Crew (Cockpit) Resource Management

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Preface

One of the most striking developments in aviation safety during the past decade has been the overwhelming endorsement and widespread implementation of training programs aimed at increasing the effectiveness of crew coordination and flightdeck management. Civilian and military organizations have developed programs that address team and managerial aspects of flight operations as complements to traditional training that stresses the technical, ″stick-and-rudder″ aspects of flight. The original, generic label for such training was cockpit resource management, but with recognition of the applicability of the approach to other members of the aviation community including cabin crews, flight dispatchers, and maintenance personnel, the term crew resource management (CRM) is coming into general use.

Crew (or Cockpit) Resource Management (CRM) training originated from a NASA workshop in 1979 that focused on improving air safety. The NASA research presented at this meeting found that the primary cause of the majority of aviation accidents was human error, and that the main problems were failures of interpersonal communication, leadership, and decision making in the cockpit. CRM training encompasses a wide range of knowledge, skills and attitudes including communications, situational awareness, problem solving, decision making, and teamwork; together with all the attendant sub-disciplines which each of these areas entails.

Just as CRM has evolved from ″cockpit″ to ″crew″ over its short history, the field of human factors has similarly changed in its scope. From an initial marriage of engineering and psychology with a focus on ″knobs and dials,″ contemporary human factors has become a multidisciplinary field that draws on the methods and principles of the behavioral and social sciences, engineering, and physiology to optimize human performance and reduce human error (National Research Council, 1989). From this broader perspective, human factors can be viewed as the applied science of people working together with devices. Just as the performance and safety of a system can be degraded because of poor hardware or software design and/or inadequate operator training, so too can system effectiveness be reduced by errors in the design and management of crew-level tasks and of organizations. CRM is thus the application of human factors in the aviation system. John K. Lauber (1984), a psychologist member of the National Transportation Safety Board (NTSB), has defined CRM as ″using all available resources d information, equipment, and people d to achieve safe and efficient flight operations″. CRM includes optimizing not only the person–machine interface and the acquisition of timely, appropriate information, but also interpersonal activities including leadership, effective team formation and maintenance, problem-solving, decision-making, and maintaining situation awareness. Thus training in CRM involves communicating basic knowledge of human factors concepts that relate to aviation and providing the tools necessary to apply these concepts operationally. It represents a new focus on crew-level (as opposed to individual-level) aspects of training and operations.

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 organized aviation system. In this context, cognitive skills are defined as the mental processes used for gaining and maintaining situational awareness, for solving problems and for making decisions. Interpersonal skills are regarded as communications and a range of behavioral activities associated with teamwork. In aviation, as in other walks of life, these skill areas often overlap with each other, and they also overlap with the required technical skills. Furthermore, they are not confined to multi-crew aircraft, but also relate to single pilot operations, which invariably need to interface with other aircraft and with various ground support agencies in order to complete their missions successfully.

CRM training for crew has been introduced and developed by aviation organizations including major airlines and military aviation worldwide. CRM training is now a mandated requirement for commercial pilots working under most regulatory bodies worldwide

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An Introduction to Human Factors

Modern Human Factors

Human Error in Flight Operation

Contributive Factors in Aviation Accidents

Technological advances since the early days of flight have significantly transformed the aircraft cockpit and have altered the relationships among the human pilot, the aircraft, and the environment. Consistent with technological advances in aviation — many of which occurred after publication of the Wiener and Nagel (1988) volume — the role of the pilot has evolved from one characterized by sensory, perceptual, memory, and motor skills (Liebowitz, 1988) to one characterized primarily by cognitive skills. The flightdeck has evolved into a hybrid ecology comprised of both naturalistic and electronic elements. The environment is deterministic in that much of the uncertainty has been engineered out through technical reliability, but it is naturalistic in that conditions of the physical and social world — including ill-structured problems, ambiguous cues, time pressure, and rapid changes — interact with and complement conditions in the electronic world. Cues and information may originate in either the naturalistic (external, physical) environment or the deterministic systems (internal, electronic).

Modern Human Factors

What is human factors?

The scope of human factors can make it a hard discipline to define. There are many definitions, but most share some key elements:

- It is a multidisciplinary science that includes research from the fields of psychology, biology, sociology and engineering.
- Human factors research is aimed at improving the safety and efficiency of a system, a system being a collection of components such as humans, procedures, and/or machines that are designed to achieve something.
- By optimizing these components, especially the human component, and by optimizing the interfaces among components, the system can be made to work as safely and efficiently as possible.

As systems become more and more complex, it can be difficult to predict where failures will occur and how they will evolve and affect the operation of the system. It is also important in human factors to respect that there needs to be a balance between safety and efficiency and that by trying to maximize safety with more checks, rules, and procedures, the efficiency of the system can be compromised to the extent that it no longer works. Where the optimum balance is will be different for every system. Human factors is about finding this balance point and then optimizing the system by optimizing the function of the components of the system and the interfaces among them.

A picture of human factors in aviation

A commonly used statistic is that 70% of aviation accidents are a result of human error. This statistic has been accepted for the past few decades but conceals a more troubling truth. If 70% of aviation accidents are caused by human error, what are the other 30% caused by? The most common answer is that these are due to technical failures. However, machines do not fail by themselves. If part of an aircraft breaks, it is either because it has been designed incorrectly (the design is insufficient for its intended purpose), it has been built or maintained incorrectly, or it has been used in the wrong way. When you probe into “technical accidents”, human error will be involved somewhere. With the possible exception of a completely freak accident that no one could possibly predict (e.g., a plane being hit by a falling meteorite), every accident, incident, and near miss will have some element of human involvement in the sequence of events leading up to it. If human error is everywhere, why do we insist on classifying accidents and incidents as human related or technology related? In fact, this classification is something of a fallacy. Once an accident cause has been determined as human error, the reaction of the people with a stake in determining its cause is that an isolated, one-off, human-mediated event occurred and that this can be easily corrected by dealing with the human. The quality and success of the complex interactions between humans and other humans, humans and machines, and the associated procedures that are used to achieve this are at the root of aviation safety. Hence, an understanding of human factors is the first and most important step in understanding where success and failure come from.

As the name suggests, for human factors to be applicable there must be a human in the system somewhere. If not, it becomes an engineering problem. For example, the design of a small component that will be integrated into a larger machine might not need any human factors input unless that component has some part to play when the human interacts with the machine (e.g., an indicator light or a dial). For most other systems, however, there will be a human operating within the system. The early work that considered types of systems that combined human and mechanized components was carried out in the 1940s in the British coal-mining industry and led to the concept of a "sociotechnical system." During the 1970s, this idea of a sociotechnical system was expanded to cover human factors in the aviation industry and led to the development of the SHEL model by Edwards, later developed further by Hawkins. The SHEL model, SHEL being the acronym of its four components (software, hardware, environment and liveware), considers all the elements of an aviation system and is shown in Figure 1.1.

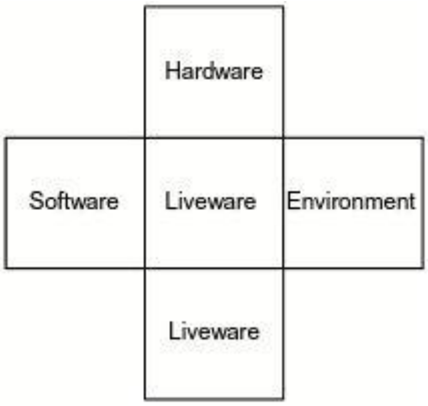

Figure 1.1 The SHEL model

The "environment" component is self-explanatory, liveware refers to the human components, hardware to the machine components and software to any procedures. As you can see from Figure 1.1, there is liveware at the center of the model. This liveware is, essentially, the human operator. That human operator will need to interact with machines (hardware), procedures (software) and other people (liveware). All of this is done in some sort of environment, perhaps on the ground, in an office, or in a flight deck at high altitude. Although the SHEL model has been around for decades, it has fallen slightly out of favor in human factors. It is not mentioned as much as it used to be and, as suggested in the Preface to this book, may be one of the "old" concepts in human factors that people are all too willing to try to replace. The reality is that the SHEL model is as relevant today as it ever was, perhaps even more so given the highly automated nature of modern aviation. Aside from the individual components of the model, the real insight that the original designers of this model had was to focus on the interfaces among components, that is, the points where the squares touch. As well as wanting to optimize the components themselves, we need to consider how we can optimize the interfaces among components. Although the SHEL model can serve as the foundation for our understanding of human factors, to make it more relevant to aviation it can be adapted in a few ways:

- First, to give us a point of focus, let's make the human in the center of the model more prominent.
- The environment affects all the components of the model and can be shown surrounding all the other components.

- The software (procedures) are one way that the central liveware interacts with other liveware and with the hardware. As well as procedural interaction, there can also be direct, nonprocedural interaction between liveware and hardware.

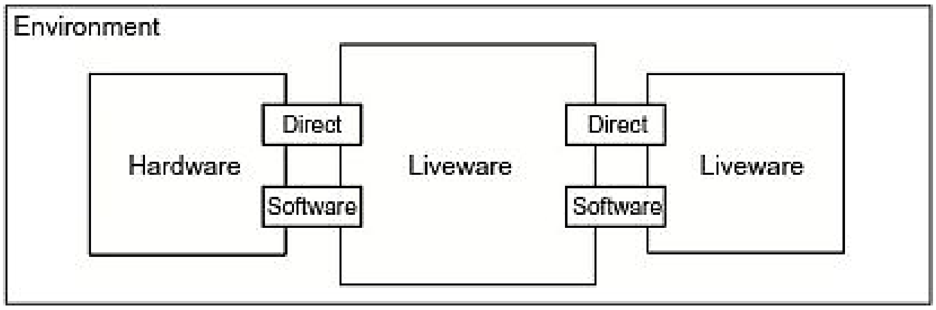

Figure 1.2 Adapted SHEL model

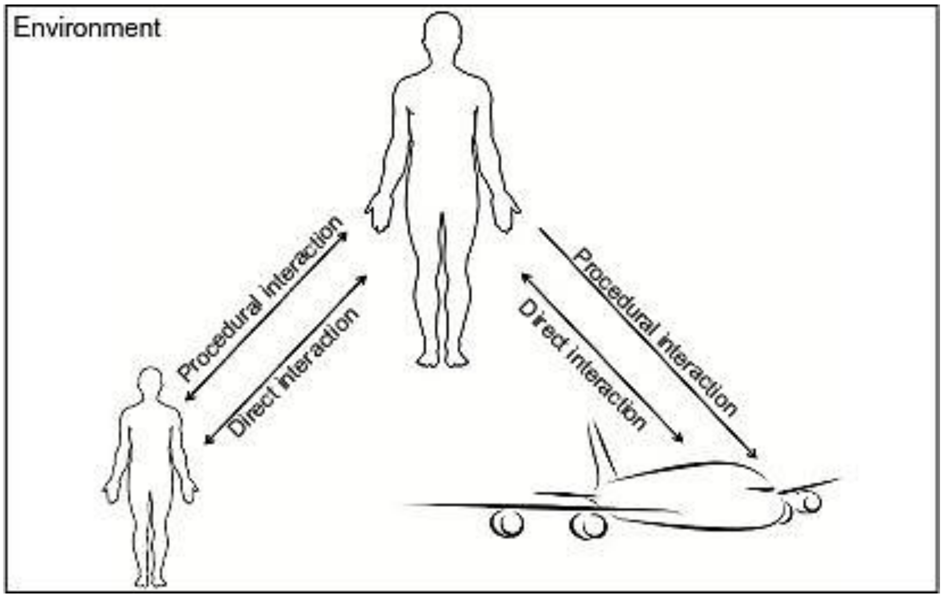

Figure 1.3 Aviation-specific human factors model

With these adaptations, the new model looks something like Figure 1.2.

We can now make this model more pictorial and more specific to aviation, as shown in Figure 1.3. For the purposes of this illustration, the interaction between the second liveware component and the hardware is not shown.

We can divide the human up into two main sections, the body and the brain, each of which has characteristics that would be of interest when considering that human's involvement with the system:

- the body – strength, nutritional state, muscle fatigue, general health and disability
- the brain – information processing capabilities, personality, general intelligence, communication skills, fatigue levels, mental health and cognitive disabilities

Because the human is at the center of our model of human factors, optimizing the human's performance is key to optimizing the entire system.

The other component of the system that the human may have to deal with on a regular basis is other humans (other liveware). Now that we are looking at interactions between two components of the system, the human factors practitioner must start to consider how these interactions occur and how they can be optimized. Humans can interact with each other in two ways:

- directly
- procedurally, using standard operating procedures (SOPs)

The distinction is subtle but important. In aviation, the two pilots will interact with each other procedurally by making standard callouts during take-off and approach and the procedural interactions are important for maintaining safety. However, if the interaction between the two pilots was limited to procedural communication only, the atmosphere in the flight deck may end up being quite cold and unfriendly. We therefore have direct interaction and this can be important in establishing rapport, detecting errors and solving novel problems that are not covered by procedures.

We next have to consider the technology that the human operator must interact with for the system to be successful, in this case, the aircraft. The range of technologies that humans may have to interact with is vast, but a general consideration for the human factors practitioner would be how easily the human can interact with the technology and how clearly the technology can give feedback and information to the human. A machine, no matter how clever it is, is useless if it is unusable; for example, a powerful computer is useless if it is too complicated for the human operator to use. In this book, we will be looking especially at the interaction between pilots and the aircraft that they fly. In the same way that two humans can interact either directly or procedurally, humans can interact with technology either directly or procedurally. The direct interaction between humans and technology is two way as the machine will usually give indications of its status to the human. Procedural interaction tends to be one way, from human to machine, as there are likely to be SOPs that determine how the pilots control the aircraft.

The rest of this book will focus on optimizing the pilot, optimizing the direct interaction between the pilot and the other pilot (and any other humans), optimizing the interaction between the pilot and the aircraft and, finally, optimizing the procedures through which the pilot can interact with the other pilot (or other humans) and the aircraft. Crew Resource Management (CRM) training is intended to achieve the same aim but does so with only variable success. There is considerable variability in the quality of CRM training, a worrying fact given that this is the only dedicated way of delivering human factors knowledge to crew working in this high-stakes environment.

Human factors and non-technical skills

While having a knowledge of the science of human factors is a good first step, the science must be put into practice in order to be useful. A captain who understands the science behind intercultural communication and conflict-solving strategies should also know how to use this knowledge in practice. As the aviation industry puts increasing emphasis on good CRM skills, a framework has been introduced to formally assess these skills in both the simulator and the aircraft environments. In Europe, assessment of non-technical skills forms part of operator proficiency checks, license proficiency checks and line checks. The Federal Aviation Authority in the USA has similar processes to assess non-technical skills. Although an operator can elect to use any framework for their non-technical skills assessment (provided it is acceptable to their national authority), a commonly used framework is the NOTECHS system. NOTECHS divides non-technical skills up into four major domains, each with three or four subdomains. These are shown below:

1. Cooperation
    a. team building and maintaining
    b. considering others
    c. supporting others
    d. conflict solving
2. Leadership and managerial skills
    a. use of authority and assertiveness
    b. providing and maintaining standards
    c. planning and coordination
    d. workload management
3. Situation awareness
    a. awareness of aircraft systems
    b. awareness of external environment
    c. awareness of time
4. Decision making
    a. problem definition and diagnosis
    b. option generation
    c. risk assessment and option selection
    d. outcome review

Formal assessment of non-technical skills using any framework such as NOTECHS relies on the examiner detecting and recording specific behavioral markers that indicate the presence or absence of particular skills. A behavioral marker is a specific, observable behavior that demonstrates the presence of a particular non-technical skill or, in the case of an expected positive behavioral marker being absent or the presence of a negative behavioral marker, that the non-technical skill is deficient. For example, a crew member who actively seeks the input of other crew members when solving a technical problem will have demonstrated good option generation skills. On the other hand, the crew member who makes no effort or disregards the input of other crew members could be said to be lacking in option generation skills. A crew member cannot fail a simulator check or line check based solely on deficient non-technical skills unless there is an associated technical failure. For example, if a crew member elects to land at an inappropriate airport, that could be seen as a technical failure. If the decision to go to that particular airport was reached without discussion with other crew members or any sort of risk assessment, the technical failure is associated with failure of a particular non-technical skill, and this information allows for appropriate remedial training to be planned in order to correct the deficiency. The purpose of nontechnical skill assessment is not to pass or fail people purely on their CRM abilities but to provide a better framework for understanding where people's strengths and weaknesses are in this regard and to allow weaknesses to be addressed when they may have an impact on flight safety. Based on feedback from examiners, it seems that the vast majority of technical failures during checks are the result of problems with non-technical skills.

In developing guidance for implementing and using the NOTECHS system, five principles were identified to ensure that the system is used fairly and reliably:

1. Only observable behavior is to be assessed – It is not appropriate to make judgments on the crew member's personality or attitude. The aim is to be as objective as possible.

2. Technical and non-technical skills are associated – For non-technical skills to be rated as unacceptable, flight safety must be actually or potentially compromised.
3. Repetition is required – Repetition of an unacceptable behavior must be observed to conclude that there is a significant problem.
4. Acceptable or unacceptable rating is required – The result of the check should include a rating of whether the overall non-technical skills were acceptable or unacceptable.
5. Explanation is required – In the event that a skill is rated as unacceptable, the examiner must be able to defend this assessment using examples of negative behavioral markers and how these led to safety consequences.

To ensure maximum objectivity in assessing behavioral markers in the context of non-technical skills, studies were carried out to determine the validity of the framework. It was found that 80% of examiners were consistent in their ratings of nontechnical skills and 88% were satisfied with the consistency of the method.

Human Error in Flight Operation

The introduction of reliable turbojet transports in the 1950s was associated with a dramatic reduction in air transport accidents. As problems with airframes and engines diminished, attention turned to identifying and eliminating other sources of failure in f light safety. Figure 1.1 gives statistics on the causes of accidents from 1959 through 1989, indicating that flightcrew actions were casual in more than 70% of worldwide accidents involving aircraft damage beyond economical repair. Recognition of this human performance problem stimulated a number of independent efforts to understand what the term ‘’pilot error’’ encompassed and what could be done to reduce it.

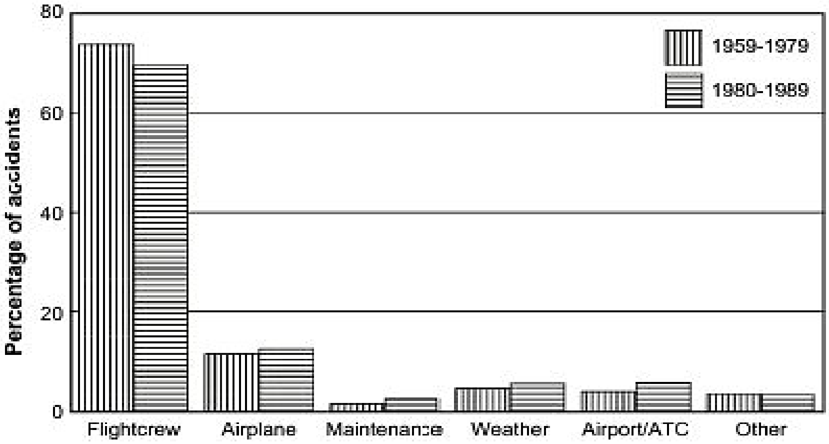

Figure 1.4 Primary causes of hull loss accidents (excluding military and sabotage): worldwide commercial jet fleet, 1959–1989. Data from Boeing Aircraft Company

The formal record of investigations into aircraft accidents, such as those conducted by the NTSB, provides chilling documentation of instances where crew coordination has failed at critical moments.

- A crew, distracted by the failure of a landing gear indicator light, failing to notice that the automatic pilot was disengaged and allowing the aircraft to descent into a swamp.
- A co-pilot, concerned that take-off thrust was not properly set during a departure in a snowstorm, failing to get the attention of the captain with the aircraft stalling and crashing into the Potomac River.

- A crew failing to review instrument landing charts and their navigational position with respect to the airport and further disregarding repeated Ground Proximity Warning System alerts before crashing into a mountain below the minimum descent altitude.
- A crew distracted by nonoperational communication failing to complete checklists and crashing on take-off because the flaps were not extended.
- A breakdown in communication between a captain, co-pilot, and Air Traffic Control regarding fuel state and a crash following complete fuel exhaustion.
- A crew crashing on take-off because of icing on the wings after having inquired about de-icing facilities. In the same accident the failure of a flight attendant to communicate credible concerns about the need for de-icing expressed by pilot passengers.

The theme in each of these cases is human error resulting from failures in interpersonal communications. By the time these accidents occurred, the formal study of human error in aviation had a long tradition (e.g., Fitts & Jones, 1947; Davis, 1948). However, research efforts tended to focus on traditional human factors issues surrounding the interface of the individual operator with equipment. This type of investigation did not seem to address many of the factors identified as causal in jet transport accidents, and researchers began to broaden the scope of their inquiry.

In the United States, a team of investigators at NASA–Ames Research Center began to explore broader human factors issues in flight operations. Charles Billings, John Lauber, and George Cooper developed a structured interview protocol and used it gather firsthand information from airline pilots regarding human factors in crew operations and ''pilot error'' accidents. At the same time, George Cooper and Maurice White analyzed the causes of jet transport accidents occurring between 1968 and 1976 (Cooper, White, & Lauber, 1980), while Miles Murphy performed a similar analysis of incidents reported to NASA's confidential Aviation Safety Reporting System (Murphy, 1980). The conclusion drawn from these investigations was that ''pilot error'' in documented accidents and incidents was more likely to reflect failures in team communication and coordination than deficiencies in ''stick-and-rudder'' proficiency. A number of specific problem areas were identified, including workload management and task delegation, situation awareness, leadership, use of available resources including other crewmembers, manuals, air traffic control, interpersonal communications (including unwillingness of junior crewmembers to speak up in critical situations), and the process of building and maintaining an effective team relationship on the flightdeck.

In Europe, Elwyn Edwards (1972) drew on the record of accident investigation and developed his SHEL model of human factors in system design and operations. The acronym represents software, usually documents governing operations; hardware, the physical resources available; liveware, consisting of the human operators composing the crew; and environment, the external context in which the system operates. Elaborating his model to examine the functioning of the liveware, Edwards (1975) defined a new concept, the trans-cockpit authority gradient (TAG). The TAG refers to the fact that captains must establish an optimal working relationship with other crewmembers, with the captain's role and authority neither over- nor underemphasized.

In the operational community in the early 1970s, Pan American World Airways management became concerned about crew training issues following several ''pilot error'' accidents in the Pacific. In 1974, a flight operations review team headed by David D. Thomas, retired Deputy Administrator of the Federal Aviation Administration (FAA), examined all aspects of flightcrew training and made a number of significant recommendations. The foremost of these was to utilize ''crew concept training.'' Under this approach, both simulator training and checking were to be conducted not as singlepilot evolutions but in the context of a full crew conducting coordinated activities. At the same time, Pan Am manuals were revised to incorporate crew concepts and to explain more completely responsibilities for team activities and communications. These actions represented a fundamental change in the operating environment and provided an organizational framework for more effective crew coordination. Although the focus in training was now on crew activities, the shift was not accompanied by a program of formal instruction in communications and coordination. Crewmembers were mandated to operate as effective teams but were left to develop means of achieving this goal without formal guidance and instruction.

Identifying crew-level issues as central to a high proportion of accidents and incidents was a significant achievement in the process of understanding the determinants of safety in flight operations. However, development of successful strategies to improve crew performance requires an understanding of the determinants of group behavior and how they can be influenced. In the following section we describe a model of group processes and performance and its implications for training and organizational actions.

Contributive Factors to Aviation Accidents

The analyze of aircraft accidents in Brazil

Aviation is a transportation activity that involves different levels of operation and interrelated tasks, some highly complex and subject to various occupational stressors.

The state of São Paulo, Southeastern Brazil, concentrates the bulk of aerial activity in the Country, mainly of general aviation, including training, executive, air-taxis, special air services, and agricultural aviation aircrafts.

The analysis of aircraft accidents in Brazil is carried out by the military Centro de Investigação e Prevenção de Acidentes Aeronáuticos (CENIPA – Center for Investigation and Prevention of Aviation Accidents), based on the International Civil Aviation Organization laws. These analyses deal with grouped factors (material, operational, and human), resulting in a multiple causes view of accidents. Still, these studies are restricted to the man-machine system, and failures resulting from organizational issues are not investigated.

Reason (2005) believes that accidents result from combinations that are not always predictable, from human and organizational factors within a complex system. His organizational accident model explains these events with the occurrence of failures or absent defenses and safeguards in the system developed to minimize the chance of accidents. Active failure occurs near the accident outcome involving the behavior (decisions, actions, or omissions) of operators and are difficult to predict and control. These active failures originate in latent conditions related to technical and organizational factors present in the system well before accidents occur. Reason's model also includes a demonstration of the possibility of accidents occurring without active failures, i.e., triggered directly from interactions between latent conditions.

Based on Reason's model, the Human Factors Analysis and Classification System (HFACS) has been used to analyze accidents since it can identify a great number of contributing factors.

This study aimed to compare the results of the investigations of Brazilian general aviation accidents by CENIPA with the HFACS model.

We used the final reports of accidents involving general aviation aircrafts in São Paulo between the years of 2000 and 2005, concluded by CENIPA until December 2008. This state was chosen because it has the largest percentage of aircrafts in the country (28%), including all categories of "general aviation". Commercial aviation was excluded because of major differences in its operation.

Data were obtained from final reports issued by CENIPA with information on aviation accidents: accident data [history, damage caused, personnel involved, aircraft, weather conditions, navigation, communications, airfield, crash, wreck, fire, survival, flight recorders, operational aspects, human factors (physiological and psychological)], and what was investigated (analyses, conclusions and flight safety recommendations). Data on contributing factors of accidents in these final CENIPA reports were obtained from the "conclusion".

The HFACS model used was based on Shappell et al (2007) and is supported by Reason's Theory. This model was chosen for comparison with CENIPA's because it has been used in the investigation of general aviation accidents in the United States and enables an evaluation of a larger number of contributing factors.

The factors considered in the HFACS model are: organizational influences (organizational climate, organizational process, resource management), unsafe supervision (inadequate supervision, planned inappropriate operations, failed to correct problems, supervisory violations), preconditions for unsafe acts (environmental, physical, and technological factors), condition of operators (adverse mental and physiological states, physical/mental limitations), personnel factors (crew resource management and personal readiness), and unsafe acts (decision errors, skill-based errors, perceptual errors, routine and exceptional violations).

During the period, there were 74 general aviation accidents. For 38 of these, the final reports had not yet been released, leaving us with a total of 36 to analyze. Final reports were thus distributed: 2000 (27.8%); 2001 (22.2%); 2002 (19.5%); 2003 (16.7%); 2004 (11.1%) and 2005 (2.8%).

The distribution of cases by category of operations showed that 44.5% involved private air service operators, 25% private instruction aircrafts, 16.7% special air services, 11.1% air taxi, and 2.8% public air transport.

These accidents involved 114 people, of which 50% were crewmembers, 41.2% passengers, and 8.8% other victims. A total of 42.1% resulted in fatal injuries, 8.7% led to severe injuries, 26.3% to mild, and 22.8% of cases were unharmed.

The distribution by type of occurrence was: engine failure in flight (33.3%), mid-air collision with obstacle (30.5%), loss of control in flight (16.7%), loss of control in soil (5.5%), failure of control in flight (2.8%), weather phenomenon (2.8%), collision with obstacles in soil (2.8%), system failure (2.8%) and special disorientation (2.8%).

Contributing factors as noted in the final CENIPA reports were categorized as: human factors (10.4%) and operational factors (89.6%). No failures due to material factors were identified. The total number of contributing factors in the CENIPA model was 163, resulting in an average of 4.52 factors per accident. The distribution of these factors, considering the frequency of citations were: misjudgment (80.5%), poor planning (66.7%), poor supervision (66.7%), psychological aspects (44.4%), flight indiscipline (38.9%), poor cockpit coordination (30.5%), adverse weather conditions (25%), lack of experience (22.2%), poor control application (22.2%), other operational aspects (19.4%), poor maintenance (16.7%), poor instruction (8.3%), influence of the environment (5.5%), forgetfulness (2.8%) and physiological aspect (2.8 %).

The total number of contributing factors in the HFACS model was 370, averaging 10.3 per accident, with the following distributions by categories according to types of events: unsafe acts (36%), unsafe supervision (28.3%), organizational influences (18.1%), and preconditions for unsafe acts (17.6%) (Figure).

The main contributing factors seen in the HFACS and CENIPA analytical models were “misjudgment” and “decision error”. In both methods, the main factor was failure by operators (pilots) and secondly, poor supervision in the CENIPA model, and unsafe supervision in the HFACS. It is possible that the high frequency of failures attributed to supervision in both cases reflects the influence of traditional practices in the training of analysts and their experience.

The results suggest that security be understood as a product of adherence to rules and/or to the right way of doing things, and that such practices be ensured, among other things, by training and supervision.

The small proportion of cases attributed to mechanical failure is consistent with the literature dealing with the histories of aviation and safety. Pariès & Amalberti5 showed that accident rates tend to be higher in the first years after the introduction of new technologies, followed by rapid reductions to levels below those obtained in the previous situation.

The low average number (less than five) of contributing factors in accidents by the CENIPA analysis shows that accidents tend to be addressed as simple events with few causes, given the number of associated factors. This happens when the analysis tends to focus on factors close to the outcome of the accident, without exploring its origins in depth or without adopting explicit procedures for systematic data collection and organization of findings.

According to the HFACS, these accidents had a higher average number of contributing factors; more than twice that of CENIPA. HFACS also identified organizational factors related to human resource management that the CENIPA assessment failed to observe. This difference can be explained partly by the fact that the HFACS model supports the exploration and systematic organization of findings.

According to Leveson, accident investigation should take broad view of the incident and include information to increase the perimeter of analysis beyond proximal events, exploring structural deficiencies in organization and management deficiencies, as well as failures in the safety culture within the system or society.

The findings on organizational influences in the analysis conducted with the HFACS method should initially be interpreted as evidence of the effective contribution of aspects from this dimension in the origins of accidents analyzed.

From the CENIPA list of contributing factors, we should highlight aspects centered on people and those represented in the group of operational factors. The CENIPA analysis considered the latter together with others from the group of human factors. The creation of instruments for accident analysis able to explain both the relational nature and the existence of interactions between various technical devices on the behavior in work situations is still a challenge.

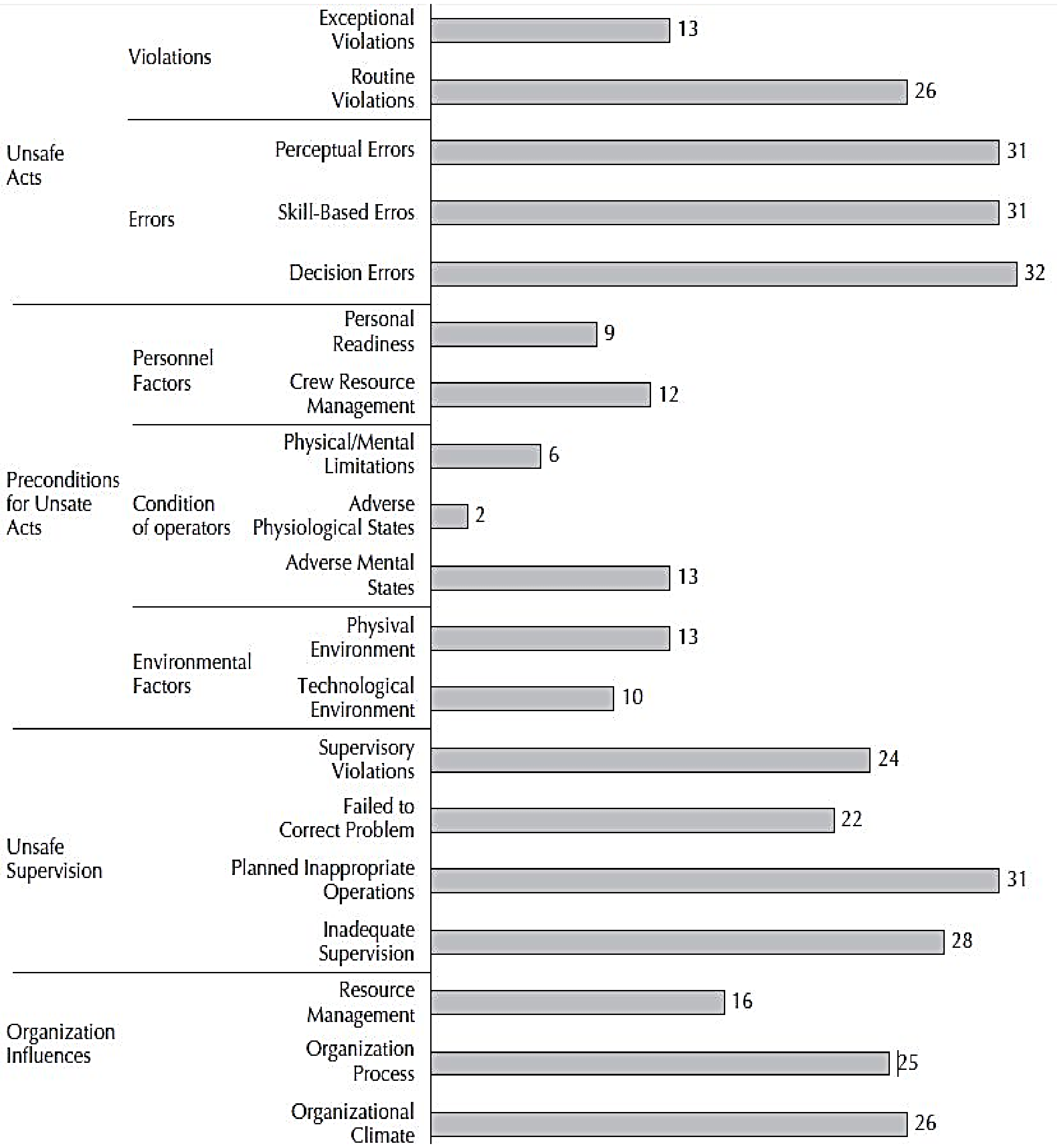

Figure 1.5 Aircraft accident contributive factors

One of the practical contributions of this study is that the way air accidents are analyzed, particularly in the model used by CENIPA, shows no evidence that the system is appropriating the contributions of studies that emphasize the need to explain the accidents. In other words, it is not exploring the latent or incubated origins of these events in the history of the system, or still, discussing these findings with the help of disciplines such as Social Sciences, Cognitive Psychology, Ergonomics, Anthropology, and Engineering Systems.

2

Information Processing

Information processing is the subject that causes the most confusion during Crew Resource Management (CRM) classes a lot of difficulties. CRM instructors tend to deal with information processing in one of two ways. The instructor either makes the effort to cover the subject comprehensively and risks losing the class because of the technical detail involved or, alternatively, glosses over the subject quickly and moves on to other topics which are deemed to be more practically relevant. The latter strategy, although understandable, means that the students miss out on learning about the most fundamental area of human factors.

This section 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.