U.S. Department of Transportation
Federal Aviation Administration

Advisory Circular

Subject: Standard Operating Procedures and Pilot Monitoring Duties for Flight Deck Crewmembers

Date: 1/10/17
Initiated by: AFS-200

AC No: 120-71B
Change:

This advisory circular (AC) provides guidance for the design, development, implementation, evaluation, and updating of standard operating procedures (SOP), and for pilot monitoring (PM) duties. SOPs are universally recognized as fundamental to safe aviation operations. Their importance cannot be overstated, especially in light of the advent of PM standards with respect to the use of increasingly modernized automated systems. This AC provides a process for developing procedures that meet clear and specific requirements. Safe operations are founded on comprehensive SOPs made readily available within the manuals used by flight deck crewmembers. This AC also provides guidance on the definition and the training of PM duties and their integration into SOPs. Although this AC is directed towards Title 14 of the Code of Federal Regulations (14 CFR) part 121 and part 135 air carriers, the Federal Aviation Administration (FAA) encourages all air carriers, aircraft operators, pilot schools, and training centers to utilize this guidance.

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CHAPTER 1. BACKGROUND INFORMATION

1.1 General. Standard operating procedures (SOP) are universally recognized as fundamental to safe aviation operations, yet accidents and incidents continue to occur as a direct result from, or related to, a failure by the flightcrew to follow SOPs, particularly during critical phases of flight.

This advisory circular (AC) provides guidance for the design, development, implementation, evaluation, and updating of SOPs. It emphasizes that SOPs should be clear, comprehensive, and readily available within the manuals used by flight deck crewmembers. Although this AC is directed towards Title 14 of the Code of Federal Regulations (14 CFR) part 121 and part 135 air carriers, the FAA encourages all air carriers, aircraft operators, pilot schools, and training centers to utilize this guidance. The basis for this guidance is contained in the related regulations and FAA guidance sections of this AC. This AC is not mandatory and does not constitute a regulation. This AC describes an acceptable means, but not the only means, to design, develop, update, and use SOPs.

Effective crew coordination and crew performance depend on the crew's having a shared mental model of each task. That mental model, in turn, is founded on SOPs. SOPs should serve to provide a consistent, standardized model of each task that must be performed by each crewmember during each phase of flight and during any reasonably anticipated abnormal, non-normal, or emergency situation. SOPs must be kept current and may be individually developed by the operator or by incorporating those procedures found in their aircraft operating manuals into their daily operations. Once established, the SOPs must be applied with consistency and uniformity throughout the operation.

Implementation of any procedure as an SOP is most effective when:

1. The procedure is appropriate to the situation.
2. The procedure is practical to use.
3. Crewmembers understand the reasons for the procedure.
4. Pilot flying (PF) and pilot monitoring (PM) duties are clearly delineated.
5. Effective training is conducted.
6. Adherence to the standard is emphasized by flightcrews, and reinforced by instructors, check pilots, and managers alike.
7. Crewmembers are aware of the potential risks/hazards if SOPs are not followed.

1.2 Cancellation. This AC cancels AC 120-71A, Standard Operating Procedures for Flight Deck Crewmembers, dated February 27, 2003.

1.3 Summary of Changes. Many changes have been made to improve clarity, accuracy, completeness, and consistency. Significant changes include adding regulatory

requirements contained in part 121 for PM and removing many of the examples previously found in the appendices. The stabilized approach criteria has been removed from this AC and can be found in AC 91-79A, Mitigating the Risks of a Runway Overrun Upon Landing (include Chg 1).

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

1. **Checklist.** A checklist is a tool to reduce the potential for flightcrew error in configuring the aircraft safely for various phases of flight, and for any malfunctions that may have occurred.
2. **Crew Resource Management (CRM).** The effective use of all available resources to achieve safe and efficient flight, to include human resources, hardware, and information.
3. **Electronic Checklist.** A checklist that is displayed to the flightcrew by means of an electronic device.
4. **Flightpath.** The aircraft trajectory and energy state, in flight.
5. **Flightpath Management.** Flight deck planning, execution, and assurance of the guidance and control of the flightpath.
6. **High Workload Environment.** Any environment in which multiple demands on the flightcrew necessitate the prioritizing of work functions. For example, IFR operations below 10,000 feet during arrival or departure from a terminal area (including taxiing) are considered to be high workload environments.
7. **Pilot Flying (PF).** The pilot who is controlling the path of the aircraft at any given time, in flight or on the ground.
8. **Pilot Monitoring (PM).** The PM monitors the aircraft state and system status, calls out any perceived or potential deviations from the intended flightpath, and intervenes if necessary.
9. **Procedure.** A logical progression of actions, decisions, or both in a sequence which is prescribed to achieve a specified objective.
10. **Standard Operating Procedure (SOP).** Written and tested procedures that are applied uniformly and consistently within an operation and involve all aspects of flight operations, normal, abnormal, non-normal, and emergency.

1.5 Related 14 CFR Sections.

- Part 91, §§ 91.1033 and 91.1079.
- Part 121, §§ 121.133, 121.135, 121.141, 121.315, 121.401, 121.403, 121.424, 121.542, and 121.544.
- Part 125, § 125.287.
- Part 135, §§ 135.83, 135.100, 135.293, and 135.327.

1.6 Related Guidance and Information. Related FAA guidance and other reading material may be found in Appendix A.

CHAPTER 2. DETERMINING WHEN PROCEDURES NEED TO BE DESIGNED OR MODIFIED

2.1 Requirements for Procedures. Operators are required to provide flightcrews with operating procedures per the applicable regulations as identified in the related regulations section. Although an Original Equipment Manufacturer (OEM) will typically supply its customers with suggested procedures and checklists for its equipment, operators may choose to develop, or modify, the procedures and checklists provided by the OEM. Some procedures may require a "No Technical Objection" from the OEM to modify them. Also, some procedure modifications may require acceptance or approval from an operator's principal operations inspector (POI). Operators should work with the OEM and FAA to determine if involvement in a SOP modification is necessary.

2.2 Modifying OEM Procedures. Procedures and checklists published by the OEM are designed to reflect that manufacturer's flight deck design and operating procedures. They promote optimum use of aircraft features as envisioned by the designers, but may be generic in their applicability. Potential factors which may drive changes to OEM procedures and checklists include new or modified equipment, changes to the operational environment, company mandated procedures, standardization among related fleets, observed operational problems, incidents, accidents, or airline mergers.

CHAPTER 3. CREATING A PROCEDURE DEVELOPMENT PROCESS

3.1 Characteristics of Good Procedures. A well-designed procedure aids flightcrews by specifying a sequence of actions that, if followed, helps ensure that the primary task will be carried out in a manner that meets the basic guidelines of being clear, correct, reliable, and robust.

In general, as a minimum, good procedures cover the following elements:

- What the procedure is designed to accomplish.
- When and under what conditions the procedure should be executed.
- Who is responsible for executing each step in the procedure.
- How, in sufficient detail, the procedure is to be performed.
- How to confirm the procedure has been accomplished properly.

3.2 Collaborating for Effective SOPs. Collaboration can improve the effectiveness of SOPs. Partners in the collaboration could include representatives of the aircraft manufacturer, pilots having previous experience with the aircraft or with the type of operations planned by the operator, training organizations, and representatives from the FAA. Procedure developers should pay close attention to the approved Airplane Flight Manual (AFM) or Rotorcraft Flight Manual (RFM), to AFM/RFM revisions and operations bulletins issued by the manufacturer, and to the applicable FAA Flight Standardization Board (FSB) report. It is especially important for a new operator to establish a periodic review process that includes line flightcrews. Together, managers and flightcrews are able to review the effectiveness of SOPs and to reach valid conclusions for revisions. A trial period might be implemented, followed by feedback and revision, in which SOPs are improved. The review process will be meaningful and effective when managers promote prompt implementation of revisions to SOPs when necessary.

3.3 Resources to Develop SOPs. The procedure development process should start with a careful analysis of the factors driving the need to develop or modify a procedure and the implications of these factors.

Procedure developers should research all available sources of information that pertain to the process or procedure being developed or revised. This may include reviewing data from an Aviation Safety Action Program (ASAP) or a flight operations quality assurance (FOQA) program. Procedure developers should also understand the entire system of procedures and how they fit within the framework of existing policies, guidance, and the operator’s overall operational philosophy. Any new process or procedure should be consistent with that framework.

Employee groups who will be affected by the procedures in question may also add value in the development process. Procedures which interface with other employee groups should be coordinated accordingly.

CHAPTER 4. WRITING PROCEDURES

4.1 General Guidelines. Procedures should be communicated and trained effectively after they are developed.

4.1.1 Information to Include. Include only the information needed to validate it is the correct procedure to use and information to properly execute the procedure. While it is important to document and communicate the rationale behind the procedure design, this information should be provided in a separate training manual or other document.

4.1.2 Avoid Visual Clutter. Include supplemental detail only when necessary. When the addition of supplemental information is necessary, separate the supplemental information from the presentation of the actual steps to be accomplished.

4.1.3 Use Plain Language. Use simple English; the use of uncomplicated wording will increase comprehension while reducing ambiguity.

4.1.4 Use Short Sentences. Break long sentences into short sentences with a simple sentence structure.

4.1.5 Use Active Verbs. Sentences with active verbs (e.g., "Do X") are easier to read and less likely to be misunderstood than sentences using passive verb forms (e.g., "X should be done").

4.1.6 Write Steps as Imperatives. Imperative commands are direct; they tell someone what to do, and are often used when giving instructions. Avoid negatives when possible. Negative statements are difficult to read and if it is missed, the meaning of the sentence will be misunderstood. When negatives are required, clearly specify what is being negated.

4.2 Organization.

4.2.1 General Organization. Procedures should be organized as simply as possible by order of tasking. Normal procedures are typically organized in sequence by phase of flight. When applicable, abnormal, non-normal, and emergency procedures should be organized by the triggering condition (e.g., smoke in the flight deck) rather than the potentially related system (e.g., electrical system).

4.2.2 Navigation and Place Keeping. Steps should follow a simple numbering system to assist pilots in maintaining their place in the procedure. Excessively detailed hierarchies should be avoided. Use headers when necessary to distinguish major sections of multifaceted procedures. Headers should provide useful cues to the purpose of the section of the procedure they address.

4.2.3 Lists. One step in a procedure may require that the pilot perform several actions or check several different indications. These components should be presented on separate lines in an indented numbered or bulleted list rather than in the body of the text.

4.2.4 References. References to other procedures or appendices should be avoided unless necessary for completion of the procedure.

4.2.5 Memory Items. Memory items should be avoided whenever possible. If the procedure must include memory items, they should be clearly identified, emphasized in training, less than three items, and should not contain conditional decision steps.

4.2.6 Indices. An index should be provided for every procedure manual. In designing the index, ensure that the format accurately reflects the operator's philosophies and training. If a procedure is identified in more than one way (e.g., if there are multiple indications), include all likely parameters in the index.

4.3 Vocabulary.

4.3.1 Use Words Consistently. Word use should be simple and consistent throughout the SOPs. If possible, avoid creating new terms. Use words in their common English sense unless they have a widely accepted aviation-specific meaning. Match flight deck nomenclature.

4.3.2 Avoid Using Words with Multiple Common Meanings. Avoid using words with multiple meanings (e.g., use "correct" rather than "right"). Avoid using the same words as both nouns and verbs (e.g., display, position); if a word is to be used that could be a noun or a verb, choose one usage and apply it consistently (e.g., move the switch into the ON position vs. position the switch to ON).

4.3.3 Use Abbreviations Carefully. Only use abbreviations that are defined and commonly used in the industry (e.g., Vertical Navigation (VNAV), reference landing speed (V_{REF}), air traffic control (ATC)), and avoid creating new abbreviations whenever possible. Abbreviations should also only be used that are defined in the operating environment.

4.4 Numbers.

4.4.1 Use Arabic Numbers. Arabic numbers (e.g., 0, 1, 2) are easier to read than numbers that are spelled out (e.g., one, two). However, use spelled-out numbers for references when two or more different values must be presented in close proximity to other numbers (e.g., use "one 10 kg weight," rather than "1 10 kg weight").

4.4.2 Include Units of Measurement. Do not specify numbers in greater precision than is necessary, or than can be read from instruments.

4.5 Format. In determining how to format procedures, the purpose, mode, and conditions under which the displayed procedures will be used must be considered. The presentation of procedures that are meant to be used on the ground at leisure in printed form may use a different format from procedures that will be read from a tablet computer in flight during turbulence or at night under time pressure. The presentation should be evaluated under conditions approximating those under which the procedure display might be needed.

4.5.1 Type Size. Use a type size that is large enough to be readable under all conditions likely to be encountered. In general, a 14- to 20-point laser printed sans serif font is adequate

for flight deck conditions. However, this should be tested under all potential operational conditions.

4.5.2 Line Spacing. Place sufficient space between lines of text. Using 25 to 33 percent of the font size between lines (e.g., 3 to 5 points space between lines using 14 point font) will make the text easier to read than if there was less space between the lines.

4.5.3 Font. Unusual or ornate fonts should be avoided.

4.5.4 Case. Use standard capitalization rules. Text in all capital letters is harder to read than text in lowercase. Use all capitals very sparingly and only for meaningful emphasis, or to represent labels that are commonly encountered in capitals (e.g., VNAV).

4.5.5 Grouping. Use visual techniques (e.g., white space created by extra lines, indentation) to delineate grouping of steps, lists, and the components of logic statements.

4.5.6 Justification. Paragraphs of text should be left aligned. Do not use right and left justified to produce aligned right and left edges, because it adds spaces between letters and/or words that make the paragraph harder to read.

4.5.7 Line Length. Traditionally, checklists have been formatted to resemble an index or table of contents with corresponding components (e.g., Challenge…Response) left and right justified and joined with dots or lines. This format is acceptable; however, excessively large gaps between the components should be avoided. The wider the gap, the greater the chance the pilot will inadvertently skip to the next line due to perceptual misalignment.

4.6 Place Keeping.

4.6.1 Title. Clearly identify the procedure by title (e.g., “Before Start”) and the objective of the procedure when it is not obvious from the title.

4.6.2 New Lines. Begin each step in a procedure, each element in a logic statement, and each item in a multiple item list on a separate line.

4.6.3 Bullets and Numbering. Use numbers, bullets, and lines, as appropriate, to indicate the beginning of each step. Using numbered lines can reduce navigation and place-keeping errors in the event that an interruption occurs. Numbered steps also facilitate navigation between procedures when it is necessary to “GO TO” a step within a procedure.

4.6.4 Continuation. Clearly specify if a procedure continues onto another page (e.g., “Continues on Next Page”).

4.6.5 End. Clearly mark the end of a procedure with a standard symbol or wording (e.g., “Checklist Complete”).

4.7 Emphasis. Emphasize cautions and warnings (e.g., CAUTION, WARNING), conditional words (e.g., IF, THEN), and important notes (e.g., NOTE). Timed events or steps that must be monitored for a period of time should be emphasized. Irreversible items should

be emphasized before the action is specified or taken. Techniques for calling attention to certain words or phrases should be used sparingly but consistently. Overuse of emphasis reduces its effectiveness and makes the procedure hard to read. Techniques for emphasis include:

4.7.1 Typographical. Typographical emphasis techniques include bolding, italicizing, underlining, and capitalization.

4.7.2 Graphical. Graphical emphasis techniques include framing, shading, coloring, and the use of standard symbols.

4.7.3 Spatial. Spatial techniques for conveying emphasis include using white space to group text and reserving places on the page or screen for selected types of messages.

4.7.4 Verbal. Verbal emphasis may be conveyed by using reserved words (e.g., Important, Note, Caution, and Warning).

4.8 Conditional Steps. In many procedures, some steps should be executed only when specified conditions occur. These conditional statements are a frequent source of confusion, particularly for novices, or with rarely used procedures. This problem can be alleviated by keeping the statements well structured, clearly phrased, and as short as possible.

Conditional statements should present all of the conditions clearly so that the correct choice is easy to identify. The steps that are associated with each condition should be grouped clearly. The end of this block of steps should be clearly identified and the action or procedure to be performed after completion of the block should be clearly specified. If there are embedded choices, then these subsidiary conditions also should be clearly delineated and the associated steps grouped in an unambiguous fashion.

Conditions should always precede actions. Actions that are irreversible should be identified in the condition preceding the action. Conditional statements may begin with one of the following words:

1. IF – use to indicate a condition that may or may not happen.
2. WHEN – use to indicate a condition that must be met before an action is taken and that condition is very likely to occur (e.g., “WHEN pressure reaches 120 psi THEN put gear down.”).
3. THEN – use to identify actions that should be taken when the specified condition occurs.
4. AND – use to combine two conditions that *must* be met before the action is taken.
5. OR – use to indicate that one or more of several conditions must be met before the action is taken.

If alternative formats are used, ensure they are used consistently and the intention is clear. For example:

IF light x is lit
THEN open valve y
IF light x is NOT lit
THEN open valve z

Which also may be expressed as:

CHOOSE one:
Light x is illuminated
- Open valve y

Light x is extinguished
- Open valve z

4.8.1 Complex Conditional Statements. Avoid using combinations of AND and OR whenever possible. In general, use separate steps instead.

4.8.2 Waiting, Continuous Actions, Repeated Actions. In some cases, an action must be continued or repeated until some condition occurs. In these cases, specify (1) what actions are to be repeated, (2) the conditions under which those actions should be stopped, and (3) whether the remaining steps in the procedure can be continued in the meantime. For example: "Hold button depressed UNTIL pressure reaches 120 psi, THEN GO TO step 5 in this procedure."

4.9 Cross-References. Cross-references to other procedures should be avoided whenever possible. In most cases, a "Go-in, Stay-in" strategy should be used whereby all necessary steps for completing a procedure are included in that procedure. In some cases, this may prove impractical.

4.9.1 Explicit Reference. When used, cross-references should be explicit and use consistent wording.

4.9.2 Version Control. When references to other procedures are required, a system should be in place to monitor version control. Changes made to either the referring or referred procedures could affect the execution of the included steps.

4.10 Warnings and Cautions. Warnings and cautions in procedures should be used sparingly. Overuse of warnings will decrease their effectiveness. Often "warning" is used to convey a more urgent or critical matter than "caution." AC 25.1322-1, Flightcrew Alerting, contains definitions for these terms.

4.10.1 Components of Warnings and Cautions. Each warning or caution should identify a single hazard, the consequences of the hazard, and any critical time constraints. Actions should not appear in warnings or cautions.

4.10.2 Placement. Warnings and cautions should be placed on the same page, and prior to, the steps to which they apply. Procedural steps should be graphically separated from warnings and cautions.

CHAPTER 5. DEVELOPING CHECKLISTS

5.1 General. Checklists are a special type of procedure. They are often the form into which extended procedures are distilled, and often the most common and most frequent form through which people interact with formal procedures. On the flight deck, checklists are an important tool in making sure that operational tasks are performed in a standardized fashion.

Checklists are of no value if the flightcrew is not committed to their use. Without discipline and dedication to using the checklist at the appropriate times, errors will inevitably occur.

Although it may be published in a manual, a checklist is designed for independent use so that the user will seldom need to reference that manual, especially after having been previously trained on the content therein. Checklists are used to ensure that a particular series of specified actions are accomplished in the correct sequence and to verify that the correct aircraft configuration has been established in specified phases of flight.

Checklists have been a significant part of the foundation of pilot standardization and flight deck safety for years. Such procedures, when applied in a disciplined and standardized fashion, are intended to support human performance regardless of circumstance. The checklist is an aid to the memory and helps to ensure that critical items necessary for the safe operation of aircraft are not overlooked or forgotten.

Checklists must be easy to access, easy to read, and easy to use. Checklists should provide enough information to enable the flightcrew to verify it is the correct checklist before they begin using it. Instructions should be concise, but sufficient information must be provided so that actions are performed correctly and essential issues are considered. The checklist must accommodate the demands of high-workload phases of flight and the performance limitations experienced by humans when under stress. It should respond to the specifics of the situation but also assist crews in their management of the overall task.

5.1.1 Consistency. Operators should standardize checklist items and the sequence of those items to the maximum extent practicable, given possible make, model, and series (M/M/S) and variant differences across the fleet.

5.1.2 Type of List and Manner of Execution. For most normal procedures on the flight deck, a "flow" is conducted as a sequence of actions done from memory to configure the aircraft and its systems. The flow is followed by a checklist containing a subset of items from the flow that may be the most critical items within that flow and items that confirm the flow was done correctly.

5.1.3 Timing. Given the criticality of the checklist procedure, the crew's ability to pay full attention to its execution is crucial. The timing of the checklist must be such that it would minimize the distractions and concurrent tasks. Timing of checklists should be designed not to interfere with other tasks and be resistant to interruption. For example, a "Taxi Checklist" that is to be accomplished during taxi might appear as an efficient use of crew

time, but it creates a high-risk situation because the crew cannot pay full attention to both the taxi and the checklist.

5.1.4 Roles. The role of providing the right cue at the right time for initiating the checklist is always assigned to one of the two pilots; usually, the pilot in command (PIC) on the ground and the PF in the air. Typically, the cue comes in the form of a verbal call (e.g., "before start checklist"), and serves to prompt the other pilot to retrieve the checklist. Assuming a checklist for normal operation involves both crewmembers in a challenge-response method, both pilots would then be expected to direct their attention to the checklist task. The pilot responsible for leading the checklist begins by calling out (or "challenging") the first item on the list. The other pilot verifies that the item has been done correctly and provides the relevant response. There are several variations on the theme of the challenge-response method: Following the response of the responding pilot, the challenging pilot may go on to challenge the next item, may also verify the state of the item, and may or may not provide a verbal response. The verification may or may not involve specific gestures such as pointing to the relevant switch, lever, or indication.

5.1.5 Initiation Anchor. The initiation of a checklist is best anchored in a clear cue that cannot be easily removed, obstructed, or forgotten, such as the occurrence of a particular event (e.g., arrival at a point 2,000 feet prior to the hold-short line cues the initiation of the Before Takeoff checklist). Often, initiation of a checklist is left open, only constrained by a time window (e.g., Taxi checklist to be completed anytime during taxi) and acceptable circumstances (e.g., when both pilots are free of other duties). Cues for initiating checklists in these situations are often more of a personal technique among pilots, who use internal as well as external flight deck cues to aid them in remembering to initiate the checklist at the correct time. However, such "floating" checklist initiations create a high risk of failing to initiate the checklist on time and thus having to rush through it, or failing to initiate the checklist altogether. The importance of having clear and reliable external cues to trigger the initiation of the checklist procedure at the right pause point cannot be overemphasized.

5.1.6 Completion Signal. The checklist completion signal indicates that the checklist has indeed been performed in its entirety and leads into the next segment of activities. The most common completion cue is a verbal annunciation such as the "Before Taxi checklist complete" by the pilot who has been responsible for leading the respective checklist. The completion call should be written out as the last line item, or centered under each checklist. When the completion call is not explicitly listed on the checklist, a layer of redundancy is removed and the risk of omissions increases.

5.1.7 Checklist Verification. During the design of the checklist it is important to keep in mind that all checklist designs are subject to human error. Crewmembers may omit and skip checklist items or erroneously respond to a checklist at times believing that an item or a task was accomplished when it was not. At other times, crewmembers may see what they expect to see rather than what is actually accomplished or indicated.

One strategy that helps to overcome human error is to develop policies for using checklists which require stringent cross-checking and verification and reinforce those

policies through crew training programs. The procedures intended for checklist use should be clearly written in the operator's operating manual and must be compatible with the operator's CRM philosophy.

The policy should include, but not be limited to, the following items:

1. Flightcrew responsibilities for maintaining aircraft control, analyzing situations, and requesting the appropriate checklist in normal, abnormal, non-normal, and emergency situations.
2. The specified crewmember responsible for initiating each checklist.
3. The specified time when each checklist is to be initiated.
4. The specified crewmember responsible for accomplishing each item on the checklist.
5. The specified crewmember responsible for ensuring that each checklist is completed and reporting that completion to the crew.
6. Crewmember responsibilities for bringing to the attention of the PIC and the rest of the crew any observed deviation from prescribed procedures.

5.2 Methods for Managing Checklist Accomplishment.

5.2.1 Single-Pilot Aircraft. For single-pilot aircraft, operators should mount the Before-Takeoff and the Before-Landing checklists on the instrument panel. When aircraft characteristics allow, the operator should develop touch-verification procedures which include a requirement that the pilot touch each control to verify it is in the correct position.

5.2.2 Multi-Pilot Aircraft.

5.2.2.1 Flight-Related Checklists. Flight-related checklists should be accomplished by one crewmember reading the checklist and the second crewmember confirming and responding to each item, as appropriate. Exceptions to this may be the After-Takeoff and After-Landing checklists. While airborne the PF should not be distracted from controlling the aircraft flightpath to perform a checklist item that another crewmember can accomplish. Only one pilot should be in a head-down posture at any time the aircraft is in motion.

5.2.2.2 Verification. Crewmembers should be directed that when they observe that another crewmember is not taking or has not taken a required action, they are required to inform the crewmember.

5.2.2.3 Checklist Completion Tracking. The crewmember responsible for initiating the checklist should be responsible for ensuring that the checklist is completed systematically and expeditiously. This crewmember should be responsible for managing interruptions, cross-checking controls and indicators to ensure that the required actions have been accomplished, and reporting that the checklist has been completed.

5.2.2.4 Callouts. A callout should be made by the pilot if he or she is accomplishing a task that requires him or her to be "heads down." This helps ensure the other pilot is not heads down at the same time.

5.2.2.5 Critical Items. Critical items should be verified by both the PF and PM.

1. In the before-start phase, flight guidance and navigation items are considered critical items. Concurrence should be required from both pilots when the same setting is required for more than one device (such as computers, flight instruments, and altimeters). Inertial platform alignment and computer programming should be accomplished by one crewmember and independently confirmed by another. As many of these checklist items as possible should be accomplished and verified before the aircraft is moved.
2. In the taxi and pre-takeoff phases, aircraft configuration (such as flaps, trim, and speed brakes) and flight guidance items (such as heading, flight-director, altitude select panel settings, and airspeed cues) are also critical items. Consideration must be given to non-standard operations such as deicing which may result in configuration changes from what was previously set.
3. On approach, flight guidance checklist items are critical. The PF and PM should be required to confirm and respond to these items when incorporated in a checklist. Concurrence should be required when the same setting is required on two separate devices (such as computers, flight instruments, or altimeters).
4. Checklist items that are critical in the before-landing phase vary with the type aircraft involved. The landing gear and flaps are critical items and should require a confirmation and response by both pilots when incorporated in a checklist.
5. A checklist should not be depended upon to initiate a change in aircraft configuration. Operators should key aircraft configuration changes to specific operational events (e.g., direct the landing gear to be extended at glide slope intercept). For any change in configuration, a command from the PF and an acknowledgment from the crewmember taking the action should be required.

5.2.3 Interruptions. Crewmembers frequently cannot complete a checklist because of interruption or an item on the checklist has not yet been accomplished. Operating procedures must be established to ensure that the correct checklist sequence is completed after an interruption. If the sequence cannot be re-established or the crew is unclear on where to resume the checklist, the appropriate section of the checklist should be reaccomplished from the beginning.

5.2.4 Representative Items. Representative items are selected items that represent a whole subset of flow actions such that if the selected item was performed, the whole subset must have also been performed. For instance, if all engine indications are in the green, the whole engine start sequence must have been done correctly; therefore, checking the engine indications can serve as a representative item for the engine start sequence.

5.3 Item Order. The order of the items on the checklist can mirror the sequence of the flow or of the operation if the flow preceding the checklist is carefully designed to:

- Take advantage of the physical layout and location of switches, displays, and indicators in the flight deck (e.g., going from left to right, or from top to bottom);
- Account for the inherent dependencies between the systems involved;
- Support human memory; and
- Be short.

Such order aids in learning and increases ease of use. Another possible ordering consideration is item priority. The probability of interruptions and distractions increases with checklist length and the time it takes to execute it. Thus, even though checklists mainly contain critical items, these could be prioritized, and those with higher importance could be placed first on the checklist.

5.4 Phraseology. The challenge portion of a checklist item is best phrased to mirror the label used in the flight deck for the corresponding switch, lever, indicator, or system. The response portion is best phrased in terms of the actual system status, switch or lever position, or the specific parameter value. For example, the autobrake system may be set to RTO, OFF, ARM, DISARM, 1, 2, 3, etc. The challenge for this system may be "Autobrake," and the response may be "RTO". The PF and PM should only use the phrases listed in the SOP or checklist to help reduce any ambiguity or confusion.

The generic responses of "set" or "checked" may not be very informative and does not provide as good of an opportunity to confirm correct action as the actual indication.

5.5 Common Errors That Occur When Using Checklists. Checklist errors can occur in the following areas:

- Crew overlooked item(s) on the checklist.
- Crew failed to verify settings visually.
- Operator or aircraft manufacturer checklist contained error(s) or was incomplete.
- Failing to complete a step after an interruption.
- Failing to complete a checklist.
- Completing the wrong checklist
- Difficulty in finding a checklist.
- Becoming disoriented within the checklist.
- Difficulty in confirming that the checklist action was carried out correctly.
- Problems in understanding and interpreting the checklist.
- Difficulty in determining who should be carrying out the checklist actions (PF vs. PM).

5.6 Preventing Checklist Errors. All checklists are subject to interruption at any point in the flight by ATC or for other operational reasons. However, operational data indicates that flightcrews are most susceptible to interruption and distraction during the ground phases before flight (i.e., "BEFORE START," "PUSHBACK," "START," "TAXI," and "BEFORE TAKEOFF") due to time pressure and interruptions from support personnel (e.g., ramp crew, deice crew).

5.6.1 Training Support Personnel. Many of the distractions or interruptions occurring on the ramp area can be reduced to a minimum by the aircraft operators through training of support personnel. Operators should ensure that ground support personnel who communicate directly with flightcrews are familiar with the procedures used on the flight deck and the need to avoid interrupting the crew during a checklist flow. Persons entering the flight deck to talk to the crew, or contacting the crew via interphone, should make their presence known and unless an emergency exists, refrain from interrupting any flight deck activity or talking to the crew until the crew indicates that they have completed their task and acknowledges their presence.

5.6.2 Restarting From the Beginning. It is recommended that anytime the crew is not clear as to their progress through the checklist the PIC should, without hesitation, direct that the appropriate section of the checklist be reaccomplished from the beginning.

5.6.3 Cognitive Limitations. Cognitive limitations experienced by humans when dealing with stress, concurrent task demands, and time pressure underlie many of the errors made by crews when responding to emergencies. Including more information in checklists can reduce memory load and other cognitive demands. However, the more information included in a checklist, the longer it becomes and the more time needed to complete it. Checklist designers should include items within checklists that remind crews of information they may not easily recall and other cues they should attend to as they respond to a particular situation.

5.6.4 Checklist Error Prevention Tips.

1. Remember to use the checklist.
2. Check every item, every time.
3. Slow down and confirm significant items.
4. Deliberately read the checklist.
5. If interrupted, restart from the beginning.

CHAPTER 6. PILOT MONITORING

6.1 General. 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. Flightcrews must use monitoring to help them identify, prevent, and mitigate events that may impact safety margins. Therefore, it is imperative that operators establish operational policy and procedures on PM duties, including monitoring, and implement effective training for flightcrews and instructors on the task of monitoring to help the PM expeditiously identify, prevent, and mitigate events that may impact safety margins.

This section describes effective monitoring, how to define and train PM duties, and integration of monitoring into SOPs. Additionally, the section discusses special considerations for monitoring autoflight operations.

6.2 Effective Monitoring. A pilot is effectively monitoring if he or she is:

1. Following SOPs consistently;
2. Clearly communicating deviations to other crewmembers;
3. Effectively managing distractions;
4. Remaining vigilant;
5. Advising the PF if the flight guidance modes or aircraft actions do not agree with expected or desired actions and intervening if necessary;
6. Continuously comparing known pitch/power settings to current flightpath performance; and
7. Considering that the primary flight displays (PFD), navigation displays (ND), and other sources of information (for example, electronic flight bag (EFB)), might be displaying incorrect information and always on the lookout for other evidence that confirms or disconfirms the information the displays are providing.

6.3 Challenges and Barriers to Effective Monitoring. There are several potential challenges and barriers to effective monitoring:

6.3.1 Time Pressure. Time pressure can exacerbate high workload and increase errors. It can also lead to rushing and “looking without seeing.”

6.3.2 Lack of Feedback to Pilots When Monitoring Lapses Occur. Pilots are often unaware that monitoring performance has degraded.

6.3.3 Design of SOPs. SOPs may fail to explicitly address monitoring tasks.

6.3.4 Pilots' Inadequate Mental Model of Autoflight System Modes. Pilots may not have a complete or accurate understanding of all functions and behaviors of the autoflight system. Some aspects of automated systems for flightpath management are not well matched to human information processing characteristics.

6.3.5 Training. Training may overlook the importance of monitoring and how to do it effectively. Lack of emphasis on monitoring may occur in training and evaluation.

6.3.6 Pilot Performance. High workload, distraction, and inattention can all lead to monitoring errors.

In addition, human performance limitations should be acknowledged as potential challenges for effective monitoring. The human brain has difficulty with sustained vigilance and has quite limited ability to multitask. Pilots are vulnerable to interruptions and distractions and to cognitive limitations that affect what they notice and do not notice.

It can be difficult for humans to monitor for errors and deviations on a continuous basis when errors and deviations rarely occur. This is true for the range of workload conditions experienced by the flightcrew members. Monitoring during high-workload periods is important since these periods present situations in rapid flux and because high workload increases vulnerability to error. However, studies show that poor monitoring performance can be present during low-workload periods as well. Lapses in monitoring performance during lower-workload periods are often associated with boredom, complacency, or both.

6.4 Defining Pilot Monitoring Duties. In a two-pilot operation, one pilot is designated as PF and one pilot is designated as PM. A review of operators' manuals indicates that the roles and associated tasks of the PF and PM are not always clearly defined. Each operator should explicitly define the roles 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 PM is 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.

6. The PM monitors the aircraft state and system status, calls out any perceived or potential deviations from the intended flightpath, and intervenes if necessary.
7. The PF provides a briefing to a pilot returning from a break. The briefing should include appropriate information to ensure the pilot returning from the break is updated on aircraft and systems states and current ATC instructions and assignments.

6.5 Operational Policies and Procedures. Operational policies and procedures should be reviewed or developed to ensure the division of duties and responsibilities between flightcrew members protects the ability of the PF to control the flightpath. Assigning non-flightpath-related tasks to the PF should generally be avoided. Operational data should be collected and used to revise definitions of PF and PM roles and responsibilities to ensure their effectiveness. Operators are encouraged to take an integrated approach in operations and training (e.g., initial and recurrent) to emphasize the responsibilities and importance of PF and PM roles.

A critical aspect of monitoring duties includes intervention when a deviation is identified. Each operator's policies, procedures, and training should adequately cover flightpath intervention including human-to-human intervention.

6.6 Intervention Strategies.

6.6.1 What Intervention Strategies Should Include. Intervention assumes an actual, or potential, problem has been detected. Effective PM can help detect a problem, which is necessary before intervention can begin. This is an important point since the pilot cannot intervene unless a condition requiring intervention is correctly recognized. If the monitoring activity is successful (problematic condition is recognized) then the pilot must know what intervention is appropriate for that situation.

Policies and procedures for expected interventions should be established and include:

1. Deviation parameters;
2. Required callouts; and
3. Conditions for takeover.

6.6.2 Human-to-Human Intervention. If a flightpath problem occurs, the PM should notify the PF about the problem and expect that the PF will then correct the problem. One way for the PM to accomplish notifying the PF is to verbalize a deviation callout followed by an expected response from the PF to that callout with corrective action.

6.6.2.1 SOPs should indicate what to say, how to say it, when to say it, and with what level of appropriate assertiveness. SOPs should also address if or when the PM should take over the PF role if it is determined that the PF is not correcting the flightpath problem in a timely manner. Considerations for the decision to take over control should include subtle incapacitation or no

response or flightpath correction after two challenges. The SOP should also specify what the specific callouts and associated actions are required with a takeover to ensure a positive exchange of aircraft control occurs. Policies must be clear to ensure there is no confusion over who is PF at any time.

6.6.2.2 Similarly, SOPs should describe how the PF notifies the PM about a flight guidance issue. For example, in some operations, if the AP is off with the flight director (FD) on, the PF hand-flies the aircraft, but the PM makes all flight guidance inputs. In this situation, consider the case where the PM makes an erroneous flight guidance input, and the PF notices it. In this case, Human-to-Human intervention would involve the PF verbalizing to the PM the error and desired correction. (e.g., "approach mode still isn't armed – arm approach, please."). To capture all of this, the recommendation wording may be something like: "PM communicating effectively to the PF about the flightpath problem, expecting that the PF will then correct the problem, or the PF communicating to the PM about a flight guidance problem (if the PM is responsible for flight guidance inputs), expecting that the PM will correct that problem."

6.6.2.3 Another example is where a PM calls "1-dot high" and the PF responds with "correcting" and returns to glidepath in a timely manner. If, for example, the PF does not respond to two successive challenges, then, per operator's SOP, if safety indicates, the PM calls "I have control, going around" and initiates a go around as PF.

Note: Flightpath control is the responsibility of the PF, whereas flightpath guidance may be the responsibility of either pilot, depending on the operator's SOPs.

6.7 Training for PM. An operator should train its pilots on all policies and procedures related to monitoring the flightpath (e.g., callouts, double-pointing, etc.). This training should also include any of the operator's recommended practices.

1. Pilots should be trained on the responsibilities of the PM to monitor the flightpath. In particular, 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.
2. Pilots should be trained on applicable common errors in monitoring the flightpath. This includes training on appropriate methods of recognizing precursors to, and signs of, degraded monitoring and on resolving monitoring errors and/or lapses.
3. Pilots should be trained on the concept 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. If the PM is

trained to recognize the flight phases or situations when they are most vulnerable to flightpath deviations (including when little time exists to correct deviations), he or she could strategically plan tasks and workload to maximize monitoring during those phases.

4. Pilots should be trained on CRM/threat and error management (TEM) principles and human performance vulnerabilities related to monitoring, the importance of monitoring, and the operator approved practices that achieve effective monitoring of the flightpath.
5. Pilots should be trained on system failures that may distract from effective monitoring and proper flightpath management.
6. Pilots should be trained to manage distractions that interfere with monitoring the flightpath. Provide guidance on managing task priorities and train them to effectively switch between other tasks and monitoring of the flightpath so that flightpath vigilance is always maintained. Include information and task management strategies that enable pilots to use charts, EFB, ACARS, etc. while also effectively monitoring the flightpath and airplane energy state.
7. Pilots should be trained on intervention methods that the PM can use to help the PF regain proper control of the flightpath and provide opportunities for the PM to practice these methods (e.g., calling out deviations, levels of assertiveness).
8. Pilots should be trained on and be able to demonstrate understanding of operationally relevant combinations/levels of flight guidance and flight control automation (e.g., given a certain set of circumstances, what will happen next?).
9. Ensure pilots can transition seamlessly between combinations/levels of flight guidance/flight control automation (including manual flight) by training them to anticipate, recognize, and recover from known flight guidance (includes Flight Management System (FMS)) and flight control (includes AP and, autothrottles) system-behavioral challenges (e.g., subtle mode reversions), and environmental/ circumstantial traps that are known to lead to flightpath-related errors (e.g., vectors off, then back on, a Standard Terminal Arrival Route (STAR) during a “descend via” clearance).
10. Flight guidance and flight control systems training should include an assessment of a pilots understanding of those systems and what will happen ‘next’ given a certain set of flight circumstances, and the reasons why. The training should incorporate FMS degradations and failures and operational consequences requiring flightcrew action, known flight guidance and flight control system-behavioral challenges (e.g., subtle mode reversions), and environmental/circumstantial traps (e.g., vectors off, then back on, a STAR during a “descend via” clearance) that are known to lead to flightpath-related errors.

6.8 Incorporate Monitoring into SOPs. Monitoring performance can be significantly improved by: (1) developing and implementing effective SOPs to support monitoring and

cross-checking functions, and appropriate interventions, (2) by training crews on monitoring strategies, and (3) by pilots following those SOPs and strategies.

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.

6.9 Autoflight Considerations.

6.9.1 Autoflight Mode Confusion. Safety data (including accident, incidents, Line Operations Safety Audit (LOSA), FOQA, and ASAP data) have shown that autoflight mode confusion is a potential vulnerability in flight operations and merits special attention during monitoring tasks. Pilots should be able to demonstrate the knowledge and skill necessary to correctly select, interpret, and anticipate normal autoflight modes as well as be able to demonstrate appropriate remedial actions for inappropriate or unexpected autoflight modes. This should include the ability to:

1. Correctly identify and interpret individual flight mode annunciations;
2. Describe the respective mode's impact on the related systems and airplane operation; and
3. Understand pitch mode annunciations and their relationship to available thrust as well as the aircraft's energy state (e.g. the risk of using vertical speed mode to climb at high altitudes with limited available thrust).

6.9.1.1 Equipment and operator culture may influence how mode awareness protocols are designed and implemented. Therefore, an operator should create mode awareness procedures that reflect the equipment and how the operator employs the equipage and train/assess the procedures. When formulating mode awareness SOPs, consider the following:

1. When to require verbal callouts of mode status and changes, keeping in mind workload during specific phases of flight, pilot tasks, and unanticipated mode changes;
2. Operators should describe the mode confirmation methodology for the PF/PM roles. It is important that an operator's procedures for mode confirmation take into account differences in phases of flight, pilot tasks, and high workload situations.
3. One example is briefing current autoflight mode status to any pilot that is returning to a pilot seat after a physiological break or distraction from flying (communicating with dispatch, flight attendant, etc.). Following a distraction,

pilots should discuss flight deck status. For a pilot that is returning to a pilot seat after a break, develop a formal briefing that is appropriate for the equipment with required items to ensure the pilot is updated on systems status.

4. Create phase of flight procedures/dialog boxes (for example: takeoff, climb, cruise, descent, approach) that include mode changes and indications for each level of automation allowed.

5. Include mode change indication in maneuver procedures/dialog boxes. When possible, associate callout names and timing to match mode changes. For example, some operators have implemented operator standard procedures such as "Confirm, Activate, Monitor, Intervene (CAMI)," or "Verbalize, Verify, and Monitor (VVM)," or 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. Regardless of the form of the strategy, the objective is to ensure that everyone in the flight deck understands the active mode, the effects of the newly engaged mode, and skillfully reacts to ensure the aircraft trajectory and energy remains as desired. Some effects of input and selection are delayed (e.g., armed to active) and latent errors may not become apparent until some time has passed. Verification of intended path/functions and awareness of modes is important throughout all phases of flight, including ground operations.

6.9.2 Autoflight Mode Awareness. The Flight Mode Annunciator (FMA) provides the flightcrew with information on the status of the autoflight/automated systems, specifically with respect to the guidance and control functions being utilized. Whether manually controlling the aircraft, using the automated systems to control the aircraft flightpath and energy, or various combinations of both, the FMAs are the information source for depicting "who is doing what."

6.9.2.1 It is important that flightcrews are thoroughly trained to understand the implications and relationships of each mode since the respective mode communicates the source of the aircraft flightpath and energy. It is also imperative that both crewmembers, as a team, understand the current mode status and its controlling system to effectively manage flightpath and energy. Just as the monitoring function is the concurrent responsibility of both pilots (and potential auxiliary crews when in the flight deck), awareness of the FMAs and their affects are also the duty of both pilots. Understanding the consequences of modes, either expected or unanticipated, and the ability to anticipate subsequent modes and the comprehension of the significance and system effects of the mode is central to flightpath management.

6.9.2.2 Autoflight system mode awareness requires effective monitoring of autoflight modes. Below are a few strategies that could be trained to improve monitoring of the autoflight modes:

1. Stay in the loop by mentally flying the aircraft even when the AP or other pilot is flying the aircraft.
2. When you have been distracted, ensure that you always check the FMAs and your flight instruments to get back in the loop as soon as possible.
3. Monitor the flight instruments just as you would when you are manually flying the aircraft.
4. Be diligent in monitoring all flightpath changes – pilot actions, system modes, aircraft responses.
5. Always make monitoring of the PF a priority task when flightpath changes are being made.
6. Always check the FMA after a change has been selected on the AP mode control panel.
7. Maintain an awareness of the autoflight systems and modes selected by the crew or automatically initiated by the flight management computer (mode awareness) to effectively monitor 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 determine that the aircraft is on the desired flightpath.

APPENDIX A. RELATED GUIDIANCE AND INFORMATION

A.1 Related FAA Guidance (current editions).

- Information for Operators (InFO) 08029, Approach and Landing Accident Reduction (ALAR): Recommended Flight Crew Training.
- InFO 08049, Preventing Wrong Runway Takeoffs.
- Safety Alert for Operators (SAFO) 07003, Confirming the Takeoff Runway.
- SAFO 12003, SOP for Title 14 CFR Part 135 Certificate Holders and Part 91K Program Managers.
- SAFO 13002, Manual Flight Operations.
- SAFO 15011, Roles and Responsibilities for Pilot Flying (PF) and Pilot Monitoring (PM).
- AC 91-73, Parts 91 and 135 Single Pilot, Flight School Procedures During Taxi Operations.
- AC 91-79, Mitigating the Risks of a Runway Overrun Upon Landing.
- AC 120-35, Flightcrew Member Line Operational Simulations: Line-Oriented Flight Training, Special Purpose Operational Training, Line Operational Evaluation.
- AC 120-48, Communication and Coordination Between Flight Crewmembers and Flight Attendants.
- AC 120-51, Crew Resource Management Training.
- AC 120-54, Advanced Qualification Program.
- AC 120-64, Operational Use and Modification of Electronic Checklists.
- AC 120-74, Parts 91, 121, 125, and 135 Flightcrew Procedures During Taxi Operations.
- AC 120-92, Safety Management Systems for Aviation Safety Providers.
- AC 121-32, Dispatch Resource Management Training.
- FAA-H- 8083-2, Risk Management Handbook.
- FAA Human Performance Considerations in the Use and Design of Aircraft Checklists, January 1995 [FAA 1995].
- FAA Order 8900.1, Flight Standards Information Management System (FSIMS).

A.2 Related Reading Material.

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Subject: AC 120-71B, Standard Operating Procedures and Pilot Monitoring Duties for Flight Deck Crewmembers

Date: _____

Please check all appropriate line items:

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

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