Human Factor and CRM: increasing efficiency and managing errors within a flight inspection mission by improving non-technical skills.

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ABSTRACT

Errare humanum est, a very famous Latin quote, encapsulates the inconvenient truth that every human being, regardless of the level of commitment and good will, is subject to make mistakes. Since human errors are inevitable, they need to be addressed, understood and managed at different levels, starting with the individual, moving to the crew, ending with the organization. Crew Resource Management plays a key role in enhancing both safety and efficiency within air operations of all kinds by providing useful tools in order to use all the available resources at their best. This is even more true when applied to a complex environment such as flight inspection. This paper will investigate CRM training needs in general and peculiar for a flight inspection organization in order to improve non-technical skills such as situational awareness, communication, decision making, leadership, and cooperation.

HUMAN FACTORS AND CREW RESOURCE MANAGEMENT

Whenever we deal with aviation, it is widely accepted that human beings can be at the same time the source of some risks and their solution, since everyone, regardless of the level of commitment and good will, is subject to make mistakes but capable to recover from them, especially if properly trained. “Historically, thinking about the human contribution to the aviation system has largely focused on the errors and violations people make that adversely affect safety. More recently, there has been a shift in focus to the positive contribution to safety, resilience, and efficiency made by people in the system.” [1] Therefore, enhancing human performance within the system will improve both safety and efficiency.

In literature there are many definitions of Human Factors (HF) and Human Performance (HP), in order to set a common understanding we will consider that HF “is concerned with the application of what we know about human beings, their abilities, characteristics and limitations, to the design of equipment they use, environments in which they function and jobs they perform”[2], and “Human Factors is that field which is involved in conducting research regarding human psychological, social, physical, and biological characteristics, maintaining the information obtained from that research, and working to apply that information with respect to the design, operation, or use of products or systems for optimizing human performance, health, safety, and/or habitability”[3]. According to this last definition, the idea is to take as input the results obtained from different fields of research and as output the maximization of HP. Human performance to this extent is “how people perform their tasks. HP represents the human contribution to system performance.” [4]. We have defined that the objective of human factor is the optimization of human performance, to achieve this goal a management strategy is needed and that is represented

by the Crew Resource Management (CRM). CRM "is a set of training procedures for use in environments where human error can have devastating effects. Used primarily for improving aviation safety."[5] In other words, CRM may be considered as an efficient management of the crew resources, with the objective of improving the level of safety, out of a specific training targeted on the acquisition of non-technical skills (NOTECHS). "Non-technical skills are defined as pilots' attitudes and behaviors not directly related to aircraft control, systems control and standard operating procedures (SOPs). Classic examples of non-technical skills are in-cockpit authority, crew coordination and cooperation, communication, decision making, conflict and error management, stress and workload management, attention, vigilance, and confidence. In short, non-technical skills cover both the social and cognitive side of the pilot."[6] To conclude this introduction we need to clarify that even though CRM uses the results of psychological studies to improve human performance, this is by no means related to any kind of group psychoanalysis, on the contrary it aims to develop attitudes and behaviors functionals to the scope of the mission.

EASA CRM REGULATORY FRAMEWORK

The importance of the Crew resource management training is also recognized at European level within the Regulation (EU) 965/2012, the guidance material (GM1) to the ORO.FC.115 recalls the idea that "CRM is the effective utilization of all available resources (e.g. crew members, aircraft systems, supporting facilities and persons) to achieve safe and efficient operation. The objective of CRM is to enhance the communication and management skills of the flight crew member concerned. Emphasis is placed on the non-technical knowledge, skills and attitudes of flight crew performance."

The regulation prescribes that "before operating, the flight crew member shall have received CRM training, appropriate to his/her role, as specified in the operations manual". In addition, the relevant acceptable means of compliance (AMC), states that the training should be combined for the flight and technical crew. The AMC also defines the specifications of the CRM training syllabus according to the following table.

CRM training elements	Initial operator's CRM training	Operator conversion course when changing aircraft type	Operator conversion course when changing operator	Annual recurrent training	Command course
General principles					
Human factors in aviation; General instructions on CRM principles and objectives; Human performance and limitations; Threat and error management.	In-depth	Required	Required	Required	Required
Relevant to the individual flight crew member					
Personality awareness, human error and reliability, attitudes and behaviours, self-assessment and self-critique; Stress and stress management; Fatigue and vigilance; Assertiveness, situation awareness, information acquisition and processing.	In-depth	Not required	Not required	Required	In-depth
Relevant to the flight crew					
Automation and philosophy on the use of automation	Required	In-depth	In-depth	In-depth	In-depth
Specific type-related differences	Required	In-depth	Not required	Required	Required
Monitoring and intervention	Required	In-depth	In-depth	Required	Required

Relevant to the entire aircraft crew					
Shared situation awareness, shared information acquisition and processing; Workload management; Effective communication and coordination inside and outside the flight crew compartment; Leadership, cooperation, synergy, delegation, decision-making, actions; Resilience development;	In-depth	Required	Required	Required	In-depth
Surprise and startle effect; Cultural differences.					
Relevant to the operator and the organisation					
Operator's safety culture and company culture, standard operating procedures (SOPs), organisational factors, factors linked to the type of operations; Effective communication and coordination with other operational personnel and ground services.	In-depth	Required	In-depth	Required	In-depth
Case studies	In-depth	In-depth	In-depth	In-depth	In-depth

Figure 1 - EASA Flight Crew CRM training

The table describes the CRM training elements to be covered according to the type of training, in addition 'Required' means training that should be instructional or interactive in style to meet the objectives specified in the CRM training program or to refresh and strengthen knowledge gained in a previous training. 'In-depth' means training that should be instructional or interactive in style taking full advantage of group discussions, team task analysis, team task simulation, etc., for the acquisition or consolidation of knowledge, skills and attitudes. The CRM training elements should be tailored to the specific needs of the training phase being undertaken."

Design and implementation of CRM training

Since each organization is different, the CRM training program should be customized according to the goals identified throughout a needs analysis. The training objectives, what and how to measure should be addressed in the design phase. The development of the program should consider the learning environment and include a process of validation or modifications, if needed. Finally, the implementation requires to prepare the trainees and the environment which should allow the best climate for learning. The last two phases are the evaluation and the incorporation. The first one is used to determine the CRM effectiveness and make a revision if areas of improvement are identified. The second one aims to reinforce CRM behaviors in daily work, which at the end is the true goal of the entire process.

The six steps suggested for the design and implementation of the CRM training as briefly described above are:

1. Needs analysis
2. Design
3. Development
4. Implementation
5. Evaluation
6. Incorporation

Non-technical skills assessment

Alike any other training, it is required to assess CRM skills, NOTECHS can be used for this purpose. Guidance material is provided and identifies four main categories that should be evaluated: cooperation; leadership and managerial skills; situation awareness; and decision-making. Each category is characterized by elements and behavioral marker as described in the table below.

Category	Element	Behavioural marker (examples)
Cooperation	Team building and maintaining	Establishes atmosphere for open communication and participation
	Considering others	Takes condition of other crew members into account
	Supporting others	Helps other crew members in demanding situations
	Conflict solving	Concentrates on what is right rather than who is right
Leadership and managerial skills	Use of authority and assertiveness	Takes initiative to ensure crew involvement and task completion
	Maintaining standards	Intervenes if task completion deviates from standards
	Planning and coordination	Clearly states intentions and goals
	Workload management	Allocates adequate time to complete tasks
Situation awareness	Awareness of aircraft systems	Monitors and reports changes in systems' states
	Awareness of external environment	Collects information about environment (position, weather and traffic)
	Anticipation	Identifies possible future problems
Decision-making	Problem definition and diagnosis	Reviews causal factors with other crew members
	Option generation	States alternative courses of action
		Asks other crew members for options
	Risk assessment and option selection	Considers and shares estimated risk of alternative courses of action
	Outcome review	Checks outcome against plan

Figure 2. EASA categories, elements, and behavioral markers of NOTECHS

Just as an example, to better understand the table, according to GM6 ORO.FC.115, the category Situation awareness "relates to one's ability to accurately perceive what is in the flight crew compartment (awareness of aircraft system) and outside the aircraft (awareness of the external environment). It is also one's ability to comprehend the meaning of different elements in the environment and the projection of their status in the near future (anticipation)." Having defined the category and the elements we now need to objectively measure the crew member skills using specific behavioral markers. In this example the evaluator will verify if the trainee monitors and reports changes in systems' state, collects information about environment and identifies possible future problems.

ENAV CRM TRAINING

ENAV S.p.A. has developed a CRM training program that not only responds to the requirements but, in addition, takes into consideration specific needs of the Flight Inspection and Validation department. The process started in 2010 and has been initially presented during the 2014 IFIS [7] with reference to the first three steps of the design and implementation process previously described. For completeness, a brief review will be provided but the focus of this paper will be on the implementation, evaluation, and incorporation. Throughout the years regulations have evolved, and the program has been adapted accordingly.

The norm is now divided in Implementing Rules (IR), Acceptable Means of Compliance (AMC) and Guidance Material (GM) as described above, a certain degree of freedom is provided and has been used for customization of the program to the needs and the objectives found during the initial analysis and the design phase. As it is well known, the flight inspection world is different from any other sector in the aviation industry. To analyze the specific components involved in a flight inspection mission and their interactions, the SHELL model has been used.

S – Software refers to norms and procedures. The specific flight inspection Standard Operating Procedures have been reviewed with special attention to the communication needs related to each phase of the flight check.

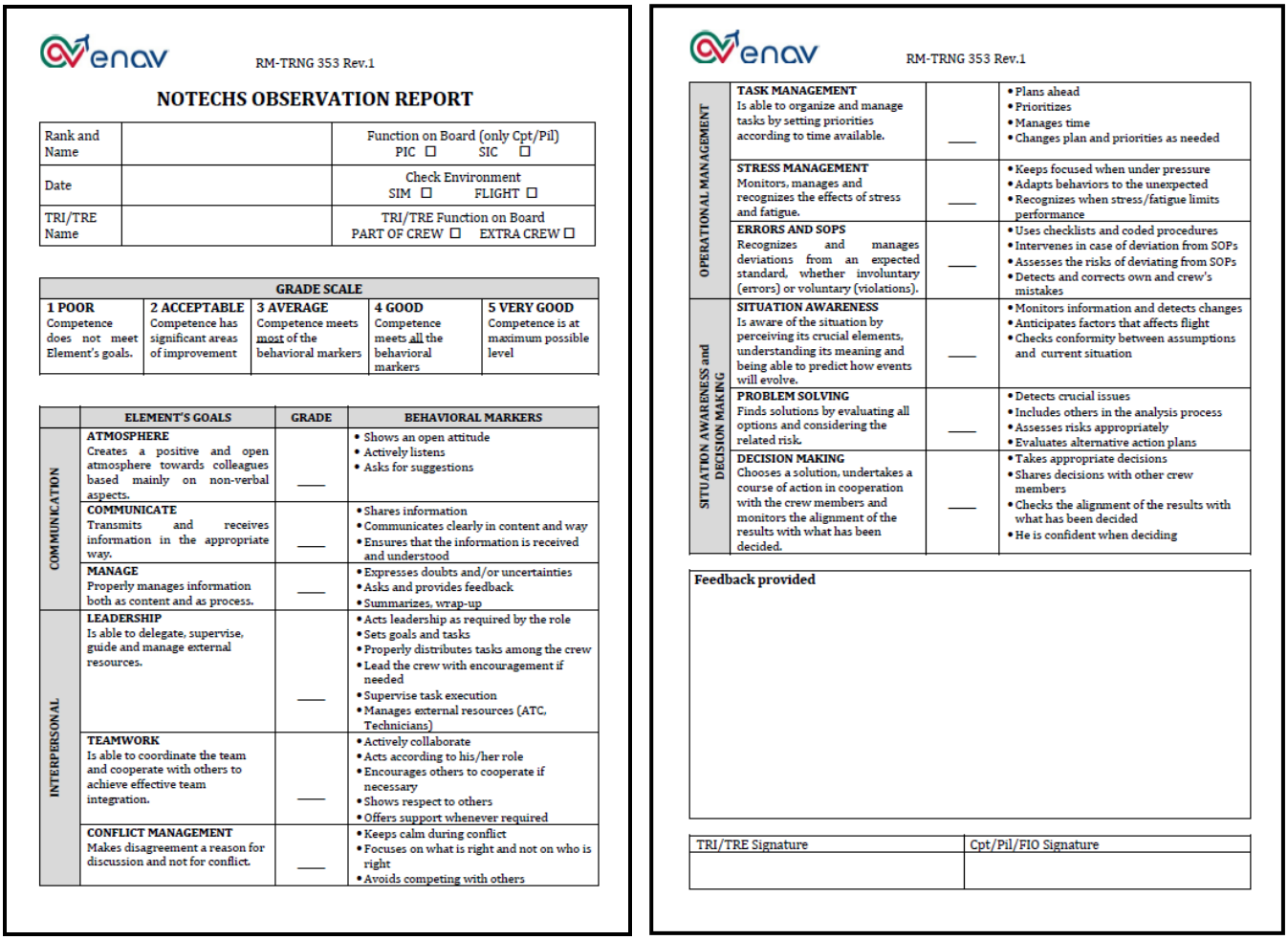
H – Hardware is the physical part of the system. The aircraft and the Flight Inspection System have been analyzed especially considering the human machine interface and the usage of automation during the flight inspection.

E – Environment refers both to the physical and organizational context. In particular, the flight inspection mission usually takes place in high traffic terminal areas and at low altitude, both these factors increase the level of stress. At the organizational level, the main difference identified, for example with an airline, is that a flight inspection organization is usually smaller, therefore, the group dynamics will be affected by the fact that each person within the group will have a high level of reciprocal knowledge.

L - Liveware is the human component of the system. The crew composition, two pilots and a Flight Inspection Operator, has been considered as well as the interaction with the ground technical staff and ATC.

To complete the analysis process, surveys were conducted as well as flight and simulator observation. The results of these activities showed that communication, interpersonal, operational management, and situation awareness/decision making were the principal training goals.

The Design phase started from these training goals to develop a customized NOTECHS form as reported below.



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NOTECHS OBSERVATION REPORT

Rank and Name		Function on Board (only Cpt/Pil) PIC ☐ SIC ☐
Date		Check Environment SIM ☐ FLIGHT ☐
TRI/TRE Name		TRI/TRE Function on Board PART OF CREW ☐ EXTRA CREW ☐

GRADE SCALE				
1 POOR Competence does not meet Element's goals.	**2 ACCEPTABLE** Competence has significant areas of improvement	**3 AVERAGE** Competence meets most of the behavioral markers	**4 GOOD** Competence meets all the behavioral markers	**5 VERY GOOD** Competence is at maximum possible level

	ELEMENT'S GOALS	GRADE	BEHAVIORAL MARKERS
COMMUNICATION	**ATMOSPHERE** Creates a positive and open atmosphere towards colleagues based mainly on non-verbal aspects.	____	• Shows an open attitude • Actively listens • Asks for suggestions
	COMMUNICATE Transmits and receives information in the appropriate way.	____	• Shares information • Communicates clearly in content and way • Ensures that the information is received and understood
	MANAGE Properly manages information both as content and as process.	____	• Expresses doubts and/or uncertainties • Asks and provides feedback • Summarizes, wrap-up
INTERPERSONAL	**LEADERSHIP** Is able to delegate, supervise, guide and manage external resources.	____	• Acts leadership as required by the role • Sets goals and tasks • Properly distributes tasks among the crew • Lead the crew with encouragement if needed • Supervise task execution • Manages external resources (ATC, Technicians)
	TEAMWORK Is able to coordinate the team and cooperate with others to achieve effective team integration.	____	• Actively collaborate • Acts according to his/her role • Encourages others to cooperate if necessary • Shows respect to others • Offers support whenever required
	CONFLICT MANAGEMENT Makes disagreement a reason for discussion and not for conflict.	____	• Keeps calm during conflict • Focuses on what is right and not on who is right • Avoids competing with others

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OPERATIONAL MANAGEMENT	**TASK MANAGEMENT** Is able to organize and manage tasks by setting priorities according to time available.	____	• Plans ahead • Prioritizes • Manages time • Changes plan and priorities as needed
	STRESS MANAGEMENT Monitors, manages and recognizes the effects of stress and fatigue.	____	• Keeps focused when under pressure • Adapts behaviors to the unexpected • Recognizes when stress/fatigue limits performance
	ERRORS AND SOPS Recognizes and manages deviations from an expected standard, whether involuntary (errors) or voluntary (violations).	____	• Uses checklists and coded procedures • Intervenes in case of deviation from SOPs • Assesses the risks of deviating from SOPs • Detects and corrects own and crew's mistakes
SITUATION AWARENESS and DECISION MAKING	**SITUATION AWARENESS** Is aware of the situation by perceiving its crucial elements, understanding its meaning and being able to predict how events will evolve.	____	• Monitors information and detects changes • Anticipates factors that affects flight • Checks conformity between assumptions and current situation
	PROBLEM SOLVING Finds solutions by evaluating all options and considering the related risk.	____	• Detects crucial issues • Includes others in the analysis process • Assesses risks appropriately • Evaluates alternative action plans
	DECISION MAKING Chooses a solution, undertakes a course of action in cooperation with the crew members and monitors the alignment of the results with what has been decided.	____	• Takes appropriate decisions • Shares decisions with other crew members • Checks the alignment of the results with what has been decided • He is confident when deciding

Feedback provided

TRI/TRE Signature	Cpt/Pil/FIO Signature

Figure 3. ENAV FIV NOTECHS observation report

As an example, communication is divided in three training objectives (Atmosphere, Communicate, Manage) each one defined by specific element's goals (e.g., Atmosphere: creates a positive and open atmosphere towards colleagues based mainly on non-verbal aspects). Since we need to measure each element in an objective way, a grade scale has been adopted and behavioral markers have been identified to help both assessors and trainees to reach the training objectives. During the annual training staff meeting the form has been shared with the examiners to standardize its use. In addition, during the annual CRM recurrent training event all crew members have familiarized with its usage playing the role of the examiner assessing NOTECHS of a crew involved in a case study.

According to AMC1 ORO.FC.115 (d) (1 and 2) a three-year program has been developed to cover all the training elements reported in figure 1. The first year of the cycle focuses on the individuals, the second on the crew and the third on the organization; case studies, group exercise and lectures have been chosen accordingly.

2021	2022	2023
• Human factors in aviation; • General instructions on CRM principles and objectives; • Human performance and limitations; • Threat and error management. • Personality awareness, human error and reliability, attitudes and behaviours, self-assessment and self-critique; • Stress and stress management; • Fatigue and vigilance; • Assertiveness, situation awareness, information acquisition and processing; • Case Study	• Automation and philosophy on the use of automation • Specific type-related differences • Monitoring and intervention • Shared situation awareness, shared information acquisition and processing; • Workload management; • Effective communication and coordination inside and outside the flight crew compartment; • Leadership, cooperation, synergy, delegation, decision-making, actions; • Resilience development; • Surprise and startle effect; • Cultural differences; • Case Study	• ENAV safety culture and company culture, standard operating procedures (SOPs), organisational factors, factors linked to the type of operations; • Effective communication and coordination with other operational personnel and ground services. • Case study.

Figure 4. ENAV FIV CRM recurrent training program 2021-2023

At the end of every training event a feedback form is forwarded to all the participants and the suggestions received are implemented as soon as possible. Whereas the dematerialized NOTECHS observation forms collected from the examiners and the information from the operator's management system are used to optimize and update the next triennial CRM recurrent training program.

One suggestion received by several participants from the very first training event was to complete the first cycle not allowing too much time between two consecutive events, this request was motivated by the need to consolidate the training elements discussed and that would not be recalled as clearly after a twelve-month period. Therefore, a decision was taken to perform all the three events within fifteen months, the first one at the end of 2021, the second at mid-2022 and the third will be held early in 2023.

A second suggestion received was to present the training in an interactive and practical way. To respond to this request and at the same time considering the norm, each event has been structured with a short introduction where the training objectives are shared, and the expectations are collected from the class. A case study is then introduced by means of interactive media and a group exercise is performed. A lecture is provided on the subjects within figure 4 by the CRM trainers. Finally, a feedback is requested to compare the initial expectations and the actual training delivered.

CONCLUSIONS

The CRM training is vital for the improvement of safety and efficiency of the operations. We have tried to demonstrate that this statement is true discussing, at first, the context and definitions needed to set a common understanding of Human Factors and CRM. We have seen the training requirements contained in the EASA Regulation 965/2012 and how a flight inspection organization has implemented a CRM training program. To reach the training objectives identified in the needs analysis, we have created three opportunities of improvement. The first one is the class event where, as individuals and as a group, we can take four toolboxes, each one representing one of our training goals (communication, interpersonal, operational management, and situation awareness/decision making), fill it in with the tools provided or the objective that we want to reach and, finally, receive the instructions on how to use these tools, for example using as reference the behavioral markers. Every flight inspection mission after the CRM training can be considered a second opportunity to apply what has been learned. Each crew member is encouraged to take his/her toolbox and use it during the flight. At the end of the shift, as a crew, it is possible to discuss CRM elements noted during the mission within the de-briefing. The third opportunity are the operator proficiency check and the simulator check ride where each crew member receives a feed back by the examiner on the NOTECHS and has the possibility to compare his/her personal perception with an external one. The positive response received so far is very encouraging and makes us believe that we are on the right path.

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