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Designing Flightdeck Procedures: Literature Resources

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Designing Flightdeck Procedures: Literature Resources

Jolene Feldman[1], Immanuel Barshi[2], Asaf Degani[3], Loukia Loukopoulou[4], and Robert Mauro[5]

This technical publication contains the titles, abstracts, summaries, descriptions, and/or annotations of available literature sources on procedure design and development, requirements, and guidance. It is designed to provide users with an easy access to available resources on the topic of procedure design, and with a sense of the contents of these sources. This repository of information is organized into the following publication sources: Research (e.g., journal articles, conference proceedings), Manufacturers' (e.g., operation manuals, newsletters), and Regulatory and/or Government (e.g., advisory circulars, reports). An additional section contains synopses of Accident/Incident Reports involving procedures.

This work directly supports a comprehensive memorandum by Barshi, Mauro, Degani, & Loukopoulou (2016) that summarizes the results of a multi-year project, partially funded by the FAA, to develop technical reference materials that support guidance on the process of developing cockpit procedures (see "Designing Flightdeck Procedures" **https://ntrs.nasa.gov/archive/nasa/casi.ntrs.nasa.gov/20160013263.pdf**). An extensive treatment of this topic is presented in a forthcoming book by the same authors.

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1. Research Literature

Amalberti, R. (2001). The paradoxes of almost totally safe transportation systems. *Safety Science, 37,* 109–126.

Abstract: Safety remains driven by a simple principle: complete elimination of technical breakdowns and human errors. This article tries to put this common sense approach back into perspective in the case of ultra-safe systems, where the safety record reaches the mythical barrier of one disastrous accident per 10 million events (10−7). Three messages are delivered: (1) the solutions aimed at improving safety depend on the global safety level of the system. When safety improves, the solutions used to improve the safety record should not be further optimised; they must continue to be implemented at present level (to maintain the safety health obtained), and supplemented further by new solutions (addition rather than optimisation rationale); (2) the maintenance and linear optimisation of solutions having dwindling effectiveness can result in a series of paradoxes eventually replacing the system at risk and jeopardising the safety record obtained in the first place; and (3) after quickly reviewing ambiguities in the definition of human error and the development of research in this area, this article shows, through recent industrial examples and surveys, that errors play an essential role in the acquisition and effectiveness of safety, at individual as well as collective levels. A truly ecological theory of human error is developed. Theories of error highlight the negative effects of an over-extensive linear extrapolation of protection measures. Similarly, it is argued that accepting the limitation of technical systems performance through the presence of a minimum breakdown and incident 'noise' could enhance safety by limiting the risks accepted. New research opportunities are outlined at the end of this paper, notably in the framework of systems now safe or ultra-safe.

Antonsen, S., Almklov, P., & Fenstad, J. (2008). Reducing the gap between procedures and practice—Lessons from a successful safety intervention. *Safety Science Monitor, 12*(1), 1–16. Retrieved from Safety Science Monitor website: http://ssmon.chb.kth.se/volumes/vol12/2Antonsen.pdf

Abstract: Formal work procedures are central parts of an organization's safety management system. However, there always seem to be some discrepancy between work as prescribed in procedures, and the way work is actually carried out. Although it is neither possible nor desirable to eliminate this discrepancy completely, too large a gap represents a problem for safety management. Furthermore, it is a problem to which traditional approaches to safety management have found no solution. In this paper we present an empirical analysis which highlights some fundamental conditions that facilitate compliance: by keeping procedures few and simple and, more importantly, by emphasizing broad and direct worker participation in the process of implementing the procedures, a greater level of commitment and adherence to procedures was achieved. It is proposed that addressing the gap between 'work as imagined' and 'work as actually done' can serve as an opportunity for building organizational resilience through organizational learning.

Antonsen, S., Skarholt, K., & Ringstad, A. J. (2012). The role of standardization in safety management—A case study of a major oil & gas company. *Safety Science, 50*, 2001–2009.

Abstract: This article discusses the strengths and weaknesses of various kinds of standardization, when applied to the field of safety management. Recently, there are signs that organizations operating in high-risk environments take further steps towards standardization. On the positive side, standardization has the potential to enhance the predictability of normal operations as well as facilitating the transfer of lessons learnt across organizational contexts. On the negative side, standardization is by definition a strategy for dealing with known hazards and accident scenarios. We discuss how too strong an emphasis on standardization can involve unintended negative consequences for organizations' crisis-handling capabilities.

Arriaga, A., Bader, A., Wong, J., Lipsitz, S., Berry, W., Ziewacz, J., Hepner, D., Boorman, D., Pozner, C., Smink, D., & Gawande, A. (2013). Simulation-based trial of surgical-crisis checklists. *New England Journal of Medicine, 368(*3), 246–253. Retrieved from The New England Journal of Medicine http://www.nejm.org/doi/full/10.1056/NEJMsa1204720#t=articleBackground

Abstract: Operating-room crises (e.g., cardiac arrest and massive hemorrhage) are common events in large hospitals but can be rare for individual clinicians. Successful management is difficult and complex. We sought to evaluate a tool to improve adherence to evidence-based best practices during such events.

Au, H. (2005). Line pilot performance of memory items. *Proceedings of the 13th International Symposium on Aviation Psychology,* Oklahoma City, OK. Retrieved from http://www.faa.gov/about/initiatives/maintenance_hf/library/documents/media/human_factors_maintenance/line_pilot_performance_of_memory_items.pdf

Abstract: An evaluation of Boeing 737 line pilot performance of memory items in 5 abnormal checklists was performed in a single-blind experiment using tabletop exercises at the crew base of a major U.S. airline. A study of 16 pilots shows that performance of memory items results in errors in identifying the failure, selecting the proper checklist to be completed, and checklist step errors.

Bainbridge, L. (1993). Planning the training of a complex skill. *Le Travail Humain, 56*(2/3), 211–232.

Abstract: The first half of this paper is on normal operation. This introduction will outline how an operator thinks, and the knowledge they use. The first two main sections of the paper will then be on training for understanding the process and its constraints, and how to operate it. Fault management is treated as a special case, in the second half of the paper, which outlines the categorisation and problem solving processes by which operators deal with unfamiliar situations. Any situation in which training is needed is by definition unfamiliar. However the aim of most training schemes (and the first part of the scheme proposed here) is

to minimise the extent to which trainees have to think out for themselves what to do in this unfamiliar situation. But in training for fault management the emphasis shifts, to explicit training in dealing with unfamiliarity.

Bakdash, J. Z., & Drews, F. A. (2012). Using knowledge in the world to improve patient safety: Designing affordances in health care equipment to specify a sequential "checklist". *Human Factors and Ergonomics in Manufacturing & Service Industries, 22*(1), 7–20.

Abstract: Use of current health care equipment for medical procedures (e.g., central line insertions and central line care) is primarily dependent on the cognition of the health care worker. That is, the present design of equipment (typically numerous, separately packaged individual items) provides minimal information about the optimal order of procedure steps and no defenses against human error, such as omitting steps in procedure. In this article, we propose patient safety may be improved by redesigning equipment to integrate a "checklist" using sequencing, color-coding, and visual icons. We hypothesize this reduces cognitive demand by off-loading knowledge into the world, creating affordances that provide guidance reducing the likelihood of errors and promoting adherence to best practices.

Baron, R. (1997). The cockpit, the cabin, and social psychology [Online forum]. Retrieved from http://airlinesafety.com/editorials/CockpitCabinPsychology.htm

Abstract: All airline pilots are required to receive crew resource management (CRM) training, which augments technical flight and ground training with human factors subjects. There has also been an increase in this type of training for flight attendants. CRM training has been shown to be efficacious for both groups when viewed separately. Unfortunately, in real flight operations, there are cognitive and physical factors that cause these disparate groups to work less than efficiently between their groups, particularly when a cohesive environment is critical, such as in an emergency. This paper looks at the factors that influence the separation of these two groups and offers recommendations to address this critical issue.

Barshi, I. & Healy, A. (1993). Checklist procedures and the cost of automaticity. *Memory & Cognition, 21*(4), 496–505.

Abstract: Automaticity is usually discussed in terms of its benefits. Automaticity has, however, a cost that manifests itself in procedures that are highly routinized but require close attention, such as verbal checklist procedures. In such procedures, errors occur because the routine leads to automaticity. In three paper-and-pen experiments, we tested this manifestation and investigated ways to decrease automaticity in verbal checklist procedures. In the experiments, subjects proofread sets of multiplication problems to detect erroneous operations, simulating the checklist procedure. In Experiments 1 and 2, two conditions were compared: a fixed-order condition (in which each set contained operations in the same order) and a varied-order condition (in which the operations were in a different order in each set). In Experiment 1, proofreading times were measured to establish the role of fixed sequential order as a consistent environment promoting the emergence of automaticity. In Experiment 2, we introduced errors into the material, and in Experiment 3 we introduced "alerting"

conditions to interfere with the development of automaticity. The results indicated that the subjects in the varied-order and alert conditions detected significantly more errors than did those in the fixed-order condition. The implications of the findings for current theories of automaticity are discussed as well as those for the design of checklist procedures.

Baum, M.S., Neal, D., Peri, R., Randomsky, M., Rhodes, B., Sachs, R., Smith, J., Steinman, D., & Turner, T. (Eds.). (n.d.). *Helicopter pilots model code of conduct: Tools to advance helicopter flight safety and professionalism* (Version 1.0). Retrieved from Aviators Model Code of Conduct website: http://www.secureav.com/HMCC-v1.0.pdf

Abstract: The Helicopter Pilots Model Code Of Conduct (HMCC) offers recommendations to advance helicopter flight safety, airmanship, and professionalism. The Code of Conduct presents a vision of excellence for helicopter pilots. Its principles complement and underscore legal requirements. The FAA Practical Test Standards (PTS) and comparable international materials set the standard of evaluation for pilot certification. As such, the PTS focus mainly on basic flying knowledge and skills. However, standards and regulations by themselves do not provide a framework for how to think and act in situations that may not be covered by procedures, checklists, or operating manuals. In contrast, the HMCC articulates broader guidance—a set of values—to help a pilot interpret and apply standards and regulations, and to confront the real world challenges that could lead to a mishap. The Code of Conduct is a model, not a standard. The Code of Conduct will be most effective if users commit to the pursuit of professionalism as well as a firm grasp of the fundamentals of flight. The Code of Conduct has seven sections, each presenting Principles and Sample Recommended Practices.

Baum, M.S., Peri, R., Randomsky, M., Rhodes, B., Sachs, R., Smith, J., Steinman, D., & Turner, T. (Eds.). (n.d.). *Aviators model code of conduct: Tools to advance aviation safety and professionalism* (Version 2.0). Retrieved from Aviators Model Code of Conduct website: http://www.secureav.com/AMCC-v2.pdf

Abstract: The Aviators Model Code Of Conduct offers recommendations to advance flight safety, airmanship, and professionalism. The Code of Conduct presents a vision of excellence for aviators. Its principles complement and underscore legal requirements. The Code of Conduct is a model, not a standard. Users should customize or otherwise revise the document—including title, length, and organization—to fit their needs. See "Additional Resources" (below) for materials to help facilitate such customization. The Code of Conduct will be most effective if users have a firm grasp of the fundamentals of flight as well as a commitment to the pursuit of professionalism. The Code of Conduct has seven sections, each presenting Principles and Sample Recommended Practices.

Berry, K.A., & Sawyer, M.W. (2013). Understanding the human component of area navigation procedures across the national airspace system. *Proceedings of the Human Factors and Ergonomics Society 57th Annual Meeting, San Diego, CA,* 76–80. Retrieved from Sage Journals website: http://pro.sagepub.com/content/57/1/76

Abstract: The FAA intends to considerably increase the usage of area navigation (RNAV) approach and departure procedures in order to achieve the proposed NextGen goals for improved efficiency and capacity. RNAV procedures enable aircraft to have better access and flexibility for point-to-point operations. In an effort to better understand the potential impact of increased RNAV usage, a human factors safety assessment was conducted to identify the key human factors issues present in current RNAV operations. An analysis of 100 RNAV narrative-based safety reports from the Air Traffic Safety Action Program (ATSAP) and 68 narrative-based safety reports from the Aviation Safety Reporting System (ASRS) was conducted to identify key causal factors. The analysis found several key causal factors related to RNAV procedure design, controller-pilot communication, automation systems, and track deviations. Specific human performance concerns and mitigation strategies for each causal factor were developed. These results should drive future requirements associated with the implementation of future RNAV procedures.

Blomberg, R., Ramu J., Degani, A., Speyer, J., & Kanki, B. (1999). Evolving flight operations data standards: Is there a need for early identification of specifications? In R. Travers (Moderator), *Proceedings of American Association for Artificial Intelligence* (pp. 195–197). Retrieved from AAAI website: http://www.aaai.org/Papers/HCI/2002/HCI02-032.pdf

Abstract: There are attempts by organizations and industry research groups to highlight the need for common information standards within air carriers. Each of these targets the air carriers themselves, and yet often misses the concept of industry wide standards in which information should flow more seamlessly. In a variety of aeronautics support groups, common data standards are espoused but often overlooked. In today's information rich environment, industry data standards have become essential. Common terminology, data standards and cross-functional information libraries are required in order to catalogue, analyze and prepare flight operations information systems for the future.

Bolton, M.L., & Bass, E.J. (2012). Using model checking to explore checklist-guided pilot behavior. *The International Journal of Aviation Psychology, 22*(4), 343–366.

Abstract: Pilot noncompliance with checklists has been associated with aviation accidents. This noncompliance can be influenced by complex interactions among the checklist, pilot behavior, aircraft automation, device interfaces, and policy, all within the dynamic flight environment. We present a method that uses model checking to evaluate checklist-guided pilot behavior while considering these interactions. We illustrate our approach with a case study of a pilot performing the "Before Landing" checklist. We use our method to explore how different design interventions could impact the safe arming and deployment of spoilers. Results and future research are discussed.

Boorman, D. (2000, September). Reducing flight crew errors and minimizing new error modes with electronic checklists. *Proceedings of the International Conference on Human-Computer Interaction in Aeronautics*, Toulouse, France.

Abstract: This paper discusses electronic checklist (ECL) system design, focusing on ECL as an automated tool for reducing or eliminating certain types of flight crew errors. Paper checklist error modes are listed. New errors that may be introduced by the ECL and the relationship with degree and characteristics of automation are discussed. Examples are offered from Boeing 777 ECL design experience. Comparisons are drawn between ECL, particularly emergency checklist features which are infrequently used and associated with high stress, high workload conditions, and other automated human-computer interfaces (HCI). Similar design rationale can be applied to all of these interfaces to ensure that error modes are minimized in future automated tools.

Boorman, D. (2001). Today's electronic checklists reduce likelihood of crew errors and prevent mishaps. *ICAO Journal, 1,* 17–36.

Abstract: Automation on the flight deck produces some important benefits but can also bring training challenges, mode confusion and new possibilities for errors. With this in mind, designers of a modern electronic checklist made a special effort to ensure this automated cockpit tool would not introduce new error modes.

Bourrier, M., & Bieder, C. (2013). Trapping safety into rules: An introduction. In M. Bourrier & C. Bieder (Eds.), *Trapping safety into rules: How desirable or avoidable is proceduralization?* (pp. 1–8). Burlington, VT: Ashgate.

Abstract: The provocative title of this book aims to encourage interested readers to think of the proceduralization of safety with a renewed perspective. This phenomenon is one of axis of a more general trend towards normalization of social interactions and practices, leading to the bureaucratization of everyday life, a phenomenon long envisioned by Max Weber and regularly re-assessed and commented by sociologists (Perrow, 1991, Shapiro and Carr 1991, Webb, 2006).

Bovair, S., & Kieras, D. E. (1989). *Toward a model of acquiring procedures from text.* (No. TR-89/ONR-30). Michigan University Ann Arbor Technical Communication Program.

Abstract: In this paper, the criteria for the development, implementation, and control of operating and safety limits of parameters like pressure, temperature, level, composition, etc., are described. Operating and safety limits are required by Elements 2 'process safety information" and 4 "operating procedures" of the information package for OSHA Process Safety Management (PSM). A brief description is also given of how these limits should be established and the information, with respect to consequences, safeguards, and corrective actions, that should be obtained during a detailed analysis of deviation from an operation or process parameter. This paper looks for an easier method of developing operating and safety limits within chemical and petrochemical plants to prevent and control undesirable events (human losses, material losses, economic losses, or environmental pollution) through adequate emergency plans and response programs.

Callantine, T.J. (2001, October). ***The crew activity tracking system: Leveraging flight data for aiding, training and analysis*****. Paper presented at the 20th Digital Avionics Systems Conference, Dayton Beach, FL. doi 10.1109/DASC.2001.963408**

Abstract: Technological advances have made flight data a viable real-world data source for studies of human error and error prevention; hundreds of parameters are currently available for analysis. These data have enabled airlines to institute increasingly advanced Flight Operational Quality Assurance (FOQA) programs, which analyze flight data from line operations to detect "operational irregularities that can foreshadow accidents and incidents," and proactively disseminate this information to flight crews and maintenance personnel. This paper presents an intent inference technology, referred to as activity tracking, that in the future could also support flight-data-driven safety-enhancement efforts. A methodology for activity tracking has been implemented and validated in the Crew Activity Tracking System (CATS) as implemented for the flight deck, CATS uses knowledge about the pilot's task and the current operational context to predict nominal activities and interpret actual pilot actions. By analyzing pilot action data in conjunction with clearance constraints and other flight data parameters, CATS can help disambiguate errors from other causes of abnormal flight conditions, and characterize error-inducing contexts in operational terms.

Chandra, D.C., & Grayhem, R. (2013). Evaluation of a technique to simplify depictions of visually complex aeronautical procedures for NextGen. ***Proceedings of the Human Factors and Ergonomics Society 57th Annual Meeting, San Diego, CA,*** **86–90. Retrieved from Sage Journals website: http://pro.sagepub.com/content/57/1/86**

Abstract: Performance based navigation supports the design of more precise flight procedures. However, these new procedures can be visually complex, which may impact the usability of charts that depict the procedures. The purpose of the study was to evaluate whether there are performance benefits from simplifying aeronautical charts that depict visually complex flight procedures by separating the procedures onto different chart images. Forty-seven professional pilots participated. They used high-fidelity current and modified charts to find specific information from approach and Standard Instrument Departure (SID) chart images that were shown one at a time on a computer monitor. Response time and accuracy were recorded. Results show a consistent and significant reduction in the time to find information from the simplified chart images. Response time varied linearly with a simple clutter metric, the sum of visual elements in the depiction, indicating serial visual search. Most questions were answered with high accuracy, but some questions about altitude constraints yielded low accuracies.

Choi, S.Y., & Park, J. (2012). Operator behaviors observed in following emergency operating procedures under a simulated emergency. *Nuclear Engineering & Technology, 44*(4), 379–386.

Abstract: A symptom-based procedure with a critical safety function monitoring system has been established to reduce the operator's diagnosis and cognitive burden since the Three-Mile Island (TMI) accident. However, it has been reported that a symptom-based procedure also requires an operator's cognitive efforts to cope with off-normal events. This can be caused by mismatches between a static model, an emergency operating procedure (EOP), and a dynamic process, the nature of an on-going situation. The purpose of this study is to share the evidence of mismatches that may result in an excessive cognitive burden in conducting EOPs. For this purpose, we analyzed simulated emergency operation records and observed some operator behaviors during the EOP operation: continuous steps, improper description, parameter check at a fixed time, decision by information previously obtained, execution complexity, operation by the operator's knowledge, notes and cautions, and a foldout page. Since observations in this study are comparable to the results of an existing study, it is expected that the operational behaviors observed in this study are generic features of operators who have to cope with a dynamic situation using a static procedure.

Clay-Williams, R., & Colligan, L. (2015). Back to basics: Checklists in aviation and healthcare. *BMJ Qual Saf, 24,* 428–431.

Abstract: The checklist approach has the same potential to save lives and prevent morbidity in medicine that it did in aviation over 70 years ago by ensuring that simple standards are applied for every patient, every time.1 Healthcare safety activists have looked to checklists to solve a myriad of problems, particularly with the current iteration of checklists that have been imported from aviation. Large-scale implementations with conflicting outcomes suggest that these tools are not as simple or effective as hoped. Scholars debating the efficacy of checklist implementation in healthcare have identified important reasons for varying results: that success requires complex, cultural and organisational change efforts, not just the checklist itself confounded by a mix of the technical and socio-adaptive elements, and that local contexts may either augment or undermine the implementation with conflicting outcomes; that results may be confounded by a mix of the technical and socio-adaptive elements, and that local contexts may either augment or undermine the implementation's outcomes.

de Brito, G. (1998, May). Study of the use of airbus flight deck procedures and perspectives for operational documentation. In G. Boy, C. Graeber, & J. M. Robert (Eds.), *International Conference on Human Computer Interaction in Aeronautics, HCI-Aero'98* (pp. 195–201). Ecole Polytechnique de Montréal, Montreal, Canada.

Abstract: Cockpit automation is increasing with each new generation of airplane. This technological evolution has numerous effects on tasks and activities related to flying. We will focus on the use of written procedures. The study reported here deals with the way in which pilots use these written procedures. Indeed, even if everyone agrees on the validity of written procedures, their content and their use sometimes lead to problems. This article presents current trends concerning the use of operator assistance and in particular, written procedures in new generation aircraft of the Airbus A320, A330 or A340 family.

de Brito, G. (2002). Towards a model for the study of written procedure following in dynamic environments. *Reliability Engineering and System Safety, 75,* 233–244.

Abstract: Flight safety relies on a large number of automatisms and on strict written procedure following. This article presents a psycho-cognitive analysis of the procedure following task. Consequently, we have proposed a model called SPEED (Suivi de Procedures Ecrites dans les Environnements Dynamiques: Written Procedure Following in Dynamic Environments). SPEED enables the understanding of the use of written procedure in dynamic environments. It describes the reasons why pilots do not follow procedures as the manufacturers and airlines require. SPEED breaks down the activities involved in the use of procedures into nine stages: (1) detecting triggering conditions, (2) elaborating a diagnosis, (3) determining whether a procedure is needed, (4) accessing and searching for the appropriate written procedure, (5) reading and understanding the items of the procedure, (6) assessing the relevance of the procedure, (7) planning actions, (8) executing the planned actions and (9) evaluating the outcome of actions. SPEED is not as a sequential model. It is an iterative model, where some steps may be optional.

de Brito, G., & Boy, G. (1999, September). Situation awareness and procedure following. *Seventh European Conference on Cognitive Science Approaches to Process Control (CSAPC '99)*, Paper presented at the European Association of Cognitive Ergonomics, Villeneuve d'Ascq, France.

Abstract: Aeronautics procedures are used as prescribed action lists to help human operators remember and follow mandatory steps that guarantee safety, workload and performance criteria. A study of the use of procedures in the civil aviation domain surveyed 207 pilots using four investigation methods, including the observation of 140 hours of full-flight simulator. The results of this study are used to address why human operators of safety-critical systems use, misuse or do not use procedures to keep control of a situation, and how they cope with situation awareness. This paper suggests that new perspectives on design may be required to support the further development of warning systems, the design of procedure and the definition of the pilots' role.

Degani, A. (n.d.). *Schemes and techniques of information organization: The case of the London underground "diagram"* (Human-Machine Interface GM Report). Israel: GM Advanced Technical Center.

Abstract: This report describes an analytical approach for considering the schemes and techniques used to organize visual information. The approach centers on three dimensions: (1) abstraction of data into representational elements, (2) integration of these elements to create coherent structures of information, and (3) organization of such coherent structures, by means of some (underlying) order, into a whole. To illustrate this approach, we have analyzed the abstract map ("Diagram") of the London underground, and discuss some of the schemes and techniques employed in this renowned (information-design) artifact. We also try to provide some clues about the creative processes of its designer. We conclude with several implications of this analysis to the design of HMI displays such as navigation maps, HVAC system layout, and adaptive (i.e., system generated) interfaces.

Degani, A. (1999, April). *Pilot-error in the 90's: Still alive and kicking.* Paper presented at the meeting of the Flight Safety Foundation of the National Business Aviation Association, Cincinnati, OH.

Abstract: In this keynote address, I will describe the notion of human- and pilot-error. I will show, given actual examples, why it is still alive and kicking, and what can be done to ameliorate this problem. The main thesis of this talk is about going beyond the mere classification of pilot-error into a detailed analysis of the events and a thorough consideration of all other factors that have contributed to the mishap. I will argued using three examples: The first example describes a certain crew interaction that, from the outset, appears problematic, yet once the details are revealed, all falls into place. The second example is about a pilot-error that is actually due to deficiency in the design of a "Before Landing Checklist" procedure. The last example describes problems that pilot encounter while operating an autopilot.

Degani, A. (2003a). Procedures, synchronization, and automation. In *Taming Hal* (pp. 177–199). New York, NY: Palgrave Macmillan.

Notes: Chapter 13 addresses the kinds of problems operators, such as pilots and technicians, encounter when using checklists and procedures to manage a complex and dynamic system. Although the example in this chapter comes from the world of aviation, the concepts that are discussed and developed throughout are common to medical and manufacturing settings, nuclear power, space flight, and many other domains where procedures are a necessity.

Degani, A. (2003b). *Taming Hal*. New York, NY: Palgrave Macmillan.

Abstract: Machines dominate our lives, from alarm clocks that wake us up in the morning to radios that lull us to sleep. Most of our interactions with automated machines and computers are problem-free, but more often than we would like, they can be irritating and confusing. This is frequently harmless, such as a VCR recording the wrong show, but when it involves a critical system like an autopilot or medical device it can be a matter of life or death. *Taming HAL* seeks to explain these miscommunications between humans and machines by exploring user interfaces of everyday devices. Degani examines thirty different systems for human use, including watches, consumer electronic products, Internet applications, cars, medical equipment, navigation systems onboard cruise ships, and autopilots of commercial aircraft. Readers will discover why interfaces between people and machines all too often do not work and what needs to be done to avoid potential tragedies.

Degani, A. (2013, July). A tale of two maps: Analysis of the London Underground "Diagram." *Ergonomics in Design, 2*(3), 7–16.

Abstract: This article presents an analytical approach to the problem of information organization, with special emphasis on diagrammatic design. The approach involves three levels: (a) abstraction of data into representational elements, (b) integration of these elements to create coherent structures of information, and (c) configuration of such coherent structures, through underlying order, into a whole. To illustrate this approach, the abstract map (the "Diagram") of the London underground is analyzed, and the design techniques observed are brought to the fore. The article concludes with several principles that can be encapsulated as constraints for an algorithmic approach to diagram generation."

Degani, A., Barshi, I., & Shafto, M.G. (2013). ***Information organization in the airline cockpit: Lessons from flight 236.*** **Retrieved from Sage Journals website: http://journals.sagepub.com/doi/abs/10.1177/1555343413492983**

Abstract: We describe the all-engine-out landing of Air Transat Flight 236 in the Azores Islands (August 24, 2001) and use certain aspects of that accident to motivate a conceptual framework for the organization and display of information in complex human-interactive systems. Four hours into the flight, the aircraft experienced unusual oil indications. Two hours later, a fuel system failure led to a full-blown emergency that was not evident to the crew until it was too late. Although all relevant data to avoid the emergency were available to the aircraft computer systems, the design choices made about what to display and how to display it kept the pilots "in the dark." The framework proposed here consists of six levels, beginning from the extraction of data from physical signals, abstracting from raw data to form visual representations on the user interface, and finally integrating high-level elements and information structures. We illustrate how the framework can be used to analyze some of the shortcomings in current display design, and we discuss some principles of information organization and formal analysis of task logic that might help to improve design. Finally, we sketch a design for a helicopter engine display based on these principles.

Degani, A., Heymann, M., & Shafto, M. (1999). Formal aspects of procedures: The problem of sequential correctness. ***Proceedings of the Human Factors and Ergonomics Society 43rd Annual Meeting, TX, Vol. 43(20)*****, 1113–1117.**

Abstract: A formal, model-based approach is proposed for the development and evaluation of the sequences of actions specified in procedures. The approach employs methodologies developed within the discipline of discrete-event and hybrid systems control. We demonstrate the proposed approach through an evaluation of a procedure for handling an irregular engine-start on board a modern commercial aircraft.

Degani, A., & Wiener, E. (1990). ***Human factors of flight-deck checklists: The normal checklist*** **(NASA Contractor Report 177549). Retrieved from SKYbrary: http://www.skybrary.aero/bookshelf/books/1568.pdf**

Abstract: Although the aircraft checklist has long been regarded as the foundation of pilot standardization and cockpit safety, it has escaped the scrutiny of the human factors profession. The improper use, or the non-use, of the normal checklist by flight crews is often cited as the probable cause or at least a contributing factor to aircraft accidents. In this report the authors attempt to analyze the normal checklist, its functions, format, design, length, usage, and the limitations of the humans who must interact with it. The development of the checklist from the certification of a new aircraft to its delivery and use by the customer is discussed. The influence of the government, particularly the FAA Principal Operations Inspector (POI), the manufacturer's philosophy, the airline's "culture," and the end user—the

pilot, all influence the ultimate design and usage of this device. The effects of airline mergers and acquisitions on checklist usage and design are noted. In addition, the interaction between production pressures ("making schedules"), checklist usage and checklist management are addressed. Finally, the authors provide a list of design guidelines for normal checklists.

Degani, A., & Wiener, E. (1993). Cockpit checklists: Concepts, design, and use. *Human Factors, 35*(2), 28–43.

Abstract: Although the aircraft checklist has long been regarded as a foundation of pilot standardization and cockpit safety, it has escaped the scrutiny of the human factors profession. The improper use, or the non-use, of the normal checklist by flight crews is often cited as a major contributing factor to aircraft accidents. This paper reports the results of a field study of flight-deck checklists, and examines this seemingly mundane, yet critical device, from several perspectives: its functions, format, design, length, usage, and the limitations of the humans who must interact with it. Certain socio-technical factors, such as the airline "culture," cockpit resource management, and production pressures that influence the design and usage of this device are also discussed. Finally, a list of design guidelines for normal checklists is provided. While the focus of this paper is on the air transport industry, most of the principles discussed apply equally well to other high-risk industries such as maritime transportation, power production, weapons systems, space flight, and medical care.

Degani, A., & Wiener, E. L. (1994a). *On the design of flight-deck procedures* (NASA Contractor Report 177642). Retrieved from NASA website: http://ti.arc.nasa.gov/m/profile/adegani/Flight-Deck_Procedures.pdf

Summary: In complex human-machine systems, operations, training, and standardization depend on an elaborate set of procedures, which are specified and mandated by the operational management of the organization. These procedures indicate to the human operator (in this case the pilot) the manner in which operational management intends to have various tasks performed. The intent is to provide guidance to the pilots, to ensure a logical, efficient, safe, and predictable (standardized) means of carrying out the mission objectives. However, in some operations these procedures can become a hodge-podge, with little coherency in terms of consistency and operational logic. Inconsistent or illogical procedures may lead to deviations from procedures by flight crews, as well as difficulty in transition training for pilots moving from one aircraft to another. In this report the authors examine the issue of procedure use and design from a broad viewpoint. The authors recommend a process which we call "The Four P's:" philosophy, policies, procedures, and practices. We believe that if an organization commits to this process, it can create a set of procedures that are more internally consistent, less confusing, better respected by the flight crews, and that will lead to greater conformity. The "Four-P" model, and the guidelines for procedural development in Appendix 1, resulted from cockpit observations, extensive interviews with airline management and pilots, interviews and discussion at one major airframe manufacturer, and an examination of accident and incident reports involving deviation from standard operating procedures (SOPs). Although this report is based on airline operations, we believe that the principles may be applicable to other complex, high-risk systems, such as nuclear power production, manufacturing process control, space flight, law enforcement, military operations, and high-technology medical practice.

Degani, A., & Wiener, E.L. (1994b). Philosophies, policies, procedures, and practices: The four 'P's of flight deck operations. In N. Johnston, N. McDonald, & R. Fuller (Eds.), *Aviation psychology in practice (*pp. 44–67). Aldershot, England: Avebury Technical.

Abstract: This chapter is a continuation of our previous work on the human factors of aircraft checklists in air carrier operations (Degani and Wiener, 1990). Our work in this area was largely undertaken as a result of the discovery, during the investigation of Northwest 255 crash, that checklists, for all their importance to safe operation, had somehow escaped the scrutiny of the human factors profession. The same, we found out, can be said of most flight procedures. We felt that our work in checklist design and usage would not be complete until we gave equal consideration to cockpit procedures.

Degani, A., & Wiener, E. (1998). Design and operational aspects of flight-deck procedures. *Proceedings of the International Air Transport Association (IATA) Annual Meeting*, Montreal, Canada.

Abstract: In complex human-machine systems, training, standardization, quality assurance, and actual operations depend on an elaborate set of procedures. These procedures indicate to the human operator the manner in which operational management intends to have various tasks performed. The objective is to provide guidance to the operators—in this case, pilots—to ensure a safe, logical, and efficient flight operations. However, all too often these procedures can become a hodge-podge, with little internal consistency and lack of a clear operational logic. Inconsistent or illogical procedures may lead to deviations from procedures by the flight crews, as well as difficulty in transition training for pilots moving from one aircraft to another. This paper examines the issue of procedurization from two different, yet related, aspects: the overall design process of procedures and operational considerations. First, the authors describe a process that we call "The Four P's": philosophy, policies, procedures, and practices. We argue that an organization which commits to this process can create a set of procedures which are more internally consistent, which will be better respected by the flight crews, hence leading to greater conformity, and which will reduce the cost of transition training. Second, we discuss some of the operational considerations that must be taken into account while designing or evaluating flight-deck procedures. We focus our attention on extra-cockpit demands (e.g., scheduling of tasks based on demands from the environment) and intra-cockpit demands (e.g., procedure flow and cockpit layout). The design process and operational considerations resulted from cockpit observations, extensive interviews with airline management and pilots, interviews and discussion at one major airframe manufacturer, and an examination of accident and incident reports involving deviation from standard operating procedures (SOPs). Although this paper is based on airline operations, it has been repeatedly demonstrated that these principles are also applicable to other complex human-machine systems, such as corporate aviation, nuclear power, chemical process control, military operations, and medical practice.

Desaulniers, D.R. (1987, September). Layout, organization, and the effectiveness of consumer product warnings. ***Proceedings of the Human Factors and Ergonomics Society Annual Meeting 31*****(1), 56–60. SAGE Publications.**

Abstract: Three experiments are presented examining the effects of warning layout (spatial structure) and organization (semantic structure) on the readability and memorability of warning information. In Experiment 1 these factors were tested in a 2 (levels of layout) x 3 (levels of organization) factorial. design. The two levels of layout were the typical paragraph format and an experimental version having the appearance of an outline. Warning content was organized according to hazard, type of statement, or randomly. Warnings were ranked according to three criteria; eye appeal, ease of processing, and effectiveness. In general, warnings in outline layout and type of hazard organization were ranked as having greater eye appeal, easier to process, and more effective than alternative organization-layout conditions. In Experiments 2 and 3, only warning layout was manipulated and a cover story was used to elicit reading and compliance behaviors likely to occur in the home. Experiment 2 results indicate that, when asked to read the warnings, subjects spent less time reading warnings in paragraph layout than warnings in outline layout. In Experiment 3, the decision to read the warning was at the discretion of the subjects. Results indicated that warnings in outline layout were read and complied with by a larger proportion of subjects than warnings in paragraph layout. Implications for warning design and future research are discussed.

Dismukes, R.K., & Berman, B.A. (2010). ***Checklists and monitoring in the cockpit: Why crucial defenses sometimes fail*** **(NASA Technical Memorandum 2010–216396). Moffett Field, CA.**

Abstract: Checklists and monitoring are two essential defenses against equipment failures and pilot errors. Problems with checklist use and pilots' failures to monitor adequately have a long history in aviation accidents. A typical airline flight requires a great number of routine flight control inputs and switch actions and frequent reading and verification of visual displays. Many of these actions are governed by formal procedures specifying the sequence and manner of execution, after which checklists are used to bolster reliability. Throughout the flight, pilots are required to monitor many functions, the state of aircraft systems, aircraft configuration, flight path, and the actions of the other pilot in the cockpit. Thus, the number of opportunities for error is enormous, especially on challenging flights, and many of those opportunities are associated with checklists and monitoring—themselves safeguards designed to protect against error. Our study was conducted to explore why checklists and monitoring sometimes fail to catch errors and equipment malfunctions as intended. In particular, we wanted to: 1) collect data on monitoring and checklist use in cockpit operations in typical flight conditions; 2) provide a plausible cognitive account of why deviations from formal checklist and monitoring procedures sometimes occur; 3) lay a foundation for identifying ways to reduce vulnerability to inadvertent checklist and monitoring errors; 4) compare checklist and monitoring execution in normal flights with performance issues uncovered in accident investigations; and 5) suggest ways to improve the effectiveness of checklists and monitoring.

Dismukes, R.K., Berman, B.A., & Loukopoulos, L.D. (2007). ***The limits of expertise: Rethinking crew error and the causes of airline accidents.*** **Burlington, VT: Ashgate.**

Abstract: "The Limits of Expertise" reports a study of the 19 major U.S. airline accidents from 1991–2000 in which the National Transportation Safety Board (NTSB) found crew error to be a causal factor. Each accident is reported in a separate chapter that examines events and crew actions and explores the cognitive processes in play at each step. The majority of all aviation accidents are attributed to human error, but this is often misinterpreted as evidence of lack of skill, vigilance, or conscientiousness of the pilots. Why would highly skilled, well-trained pilots make errors performing tasks they had successfully executed many thousands of times in previous flights? The approach is guided by extensive evidence from cognitive psychology that human skill and error are opposite sides of the same coin. The book examines the ways in which competing task demands, ambiguity and organizational pressures interact with cognitive processes to make all experts vulnerable to characteristic forms of error. The final chapter identifies themes cutting across the accidents, discusses the role of chance, criticizes simplistic concepts of causality of accidents, and suggests ways to reduce vulnerability to these catastrophes. The authors' complementary experience allowed a unique approach to the study: accident investigation with the NTSB, cognitive psychology research both in the lab and in the field, enormous first-hand experience of piloting, and application of aviation psychology in both civil and military operations. This combination allowed the authors to examine and explain the domain-specific aspects of aviation operations and to extend advances in basic research in cognition to complex issues of human performance in the real world. Although "The Limits of Expertise" is directed to aviation operations, the implications are clear for understanding the decision processes, skilled performance and errors of professionals in many domains, including medicine.

Dowell, A.M. (2001). Critical safe operating parameters: "Never exceed" limit and "never deviate" action. ***Process Safety Progress, 20*****(3), 208–214.**

Abstract: Where does the human being fit in the normal operating system and where does he/she fit in the safety shutdown system? Planning ahead can make human interaction inherently safer. This paper offers the following suggestions for managing that interaction: (1) Use inherently safer principles in the design of the process and its layers of protection. (2) Define "Never Exceed" limits for critical safe operating parameters. (3) Define a mandatory action point and a "Never Deviate" action with enough response time to prevent exceeding the Never Exceed limit. (4) Train and drill.

Drury, C.G. (2000). Development and use of the documentation design aid. ***Proceedings of the IEA/HFES Congress, 44*****(22), 783–786. Retrieved from: http://www.faa.gov/about/initiatives/maintenance_hf/library/documents/media/roi/development_and_use_of_the_documentation_design_aid_.pdf**

Abstract: In aviation maintenance and inspection; work documents are critical to safety, as they act as both production control devices and job aids for mechanics and inspectors. Based on an analysis of the current state of documentation in aviation maintenance, there was a clear need to help document designers/writers utilize good human factors practice. Design guidelines were developed and tested (Pate1 et al, 1994) and then made accessible through a Visual Basic window, called the Documentation Design Aid or DDA, available on-screen while writing a procedure. This DDA was tested for usability by writers and for comprehension of the documents produced. A number of different evaluations showed that the DDA reduced comprehension errors significantly. The DDA is now available via's WWW site for users to download and use.

Drury, C.G., & Gramopadhye, A.K. (1992, August). Training for visual inspection: Controlled studies and field implications. ***Proceedings of the Seventh Federal Aviation Administration Meeting on Human Factor Issues in Aircraft Maintenance and Inspection: Science, Technology, and Management: A Program Review,*** **135–146. Retrieved from FAA website: http://www.faa.gov/about/initiatives/maintenance_hf/library/documents/media/mx_faa_%28formerly_hfskyway%29/human_factors_issues/meeting_7/trainingforvisualinspection.pdf**

Abstract: The three factors most affecting visual inspection performance were derived from a generic task analysis of inspection. For each of these three, possible training interventions were found from the literature on industrial inspection. Direct tests of these interventions were made through five experiments on a computer-based simulator for aircraft visual inspection. One experiment is presented, showing how the size of the area seen by an inspector in a single visual fixation can be trained to improve search performance. Implications of the results of this controlled study for the training of aircraft inspectors are given.

Erdinc, O. (2010). Comprehension and hazard communication of three pictorial symbols designed for flight manual warnings. ***Safety Science, 48*****(4), 478–481.**

Abstract: Military flight manuals contain three types of warnings; WARNING, CAUTION and NOTE messages convey personal injury or loss of life hazards, material damage hazards and essential information respectively. Effectiveness of these warning messages is crucial for flight safety. A way to enhance warning effectiveness is pairing warning messages with compatible symbols. However, no symbol was used with warning messages in current flight manuals. In this study, three pictorial symbols were designed for flight manual warnings. Comprehension and hazard perception of designed symbols were tested through matching test and psychometric rating, respectively, by Turkish military pilots. Results showed that comprehension and hazard perception of the symbols were sufficient and compatible with content of warning messages in flight manuals. It was concluded that accompanying warning messages with these symbols could contribute to effectiveness of flight manual warnings.

File, S.E., & Jew, A. (1973). Syntax and the recall of instructions in a realistic situation. *British Journal of Psychology, 64*(1), 65–70.

Abstract: Airline passengers were presented with emergency landing instructions, either visually or auditorily, and subgroups received instructions of different syntactical forms. Regardless of their original form, instructions were mainly recalled in the active affirmative. Significantly fewer instructions were recalled when they were in the negative than when they were in the affirmative, but the use of the passive, rather than the active, voice did not reduce the amount recalled.

Flight Safety Foundation. (1993, September-October). 'Hurry up' syndrome identified as causal factor in aviation safety accidents. *Flight Safety Foundation: Human Factors & Aviation Medicine, 40*(5), 1–5.

Summary: Research indicates that many incidents could have been prevented if the human factors elements of time pressure had been better understood.

Flight Safety Foundation. (2000a, August-December). *FSF ALAR briefing note: 1.1—Operating philosophy*. Retrieved from FSF website: http://flightsafety.org/files/alar_bn1-1-ops_philosophy.pdf

Summary: Adherence to standard operating procedures (SOPs) is an effective method of preventing approach-and-landing accidents (ALAs), including those involving controlled flight into terrain (CFIT). Crew resource management (CRM) is not effective without adherence to SOPs.

Flight Safety Foundation. (2000b, August-November). *Standard operating procedures template,* 6–9. Retrieved from FSF website: http://flightsafety.org/files/alar_bn1-1-ops_philosophy.pdf

Abstract: The following template is adapted from US. Federal Aviation Administration (FAA) Advisory Circular 12071, Standard Operating Procedures for Flight Deck Crewmembers. A manual or a section in a manual serving as the flight crews guide to standard operating procedures (SOPs) may serve also as a training guide. The content should be clear and comprehensive, without necessarily being lengthy. No template could include every topic that might apply unless it were constantly revised. Many topics involving special operating authority or new technology are absent from this template, among them extended-range twin-engine operations (ETOPS), precision runway monitor (PRM), surface movement guidance system (SMGS), required navigation performance (RNP) and many others." The document lists industry and FAA examples of topics that constitute a useful template for developing comprehensive, effective SOPs.

Flight Safety Foundation. (2005a, June). Flight crew procedures streamlines for smoke/fire/fumes. *Flight Safety Digest, 24*(6), 31–36.

Summary: Based on accident/incident research and discussions during international meetings, a philosophy and a checklist template aim to standardize and optimize responses to non-alerted smoke/fire/fumes events.

Flight Safety Foundation. (2005b, June). 'Paperless cockpit' promises advances in safety, efficiency. *Flight Safety Digest, 24*(6), 1–30.

Summary: Electronic flight bags are eliminating considerable paper from the flight deck while offering the flight crew a wide array of technological assistance. Nevertheless, these still-changing tools require more than casual understanding before flight crews can replace paper with electronics.

Flight Safety Foundation. (2009a). *FSF ALAR briefing note 1.2 - Automation* (Issue Brief No. 1.2). Alexandria, VA: Author.

Summary: For optimum use of automation, the following should be emphasized: understanding of AP/FD and A/THR modes integration (pairing); understanding of all mode-change sequences; understanding of the pilot-system interface: pilot-to-system communication (mode selection and target entries); and, system-to-pilot feedback (modes and target cross-check); awareness of available guidance (AP/FD and A/THR status, modes armed or engaged, active targets); and, alertness and willingness to revert to a lower level of automation or to hand flying/manual thrust control, if required.

Flight Safety Foundation. (2009b). *FSF approach and landing accident reduction toolkit briefing note: 1.1—Operating philosophy* (Issue Brief No. 1.1). Alexandria, VA: Author.

Summary: Deviations from SOPs occur for a variety of reasons; intentional deviations and inadvertent deviations from SOPs have been identified as causal factors in many ALAs. CRM is not effective without adherence to SOPs, because SOPs provide a standard reference for the crew's tasks on the flight deck. SOPs are effective only if they are clear and concise. Transition training provides the opportunity to establish the disciplined use of SOPs, and recurrent training offers the opportunity to reinforce that behavior."

Fucks, I., & Dien, Y. (2013). 'No rule, no use'? The effects of over-proceduralization. In M. Bourrier & C. Bieder, *Trapping safety into rules: How desirable or avoidable is proceduralization?* (pp. 27–38). Burlington, VT: Ashgate.

Abstract: After several decades, we are still confronted with a challenge: on the one hand, procedures are essential for safety and their role and number are increasing and, on the other hand, there are still fuzziness and implicit features related to them. In this chapter we tackle the role of procedures and some paradoxes surrounding procedures. We then focus on the side effect of the over-proceduralization, a phenomenon we call the 'no rule, no use'. This

side effect will be interpreted as a defensive behavior developed within organizations characterized by over-proceduralization, over-control practices and blame culture. This side effect will also be discussed within the context of high-risk organizations.

Funk, K. (2009). A methodology and tools for the prospective identification of NEXTGEN human factors issues. *Proceedings of the International Symposium of Aviation Psychology, Dayton, OH,* 106–111. Retrieved from: http://classes.engr.oregonstate.edu/mime/spring2009/ie548/Resources/NextGen.pdf

Abstract: The Human-Machine Systems Engineering Methodology (HMSEM) is a systematic method to prospectively identify relevant human fallibilities, potential errors, and general human factors issues in a complex, high-risk system, then develop design recommendations for remediations to counteract the fallibilities, avoid or mitigate the errors, and resolve the issues. HMSEM uses IDEF0 functional modeling, task analysis, human fallibilities analysis, and Failure Modes and Effects Analysis, organizing the information for and from the analyses in a workbook. The results of its application to several tasks on the NextGen flight deck suggest that it can be a valuable complement to other means to anticipate and resolve human factors issues in NextGen development.

Funk, K., Mauro, R., & Barshi, I. (2009). NextGen flight deck human factors issues. *Proceedings of the 15th International Symposium on Aviation Psychology*, *Dayton, OH,* 208–213. Retrieved from: http://web.engr.oregonstate.edu/~funkk/Publications/NextGenIssuesISAP2009.pdf

Abstract: This paper describes a project to compile, from a literature review and preliminary analyses, an initial but reasonably comprehensive list of NextGen flight deck human factors issues. It describes the methodology that was used, presents representative issues from the list that resulted, and makes recommendations to continue work to update the list and use it as the basis for suggested NextGen flight deck standards and design requirements.

Gasser, M., Boeke, J., Hatternan, M., & Tan, R. (2005). The influence of font type on information recall. *North American Journal of Psychology, 7*(2), 181–188.

Abstract: Previous research on reading has primarily focused on the cognitive and neurological aspects of learning to read and reading disabilities. In this study, the physical characteristics of the text itself were examined in an applied setting. Specifically, the influence of two common characteristics of font types (serif or san serif markings and proportional or monospacing) on recall of information was investigated. The participants were college students (N = 149). Each participant received a one page discussion of Tuberculosis, in the form of an office memorandum distributed in a healthcare facility, and was then tested on recall of the important points discussed in the memorandum. Serif fonts significantly improved recall of the information.

Giles, C.N. (2013). Modern airline pilots' quandary: Standard operating procedures - to comply or not to comply. *Journal of Aviation Technology and Engineering, 2*(2), 2–12.

*Abstrac*t: Modern airline pilots are tasked every flight with the safe and efficient operation of highly automated airliners in today's complicated global and economic environments. Airlines have developed standard operating procedures (SOP) for normal, abnormal, and emergency operations. These procedures serve as a script for crews to follow. These procedures are designed by airlines to ensure that aircraft are operated in the (1) most safe, (2) most efficient, and (3) most on-time manner. For the most part pilots will comply with SOP, but when they (1) don't agree with SOP, (2) don't understand SOP or the risks associated with not complying with SOP, or (3) don't feel adequately trained to know what SOP is, it is difficult to motivate them to comply. Airlines have the means to measure compliance through Flight Operations Quality Assurance (FOQA) and Line Operations Safety Audit (LOSA). The purpose of this research is to determine if increased understanding, knowledge and awareness of the risk of noncompliance with SOP increase airline pilots' compliance with SOP. This research explores data from line checks at a major US airline that was gathered in pursuit of understanding what drives SOP compliance. Baseline data was gathered and analyzed to determine the top 12 noncompliant items. The airline provided training during the Human Factors module in each pilots recurrent training on Pilot Intentional Non Compliance (PINC). The training including developing pilots' understanding that while most Aviation Safety Action Program (ASAP) reports grant pilots immunity from legal action, if a violation is labeled PINC, ASAP protections do not apply. Further line checks were conducted after the pilots received the PINC training. The top 12 noncompliant items from the pre-PINC training group were compared to the same 12 items in the post-PINC training group. Significant improvement in SOP compliance was found in six of the 12 items tested. The results established that training pilots on the risk of PINC did significantly increase SOP compliance.

Gross, R.L. (1995, May). Studies suggest methods for optimizing checklist design and crew performance. *Flight Safety Digest, 14*(5), 1–10.

Summary: Improved readability, color coding, listing steps in logical sequence, thoughtful indexing, convenient placement within the cockpit, attention to human factors and many other principles will help to ensure that checklists are used as intended.

Grote, G. (2009). Coordination in organizations: Creating flexible routines. In *Management of uncertainty: Theory and application in the design of systems and organizations* (pp. 57–74). London: Springer-Verlag.

Summary: In this chapter, coordination in organizations was discussed with the specific focus on rules and routines as a coordination mechanism. From a contingency perspective, the issue is to establish a balance between stability and flexibility by rules and routines that allow uncertainty to be coped with while at the same time, providing sufficient orientation to ease coordination demands. Based on newer research on organizational routines, it was argued that routines can be sufficiently flexible to support adaptation in unforeseen situations, especially when they are backed by flexible rules. Subsequently, some research on different types of rules and their relationship to coordination patterns and performance was

discussed, indicating the importance of a more sophisticated perspective on rules and standardization. Instead of only taking the amount of rules as an indication of more or less standardization, types of rules need to be studied. One way of distinguishing rule types is based on the level of action regulation targeted; that is, goal, process, or concrete action. An example of a rules analysis was presented which showed a mismatch between rule types, uncertainties to be handled and actors' competence profiles. Such analyses can serve as input into the redesign of rules aimed at creating flexible routines capable of absorbing uncertainty when needed. As part of a systematic rule management, different ways of managing uncertainties by means of different types of rules need to be explored, for which the decision process presented in Chapter 3 can provide some guidance. Furthermore, the process used for (re)designing rules has to be chosen, considering the participation of future rule users and the level of the organization at which decisions on rules are made. Finally, it was acknowledged that rule management will only be able to partially resolve the dilemma stemming from the contradictory requirements in non-routine situations of reducing demands on cognitive and organizational resources, while also increasing more resource-intensive behavioural flexibility and adaptability.

Grote, G., & Zala-Mezö, E. (2004). ***The effects of different forms of coordination in coping with workload: Cockpit versus operating theatre*** **(Report on the psychological part of the project). Retrieved from ETH Institutional Repository website: http://e-collection.library.ethz.ch/eserv/eth:27237/eth-27237-01.pdf**

Executive summary: There is a general understanding that rules and standards support safe operation in complex systems. At the same time, it is also known that high levels of standardization may impede flexible adaptation to changing demands. Comparing team coordination in the highly standardized setting of cockpits of commercial aircraft with coordination in anesthesia teams who operate with far fewer standards helps to understand the impact of rules on team performance. In order to analyze team coordination in these two settings, 42 cockpit crews were videotaped during a simulator training session, which required performing a so-called clean approach, i.e. a landing without flaps and slats, as well as 23 anesthesia teams performing anesthesia inductions. The behavior was coded based on four sets of categories, i.e. implicit vs. explicit coordination, leadership, and heedful interrelating. Hypotheses concerning the effects of different levels of standardization and task load were tested, derived from the general assumption that successful teams change between different coordination modes in accordance with changing situational demands. Contrary to our original assumptions, we found that anesthesia teams coordinated more implicitly than cockpit crews despite having fewer written rules guiding their behavior. Several reasons may account for this finding: cockpit crews have been trained much more to coordinate explicitly even in seemingly obvious situations in order to prevent over-reliance on common standards as basis for a common understanding of the situation and its demands; anesthesia teams share a common field of action and use cues provided by each other's actions much more for seamless coordination than pilots who operate in different visual fields; there are manifold unwritten rules in medicine which support a common understanding of the situation and the actions required. For the aviation data, a clear link between higher levels of explicit coordination and higher levels of performance could be established, which hints at the importance of backing up standards with a constant effort to reassure a common understanding of the situation and the relevance of the standards for the situation. A second set of analyses concerned patterns of coordination within each professional setting, comparing work phases with different degrees of standardization and task load. One important finding here was that personal leadership is only required in situations with few standards. In highly standardized situations, the standards act as a form of impersonal leadership, which does not require additional efforts of personal leadership. To the contrary, high levels of personal leadership in highly standardized situations appear to be related to worse team performance. The results help to improve both our theoretical understanding of adaptive coordination as well as practical measures taken to support teams in dealing with changing demands on team coordination. Especially in anesthesia more research is needed, though, to establish sounder links between coordination behavior and team performance than we were able to demonstrate. In a third set of analyses, the rules themselves were investigated by determining the level of action regulation they concerned: specifying a goal to be achieved vs. specifying the process to be followed to determine the correct course of action vs. specifying the course of action to be followed. In aviation, the vast majority of rules prescribed the course of action to be taken, while in medicine, more often the process to determine the correct course of action is specified. Considering the higher degrees of operational uncertainty contained in handling a patient as compared to flying an aircraft, the less specific rules in medicine seem appropriate. Such analyses may help to support a more systematic rules management taking into account an appropriate balance between guidance and scope of action.

Hale, J. (1990). Safety rules o.k.? Possibilities and limitations in behavioural safety strategies. *Journal of Occupational Accidents, 12,* 3–20.

Abstract: The paper considers the basis for the development and use of safety rules imposed by a company or national organisation. It starts from a consideration of individual behaviour and error in terms of cognitive psychological theory. This postulates that behaviour is governed by individual "production rules." Imposed safety rules are only needed where individuals' own rules are not sufficient to prevent accidents. From a classification of error types it is possible to derive a classification of types of safety rules and to speculate both upon the characteristics, which each type needs to have, and on how and where they need to be developed and applied. The paper is illustrated by examples from a number of activities at individual, company and national level.

Hale A., Borys D., & Else D. (2012). *Management of safety rules and procedures: A review of the literature* (Research Report 12.3). Retrieved from The Institute of Occupational Safety and Health website: www.iosh.co.uk/rulesandprocedures

Abstract: A review was conducted of the literature on the management of rules and procedures that affect safety, concentrating on rules at the workplace level. A literature search in the scientific and grey literature revealed 180 key references for study. The literature fell into two contrasting paradigms. The first is a relatively static, rationalist, top–down view of rules as the one best way of working, devised by experts distant from the workplace, imposed on operators as a way of constraining incorrect or inadequate behaviour, where violations are seen as aberrations to be suppressed. The second is a relatively dynamic, bottom–up view of rules as local, situated, socially constructed, devised by those at the sharp end, embodying their tacit knowledge from their experience of diverse reality. The report explores these two paradigms, the evidence from theory and field studies which supports or fills them out, and their consequences for procedure management. It proposes a model of procedure management that attempts to draw the lessons from both paradigms and combine their strong points. This is a nine-step dynamic cycle, driven by the central task of monitoring rule and procedure use in order to optimise it through a combination of learning and procedure modification, rule scrapping and rule enforcement. This framework forms the basis for the stand-alone 'Notes of guidance,' including a summary intervention plan to review and improve practice in organisations."

Hale, A.R., Heijer, T., & Koornneef, F. (2003). Management of safety rules: The case of railways. *Safety Science Monitor, 7*(1), 1–11. Retrieved from Safety Science Monitor website: http://ssmon.chb.kth.se/volumes/vol7/3-2.pdf

Abstract: Every technology and activity has safety rules, which are usually formulated explicitly, taught to those operating in the system and imposed on them. Safety rules also determine liability after accidents. Yet there is very little systematic scientific or management literature on how to devise and manage safety rules. This paper uses a simple framework to draw together what is known of good and bad practice in this area, particularly in deciding what rules should be explicitly formulated and imposed. It draws on the literature on violations, on rule learning and on organizational control. The paper concludes with a case study of safety rules in the railways, derived from a larger European study of safety rule management for railway operations. It shows that the nature of the system dynamics and the current communications within railway operations result in a largely open loop operation of the system. This makes it vulnerable to any form of deviation from strictly defined operations. Safety rules are part of the apparatus to render the behaviour of the various people in the system sufficiently predictable that this open-loop operation can succeed in a large proportion of situations. However this requires that adherence to rules is very strict and has great problems coping with any deviations, even those required to respond to situations, which cannot be dealt with following the existing rules. This requirement conflicts with much of the available literature on organisational control and high reliability organisations. However, the more interactive derivation of rules specific to the range of system conditions requires a far greater communication between system operators than the railway system currently requires. The room for manoeuvre in optimising safety rule use in railways is therefore currently limited."

Hale, A.R., & Swuste, P. (1998). Safety rules: procedural freedom or action constraint? *Safety Science, 29,* 163–177.

Abstract: The paper presents a partial classification of safety rules as constraints imposed from outside on the freedom of choice of individuals or companies. The classification is linked to the reason model of skill-, rule-, and knowledge-based behaviour. The imposition of constraints is related to a number of criteria concerning the context and use of the rules to arrive at proposals for when and where to apply what type of rule. To illustrate the principles discussed an example is given of the rule from the Dutch Working Environment legislation concerning the requirement to use "current state of the art in prevention" in companies. The paper proposes providing procedural rule support to companies on how to meet the rule, in the form of a data bank of practicable solutions to health and safety problems.

Herry, N. (1987). Errors in the execution of prescribed instructions: Design of process control work aids. In J. Rasmussen, K. Duncan, & J. Leplat (Eds), *New technology and human error* (pp. 239–245). Chichester, UK: Wiley.

Abstract: Errors in the execution of prescribed instructions are analysed in terms of deviations between the operator's action logic and the action logic of the designer of the instructions. These logics are characterized by the implementation of distinct properties of action organization; that of the operator being unsuitable to understand the bases of the instructions.

Heymann, M., Degani, A., & Barshi, I. (2007). Generating procedures and recovery sequences: A formal approach. *Proceedings of the 14th International Symposium of Aviation Psychology*, Dayton, Ohio, 252–257.

Abstract: This paper presents a formal approach for the analysis and development of effective, safe, and efficient procedures for abnormal and emergency situations. The focus is on methods for describing the behavior of the underlying machine, specification of desirable and unsafe regions of operation, and an algorithmic approach for computation of optimal action sequences. We discuss current gaps in procedure development and conclude with some of the challenges that lie ahead.

Hilton, B. (2012). *Comparing the effects of simulated, intelligent audible, checklists and analog checklists in simulated flight* (Doctoral dissertation, Western Michigan University). Retrieved from: http://scholarworks.wmich.edu/dissertations/109/

Abstract: This study examined the effect of using a simulated intelligent audible checklist in simulated flight as compared to a standard analog (paper) checklist. Participants were three Western Michigan University students in the College of Aviation. All participants were licensed pilots with instrument ratings. The main dependent variable was the number of checklist errors or omissions committed by the pilots in simulated flight. During each flight, each participant could make up to 42 errors. The error count would initiate at the appropriate time to perform the "before-takeoff checklist" and would end one minute after parking the plane, the logical time to complete an "after landing checklist." A multiple baseline design was implemented in this research with the treatment being implemented at a different point in time for each participant. Either stability in performance or a decrement in performance determined the introduction of the audible checklist. Once stability or a descending trend in paper checklist use had been established, each participant was placed in the intervention phase. During baseline phase the three participants averaged 22.7% compliance per flight. After the simulated audible intelligent checklist intervention was introduced compliance increased to 97%. During the reversal phase compliance decreased to an average of 34%. Visual inspection of the data suggests that an intelligent audible checklist used during actual flights may decrease in-flight errors and possibly decrease aviation incidents and accidents.

Jaynes, L.S., & Boles, D.B. (1990, October). The effect of symbols on warning compliance. *Proceedings of the Human Factors and Ergonomics Society Annual Meeting, Vol. 34, No. 14,* 984–987. Retrieved from Sage Journals website: http://journals.sagepub.com/doi/abs/10.1177/154193129003401405

Abstract: The present study investigated whether different warning designs, specifically those with symbols, affect compliance rates. Five conditions were tested: a verbal warning, a pictographs warning with a circle enclosing each graphic, a pictographs warning with a triangle on its vertex enclosing each graphic, a warning with both words and pictographs (triangular enclosures), and a control (no warning). Participants performed a chemistry laboratory task using a set of instructions that contained one of the five conditions. The warnings instructed them to wear safety goggles, mask and gloves. All four warning conditions had significantly greater compliance than the no-warning condition. The highest rate of compliance occurred with the verbal plus pictographs condition, although it did not differ significantly from the verbal condition. A significant main effect was found for the "presence of pictographs" variable, suggesting that the addition of pictographs to a verbal warning will increase compliance rates. The unexpected finding that the pictographs warning with triangular enclosures had significantly lower compliance means than the verbal warning may be due to the different types of message modes or design criteria used. The enclosure shape made no difference in compliance rates, despite research that indicates that unstable shapes are preferred as warning enclosures. The results suggest the importance of conducting behavioral studies rather than relying on preference data.

Johnston, N. (2003). The paradox of rules: Procedural drift in commercial aviation. In R. Jensen (Ed), *Proceedings of the Twelfth International Symposium on Aviation Psychology, April 14–17*, Dayton, Ohio.

Abstract: This paper considers the inescapable tendency for procedures and remedial rule-based interventions in organisations to "drift" in a fashion that is often inconsistent with the intentions of those responsible for original system design. Taking Snook's (2000) notion of Practical Drift as a point of departure, the paper discusses a range of examples from commercial aviation, with a view to establishing the potential implications for safe and efficient sociotechnical systems. The paper argues for a programme of research into the nature of such drift and its driving forces.

Jones, S. (1966). The effect of a negative qualifier in an instruction. *Journal of Verbal Learning and Verbal Behavior, 5*(5), 497–501.

Abstract: This study investigates the effect of using a qualifying negative—"except"—on performance of a task, for which an equivalent positive form of instruction was available. The hypothesis was tested that in a task requiring response to five out of every eight items, an instruction of the form "Respond to all except three items" would be less efficient, in terms of speed of performance, than would the positive form of instruction "Respond to five items." The results confirmed this hypothesis. Furthermore, the errors made on the three items, specified in the instruction containing "except," were significantly greater than those made on the five items specified in the positive form, despite the fact that the probability of making errors on the latter was greater. The difficulty of handling an instruction defined in terms of an

exclusion class appeared to be a consequence of having to search for one class of items and respond to another. However, in Exp. I the scanning procedures under the two forms of instruction were not identical, and a second experiment was carried out in which the number of items in both classes was the same. With the scanning process equated for both groups, any difference in performance could be attributed to the differing response requirements under the two forms of instruction. The results again showed a significantly slower rate of performance under the instruction containing "except," and are discussed in terms of a conflict engendered by opposing sets within the linguistic sequence of the instruction.

Kanki, B.G., & Seamster, T.L. (2003, February). ***Operating documents: From documents to data*****. Presented at the FAA Air Transportation Human Factors Research Review Meeting, Irvine, CA.**

Background: Original goals: Identify key issues in the development of operating documents/operational information; Assemble guidelines that will help operators develop operating documents/information systems; Incorporate examples of current approaches to resolving key issues.

Kanki, B.G., Seamster, T.L., Lopez, M., Thomas, R.J., & LeRoy, W.W. (2001). Design and use of operating documents. ***Proceedings of the 11th International Symposium on Aviation Psychology, Dayton, OH*****.**

Abstract: Operating documents, especially those used by crews in the cockpit, need to be compatible with regulations, aircraft systems, and, most importantly, the operational environment. In addition, operating documents must be internally consistent with the entire system of documents. There are many guidelines covering most aspects of document development. It is difficult for operators to use these guidelines in their current form, which is distributed across a number of reports and other publications. To correct this situation, representatives from many of the US operators have been involved in two workshops to identify their most important document development issues and to organize those issues in a way that is operationally meaningful. Results from the workshops are being used to assess existing guidelines and reorganize them into a manual for operators. One group of results indicates differences in priorities among the three different types of operations involved in these workshops: 1) Majors, 2) Regionals, and 3) Cargo. A second set of results identifies the most important guideline issues. These results provide a detailed outline for organizing operating document guidelines according to five primary issues: 1) organization of documents, 2) standardization of documents, 3) usability of documents, 4) document development process, and 5) transition to electronic media. Additional results from these workshops have shown the importance of using examples to illustrate issues and to demonstrate the application of specific guidelines. Collectively, the results highlight the main document development issues and show how guidelines should be organized and presented in order to help carriers address those issues.

La Cruz-Guerra, D., & Cruz-Gomez, M.J. (2002). Using operating and safety limits to create safety procedures. *Process Safety Progress, 21*(2), 115–118.

Abstract: In this paper, the criteria for the development, implementation, and control of operating and safety limits of parameters like pressure, temperature, level, composition, etc., are described. Operating and safety limits are required by Elements 2 "process safety information" and 4 "operating procedures" of the information package for OSHA Process Safety Management (PSM). A brief description is also given of how these limits should be established and the information, with respect to consequences, safeguards, and corrective actions that should be obtained during a detailed analysis of deviation from an operation or process parameter. This paper looks for an easier method of developing operating and safety limits within chemical and petrochemical plants to prevent and control undesirable events (human losses, material losses, economic losses, or environmental pollution) through adequate emergency plans and response programs.

Landry, S. J., Jacko, J. A., & Coulter, W. H. (2006). Impact of the use of techniques and situation awareness on pilots' procedure compliance. *Proceedings of the Human Factors and Ergonomics Society Annual Meeting 50th*, 40–44. Retrieved from Sage Journals website: http://journals.sagepub.com/doi/abs/10.1177/154193120605000109

Abstract: In two empirical studies using desktop flight simulators, pilots were monitored while following procedures. In both experiments, pilots demonstrated a high degree of reliance on rule-based heuristics for following procedures (techniques), rather than on the procedures themselves. This was true regardless of the resulting compliance with the procedure. Changes to the procedure and changes to the content of displayed information had no effect on the use of techniques. In addition, frequent instances of noncompliance to procedure were recorded. The most common types of noncompliance, technical failures in implementing the procedure, were found to be nearly all-innocuous, while failures related to a lack of situation awareness comprised the bulk of unsafe instances of noncompliance. Also found were a number of instances of noncompliance, which actually enhanced the safety of the procedure. The results have implications for the design of procedures and for automated aids for procedure following.

Latorella, K.A., & Drury, C.G. (1992). A framework for human reliability in aircraft inspection. *Proceedings of the Seventh Federal Aviation Administration Meeting on Human Factors Issues in Aircraft Maintenance and Inspection: Science, technology, and management: A program review,* 71–82. Washington, DC: Federal Aviation Administration/Office of Aviation Medicine.

Abstract: ...a framework has been provided for the classifications and control of human error in aircraft inspection. The proposed system model of aircraft inspection and maintenance recognizes the fact that the interaction of the task with the human and the environment is the basis of most human errors. Thus an attempt is made to shift the attention from the task to these interactions. Based on the system models, the S-R-K framework of Rasmussen (1983) and the systemic error categories of Rasmussen and Vicente (1989), a methodology for identifying intervention strategies has been proposed.

Laughery, K. R., & Wogalter, M. S. (2006). Designing effective warnings. *Reviews of Human Factors and Ergonomics, 2*(1), 241–271.

Abstract: Since the early 1980s there has been an increased interest in research on warnings. This chapter has several objectives. First, we describe the purpose of warnings and where warnings fit with other safety considerations, such as design and guarding. Next, we present a model that incorporates both communication and information-processing concepts, which is characteristic of theoretical orientations that have guided much of the warning research. The research and application issues have generally focused on two themes: design factors and non-design factors that influence warning effectiveness. Third, we review the progress and status of research and application, with an emphasis on identifying those factors that appear to be most important in determining warning effectiveness. Finally, we conclude with a discussion of some of the challenges and opportunities facing warning designers and researchers in the future.

Lawton, R. (1998). Not working to rule: Understanding procedural violations at work. *Safety Science, 28*(2), 77–95.

Abstract: This paper begins by presenting a brief synopsis of the literature regarding the relationship between rule violations and accidents. The paper goes on to report a study of UK railway shunters' motives for rule violations. Violations are defined as behaviours that involve deliberate deviations from the written rules. Preliminary investigation elicited the motives to be included in the main questionnaire survey, which required 36 shunters to rate the importance of various motives for violating. Generally, violations were perceived to be the result of a well-intentioned desire to get the job done. Together with previous analysis of shunting accidents, observations of, and discussions with shunters in the workplace, the results of this study were used to develop a classification of violations, which includes situational, exceptional and routine violations. Erroneous behaviours that also involved deviations from rules were recorded as a separate category, namely unintentional violations. The results of the study, together with the findings of other research in this area, are used to describe a model for the investigation of violating behaviour in an organizational setting. This model depicts the factors that promote violations at work and, as such, may aid managers and health and safety practitioners to develop appropriate preventative measures.

Layton, C. F. (1992). Emerging technologies for maintenance job aids. *Proceedings of the Seventh Federal Aviation Administration Meeting on Human Factors Issues in Aircraft Maintenance and Inspection: Science, Technology, and Management: A Program Review,* 107–124. Washington, DC: Federal Aviation Administration/Office of Aviation Medicine. Retrieved from FAA website: http://www.faa.gov/about/initiatives/maintenance_hf/library/documents/media/mx_faa_%28formerly_hfskyway%29/human_factors_issues/meeting_7/emergingtechnologies.pdf

Abstract: Maintenance is fast becoming one of the most frequent applications of computer-based job aiding. Maintenance job aids range from automatic preventive maintenance schedulers, to systems that monitor equipment status and recommend maintenance, to systems that aid in fault diagnosis and repair. Application domains range from production equipment (e.g., clutch assembly machines), to process equipment (e.g., turbine generators),

to high technology specialized equipment (e.g., fighter aircraft). There is a range of methodologies employed, including algorithmic approaches for preventive maintenance schedulers to expert systems for fault diagnosis and repair. The technologies employed encompass a range from mini computers to desktop microcomputers linked to video disks. This paper addresses extant approaches to job aiding in maintenance, the prospects for using emerging technologies for such systems, and the impact of emerging technologies on human performance, particularly in aviation maintenance applications. It also calls for a new design philosophy in building job aids. A study, which used this philosophy and compared three different levels of aiding on a task is also discussed. Some of the results of the study and their applicability to maintenance job aids are presented.

Lindvall, J. (2011). ***Aeronautical decision-making in context: Influence of affect and experience on procedure violations*** **(Doctoral dissertation, Department of Psychology, University of Gothenburg, Sweden). Retrieved from:** **https://gupea.ub.gu.se/bitstream/2077/27956/4/gupea_2077_27956_4.pdf**

Abstract: Although pilots are well trained and there are rules, models and standard operating procedures to use in decision-making situations, aviation accidents do occur. One reason why accidents may occur is because pilots sometimes decide to violate, or deviate from standard operating procedures. The overall aim of the present thesis was to explore possible reasons for violating behavior. In Study I and II, cognitive and affective processes were studied in experimental designs. Study I took place in a laboratory setting where non-pilots made a choice between a sure or uncertain loss. Study II took place in naturalistic settings were car drivers and commercial airline pilots made a choice between either, comply with or violate a rule. In Study I and II participants made the choice either after reading or experience a probability distribution. The conditions were either affect-rich or affect-poor in both studies. Some support was found for underweighting of small probabilities in Study I replicating Hertwig, Baron, Weber and Erev (2004). Overall, the affect rich condition in Study I produced more random choices compared to the affect poor condition. However, no effect of probability presentation format or affect was found in the naturalistic settings of Study II. Data for Study III and IV were collected in connection with Study II. In Study III, other possible reasons for violating procedures among airline pilots were added, such as organizational, social, and individual factors. The result of Study III showed differences between violators and compliers in terms of subjective risk judgment, attitudes and, reasons for violation. In addition, it was found that the majority used experience-based decision-making. In Study IV focused turned towards individual differences in decision-making style, non-technical skills, and overconfidence as possible antecedents to violations. Decision-making styles were measured with the GDMS inventory (Scott & Bruce, 1995). Non-technical skills were measured with the NOTECHS system (Flin et al., 2005). Pilots were found to have a predominantly rational decision-making style. A relation between decision-making style and procedure violation was found were violators are less rational and more spontaneous compared to compliers. The result showed that not all NOTECHS items correlated with the decision-making styles in the expected direction. Furthermore, overconfidence about own non-technical skills were related to procedure violation. The results of Studies I-IV demonstrate that underweighting of probabilities might exist in a laboratory setting and that affect cannot be ignored. However, probabilities were not automatically used when people made decisions about whether to follow a rule or not, in naturalistic settings. Instead organizational, social, and individual factors were more important. The NOTECHS system may be thought of as reflecting systematic, analytic and normatively correct decision-making. The result from Study IV show that this is not always the case and that there might be reason to further develop the NOTECHS system. In conclusion: to take safety a step further and create a resilient system it is necessary to take both an individual and systemic viewpoint, and to acknowledge that these viewpoints may interact."

Lorch, R.F., & Chen, A.H. (1986). Effects of number signals on reading and recall. *Journal of Educational Psychology, 78*(4), 263.

Abstract: In this study, we investigated the effects of number signals on text recall, College-age subjects (N = 120) read and recalled two texts containing 10 target sentences each. Reading times were recorded for each target sentence. For half of the subjects, the target sentences were preceded by numbers indicating their organization; for the other half, the target sentences were not signaled. Half of the subjects did a free-recall task, whereas half did a cued recall task. Subjects read target sentences more slowly if they were signaled than if they were unsignaled. Subjects' recalls of target information followed the text organization more closely if the sentences were signaled. Finally, signaling aided free recall of target sentences but had no effect on cued recall. The results demonstrated that number signals directed attention to the sentences they marked, led to better encoding of the organization of target information, and influenced the process of recalling the target information.

Loukopoulos, L.D., Dismukes, R.K., & Barshi, I. (2009). *The multitasking myth: Handling complexity in real-world operations.* Burlington, VT: Ashgate.

Abstract: Despite growing concern with the effects of concurrent task demands on human performance, and research demonstrating that these demands are associated with vulnerability to error, so far there has been only limited research into the nature and range of concurrent task demands in real-world settings. This book presents a set of NASA studies that characterize the nature of concurrent task demands confronting airline flight crews in routine operations, as opposed to emergency situations. The authors analyze these demands in light of what is known about cognitive processes, particularly those of attention and memory, with the focus upon inadvertent omissions of intended actions by skilled pilots. The studies reported within the book employed several distinct but complementary methods: ethnographic observations, analysis of incident reports submitted by pilots, and cognitive task analysis. They showed that concurrent task management comprises a set of issues distinct from (though related to) mental workload, an area that has been studied extensively by human factors researchers for more than 30 years. This book will be of direct relevance to aviation psychologists and to those involved in aviation training and operations. It will also interest individuals in any domain that involves concurrent task demands, for example the work of emergency room medical teams. Furthermore, the countermeasures presented in the final chapter to reduce vulnerability to errors associated with concurrent task demands can readily be adapted to work in diverse domains.

Lupton, L.R., Lipsett, J.J., Olmstead, R.A., & Davey, E.C. (1990, July). ***A foundation for allocating control functions to humans and machine in future CANDU nuclear power plants*****. Paper presented at the International Symposium on Balancing Automation and Human Action in Nuclear Power Plants, Munich, Germany. Retrieved from International Atomic Energy Agency website: http://www.iaea.org/inis/collection/NCLCollectionStore/_Public/23/002/23002192.pdf**

Abstract: Since the control room for the Atomic Energy of Canada Limited CANDU 6 plant was designed in the 1970s, requirements for control rooms have changed dramatically as a result of new licensing requirements, evolution of major new standards for control centre design and technological advances. The role of the human operator has become prominent in the design and operation of industrial and, in particular, nuclear plants. Major industrial accidents in the last decade have highlighted the need for paying significantly more attention to the requirements of the human as an integral part of the plant control system. A Functional Design Methodology has been defined that addresses the issues related to maximizing the strengths of the human and the machine in the next generation of CANDU plants. This method is based, in part, on the recently issued international standard IEC 964. The application of this method will lead to the definition of the requirements for detailed design of the control room, including man-machine interfaces, preliminary operating procedures, staffing and training. Further, it provides a basis for the verification and validation of the allocation of functions to the operator and the machine."

Mauro, R., Barshi, I., & Pederson, S. (2001). Affect, experience, & aeronautical decision-making. ***Proceedings of the 11th International Symposium on Aviation Psychology, Ohio State University.***

Description: To examine how individual differences in cognitive and affective processes interact with differences in training, experience, and decision strategy we observed how 431 pilots made decisions related to a simulated flight in a General Aviation (GA) aircraft. The research was conducted remotely over the Internet using the newly developed Internet Based Decision Research System. The time the pilots spent accessing different sources of information related to the flight and the order in which this information was accessed was related to measures of affective and cognitive processing, training, and experience.

Mauro, R., Degani, A., Loukopoulos, L., & Barshi, I. (2012). The operational context of procedures and checklists in commercial aviation. ***Proceedings of the 56th Annual Meeting of the Human Factors and Ergonomics Society*****, 758–762. Retrieved from: http://journals.sagepub.com/doi/pdf/10.1177/1071181312561158**

Abstract: To design effective and efficient procedures and checklists, one must take into account the full operational context within which these procedures are embedded. This context is defined by the requirements of the technology, the limitations and capabilities of the human operators, and the constraints and affordances of the operational environment. The complexity of this context arises from the interactions of the human, machine, and environment. We present a model of that operational context, THE Model, that lays the foundations for analyzing each of these elements and their interactions, and illustrate its application through the analysis of an aviation accident.

Moore, C.J. (1991). Cross references in step-by-step procedures: uses, usability problems, and possible solutions. *Professional Communication Conference, 1991. IPCC '91 Proceedings. The Engineered Communication. International (Vol. 1),* 369–374. Retrieved from 10.1109/IPCC.1991.172808

Abstract: Cross-references, a form of nonlinear information common in some procedures, can create substantial usability problems in procedures. These usability problems can be reduced by minimizing the use of cross references, formatting cross references effectively, and incorporating place keeping aids in documents that contain cross references.

Moret-Tatay, C., & Perea, M. (2011). Do serifs provide an advantage in the recognition of written words? *Journal of Cognitive Psychology, 23*(5), 619–624.

Abstract: A neglected issue in the literature on visual-word recognition is the careful examination of parameters such as font, size, or interletter/interword spacing on reading times. Here we analysed whether serifs (i.e., the small features at the end of strokes) play a role in lexical access. Traditionally, serif fonts have been considered easier to read than sans serif fonts, but prior empirical evidence is scarce and inconclusive. Here we conducted a lexical decision experiment (i.e., a word/nonword discrimination task) in which we compared words from the same family (Lucida) either with a serif font or with a sans serif font - in both block list and a mixed list. Results showed a small, but significant advantage in response times for words written in a sans serif font. Thus, sans serif fonts should be the preferred choice for text in computer screens - as already is the case for guide signs on roads, trains, etc.

Mosier, K.L., Palmer, E.A., & Degani, A. (1992). Electronic checklists: Implications for decision making. *Proceedings of the 36th Annual Meeting of the Human Factors Society. Santa Monica, CA,* 7–11. doi: 10.1177/154193129203600104. Retrieved from SAGE website: http://pro.sagepub.com/content/36/1/7.full.pdf+html

Abstract: Checklists are a way of life on the flight deck, and, undoubtedly, are indispensable decision aids due to the volume of technical knowledge that must be readily accessible. The improper use of checklists, however, has been cited as a factor in several recent aircraft accidents (National Transportation Safety Board, 1988, 1989, 1990). Solutions to checklist problems, including the creation of electronic checklist systems, which keep track of skipped items, may solve some problems but create others. In this paper, results from a simulation involving an engine shutdown are presented, and implications of the electronic checklist and "memory" checklist are discussed, in terms of potential errors and effects on decision-making. Performance using two types of electronic checklist systems is compared with performance using the traditional paper checklist. Additionally, a "performing from memory" condition is compared with a "performing from the checklist" condition. Results suggest that making checklist procedures more automatic, either by asking crews to accomplish steps from memory, or by checklists that encourage crews to rely on system state *as indicated by the checklist*, rather than as indicated by the system itself, will discourage information gathering, and may lead to dangerous operational errors.

Norman, D.A. (2005, July/August). Human-centered design considered harmful. *Interactions*, *12*(4), 14–19.

Abstract: Human-centered design has become such a dominant theme in design that it is now accepted by interface and application designers automatically, without thought, let alone criticism. That's a dangerous state—when things are treated as accepted wisdom. The purpose of this essay is to provoke thought, discussion, and reconsideration of some of the fundamental principles of human-centered design. These principles, I suggest, can be helpful, misleading, or wrong. At times, they might even be harmful. Activity-centered design might be superior.

Novick, D., & Chater, M. (1999, September). Evaluating the design of human-machine cooperation: The cognitive walkthrough for operating procedures. *Proceedings of the Conference on Cognitive Science Approaches to Process Control, Villeneuve d'Ascq, FR*. Retrieved from University of Texas at El Paso Computer Science website: http://www.cs.utep.edu/novick/papers/cw-op.csapc99.html

Abstract: The methodology of development of interfaces can be adapted to development of operating procedures. In particular, the cognitive walkthrough can be adapted to account for steps and resources outside the computer's part of the system interface. Empirical evaluation suggests that a cognitive walkthrough for operating procedures (CW-OP) is reasonably efficient and can provide useful information for developers.

Ockerman, J. (2007). Task-guidance systems and procedure context: Enabling procedures to enhance worker performance. In D. Alamargot, P. Terrier, & J.M. Cellier (Eds.), *Studies in writing: Written documents in the workplace* (pp. 217–230). Amsterdam: Elsevier.

Abstract: In work practice, the term "procedure" almost always refers to a written document. Procedures are an integral part of many work environments. They provide a structured and tested method of completing an often-complicated task. With the miniaturization of highly capable technology, it is possible to provide procedures on small, easily transported electronic devices that have been defined as task-guidance systems. Task-guidance systems have been shown to be feasible and effective, but care needs to be taken in their design to ensure this outcome. Procedure context has been suggested as one important component of well-designed procedures, and has also been shown to positively impact worker performance when presented to the worker, either in a task-guidance system or other format. This chapter provides a background on the use of procedures, a description of task-guidance systems, and an explanation of procedure context, including results of some empirical investigations into their efficacy.

Ockerman, J., & Pritchett, A. (2000). A review and reappraisal of task guidance: Aiding workers in procedure following. ***International Journal of Cognitive Ergonomics, 4*****(3), 191–212.**

Abstract: Procedures can greatly benefit workers at tasks such as inspection, maintenance, and assembly. Procedures may serve as a guideline for expert workers or they may provide a list of directives to be followed exactly; either way, procedures serve to structure a task, to aid worker memory, and to guarantee consistency and safety. Light, inexpensive electronics may allow for the development of task guidance systems to further help workers by presenting procedures and associated information about the task. This article reviews the current state of knowledge about the development of task guidance systems, and highlights their potential value in a variety of domains. First, the characteristics of procedural tasks are discussed, as a basis for a discussion on the benefits of procedure following that task guidance systems can support, and potential problems in procedure following that task guidance systems can mitigate. Then, current research results in task guidance systems are summarized. Finally, a discussion is given on the contextual information that a task guidance system may need to provide.

Olson, D.R., & Filby, N. (1972). On the comprehension of active and passive sentences. ***Cognitive Psychology, 3*****(3), 361–381.**

Abstract: In a series of five experiments the ease of processing active and passive sentences was shown to be a function of the prior coding of a perceptual event. When the event was coded in terms of the actor, active sentences were more easily verified, when the event was coded in terms of the receiver of the action, passive sentences were more easily verified. This same pattern was shown to hold for answering active and passive questions. From this it was inferred that a passive sentence can be comprehended directly in the logical object-verb-logical subject word order without recovering its active sentence equivalent base structure. A processing model for the verification of active and passive sentences was proposed in terms of a series of binary comparison operations each of which requires additional time; this model was shown to account for about 90% of the variance in the time Ss required to verify these sentences.

Orasanu, J., Mosier, K., & Fischer, U. (2012). ***Recommended updates to FAA Advisory Circular No. 120-51E on crew resource management*** **(Report #4). FAA/NASA NextGen Flight Deck Human Factors Research Interagency Agreement #DTFAWA-10-X-80005, Annex 9. Unpublished report.**

Annotation: Researcher recommendations regarding the following topics: system awareness and interaction with automation, changing expertise, crew communication in NextGen, erosion of skills, stress and fatigue effects on crew decision making, and team biases and decision making. This document provides useful recommendations that apply to the current AC120-51E (1/22/04).

Palmer, E.A., and Degani, A. (1991). Electronic checklist: Evaluation of two levels of automation. *Proceedings of the Sixth International Symposium on Aviation Psychology,* 178–183. Columbus, OH: Ohio State University.

Abstract: Two versions of an electronic checklist have been implemented in the Advanced Concepts Flight Simulator (ACFS) at NASA Ames Research Center. The two designs differ in the degree of pilot involvement in conducting the checklists. One version (manual-sensed), requires the crew to manually acknowledge the completion of each checklist item. The other version (automatic-sensed), automatically indicates completed items without requiring pilot acknowledgement. These two designs and a paper checklist (as a control condition) were evaluated in line-oriented simulation. Twelve aircrews from one major air carrier flew a routine, four-leg, short-haul trip. This paper presents and discusses the portion of the experiment that was concerned with measuring the effect of the degree of automation on the crews' performance. It discusses and presents evidence for a potential down side of implementing an electronic checklist that is designed to provide fully redundant monitoring of human procedure execution and monitoring.

Park, J., & Jung, W. (2003). The operators' non-compliance behavior to conduct emergency operating procedures—Comparing with the work experience and the complexity of procedural steps. *Journal of the Korean Nuclear Society, 35(*5), 412–425.

Abstract: According to the results of related studies, one of the typical factors related to procedure related human errors is the complexity of procedures. This means that comparing the change of the operators' behavior with respect to the complexity of procedures may be meaningful in clarifying the reasons for the operators' non-compliance behavior. In this study, to obtain data related to the operators' non-compliance behavior, emergency training records were collected using a full scope simulator. And three types of the operators' behavior (such as strict adherence, skipping redundant actions and modifying action sequences) observed from the collected emergency training records were compared with the complexity of the procedural steps. As the results, two remarkable relationships are obtained. They are: 1) the operators seem to frequently adopt non-compliance behavior to conduct the procedural steps that have an intermediate procedural complexity, 2) the operators seems to accommodate their non-compliance behavior to the complexity of the procedural steps. Therefore, it is expected that these relationships can be used as meaningful clues not only to scrutinize the reason for non-compliance behavior but also to suggest appropriate remedies for the reduction of non-compliance behavior that can result in procedure related human error.

Park, J., Jung, W., & Ha, J. (2001). Development of the step complexity measure for emergency operating procedures using entropy concepts. *Reliability Engineering & System Safety, 71*(2), 115–130.

Abstract: For a nuclear power plant (NPP), symptom-based emergency operating procedures (EOPs) have been adopted to enhance the safety of NPPs through reduction of operators' workload under emergency conditions. Symptom-based EOPs, however, could place a workload on operators because they have to not only identify related symptoms, but also understand the context of steps that should be carried out. Therefore, many qualitative checklists are suggested to ensure the appropriateness of steps included in EOPs. However, since these qualitative evaluations have some drawbacks, a quantitative measure that can roughly estimate the complexity of EOP steps is imperative to compensate for them. In this paper, a method to evaluate the complexity of an EOP step is developed based on entropy measures that have been used in software engineering. Based on these, step complexity (SC) measure that can evaluate SC from various viewpoints (such as the amount of information/operators' actions included in each EOP step, and the logic structure of each EOP step) was developed. To verify the suitableness of the SC measure, estimated SC values are compared with subjective task load scores obtained from the NASA TLX (task load index) method and step performance time obtained from a full scope simulator. From these comparisons, it was observed that estimated SC values generally agree with the NASA-TLX scores and step performance time data. Thus, it could be concluded that the developed SC measure would be considered for evaluating SC of an EOP step.

Park, J., Jung, W., Kim, J., Ha, J., & Shin, Y. (2001). The step complexity measure for emergency operating procedures—comparing with simulation data. *Reliability Engineering & System Safety, 74(*1), 63–74.

Abstract: In complex systems, such as nuclear power plants (NPPs) or airplane control systems, human errors play a major role in many accidents. Therefore, to prevent occurrences of accidents or to ensure system safety, extensive effort has been made to identify significant factors that cause human errors. According to related studies, written manuals or operating procedures are revealed as one of the most important factors, and complexity or understandability of a procedure is pointed out as one of the major reasons that make procedure-related human errors. Many qualitative checklists are suggested to evaluate emergency operating procedures (EOPs) of NPPs. However, since qualitative evaluations using checklists have some drawbacks, a quantitative measure that can quantify the complexity of EOPs is imperative to compensate for them. In order to quantify the complexity of EOPs, Park et al. suggested the step complexity (SC) measure to quantify the complexity of a step included in EOPs. In this paper, to ensure the appropriateness of the SC measure, SC scores are compared with averaged step performance time data obtained from emergency training records. The total number of available records is 36, and training scenarios are the loss of coolant accident and the excess steam dump event. The number of scenario is 18 each. From these emergency training records, step performance time data for 39 steps are retrieved, and they are compared with estimated SC scores of them. In addition, several questions that are needed to clarify the appropriateness of the SC measure are also discussed. As a result, it was observed that estimated SC scores and step performance time data have a statistically meaningful correlation. Thus, it can be concluded that the SC measure can quantify the complexity of steps included in EOPs.

Parker, J.F., & White, A.D. (1992). Maintenance 2000. *Proceedings of the Sixth Meeting on Human Factors Issues in Aircraft Maintenance and Inspection*, Alexandria, VA. Retrieved from FAA website: https://www.faa.gov/about/initiatives/maintenance_hf/library/documents/media/human_factors_maintenance/maintenance_2000.pdf

Executive Summary: The Federal Aviation Administration (FAA) program on Human Factors in Aviation Maintenance includes support of a series of meetings addressing specific topics of interest in air carrier maintenance. The purpose of this two-day meeting, held in January 1992, was to consider maintenance support for the air carrier industry a decade from now, to identify problems likely to exist at that time, and to begin planning toward solutions for these problems. The meeting was attended by representatives of all segments within the air carrier industry, including airline operators, manufacturers, maintenance managers, union representatives, regulators, and scientists and engineers working on new technologies of possible applicability. Presentations reviewed problems facing the air carrier maintenance industry at this time and trends likely to affect these problems in coming years. Other presentations reviewed information management technologies which are just becoming available and which might be employed to advantage as the industry works toward solutions in the coming decade. Specifically, the goal of the meeting, as supported by these presentations, was to ensure that over the next ten years the industry could achieve: continuing improvement in the quality and effectiveness of air carrier maintenance, productive and efficient utilization of maintenance personnel, incorporation of new technologies beneficial to the air carrier maintenance industry, and adherence to rigorous cost control procedures. Based on presentations given and ensuing discussions, recommendations are presented.

Parsons, S.O., Seminara, J.L., & Wogalter, M. S. (1999). A summary of warnings research. *Ergonomics in Design: The Quarterly of Human Factors Applications, 7*(1), 21–31.

Abstract: Over the past decade and a half, a tremendous volume of research has accumulated in the area of warnings and risk perception. We have learned a great deal about the factors that influence safety-related information processing and behavior. Guidelines for warning design no longer need to be based on expert opinion; they can now be supported by the results of empirical research. This article reviews and summarizes data from more than 150 laboratory and field studies published mainly in the last 15 years and mostly in the Proceedings of the Human Factors and Ergonomics Society Annual Meeting (HFES). A broad overview of research findings is presented in 24 alphabetized sections. Although we do not explicitly give design recommendations, these studies contain implicit design guidelines. The summaries reflect our current knowledge on the factors that influence warning effectiveness. We believe this review will be useful to human factors designers and consultants who produce and evaluate warnings. Additionally, it can serve as a handy reference guide that could be useful to government regulators, industry managers, consumer product organizations, industrial hygienists, marketers, researchers, expert witnesses, and attorneys who need guidance on warnings. As is common in many kinds of active research activities, the results of studies on any given topic will not concur with other study results. Despite this, we try to give general conclusions in our summaries. Further research will bring more detail and clarity to the field. The major findings are given below in alphabetical order.

Pélegrin, C. (2013). The never-ending story of proceduralization in aviation. In M. Bourrier & C. Bieder, *Trapping safety into rules: How desirable or avoidable is proceduralization?* (pp. 13–24). Burlington, VT: Ashgate.

Summary: The aviation answer to internalization is proceduralization. The aviation answer to the increasing complexity of organizations has also been proceduralization. We have seen that high proceduralization does not guarantee safety.

Rantz, W.G. (2005). Strategies for controlling checklist behaviors: A literature review. *Proceedings of the 13th International Symposium on Aviation Psychology,* 497–503. Columbus, OH: The Ohio State University.

Abstract: One of the highest frequencies of errors recorded by recent Line Oriented Safety Audits (LOSA) is within the category of intentional non-compliance of which checklists use is included. These errors have led to serious lapses in risk management and many well-documented cases of aircraft accidents. This paper reviews the literature of both organizational behavior management and applied behavior analysis where checklist use is an independent variable. This report presents various methods and technologies from other settings, which may prove useful in the flight-training environment. Also included is a proposed study that will be conducted at a major flight training facility using undergraduate participants involved in checklist use while undergoing instrument flight training. This study applies various treatments to the participants to measure the effectiveness of checklist reading behavior and performance. Measures examine both, short term and long-term effects of treatment, as well as any generalization of checklist reading performance to more advanced training environments.

Rantz, W.G. (2009). *Comparing the accuracy of performing digital and paper and pencil checklists using a feedback package during normal workload conditions in simulated flight* (Doctoral dissertation). Western Michigan University: Michigan.

Abstract: This study examined whether pilots completed airplane digital or paper checklists more accurately when they received post-flight graphic and verbal feedback. Participants were 6 college student pilots with instrument rating. The task consisted of flying flight patterns using a Frasca 241 Flight Training Device, which emulates a Cirrus SR20 aircraft. The main dependent variable was the number of checklist items completed correctly per flight. An alternating treatment, multiple baseline design across pairs with reversal, was used. During baseline, the average percent of correctly completed items per flight varied considerably across participants, ranging from 13% to 57% for traditional paper checklists and ranging from 11% to 67% for digital checklists. Checklist performance increased to an average of 90% for paper checklist and an average of 89% for digital checklists after participants were given feedback and praise, and continued to improve to an average of nearly 100% for paper checklists and an average of 99% for digital checklists after the feedback and praise were removed. A slight decrement in performance was observed during a post-experiment probe between 60–90 days. Visual inspection and statistical analysis of the data suggest that paper checklist accuracy does not differ significantly from digital checklist accuracy. The results suggest that graphic feedback and praise can be used to increase the extent to which pilots use both digital and paper checklists accurately during normal workload conditions.

Rantz, W.G. (2010). Using graphic feedback to eliminate checklist segment timing errors. *Journal of Aviation/Aerospace Education & Research, 20*(1), 23–40. Retrieved from: http://commons.erau.edu/jaaer/vol20/iss1/8

Abstract: This study examined whether pilots initiated paper or digital checklist use from environmental prompts accurately when they receive post-flight graphic and limited verbal feedback. Participants were 6 college students who are pilots with instrument rating. The task consisted of flying a designated flight pattern using a Frasca 241 Cirrus Flight Training Device. The dependent variable was the percentage of paper and digital checklist segments initiated at the proper time. A single-subject, alternating treatment, multiple baseline design with withdrawal and delayed probes was employed in this study. During baseline, participants were given only post-flight technical skills feedback. During intervention, participants were given both technical skills feedback and post-flight graphic feedback on both paper and digital checklist use and praise for improvements. A probe was used between 60-90 days to assess any decrement in participant's performance. The intervention produced highly improved paper and digital checklist timing performance, which improved to nearly perfect following the withdrawal of treatment and increased to perfect performance through the probe sessions.

Rantz, W.G., Dickinson, A. M., Sinclair, G.A., & Van Houten, R. (2009). The effect of feedback on the accuracy of checklist completion during instrument flight training. *Journal of Applied Behavior Analysis, 42*(3), 497–509.

Abstract: This study examined whether pilots completed airplane checklists more accurately when they receive post flight graphic and verbal feedback. Participants were 8 college students who are pilots with an instrument rating. The task consisted of flying a designated flight pattern using a personal computer aviation-training device (PCATD). The dependent variables were the number of checklist items completed correctly. A multiple baseline design across pairs of participants with withdrawal of treatment was employed in this study. During baseline, participants were given post flight technical feedback. During intervention, participants were given post flight graphic feedback on checklist use and praise for improvements along with technical feedback. The intervention produced near perfect checklist performance, which was maintained following a return to the baseline conditions.

Rantz, W.G., & Van Houten, R. (2011). A feedback intervention to increase digital and paper checklist performance in technically advanced aircraft simulation. *Journal of Applied Behavior Analysis, 44*(1), 145–150.

Abstract: This study examined whether pilots operating a flight simulator completed digital or paper flight checklists more accurately after receiving post flight graphic and verbal feedback. The dependent variable was the number of checklist items completed correctly per flight. Following treatment, checklist completion with paper and digital checklists increased from 38% and 39%, respectively, to nearly 100% and remained close to 100% after feedback and praise for improvement were withdrawn. Performance was maintained at or near 100% during follow-up probes.

Romera, M.E. (2000). *Using finite automata to represent mental models* (Unpublished master's thesis). San Jose State University, San Jose, CA.

Abstract: The element lacking from past Human-Computer Interaction research is a method for systematically comparing a user's mental model to the way the machine actually works. The formal language of automata was used to represent both a device and students' mental models of it. Mental models were elicited during an interview with two parts. The first part consisted of a spontaneous description. The second part consisted of structured questions used to confirm what was said in the description, and uncover any further knowledge. Student models were compared to the model of the device to find missing or incorrect information. Participants were also tested with a compound task and true-false and multiple-choice problems to see if the mental model predicted task performance. The more similar the student's model was to model of the device, the better their performance. This methodology holds promise for examining the mental model of any system.

Russell-Minda, E., Jutai, J. W., Strong, J. G., Campbell, K. A., Gold, D., Pretty, L., & Wilmot, L. (2007). The legibility of typefaces for readers with low vision: A research review. *Journal of Visual Impairment & Blindness, 101*(7), 402–415.

Abstract: This article presents a systematic review of the research evidence on the effects of the characteristics of typefaces on the legibility of text for adult readers with low vision. The review revealed that research has not produced consistent findings and thus that there is a need to develop standards and guidelines that are informed by evidence.

Schelling, T.C. (1985). Enforcing rules on oneself. *Journal of Law and Economics, 1*(2), 357–374.

Introduction: How does one devise a contract that it is easily enforced on each party by the other? How are rules designed for the behavior of each party, and incentives attached to compliance, so that the temptations and opportunities for non-compliance are minimized? How does an agreement make room for exceptions, for discretionary judgment about what is required, and for penalties on violations so that the whole arrangement need not collapse upon the first failure? How are the terms of agreement structured so that invisible noncompliance can be made visible or noncompliant intention be revealed in time to be challenged…I am interested in the special case of rules that people impose on themselves."

Scholtz, C. R., & Maher, S. T. (2014). Tips for the creation and application of effective operating procedures. *Process Safety Progress, 33*(4), 350-354. Retrieved from Wiley Online Library website: http://onlinelibrary.wiley.com/doi/10.1002/prs.v33.4/issuetoc

Abstract: Specific requirements exist in all Safety Management Systems Requirements (e.g., Process Safety Management and Risk Management Program) for the creation, content, and periodic update of operating procedures (OP). However, the development and actual implementation of OP has challenges that often result in deficiencies, regulatory citations, and in some cases, unfortunate tragedies. Although OP concepts involve the straightforward documentation of specific steps for safe and effective operation, many process facilities struggle with: securing the focus from operations personnel for the creation of quality

procedures, securing feedback from operations personnel if procedural steps do not coincide with actual practices, ensuring the steps outlined in procedures avoid introducing additional process hazards, creating procedures that are in a user-friendly format, identifying the most effective level of information and depth to include in the procedure, and addressing all modes of operations, including defining appropriate responsibilities. Good-quality OP are critical for encapsulating operational best practices and also provide a basis for ensuring consistent quality assurance. The objective of this article is to convey an understanding of the challenges that must be considered with the development of OP and provide specific examples that will facilitate the creation and ongoing application of OP.

Schulmann, P. (2013). Procedural paradoxes and the management of safety. In C. Bieder & M. Bourrier (Eds.), *Trapping safety into rules* (pp. 243–254). Burlington, VA: Ashgate.

Abstract: Schulmann considers the characteristics of the situations procedures are designed for and he proposes to revisit and adapt the notion and philosophy of procedure to the dominant characteristics, especially task repetitiveness and knowledge available to perform it.

Seamster, T.L., & Kanki, B.G. (2000). User-centered approach to the design and management of operating documents. *Proceedings of the HCI-Aero International Conference on Human-Computer Interaction in Aeronautics*. Eurisco: Toulouse, France.

Abstract: This paper presents the ongoing process and current results of a collaboration between NASA/FAA researchers and commercial aviation operators to restructure and update operating document guidelines and to develop a user interface for managing those documents. The paper first presents the background of this collaborative effort that started with a review of existing flight operating document guidelines. There are many guidelines covering most aspects of document development, but they can be difficult to access because they are distributed across different reports or hard to locate publications. To correct this situation, researchers and US operators have identified the most important document development topics and organized them in operationally meaningful ways. This paper outlines the user-centered approach taken to identify the key flight document issues and presents two applications based on the results: 1) a new structure for an operating document guidelines manual, and 2) a prototype user interface for a tool to manage the development and maintenance of documents.

Seamster, T.L., & Kanki, B.G. (2003) Structured information for flight operations and the flight deck. *Proceedings of the 12th International Symposium on Aviation Psychology*, 1042–1046. Dayton, OH: Wright State University.

Abstract: As operators move from paper to electronic documentation within flight operations and on the flight deck, there is a growing need for standards and efficient information structures. The current state of operational information, with its different formats and varying degrees of structure has complicated its management and hampered repurposing, the efficient reuse of information within flight operations. Long-term data standard efforts, such as that of the Air Transport Association's Flight Operations Working Group, have been developing a comprehensive model for the interchange of operational data, but there has been limited

success in developing common information structures for the near-term interchange and management of data and documents for such applications as automated revisions and the electronic flight bag. The challenge for industry is to develop information structures that meet near-term operator needs in a relatively short period of time based on the best emerging data models available today so they will be consistent with longer-term data standards. To develop these near-term common structures, industry needs an understanding of the functions that must be addressed and the main information categories that must be targeted or tagged. Working with representatives of North American operators and suppliers, this study collected data on the most important near-term electronic data functions, to identify the common needs of operators and suppliers. Additional data was collected to identify the key data elements for a common information structure. The results of this study support the development a common data structure needed for the repurposing of flight operational information as it is used across flight operations and on the flight deck.

Seamster, T.L., & Kanki, B.G. (2005). Human factors design of electronic documents. *Proceedings of the 12th International Symposium of Aviation Psychology*. Dayton, OH: Wright State University.

Abstract: The Federal Aviation Administration (FAA), working with the Master Minimum Equipment List (MMEL) Industry Group, is developing a new MMEL electronic format. The MMEL refers to a series of documents controlled by the FAA that lists equipment that may be inoperative under certain conditions while still allowing the aircraft to be airworthy. Each aircraft model has an MMEL, and operators must work with that master document to determine the relief items for their specific aircraft. The resulting Minimum Equipment List (MEL) for an operator's aircraft is used by both ground personnel and pilots to determine the procedures for maintaining airworthiness. Currently, the MMEL is available in text format, and the industry needs an electronic format that is more efficient and that will be compatible with key aspects of future data standards. Members of the MMEL Industry Group were surveyed to determine the main user needs and human factors considerations for the development and evaluation of the MMEL electronic format. This study identifies key operator needs that can direct the development of not only the new MMEL format but also the broader category of aviation electronic documents.

Singer, G., & Dekker, S.W.A. (2000). Pilot performance during multiple failures: An empirical study of different warning systems. *Transportation Human Factors, 2*(1), 63–76.

Abstract: Dynamic fault management—that is, dealing with a cascade of failures while maintaining process integrity—is a dominant human task in various transportation modes (e.g., commercial aviation, shipping). The way in which a warning system represents failures and the way in which the system contributes to failure management jointly determine the amount and kind of cognitive work in which the human has to engage to manage multiple failures. In this study pilot performance on 4 different commercial aviation warning systems was tested by measuring time and error rates in identifying root causes in a cascade of failures. All systems tested represent failures in the same basic way (a message list) but differ in the kind of contribution they make to the failure management task; for example, by sorting failures, prioritizing them, selecting only some failures for presentation, guiding the pilot on what to do next, or showing the pilot which systems are still operational. Human

performance benefits accrued in systems that (a) provided guidance on what to do next and (b) showed which systems were still operational. These findings are consistent with the cognitive demands of dynamic fault management and carry important messages for how those demands should be supported. The results suggest that rather than automating even more of the human role in fault management to minimize error counts, attention should be paid to the kinds of referents and representations that are most useful in informing the operator of what is going on in the underlying process and how best to cope with it.

Sukenik, N. (1998). Coordination in the cockpit: A game-theory view of standard operation procedures. *The International Journal of Aviation Psychology, 8*(4), 405–412.

Abstract: Some basic principles of game theory confirm that flying according to standard operating procedures (SOP) leads to greater flight safety. In this article, the interaction in the cockpit is analyzed as a game whose goal is flight safety. The crewmembers are involved in interactions that determine the extent of their utility. It is demonstrated that adhering to SOP leads to maximum utility and, thus, to greater flight safety than deviating from it, even if an alternative procedure is equivalent as far as safety is concerned or seems to lead to greater utility.

Surabattula, D., & Landry, S.J. (2011, August). Toward providing guidance for procedure design: Formal definitions of procedure characteristics. *Proceedings of the 2001 International Symposium on Resilient Control Systems*, Boise, ID. Retrieved from IEEE Xplore website: http://ieeexplore.ieee.org/document/6016079/

Abstract: Researchers from Purdue University develop a framework - a symbolic formulation - that can be applied by designers to quantify the various characteristics of the procedure. They discuss issues around compliance, procedure development, and characteristics of checklists, the environment, and of the operator. Need for validation and refinement are the next steps proposed for the framework.

Tremaud, M. (2002, October). *Operational and human factors involved in situations beyond the scope of published procedures.* Symposium conducted at the meeting of the Airbus 16th Human Factors Symposium, Singapore.

Annotation: Michel Tremaud, Sr. Dir. of Operational Standards Development and Flight Operations Safety, presents a review of operational and human factors in: in-service occurrences, runway excursions and overruns, non-adherence to published procedures, unstabilized approaches, situations beyond the scope of published procedures, and situational awareness.

Tremaud, M. (2005, December). *Guidelines for management of complex situations: An operational and human factors view*. Presentation at the Flight Operations Safety Awareness Seminar, Moscow, Russia.

Summary: Michel Tremaud, Senior Director and Head of Safety Management and Customer Services, follows up his previous work (see Tremaud, 2002) with a presentation based on the operational and human factors analysis of events involving complex situations within or beyond the scope of published procedures. This synthesis provides an overview of observed factors and related prevention strategies in terms of situation recognition, crew diagnosis (warnings/cockpit effects), procedures (access, contents, execution), crew performance (actions/flight-path control), and crew coordination.

Trommelen, M. (1997). Effectiveness of explicit warnings. *Safety Science, 25(*1), 79–88.

Abstract: In the present study the effectiveness of explicitness in warnings provided with children's products was investigated. Unsafe use of children's products leads to many accidents. One way to reduce the number of accidents is to provide products with adequate warnings. A consistent finding in the literature is that a consumer's responsiveness to warnings is affected by perceived hazardousness, which in turn is affected by explicit warnings. A warning is explicit when it informs a consumer on 1.(1) what to do/avoid. 2(2) the product-related hazards. 3(3) the consequences of unsafe behaviour in terms of injuries. Subjects were randomly assigned to one of three conditions. They were presented with a product manual of a child-care product, either a baby carrier or a feeding bottle, in which 1.(i) no warnings 2.(ii) non-explicit warnings 3.(iii) explicit warnings were provided. The effect of warning condition on perceived hazardousness, perceived severity of injury, intended compliance, comprehension, and recall of the warning was measured. The results indicate that with explicit warnings, subjects perceived the products investigated as more hazardous and the possible injuries as more severe. Results also show that explicit warnings were better understood and remembered. However no significant offer of explicitness was found on intended compliance.

Turner, T.P. (2001). *Controlling pilot error: Checklists and compliance.* McGraw-Hill: New York.

Summary: CHECKLISTS & COMPLIANCE: Do it or don't fly. Read and learn: Why highly skilled, highly proficient pilots make tragic errors, reasons that pilots too often take off without fuel, how to avoid a myriad of mishaps and accidents resulting from inadequate attention to protocols and details, why gear-up landings are a recurring pattern, despite safeguards, how to beat the most common causes of takeoff and landing misconfigurations, ways to build good piloting habits and keep them strong, real-life pilot near-miss stories you won't forget. FAST & FOCUSED RX FOR PILOT ERROR: The most effective aviation safety tools available, CONTROLLING PILOT ERROR guides offer you expert protection against the causes of up to 80% of aviation accidents--pilot mistakes. Each title provides: Related case studies, valuable "save yourself" techniques, clear and concise analysis of error sets.

Turner, J.W., & Huntley Jr., M.S. (1991, April). *The use and design of flightcrew checklists and manuals* (Report No. FAA-AM-91-07). Washington, D.C.

Abstract: A survey of aircraft checklists and flight manuals was conducted to identify impediments to their use and to determine if standards or guidelines for their design were needed. Information for this purpose was collected through the review of checklists and manuals from six Part 121 and nine Part 135 carriers, review of NTSB and ASRS reports, analysis of an ALPA survey of air carrier pilots, and by direct observation in air carrier cockpits. The survey revealed that some checklists and manuals were difficult to locate and were poorly designed for use in the cockpit environment, the use of checklists by flight crews was not always well defined, the use of checklists interfered with other flight operations, and flight operations often made it difficult to use checklists effectively. The report contains recommendations for the formatting and content of checklists and manuals, their use by flight crews, and areas of research relevant to checklist design.

Van der Meij, H., & Gellevij, M. (2004). The four components of a procedure. *Professional Communication, IEEE Transactions on Professional Communication, 47*(1), 5–14.

Abstract: As they guide people in performing a task, procedures are the heart of most manuals. It is, therefore, somewhat surprising that the theoretical and empirical knowledge of their nature has remained somewhat elusive. This paper describes a theoretical framework for procedures, summarized as the four components model, which is grounded in systems theory and rhetoric. The study addresses two research questions: (1) What are procedures made of? and (2) Which design guidelines for procedures can be abstracted from theory and research? The model distinguishes between: goals, prerequisite states, unwanted states (warnings and problem-solving information), and actions and reactions. For each component pertinent research findings are summarized and lead to the formulation of design guidelines. Occasionally these guidelines are compared with existing procedures from a sample of 104 manuals to see how well theory and practice agree. The model offers a manageable and expandable framework for creating user support that is based on scientific research. It can be used for a systematic analysis of procedures and for their (re)design.

Wickens, C.D. (1999). Aerospace psychology. In M. Friedman, & E. Carterette (Eds.), *Handbook of perception and cognition: Human performance and ergonomics* (pp. 195–243). San Diego, CA: Academic Press.

Summary: This chapter highlights the critical relationship between theoretical constructs in the study of perception and cognition on the one hand, and the pilot's (and air traffic controller's) tasks on the other. The chapter begins by presenting a broad model of the flight task, written from a perceptual-cognitive perspective (more than from an aviation perspective), and then describes in detail certain key areas where the study of perception and cognitive psychology has provided insights to the task of controlling the aircraft, whether from within the cockpit (the pilot) or from the ground (the controller)." Many areas of a pilot's task are discussed; other areas include display integration, air traffic control, and knowledge. Key references described in the paper are also noted.

Wickens, C.D. (1999). Cognitive factors in aviation. In F.T. Durso, R.S. Nickerson, R.W. Schvaneveldt, S.T. Dumais, D.S. Lindsay, & M.T.H. Chi (Eds.), *Handbook of applied cognition* (pp. 247–282). Chichester, UK: John Wiley & Sons.

Summary: This chapter describes the task of flying an aircraft from a cognitive perspective as involving a time-shared collection of four meta tasks: aviating, navigating, communicating, and systems management. The pilot is described within an information processing framework and then each of the four meta tasks are described in detail, considering their implications for displays, pilot error and automation. We then consider the cognitive constructs for decision-making, situation awareness, procedures following and mental workload, which apply across all four metal tasks. The last section addresses the cognitive issues as pilots deal with aircraft automation.

Wickens, C.D. (2003). Pilot actions and tasks: Selections, execution, and control. In P. Tsang, & M. Vidulich (Eds.), *Principles and practices of aviation psychology (*pp. 147–199). Mahwah: NJ.

Summary: In most circumstances, a pilot's task involves a continuous stream of activities. Many of these activities are overt and easily observable, such as movement of the flight control sticks, communications with air traffic control, or manipulating switches. Others are much more covert and less observable, such as planning, diagnosing or monitoring. A skilled pilot will selectively choose which tasks and actions to perform at the appropriate time, knowing which tasks to emphasize and which ones to ignore when workload is high (Adams, Tenney, & Pew, 1995; Funk, 1991; Orasanu & Fischer, 1997). This skilled pilot will also execute those actions smoothly and appropriately, the most important of which is control of the aircraft. In this chapter, we will first focus on the choice of actions and tasks, and then describe the execution of the most important of those tasks - those involved in flight control and navigation.

Wickens, C.D., & Andre, A.D. (1998). Psychology applied to aviation. In A. M. Stec, & D. Bernstein (Eds.), *Psychology: Fields of application* (pp. 184–198). Stamford, CT: Cengage Learning.

Summary: Aviation psychology is the study of the psychological aspects of flying an aircraft. In order to demonstrate some of these aspects, we will first take a look at the pilot's tasks. Then we will trace the important historical developments in aviation psychology, and follow with a description of current themes in aviation psychologists' research. We will also discuss where aviation psychologists work and what they do, and list some challenges in the future of aviation psychology.

Wieringa, D.R., & Farkas, D.K. (1991). Procedure writing across domains: Nuclear power plant procedures and computer documentation. ***Proceedings of the 9th Annual International Conference on Systems Documentation, SIGDOC, New York, NY*****, 49–58. Retrieved from University of Washington faculty website: http://faculty.washington.edu/farkas/dfpubs/Weiringa-Farkas-Nuclear%20PowerPlant%20Procedures%20And%20Computer%20Doc.pdf**

Abstract: Computer documentation, and in particular documentation for end-user software applications, is so prevalent today that it is easy to forget the larger world of procedure writing, of which computer documentation is only a part. Numerous types of procedures exist, ranging from administrative procedures that focus on human activities, to procedures for assembling consumer products, to procedures governing the operation, maintenance, and repair of complex industrial equipment. One domain in which procedures play an important role is the large and complex process-control facilities such as oil refineries and chemical plants. This paper discusses procedures and procedure writing at one kind of process-control facility--the nuclear power plant. We think that the differences between nuclear power plant documentation and the documentation of computer systems--especially software applications--are interesting and instructive, and we will try to point out some lessons learned from procedure writing in the nuclear power industry that apply directly to software documentation. We first provide an overview of recent efforts to improve procedure quality at nuclear power plants and discuss some of the distinctive challenges faced in documenting nuclear power plant procedures. We then describe how some of the techniques used by nuclear power plant procedure writers can be applied to software documentation. We cover the process of developing and testing nuclear power plant procedures and two of the formats that have proven valuable in creating usable plant documentation. The first is a two-column text format in which users can select either general or highly detailed instruction. The second is a flowchart format that reduces the user's cognitive burdens in following highly branching procedures. The paper concludes with comments on the potential of online procedures, an area in which the nuclear power industry could learn from the writers of computer documentation. This paper has its basis in the work that Battelle's Human Affairs Research Centers (HARC)[1] has done with nuclear power plant procedures over the past twelve years, working for the U.S. Nuclear Regulatory Commission (NRC), the U.S. Department of Energy, and various private utilities[2] Over a 5-year period, Wieringa has taken part in and managed numerous projects pertaining to nuclear power plant procedures. Farkas has worked for Battelle as a consultant and contributes to the paper an understanding of the relationship between documentation in the nuclear power and computer industries.

Wieringa, D.R., Moore, C., & Barnes, V. (1998). ***Procedure writing: Principles and practices*****. Battelle Press: Columbus, OH.**

Description: A definitive guide for writing procedures in business, ISO compliance, plant, or safety procedures. Written in easy-to-understand terms, it presents principles that underlie effective procedures.

Wogalter, M.S. (1999). Factors influencing the effectiveness of warnings. In H. Zwaga, T. Boersema, & H. Hoonhout (Eds.), *Visual information for everyday use: Design and research perspectives* (pp. 93–110). London: Taylor & Frances, Ltd.

Description: Warnings are necessary when other hazard-control methods cannot be effectively employed. Given this state of affairs and the fact that warnings are not totally reliable, the principle question is: How can warnings be designed to maximize their effectiveness. This chapter addresses this question.

Wogalter, M., Sojourner, R., & Brelsford, J. (1997). Comprehension and retention of safety pictorials. *Ergonomics, 40*(5), 531–542.

Abstract: The use of pictorials to communicate safety-related information has been widely offered as a way of reaching diverse users owing to the pictorials' assumed universal information transmission potential. The present study examined comprehensibility of a set of safety pictorials, and then employed a training procedure (providing short verbal descriptions of the pictorials) to enhance comprehension and retention. Comprehension was tested for all participants prior to training, and after 1 week. Additionally, comprehension was also tested for some participants immediately following training, and 6 months after training. Also manipulated was the content of instruction (supplying either the pictorial's associated verbal label or verbal label plus a more detailed explanatory statement), and difficulty level ('easy' versus 'difficult' to understand pictorials, as determined by prior research). The results showed that training led to a significant increase in pictorial comprehension. Easy pictorials were comprehended (both initially and following training) better than difficult pictorials, with the latter showing a more dramatic improvement in comprehension following training. Post-training pictorial comprehension was also relatively stable over time. The additional explanatory content statement had no effect on comprehension and recall. The substantial gains in understanding the more difficult pictorials suggest that brief training can substantially facilitate comprehension for pictorials that would otherwise not be readily understood.

Wogalter, M.S., & Young, S.L. (1994). The effect of alternative product-label design on warning compliance. *Applied Ergonomics, 25*(1), 53–57.

Abstract: Many potentially hazardous products are packaged in small containers. Because of the limited amount of space available on these containers for warnings and other information, manufacturers often reduce the size and amount of printed material on the labels. This frequently impairs the message's legibility, noticeability and comprehensibility. Recently, several alternative label designs have been investigated using preference ratings, but whether the designs facilitate safer behaviour has not been determined. In the present experiment, two alternative designs (tag and wings) were compared with a conventional (control) design for their effect on behavioural compliance with a warning on a very small container of glue. Participants performed a parts-assembly task using the glue without being informed of the study's real purpose. Whether participants wore protective gloves as directed by the warning was measured. Results showed that the tag design produced significantly greater compliance than the other two designs. Measures of noticing, reading and recall of the warning mirrored the compliance results. While participants generally preferred the control label, they most preferred the tag warning. Overall, the results suggest that alternative designs like the tag can enhance warning communication and compliance in cases where surface area is limited."

Wright, P., & McCarthy, J. (2003). Analysis of procedure following as concerned work. In E. Hollnagel (Ed.), *Handbook of cognitive task design* (pp. 679–700). Mahwah, NJ: Lawrence Erlbaum Associates.

Summary: In this chapter our concern is with the design and use of operating procedures. Operating procedures feature strongly in safety-critical work domains, where it is argued they reduce the likelihood of human error. Procedures can be viewed as the result of cognitive task design. Information processing analyses of procedure following have shown how the design of procedures can be improved. Here we explore an alternative to the prevalent information processing approach to take a more critical view of the proceduralization of the workplace. Our approach takes as its starting point ideas from the field of literary studies and narrative rather than information processing psychology. The analysis focuses on autobiographical data. Unlike a more traditional cognitive analysis, it highlights the concerns facing operators who have to make procedures work in practice, the paradoxes and dilemmas they face in doing this, and the amount of intelligent effort that goes into making sense of procedures. Our analysis leads us to conclude that the gap between procedures and practice is filled by the creative work of the operator. Such creative work is based on a history of experiences both inside and outside the workplace. Currently, there are very few ways in which this experience can be given a legitimate voice in the process of procedure design.

Wynne, B. (1988). Unruly technology: Practical rules, impractical discourses, and public understanding. *Social Studies of Science, 18*, 147–167.

Abstract: This paper examines technologies as rule-following behaviour, arguing that emerging practices define 'rules', rather than rules controlling practices. With the aid of several examples, it suggests that technologies should be conceptualized as extensive, open-ended technical-social systems whose local behaviour is underdetermined by any overall rationality. Contextual normalization of working technologies takes place according to local rationalities, but this may fragment the overall technology, whilst evolving its informal practical 'rules'. Expert and public discourses present a more rule-bound concept of technology than the more private, contingent world of practice. The implications for public decisions and social control of technology are examined.

Young, S.L. (1991, September). Increasing the noticeability of warnings: Effects of pictorial, color, signal icon and border. *Proceedings of the Human Factors and Ergonomics Society Annual Meeting, 35*(9), 580–584. SAGE Publications.

Abstract: Because of the importance of noticeability on subsequent comprehension and compliance to warnings, guidelines suggest increasing the salience or conspicuity of warnings. Surprisingly, only a small amount of research has examined different methods of increasing the noticeability of warnings. Therefore, the current research orthogonally manipulated four salience variables (pictorial, color, signal icon and border) to determine their effect on noticeability of warning information. Subjects viewed 96 simulated alcohol labels on a computer, half with a warning and half without. Subjects indicated whether or not a warning was on the label and response latencies were recorded. The results showed that warnings containing a pictorial, color or an icon had significantly faster response times than warnings without them. However, the addition of a border did not improve response times. More detailed

analyses showed interactions between the four-salience manipulations. These results demonstrate that pictorials, color and icons can enhance the noticeability of warning information. Moreover, it is clear that these salience manipulations interact with each other and that they should not be used indiscriminately without adequate knowledge of these interactions.

Young, S.L., & Wogalter, M.S. (1990). Comprehension and memory of instruction manual warnings: Conspicuous print and pictorial icons. ***Human Factors: The Journal of the Human Factors and Ergonomics Society, 32*****(6), 637–649.**

Abstract: Two experiments examined the effects of increasing the noticeability of instruction manual warnings on subsequent comprehension and memory performance. Participants read one of four instruction manuals for a gas-powered electric generator (Experiment 1) or a natural-gas oven (Experiment 2) on the assumption that they would later operate the equipment. The appearance of eight different warning messages in the manuals was altered in two ways: (1) the verbal messages were printed either in conspicuous print (larger text with color highlighting) or in plain print (same as the other text), and (2) either the verbal warning messages were accompanied by compatible pictorial icons or the icons were absent. Results showed that participants who received the conspicuous print, icons present manual better comprehended and recalled the verbal warning messages (Experiments 1 and 2) and better identified the semantic meaning of the icons (Experiment 1) than did participants who received the other three manuals. Implications for the design of instruction manual warnings are discussed.

2. Manufacturers' Literature

Aarons, R. N. (2001, March). Customizing your aircraft's checklist. *Business & Commercial Aviation*. Retrieved from: http://aviationweek.com/awin/customizing-your-aircrafts-checklist

Summary: Checklists have popped up in several recent Cause & Circumstance columns and safety articles—checklists ignored, misread, misplaced and misunderstood. We all agree, I think, that checklists deserve better treatment from us in that they are the undisputed mom and apple pie of cockpit management philosophy. Several training experts we consulted suggest all operators design their checklists and related SOPs to optimize their operational environment.

Airbus. (n.d.). Auto flight: General (1.22.10, Seq 100, Rev 32). *Flight Crew Operating Manual A320 - For Training Only* (Volume 1), 1–2. France: Author.

Description: Preamble, description and general philosophy for A320.

Airbus. (n.d.). FMGS overview - General philosophy (4.01.10, Seq 001, Rev 06). *Flight Crew Operations Manual A320 - For Training Only* (Volume 4). France: Author.

Description: Preamble and general philosophy of FMGS from training manual.

Airbus. (n.d.). Standard operating procedures - General information (3.03.01, Seq 001, Rev 35). *Flight Crew Operating Manual A320* (Volume 3), 1. France: Author.

Description: SOPs for A320.

Airbus. (2002). Operational philosophy: Introduction (01.010, July 28/05). *A318/A319/A320/A321: Flight Crew Training Manual*. France. Author.

Description: Operational philosophy from flight crew training manual.

Airbus. (2013a). *Flight operations briefing notes: Standard operating procedures - Normal checklists*. Retrieved from: https://www.scribd.com/document/55881534/Airbus-Safety-Lib-Flt-Ops-Sop-Seq05

Description: This briefing note provides an overview of the scope and use of normal checklists, and the factors and conditions that may affect the normal flow and completion of normal checklists.

Airbus. (2013b). ***Flight operations briefing notes: Standard operating procedures - Operating philosophy*****. Retrieved from:** **https://www.scribd.com/document/267692395/Airbussafetyib-Flt-Ops-Sop-Seq01-1**

Description: This flight operations briefing note provides an overview of the following aspects: establishment and use of (SOPs), training aspects, and factors and conditions that may affect the compliance with published rules and procedures.

Baldwin, H. (2010, June). Rethinking the checklist. ***Overhaul & Maintenance.*** **Retrieved from:** **http://aviationweek.com/awin/rethinking-checklist**

Summary: Why is it that despite revolutionary training, advanced technology and unprecedented knowledge of the causes of errors, we continue to make those errors? That, of course, is the million-dollar question, a question that Atul Gawande, a Harvard Medical School associate professor and thought leader in error reduction, seeks to answer in his book The Checklist Manifesto: How to Get Things Right. Gawande's research spans multiple industries, including aviation.

Boeing. (1999, July 30). Checklist information—Normal checklists (Chapter 1, Section 1). ***737 Quick Reference Handbook*****. Washington: Author.**

Description: This introduction contains guidelines for checklist operations.

Boeing. (2013a, October 21). ***Aviation safety: Working together to make sure flying is as safe as possible.*** **Retrieved from:** **http://www.boeing.com/boeing/commercial/safety/industry.page**

Description: This is a description on Boeing's company website about the company's position and approach to aviation safety, and collaborative work with Commercial Aviation Safety Team and the Industry Safety Strategy Group.

Boeing. (2013b, October 21). ***The boeing edge: Electronic checklist.*** **Retrieved from:** **http://www.boeing.com/boeing/commercial/aviationservices/flight-services/flight-operations/flight-documents/ecl.page**

Description: This is a statement on Boeing's company website about the use of electronic checklists and updates.

Boeing. (2013c, October 21). ***The boeing edge: Flight operations.*** **Retrieved from:** **http://www.boeing.com/boeing/commercial/aviationservices/flight-services/flight-operations/index.page**

Description: This is a statement on Boeing's company website about their flight operations.

Boeing Flight Technical & Safety. (2011, May). ***The checklist builder*** **(Rev 3). Washington: Author.**

Description: Defines what a checklist is, the kinds of checklists and steps in the checklist builder; it also covers operational concepts, critical items, pause points, and guidance to reduce and phrase, format, and test and improve.

George, F. (2015, April). Checklists and callouts: Keep it simple, avoid distraction, prevent ineptitude. ***Business & Commercial Aviation*****. Retrieved from: http://aviationweek.com/business-aviation/checklists-and-callouts-keep-it-simple-avoid-distraction-prevent-ineptitude**

Description: 'Less is more' appears to be the current checklist design theme.

Kurtz, K. (2013, Quarter 01). Interactive version of the quick reference handbook: Fault troubleshooting with interactive fault isolation manual. ***The Boeing Edge Aeromagazine, Is. 49,*** **11–13. Retrieved from Boeing website: http://www.boeing.com/commercial/aeromagazine/articles/2013_q1/pdf/AERO_2013q1.pdf**

Description: A Senior Manager from Boeing describes the electronic tablet version of the QRH and its advantages and regulations.

Lacagnina, M. (2013, July). Automation surprise. ***Aerosafety World Magazine*****, 50–51. Retrieved from FSF website: http://flightsafety.org/aerosafety-world-magazine/july-2013/on-record**

Summary: The captain's reaction to an unexpected autopilot pitch change resulted in an unsafe descent… The following information provides an awareness of problems that might be avoided in the future. The information is based on final reports by official investigative authorities on aircraft accidents and incidents.

Neville, R. & Dey, M. (2012, Quarter 01). Innovative 787 flight deck designed for efficiency, comfort, and commonality. ***Boeing Aeromagazine, Is. 45,*** **11–17. Retrieved from Boeing website: http://www.boeing.com/commercial/aeromagazine/articles/2012_q1/index.html**

Annotation: An article, by a Boeing Chief Pilot and a Flight Deck Product Developer, that describes the new 787 displays, dual EFBs, and dual HUDs. Authors describe "operational commonality", or the similarity between airplanes (e.g., 787 vs. 777) in operating procedures, checklists, and flight crew interfaces - to reduce training time for pilots between aircraft.

Pélegrin, C. (2007, December). Compliance to operational procedures: Why do well trained and experienced pilots not always follow procedures? *Safety First: The Airbus Magazine, 5*, 20–23.

Abstract: In the aviation domain, the purpose of introducing procedures was to enhance safety in normal and abnormal conditions, by reducing uncertainty and thus risks. The rationale was obvious, and the benefits so blatant that the aeronautical industry has been using procedures for many years. It is now undisputed that pilots shall adhere to the procedures designed for them. But real life is not always that simple. The objective of this article is to understand the complete picture: good procedures design is important as well as appropriate explanations to ensure pilots have sufficient confidence in their skills and judgment to manage the situation. Each procedure is designed as the best and safest way to do a given task. Flight deck procedures are the skeleton of flight operations. They are the structure and the organisation by which a pilot can fly and interact with the aircraft and other crewmembers. When incidents or accidents occur, most of the time a non-adherence to procedures is mentioned. But this is not sufficient to explain accidents, because every day pilots do not follow procedures and this does not always lead to accidents!

Shaw, J. (2013, Quarter 02). Faster troubleshooting with interactive fault management. Fault troubleshooting with interactive fault isolation manual. *The Boeing Edge Aeromagazine, Is. 50,* 19–23. Retrieved from Boeing website: http://www.boeing.com/commercial/aeromagazine/articles/2013_q2/pdf/AERO_2013q2.pdf

Description: Boeing has developed an Interactive Fault Isolation Manual that makes it easier to identify and correct faults. A Senior Airplane Maintenance Engineer describes fault conditions, codes, operations and provides examples. Shaw describes procedure blocks and procedure maps.

Sumwalt, R. (2003, August). Using procedures to enhance crew vigilance. *Professional Pilot*, 2–6.

Annotation: Airbus Captain for a major US airline, Robert Sumwalt, describes instances of failure of pilots to adequately monitor the aircraft. The article includes reference to the AC 120-71A and how operators should review existing SOPs and modify those that can detract from monitoring. Other areas of discussion include improving taxi awareness, critical-phase monitoring (waiting for level-off for example, on activities that can increase errors during times when monitoring is required), avoiding automation traps (Wierner's FMS-vacuum comparison), and balancing pilot workload.

Veillette, P. R. (2006a, May). A non-error resistant checklist. *Business & Commercial Aviation*. Retrieved from: http://aviationweek.com/awin/non-error-resistant-checklist

Summary: An abnormal procedures checklist should help us determine the cause of a malfunction, and take the proper corrective actions, but sometimes what seems obvious to a procedure designer on the ground is much less so to the busy pilot who must deal with the malfunction in flight.

Veillette, P. R. (2006b, May). The what and whys of good procedures. *Business & Commercial Aviation*. Retrieved from: http://aviationweek.com/awin/what-and-why-good-procedures

Summary: When an organization has an aircraft accident, it is inevitable that upper management will focus on the aviation unit to avoid a recurrence. I know of a Twin Otter belonging to a large government agency that landed hard on a canted nose wheel and quickly departed the runway, plowing through bushes and a fence before coming to a halt. Both the aircraft and airman's ego suffered substantial damage in the mishap.

Veillette, P. R. (2006c, May). The who, what, when of your SOPs. *Business & Commercial Aviation.* Retrieved from: http://aviationweek.com/awin/who-what-when-your-sops

Summary: What follows is a compilation of subjects SOP designers need to consider and address. The list was culled from SOP post-accident recommendations by the NTSB as well as from similar investigative bureaus in other countries. It was also assembled from input by the Human Factors Division at NASA Ames Research Center and the FAA's Advisory Circulars.

Veillette, P. R. (2007, August). The problem of checklist errors. *Business & Commercial Aviation*. Retrieved from: http://aviationweek.com/awin/problem-checklist-errors

Summary: "Dangle the Dunlops!" Heard that before? How about, "Rollers!"? These are two of the colorful, but definitely non-standard expressions used to call for extending the landing gear. While some might regard such callouts as those of a pilot merely trying to introduce some originality and humor in the cockpit, and dismiss any suggestion that they pose some kind of a problem, statistics suggest otherwise.

Veillette, P. R. (2008, August). The benefits of proper checklist design. *Business & Commercial Aviation*. Retrieved from: http://aviationweek.com/awin/benefits-proper-checklist-design

Summary: Recently one of your flight crews took off after wrongly assuming they had been refueled, but then discovered the mistake en route and diverted for an unplanned fuel stop. (This happens with surprising frequency.) You've been tasked with preventing this from happening again. You consider adding an item to the checklist reminding the flight crews to check fuel before leaving the ramp, but where do you put the new line item, and how will you phrase it?

Wiley, J. (2003, July). To call out or clam up? *Business & Commercial Aviation*. Retrieved from: http://aviationweek.com/awin/call-out-or-clam

Summary: "Start valve open...Rotation...Oil pressure...Fuel flow...Ignition... Peak EGT...Start valve closed...Turning number two.'" This was the litany heard every time we cranked the JT-8Ds that powered Boeing's mighty tri-motor, the B727. The flight engineer and first officer would go through this singsong duet, calling out what was expected and normal in a routine engine start. Time and again.

3. Regulatory and/or Government Literature

Barazandeh, A.F. (2012). ***Aviation checklists: Normal/abnormal & emergency for fixed-wing & helicopters*** **(EASA Research Project EASA.2012/1 Principles and guidelines relative to the design of checklists and working methods in the cockpit). Retrieved from the EASA website: https://www.easa.europa.eu/safety-and-research/research-projects/docs/large-aeroplanes/Final_Study_Report_1-2012.pdf**

Summary: Performing normal/abnormal and emergency checklist is one of the key tasks of the flight crew. This paper present a summary of the results of studies and works done, as well as latest instructions and directives issued by Civil Aviation Authorities (CAAs), concerning the principles and guidelines relative to the design of checklist and working methods in the cockpit for fixed-wing and helicopters. This allows European manufacturers and operators as well as National Aviation Authorities (NAAs) to have clear references on the state of the art in the design and application of checklists. Numerous accidents and occurrences caused by performing checklist incorrectly were searched and analysed. Various research institutions, National Aviation Authorities, operators and aircraft manufacturers have given their feedbacks on how to design and perform a checklist. Also Human Factor has been taken into account.

Civil Aviation Authority. (2002). ***CAP 719: Fundamental human factors concepts.*** **Retrieved from the Civil Aviation Authority website: https://publicapps.caa.co.uk/docs/33/CAP719.PDF**

Summary: The scope of this digest includes: a) the meaning and definition of Human Factors, a conceptual model of it, and clarification of common misconceptions; b) the industry need for Human Factors; c) the application of Human Factors in flight operations; and d) the levels of expertise required and the formal approaches to education.

Civil Aviation Authority. (2005). ***CAP 708: Guidance on the design, presentation and use of electronic checklists*****. Retrieved from the Civil Aviation Authority website: https://publicapps.caa.co.uk/docs/33/CAP708.PDF**

Summary: Objectives: 1.1 This guidance is intended to promote best practice amongst UK aircraft operators with regard to electronic checklists (ECLs), maximising the potential safety benefits and minimising the potential disbenefits. The document complements CAP 676, which provides guidance on paper-based checklists. In some areas the guidance outlines the factors to take into account when deciding which approach is appropriate for the particular circumstances at the time, rather than providing a definitive answer. 1.2 Details of the process by which the guidance was derived, and discussion of aspects on which it is not possible to issue definitive guidance, are provided in CAA Paper 2000/09.

Civil Aviation Authority. (2006). C*AP 676: Guidance on the design, presentation and use of emergency and abnormal checklists*. Retrieved from: http://publicapps.caa.co.uk/docs/33/CAP676.PDF

Executive Summary: Concern has been expressed that the potential for an accident or incident is increased by the pilot misinterpreting the checklist due to poor design. The primary goal of this guidance is to improve Emergency and Abnormal Checklist usability in assisting the flight crew to manage and contain system faults and other situations that adversely affect flight safety. Additionally this CAP will assist all stakeholders involved in the design, presentation and use of Emergency and Abnormal Checklists to take account of best human factors principles within their processes. It is the responsibility of both the aircraft manufacturer and aircraft operator to work together throughout the Emergency and Abnormal Checklist design, development and amendment process to ensure that optimum system configuration following a failure is assured commensurate with best operational practice. In addition to providing process information in Chapters 2 through to 6 of this document, guidance is provided in the application of good human factors principles in the design of the checklist. This covers the physical structure, content and layout. A Checklist Assessment Tool (CHAT) has been developed to allow Regulators, Manufacturers and Operators to review checklists against these design principles and thus be able to recognise a potentially error-prone checklist. The tool provides usability rationale to support the design attributes, which are contained in Chapter 7 of this document. CHAT is a stand-alone paper based tool and is presented as part of the Executive Summary.

Commercial Aviation Safety Team. (2008). *Mode awareness and energy state management aspects of flight deck automation, Final report—Safety enhancement 30, Revision 5*. Retrieved from: http://www.skybrary.aero/bookshelf/books/1581.pdf

Summary: Automation has contributed substantially to the sustained improvement in air carrier safety around the world. Automation increases the timeliness and precision of routine procedures, and greatly reduces the opportunity to introduce risks and threatening flight regimes. In short, automation has been very positive for safety. Nevertheless, in complex and highly automated aircraft, automation has its limits. More critically, flight crews can lose situational awareness of the automation mode under which the aircraft is operating or may not understand the interaction between a mode of automation and a particular phase of flight or pilot input. These and other examples of mode confusion often lead to mismanaging the energy state of the aircraft or to the aircraft's deviating from the intended flight path for other reasons. The Loss of Control (LOC) Joint Safety Analysis Team (JIMDAT), chartered by the Commercial Aviation Safety Team (CAST), identified these issues as factors or problems in several major accidents in the United States and around the world. Subsequently, a Joint Safety Implementation Team recommended in Safety Enhancement (SE) 30 that CAST charter a JIMDAT sub-team to address mode confusion in cooperation with a working group chartered earlier by the Performance-Based Aviation Rulemaking Committee (PARC), which was in the midst of a more broadly based study of issues related to automation. In late 2005, CAST chartered the SE-30 Data Review Team to undertake this task. CAST directed the team to restrict its work to the issues of mode confusion and mode awareness, and to work closely with PARC, which continued to address a more comprehensive range of automation issues. The SE-30 Data Review Team was charged with producing a prototype automation policy, or an "exemplar," for air carriers. The ultimate objective of any policy exemplar

would be to help minimize the frequency with which pilots experience mode confusion and undesirable energy states. This, in turn, required some assurance that crews understand the functions of the various modes of automation. Accordingly, this report presents a policy exemplar based on a set of common industry practices that are known to be effective, against which operators may compare their existing policies and identify any appropriate changes in their policies. In addition, the exemplar includes practical guidance that air carriers could include in their policies in order to help pilots respond effectively to particular types of automation anomalies. The suggested guidance is intended only as examples of effective responses to selected circumstances. The suggested guidance does not necessarily identify the only proper response. Note, too, that the terminology used in this document and in the examples reflects terminology for Airbus and Boeing aircraft. Air carriers may need to amend the terminology to apply this document to their own fleet mixes, the need for consistent language within a single air carrier, or other unique characteristics. However, the use of Airbus and Boeing terminology is reasonable for this type of document, since Airbus and Boeing products account for 80 percent of in-service air transport aircraft in the world (as of mid-2008).

Dismukes, K., Young, G., & Sumwalt, R. (1998). Cockpit interruptions and distractions. *ASRS Directline* (Issue No. 10). Washington DC: FAA.

Summary: Distraction is a commonly cited contributor to incidents in ASRS reports. This excellent article examines common sources, results, and management strategies for cockpit interruptions and distractions.

European Aviation Safety Agency IGPT. (2013). *EASA automation policy: Bridging design and training principles*, *EASp Action SYS5.6—Automation policy.* Retrieved from EASA website: http://easa.europa.eu/sms/docs/EASp%20SYS5.6%20-%20Automation%20Policy%20-%2014%20Jan%202013.pdf

Introduction: The EASA Automation Policy adopts an innovative approach consisting of mapping crew automation interaction issues, design and certification and training principles, and respective regulatory provisions to identify top challenges and paths for improvement. It was developed by the EASA Internal Group on Personnel Training (IGPT) set up by Agency to follow up the EASA International Conference on Pilot Training of Nov 2009. Modern aircraft are increasingly reliant on automation for safe and efficient operations, whether commercially operated or not. Automation has brought significant advantages for flight safety and operations and is required for certain types of operations and for precision navigation. Automation can however cause problems for instance to senior pilots who may be less comfortable with automation while the new generation of pilots may lack basic flying skills when the automation disconnects or fails or when there is a need to revert to a lower automation level, including hand flying the aircraft. Development and promotion of an EASA Automation Policy are actions of the European Aviation Safety plan (EASp), Editions 2011-2014 and 2012-2015, Section Next Generation of Aviation Professionals.

Federal Aviation Administration. (1978). *Water, slush, and snow on the runway.* (Advisory Circular 91-6A). Retrieved from FAA website: http://www.faa.gov/regulations_policies/advisory_circulars/index.cfm/go/document.information/documentID/23145

Summary: This advisory circular is issued to provide information, guidelines, and recommendations concerning the operation of turbojet aircraft when water, slush, and snow are on the runway. A memorandum cancelled this AC on 1/19/2016, and has been updated and incorporated into AC 91.79A, Mitigating the Risks of a Runway Overrun Upon Landing.

Federal Aviation Administration. (1981). *Operations of large airplanes subject to federal aviation regulation part 125.* (Advisory Circular 125-1). Retrieved from FAA website: http://www.faa.gov/regulations_policies/advisory_circulars/index.cfm/go/document.information/documentID/22524

Annotation: This advisory circular provides guidance for operators to comply with Part 125 requirements. It also includes an interesting discussions about "policy vs. procedure" - addressing issues/concerns that remain relevant today. This depth of discussion of procedures and development is similar to the FAA "Human Performance Considerations in the Use and Design of Aircraft Checklists" (1995) document. The circular states, "The user must know the purpose of the procedure and view the procedure as an acceptable method of accomplishing that purpose''. It also covers what authors of procedures should identify, including the need to consider and adapt to the user. This AC was cancelled on 9/15/2016.

Federal Aviation Administration. (1983). *Pilots' role in collision avoidance.* (Advisory Circular 90-48c). Retrieved from FAA website: http://www.faa.gov/regulations_policies/advisory_circulars/index.cfm/go/document.information/documentID/23090

Summary: This advisory circular is issued for the purpose of alerting all pilots to the potential hazards of midair collision and near midair collision, and to emphasize those basic problem areas related to the human causal factors where improvements in pilot education, operating practices, procedures, and improved scanning techniques are needed for reduced midair conflicts. This AC was cancelled on 4/19/2016.

Federal Aviation Administration. (1990a). *Operational landing distances for wet runways; Transport category airplanes.* (Advisory Circular 121-195(d)-1A). Retrieved from FAA website: http://www.faa.gov/regulations_policies/advisory_circulars/index.cfm/go/document.information/documentID/22523

Summary: This advisory circular (AC) sets forth an acceptable means, but not the only means, of showing compliance with Federal Aviation Regulations (FAR) 8 121.195(d) pertaining to operating landing distances on wet runways. It is for guidance purposes and provides an example of a method of compliance that has been found acceptable.

Federal Aviation Administration. (1990b). ***Traffic advisory practices at airports without operating control towers.*** **(Advisory Circular 90-42F). Retrieved from FAA website: http://www.faa.gov/regulations_policies/advisory_circulars/index.cfm/go/document.information/documentID/23088**

Summary: This advisory circular (AC) contains good operating practices and procedures for use when approaching or departing airports without an operating control tower and airports that have control towers operating part time. This AC has been updated to include changes in radio frequencies and phraseology.

Federal Aviation Administration. (1993). ***Recommended standards traffic patterns and practices for aeronautical operations at airports without operating control towers.*** **(Advisory Circular 90-66A). Retrieved from FAA website: http://www.faa.gov/regulations_policies/advisory_circulars/index.cfm/go/document.information/documentid/23093**

Summary: This advisory circular (AC) calls attention to regulatory requirements and recommended procedures for aeronautical operations at airports without operating control towers. It recommends traffic patterns and operational procedures for aircraft, lighter than air, glider, parachute, rotorcraft, and ultra light vehicle operations where use is not in conflict with existing procedures in effect at those airports.

Federal Aviation Administration. (1995). ***Human performance considerations in the use and design of aircraft checklists*****. Retrieved from SKYbary website: http://www.skybrary.aero/bookshelf/books/1566.pdf**

Annotation: This document describes some history of checklist usage and design. It also details incidents and accidents from ASRS reports, and takes a human factors perspective by answering the "whys" of specific design recommendations – citing relevant human factors work (by Degani & Weiner). It cites some FAA requirements (e.g., sequencing of checklist items). It also describes some areas and requirements, backed by research, to support the evidence (e.g., at age 50, 50% reduction in retinal illumination as compared to age 20 – which ties directly to recommendations to checklist format). It covers an analysis of checklist error incident data (from 300 "checklist" reports) and discusses the following areas: fatigue and stress effects ("getting behind the aircraft"), "chunked responses" from lengthy checklist items, illogical flow patterns that lead to omissions, cueing, checklist content and criticality, workload, and typography. It also includes sections from the FAA FSIMs 8400.10 document. A solid list of reference material and related reading material, which are worth further exploration. A good overall document that provides background research on the "whys" of the reported guidelines.

Federal Aviation Administration. (1996). *Operational use and modification of electronic checklists.* (Advisory Circular 120-64). Retrieved from FAA website: http://www.faa.gov/regulations_policies/advisory_circulars/index.cfm/go/document.information/documentID/23204

Summary: This advisory circular addresses the processes for approval, operational use, and modification of electronic checklists (ECL) and ECL data by air carriers.

Federal Aviation Administration. (2000). *Standard operating procedures for flight deck crewmembers* (Advisory Circular 120-71). Retrieved from FAA website: http://rgl.faa.gov/Regulatory_and_Guidance_Library/rgAdvisoryCircular.nsf/list/AC%20120-71/$FILE/AC120-71.pdf

Summary: Standard operating procedures (SOPs) are universally recognized as basic to safe aviation operations. Effective crew coordination and crew performance, two central concepts of crew resource management (CRM), depend upon the crew's having a shared mental model of each task. That mental model, in turn, is founded on SOPs. This advisory circular (AC) presents background, basic concepts, and philosophy in respect to SOPs. It emphasizes that SOPs should be clear, comprehensive, and readily available in the manuals used by flight deck crewmembers. This AC is designed to provide advice and recommendations about development, implementation, and updating of SOPs. Many important topics that should be addressed in SOPs are provided in Appendix 1, Standard Operating Procedures Template. Stabilized Approach, characterized by a constant-angle, constant-rate of descent ending near the touchdown point, where the landing maneuver begins, is among the SOPs specifically identified in this AC, and is described in Appendix 2, Stabilized Approach: Concepts and Terms. These and the other Appendices following them represent a baseline and a starting point. Start-up certificate holders and existing certificate holders should refer to the Template in Appendix 1, to Stabilized Approach in Appendix 2, and to the other Appendices to this AC in developing comprehensive SOPs for use in training programs and in manuals used by their flight deck crewmembers.

Federal Aviation Administration. (2002). *Aviation safety reporting system (ASRS).* (Advisory Circular 120-66B). Retrieved from FAA website: http://rgl.faa.gov/Regulatory_and_Guidance_Library/rgAdvisoryCircular.nsf/list/AC%20120-66B/$FILE/AC120-66B.pdf

Summary: This Advisory Circular (AC) provides guidance for establishing an air transportation Aviation Safety Action Program (ASAP). The objective of the ASAP is to encourage air carrier and repair station employees to voluntarily report safety information that may be critical to identifying potential precursors to accidents. The Federal Aviation Administration (FAA) has determined that identifying these precursors is essential to further reducing the already low accident rate. Under an ASAP, safety issues are resolved through corrective action rather than through punishment or discipline. The ASAP provides for the collection, analysis, and retention of the safety data that is obtained.

Federal Aviation Administration. (2003a). ***Parts 91, 121, 125, and 135 flightcrew procedures during taxi operations*****. (Advisory Circular 120-74A). Retrieved from FAA website:** **http://www.faa.gov/regulations_policies/advisory_circulars/index.cfm/go/document.information/documentid/23220**

Summary: [Cancelled] Provides guidelines for the development and implementation of standard operating procedures for conducting safe aircraft operations during taxiing. It is intended for use by persons operating aircraft under parts 121, 125, and 135 (those part 135 flight operations where two or more pilots are in the cockpit) of Title 14 CFR. This AC was cancelled on 7/30/2012.

Federal Aviation Administration. (2003b). ***Standard operating procedures for flight deck crewmembers*** **(Advisory Circular 120-71A). Retrieved from FAA website:** **http://www.faa.gov/regulations_policies/advisory_circulars/index.cfm/go/document.information/documentID/23216**

Annotation: This advisory circular provides guidelines and requirements for operators in developing FAA standard operating procedures (SOPs). It is described as a baseline or starting point for POI guidance. The document discusses how the development and revision of procedures should be meaningful, iterative, and with no inappropriate carryovers. Several "templates" or topics are included in the Appendices - which are the "to dos" and answers some of the "why" of procedure development. This circular focuses on the need for operators to be congruent in their philosophy, policies, procedures, and practices (cited work by Degani & Weiner, 1994). Also included are discussions addressing: "techniques" – personal methods for carrying out a task (e.g., pilot "tricks" computer for passenger comfort), automation, crew monitoring and cross-checking, and issues around "systems procedures" – involves not only cockpit crew but external agents, task de-coupling, sequencing of tasks, changes and updates to checklists when new designs exist, and the role of managers to minimize changes just for the sake of changes but to truly explain/clarify the rationale behind the changes. This AC was cancelled on 1/10/2017.

Federal Aviation Administration. (2003c). ***Standard terminal arrival program and procedures*** **[Order 7100.9D]. Retrieved from FAA website:** **http://www.faa.gov/documentLibrary/media/Order/7100.9D.pdf**

Description: This order provides guidance and standardization for procedures development and management of the Standard Terminal Arrival (STAR) program.

Federal Aviation Administration. (2004a). ***Airplane flying handbook*****. Retrieved from FAA website:** **https://www.faa.gov/regulations_policies/handbooks_manuals/aviation/airplane_handbook/**

Summary: The Airplane Flying Handbook is designed as a technical manual to introduce basic pilot skills and knowledge that are essential for piloting airplanes. It provides information on transition to other airplanes and the operation of various airplane systems. It is developed by the Flight Standards Service, Airman Testing Standards Branch, in cooperation with various aviation educators and industry.

Federal Aviation Administration. (2004b). *Crew resource training.* (Advisory Circular 120-51E). Retrieved from FAA website: http://www.faa.gov/documentLibrary/media/Advisory_Circular/AC120-51e.pdf

Summary: This Advisory Circular (AC) presents guidelines for developing, implementing, reinforcing, and assessing crew resource management (CRM) training for flight crewmembers and other personnel essential to flight safety. CRM training is designed to become an integral part of training and operations. These guidelines were originally intended for Title 14 of the Code of Federal Regulations (14 CFR) part 121 certificate holders who are required by regulation to provide CRM training for pilots and flight attendants, and dispatch resource management (DRM) training for aircraft dispatchers. Fractional ownership program managers, required by 14 CFR part 91, subpart K to provide CRM training to pilots and flight attendants, and those 14 CFR part 135 operators electing to train in accordance with part 121 requirements, should also use these guidelines. Certificate holders and individuals operating under other operating rules, such as parts 91 (apart from subpart K), 125, and part 135 operators not electing to train in accordance with part 121, and others, should find these guidelines useful in addressing human performance issues. This AC presents one way, but not necessarily the only way, that CRM training may be addressed. CRM training focuses on situation awareness, communication skills, teamwork, task allocation, and decision making within a comprehensive framework of standard operating procedures (SOP).

Federal Aviation Administration. (2004c). *Flight operational quality assurance.* (Advisory Circular 120-82). Retrieved from FAA website: http://www.faa.gov/regulations_policies/advisory_circulars/index.cfm/go/document.information/documentID/23227

Summary: "This Advisory Circular (AC) provides guidance on one means, but not necessarily the only means, of developing, implementing, and operating a voluntary Flight Operational Quality Assurance (FOQA) program that is acceptable to the Federal Aviation Administration (FAA)."

Federal Aviation Administration. (2005). *Dispatch resource management (DRM) training.* (Advisory Circular 121-32A). Retrieved from FAA website: http://www.faa.gov/regulations_policies/advisory_circulars/index.cfm/go/document.information/documentID/22513

Annotation: This Advisory Circular (AC; a non-regulatory document) provides guidelines to developing, implementing, reinforcing, and assessing DRM training programs for aircraft dispatchers. It defines and describes human factors, and also describes DRM training, information transfer, dissemination, and problem solving. Discussion includes how the NTSB and FAA have found that failing to adhere to SOPs is a persistent element in these problems encountered by flight crews and aircraft dispatchers – some SOPs have unconsciously and consciously ignored – or, significant SOPs have been omitted from an operator's training program. The circular also refers to the Commercial Aviation Safety Team (CAST) to address such issues and decrease accident rates. An interesting description of the focus and process of DRM is included. There is no discussion on how to develop procedures, but discusses human factors and the focus by CAST on non-adherence to SOPs.

Federal Aviation Administration. (2007a). ***Confirming the takeoff runway*** **[Safety Alert for Operators 07003]. Retrieved from FAA website: http://www.faa.gov/other_visit/aviation_industry/airline_operators/airline_safety/safo/all_safos/media/2007/safo07003.pdf**

Description: This SAFO emphasizes the importance of implementing standard operating procedures (SOPs) and training for flight crews to ensure that an airplane is at the desired takeoff runway, and to recommend some modern resources and procedures for doing so.

Federal Aviation Administration. (2007b). ***Manuals, procedures, and checklists for 14 CFR Parts 91K, 121, 125, and 135*** **(Flight Standards Information Management Systems 8900.1, Vol 3, Chapter 32, Section 1). Washington: Author.**

Description: This chapter contains direction and guidance to be used by principal operations inspectors (POI) and inspectors for processing, reviewing, and accepting or approving manuals, procedures, and checklists.

Federal Aviation Administration. (2007c). ***Manuals, procedures, and checklists for 14 CFR Parts 91K, 121, 125, and 135*** **(Flight Standards Information Management Systems 8900.1, Vol 3, Chapter 32, Section 12). Washington: Author.**

Description: This section contains direction and guidance for principal operations inspectors (POI) for the review of aircraft checklists for Title 14 of the Code of Federal Regulations (14 CFR) part 121 and 135 operators. All part 121 and 135 operators must provide aircraft checklists to their flight crewmembers. Flight crewmembers are required to use these aircraft checklists in air transportation operations. For part 121 operators, aircraft checklists must be approved by the Federal Aviation Administration (FAA), and for part 135 operators these checklists must be acceptable to the FAA (see section 1 of this chapter for definitions of acceptance and approval).

Federal Aviation Administration. (2007d). ***Pilot guide: Flight in icing conditions.*** **(Advisory Circular 91-74A). Retrieved from FAA website: http://www.faa.gov/regulations_policies/advisory_circulars/index.cfm/go/document.information/documentID/74471**

Summary: This advisory circular (AC) contains updated and additional information for the pilots of airplanes under parts 91, 121, 125, and 135 of Title 14 of the Code of Federal Regulations (14 CFR). The purpose of this AC is to provide pilots with a convenient reference on the principal factors related to flight in icing conditions and the location of additional information in related publications. This AC does not authorize deviations from established company procedures or regulatory requirements. This AC was cancelled on 10/8/2015.

Federal Aviation Administration. (2007e). ***Runway light required for night takeoffs part 121*** **[InFO 07009]. Retrieved from FAA website: http://lessonslearned.faa.gov/Comair5191/InFO_07009.pdf**

Description: This InFO reminds pilots operating under 14 CFR part 121 that runway lights are required for takeoff at night, and that checking pertinent Notices to Airmen (NOTAMs) and doing some extra headwork are essential in making a "go/no go" takeoff decision.

Federal Aviation Administration. (2007f). ***Runway overrun prevention*****. (Advisory Circular 91-79). Retrieved from FAA website: http://www.faa.gov/regulations_policies/advisory_circulars/index.cfm/go/document.information/documentID/73552**

Summary: This advisory circular (AC) provides ways for pilots and operators of turbine-powered airplanes to identify, understand, and mitigate risks associated with runway overruns during the landing phase of flight. It also provides operators with detailed information that may be used to develop company standard operating procedures (SOP) to mitigate those risks. This AC was cancelled on 9/17/2014.

Federal Aviation Administration. (2008a). ***Approach and landing accident reduction (ALAR): Recommended flightcrew training*** **[InFO 08029]. Retrieved from FAA website: https://www.faa.gov/other_visit/aviation_industry/airline_operators/airline_safety/info/all_infos/media/2008/info08029.pdf**

Description: More than half of all transport category airplane accidents occur during approach and landing. This InFO promotes flightcrew training to reduce approach and landing accidents, using new training materials developed specifically for that purpose and it applies to the operations of transport category airplanes under parts 121 and 135. In addition, this InFO has been developed in response to NTSB recommendations A-00-93, A-00-94, and A-00-99 and supersedes Flight Standards Information Bulletin for Air Transportation (FSAT) 01-12.

Federal Aviation Administration. (2008b). ***Design and content of check-lists for in-flight smoke, fire and fumes (SFF)*** **[InFO 08034]. Retrieved from FAA website: http://www.faa.gov/other_visit/aviation_industry/airline_operators/airline_safety/info/all_infos/media/2008/info08034.pdf**

Description: To make known a philosophy and a template for use in designing checklists for flight crews in response to evidence of a fire in the absence of a cockpit alert.

Federal Aviation Administration. (2008c). ***Checklist review*** **[InFO 08041]. Retrieved from FAA website: https://www.faa.gov/other_visit/aviation_industry/airline_operators/airline_safety/info/all_infos/media/2008/info08041.pdf**

Description: This InFO provides guidance for air carriers, which operate under Title 14 of the Code of Federal Regulations (14 CFR) parts 121 and 135. The guidance is intended to ensure that all checklists comply with the information presented in the Federal Aviation Administration (FAA) report, "Human Performance Considerations in the Use and Design of Aircraft Checklists," dated January 1995. In addition, this InFO has been developed in response to National Transportation Safety Board (NTSB) safety recommendation A-97-9 and supersedes Flight Standards Information Bulletin for Air Transportation (FSAT) 98-08.

Federal Aviation Administration. (2010a). ***Industry best practices reference list*** **[InFO 10002). Retrieved from FAA website: http://www.faa.gov/other_visit/aviation_industry/airline_operators/airline_safety/info/all_infos/media/2010/info10002SUP.pdf**

Description: To consolidate guidance on industry best practices in operational areas such as checklist design, training, procedures, crew resource management, and error trapping… Recommended Action: Directors of safety, directors of operations, training managers, and trainers of flight crew should be familiar with the list of best practices resources in this InFO. Directors of operations and training managers should review their approved programs and operating procedures to determine if any areas of operation need to be improved based on these best practice documents.

Federal Aviation Administration. (2010b). ***NAV lean: Instrument flight procedures.*** **Retrieved from FAA website: http://www.faa.gov/nextgen/media/NAV%20Lean%20Final%20Report.pdf**

Description: As the demand for Instrument Flight Procedures (IFP) has grown over the past decade and in order to meet the needs of the Next Generation (NextGen) Air Transportation System, the Federal Aviation Administration (FAA) has sought opportunities to streamline and optimize current processes. In response to an RTCA NextGen Mid-Term Implementation Task Force Report (TF-5) recommendation to identify and solve operational approval and certification issues that may impede adoption and acceleration of NextGen capabilities, the FAA initiated a cross-agency Navigation Procedures project to streamline all policies and processes used to implement IFPs. This initiative was headed by Aviation Safety (AVS) and the Air Traffic Organization (ATO). Using the "Lean Management Process," the Working Groups reviewed all processes used to request, prioritize, process, improve, and implement IFPs, and provided recommendations to maximize customer value and reduce waste in the development and delivery of all IFPs in the National Airspace System (NAS).

Federal Aviation Administration. (2010c). *Part 121 air carrier operational control.* (Advisory Circular 120-101). Retrieved from FAA website: http://www.faa.gov/regulations_policies/advisory_circulars/index.cfm/go/document.information/documentid/305074

Annotation: This Advisory Circular provides guidelines and requirements for aviation safety inspectors and air carrier management personnel to comply with regulations, and describes information to consider regarding certificate management and internal evaluation of operational control functions. It documents the requirements and includes reference to the FAA Order 8900.1, Volume 3, Chapter 25, and Operational Control for Air Carriers. The circular does not provide guidance for developing procedures, but lists requirements (e.g., "manuals and checklists must contain clear and concise instructions and information").

Federal Aviation Administration. (2010d). *Scope and recommended content for a contractual agreement between an air carrier and a contract maintenance provider (CMP)*. (Advisory Circular 120-106). Retrieved from FAA website: http://www.faa.gov/regulations_policies/advisory_circulars/index.cfm/go/document.information/documentID/780197

Annotation: This Advisory Circular describes the scope and recommended content requirements between an air carrier and contract maintenance provider for contractual agreements. It describes what "should be" included in procedures (e.g., "all policies and procedures are mutually agreed upon"), and who is specifically responsible for the various parts. Some discussion on subcontractors, and what requirements need to be followed by CMPs. This AC was cancelled on 1/4/2016.

Federal Aviation Administration. (2011). *Title 14 Aeronautics and space* [electronic database]. Retrieved from FAA website: http://www.faa.gov/regulations_policies/faa_regulations/

Annotation: The Title 14 Aeronautic and Space regulations are rules, established by the FAA, governing all aviation activities in the United States. These regulations are organized into sections, called parts. Many Federal Aviation Regulations (FARs) are designed to regulate certification of pilots, schools or aircraft rather than the operation of airplanes. Once an airplane design is certified using some parts of these regulations, it is certified regardless of whether the regulations change in the future. Subparts 1-59 and 60-109 cover some areas of standard operating procedures (SOPs). Part 25.1585 describes normal and non-normal operating procedure requirements. Part 91.1033 describes general operating information requirements and state "what to" include. Part 121.315 describes the cockpit check procedure requirements. A Safety Attribute Inspection (SAI) Data Collection Tool (3.1.3. Airman Duties - Flight deck Procedures (OP) Revision #: 10 Revision Date: 03/01/2012) is also included, to ensure that the procedures and duties meet all of the Title 14 requirements, incorporates the safety attributes, and identifies any shortfalls in the operator's procedures. The SAI is a "check the box" document to verify that the operator's procedures identify "who, what, where, and how those procedures are accomplished". It also refers to the FAA Order 8900.1 document and to various Advisory Circulars (i.e., AC 120-71, AC 120-48). The following regulations are referenced in the FAA AC 120-71A: 14 CFR part 121, sections 121.133 (Preparation), 121.141 (Airplane flight manual), 121.401 (Training program: General); 14 CFR part 125, section 125.287 (Initial and recurrent pilot testing requirements); and 14 CFR part 135, section 135.293. This guidance establishes regulations, general requirements, and "what to" include for checklists and types of procedures but not "how to" develop or write them. It is similar to the Flight Standards Information Management Systems (FSIMs) in terms of "check the box" requirements.

Federal Aviation Administration. (2012a). ***Parts 91, 121, 125, and 135 flightcrew procedures during taxi operations*****. (Advisory Circular 120-74B). Retrieved from FAA website: http://www.faa.gov/regulations_policies/advisory_circulars/index.cfm/go/document.information/documentID/1020233**

Annotation: This Advisory Circular provides guidelines and requirements that cover the rules to follow and things to consider for SOP guidance during taxiing and also for flight crew workload during taxi. It does not include how to setup or design procedures themselves. The Appendices are not directive or prescriptive and do not represent a rigid view of FAA Best Practices. The document lists several related reading materials such as: AC 90-42, AC 90-66, AC 120-57, AC 120-71, and other sources of guidance such as: AIM, SAFO, and ASRS. Some websites referenced include: AOPA and NOTAMS.

Federal Aviation Administration. (2012b). ***Standard operating procedures (SOP) for title 14 of the code of federal regulations (14 CFR) part 135 certificate holders and part 91K program managers*** **[Safety Alert for Operators 12003]. Retrieved from FAA website: http://www.faa.gov/other_visit/aviation_industry/airline_operators/airline_safety/safo/all_safos/media/2012/SAFO12003.pdf**

Description: This SAFO reminds part 135 certificate holders and part 91K operators of the criticality of using SOPs during all phases of flight.

Federal Aviation Administration. (2013a). ***Aircraft equipment and operational authorization*****. Flight Standards Information Management Systems 8900.1, Vol 4, Chapter 2, Section 5. Retrieved on 8/16/2012 from FAA website: http://fsims.faa.gov/PICDetail.aspx?docId=8900.1,Vol.4,Ch2,Sec5**

Summary: This section includes guidance for operations other than Category (CAT) II/III approaches for Title 14 of the Code of Federal Regulations (14 CFR) parts 91, 91 subpart K (part 91K), 121, 125, 129, and 135 operators. Approach and landing operations other than CAT II/III include visual approaches, contact approaches, circling approaches, Non-precision Approaches (NPA), approach procedures with vertical guidance (APV), and CAT I instrument landing system (ILS) approaches. This section includes guidance for both approach procedures using ground-based and/or satellite-based Navigational Aids (NAVAID).

Federal Aviation Administration. (2013b). *Flight standards information management systems 8900.1.* Retrieved from FAA website: **http://fsims.faa.gov/PICResults.aspx?mode=EBookContents&restricttocategory=all~menu**

Annotation: This evolving reference document provides guidance or principal operations inspectors (POIs), in the development of procedures and checklists with operators. Volume 3 entitled, "General Technical Administration", within the chapter "Manuals, Procedures, and Checklists for 14 CFR Parts 91K, 121, 125, and 135" is a section specifically dedicated to procedure and checklist development. It is intended to direct and guide the processing, reviewing, and accepting or approving of manuals, procedures, and checklists. This document is THE guiding document for POIs – providing the regulatory guidelines. It does not include the history, research, or background about procedures or checklists, or the "how's" of checklist and procedures design. This document focuses primarily on the rules, "check the box" requirements (e.g., if a procedure exists or not).

Federal Aviation Administration. (2013c). *Safety attribute inspection (SAI) data collection tool: 3.1.3 Airman duties / flightdeck procedures (OP)*. Flight Standards Information Management Systems 8900.1, ATOS Data Collection Tool, 3.0 Flight Operations, 3.1 Air Carrier Programs and Procedures, SAI 3.1.3. Retrieved on from FAA website: **http://fsims.faa.gov/PICDetail.aspx?docId=SAI%203.1.3%20%28OP%29**

Description: Purpose (operator's responsibility): To ensure that Airman Duties/Flightdeck Procedures provide for the safe operation of the airplane. Objective (FAA oversight responsibility): To determine if the operator's Airmen Duties/Flightdeck Procedures: Meets all applicable requirements of Title 14 of the Code of the Federal Regulations (14 CFR) and FAA policies', Incorporates the safety attributes, and Identifies any shortfalls in the operator's Airman Duties/Flightdeck Procedures.

Federal Aviation Administration. (2016). *Airplane flying handbook*. Retrieved from FAA website: **https://www.faa.gov/regulations_policies/handbooks_manuals/aviation/airplane_handbook/media/airplane_flying_handbook.pdf**

Description: This technical manual to introduce basic pilot skill and knowledge is an update to the FAA's Airplane Flying Handbook 2004 edition.

Federal Aviation Administration. (2017). *Standard operating procedures and pilot monitoring duties for flight deck crewmembers* (Advisory Circular 120-71B). Retrieved from FAA website: https://www.faa.gov/documentLibrary/media/Advisory_Circular/AC_120-71B.pdf

Description: This Advisory Circular (AC) provides guidance for the design, development, implementation, evaluation, and updating of standard operating procedures (SOP), and for pilot monitoring (PM) duties. SOPs are universally recognized as fundamental to safe aviation operations. Their importance cannot be overstated, especially in light of the advent of PM standards with respect to the use of increasingly modernized automated systems. This

AC provides a process for developing procedures that meet clear and specific requirements. Safe operations are founded on comprehensive SOPs made readily available within the manuals used by flight deck crewmembers. This AC also provides guidance on the definition and the training of PM duties and their integration into SOPs. Although this AC is directed towards Title 14 of the Code of Federal Regulations (14 CFR) part 121 and part 135 air carriers, the Federal Aviation Administration (FAA) encourages all air carriers, aircraft operators, pilot schools, and training centers to utilize this guidance.

Annotation: Some concepts from Barshi, Mauro, Degani, & Loukopoulou's "Designing Flightdeck Procedures" memorandum (2016) are included in this updated AC (e.g., Characteristics of Good Procedures). See memorandum for a more in depth understanding and rationale of these concepts, and for further procedure development process guidance.

Flight Deck Automation Working Group. (2013). ***Operational use of flight path management system—Final report of the PARC/CAST flight deck automation WG.*** **Retrieved from FAA website: http://www.nbaa.org/ops/safety/Final_Report_Recommendations.pdf**

Description: In summary, the Working Group identified numerous areas that contribute to safety and operational effectiveness. However, vulnerabilities were identified in the accident, incident and operational data reviewed by the Working Group. Some underlying themes that the Working Group has identified include complexity (in systems and in operations); concerns about degradation of pilot knowledge and skills; and integration and interdependence of the components of the aviation system. Since the Working Group completed its data collection and analysis, several accidents have occurred where the investigative reports identified vulnerabilities in the events that are similar to those vulnerabilities identified in this report. The Working Group believes that implementing these recommendations will be necessary to make improvements in safety and operational effectiveness, especially considering the expected changes in future operations. The findings listed include various issues (e.g., vulnerability with automation use), and raised an important recommendation stating that, "This guidance should be updated to reflect operational experience and research findings on a recurring basis."

Institute of Nuclear Power Operations. (2009). ***Procedure use and adherence.*** **(INPO 09-004). Retrieved from Smart Procedures website: http://www.smartprocedures.com/pdfs/inpo-09-004-use-and-adherence-guidelines.pdf**

Summary: The Institute of Nuclear Power Operations (INPO), as part of an industry task force, started work in June 2007 to develop an industry standard for the scope of a procedure use and adherence document. This task force was composed of representatives from INPO and Nuclear Information Management Strategic Leadership (NIMSL), as well as industry subject-matter experts**.** This document describes components of procedure use and adherence to assist the nuclear utility industry in the operation and support of nuclear plants. For a utility, effective implementation of sound procedure use and adherence methods is tied directly to human error reduction, event prevention, and safety and is an integral part of sound revenue generation and maintaining shareholder value. The purposes of this procedure use and adherence document are as follows: Provide an industry guideline based on the experience and knowledge of nuclear industry peers, factoring in the best available human performance strategies. Provide procedure use guidance based on the types of procedures. Provide guidance for adherence to procedures by establishing principles, guidelines, and rules. This will help ensure safe, effective application and use of procedures in the administration and performance of activities at nuclear power stations. Although most stations differentiate between procedures and work instructions, part of the guidance provided herein can be applied to work instructions. This guidance does not apply to the use of emergency and abnormal operating procedures. Each owners group provides standard guidance for its procedure set. INPO 09-004 is intended to be used by nuclear plant owners and operators as part of their procedure use and adherence programs. Each facility is encouraged to assess its own procedure-writing process and to adapt this information as appropriate to best meet its unique needs. The intent of this guideline is to identify standard elements that should be considered, not to provide an all-inclusive list.

International Civil Aviation Organization. (2006). *Aircraft Operations: Volume 2—Procedures for air navigation services—Construction of visual and instrument flight procedures* (Doc 8168, 5th ed.). Montréal, Canada: Author.

Summary: The Procedures for Air Navigation Services: Aircraft Operations (PANS-OPS) consists of two volumes as follows: Volume I: Flight Procedures and Volume II: Construction of Visual and Instrument Flight Procedures. Volume II is intended for the guidance of procedures specialists and describes the essential areas and obstacle clearance requirements for the achievement of safe, regular instrument flight operations. It provides the basic guidelines to States, and those operators and organizations producing instrument flight charts that will result in uniform practices at all aerodromes where instrument flight procedures are carried out.

International Civil Aviation Organization. (2007). *Aircraft operations: Volume 1—Flight procedures* (Doc 8168, 5th ed.). Retrieved from Information Handling Services website: http://www.ihs.com/products/industry-standards/org/icao/manuals/index.aspx

Summary: The Procedures for Air Navigation Services: Aircraft Operations (PANS-OPS) consists of two volumes as follows: Volume I: Flight Procedures and Volume II: Construction of Visual and Instrument Flight Procedures. Volume I describes operational procedures recommended for the guidance of flight operations personnel and flight crew. It also outlines the various parameters on which the criteria in Volume II are based so as to illustrate the need to adhere strictly to the published procedures in order to achieve and maintain an acceptable level of safety in operations.

Joint Aviation Authorities. (2007). *JAR-OPS subpart P: Manuals, logs and records*. Joint aviation requirements JAR-OPS 1 Commercial air transportation (Aeroplanes), Section 1, Amendment 12, 229–238. Retrieved from JAA website: http://www.jaa.nl/publications/jars/jar-ops-1.pdf

Summary: The members of the Joint Aviation Authorities Committee are representatives of the Civil Aviation Authorities of the countries that have signed the ‘Arrangements Concerning the Development and the Acceptance of Joint Aviation Requirements’. The Civil Aviation Authorities of certain European countries have agreed common comprehensive and detailed aviation requirements, referred to as the Joint Aviation Requirements (JAR), with a view to minimising Type Certification problems on joint ventures, to facilitate the export and import of aviation products, to make it easier for maintenance carried out in one European country to be accepted by the Civil Aviation Authority in another European country and to regulate commercial air transport operations. JAR–OPS has been issued with no National Variants. It may be felt that the document does not contain all of the detailed compliance and interpretative information, which some Civil Aviation Authorities and Industry organisations would like to see. However, it has been accepted that JAR–OPS should be applied in practice and the lessons learned embodied in future amendments. The Civil Aviation Authorities of the JAA are therefore committed to amendment in the light of experience.

Klement, R. E. (1995). *Procedure preparation for ISO 9000 certification*. Paper presented at the American Production Inventory Control Society International Conference and Exhibition, Orlando, FL. Retrieved from OSTI website: http://www.osti.gov/scitech/servlets/purl/132703

Summary: The purpose of this paper is to share information about the successful implementation of centralized procedure administration and the re-engineering of the procedure system, leading to successful ISO 9001 certification at AlliedSignal Inc., Kansas City Division. The Kansas City Division (KCD) produces non-nuclear components for nuclear weapons. The company has operated the plant for the US Department of Energy since 1949. Throughout the history of the plant, procedures were written to reflect the nuclear weapons industry best practices, and the facility built a reputation for producing high quality products. In 1991 a critical process team was asked to use Just In Time principles to determine a better way to administrate procedures. By 1992 the team was successful in implementing a full-time centralized procedure group to handle the creation, coordination, review, resolution, and publication of plant-wide administrative and operating procedures. In 1993 AlliedSignal was commissioned by its President and CEO Larry Bossidy to register all of the worldwide sites under the ISO 9000 quality standard. This presented a formidable challenge for the Kansas City Division. Though the independent third-party auditors conceded during a pre-assessment that the company did in fact build high quality products, the procedures and procedure system did not accurately reflect the current business practices. The purpose of this paper is to share information about the successful implementation of centralized procedure administration and the re-engineering of the procedure system, leading to successful ISO 9001 certification at AlliedSignal Inc., Kansas City Division.

McLaughlin, A.C. (2010). What makes a good checklist: Perspective [online forum]. Retrieved from the United States Department of Health and Human Services Agency for Healthcare Research and Quality: Morbidity & Mortality Rounds on the Web website: http://webmm.ahrq.gov/perspective.aspx?perspectiveID=92

Summary: The use of checklists is a primitive yet remarkably effective strategy for ensuring accuracy in complex tasks. Checklists have long been used in fields such as aviation and space exploration but have only recently made headway in medicine. The reluctance of medical professionals to adopt checklists is often framed as pushback against "more paperwork" and "cookbook medicine," or due to disbelief in their effectiveness. However, a rich literature has helped establish many best practices in checklist design, and health care now stands to benefit.

National Aeronautics and Space Administration, & Federal Aviation Administration. (2000). ***NASA/FAA Operating documents project: Developing operating documents: A manual of guidelines—E-Version*. Retrieved from Airsafety website: http://www.airsafety.aero/getattachment/Requirements-and-Policy/OTACs/OTAR-Part-119-Air-Operator-Certification/Flight-Safety-Documents-System/Useful-references/Developing_Operating_Documents_Manual.pdf.aspx?lang=en-US**

Annotation: A collaborative work involving NASA, the FAA, and several corporations and industries—including Boeing, United Airlines, Bombardier Aerospace, and many others. This manual provides an internally and externally consistent document that covers the entire flight document development process. It reviews best practices, but does not represent regulatory requirements. Some areas of development include: organization of documents, standardization, usability, and transition to electronic media. The manual also addresses important issues (e.g., optimizing and coordinating procedures), and provides several relevant guidelines, with industry participation and from a human factors perspective, for developing procedures and checklists. It is a solid and informative document for reference.

National Aeronautics and Space Administration, & Federal Aviation Administration. (2004). ***ASRS Callback: Checklist checkup* (Issue 292). Retrieved from: http://asrs.arc.nasa.gov/publications/callback/cb_292.htm**

Description: An FAA review of National Transportation Safety Board (NTSB) accident data revealed that during the period 1983 to 1993, approximately 279 aircraft accidents occurred in which a checklist was improperly used or not used. A review of ASRS "checklist" related reports for 2003 suggests that many of the same errors identified by the FAA and NTSB continue to be reported. The most common checklist errors include the following: 1. Failure to use a checklist., 2. Use of the wrong checklist., 3. Checklist flow interrupted., and 4. Checklist item(s) overlooked. Recent examples of these errors are detailed in the following ASRS reports.

National Aeronautics and Space Administration, & Federal Aviation Administration. (2014). ***ASRS Callback: Checklist checkup* (Issue 410). Retrieved from: http://asrs.arc.nasa.gov/publications/callback/cb_410.html**

Description: Checklists are used by pilots to assure that the aircraft is properly configured for each phase of flight. Checklists are also used to provide appropriate response to abnormal or emergency situations. While checklists do provide a means of guiding a pilot or flight crew through complex procedures, they are not impervious to human error. Reports submitted to ASRS indicate that errors related to checklist usage generally fall into one of these five categories: (1) Checklist interrupted, (2) Checklist item overlooked, (3) Use of the wrong checklist, (4) Failure to use a checklist, and (5) Checklist confusion. Examples of these errors are found in the following reports.

National Aeronautics and Space Administration, & Federal Aviation Administration. (2015). *ASRS Callback: A checklist checklist* (Issue 428). Retrieved from NASA website: https://asrs.arc.nasa.gov/publications/callback/cb_428.html

Description: Checklists were developed to ensure consistency and completeness in the performance of complex tasks. Aviation checklists provide an orderly and sequential collection of vital steps for configuring an aircraft for different phases of flight or for resolving abnormal situations. Since ASRS continues to receive a significant number of incident reports related to checklist errors, perhaps another look at some of the factors affecting proper checklist usage is warranted. See CALLBACK Issues #292 and #410. These recent ASRS reports highlight five items that should be on everyone's Preventing Checklist Errors checklist.

NLR Air Transport Safety Institute. (2003). *Airline industry survey of hazards associated with reliance on flight deck automation.* Retrieved from NLR-ATSI website: http://www.nlr-atsi.nl/fast/downloads/AIRLINE%20INDUSTRY%20SURVEY%20OF%20HAZARDS%20ASSOCIATED%20WITH%20RELIANCE.pdf

Summary: Scope of Survey - The objective of this questionnaire was to determine the opinion by senior members from the airline sector to the JAA industry based research project "Future Hazards Associated with Flight Deck Automation". This particular questionnaire was seen as an integral part of the validation process of the work performed by the ad-hoc expert panel, which was convened for this area of research. The target response group for this questionnaire was the more experienced and senior members of the various airline operations and regulatory departments. More specifically this survey was aimed at those involved in pilot training and testing at different levels. Statistical data has been generated as a result of the answers given and is presented in this report.

Nuclear Energy Institute. (2014). *Emergency response procedures and guidelines for extreme events and severe accidents*. Retrieved from: http://pbadupws.nrc.gov/docs/ML1404/ML14049A005.pdf

Summary: U.S. nuclear power plant licensees currently maintain the capability to implement beyond design basis accident mitigation and management strategies developed through several separate initiatives. Each strategy has been converted into implementing actions and recommendations within three separate sets of procedures and guidelines: Emergency Operating Procedures (EOPs), Severe Accident Management Guidelines (SAMGs), and Extensive Damage Mitigation Guidelines (EDMGs). In addition to these existing procedure and guideline sets, the industry is currently developing a new set of guidelines, referred to as FLEX Support Guidelines (FSGs), in response to Order EA-12-049 issued by the U.S. Nuclear Regulatory Commission (NRC). Having been developed separately, each of these procedure and guideline sets are subject to varying levels of regulatory requirements and industry commitments, as are the training, drills, and exercises intended to maintain the capability for effective implementation. The EOPs were designed to restore and maintain safety functions, and place the plant in a safe shutdown condition. This document provides guidance for ensuring that EOPs, EDMGs, FSGs and SAMGs are integrated in a cohesive, effective and usable manner. It also addresses recommendations for the development of accident or event mitigation and management guidelines, and command and control structures for responding to severe accidents and extreme events4. Guidance concerning the related aspects of training, drills and exercises is contained in NEI 13-06, Enhancements to Emergency Response Capabilities for Beyond Design Basis Accidents and Events.

Nuclear Information Management Strategic Leadership. (2006). ***Procedure writers' manual*** **(NEI AP-907-005, Rev. 0). Nuclear Energy Institute: Washington, DC.**

Summary: The purpose of this Procedure Writers' Manual is to provide an industry standard based on the consensus of nuclear industry peers. NEI AP-907-005 is a general Procedure Writers Manual and is intended to be used by nuclear plant owners or operators to assess their procedure writing process. This standard should be used in conjunction with NEI AP-907-001, Procedure Process Description. The standard for writing procedures is intended to be applied at sites as appropriate, considering corporate and site-specific policies and objectives. The format and writing methodology contained within NEI AP-907-005 should be considered for incorporation into site-specific procedures. Each facility is encouraged to assess their own procedure writing process and to adapt this information as appropriate to best meet its unique needs. The intent of this manual is to identify standard elements that should be considered, not to provide an all-inclusive list. The basic elements in this standard apply whether the document is an administrative or technical procedure. However, the level of detail required is greatest for technical procedures. Therefore, this standard as written and the detailed information contained in this document may not apply to all procedures.

Nuclear Regulatory Commission. (1995). ***NRC Inspection manual—Inspection procedure 42700.*** **Retrieved from NRC website: http://www.nrc.gov/reading-rm/doc-collections/insp-manual/inspection-procedure/ip42700.pdf**

Summary: Objectives. To verify that plant procedures are reviewed and approved in accordance with technical specifications and regulatory requirements. To verify that the technical adequacy of procedures is consistent with desired actions and modes of operation. To verify the usability of procedure content and format by determining the degree to which accepted human factors principles have been incorporated. To verify that temporary procedure changes were made in accordance with plant administrative procedures and technical specification requirements.

Nuclear Regulatory Commission. (2007). ***Standard review plan: Human factors engineering*** **(NUREG 0800, Rev 2). Retrieved from NRC website: http://pbadupws.nrc.gov/docs/ML0706/ML070670253.pdf**

Summary: This SRP chapter will be used by the staff when performing safety evaluations of license applications submitted by applicants pursuant to 10 CFR Part 50 and 10 CFR Part 52. This SRP chapter describes a process for evaluating (1) designs, (2) design processes, (3) design reviews, and (4) operator actions submitted by applicants and licensees for the broad range of NRC review responsibilities. Chapter 18 contains an area of review titled "Procedure Development," which provides criteria for the review of the procedure development process rather than the actual procedures. *Procedure Development* - The objective of this review is to confirm that the applicant's procedure development program incorporates HFE principles and criteria, along with all other design requirements, to develop procedures that are technically accurate, comprehensive, explicit, easy to utilize, validated, and in conformance with 10 CFR 50.34(f)(2)(ii). Because procedures are considered an essential component of the HFE design, they should be derived from the same design process and analyses as the other components of the HSI (e.g., displays, controls, operator aids) and subject to the same evaluation processes. The applicant's procedure development program should be evaluated in accordance with the review criteria of NUREG-0711. The review should be coordinated with the review of procedures described in SRP Section 13.5. The full procedures program is considered to be an operational program as discussed in SECY-05-197 and in RG-1.206 Section C.IV.4.

Nuclear Regulatory Commission. (2010). *NRC Inspection manual—Inspection procedure 42401.* Retrieved from NRC website: http://pbadupws.nrc.gov/docs/ML0801/ML080140332.pdf

Summary: Objectives. To confirm that the scope of the plant procedures are adequate to control safety related operations within applicable regulatory requirements. To determine the adequacy of management controls in implementing and maintaining a viable procedure control process. To verify that the technical adequacy of procedures is consistent with desired actions and modes of operation. To verify the usability of procedure content and format by determining the degree to which accepted human factors principles have been incorporated.

Nuclear Regulatory Commission. (2012). *Human factors engineering—Program review model* (NUREG-0711, Rev. 3). Retrieved from NRC website: http://pbadupws.nrc.gov/docs/ML1232/ML12324A013.pdf

Summary: This document is used by the staff of the Nuclear Regulatory Commission to review the human factors engineering (HFE) programs of applicants for construction permits, operating licenses, standard design certifications, combined operating licenses, and license amendments. The purpose of these reviews is to verify that the applicant’s HFE program incorporates HFE practices and guidelines accepted by the staff as described within the twelve elements of an HFE program: HFE Program Management, Operating Experience Review, Functional Requirements Analysis and Function Allocation, Task Analysis, Staffing and Qualifications, Treatment of Important Human Actions, Human - System Interface Design, Procedure Development, Training Program Development, Human Factors Verification and Validation, Design Implementation, and Human Performance Monitoring. Each element encompasses five sections: Background, Objective, Applicant Products and Submittals, Review Criteria, and Bibliography.

Planzer, N., & Hofmann, M.A. (1995). *Advancing free flight through human factors.* Retrieved from: https://ntl.bts.gov/lib/000/800/833/freeflt.pdf

Executive summary: This report describes the results of the Advancing Free Flight Through Human Factors technical workshop held on June 20 and 21, 1995. The purpose of this technical workshop was to begin the process of identifying and solving human factors issues related to a new aviation concept called "free flight." The FAA sponsored an RTCA select committee to define the concept of free flight and to identify the issues and activities that must be undertaken to advance the concept. The select committee prescribed free flight as a concept encompassing a real time air traffic management triad: People, Procedures, and Technologies. The long range changes envisioned by the RTCA select committee to move the system toward free flight will involve the human as the most critical element in the use of new technologies, equipment, and procedures…The findings and conclusion of the workshop provide insight into the challenges associated with human factors and free flight.

Procedures Professionals Association. (2011). *Procedures process description PPA AP 907-001 Revision 1.* Retrieved from PPA website: http://www.ppaweb.org/documents/PPA-AP-907-001.pdf

Description: Forward - In March 2005, at the direction of the Nuclear Information Management Strategic Leadership (NIMSL) steering committee, an Institute of Nuclear Power Operations (INPO) Community of Practice (CoP), an industry task force was chartered to address the broader scope of the procedure process through the development of an industry process description. This task force was composed of representatives from the NIMSL CoP and industry subject matter experts. In 2010, the Procedure Professionals Association (PPA) assumed ownership and maintenance responsibilities for AP-907-001 (Procedure Process) and AP-907-005 (Procedure Writers' Manual). PPA is an industry-working group for procedure related interests and is composed of subject matter experts from the U.S. commercial nuclear field, the U.S. Department of Energy, and other similar business interests. PPA is an open forum for procedure related issues and accepts membership from In November 2010, PPA formed a standards committee and commenced work on a revision to AP-907-001 and AP-907-005. These revisions were completed and published in August 2011. Purpose and scope: The purpose of this procedure process description is to provide a standard process for creating and altering procedures. This document is intended to be used by nuclear facility owners and operators to assess their organization's management of the procedure process as defined in the EUCG Standard Nuclear Performance Model. This process description establishes a baseline for consistent procedure activities and discusses performance measures. This document is also intended to be used as a tool for performing effective self-assessments and benchmarking. An effective process description enables standardized comparisons to be made and provides a basis for improvement suggestions. This document was revised and updated in January 2016.

Sands, J.I. (2003). *Technical evaluation report*. McLean, Virginia: MITRE Corporation.

Description: Overview - Automation may increase efficiency, but it also raises doubts about adequate human control over automated systems and making sure that system effectiveness is not jeopardized. This symposium focused on the interaction of humans with a growing array of automated functions and automated and intelligent systems. During the symposium, participants discussed how to harmonize the interactions of humans with automated and semi-automated systems to increase overall mission performance. The symposium participants outlined recommendations for development of human-centered automation in military environments, addressing key areas such as providing levels of automation that are appropriate to levels of risk, examining procedures for recovery from emergencies, and ensuring human control of automation. This evaluation presents an overview of the problem, and reviews design philosophy, methodology and evaluation as presented by paper authors. The report also evaluates the content presented, discussions, and recommendations.

Schutte, P.C., & Willshire, K.F. (1997). *Designing to control flight crew errors* (Technical Report #200401106681). Retrieved from NASA Technical Reports Server website: https://ntrs.nasa.gov/search.jsp?R=20040110681

Abstract: It is widely accepted that human error is a major contributing factor in aircraft accidents. There has been a significant amount of research in why these errors occurred, and many reports state that the design of flight deck can actually dispose humans to err. This research has led to the call for changes in design according to human factors and human-centered principles. The National Aeronautics and Space Administration's (NASA) Langley Research Center has initiated an effort to design a human-centered flight deck from a clean slate (i.e., without constraints of existing designs.) The effort will be based on recent research in human-centered design philosophy and mission management categories. This design will match the human's model of the mission and function of the aircraft to reduce unnatural or non-intuitive interfaces. The product of this effort will be a flight deck design description, including training and procedures, and a cross reference or paper trail back to design hypotheses, and an evaluation of the design. The present paper will discuss the philosophy, process, and status of this design effort.

Seamster, T.L., Boehm-Davis, D.A., Holt, R.W., & Schultz, K. (1998). *Developing advanced crew resource management (ACRM) training: A training manual.* Retrieved from the FAA website: https://www.faa.gov/training_testing/training/aqp/training/manual/media/dacrmt.pdf

Summary: ACRM is a comprehensive implementation package including the CRM procedures, training of the instructor/evaluators, and training of the crews, a standardized assessment of crew performance, and an ongoing implementation process. ACRM has been designed and developed through a collaborative effort between the airline and research community. ACRM training is an ongoing development process that provides airlines with unique CRM solutions tailored to their operational demands. Design of CRM procedures is based on critical CRM principles that require emphasis in airline's specific operational environment. Procedures were developed to emphasize these CRM elements by incorporating them into SOPs for normal as well as abnormal and emergency flight situations.

Tarnowski, E. (1999). Understanding design philosophy can help pilots benefit from modern automated flight systems. *ICAO Journal,* 22–30.

Summary: A set of guidelines or "golden rules for the operation of automated systems can help crew members to remain fully aware of the status of the aircraft and its sophisticated systems - ready to react should an unexpected or critical event arise.

U.S. Department of Health and Human Services, The National Commission for the Protection of Human Subjects of Biomedical and Behavioral Research. (1979). *The belmont report - Ethical principles and guidelines for the protection of human subjects of research*. Retrieved from the United States Department of Health and Human Services website: http://www.hhs.gov/ohrp/humansubjects/guidance/belmont.html

Summary: On July 12, 1974, the National Research Act (Pub. L. 93-348) was signed into law, thereby creating the National Commission for the Protection of Human Subjects of Biomedical and Behavioral Research. One of the charges to the Commission was to identify the basic ethical principles that should underlie the conduct of biomedical and behavioral research involving human subjects and to develop guidelines, which should be followed to assure that such research is conducted in accordance with those principles. In carrying out the above, the Commission was directed to consider: (i) the boundaries between biomedical and behavioral research and the accepted and routine practice of medicine, (ii) the role of assessment of risk-benefit criteria in the determination of the appropriateness of research involving human subjects, (iii) appropriate guidelines for the selection of human subjects for participation in such research and (iv) the nature and definition of informed consent in various research settings. The Belmont Report attempts to summarize the basic ethical principles identified by the Commission in the course of its deliberations. It is the outgrowth of an intensive four-day period of discussions that were held in February 1976 at the Smithsonian Institution's Belmont Conference Center supplemented by the monthly deliberations of the Commission that were held over a period of nearly four years. It is a statement of basic ethical principles and guidelines that should assist in resolving the ethical problems that surround the conduct of research with human subjects. By publishing the Report in the Federal Register, and providing reprints upon request, the Secretary intends that it may be made readily available to scientists, members of Institutional Review Boards, and Federal employees. The two-volume Appendix, containing the lengthy reports of experts and specialists who assisted the Commission in fulfilling this part of its charge, is available as DHEW Publication No. (OS) 78-0013 and No. (OS) 78-0014, for sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402. Unlike most other reports of the Commission, the Belmont Report does not make specific recommendations for administrative action by the Secretary of Health, Education, and Welfare. Rather, the Commission recommended that the Belmont Report be adopted in its entirety, as a statement of the Department's policy. The Department requests public comment on this recommendation.

Veillette, P.R. (2012). *Give e-checklists an A+*. Business & Commercial Aviation. Retrieved from FAA website: http://lessonslearned.faa.gov/Northwest255/E_Checklists.pdf

Summary: The introduction of any new technology to a cockpit always carries the risks of unanticipated errors and unintended consequences. But electronic checklist technology has matured and proven itself and should be embraced. We need to learn from past checklist-related incidents and accidents and adapt electronic lists and presentations accordingly. Also, users should insist that manufacturers design electronic checklists so they can be easily modified to coincide with an operator's FAA-approved checklists. It is time for this technology to be fully implemented to its maximum potential. It stops errors and can save lives.

Veitengruber, J.E., & Rankin, W.L. (1995). Use of crew-centered design philosophy allows the introduction of new capabilities and technology. *ICAO Journal*, 20–22.

Abstract: Crew-centered principles used in designing the Boeing 777 flight deck were developed from worldwide operational experience with previous generations of commercial jet transport aircraft.

Wiener, E.L. (1993). *Intervention strategies for the management of human error* (NASA Contractor Report #4547). Moffett Field, CA: NASA Ames Research Center.

Summary: This report examines the management of human error in the cockpit. The principles probably apply as well to other applications in the aviation realm (e.g. air traffic control, dispatch, weather, etc.) as well as other high-risk systems outside of aviation (e.g. shipping, high-technology medical procedures, military operations, nuclear power production). Management of human error is distinguished from error prevention. It is a more encompassing term, which includes not only the prevention of error, but also a means of disallowing an error, once made, from adversely affecting system output. Such techniques include: traditional human factors engineering, improvement of feedback and feedforward of information from system to crew, 'error-evident' displays which make erroneous input more obvious to the crew, trapping of errors within a system, goal-sharing between humans and machines (also called 'intent-driven' systems), paperwork management, and behaviorally based approaches, including procedures, standardization, checklist design, training, cockpit resource management, etc. Fifteen guidelines for the design and implementation of intervention strategies are included.

4. Accident and Incident Reports

Aviation Safety Reporting System. (2012a). [Report Number 989180]. Retrieved March 29, 2013, from: http://asrs.arc.nasa.gov

Synopsis: B737-800 flight crew experiences a LE flap transit light after flap retraction. QRH procedures do not remedy the situation and flight returns to departure airport for a partial flap landing. Database search on "checklist incidents" results in a pilot's report that, "procedures do not remedy the situation."

Aviation Safety Reporting System. (2012b). [Report Number 1006482]. Retrieved March 29, 2013, from: http://asrs.arc.nasa.gov

Synopsis: A B767-300 experienced smoke and fumes in flight followed by numerous EICAS messages and warning lights associated with system anomalies that would contribute to the physical evidence. They [the pilots] declared an emergency and made a rapid descent and overweight landing at a nearby enroute airport. Pilot reports, "too much…with not a lot of time in an emergency."

Aviation Safety Reporting System. (2012c). [Report Number 1008744]. Retrieved March 29, 2013, from: http://asrs.arc.nasa.gov

Synopsis: B777 flight crew discovers airborne that they have departed with conflicting MEL's concerning Main Deck shut off valves. After consulting with Maintenance the flight continues to destination. Pilot reports, "they [procedures] conflicted with MELS."

Aviation Safety Reporting System. (2012d). [Report Number 1009419]. Retrieved March 29, 2013, from: http://asrs.arc.nasa.gov

Synopsis: Following a go around for a TE FLAP DISAGREE EICAS, the B757 Captain expressed frustration with the lack of training and flight crew communications to address new and revised Company procedures. Pilot states, "I do not like to criticize, but my level of frustration relating to all of the new protocols is very high. I have been on this fleet for somewhere upward of 21 years. I do not worry about flying the airplane but I do worry about how we are being trained on our New and Improved Procedures and using them on a daily basis. While I have been using the QRH, it is still not fluid as the old ways were. I firmly believe that all of the pilots affected by these new protocols should be trained in a simulator."

Aviation Safety Reporting System. (2012e). [Report Number 1012507]. Retrieved March 29, 2013, from: http://asrs.arc.nasa.gov

Synopsis: A320 Captain reports departing late due to a maintenance required repair of the Green hydraulic system. Once in cruise the Green system quantity is found to be decreasing

and the crew elects to divert. The pilot reports, "...By this time we had already reviewed the QRH, and had not found any procedure for our situation."

Bureau Enquêtes-Accidentes. (1999). ***Airfrance boeing 747-428B. Tahiti faa'a international airport, French polynesia. December 13, 1993*****. (Aircraft accident report, F-TA930913). Le Bourget cedex, France.**

Summary: On final approach, the pilot flying countermanded an automatic go-around initiated by the automatic flight system. He continued the approach by overriding the auto throttle. During landing, the outside left engine went into full forward thrust; the aircraft left the runway to the right and came to a halt in the lagoon. Probable Causes: The accident was caused by a non-stabilized approach and a strong forward thrust application to engine 1 on landing, consequences of an idiosyncrasy of the automatic flight system that caused a shift into go-around mode at a point in the path that corresponded to the à la decision height. This caused: a long touchdown at excessive speed and a trajectory that pulled right so that the airplane left the runway sideways. *Failure to observe operational procedures* regarding call-outs during approach and landing as well as the lack of communication between the pilots were factors that contributed greatly to the accident. In particular, deviations from the norms for several flight parameters should have led to initiating a go-around. The absence of information from the manufacturer to operators and crews regarding this particular feature of the automatic flight system was also a contributing factor to the accident.

Comisión de Investigación de Accidentes e Incidentes de Aviación Civil. (2008). ***Accident involving a McDonnell Douglas DC-9-82 (MD-82) aircraft, registration EC-HFP, operated by Spanair, at Madrid-Barajas Airport, on 20 August 2008*** **(Report A-032/2008). Madrid, Spain.**

Summary: The Civil Aviation Accident and Incident Investigation Commission was notified of the accident at 14:43 on 20 August 2008 by means of a telephone call placed from the Airport Operations Office (AOO) at Barajas Airport. A team consisting of six investigators, as well as the President of the Commission, immediately proceeded to Barajas. In keeping with international regulations, the NTSB of the United States of America was notified as the representative of the State of design and manufacture of the aircraft. Also informed were national civil aviation authorities, the European Aviation Safety Agency (EASA) and the International Civil Aviation Organization (ICAO). The NTSB appointed an accredited representative to participate in the investigation, assisted by experts from the NTSB, the FAA, Boeing, as successor of the rights and obligations of the original aircraft manufacturer, and from Pratt & Whitney, the engine manufacturer. Spanair, the operator of the aircraft, participated in and cooperated with the investigation, providing experts on operations, airworthiness and maintenance. Spain's DGAC and the Aviation Safety Agency also collaborated in supplying information and were kept apprised of the more important aspects of the investigation. The investigation has determined that the accident occurred because: The crew lost control of the airplane as a consequence of entering a stall immediately after takeoff due to an improper airplane configuration involving the non-deployment of the slats/flaps following a series of mistakes and omissions, along with the absence of the improper takeoff configuration warning. The crew did not identify the stall warnings and did not correct said situation after takeoff. They momentarily retarded the

engine throttles, increased the pitch angle and did not correct the bank angle, leading to a deterioration of the stall condition. The crew did not detect the configuration error because they did not properly use the checklists, which contain items to select and verify the position of the flaps/slats when preparing the flight. Specifically: They did not carry out the action to select the flaps/slats with the associated control lever (in the "After Start" checklist);They did not cross check the position of the lever or the status of the flaps and slats indicating lights when executing the "After Start" checklist; They omitted the check of the flaps/slats when doing the "Takeoff Briefing" in the "Taxi" checklist; During the visual check performed as part of the "Final Items" in the "Takeoff Imminent" checklist, the actual position of the flaps/slats as shown on the cockpit instruments was not verified. The CIAIAC has identified the following contributing factors: The absence of a takeoff configuration warning resulting from the failure of the TOWS to operate, which thus did not warn the crew that the airplane's takeoff configuration was not appropriate. The reason for the failure of the TOWS to function could not be reliably established. Improper crew resource management (CRM), which did not prevent the deviation from procedures in the presence of unscheduled interruptions to flight preparations. As a result of the investigation, 33 recommendations on operational safety have been issued to the International Civil Aviation Organization (ICAO), the Federal Aviation Administration (FAA) of the United States, the European Aviation Safety Agency (EASA), Spain's Aviation Safety Agency (AESA), the provider of airport and air navigation services in Spain, AENA (Spanish Airports and Air Navigation), and to the operator, Spanair, as appropriate.

Grand-Duchy of Luxembourg. (2003). ***Accident of Fokker 27 Mk050 registered LX-LGB, LG 9642/LH 2420. Niederanven, Luxembourg. November 6, 2002.*** **Luxembourg, Europe. Retrieved from: http://www.skybrary.aero/bookshelf/books/674.pdf**

Summary: During an ILS approach to runway 24, whilst established on the centreline, the aircraft disappears from the radar screens. It is located again at three point five kilometres to the east of threshold runway 24, seven hundred metres north of the centreline. Causes: The initial cause of the accident was the acceptance by the crew of the approach clearance although they were not prepared to it, namely the absence of preparation of a go-around. It led the crew to perform a series of improvised actions that ended in the prohibited override of the primary stop on the power levers. Contributory factors can be listed as follows: 1. A lack of preparation for the landing, initiated by unnecessary occupations resulting from an obtained RVR value, which was below their company approved minima, created a disorganisation in the cockpit, leading to uncoordinated actions by each crewmember. 2. *All applicable procedures as laid down in the operations manual were violated at some stage of the approach.* All this did not directly cause the accident, but created an environment whereby privately designed actions were initiated to make a landing possible. 3. Routine and the will to arrive at its destination may have put the crew in a psychological state of mind, which could be the origin of the *deviations from standard procedures* as noticed. 4. The low reliability of the installed secondary stop safety device that was favoured by the non-application of service bulletin ABSC SB F050-32-4. Also the mode of distribution of the safety information (Fokker Aircraft B.V. – Service letter 137) to the operator as well as the operator's internal distribution to the crews that did not guarantee that the crews were aware of the potential loss of secondary stop on propeller pitch control. 5. The lack of harmony resulting from the use of various training centres and non-standardised programs that might have impaired the synergy of the crew.

National Transportation Safety Board. (1988). ***Aircraft accident report—Northwest Airlines, Inc., McDonnell Douglas DC-9-82, N312RC, Detroit Metropolitan Wayne County Airport, Romulus, Michigan. August 16, 1987*** **(Aircraft accident report, NTSWAAR-88/OS). Washington, DC.**

Summary: About 2046 eastern daylight time on August 16, 1987, Northwest Airlines, Inc., flight 255 crashed shortly after taking off from runway 3 center at the Detroit Metropolitan Wayne County Airport, Romulus, Michigan. Flight 255, a McDonnell Douglas DC-9-82, U.S. Registry N312RC, was a regularly scheduled passenger flight and was en route to Phoenix, Arizona. According to witnesses, flight 255 began its takeoff rotation about 1,200 to 1,500 feet from the end of the runway and lifted off near the end of the runway. After liftoff, the wings of the airplane rolled to the left and the right about 35” in each direction. The airplane collided with obstacles northeast of the runway when the left wing struck a light pole located 2,760 feet beyond the end of the runway. Thereafter the airplane struck other light poles, the roof of a rental car facility, and then the ground. It continued to slide along a path aligned generally with the extended centerline of the takeoff runway. The airplane broke up as it slid across the ground and post impact fires erupted along the wreckage path. Three occupied vehicles on a road adjacent to the airport and numerous vacant vehicles in a rental car parking lot along the airplane’s path were destroyed by impact forces and/or fire. Of the persons on board flight 255, 148 passengers and 6 crewmembers were killed; 1 passenger, a 4-year-old child, was injured seriously. On the ground, two persons were killed, one person was injured seriously, and four persons suffered minor injuries. The National Transportation Safety Board determines that the probable cause of the accident was the flight crew’s failure to use the taxi checklist to ensure that the flaps and slats were extended for takeoff. Contributing to the accident was the absence of electrical power to the airplane takeoff warning system, which thus did not warn the flightcrew that the airplane was not configured properly for takeoff. The reason for the absence of electrical power could not be determined.

National Transportation Safety Board. (2000). ***Controlled flight into terrain, Korean Air flight 801, Boeing 747-300, HL7468. Nimitz Hill, Guam. August 6, 1997*** **(Aircraft accident report, NTSB/AAR-00/01). Washington, DC.**

Summary: This report explains the accident involving Korean Air flight 801, a Boeing 747-300, which crashed into high terrain at Nimitz Hill, Guam, on August 6, 1997. Safety issues in the report focus on flight crew performance, approach procedures, and pilot training; air traffic control, including controller performance and the inhibition of the minimum safe altitude warning system at Guam; emergency response; the adequacy of Korean Civil Aviation Bureau and Federal Aviation Administration oversight; and flight data recorder documentation. Safety recommendations concerning these issues are addressed to the Federal Aviation Administration, the Governor of the Territory of Guam, and the Korean Civil Aviation Bureau. The National Transportation Safety Board determines that the probable cause of this accident was the captain’s failure to adequately brief and execute the non-precision approach and the first officer’s and flight engineer’s failure to effectively monitor and cross-check the captain’s execution of the approach. Contributing to these failures were the captain’s fatigue and Korean Air’s inadequate flight crew training. Contributing to the accident was the Federal Aviation Administration’s intentional inhibition of the minimum safe altitude warning system at Guam and the agency’s failure to adequately manage the system.

National Transportation Safety Board. (2007a). ***Attempted takeoff from wrong runway, Comair flight 5191, Bombardier CL-600-2B19, N431CA. Lexington, Kentucky. August 27, 2006*** **(Aircraft accident report, NTSB/AAR-07/05). Washington, DC.**

Summary: This report explains the accident involving a Bombardier CL-600-2B19, N431CA, operated by Comair, Inc., which crashed during takeoff from Blue Grass Airport, Lexington, Kentucky. The safety issues discussed in this report focus on the need for (1) improved flight deck procedures, (2) the implementation of cockpit moving map displays or cockpit runway alerting systems, (3) improved airport surface marking standards, and (4) air traffic control policy changes in the areas of taxi and takeoff clearances and task prioritization. Safety recommendations concerning these issues are addressed to the Federal Aviation Administration. Probable Cause: The National Transportation Safety Board determines that the probable cause of this accident was the flight crewmembers' failure to use available cues and aids to identify the airplane's location on the airport surface during taxi and their *failure to cross-check* and verify that the airplane was on the correct runway before takeoff. Contributing to the accident were the flight crew's nonpertinent conversation during taxi, which resulted in a loss of positional awareness, and the Federal Aviation Administration's failure to require that all runway crossings be authorized only by specific air traffic control clearances.

National Transportation Safety Board. (2007b). ***Runway overrun and collision, Southwest airlines flight 1248, Boeing 737-7H4, N471WN. Chicago Midway International Airport, Chicago, Illinois. December 8, 2005*** **(Aircraft accident report, NTSB/AAR-07/06). Washington, DC.**

Summary: This report explains the accident involving a Boeing 737-7H4, N471WN, operated by Southwest Airlines (SWA), which departed the end of runway 31C after landing at Chicago Midway International Airport. The safety issues discussed in this report include the flight crew's decisions and actions, the clarity of assumptions used in on board performance computers, SWA policies, guidance, and training, arrival landing distance assessments and safety margins, runway surface condition assessments and braking action reports, airplane-based friction measurements, and runway safety areas. Safety recommendations concerning these issues are addressed to the Federal Aviation Administration. Probable Cause: The National Transportation Safety Board determines that the probable cause of this accident was the pilots' failure to use available reverse thrust in a timely manner to safely slow or stop the airplane after landing, which resulted in a runway overrun. This failure occurred because the pilots' first experience and lack of familiarity with the airplane's auto brake system distracted them from thrust reverser usage during the challenging landing. Contributing to the accident were Southwest Airlines' 1) *failure to provide its pilots with clear and consistent guidance and training regarding company policies and procedures* related to arrival landing distance calculations; 2) programming and design of its on board performance computer, which did not present inherent assumptions in the program critical to pilot decision-making; 3) plan to implement *new auto brake procedures without a familiarization period*; and 4) failure to include a margin of safety in the arrival assessment to account for operational uncertainties. Also contributing to the accident was the pilots' failure to divert to another airport given reports that included poor braking actions and a tailwind component greater than 5 knots.

Contributing to the severity of the accident was the absence of an engineering materials arresting system, which was needed because of the limited runway safety area beyond the departure end of runway 31C.

National Transportation Safety Board. (2009). ***In-flight left engine fire, American Airlines flight 1400, McDonnell Douglas DC-9-82, N454AA. St. Louis, Missouri. September 28, 2007*** **(Aircraft accident report, NTSB/AAR-09/03). Washington, DC.**

Summary: This report explains the September 28, 2007, accident involving a McDonnell Douglas DC-9-82, N454AA, operated as American Airlines flight 1400. The airplane experienced an in-flight engine fire during departure climb from Lambert St. Louis International Airport, St. Louis, Missouri, and the flight crew conducted an emergency landing. The safety issues discussed in this report relate to the following: characteristics of the "Air Turbine Starter Valve (ATSV) Open" light; emergency task allocation guidance; guidance and training on the interrelationship between pneumatic cross feed valves and engine fire handles; multiple simultaneous emergencies training; guidance on evacuation preparation on the ground; guidance and training on communications between flight and cabin crews during emergency and unusual situations; ATSV air filter replacement intervals; and American Airlines' Continuing Analysis and Surveillance System. Safety recommendations concerning these issues are addressed to the Federal Aviation Administration and American Airlines. 3.2 Probable Cause: The National Transportation Safety Board determines that the probable cause of this accident was American Airlines' maintenance personnel's use of an *inappropriate manual engine-start procedure*, which led to the uncommanded opening of the left engine air turbine starter valve, and a subsequent left engine fire, which was prolonged by the flight crew's interruption of an emergency checklist to perform nonessential tasks. Contributing to the accident were deficiencies in American Airlines' Continuing Analysis and Surveillance System program.

National Transportation Safety Board. (2010). ***Loss of control on approach, Colgan Air, Inc., Operating as continental connection flight 3407, Bombardier DHC-8-400, N200WQ. Clarence Center, New York. February 12, 2009*** **(Aircraft accident report, NTSB/AAR-10/01). Washington, DC.**

Summary: This report discusses the accident involving a Colgan Air, Inc., Bombardier DHC-8-400, N200WQ, operating as Continental Connection flight 3407, which experienced a loss of control on an instrument approach to Buffalo-Niagara International Airport, Buffalo, New York, and crashed into a residence in Clarence Center, New York, about 5 nautical miles northeast of the airport. The safety issues discussed in this report focus on strategies to prevent flight crew monitoring failures, pilot professionalism, fatigue, remedial training, pilot training records, airspeed selection procedures, stall training, Federal Aviation Administration (FAA) oversight, flight operational quality assurance programs, use of personal portable electronic devices on the flight deck, the FAA's use of safety alerts for operators to transmit safety-critical information, and weather information provided to pilots. Safety recommendations concerning these issues are addressed to the FAA. Probable Cause: The National Transportation Safety Board determines that the probable cause of this accident was the captain's inappropriate response to the activation of the stick shaker, which led to an aerodynamic stall from which the airplane did not recover. Contributing to the accident were

(1) the flight crew's failure to monitor airspeed in relation to the rising position of the low-speed cue, (2) the *flight crew's failure to adhere to sterile cockpit procedures*, (3) the captain's failure to effectively manage the flight, and (4) Colgan Air's *inadequate procedures* for airspeed selection and management during approaches in icing conditions.

National Transportation Safety Board. (2011a). *Crash during approach to landing, Empire Airlines flight 8284, Avions de transport régional aerospatiale alenia ATR 42-320, N902FX. Lubbock, Texas. January 27, 2009* (Aircraft accident report, NTSB/AAR-11/02). Washington, DC.

Summary: This accident report discusses the January 27, 2009, accident involving Empire Airlines flight 8284, an Avions de Transport Régional Aerospatiale Alenia ATR 42-320, N902FX, which crashed short of the runway at Lubbock Preston Smith International Airport, Lubbock, Texas. The captain sustained serious injuries, and the first officer sustained minor injuries. The airplane was substantially damaged. The airplane was registered to FedEx Corporation and operated by Empire Airlines, Inc., as a 14 Code of Federal Regulations Part 121 supplemental cargo flight. Instrument meteorological conditions prevailed, and an instrument flight rules flight plan was filed. The safety issues discussed in this report include the flight crew's actions in response to the flap anomaly, the continuation of the un-stabilized approach, the dispatch of the flight into freezing drizzle conditions, the efficiency of the emergency response, and simulator-based training for pilots who fly in icing conditions. Nine safety recommendations are addressed to the Federal Aviation Administration. Probable Cause: The National Transportation Safety Board determines that the probable cause of this accident was the flight crew's failure to monitor and maintain a minimum safe airspeed while executing an instrument approach in icing conditions, which resulted in an aerodynamic stall at low altitude. Contributing to the accident were 1) the *flight crew's failure to follow published standard operating procedures* in response to a flap anomaly, 2) the captain's decision to continue with the un-stabilized approach, 3) the flight crew's poor crew resource management, and 4) fatigue due to the time of day in which the accident occurred and a cumulative sleep debt, which likely impaired the captain's performance.

National Transportation Safety Board. (2011b). *Runway collision of USAir flight 1493, Boeing 737 and Skywest flight 5569, Fairchild metroliner. Los Angeles International Airport, Los Angeles, California. February 1, 1991* (Aircraft accident report, NTSB/AAR-91/08). Washington, DC.

Summary: This report explains the collision of USAir flight 1493 and Skywest flight 5569 on a runway at the Los Angeles International Airport on February 1, 1991. The safety issues discussed in the report are air traffic management and equipment at the airport; aircraft exterior lighting and conspicuity; pilot situational awareness during takeoff and landing and operations on airport surfaces; air traffic controller workload, performance, and supervision; and air transport accident survivability, evacuation standards and procedures, interior furnishing flammability standards, and survival devices. Recommendations concerning these issues were made to the Federal Aviation Administration. Probable cause: The National Transportation Safety Board determines that the probable cause of the accident was the *failure* of the Los Angeles Air Traffic Facility Management *to implement procedures* that provided redundancy comparable to the requirements contained in the National Operational

Position Standards and the failure of the FAA Air Traffic Service to provide adequate policy direction and oversight to its air traffic control facility managers. These failures created an environment in the Los Angeles Air Traffic Control tower that ultimately led to the failure of the local controller 2 (LC2) to maintain an awareness of the traffic situation, culminating in the inappropriate clearances and the subsequent collision of the USAir and Skywest aircraft. Contributing to the cause of the accident was the failure of the FAA to provide effective quality assurance of the ATC system.

National Transportation Safety Board. (2013). ***Southwest Airlines, Flight 812, Boeing 737-3H4, N632SW. Yuma International Airport, Yuma, Arizona. April 11, 2011*** **(Aircraft accident report, NTSB/AAB-13/02). Washington, DC.**

Summary: On April 1, 2011, about 1558 mountain standard time (MST),1N632SW, operating as Southwest Airlines flight 812 experienced a rapid decompression while climbing through flight level 340. The flight crew conducted an emergency descent and diverted to Yuma International Airport (NYL), Yuma, Arizona. Of the 5 crewmembers and 117 passengers on board, one crewmember and one non-revenue off-duty airline employee passenger sustained minor injuries. Probable cause: The National Transportation Safety Board determines that the probable cause of this accident was the improper installation of the fuselage crown skin panel at the S-4L lap joint during the manufacturing process, which resulted in multiple site damage fatigue cracking and eventual failure of the lower skin panel. Contributing to the injuries was flight attendant A's incorrect assessment of his time of useful consciousness, which led to his *failure to follow procedures* requiring immediate donning of an oxygen mask when cabin pressure is lost.

Statens Haverickommission. (1993). ***Air traffic accident on 27 December 1991 at Gottrora, AB county, Case L-124/91*****. Retrieved from SKYbary website: http://www.skybrary.aero/bookshelf/books/540.pdf**

Summary: The accident was caused by SAS' instructions and routines being inadequate to ensure that clear ice was removed from the wings of the aircraft prior to takeoff. Hence the aircraft took off with clear ice on the wings. In connection with lift off, the clear ice loosened and was ingested by the engines. The ice caused damage to the engine fan stages, which led to engine surges. The surges destroyed the engines. Contributory causes were: The pilots were not trained to identify and eliminate engine surging. ATR - which was unknown within SAS - was activated and increased the engine power without the pilots' knowledge. As a result of its investigation the Board of Accident Investigation is submitting 15 recommendations.

Transportation Safety Board. (2012). ***In-flight fire leading to collision with water, Swissair transport limited, McDonnell Douglas MD-11 HB-IWF. Peggy's Cove, Nova Scotia 5 nm SW. September 2, 1998*** **(Report number, A98H0003). Retrieved from: Transportation Safety Board of Canada website: http://www.tsb.gc.ca/eng/rapports-reports/aviation/1998/a98h0003/a98h0003.pdf**

Summary: On 2 September 1998, Swissair Flight 111 departed New York, United States of America, at 2018 eastern daylight savings time on a scheduled flight to Geneva, Switzerland, with 215 passengers and 14 crew members on board. About 53 minutes after departure, while cruising at flight level 330, the flight crew smelled an abnormal odour in the cockpit. Their attention was then drawn to an unspecified area behind and above them and they began to investigate the source. Whatever they saw initially was shortly thereafter no longer perceived to be visible. They agreed that the origin of the anomaly was the air conditioning system. When they assessed that what they had seen or were now seeing was definitely smoke, they decided to divert. They initially began a turn toward Boston; however, when air traffic services mentioned Halifax, Nova Scotia, as an alternative airport, they changed the destination to the Halifax International Airport. While the flight crew was preparing for the landing in Halifax, they were unaware that a fire was spreading above the ceiling in the front area of the aircraft. About 13 minutes after the abnormal odour was detected, the aircraft's flight data recorder began to record a rapid succession of aircraft systems-related failures. The flight crew declared an emergency and indicated a need to land immediately. About one minute later, radio communications and secondary radar contact with the aircraft were lost, and the flight recorders stopped functioning. About five and one-half minutes later, the aircraft crashed into the ocean about five nautical miles southwest of Peggy's Cove, Nova Scotia, Canada. The aircraft was destroyed and there were no survivors. One of the findings as to causes and contributing factors: There was no integrated in-flight firefighting plan in place for the accident aircraft, nor was such a plan required by regulation. Therefore, *the aircraft crew did not have procedures* or training directing them to aggressively attempt to locate and eliminate the source of the smoke, and to expedite their preparations for a possible emergency landing. In the absence of such a firefighting plan, they concentrated on preparing the aircraft for the diversion and landing.