b) multi-crew training in an FSTD; and

c) type-specific training in an FSTD.

Note.— Doc 10011 provides detailed guidance on training topics, training elements and their descriptions to enable ATOs to develop comprehensive programmes for all three areas of UPRT. This information is further supplemented by OEM-supported recommendations in prevention and recovery techniques, as well as suggested training scenarios for the FSTD.

4.5.3 The logical delivery of the training syllabus is the second part of the programme integration issue. In this regard, the programme should commence with either the creation or confirmation of a solid foundation of baseline knowledge levels. These should then be reinforced by practical exercises that demonstrate the application of those learned principles. Finally, this level of understanding should then be further enhanced by introducing scenarios during flight (actual or simulated, as applicable) that provide the trainees with a comprehensive set of descriptors in order to expand their ability to recognize specific threats to safe conditions of flight and take deliberate and effective avoidance actions. The first emphasis of UPRT shall, therefore, be on awareness, recognition, and avoidance, as part of the prevention equation of UPRT. The second part of UPRT shall involve developing the analytical and manual handling abilities of the trainee to recognize the type of upset event and then effectively apply the correct recovery actions.

4.5.4 Care must be taken at the early stages of UPRT implementation not to assume the existence of a comprehensive level of UPRT-related knowledge, particularly at the commercial air transport type rating and recurrent training levels, as LOC-I accident data strongly indicates that even highly experienced flight crews exhibited signs of shortcomings in understanding and reacting to their predicament, which indicated potential knowledge deficiencies.

4.5.5 ATOs are required by Annex 1, Appendix 2 to establish a quality assurance (QA) system. The objective of QA is to assure the achievement of results that conform to the standards set out in the ATOs' manuals and in those requirements and documents issued by the Licensing Authority. QA attempts to improve and stabilize the training process and to identify and avoid, or at least minimize, issues that could lead to problems. It continuously verifies that standards are adhered to throughout the training process by introducing various checkpoints and controls. It further introduces a system of audits to assure that documented policies, processes and procedures are consistently followed. It is the "assurance" part of quality management and its effective operation is crucial to the success of a competency-based training and assessment programme. Quality management focuses on the means to achieve product or service quality objectives through the use of four key components: quality planning; quality control; quality assurance; and quality improvement.

4.5.6 A large portion of a fully integrated UPRT programme involves the training of flight crews in a simulated environment. Most FSTDs can be used satisfactorily for a significant portion of upset training, including training close to the critical angle of attack but not involving full aerodynamic stalls. However, ATOs and commercial air transport operators shall take into account the fact that existing FSTD flight models have deficiencies in adequately representing aircraft characteristics outside the valid training envelope, i.e. in conditions which exceed the aeroplane flight envelope data used for the FSTD qualification. Furthermore, many current FSTDs lack enhanced instructor feedback tools to allow for a complete and accurate assessment of the trainee's performance. These limitations, if not fully appreciated by training programme designers and instructional staff, can have serious and long-term repercussions by which trained flight crews could be left with significant misunderstandings of upset events. While the industry moves towards introducing improvements to FSTD models and instructor operating station design, ATOs shall conduct all FSTD training in an FSTD qualified to an appropriate level in accordance with civil aviation authority rules (Doc 9625 — *Manual of Criteria for the Qualification of Flight Simulation Training Devices* refers) and approved for each intended training task. Detailed guidance on the technical requirements and on the instructor operating station functions and tools for UPRT can be found in Doc 9625, Volume I.

Note.— Regarding 3.5.4 and 3.5.5, ATOs are encouraged to establish more robust quality-related processes to optimize their efforts in achieving excellence in the provision of training. The subject of QA and the implementation of quality systems (QS) are detailed in Appendix B to the Manual on the Approval of Training Organizations *(Doc 9841).*

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4.5.7 On-aeroplane training shall include special risk mitigation measures. This is particularly true when the training programme involves the development of analytical and handling abilities among pilots with low levels of experience and often under conditions of high stress. Robust instructor training and qualification requirements, aircraft certification and capabilities appropriate for the training tasks, strict operational control involving appropriate minimum dispatch and weather conditions, adhering to minimum safe altitudes, use of collision avoidance equipment and establishing special separation criteria, and contingency considerations are just some proactive examples to marginalize threats to safety levels. The ATOs' ability to establish robust risk mitigation strategies under the umbrella of a mature safety management system (SMS) is critical to the safe and effective implementation of an on-aeroplane UPRT programme. The primary objective of on-aeroplane UPRT shall be to learn best practices in upset avoidance and recovery in a safe and controlled environment.

Note 1.— Doc 10011 makes several recommendations for the ATOs' risk mitigation efforts.

Note 2.— On-aeroplane UPRT is not to be considered synonymous with aerobatic training. While aerobatic training does provide improved manual handling skills, the primary objective to training aerobatics is proficiency in precision manoeuvring. Aerobatic flight training does not necessarily provide the best medium to develop the full spectrum of analytical reasoning skills required to rapidly and accurately determine the best course of recovery action during periods of high stress.

4.5.8 Regardless of an individual's background, all instructors designated to provide training in a UPRT programme should successfully complete an approved UPRT instructor qualification training course in accordance with the applicable provisions in Part I, Chapter 3, 3.2. Both initial qualification and recurrent training curriculum for instructors should address training elements appropriate to the level of an instructor's participation in delivering a UPRT programme, as a minimum, to ensure that the designated instructor acquires and maintains the required UPRT knowledge levels and skill sets. The UPRT on-aeroplane environment may be beyond that which is experienced during normal training operations. The unpredictable nature of trainee inputs, reactions, and behaviour requires fluency in response to a wide variety of potential situations requiring a time-constrained and accurate response. This specialized expertise cannot be acquired through routine flight operations alone, but demands that instructor training provides the appropriate degree of exposure necessary to develop complete knowledge and understanding of the entire UPRT operating environment. As part of their QA effort, ATOs shall ensure that all UPRT instructors are qualified, competent, and current in delivering the course material as well as possessing the ability to make accurate performance assessments and recommendations for remediation, whenever necessary.

Note.— Many LOC-I accident investigations have revealed that the affected flight crew had received misleading information from well-meaning training staff or their organizations. Indeed, some existing trained practices were found to be not only ineffective but were also considered a contributory factor, which led to inappropriate responses by some flight crews. For example, in certain cases, the methodologies being applied in training and checking a recovery from an approach to stall condition of flight were based on the pilot being able to achieve recovery with a minimal loss of altitude. This resulted in training practices emphasizing the importance of a rapid application of power with the least amount of reduction in angle of attack to minimize the loss of altitude rather than appreciating the importance of reducing the angle of attack to effectively increase the ability of the wing to restore its capability to generate lift. Action has now been taken by both regulators and training providers to amend such procedures with new training and testing standards emphasizing that effective recovery from an approach to stall requires, foremost, an immediate and deliberate reduction in the angle of attack. This reduction, while operating at high altitude and depending on the aeroplane energy state, might result in a substantial loss in altitude necessary to ensure that an effective recovery from an impending or actual aerodynamic stall condition is achieved.

4.5.9 Training that is delivered under a quality system as described in Appendix B to Doc 9841 should prevent instances of inappropriate or incomplete training.

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4.6 REGULATORY OVERSIGHT

4.6.1 UPRT programmes should be competency-based in their design and delivery in accordance with those principles outlined in Part I, Chapter 2. UPRT shall be treated as purely a training programme, which is outcome-focused and permits trainees to gain the skill sets and confidence to effectively manage conditions that may pose a threat to safety. As opposed to regulatory testing criteria, an individual shall not be considered to have completed the training if the required competency standards are achieved.

4.6.2 The Authority should ensure levels of safety and quality of the training by applying due diligence processes upon the training providers and their QA policies, processes, procedures and observed practices. The application of this form of oversight is particularly conducive to achieving the best results in competency-based training and assessment environments. Although not required, CAAs should also consider requiring that training programmes approved under the training criteria outlined in Annex 6, Part I, Chapter 9, 9.3, be similarly conducted within a QA governance structure to assure the maintenance of high delivery standards in UPRT.

Note.— Doc 9841 and Chapter 6 of Doc 10011, provide detailed guidance on the oversight of ATOs and such specially-designed curricula.

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Chapter 5

COMPETENCY-BASED TRAINING AND ASSESSMENT OF PILOTS FOR THE TYPE RATING

5.1 GENERAL PROVISIONS FOR CBTA OF PILOTS FOR THE TYPE RATING

5.1.1 Introduction

This chapter outlines the requirements to be met in order to implement CBTA of pilots for the type rating. Implementation of such training is, however, optional.

5.1.2 Applicability of CBTA for type rating

5.1.2.1 This chapter applies only to CBTA for the type rating in the aeroplane category.

5.1.2.2 CBTA for type rating may be implemented by an approved training organization (ATO) or an operator certified in accordance with Annex 6. This chapter provides the procedures, with which ATOs and operators must comply with when implementing a CBTA type rating programme. These procedures are complementary to those provided in Part I, Chapter 2.

5.2 PROCEDURES FOR CBTA OF PILOTS FOR THE TYPE RATING

5.2.1 Adapted competency model

The ICAO competency framework for aeroplane pilots provided in Part II, Section 1, Chapter 1 must be used to develop the adapted competency model for type rating.

5.2.2 Training and assessment

5.2.2.1 To be considered as qualified to conduct CBTA for type rating, the instructor/evaluator must meet the requirements of the pilot instructor and evaluator competency framework defined in Part II, Section 1, Chapter 7.

5.2.2.2 Guidance to Licensing Authorities, ATOs and operators on the measures to be taken to facilitate design, development and implementation of CBTA type ratings are defined in the Appendix to this chapter.

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5.2.3 Evaluation of training programmes

5.2.3.1 The CBTA type rating training programme shall include an ongoing evaluation of the training programme acceptable to the Licensing Authority.

5.2.3.2 The evaluation shall ensure that:

a) the training and assessment plans are relevant to the aeroplane type;

b) the trainees meet the competency standards as defined in the training and assessment plan; and

c) remedial actions are taken if in-training or post-training evaluation indicates a need to do so.

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Appendix to Chapter 5

GUIDELINES FOR THE DESIGN, DEVELOPMENT AND IMPLEMENTATION OF COMPETENCY-BASED TYPE RATING

1. Introduction

Approved training organizations and operators may elect to develop a CBTA type rating.

Note.— Detailed guidance on the principles of CBTA for pilots can be found in the Manual on Aeroplane Pilot Competency-based Training and Assessment *(Doc xxxxx). (To be developed).*

2. Course Design and Development

2.1 Course design must include the mandatory training elements or specific training requirements published by the original equipment manufacturer (OEM) or the State approving the course.

2.2 Course design should consider training design guidelines (if any) provided by the OEM and the State approving the course.

2.3 Course content must focus on the development of pilot competencies rather than focus on pure task orientated training.

2.4 Course design should require the use of representative training and simulation tools as early as possible in the training process in order to contextualize all pilot competencies.

2.5 CBTA type rating programmes should follow a progressive approach to achieve the final competency standard by initially acquiring the basic knowledge and skills for operation of the aircraft; then developing the competencies; and finally consolidating all competencies in conditions as close as possible to the real environment, in real-time (scenario based training/line orientated simulations).

2.6 The course design should group aircraft system malfunctions by reference to malfunction characteristics and the underlying elements of crew performance required to manage them. (Class of Equivalence principle or Equivalency of Malfunctions).

Note.— Guidance on equivalency of malfunctions is contained in the Manual of Evidence-based Training *(Doc 9995), Part I, 3.8.*

2.7 The CBTA programme should integrate threat and error management and surprise elements throughout the complete course syllabus with an increase of these factors towards the end of the syllabus.

2.8 Course design should enable the instructor to apply a wide range of competency-based instructional techniques. For details see the *Manual on Aeroplane Pilot Competency-based Training and Assessment* (Doc xxxxx). (To be developed).

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3. Guidelines for the authority

3.1 Guidance material regarding the approval of the training and assessment plans of a CBTA programme, as well as the quality assurance and safety management system used by an ATO or an operator in implementing these programmes can be found in the *Manual on the Approval of Training Organizations* (Doc 9841).

3.2 One of the attributes of CBTA, as defined in this document, is the use of an ongoing process for the evaluation of the training programme. The licensing authority shall therefore ensure that the ATO or the operator continuously monitors the effectiveness of the training.

3.3 The need for regular feedback from the ATO or operator to the Licensing Authority on the progress and problems faced during and after the delivery of the first programme(s) is important. How this feedback is to be provided to the Licensing Authority should therefore be clearly stated as part of the approval.

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Chapter 6

THREAT AND ERROR MANAGEMENT (TEM)

6.1 General

6.1.1 Threat and error management (TEM) is an overarching safety concept regarding aviation operations and human performance. TEM is not a revolutionary concept; it evolved gradually, as a consequence of the constant drive to improve the margins of safety in aviation operations through the practical integration of human factors knowledge.

6.1.2 TEM developed as a product of the collective industry experience. Such experience fostered the recognition that past studies and, most importantly, operational consideration of human performance in aviation had largely overlooked the most important factor influencing human performance in dynamic work environments: the interaction between people and the operational context (i.e. organizational, regulatory and environmental) within which they perform their operational duties.

6.1.3 The recognition of the influence of the operational context in human performance led to the conclusion that study and consideration of human performance in aviation operations must not be an end in itself. In regard to the improvement of margins of safety in aviation operations, the study and consideration of human performance without context address only part of a larger issue. TEM therefore aims to provide a principled approach to the broad examination of the dynamic and challenging complexities of the operational context in human performance, for it is the influence of these complexities that generates consequences directly affecting safety.

6.2 Meeting training and licensing requirements for TEM

6.2.1 As the management of operational threats and errors is considered to be a key aspect of safety critical aviation disciplines, TEM knowledge, threat and error recognition and its management are part of licensing and rating requirements in Annex 1. TEM pilot training requirements for commercial air transport operations are identified in Annex 6, Parts I and III. TEM is applicable to all flight crews conducting flight operations and is to be adapted according to the operational context.

6.2.2 In traditional training, TEM can be trained as a separate module or as parts of several modules to recognize and manage threats and errors to the appropriate level of performance.

6.2.3 In competency-based training, TEM is naturally and fully embedded in the training curriculum. The competencies of the approved adapted competency model provide individual and team countermeasures to threats and errors to avoid undesired aircraft states.

6.3 The threat and error management (TEM) model

6.3.1 The threat and error management (TEM) model is a conceptual framework that assists in understanding, from an operational perspective, the interrelationship between safety and human performance in dynamic and challenging operational contexts.

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6.3.2 The TEM model focuses simultaneously on the operational context and the people performing operational duties in such context. The model is descriptive and diagnostic of both human and system performance: descriptive because it captures human and system performance in the operational context, resulting in realistic descriptions; diagnostic because it allows qualifying and quantifying complexities of the operational context in relation to the description of the contextual human performance, and vice versa.

6.3.3 The TEM model can be used in several ways:

a) safety analysis tool — can focus on a single event, as is the case with accident/incident analysis, or can be used to understand systemic patterns within a large set of events, as is the case with operational audits;

b) licensing tool — helps clarify human performance needs, strengths and vulnerabilities, allowing the definition of competencies from a broader safety management perspective;

c) training tool — helps an organization improve the effectiveness of its training interventions and, consequently, of its organizational safeguards; and

d) operational tool — helps an organization to increase its safety margins by providing the operational personnel tools as well as strategies and tactics to manage potential threats and errors.

6.3.4 From a training perspective, the broadest application to date of the TEM model is in flight crew human performance training, especially in crew resource management (CRM) training, a widely implemented human factors-based training intervention. This may lead to questions about the relationship between TEM and CRM, and it is therefore essential to clarify potential confusions from the outset.

6.3.5 TEM is an overarching safety concept with multiple applications in aviation, while CRM is exclusively a training intervention.

6.3.6 From a traditional training perspective, the basic concepts underlying TEM (threats, errors and undesired aircraft states) have been systematically only integrated into existing CRM programmes because TEM countermeasures build in large measure — although not exclusively — upon CRM skills. The combination of TEM concepts with CRM skills thus introduces the opportunity to present the utilization of CRM skills by flight crews anchored in the operational environment and from a purely operational perspective. TEM training does not replace CRM training but rather complements and enhances it.

6.3.7 From a competency-based training and assessment perspective, the competencies of the approved adapted competency model provide individual and team countermeasures to threats and errors and undesired aircraft states. CRM skills are embedded in the approved adapted competency model. Therefore, the CRM training supports the development of the competencies as countermeasures in the TEM concept.

6.3.8 Originally developed for flight deck operations, the TEM model can nonetheless be used at different levels and in different sectors within an organization, and across different organizations and activities within the aviation industry. It is therefore important, when applying TEM, to keep the user's perspective in the forefront. Depending on "who" is using TEM (front-line personnel, intermediate management, senior management; flight operations, maintenance, air traffic control), slight adjustments to related definitions may be required. This document focuses on the flight crew as "user", and the discussion herein presents the perspective of flight crews use of TEM.

6.4 The challenges in the TEM model

There are three basic challenges in the TEM model, from the perspective of flight crews: threats, errors and undesired aircraft states. The model proposes that threats and errors are part of everyday aviation operations that must be managed

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by flight crews, since both threats and errors carry the potential to generate undesired aircraft states. Flight crews must also manage undesired aircraft states, since they carry the potential for unsafe outcomes. Undesired aircraft state management is an essential component of the TEM model, as important as threat and error management, because it largely represents the last opportunity to avoid an unsafe outcome and thus maintain safety margins in flight operations.

6.5 Threats

6.5.1 Threats are defined as events or errors that occur beyond the influence of the flight crew, increase operational complexity, and must be managed to maintain the margins of safety. During typical flight operations, flight crews have to manage various contextual complexities, for example, adverse meteorological conditions, airports surrounded by high mountains, congested airspace, aircraft malfunctions, and errors committed by other people outside of the cockpit, such as air traffic controllers, flight attendants or maintenance workers. The TEM model considers these complexities as threats because they all have the potential to negatively affect flight operations by reducing margins of safety.

6.5.2 Some threats can be anticipated, since they are expected or known to the flight crew. For example, flight crews can anticipate the consequences of a thunderstorm by briefing their response in advance or can prepare for a congested airport, as they execute the approach, by making sure they keep a watchful eye out for other aircraft.

6.5.3 Some threats can occur unexpectedly and without warning, such as an in-flight aircraft malfunction. In this case, flight crews must demonstrate competencies developed through training and operational experience to manage such unexpected threats.

6.5.4 Some threats may not be directly obvious to, or observable by, flight crews as they are immersed in operational context. Such threats can potentially be uncovered by safety analysis. These are considered latent threats. Examples include equipment design issues, optical illusions, or shortened turn-around schedules.

6.5.5 Regardless of whether threats are expected, unexpected, or latent, one measure of the effectiveness of a flight crew's ability to manage threats is whether threats can be anticipated so as to enable the flight crew to respond to them through deployment of appropriate countermeasures.

6.5.6 Threat management is a building block to error management and undesired aircraft state management. Although the threat-error linkage is not necessarily straightforward (i.e. it may not always be possible to establish a linear relationship or one-to-one mapping between threats, errors and undesired states), safety analysis data demonstrate that mismanaged threats are normally linked to flight crew errors, which in turn are often linked to undesired aircraft states. Threat management provides the most proactive option to maintain margins of safety in flight operation, by avoiding safety-compromising situations at their roots. As threat managers, flight crews are the last line of defence to keep threats from impacting flight operations.

6.5.7 Table II-1-6-1 presents examples of threats, grouped under two basic categories derived from the TEM model. Some environmental threats can be planned for and some will arise spontaneously, but they all have to be managed by flight crews in real time. Organizational threats, on the other hand, can be controlled (i.e. removed or, at least, minimized) at source by aviation organizations and are usually latent in nature. Flight crews still remain the last line of defence, but there are earlier opportunities for these threats to be mitigated by aviation organizations themselves.

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