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Crew Resource Management in Aviation: The Analysis of the Air France Flight 447 Crash

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Abstract

01 June 2009, the Air France Flight 447 crashed into the Atlantic on a night flight from Rio to Paris. The aim of the research is to analyze and evaluate the Air France 447 Crash in the context of crew resource management practices. Crew resource management refers to the appropriate use of technical and non-technical skills and all available resources. In the research, the qualitative research case study method using the intensive description and analysis of a phenomenon or social unit was used. The case, Air France Flight 447, occurded in 2009 and accident report was completed in 2012. The accident report (BEA, 2012) and National Geographic - Air France Flight 447 Documentary HD were examined through document analysis. The data obtained from the documents were analyzed by content analysis method. The research examined with crew resource management skills, which is designated as the communication, situational awareness, team work, decision making, leadership, and personal limitations. As a result, the biggest share of the accident is seen as the "human factor".

Keywords: *Crew Resource Management, Air France Flight 447, Aviation Psychology*

Havacılıkta Ekip Kaynak Yönetimi: Air France 447 Kaza Analizi

Öz

Air France 447 kazası, 1 Haziran 2009'da, Rio'dan Paris'e bir gece uçuşu sırasında gerçekleşmiştir. Araştırmanın amacı Air France 447 kazasını ekip kaynak yönetimi uygulamaları bağlamında analiz etmek ve değerlendirmektir. Ekip kaynak yönetimi, teknik ve teknik olmayan tüm yetenek ve ulaşılabilir kaynakların kullanılmasıdır. Araştırmada, nitel araştırma yöntemlerinden doküman analizi ile içerik analizi bağlamında incelenmiştir. Araştırmada temel olarak, 2012'de tamamlanan kaza raporu (BEA, 2012) ve National Geographic'in Air France 447 konulu uçuş belgeselinden yararlanılmıştır. Araştırma ekip kaynak yönetimi uygulamaları, iletişim, durumsal farkındalık, takım çalışması, karar alma, liderlik ve kişisel sınırlılıklar boyutları ile incelenmiştir. Araştırmada, kazanın en temel sebebinin "insan faktörü" olduğu saptanmıştır.

Anahtar Kelimeler: *Ekip Kaynak Yönetimi, Air France 447 Uçuşu, Havacılık Psikolojisi*

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Introduction

Helmreich and Foushee (1993) expressed that flight accidents between 1950-1959 were mostly due to human error and miscommunication. According to authors, in the 1970s, Pan American World Airways wondered about crew training issues in pilot error accidents in the Pacific. NASA Ames Research Center has initiated a number of human factor-based research in aviation activities, and Charles Billings, John Lauber and George Cooper began to investigate pilot-based accidents in aviation accidents, with structured interview forms and first-hand information gathering (Kanki, 2019). At the same time, George Cooper and Maurice White examined jet transport accidents between 1968 and 1976 (Cooper et al.,1980). Then, In 1974, the Federal Aviation Administration (FAA) examined the entire flight crew training and numerous recommendations. Firstly, by using crew concept training, not only the development of single pilot's but also the coordination activities of the whole crew were taken into consideration in simulator trainings and controls. During the early 1980s, commercial aviation experienced human factors-related disasters. Thus, efforts have been made to improve flight-crew team working (Bennett, 2015). In addition, according to Harris (2014, 90-91), "*Human error is now the principal threat to flight safety: it is estimated that up to 75% of all aircraft accidents now have a major human factors component"*.

Cooper, White, and Lauber (1980) mentioned that three basic human errors in air accidents: interpersonal communication failures, decision making and leadership. Crew resource management trainings positively affects performance by increasing coordination and group relations (Helmreich, 1980). Efficient crew resource management task analysis is effective by detecting threats for performing a flight mission safely, recognizing hazards and identifying risk. In addition, the captain pilot's attitudes and behaviors, leadership and command understanding, communication skills, and his predisposition to team work are decisive in the effective management of this process (Eyüboğlu, 2010).

Flin and Maran (2015) pointed out that pilots with non-technical skills better understand the importance of safety behavior and get opportunities in exercises and simulations. They listed these abilities as follows: situation awareness, decision making, teamwork, leadership, coping with stress, managing fatigue. Crew resource management refers to the appropriate use of technical and non-technical skills and all available resources. Many aviation accidents have occurred as a result of the inability to use the skills and

resources. The aim of the research is to analyze and evaluate the Air France 447 Crash in the context of crew resource management practices.

1. Literature Review

1.1. Crew Resource Management

The term originally used as *cockpit resource management* is recognized as a crew resource management in general use, with applicability for other aviation members, including cabin crews, flight dispatchers, and maintenance personnel (Helmreich and Foushee, 2010). Although the origin of the crew resource management is based on reducing pilot errors, over the years, it has been expanded in areas other than the cockpit, including the cabin, maintenance, and dispatch (Helmreich et al., 1999). In 1983-1999, Salas et al., (2001), examined 58 studies to evaluate the effectiveness of crew resource management training for cabin crews in commercial and civil aviation. According to research findings, the authors found that crew resource management training often led to positive responses (emotional and useful), strengthening learning (towards attitude change) and desired behavior change in the cockpit.

Resource management means effective coordination and availability of all available resources in flight services (Helmreich, 1987). Crew resource management are techniques applied for crew training in aviation and other sectors that require high risk and attention. The term was first used in practices in aviation industry, including aviation maintenance, cabin crew, and air traffic control. Currently, it is used in high-risk industries such as the fire service, emergency medicine, nuclear operator teams, and merchant marine (O'Connor et al., 2008). Although crew resource management training was voluntary in commercial flights in the early 1990s, it did not become mandatory in military aviation until 1998 (Salas et al., 2006).

Lauber (1984) described team resource management as the use of all available resources, such as information, equipment and people, to ensure safe and effective flight. Crew resource management provides pilots and cabin crew with the necessary abilities for a safe and efficient flight (Bennett, 2019). Thus, crew resource management training includes interpersonal communication, group processes, team decision making, leadership, conflict resolution, situational awareness, defining our behaviors and defining the behaviors of others (Jensen, 1997). The personal characteristics of crew members (including skills) increase or decrease possibility of accidents. Jensen (2017) described crew resource management is the

implementation of aviation decisions in multi-person teams. According to him, crew resource management adds a social dimension to decision making and requires strong emphasis on interpersonal communication. Helmreich and Merritt (2017) stated that safe flight will be provided when crew members implement crew resource management concepts such as briefings, positive leadership, monitoring, and standard operating procedure compliance. Crew resource management has a healing role not only in human-machine interaction and time savings, but also in interpersonal activities such as leadership, effective team building and maintaining, problem solving, decision making, and maintaining awareness of the situation (Kanki, 2019).

Helmreich et al., (1999) expressed the development of crew resource management in five phases. The authors called the first generation crew resource management the *cockpit resource management.* This phase includes focusing on training programs, applying psychological tests for leadership, describing the behaviors in the cockpit with many employed games and exercises, applying LOFT (Line Oriented Flight Training) training programs and applying interpersonal skills with simulators. In the second generation crew resource management, the concept of *cockpit resource management* has changed as a *crew resource management* by focusing on the studies on group dynamics. As basic trainings, seminars such as team building, briefing strategies, situation awareness and stress management were organized. In the third generation crew resource management, organizational culture training activities started in order to ensure safety since the early 1990s. At the same time, trainings for the flight crew started to be provided for flight attendants, dispatchers, and maintenance personnel. In the fourth generation crew resource management, FAA (Federal Aviation Administration) and AQP (Advance Qualification Program) developed for the improvement of the qualifications and training of flight crews. In order to provide flexibility in training, it was emphasized that CRM and LOFT programs in carriers should be provided for the entire flight crew and the CRM concept should be integrated into technical training. In the last phase, fifth generation crew resource management, studies to collect and report data on errors have been initiated in order to identify the root causes of errors in the context of error management. In this generation, it has been stated that stress factors such as fatigue, workload and emergencies that limit human performance may cause accidents with human error and should be in official training.

Musson and Helmreich (2004) mentioned that with the idea that mistakes caused by the human factor can be prevented by training, a number of training practices have been initiated to bring the attitudes, behaviors and beliefs to the cockpit crew. Civil and military organizations have developed flight crew resource management training programs, focusing on topics such as teamwork, leadership, communication, stress management and executive skills (Aktaş ve Tekarslan, 2013). Besides, Helmreich and Wilhelm (1991) expressed that crew resource management trainings have the following results: (1) trainings are useful, (2) changing organizational culture, (3) training and attitude change, (4) evaluation and attitude change. Authors emphasized that there was a positive change in team coordination and personal abilities and boomerang effect (negative change) in the attitudes of the participants sub-team.

Mearns et al. (2001) seperated the crew resource management into six main topics: communication (exchange of ideas, information and command with minimum confusion), situational awareness (understanding and interpretation of environmental factors), team work (crew members working efficiently and sharing), decision making (selecting a course of action, implementing the decision and evaluating the outcome), leadership (ability to influence ideas and behaviors in cockpit and interpersonal behavior), personal limitations (fatigue, time-pressure, difficult or unexpected situations). In addition, Kanki (2019) stated that there are some input factors related to the flight crew's performance model: individual (intelligence, motivation, personality, physical condition, emotional state), group (composition, climate, structure, norms), organizational (culture, norms, resources, dispatch, evalution, process), regulatory (regulations, training requirements, evalution standars, facilities), and environmental (aircraft condition, aircraft equipment, weather, operating). According to her, these factors affect team interaction singly and in combination.

Helmreich et al. (1999) seperated the threats that might occur during the flight into expected and unexpected threats. Expected threats consist of factors such as terrain, predicted air and airline conditions. On the other hand, unexpected threats include air traffic control commands, system error, and operational pressures. Crew resource management is used to manage some problems in teamwork and ensure safety of the flight. Helmreich (1999) expressed that in order to create a safety culture, the willingness to share information should increase in operational errors. In addition, according to him, improve the safety of operations, they must include wider system issues as well as training at the individual and

crew level. Also, Ford et al., (2014) found out that experience, team position, seniority, leadership role, team size and flight flow are the main determinants of flight candidates safety attitudes. Terzioğlu (2018), findings about the effect of crew resource management on flight safety culture showed that crew resource management statistically positive affected flight safety culture.

1.2. Crew Resource Management Skills

Mearns et al. (2001) seperated the crew resource management into six main skills. In the context of these skills, Air France Flight 447 Crash will be examined. In this section will be given about the crew resource management skills, which is designated as the communication, situational awareness, team work, decision making, leadership, and personal limitations:

Communication: Communication in crew resource management is the exchange of ideas, information, and instructions to understand messages conveyed with other cabin crew members with minimal complexity. Communication provides support for crew resource management elements with verbal and nonverbal skills (Mearns et al., 2001). The Tenerife Air Disaster occured because of lack communication and misinterpretation of verbal message (Flin et al., 1998). Foushee and Helmreich (1988) expressed the that the aircrafts were designed in such way that they could make verbal communication compulsory, since they carry the limits and disabilities of each individual to the cockpit. When the accidents are examined, there are a lot of samples in the literature where co-pilots made numerous fatal accidents due to the communication channels in the cockpit.

Communication is a tool to achieve crew resource management goals: (1) communication conveys information, (2) communication creates interpersonal/team relationship, (3) communication creates predictable behavior and expectations, (4) communication maintains attention and situational awareness, (5) communication is a method tool (Kanki, 2019). Communication skills effectiveness plays an important role in success or failure in achieving goals. On January 25, 1990, Avianca Airlines Flight AVA 052 Flight B707B, which departs from Bogata to John F. Kennedy New York International Airport, run out of fuel and crashed on Long Island. When the plane crash records were examined, it was seen that even at the simplest level on NTSB, obvious mistakes were made in communication. Specially, communication errors were made while the flight crew was telling the air traffic controller how little fuel they had left and they had to land immediately.

When the conditions of the accident were examined, it was found that important critical communication connections were missing. The bad weather conditions caused the plane to be kept in the air three times, one hour and 17 minutes by the air traffic controller. Until the third air wait period, the flight crew did not convey to the air traffic controller that the aircraft would not be in the air for more than five minutes. They could not reach the Boston-Logan International Airport, which is reserve square. After passing the JFK Airport, four engines stopped and the plane crashed 16 miles from the airport. As a possible cause of accident, NTSB showed that the flight crew was unable to plan the fuel load properly and there was a lack of communication in informing the air traffic controller about the emergency fuel conditions before their fuels run out. Another reason, under these difficult conditions, the flight crew contacted the flight planning system of the airlines and did not call for help from flight operations specialists (Wiener et al., 1995).

Flight crews should be constantly aware of the obstacles in communication, not be shy on issues such as confirming, asking again, and defending ideas. It is possible to improve communication through good listening skills and transferring them. Professional aviators need to put aside rank and cultural issues in the cockpit to ensure the team coordinate level required in the modern aviation enviroment. Each crew member is both a speaker and listener. The person who wants to have a good communication should listen to others. (Terzioğlu, 2007).

Situational Awareness: The perception of the elements in the environment within a volume of time and space, the comprehension of their meaning, and the projection of their status in the near future (Endsley, 1988; 97). Situation awareness (SA) is a term that emerged from aviation psychology to describe the component of tactical flight operations that involves the pilot 's understanding (Durso and Gronlund, 1999). Situational awareness was initially researched and developed to help pilots and air traffic controllers develop better situational awareness in the aviation industry (Jensen, 1997). To maintain maintain situational awareness (Reinhart, 2007):

- Being constantly alert to the current location, radio conservations, other traffic around, the weather and many other factors,
- Each flight crew has to adapt to many systems using constantly changing aircraft performance and a wide variety of tips, flight tools, their own observations and other data sources,

- Each pilot has awareness about what is happening around and inside the aircraft, in the airspace in which he/she flies and in him/her enviroment, that is *big picture* awareness,
- The flight crew should be able to evaluate all these parameters and have the ability to make the right decision before the current situation turns into a crisis.

Endsley (1995) explained situational awareness three-level model: (1) perception; it is the perception of situations that have occurred in the recent past and whose effect is still on the basis of clues, (2) comprehend; it is the correct creation of the current state, that is, the mental picture of the real situation by passing the perceived clues through the mental process, (3) foresee; based on the mental picture that is created and reflects the real situation, it is primarily the preparation of the appropriate ground for appropriate decision making by foreseeing what will happen in the near future.

Situational awareness errors are divided into three as first level, second level and third level. First level situational awareness errors occur when is imperceptible certain information that is important for situational awareness while performing the task assigned to it. Second level situational awareness errors can be caused even though the data is mostly perceived, by the pilot not being able to properly integrate this information or not to understand their meaning. For example, the pilot, whose system information for the aircraft she/he is flying is missing, cannot remembering/knowing what the warning she/he received or having more than one warning at the same time, having problems in prioritization. Third level situational awareness errors arise under conditions where it is difficult to predict the future dynamics of this situation without a high level of mental model, no matter how clearly a situation is understood (Endsley, 1995).

In order to fly safely, a pilot must be healthy and at the same time have a sense of personal awareness of protecting her/his own health. Self-Imposed Stresses negatively affects situational awareness and means stress that we woluntarily expose ourselves or impose on ourselves. The stresses that not only pilots, but all people voluntarily impose on them are: drug abuse, exhaustion, alcohol, tobacco, hypoclicemia (Bingöllü, 2019).

In the Air France Flight Crash, the aircraft disappeared over the mid-Atlantic without providing any clue about the cause of accident. The investigation which took over two years, revealed that the pilot was confused when the auto pilot was disengaged. Although the

copilot tried to take over, he was not successful in comprehending the situation. The pilots lost SA and control of the aircraft and it crashed in to the mid-Atlantic (Kilingaru et al., 2013).

Teamwork: Teams are often better equipped to accomplish such assignments because each member possesses the distinct skills and diverse experiences needed for the team to complete its tasks successfully (Katzenbach and Smith, 1993). Tjosvold (1990) investigated the behaviors of flight crews when faced with critical in-flight events. The author suggested that when faced with threats to the safety of the aircraft, in collective purposes, the crew could be sharing information and problem solving as a better crew. Tjosvold's hypothesis was supported in that crew members with cooperative goals indicated that they were able to work more effectively to find ways to mitigate safety threats. Common tasks and a shared purpose (the safety of the flight) had produced positive mutual interdependence (Ford and O'Hare, 2013). Before the official team coordination training programs, the aviation community realized the importance of this issue and it was investigated to provide better coordination among cabin crews. One approach was that certain cabin crews formed "fixed" or "battle-rostered" teams together (Leedom and Simon, 1995). Foushee et al. (1986) stated that better coordination would be achieved when they act together in the decisions and actions of commercial aviation teams.

Prince and Salas (1993) incorporated information from three different sources (i.e., a literature review, critical incident interviews with aviators, and a team task inventory form on which aviators rated team process behaviors for importance to training and importance to mission accomplishment and safety). Seven skills emerged from the data: communication, decision making, leadership, situation awareness, mission analysis, assertiveness, and adaptability/flexibility. Salas et al. (1999), concluded that trained teams demonstrated a greater number of teamwork skills than control teams when their behavior was evaluated over the course of a 45-min simulated mission; trained teams engaged in a significantly greater number of teamwork behaviors during the higher-workload flight segment.

As a result of the analysis made by analyzing 7518 aircraft accidents and incidents that occurred between 1958 and 1951 in the US Air Force in 1951, a study report called Poor Teamwork as a Cause of Aircraft Accidents was prepared as the cause of aircraft accidents (Terzioğlu, 2007).

In this study, it was stated that weak organizations, personnel errors, and weak teamwork are the main causes of aircraft accidents, and accident rates can be reduced by combining human element with effective teamwork. This study, which focused on the concept of teamwork, was ignored and neglected in those years. The issue came to the agenda again with the concept of team in preventing plane accidents after a long time (Terzioğlu, 2007). For aviation teams, given that team training-for example, in the form of Crew Resource Management (CRM) training-has become an accepted part of aviation culture in both military and commercial sectors (Stout et al., 1997). Hoermann and Goerke (2014) pointed out that airlines use diagnostic methods for their social skills and pilot's teamwork skills, especially during their selection process, because they are concerned about their tendency to team work.

Salas et al. (1999), in two studies with 96 naval aviators, reached the result of team training that concentrates on the critical skill competencies needed for effective performance. As a team, the qualities of the cockpit crew are defined by four features: 1) two or more pilots; 2) sharing a common safe flying goal; 3) task-interdependent; and 4) having a desired outcome, to be defined as a team (Baker et al., 2004).

Decision Making: Diehl (1992) stated that more than 50% of military and civil aviation accidents from 1987 to 1989 were caused by decision errors. When cabin crews have had collaboration mistakes, often the decision-making process and tragically many things went wrong in a few aircraft crashes. For example, In 1983, 23 people died from smoke and fire in Air Canada Flight 797, as communication between the cabin and cockpit crews was not controlled. Due to incomplete information and misunderstandings, pilots had underestimated the risk posed by the smoke whereupon they delayed the decision, losing vital time (Bienefeld and Grote, 2011). Most cockpit decisions are made outside of normal conditions, such as a warning lamp flashing, an indicator falling or rising to the yellow or red warning level, and a vibration in the aircraft. These symptoms are sometimes in a situation that is not easily detected, and can be clearly seen as in the digital cockpit aircraft (Terzioğlu, 2007).

Jensen (1997) concluded that there are five major components of expert aviator decision making expected by passengers of their pilots both in General Aviation (GA) and in the airlines: (1) experience, (2) risk management, (3) dynamic problem solving, (4) crew resource management, and (5) attention control. Moiser, Skitka, Heers, and Burdick (1998)

designed to investigate automation bias, a recently documented factor in the use of automated aids and decision support systems. They found out that those pilots who reported an internalized perception of "accountability" for their performance and strategies of interaction with the automation were significantly more likely to double-check automated functioning against other cues and less likely to commit errors than those who did not share this perception. Pilots were also likely to erroneously "remember" the presence of expected cues when describing their decision-making processes.

In a study by the Federal Aviation Agency (FAA), five dangerous behaviors were identified when making risks in aviation (El Kitabı, 2011):

- Anti-authority (Don't tell me what I can do): Some people do not like anyone telling them what to do. There are probably times when we all feel this way. The person who constantly acts in this behavior is someone who resists the rules and instructions as a personal policy.
- Impulsivity (Overeagerness): This behavior refers to those who react without thinking about anything. They never analyze a situation or think of alternatives. They never give them time.
- Invulnerability (That will never happen to me): To some extent everyone can think that there will be no accidents. If it is not thought so, the plane will never be boarded. If we are afraid, we cannot do our job. There is a fine line between complete trust and common sense. Pilots who lacking common sense are unacceptable. Such pilots tend to take more risks.
- Machoizm (I can do it): Some pilots treat each flight as a new need to prove their abilities. They accept each task as a competition and engage in additional risks to prove themselves.
- Resignation (Give up): This is sometimes a cultural problem. Some people have strong beliefs like luck and fate. In order to protect itself against malfunction or failure, trained pilots should not despair and evaluate different alternatives.

The pilot decision is the process of recognizing, analyzing and evaluating information about what she/he, the aircraft and other team members are doing, depending on the flight environment in which they are located. Reasoning often requires decision making based on data and experience at hand when events are not complete and clear. For

example, if the air traffic controller frees you from take-off under low visibility conditions, you agree that the take-off runway is clean. If the air traffic controller is asked if the runway is clean before departure, a good example of judgment is given. If you have a question in your mind and you ask the air traffic controller and start taking off suspiciously without answering, you will show a weak example of reasoning (Terzioğlu, 2007).

Leadership: It is expressed as a skill that must be gained in management understanding and task planning of today, which includes leadership, command and cooperation issues that form the basis and most important skills of crew resource management (Baltaş, 2003). According to the Aircrew Coordination Training Case Study Development Handbook, there are critical elements such as delegation, directing, coordination, which a leader who is thought to have leadership qualities must comply with when using this authority (Kern, 2001). Bienefeld and Grote (2011) found that formal and informal leaders played an important role in decision making. Also authors pointed out that leadership was a significant predictor for crew performance, but only in crews who had reached the appropriate decision. This effect was insignificant in crews with erroneous decision making. The leadership work onboard a passenger airplane is very unique in many ways. At the same time, it is shaped by several principles that also apply in other professional enviroments, in which the essence is effective leadership and the cooperation of people: clarity and honesty. In addition communication, respect and mutual trust as well as adhering to standard operational procedures, so called SOP's (Standard Operating Procedure) (Gelmi, 2019). Helmreich et al. (1986) stated that the good performance of the crew was due to the captains who allowed communication in the cockpit and gave importance to good interpersonal relationships among team members. Followership is one of the essential skills for a successful crew resource management. If there are no supporters and followers, it is impossible to talk about leadership (Kern, 2001).

Leaders must be empowering. The captain, who had a heart attack, was ecstatic and continued to keep him hands in control, informally. The co-pilot did not notice the incident and the plane crashed to the ground during the final approach. When the accident was examined, it was concluded that the captain pilot was known to be very authoritative and did not create an environment permitting delegation, and at the same time that his second pilot did not find the courage to interfere with the controls due to the stress he caused during his trial period in that company (Terzioğlu, 2007). Many studies show that shared leadership

positively affects performance in teams. If the leadership process shared in the cabin crew teams is supported by the formal leader, the team will have higher achievement of the goal (Bienefeld and Grote, 2014). In addition, the authors found that shared leadership in their study on cockpit and cabin crews positively affected the achievement of goals and success of multi-team systems in the context of dual leadership.

It is important to learn to be a leader in that position, not in what position within the team. There are principles that a leader must comply with in order for a safe flight to take place: (1) organize the flow of information, (2) guiding and coordinating the crew's duties, (3) motivating to crew, (4) decision making (Şentürk, 2003). It seemed reasonable to expect a team leader to (Ginnett, 2019):

- Discuss the task to be accomplished by the group.
- Discuss the relevant team boundaries. Since this was a team that had never worked together before, I expected the leader to build a tight-knit working group.
- Discuss relevant norms for the group's effective performance.

Personal Limitations: This component consists of reasons such as fatigue, time pressure, stress, fatigue, workload, condition reasoning ability or disorientation. Crew resource management and non-technical skills result from work-related stress or fatigue (Helmreich, 2003). The NASA Ames Fatigue Countermeasure Program has done some work on pilot fatigue. As a result of these studies, the most important danger of pilot fatigue was indifference and indifference to apathy. The same studies showed that a person who was sleepless for 18-20 hours experienced the same effects as a person who drank 2-3 beers. Control ability is also reduced inversely proportional to the level of fatigue (Şentürk, 2003). Stress also may affect crew communication, which can interfere with building situation models, sharing information, contingency planning, and error trapping (Orasanu-Engel and Mosier, 2019).

Sources of stress in aviation can be cited as medicines, illnesses, discussions, fear of flight, timelines, passengers, noise and vibration, temperature and humidity, diet, water loss, altitude changes, limited range of motion, low vision conditions, fatigue. The stress and mistakes made by the pilot are parallel. The most striking phase in flight is the approach and landing phase in terms of workload, external threats and potential for making mistakes. At this phase, where the stress load is high and the physical endurance capacity is low, pilots

should reduce these threats with methods to increase their condition. Disorientation is a condition in which a person perceives movement and position incorrectly relative to the earth's surface, but also needs a correct orientation perception to control position and movement. In other words, any of the flight parameters in aircraft control and performance instruments are detected incorrectly. The pilot's inability to perceive the correct flight conditions according to a reference is his / her spatial disorientation. The pilot's distraction, the piloting of the pilot, her inexperience are factors of loss of reasoning. These eliminate the attention to instruments and flight duty in limited visibility conditions, thereby increasing the disorientation trend. It causes the pilot to transfer control of the plane to the subconscious and fly unaware of the actual flight situation (Üçgöz, 2006). Effective resource management recognizes that under some circumstances, such as 'night-workload situations, human error is likely; steps must be taken to reduce the probability of error (Hamman, 2010).

1.3. Crew Resource Management and Civil Aviation Accidents Case Studies

On December 29, 1972, Lockheed L-1011, with its 163 passengers and 13 flight crew, fell 19 miles to Miami International Airport and 99 passengers and 5 flight crew died. It is explained that the accident happened as a result of the flight crew not controlling the flight equipment adequately in the last 4 minutes of the flight and noticing a slight unexpected lowering. In the statement made as a result of the related accident, it was reported that the accident happened as a result of the failure of the lamp indicating the status of the nose landing gear to turn on this lamp and the flight crew did not notice the lowering of the aircraft (Mengenci, 2014).

On March 27 1977, The Tenerife Air Disaster occurred as a result of a collision of KLM 747 and Pan Am 747 aircraft. The collision was largely caused by lack of communication. Before the accident, KLM landed first at 1:38 PM, followed by Pan Am which landed at 2:15 PM. The weather was very cloudy and foggy. When the flight time approached, the KLM captain seemed a little absent from all that was heard in the cockpit. He inquired several times and after the confirmed to co-pilot order to backtrack, he asked the tower if he should leave the runway by C-1, and subsequently asked his co-pilot if he should do so by C-4. After that, co-pilot repeated the ATC clearance and the captain opened the throttle and started takeoff. Co-pilot, instead of asking for clearance or asking advice, he added "We are now at takeoff." The tower was not expecting the aircraft takeoff because no clearance was given. The tower added "We are now at takeoff position." (When the Spanish,

American and Dutch investigating teams heard the tower recording together and no one understood that transmission meant that they were taking off.) Meanwhile, the Pan Am told the tower that they have not yet emptied the runway and are still taxing down the runway. The controller: "OK.. stand by for takeoff.. I will call you." However, because of causing a whistling sound in the tower transmission only "OK" part was heard by KLM. In the cockpit of the KLM, nobody at first confirmed receiving these communications until Pam Am responded to the tower's request: "OK. We'll report when we're clear." Hearing this, the KLM flight engineer asked to captain "Is he not clear then?" The captain didn't reply and he repeated "Is he not clear that Pam Am?" The captain replied "Yes." The collision occurred 13 seconds later at 5:06 PM. 583 people died in total. In the context of crew resource management, an accident occurred due to lack of communication, hierarchical distortions, lack of necessary and procedures, and control operations (Weick, 1990).

United Airlines Flight 232, departed from Denver on July 19, 1989. After taking off, the right engine of the plane exploded. After the explosion, primary and spare hydraulic systems were separated and 70 shrapnel were sent to the tail of the aircraft. For a crash landing, the crew successfully took care of the jet. Despite a situation that could not survive, the flight crew was saved 184 out of 296 passengers thanks to their creative behavior. Despite the deaths, the accident is considered a prime example of successful crew resource management. The reason for this, the crew coped with the emergency, providing cooperation, interaction and adequate communication (Mckinney et al., 2005).

On 4 November 2010, Qantas Flight 32 departed from London to Sydney. The aircraft suffered an uncontained failure in one of its four Trent 900 engines. Although the aircraft's controls were weakened, the control was still in the hands of pilots. The pilots did not want to manoeuvre the aircraft hard, otherwise the damaged aircraft would be destroyed. In this process, the pilots decided to activate the engines for control. The engines on the left of the aircraft were turning to the right when too much power was given, and when the right ones were given too much power, the aircraft was turning to the left. At the same time, the aircraft rises when it powers all of them, and then lowers when the power goes off. The pilots succeed to return to Singapore by performing delicate manoeuvres on the aircraft. In this accident, there were no injuries reported. The cabin members, who implemented crew resource management with status awareness, efficient communication, and active monitoring, successfully survived the accident (Rosenkrans, 2013).

On 20 August 2011, First Air Flight 6560 departed from Yellowknife Airport. A malfunctioning compass gave the crew an incorrect heading, although the Instrument Landing System and Global Positioning System indicated they were off course. The first officer tried to show the problem to the captain and suggested making a go around several times during the approach. However, failure to comply with airline procedures and not establishing a standard communication channel to indicate a problem caused the captain not to listen to the first officer. Both pilots were also overburdened with making preparations to land. 12 of 15 people died as a result of the accident (Aviation Safety Network, 2020).

2. Method

2.1. Sample and Measurement

This research aims to examine how crew resource management is related with to an important sample case in aviation sector. In the research, the qualitative research case study method (Merriam, 2015) using the intensive description and analysis of a phenomenon or social unit was used. The case, Air France Flight 447, occurded in 2009 and accident report (BEA, 2012) was completed in 2012. The accident report (BEA, 2012) and National Geographic - Air France Flight 447 Documentary HD (2016) were examined through document analysis. Document analysis is qualitative research method that examines and evaluates records and documents (Sığrı, 2018). The data obtained from the documents were analyzed by content analysis method. Downe-Wamboldt (1992) stated that the goal of content analysis is “to provide knowledge and understanding of the phenomenon under study”. Content analysis examines the relationship between data through coding with an inductive approach. The codes obtained are classified, and themes are created with their classification. In content analysis, the following steps are applied to the data: (1) conceptualization of data, (2) organizing data in the context of concepts, (3) determination of the themes and codes explaining the data (Sığrı, 2018).

Mearns et al. (2001) seperated the crew resource management into six main skills. In the context of these skills, Air France Flight 447 Crash will be examined. In Table 1, will be given about the crew resource management skills, which is designated as the communication, situational awareness, team work, decision making, leadership, and personal limitations:

Table 1: Crew Resource Management Skills

Communication	Exchange of ideas, information, or instructions, so that other members of the crew understand a message with minimum confusion. It involves both verbal and nonverbal skills and underpins all the other CRM elements. Using effective and unambiguous words; the ability to defend the idea and express potential risks and dangers.
Situational Awareness	The perception of the elements in the environment within a volume of time space, the comprehension of their meaning and the projection of their status in the future; making decisions before possible dangers turn into a crisis; perception, comprehension, interpretation.
Teamwork	Efficient and sharing work of the whole team; coordination and collaboration among team members; sharing among team members for safe flight.
Decision Making	Choosing the appropriate one by evaluating each criterion; to make decision based on experience.
Leadership	Ability to influence behavior and thoughts in the cockpit and interpersonal relations; having the power to make decisions; being in an authoritative position.
Personal Limitations	Ability to manage factors such as fatigue, stress, time pressure, workload, condition judgment, passengers, noise, temperature, light, humidity.

Reference: Kathryn Mearns, Rhona Flin & Paul O'Connor (2001). Sharing "Worlds of Risk"; Improving Communication with Crew Resource Management. Journal of Risk Research, 4:4, 377-392.

2.2. Air France Flight 447 Crash

The research was examined on the basis of the Air France 447 Flight accident report. In order to the better understand the findings, in this section will be given about Air France 447 Flight crash (Bottyan and Palık, 2010; Wise et al., 2011; BEA, 2012; National Geographic - Air France Flight 447 Documentary HD, 2016; Oliver, Calvard and Potocnik, 2020):

01 June 2009, the Air France Flight 447 crashed into the Atlantic on a night flight from Rio to Paris. On Sunday 31 May 2009, the departure was planned for an 11-hour direct flight from Rio to Paris. There were twelve crew members (3 flight crew, 9 cabin crew) and 216 passengers were on board. The captain, Marc Dubois, 58 aged, 10,988 flight hours, and he was one of the most senior captains of Air France. Co-pilot in left seat, David Robert (FO-B), 37 aged, 6,547 flight hours as a first officer. Co-pilot in right seat, Pierre-Cedric Bonin (FO-A), 32 aged, 2,936 flight hours, and he was flying with the A-330 for about a year. Air France 447 left Rio at 22:29 UTC. At the beginning of the flight, the FO-B was resting. While the aircraft was crossing the Inter-Tropical Convergence Zone (ITCZ), there was a strong thunderstorm. The BEA's final report released that speed indications disabled because of icing of the pitot tubes. The captain and FO-A noticed that they were entering the cloud layer and discussed the strategy to adopt. To avoid flying in the cloud layer while crossing the ITCZ and therefore to limit flight in the turbulent conditions that he mentioned several times, the FO-A wanted to change flight level and fly above the cloud cover. The

final report released that the captain “very unresponsive” about the FO-A’s concerns about the ITCZ. After FO-B backed to the flight deck, he took to Captain’s place and Captain left for his break. After eight minutes, FO-A asked about a strange odour and FO-B answered what caused it. The first and second speed disruptions occurred at 2:10:04, and the autopilot was disabled. The pilots did not detect the cause of these disturbances and speedometer problems. The reason for this was the icing of the pitot tubes of the plane. The pilots reacted with the normal and took over manual control.

02:10:06: FO-A (Bonin):

I have the controls.

02:10:07: FO-B (Robert):

Okay.

FO-A pulled back on his stick and putting the aircraft into a climb. Pitot tubes blocked and this situation indicated of slight loss of altitude. The pilots try to understand the situtation while voice announcing “stall, stall” sounded three times. Within 10 seconds of the disconnection, the pilots called out the loss of airspeed indication.

02:10:07 FO-B (Robert):

What’s this?

02:10:15 FO-A (Bonin):

There’s no good.. there’s no good speed indication.

02:10:16 FO-B (Robert):

We’ve lost the, the, the speeds, then?

02:10:27 FO-B (Robert):

Pay attention to your speed. Pay attention to your speed.

02:10:28 FO-A (Bonin):

Okay, okay, I’m descending.

02:10:30 FO-B (Robert):

Stabilize..

02:10:31 FO-A (Bonin):

Yeah.

02:10:31 FO-B (Robert):

Descend.. It says we're going up.. It says we're going up, so descend.

02:10:35 FO-A (Bonin):

Okay.

FO-A unaware of the climb. Control of the flight path does not correspond to what is expected. Despite the FO-B's warnings, FO-A continued to pull back on his sidestick. Air France Flight 447 had climbed to nearly 38,000 feet. At the same time, thanks to the effects of the anti-icing system, one of the pitot tubes began to work again. STALL 2 warning was triggered and a few seconds later buffet started. FO-B recalled Captain to the flight deck. Despite FO-B made at least six calls to crew rest area within about 30 seconds.

02:10:49 FO-B (Robert):

Damn it, where is he?

02:10:55 FO-A (Bonin)

I'm in TOGA, huh?

TOGA is means Take Off, Go Around. The BEA report expressed that called out stall a total of 75 times. FO-A thought that would disappear when his speed increased the danger.

02:11:32 FO-A (Bonin):

Damn it, I don't have control of the plane, I don't have control of the plane at all!!

02:11:37 (Robert):

Left seat taking control!

FO-B was not aware that FO-A was pulling the sidestick in the wrong direction, and were at the stalled. The captain returned to the cockpit at 02:11:42 while aircraft was passing out through 35,000 feet. When the captain returned to cockpit, the stall alarm was continuing to sound.

02:11:43 Captain (Dubois):

What the hell are you doing?

02:11:45 FO-A (Bonin):

We've lost control of the plane!

02:11:47 FO-B (Robert):

We've totally lost control of the plane. We don't understand at all.. We've tried everything.

Captain needed to question of the co-pilots about the sequence of events. The start of the stall warnings caused pilots get confused. The captain focused on the parameters and indicators.

02:12:14 FO-B (Robert):

What do you think? What do you think? What should we do?

02:12:15 Captain (Dubois):

Well, I don't know.

02:13:40 FO-B (Robert):

Climb.. climb..climb.. climb..

02:13:40 FO-A (Bonin):

But I have had a stick back the whole time!

02:13:42 Captain (Dubois):

No, no, no.. Don't climb.. no, no.

02:13:43 FO-B (Robert):

Descend then.. Give me the controls.. Give me the controls!

02:14:23 FO-B (Robert):

Damn it, we're going to crash.. This can't be happening!

02:14:25 FO-A (Bonin):

But what's happening?

02:14:27 Captain (Dubois):

Ten degrees of pitch..

The cockpit voice recording ended at 02:14:28 hours.

After the accident, a research team was formed under the leadership of a 20-year-old pilot and aircraft engineer. Two of the most important evidences were the FVR (Flight Voice Recorder) device, and the FDR (Flight Data Recorder) devices. The most concrete evidence found was "ACARS" (Aircraft Communications Adressing Reporting System) data, which is communication and transmission of messages between aircraft and ground stations. Afterwards, experts detected to block because of the pitot tubes icing. Two other devices were found as a result of 2 years of long and costly researchs. There was a loud warning during the auto pilot's deactivation. The researcher stated that this warning caused the pilots to stress and caused the reaction of the pilots to this warning. In the training, pilots were told that the pitot tubes would be removed from the ice after 1 minutes. It was understood that the tubes were blocked for 56 seconds due to icing on the plane. In order for the problem to disappear, the pilot only had to keep the plane in balance during this time. However, the pilot FO-A did not try to keep the plane in the balance, incomprehensibly he pulled the side stick and raised the nose of the plane. He changed the angle of the plane. As the pilot lifted the nose of the plane at high altitude, the plane went into stall situation. Wise et al. (2011) expressed that the speed sensors were freezing due to thunderstorms, and the autopilot was deactivated. Pilots reacted incorrectly, losing control of the plane because the events were confusioned and pilots did not understand the real problem. As a result, caused an accident because of simple mistake on the part of one of the pilots, not due to bad weather or complex chain of error.

3. Results

Table 2: Content Analysis

	Air France Flight 447 Crash	**Content Analysis**	**CRM Skills**
1	The Captain did not express his position clearly. He had a good experience with ITCZ, but did not express his concern about it. The captain reported the situation as "normal" while crossing through ITCZ.	The captain did not use her ability to communicate correctly by not expressing his opinion about turbulence.	Communication
2	FO-A did not try to keep the plane in the balance, incomprehensibly he pulled the side stick and raised the nose of the plane. FO-A changed the angle of the plane. As the pilot lifted the nose of the plane at high altitude, the plane went into stall situation.	It was determined that the FO-A was confused and unable to provide situational control.	Situational Awareness
3	The FOs identified that speed information was lost. However, this was not enough to create a plan. The FO-B read hesitantly on ECAM messages, which had a negative efffect on FO-A's attention. With the	It was determined that the FOs hesitated while acting together and	Teamwork

	exception of the FO-B's intervention on the control of the flight path, pilots did not communicate correctly about clear objectives related to their mission.	could not provide cooperation correctly.	
4	FO-A wanted to change flight level and fly above the cloud cover. The final report released that the captain "very unresponsive" to the concerns expressed by the FO-A about the ITCZ.	The captain did not make the right decision against the request of the FO-A and remained unresponsive.	Decision Making
5	The pilots was not able to make a clear division of jobs before and during the crisis. The captain did not give any guidance before leaving the cockpit, so it may be possible to state that the captain's leadership role was also effective here. On the other hand, it was understood that the senior pilot FO-B did not do any division of jobs.	The captain did not take the necessary measures for possible crises before leaving the cockpit.	Leadership
6	When you listened to the FVR recordings, after 3 hours of flight, when the captain returned to the cockpit he asked to FO-B "could you sleep?" and FO-B replied as "so-so". After captain asked the same question FO-A and he replied as FO-B. It was noted that the captain then left the cockpit to rest.	FO-B did not rest enough and returned to the cockpit.	Personal Limitations
7	Whether the FO-A's nose-up inputs were deliberate or not, there was no verbal expression of this to the FO-B. At no time did the FO-A indicate his intentions or objectives with respect to the control and stabilisation of the flight path.	FO-A did not express his actions verbally to the FO-B.	Communication
8	As the researchers stated in the documentary, it is understood that two FOs were stressed together with the first warning announcement as a result of blockage of the pitot tubes and exit from the autopilot while the plane was 35,000 feet.	FOs were stressed because of blockage of the pitot tubes and did not take the necessary measures.	Situational Awareness
9	According to the FVR records, it was observed that the two pilots' inability to understand what was happening caused them to stress seriously.	The pilots did not perceive the situtation clearly because of under the stress.	Personal Limitations
10	The rapid increase in crew workload in an unusual and unexpected situation led to the degradation of the quality of communication and coordination between the pilots.	Because of workload, cooperation as a team was not achieved.	Teamwork

In Table 2, Holsti (1968)'s tabulation method was used for content analysis of the accident. In the table, the events that took place in the accident were explained by content analysis and classified according to CRM skills.

In the 1st and 7th rows, the lack of communication ability was detected in the accident. Verbal and non-verbal expressions did not report of possible dangers and there were disabilities and limits within the cockpit. The communication ability did not use correctly because of sufficient information did not provide on time.

In the 2nd and 8th rows, it was found that right decisions were not made just in time due to confusion and stress. Situational awareness would be provided if the FO-A could

correctly control the situation when the stall alert began to come. Also, if the first warning about the pitot tubes was responded correctly, subsequent errors would not occur. In particular, stress prevented pilots from forecast correctly.

In the 3rd and 10th rows, coordination as a team could not be achieved due to the hesitation of the crew members and the workload. Collaboration among crew members as a team affected performance. If the information was shared and the crew members acted together to solve the problem, different results would come out.

In the 6th and 9th rows, fatigue and stress were not managed correctly. One of the pilots did not get enough sleep and started flying tired. Also, the pilots did not perceive the instructions correctly because they were under stress. These factors caused pilots personal limitations in the crew resource management.

In the 4th row, the captain remained unresponsive in case of an important decision. The captain did not manage the risk and was unable to make the right decision just in time. The captain unable to use his decision making skills, one of the most important factors correctly. Finally, in the 5th row, as a leader, the captain did not take action against possible dangers and the left the cockpit. If the captain had given the correct instructions before leaving the cockpit and after returning to the cockpit, the pilots could act differently. The captain did not use his leadership skills properly in the crew resource management. FOs were stressed because of blockage of the pitot tubes and did not take the necessary measures.

4. Discussion and Conclusion

Crew resource management is used as a way to focus on teamwork capabilities that minimize errors, detect errors early, and minimize results from CRM errors. Air France Flight 447, which was largely due to human error, was examined in the context of crew resource management. The first conclusion about the research was about the communication between the pilots. Verbal and non-verbal expressions did not report of possible dangers and there were disabilities and limits within the cockpit. It was determined that pilots did not understand each other at the right time due to lack of communication. The Tenerife Air Disaster occured because of lack communication and misinterpretation of verbal message (Flin et al., 1998). Also, Avianca Airlines Flight AVA 052 Flight B707B occurred because of communication errors (Wiener et al., 1995). The most important communication error was that the pilot did not inform about the movement the caused the accident. Second conclusion about the research was about the situational awareness in the pilots. It was found

that pilots did not maintain their situational control due to stress and confusion and did not act properly. Similarly, Kilingaru et. al. (2013) expressed that in the Air France 447 Flight, revealed that the pilot was confused when the auto pilot was diengaged. Although the copilot take over he was not successful in comprehending the situation. The pilots lost situation awareness and control of the aircraft and it crashed in to the mid-Atlantic. Situational awareness loss may also develop due to fatigue and stress. As a matter of fact, there is a lot of news that the captain was sleepless the day before the flight. Third conclusion about the research was about the teamwork in the cockpit. In the accident, teamwork ability was not applied because pilots hesitated, did not cooperate and did not act together. As a team, the qualities of the cockpit crew are defined by four features: 1) two or more pilots; 2) sharing a common safe flying goal; 3) task-interdependent; and 4) having a desired outcome, to be defined as a team (Baker et al., 2004). Pilots did not apply these factors correctly. Fourth conclusion about the research was about the decision making between pilots. The captain did not make the right decision against the request of the FO-A and remained unresponsive. In 1983, 23 people died from smoke and fire in Air Canada Flight 797, as communication between the cabin and cockpit crews was not controlled. Due to incomplete information and misunderstandings, pilots had underestimated the risk posed by the smoke whereupon they delayed the decision, losing vital time (Bienefeld and Grote, 2011). In addition, Jensen (1997) concluded that there are five major components of expert aviator decision making expected by passengers of their pilots both in General Aviation (GA) and in the airlines: (1) experience, (2) risk management, (3) dynamic problem solving, (4) crew resource management, and (5) attention control. The captain did not apply these factors correctly as a decision maker. Fifth conclusion about the research was about the leadership in the cockpit. The captain did not take the necessary measures for possible crises before leaving the cockpit. The captain did not give any guidance before leaving the cockpit, so it may be possible to state that the captain's leadership role was also effective here. Helmreich et al. (1986) stated that the good performance of the crew was due to the captains who allowed communication in the cockpit and gave importance to good interpersonal relationships among team members. Finally, sixth conclusion about the research was about the personal limitations between the pilots. In the research, FO-B did not rest enough and returned to the cockpit. Also, the pilots did not perceive the situtation clearly because of under the stress. When considered in terms of workload and fatigue management, although the FO-B had sufficient experience in Airbus, it was seen that the Captain had a break when approaching

an important stage of flight, such as a severe turbulence. It took 90 seconds the captain returned to the cockpit after the aircraft's adverse situation, despite the emergency calls of the pilots in the cockpit, This situation made us think that the captain might have had problems with fatigue management before the flight, and more research specific to this accident has been done in this field (Fanjoy et al., 2010). Fatigue and stress factors had personal limitations in pilots crew resource management skills. Gross (2014) expressed that stress caused personal limitations and physical difficulties. Also, author emphasized that strategies to cope with will reduce stress. In addition, Şentürk (2003) stated that control ability is reduced inversely proportional to the level of fatigue.

The investigators have repeatedly stated in their explanations that it is very difficult falling an airplane from 35,000 feet. Clogging of pitot tubes is also not considered a fatal failure and had been found that they had returned to normal in 56 seconds in this case. As a result, the biggest share of the accident is seen as the "human factor". According to some sources, there are reports that the root cause of this accident is fatigue management (ECA, 2013). In academic publications related to the accident, it is emphasized that the accident is due to the human factor, and especially among these factors, reference is made to fatigue management.

In the future research, it is hoped that crew resource management skills will be examined on different aviation accidents. In addition to the content analysis used in the research, the use of interview (maybe with accident investigation team), can expand the scope of research.

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