

Article

## CRM: Development of Pending Critical Aspects

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### ABSTRACT

The evolution of CRM programs has meant enormous progress for aviation in terms of the study of human factors and their relationship with the reduction of air accidents. Although it is true that CRM programs have undergone a successful evolution since their appearance in 1979, it is also true that the advances in psychological science in recent decades make it necessary to review and expand on aspects already addressed in previous stages by these programs. One of these aspects is the importance of the cabin crew members (CCM) as members of the flight team. Going back to the third generation programs, this paper analyzes the actions that the CCM have taken in different air accidents, highlighting the importance of their performance and their coordination with the rest of the crew in order to achieve success in resolving the air emergency.

## CRM: Desarrollo de Aspectos Críticos Pendientes

### RESUMEN

La evolución de los programas de CRM ha supuesto para la aviación un enorme progreso en cuanto al estudio de los factores humanos y su relación con la reducción de los accidentes aéreos. Si bien es cierto que los programas de CRM han sufrido una exitosa evolución desde su aparición en 1979, no lo es menos, que los avances en la ciencia psicológica de las últimas décadas hacen necesario revisar y profundizar en aspectos ya abordados en etapas anteriores por dichos programas. Uno de estos aspectos es la importancia que presentan los Tripulantes de Cabina de Pasajeros (TCP) como integrantes del equipo de vuelo. Retrotrayéndose a los programas de CRM de tercera generación, el presente artículo analiza las actuaciones que han tenido los TCP en diferentes accidentes aéreos, poniendo de manifiesto la importancia que tiene su ejecución y la coordinación de la misma con la del resto de la tripulación de cara al éxito en la resolución de la emergencia aérea.

#### Palabras clave

Factores humanos  
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Tripulación (CRM)  
Psicología de la Aviación  
Seguridad Aérea  
Tripulantes de Cabina de Pasajeros  
(TCP)

## Introduction

The human factor is one of the keys that is constantly taken into account when determining the success or failure of any project (Martínez Oropesa, 2021). In the field of aeronautical psychology, today, there is no doubt in stating that a large percentage of air accidents are caused directly or indirectly by human error (Boyd, 2017). As a tool to combat this large number of accidents in which the human factor is determinant, crew resource management (CRM) programs emerged in the last decades of the 20th century. CRM can be defined as a global program of education and training in management skills and capabilities (Shuffler et al., 2011), consisting of a set of strategies the strengthening of which seeks to train flight crews for the optimal use of all available human and material resources in the achievement of safe and efficient flight operations (Lauber, 1984). Used by air crews for reasons of safety (Helmreich & Foushee, 1993), they constitute the formal recognition by the aeronautical sector of the importance of the study of human factors in the optimization of air operations (Muñoz-Marrón, 2018), making them safer and more efficient (Federal Aviation Administration [FAA], 2012).

The skills that these programs aim to develop and enhance are used with the objective of reducing human error and thereby reducing accidents, providing the teams with the necessary training to enable them to make use of all the resources available to them (Salas & Cannon-Bowers, 2001). All CRM courses and training are based on the instruction, among other aspects, of cognitive skills, which have a marked "interpersonal" character, with the aim of developing what are known in the aeronautical world as *non-technical skills* (NOTECHS<sup>1</sup>), which include concepts such as leadership, teamwork, situational awareness<sup>2</sup>, problem solving, communication, decision making, and workload management. To these concepts, some programs add others such as Threat and Error Management (TEM model) (Maurino, 2005), the development of resilience, or surprise and its effects, motivation, addressing cultural differences, etc. Last but not least, the training includes psychoeducation training, with the aim of developing good emotional management, and stress and fatigue control (Salas et al., 2006) on the part of the crews.

Today, we talk about the enormous evolution that these CRM programs have undergone (Ínan, 2018) and the great success they have brought in terms of human factor advances and their impact on aviation safety (Muñoz-Marrón, 2018). Since the International Civil Aviation Organization imposed its application to all airlines worldwide (ICAO, 1998), the proliferation of CRM concepts has been increasing its value (Helmreich et al., 2010), while training has also been directed towards an increased awareness of different aspects of the human component involved in the review and analysis

of accidents (Dismukes & Smith, 2000). Throughout this process, there are numerous authors who speak of the different stages through which these training programs have passed (Helmreich et al., 1999; Marshall, 2010) in a constant and inexorable evolution. While it is true that one of the defining characteristics of this development is that each move from one stage to the next involves overcoming the most relevant aspects of the previous stage, it is also true that there are aspects of some of these periods that have not been worked on in depth before moving on, thus leaving part of their study pending further analysis. This is due, on the one hand, to the ambitious nature of these programs and the large number of psychological factors (the aforementioned NOTECHS) that CRM has addressed since its emergence (Flim, 2010). On the other hand, this deficiency is caused by the complexity of human resources management in the difficult but necessary human-machine coupling (FAA, 1996) that must necessarily take place in the cockpits and in which psychology has much to contribute. To this must be added the fact that both pilots and cabin crew have the greatest distance from the organization with respect to other groups, as they carry out a large part of their work far from their base and the company's headquarters (Chan & Li, 2022), which makes their management even more difficult.

One of these aspects that has remained pending, and that we consider relevant to recover, belongs to that defined by Helmreich as the third generation of CRM (Helmreich 2006), which was characterized by the extension of training in psychological, human, and teamwork skills, to other groups of non-pilot professionals belonging to the aeronautical sector, such as cabin crew members, thus expanding the concept of *flight crew* (Muñoz-Marrón, 2018). We should not forget that in their initial stages, CRM programs were aimed solely at pilots (Helmreich 2006).

### Third Generation CRM Programs

Since their origin in 1979 (FAA, 2012; Helmreich et al., 1999; Marshall, 2010; McKeel, 2012), CRM programs acquired such relevance that their use had spread in an unstoppable way both in the field of civil aviation (Ínan, 2018) and in the air forces of countries around the world. However, it was during what is referred to as the third generation that CRM programs managed to provide a breakthrough in the specific training of flight crews, thanks to the fact that they began to take into account aviation systems (Salas et al., 2001) and their design began to incorporate aspects specific to the aviation sector. The objective was none other than the integration of *non-technical skills* with technical training, for which special attention is paid to the enhancement of the specific skills that flight crews need to master for the correct development of any flight in order to optimize its execution and thus reduce the accident rate.

Parallel to this progress in aspects related to the human factor, during these years, aircraft reliability increased (Alkov, 1989) thanks to the enormous evolution that took place in the aeronautical industry (Dekker, 2002), resulting in a huge change in the design of aircraft cockpits. These were modernized and their ergonomics

<sup>1</sup> Term first used in aviation by the U.S. Joint Aviation Authorities [JAA] and defined as "cognitive and social skills of flight deck crew members not directly related to aircraft control, system management, or standard operating procedures" (Flim et al., 2003, p. 96).

<sup>2</sup> Situational awareness is a concept widely used in aviation that refers to the ability, in this case of the pilot or crew, to be fully aware of what is happening in the present time around them. In C.R.M. situational awareness has three levels: Level 1, recognition of what is happening at this moment (perception); Level 2, understanding of the situation; and Level 3, projection into the future (Endsley, 1995).

improved, while at the same time including increasingly safe and complex systems (Muñoz-Marrón, 2019). It was then that the need arose to achieve a correct coupling of the crews to these new cabins and their systems. Thus, airlines undertook the design of specific CRM modules with which they sought optimization in the operation of the different elements that from then on were present in the aircraft cockpits (Chen et al., 2017), aiming to achieve a perfect human-machine connection, a connection that incidentally is not without problems (Adeniyi, 2021). It was also during this stage that training programs were initiated in other aspects related to the human factor, and directly related to aviation safety, such as the search, identification, evaluation, and possible resolution of critical elements, both of the crew's teamwork and of the organizational culture in which they are immersed. The design of specific leadership training aimed at combating the hitherto excessive hierarchical organization predominant in airplanes, with aircraft commanders at the top, is a clear example of the changes that appeared during this stage.

But, in addition to all this, there is one aspect that characterizes this period, and that is the fact that CRM training programs began to be aimed at the training of non-pilot professionals in the airline industry (Helmreich, 2006). Thus, specific programs were created for those responsible for the evaluation and training of technical and human factors in airlines, while CRM began to be extended to other groups of professionals that are vital in the airline industry, such as cabin crew members (CCMs) or maintenance personnel (Taylor & Thomas, 2003), among others.

### Joint CRM Training for Crews

Although it is true that the advances in CRM programs were noteworthy in this third generation, the psychological advances that have taken place in recent decades, in terms of teamwork, have highlighted the need to revisit some of the aspects already addressed in previous stages of CRM in order to go into greater detail in them. One of these aspects that we consider fundamental is the coordination between all crew members.

It seems logical to think that, in the beginning, CRM training began with pilots, however, currently, airlines around the world, in compliance with existing regulations, provide and require such training of both pilots and cabin crew members (ICAO, 2018). However, while in recent years there are airlines that have developed CRM programs for all crew members, thus overcoming the initial limitations of conducting programs exclusively for pilots, such training is usually carried out according to the different roles, integrating all individuals of each role in a single program on the fewest number of occasions, that is, pilots, flight engineers or mechanics, CCM, ground personnel, etc., so this inclusion has not been entirely real when planning CRM training.

CRM training for CCMs, at present, has the main objective of ensuring the highest level of safety during flight operations by achieving an improvement in human performance based on aspects such as fatigue management (Sammito & Cyrol, 2022) or the optimization of communication processes. To this end, it takes as a

unit of action the whole crew as a team (pilots and cabin crew members), aiming to improve their performance and efficiency, which leads to the enhancement of flight safety. Through joint training, training is given in CRM best practices, either in simulators or in the classroom, as the key to safe flight operation (Andreas, 1997).

But why is it so important to include CCMs in crew resource management training programs? What is the manifest advantage of such an effort? There are several reasons that lead us to this objective, some of which have been mentioned in previous paragraphs. Starting from the now well-proven assertion that human factors development has proven to be a first step in establishing safer operations and reducing accident rates (Shappell & Wiegmann, 2000), and based on the idea that the joint training of flight deck and cabin crews is an extension of the scope of error management to all employees in a safety culture (Merritt & Helmreich, 1997), the present paper intends to focus on one of the most important reasons that historical evidence has left us with: the crucial performance of CCMs in air emergency situations and the consequences derived from such actions. Numerous conclusions can undoubtedly be drawn from its analysis.

### CCMS and Their Performance in Air Emergencies

It is widely known that one of the areas where correct execution by aircrews is key is when they are faced with air emergencies (Martinussen & Hunter, 2018). The times when aircraft commanders believed they were capable on their own of successfully resolving an in-flight emergency are long gone, giving rise to a new approach to flight management and thus to associated flight emergencies. Efficacy in successfully resolving such events is now a team issue (Green, 2020). When the successful management of an air emergency occurs, no one doubts anymore that the success achieved is the result of a multidisciplinary work process of a large number of professionals involved (Murphy, 2001). And when it occurs, its repercussion is enormous, often being news in the different media all over the world. The recognition of the crews is usually noteworthy both inside and outside the aeronautical world, although it is true that at such moments the image of the pilot usually comes to the observer's mind, overlooking or paying little attention to the rest of the crew, as active and key members in the success of the emergency. However, the performance of the cabin crew members, in coordinated action with all the members of the flight crew, is vital in the successful resolution of numerous emergencies, fundamentally those in which a quick and accurate action directed towards the passengers is required, since passenger care is one of the fundamental tasks performed by the cabin crew members during the flight.

This is so much the case, that if we analyze in detail some of the most relevant and, therefore, well-known events in the airline industry, we can see that in a large number of them, the performance of cabin crew members was critical in achieving a successful or disastrous outcome.

### Air Ontario, Flight 1363

On March 10th, 1989, a Fokker F28-1000 Fellowship, operated by Air Ontario, crashed in the vicinity of Dryden Regional Airport (Ontario, Canada), resulting in 24 fatalities (Ranter, 1989; Robertson, 2010). As advocated at the end of the last century by, among others, the British professor in his *Swiss Cheese Model* (Reason, 1990), there were, once again, numerous factors that precipitated the accident (Acuña, 2013). The subsequent investigation (Minister of Supply and Services Canada, 1992), revealed aspects such as adverse weather (it was snowing lightly which caused a thin layer of ice on the aircraft's wings), the existence of an inoperable auxiliary power unit (APU), and the lack of equipment at Dryden airport to replace the function of the APU (a ground power unit, GPU), led the crew to make a series of decisions that, linked together, led to the fatal outcome. Among the most relevant aspects that led to the disaster were the loss of situational awareness, as well as very poor communication skills among the crew members, which caused the snow accumulated on the aircraft's wings not to be de-iced. In addition, the subsequent investigation detected aspects related to the safety culture derived from organizational factors that hindered correct decision making as the final trigger for the accident.

Going deeper into the subject of the present work, it is essential to focus our attention on the communication processes that preceded the accident. Minutes before takeoff, one of the passengers told one of the cabin crew members that the presence of ice could be seen on the wings. The CCM did not consider this communication relevant, so she did not report the incident to the flight deck, i.e., the communication process between cabin crew members and pilots failed. It is necessary to know that the Fokker F28-1000 (like most aircraft) does not have a system that indicates the presence of ice on the aircraft wing surfaces, so the flight procedures of the different types of aircraft include the visual inspection of such surfaces among the checks prior to takeoff. Added to this error in communications between crew members, was the haste or operational pressure to take off and the fact that the entire crew was focused on prioritizing this aspect, to which air operators attach great importance due to the economic and prestige repercussions of non-compliance.

The Air Ontario accident is one of the many examples of evidence that highlight how poor CRM training (specifically, in the interpersonal communication skills aspects of team management) of non-pilot crew members (in this case the CCMs) critically influences the disaster. What would have happened if the CCM had listened to the passenger's indications? Would the Fokker F28 have crashed if the CCM had communicated the presence of ice on the wings? Why did the CCM not pass on the information to the pilots? Was there an adequate system of information flow and authority gradient among the flight crew members? Could the accident have been avoided with CRM training that included all crew members?

### Air France, Flight 358

On August 2nd, 2005, an Air France Airbus A340-313X, with 297 passengers and twelve crew members on board, overran the runway at Toronto Pearson International Airport (Mississauga, Ontario) and came to rest in a small ravine 300 meters from the end of the runway (Ranter, 2005). All passengers and crew members evacuated the aircraft successfully. There were only 43 minor injuries, and no fatalities were reported as a result of the accident (Transportation Safety Board of Canada [TSBC], 2007). The fall into a ravine and subsequent fire destroyed the aircraft. However, the actions of the cabin crew allowed all passengers to exit the aircraft quickly and helped to prevent further injury to the passengers. The last to leave the aircraft was the co-pilot, who nevertheless exited the plane in less than 90 seconds.

The circumstances that occurred inside the aircraft, directly related to its evacuation, required skills related to good training of the cabin crew members in both technical and NOTECHS. Aspects such as high situational awareness, correct and quick decision making, as well as the coordination in carrying out the different actions, were key for the complete evacuation of the aircraft in record time. Immediately after the evacuation, the plane caught fire. Would there have been fatalities if the performance of the cabin crew members had not been so effective? Was the coordination of the whole team the crucial aspect in the success of the evacuation after the accident? Was the successful outcome-the result of an optimal execution-caused by the deployment in the behavior of the CCMs of their skills in the *non-technical skills* typical of human factors training such as CRM programs?

### US Airways, Flight 1549

On January 15th, 2009, Flight 1549 operated by US Airways took off from LaGuardia Airport in New York. On board the Airbus 320 were 150 passengers bound for Charlotte International Airport (Charlotte, North Carolina) (Ranter, 2009). The aircraft was commanded by Commander Chesley Sullenberger. After both engines stopped, Commander Sullenberger quickly analyzed the situation and, unable to return to the airport, decided to perform an emergency ditching in the Hudson River. No casualties were reported and the ditching operation and subsequent evacuation were a true success and a clear example of the coordination and response of a team in a maximum emergency situation. The significance of the event caused that, years later (in 2016), the events of flight US1549 were made into a movie entitled *Sully* (Eastwood, 2016), directed by the acclaimed actor and director Clint Eastwood.

Thanks to the successful outcome of this accident, we have a large number of testimonies that emphasize the emotional and psychological state of the passengers and how they were influenced by the effective performance and emotional management carried out by the crew, which contributed greatly to the adoption of appropriate measures, both for the ditching and for the subsequent evacuation of the aircraft, and led to the subsequent success of the

emergency operation. Analyzing the accident report (NTSF, 2019), we could ask ourselves the following questions: Would the same success have been achieved if the whole team had not prepared the passengers for the emergency ditching? Did the trust and good coordination between the crew members (pilots and CCMs) represent an important element when executing the different steps during the management of the emergency? Could the number of injured people have been higher if the evacuation had not been so fast? Were aspects of CRM training—such as explicit and implicit coordination processes, communication, time management, management of available resources, or stress management—key to the successful outcome of the emergency situation?

### **Asiana Airlines, Flight 214**

On July 6th, 2013, the Boeing 777 belonging to the Korean company Asiana Airlines, which had taken off from Incheon International Airport (South Korea), hit, during the landing maneuver, a breakwater located in front of the runway threshold of the San Francisco International Airport (California), in the United States (Ranter, 2013). The impact of the tail of the aircraft with the ground caused an explosion and the subsequent fire of the aircraft, with a balance of 3 fatalities and 181 people injured (of the 292 passengers and 16 crew members on board) caused largely by the errors of the crew (pilots and CCMs) in managing the emergency (NTSF, 2014).

The importance of good training in emergency management and CRM for cabin crew members (Green, 2020) was once again highlighted in this accident. Checking after an accident that pilots in the flight deck are alive and waiting for an emergency evacuation order while calming passengers is possible with good training and internalized CRM. In this accident, moreover, the baggage compartments were detached, the ramps did not inflate to the correct side of the aircraft, the emergency declaration by the pilot did not occur, and more seriously, the subsequent evacuation order was delayed for organizational reasons (the excessively hierarchical organization of the company, a characteristic element of Korean culture, did not facilitate the flow of communication between pilots and CCMs) and required a very complex intervention to achieve the desired access to the aircraft exit. There was even the fact that the passengers themselves assisted in the evacuation of one of the CCMs who had been trapped when one of the emergency slides was triggered. To this can be added the poor organization of the evacuation of the aircraft, which led to the alleged running over of one of the passengers by an emergency vehicle, causing death. Would the fatal outcome have been the same if the gradient of communication between crew members had been adequate? Was the organizational culture of Asiana Airlines adequate? Could the number of fatalities and injuries have been minimized if the entire crew had been trained in CRM as a whole (i.e. as a team)? Could the training of CCMs in human factors have helped to make the evacuation more efficacious?

There are many questions we could ask ourselves every time an air emergency occurs, whether or not it culminates in an accident.

And there are many possible proposals that we could make to continue working on the search for the greatly desired and, little by little, real decrease in air accidents. However, past events must make us learn lessons for the future and, as has been shown, air accidents are a very useful tool to help us on this path (Mínguez & Muñoz-Marrón, 2023). The events presented above represent clear examples in which the performance of the CCMs was critical, both for the success and failure of the development and management of the air emergency. This again highlights the need for further research in the field of human factors in aviation and, more specifically, in aspects directly related to training (Muñoz-Marrón et al., 2018). Thus, we can safely state that: (1) CRM training should include joint work modules for all flight personnel on board an aircraft, so that pilots, engineers, flight mechanics, and cabin crew form an indivisible work unit; (2) psychological science continues to be one of the key pillars in terms of training in non-technical constructs and skills (NOTECHS) within the aeronautical sector.

### **Conclusions**

CRM training, which has subsequently been exported to many other fields of knowledge (Acuña, 2013; Gordon et al., 2013; Helmreich, 2006; O'Connor & Flin, 2003; O'Connor & Muller, 2006; Sebastián, 2002, 2009; Taylor & Thomas, 2003), first appeared in 1979 (FAA, 2012; Helmreich et al., 1999; Marshall, 2010; McKeel, 2012), a date that, as can be seen, is prior to the accidents mentioned above. However, in those early years, the participation of professionals in these non-technical interpersonal skills training programs (NOTECHS) was not extended to all crew members, these programs mainly being aimed at pilots. CRM training was extended to other groups of professionals, but in these cases, the format was defined for each of the groups, without considering the creation and implementation of training programs that would include all the actors of the air sector as a work team, that is, as a minimum unit of action.

The terrible events presented above, and many other accidents not included here, and their analysis, show us a very concrete reality in the world of aviation. Following the maxim that the analysis of human error allows us to examine the wide range of causes that may be behind an accident (Reason, 1990), this article aims to provide, based on the study of human behavior and more specifically that carried out by CCMs in a series of accidents, representative for the striking nature of their outcome, the following conclusions, which both future research on aviation safety and the aviation industry should take into consideration.

The first of these is, without a doubt, that successful action in any air emergency requires the participation of all the professionals who make up the aeronautical sector. It has been widely demonstrated that a highly qualified team is the best way to deal with problems that are difficult to solve, and air emergencies are no exception. It is currently unthinkable that any air catastrophe can be avoided by the isolated action of a single person. It is undoubtedly the coordinated action of the members of a work team that makes

it possible to avoid a disaster. In the case at hand, the successful performance in any air emergency requiring actions related to passengers and their evacuation (such as the ones presented here) makes the participation of the whole team of professionals that make up the crew of an aircraft crucial, the cabin crew being an essential element in the management and subsequent outcome of the incident.

It is therefore crucial that crew resource management (CRM) training programs include joint sessions for pilots and CCMs to enhance both routine procedures and those related to in-flight emergency management.

It would also be advisable to promote, in the aviation sector as in many others, actions that provide the different professionals with greater learning about our daily work, and joint learning between professions, for the improvement of both safety and service. It is essential that we all (psychologists, pilots, air traffic controllers, CCMs, engineers, mechanics, airport staff, etc.) work and learn together as a team, regardless of the barriers (physical or mental) that may exist. We are all essential pieces in the jigsaw of air safety.

As a science that studies human behavior, psychology has been present since the beginnings of aviation, and can and should continue its development, enhancing an industry that provides enormous commercial and human benefits (communication and contact between cultures, among many others). Non-technical skills (NOTESHS) are a key element in the development of more humane, efficient, and safe air operations, and professional psychologists are an essential part in the optimization of the teaching and learning processes of these skills.

Finally, we must not forget the importance of the airlines in this complex and well-meshed system. Companies that, putting into practice the advances in the aeronautical sector, have made it possible to unite distant points of the planet in a few hours, and that implement at a good pace the advances that psychology provides in this sector, once their benefits in terms of air safety have been proven. Therefore, they must continue working, supporting the functions of the cabin crew members more and more, valuing their work, and providing them with regular training in human factors that will, as outlined above, result in the success of emergency situations that require their actions as members of the team of professionals who carry out their work inside an aircraft.

### Conflict of Interest

There is no conflict of interest.

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