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**Crew Resource Management In Aviation**

*The article investigates the question of formation, development, influence and practical value of one of the components of the holistic process of securing the aviation system in the process of aircraft operation – Crew Resource Management. It analyses CRM training, taking into account the concept of human factor in aviation.*

The airline industry, perhaps more than any other, has throughout its history been subject to cyclic variations of the world markets. Some of these have been quite spectacular and damaging for the industry. However, these crises do not mask the underlying growth trend.

Flying operations is not a one man show, rather a managerial process shared by the regulators, operators, flight training organisation, airplane manufacturers, and pilots. Adequate crew coordination and teamwork is thus crucial for providing a safe operational environment.

Today’s tasks range from pure handling of the aircraft, to managing the whole event of a commercial flight which requires a completely different set of skills. While much of the work is procedural in nature, pilots have to be trained to be able to depart from linear thinking and quickly shift to “thinking outside the box” in order to deal with unexpected and undefined events. This is a key ability to prevent an accident from happening.

Therefore, being a professional pilot requires very specific skill sets and competencies meaning that professionalism can only be created by combining a thorough education with a constant development throughout the entire career of a professional pilot.

Most pilots are aware that human behaviour and performance are cited as causal factors in the majority of aircraft accidents. While the aviation industry has benefited from technology, with hardware and software becoming more reliable, human operators still continue to make errors. We cannot eliminate human error, but we can catch and minimise errors before their consequences become unacceptable. One of the best ways to do this is to train pilots so that they have the necessary human factors skills to cope with the risks and demands of flying.

**Crew Resource Management: fundamental concepts**

Crew Resource Management (CRM) training for crew has been around in different forms since the early years of aviation. It has been introduced and developed by aviation organisations including major airlines and military aviation worldwide. CRM training is now a mandated requirement for commercial pilots working under most regulatory bodies worldwide.

Crew Resource Management can be defined as a management system which makes optimum use of all available resources – equipment, procedures and people – to promote safety and enhance the efficiency of flight operations. CRM is a safety barrier against human error by managing resources within the flight crew team.

***CRM historical background.*** Historically, the question of crew training arose in the 1970s. Investigators discovered that more than 70 per cent of air crashes involved human error rather than failures of equipment or weather. A NASA workshop examining the role of human error in air crashes found that the majority of crew errors consisted of failures in leadership, team coordination and decision-making.

The aviation community responded by turning to psychologists J. K. Lauber and R. Helmreich to develop new kinds of psychological training for flight crews. That training focuses on group dynamics, leadership, interpersonal communications and decision-making and is known nowadays as crew resource management.

John K. Lauber, a former member of the National Transportation Safety Board, defined CRM as “using all available sources – information, equipment and people – to achieve safe and efficient flight operations”. More specifically, CRM is the process used by crew members to identify existing and potential threats and to develop, communicate and implement plans and actions to avoid or mitigate perceived threats. Using CRM methods, airplane crews can avoid, manage and mitigate human errors. And as secondary benefits, CRM programs improve morale and enhance efficiency of operations [5; 6].

## *Six generations of CRM.* Since its introduction in the early 1980’s, there have been six generations of Crew Resource Management. Each successive generation was enhanced to build upon the successes and lessons learned from the previous generations. The following are overviews of each generation [7; 8].

## *First Generation: Cockpit Resource Management.* With crew-based training validated in concept, United Airlines (UA) initiated the first formal CRM training course in 1981. This initiative followed the alluded to rash of serious accidents, none of which were attributable to a specific problem that would have prevented a safe flight.

UA developed its program with the input of experts on improving business management. Other airlines took the same management-focused approach in their early CRM programs. Some of them included full-mission LOFT training in addition to classroom work. UA made its C/L/R program available to other carriers, but they were slow to respond. However, UA continued to fine-tune its program, making it an integral part of UA’s own flight officer training. Consistent with the FAA recommendations, the main tenets of the program were to institute:

* A comprehensive system for improving crew performance.
* An operational focus on safety improvement.
* A study of how team member attitudes and behavior affect safety.
* A training method using the team, not the individual, as the training unit.
* Active training where the participants experience and participate.

In retrospect, the business management focus of these first-generation programs proved unduly narrow. Virtually all of those programs emphasized correcting deficiencies in individual behaviour such as a lack of assertiveness by juniors and authoritarian behaviour by captains. The programs featured psychological testing and explored abstract concepts such as leadership. They advocated general strategies of interpersonal behaviour but did not clearly define appropriate cockpit behaviour.

Overall, despite these shortcomings, the early Crew Resource Management programs were generally well received.

*Second Generation: Crew Resource Management.* During the middle and second half of the 1980’s, many commercial airlines, domestic and foreign, developed and implemented their own CRM programs. By the time NASA held its May 1986 industry workshop, a new generation of CRM courses had emerged. These newer programs expanded the scope of the first-generation efforts, embracing more modular, real world operations.

Second-generation programs emphasized cockpit group dynamics and led to a name change, from Cockpit to Crew Resource Management. The expanded training included new topics such as team building, briefing strategies, situational awareness, and stress management and featured distinct modules on decision making and breaking error chains that can cause catastrophe. These refinements were intended partly to address pilots’ resistance to first-generation programs, but also to translate abstract concepts into everyday operational tools.

However, in order to teach CRM concepts, many of the second-generation courses still relied on exercises and games unrelated to aviation. Therefore, although the new courses were better received by trainees than those of the first generation, the criticism persisted that the training was heavily laced with psycho-babble.

*Third Generation: Further Expanding the Scope.*In the early 1990’s, the CRM training began to aim at increased relevance. CRM was integrated with technical training, focusing on specific skills and behaviour that would help pilots function more effectively in actual flight deck operations. Several airlines introduced modules connecting CRM and flight deck automation.

Significantly, third-generation CRM programs also expanded to address:

* Issues related specifically to the aviation system in which crews function. This included the elements of organizational culture that affect safety.
* The recognition and assessment of human factor issues.

As the name change suggests, training in Crew Resource Management was extended to other groups that shared the responsibility for aviation safety, including flight attendants, dispatchers, and maintenance personnel. Many airlines, in fact, initiated joint cockpit-cabin CRM training. A number of carriers developed CRM training specifically for captains, related to the leadership demands that accompany command. Advanced Crew Resource Management training was given to check airmen and others responsible for training and evaluating crew members.

Third-generation CRM programs filled the identified need to expand the emphasis on, and the definition of, the flight crew. But they may also have had an unintended consequence: diluting the original Crew Resource Management mandate to reduce human error.

*Fourth Generation: Integrating Crew Resource Management and Establishing Formal Procedures.* In 1990, the FAA issued an advisory circular on Crew Resource Management; comprehensive Crew Resource Management training became a not only a reality, but a regulatory requirement. The FAA also introduced another major change with its Advanced Qualification Program (AQP).

AQP allowed carriers to develop customized CRM training for their own organizations. In exchange for this greater flexibility, carriers would be required to:

* Provide both CRM and LOFT for all flight crews.
* Integrate CRM concepts into technical training.
* Create detailed analyses of training requirements for each aircraft.
* Develop programs for addressing human factors in each aspect of training.

Most major U.S. airlines and several regional carriers chose AQP. A consensus found that the AQP approach improved flight crew training and qualifying.

To assimilate Crew Resource Management into actual operations, airlines began to formalize CRM concepts by adding specifically prescribed behaviour to their checklists. This was done to ensure that decisions and actions would be informed by bottom line considerations and that the basics of Crew Resource Management would be observed, particularly in non-standard situations.

By making Crew Resource Management an integral part of all flight training, the fourth generation of Crew Resource Management made progress in solving the persistent problems with human error. But even more progress was needed.

*Fifth Generation: Error Management.* The fifth generation of Crew Resource Management aimed at resolving reported deficiencies in the previous iterations.

Dr. Robert Helmreich and his colleagues set out to fix the education shortfall by defining a single, universal rationale that could be supported by pilots worldwide. They circled back to the basics: returning to the original concept of Crew Resource Management as a way to avoid error, we concluded that the overarching justification for Crew Resource Management should be error management. Effective error management is the hallmark of effective crew performance and the well-managed errors are indicators of effective performance.

The Helmreich team advocated sharply defined justification accompanied by proactive organizational support. The fifth generation of CRM would:

* Introduce and emphasize the concept of error management: managing and living with human error.
* Flow from the recognition that human error is ubiquitous, inevitable and a valuable source of information.

Therefore, Crew Resource Management would concentrate on error countermeasures that would apply to each situation:

* Avoiding error altogether. (For example, advance briefing on landing approach procedures and potential pitfalls, combined with intra-crew communication and verification.)
* Identifying and trapping incipient errors before they are committed. (For example: cross-checking navigation information before executing on it.)
* Mitigating the consequences of errors that do occur. (For example, remembering to fly the plane after a warning alarm sounds.)

Fifth-generation CRM would include formal instruction about the limitations of human performance, including the nature of cognitive errors and slips and the performance-degrading effects of stressors such as fatigue, work overload, and emergencies.

Fifth-generation Crew Resource Management posited that in order for the error management approach to achieve full traction, organizations should (1) affirmatively concede that errors will inevitably occur and (2) adopt a non-punitive approach to all errors (except for wilful violations of rules or procedures).

As suggested above, fifth-generation Crew Resource Management also stressed data gathering and reporting. Doing so would advance deeper understanding, but also help gauge program success. The FAA took the cue and, in 1997, enacted Aviation Safety Action Programs (ASAP), intended to encourage aviation organizations to take proactive safety measures and freely report incidents. American Airlines (AA) was an early adopter, working in cooperation with both the FAA and the pilots’ union. Through AA’s confidential, non-punitive reporting program, pilots reported safety concerns and errors. The AA program was a resounding success: during its first two-years, nearly six thousand reports were received. The data generated by its ASAP helped AA refine and improve its Crew Resource Management training program.

Although each ASAP requires delicate negotiation among the carrier, the FAA, and the pilots’ union (which seeks to protect the confidentiality and non-punitive nature of incident reports), ASAP continues today to be a vital element of airline safety.

*Sixth Generation: Threat Management.*Crew Resource Management has evolved to a sixth generation, which builds on the fifth generation’s error management theme. The sixth generation recognizes that the fifth generation’s focus on pilot error was appropriate; it further addresses the reality that flight crews must not only cope with human error inside the cockpit but also with threats to safety arising from the work environment as a whole.

Thus, in the sixth generation, the Crew Resource Management lens has been widened from error management to threat management. These days, traditional Crew Resource Management skills and methods are applied not only to eliminate, trap, or mitigate errors, but to identify systemic threats to safety.

***CRM significance.*** CRM alerted the aviation industry to the human interactions that are an integral part of any team performance. This training has the potential to save lives and money, as well as prevent accidents and lawsuits.

While no one can assess how many lives have been saved or crashes averted as a result of CRM training, the impact has been significant. The Line Operations Safety Audit (LOSA) data demonstrate that 98 per cent of all flights face one or more threats, with an average of four threats per flight. Errors have also been observed on 82 per cent of all flights with an average of 2.8 per flight. Consistent with the outstanding safety record of commercial aviation, the great majority of errors are well managed and inconsequential, due in large measure to effective CRM practices by crews. LOSA provides organizations and regulators with a valid means of monitoring normal operations. By understanding what crews do successfully as well as where things go wrong, researchers can help develop more effective training and safety initiatives.

One of the basic underlying premises of CRM is that a team can, and should, perform successfully. The aim of CRM is to ensure that team performance takes precedence over individual performance. CRM principles may also extend to situations where ATC, maintenance, company experts, etc., are considered to be part of the team especially in emergency situations or in a single pilot environment. Thus, it is concerned with the cognitive and interpersonal skills needed to manage the flight within an organised aviation system [1].

***CRM practical application.*** Based on the evidence that CRM is effective, the International Civil Aviation Organization, a regulatory component of the United Nations, began requiring CRM programs for member countries. CRM also informed the development of maintenance resource management, an effort to improve teamwork among aircraft maintenance workers.

CRM training is also being used in air traffic control, fire fighting and industrial settings, including offshore oil operations and nuclear power plants. The training helps workers in control rooms and emergency command centres avoid making operational errors that may lead to accidents. The medical community is also responding to findings of human error and failures by adapting aviation’s approach to crew coordination.

**Crew Resource Management Training: brief overview**

CRM training encompasses a wide range of knowledge, skills and attitudes including communications, situational awareness, problem solving, decision making, and teamwork; together with all sub-disciplines which each of these areas entails. A high level of proficiency in CRM requires continuous training, evaluation, and feedback. CRM is concerned not so much with the technical knowledge and skills required to fly and operate an aircraft but rather with the cognitive and interpersonal skills needed to manage the flight within an organised aviation system and to complete the missions successfully. CRM training includes the following integrals [2; 5; 6]:

# Information processing.

# Human error, reliability and error management.

# Fatigue and workload management.

# Situational awareness.

# Communication and management.

# Automation.

# CRM for single pilots.

# *Information Processing* provides an overview of mental human performance characteristics which flight crew use, it examines the way in which information gathered by the senses is processed by the brain. The limitations of the human information processing system are also considered. The basic theory of decision making is also covered, although not in depth.

# *Human Error, Reliability and Error Management* addresses both types of mitigating strategies, but concentrates particularly on error detection, especially in the multi-crew situation.

# *Fatigue and Workload Management* deals with ‘readiness to cope’ in some sense, in terms of an individual’s physical and mental ability to cope with work demands, and how he manages those work demands. CRM aims to help flight crew to plan their workload as far as they are able, making best use of the team, and taking into account the fact that some individuals may be performing below peak levels (e.g. due to fatigue, etc.). It is also important for managers to be aware of such human performance issues when planning (rosters etc.).

# *Situational Awareness* is a knowing what is going on around you recognising “the big picture”. It’s is fundamental to correct decision making and action. Information processing tends to be the term used for the psychological mechanism of receiving and analysing information; situation awareness is a description of an individual’s – or a team – understanding of the aircraft state and environment, based on perceived and processed information.

The aim of SA training should be to ensure that all flight crew members have good SA and a common (and correct) perception of the state of the aircraft and environment. This can be achieved by good team working and communication.

Breakdown of situation awareness is the root cause of so many aircraft incidents that eliminating it would dramatically reduce the accident rate. SA is, therefore, an important element of CRM.

# *Communication and Management is* one of the basic underlying premises of CRM which lies in understanding that a team can, and should, perform successfully in the cockpit. Good CRM is getting the balance right as a team. The emphasis in CRM is primarily upon the cockpit crew, and how they work as a team.

# *Automation* in the aviation domain has been increasing for the past two decades. Pilot reaction to automation varies from highly favourable to highly critical depending on both the pilot’s background and how effectively the automation is implemented.

Modern aircraft feature a variety of automation technologies to help the pilot with such things as checklist execution, navigation, descent planning, engine configuration, and system monitoring.

One of the goals of automation is to improve the pilot’s situational awareness. A related goal is to decrease the workload required to maintain a given level of awareness.

Technologies assist the pilot with awareness of position, terrain, traffic, fuel usage and remaining aircraft range, engine operating characteristics, etc. Pilots have various reactions to automation. CRM in highly automated aircraft presents special challenges, in particular in terms of situation awareness of the status of the aircraft.

**Conclusions**

Aviation industry today as ever before is subject to cyclic developments: either damaging or prosperous. In the course of its development lots of problems have been successfully tackled. Still, the human capabilities aren’t almighty, we need clear minds, necessary resources, and scientific researches and, definitely, time to investigate the problem(s) in this domain and minimize errors. Effective good human factors can reduce the likelihood of error and resultant accidents/incidents.

Thus, today professionally-minded pilots are trained to use crew resource management as a vital decision-making tool meaning that the CRM concept goes beyond seeking input from crewmembers; all resources at the airline pilot’s command are tapped to help manage the flight with sound decisions. Crew Resource Management becomes a natural part of pilots’ lives aloft.

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