Recommendation 17-1
Manual Recovery From Unintended Autoflight States

I. Submission

The recommendations below 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-12. 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 17-1.

II. Statement of the Issue

Numerous sources[1] offer a wealth of cases where autoflight[2] system usage placed the aircraft on a flight path that differed from what was desired by the pilot(s). These cases of divergence between autoflight behavior and the pilots' intentions have had numerous causes, but all illustrate the importance of pilot competency in recognition of, and recovery from, this situation. Protection of a safe flight path is always the pilots' top priority.

The "Operational Use of Flight Path Management Systems", the PARC/CAST report of September 2013, identified that pilots lack practice in manual flight operations which has contributed to the degradation of manual flying skills. The PARC also found that problems transitioning from autoflight to manual flight often co-occur with manual handling errors.

While recovery from unintended autoflight states may not always involve manual handling interventions, it is certainly true that pilots must be capable of recovering manually. To ensure pilots possess this capability, improved training is indicated. Such training involves knowledge and skill in both manual flight operations, and autoflight system management; therefore, this recommendation contains elements of both.

With respect to manual flight operations training, the FPM WG recognizes that other work being conducted for Upset Prevention and Recovery Training (AC 120-111) and Stall Prevention and Recovery Training (AC 120-109A) also cover areas of manual flight operations and thus the following areas are not directly addressed in the FPM WG proposed recommendations: slow flight, loss of reliable airspeed, upset recovery maneuvers, recovery from bounced landings, and recovery from full stalls. The aforementioned advisory circulars and the companion Recommendation 16-9 Manual Flight Operations should be considered when developing guidance based on the proposed recommendations herein.

Finally, the FPM WG emphasizes that the FAA should view all the FPM WG recommendations collectively and not in isolation.

III. Recommendations

The ACT ARC proposes the following recommendations for FAA consideration:

[1] See V. Background Information, Source Reports.

[2] For the purpose of this recommendation, "autoflight," means any flight guidance and/or flight control automation system installed on the aircraft, which may include flight director, autopilot, and/or autothrottles.

The ACT ARC recommends that the FAA publish guidance to operators advising the following:

(a) Operators should develop and publish procedures for flightcrew response to unintended autoflight states[3].

Procedures should emphasize that the pilot flying (PF)'s primary duty is to control the flight path and the pilot monitoring (PM)'s duty is to (1) monitor/ensure the flight path, then (2) assist the PF by assessing and correcting the autoflight settings as needed to restore desired behavior.

(b) Operators should develop and provide training for prevention, recognition, and recovery from unintended autoflight states.
   (1) Recovery training should include manual control interventions to correct the flight path, with the objective of ensuring pilot competency and confidence in executing manual recoveries[4].
   (2) In developing recovery training, operators should consider the recommended scenarios and explanatory discussion in the Attachment.

(c) The procedures and training described in 17-1(a) and (b) above should cover the set of unintended autoflight states that are known for the aircraft type, installed autoflight equipment, operation type, operating environment, etc., based on both industry information and internal data analysis (e.g., Safety Management System (SMS) processes).

IV. Rationale and Discussion

While the core of this recommendation involves training, 17-1(a) advises that operators develop flightcrew procedures. This aligns with the FPM WG previously-submitted recommendations, which state that training development must follow procedural development, as published procedures form the basis on which training objectives and performance standards are built.

Recommendation 17-1(b) covers training for "prevention, recognition, and recovery" actions. With regard to undesired flight states, it is always preferable to prevent occurrence. If prevention fails, early recognition of a developing undesired state with immediate correction is the second most preferred action. If both prevention and early recognition/correction fail, then recognition and recovery from the undesired state are required. Therefore, competence in this regime (recovery actions) must be developed via training. This recommendation focuses on RECOVERY. Further recommendations will be forthcoming as the FPM WG completes additional work on Management of Automated Systems, in the aforementioned expanded ToR 2b.

As expressed in the FPM WG's foundational philosophy[5], safe and effective flight path management must be based on a foundation of pilot skill in manually controlling the aircraft's

[3] For purposes of this recommendation, 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). Colloquially, scenarios fitting this description are commonly referred to as "gotchas". See also previously submitted Recommendation 16-4 (excerpt included in V. Background Information).

[4] "Manual recovery" means recovery actions involving manual manipulation of pitch, bank, yaw, or thrust, or any combination of these.

[5] See Recommendation 16-10: Flight Path Management Philosophy, Policy, and Procedures.

trajectory and energy. A high level of competency in hand-flying (both the physical and cognitive aspects) is necessary for safe flight operations, regardless of the level of autoflight equipment installed, or used, in the aircraft. The FPM WG acknowledges that multiple ways may exist to recover from unintended autoflight states. One method may even involve "finding an autoflight solution to an autoflight problem."[6] However, the FPM WG believes that manual recovery should always be a fail-safe option and therefore must be trained.

The proposed scenarios provided in the Attachment to this recommendation are based on actual airline training and line experience. The intent of these scenarios is to develop a pilot's knowledge and skills to competently and confidently recognize each situation and recover the aircraft to the desired flight path.

V. Background Information

This recommendation addresses item 2 in the FPM WG Scope of Work and ACT ARC Initiative #35 (see below):

FPM WG Scope of Work:

2. Recommend guidance for developing training for flight path management policy and procedures:
   a. Manual flight operations, including training, practice, and checking.
   b. Management of automated systems for flight path management, especially autoflight mode awareness[7].

ACT ARC Initiatives:

- Initiative #35: Develop training/qualification to improve knowledge and skills for successful flight path management, to include:
  a. Manual flight operations, including training, practice, and checking.

Excerpts from Recommendation 16-4 Training Elements for Training the Pilot Monitoring:

Recommendation 16-4, Attachment A, "Academic and Flight Training Elements for Training the Role of Pilot Monitoring," paragraph 6:

> *Train pilots to anticipate, recognize, and recover from known flight guidance (includes FMS) and flight control (includes autopilot and, autothrottles) system-behavioral challenges (e.g., subtle mode reversions), and environmental/ circumstantial traps that are known to lead to flight path-related errors (e.g., vectors off, then back on, a STAR during a "descend via" clearance).*
>
> *Note: Pilots commonly refer to such examples as "gotchas."*

[6] "Finding an autoflight solution to an autoflight problem" means addressing an unintended autoflight state by interacting with the autoflight system. Typically, this involves reducing the complexity of the autoflight modes being used. For example, if LNAV is engaged, and a change to the FMS produces an unexpected/undesired change of heading, the pilot could change to a "simpler" level of lateral guidance (e.g., HDG mode) to "point" the airplane in the desired direction until the FMS-related lateral guidance issue is sorted out.

[7] Terms of Reference (ToR) 2b has been assigned by the ACT ARC Steering Committee. The scope of 2b is being revisited in a larger context by the FPM WG and the FAA should include this recommendation as part of the FPM WG response to the expanded ToR 2b.

Recommendation 16-4, Section IV, “Rationale,” subsection 6:

> *Rationale: A key aspect of training known system challenges and real world events is for pilots to be able to identify common drivers for divergences from the desired path quickly. Based on Safety Assurance data (internal and industry) as Safety Management Systems mature, the air carrier should incorporate hazards identified through safety assurance data into the training program. The use of this data has the potential to create variability in training syllabi, however, these changes could be managed through current AQP programs.*

Source Reports

- 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 5, 2013.
- SAFO 13002, Manual Flight Operations, January 4, 2013.
- Office of Inspector General Audit Report – Enhanced FAA oversight could reduce hazards associated with increased use of flight deck automation. Report Number: AV-2016-013, January 7, 2016.
- The Retention of Manual Flying Skills in the Automated Cockpit, National Aeronautics and Space Administration, December 2014.
- EASA Safety Information Bulletin, SIB No. 2013-05, 23 April 2013. Manual Flight Training and Operations.

Attachment: Training Recommendations for Manual Recovery from Unintended Autoflight States

Background

For many decades, every flight training program has included a module on unusual attitude recoveries. Because it is every pilot's responsibility to prevent an unusual attitude from occurring, one might ask why we include training on recovery from a situation we train pilots to avoid. The answer is: to create a robust, multi-layered defense against disaster. Prevention defenses are important, but recovery defenses are no less important, because unusual attitudes do sometimes occur in the real world.

Modern day training on autoflight systems has tended to focus on how to use the autoflight systems to fly specific profiles and maneuvers. When the autoflight system does something unintended or unexpected, today's training tends to only address what to do differently WITH THE AUTOFLIGHT SYSTEM. ("No, no, don't push that button. You don't want that. Push THIS button instead.") Historically, little training time is spent on flying with the automation off and manually correcting the flight path.

When an undesired flight path occurs due to an unintended autoflight state, a pilot must be competent and confident in his/her ability to manually correct the flight path (just as he/she must be able to competently and confidently perform an unusual attitude recovery). Today's training programs address the manual flying skills required for unusual attitude recovery, but they do not adequately address the manual flying skills required for recovery from unintended autoflight states.

This fact has led the FPM WG to adopt a catch-phrase that succinctly captures the essence of this recommendation:

"Automation gotchas[8] are the new unusual attitudes."

Unintended Autoflight States Explained

The FPM WG uses the phrase "unintended autoflight states" to mean situations/scenarios where operational experience has shown that pilots' desires and autoflight behaviors sometimes do not match. This does NOT necessarily imply situations driven by system failures, flightcrew failures, nor design deficiencies, as the FPM WG recognizes that there are many possible causes for the mismatch between pilot intent and the autoflight system state. For the purpose of this recommendation, the FPM WG is highlighting situations where, for whatever reason, it might be possible for the pilot and the autoflight system to be inadvertently working at cross-purposes.

[8] As mentioned in a previous footnote, the term "gotchas" is colloquial shorthand for what the FPM WG is defining more formally as "unintended autoflight states".

Training Description

Objectives: Develop pilot knowledge and skill in the recognition and recovery from unintended autoflight states. The four areas to be emphasized are (1) recognition of the situation, (2) manual flight path recovery actions by the pilot flying (PF), (3) assistive actions by the pilot monitoring (PM), and (4) effective communication and coordination of actions between the PF and PM.

1. **Recognition**: For the selected scenarios, training must start by developing the pilots' ability to recognize the undesired situation. The various cues and indications must be highlighted and the pilots' understanding ensured.

2. **Manual Recovery Actions by the PF**: For the purposes of this training, manual intervention consists of action taken by the PF to directly control pitch, bank, yaw, or thrust (or any combination thereof) so as to correct the trajectory or energy of the aircraft. This will generally involve disconnecting the autopilot, or autothrust, or both, and establishing an attitude and power setting that places the aircraft on the desired flight path. This also means that initially the PF may have to disregard some aspect of the flight guidance (e.g., disregard the flight director if it is not giving helpful information) while the PM resets the guidance (see objective no. 3, below). For this objective, pilot competence and confidence in manual handling across all flight regimes is needed, and therefore this scenario-based recovery training module must be built on a foundation of basic hand-flying competency training.

3. **Assistive Actions by the PM**[9]: While the PF is focused on hand-flying, once the PM has confirmed that the PF has initiated proper recovery actions, the PM should handle autoflight system analysis, and if necessary, system re-configuration. The FPM WG has observed that some operators' programs (both procedures and training) place the entire burden of manually flying, assessing the autoflight dilemma, and commanding autoflight reconfiguration actions all on the PF. This represents a very high level of cognitive workload, which may exceed the capabilities of a single pilot under high stress. Instead these duties should be divided to leverage crew resource management (CRM) and enhance the efficiency and accuracy of the actions. The PF should be free to focus his/her attention on flight path control, and the PM, after confirming that the PF's actions are returning the aircraft toward the desired flight path, should assess and reconfigure the autoflight system(s) as required. For this objective, the goal is to ensure pilot competence and confidence in the PM actions (ensure flight path, assess and reset autoflight system as needed).

4. **Effective Communication and Coordination**: Throughout the course of recognition and recovery, effective communication and coordination between the pilots should be emphasized. Examples include: The pilot first recognizing the problem should alert the other pilot (e.g., *"Hey, why are we turning? We should still be heading South.")* The PF should inform the PM what he/she is doing (e.g., *"OK, autopilot is off, and I'm just going to head 180 for now."*) The PM should also communicate what he/she is doing, and add as necessary those elements of information that are helpful to the PF. (e.g., "*OK, I've put you in heading mode, 180. 180 degrees for 10 more miles is correct. Looks like*

[9] Instructors should explicitly emphasize that the PM's first duty, at all times, is to monitor and ensure the safe flight path of the aircraft.

we've got the wrong SID in the FMS. I'll reprogram the box while you fly this heading." etc.)

Suggested Scenarios: Below is an example set of scenarios which could serve as a basis for a training module. This list is not intended to be exhaustive or all inclusive, but is instead a representative sample. Individual operators should use their SMS (or similar) safety- and training-data mining programs to determine the most appropriate set of scenarios that apply to their respective operating environment and equipment.

a. Go-around scenarios:
   i. Inadvertent activation of TOGA on approach.
   ii. A go-around from decision height with a TOGA mode engagement failure.
   iii. A go-around or new air traffic management heading and altitude instructions immediately after localizer and glideslope intercept using TOGA.
   iv. A go-around or new air traffic management heading and altitude instructions immediately after localizer and glideslope intercept with TOGA mode engagement failure.

b. LNAV/VNAV scenarios:
   i. After takeoff while on an RNAV departure that was incorrectly loaded into the FMS.
   ii. While on a SID or STAR, simulating a radar vector off course and a clearance to re-intercept the original routing. If using a STAR, consider combining the rejoin clearance with a "descend via" clearance to include the complexity of vertical navigation.

c. Holding scenario:
   i. Aircraft turns wrong way on initial hold entry due to mis-programming. Consider terrain or weather on the incorrect side, emphasizing need to intervene expeditiously.

d. Autothrust scenarios:
   i. TCAS RA in FLCH (OP CLB/OP DES) with autothrust engaged.
   ii. [Airbus]: Inadvertent activation of FMS Approach Phase.
   iii. [Airbus]: High-alpha event (Go-Around, Cruise) with TOGA Lock activation.
   iv. Max power go-around, light aircraft, low missed approach altitude.
   v. Visual approach with autothrust in a fixed-thrust mode (e.g., FLCH, OP DES, SPDE, etc.)

e. Post-Escape[10]scenarios. This involves dealing with the autoflight system consequences of, and the return to a normal flight state subsequent to, the recovery actions associated with events[11] such as—
   i. EGPWS escape maneuver.
   ii. Windshear escape maneuver.
   iii. ILS PRM breakout maneuver.

[10] Also known as "recovery from the recovery" scenarios.

[11] The suggested scenarios in item e. are included to address the desired pilot actions as described in objective Nos. 1 through 4. The FPM WG understands that example maneuvers i. through iii. are already included in current training programs due to pre-existing requirements, however, the training for these maneuvers merits improvement in light of the newly-described objectives.

Curriculum Inclusion

For both Advanced Qualification Programs (AQP) and traditional training programs, training in Manual Recovery from Unintended Autoflight States should be included in in all courses (initial, recurrent, transition, upgrade, and requalification). This training should be accomplished for each pilot in both the PF and PM roles.

Training Development Considerations

The following should be considered when developing scenarios for this training module.

- ***Scenario Development and Selection.***
  - Data-Driven Scenario Selection. The scenarios listed above are suggestions which may form a "starter set" for an operator. The FPM WG recommends that operators employ their internal safety assurance analysis processes (SMS or similar) to review actual operational safety and training data to choose the best set of scenarios for their own operating environment and equipment type.
  - Combinations of Autoflight Component Use. It is desirable that recovery training scenarios take into account the different possible usable combinations of the autoflight system components installed on the aircraft. Pilot proficiency should be developed in all allowable combinations. Example combinations may include the following:
    - Flight director on, with autopilot and auto-throttles off.
    - Flight director on, autopilot on, autothrottles off.
    - Flight director off, autopilot off, autothrottles on.
  - Mis-trim condition. If any of the selected scenarios can result in an aircraft mis-trim condition, then it is recommended that the scenario should be set up so as to create this mis-trim condition, thereby to ensure pilot competency in dealing with a worst-case version of the scenario.
- ***Scenario Setup and Initiation.*** It is undesirable to have one pilot trainee introduce the above scenarios to the other trainee. Students should not be asked by their instructor to perform an incorrect action to set up a training scenario. Therefore, the FPM WG strongly recommends that these scenarios be set up and initiated by the instructor, and only by the instructor. Two possible ways this could be accomplished are:
  - Instructor input from the Instructor-Operator Station (IOS) panel. This would require development of the simulation capability to support the selected scenarios.
  - Instructor input to the simulator cockpit controls. For example, this could be done either by the instructor "leaning up" (into the cockpit operating space), or by the instructor occupying one of the pilot seats.