Mechanisms in the Chain of Safety

Research and Operational Experiences in Aviation Psychology

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Chapter 12
Conclusions: Extending the Chain

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Previously, most references on Human Factors in Aviation have considered such traditional topics as basic psychological processes (i.e., workload, stress, decision making and situation awareness), organizational practices (i.e., personnel selection and training) and technological challenges resulting from growing automation or increased airspace capacity. Improvements in system safety and performance are typical criterion of reference for a variety of interventions.

However, the isolated consideration of each topic fails to capture the dynamic nature of the aviation industry and its operational challenges. "Mechanisms in the chain of safety" was devised with two objectives: to present the most recent research and operational efforts in aviation safety and performance and to illustrate the need for full circle approaches.

In this volume, the adoption of an IPO approach (Inputs-Processes-Outputs) to safety and performance led to the identification of three major topics: inputs, coping and control mechanisms.

Inputs in the aviation industry typically involve personnel selection, the validation of selection batteries and the use of psychological measures that take advantage of recent technological developments. Distinct contributions associated with inputs mechanisms were included in this volume: proposals that take advantage of the use of computerized tasks and suggestions linked with the identification and study of new performance indicators. Potential improvements resulting from technological developments were presented by Oubaid, Zinn and Gundert and by Uyttendaele and de Voogt.

At the center of Oubaid, Zinn and Gundert's proposal are the interpersonal interactions in aviation. Programs and interventions promoting teamwork have been underlined for almost three decades by programs such as CRM—Crew Resource Management in pilots or TRM—Team Resource Management for air traffic controllers, central for basic and recurrent training. Although some form of evaluation of characteristics promoting or associated with team work is included in most selection programs, improvements are needed in the scenarios presented and the evaluations conducted. The authors propose a new computerized tool that allows multi-observations of several applicants that interact face-to-face and through their touch screens. Conventionally, the aviation industry viewed interpersonal competence as trainable but Oubaid, Zinn and Gundert propose that the inclusion of more structured selection systems may benefit training interventions, a proposal that echoes trainability concerns.

Uyttendaele and de Voogt consider that the ability to remember and execute specific delayed tasks without being prompted to do it, that is, prospective memory, is central for air traffic controllers and also propose its inclusion in air traffic controllers' selection processes. Similarly, the suggestion follows the use of computerized tasks that try to tap distinct psychological contributions.

A final proposal, presented by Oprins, Burggraaff and Roe, explores the benefits of considering individual learning curves in the evaluation of on-the-job training. The authors starting point is the limitations associated with pass-fail decisions in most training programs; such decisions are based on experts' evaluations of continuous progression. Their proposal is that such subjective appreciation may be improved by modeling learning processes. Despite the recommendations for reliability improvements of some indicators, the authors propose that the use of learning curves provides greater insight to individual learning processes, captures the dynamic nature of OTJ training and allows adaptive training. Similarly to Oubaid, Zinn and Gundert; Oprins, Burggraaff and Roe also purport that a trainability approach for selection purposes may be possible and efforts should be developed in this direction.

Common to the three proposals is the creative use of computerized measures to tap specific psychological processes and distinct performance indicators and the advantages that may be introduced in the system by exploring the links between personnel selection and training.

Coping mechanisms refer to individual and organizational processes that may better prepare one to deal with high situational demands and critical or exceptional events. Haeusler, Hermann, Bienefeld and Semmer suggest that adaptive expertise needs to be fostered in training. The adaptation to task demands and situational changes, along with the anticipation of future developments, requires situation awareness and explicit planning; in other words, it entails working smarter and not simply working harder. It is through diversified training scenarios that the ability to proactively adapt to high demands may be developed. In a clear association with different organizational factors and interventions, the authors advocate that a change in most operational philosophies is needed; one has to overcome a training perspective that emphasizes minimum compliance in favor of an approach that allows exploring the true potential of training investments.

The relevance of anticipations processes is also pondered by Kallus who recommends that the anticipation of and coping with critical flight situations must be considered in training and opportunities for the development of these skills. The author goes even further and believes that the consequences of anticipation processes need to be taken into consideration in accident-incident investigations and can also be explored in selection processes.

Identical concerns are expressed by Ebbatson, Harris, Huddlestone and Sears regarding events and situations that require manual flight. Although manual flight is limited in normal operations, recurrent training and proficiency checks require it. Since only infrequent opportunities to exercise manual flying skills exist, the authors propose that new performance indicators and training programs should be restructured to compensate.

Training issues and customized solutions are also submitted by Cherng, Shiu and Wen. Their study suggests that different stressor profiles and coping behaviors are found in Taiwanese and foreign pilots, a scenario that may be typical of multicultural airlines.

While inputs components are mainly concerned with providing the system with new information, either of psychological processes or on individual performance, coping mechanisms emphasize the dynamic nature of operations and how organizational practices may foster proactive behaviors.

Control mechanisms also stress the need for a culture of information but enlarge the concept proposed by Reason (1998). While Reason's approach refers to a profound knowledge of the organization, control interventions take into account the interconnected nature of activities and information in the system. For example, information regarding interpersonal competence, as proposed by Oubaid, Zinn and Gundert, may be relevant not only for selection purposes but also for the development of diversified training scenarios and learning processes, accident-incident investigation, among others.

The feedback loop proposed in control mechanism suggests the relevance of adaptive and customized organizational interventions.

The associations of distinct detection mechanisms to different types of errors led Thomas to propose an organic approach according to which variability in performance and human error requires parallel defense strategies and an adaptive approach and not the traditional serial protective layers as illustrated by Reason's Swiss Cheese Model.

Training implications are proposed both by Stánski-Pacis and de Voogt and Hayward, Lowe and Brandford. While the former considers technological innovations and improvements in user interface, the latter focuses on proactive training practices.

Stánski-Pacis and de Voogt's analysis of the role of GPS in aviation incidents and accidents proposes customized training according to user's profile.

Hayward, Lowe and Brandford suggest a proactive training methodology that draws on participants' experiences and that may help to promote organizational learning and safety risk management.

Finally, D'Oliveira reviewed data from a safety reporting system and highlights the need for translating the results of this voice mechanism into operational practices; the growing interest and adherence to the reporting system can be associated with a culture of information, reporting and trust. However, if the concerns expressed cannot be linked with significant organizational changes, the chain of safety is broken.

Inputs and coping mechanisms emphasize the need for information associated with system's monitoring and critical events or situations and the ability to deal with such occurrences. Control mechanisms accentuate the need to give feedback to the organization so that improvements can be introduced into normal operations.

The different components in the chain of safety discussed in this volume reflect concerns that involve different organizational levels from micro-interventions that reflect basic psychological processes such as prospective memory to macro-proposals that involve using previous experiences as training tools. A multi-level approach is therefore needed for improvements in performance and systems safety to take place.

An additional characteristic can be inferred from the distinct contributions to the chain of safety: organizational learning.

Organizational learning is the process of increasing the potential for improved organizational action through knowledge and understanding (Carroll and Edmondson, 2002) and, according to Pidgeon (2010), is a key element of effective safety cultures. Organizational learning involves internal and external flows of information, that is, sharing and learning from experience and from others (Saw, Wilday and Harte, 2010) or a culture of information (Reason, 1998). Due to heterogeneity of experiences and specificity of operations (generalized airlines versus specialist airlines) customized organizational learning is proposed in the literature (Haunschild and Sullivan, 2002).

Yeo (2002) suggests that organizational learning may be linked with three learning loops. The single loop refers to learning processes that take place at the individual level and connect the individual with specific organizational norms (e.g., personal goals, abilities, competences and mental models). Single loop processes can be enhanced by improvements in input mechanisms and individual coping strategies.

Double loop processes involve higher-level performance as team or group outputs and require greater dynamics in feedback and inquiry in order to change organizational norms (Yeo, 2002). Most control mechanisms (e.g., safety reporting systems or the analysis of GPS involvement in accident and incidents) can be understood as double loop learning processes. Improvements of work practices or processes in general and operational control efforts are associated with this systemic learning.

Triple loop learning involves the overall vision of the organization, organizational goals and strategic management. Recommendations for new operational philosophies, as proposed by Thomas and D'Oliveira, emphasize the need for "feedforward" as an organizational tool (i.e., using the culture of information to anticipate future changes and not only to gain better understanding of past events) thus promoting triple loop processes or strategic learning. Strategic learning is associated with strategic control that involves macro goal definition and its translation into policies and specific plans of action (Child, 2005).

"Mechanisms in the chain of safety" illustrates different organizational learning opportunities and the potentially rich information they can derive.

However, feedforward or triple loop processes have to be associated with operational changes. The anticipation of future events and situations and the scenario planning associated with these macro processes require organizational flexibility and play an important role in strategic learning.

If one considers that mechanisms in the chain of safety involve monitoring normal and critical events, the ability to anticipate future disruptions and the mitigation of its consequences, the capacity to learn from experience and the introduction of changes in procedures, routines, jobs and roles, then one is envisioning the operational pillars of resilient systems (Hollnagel, 2008). In order words, mechanisms in the chain of safety allow us to analyze and improve different paths to operational resilience. If research proposes that customized training opportunities should be put forward in order for technical and systemic learning to take place, then similar suggestions can be presented for macro interventions with customized strategic learning being associated with greater organizational resilience.

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