Recommendation 16-3: Operational Mode Awareness

I. Submission

The attached recommendations were submitted by the Flight Path Management Workgroup (FPM WG) for consideration by the Air Carrier Training Aviation Rulemaking Committee (ACT ARC) Steering Committee at F2F-8. The ACT ARC Steering Committee adopted the recommendations with unanimous consent, and they are submitted to the Associate Administrator for Aviation Safety (AVS-1) as ACT ARC Recommendation 16-3.

II. Statement of the Problem

A. Background

Flight Mode Annunciations (FMA) provide the flight crew 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 flight path and energy, or various combinations of both manual and automation, the FMAs are the information source for depicting “who is doing what.” Unfortunately, aircraft and avionics manufacturers have complicated the flight crew’s task by designing complex interrelationships across the automated systems and by implementing the large number of autoflight modes and sub-modes available for activation. The resulting complexity has been the subject of numerous research studies and also received heightened industry awareness when identified as a contributing factor in accident/incident/ASRS/ASAP reports. Corrective action and advances on systems design should be pursued, but even minor improvements could be a long term process. As a result, the current configurations in existing fleets will continue to operate for the foreseeable future. Therefore, it is imperative that flight crews are thoroughly trained and understand the implications and relationships of each mode since the respective mode communicates the source of the aircraft flight path and energy. It is also imperative that both crew members, as a team, understand the current mode status and its controlling system to effectively manage flight path 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. It is the position of this paper that the simple action of “calling out” (by any method) is not the primary concern of mode awareness. Understanding the consequences of modes, either expected or unanticipated, the ability to anticipate subsequent modes and the comprehension of the significance and system effects of the mode is central to FPM.

Advisory Circular (AC) 120-71A, Standard Operating Procedures for Flight Deck Crewmembers, recommends that “Autopilot/flight director mode control inputs” be incorporated into the operator’s standard operating procedures (SOP) for operations when the automation is being used. Subsequently, it is understood by the FPM WG (via industry surveys of operator SOPs) that operators do in fact address autoflight modes in their SOPs albeit varied in degree. The surveys reveal that individual operators create procedures to meet regulatory guidance, to mitigate risk and address known events, and ensure operations conform to their company culture. As a result, guidance to flight crews across the industry varies significantly. The surveys also demonstrate that guidance on

autoflight mode awareness may not be sufficient to help flight crews understand the importance of mode awareness' contribution to flight path and energy management.

Therefore, due to the complex configurations of autoflight modes and the wide range of guidance to flight crews from air carriers, the ACT ARC recommends the FAA incorporate the following information on autoflight mode awareness into guidance material for air carriers.

B. Questions from the FAA

The FAA posed the following questions to the ACT ARC relative to Autoflight Mode Awareness. These questions were assigned to the FPM WG and incorporated in the FPM WG Terms of Reference (TOR) document. (See FPM WG TOR, Section II.3.a.i, ii & iv.)

- Identify the different methodologies used for flight crew awareness/confirmation of aircraft mode engagements and changes (e.g., Silent vs Verbal Confirmation of each mode change).
- Identify the benefits and the hazards for each methodology identified.
- Can enhanced mode awareness also support monitoring duties? Why/Why not?

C. Discussion

The FPM WG submits the following discussion in response to the questions presented:

1. *Question: Identify the different methodologies used for flight crew awareness/confirmation of aircraft mode engagements and changes.*

2. *Question: Identify the benefits and the hazards for each methodology identified.*

Specific to flight crew SOPs and how autoflight modes and mode changes might be proceduralized, there are generally four methodologies as noted below (and there are certainly variations on each).

a. Verbalize Mode Changes

Both Airbus and Boeing recommend that it is a good crew resource management (CRM) technique to announce FMA and thrust mode changes. The intent is to ensure the mode changes do not go unnoticed and the flight crew remains aware of the current mode status. In their literature however, they simply recommend the practice and allow the operator to form their own SOPs. The benefit to Flight Path Management (FPM) of verbalizing all mode changes, if the function is cognitive as opposed to rote, is that each crew member "should" continually be aware of the active modes of those systems providing guidance and control inputs to the flight path. Unfortunately, research results are mixed on the effectiveness of this method.

During the Flight Deck Automation Working Group (FltDAWG) investigation of the *Operational Use of Flight Path Management Systems*, operators reported that calling out all FMA changes was perceived as a burden on flight crews and increased the activity and workload within the flight deck. During high workload phases, callouts were reported being missed and also seen as counterproductive when required to call out changes that were considered normal and anticipated. The FltDAWG findings have been corroborated by researchers and observers (e.g., Line Operations Safety Audits (LOSA)) who also noted that mode callouts were frequently missed (when the mode change occurred) or intentionally not made during periods of

high workload, particularly in the terminal area. Researchers also described cases where flight crews sometimes developed their own unique (and quite varied) mode awareness strategies that did not follow the company's SOPs.

Some operators reported to the FltDAWG that they had attempted to implement a verbal exchange between the PF and PM when all mode changes occurred but experienced many of the issues noted above. As a result, the operators then reverted to their previous strategy or made amendments to the "callout all modes" methodology to suit the operation at hand. Noteworthy are the efforts by some operators to identify the modes they believe are important to call out (e.g., unanticipated changes or procedural changes to ensure proper modes during critical phases of flight) versus those which can be assumed (normal or expected mode sequencing). These operators reported that additional flight crew training was required but continue to assess the effectiveness of calling some, but not all, mode changes.

To summarize, research has indicated that there are benefits to calling out all mode changes, specifically that when done universally, flight crew awareness of the modes was enhanced during test trials. However, strict adherence to calling all modes also detracts from other tasks and/or increases workload during already high workload phases of flight. Subsequently, the SOP of calling out all mode changes tends to be shed at a higher rate during high workload phases.

Note: The terms "callout" and "verbalize" may have different connotations for some operators. For purposes of this document, the terms "callout" and 'verbalize' are used interchangeably without necessarily implying verbatim language.

b. Non-Verbally Communicate Mode Changes

Although not proceduralized by US operators, non-verbal communication techniques such as pointing to a mode or a change in status can be useful to emphasize or confirm an item of interest. Examples of the technique are pointing to the altitude window to confirm an altitude directed by ATC that is not published as a restriction on the procedure, or pointing to the respective FMA when localizer and glideslope engage. Even though purely technique, it can reinforce mode awareness and help to ensure the change has been observed by both pilots. It can be effective in a range of workload environments or when one pilot is momentarily occupied with another task. The downside to this technique, however, is that if subscribed to as the primary mode awareness methodology, it is also susceptible to missed changes particularly in high workload or distracting conditions where the task may be shed.

c. Individually Verify Mode Changes (Without Communication)

This method simply places the responsibility of mode awareness on the individual pilots and assumes that the crew will perceive and appropriately react to mode changes, particularly those that occur during the normal course of the flight. This method enhances a "quiet" concept within the flight deck but also may allow mode changes to go unnoticed and therefore may reduce the probability that both pilots are aware and coordinated on the current mode status and subsequent system effects. Unfortunately, execution of this method cannot be observed (by another crewmember, or an evaluator), therefore it is difficult to confirm whether an individual is correctly performing his/her individual verification. If this method is used, it may be more beneficial to reserve this method for normal, anticipated mode changes and those that are pre-briefed.

d. Combination of Above Methods

A combination strategy which incorporates verbal, non-verbal and individual methods may be more effective than any single method alone for all levels of workload. For example, normal, anticipated or pre-briefed FMA mode engagements/changes could be communicated by pointing to the FMA or not communicated at all if the operator has incorporated the individual verification method into an effective combined methodology. However, the operator may require that some normal/anticipated mode changes or status (e.g., those during a missed approach/go-around) are verbalized because of the critical nature of the procedure. Unusual or indirect mode changes that may not have been expected may require the higher level of attention initiated by a verbal callout and/or non-verbal emphasis. Potentially, verbal communication / discussion between the two pilots could be required to confirm the unexpected mode change and that the automated systems are controlling as desired. The interchange between the pilots may then lead to a decision that pilot action is required to change to a different mode or alternative level of automation. A verbal discussion is more effective when uncertainty exists and either (or both) pilots are confused on the respective mode status. The mix or selection and implementation of specific methodologies would be determined by the operator as described in the recommendations below.

A benefit of an operator's combined verbal/non-verbal strategy is that it provides the flight crew with flexibility to address the mode change depending upon the level of attention required.

3. *Question: Can enhanced mode awareness also support monitoring duties?*

The short answer to the FAA's question is yes, but we would reference the Flight Safety Foundation's "*A Practical Guide for Improving Flight Path Monitoring*" (November 2014) and the CAA's "*Monitoring Matters*" (April 2013) for greater detail on flight path monitoring and the role that enhanced mode awareness can play. Both papers explain that monitoring the flight path incorporates tasks such as observing cockpit displays, indications, and system modes to ensure that the aircraft response matches mode selections and guidance target entries. Additionally, the CAA points to system mode awareness as a skill to enhance monitoring and includes mode awareness as one of several important monitoring strategies:

"These are a few strategies that could be employed to enhance good monitoring behavior:

- Stay in the loop by mentally flying the aircraft even when the autopilot or other pilot is flying the aircraft.
- 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.
- Monitor the flight instruments just as you would when you are manually flying the aircraft.

- Be diligent in monitoring all flight path changes – pilot ACTIONS, system MODES, aircraft RESPONSES.
  - Always make monitoring of the PF a priority task when flight path changes are being made.
  - Always check the FMA after a change has been selected on the autopilot mode control panel."[1]

The FSF paper also points to other research that explains the complexity of automated systems and the need for flight crews to fully understand the operation of each mode and the system interrelationships and results of a forthcoming mode, either expected, unexpected, or an anomaly. Given a thorough understanding of the modes, the flight crew can skillfully react to modes much quicker and more efficiently and therefore enhance the monitoring efficiency. In their list of recommendations, the FSF identifies skills to be maintained by both pilots relative to mode awareness and it contribution to monitoring and situation awareness:

- Maintain an awareness of the automation systems and modes selected by the crew or automatically initiated by the flight management computer (mode awareness) to effectively monitor flight path;
- Maintain an awareness of the capabilities available in engaged automation modes (mode confusion);
- Effectively monitor systems and selected modes to ascertain that the aircraft is on the desired flight path;[2]

III. Proposed Recommendation

The ACT ARC submits the following recommendations on the development of advisory guidance material (e.g., Advisory Circular) for industry stakeholders incorporating suggested tools/techniques for effective mode awareness/understanding that enhance flight path/energy management for FAA consideration, including strategies for addressing how to:

(a) Train autoflight modes to a correlation level.
(b) Incorporate autoflight mode awareness into Standard Operating Procedures (SOP).
(c) 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.
(d) Incorporate a communication/confirmation methodology that works for the equipment and/or within the company culture.
(e) Define the mode confirmation methodology in relation to PF/PM roles and areas of vulnerability.

IV. Rationale

Note: The content included with the rationale and explanation for this recommendation reflects a "recommended practice" approach. It is also important to understand that the simple action of "calling out" (by any method) is not the primary concern of mode awareness. Understanding the consequences of modes, either expected or unanticipated, the ability to anticipate subsequent modes and the comprehension of the significance and system effects of the mode is central to FPM.

[1] UK CAA, Monitoring Matters, *Guidance on the Development of Pilot Monitoring Skills*, February 2013.
[2] Flight Safety Foundation, *A Practical Guide for Improving Flight Path Monitoring*, November 2014.

(a) Train autoflight modes to a correlation level.

Training autoflight modes to an understanding level is fundamental and identified by almost every researcher who has investigated the mode awareness topic. However, that understanding must be practically applied when interfacing with the aircraft so that correct decisions can be made to correlate systems interaction, anticipate mode changes and be ready to react when either the expected mode or an unanticipated mode change occurs. Flight Simulation Training Device (FSTD) training curricula should be developed to exercise unanticipated mode changes and/or autoflight anomalies to train strategies for recovering to desired system operation.

An appropriate knowledge level of the respective autoflight modes should be the same as it would be if the pilot was manually flying the aircraft to accomplish the same profile.

Note: This recommendation complements ACT ARC Recommendation 15-11: Auto Flight Mode Training.

(b) Incorporate autoflight mode awareness into Standard Operating Procedures (SOP).

Equipment and/or company culture may influence how the mode awareness procedure for flight crews is proceduralized. Therefore, **create mode awareness procedures** that reflect the equipment and how the company employs the equipage **and train/assess the procedures.** When formulating mode awareness SOPs, consider the following:

(i) Research has shown that mode awareness is critical to controlling the aircraft and that callouts are an effective method to make crews aware of the controlling mode if done cognitively as opposed to rote.

(ii) The FltDAWG reported that several operators found that calling out ALL mode changes was cumbersome and ineffective. Research has shown that calling out all mode changes works well until workload increases, then the verbal callouts are sometimes shed.

(iii) Surveys have shown that 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.

(iv) Some mode changes may not need to be addressed (verbal or non-verbal) 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.

(v) 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, etc.). Following a distraction, verbally discuss flight deck status. For a pilot that is occupying 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.

Therefore, a well-defined and standard communication methodology may increase mode awareness and enhance flight path and energy management.

(c) 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.

Include mode change indication in maneuver procedures/dialog boxes. When possible, associate callout names and timing to match mode changes.

Dialogue boxes are one way to provide guidance and SOPs to flight crews on individual pilot responsibilities or actions during each flight phase. (See Attachment A: Example of Flight Crew Procedures)

(d) 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),” or similar systems, or even variations thereof. Such procedures provide the flight crew 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 Threat and Error Management 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.”

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.

(e) Define the mode confirmation methodology in relation to PF/PM roles and areas of vulnerability.

Define the mode confirmation methodology in relation to PF/PM roles and areas of vulnerability, specifically when the level of vulnerability may lead to a flight path deviation. The Flight Safety Foundation 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 flight path deviation or the increased severity of potential consequences if such a deviation occurs.”[3] Additionally, certain situations, such as Non-normal malfunctions, drive an increase in workload which increases the flight crew’s susceptibility to monitoring errors.

Identification of high, medium and low areas of vulnerability conditions would be defined by the operator using the Flight Safety Foundation paper on Monitoring previously referenced as a guide. It is important that an operator’s procedures for mode confirmation take into account differences in areas of vulnerability and/or high-workload situations.

[3] Flight Safety Foundation, *A Practical Guide for Improving Flight Path Monitoring*, November, 2014.

V. Background Information

FPM WG Scope of Work:

ACT ARC Recommendation 16-3 partially addresses the Scope of Work by answering the questions incorporated in the FPM WG TOR, Section II.3.a.i, ii & iv.

3. When developing guidance recommendations, the WG will initially answer the following questions:
   a. Mode Awareness:
      i. Identify the different methodologies used for pilot awareness/confirmation of aircraft mode engagements and changes. (e.g., Silent vs Verbal Confirmation of each mode change)
      ii. Identify the benefits and the hazards for each methodology identified.
      v. Can enhanced pilot mode awareness also support pilot monitoring duties? Why/Why not?

ACT ARC Initiatives:

ACT ARC Recommendation 16-3 partially addresses Initiative #35 assigned to the FPM WG.

Source Reports:

UK CAA, *Monitoring Matters, Guidance on the Development of Pilot Monitoring Skills*, February 2013

Flight Safety Foundation, *A Practical Guide for Improving Flight Path Monitoring*, November 2014

Operational Use of Flight Path Management Systems, Performance-Based Operations Aviation Rulemaking Committee (PARC)/Commercial Aviation Safety Team (CAST) Flight Deck Automation Working Group (FltDAWG) final report, September 2013

Current Guidance Documents:

AC 120-71A, Standard Operating Procedures for Flight Deck Crewmembers (2/27/03)

Attachment A: Example of Flight Crew Procedures

The dialogue box below is an example of an event and resulting crew actions that demonstrate crew coordination and could be used as a framework for operators to design their procedures. The reference event (Trigger) would evoke an action (and communication) by the flight crew relative to their designated role (PF or PM).

Note 1: For the purpose of this example, assume this is an Airbus operator, and the operator has established a policy whereby FMA changes are verbalized under 2 conditions: (a) if a non-standard mode is to be used (where the operator has defined what is considered “standard”, and (b) in certain conditions deemed by the operator to be of critical importance (e.g., capture conditions, such as ALT cap, LOC cap, and GS cap).

Note 2: It is important for the reader to understand this is only an example – individual operators should revise and extend such dialog boxes to match their own procedures.

Descent – Autopilot On			
		Actions & Callouts	
Trigger	**Sequence**	**PF**	**PM**
ATC issues a "Descent " clearance.	1		Read back Clearance with ATC
	2	Acknowledge clearance with PM	
	3	Sets assigned altitude in altitude selector	
	4	Points at PFD and announces the altitude setting (e.g., "5,000")	
	5		Verifies correct setting, points at PFD and calls out the setting (e.g., "5,000")
If Open Descent mode is used…	6	Selects OP DES mode, verifies mode engagement.	
If vertical mode OTHER than Open Descent is used	6	Selects desired vertical mode, verifies mode engagement, and calls out the newly engaged vertical mode	
	7		Verifies engagement of proper vertical mode on FMA and verifies correct flight path

Descent – Autopilot On			
		Actions & Callouts	
Trigger	**Sequence**	**PF**	**PM**
During Descent		Monitor Flight Path	Monitor Flight Path
1000’ feet prior to level-off	1	Makes altitude awareness callout (e.g., “6,000 for 5,000”	
	2		Confirms altitude
At Altitude Capture engagement	1	Calls out mode engagement indication on FMA (e.g., “Alt star”) and verifies proper flight path	
	2		Confirms FMA and flight path
At Altitude Hold engagement	1	Verifies mode engagement indication on FMA and proper flight path	
	2		Confirms FMA and flight path.