

IMPLEMENTING CRM SKILLS WITHIN CREW TRAINING PROGRAMS

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ABSTRACT

Crew Resource Management (CRM) skill identification and specification has been problematic with difficulties becoming apparent in the broader context of the training enterprise especially in the areas of crew assessment and operational integration. Airlines have developed listings of CRM skills over the last ten years with many working at the more general marker level. There has been a recent shift from general markers to the more detailed observable behaviors which has provide an airline with more focused assessments, but there are still problems integrating the behaviors across flight operations. Airlines need a flexible, iterative method to identify, specify, and link CRM skills to key elements of training and flight operations. Such a method should be adaptable to the operational and organizational factors essential to the long-term implementation of a skill-based training program. This paper presents an approach used by one airline to identify CRM skills and to integrate those skills within their training and assessment allowing them to revitalize their CRM skill training.

INTRODUCTION

This skills implementation effort is based on a research project to analyze CRM skills in the context of airline training programs. The goal of the project has been to identify primary CRM skills required for good crew performance and to link those skills to curriculum and observable behaviors used in Line Oriented Flight Training (LOFT) and Line Operational Evaluation (LOE). The preliminary research included a review of skill analysis methods (Seamster, Prentiss, & Edens, 1997) and an analysis of a skill listing within an Advanced Qualification Program (AQP) fleet (Lanzano, Seamster, & Edens, 1997). The applied research reported in this paper examines the skill identification and implementation steps used at an airline to not only specify a set of skills but also to integrate those skills within the training and assessment process.

Early on, CRM training showed an emphasis on pilot attitudes that has changed over the last ten years to a focus on behavioral markers. Although the relationship between behavioral markers and skills is not explicit, airlines tend to treat them as similar elements. A survey of representative carriers from around the globe (Flin & Martin, 1998) showed that the majority of the 14 airlines surveyed, used the NASA/UT Line/LOS Checklist (LLC) as the basis for their markers or skills. The 25 CRM behavioral markers on the LLC were intended to be used as general examples of crew behaviors with an emphasis on automation, team management and special situations. Most of the carriers surveyed adapted these 25 general markers to their own operations with some of the airlines making a point of keeping the markers generic in order that they be equivalent to other airlines and pilot communities.

In contrast to the generic approach, a few carriers have examined existing markers and CRM skills and have developed their own listings. One carrier has produced a specific set of CRM procedures to support skills closely tailored to its operations (Seamster, Boehm-Davis, Holt, and Edens, in press). Such an approach requires the involvement of the airline organization, not just that of the training department, and raised CRM skills to the level of standard operating procedures (SOP). The approach described here supports the identification of specific rather than generic skills and is geared toward affecting the entire organization, not just the training center.

Advanced Qualification Program, AQP, has provided the carriers with incentive and a framework within which to develop a specific CRM skill listing. Early AQP CRM skill identifications, like that reviewed by Lanzano, Seamster, and Edens (1997), have resulted in listings more closely related to the general CRM behavioral markers. Although these early AQP skill specifications were similar to existing CRM listings, their detailed task and subtask listings provided carriers with comprehensive understanding of the job of flying

a commercial aircraft along with a framework for linking specific crew performance elements to the curriculum and task listings. In essence, AQP has provided airlines with the structure and framework with which they can now develop a detailed CRM skill listing.

What are CRM Skills?

From an operational perspective, a skill is an element that is tightly linked with a specific set of subtasks, closely related to performance, and requires practice to perfect. Proctor and Dutta (1995) provide a good starting point for an operational definition of skill. "Skill is a goal-directed, well-organized behavior that is acquired through practice and performed with economy of effort" (p. 18). Most CRM skills are complex cognitive skills that involve problem solving, efficient grouping or chunking of information, or utilize specialized forms of mental representations. These skills take time to develop and they are specific to the aviation domain.

There is agreement among the airlines that CRM skills need to be trained, but little consensus on exactly how those skills are best trained. Most CRM skills and markers have been trained at the knowledge level (Mancuso, 1995) with some actual skill training taking place in LOFT sessions and their subsequent debriefings. Airlines have not clearly understood the value of distinguishing between knowledge and skill. This distinction is essential because it allows an airline to train knowledge through presentations and documents while training skills through practice and feedback. Thus, CRM skills do have a knowledge component that can be trained in classroom settings, but the actual skills need to be trained in interactive CBT and simulator environments where crew members can actually practice and receive feedback.

Why Should Airlines Address the Skill Level?

Proctor and Dutta (1995) highlight the need to carefully address skills when they make the case that the less one knows about the precise nature of skills, the more one needs higher fidelity simulation and training. This reflects the current state of CRM training where little is understood about the different management skill types, and consequently, much of the training is done either in the classroom or in the relatively expensive simulator environment. Depending on the skill development level of the pilot or crew and the CRM skill types being trained, LOFT may not be the most efficient training environment. The aviation community needs to be able to link the training of specific CRM skill types to the appropriate level of simulator fidelity, and not always use the highest and most expensive level of simulation.

Airlines have different combinations and numbers of training device types from CBTs through to full motion simulators. The greatest training bottleneck tends to be with full motion simulators that have become an essential part of not only training, but also of the assessment and of the checking function in both transition and continuing qualification training. A more detailed understanding of pilot skills, especially the CRM skills, will provide airlines with the ability to maximize their unique mix of training devices by training CRM skills across the range of appropriate devices.

Skills and the Organization

CRM skills and the skill identification process are no longer limited to the domain of training centers. This shift has been noted industry wide and highlighted by Merritt (1996) through a comparison of the traditional *skill-components model* to the newer *professional model*. Under the *skill-components model*, exemplified by the traditional instruction systems development (ISD) approach, managers controlled the identification and development of skill standards which were developed by an analyst or Subject Matter Expert (SME). The *professional model* is very different assuming that the workers are in charge and are able to make decisions. With the professional model, the worker is in control of the work, is given credit for being able to manage aspects of the environment and resources, and should be part of the skill and standards specification process.

Airlines need to move to a professional model by involving a greater part of the organization in developing skill standards. Performance, skills, and standards are an integral part of the pilot's and the airline's vocabulary. Airlines understand the concept of skill and use it frequently in the context of technical training. Technical skills are an accepted and known quantity, and that concept can fairly easily be expanded to address management skills essential to CRM. Thus, CRM skill development is a key process that can be used to move airlines toward a broader-based professional model of skill standards.

The greater organizational involvement will facilitate the integration process that will ensure that the skill standards become part of the operation. The organization should play a central part in ensuring that CRM skills and procedures are properly developed, trained, and assessed. Further, the airline organization facilitates the development of appropriate philosophy, policies, and reward systems to ensure that pilots and crews are properly motivated to develop and maintain high levels of skill proficiency.

Skill Analysis Methods

Many of the skill analysis methods employed by carriers are based on the traditional ISD approach and may not be highly systematic or repeatable (Lanzano, Seamster, and Edens, 1997). A major limitation of these analysis methods has been the lack of reliability, the type of control that can be achieved through Inter-Rater Reliability (IRR) control. Without IRR control, the carriers will get very different results depending on SME types or the specific individual used to perform the analysis. A set of IRR tools have been developed and implemented at air carriers (Holt, Meiman, & Seamster, 1996) that provide an efficient way to train and manage SME agreement, consistency, and congruency.

Based on a review of skill analysis methods (Seamster, Prentiss, & Edens, 1997), airlines need a flexible method to identify CRM skills and link those skills to subtasks and observable behaviors. The method should be easy to use by airline personnel and should be based on analysis tools already in use at the carriers such as those developed for IRR. The method should involve a broader sample of SMEs to allow greater organizational participation. The method should also include a specification of work context in the same way that the scenario event set has provided context for the training and assessment of CRM (Hamman, Seamster, & Edens, 1995). The method should be usable throughout the training and assessment process, and not just during the front-end analysis. What is being called for is a method that can be used by airline personnel. Even though some CRM skills are complex cognitive skills best analyzed through cognitive task analysis (Seamster, Redding, & Kaempf, 1997), the preliminary identification of those skills should come from the airlines.

METHOD

This analysis was motivated by a need to identify a key set of trainable CRM skills. The analysis served two purposes. First, it was used to generate a skill-based task list for the CRM curriculum, and second, the process involved personnel at the airline in the systematic identification of CRM skills, personnel that would ultimately influence the training and assessment of those skills. The methods required the collection of rating and agreement index data to help representatives from different departments form a consensus about the nature and identity of CRM skills. The airline used Subject Matter Experts (SMEs) from their AQP group, their Human Factors group, as well as several check airmen from flight training. From 5 to 10 SMEs were involved in each of the steps. Using a greater number of SMEs for each of the steps allowed for a broader consensus and also distributed the workload across a

large number of individuals reducing some of the bottlenecks encountered when one or two SMEs are asked to perform the analysis. The validation step was designed to integrate the results of the skill analysis with the CRM assessment process. This phase had the following two steps related to LOFT/LOE event sets and observable behavior specification: 1) Observable behaviors, and 2) Links between behaviors and CRM skill. The four skill analysis steps are presented first followed by the validation step.

Step One - CRM Skill Definition

The initial step in the analysis was to define the concept of "CRM skill" as it related to aviation skills in general and to cognitive skills in particular. Existing definitions for skills and knowledge were reviewed, and a total of 19 criteria were identified that could be used to specify a CRM skill. That list was narrowed down to the five most important criteria through group discussion. Those five criteria were then evaluated by having SMEs check the criteria against a set of 20 potential CRM skill statements. Each criteria was refined until the group of SMEs, working individually, were able to reach a minimal level of agreement about the number of criteria that applied to each skill statement (see the next paragraph for a description of the agreement index).

There were 5 SMEs involved in this first step. The SMEs worked as a group to refine the list of criteria. The SMEs then worked individually to evaluate the criteria against specific skill statements. One statistic, the agreement index, was computed to determine whether the group had reached consensus on how to apply the criteria against skill statements. Agreement is the degree to which SMEs give the same rating for the same item based on a statistic, *r_{wg}*. By itself, the agreement index is not sufficient to establish reliability; but the mean agreement index across all items does provide an indicator of group consensus. For this first step, the mean agreement index was .5 or greater (were 1.0 is perfect agreement). When that index was met, no additional IRR statistics were used. In cases where the mean agreement fell below the benchmark, other IRR statistics were used including congruency and consistency (for more details on these measures, see Williams, Holt, & Boehm-Davis, 1997).

The results for this step were five primary criteria for CRM skills. The criteria statements specified that a CRM skill:

- Is assessed through observable behaviors
- Is a measurable level of proficiency to perform a task - requires practice to meet a standard of performance

- Is directly related to a knowledge of one or more CRM components
- Improves individual performance in a crew setting
- Enhances mission awareness.

Step Two - CRM Skill Verbs

The second step in the analysis phase was to identify a set of verbs closely related to CRM skills. A listing of about 400 CRM skills was reviewed and 109 verbs were extracted from those skill statements. The purpose of this step was to identify verbs that could be used to standardize CRM skill statements and to be used to specify new skills. A rating instrument was developed to allow SMEs to rate each verb on a 5-point scale where 1 = Not Related and 5 = Completely Related (to CRM skills). The results of this instrument were used to identify the CRM skill verbs.

There were 5 SMEs in this second step. The SMEs worked individually to rate the set of verbs based on how closely each verb was related to CRM skills. The mean rating and agreement index were computed for each verb. Verbs with a mean greater than or equal to 3.5 and an agreement index greater than or equal to .6 were considered to be CRM skill verbs.

Step Three - CRM Skill List

Once a CRM skill was defined and verbs identified, the next step consisted of examining an extensive list of potential CRM skill statements to determine which met the CRM skill criteria. The listing of 400 CRM skills was refined by deleting or changing those skill statements that were not based on the CRM skill verbs. This resulted in 320 uniform skill statements. An instrument was developed for SMEs to specify which CRM skill criteria were met by each of the skill statements. SMEs were asked to work individually and to place a "1" in each cell where the criteria was met and leaving the cell blank where the criteria was not met by the skill statement. If a skill statement satisfied all the criteria, it would receive a score of 5.

There were 6 SMEs in the third step. The SMEs worked individually to determine how well each skill statement satisfied the CRM skill criteria. The mean rating and agreement index were computed for each skill statement. Statements with a mean greater than or equal to 4.0 (i.e., met four out of the five CRM skill criteria) and an agreement index greater than or equal to .9 were considered to be CRM skill verbs.

The results of this step were 180 CRM skill statements. This CRM skill list contained some duplication and had some statements that were specified at too high or too low a level of detail, but it served as the preliminary set of CRM skills.

Step Four - CRM Skill Grouping

After a list of CRM skills was identified, the final step in the analysis phase consisted of grouping these skills into categories based to the following six airline CRM topics:

- Briefing and Communication
- Leadership and Teamwork
- Situational Awareness
- Decision Making / Planning
- Crew Self Evaluation
- Automation and Technology.

An instrument was developed for SMEs rate the CRM skills by specifying the degree to which they were related to each of the CRM topics. SMEs were provided with instructions and practice, and were then asked to work individually when rating. For this instrument, SMEs worked with a 3-point scale where 1 = Fully Related, 2 = Partially Related, and 3 = Not Related At All.

There were 7 SMEs in this step working individually to rate a subset of the 180 CRM skills. The mean rating was computed for each CRM skill. Statements with a mean equal to 1.0 (i.e., was rated as Fully Related by all rates) were considered to be part of the CRM topic. The rating results were reviewed through group discussion, and in cases where a CRM skill belonged to more than one CRM topic, group majority was used to determine the primary CRM topic. Finally, several SMEs reviewed the CRM skills under each topic and combined related skills into skill clusters.

The results of this step were a total of 49 CRM skill clusters across the six CRM topics. The CRM topic, Maintain Situational Awareness, had the largest number of CRM skill clusters with a total of 12. While Crew Self Evaluation had the smallest number of CRM skill clusters with just 4. These CRM skill clusters are specified at the next level above the CRM skill statement, and each CRM skill cluster includes from 1 to 6 skill statements. The 49 CRM skill clusters, organized by the 6 CRM topics, provide a usable set of CRM skill groupings for curriculum development and crew proficiency assessment.

Step Five - Linking Skills to Observable Behaviors

The validation phase started with the identification of a set of observable behaviors that could be used in the assessment of LOFT/LOE event sets. This involved working with 54 different event sets that had been refined from existing LOFT scenarios. The purpose was to identify the most relevant observable behaviors for each of the event sets. A rating instrument was developed to allow SMEs to rate each observable

behavior on a 5-point scale where 1 = Most Important and 5 = Not Important (for crews to demonstrate the behavior under the specified set of conditions). The results of this instrument were used to identify a working set of observable behaviors.

There were 10 SMEs participating in this step. The SMEs worked individually to rate a set of observable behaviors based on how important it was for crews to demonstrate the behavior in order to complete the event set successfully. The mean rating and agreement index were computed for each observable behavior by event set. Observable behaviors with a mean less than 2.0 and an agreement index greater than or equal to .6 were considered to be important for that event set.

Next, a group process was used to link the key observable behaviors to its primary CRM skill. An instrument was developed with a description of the main elements of each event set followed by the key observable behaviors. Most event sets had between 2 and 4 observable behaviors. The instrument was designed for a group process, and SMEs were asked to agree by a majority on the CRM topic specified by the observable behavior. The group was then instructed to work with the CRM skill grouping list to identify the

specific skill under the relevant CRM topic. SMEs were asked to reach a group consensus for just the primary CRM skill cluster. Finally, SMEs were asked to identify the primary CRM skill cluster for each of the key observable behaviors. This allowed the airline to assess each event set based on observable behaviors and to then specify the key CRM skill cluster associated with that behavior.

RESULTS

In Step One the airline had 5 SMEs rate the 20 possible criteria and used an Agreement Index of 0.6 and a Mean of 4.0 (on a 5-point scale) for its cutoff. The SME ratings resulted in 5 criteria that met their cutoff and their overall Agreement Index across all criteria was 0.51

In Step Two the airline had 5 SMEs rate the verbs and used an Agreement Index of 0.6 and a Mean of 3.6 (on a 5-point scale) for its cutoff. The SME ratings resulted in 46 skill verbs that met their cutoff and their overall Agreement Index was 0.70 (see Table 1 for a sample of those skill verbs).

Table 1. Sample of CRM Skill Verbs

acknowledge	analyze	brief	coordinate
adhere	ask	choose	decide
advise	assess	communicate	define
advocate	assign	compare	delegate

In Step Three, it had 6 SMEs rate the skill statements and used an Agreement Index of 0.9 and a Mean of 4.0 (working with 5 criteria) for its cutoff. SME ratings resulted in 180 skill statements that met their cutoff with an overall Agreement Index was 0.81. For Step Four, 7 SMEs rated the skill statements and used a Mean of 2.0 (on a 5-point scale where 2 was the highest possible score) for its cutoff. Finally, in Step Five, the

validation process resulted in the specification of a primary CRM skill cluster for each of the key observable behaviors. As can be seen from Table 2, with each step, the SME team reached higher levels of agreement as they worked through the process and had many opportunities to discuss the key concepts and specific CRM skills.

Table 2. Increasing Agreement Index Across Steps

SKILL IMPLEMENTATION STEP	AGREEMENT INDEX
CRM Skill Definition (Rating of 20 Potential Skill Statements Against the 5 Skill Criteria)	0.51
CRM SKILL VERB IDENTIFICATION (Rating of 109 Potential CRM Verbs)	0.70
CRM SKILL SPECIFICATION (Rating of 320 Potential CRM Skill Statements)	0.81
CRM SKILL GROUPING (Rating of Briefing & Communication Skills)	0.80

Table 3. Sample CRM Skills by Observable Behaviors for Preflight Through Taxi

CRM SKILL	OBSERVABLE BEHAVIOR FOR PREFLIGHT THROUGH TAXI
PLAN FOR, BRIEF, AND DEBRIEF OPERATIONAL REQUIREMENTS, SAFETY ISSUES, AND AIRCRAFT CONFIGURATION	<ul style="list-style-type: none"> • Captain briefs conditions and plans regarding high winds with both the cockpit and cabin crew • Captain briefs crew about de-icing, departure, enroute, and destination weather
ADVOCATES OWN POINT OF VIEW AND VERBALIZES RECOMMENDATIONS CLEARLY	<ul style="list-style-type: none"> • First Officer communicates the changes to weight and balance for passenger count • First Officer is assertive in providing feedback to the Captain
KEEP CREW CABIN AND PASSENGERS INFORMED AND UPDATED	<ul style="list-style-type: none"> • Captain insures a PAX announcement is made about the expected turbulence after takeoff

SUMMARY

This set of steps has been used at one airline in the development of their AQP pilot task and skill listing. The main lessons learned are to work with a team of SMEs rather than a single SME or analyst, formulate that team early in the process and keep the membership relatively stable. This is particularly important in airline environments where individuals are likely to rotate from one job to the next with some frequency. By keeping the team intact, there is a much better chance that the group can develop a common understanding of the key concepts and establish and maintain a relatively high level of agreement. Work with a team of SMEs (from 5 to 10) when identifying resource management skills to ensure stable ratings, to reduce individual team member workload, and to promote greater participation in the specification of those skills. Establish team membership early in the skill identification process, and use a form of inter-rater reliability (IRR) analysis, if possible, based on a set of analysis tools already in use at the organization such as those used in training raters or observers of individual or team behavior.

Skills, especially technical or flying skills form the basis of much pilot training. As Proctor & Dutta (1995) explain, the principles underlying complex cognitive skills are similar to those associated with perceptual motor skills. Thus, airlines are justified in expanding their emphasis on skill development and practice to identifying and training CRM skills.

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