and reduce the human error (Wagener, Ison, 2014). At the same time CRM which at the beginning meant Cockpit Resource Management, began to configure and was driven by phycology and management which set up the main frame (Civil Aviation Authority, 2014). NASA conducted a research including the statistics of air accidents between1968-1976. The results revealed that more than 60% of incidents occurred due to poor crew coordination and decision making (Cooper G. E., White M. D., & Lauber J. K., 1980). The research also included questionnaires and interviews of the flight crews. Once again, the results were totally disappointing. In most of the cases, it was found inadequate training in leadership skills, inter-personal communication, poor resource management and inability to share workload. As a result, NASA took the initiative and organized a workshop called Resource Management on the Flight deck. The main target was through thorough training to reduce as much as possible the human error by using properly the human resources in the cockpit. Except USA, in Europe there were also making some beneficial steps to enhance CRM. Edwards in 1975 also ascertained that aircraft commanders need to upgrade their cooperation with the rest crew and at the same time preserve their fundamental role and authority in the aircraft. This concept was named Trans-cockpit Authority Gradient (TAG) and was extensively used in order to study the human performance (Edwards E., 1972). The findings of the Edward's research were implemented in the training of KLM's (Dutch airline) crews by means of human factors. It is believed that Edwards's research is the beginning of CRM in Europe.

Until 1995 CRM wasn't accepted widely by the pilot's community. It was characterized as a useless school which was dealing with psychological issues and which was making a brain wash by management (Kanki B. G., Helmreich R. L. & Anca J., 2010). Nowadays, aviation industry traverses the sixth generation of CRM highlighting the Threat and Error Management. In order to thoroughly understand CRM's development through the past years, a brief report to the previous generations is imperative.

2.2 CRM’s Generations

Since CRM was first introduced in the early 80’s, it has now proliferated all over the world. In fact it was more a change in mentality than a change in technical skills. According to Helmerich, five generations were distinguished in the previous decades while the sixth generation, started in 2001, is still ongoing as mentioned above. The term ‘’generation’’ describes the process of growth and development of CRM. In the next lines, the context and emphasis of CRM’s generations is briefly presented.

2.2.1 First Generation Cockpit Resource Management.

In this very first generation, infant steps to construct new programs in CRM training took place. It’s the beginning of the ‘’story’’ and the point where there is a connection between previous incidents and the need of the aviation industry to enhance safety. The findings of the air disaster of United Airlines in 1978, revealed useful evidence. According to the National Transportation Safety Board (1979), the cause of the fatal accident was the refusal of the aircraft’s commander to accept co-pilot’s inputs during flight and the lack of assertiveness by the flight engineer. After this incident, United Airlines was the first company to conduct a comprehensive program in CRM training. The main target was to indicate the appropriate managerial style by alleviating authoritarian behavior, usually found in captains and enhancing assertiveness in first officers. These programs were totally based in psychology with a focus on interpersonal skills and leadership. The programs included theoretical courses and practical sessions in the flight simulator-LOFT (Line Oriented Flight Training). For the first time, it was instituted an annual training in CRM for pilots. Till then, the need for CRM training would take place only once in a pilot’s career. Despite all the advantages, CRM was still considered by many aviators as an attempt to manipulate their personalities (Helmreich R., Ashleigh C. Merritt, John A. Wilhelm, 1999).

2.2.2 Second Generation Crew Resource Management.

By the time second generation began to emerge in the aviation world, many airlines around the world had already incorporated the CRM in their daily training. The difference between the first and the second generations, was basically that the second focused on pure aviation problems dealing with flight operations, therefore became more modular and team oriented. Trainees accepted the second generation as an improved form of CRM but still the criticism was intense. Once again, the reason was that according to trainees the courses were ‘’psycho-babble’’ oriented. The first company which implemented those courses was Delta Airlines. At that time CRM finally renamed to Crew Resource Management instead of Cockpit. Courses in the form of seminars were teaching concepts such as team building, how to make a thorough preflight briefing, situational awareness and stress management (Lazopoulos, 2013). The foundations established during this generation are until now the main body of the modern CRM.

2.2.3 Third Generation Crew Resource Management.

This generation emerged in the early 1990’s. During this period it was given particular emphasis on crew members apart from pilots. CRM began to apply to other specialties of an airline such as flight attendants, maintenance staff, dispatchers and airport personnel. It was found that in order a safe flight to be ensured, a proper communication between pilots and the rest crew members was imperative. By means of training, joint pilots-flight attendants scenarios began to emerge. For instance, an emergency ground evacuation procedure thoroughly analyzed and practiced in a very short time. Moreover, CRM adapted in the modern cockpits, in order to instruct pilots to acquire specific skills in conjunction with flight automation. Meaning that CRM integrated with technical training would make pilots even more effective in a contemporary environment (Helmreich R., and others, 1999).

2.2.4 Fourth Generation Crew Resource Management.

In the fourth generation, a decisive step to mitigate human errors took place. This was attempted by using CRM as an integral part of the flight training. Furthermore, many airlines around the world instituted in their CRM’s training policy the national and organizational culture. The first initiative was made by FAA (Federal Aviation Administration) by using the AQP-Advanced Qualification Program (Birnbach R., & Longridge T., 1993). This was a pioneering program allowing carriers to adapt and customize their training, with integrated CRM concepts, according to their needs. Nevertheless, in order to acquire this flexibility, carriers were obliged to provide CRM and LOFT to all flight crews and to integrate CRM principles in the technical training by adding prescribed behaviours to the standard operating procedures. Additionally, it was crucial for the carriers to introduce a detailed analysis of training for each aircraft, to develop programs which focus on human factors and finally to implement a special course of training for people in charge with certification of crews. These requirements had to be placed in a specific framework of Line Operational Evaluation in the form of simulation. However, during this generation it was believed that there was a deviation from the principle of making explicit CRM training (Taggart W.R., 1994).

2.2.5 Fifth Generation Crew Resource Management.

The primary idea of this generation is the Human Error. Merritt & Helmreich strongly believed that what makes CRM so distinct is the Error Management. It is well known that Human Errors are in the man's nature however, errors may turn to a valuable source of collecting information. After collecting and analyzing this information, an effective way of reducing the errors, must be chosen. The most effective manner found was the so called error management troika. According to troika, there are three steps of defense: avoid error, trap error before occurring and mitigate the consequences when an error has occurred or not trapped (Helmreich R., and others, 1999). These steps are illustrated in Figure 1.3.1. From organization's standpoint, a recognition of human errors and a non-punitive policy for the errors (except willful violations) was imperative. Human performance was also the central interest in the Fifth Generation. Special emphasis was given on cognitive errors and stressors which affect human performance such as fatigue, task saturation and emergencies. Despite the severity of human error, this generation didn't last long. Helmreich believes that this fact can be justified by a pilot's statement: ''I feel insulted being labelled as an error management. It implies that my job is to screw up and then correct mistakes'' (Foushee H.C., Helmreich R.L., 2010).

Figure 2.2.5.1 The error Troika

Source: Helmreich R., Merritt L. and Wilhelm J., (1999). The Evolution of Crew Resource Management Training in Commercial Aviation

2.2.6 Sixth Generation Crew Resource Management.

As mentioned above, CRM nowadays traverses the sixth Generation with a main focus on Threat and Error Management-TEM. The start was made back in 1994 when Delta Airlines and Texas University of Human Factors commenced a partnership program. The program was named Line Operations Safety Audits-LOSA, and it was an expedient to evaluate pilots' CRM attitudes during daily flights. This was achieved by the presence of an evaluator in the cockpits of Delta Airlines in the jump seat (Klinect J.R., Murray P., Merritt A., Helmreich R., 2003). In addition to the previous generations, TEM immediately attracted the attention of pilots, managers and regulators. In a manner of speaking, TEM presented a more technocratic concept by investigating an ordinary flight from one destination to another. During these flights, it was given emphasis on internal and external threats. Internal threats were associated with the crew or the aircraft's status and external with the intense weather phenomena, air traffic controllers, delays and others. Nevertheless, TEM principles may be applied to all operations of an organization and it's a good criterion for the analysis of bad CRM air disasters (Foushee H.C. and others, 2010). Because of its great importance for this writing, TEM will be further analyzed in the next chapter dealing with Human Errors.

In conclusion, through the years of its development, CRM has managed to overcome the criticism and the doubts that were stated when firstly introduced. Additionally, it was achieved to engulf in its spectrum not only pilots but also every speciality working in critical positions such as cabin crew and ground personnel. Nowadays it is considered the finest mean of training targeting in the mitigation of human errors and in flight safety.

2.3 CRM Training

So far, a presentation of CRM's nature and history has been attempted. By this process, it is clarified that CRM managed to be globally appreciated. In this subsection a quick presentation of CRM training is explained. Before proceeding to the main body of this section, a reference to the modern aviation is required.

Nowadays, aviation has expanded widely and the personnel of the airlines is multicultural, multinational in most of the cases. The most typical example is in the Middle East where the greatest airline consists of 160 different nationalities. In that case, an operation without proper CRM is impossible. Aviation has turned to an international industry and CRM must also be global. The authority that sets the main framework of an international approach to CRM is the International Civil Aviation Authority-ICAO.

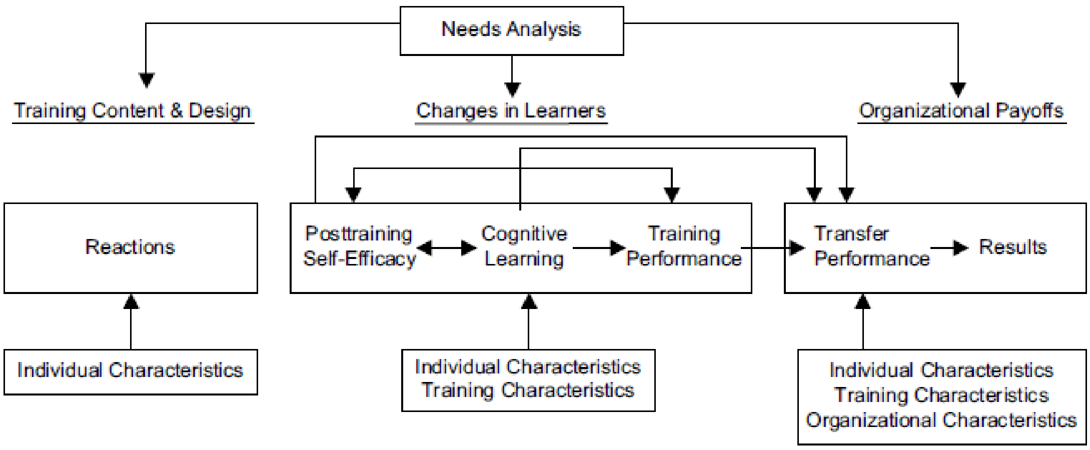
Crew members trained in an aircraft, except the technical knowledge and the skills, ought to acquire experiential learning. In further analysis, they need to acquire cognitive and interpersonal skills which are the foundation of prosperous CRM. Nevertheless, these skills can't be learnt in the same way as the technical knowledge of aircraft's systems and the emergency procedures checklists. In order to acquire them, it's essential to understand and interpret behavior in a group context. Besides, this is the reason CRM is analyzed in groups by a special trained facilitator who fosters the learning procedure (Royal Aeronautical Society, 1999). During this procedure, past behavior of every individual during an organizational situation is analyzed in order to gain sufficient insight and predict any possible faults in the future. That's the reason why a training is considered effective when the trainee successfully achieves learning outcomes from this process. Additionally, it is suggested that the most effective way of CRM's training is when technical knowledge and skills are embedded to each other from the beginning of the aircrew's training. Apart from that, this is the idea expressed during the third generation of CRM. In figure 1.4.1 a sophisticated flight simulator cockpit is projected respectively to those used in modern airlines, where technical, cognitive and interpersonal skills are built.

Figure 2.3.1 Boeing 787 console

Note: source www.virtualaviation.co.uk

Because training is an ongoing process, an evaluation model needs to define the effectiveness of this process. One of the best models of evaluation until today is considered the Kirkpatrick's (1976). First of all, a modern training in CRM requires to discriminate the individual differences of every person, the organizational environment and the tasks to be analyzed. Regarding to trainees, it must be taken into account individual characteristics such as personality, motivation, attitudes and level of experience. In the final stage, it must be evaluated whether all the knowledge learned during the training, is successfully transferred to the job (Alvarez K., Salas E., Garofano C.M., 2004). However, not all of the trainees absorb the knowledge in a satisfactory rate. These trainees lack in CRM concept completing the training. For CRM these cases are called as ‘’boomerangers’’ requiring special handling (Helmreich R.L., & Merritt A.C., 2000). In figure 1.4.2 an integrated model of training and evaluation is depicted, presented by Alavarez in 2004 (Kanki, Helmreich, Anca, 2010). In this model, all the necessary parameters of an effective training and evaluation are presented. Additionally, it’s an example of how training effectiveness and evaluation can be integrated.

Figure2.3.2 Model of training effectiveness and evaluation



Note: source Kanki, B. G., Helmreich, R. L., & Anca, J. (Eds.). (2010). CRM, second edition.

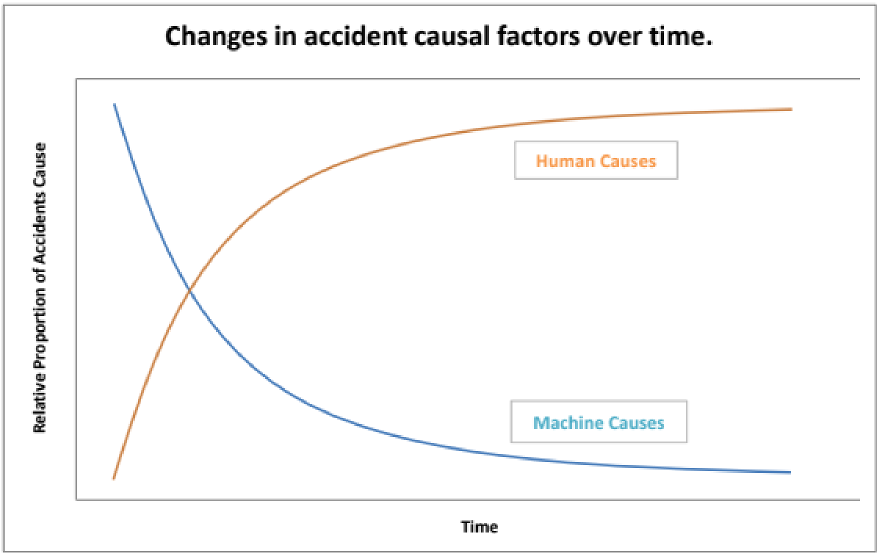
However, still there are much more to learn about effectiveness of CRM training as well as factors that impact on CRM training such as individual characteristics (intelligence, motivation or expectations) and organizational characteristics. Additionally, the CRM training culture must be generalized for every operator. Until today, programs regarding the proper way of training are not adopted equally from every culture. For example, in some countries co-pilots are not allowed to be assertive and question captain’s decisions. This fact is down to country’s tradition where young members are forbidden to question their superiors (Helmreich R.L., & Merritt A.C., 1998). These attitudes directly compromise flight safety cancelling CRM’s attempt for safer flights and need to be changed as soon as possible.

Human Error in Aviation

The first aviation mishap ever happened was reported in the Greek mythology. It was the myth with the young Icarus and his father Daedalus who were trying to escape from the island of Crete according to the myth. The young aviator Icarus rapt by the majestic feeling of flight attempted to fly even higher despite his father's disagreement. His wings constructed by wax, melted by the heat of the sun resulting in the fall of Icarus in the Aegean Sea. That was the first fatal incident in the aviation provoked by the aviator itself- a so called human error. Since then, the aviation industry has developed rapidly as seen from the previous chapter, resulting in the 21st century were modern jets dominate in the skies conducting thousands of flight per day. According to statistics kept by the flight radar which is tracking flights all over the world, in a peak day of July or August at time between 2pm and 4pm (UTC time) there have been reported more than 16.000 flights in the sky (The Telegraph, 2017).

Human errors in this tremendous air activity, still play a key role to the safety of aviation industry. As underlined in the beginning, the 80% percentage reveals that the greatest amount of fatal accidents is down to human factor, the rest 20% is faulty equipment or weather related accidents (Helmreich, 2000). This fact, is a strong message to the managers of every organization. Managers ought to pay attention in the human factor, especially to those employees who carry critical positions- the so called ''sharp end'' of a company (Flin, O'Connor, Chrichton, 2008). According to psychologists, human errors can be mitigated when all kinds of employees are familiar with non-technical skills. Non-technical skills are the cognitive and social skills that complement workers' technical skills (Flin R., 2003). In the diagram below a straightforward depiction of the proportion between Human and Machine causes in aviation accidents is presented (Hobbs A., 2004).

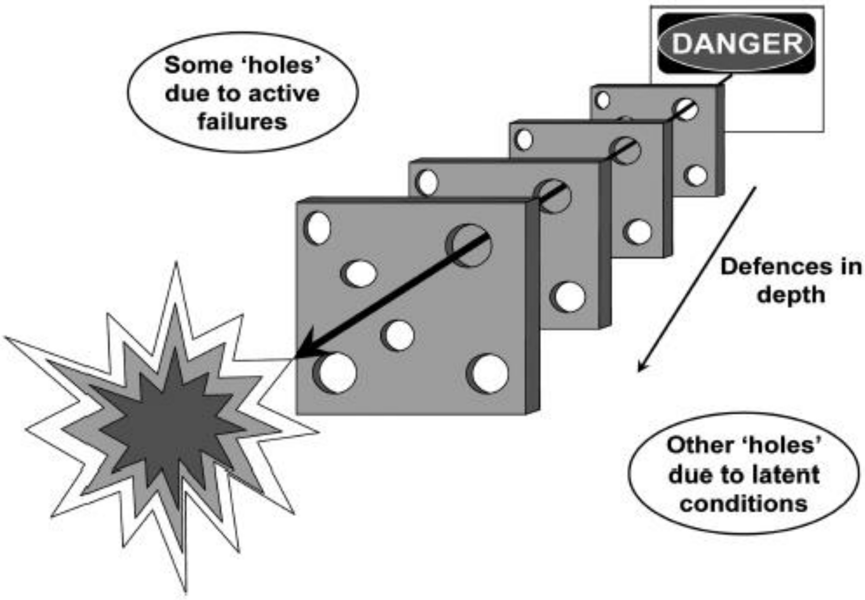
Figure 3.1 Human-Machine causes of aviation accidents over time



Source: ICAO, 1984

At the same time, many models have been designed in order to represent the sequence of faults that lead to an accident. Reason's model-the Swiss Cheese (1997), depicted in figure 2.1.1 is until today one of the most successful models used in many organizations as well as in pilot's training. According to this model, a sequence of faults and violations created by the operational workers and the latent unsafe conditions in the work ''chain'' created by managers, engineers etc. can lead to the disaster. When a combination of factors commence to lead to a distress situation the last line of protection, or the last slice of cheese according to the model, is the human factor. Humans, even in the last minute, can catch theirs or other's mistakes preventing imminent losses, injuries or even disasters (Helmreich, Klinect J. and Wilhelm J., 2003). Speaking in terms of aviation, it is an established fact that pilots usually make two errors in every flight leg. It is also found that under specific conditions such as fatigue, stress, circadian lows and task saturation, humans are more prone to errors (Civil Aviation Authority, 2014). However, they are trained in order to perceive and correct them before creating a situation of distress. Moreover, trained employees in general, can deal with technical malfunctions and a wide variety of harmful factors.

Figure 3.2 ''Swiss Cheese'' model.



Source: Flin, O'Connor, Chrichton (2008), Safety at the Sharp End

3.1 Division of Human Errors in Aviation

An error in aviation is a sequence of faulty actions leading to other than the desired outcome. Their division is made firstly according to cognitive criteria and secondly whether they occur during planning or executing the mission. Human errors may happen in two different circumstances. The first is when a pilot executes with accuracy the required actions, but his/her plan is unsatisfactory, and the second one when the plan is well designed but the performance is poor (Hollnagel E., 1993). As a result, Kern in 1998 made a plain categorization of human errors. The first category was Omission Errors and the second Commission Errors. The first category included cases of pilots failing to accomplish a required task while the second included cases of accomplishing tasks incorrectly or doing unessential actions (Kern T., 1998). In the next years, researchers further analyzed human errors but the division remained simple.

Until now, human errors are distinguished in two categories. The first category is quite the same with Omission Errors. A person takes on the responsibility to carry out a task. The task is appropriate but the execution is inadequate resulting in other than the desired goal, thus human error. These errors named Slips and Lapses. Slips, have to do with poor attention in the task or inadequate perceptual. Aviation industry works on it for every new type of aircraft, meaning that it accounts for human vulnerabilities. A typical example is the placement of critical levers such as flaps or fire emergency control handles in a position where pilots may not be mistaken and select them accidentally (Civil Aviation Authority, 2014). Lapses regard to human characteristics and are commonly associated with memory failures (Strauch B., 2004). Another significant difference between Slips and Lapses is this: on the one hand, the term Slips is used when a person is intended to take an action properly but his execution was flawed. On the other hand, the term Lapses is used when an action has not done at all. For example, in aviation Slips and Lapses can occur in the form of forgetting to follow crucial steps in the aircraft's checklist or forgetting the briefed plan e.g. how to approach the airport for landing. Many accidents have happened because of the interruption of the checklist. The result is that when pilot returns to the checklist after the interruption a crucial action has been omitted. This is a case of skill based mistakes. The phenomenon, is even more intense when a crew is facing an emergency, meaning that it works under pressure. A typical example is that of a crew faced a minor emergency of a burned out light in the cockpit while in the same time nobody made the required actions to navigate the aircraft. As a result the aircraft acquired an excessive descend rate, the airspeed built up quickly and the recovery was inevitable (European Organization for the Safety of Air Navigation [EUROCONTROL], 2002).

Conversely, the second category includes the cases of people executing an action with a proper way but the action itself is unsatisfactory. In that occasion a planning failure is met thus the term Mistake is used instead of Error. According to researches, when humans recognize a faulty situation they reject skill performance and seek for memorized rule performance. In that case, either a good rule may be used in a wrong situation or a completely wrong rule may be applied. The next step is when humans recognize that the problem dealing with, does not correspond to a proper rule. The consequent reaction is to look for knowledge based plans. When the collection of information and the splitting process of the situation is poor, human's knowledge is based on mistakes resulting in planning errors. By means of numbers, the greatest percentage of errors are down to poor skills (61%), while inappropriate rules gather a lower percentage (27%) and finally deficient knowledges gather the smallest percentage (11%) (EUROCONTROL, 2004).

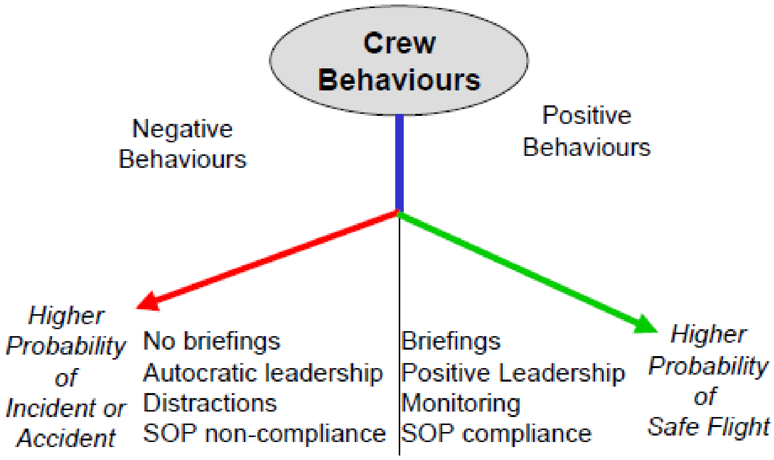
Modern socio-technical approaches to errors are focused in the system in which the error occurred. Parts of a system include procedures, techniques, design of interfaces and human vulnerabilities. These elements are considered interdependent and connected to each other. Therefore, when a Human Error takes place, it’s an indication of a system’s decease. The analysis then turns to the system’s elements and not just to the human agent who committed the error. Some of the factors investigated include the reasons which the system didn’t protect the person from making an error, why the person was forced to act the way he did and finally why the system itself didn’t prevented or managed the error. Certainly, this modern philosophy of investigating the errors is not to be interpreted as an excuse for deficient performance (Civil Aviation Authority, 2014).

3.2 Mitigating Errors through CRM

The very first steps to mitigate the inevitable Human Error were made during the fifth Generation of CRM’s evolution. As shown above, the error management troika helped investigators and pilots themselves to comprehend the nature of their errors and the necessary steps to prevent it from occurring (Figure 1.3.1). One of the most appropriate situations to simulate this procedure is the Controlled Flight into Terrain (CFIT). In this case an aircraft without experiencing any problem, heads straight down to the terrain. The situation could have been prevented if the pilots have crosschecked the information of the waypoints programmed in the aircraft’s Flight Management System. Even though they failed to do so, the last line of defense as shown in the Swiss Cheese model, is the Human Factor. Pilots are trained to perceive mistakes and promptly prevent them. In order to catch errors timely, the Set-Check-Confirm philosophy has been established. In our example, the co-pilot sets a waypoint to the Flight Management System and he states his input (1st step-Avoid Error). The aircraft’s commander states ‘’Checked’’ and if there is a third member in the crew (e.g. Flight Engineer or Navigator) states ‘’Confirm’’ (2nd step-Trap Error) after both have inspected the validity of co-pilot’s inputs. In case that this procedure fails to operate properly and the aircraft upon reaching the critical point descends down to the terrain, the pilot flying has the option to disengage the autopilot and recover the aircraft in straight and level flight (3rd step-Mitigate Consequences), (Helm Reich and others, 1999). In this way, crew members learn to cooperate harmonically during flight and correct theirs or others mistakes so that to ensure the flight safety. CRM suggests that pilots have to learn to fly by keeping in mind that their colleague may make mistakes especially in critical phases such as when reading checklists or when dealing with an emergency (Civil Aviation Authority, 2014). Additional defenses enhancing the error management are considered the standard call outs between crew members, pre-flight checks and warning systems. When defenses start to weaken or breach, an accident is likely to happen via the Human Error.

In the same time, it was given particular emphasis to the pre-flight briefings between the cockpit and cabin crew as one of the first countermeasures against Errors. Common briefings between pilots and cabin crew was the transference of error management philosophy in all persons contributing to the safety culture (Helmreich R., 1997). Equally important were the inflight briefings. During the preparation for taxi, take off and descend, Pilot Flying (PF) must inform the Pilot Not Flying (PNF) about his/she's intentions. This procedure is underlined as a good measure for preventing errors promptly. Briefing is considered fully effective only when the PF has thoroughly explained all the necessary information to the PNF. Items to be analysed include runway's dimensions, obstacles in the vicinity of the airport, frequencies, airport's facilities, minimum off route altitudes etc. Because of its great importance, special procedures extending from the tighten aviation framework were developed. For example, it is proposed to keep a positive eye contact during the briefing process, to maintain continuous engagement. Additionally it is highly recommended to change regularly the briefing's script. Otherwise, PNF will feel that he/she knows exactly what is going to be said losing attention (Moriaty, 2015). Briefings between cockpit and cabin crew are equally essential. Pilots and cabin crew pass to each other useful information trying to manage threats or possible errors. For instance, pilots shall give notice to cabin crew for imminent turbulence and cabin crew ought to inform aircraft commander about passenger's status. In figure 2.2.1 suggested crew behaviors harmonized with CRM's regulations are depicted.

Figure 3.2.1 Mitigating errors following CRM based Behaviours



Source: Helmreich, R.L., & Merritt, A.C. (1998). Culture at work: National, organizational, and professional influences

Nevertheless, nothing from the above would have ever been achieved if the organizations hadn't convinced pilots to share their errors within the pilot's community. Researchers in 1997 found that a common characteristic of pilots was the feeling of personal invulnerability which was making them over-confident (Helmreich, R., Merritt A, 1998). As a result, the acceptance of their mistakes was barely unusual. Federal Aviation Administration (FAA) in the same year suggested a breakthrough program. According to this, airlines should encourage pilots to report their mistakes by adopting a non-punitive confrontation against them. Meanwhile it was set clear that this new approach in errors would not be implemented in cases of willing illegality in the organization's rules. The first organization which initiated the program along with FAA's regulations was American Airlines. This confidential program succeeded immediately by gathering more than three thousand reports in one year (Federal Aviation Administration, 1997). By this way, casual every day Human Errors were collected and analyzed from the appropriate authorities. By the time more and more incident reporting systems were developed, such as BASIS (British Airlines Safety Info) and ASAP (Air Safety Action Partnership), in order to investigate aspects of potential vulnerability in aviation industry (Sherman P., Helmreich R., & Merritt A., 1997).

The spectacular results in the reduction of Human Errors through CRM led other specialties such as healthcare, oil industry as well as general transportation to embrace it in theirs operational statute (Kanki, Helmreich, Anca, 2010). Another essential element of CRM against Human Errors which was also widely recognized in businesses and organizations was the ‘’Dirty Dozen’’ found by Gordon Dupont in 1993. According to this, twelve main precursors lead humans towards error hence in the accident. Although aviation science has concluded that there are more than three hundred precursors which may provoke a Human Error, these specific twelve are considered the base for every analysis (ICAO, 1993). More precisely, ‘’Dirty Dozen’’ includes, without priority order (Skybrary, 2017).

1. Lack of communication
2. Distraction
3. Lack of resources
4. Stress
5. Complacency
6. Lack of teamwork
7. Pressure
8. Lack of awareness
9. Lack of knowledge
10. Fatigue
11. Lack of assertiveness
12. Norms

Nevertheless, the number of potential factors provoking human errors is excessive and so are the operating procedures for prevention against them. CRM highlights to pilots the need for learning the error theory. By this process, it is considered that pilots recognize their vulnerability and the possibility of committing errors in the right moment. Efficient crews learn to pause and check twice or more a situation which embeds doubt (Civil Aviation Authority, 2014). Contemporary methods for dealing with Human Errors such as the ‘’Dirty Dozen’’, Slips, Lapses and Mistakes are given through CRM’s sixth generation, Threat and Error Management (TEM). This philosophy was firstly introduced in 1990 and it’s still ongoing. In fact, TEM doesn't consist a revolutionary idea in CRM's evolution but it's an upgraded approach in human errors included in a broader context (Helmreich R. and others, 2000).

3.3 Threat and Error Management (TEM)

In the previous chapter, a short report in TEM was made as the most recent stage of CRM's evolution. In the lines below, a further analysis will be given in the perspective of how TEM is used to manage Human Errors. Even though TEM was initially used for cockpit operations, it ultimately expanded in many different sectors and positions within an organization. When using TEM within an organization a clarified discrimination is imperative because slight differences may be required depending on who is working on it (ICAO, 2005). In aviation industry TEM is covered in all training stages of pilot's training according to European Aviation Safety Agency regulations.

An operational environment such as the cockpit environment is considered complex itself. These complexities negatively affect the aviation safety. Therefore, TEM's principal object is to study the way people act within an operational environment (Dan Mauriono, 2005). In other words, TEM is a safety process dealing with aviation issues and human performance. Nevertheless, TEM doesn't entirely underlines human factors but focuses in the operational context as well. Although TEM was recently presented, in fact its development came along with the collection of aviation industry experience. The object that discusses, is the safety in aviation via safety in aviation operations and human performance thus, how people interact within an operational environment (Dan Mauriono, 2005). The first steps towards the development of TEM were made through LOSA as mentioned in the previous chapter. Delta airlines was the first organization to adopt this program. Nevertheless, Continental airlines in 1996 conquered it by using a full scale TEM philosophy in conjunction with CRM principles in order to record the most frequent errors and threats during a flight and how pilots were dealing with them (Meritt, Klinect, 2006). Since then, TEM is considered an essential process for the On the Job Training (OJT) because its framework indicates the training requirements and acts as a shield for the organization. Moreover, TEM is equally useful whether we examine an air incident separately or systemic patterns in an operational context.

In further analysis, TEM has three main components. The first two include threats and errors, as tormented by the definition. These two components according to flight crews are part of the daily routine and need to be treated timely. If they don't, an undesired state of the aircraft will occur which happens to be the third component. This part is significantly essential as it's the last line of defense before facing an accident. In the lines below, a more detailed presentation of the TEM's components is attempted.

As mentioned in the beginning, an aircraft's cockpit is a complex environment itself, thus pilots are dealing with contextual complexities. Threats, are defined as events not associated with pilot's handling skills, making even more complex the operational environment and need to be faced properly in order to prevail the flight safety. Threats are not classified all in one category. Conversely, depending on their occurrence, are divided between expected, unexpected or latent. A typical example of an expected threat is when the destination airport includes a short runway. The landing is expected challenging but through the approach briefing, safety valves will be set therefore managing threat. Contrariwise, an in-flight emergency such as an engine flame out is an unexpected threat. In that case knowledge, preparation and calmness aid in treating the threat. Last but not least, are the latent threats. These threats, also called as organizational, are hidden into the operational context and most of the times are not observable by the pilots. Cases of latent threats are the schedule changes, delays, maintenance and ground handling errors. Flight crews using TEM's principles, cut off any doubt regarding the flight safety. That's the reason besides that pilots are called threat managers.

Consequently, errors will be examined. In contrast with threats, errors are directly connected to the pilot's actions. These actions may compromise the flight safety by provoking an undesired aircraft state if they are not corrected timely. Errors may not be associated with threats. For that reason they are called spontaneous. A usual occasion is when the pilot flying (PF) selects a wrong mode in the autopilot making the aircraft to fly other profile than it was programmed to do. For that reason, TEM's objective is to detect and respond in errors timely rather than underlining the commission. Besides, when an error is trapped successfully, undesired aircraft state is avoided preserving flight safety. According to TEM, errors are divided in three subcategories. These subcategories include errors regarding airplane's handling, procedures and communication. The criterion according to which errors are sorted in those subcategories is the interaction of pilots the time that error occurred. When a handling error is mentioned it means that the PF is using the aircraft's control system. Hence, whenever humans interfere in the aircraft improperly a handling error may emerge. The most usual cases include improper use of the autopilot, deviation from the aircraft's limits when flying manually or even ground mistakes (e.g. turning in the wrong taxiway or unintentional runway incursion). In the case of procedural errors a standard procedure is violated. This may include aircraft's checklist, adherence in the operational manual, briefing procedures, and unclear response in callouts during cockpit operations. Finally, when speaking about communication errors, failures in communication between flight crews and other specialties are taking place. For instance, poor communication between pilots and traffic controllers is part of the everyday operations. Respectively, communication errors may also occur in ground operations. This is possible to happen when the aircraft is ready for start-up and push back from the gate and there is a lack in communication between flight deck and ground personnel. In that case, flight safety is compromised because a personnel's injury may happen or a damage in the aircraft.

The final category is associated with undesired airplane's states. These states it's possible to happen any time during flight (Moriaty, 2015). An aircraft may be leaded in other than the desired state when threats and errors emerged did not confront effectively. For example, when selecting a wrong mode on the autopilot (handling error) a greater descent rate will be set making the aircraft to dive rapidly. The airspeed consequently will increase and the limits of aircraft's control surfaces (landing gear, flaps etc.) may be exceeded. Regarding the inadequate communication with the controllers, pilots may confuse the assigned heading given by the controllers thus navigate in a wrong track. In congested airports where the airspace is limited this may turn to a dangerous situation compromising flight safety. Aircrafts will fly in convergent course resulting in the activation of protective systems to avoid collision. In the table 2.3.1 further cases of undesired states of aircraft are written on.

Table 3.3.1 Cases of undesired aircraft states

Aircraft handling	➢ Aircraft control (attitude). ➢ Vertical, lateral or speed deviations. ➢ Unnecessary weather penetration. ➢ Unauthorized airspace penetration. ➢ Operation outside aircraft limitations. ➢ Unstable approach. ➢ Continued landing after unstable approach. ➢ Long, floated, firm or off-centreline landing.
Ground navigation	➢ Proceeding towards wrong taxiway/runway. ➢ Wrong taxiway, ramp, gate or hold spot
Incorrect aircraft configurations	➢ Incorrect systems configuration. ➢ Incorrect flight controls configuration. ➢ Incorrect automation configuration. ➢ Incorrect engine configuration. ➢ Incorrect weight and balance configuration.

Source: Canadian Aviation Safety Seminar. Vancouver 2005. https://www.skybrary.aero/bookshelf/books/515.pdf (05/11/2018)

When an aircraft has reached an undesired state an incident or accident is about to happen if not treated immediately. TEM teaches flight crews that upon reaching a distress situation the very first priority is to correct the aircraft's state disregarding what caused the error. For example, when flap's maximum speed is exceeded pilots must control the airspeed's build up by disengaging the autopilot or selecting a level off mode in the autopilot rather than investigate the reason generating this problematic situation.

Countermeasures oriented towards flight crews are divided between ''hard'' and ''human based''. According to statistics more than 70% of pilots' activities are related to countermeasures based on TEM's principles. This is to say the great importance that countermeasures provide in modern aviation. Hard measures are connected with aircraft's systems. Since the decades of '40s and '50s scientists P. Fitts and A. Chapanis had foreseen the key role of installing critical levers in the cockpit in the proper position. This was made in order to avoid slips from pilots. Meaning to reduce the possibility of selecting a wrong lever in an undesired phase of flight. This idea consisted the first countermeasure against threats and remains unspoiled until today (Civil Aviation Authority, 2014). Contemporary systems developed through years were also oriented in supporting pilots and acting as a shield against threats and errors. Some of these are Ground Proximity System, Collision

Avoidance System and Annunciator panels. Operator's safety lines such as Checklists, Standard Callouts, and Operating procedures point to the same target as well. Humans from the beginning of their training, learn how to exploit and manage all of the information provided by those systems. Nevertheless it is apparent that their usage must be attuned to pilots' capabilities. For that reason strategies to counteract threats and errors are based on the human factor as well. These strategies are mainly developed via CRM. But since TEM consists a part of the broader CRM, many of them are engulfed in TEM's philosophy. Their separation is made based on the action point. For example, measures planning to counteract for unexpected threats include workload assignment and contingency management. Measures for error prevention and response are related with automation management and advanced cross-checking strategies. Finally, countermeasures against undesired aircraft's state contain assertiveness, evaluation and modification of plans.

As incidents dealing with human errors continue to happen in aviation, CRM as well as TEM are under intense criticism. The accusation that CRM has failed is totally inaccurate and reveals a lack in understanding the human factors. As stated above, humans will necessarily continue to err because they are imperfect organisms. Especially when they are under stress, fatigue or overload the possibility of making mistakes is even closer. In this sharp end of aviation CRM in conjunction with TEM act as effective but imperfect tool in humans' service for improving operational effectiveness and mitigation of errors.

Resilience

Aviation industry through the past years has been expanded immensely. In fact, still the parameters that shape the market are constantly changing. Airlines in order to survive, adapt in their operation minimum costs policy, set alliances and specialize in close markets. Both civil and military aviation closely monitor and keep up with the technological evolution as it is considered that the more new is the aircraft the more safe and efficient it is. Like in domino effect, when changing a parameter such as the airline's policy the rest will follow as well. Last but not least in this constantly changing environment is the human factor (Hollangel, Woods, Leveson, 2006). As shown in the previous charters human factor still plays key role in aviation industry. For that reason, sciences such as CRM follow the industry's developments by changing, improving or even setting new rules. Stress management for example, has extremely puzzled scientists for many years in the past. Nowadays the 'successor' of stress management is considered to be the Resilience. Although resilience has featured many years before in phycology, in aviation was recently presented as an improved and evolved version of stress management.

Resilience is defined by the Concise Oxford English Dictionary (Catherine Soanes, Angus Stevenson, 2004) as the ability of a person to 'withstand or recover quickly from difficult conditions'. More than a return to the initial state, it engulfs the idea of learning from adverse situations, and enhancing one's personality (Vanistaendael S., 2006). It is the ability to successfully cope with a crisis and to return to pre-crisis status quickly (Terte, Stephens, Christine, 2014). It seems a crucial capability for a pilot in order to remain focused and tranquil during crises and stressful incidents, which combines cognitive, emotional, behavioral and relational factors.

Significantly, Deb, A. and M. Arora (2012), examined the purpose of resilience and academic achievement among adolescents and they revealed that individuals reporting high resilience showed better academic performance as compared to those perceiving themselves to be low on resilience. Males scored higher on resilience and performed better in competitive examinations than females did. Consequently, resilience encompasses that the person understands the complexity of the situation and manages to retain optimistic but realistic expectations and motivations (Siebert. A., 2005). This is achieved by maintaining a positive self-image, being confident and keeping a positive cognitive self-concept. As a matter of fact, this means that the person believes in his strengths, abilities and that he can actually handle the stressful situation, he can actually manage his stress, overwhelm the danger and remain calm.

As far as the emotional factors are concerned, these have to do with the ability to identify and handle the negative emotions the person might have. It sounds challenging, as yet, if the person is focused on his mission and gives a meaning of purpose to his actions, trying to accomplish his target, resilience can be reached. It should be noted that the person must not restrain his emotions or negative thoughts and find resourceful ways to express them. According to cognitive behavioral therapy, which is a psychosocial model, aiming at improving mental health (Field TA, Beeson ET, Jones LK, 2015), a person can build resilience by taking care of himself. The person needs to exercise regularly, eat healthy foods, get enough sleep and do things he enjoys. Therefore, paying attention to his own needs, might aim at enhancing the person's self-efficacy and keeping things in perspective (American Psychological Association, 2014).

Phycologists when firstly commenced to study resilience through dysfunctional families, came to the conclusion that even siblings are resilient between each other. Despite siblings had the same stimulus and common experiences their life in the future could radically differ. For example, the one of them could be disengaged from the parent's background, creating a more favorable quality of life. In aviation industry on the other hand, resilience was developed only through the past years despite the fact that phycologists were studying this phenomenon since 1970. It's worth mentioning that Royal Aeronautical Society in 2011 after researches concluded that today's aircrews need to improve their resilience and professionalism abilities (Learmount, 2011). Regarding the global aviation authorities, resilience became a mandatory part of CRM's training in 2016 according to EASA regulations. It is believed that after German Wings fatal crash in Alps (2015) when the co-pilot dived the aircraft towards terrain killing 150 souls, the role of phycology in the aviation industry became even more strong and countable (Patton, 2015). According to a research made straight after that fatal incident and regarding the mental health of pilots the results revealed the following. In a sample of 2000 EU's and US's aviators, approximately 12% of them were dealing with clinical depression. These results were in fact a clear evidence of pilot's human nature which needs to be closely monitored as with every employee, working in the sharp end of an organization (Gitte, Furdal, Matt, 2017). Although resilience is a part of CRM's whole there are some differences between their theories. For example, resilience does not deal with human's behaviors, roots of pilots' interactions or categorization of errors. Contrariwise, it focuses on the operation of control, coordination and how to connect gaps provoked by the system's complexity (Bergström, Henriqson, Dahlström, 2011). The same process is followed in other domains such as medicine or power production since resilience is designed for high risk activities (Hollnagel, E., Woods, D., Leveson, N., 2006).

The question that finally arises concerns the characteristics that flight crews should adopt in order to be more resilient. In the lines below, these characteristics will be presented as perceived by the aviation industry and from the science of psychology respectively. According to a research published in the journal of Human Factors and Safety in 2007, the following elements indicate crews with satisfactory resilience (Dekker, Lundström, 2007). The first indicator is the way that flight crew faces sacrificing decisions. As mentioned in the beginning, airlines force pilots not to deviate from the timetable as this would be detrimental for the airline's profits. Well trained crews are considered not only fast but also safe. Following CRM's regulation regarding resilience, crews must not trade the flight safety for taking advantage against time. The second indicator reveals that effective crews are familiar with different situations during flight as well as the way to deal with them. This fact is particularly significant and it is based upon the rule that flight is taking place in a dynamic environment where all the parameters constantly change. Resilient crews also keep in considering threats and risks during flight. Analyzing the ''what if's'' scenarios even when everything is looking safe, is an indication of a crew ready to face any abnormal situation which may arise unexpectedly. According to the research this fact gives to the crews the time to think about a distress scenario that may be forced to follow, for example a missed approach in the destination airport, as well as a confidence feeling for the upcoming situation. In order to gain confidence, crews are looking for essential, joint and homogenous information which will help them discriminate the gradual extinction of safety constraints. Finally, resilient crews should be open minded by means of finding and accepting innovative perspectives on a problem. Diverse viewpoints have proven to be more effective by setting more hypotheses, assumptions, covering more scenarios and ultimately aiding in decision making.

Regarding the psycho-medical effects, it has been proven that resilient people return quicker in tranquility than other people. In human brain amygdala- a part of brain playing key role in emotions- is the survival shield for every human when facing a threat by producing hormones for self-protection such as Adrenaline and Cortisol. The main difference so that discriminates resilient from non-resilient people is that the last preserve these hormones longer. This fact forces them to feel like being under constant threat, thus ''blocking'' the rationality and the prefrontal cortex.

Contrariwise, resilient people withdraw these hormones the time the threat is no longer present. Therefore they engage the prefrontal cortex quicker which makes them even more effective in problem-solving. Typical characteristics of resilient people is the confidence, sociability, conformity and decisiveness (Gitte and others, 2017). Indeed, as analyzed above resilient people have a strong belief in their abilities and a strong feeling for a positive outcome, they preserve good relationships with their colleagues without hesitating to seek for help and support. Finally, they are easily getting used to new ideas and conditions discriminating the essential goals and values from all the rest.

In the following section, a tangible case of resilience in a real aviation incident happened in 2009 will be presented. It can't be anything else than the ''Miracle on the Hudson River'' when an Airbus 320 ditched successfully after an exemplary cooperation between crew members and the unshaken decisions of Captain Sullenberger (Sully). This incident led the timeliness for many days and gripped millions of citizens around the world. Until now it is considered one of the most characteristic cases of strategic resilience in aviation industry (Cooke R., 2016). It is also considered as an extreme and rare case as in aviation history there is only one more successful ditching incident which occurred in Russia (St. Petersburg) in 1963 when a commercial aircraft ditched on Neva River after running out of fuel. But the ''Miracle on the Hudson River'' bequeathed the aviation system with many useful conclusions and generated new safety recommendations which are essential for every resilient system until nowadays.

4.1 Captain Sully's Case

On 15 January 2009, an Airbus 320 operated by US Airways, took off from LaGuardia airport (New York), with destination Charlotte- flight number 1549 with 155 souls on board. Aircraft commander for that flight was Captain Sullenberger (Sully) born in 1951. His experience in aviation was over 40 decades, since he had a military air force background before switching to commercial aviation. Weather conditions on that day were ideal. The snowfall had ceased, the sky's condition was reported clear of clouds and the temperature was slightly above zero degrees thus enhancing engine's performance. The take-off from LaGuardia was normal according to standard operating procedures without any failure. As the aircraft was climbing before even reaching 3000 feet above ground, a formation of Canada geese (enormous birds weighting up to 9 kg) appeared in the sky right in front of the aircraft. The reaction time was null, and the aircraft sustained a serious bird strike. During the research conducted after the incident, the voices of the pilots can be clearly heard from the recorders as well as the aircraft's engines silencing. Both engines had lost thrust and as crew and passengers reported there was an intense smell of burning birds. Every experienced pilot in his/hers career is often dealing with bird strikes incidents because birds are part of the environment that aircrafts operate. But as Sully reported, this was something different. Nobody warned them on that day that they were going to deal with a dual engine power loss in low altitude (Foust D., 2019).

Until the time the aircraft hit the birds, the aircraft was flown by the co-pilot and the captain was acting as pilot not flying. But after the bird strike and according to the protocol, the captain took the aircraft's control changing duties with the co-pilot. An emergency state of the aircraft was immediately declared (''MAYDAY'') to the air traffic controller. Consequently, the controller attempted to support the captains by providing heading instructions towards alternate airports in New Jersey or back to LaGuardia. Despite the helpful instructions of the controller, Captain Sully concluded that none of the airports would be feasible to be reached as the aircraft didn't have any thrust available. In fact, the aircraft was flown without autopilot and thrust, thus alike a common glider. Excluding all the airports for immediate landing Sullenberger was doomed to ditch on the Hudson River. The aircraft continued to be flown manually with a slight descent rate producing lift on the wings by exchanging altitude for speed. Captain Sully stated during the post incident researches that once he decided to end up in Hudson he stayed focused on it, he knew that the aircraft was flying properly and he continued to control it. Shortly before the impact Sully addressed the passengers to brace for impact. As he stated, the word ''impact'' was used to prepare everyone on board for an imminent ditching as preparing for a hard landing. The aircraft's belly, 3 minutes and 32 seconds after the bird strike, smoothly touched the water fortunately avoiding a crash scenario. Nevertheless, the situation was still critical. All passengers should immediately evacuate the aircraft but without jumping on the frozen water. Thanks to crew's professionalism and calmness, passengers successfully evacuated the aircraft remaining on the aircrafts wings. Before leaving the aircraft, Sully walked twice through the cabin making sure that no trapped passengers were still inside. The search and rescue mechanism (coast guard, fireboats and even commuter ferries) which was already triggered by the air controllers immediately rushed through the aircraft salvaging 155 souls (Fearn, Banks K., 2016). Immediately after their rescue, passengers and crew members were transported in hospitals in Manhattan and N. Jersey for treatment due to the exposure in low temperature. None of them was reported to be in a critical situation.

Figure 4.1.1 Flight 1549 on Hudson River.

Source: The Wall Street Journal (https://blogs.wsj.com/middleseat/2009/03/17/us-airways-flight-1549-update-ferry-company-preparing-lawsuit-against-carrier/)

According to the protocol, following an air accident investigators of the National Transportation Safety Board (NTSB) commenced the collection of all necessary evidence for the post incident research. For that reason the airline, notified all passengers that their belongings would remain in the investigator's disposal and at the same time a severance was sent in every passenger. Meanwhile, the publicity of the event was growing day by day. The crew was hosted in many TV shows such as CNN, Letterman Show and 60 Minutes. Sully's story was even reproduced in Hollywood, in a production directed by Clint Eastwood named ''Sully'' starring Tom Hanks (Foust D., 2009). Despite the avoidance of the disaster and the promotion of the incident, the pilots repeatedly reported that they were suffering from post-traumatic anxiety disorder. Sullenberger stated that for several months his pulse and blood pressure were retained in high levels and his sleeping time didn't exceed 30' at a time. After the completion of the NTSB's research, more than 35 safety recommendations were made to improve flight safety. Nevertheless, less than one third of them was seriously implemented. Airlines which are cost competitive businesses, were reluctant to take additional safety measures except from those mandated by the FAA.

Figure 4.1.2. On the left: Tom Hanks starring Captain Sully. On the right: Captain Sully and Co-Pilot Skilles hosted in a live TV Show.

Source: IMDB (2016) https://www.imdb.com/title/tt3263904/mediaindex

In the lines below a closer analysis in the crew's decisions will be attempted, as their success established this event as an epitome in strategic resilience. To begin with, a statement of the captain in the NTSB researches, reveals the reason why this incident is considered as a typical case of strategic resilience. The statement was the following: This wasn't as any typical flight I'd flown in my career so far. It was for sure that the airplane wouldn't land on a runway or without damages. This statement clearly reveals the uncertainty that suddenly prevailed in the cockpit once the bird strike occurred. The first reaction was a strong feeling of shock and denial originating from a cognitive battle between experience and mental representations (Leapen L., Brennan T., Laird N., Lawthers, A., Localio, A., Barnes, B., 1991). What was going to follow was absolutely uncertain while critical and potentially irreversible decisions had to be taken. The decisions were based on the captain's experience, airmanship, quick judgments and risk assessments. The lack of procedural and factual references though made these decisions even more critical. Human's behavior is explained as ''bounded rationality''. These bounds may vary depending on the situation. For example, in crises, bounds get far worse because the lack of resources or time becomes overwhelming (Simon H., 1982). On that particular incident, there was an implacable trade off putting a crucial dilemma on the crew. On the one hand was the option of ditching on the Hudson River meaning that it was a risky but probably not catastrophic scenario. On the other hand, Captain had to decide whether to follow the controller's instructions for diversion in alternate airports. If that scenario was chosen, the airplane would probably safely be flown towards an airport and minor damages would happen without any particular injuries. But if the attempt was unsuccessful, the result would be catastrophic leading in the crash of the aircraft in populated areas. Humans in order to realize and assess a situation need a critical time also known as ''Human Factor''. This parameter wasn't calculated by the NTSB during the post-event conclusions. In fact, there was an aggressive tendency towards Captain Sully. As he stated: ''the investigators from the NTSB were not there to be on my side. Their purpose is to be on the side of truth and fact. Our professional reputations were expendable. I was just an individual'' (The Guardian, 2016).

In aviation system, as analyzed in ''Human Errors in Aviation'' chapter, there are multiple layers of defense in depth. In cases of strategic resilience, similarly to Captain Sully's case, there is a shift from one line of defense to another. For instance, the first line is to minimize the possibility of hitting birds. Controllers in the airports frequently inform the pilots with reports regarding the bird status in the airport's vicinity in order to increase pilot's situational awareness. The second line is the safety provisions of modern jet aircrafts to sustain a bird strike as far as practical in case of avoiding the collision is impossible. The next line is the ability of pilots to navigate the aircraft safely towards an alternate airport after losing one engine because of the bird strike. The final line also depends on human factor. It's the ability of the crew to maintain the aircraft's control using basic rules of aerodynamics in order to fly the aircraft like a common glider towards an alternate airport or a crash area. Each shift from one layer to another is characterized as a tactical retreat because sights are languished, critical and sacrificing decisions have to be taken. In every layer the situation becomes more improbable and variable thus less manageable. At the same time, the potential magnitude of damage is highly increased. The ability to respond in difficulties is more restricted as time passes and less reversible. Generally, there is a change between normal procedures protocols to a generic action framework regarding emergency incidents. Consequently, resilient crews must be both prepared and prepared to be unprepared (Paries, Hollangel, Woods, 2011). Pilots are aware of the fact that in such cases they have only one chance of taking the right decision. The ditching on the Hudson River was the outcome of a sweet balance between experience and opportunism. In fact, the proper evaluation of the situation led in a series of correct decisions. Captain Sully, was familiar with the aircraft's limitations and after assessing the situation he acquired a strong feeling of self-confidence. As he stated in the post incident research, he was sure for his decisions. Even the fact that across the river there were operating commercial and coastguard boats was taken into consideration in order to increase the odds of a quick rescue.

Nevertheless training rules and aircraft's evolution frequently do not assist pilots when they are dealing with extreme and rare emergencies similar to flight's 1549. In fact, training in modern simulator, as shown in the first chapter, primarily includes pre-determined situations and how these can be anticipated according to a pre-briefed procedure. This makes aircrews to emphasize on anticipation and planning passing over the possibility of an unexpected event. In other words, an illusion is generated that in flight events will unfold as anticipated (Mintzberg H., 1996). Furthermore, the evolution of automation and standard operating procedures, apply side effects in pilots despite the fact that both focus on reducing the uncertainty, instability, variety and diversity. Side effects are considered the lack of creativity-reactivity and the reduced autonomy of pilots in modern cockpits (Hollnagel, Woods, Leveson, 2006).

PART B- Methodology and Fieldwork Research

B.1 Methodology

The second part of this diplomacy exercise consists of the research. A questionnaire with twenty five (25) questions was constructed (see Appendix 1) and delivered exclusively in a random sample of pilots (military and civil) via Google forms. In the category ‘’military’’, pilots of the Air Force flying multi crew aircrafts were included in order to investigate CRM attitudes as well as their opinion in questions regarding Human Errors and Resilience. On the other hand, in ‘’civil’’ category, airline pilots operating in local and international destinations were included. Last but not least for the ‘’civil’’ category, some few pilots flying in business aviation industry also answered this questionnaire enriching even more the collected answers. Ultimately, a satisfactory amount of eighty four (84) answers was gathered yielding useful and valid conclusions. A thorough analysis of their answers with the SPSS is presented in the next chapter, along with comments regarding the results.

In the main body of the questionnaire, participants were asked to answer in a classic Linkert scale from zero to four (0: Not at all, 1: slightly, 2: Moderately, 3: Very, 4: Extremely). Linkert scale was chosen as the most appropriate for measuring participant’s attitudes and opinions. Moreover the advantages that offer this scale, such as the ability to provide prompt and highly reliable results with valid interpretations, was taken into account (Nemoto T., Beglar D., 2014). Finally, a five-point scale was found as the most suitable because it gives participants the choice of neutral answer (contrary to 4-points scale), it measures precisely respondents’ attitudes without putting a lid on working memory’s occupancy (contrary to 6-point scale), (Smith J., Wakely M., DeKruif R., & Swartz C., 2003). In every part, all of the questions were selected as obligatory except from those addressed to special categories (e.g. only for co-pilots). This instruction was clearly stated in the beginning of every section and in the specified question as well, in order to avoid any misunderstandings. Hopefully, no mistakes have been made by the participants. The questionnaire which was used as the primary mean of collecting and analysing the required data was divided in four sections. In the first section, general questions had to be answered in order to discriminate the different categories of the participants as shown in the next chapter, aiding in the thesis analysis. Following the structure of the theoretical part, the main body of the questionnaire was divided in three individual sections: questions regarding CRM, Human Errors in aviation and finally Resilience. In every part the amount of the questions was approximately the same. Some slight differences in the proportion emerged from the need of further analysing some particular objectives.

Regarding the analysis of the results, in every section a presentation of the findings in the overall sample is initially depicted and explained. For every individual question though a different approach is attempted in respect of the contextual objective as explained in the following chapter. Afterwards, the results are afresh summarized and written on an individual chapter in order to make a harmonious transition between results analysis and conclusions. Discussion-suggestions are stated in the last lines of this paper as a result of a sweet balance between theory and the research's findings.

B.2 The Questionnaire

In the lines below, a meticulous analysis of the question's selection will be presented. Simultaneously, the expected outcome from every question will be mentioned explaining the analysis which will follow in the next chapter. As already mentioned in the methodology, questions were divided in different thematic sections according to the theoretical part. Every question is unique and unrepeatable targeting in the examination of different objectives.

Pilots before proceeding to the main body of the research, had to answer in four (4) general questions regarding their gender (male, female), position in the crew (captain, first or second officer), flight experience (less than 1000 hours, 1000-3000 hours, 3000-5000 hours, 5000-10000 hours, more than 10000 hours) and aviation background (airline, business aviation, military or state). Concerning the last question, participants had the ability to check all the applicable according to their career. For example, someone who in present time works in civil aviation but with a military background as well, was given the authority to choose both airline and military/state. These preliminary questions aid in the analysis of the results by dividing the participants in specified categories as will be thoroughly explained.

The second section, investigates purely CRM attitudes and contains seven questions. The purpose of those questions was firstly to examine whether pilots believe that a good knowledge of CRM mitigates human errors or not (Questions One, Two). Moreover the interest points to what captains and first officers answered as well as according to the flight experience. In the next question, the level of satisfaction from the given training on CRM was asked. In that case, a compare between the answers of military and civil aviators was judged as imperative. In fourth question, the knowledge of pilots in CRM sub categories was asked. In order to assist participants in their answers and to clarify the question completely, some of the sub-categories were mentioned in the end. Resilience for example, was also included because of its recent use in aviation industry as analyzed in the respective chapter. Questions five and six are characterized as conditional, because only specific categories could answer them accordingly. Nevertheless, their objective is common but from different point of view. More precisely, in the fifth, pilots with military background who continue to operate in civil aviation are in the point of interest. They are asked if they have spotted any differences in CRM's regulations between civil and military air force. If the answer was positive then they had to state in what extent. On the other hand, pilots graduated from private academies are asked if their colleagues derived from the air force implement CRM rules on a different way. Again if the answer was positive, the amount of difference had to be declared approximately. Questions Five and Six are considered of paramount meaning for this exercise and their objective was covered from different points of view. Last but not least is the seventh question. In that question, aviators are asked to what extent CRM may be further developed. In fact it's a typical question to the participants and points their need-belief for more knowledge. Answers given on that issue from Captains and Co-pilots are examined separately.

Third section is oriented towards Human Errors in conjunction with the theoretical part. Its extent is slightly bigger from the previous section, including ten questions. In the eighth question, it is investigated how often a specific scenario happens during daily operations that as shown in Part A may lead in Human errors. For that reason, the overall answers of pilots is examined without taking into consideration any other parameters. As discussed in theory, flight simulator not only builds CRM philosophy but also contributes in the mitigation of Human Errors.

Pilot's satisfaction on the simulator is examined via the following two questions. Furthermore, the need for dealing with even more scenarios during training is asked in the tenth question. The answers taken from captains and first officers was imperative to be analyzed separately as well as the answers according to experience.

Another factor which puts additional stress in pilots and makes them vulnerable to errors is the time pressure as analyzed in chapter 2. In the eleventh question this factor is investigated. To make the query even more realistic, in the parenthesis an example is quoted for civil (maximizing the costs) and military (operational reasons) pilots respectively. Nevertheless, the target of that question was to examine attitudes of captains, first officers and according to experience instead of making a comparison between Air force and Airlines. However, this comparison was vital for the following three questions as a totally different objective was under research. In the twelfth question a main issue, arising more and more nowadays, is asked to the participants. Civilians and militaries answered from a different point of view but pointing in the same direction: if the flight safety is degraded (see Threat and Error Management- latent threats). Additionally, in the second chapter the importance of an organization engulfing the aviators was highly emphasized. Questions thirteen and fourteen had the same objective but again different points of view for the participants. Civilians had to answer considering as organization the airline and militaries the air squadron.

Consequently, the following two questions aim to discover any potential hazards of making an inflight mistake via slips and lapses theory. The goal was to investigate what participants answered when asked in what extent they act primarily by memory and secondarily from the checklists in normal and emergency procedures respectively. In the analysis of the results, the interest was pointed towards captains, first officers and answers according to flying experience. The last question of this section, was purely aimed at first/second officers. One major scenario is given according to which a captain might have taken a wrong decision. Co-pilots are asked how they would react in this situation. In further analysis, the scenario progresses and co-pilots are afresh asked how confident are to take more effective decisions. Between those questions, it was investigated whether the captain's character/experience may weaken their confidence.

Last but not least, strictly following Part A, Resilience is examined. This part constitutes from eight questions completing the circle of twenty five questions on this questionnaire. It can also be concluded that in every part, questions are divided quite equally in order to indiscriminately emphasize all three sections.

To begin with, question eighteen is a combinatorial issue between CRM and resilience. Equivalently to the original query, participants are asked if a good CRM contributes to resilience. In a parenthesis, a quick reference of resilience's meaning is given in order to avoid misunderstandings supposing that not all of pilots are familiar with the concept. Answers from captains and first officers are in the point of interest, similarly to the next question. Question nineteenth is directly connected with the core of resilience. Pilots are asked if nowadays flight simulators prepare them adequately to deal with extreme and unexpected scenarios meaning how ''resilient'' they are by means of training. Another major issue covered in Resilience section is the lack of creativity-reactivity from pilots due to advanced automation in modern aircrafts. As this questionnaire was also distributed in pilots of civil aviation, most of them flying the most sophisticated and automated aircrafts, their opinion was valuable for this dissertation. On that question, flight experience is also counted along with captains' and first officer's opinion.

The following four questions are purely absorbed from Sully's case. An incident that stimulated aviation industry ten years ago couldn't be out of this research. Besides, in this paper an individual part was attributed on this incident along with a detailed analysis of human factors. Commencing with questions twenty one, twenty two and twenty three, the interest of the analysis turns towards captains, first officers and the flight experience factor. Pilots are initially asked to state how prepared do they find themselves dealing with an extreme and unexpected scenario, similar to Sully's case. Thereupon, the scenario is even more aggravated but still realistic. Pilots are asked to evaluate their training in the worst case scenario that may happen during flights, revealing the quality of their training and the handling preparation. Nevertheless, what Sully impart in aviation community was that handling skills wasn't enough for a successful outcome. Personal certainty and positive attitude had to be combined along with a good training in order to succeed.

For that reason, pilots in question twenty three are asked to express the level of their optimism after dealing with a ditching scenario.

The final two questions of this research are dealing with the standard operating procedures. As shown in Resilience section, humans learn to loyally follow standard operating procedures. In aviation industry, these procedures are formulated in checklists, which pilots use in the everyday operations. However, in flight 1549 the sequence of those items was successfully amended proving that checklists don't cover all of the circumstances. Still human's critical thinking plays a vital role in the decision making during a situation in distress. Pilots are asked to state their opinion on the amendment of the checklist even by changing the item's sequence or in some cases not following it at all. In the analysis of the results, a comparison between Air Force and Civil Aviation wasn't essential for that part. Contrariwise, the interest was pointed towards captains, co-pilots and answers according to flying experience.

B.3 The Results

B.3.1. Sample Profile

In the empirical part of this dissertation, as mentioned in the beginning of Part B, a sample of 84 pilots of civil and military aviation was used. This sample consists of men pilots of several ages. More characteristics concerning position in the crew, flight experience, aviation experience and aviation background are presented in the table B.3.1 just below.

Table B.3.1 Pilots Profile

Position in the Crew	N	%
Captain	45	53.6
First or Second Officer	39	46.4
Σύνολο	84	100.0

Flight Experience	N	%
Less than 1000hrs	8	9.5
1000-3000hrs	25	29.8
3000-5000hrs	18	21.4
5000-10000hrs	16	19.0
More than 10000hrs	17	20.2
Σύνολο	84	100.0

Aviation Experience	N	%
Civil Airway	39	47.0
Military Airway	44	53.0
Σύνολο	83	100.0

Aviation Background	N	%
Airline	35	42.2
Airline, Business Aviation	3	3.6
Airline, Military or State	9	10.8
Airline, Military or State, Business Aviation	1	1.2
Business Aviation	1	1.2
Military or State	33	39.8
Military or State, Business Aviation	1	1.2
Σύνολο	83	100.0

Slight above of half of pilots in the sample are captains (53.6%), while the rest pilots are first or secondary officers (46.4%). Concerning, flight experience in flight hours' distribution, an important sample fraction has less than 3000 flying hours (39.3%), while the rest of sample has equal distribution. Slightly less than half of pilots in the sample have experience only in civil aviation (47%), while the rest pilots have military aviation experience in the present or in the past (53%). Actually, a fraction of the sample (13.2%) has experience in both of aviation sectors.

This sample, generally, consists of many captains and experienced pilots in each of aviation sectors, while some pilots have experience in both sectors.

B.3.2. Results Concerning CRM

For all variables measured in Likert scale 0-4, mean score difference from value '2' which reflects neutral attitude level will be examined. The rationale is that in case of null hypothesis rejection, then there is a small or big but significant tense for some positive or negative attitude in each variable – statement. Moreover, percentages of each 0-4 values are also presented for a more accurate illustration of attitude extent. Results concerning CRM are presented in table B.3.2.1 just below.

Table B.3.2.1 Results Concerning CRM - Overall Sample

	N	Low %		Medium		High %	Mean	SD	t-statistic	p-value	
To what extent human errors are mitigated when CRM rules are followed?	84	1.2	10.7	8.3	56.0	23.8	**2.90**	0.93	8.95	0.0000	***
Are pilots more vulnerable to errors in a flight with poor CRM between crew members?	84	0.0	0.0	3.6	36.9	59.5	**3.56**	0.57	25.20	0.0000	***
How satisfied do you feel from your CRM training?	84	3.6	3.6	29.8	48.8	14.3	**2.67**	0.90	6.82	0.0000	***
Are you familiar with the sub-categorie of CRM? (threat & error management, stress management, resilience, startle effect)	84	2.4	8.3	26.2	39.3	23.8	**2.74**	1.00	6.80	0.0000	***
	N	Yes	No								
Have you spotted any differences in CRM application between military and civil aviation?	12	100.0	0.0								
	N	Low %		Medium		High %	**Mean**	SD	t-statistic	p-value	
How different is the CRM in Air Force compared with an airline?	12	0.0	8.3	41.7	25.0	25.0	**2.67**	0.98	2.35	0.0388	**
	N	Yes	No								
Do you believe that pilots with a military background usually present a different approach in CRM rules compared to what you have learned in the private academy?	40	75.0	20.0								
	N	Low %		Medium		High %	**Mean**	SD	t-statistic	p-value	
To what extent is that different?	39	10.3	7.7	53.8	20.5	7.7	2.08	1.01	0.48	0.6371	
According to your opinion, to what extent could CRM be further developed?	84	0.0	3.6	19.0	53.6	23.8	**2.98**	0.76	11.77	0.0000	***

* Significant in 10% ** Significant in 5% *** Significant in 1%

For all statements concerning overall sample, a very high mean score was resulted, over than value '2', with a statistically significant difference in 1% level ($p<0.01$). Highest mean score was resulted for the statement "Are pilots more vulnerable to errors in a flight with poor CRM between crew members" (M = 3.56), while high mean score was also resulted for the statement "to what extent could CRM be further developed" (M = 2.98) and also for the statement concerning "to what extent human errors are mitigated when CRM rules are followed" (M = 2.90). Moreover, mean score above neutral level were resulted for statements regarding "are pilots familiar with the sub-categories of CRM" (M=2.74) and "how satisfied pilots feel from your CRM training" (M = 2.67).

Concerning pilots in sample with experience both in civil and military aviation (N = 12), all of them have spotted some differences in CRM application between military and civil aviation. Moreover, their mean score regrading "how different is the CRM in Air Force compared with an airline" a higher than neutral mean score was resulted (M = 2.67) statistically significant in 5% level ($p < 0.05$), indicating that there are some differences and big enough.

Concerning pilots in the sample who have only civil aviation experience (N=40), most of them (75%) believe that pilots with a military background usually present a different approach in CRM rules compared to what civil pilots have learned in the private academy. However, they don't believe that such differences are so important in a sense that mean score is higher than value '2' ($M = 2.08$), but this difference is not statistically significant not even in 10% level ($p > 0.10$).

Therefore, civil pilots have spotted some differences in CRM rules, but not so important.

After that, pilots' attitudes differences are examined concerning CRM, with respect to position in the crew, flight experience and aviation experience. When grouping consists of two categories (position in the crew, aviation experience) t-test criterion is applied for testing two means differences, after variances equality is first examined applying Levene's criterion, so that the appropriate t-test criterion is employed, assuming for equal or non-equal variances.

When grouping consists of multiple categories (flight experience), one way ANOVA criterion is employed. First again Levene's criterion is applied in order to examine variances equality. If variances equality is not rejected, ANOVA criterion is reliably applied and in case of significant means difference exists, then post-hoc tests are applied with LSD criterion for multiple pairwise comparisons, which takes into consideration equal variances. In case of non-equal variances, ANOVA criterion reliability is not sure, especially if means difference exists. In that case, post-hoc tests with Dunnett criterion are applied witch takes into consideration non-equal variances. Results are presented in B.3.2.2 just below.

Table B.3.2.2 Results Concerning CRM with Respect to Pilots Profile

To what extent human errors are mitigated when CRM rules are followed?				
	Levene's Test	p-value	Means Test Statistic	p-value
Position in the Crew	0.74	0.393	0.77	0.441
Flight Experience	1.41	0.238	0.33	0.859

* Significant in 10% ** Significant in 5% *** Significant in 1%

Are pilots more vulnerable to errors in a flight with poor CRM between crew members?				
	Levene's Test	p-value	Means Test Statistic	p-value
Position in the Crew	0.46	0.498	1.49	0.141
Flight Experience	1.03	0.397	0.48	0.749

* Significant in 10% ** Significant in 5% *** Significant in 1%

How satisfied do you feel from your CRM training?				
	Levene's Test	p-value	Means Test Statistic	p-value
Aviation Experience	2.75	0.101	1.92	0.059 *

* Significant in 10% ** Significant in 5% *** Significant in 1%

	N	Mean	SD
Civil Airway	39	2.85	0.81
Military Airway	44	2.48	0.93

Are you familiar with the sub-categorie of CRM? (threat & error management, stress management, resilience, startle effect)				
	Levene's Test	p-value	Means Test Statistic	p-value
Position in the Crew	1.39	0.242	1.72	0.087 *
Aviation Experience	1.52	0.220	4.67	0.000 ***

* Significant in 10% ** Significant in 5% *** Significant in 1%

	N	Mean	SD
Captain	45	2.91	0.95
First or Second Officer	39	2.54	1.02
Civil Airway	39	3.21	0.80
Military Airway	44	2.30	0.95

According to your opinion, to what extent could CRM be further developed?				
	Levene's Test	p-value	Means Test Statistic	p-value
Position in the Crew	0.14	0.705	-0.55	0.582

* Significant in 10% ** Significant in 5% *** Significant in 1%

Concerning the statements "to what extent human errors are mitigated when CRM rules are followed" and whether "are pilots more vulnerable to errors in a flight with poor CRM between crew members", a statistically significant difference was resulted nor for position in the crew neither for flight experience even in 10% level ($p>0.10$), given variances equality in 10% level ($p > 0.10$). Therefore, irrespectively pilots are captains or first or second officers and irrespectively their flight experience, they express similar high positive attitude concerning that CRM may contribute to mitigation of human errors and that there is higher possibility of them in case that there is poor CRM between crew members.

Concerning the statement "how satisfied pilots feel from their CRM training", a marginal statistical significant difference between captains and first or second officers was resulted in 10% level ($p < 0.10$), given variances equality in 10% level ($p > 0.10$). More particularly, civil pilots perform higher mean score ($M = 2.85$) compared to military pilot ($M = 2.48$), indicating that they express a higher positive attitude.

Concerning the statement "are pilots familiar with the sub-categories of CRM", a marginal statistical significant difference was resulted in 10% level ($p < 0.10$), between captains and first or second officers, given variances equality in 10% level ($p>0.10$). More particularly, captains performing higher mean score ($M = 2.91$), compared to first or second officers ($M = 2.54$), express higher familiarity with the sub-categories of CRM. A statistically significant difference was also resulted in 1% level ($p < 0.01$) between civil and military pilots, given variances equality in 10% level ($p > 0.10$). More particularly, civil pilots, performing higher mean score ($M=3.21$), compared to military pilots ($M = 2.30$), they express a higher familiarity with the sub-categories of CRM.

Finally, regarding to statement "to what extent could CRM be further developed", no statistically significant difference even in 10% level between captains and first or second pilots was resulted ($p > 0.10$), given variances equality in 10% level ($p > 0.10$). Therefore, irrespectively the position in the crew, there is a high positive attitude in this statement.

B.3.3. Results for Human Errors

Results for pilots' attitudes concerning human errors s are presented in table B.3.3.1 in the next.

Table B.3.3.1 Results Concerning Human Errors – Overall Sample

	N	Low %		Medium	High %		Mean	SD	t-statistic	p-value	
How often does it happen to set a plan before or during your flight (SID procedures for the runway in use or procedures for a visual approach/STAR) and that plan to be changed at the eleventh hour? (due to change in meteorological conditions or ATC reasons etc.)	84	0.0	23.8	44.0	27.4	4.8	2.13	0.83	1.44	0.1533	
How satisfied do you feel with your standard training in the flight simulator?	84	9.5	14.3	22.6	36.9	16.7	**2.37**	1.20	2.82	0.0060	***
Do you feel the need to experience more scenarios during your training/preservation at the flight simulator	84	3.6	10.7	26.2	32.1	27.4	**2.69**	1.10	5.77	0.0000	***
How possible is to make mistakes when operating under time pressure? (Because of the company's policy, operational missions, CTOT etc.)	84	1.2	9.5	28.6	42.9	17.9	**2.67**	0.92	6.62	0.0000	***
To what extent do you believe that the safety of flights is degraded for economic reasons? (for maximising the profit or limiting the cost)	84	10.7	25.0	29.8	22.6	11.9	2.00	1.18	- 0.00	1.0000	
How important is it for a pilot to be supported by a friendly and willing organization? (As organization consider an air squadron or an airline accordingly)	84	0.0	0.0	3.6	28.6	67.9	**3.64**	0.55	27.28	0.0000	***
To what extent do you believe that the organization□s policy contributes to the prevention of human errors?	84	2.4	3.6	7.2	52.4	34.5	**3.13**	0.88	11.84	0.0000	***
To what extent do you execute standard procedures (before landing checklist etc.) based primarily on your memory/experience and secondarily on the reading of the checklist?	84	29.8	29.8	17.9	14.3	8.3	**1.42**	1.28	- 4.17	0.0001	***
In case of an emergency, to what extent would you execute the required procedures primarily by memory and secondarily by the checklis	84	19.0	47.6	23.8	6.0	3.6	**1.27**	0.96	- 6.92	0.0000	***

* Significant in 10% ** Significant in 5% *** Significant in 1%

You are acting as a Pilot Not Flying and you feel that the Captain made a decision which might lead to a harmful situation	N	Low %		Medium	High %		Mean	SD	t-statistic	p-value	
How confident do you feel to state your opinion?	40	2.5	0.0	5.0	55.0	37.5	**3.25**	0.78	10.18	0.0000	***
To what extent does the Captain□s experience/character affect your stating ?	41	4.9	9.8	41.5	36.6	7.3	**2.32**	0.93	2.17	0.0357	**
If the situation is further escalated, how confident would you feel to state your opinion with an even more intense tone?	42	0.0	0.0	19.0	42.9	38.1	**3.19**	0.74	10.42	0.0000	***
How certain would you feel to take the aircraft□s control if the Captain did not correct the situation considering your statement?	41	0.0	9.8	39.0	29.3	22.0	**2.63**	0.94	4.31	0.0001	***

* Significant in 10% ** Significant in 5% *** Significant in 1%

For most statements concerning human errors, for overall sample, a high mean score over value '2' was resulted, where this difference is statistically significant in 1% level ($p < 0.01$). Highest mean score was resulted for statement "How important is it for a pilot to be supported by a friendly and willing organization" (M=3.64), while very high mean score was also results for the statement concerning " To what extent pilots believe that the organization's policy contributes to the prevention of human error" (M = 3.13) and, similarly, for the statements concerning "whether pilots feel the need to experience more scenarios during your training/preservation at the flight simulator" (M = 2.69) and concerning "how possible is to make mistakes when operating under time pressure" (M=2.67). Moreover, above neutral level mean score was also resulted for the statement "How satisfied pilots feel with your standard training in the flight simulator" (M = 2.37).

There are also statements where no statistically significant difference from value '2' was resulted even in 10% level ($p > 0.10$). More particularly, for statements concerning "how often does it happen to set a plan before or during your flight and that plan to be changed at the eleventh hour" and "To what extent do you believe that the safety of flights is degraded for economic reasons" a neutral attitude was actually resulted.

Finally, there are some statements with low mean score less than value '2', with statistically significant difference in 1% level ($p < 0.01$). Higher disagreement degree was resulted for the statement "in case of an emergency, to what extent would pilots execute the required procedures primarily by memory and secondarily by the checklist" (M = 1.27) and after for the statement "to what extent pilots execute standard procedures based primarily on their memory/experience and secondarily on the reading of the checklist" (M = 1.42).

Concerning all human errors statements, for the first or second officers when they feel that the Captain made a decision which might lead to a harmful situation, a high mean score over value '2' was resulted, where this is a statistically significant difference in 1% level ($p < 0.01$). Highest mean score was for the statement "How confident first or second officers feel to state their opinion (M = 3.25), while very high mean score was also resulted for the statement "if the situation is further escalated, how confidently would first or second officers state their opinion with an even more intense tone" (M = 3.19) and for the statement concerning "how certain first or second officers feel to take the aircrafts control if the Captain did not correct the situation considering their statement" (M = 2.63). Finally, more than neutral mean score was resulted for the statement concerning "to what extent does Captain's experience/character affect first or second officers' stating" (M = 2.32).

In the next, differences concerning pilots' attitudes for human errors are examined, according to position in the crew, flight experience and whether they are civil or military pilots. This examination takes place with t-test and ANOVA application, as described before.

Table B.3.3.2 Results for Human Errors with Respect to Pilots Profile

How satisfied do you feel with your standard training in the flight simulator?				
	Levene's Test	p-value	Means Test Statistic	p-value
Position in the Crew	0.12	0.735	0.98	0.329

* Significant in 10% ** Significant in 5% *** Significant in 1%

Do you feel the need to experience more scenarios during your				
	Levene's Test	p-value	Means Test Statistic	p-value
Position in the Crew	1.06	0.305	0.38	0.703
Flight Experience	1.87	0.123	4.05	0.005 ***

* Significant in 10% ** Significant in 5% *** Significant in 1%

	N	Mean	SD
Less than 1000hrs	8	3.63	0.52
1000-3000hrs	25	3.00	0.91
3000-5000hrs	18	2.11	1.28
5000-10000hrs	16	2.38	1.15
More than 10000hrs	17	2.71	0.92

	Post-Hoc Tests	1	2	3	4
1	Less than 1000hrs	-			
2	1000-3000hrs	0.137	-		
3	3000-5000hrs	0.001 ***	0.006 ***	-	
4	5000-10000hrs	0.006 ***	0.060 *	0.456	-
5	More than 10000hrs	0.040 **	0.364	0.090 *	0.357

* Significant in 10% ** Significant in 5% *** Significant in 1%

How possible is to make mistakes when operating under time pressure? (E.g. Because of the company[]s policy, operational missions, CTOT etc.)				
	Levene's Test	p-value	Means Test Statistic	p-value
Position in the Crew	3.16	0.079 *	0.71	0.480
Flight Experience	5.58	0.001 ***	0.58	0.675

* Significant in 10% ** Significant in 5% *** Significant in 1%

To what extent do you believe that the safety of flights is degraded for economic reasons? (e.g. for maximising the profit or limiting the cost)				
	Levene's Test	p-value	Means Test Statistic	p-value
Aviation Experience	3.98	0.049 **	-2.55	0.013 **

* Significant in 10% ** Significant in 5% *** Significant in 1%

	N	Mean	SD
Civil Airway	39	1.67	1.28
Military Airway	44	2.32	1.01

How important is it for a pilot to be supported by a friendly and willing organization? (As organization consider an air squadron or an airline accordingly				
	Levene's Test	p-value	Means Test Statistic	p-value
Aviation Experience	0.45	0.499	0.07	0.948

* Significant in 10% ** Significant in 5% *** Significant in 1%

To what extent do you believe that the organization[]s policy contributes to the prevention of human errors?				
	Levene's Test	p-value	Means Test Statistic	p-value
Aviation Experience	0.67	0.415	0.46	0.650

* Significant in 10% ** Significant in 5% *** Significant in 1%

To what extent do you execute standard procedures (e.g. before landing checklist etc.) based primarily on your memory/experience and secondarily on the reading of the checklist?				
	Levene's Test	p-value	Means Test Statistic	p-value
Position in the Crew	0.03	0.872	-2.60	0.011 **
Flight Experience	3.27	0.016 **	1.25	0.298

* Significant in 10% ** Significant in 5% *** Significant in 1%

	N	Mean	SD
Captain	45	1.09	1.28
First or Second Officer	39	1.79	1.20

In case of an emergency, to what extent would you execute the required procedures primarily by memory and secondarily by the checklis				
	Levene's Test	p-value	Means Test Statistic	p-value
Position in the Crew	0.36	0.551	-0.30	0.766
Flight Experience	3.20	0.017 **	0.93	0.451

* Significant in 10% ** Significant in 5% *** Significant in 1%

You are acting as a Pilot Not Flying and you feel that the Captain made a decision which might lead to a harmful situation

How confident do you feel to state your opinion?				
	Levene's Test	p-value	Means Test Statistic	p-value
Aviation Experience	2.41	0.129	1.32	0.196

* Significant in 10% ** Significant in 5% *** Significant in 1%

To what extent does the Captain's experience/character affect your stating ?				
	Levene's Test	p-value	Means Test Statistic	p-value
Aviation Experience	0.82	0.372	-0.87	0.388

* Significant in 10% ** Significant in 5% *** Significant in 1%

If the situation is further escalated, how confident would you feel to state your opinion with an even more intense tone?				
	Levene's Test	p-value	Means Test Statistic	p-value
Aviation Experience	0.01	0.038	1.26	0.216

* Significant in 10% ** Significant in 5% *** Significant in 1%

How certain would you feel to take the aircraft's control if the Captain did not correct the situation considering your statement?				
	Levene's Test	p-value	Means Test Statistic	p-value
Aviation Experience	1.67	0.204 **	1.69	0.099 *

* Significant in 10% ** Significant in 5% *** Significant in 1%

	N	Mean	SD
Civil Airway	39	1.67	1.28
Military Airway	44	2.32	1.01

Concerning "how satisfied pilots feel with their standard training in the flight simulator", "whether pilots feel the need to experience more scenario during their training at the flight simulator" and "how possible is to make mistakes when operating under time pressure" there is not any statistical difference, even in 10%

level ($p > 0.10$) between captains and first or second officers, after variances equality was not rejected even in 10% level ($p > 0.10$). However, concerning "whether pilots feel the need to experience more scenarios during their training at the flight simulator" there is a significant difference in 5% level ($p < 0.05$) according to flight experience, given variances equality in 10% level ($p > 0.10$). More particularly, less experienced pilots have higher mean scores, indicating that they express more this need for more scenarios during their training at the flight simulator.

Concerning "to what extent pilots believe that flight safety is degraded for economic reasons", there is some statistical significant difference in 5% level ($p<0.05$), given that there is also variances inequality in 5% level ($p < 0.05$). More particularly, pilots with military background have higher mean score (M = 2.32), indicating that they tend to agree that flights' safety is degraded for economic reasons, while civil pilots have lower mean score (M = 1.67), indicating that they don't actually agree with that.

Concerning "how important is for a pilot to be supported by a friendly and willing organization" and "to what extent pilots believe that organizations' policy contributes to the human errors prevention", there is not any statistically significant difference between civil pilots and pilots with military background even in 10% level ($p > 0.10$), after equality of variances is also not rejected in 10% level ($p > 0.10$).

Concerning "to what extent pilots execute standard procedures based primarily on their memory / experience and secondary on checklist reading" there is not any statistically difference according to flight experience even in 10% level ($p>0.10$), although there is variances inequality in 5% level ($p < 0.05$). However, there is statistically significant difference between captains and first officers in 5% level ($p < 0.05$), given variances equality even in 10% level ($p > 0.10$). More particularly, first or second officers have even lower score (M = 1.20), compared to captains' mean score (M = 1.28), indicating that first or second officers tend to execute even less standard procedures based primarily on their memory experience.

Concerning "in a case of emergency, to what extent pilots execute required procedure primarily based on their memory and secondly by checklists" there is not any statistically difference between captains and first or second officers and according to their experience even in 10% level ($p > 0.10$), given variances equality in 10% level ($p > 0.10$) and variances inequality in 5% level ($p < 0.05$) respectively.

For the first or second officers who feel that during flight the captain made a decision which might lead to a harmful situation, there was not any statistically significant difference between civil and military pilots concerning “how confident pilot feel to state their opinion”, “to what extent captain’s experience affect their stating” and “if the situation is further escalated, how confident they feel to state their opinion with an even more intense tone”, given variances equality in 10% level ($p>0.10$). Only for the statement “how certain pilots feel to take aircraft’s control, if captain didn’t correct the situation considering their statement” there is a marginal statistically significant difference in 10% level ($p < 0.10$), given variances equality in 10% level ($p > 0.10$). More particularly, military pilots perform an even lower mean score ($M = 1.01$) compared to civil pilots mean score ($M = 1.28$), indicating that military pilots seem more reluctant to take over the aircraft obeying to hierarchy much more.

B.3.4. Results Concerning Resilience

Results concerning pilots’ attitudes about resilience are presented in table B.3.4.1 in the next lines.

Table B.3.4.1 Results Concerning Resilience – Overall Sample

	N	Low %		Medium	High %		Mean	SD	t-statistic	p-value
How "resilient" do you feel when flying with a well trained crew in CRM? (Resilience is defined as the ability of a person to withstand or recover quickly from difficult conditions)	84	0.0	0.0	8.3	56.0	35.7	3.27	0.61	19.20	0.0000 ***
To what extent did the flight simulator train you to deal with unexpected and extreme scenarios? (E.g. bird strike and total power loss in low altitude during climb)	84	3.6	13.1	15.5	42.9	25.0	2.73	1.09	6.10	0.0000 ***
To what extent does the extremely advanced automation of the aircrafts limit your effectiveness?	84	11.9	34.5	35.7	15.5	2.4	1.62	0.97	- 3.61	0.0005 ***
How prepared do you feel to deal with a "total power loss in low altitue"?	84	4.8	21.4	33.3	33.3	7.1	2.17	1.00	1.52	0.1320
How trained do you feel in case of a forced and unexpected ditching?	84	14.3	25.0	32.1	21.4	7.1	1.82	1.14	- 1.43	0.1557
How optimistic do you feel for a successful outcome after a forced or unexpected ditching?	84	8.3	22.6	44.0	21.4	3.6	1.89	0.96	- 1.03	0.3079
In case of an emergency, to what extent do you think there are essential procedures not included in the checklist, but very helpful when dealing with it?	84	4.8	34.5	41.7	16.7	2.4	1.77	0.87	- 2.39	0.0194 **
According to your discretion and the prevailing conditions, how possible would it be to change the sequence of the checklist's items during an emergency in order to better deal with it? (immediately turning on the APU in total power loss)	84	6.0	22.6	28.6	35.7	7.1	2.15	1.05	1.35	0.1792

* Significant in 10% ** Significant in 5% *** Significant in 1%

Only for two statements mean score is statistically significant higher than value ‘2’, in 1% level ($p < 0.01$). More particularly concerning “How "resilient" pilots feel when flying with a well-trained crew in CRM?” mean score is very high ($M = 3.27$), indicating that pilots really feel very resilient with that. Moreover, concerning “To what extent did the flight simulator train pilots to deal with unexpected and extreme scenarios?” mean score is also very high ($M = 2.73$), indicating that pilots really feel that flight simulators trained them to deal with unexpected and extreme scenarios.

There are a lot of statements where mean score is not statistically significant different from value ‘2’ even in 10% level ($p > 0.10$). More particularly, concerning “How prepared pilots feel to deal with a "total power loss in low altitude"”, “How trained pilots feel in case of a forced and unexpected ditching”, “How optimistic pilots feel for a successful outcome after a forced or unexpected ditching” and “according to pilots’ discretion and the prevailing conditions, how possible would it be to change the sequence of the checklist's items during an emergency in order to better deal with it” pilots seem to express a more neutral attitude.

Finally, there are some statements where mean score is statistically significant lower than value ‘2’, in 1% level ($p < 0.01$) and 5% level ($p < 0.05$). More particularly, concerning “to what extent does the extremely advanced automation of the aircrafts limit pilots’ effectiveness” and “in case of an emergency, to what extent pilots think there are essential procedures not included in the checklist, but very helpful when dealing with it”, pilots seem not to agree with them.

In the next, differences concerning pilots’ attitudes for resilience are examined, according to position in the crew and flight experience. This examination takes place with t-test and ANOVA application, as mentioned above.

Concerning “How "resilient" pilots feel when flying with a well-trained crew in CRM” and “to what extent did the flight simulator train pilots to deal with unexpected and extreme scenarios” there is not any statistically significant difference between captains and first or second officers even in 10% level ($p > 0.10$), given variances equality in 10% level ($p > 0.10$).

Table B.3.4.2 Results Concerning Resilience with Respect to Pilots Profile

How "resilient" do you feel when flying with a well trained crew in CRM?
(Resilience is defined as the ability of a person to []withstand or recover quickly

	Levene's Test	p-value	Means Test Statistic	p-value
Position in the Crew	0.01	0.930	-0.12	0.909

* Significant in 10% ** Significant in 5% *** Significant in 1%

To what extent did the flight simulator train you to deal with unexpected and extreme scenarios? (E.g. bird strike and total power loss in low altitude during climb)

	Levene's Test	p-value	Means Test Statistic	p-value
Position in the Crew	0.03	0.865	-0.34	0.739

* Significant in 10% ** Significant in 5% *** Significant in 1%

To what extent does the extremely advanced automation of the aircrafts limit your effectiveness?

	Levene's Test	p-value	Means Test Statistic	p-value
Position in the Crew	1.34	0.250	-2.04	0.045 **
Flight Experience	0.86	0.494	0.68	0.608

* Significant in 10% ** Significant in 5% *** Significant in 1%

	N	Mean	SD
Captain	45	1.42	0.99
First or Second Officer	39	1.85	0.90

How prepared do you feel to deal with a "total power loss in low altitue"?

	Levene's Test	p-value	Means Test Statistic	p-value
Position in the Crew	1.26	0.264	-0.11	0.914
Flight Experience	0.21	0.935	1.58	0.187

* Significant in 10% ** Significant in 5% *** Significant in 1%

How trained do you feel in case of a forced and unexpected ditching?

	Levene's Test	p-value	Means Test Statistic	p-value
Position in the Crew	1.17	0.282	0.77	0.443
Flight Experience	0.51	0.726	3.11	0.020 **

* Significant in 10% ** Significant in 5% *** Significant in 1%

	N	Mean	SD
Less than 1000hrs	8	1.25	1.39
1000-3000hrs	25	1.40	1.12
3000-5000hrs	18	1.78	1.11
5000-10000hrs	16	2.31	0.87
More than 10000hrs	17	2.29	1.05

	1	2	3	4
1 Less than 1000hrs	-			
2 1000-3000hrs	0.735	-		
3 3000-5000hrs	0.257	0.265	-	
4 5000-10000hrs	0.027 **	0.011 **	0.157	-
5 More than 10000hrs	0.028 **	0.011 **	0.165	0.961

* Significant in 10% ** Significant in 5% *** Significant in 1%

How optimistic do you feel for a successful outcome after a forced or unexpected ditching?

	Levene's Test	p-value	Means Test Statistic	p-value
Position in the Crew	0.01	0.915	-0.27	0.789
Flight Experience	0.34	0.853	4.41	0.003 ***

* Significant in 10% ** Significant in 5% *** Significant in 1%

	N	Mean	SD
Less than 1000hrs	8	1.50	0.76
1000-3000hrs	25	1.40	0.91
3000-5000hrs	18	2.22	0.81
5000-10000hrs	16	1.94	1.00
More than 10000hrs	17	2.41	0.87

	1	2	3	4
1 Less than 1000hrs	-			
2 1000-3000hrs	0.782	-		
3 3000-5000hrs	0.059 *	0.004 ***	-	
4 5000-10000hrs	0.258	0.062 *	0.353	-
5 More than 10000hrs	0.018 **	0.001 ***	0.529	0.129

* Significant in 10% ** Significant in 5% *** Significant in 1%

In case of an emergency, to what extent do you think there are essential procedures not included in the checklist, but very helpful when dealing with it?				
	Levene's Test	p-value	Means Test Statistic	p-value
Position in the Crew	0.01	0.919	-3.13	0.002 ***
Flight Experience	0.95	0.437	1.05	0.387

* Significant in 10% ** Significant in 5% *** Significant in 1%

	N	Mean	SD
Captain	45	1.51	0.79
First or Second Officer	39	2.08	0.87

According to your discretion and the prevailing conditions, how possible would it be to change the sequence of the checklist's items during an emergency in order to better deal with it? (immediately turning on the APU in total power loss)				
	Levene's Test	p-value	Means Test Statistic	p-value
Position in the Crew	0.23	0.636	-1.68	0.096 *
Flight Experience	1.75	0.147	0.51	0.732

* Significant in 10% ** Significant in 5% *** Significant in 1%

	N	Mean	SD
Captain	45	1.98	1.08
First or Second Officer	39	2.36	0.99

Concerning “to what extent does the extremely advanced automation of the aircrafts limit your effectiveness”, there is statistically significant difference between captains and first or second officers in 5% level ($p < 0.05$), given variances equality in 10% level ($p > 0.10$). More particularly, first or second officers have somewhat higher mean score ($M = 1.82$), compared to captains’ mean score ($M = 1.42$), indicating that first or second officers have a more neutral attitude.

Concerning “How prepared pilots feel to deal with a "total power loss in low altitude"”, there is not any statistically significant difference between captains and first or second officers or according to experience even in 10% level ($p > 0.10$), given variances equality in 10% level ($p > 0.10$).

Concerning “how trained pilots feel in case of a forced and unexpected ditching”, and “how optimistic pilots feel for a successful outcome after a forced or unexpected ditching”, there is not any statistically significant difference between captains and first or second officers, given variances equality in 10% level ($p > 0.10$). There is, however, a statistically significant difference according to experience in 5% level ($p<0.05$) and in 1% level ($p < 0.01$) respectively, given variances equality in 10% level ($p > 0.10$). More particularly, less experienced pilots have lower mean score in both statements, indicating that these pilots feel less trained in case of a forced and unexpected ditching and less optimistic for a successful outcome after a forced or unexpected ditching.

Concerning “in case of an emergency, to what extent pilots think there are essential procedures not included in the checklist, but very helpful when dealing with it” and “according to pilots discretion and the prevailing conditions, how possible would it be to change the sequence of the checklist's items during an emergency in order to better deal with it”, there is not any statistically difference according to experience, even in 10% level ($p > 0.10$), given variances equality in 10% level ($p>0.10$). There is, however, a statistically significant difference between captains and first or second officers in 1% level ($p < 0.01$) and 10% level ($p < 0.10$) respectively, given variances equality in 10% level ($p > 0.10$). More particularly, first or second officers express higher mean score compared to captains, expressing a neutral attitude ($M = 2.08$) whether in an emergency case there are essential procedures not included in the checklist, but very helpful when dealing with it, while captains don’t actually agree with that ($M = 1.51$). Moreover, first or second officers tend to agree ($M = 2.36$) that it is possible to change the sequence of the checklist's items during an emergency in order to better deal with it, while captains feel more neutral about that ($M = 1.98$).

B.4 Summary of findings

The purpose of this section is to gather and highlight the most important points of the findings. Moreover it serves as an interface between chapters, aiding in the smooth transition from results to conclusions-recommendations. The summary will follow the sequence of results’ extraction.

To begin with, regarding CRM in the overall sample the results revealed, according to the highest mean scores, that pilots do believe that they are more vulnerable to errors when operating with a poor CRM between crew members. This fact was shown as well, irrespectively of the position in the crew or the flight experience. Results were approximately equal for the composite question: ‘’to what extent human errors are mitigated when CRM rules are followed’’. Pilots, co-pilots and regardless of flight experience highly positive attitudes were expressed. Another question which ‘’scored’’ high mean score was: ‘’to what extent could CRM be further developed’’. On that question, once again pilots and co-pilots have a common thesis. Both have high positive opinion regarding this question meaning that they do believe that CRM could still be further advanced.

Nevertheless, questions searching for CRM knowledge (are you familiar with the sub categories of CRM) and satisfaction from CRM training, were positive but slightly above neutral. This fact constitutes a concern for the level of CRM's knowledge which can be possibly attributed to the unsatisfactory training. Besides, the slightly above neutral statement for satisfaction from CRM training drops a hint for the quality of training. More precisely, when opinions from captains and first officers were compared a marginal statistical difference was found. Nevertheless, a statistical significant difference between civilians and military pilots was found. Civilians expressed higher self-confidence regarding their knowledges and a greater satisfaction from their acquired training.

Probably the most worrying results in that section were found when pilots were asked for differences in application between civil and military CRM. Despite the fact that CRM is common for every pilot, all ex-military aviators working on present as ''airliners'' have spotted significant differences on CRM applications respectively. This statement is verified as well from pilots graduated from flight academies. According to their answers, ex-military pilots present a different approach in CRM regulations but not as important as it was found in the previous question. These differences may be attributed to the military environment where Air Force's pilots operate. The respect in the hierarchy and the discipline which are common characteristics in the army may be the roots of this different approach. As it will be further analyzed in the conclusions, this element requires further research because it may hide a potential hazard for flight safety.

Observing the results for Human Errors the following remarks are noted. To begin with, the highest means scored when pilots were asked how important is for them to be supported by a friendly-willing organization and to what extent organization's policy contributes in prevention of human errors. It is worth noting that these statements were equally high for both military and civil aviators. This finding is very telling about the importance of an organization embracing employees. It must be clarified, that whether speaking in terms of aviation or any kind of organization, human factors are the number one priority for safety and success. This fact is even more critical for employees operating in critical positions of a firm. It is a typical example that the findings and the recommendations of this dissertation present a wider meaning and can be adopted by many other organizations.

A question which also noted a high mean score but with a negative meaning was: ‘’Do you feel the need to experience more scenarios during your training/preservation at the flight simulator?’’. The mean was high enough for the overall sample indicating a pilots’ desire to broaden their horizons and knowledges during training in the simulators. When the results were further analysed it was indeed found that captains and first officers didn’t express any disunity in their answers meaning that the need for more scenarios is common. It was also noted that less experienced pilots note an even more intense need for further training in flight simulators. The next question which belongs in the same thematic section with the pre mentioned question was: ‘’how satisfied do you feel with your standard training in the flight simulator?’’. Pilots express a positive attitude for that question but the mean was just above neutral for the overall sample indicating a trend rather than a fact. It should be noted that once again captains and first officers have a common belief for that particular question.

A question which was purely extracted from the theory of human errors (see slips/lapses) was the pilots opinion when they were asked about the possibility of making errors when operating under time pressure. As it was clarified in the questionnaire, pilots may sustain time pressure in order to be accurate and efficient. For example, when air traffic controllers issue a take-off clearance but within a time window, because of heavy traffic, pilots operate in a hurry and under stress. For the Air Force respectively, many missions require accuracy and delicacy. The so called T.O.T. (time on target) requires military pilots to be over the battle zone in a specific time. As a result, it is easily understood that pilots from civil or Air Force operate in stressful circumstances. According to the overall sample, the high possibility of making mistakes when operating under pressure, is confirmed by a high mean score. Afterwards, pilots were asked how often it happens their scheduled plans to be changed at the eleventh hour. The purpose of this question was to support the previous query by investigating another branch of human errors. Their answers ranged in neutral level indicating that this change really happens but not so often. According to theory (see slips/lapses) last minute changes hide a great potential of making an error.

Subsequently, fliers were asked about the way of executing emergency and standard procedures. The aim was to reveal whether they act by memory or by reading of the checklist as analysed in the questionnaire's section. In both questions the attitudes of the overall sample were neutral. For the question regarding emergency procedures, there were not any differences found between captains, first officers and for any level of experience. On the other hand, for standard procedures the detailed analysis revealed that captains tend to execute the checklist by memory more than co-pilots do. This is a clear message that captains who are more experienced and familiar with the aircraft, tend to omit the reading of the checklist. This fact is against the standardized way of operating and may lead to an error by skipping an essential item of the checklist. Nevertheless, for the emergency procedures pilots seem to be more careful and typical. This is a positive message for the flight safety but it requires further research. In the case of Captain Sully, it was explained that the sequence of some items was changed in order to better deal with the unexpected situation. In a research focused exclusively on emergency procedures, pilots' readiness to amend the checklist and lean on their critical thinking must be examined.

Another question which produced positive and useful results was the following: ''how confident would you feel to state your opinion when the captain takes a decision which may lead to a harmful situation''. This question which had multiple layers was addressed only to co-pilots from military and civil aviation. Hopefully, positive attitudes were emerged even for the next sub questions. It was assumed that the situation was further escalated and first officers were asked how confident would they feel to state their opinion in a more intense tone and finally take over the aircraft's controls if the situation was not corrected. Nevertheless, it was observed that as the situation was escalating and more powerful and unusual measures were required the assertiveness of co-pilots was also decreasing. Especially for the co-pilots of the Air Force, their intention to take the controls was even lower than civilians' intention. On the one hand, the positive reactions indicate a good education and training but the gradual decrease of assertiveness on the other, leaves a suspicion for their effectiveness in real time. For the military pilots, the even lower assertiveness may be attributed once again to the discipline and hierarchy.

Finally, neutral results emerged when pilots were asked if the flight safety is degraded for economic reasons. The maximization of profits, the economic austerity and the limitation of costs could be the roots for this degradation. More particularly, military pilots operating in state aircrafts tend to have a more positive attitudes from the civilians. The negative effects of this degradation extent beyond the profound. A special research on that issue could reveal not only the level of this degradation but also the amount of psychological influence on pilots. However in this questionnaire extracted neutral results with some positive trends for the Air Force though.

Last but not least, results from Resilience will be commented. Commencing with the questions which noted the higher mean scores, the following results were found. As it was expected, pilots feel very resilient when flying with a well-coordinated crew thus with a good CRM. In fact it's a proof that CRM and Resilience are interdependent and that the more trained a crew is in CRM, the more resilient it is. A very positive attitude was also found when pilots were asked if the simulators trained them properly to deal with extreme and unexpected scenarios. The findings were equally positive for captains and first officers and regardless of the flight experience.

Afterwards, a combination of questions planned to examine the readiness and the preparation of pilots for extreme and unexpected scenarios. More precisely, pilots were asked about their ability to deal with total power loss in low altitude and an unexpected ditching. Moreover their belief for a positive outcome was investigated. The overall sample expressed a neutral attitude indicating that an uncertainty prevails regarding this aspect. In deeper analysis, answers from captains and first officers didn't differ in any of these questions. According to the experience however, it was found that less experienced pilots feel even less optimistic and trained to deal with a forced ditching.

The next combination aimed to search the checklist's use in case of an emergency. Flyers were asked how possible would it be to change the sequence of the checklist's items or add on some items in order to better deal with an emergency. For the overall sample the answers were neutral to ''negative'' (below value 2). Nevertheless, discriminating captains' and co-pilots' answers a difference in their statements was noted. More specifically, co-pilots tend to agree that the sequence of the checklist's items may be changed but they express a neutral attitude in adding more items. Contrariwise, captains have negative attitudes in both questions. This fact, shows that especially captains respect and follow devoutly the standard procedures even in an emergency. Beyond a doubt, this is the most safe and appropriate way of dealing with an emergency. Nevertheless, speaking about unexpected and extreme scenarios thus for Resilience, it may be required some of the standard procedures to be changed as shown in theory. Taking into account the captains' answers, a doubt arises about their belief and preparation to make slight differences in the checklist. Therefore the captain's resilient attitude is questioned.

Finally, captains and first officers were asked if the extremely advanced and sophisticated aircrafts limit their effectiveness. Both tend to disagree with that question, indicating that the operation in an automated environment does not affect their capabilities. It is noted that co-pilots expressed a more neutral attitude, possibly because of the low level of experience, but this doesn't leave any hint for degradation of flight safety.

Conclusions and Recommendations

As a result of theory and research, it is essential the conclusions and suggestions to be presented. From the previous chapter many recommendations had already emerged through the process of gathering the results. On that section, all of the recommendations are summarized and stated in the lines below.

To begin with, for CRM it was ascertained that pilots recognize its value and contribution in the prevention of human errors and in flight safety overall. It was also clearly stated that pilot's resilience is proportional to the level of CRM training. Moreover, regardless of pilot's experience and background, it is a common belief that the aviation community has much more to learn regarding CRM. It is imperative for the organizations that legislate international regulations in aviation (ICAO, EASA as shown in CRM's chapter) to promote CRM's necessity not only in theory but also with empirical research. Additionally, as analyzed in theory, CRM was developed through some discrete generations. This evolution must be continued in the future. As aircrafts become more and more sophisticated and the human factor is also transmuted, CRM must keep up with these developments.

At the same time, the questionnaire indicated some alarming elements regarding pilots' knowledge of CRM training and their level of satisfaction. Especially for the Air Force, the respective results were slightly lower compared to the civil aviation. More precisely, it seems that pilots are familiar with the main principles of CRM but when asked for deeper knowledge (threat and error management, Resilience etc.) the results were not that encouraging. Operators of civil and military aviation must keep a constant training of CRM in flight crews with seminars, questionnaires, empirical examples and evaluation. It is of paramount meaning for the aviators to become masters in CRM's knowledge because of its great importance in flight safety.

Another finding that calls for immediate action, is the difference in application of CRM in military and civil aviation. As analyzed in the previous chapter, this difference is probably emerged by the strictly military environment that pilots of the Air Force operate. It is imperative for the administration of military squadrons to recognize that the legislation concerning CRM is common for every operator. There is no difference in the rules and guidelines between military and civil environment. There is a common code of communication between crew members which guarantees the supreme target of flight safety. The Air Force must be attuned to the national legislation, discriminating the military role from the aviation.

Except from improving CRM, an additional aim of this dissertation was the prevention of human errors. Certainly, the mitigation of errors comes along with an improvement of CRM. Besides, as shown in theory, the poorer the CRM, the less safe a flight becomes. The questionnaire revealed interesting facts in this part and the following recommendations are stated.

Firstly, pilots recognize the imperative need of being supported by a willing and friendly organization. Moreover pilots believe that the organization's policy significantly protects them against errors .As stated at the introduction, the results of this dissertation present a wider meaning. Human factors still own the businesses' number one priority for success and safety. This fact must be adopted and taken into account for many other firms. It's a fact that no matter how confident or trained humans are, the business's support and friendly profile will always contribute to the employee's performance. Additionally, this suggestion is even more important for employees working in critical positions or the so called ''sharp end'' of a business. Positions were humans are vulnerable to errors and the safety is at stake.

The training of pilots in modern and sophisticated flight simulators was presented in the second chapter along with a figure. Despite the fact that these tools are extremely advanced and realistic, pilots when asked about the need of further training and more scenarios, they showed a positive attitude (see summary of findings). An extended and more frequent training in the flight simulators would give the opportunity to trainee pilot to deal with more unusual scenarios, procedures and increase their self-confidence. It is also believed that a long lasting training in simulators would convert pilots into more resilient professionals. To be noted that pilots expressed a neutral attitude when asked for a positive outcome after a ditching or bird strike in low altitude. This extended training may be combined with CRM's proposals as stated above, in a global attempt to reduce human errors and upgrade CRM. This fact would offer multi-layered benefits for the aviators. A theoretical penetration into CRM supported by an extended section in flight simulators, would make pilots even more optimistic, trained for the unexpected and safe.

Regarding the time pressure which hides a great potential of an in-flight hazard, the following is recommended. As analyzed in the previous chapter, military and civil fliers usually operate in a stressful environment. Pilots must comprehend from the beginning of their training that time accuracy is of paramount meaning for a successful and prosperous flight. Nevertheless, safety valves must be always preserved in order to avoid slips and lapses. An effective coordination between air and ground personnel as well as the compliance with CRM principles (e.g. set-check-confirm as analyzed in theory) set lines of defense against the threat of time pressure. The need of maximum performance in the minimum possible range is a common characteristic for every firm. The theory and training policy of CRM in slips/lapses, must be adopted in every organization beyond aviation. Understanding the way humans operate under time pressure and the discrimination of their errors based on different circumstances, gives operators the advantage of better perceiving the human nature.

Another aspect of aviation training which can lead to the mitigation of errors is the reading of the checklist. In the research, it is shown that pilots tend to follow the checklists both by memory and by reading. Especially for standard procedures, captains tend to skip the reading and act by memory more often than co-pilots do. This is an indication of a potential error as essential items may be omitted. CRM training must focus on the necessity of following the checklist's sequence word for word. Pilots must be standardized and obliged to follow the aircraft's procedures by reading the checklist and not by using their memory. This will help them avoid errors, especially when operating under pressure, where the possibility of disregarding standard procedures is even higher. On the other hand, in case of an emergency situation, captains and first officers stated that they will choose the reading of the checklist. Undoubtedly, this is a sign of professionalism and standardized attitude. An effective CRM must teach pilots to keep the same attitude for the standard procedures. Moreover, a particular emphasis must be given in more experienced pilots. Despite the fact that pilots with many flight hours lean on their experience and knowledges, at the same time they may turn into a potential hazard for the flight safety. The excessive trust in their abilities and a possible disdain in a much younger co-pilot are indicators of a deceased CRM thus in a risky flight safety. Their attitudes and interactivity with other crew member must be periodically evaluated within a CRM framework.

Another issue that also deals with the checklist, is the possible amendment of its items, in order to deal in a better way with an emergency. For that question, pilots expressed neutral to negative attitudes (see summary of findings). Captains expressed even lower willingness to amend the checklist. This is a concrete indication that pilots respect the operator's procedures and follow the items devoutly in an emergency. Nevertheless, CRM training must emphasize more on empirical scenarios, such as Sully's case, where some of the checklist's items had to be amended. This would make pilots understand that due to the possibility of encountering an unusual situation, their judgment must be primarily used in order to deal with an emergency efficiently. This suggestion does not constitutes a drift from the reading of the checklist but it's a reminding in pilots that their critical thought must always be on alert.

The final suggestions targeting to the decrease of human errors are addressed towards co-pilots. As analyzed in the previous chapter, co-pilots indicated certainty to state their opinions against a captain's harmful decision. However, as the situation was aggravated, and more effective measures were necessary, their willingness was decreased. Moreover, as shown, the captain's character plays a key role in co-pilots certainty to state their opinion. It is imperative via CRM to be further emphasized to the need of creating a common trust between crew members. Captains must cooperate harmonically with their partners, but firstly they need to build up a conciliatory attitude. At the same time, co-pilots must feel free to state their opinion and even take over the aircraft's control in captain's incapacitation. CRM emphasizes on the creation of an ideal model of attitude between crew members. But, captain's domination and co-pilot's hesitation which in some cases still prevail, is a lurking danger for flight safety. Through questionnaires, researches and in flight evaluations, nonprofessional attitudes should be isolated. From pilot's perspective, the CRM's knowledge will help them understand the substantial need for trust between crew members and mutual respect.

In conclusion, this dissertation as stated in the introduction, is not exclusively oriented towards aviation. On the contrary, the management of a crew does not differ that much from a business administration. What CRM states in its theory for aviators, may also be adopted in many other sectors. Moreover, the findings of this research indicate some weaknesses of modern CRM which may have a wider implementation. The suggestions made for the improvement of CRM and flight safety must be taken into account for the managers of businesses as well. For example, the pilot's subjunctive need to be supported by a friendly and willing organization, the call for an extended training and the compliance with the standard procedures, are of paramount meaning for every firm. Additionally, issues such as the time pressure imposed in the employers and the interpersonal relationships between them, are some of the main concerns of a modern manager. Even the more technical fields of CRM such as the crews' readiness for the unexpected and the proper way to deal with extreme scenarios, are also techniques which may guarantee the safety in other fields. It is comprehended that these sciences focus on the human factors. Through them, the human nature is studied and for the emerged weaknesses particular countermeasures are imposed. In a research which may be the next step of this dissertation, it is recommended that CRM and Business Administration are studied simultaneously. From that study, the common regulations between them will be underlined as well as a trade-off between their principles. Like this study, the main target will be after all… safety!

REFERENCES

Airbus (2019). *The A380*- Facts and Figures. Airbus Press office. Cedex, France. Retrieved from: https://www.airbus.com/content/dam/corporate-topics/publications/backgrounders/Backgrounder-Airbus-Commercial-Aircraft-A380-Facts-and-Figures-EN.pdf

Alvarez, K., Salas, E., Garofano, C.M., (2004). *An integrated model of training evaluation and effectiveness.* Human Resources Development Review 3. University of Central Florida. pp 385–416.

American Psychological Association. (2014). *The Road to Resilience*

Bainbridge, L. (1987). The ironies of automation. In J. Rasmussen, K. Duncan and J. Leplat (Eds). *New Technology and Human Error*. London: Wiley.

Baker, D., Prince, C., Shestha, L., Oser, R. & Salas, E. (1993). Aviation computer games for crew resource management training. *The International Journal of Aviation Psychology*, 3(2), pp. 141-156.

Bergström, J. Henriqson, E. Dahlström N. (2011). *From CRM to Opeartional Resilience*. Lund University. Sweden: Presses des Mines. Pp 1-3

Birnbach, R., Longridge, T. (1993). The regulatory perspective. In E. Wiener, B. Kanki& R. Helmreich (Eds.), *Cockpit Resource Management* (pp. 263-282). San Diego, CA: Academic Press.

Brannick, M., Prince, C. & Salas, E. (1995). *The measurement of team process*. Human Factors, 37(3), pp. 641-650.

Byrnes, R. & Black, R. (1993). Developing and implementing CRM programs. In E. Wiener, B. Kanki & R. Helmreich, *Cockpit Resource Management*. San Diego, CA: Academic press, pp. 421-446.

Childester, T., Helmreich, R., Gregorisch, S. & Geis, C. (1991). Pilot personality and crew coordination: Implications for training and selection. *The International Journal of Aviation Psychology,* 1(1) pp. 25-44.

Civil Aviation Authority (2014). *Flight Crew human factors Handbook-CAP 737*. UK, West Sussex. Aviation House CAA.

Cooke, R. (2016/11/27). Sullenberger: an old-fashioned kind of hero. *The Guardian*. Retrieved from: https://www.theguardian.com/film/2016/nov/27/chesley-sullenberger-sully-film-clint-eastwood-tom-hanks-miracle-hudson-river

Cooper, G. E., White, M. D., & Lauber, J. K., (1980). *Resource management on the Flight deck*. (Conference Publication 2120). Moffett Field: NASA-Ames Research Center. Retrieved from: *http://ntrs.nasa.gov/archive/nasa/casi.ntrs.nasa.gov/19800013796_1980013796.pdf*

Corker, K. and Smith, B. (1993). *An architecture and model for cognitive engineering simulation analysis: application to advanced aviation analysis*. Presented at the AIAA Conference on Computing in Aerospace, San Diego, CA.

Dan Mauriono (2005, Apr.). *Threat and Error Management.* Canadian Aviation Safety Seminar. Vancouver, BC. 18-20 Apr. 2005

De Terte, I. & Stephens, C. (2014). *"Psychological Resilience of Workers in High-Risk Occupations".* Stress and Health. **30** (5): 353–355. Doi: 10.1002/smi.2627. ISSN 1532-3005

Deb, A. and Arora M. (2012). "Resilience and academic achievement among adolescents." *Journal of the Indian Academy of Applied Psychology.* 38(1): 93-101

Dekker, S.W.A. (2006). Resilience Engineering: chronicling the emergence of confuse consensus. In: Hollnagel E., Woods D. & Leveson N. (eds). *Resilience Engineering: concepts and percepts.* Aldershot, UK: Ashgate

Dekker, Lundström (2007). *From TEM to Resilience.* In: Journal of Human Factors and Aerospace Safety. Lund University. Pp 7-9

Edwards, E. (1972). *Man and machine: Systems for safety*. In: proceedings of British Airline Pilots Association Technical Symposium. British Airline Pilots Association, London, pp. 21-36.

EUROCONTROL (1997). *Human Factors Module Interpersonal Communication*. European Air Traffic Control Harmonization and Integration Programme. Brussels, BE. Retrieved from: https://www.skybrary.aero/bookshelf/books/201.pdf

EUROCONTROL (2002). *Technical Review of Human Performance models and Taxonomies of Human Error in ATM (HERA)*. (Technical report no. HRS/HSP-002-REP-01. Brussels, BE. Retrieved from: https://www.skybrary.aero/bookshelf/books/3223.pdf

EUROCONTROL (2004). *A Method for Predicting Human Error in ATM (*HERA-*predict).* Brussels, BE. Retrieved from: https://skybrary.aero/bookshelf/books/327.pdf

European Union Aviation Safety Agency (EASA) (2017). *Crew Recourse Management in Practice.* Version 1. Cologne, Brussels.

Fearn-Banks, K. (2016). "Transportation Crises." *In Crisis communications: A casebook approach*. Abington, UK: Routledge. Pp 281-302.

Federal Aviation Administration (1997). *Aviation safety action programs*. Advisory Circular 120-66. Washington, DC. Retrieved from: https://www.faa.gov/about/initiatives/asap/

Field TA, Beeson ET, Jones LK (2015), "The New ABCs: A Practitioner's Guide to Neuroscience-Informed Cognitive-Behavior Therapy" (PDF), *Journal of Mental Health Counseling*, 37 (3): 206–220, doi:10.17744/1040-2861-37.3.206

Flight Safety Foundation (2000). FSF ALAR Briefing Note 2.2. *Crew Resource Management.* Madison, USA. Retrieved from: https://www.skybrary.aero/bookshelf/books/851.pdf

Flin, R. (2003). *'Danger – Men at Work'.* Management influence on safety. Human Factors and Ergonomics in Manufacturing, University of Aberdeen. 13, pp. 261– 268.

Flin, R., O'Connor, Chrichton (2008), *Safety at the Sharp End: A guide to nontechnical skills.* Burlington, VT: Ashgate

Foushee, H.C., Helmreich, R.L., (2010). Why CRM? Empirical and Theoretical Bases of Human Factors Training. In: Anka J., Kanki G., & Helmreich, R. (2010). *Crew resource management*. Elsevier, USA

Foust, D. (2009/02/19). "US Airways: After the 'Miracle on the Hudson.'' *Bloomberg Businessweek.* Retrieved from: https://www.bloomberg.com/news/articles/2009-02-18/us-airways-after-the-miracle-on-the-hudson

Gitte Furdal D. (2017). *Is resilience the most valuable skill for a pilot?* Aerotime News Hub. Retrieved from: https://www.aerotime.aero/aerotime.team/19764-is-resilience-the-most-valued-skill-for-a-pilot

Gray F.C., (2002). *The Five First Flights*. *WW1 AERO*- The journal of the Early Airplane, issue 177, pp 26-39. Retrieved from: http://www.thewrightbrothers.org/fivefirstflights.html

Helmreich, R. L. Foushee, H. C. Benson, R. & Russini, W. (1986). *Cockpit Management Attitudes: Exploring the Attitude-Performance Linkage.* Aviation Space and Environmental Medicine, 57, 1198-1201

Helmreich, R. L. (1997). *Managing human error in aviation*. Scientific American. pp. 62-67.

Helmreich, R.L., & Merritt, A.C. (1998). *Culture at work: National, organizational, and professional influences*. Aldershot, United Kingdom: Ashgate.

Helmreich, R. L. & Merritt, A. C. (1998). *Culture at work in aviation and medicine: National, organizational, and professional influences.* Aldershot, U.K.: Ashgate

Helmreich, R.L, Merritt, A. C. & Wilhelm, J. A. (1999). The Evolution of Crew Resource Management Training in Commercial Aviation. *International Journal of Aviation Psychology* Vol 9, Iss.1. 1999

Helmreich, R.L. (2000). *Error management: lessons from aviation*. British Medical Journal, 320. pp 781–785

Helmreich, R.L., & Merritt, A.C. (2000). Safety and error management: The role of Crew Resource Management. In B.J. Hayward & A.R. Lowe (Eds.). *Aviation Resource Management* (pp. 107-119). Elsevier, USA

Helmreich, R.L., Klinect, J. and Wilhelm, J. (2003) .Managing threat and error: Data from line operations. In Edkins G. and Pfister P. (eds.) *Innovation and Consolidation in Aviation.* Aldershot: Ashgate

History.com Editors (2019). *Red Baron*. A&E Television Networks. Retrieved from: https://www.history.com/topics/world-war-i/manfred-baron-von-richthofen

Hobbs A. (2004). *Human Factors: The Last Frontier of Aviation Safet*y? The International Journal of Aviation Psychology, 14:4, pp 331-345

Hollnagel, E. (1993). *Human reliability analysis: Context and control*. Academic Press. San Diego, California

Hollnagel, Woods, Leveson, (2006). *Resilience Engineering Concepts and Precepts*. Farnham, UK: Ashgate. Pp. 315–324

ICAO (1993). *Human Factors Digest No.7. INVESTIGATION OF HUMAN FACTORS IN ACCIDENTS AND INCIDENTS*. Montreal Canada: ICAO

ICAO Annex 6 (2001). *Operation of Aircraft. Part I International Commercial Air Transport Airplanes.* Montreal, Canada: ICAO

ICAO (2005). *Threat and Error Management in Air Traffic Control*. Amendment No 2. Montreal Canada: ICAO. pp 2-3

Jensen, R. S. (1995). *Pilot Judgement and Crew Resource Management.* UK: Ashgate Publishing Limited.

Kanki, B. G., Helmreich, R. L., & Anca, J. (Eds.). (2010). *Crew Resource Management* (2nd edition). San Diego, CA: Press/Elsevier

KERN, T. (1998). *Flight discipline.* New York: McGraw-Hill.

Klinect, J.R., Murray, P., Merritt, A., Helmreich, R., (2003*). Line Operations Safety Audit (LOSA): Definition and operating characteristics.* In: Proceedings for the 12th International Symposium on Aviation Psychology. Columbus, OH. Dayton, The Ohio State University, pp. 663–668.

Lazopoulos, D. (2013). *Crew Resource Management Training, Evaluation of Effectiveness: Hellenic Air Force C-130 aircrew case study* (Dissertation). Hellenic Open University, Athens.

Leape, L.L., Brennan, T.A., Laird, N., Lawthers, A.G., Localio, A.R., Barnes, B.A. (1991). *The nature of adverse events in hospitalized patients*. *Results of the Harvard Medical Practice Study II*. Boston, NCBI.

Learmount, D. (2011/10/31). Airline pilot training revolution needed. *Flight International. Pioneering Aviation Insight. London.* Retrieved from: https://www.flightglobal.com/news/articles/airline-pilot-training-revolution-needed-363801/

Li W-C, Harris D. (2006). The evaluation of the Decision Making Process Employed by Cadet Pilots Following a Short Aeronautical Decision-Making Training Program. *International Journal of Applied Aviation Studies*, 6, pp. 315-33.

Maurino D., Murray P., (2010). *Crew resource management.* In: Garland D., Wise J. & V. Hopkin D. 2010, Handbook of aviation human factors, second edition, CRC Press, USA.

Meritt, A., Klinect, J. (2006). *Defensive flying for pilots: An introduction to Threat and Error Management.* The LOSA collaborative. University of Texas Human Factors Research Project

Mintzberg, H. (1996). *The Rise and fall of Strategic Planning.* New York, USA: Free Press

Moriaty, D. (2015). *Practical Human Factors for Pilots.* Oxford, UK. Academic Press, Elsevier. Pp 86-88

Morris H., (2017/08/16). How many planes are there in the world right now? *The Telegraph.* Retrieved from: https://www.telegraph.co.uk/travel/travel-truths/how-many-planes-are-there-in-the-world/

National Transportation Safety Board. (1979). *Aircraft Accident Report: United Airlines, Inc.*, Douglas DC-8-54, N8082U, Portland, Oregon, and December 28, 1978. Washington, DC: Author. (NTSB-AAR-79-7).

Nemoto, T., & Beglar, D. (2014). *Developing Likert-scale questionnaires*. In N. Sonda & A. Krause (Eds.), JALT2013 Conference Proceedings. Tokyo: JALT.

Oxford Dictionary Concise (2004) Ed. Catherine S. and Angus S. Oxford University Press. *Oxford Reference Online. Oxford University Press*. Manchester University. Retrieved from: http://www.oxfordreference.com/views/ENTRY.html?subview=Main&entry=t23.e47692

Paries, Hollangel, Woods (2011). *Resilience Engineering in Practice. A Guidebook*. Farnham, UK: Ashgate. Pp 9-27

Patton, J. (2015). HRM in the aviation industry. *The journal of Global Business Management.* Vol. 11. April 2015 Issue.

Povenmire, H., Rockway, M., Bunecke, J., Patton, M. (1989). *Cockpit Resource Management skills enhance combat mission performance in a B-52 simulator*. In: Jensen, R., Proceedings of the Ninth International Symposium on Aviation Psychology. Ohio State University, Columbus.

Royal Aeronautical Society (1999). *CRM, A Paper by the CRM Standing Group of Royal Aeronautical Society.* London. Pp. 6-7

Sexton, B., Helmreich, R., Wilhelm, J., Meritt, A. & Klinect, R. (2001). *Flight Management Attitudes and Safety Survey (FMASS): A shortened version of the FMAQ.* University of Texas at Austin. Human Factors Research Project. Technical Report 01-01.

Sherman, P.J., Helmreich, R.L., & Merritt, A.C. (1997). *National culture and flight deck automation: Results of a multination survey.* International Journal of Aviation Psychology, 7:311-329

Siebert, A. (2005). The Resiliency Advantage, pp. 2–4. Berrett-Koehler Publishers. ISBN 1576753298.

Silverman, D., Spiker, V., Tourville, S. & Nullmeyer, R. (1997). *Team coordination and performance during combat mission training.* Paper presented at the Interservice/ Industry Training, Simulation and Education Conference. Orlando, FL.

Simon, H. (1982). *Models of Bounded Rationality: Behavioural Economics and Business Organization (*Vols 1 & 2). Cambridge, MA: The MIT Press.

Smith, Jr., E. V., Wakely, M. B., DeKruif, R. E. L., & Swartz, C. W. (2003). *Optimizing rating scales for self-efficacy*. Educational and Psychological Measurement, 63(3), 369-391.

Spidell, S. (2014). Resilience and Professional Chaplaincy: A Paradigm Shift in Focus. *Journal of Health Care Chaplaincy, 20*(1), 16-24. Doi: 10.1080/08854726.2014.869994

STRAUCH, B. (2004). *Investigating human error: Incidents, accidents and complex systems.* Aldershot, England: Ashgate Publishing Ltd.

Taggart, W.R. (1994). Crew Resource Management: Achieving enhanced flight operations In N. Johnston & N. McDonald & R. Fuller (Eds.), *Aviation Psychology in Practice (pp. 309-339)*. N.Y. USA, Ashgate Publishing.

Valverde, H. H. (1968). *Flight simulators: A review of the search and development* (Technical Rep. No. AMRL-TR-68-97). Wright-Patterson Air Force Base, Aerospace Medical Research Laboratory.

Wagener, F., Ison, D. (2014). Crew Resource Management Application in Commercial Aviation. *Journal of Aviation Technology and Engineering 3:2* p.p. 2-13

Appendix 1- The Questionnaire

Preventing Human Error and Enhancing Resilience through CRM (Questionnaire)

This questionnaire is a part of the research for my dissertation for the Master course in Applied Economics and Business Administration of the Panteion University. The subject is "Preventing Human Error and Enhancing Resilience through CRM" and it concerns pilots of multi crew aircrafts. The first part is about personal data while the second part consists of the main body of the research with questions regarding CRM, Human Errors in aviation and Resilience. The expected time needed for the completion of the questionnaire is approximately 20 minutes.
It is anonymous and the data will be used only for the purpose of this dissertation.
Thank you in advance for your time and your contribution in this research.

Vrouvas Nickolaos, Applied Economics and Business Administration student in Panteion University
Supervising Professor: Mr Palaskas Theodosios

* Απαιτείται

Personal Data

1. **Gender** *
   Να επισημαίνεται μόνο μία έλλειψη.
   - ◯ MALE
   - ◯ FEMALE

2. **Position in the Crew** *
   Να επισημαίνεται μόνο μία έλλειψη.
   - ◯ Captain
   - ◯ First or Second Officer

3. **Flight Experience**
   Να επισημαίνεται μόνο μία έλλειψη.
   - ◯ Less than 1000hrs
   - ◯ 1000-3000hrs
   - ◯ 3000-5000hrs
   - ◯ 5000-10000hrs
   - ◯ More than 10000hrs

4. **Aviation Background (check all applicable)**
   Επιλέξτε όλα όσα ισχύουν.
   - ☐ Airline
   - ☐ Military or State
   - ☐ Business Aviation

Questions regarding CRM

Answer on a scale from 0-4
0: Not at all, 1: Slightly, 2: Moderately, 3: Very, 4: Extremely
Please pay attention on questions 5,6. Instructions are noted accordingly.

5. **1. To what extent human errors are mitigated when CRM rules are followed?** *
Να επισημαίνεται μόνο μία έλλειψη.

0	1	2	3	4
◯	◯	◯	◯	◯

6. **2. Are pilots more vulnerable to errors in a flight with poor CRM between crew members?** *
Να επισημαίνεται μόνο μία έλλειψη.

0	1	2	3	4
◯	◯	◯	◯	◯

7. **3. How satisfied do you feel from your CRM training?** *
Να επισημαίνεται μόνο μία έλλειψη.

0	1	2	3	4
◯	◯	◯	◯	◯

8. **4. Are you familiar with the "sub-categories" of CRM? (e.g. Threat and error management, stress management, resilience, startle effect.)** *
Να επισημαίνεται μόνο μία έλλειψη.

0	1	2	3	4
◯	◯	◯	◯	◯

9. **5. The following two questions regard ONLY pilots working in civil aviation with a military background: A) Have you spotted any differences in CRM application between military and civil aviation?**
Να επισημαίνεται μόνο μία έλλειψη.

◯ YES
◯ NO

10. **B) How different is the CRM in Air Force compared with an airline?**
Να επισημαίνεται μόνο μία έλλειψη.

0	1	2	3	4
◯	◯	◯	◯	◯

11. **6. The following two questions regard ONLY pilots who have graduated flight academies: A) Do you believe that pilots with a military background usually present a different approach in CRM rules compared to what you have learned in the private academy?**
Να επισημαίνεται μόνο μία έλλειψη.

◯ YES
◯ NO

12. **B) To what extent is that different?**
Να επισημαίνεται μόνο μία έλλειψη.

0	1	2	3	4
◯	◯	◯	◯	◯

13. **7. According to your opinion, to what extent could CRM be further developed?** *
Να επισημαίνεται μόνο μία έλλειψη.

0	1	2	3	4
◯	◯	◯	◯	◯

Questions regarding Human Errors

Answer on a scale from 0-4
0: Not at all, 1: Slightly, 2: Moderately, 3: Very, 4: Extremely
Please pay attention on question 17. Instructions are noted accordingly.

14. **8. How often does it happen to set a plan before or during your flight (e.g. SID procedures for the runway in use or procedures for a visual approach/STAR) and that plan to be changed at the eleventh hour? (E.g. due to change in meteorological conditions or ATC reasons etc.)** *
Να επισημαίνεται μόνο μία έλλειψη.

0	1	2	3	4
◯	◯	◯	◯	◯

15. **9. How satisfied do you feel with your standard training in the flight simulator?** *
Να επισημαίνεται μόνο μία έλλειψη.

0	1	2	3	4
◯	◯	◯	◯	◯

16. **10. Do you feel the need to experience more scenarios during your training/preservation at the flight simulator?** *
Να επισημαίνεται μόνο μία έλλειψη.

0	1	2	3	4
◯	◯	◯	◯	◯

17. **11. How possible is to make mistakes when operating under time pressure? (E.g. Because of the company's policy, operational missions, CTOT etc.)** *
Να επισημαίνεται μόνο μία έλλειψη.

0	1	2	3	4
◯	◯	◯	◯	◯

18. **12. To what extent do you believe that the safety of flights is degraded for economic reasons? (e.g. for maximising the profit or limiting the costs)** *

Να επισημαίνεται μόνο μία έλλειψη.

0	1	2	3	4
◯	◯	◯	◯	◯

19. **13. How important is it for a pilot to be supported by a friendly and willing organization? (As organization consider an air squadron or an airline accordingly)** *

Να επισημαίνεται μόνο μία έλλειψη.

0	1	2	3	4
◯	◯	◯	◯	◯

20. **14. To what extent do you believe that the organization's policy contributes to the prevention of human errors?** *

Να επισημαίνεται μόνο μία έλλειψη.

0	1	2	3	4
◯	◯	◯	◯	◯

21. **15. To what extent do you execute standard procedures (e.g. before landing checklist etc.) based primarily on your memory/experience and secondarily on the reading of the checklist?** *

Να επισημαίνεται μόνο μία έλλειψη.

0	1	2	3	4
◯	◯	◯	◯	◯

22. **16. In case of an emergency, to what extent would you execute the required procedures primarily by memory and secondarily by the checklist?** *

Να επισημαίνεται μόνο μία έλλειψη.

0	1	2	3	4
◯	◯	◯	◯	◯

23. **17. The following four questions regard ONLY Co-Pilots: You are acting as a Pilot Not Flying and you feel that the Captain made a decision which might lead to a harmful situation A). How confident do you feel to state your opinion?**

Να επισημαίνεται μόνο μία έλλειψη.

0	1	2	3	4
◯	◯	◯	◯	◯

24. **B) To what extent does the Captain's experience/character affect your stating ?**

Να επισημαίνεται μόνο μία έλλειψη.

0	1	2	3	4
◯	◯	◯	◯	◯

25. **C) If the situation is further escalated, how confident would you feel to state your opinion with an even more intense tone?**

Να επισημαίνεται μόνο μία έλλειψη.

0	1	2	3	4
◯	◯	◯	◯	◯

26. **D) How certain would you feel to take the aircraft's control if the Captain did not correct the situation considering your statement?**

Να επισημαίνεται μόνο μία έλλειψη.

0	1	2	3	4
◯	◯	◯	◯	◯

Questions regarding Resilience

Answer on a scale from 0-4
0: Not at all, 1: Slightly, 2: Moderately, 3: Very, 4: Extremely

27. **18. How "resilient" do you feel when flying with a well trained crew in CRM? (Resilience is defined as the ability of a person to 'withstand or recover quickly from difficult conditions')** *

Να επισημαίνεται μόνο μία έλλειψη.

0	1	2	3	4
◯	◯	◯	◯	◯

28. **19. To what extent did the flight simulator train you to deal with unexpected and extreme scenarios? (E.g. bird strike and total power loss in low altitude during climb)** *

Να επισημαίνεται μόνο μία έλλειψη.

0	1	2	3	4
◯	◯	◯	◯	◯

29. **20. To what extent does the extremely advanced automation of the aircrafts limit your effectiveness?** *

Να επισημαίνεται μόνο μία έλλειψη.

0	1	2	3	4
◯	◯	◯	◯	◯

30. **21. How prepared do you feel to deal with a "total power loss in low altitude"?** *

Να επισημαίνεται μόνο μία έλλειψη.

0	1	2	3	4
◯	◯	◯	◯	◯

31. **22. How trained do you feel in case of a forced and unexpected ditching?** *

Να επισημαίνεται μόνο μία έλλειψη.

0	1	2	3	4
◯	◯	◯	◯	◯

32. **23. How optimistic do you feel for a successful outcome after a forced or unexpected ditching?** *

Να επισημαίνεται μόνο μία έλλειψη.

0	1	2	3	4
◯	◯	◯	◯	◯

33. **24. In case of an emergency, to what extent do you think there are essential procedures not included in the checklist, but very helpful when dealing with it?** *

Να επισημαίνεται μόνο μία έλλειψη.

0	1	2	3	4
◯	◯	◯	◯	◯

34. **25. According to your discretion and the prevailing conditions, how possible would it be to change the sequence of the checklist's items during an emergency in order to better deal with it? (E.g. immediately turning on the APU in total power loss).** *

Να επισημαίνεται μόνο μία έλλειψη.

0	1	2	3	4
◯	◯	◯	◯	◯

Thank you for your time and your contribution in this research!