



TSB Recommendation A18-07

Taxiway design and conspicuity

The Transportation Safety Board of Canada recommends that the Greater Toronto Airports Authority make physical changes to the taxiway layout to address the risk of incursions between the parallel runways and, until these changes can be made, make further improvements to increase the conspicuity of the runway holding positions.

Air transportation safety investigation report	A17O0038
Date the recommendation was issued	31 January 2019
Date of the latest response	August 2023
Date of the latest assessment	February 2024
Rating of the latest response	Satisfactory Intent
File status	Active

Summary of the occurrence

Air Transportation Safety Issue Investigation A17O0038 examined 27 runway incursions that occurred between June 2012 and November 2017 at 2 closely spaced parallel runways known as the “south complex” at Toronto/Lester B. Pearson International Airport (CYYZ), Ontario. The 27 cases studied were not the only incursions at CYYZ during that period. However, their number and similarity raised concern and led the TSB to examine them more closely as a group, in order to determine their systemic underlying causes and contributing factors and to assess the degree of ongoing risk.

All of the incursions occurred on the inner runway (Runway 06L/24R) after the flight crews involved had landed on the outer runway (Runway 06R/24L), had been instructed by air traffic control (ATC) to hold short of Runway 06L/24R, and, despite intending to stop, had missed the visual cues depicting the runway holding positions.

The taxiway layout between the runways has several characteristics that are uncommon compared to those at other airports, both within North America and internationally. The runways are spaced a relatively short distance (305 m [1000 feet]) apart, and the rapid exit taxiways (RETs) provide direct access to the adjacent runway without first progressing to another transitional surface. The runway holding positions are located immediately following a

65° curve and are situated at greater distances from the protected inner runway than they are at other airports.

Regional airlines that are based in the United States and that operate regional jets were involved in a disproportionate number of the incursions, both in total and in terms of the rate of incursions per landing. This was likely due to foreign flight crews being unfamiliar with the uncommon taxiway layout between the parallel runways at CYYZ and to the increased speed at which their smaller aircraft types often approached the runway holding positions.

It is for these reasons that some foreign flight crews did not anticipate the location of the stopping position on each RET and so did not direct their attention outside the aircraft at the required time to identify the visual cues indicating the runway holding positions.

Most of the flight crews were aware of the south complex areas at increased risk for runway incursions because they are designated as “hot spots” on the airport charts supplied to crews. However, that guidance, together with limitations in operators’ requirements for taxi briefings, did not bring crews’ attention to specific strategies to mitigate the risk of incursion. Instead, the crews followed their usual routines after exiting the landing runway and proceeded with their post-landing checks. The timing of those tasks distracted them at a point when limited time was available to recognize the visual cues requiring them to stop, and contributed to their overlooking those cues.

In the occurrences examined in this study, ATC recognized the incursions quickly and took appropriate actions that either caused the incurring aircraft to stop or reduced the severity of the consequences. As a result, most of the aircraft did not reach the inner runway surface. Of the 3 that did reach the surface, 2 were at an intersection beyond the point at which the departing aircraft presented a risk of collision. In the 3rd case, ATC cancelled the takeoff clearance for the departing aircraft before it began its take-off roll.

In another occurrence, ATC instructed the incurring aircraft to stop before it had reached the runway surface, then immediately told the departing aircraft to abort its takeoff. The crew of the departing flight did not recognize the instruction to abort because the phraseology was unfamiliar and because it was not repeated as they were used to; as a result, they continued their departure. The incurring aircraft stopped before reaching the runway surface, and the departing aircraft overflew the intersection without further event.

International guidance for the prevention of runway incursions recommends that, once areas presenting a hazard of incursion have been identified, strategies to manage or mitigate that risk should be implemented and should include awareness campaigns, additional visual aids, alternate routings, or, ultimately, the construction of new taxiways.

Various awareness campaigns and advisories have been issued since 2012, and visual aids have undergone progressive but significant improvements. Those strategies have likely resulted in periodic, but not permanent, reductions in the incidence of incursions.

Revising the post-landing procedures of flight crews may lead to increased vigilance and reduced distraction, but it is unlikely to eliminate crews' expectations that visual cues will be situated in common locations or induce crews to reduce their taxiing speeds so that they have more time to recognize the cues.

All but one of the applicable strategies recommended by international guidance have been implemented on the south complex; the remaining strategy is to make physical changes to the taxiway layout. A change of this scale may be required to increase the distance and taxiing time between runway holding positions, reduce the taxiing speeds of aircraft approaching hold-short locations, and prevent direct access to adjacent runways from RETs. Among the possible reconfigurations for achieving these objectives is the addition of an intermediate taxiway between the runways and parallel to them, as found at numerous airports with parallel runways, and the re-situating of visual cues in common locations.

The Board concluded its investigation and released report A1700038 on 31 January 2019.

Rationale for the recommendation

The taxiway layout between the closely spaced parallel runways at Toronto/Lester B. Pearson International Airport (CYYZ) has several characteristics that are uncommon when compared with those at other airports, both within North America and globally. The runways are spaced a relatively short distance apart, and the rapid exit taxiways provide direct access to the adjacent runway without first progressing to another transitional surface. The runway holding positions are located immediately following a 65° curve and are situated at greater distances from the protected inner runway than is seen elsewhere.

These uncommon characteristics, and the short distance between the runways, present significant challenges for flight crews. When exiting the landing runway, crews are normally occupied with other tasks and, because they are using a rapid exit taxiway, the aircraft is usually travelling at taxi speeds that are faster than typical. A flight crew's unfamiliarity with these uncommon characteristics, the short amount of time and distance available, and distraction due to other tasks reduces their ability to identify the runway holding positions. As demonstrated by the occurrences covered in this investigation, if these positions are not identified, aircraft can incur on the other active runway and potentially collide with another aircraft.

International guidance recommends many strategies to address runway incursions. All but one of these have been implemented on the south complex at CYYZ; the remaining strategy is to make physical changes to the taxiway layout.

A change of this scale may be required to increase the distance and taxiing time between runway holding positions, to reduce the taxiing speeds of aircraft approaching the hold-short line, to prevent direct access to adjacent runways from rapid exit taxiways, and to re-situate visual cues in common locations. Among the possible reconfigurations that may address these factors is the inclusion of an intermediate parallel taxiway between the runways, as found at numerous other airports with parallel runways.

It is recognized, however, that a change this significant cannot be made overnight, and simpler incursion mitigation strategies may need to be implemented, or current strategies improved, in the meantime. Although much has been done over the past few years to improve the conspicuity of the runway holding positions, options still remain, such as altering the type, amount, or intensity of the runway holding position lighting, which may further improve the likelihood that flight crews identify the cues and stop before incurring on the runway.

Therefore, the Board recommended that

the Greater Toronto Airports Authority make physical changes to the taxiway layout to address the risk of incursions between the parallel runways and, until these changes can be made, make further improvements to increase the conspicuity of the runway holding positions.

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Previous responses and assessments

August 2019: response from the Greater Toronto Airports Authority

The GTAA has carefully considered the TSB's Report and is working diligently to assess solutions to address the TSB's recommendation. The GTAA has identified several design concepts for field test in the Fall 2019, including a significant enhancement to the lighting, runway/taxiway hold position markings, and painted information markings located on the high-speed runway exits to increase the conspicuity of the hold positions. The objective of the test in the Fall 2019 is to finalize the design concept for an operational trial in 2020, and full installation during planned runway rehabilitation activities in 2021. We are also reviewing and analyzing longer-term design solutions.

The design concepts and field testing have been developed in full consultation with Toronto Pearson's Local Runway Safety Team (LRST). The LRST is a multi-stakeholder group that includes airline representatives, the TSB experts, Transport Canada, pilots and airline pilot associations (e.g. ALPA, IFALPA), NAV CANADA, and the Canadian Business Aviation Association. It is the GTAA's view that the LRST represents the most appropriate forum to address the TSB's recommendation, as it is capable of dynamic and iterative evaluation of options.

The GTAA considers this ongoing work relating to design and concept testing and that of the LRST to be meaningful progress in addressing the TSB's recommendation to the GTAA.

March 2020: TSB assessment of the response (Satisfactory in Part)

The Board is encouraged that the Greater Toronto Airports Authority is reviewing and analyzing longer-term design solutions to address the deficiencies identified in the report, and the resultant recommendation to make physical changes to the layout.

As well, from observing the consultations in collaboration with the local runway safety team, the TSB acknowledges that progress is being made towards making further improvements to

increase the conspicuity in the area of the runway holding positions, including the recent addition of RWY AHEAD painted markings, which were installed in November 2019.

While this progress is notable, until these improvements are completely implemented as planned in 2021, and until longer-term physical design solutions are analyzed and adopted, the risk of runway incursions on the south complex will remain.

Therefore, the Board considers the response to Recommendation A18-07 to be **Satisfactory in Part**.

September 2020: response from the Greater Toronto Airports Authority

As requested in your correspondence dated June 2, 2020, the purpose of this letter is to provide you with an update regarding our action plan to address recommendation A18-07 as it relates to the issue of south complex runway incursions at Toronto Pearson International Airport.

In December 2019, a live-test was undertaken using a full-scale mock-up of the amended hold position design and associated lighting configuration with a Canadian Regional Jet (CRJ) aircraft and Flight Crew. The test resulted in a significant improvement to the conspicuity of the hold position, and an increased Flight Crew visibility of the hold position from approximately 80m in the current configuration to approximately 500m in the new design. Flight Crew feedback was also favourable and supportive of the new design.

A full installation of the amended hold position design is planned for implementation on taxiways D4 and D5, as an operational trial to commence in Q4 2020. The effectiveness of the hold position configuration can only be assessed when there is simultaneous use of the runways on the South Complex. As aviation activity has declined steeply due to COVID-19, there is currently very little demand for such simultaneous runway operation. Accordingly, the duration of the trial will be extended through 2021 and possibly longer, to determine if the hold positions on other applicable rapid-exit taxiways on the south complex should be similarly modified.

Painted information markings indicating 'Runway Ahead 200ft' have also been painted on taxiways D1, D2, D3, D4, D5 that adjoin the south complex runways.

Given that aviation activity does not warrant simultaneous operation of the two runways on the south complex, the risk of incursion onto Runway 06L/24R from aircraft landing on Runway 06R/24L, is also greatly diminished and should remain so for the foreseeable future. Accordingly, further consideration of other physical changes to the south complex taxiway design, has been deferred for the time being.

March 2021: TSB assessment of the response (Satisfactory in Part)

The TSB is encouraged to hear about the progress of the Greater Toronto Airport Authority's (GTAA's) trials related to conspicuity improvements, as well as the painting of markings indicating "Runway Ahead 200ft" on several taxiways that adjoin the south complex

runways. These markings should help increase the conspicuity of the visual cues in the area of the runway holding positions.

The TSB recognizes that there has been a reduction in risk as a result of the decreased demand for simultaneous use of the closely spaced parallel runways in the south complex during the pandemic, and understands the GTAA's decision to defer further consideration for the time being.

While the reduction in risk and deferral of further action is recognized, unless the planned improvements are completely implemented, and/or longer-term physical design solutions are analyzed and adopted, the risk of runway incursions on the south complex runways may return to its previous level once airport movements resume to a more typical activity level.

Therefore, the response to Recommendation A18-07 is assessed as **Satisfactory in Part**.

November 2021: response from the Greater Toronto Airports Authority

As requested in your correspondence dated August 3, 2021, the purpose of this letter is to provide you with an update regarding our action plan to address recommendation A18-07 as it relates to the south complex runway at Toronto Pearson International Airport.

In April 2021, an operational trial commenced using angled hold position installations at Taxiways D4 and D5 after extensive testing and live simulations involving members of our Local Runway Safety Team (LRST).

Since the commencement of the trial, approximately 10,000 aircraft have experienced the angled hold position designs with feedback from Flight Crews being positive in nature and zero runway incursions.

The GTAA has applied to Transport Canada for additional installations of the angled hold position designs as part of the scope for the planned 2022 reconstruction of Runway 06L/24R.

Further consideration of other physical changes to the south complex taxiway design may be considered in the future once the trial has concluded and the results are assessed.

March 2022: TSB assessment of the response (Satisfactory in Part)

The Board is pleased to learn of the results achieved from the ongoing Greater Toronto Airports Authority (GTAA) operational trial related to conspicuity improvements at taxiways D4 and D5 that adjoin the south complex runways. An installation of the amended hold position design was implemented on taxiways D4 and D5 to conduct an operational trial involving extensive testing and live simulations. As evidenced by the approximately 10 000 aircraft using the new angled hold position designs with no runway incursions, and the subsequent application to Transport Canada for additional installations, the Board is encouraged by the GTAA's meaningful progress and recognizes the reduction of risk related to runway incursions.

According to the GTAA, the trial will be extended through 2022 and possibly longer, to determine if the hold positions on other applicable rapid exit taxiways on the south complex should be similarly modified. As such, until the trial has concluded and the results are assessed, there is a residual risk for the remaining taxiways that adjoin the south complex runways.

Therefore, the response to Recommendation A18-07 is assessed as **Satisfactory in Part**.

September 2022: response from the Greater Toronto Airports Authority

As requested in your correspondence dated June 28, 2022, the purpose of this letter is to provide you with an update regarding our action plan to address recommendation A18-07 as it relates to the south complex runway at Toronto Pearson International Airport.¹

In April 2021, an operational trial commenced using angled hold position installations at Taxiways D4 and D5 after extensive testing and live simulations involving members of our Local Runway Safety Team (LRST).

Since the commencement of the trial, approximately 29,000 aircraft have experienced the angled hold position designs with feedback from Flight Crews being positive in nature and zero runway incursions.

The GTAA applied to Transport Canada for additional installations of the angled hold position designs as part of the scope for the planned 2022 reconstruction of Runway 06L/24R. However, following discussions with Transport Canada, it was resolved to expand our operational trial with the installation of three hold position reconfigurations on taxiways D1, D2, and D3. These installations will be configured with additional fixtures as compared to current installations at these locations, with fixtures on one side of the taxiway rotated 30 degrees in the direction of the approaching aircraft.

Further consideration of other physical changes to the south complex taxiway design may be considered in the future once the trial has concluded and the results are assessed.

February 2023: TSB assessment of the response (Satisfactory Intent)

The Board is pleased to learn of the results from the ongoing Greater Toronto Airports Authority (GTAA) operational trial related to conspicuity improvements at taxiways D4 and D5 that connect the south complex runways. An amended hold position design was implemented on taxiways D4 and D5 to conduct an operational trial involving extensive testing and live simulations. Given the approximately 29 000 aircraft using the new angled hold position designs with no runway incursions, and the expansion of the operational trial with the installation of three hold position reconfigurations on taxiways D1, D2, and D3, the Board is

¹ All responses are those of the stakeholders to the TSB in written communications and are reproduced in full. The TSB corrects typographical errors and accessibility issues in the material it reproduces without indication but uses brackets [] to show other changes or to show that part of the response was omitted because it was not pertinent.

encouraged by the GTAA's meaningful progress and recognizes the reduction of risk related to runway incursions in that area.

However, until the trial has concluded and the results are assessed, there remains a residual risk for runway incursions on taxiways that adjoin the south complex runways.

Therefore, the Board considers the response to Recommendation A18-07 to be **Satisfactory Intent**.

Latest response and assessment

August 2023: response from the Greater Toronto Airports Authority

Since April 2021, there has been an operational trial using angled hold position installations at Taxiways D4 and D5 after extensive testing and live simulations involving members of our Local Runway Safety Team (LRST).

Since the commencement of the trial in April 2021 until the end of July 2023, approximately 73,000 aircraft have experienced the angled hold position designs on Taxiways D4 and D5 with feedback from Flight Crews being positive in nature and zero runway incursions.

The GTAA applied to Transport Canada (TC) for additional installations of the angled hold position designs as part of the scope for the planned 2022 reconstruction of Runway 06L/24R; however, TC asked that we trial an alternative design.

Accordingly, in November 2022 our operational trial was expanded with the installation of three hold position reconfigurations on taxiways D1, D2, and D3. These installations are configured with additional fixtures as compared to current installations at these locations, with individual fixtures on one side of the taxiway rotated 30 degrees in the direction of approaching aircraft in accordance with Transport Canada standards defined in *TP312 – Aerodrome Standards & Recommended Practices*.

Since the addition of these installations at Taxiways D1, D2, and D3 in November 2022, until the end of July 2023, approximately 15,000 aircraft have experienced these hold position designs with feedback from Flight Crews being positive in nature and zero runway incursions.

The primary runway incursion risk on the south complex presents during what is known as “tripling” operations where Runway 06L/24R is used for departures and Runway 06R/24L is used for arrivals. This operation has not been utilized since the onset of the pandemic in Q1 2020, and we do not anticipate this type of operation to return until at least 2026 due to a combination of systemic capacity related factors. As such, the evaluation of the effectiveness of the increased conspicuity of these positions will continue.

Further consideration of other physical changes to the south complex taxiway design may be considered in the future once the trial has concluded and the results are assessed.

February 2024: TSB assessment of the response (Satisfactory Intent)

The Board is pleased with the Greater Toronto Airports Authority (GTAA) continued progress and reporting on positive results with its ongoing operational trial using angled holding position installations at taxiways D4 and D5 at the south complex runway at Toronto/Lester B. Pearson International Airport (CYYZ), Ontario.

As indicated in its latest response, the GTAA expanded the operational trial with the installation of three holding position reconfigurations with additional fixtures (at TC's request) on taxiways D1, D2, and D3. Since November 2022 to the end of July 2023, approximately 15 000 aircraft have encountered the expanded installations on taxiways D1, D2, and D3. This is in addition to the approximately 73 000 aircraft that have experienced the angled holding positions on taxiways D4 and D5 from April 2021 to the end of July 2023. The GTAA noted that feedback from flight crews remains consistently positive with no reported runway incursions.

Notwithstanding the trial data received to date, the GTAA acknowledges the primary runway incursion risk during "tripling" operations (where Runway 06L/24R is used for departures and Runway 06R/24L is used for arrivals). Although this operation has been inactive since the beginning of 2020 owing to the onset of the COVID-19 pandemic, the GTAA does not anticipate the resumption of "tripling" operations before 2026. The GTAA stated it will continue to evaluate the effectiveness of the increased conspicuity of these positions.

The Board is encouraged that the GTAA will continue with its evaluation, but acknowledges that the effectiveness of the changes may not be evident until the dormant "tripling" operations resume, which is likely not until 2026. Consequently, until the effectiveness of these improvements is verified, there remains a risk for runway incursions on the taxiways that adjoin the south complex runways.

Therefore, the Board considers the response to Recommendation A18-07 to show **Satisfactory Intent**.

File status

The TSB will continue to monitor the progress of the GTAA's actions to mitigate the risk associated with the safety deficiency identified in Recommendation A18-07, and it will reassess the deficiency on an annual basis or when otherwise warranted.

This deficiency file is **Active**.