# ACT ARC Recommendation 18-1

## Reasonableness Checks of Information Automation Systems

## I. Submission

The recommendation(s) 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-16, March 7-8, 2018. The ACT ARC Steering Committee adopted the recommendations with unanimous consent, and they are submitted to the Federal Aviation Administration as ACT ARC Recommendation 18-1.

## II. Definitions

*Flight Path Management* (FPM) is the planning, execution, and assurance of the guidance and control of aircraft trajectory and energy, in flight or on the ground.

*Information Automation* (IA) refers to automation of information-related tasks such as acquisition, calculation, management, integration, and display of information to the flight crew. Information automation may act on, process, and manage the content and format of presented information.

A *Reasonableness Check* (RC) is a method to verify/validate IA system inputs/outputs before use.

## III. Statement of the Issue

The advent of information automation (IA), while having numerous benefits, also introduces vulnerabilities. Operational feedback indicates IA system input/output problems impacting flight path management are common. Information presented to flight crews, even before the advent of IA, has always been subject to some risk of inaccuracy and/or inapplicability, and pilots have always been responsible for verifying/validating that information. However, verification/validation of IA system inputs/outputs is not always adequately accomplished because of the following:

1. IA Prevalence and Practices: IA systems are increasingly pervasive in modern flight decks. Pilots depend on these systems, and the systems are highly reliable. In addition, operational practices often encourage reliance on these systems. As a result, pilots are conditioned to trust IA system outputs.

2. Pilot Disengagement: Because the IA systems, rather than the pilots, now perform certain tasks involving acquisition, calculation, management, and integration of information, the pilots are no longer actively engaged in these processes.

3. Automation Bias: Studies[1] show that humans are predisposed to accept information displayed by automated systems; consequently, the information provided by IA systems naturally engenders trust by pilots.

[1] See Skitka, L. J., Mosier, K. L., & Burdick, M. (2000). Accountability and automation bias. International Journal of Human-Computer Studies, 52, 701 - 717.

4. Training Focus: Training has tended to focus on the operation of IA systems and the use of the information they provide, rather than verification and validation of that information before use. [2]

Procedures and training are required to address these challenges and enable pilots to verify/validate IA system inputs/outputs for accuracy and applicability before use.

For these recommendations, discussion is confined to IA system inputs and outputs that impact Flight Path Management (FPM). FPM tasks, for each phase of flight, consist of planning, execution, and assurance activities. For example, with respect to the FPM task of conducting a takeoff, pilots perform actions to plan (prepare/setup) for the takeoff, actions to execute (fly) the takeoff, and actions to assure (monitor/crosscheck) the takeoff. This recommendation should be applied only to the FPM planning activities for each phase of flight. This is not to be interpreted to mean this recommendation's scope is limited to pre-flight planning. It should be applied to the planning activities for any discrete activity or process across all phases of flight informed/impacted by IA system inputs/outputs. Examples of system inputs/outputs that would be within the scope of these recommendations include inputs to or outputs of Flight Management Systems (FMS), Aircraft Communications Addressing and Reporting Systems (ACARS), and certain Electronic Flight Bag applications that are used for FPM planning tasks.

The scope of the recommendation excludes IA system outputs that involve FPM execution or assurance activities. For example, Terrain Awareness and Warning System warnings and Traffic Alert and Collision Avoidance System Resolution Advisories may be considered outputs of IA systems, but these outputs directly drive execution activities (escape maneuvers), not planning activities, and are therefore outside of the scope of this recommendation.

## IV. Recommendations

The ACT ARC recommends that the FAA publish guidance advising operators to develop procedures and training so flight crews have the tools to verify/validate both the **accuracy**[3] and **applicability**[4] of IA system inputs and outputs by conducting Reasonableness Checks (RC). RCs allow flight crews to detect and address potentially conflicting, ambiguous, inapplicable, or erroneous IA system inputs/outputs. Operator's training programs should integrate RCs into all curricula.

Operators should develop procedures and training for RCs that specify how and when to perform such checks. These should integrate with existing procedures and training to provide guidance on the conduct of RCs of IA system inputs and outputs during the FPM planning activity for each phase of flight (e.g., pre-departure, pre-descent, pre-approach). The guidance should include these concepts:

- RCs should be conducted for IA system inputs/outputs the pilot uses in the FPM planning activity for an upcoming phase of flight.
- FPM is the primary task (that is, the RC itself, and the resolution of any discrepancies detected by the RC, must be subordinate to flying the airplane).

[2] These factors, which may collectively be characterized as "automation overreliance", are a natural tendency when conducting multiple tasks.
[3] The purpose of the accuracy assessment is to detect significant errors or conflicts of the IA system inputs and outputs.
[4] The purpose of the applicability assessment is to determine appropriateness of IA system inputs and outputs for the current situation. Some inputs/outputs may be technically correct/within regulatory limits, but may introduce or involve unnecessary risk, or require operation near performance limits.

- Reasonableness checks of IA system inputs/outputs should be easy to perform and enable pilots to reliably detect gross errors and validate operational applicability of inputs/outputs (e.g., “Does the information make sense?”).
- Operators should define when to perform an RC and should ensure that reasonableness checking does not conflict with the performance of their existing operational procedures.
- An appropriate RC methodology should enable pilots to:
  - Detect and address potentially inaccurate/inapplicable IA system inputs/outputs before using the information in a way that impacts the flight path.
    - The appropriate means to detect inaccurate/inapplicable IA system inputs/outputs could include development and training of standard “rules of thumb” or “ballpark” figures so that crews have sufficient baseline knowledge of what a “reasonable” input or output should look like, permitting the crew to detect and investigate system inputs/outputs that are outside the boundaries of “reasonable.”
    - The appropriate means to address the inaccurate/inapplicable IA input/output and maintain the integrity of the flight path will vary based on operational context. For example, if time is unlimited (e.g., reviewing performance numbers at the gate), a discrepancy might be addressed by seeking additional information from multiple sources to crosscheck the inputs/outputs. If time is limited (e.g., reviewing descent calculations approaching Top-of-Descent), a discrepancy might be addressed by reverting to a simpler, more conservative choice.
  - Maintain flight path as the primary focus[5] so that resolving inaccuracy/inapplicability of IA system inputs/outputs does not distract from the primary task of FPM.
- Operators can identify how, how many, and when to conduct RCs based on their own equipment and operating environment, and through their operational feedback, training feedback, and Safety Management System (SMS) programs. This should include safety data programs such as Line Operations Safety Audit, Aviation Safety Action Program, and Flight Operational Quality Assurance, as well as industry programs (e.g., manufacturer-operator meetings, Aviation Safety InfoShare, accident reports, the Aviation Safety Reporting System, and the Aviation Safety Information Analysis and Sharing (ASIAS) Program). See Examples of the Application of Reasonableness Checks of IA Systems Inputs/outputs, below, for examples of how and when to perform RCs.

## V. Rationale and Discussion

IA systems have become commonplace in modern flight decks. These systems automate the acquisition, processing, and integration of information the pilot uses to complete operational tasks. Consequently, this distances the pilot from the steps required to produce this information and makes it challenging for the pilot to construct a complete understanding of the accuracy and applicability of the information. While IA system inputs and outputs are used for a myriad of flight deck tasks, some directly impact the management of the flight path; therefore, the accuracy and applicability of this information can have a direct impact on safety.

While IA systems are highly reliable, there are occasions where inputs and outputs may be

[5] See Operational Philosophy of Flight Path Management/ACT ARC Recommendation 16-10, Appendix A.

inaccurate, incomplete, conflicting, or their application may be inappropriate for the current operational context. Issues with inputs and outputs may arise from a multitude of sources, including: previous input/output errors by crewmembers or others, misunderstanding of system functions, external and/or internal miscommunication, data corruption, or breaches of data security. Therefore, pilots should always maintain a "healthy skepticism" about the information presented to them, despite the natural human tendency to trust information presented by an automated system, a tendency known as automation bias (Skitka, Mosier, & Burdick, 2000).

This recommendation suggests operators provide pilots with procedures and training for conducting RCs of IA system inputs/outputs that may impact the flight path. Today, some pilots may use their own "rules of thumb" to check system input/output. However, those methods are not commonly covered in formal procedures or training, and therefore may not be consistently applied or effective. Formal procedures and training are needed to foster standardization and effectiveness. Conducting RCs is one way to mitigate the potentially negative effects associated with pilots' disconnection from IA processing, as well as their natural automation bias.

**Examples of the Application of Reasonableness Checks of IA System Inputs/outputs**

Each of the examples below presents a scenario involving IA system inputs/outputs that compares and contrasts two possible crew responses:

1) What can happen (or actually has happened) when the crew uses the information without performing an RC (that is, without verifying/validating the accuracy and applicability of the information); and
2) How the conduct of an RC prior to use of the information can trap the issue and prevent degradation of safety margins.

The following example scenarios are based on actual situations encountered in air carrier flight operations:

**Issues with the Release**

- **Fuel burn calculation.**

  Due to an error in an overnight software update to the dispatch computer systems, several morning flights were inadvertently planned with a single-engine fuel burn rate in cruise, resulting in all fuel calculation figures being much too low. All fuel numbers on the release were internally consistent but were not sensible for that type of aircraft.

  - **USE of information without RC** led several crews to simply verify that the planned fuel on board matched the indicated fuel on board – as per procedure (taking for granted that the calculation must be right, since it almost always <u>is</u> right). This led several aircraft to depart with the dispatch-planned, but wrong, fuel load. Upon realizing their problem enroute, these crews had to divert for additional fuel.
  - **RC of information BEFORE use** would involve the crew's use of a simple rule of thumb to compare the planned fuel numbers with known approximate figures, and thereby trap an error. (For example, "We burn about 6,000 lbs. per hour, so for a 2.5-hour flight we need at least 15,000 lbs. Hmmm, why does the release say only 10,000 lbs.? That can't be right.")

- **Flight plan - Is it taking you to where you need to go / are expecting to go? Does it take weather into account?**

  Dispatch planned some flights on a route leading through an area of forecast convective weather with moderate turbulence when alternative routes were available.

  - **USE of information without RC** led some crews to simply see that the release route matched the air traffic control cleared route, and also matched the FMS programmed route. (Perhaps taking for granted that the planned route must be right, since it almost always is right.)
  - **RC of information BEFORE use** would have involved the crew comparing the planned route with readily available weather information, and considering whether the route made sense. (For example, "Why are we flying the West Atlantic Route System routes to the Caribbean islands straight through the hurricane, when we could take the on-shore (coastal) route and be in the clear?")

**Issues with Performance numbers, configuration, weight and balance (takeoff or landing)**

- **Do they match what you expected, given number of passengers/baggage?**

  Mistaken load entries (either by crew or by central load planning) into performance planning software has led to computed takeoff speeds being set too low, which has resulted in some dangerous takeoff incidents (e.g., Emirates Flight 407, Melbourne, Australia, March 20, 2009). An example of this phenomenon occurred recently on several CRJ200s. *On ACARS initialization, after passenger and cargo information had been manually entered by the pilots, an auto uplink caused the passenger and cargo information to be reduced to all zeros. The performance data returned by the IA system gave performance values 10,800 pounds lighter than actual weight.*

  - **USE of information without RC** led some crews to simply check to see that the auto-generated performance numbers match numbers programmed in the FMS.
  - **RC of information BEFORE use** would involve the crew comparing computed takeoff speeds with estimated numbers for heavy weights. (For example, "We're full today. That means we should normally see takeoff speeds of at least 140 kts at this flap setting. The speeds presented are far too slow for the load we have on the plane.")

- **Issues with Top of Descent calculation**

  In the latter portion of cruise flight, the FMS has calculated, and the navigation display (ND) indicates, a top-of-descent (TOD) point for the Standard Terminal Arrival (STAR) Procedure. FMS programmed winds include a significant headwind component, but actual winds differ (no headwind). As a result, the TOD is positioned incorrectly for actual conditions.

  - **USE of information without RC** can lead a crew to simply begin descent at the FMS-generated top of descent point, resulting in being unable to meet the prescribed crossing restrictions.
  - **RC of information BEFORE use** would include a 3:1 mental math calculation (taking actual winds into consideration) to determine if the displayed TOD is sensible. Upon discovering that the FMS generated TOD point is too close to the crossing restriction, the crew knows to begin the descent sooner.

### Issues with Navigation initialization

- **Does the Nav Display match real world before takeoff? (Inertial Reference System (IRS) misalignment)** IRS misalignment at the gate drove the FMS current position calculation to be inaccurate before takeoff. (See also Air Asia X Flight 223, Sydney, March 10, 2015.)
  - **USE of information without RC** has led some crews to simply check that the FMS flight plan matches the release, which matches the clearance (per procedure), leading the crew to believe that all is well.
  - **RC of information BEFORE use** would involve comparing the picture on the ND map with what is visible out the window. (For example, "Why doesn't our takeoff runway appear here in front of us?") An RC would also involve considering whether distance to the first fix is sensible. (For example, "Why does this say our first waypoint is 500 NM away?")

## VI. Background Information

ACT ARC Recommendation 18-1 partially addresses the development of training information for Information Automation in the FPM WG Scope of Work and ACT ARC Initiative #36 (see below):

<u>FPM WG Scope of Work:</u>

- Develop or enhance guidance for training on Information Automation systems or functions (e.g., performance management calculations, multi-function displays), including FMS use, to ensure information systems policies and procedures support, and do not detract from, flight path management.

<u>ACT ARC Initiatives:</u>

- Initiative #36: Develop or enhance guidance for training Information Automation systems or functions (e.g., performance management calculations, multi-function displays), including FMS use, to ensure information systems policies and procedures support, and do not detract from, flight path management.

<u>Source Reports</u>

- Federal Aviation Administration. (2017). Standard Operating Procedures and Pilot Monitoring Duties for Flight Deck Crewmembers. Advisory Circular No. 120-71B. Washington, DC.
- PARC/CAST Flight Deck Automation Working Group. (2013). Operational Use of Flight Management Path Management Systems. Washington, DC.
- Flight Safety Foundation. A Practical Guide for Improving Flight Path Monitoring, Final Report of the Active Pilot Monitoring Working Group. November 2014.

### References

Skitka, L. J., Mosier, K. L., & Burdick, M. (2000). Accountability and automation bias. International Journal of Human-Computer Studies, 52, 701 - 717