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This advisory circular (AC) provides guidance and recommended practices for operators to implement operational procedures and training for the planning, execution, and assurance of the guidance and control of aircraft trajectory and energy. This is known as flightpath management (FPM). FPM topics addressed in this AC include manual flight operations (MFO), managing automated systems, pilot monitoring (PM), and energy management. This AC provides guidance and recommended practices to Title 14 of the Code of Federal Regulations (14 CFR) parts 121 and 135 certificate holders (CH), as well as part 142 training centers in developing operational policies, procedures, and training to support effective FPM.

This AC describes an acceptable means, but not the only means, for an operator to incorporate FPM principles into an operator's training program to meet the related requirements in part 121, §§ 121.401 and 121.419 through 121.427. The contents of this document do not have the force and effect of law and are not meant to bind the public in any way, and the document is intended only to provide information to the public regarding existing requirements under the law or agency policies.

This AC is currently directed towards parts 121 and 135 CHs conducting multicrew turbojet airplane operations, as well as part 142 training centers. However, the Federal Aviation Administration (FAA) encourages all training providers and operators to consider this guidance as applicable to the type of airplane, operational environment, and pilot demographics in which training or operations are conducted. This guidance may also be helpful for avionics and aircraft manufacturers designing equipment and systems used by pilots to manage the aircraft flightpath.

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CHAPTER 1. GENERAL

1.1 Purpose of This Advisory Circular (AC). This AC provides guidance and recommended practices to operators under Title 14 of the Code of Federal Regulations (14 CFR) parts 121 and 135, as well as part 142 training centers, in developing operational policies, procedures, and training to support effective flightpath management (FPM). FPM is the planning, execution, and assurance of the guidance and control of aircraft trajectory and energy, in flight or on the ground. FPM provides a unifying framework for operations and training to meet the regulatory requirements in part 121 and its appendices and part 135. Over the past decades, numerous reports, studies, and recommendations have been generated among industry groups, research institutions, and regulators addressing the topic of FPM. FPM topics addressed in this AC include manual flight operations (MFO), managing automated systems, pilot monitoring (PM), and energy management. These topics are required to be trained per the Federal Aviation Administration (FAA) requirements in part 121, §§ 121.419 through 121.427 and appendices E and F, and part 135.

1.1.1 The contents of this document do not have the force and effect of law and are not meant to bind the public in any way, and the document is intended only to provide information to the public regarding existing requirements under the law or agency policies. The material in this AC is advisory in nature and describes an acceptable means, but not the only means to comply with applicable regulations. The FAA will consider other means of compliance that an applicant may elect to present. While these guidelines are not mandatory, they are derived from extensive FAA and industry study of accidents and incidents where ineffective FPM was causal or contributory. These guidelines are intended to help in complying with applicable regulations to prevent similar events in the future.

1.2 Audience. This AC is directed towards certificate holders (CH) operating under parts 121 and 135, as well as part 142 training centers. The FAA encourages all training providers and operators to consider this guidance as applicable to the type of airplane, operational environment, and pilot demographics in which training or operations are conducted. This guidance may also be helpful for avionics and aircraft manufacturers designing equipment and systems used by pilots to manage the aircraft flightpath.

1.3 Where You Can Find This AC. You can find this AC on the FAA's website at https://www.faa.gov/regulations_policies/advisory_circulars and the Dynamic Regulatory System (DRS) at https://drs.faa.gov.

1.4 Related 14 CFR Parts, Reading Material, and Definitions. See Appendix B.

1.5 Background. In 1996, the Federal Aviation Administration (FAA) Human Factors Team Report on the Interfaces Between Flightcrews and Modern Flight Deck Systems was published. The review of data at that time identified issues that showed vulnerabilities in flightcrew management of automation and situation awareness. Since then, major improvements have been made in the design, training, and operational use of onboard systems for FPM (autopilot (AP), autothrottle/autothrust (AT), flight director (FD), flight management systems (FMS), etc., and their associated flightcrew interfaces).

1.5.1 To address these original vulnerability concerns, the Performance-Based Operations Aviation Rulemaking Committee (PARC) and the Commercial Aviation Safety Team (CAST) established a joint working group of authorities, industry, and researchers to update the 1996 FAA report and to address, for current and projected operational use, the safety and efficiency of modern flight deck systems for FPM (including energy-state management). The final report, Operational Use of Flight Path Management Systems: Final Report of the Performance-based operations Aviation Rulemaking Committee/Commercial Aviation Safety Team Flight Deck Automation Working Group, was issued on September 5, 2013. This report included a recommendation for revisions to relevant FAA ACs, or the creation of, or revision to, other applicable ACs and other guidance, to incorporate information on automation training and procedures for automation management.

1.5.2 On January 21, 2014, the FAA established the Air Carrier Training Aviation Rulemaking Committee (ACT ARC) to provide a forum for the U.S. aviation community to discuss, prioritize, and provide recommendations to the FAA concerning operations conducted under parts 121, 135, and 142, specifically addressing air carrier training. The ACT ARC Steering Committee established the Flight Path Management Workgroup (FPM WG), which made a number of recommendations related to FPM. The ACT ARC Steering Committee adopted the recommendations with unanimous consent, and they were submitted to the FAA as ACT ARC recommendations. Beginning in 2015, the ACT ARC began issuing a series of recommendations addressing FPM, including operator policies, MFO, the use of automation, PM, energy management, and information management. These recommendations, which are addressed in this AC, can be found at https://www.faa.gov/about/office_org/headquarters_offices/avs/offices/afx/afs/afs200/afs280/act_arc/act_arc_reco/.

1.6 **What to Consider When Reading This AC.** The FAA encourages that parts 121 and 135 operators, as well as part 142 training centers, adopt the recommendations in this AC to implement policies, procedures, and training to support effective FPM.

1.7 **AC Feedback Form.** For your convenience, the AC Feedback Form is the last page of this AC. Note any deficiencies found, clarifications needed, or suggested improvements regarding the contents of this AC on the Feedback Form.

CHAPTER 2. FLIGHTPATH MANAGEMENT—GENERAL

2.1 General. For the purpose of this AC, the meaning of FPM is the planning, execution, and assurance of the guidance and control of aircraft trajectory and energy, in flight or on the ground. "Flightpath" means trajectory (lateral, longitudinal, and vertical) and energy state of the aircraft. "Flightpath" includes "ground path" if the aircraft is in motion on the ground.

2.1.1 Ensuring that the aircraft is on a safe and correct flightpath is the highest priority of all pilots on the flightcrew. Ensuring the airplane is on the correct flightpath includes the actions necessary to check/verify that the flightpath is correct and to intervene as necessary if it is not correct.

2.1.2 Each pilot is responsible for:

- Being fully aware of the current and desired flightpath of the aircraft, and
- Being fully capable[1] of manually flying the aircraft to achieve the desired flightpath.

2.1.3 One pilot at a time (i.e., pilot flying (PF)) is responsible for controlling the flightpath. Controlling the flightpath refers to adjusting the trajectory and energy state of the airplane using any appropriate combination of manual or autoflight inputs.[2] Other pilot(s) on the flightcrew should always be ready and able to intervene if necessary. This capability should include normal and applicable non-normal[3] situations.

2.1.4 FPM provides a unifying framework for meeting the regulatory requirements in part 121 and its appendices and in part 135. The following chapters include guidance for the following topics that are interlinking aspects of FPM:

- Chapter 3, Manual Flight Operations.
- Chapter 4, Managing Automated Systems.
- Chapter 5, Pilot Monitoring (§ 121.544) (including attention management).
- Chapter 6, Energy Management.

2.1.5 No individual chapter in this AC is intended to be read or followed in isolation. For example, the trajectory and energy of the aircraft can be controlled manually, or via the autoflight systems, or various combinations of these. Chapters 3 and 4 offer guidance on MFO and managing automated systems accordingly, but that guidance should be interpreted with the understanding that manual methods, automated systems, or any combination thereof are tools to help the pilot manage the flightpath. Pilots should be

[1] "Capable" means having the knowledge, skills, and ability; it does not imply that multiple pilots are simultaneously acting as PF.
[2] The PF is always controlling the airplane whether autoflight systems are on or off.
[3] Applicable non-normal situations should include equipment failures and situations identified through an operator's Safety Management System (SMS), including safety data programs such as Line Operations Safety Audit (LOSA), Aviation Safety Action Program (ASAP), Flight Operations Quality Assurance (FOQA), and industry programs.

proficient in the use of all such methods and systems, and in the selection of the proper systems and their modes at the appropriate time, for various FPM tasks based on the situation.

2.1.6 Monitoring is an important aspect of ensuring the flightpath; therefore, Chapter 5 should be considered to be an integral aspect of FPM and not a standalone topic. Other tasks on the flight deck may provide distractions that require the pilots to actively manage attention and prioritize tasks. Therefore, the task/attention/distraction material in Chapter 5 is an integral part of the topic of FPM.

2.2 Operational Policy and Procedure Considerations. An underlying premise for this guidance material is that flight operations and pilot training should be consistent. Therefore, the policy and procedures for FPM should be clearly documented in the relevant manuals and reflected in the pilot training.

2.2.1 Operational policy and procedures for FPM should be based on guiding principles that state the general philosophy or overarching concepts and expectations for FPM. These principles should then be used to guide the development of appropriate policies and procedures that affect FPM for normal, rare normal, and non-normal operations. An appropriate set of guiding principles for FPM should include at least the following:

1. FPM is always:
   - The responsibility of the entire flightcrew, and
   - The highest priority for all members of the flightcrew.
2. Each pilot is responsible for:
   - Being fully aware of the current and desired flightpath of the aircraft, and
   - Being fully capable of manually flying the aircraft to achieve the desired flightpath.

2.2.2 All operational policies and procedures regarding or affecting FPM should be written to support the set of guiding principles. Operators should implement specific standard operating procedures (SOP) to support the FPM policy.

2.2.3 FPM policies and procedures should clearly define the roles and responsibilities of all flightcrew members, including the roles and responsibilities of the PF, PM, Captain, First Officer (F/O), and any other required flight deck crew positions. FPM policies and procedures should protect the PF's ability to maintain focus on FPM. Any non-FPM tasks[4] (e.g., communication with the company) should be performed by other members of the flightcrew (e.g., the PM) to the maximum extent possible.

2.2.4 Items that should be addressed in an operator's FPM guiding principles, policy, and procedures are listed below:

[4] A non-FPM task is any task that is not directly related to managing the flightpath at that time.

2.2.4.1 Each operator should have a clearly stated, comprehensive FPM policy supported by the FPM guiding principles and by SOPs. The guiding principles provide an overarching structure from which FPM policies and procedures should be developed. The guiding principles state the general concepts and expectations of FPM. Subsequently, the policies state how the principles are to be achieved.

2.2.4.2 The policy should highlight and stress that the responsibility for FPM remains with the pilots at all times. Procedures developed from this policy should include actions designed to mitigate or reduce hazards or risks that may influence FPM.

2.2.4.3 The operator policy should identify appropriate opportunities for MFO in line operations to maintain proficiency.

2.2.4.4 Policies and procedures should include:

2.2.4.4.1 Guidance for the appropriate use of automated systems, recognizing that they provide a set of tools (but are not the only available tools) to effectively manage the flightpath. Operators should provide guidance on the use of all these tools (e.g., automated systems and manual flight). That guidance should provide detailed information on the operational application and utility of the respective system(s) and consideration for combinations to best address the situation. The guidance should be specific to the aircraft type, operational environment, and operator culture. It should include use of MFO and use of automated systems with a focus on FPM rather than simply focusing on the manipulation of automated systems, because policies that deal only with automation use can misplace the responsibility of FPM onto the automation system, whereas it should remain with the pilots at all times.

2.2.4.4.2 Guidance for proper monitoring of the flightpath and allocation of tasks between PF and PM to include:

- Monitoring the flightpath during all combinations of manual and/or automated flight.
- Task allocation, workload, and system management strategies, as well as methods to address malfunctions, including malfunctions for which there is no specific procedure.

2.2.4.5 The policy and procedures should be customized for the specific operator and regularly reviewed and modified as necessary through a formal process. Policies and procedures should consider manufacturer recommendations and be adapted/modified according to factors including, but not limited to, the following:

- The operating environment,
- The equipment being operated,
- The demographic characteristics of the pilot group,
- Operational and safety data, and
- The operator's overall policies and organizational culture.

2.2.4.6 The policies and procedures should be validated for operational effectiveness, and should take into account lessons learned from a regular review of feedback from training, line experience, and operational and safety data.

2.2.4.7 Policies and procedures should use consistent terminology for FPM systems and information automation (IA) systems. "Guidance," "control," and other terms that form the foundation of the operator's FPM policy should be clearly defined.

2.3 Training Considerations. Each operator's training program should clearly and explicitly convey the FPM guiding principles, policies, and procedures described above. All aspects of training should clearly instill an understanding that FPM is primary at all times. Training on individual procedures or operation of individual items of flight deck equipment, under both normal and non-normal conditions, should be conveyed to ensure the trainee understands how the topic fits within the overarching context of FPM.

2.3.1 For example, operators create procedures for the execution of most maneuvers, such as a takeoff or an instrument landing system (ILS) approach, which contain highly scripted actions and callouts. Training for these maneuvers should ensure that pilots are not taught to focus on the procedural details at the expense of the "big picture," which is that FPM is the highest priority aspect of every maneuver. Standardized procedures are important, but procedures should be taught in such a way that the overall context of FPM is clearly conveyed to the trainee. Similarly, training on the use of various items of flight deck equipment (e.g., FMS and Electronic Flight Bag (EFB)) should emphasize that pilots are taught to understand its appropriate use in the context of FPM. Some examples are discussed in Chapter 4.

2.3.2 Training programs should also prioritize FPM in terms of emphasis and proportion of time spent.

2.4 Instructor/Evaluator (I/E) Considerations. It is important that each operator consider not just the curricula content, but the content delivery emphasis as conveyed by their I/Es. The I/E staff should maintain focus on FPM priority throughout all aspects of training and checking.

2.4.1 All I/Es should have appropriate I/E qualification and experience, the knowledge and skills required for effective aircraft FPM, and the knowledge and skills to instruct, assess, and evaluate the learning objectives and proficiency for FPM and the interrelated aspects of FPM.

2.4.2 A training program for I/Es should include at least the following:

- Operator's FPM policy.
- Operator's SOPs related to FPM.
- Understanding how to train and assess FPM.
- Understanding how to train and assess management of automated systems.
- Understanding how to train and assess effective monitoring, including scan techniques.
- Understanding how to train and assess energy management.
- Understanding how to train and assess Crew Resource Management (CRM) and Threat and Error Management (TEM) aspects related to FPM.
- Developing and implementing training scenarios for training and assessing FPM (where applicable to the role of the I/E).
- Effective briefing and debriefing methods and tools, including facilitated debriefs.
- Evaluating the performance of the PF and PM.

Note: Additional guidance on instructor qualifications and training related to FPM aspects of stall prevention and recovery training and upset prevention and recovery training can be found in AC 120-109, Stall Prevention and Recovery Training, and AC 120-111, Upset Prevention and Recovery Training, respectively.

2.4.3 In each of the remaining chapters of this AC, additional training and I/E considerations are included that relate to each chapter's focus.

CHAPTER 3. MANUAL FLIGHT OPERATIONS

3.1 General. MFO are those operations where the pilot is performing FPM while physically controlling pitch, roll, yaw, and/or thrust.[5] Manual flight is the foundation upon which other technical flying skills are built. MFO apply to a broad range of situations, including situations where some automated systems are engaged or operating. Manual flight knowledge and skills are required in all situations, not only when all automated systems are off.

3.1.1 MFO Uses. There are different combinations of aircraft systems that can be used to manage the flightpath, each of them having different requirements, specific knowledge, tasks, and skills for manual flight. In addition to MFO during routine normal operations, MFO includes maneuvers required to be manually flown and the requirement for intervening or taking over FPM tasks from one or more of the automated systems. MFO includes FPM using raw data, which may require performing cognitive tasks without the assistance of onboard systems, such as the FD, moving map display, or flight management system (FMS).

3.1.2 Skills Related to Performing MFO. Skills related to performing MFO include cognitive skills, psychomotor skills, and communication skills. Pilot proficiency for performing all MFO skills provides a foundation for pilots to handle any operational situation, whether expected or unexpected.

3.1.2.1 Cognitive Skills. A cognitive skill is the ability to retain and combine a variety of knowledge components about a domain and apply them to perform complex mental tasks, including problem solving, decision making, situation assessment, system monitoring, and conducting calculations and visualization for spatial flightpath planning.

3.1.2.2 Psychomotor Skills. A psychomotor skill is the ability to perform physical actions. Examples of psychomotor skills include use of the yoke or side stick, use of the thrust levers, programming the flight computer, and adjusting any system controls.

3.1.2.3 Communication Skills. A communication skill is the ability to perform a meaningful interchange with another person using some form of language or other set of signals. Examples of communication skills include conducting briefings and callouts, obtaining and responding to clearances from air traffic control (ATC), and updating dispatch on a reroute decision.

3.1.2.4 Example. An example of using all three types of skills is while descending and turning to join a Localizer (LOC) at the proper glidepath under manual control. The pilot has to mentally integrate airspeed, altitude, roll, and pitch attitude with LOC displacement and rate of capture to manually accomplish this task efficiently while analyzing the situation and

[5] "Physically controlling" may refer to physical manipulation of the corresponding flight deck control, such as side stick or control yoke.

communicating/coordinating with the other pilot(s) and ATC. It requires an integrated application of cognitive, psychomotor, and communications skills.

3.1.3 MFO Proficiency. Operational data have shown that, on average, pilots exercise manual flight control for only a small portion of total flight time (usually only during takeoff and landing). This somewhat limited operational practice in MFO may contribute to a gap between proficiency in MFO and the ability of pilots to perform manual operations when various situations require immediate manual control. Operators should promote and provide pilots with opportunities to exercise their knowledge and skills required for proficiency in MFO in training and during line operations.

3.1.4 MFO Skill Degradation. Analyses of operational, accident, and incident data show that degradation of pilot skills in MFO has been identified as a potential vulnerability to successful FPM. Therefore, policies that promote the development and maintenance of pilot skills for MFO remain important for the safety and effectiveness of air carrier operations.[6] Proficiency in MFO skills is necessary for safe flight operations, regardless of the autoflight equipment installed, or used, in the aircraft.

3.2 Operator Policy and Procedure Considerations for MFO. Many aspects of operator policies and procedures can affect the readiness of pilots to perform MFO effectively. For example, operator policies on FPM that excessively require the use of automated systems may negatively affect the retention of MFO skills. Therefore, policy should not be overly prescriptive on requiring the use of automated systems at all times but instead encourage a culture that promotes joint responsibility of operator and individual pilots for maintaining pilot proficiency in MFO.

3.2.1 Maintaining MFO Proficiency in Operations and Training. Flight operations and training for MFO are interdependent. Therefore, operators should encourage an integrated approach by incorporating emphasis of pilots maintaining proficiency of their MFO knowledge and skills using both line operations and training (initial/upgrade, requalification, and recurrent). This includes emphasizing and exercising MFO during operational experience, and consolidation of training.

3.2.2 Exercising Manual Flying Skills and Knowledge. The operator policies should ensure there are appropriate opportunities for pilots to exercise manual flying skills during both training and line operations, such as during certain weather conditions and/or low workload periods. In addition, policies should ensure that pilots understand when to use the automated systems, including during conditions or airspace procedures that require use of AP for precise operations. The operator's policy should address how to regain proficiency of MFO skills after pilots have short and long absences and include exercising skills for MFO during takeoffs, departures, arrivals, and landings.

3.2.2.1 An operator's line operations policy should permit and encourage MFO and should incorporate the following:

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[6] Safety Alert for Operators (SAFO) 17007, Manual Flight Operations Proficiency.

1. Encouragement to manually fly the aircraft including, at least periodically, the entire departure and arrival phases and potentially the entire flight.
2. When deciding whether to fly manually, crews should apply basic TEM[7] principles and take into account the various factors affecting operational workload. Factors to consider include:
   - Weather conditions, terrain, and/or other environmental threats.
   - Time of day.
   - Psychological and/or physiological factors.
   - Level of crew experience.
   - Traffic density.
   - Condition of the aircraft, and/or any non-normal conditions.
   - ATC and/or instrument procedural challenges.
   - Any other operational threats.
3. Allow and encourage pilots to conduct manual flight with different combinations of automated systems and modes based on aircraft equipage and operational situations. Examples of different combinations of autoflight systems include the following:
   - FD on, AP off, AT on.
   - FD on, AP off, AT off.
   - FD off, AP off, AT off.
   - FD on, AP on, AT off.
   - FD off, AP off, AT on.
4. A clear statement that the pilot in command (PIC) should use good judgment to consider the factors described above and to decide, on a case-by-case basis, when it is appropriate to conduct manual flying.

3.2.2.2 Operational policy guidance for manual flying during line operations should avoid:

1. Overly general statements, such as “shall never manually fly at night” or “shall always manually fly in day visual meteorological conditions (VMC).” The policy should allow the PIC to weigh all of the factors based on the situation and to apply good judgment.
2. Quotas for manual flying, unless based on validated scientific evidence (e.g., “shall fly manually at least 10 hours/month”).

[7] Or comparable operational risk management principles.

3.2.2.3 Augmented crew operations may also limit the ability of some pilots to obtain practice and maintain proficiency in FPM skills during MFO. Operational and training policies should ensure that all pilots have appropriate opportunities to exercise knowledge and skills in MFO during operational line flying as well as in the simulator. Operators should ensure they have specific policies to address and provide opportunities for augmented crew pilots to gain hands-on MFO experience in a control seat managing the flightpath on a consistent basis to maintain proficiency in skills required for FPM.

3.2.3 Standard Operating Procedures (SOP). Operators should implement specific SOPs to support the MFO portion of their FPM policy. FPM policies and procedures should protect the PF's ability to maintain focus on FPM.

3.2.3.1 FPM policies and procedures related to MFO should be validated for operational effectiveness from different data sources and should take into account lessons learned from a regular review of feedback/data sources from training, line experience, operational, and safety data. Operators should conduct a formal Safety Risk Assessment (SRA) of the threats identified by data analysis relating to FPM during MFO. This assessment will inform the operator of necessary changes to the policies and procedures in the operator's manuals. Additional information can be found in AC 120-71, Standard Operating Procedures and Pilot Monitoring Duties for Flight Deck Crewmembers, Chapter 2, Determining When Procedures Need to be Designed or Modified.

3.2.3.2 Some examples of data sources that may be used for validation include:

- Testing and checking results.
- Periodic evaluations and analyses by those who have knowledge of the training program, its content, and its goals and purpose.
- Pilot surveys, instructor surveys, peer surveys, and training data.
- Critiques from managers, instructors, check pilots, and students regarding the training, testing, checking, or qualification process as it relates to FPM.
- Data from voluntary safety programs, such as the Aviation Safety Action Program (ASAP), Flight Operations Quality Assurance (FOQA), and Line Operations Safety Audit (LOSA).
- Other data from an operator's Safety Management System (SMS).

3.3 Training and Checking Considerations. In designing their training programs (initial, transition, upgrade, and recurrent), operators should develop specific learning objectives with associated training methodologies that address knowledge and skills for MFO. MFO knowledge and skills should be emphasized throughout all flight training programs. An operator's training policy should incorporate the following:

1. All curricula should be designed in accordance with the philosophy that manual flight is the foundation upon which other technical flying skills are built. Therefore, the importance of manual flight should be emphasized throughout all flight training syllabi, while recognizing that MFO involve more than motor skills. Manual flight requires an integrated combination of cognitive, psychomotor, and communications skills.
2. All curricula should include training and proficiency assessment of MFO skills.

3.3.1 Unexpected Training and Checking Scenarios. Operators should consider that many exercises required to be hand flown are well-known and repetitive and may not measure the true underlying skill level outside of those specific exercises (e.g., single-engine, hand-flown approaches). Rather, operators should use safety system data and industry best practices to identify opportunities to present both expected and unexpected scenarios requiring manual flight that better measure and improve proficiency in FPM skills during MFO. For example, flying a hand-flown visual approach from 20 miles out without FDs, autothrust, and ATC guidance.

3.3.2 Development and Maintenance of Knowledge and Skills. The importance of developing and maintaining MFO knowledge and skills should be emphasized throughout all flight-training segments. It is essential that knowledge and both cognitive and psychomotor skills for MFO are developed from the beginning of pilot training and practiced throughout a pilot's career. Pilot knowledge and skills are not static. While pilots achieve initial skill development through training and practice over time, the variability encountered in line operations should allow pilots to continually gain experience, refine, and improve their knowledge and skills.

3.3.2.1 Fundamental skills are those skills that may be necessary across many tasks and can include cognitive, psychomotor, and communication skills. Performing MFO requires foundational knowledge and skill proficiency in the following cognitive, psychomotor, and communication areas including, but not limited to, the following:

- Pitch and power basics.
- Energy management.
- High vs. low altitude aircraft performance.
- Aircraft type-specific factors with an impact on handling (e.g., effects of swept- vs. straight-wings, turbojet vs. turboprop vs. piston prop engines, underwing- vs. tail-mounted engines, trimmable stabilizer vs. trimmable elevator, etc.).
- Scan.
- Instrument interpretation.
- Cross-check of other pilot actions.

- Aircraft control, including timing, coordination, and anticipation of control inputs.
- Steps required, corresponding instrument display changes, and manual inputs required that occur as different combinations of systems and modes are used for MFO.
- Decision making for selecting the different combinations of management, guidance, and control systems desired for FPM during line operations.
- Appropriately managing unexpected situations (e.g., due to threats, system anomalies, system failures, or pilot input/error).
- Staying engaged in the FPM task, remaining constantly prepared to make manual inputs or make decisions when needed.
- Crew coordination.
- Task and workload management during manual flight (as it pertains to both the PF and PM).
- Information integration.
- Problem solving.

3.3.2.2 Pilots returning from an absence that requires requalification training should be provided training (including simulator training) to enable proficiency in these fundamental skills as well as MFO and instrument flying skills.

3.3.3 Normal Maneuvers vs. Non-Normal Events. Training pilots on required manual maneuvers (e.g., area departures/arrivals, approaches, slow flight, stalls, upsets, and steep turns) is beneficial to developing and maintaining manual flight skills. However, the need exists to assess pilot proficiency in MFO during expected and unexpected, non-normal events that challenge the pilot's cognitive as well as psychomotor skills. For example, startle events, systems failures, congested traffic leading to multiple ATC changes during approach, and weather events all provide a significant challenge when coupled with the requirement to fly the aircraft manually. Subtle degradation of control and guidance systems also present a challenge. Accident and incident reports show a pattern of MFO errors during non-normal events related to a deficiency in cognitive skills.

3.3.3.1 **MFO Maneuvers.** Operators should develop a list of required, recommended, and other manual flight maneuvers with associated tasks, knowledge, and skills to ensure they are identifying, training, and assessing required knowledge and skills for the entire range of tasks required for manually flown maneuvers and profiles. They should also identify which maneuvers and tasks are to be accomplished only in simulator training. This helps to build and maintain overall expertise and proficiency in cognitive, psychomotor, and communication skills required for MFO, not just expertise in certain tasks within a maneuver.

3.3.3.2 **Required Maneuvers.** Required manual flight maneuvers are contained within the approved part 121 training program requirements. This includes requirements such as:

1. Manually controlled slow flight (refer to § 121.423(b) and AC 120-111, Upset Prevention and Recovery Training).
2. Manually controlled loss of reliable airspeed (refer to § 121.423(b) and AC 120-111).
3. Manually controlled instrument departure and arrival (refer to § 121.423(b) and AC 120-114, Pilot Training and Checking (14 CFR Part 121 Subparts N and O, Including Appendices E and F)).
4. Upset recovery maneuvers (refer to § 121.423(b) and AC 120-111).
5. Recovery from bounced landing (refer to § 121.423(b) and AC 120-114).
6. Stall prevention and stall recovery (refer to part 121 appendix E, row III(h), and AC 120-109, Stall Prevention and Recovery Training).
7. Takeoff with simulated engine failure (refer to part 121 appendix E, row II(d) and appendix F, row II(d); and AC 120-114).
8. Manually controlled Instrument Landing System (ILS) approach with simulated engine failure (refer to part 121 appendix E, row III(l)(2) and appendix F, row III(c)(2); AC 120-114; and AC 120-54, Advanced Qualification Program).
9. Manually flown takeoff, departure to cruise (refer to § 121.423(b) and part 121 appendices E and F).
10. Manually flown descent, arrival, approach, and landing (refer to §121.423(b) and part 121 appendices E and F).

3.3.3.3 **Recommended Practices.** In addition to the required manual flight maneuvers, there are recommended practices that could provide additional opportunities in training for practicing MFO skills, in all flight phases. In some cases, these opportunities should be accomplished in normal line operations as well. The associated maneuvers, tasks, knowledge, and skills are found in guidance material, such as AC 120-114.

3.3.4 Training Scenarios. Training scenarios should address the operator's specific circumstances (e.g., pilot demographics and operational environment) and common error trends as identified through operator/industry safety programs. Scenarios may be incorporated as part of the Maneuvers Based Training (MBT) required by § 121.423, in a Line-Oriented Flight Training (LOFT) scenario, or other scenario-based training (SBT) and integrated with the energy management training considerations and training scenarios in Chapter 6, Energy Management.

3.3.4.1 Recommended training scenarios for MFO, in addition to part 121 training requirements, include manually flying to address the following:

1. Out of trim conditions – how to recover and manually fly to a safe landing.
2. Go-arounds initiated at other than minimum descent altitude (MDA)/decision altitude (DA).
3. Visual approaches in various weather and/or lighting conditions.
4. Operations in different combinations of automated systems and modes based on aircraft equipage. Examples of different combinations include the following:
   - FD on, AP off, AT on.
   - FD on, AP off, AT off.
   - FD on, AP on, AT off.
   - FD off, AP off, AT off.
   - FD off, AP off, AT on.
5. Engine-out raw data Category (CAT) I ILS approach.
6. Manual flight with hydraulic system malfunction.
7. Manual flight with flight control malfunction(s) affecting aircraft handling characteristics.
8. Visual circuit with partial power.
9. Loss of all engines.
10. Prevention, recognition, and manual recovery from unintended deviation from flightpath.
11. Prevention, recognition, and manual recovery from unintended autoflight states.

3.3.4.1.1 Pilots must have the proficiency to manually fly the aircraft at any time (even for the entire flight), without the aid of automated systems.[8] This requires that pilot knowledge and skills be developed, and proficiency maintained, for each task associated with every manually flown flight maneuver. This also requires the pilot to have the ability to regularly exercise required tasks and their associated knowledge and skills in both the airplane and simulator to maintain proficiency. Pilots should be regularly evaluated on their proficiency to manually fly the aircraft while conducting MFO.

3.3.4.1.2 In addition to required knowledge and skills for MFO, pilots need the confidence and cognitive capacity to accomplish and manage the tasks associated with manually flying the airplane. This includes managing time, tasks, workload, and changes due to the variability of operations. For example, if an operator wants to assess pilot proficiency for a manually flown

[8] Part 121 appendix E.

visual approach, the assessment should include a major cross-section of all required tasks and their associated knowledge and skills for the maneuver. The visual approach maneuver should start during the descent phase where the pilot can demonstrate proficiency in MFO during the arrival, approach, and landing while safely managing such things as approach planning, crew briefing, energy management, ATC communications, time management, task/workload management, and ATC-directed changes. This allows the assessment of a representative set of knowledge and skills that requires the pilot to show proficiency. Experience exercising the skills and developing and maintaining proficiency results in pilot confidence in their performance abilities.

3.3.4.1.3 In contrast, an operator cannot accurately assess overall proficiency in a manually flown visual approach by only requiring a pilot to manually fly a final approach maneuver (airplane fully configured at final approach fix (FAF) to touchdown). This only assesses pilot proficiency in flying a fully configured aircraft from the FAF to landing. It does not assess proficiency for the entire visual approach maneuver. It primarily checks for certain fundamental psychomotor abilities but does very little to verify proficiency in overall pilot knowledge, cognitive, psychomotor, and communication skills, and cognitive capacity to accomplish all tasks required to manually fly a visual approach in line operations.

3.3.4.1.4 It is beneficial for manually flown maneuvers (both normal and non-normal) to be trained and checked to a defined and logical end state consistent with what would happen during line operations, not just to an unrealistic intermediate stopping point. Scenarios that require manual flight, especially scenarios involving aircraft controllability and manual handling issues, should require pilots to continue all the way to a landing. In these situations, the pilots would exercise their skills and gain experience performing their complete set of fundamental flight skills, along with their knowledge and skills (cognitive, psychomotor, and communication) required for MFO, to safely land the airplane.

3.3.4.1.5 For example, consider a runaway trim scenario where the trim operation cannot be fixed, and the pilots are required to manually fly the airplane to a safe landing with the aircraft in a compromised state. The maneuver should start when the trim starts to run away and end when the aircraft lands. The pilots would need to take over manual aircraft control, identify the problem, accomplish any immediate action steps from memory, diagnose the problem, run appropriate checklists, coordinate with ATC, and manually fly the airplane for an approach and landing at a suitable airport. Stopping an assessment after the immediate action steps are completed or after the aircraft state is stabilized does not fully show proficiency in manually flying a runaway trim situation to a safe landing.

3.3.5 Intervention Strategies. Since situations will occur where intervention in the flightpath control is required, operators should include policies and procedures for pilots to follow when intervening in automated or manual control situations, and for resumption of flightpath control.[9] These policies and procedures should apply to both pilot-to-machine intervention and pilot-to-pilot intervention and should include deviation parameters, required call-outs, and conditions for assuming control from the other pilot (e.g., a "two-challenge rule"). Operators should incorporate intervention strategy policies and procedures specific to FPM within their CRM training as well. Chapter 5, Pilot Monitoring (§ 121.544), further discusses topics related to intervention.

3.3.6 Transfer of Control. There must always be a clear understanding of which pilot has control of the aircraft. Prior to flight, the pilots involved should conduct a briefing that includes reviewing the procedures for exchanging flight controls.

3.3.6.1 The FAA recommends a positive three-step process for exchanging flight controls between pilots:

1. When one pilot seeks to have the other pilot take control of the aircraft, the first pilot will say, "You have the flight controls."
2. The second pilot acknowledges immediately by saying, "I have the flight controls."
3. The first pilot again says, "You have the flight controls," and visually confirms the exchange.

3.3.6.2 Pilots should follow this procedure during any exchange of flight controls, including any occurrence during the proficiency check. There must never be any doubt as to who is flying the aircraft.

3.3.6.3 Through analysis of accidents and incidents, situations are identified where both pilots ended up acting as the PF while monitoring was overlooked. This could happen when the PM takes over aircraft control from the PF during a critical moment, including takeoff and landing. Normally, it is easier for the PM to revert to PF than the PF to revert to PM instantly. One reason for this is that the PM may make a decision and take action to be the PF, while the PF may be startled, surprised, lost situation awareness, or trying to figure out why the PM took over, but not thinking about switching roles and being the PM. However, there are also situations where the PM is given control by the PF unexpectedly, such as in the case of lost instrumentation or the PF's seat sliding back during rotation. In any case, during any takeover or transfer of control, the new PF has to ensure control of the flightpath while the new PM immediately assumes the PM role and responsibilities, while both pilots maintain situation awareness.

3.3.6.4 The purpose of transfer of control training is to:

[9] ACT ARC Recommendation 15-10, Guidance Material Addressing Intervention Strategies, August 8, 2015.

1. Develop proficiency in changing roles (PF to PM, PM to PF) during situations where transfer of control is necessary.
2. Initiate takeover to prevent the situation from becoming critical.
3. Highlight the importance of continuously maintaining aircraft control and monitoring through the takeover and that the pilots change roles as required.
4. Make pilots aware of vulnerabilities and common errors that can occur during transfer of control, either planned or unplanned, including how to mitigate, recognize, and recover from errors.

3.3.6.5 Transfer of control training should include at least the following scenarios:

- The Captain is acting as PM and is required to take over as PF and the F/O reverts to PM.
- The Captain is identified as PM in the briefing and inadvertently assumes PF on the takeoff role and the F/O reverts to PM.
- The F/O (PM) is required to take over as PF and the Captain (PF) reverts to PM immediately.
- The F/O (PM) decides to takeover and the Captain (PF) reverts to PM instantly.
- Unexpected system behavior or failure affecting the roles of PF and PM.
- Rejected takeoff.
- Unstable approaches.
- Decision-making processes.
- PF takeover from automated systems (expected and unexpected).

3.4 Instructor/Evaluator (I/E) Considerations. All I/Es should have the foundational knowledge and fundamental skill proficiency in cognitive, psychomotor, and communication areas recommended in this chapter for effective aircraft FPM and performing MFO. In addition, all I/Es should possess the knowledge and skills to instruct, assess, and evaluate the learning objectives and pilot proficiency for MFO as it relates to FPM, including the interlinking aspects of managing automated systems, PM, and energy management.

3.4.1 Instructors providing training on MFO must have a thorough understanding of FPM and MFO learning objectives.[10] Operators should provide instructors training on the recommended strategies, including scenarios that can be used to incorporate these learning objectives.

[10] Section 121.412.

3.4.2 Throughout all aspects of training and checking, the instructors and evaluators should maintain focus on FPM priority. They should be trained to deliver realistic training scenarios for exercising, building, and maintaining proficiency in MFO skills.

CHAPTER 4. MANAGING AUTOMATED SYSTEMS

4.1 General. There are many automated systems in modern airplanes, including autoflight systems (e.g., AP, AT, and FD), FMS, and envelope protection systems. Automated systems are implemented for different functions, including aircraft control, flight guidance, alerting systems, systems management, and many others. Pilots should be adequately trained and proficient with respect to those systems.[11] This chapter focuses on automated systems that affect airplane control and guidance for FPM.

4.1.1 This chapter addresses the following major topics related to managing automated systems:

- Operational use of and training for automated systems in normal, rare normal,[12] and non-normal operations. This includes appropriate engagement, disengagement, and combinations of these systems.
- Autoflight mode awareness.
- Prevention, recognition, and response to unintended autoflight states.[13]
- Prevention, recognition, and management of common errors in use of automated systems, including data entry errors.[14]

4.1.2 The following sections provide explanation and guidance for operations, operator policy, procedures, and training for each of these topics.

4.2 Operational Policy and Procedures for Managing Automated Systems. Effective operational use of automated systems in normal, rare normal, and non-normal operations for FPM requires the pilot to understand how the automated systems work, how to use/operate those systems, how to monitor them, and how to respond in case of failure or unintended system behavior.

4.2.1 To support effective use of automated systems for FPM, operators should provide flightcrews with:

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[11] Section 121.415(h).

[12] The use of "rare normal" refers to environmental conditions that are experienced infrequently but considered to be operationally relevant. Examples may include significant winds/gusts, wind shear/microburst, severe turbulence, and asymmetric icing.

[13] An "unintended autoflight state" means a situation in which any aspect of flight guidance or flight control automation is guiding or controlling the aircraft's trajectory or energy in a manner contrary to that desired/intended by the pilot(s). This does not necessarily imply situations driven by system failures, flightcrew failures, or design deficiencies, as there are many possible causes for the mismatch between pilot intent and the autoflight system state.

[14] Flightcrews routinely input data and use automated systems properly to maintain the desired flightpath. However, industry studies note that input or usage errors occur and result in flightpath deviations, and one report sampling noted that "44% of…these errors went unnoticed by the pilots…" (International Air Transport Association (IATA), FMS Data Entry Error Prevention Best Practices, 1st Edition, 2015).

1. Operational policy with recommended strategies and procedures on the use of automated systems, including appropriate engagement, disengagement, re-engagement, and combinations of use of these systems.
2. Guidance and procedures for the use of the automated system or combination of systems, when to not use them, and which system or combinations are best suited to the different operational scenarios, including:
   - Procedures and communications strategies to support autoflight mode awareness, and
   - Flightcrew actions when an automated system does not respond or behave as expected or disengages unexpectedly. The objective is for pilots to develop an understanding of the automated system, its integration with other aircraft systems, and what might affect the automated systems' ability to function as expected.
3. Integration of strategies for achieving autoflight mode awareness into SOPs. Equipment and/or company culture may influence how the mode awareness procedures for flightcrews are designed. Therefore, the operator should create mode awareness procedures that reflect the equipment and how the company employs the equipage and should train/assess the procedures.
4. Policy and procedures for prevention, recognition and recovery from unintended autoflight states. Procedures should emphasize that the PF's primary duty is to control the flightpath and the PM's duty is to (1) monitor/ensure the flightpath, then (2) assist the PF by assessing any actual or potential deviations from the flightpath and helping to correct the autoflight settings as needed to restore desired behavior.
5. Policy and procedures for preventing, recognizing and managing common errors in use of automated systems, including data entry errors.

4.2.2 Strategies for using automated systems sometimes refer to levels of automation, defined as simple hierarchies of combinations of certain autoflight systems. While the concept of levels may be useful for communication, such a description assumes a linear hierarchy that is difficult to apply operationally. The various features of the autoflight system (AP, FD, AT, FMS, etc.), can be, and are, selected independently and in different combinations that do not lend themselves to simple hierarchical description. Therefore, operator's policies should provide strategies for the pilot to use the appropriate combination of automated system features for the situation, without rigidly defining them in terms of levels, except for the highest (everything is on) or the lowest (everything is off). The strategies should provide flightcrews with the options that match the specific operationally relevant scenario, but also allow flexibility for those unusual operations that occur. Equipping flightcrews with such practical strategies may also equip them with the knowledge to select the appropriate combination of automated systems and modes (or none at all) for those unexpected events that require informed and timely decisions (e.g. those events which may not be addressed in flightcrew checklists).

4.3 Training Considerations. As described above, effective operational use of automated systems requires the pilot to understand how the automated systems work, how to use/operate those systems, how to monitor them, and how to respond in case of failure or unintended system behavior. In designing training programs, operators should develop specific learning objectives with associated training methodologies that address knowledge and skills for managing automated systems. Pilots must be trained on the operator's policies and procedures for the use of automated systems in normal, rare normal, and non-normal operations, including appropriate engagement, disengagement, and combinations of these systems.[15] Training these strategies should be scenario-based and operationally relevant.

4.3.1 Appropriate strategies on the use and application of the respective system(s) are situation-dependent, and operators should provide training on these strategies and procedures. The training should reflect actual events captured from the various data sources.

4.3.2 Operators should train flightcrews on the following topics:

4.3.2.1 Pilots should be able to correctly interpret the automated system's engagement mode and whether the aircraft is responding as intended. If a system is not responding as intended, whoever detects an anomaly should communicate with other members of the flightcrew to ensure a shared understanding. Should the system not engage as desired, engage into an undesired mode, or disengage unexpectedly, flightcrews should be capable of returning to the previous state or manually disengaging the system in accordance with established aircraft operating procedures. Subsequently, flightcrews should be capable of analyzing the anomaly and selecting alternative options and/or corrective actions.

4.3.2.2 Flightcrews should also receive training for operational situations in which it is not appropriate to engage an automated system, such as when known system failures/anomalies exist that may adversely affect aircraft control or when the aircraft is in an undesired state (e.g., upset). An exception when the undesired state is an upset is when the aircraft is specifically designed with a recovery system to facilitate an upset recovery. In this case, flightcrews should be thoroughly trained on the use of the recovery system and recognize if it is not operating as intended to quickly intervene and manually recover from the upset before conditions deteriorate.

4.3.2.3 Operators should train flightcrews on autoflight mode awareness. The pilot should be able to demonstrate the knowledge and skill to correctly select, interpret, and anticipate normal autoflight modes, and demonstrate appropriate remedial actions for inappropriate or unexpected modes. Learning objectives include but are not limited to:

[15] Section 121.419(a)(2)(v).

- Correctly interpret individual flight mode annunciations (FMA) (e.g., AP, AT, and FD).
- Describe the respective mode's impact on the related systems and aircraft operation.
- Identify autothrottle system mode annunciations and the effects on aircraft performance.
- Describe autothrottle system effects on related system operation.
- Identify pitch mode annunciations and their relationship to AT and FD (i.e., demonstrate understanding of speed-on-pitch (speed controlled by varying the airplane pitch attitude) and speed-on-thrust (speed controlled by varying the engine thrust level)).

4.3.2.4 Managing automated system failures. This should include failures of other systems that affect the operation of automated systems, including sensor failures. Training on failures should consider operationally relevant situations and should include failures of items that provide input to the automated systems. Examples include situations where assessment is difficult; situations where recovery is difficult if not properly recognized; and conditions that do not have a checklist. For these training sessions, it is appropriate to note that it is not possible to train pilots in all possible malfunctions or failure scenarios, nor is it possible (or desirable) for line pilots to perform functions as test pilots. Pilots must be prepared to recognize the results of both complete and partial system failures (including sensor failures) and intervene appropriately.[16]

4.3.2.5 Operators should train flightcrews on how to manage automated systems after input errors (pilot- or system-generated). To reduce the likelihood of automated system input and usage errors, flightcrews should first be trained on what to look for, and then be given procedures, tools, and techniques to cross-check each other and the automated system in a combined effort to trap potential errors. The 2015 International Air Transport Association (IATA) FMS Data Entry Error Prevention Best Practices document lists some common error categories: mass/balance, flight plan, load/trim, navigation database, FMS limitations, configuration errors, data calculation, and data transcription. Instructors should offer methods for prioritizing the errors that are most likely to have significant negative consequences. Gross error checks (sometimes known as reasonableness checks, as discussed in Chapter 5) are important characteristics to instill, because such automated systems are correct in most cases, but sometimes wrong. Pilots should be trained to cross-check

[16] Part 121 appendix E.

each other so errors with a potential for significant negative consequences are detected and mitigated. This training[17] should include, but not be limited to:

- Strategies to detect and identify input or usage errors;[18]
- Training pilots on operationally relevant input and usage errors and their consequences;
- Methods for flightcrews to correct the input or usage error; and
- Methods to ensure the intended flightpath is maintained.[19]

4.4 Instructor/Evaluator (I/E) Considerations. I/Es should have a thorough understanding of FPM and associated automated systems, including but not limited to the AP, AT, and FD; FMS; and flight envelope protection. Operators should train their instructors on the recommended strategies and procedures for use of the automated systems and provide appropriate scenarios for the training topics.

4.4.1 Instructors should have a clear understanding of managing automated systems under failure conditions and accepted recovery techniques before training other crewmembers.

[17] Training elements listed relate to ACT ARC Recommendation 17-8, Management of Automated Systems, recommendations 17-8(c) and (d).
[18] Refer to ACT ARC Recommendation 15-11, Guidance Material Addressing Auto Flight Mode Training, for complementary recommended guidance.
[19] Refer to ACT ARC Recommendation 15-10 and Recommendation 16-10, Flight Path Management Philosophy, Policy, and Procedures, for complementary recommended guidance.

CHAPTER 5. PILOT MONITORING (§ 121.544)

5.1 General. Flightpath monitoring involves comparing the actual flightpath to what is expected/desired. This requires pilots to observe and interpret flightpath data, aircraft configuration status, automated system modes, and onboard systems appropriate to the phase of flight any time the aircraft is in motion, including during taxi.

5.1.1 Several studies of crew performance, incidents, and accidents have identified inadequate monitoring and cross-checking as vulnerabilities for aviation safety. Effective monitoring and cross-checking can be the last barrier or line of defense against accidents because detecting an error or unsafe situation may break the chain of events leading to an accident. Conversely, when this layer of defense is absent, errors and unsafe situations may go undetected, potentially leading to adverse safety consequences. Therefore, it is required that operators establish operational policy and procedures on PM duties, and implement effective training for flightcrews and instructors on the task of monitoring (§ 121.544). This chapter describes effective monitoring, how to define and train PM duties, and integration of the task of monitoring into SOPs. Additionally, this section discusses special considerations for monitoring autoflight operations.

5.2 Operational Policy and Procedure Considerations. Operators should have documented policies and procedures to describe the duties of both the PF and PM and to support effective flightpath monitoring. These policies and procedures should state that the primary task of the flightcrew while the aircraft is in motion is FPM and emphasize the importance of vigilance to the flightpath.

5.2.1 In a two-pilot operation, one pilot is designated as PF and one pilot is designated as PM. Each operator should explicitly define the duties of the PF and PM to include:

1. At any point in time during the flight, one pilot is the PF and one pilot is the PM.
2. The PF is responsible for managing, and the PF and PM are responsible for monitoring, the current and projected flightpath and energy of the aircraft at all times.
3. The PF is always engaged in flying the aircraft (even when the aircraft is under AP control) and avoids tasks or activities that distract from that engagement. If the PF needs to engage in activities that would distract from aircraft control, the PF should transfer aircraft control to the other pilot, and then assume the PM role.
4. Transfer of PF and PM roles should be done positively with verbal assignment and verbal acceptance to include a short brief of aircraft state.
5. The PM supports the PF at all times, staying abreast of aircraft state and ATC instructions and clearances.

5.2.2 To effectively monitor, the pilot should know what information to attend to and when. [20] The pilot should apply strategies to perceive flight deck indications and interpret their meaning for the current context and assimilate them into a mental model of airplane state

[20] For effective monitoring of the flightpath, cognitive skills of perceiving, interpreting, and assimilating are integrated with pilot knowledge into an understanding of the flightpath and the airplane's relation to it.

relative to the flightpath. The pilot actively compares their mental model of what is expected (or normal for the context) to the indications in the environment (e.g., flight instrument, mode annunciations) that are available. Therefore, the pilot needs to have sufficient knowledge to form an accurate mental model of the aircraft systems and performance, to know what information to acquire, and how to process it to formulate an accurate understanding of the current state of the aircraft flightpath. Differences between what is expected/desired and what is observed should trigger corrective action.

5.2.3 Effective flightpath monitoring also requires effective management of attention. If pilots become distracted or workload is high, attention may be insufficient. The management of attention is an important cognitive skill that requires effort. Because the modern flight deck has many visual displays and sources of information, pilot attention may be captured by interpreting aircraft system behavior or compelling, information-rich displays. Therefore, it is important that pilots are skilled at managing attention, information, and distractions to ensure flightpath remains the primary focus of the flightcrew.

5.2.4 The operator should implement the policies into SOPs to support monitoring and cross-checking functions, and appropriate interventions. If not designed appropriately, some SOPs may actually detract from effective monitoring. For example, one operator required a passenger address (PA) announcement when climbing and descending through 10,000 feet. This requirement had the unintended effect of "splitting the flight deck" at a time when frequency changes and new altitude clearances were likely. When the operator reviewed its procedures it realized that this procedure detracted from having both pilots "in the loop" at a critical point and consequently decided to eliminate it. Operators should review existing SOPs and modify those that can detract from monitoring.

5.2.5 Autoflight mode awareness is of particular importance because effective monitoring of autoflight modes is necessary for successful FPM. Below are some recommended strategies for effective monitoring of the autoflight modes that could be included in operator policies and procedures. The pilot should:

1. Stay in the loop by mentally flying the aircraft even when the AP or other pilot is flying the aircraft.
2. Monitor the flight instruments just as when the pilot is manually flying the aircraft.
3. Be diligent in monitoring all flightpath changes including pilot actions, system modes, and aircraft responses.
4. Always make monitoring of the flightpath a priority task when changes are being made.
5. Always check the FMA after a change has been selected on the autoflight mode control panel.
6. Check the FMAs and flight instruments after being distracted to regain full awareness of the flightpath state.

7. Maintain an awareness of the autoflight systems and modes selected by the crew or automatically initiated by the FMS (mode awareness) to effectively monitor the flightpath.
8. Maintain an awareness of the capabilities available in engaged autoflight modes to avoid mode confusion.
9. Effectively monitor systems and selected modes to ensure that the aircraft is on the desired flightpath.

5.2.6 Operator policies and procedures should adequately address the potential for intervention.[21] Policies and procedures for expected interventions should be established, including:

- Deviation callouts, deviation parameters, required callouts, conditions for "takeover" (e.g., "2-challenge rule"), automation management standards (e.g., "change mode of automation under the following conditions"), etc.
- Expected responses to callouts; conditions for takeover (e.g., subtle incapacitation, and/or no correction after two challenges); callouts and actions associated with a takeover of control of the aircraft; ensuring positive change of control; and the PF's expected actions after a takeover.
- If the PF does not correct the flightpath deviation in a timely manner, the PM should intervene based on operator policy and procedures.

5.2.7 Operators should have policy and procedures that enable the flightcrew to verify and validate both the accuracy and applicability of automated system inputs and outputs by conducting reasonableness checks.[22] Reasonableness checks allow flightcrews to detect and address potentially conflicting, ambiguous, inapplicable, or erroneous automated system inputs/outputs. These procedures should also specify how and when to perform reasonableness checks. These should integrate with existing procedures and training to guide the conduct of reasonableness checks of automated system inputs and outputs during the FPM planning activity for each phase of flight.

5.3 **Training Considerations.** In designing training programs, operators should develop specific learning objectives with associated training methodologies that address knowledge and skills for monitoring. Training should provide pilots with the knowledge and skills needed to satisfy the duties of PM, to effectively monitor the flightpath, to communicate with the other pilot(s) when there is a flightpath deviation, and to know when and how to intervene if necessary. Training should also include an understanding of the barriers to effective monitoring and how to mitigate them. Operators should train and check flightcrews on the following topics, including:

[21] AC 120-71, Chapter 6, Pilot Monitoring.
[22] A reasonableness check is any check that is carried out to verify that a result looks "reasonable" given other available knowledge and information.

1. The roles and duties of the PF and PM.
2. How to achieve effective flightpath monitoring.
3. Managing attention.
4. Intervention.
5. Conducting reasonableness checks.
6. Barriers to effective monitoring.
7. Common errors and mitigations in monitoring.

Note: Each of these topics is discussed more below.

5.3.1 Roles and Duties of PF and PM. Pilots should be trained on the duties of both roles as documented in the policies and procedures. Pilots should be trained to recognize when the PF is not adequately controlling the flightpath or when the PM is not adequately monitoring the flightpath. This training should include pilot task loading and signs of diminished performance. Some examples include lack of communication, channelized attention, and failure to make required callouts.

5.3.2 Effective Flightpath Monitoring. Pilots should be trained to recognize when the airplane is not conforming to the planned flightpath and on strategies for appropriate intervention (see paragraph 5.3.4). They should be trained that there are predictable situations during each flight when the risk of a flightpath deviation is increased, heightening the importance of proper task/workload management.

5.3.2.1 Training should also include recognition of and signs of diminished crewmember performance on the part of the PF or PM (e.g., lack of communication, channelized attention, failure to make required callouts, etc.). Training should include monitoring-related CRM, TEM, and human performance vulnerabilities related to monitoring, the importance of monitoring, and the operator-approved practices that achieve effective monitoring of the flightpath.

5.3.2.2 Training should ensure that pilots have a thorough understanding of the knowledge and skills to apply the combinations of flight guidance and flight control automation (e.g., given a certain set of circumstances, what will happen next?). Training should also ensure pilots are proficient and can transition seamlessly between combinations/levels of flight guidance/flight control automated systems (including manual flight) during line operations. Training should be enhanced to teach pilots to interpret the FMA and other FPM systems relative to aircraft state and to know what to expect based on programming, configuration, and aircraft state. Training should explicitly address the management of deviations or off-path operations and include strategies for managing “automation surprises” and unknown situations.

5.3.3 Managing Attention. Pilots should be trained to effectively maintain vigilance of the flightpath. Training should include specific strategies for managing attention to support flightpath monitoring and where and when to focus attention, and reinforce prioritization of flightpath. The quantity and type of information available to the flightcrew has changed substantially over the last decades. This trend is expected to continue as new technologies and products are introduced into the flight deck to enable new kinds of operations. Training should include methods to recognize the flight phases or situations when they are most vulnerable to flightpath deviations (including when little time exists to correct deviations) so flightcrews may strategically plan workload and manage distractions to maximize attention to flightpath during those phases.

5.3.3.1 Pilots should be trained how to monitor for the specific purpose of protecting the flightpath while they are engaged in concurrent tasks. They should be trained how to prioritize tasks and switch between tasks so that they do not neglect monitoring of the flightpath during potentially vulnerable states (e.g., low altitude lateral or vertical changes). Training should include information and task management strategies that enable pilots to use charts, EFBs, the Aircraft Communications Addressing and Reporting System (ACARS), etc., while also effectively monitoring the trajectory and airplane energy state.

5.3.3.2 Pilots should be trained on managing distractions to ensure the flightpath remains the primary focus of flightcrew attention. In the flight deck there are multiple competing demands for pilot attention.

5.3.4 Intervention. Pilots should be trained on progressive intervention strategies and how to apply them when they are in the role of PM, as documented in the operator's policy and procedures. A progressive intervention strategy is initiated by communicating a flightpath deviation (alert), then suggesting a course of action (advocacy and assertion), and then directly intervening, if necessary, by taking the controls to prevent an incident or accident. If the PF does not correct the flightpath deviation in a timely manner, the PM should intervene based on operator policy and procedures. A pilot taking control should announce the transfer of control. For example:

- PM calls "One dot high;" PF calls "correcting" and returns to glidepath in a timely manner.
- PF does not respond to two successive challenges; then, per operator's procedure, the PM announces, "I have control, going around," and initiates a go-around as PF.

5.3.4.1 When a flightpath problem is identified, the PF should know appropriate ways of correcting it by taking action with the flightpath guidance or control equipment. For example:

1. PF notes speed increasing on a path descent and deploys the speedbrakes.
2. After a change to the FMS, the PF expected a level turn to the right at constant speed. Instead, the aircraft begins to roll into a left turn, the power begins to increase, and the aircraft starts to pitch up. The PF

immediately disengages the AP and AT and manually returns the aircraft to the desired flightpath and energy.

3. PF notes aircraft descending slightly below glidepath and speed decreasing, but the wind-shear warnings immediately annunciate and the flight guidance automation switches to wind-shear escape commands. The PF decides not to interfere with the equipment.
4. PF notes aircraft vertical navigation (VNAV) is not functioning as expected to maintain the intended flightpath. The pilot reverts to another mode, such as vertical speed, to maintain the intended flightpath using autoflight functions.

5.3.4.2 The intervention strategies may also include the PM taking control of the aircraft if the PF is not responding correctly in time to address the flightpath problem. Training should provide effective means of taking over the PF role if it is determined that the PF is not correcting a flightpath issue in a timely manner. This should include strategies for managing the communications and methods of intervention that are appropriate for the situation (e.g., PF is becoming incapacitated vs. PF missed an important flightpath cue). Training should include communication strategies for what to say, how to say it, and when to speak up, etc. Training should also include methods for judging whether intervention is needed and deciding on an appropriate course of action (e.g., the severity of the situation, acceptable time allowed before intervention, etc.).

5.3.5 Conducting Reasonableness Checks. Pilots should be trained in how and when to do reasonableness checking. This should include training on how to detect and address potentially conflicting, ambiguous, inapplicable, or erroneous automated system inputs/outputs. These should integrate with existing procedures and training to provide guidance on the conduct of reasonableness checks of information inputs and outputs during the FPM planning activity for each phase of flight (e.g., predeparture, pre-descent, pre-approach). Operators should train pilots to conduct reasonableness checks that include how and when to perform such checks. Reasonableness checks should be conducted for automated system inputs/outputs the pilot uses in the FPM planning activity for an upcoming phase of flight.

5.3.5.1 Reasonableness checks of automated system inputs/outputs should be easy to perform and enable pilots to reliably detect gross errors and validate operational applicability of inputs/outputs (e.g., "Does the information make sense?"). Operators should define when to perform a reasonableness check and should ensure that reasonableness checking does not conflict with the performance of their existing operational procedures.

5.3.5.2 An appropriate reasonableness check methodology should enable pilots to: [23]

[23] ACT ARC Recommendation 18-1, Reasonableness Checks of Information Automation Systems.

1. Detect and address potentially inaccurate/inapplicable system inputs/outputs before using the information in a way that impacts the flightpath.

   a. The appropriate means to detect inaccurate/inapplicable system inputs/outputs could include development and training of standard “rules of thumb” or “ballpark” figures so that crews have sufficient baseline knowledge of what a “reasonable” input or output should look like, permitting the crew to detect and investigate system inputs/outputs that are outside the boundaries of “reasonable.”

   b. The appropriate means to address the inaccurate/inapplicable input/output and maintain the integrity of the flightpath will vary based on operational context. For example, if time is unlimited (e.g., reviewing performance numbers at the gate), a discrepancy might be addressed by seeking additional information from multiple sources to cross-check the inputs/outputs. If time is limited (e.g., reviewing descent calculations approaching Top of Descent (TOD)), a discrepancy might be addressed by reverting to a simpler, more conservative choice.

2. Maintain flightpath as the primary focus so that resolving inaccuracy or inapplicability of system inputs/outputs does not distract from the primary task of FPM.

5.3.5.3 Operators can identify how, how many, and when to conduct reasonableness checks based on their own equipment and operating environment, and through their operational feedback, training feedback, and SMS programs. This should include safety data programs such as LOSA, ASAP, and FOQA, as well as industry programs (e.g., manufacturer–operator meetings, accident reports, the Aviation Safety Reporting System (ASRS), and the Aviation Safety Information Analysis and Sharing (ASIAS) Program).

5.3.6 Barriers to Effective Flightpath Monitoring. Pilots should be trained and evaluated on recognizing barriers to effective flightpath monitoring and indications of inadequate flightpath monitoring. Conditions that may lead to inadequate flightpath monitoring may include high task loading, insufficient attention management, or distractions. For example, during times of high task loading, pilots may focus on individual tasks or channelize their attention, which may lead to diminished communication between the crewmembers. Training should include strategies to respond to these risks and identify the resources to be used during high workload on the flight deck.

5.3.6.1 Although communications and assertiveness skills have been mentioned, there are a variety of other “nontechnical” skills generally contained in the best CRM and TEM training programs, such as teamwork, time and task management, etc., that are also very valuable in support of a pilot’s ability to monitor and intervene effectively if needed.

5.3.7 Common Errors and Mitigations in Monitoring. Pilots should be trained on common errors in monitoring the flightpath, and potential mitigations for those errors. This includes training on appropriate methods of recognizing precursors to, and signs of, degraded monitoring and on resolving monitoring errors and/or lapses.

5.4 Instructor/Evaluator (I/E) Considerations. I/Es should have a thorough understanding of FPM, their associated systems, and their operational use; the roles of PF and PM; and the relevant operator policies and procedures to effectively train and evaluate pilots. I/Es should be taught how to properly teach and evaluate monitoring. I/Es should also be knowledgeable about managing attention, so they can effectively train pilots on the potential for distractions on the flight deck that lead to ineffective monitoring and improper FPM. I/Es should assess the pilot's monitoring skills and role as PM where applicable.

CHAPTER 6. ENERGY MANAGEMENT

6.1 General. Energy management is defined as the planning and control of airspeed (or groundspeed), altitude, thrust, aerodynamic drag (speedbrakes, slats/flaps, and gear), and trajectory to achieve desired lateral and vertical flightpath targets appropriate for the operational objectives. Energy state is the combination of kinetic and potential energy of the aircraft, which means the combination of speed (kinetic energy), altitude (gravitational potential energy), and thrust (chemical potential energy) available. During maneuvering, these three types of energy can be traded, or exchanged, sometimes at the cost of additional drag.

6.1.1 Industry reports and operational data from airlines and aircraft manufacturers indicate that pilots have vulnerabilities in awareness and management of the aircraft's energy state, across multiple phases of flight, which is potentially a significant contributing factor in flightpath deviations, incidents, and accidents. These data reveal challenges at times in complying with arrival and departure procedures, approach and landing operations, and during go-arounds. Increased precision is required on new and planned future airspace procedures (e.g., Performance-Based Navigation (PBN), area navigation (RNAV), Required Navigation Performance (RNP), Trajectory Based Operations (TBO), Radius-to-Fix (RF) legs). Therefore, pilot understanding of and proficiency for energy management during such operations are critical.

6.1.2 For example, the pilot needs to understand how to manage the vertical flightpath and aircraft energy during the arrival and approach phases; how the pilot does that will vary based on the type of approach flown (e.g., RNAV Standard Terminal Arrival (STAR) to an ILS approach or to a visual approach) and ATC interventions. Pilots need to be able to plan the tasks related to the desired aircraft energy state for the arrival and approach, in a timely manner. If the approach clearance or aircraft energy changes, the pilot needs to have the knowledge and skills to recognize actual or pending energy state changes to decide what actions need to be made to manage the flightpath and aircraft energy accurately and efficiently.

6.1.3 This chapter provides guidance on recommended operational policy, procedures, and considerations for energy management to support effective FPM. Operators should refer to their own data from SMSs and from industry reports to determine additional areas of emphasis. Section 121.423, AC 120-111, and AC 120-109 address knowledge and skill elements and training requirements for energy management as it pertains to upset prevention and recovery, including stalls, high altitude flight, and flight at minimum controllable airspeed. Thus, the material in this AC supplements but does not cover that material.

6.2 Operational Policy and Procedure Considerations for Energy Management. An operator's policy and procedures should address the roles and responsibilities for the PF, PM, and other flightcrew members related to the integration of managing energy and flightpath, in all phases of flight. Energy management is the responsibility of the PF who should take into account the aircraft's inertia, limitations, and crew ability in the prevailing environmental conditions and aircraft state. Pilots should continuously monitor and evaluate the energy state of the aircraft (high/low/fast/slow) so that they are able to assess when changes to the energy state are needed, occur, or are projected to occur. The trading of energy should be accomplished, though, with a view toward capturing and maintaining the final desired energy state. Pilots should be able to maintain the flightpath and desired energy state in any combination of manual and automated flight modes.

6.2.1 Operational policy and procedures should consider the following questions related to energy management:

- Is the aircraft high or low and is the speed fast or slow in comparison to the desired vertical flightpath and speed at the moment?
- Will the aircraft be on the desired vertical flightpath and at the desired speed target at various points in the future?
- What needs to be done to adjust the vertical flightpath or speed if it's not correct at the moment, or not on track to reach a future target?
- Is the aircraft within its operational envelopes and will the aircraft remain within operational limitations?

6.3 Training Considerations.

6.3.1 Knowledge and Skills. Energy management involves the following pilot knowledge and skills:[24]

1. Pilots should be able to determine where the aircraft is in time and space, in terms of both physical position and energy state, in relation to the desired vertical profile and speed targets (i.e., is the aircraft is too high or low, fast or slow).
2. Pilots should be able to predict where the aircraft will be in the future, in terms of both position and energy state, in relation to the desired future vertical profile and speed targets.
3. Pilots should be able to make the proper flight control inputs (whether through manual control or through automated systems) required to adjust the flightpath and energy state to achieve the desired current and future profile and speed targets.

6.3.1.1 Knowledge and skills can be developed through training on how to:

1. Determine the aircraft energy state,
2. Understand how all available flight controls (primary and secondary, manual and automatic) can be used to affect the aircraft energy state, and
3. Create action plans to meet the desired aircraft energy state targets specific to the operational requirements.

[24] ACT ARC Recommendation 19-4, Energy Management, Attachment C, Energy Management Training Objectives and Training Scenarios.

6.3.1.2 As a foundation for energy management, pilots should reinforce their basic skills and knowledge related to flying manually (as discussed in Chapter 3) and to flying with automated systems. Operator training should address energy management during normal situations, as well as during unexpected, abnormal, or emergency situations.

6.3.2 Training Topics. In designing training programs (initial, transition, upgrade, and recurrent), operators should develop specific learning objectives with associated training methodologies that address energy management knowledge and skills. Examples of topics to consider include:

1. Energy management considerations for each phase of flight, including energy-related threats and mitigations against those threats.
2. Methods to determine whether vertical path and speed constraints (published or ATC-directed) can be met.
3. How to use lift and drag devices to manage energy.
4. Techniques for flying high energy approaches (e.g., where pilots have to descend quickly for an approach and landing at an airport with terrain or other restrictions, such as Eagle County Regional Airport (EGE) or San Francisco International Airport (SFO)).
5. Common errors in energy management, operational traps, and potential threats that could lead to errors, such as:
   - Late changes in assigned routing, clearance limit, altitude assignment, or arrival procedure.
   - Loss of FMS lateral or vertical profile requiring intervention to correct path or route.
   - Untimely speed assignment changes, traffic avoidance altitude constraints, and other unexpected ATC restrictions.
   - Current forecast and unexpected weather conditions (winds, icing, high density altitude, etc.) that affect aircraft performance and energy state.

6.3.3 Training Scenarios. Recommended training scenarios include the following, but should address the operator's specific circumstances (e.g., pilot demographics and operational environment) and common error trends as identified through operator/industry data and safety programs. The recommended scenarios may be incorporated as part of the MBT required by extended envelope training, in a LOFT scenario, or other SBT and integrated with the MFO training recommendations earlier in this AC.

1. Takeoffs and go-arounds at light weight with low altitude level off.
2. Departure procedures (DP) with one or more climb restrictions, where environmental conditions and/or aircraft performance may create a challenge.

3. High altitude, performance-limited situations, to include:
   a. Flight at or near maximum altitude for the weight and conditions.
   b. Temperature changes at high altitude. Specifically, flight from colder to warmer air that may result in a reduction of available thrust.
   c. High density altitude takeoff, climb, approach, and landing.
4. Aircraft-specific deceleration and descent capabilities, to include:
   a. Aircraft-specific energy management capabilities, challenges, and common errors. Examples may include descent range at idle at best glidespeed and in contrast with other configurations, and speeds with varying wind/groundspeed.
   b. Appropriate use of speedbrakes/flaps/gear.
5. Descent restrictions, which may include procedures determined to be complex or challenging, to include:
   a. Off-route ATC vectors and descent restrictions that take the aircraft off the expected and engaged lateral and vertical profiles with subsequent ATC instructions to resume the previous route and profile.
   b. Late ATC instructions.
6. Visual approaches, including:
   a. Scenarios commenced from both "high and fast" and "low and slow" initial conditions, to include:
      - Identifying general conditions where recovery to a stable approach may not be possible and a go-around is necessary.
      - Identifying what combination of drag, thrust, and pitch is appropriate to your aircraft type.
   b. Scenarios where ATC does not vector the aircraft to final.
   c. Scenarios when groundspeed is significantly different from indicated airspeed, but when environmental conditions permit landing.
   d. Approaches where ATC does not assign speed.
   e. Approaches with a runway change.
   f. Landing heavy weight on a short/contaminated or performance-limited runway, including planning for turnoff after landing.
   g. Energy management during maximum performance escape maneuvers (e.g., wind shear, Traffic Alert and Collision Avoidance System (TCAS) or enhanced ground proximity warning system (EGPWS) responses).

6.4 Instructor/Evaluator (I/E) Considerations. In addition to understanding energy management and being able to apply it to FPM, I/E should be trained on specific techniques and maneuvers to effectively demonstrate, train, and evaluate energy management principles.

APPENDIX A. CONSIDERATIONS FOR AUTOFLIGHT MODE AWARENESS PROCEDURES

A.1 When formulating mode awareness SOPs, consider the following:

A.1.1 Mode awareness is critical to controlling the aircraft and callouts are an effective method to make crews aware of the controlling mode if done with an understanding of the mode and its effect on FPM.

A.1.2 Some operational experience has shown that calling out all mode changes works well until workload increases, then the verbal callouts are sometimes shed. Some operators have implemented a combined scheme in which normal mode changes are not verbalized but verbally called out when the change is not anticipated (not previously briefed and expected) or when normal (and expected) but during a critical phase of flight. A missed approach/go-around would be an example when expected mode changes would be verbally called out to ensure proper guidance and control during a critical phase of flight.

A.1.3 Some mode changes may not need to be addressed (verbal or nonverbal) if briefed as part of the normal operation and the transitions occur as expected. Alternatively, there may be operations when verbal callouts are mandated even for expected mode changes to ensure specific actions are completed or risks mitigated.

A.1.4 It is important to brief current mode status to any pilot that is occupying a pilot seat after a physiological break or distraction from flying (communicating with dispatch, flight attendant (F/A), etc.). Following a distraction, verbally discuss flight deck status. For a pilot that is occupying a pilot seat after a break, develop a briefing that is appropriate for the equipment with required items to ensure the pilot is updated on systems status and current/future aircraft state, desired aircraft trajectory, and energy state.

A.2 A well-defined and standard communication methodology may increase mode awareness and enhance FPM. One recommended approach is to create phase of flight procedures/dialog boxes (e.g., takeoff, climb, cruise, descent, approach) that include mode changes and indications for each combination of automation allowed. Include mode change indication in maneuver procedures/dialog boxes. When possible, associate callout names and timing to match mode changes. Dialog boxes are one way to provide guidance and SOPs to flightcrews on individual pilot responsibilities or actions during each flight phase.

A.3 Incorporate a communication/confirmation methodology that works for the equipment and/or within the company culture. For example, some operators have implemented company standard procedures such as “Confirm, Activate, Monitor, Intervene (CAMI)” or “Verbalize, Verify, and Monitor (VVM),” similar systems, or even variations thereof. Such procedures provide the flightcrew with a structured method to conduct operations within the flight deck that help to “trap” errors. Each scheme is considered an element of an effective TEM strategy. For example, the explanatory version of CAMI for an FMS data input is “confirm all FMS inputs with the other pilot when airborne, then activate the input, then monitor mode annunciations and indications to ensure the autoflight/autothrust system performs as desired, but then intervene if the operation did not go as planned."

A.4 Regardless of the form of the strategy, the objective is to ensure that all pilots in the flight deck understand the active mode and the effects of the newly engaged mode, and skillfully react to ensure the aircraft trajectory and energy remains as desired.

A.5 The mode confirmation methodology should be defined in relation to PF/PM roles and areas of vulnerability, specifically when the level of vulnerability may lead to a flightpath deviation. The Flight Safety Foundation (FSF) document describes an "Area of Vulnerability" as an operation which may occur during a phase of flight in which "either the potentially increased likelihood of a flightpath deviation or the increased severity of potential consequences if such a deviation occurs."[25] Additionally, certain situations, such as malfunctions, drive an increase in workload which may increase the flightcrew's susceptibility to monitoring errors.

A.6 Identification of high, medium, and low areas of vulnerability conditions would be defined by the operator using the FSF Practical Guide for Improving Flight Path Monitoring as a guide (see Appendix B, Related 14 CFR Parts, Reading Material, and Definitions, paragraph B.2.3). It is important that an operator's procedures for mode confirmation take into account differences in areas of vulnerability and/or high-workload situations.

[25] FSF's A Practical Guide for Improving Flight Path Monitoring: Final Report of the Active Pilot Monitoring Working Group.

APPENDIX B. RELATED 14 CFR PARTS, READING MATERIAL, AND DEFINITIONS

B.1 Related 14 CFR Parts. Each of the following 14 CFR parts can be found at https://www.ecfr.gov:

- Part 1.
- Part 60.
- Part 61, § 61.64.
- Part 91 subpart K (part 91K), § 91.1073.
- Part 121, §§ 121.401, 121.409, 121.415, 121.419 through 121.427, 121.440, 121.441, and 121.544; and appendices E and F.
- Part 125.
- Part 135, §§ 135.293, 135.297, 135.299, 135.323, 135.329, 135.335, and 135.619.
- Part 142, §§ 142.54 and 142.59.

B.2 Related Reading Material. The current editions of the following documents support the knowledge and skill standards and recommended practices for pilot training and checking.

B.2.1 ACs. The current editions of each of the following ACs can be found at https://www.faa.gov/regulations_policies/advisory_circulars and DRS:

- AC 60-28, FAA English Language Standard for an FAA Certificate Issued Under 14 CFR Parts 61, 63, 65, and 107.
- AC 120-35, Flightcrew Member Line-Operational Simulations: Line-Oriented Flight Training, Special Purpose Operational Training, Line Operational Evaluation.
- AC 120-50, Guidelines for Operational Approval of Windshear Training Programs.
- AC 120-51, Crew Resource Management Training.
- AC 120-53, Guidance for Conducting and Use of Flight Standardization Board Evaluations.
- AC 120-54, Advanced Qualification Program.
- AC 120-55, Air Carrier Operational Approval and Use of TCAS II.
- AC 120-71, Standard Operating Procedures and Pilot Monitoring Duties for Flight Deck Crewmembers.
- AC 120-74, Parts 91, 121, 125, and 135 Flightcrew Procedures During Taxi Operations.
- AC 120-88, Preventing Injuries Caused by Turbulence.
- AC 120-109, Stall Prevention and Recovery Training.

- AC 120-111, Upset Prevention and Recovery Training.
- AC 120-114, Pilot Training and Checking (14 CFR Part 121 Subparts N and O, Including Appendices E and F).
- AC 120-118, Criteria for Approval/Authorization of All Weather Operations (AWO) for Takeoff, Landing, and Rollout.
- AC 121-39, Air Carrier Pilot Remedial Training and Tracking Program.
- AC 121-42, Leadership and Command Training for Pilots in Command.

B.2.2 Other FAA Documents:

- Airplane Airman Certification Standards (ACS).
- Pilot Guide to Takeoff Safety: https://www.faa.gov/other_visit/aviation_industry/airline_operators/training/media/takeoff_safety.pdf.
- Wake Turbulence Training Aid: https://www.faa.gov/training_testing/training/wake/media/02frmatr.pdf.
- Airplane Upset Recovery Training Aid, Revision 2: https://www.faa.gov/other_visit/aviation_industry/airline_operators/training/media/AP_UpsetRecovery_Book.pdf.
- Operational Use of Flight Path Management Systems: Final Report of the Performance-based operations Aviation Rulemaking Committee/Commercial Aviation Safety Team Flight Deck Automation Working Group: https://www.faa.gov/aircraft/air_cert/design_approvals/human_factors/media/OUFPMS_Report.pdf.
- FAA-H-8083-23, Seaplane, Skiplane, and Float/Ski Equipped Helicopter Operations Handbook.
- The Flight Standardization Board Report (FSBR) for the specific airplane.

B.2.3 Flight Safety Foundation (FSF) Documents. These documents are available at https://flightsafety.org/:

- Approach and Landing Accident Reduction (ALAR) Tool Kit.
- A Practical Guide for Improving Flight Path Monitoring: Final Report of the Active Pilot Monitoring Working Group: https://flightsafety.org/wp-content/uploads/2016/09/EPMG.pdf.

B.2.4 International Civil Aviation Organization (ICAO) Doc 10011, Manual on Aeroplane Upset Prevention and Recovery Training.

B.2.5 International Air Transport Association (IATA) Documents. These documents are available at https://www.iata.org/:

- Guidance Material and Best Practices for the Implementation of Upset Prevention and Recovery Training (2nd Edition).
- Guidance Material for Improving Flight Crew Monitoring (1st Edition).
- Aircraft Handling and Manual Flying Skills Report: https://www.iata.org/contentassets/d0e499e4b2824d4d867a8e07800b14bd/iata-report-aircraft-handling-manual-flying-skills.pdf.
- FMS Data Entry Error Prevention Best Practices (1st Edition).

B.2.6 National Aeronautics and Space Administration (NASA) Technical Memorandum (TM)-20210000047, Analysis of Pilot Monitoring Skills and a Review of Training Effectiveness.

B.3 Definitions. For the purpose of this AC, the following definitions and terms are provided:

B.3.1 Energy Management. The planning and control of airspeed (or groundspeed), altitude, thrust, aerodynamic drag (speedbrakes, slats/flaps, gear), and trajectory to achieve desired lateral and vertical flightpath targets appropriate for the operational objectives.

B.3.2 Flightpath Management (FPM). The planning, execution, and assurance of the guidance and control of aircraft trajectory and energy, in flight or on the ground.

B.3.3 Flight Management System (FMS). An FMS is an onboard computer system which integrates inputs from various subsystems to aid the pilot in controlling the airplane's lateral and vertical paths. In addition to navigation, the FMS may accomplish performance functions, such as thrust management and fuel flow monitoring.

B.3.4 Information Automation (IA). Automation of information-related tasks such as acquisition, calculation, management, integration, and display of information to the flightcrew. IA may act on, process, and manage the content and format of presented information.

B.3.5 Manual Flight Operations (MFO). Those operations where the pilot is performing FPM while physically controlling pitch, roll, yaw, and/or thrust.

B.3.6 Pilot Flying (PF). The pilot that controls the path of the aircraft at any given time, in flight or on the ground.

B.3.7 Pilot Monitoring (PM). The pilot that monitors the aircraft state and system status, calls out any perceived or potential deviations from the intended flightpath, and intervenes if necessary.

B.3.8 Procedure. A logical progression of actions, decisions, or both in a sequence that is prescribed to achieve a specified objective.

B.3.9 Standard Operating Procedure (SOP). Written and tested procedures that are applied uniformly and consistently within an operation and involve all aspects of flight operations (i.e., normal, abnormal, non-normal, and emergency).

Advisory Circular Feedback Form

If you find an error in this AC, have recommendations for improving it, or have suggestions for new items/subjects to be added, you may let us know by contacting the OPR NAME or the Flight Standards Directives Management Officer at 9-AWA-AFB-120-Directives@faa.gov.

Subject: AC 120-123, Flightpath Management

Date: ______________________

Please check all appropriate line items:

☐ An error (procedural or typographical) has been noted in paragraph ____________ on page _______.

☐ Recommend paragraph _____________ on page __________ be changed as follows:

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☐ In a future change to this AC, please cover the following subject:
(Briefly describe what you want added.)

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