Takeoff Misconfiguration
Joint Safety Analysis and Implementation Team

Final Report
Analysis and Recommendations

June 7, 2018

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Provided to the Commercial Aviation Safety Team

from

The Takeoff Misconfiguration Joint Safety Analysis and Implementation Team

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OVERVIEW

The Commercial Aviation Safety Team (CAST) chartered the Takeoff Misconfiguration Joint Safety Analysis and Implementation Team (TOMC JSAIT) in August 2015 to—

1. Review the analysis and results from the Aviation Safety Information Analysis and Sharing (ASIAS) program's Aircraft Misconfiguration Directed Study.
2. Identify the occurrence of problems and contributing factors that lead to takeoff misconfiguration events.
3. Recommend mitigations, as appropriate, using the CAST analysis process.

The TOMC JSAIT was chartered after CAST reviewed the takeoff misconfiguration event rates from ASIAS and evaluated the risk of a future takeoff misconfiguration accident in the United States.

The TOMC JSAIT analyzed three misconfiguration scenarios:

1. Attempted takeoff with the flaps in the retracted position;
2. Attempted takeoff with the flaps set to a takeoff position that is different from the setting intended and/or required by performance calculations; and
3. Early flap retraction in the first 20 seconds after liftoff, typically before gear retraction.

The TOMC JSAIT performed its work in two phases. In Phase I, the team concentrated on analyzing and mitigating the risk of the first scenario, as it was considered the highest risk based on historical data. In Phase II, the team analyzed the risk of the second and third scenarios, which have not contributed to a known accident in air carrier operations, but nevertheless were determined to be a cause for further review.

PHASE I SUMMARY

The TOMC JSAIT built on the results of the ASIAS Aircraft Misconfiguration Directed Study by further correlating misconfiguration event rates, as observed in ASIAS Flight Operational Quality Assurance (FOQA) data, against the policies used by air carriers to direct the setting of takeoff configuration. From this data, the team concluded the takeoff misconfiguration event rate could be significantly improved by encouraging air carriers to conduct takeoff configuration procedures before commencing taxi.

The team also reviewed Aviation Safety Action Program (ASAP) flightcrew narrative reports in ASIAS to better understand the causes and contributing factors. These reports indicated the takeoff configuration warning system (TCWS) is a key mitigation barrier against taking off with the flaps retracted. Because the TCWS is also the final barrier, downstream of numerous checklist points and air carriers' standard operating procedures (SOP), it remains a critical element in preventing misconfigured takeoffs. The second-most prevalent mitigation reported by flightcrews was catching the error during a flow check procedure or normal flightdeck scanning.

PHASE II ANALYSIS SUMMARY

In Phase II of its work, the TOMC JSAIT focused on the remaining two scenarios:

- Attempted takeoff with the flaps set to a takeoff position that is different from the setting intended and/or required by performance calculations; and
- Early flap retraction in the first 20 seconds after liftoff, typically before gear retraction.

Without historical data showing that either of these two scenarios has caused a fatal commercial accident in the past, the team undertook an analysis to assess and quantify the potential risk that each presents. The team then reviewed the events to identify any unique issues and factors that may contribute to levels of unacceptable risk, and to determine whether additional mitigations beyond those identified in Phase I may be necessary. Based on this review, the team concluded no additional mitigation activity is warranted at this time.

SAFETY ENHANCEMENTS (SE)

The TOMC JSAIT developed three SEs to mitigate the risk of attempted flaps zero takeoff in Phase I, and concluded these SEs were also applicable to the wrong flap takeoff scenario studied in Phase II.

- SE 227 recommends air carriers review their current SOP related to configuration for takeoff in light of this new information.
- SE 228 encourages airplane manufacturers to develop enhanced airplane design features that increase flightcrew awareness of system failures or incomplete/incorrect takeoff configuration before taking the active runway.
- SE 229 encourages manufacturers and operators to review the design and maintenance of TCWS to ensure reliability.

In October 2016, CAST approved these three SEs to address the risk of takeoff misconfiguration.

SE 227—AIR CARRIER PROCEDURES FOR TAKEOFF CONFIGURATION

SE 227 recommends air carriers review and revise their SOP related to takeoff configuration as follows:

- Air carriers should review and consider modification of current policies and procedures to configure flaps and slats before taxi, consistent with other operational requirements.
- Air carriers should develop specific, robust procedures to verify takeoff flap position for those types of operation in which takeoff configuration must be delayed until after taxi commences, which include—
    - Single-engine taxi operations on some airplane models, as consistent with airplane manufacturer recommendations;

    - Taxi out on slush-covered runways, as consistent with airplane manufacturer recommendations; and
    - Operations in which the airplane must undergo deicing/anti-icing, and the holdover time for flaps-deployed deicing/anti-icing is insufficient to ensure the airplane surfaces are free of ice for takeoff.
- The Federal Aviation Administration (FAA) should evaluate the impact that icing holdover times have on the potential for increased (or reduced) likelihood of potential takeoff misconfiguration.
- Airplane manufacturers should evaluate their recommended procedures to minimize the risk of takeoff flap misconfiguration.

Most of this SE's cost will be borne by air carriers for the modification of their SOP and checklists, if necessary.

SE 228—Airplane Design Features To Facilitate Proper Takeoff Configuration

SE 228 recommends airplane manufacturers develop and make available enhanced airplane design features that increase flightcrew awareness of system failures or incomplete/incorrect takeoff configuration, before taking the active runway. These design changes are envisioned to be implemented on new type certificate programs and major derivative, amended type certificate programs involving redesign of flightdeck avionics. No retrofits of these design changes are anticipated or expected.

These design features were identified by the TOMC JSAIT based on evaluation of existing features in some new airplane models that, in the experience of the pilots on the team, greatly improved their awareness of airplane configuration and/or greatly reduced distractions that can result in a misconfiguration. These features were considered by all manufacturers on the team to represent expected improvements in newer airplanes that should be included to improve airplane performance and ease of operation. The recommended features, and their expected impact on the potential for takeoff misconfiguration, are—

- Electronic checklists, which prevent the flightcrew from advancing to the next checklist item until the airplane systems sense the completion of the current item.
- Tactile configuration tests, such as a "push to check" button, which provide a positive indication that the airplane is correctly configured when pushed, or otherwise alert the flightcrew to the element not configured correctly.
- Situational monitoring systems that—
    - Cross-check the actual airplane flap setting against the setting expected from the performance data entered in the flight management system.
    - Cross-check the airplane position against the selected runway in the flight management system and alert to a position disagreement.

- Verify and validate airplane takeoff performance data to confirm the airplane is properly configured for the selected runway.

The primary action of the SE is to provide the CAST recommendations to the manufacturers of transport airplanes and to seek their commitment to pursue implementation of these features to the highest degree practical on new airplane programs. The cost for design and certification of these systems in new airplanes is expected to be part of the entire new product development cost and is thus not broken out separately.

SE 229—Takeoff Configuration Warning System Maintenance and Operational Assurance

SE 229 recommends airplane manufacturers' and air carriers' maintenance programs include appropriate actions and procedures to ensure proper operation of the TCWS.

Specifically, SE 229 recommends manufacturers—

- Evaluate any of their airplane models with specific TCWS maintenance requirements to ensure adequate system reliability in accordance with FAA Advisory Circular 25.703–1, Takeoff Configuration Warning Systems.
- Review their airplane models' system architectures to determine which circuit breakers, if pulled, could directly or indirectly disable the TCWS, and communicate this information to air carriers.
- Review their airplane models' master minimum equipment lists (MMEL) to ensure no approved items could affect availability of the TCWS.

In addition, SE 229 recommends air carriers—

- Ensure their maintenance programs are consistent with the latest manufacturer recommendations for maintenance intervals on the TCWS.
- Review maintenance programs to ensure any circuit breakers that are pulled during maintenance or troubleshooting that could affect availability of the TCWS are re-engaged before release for flight.
- Review their minimum equipment lists (MEL) to ensure no approved procedures could allow flightcrews to disable the TCWS by pulling circuit breakers.

CONCLUSION AND RECOMMENDATIONS

The TOMC JSAIT completed its charter from CAST by recommending the adoption of three SEs to CAST in June 2016, and by completing and closing the remaining risk analyses for the early flap retraction scenario in July 2017. CAST approved all three SEs and added them to the CAST Safety Plan in October 2016. CAST recommends the CAST stakeholder community implement all three Takeoff Misconfiguration SEs to reduce the future risk and cost of takeoff misconfiguration accidents in U.S. operations. CAST also recommends international safety organizations review the Takeoff Misconfiguration SEs and develop suitable implementation plans for their regions. All CAST SEs can be found on the SKYbrary website.