JET BLAST: HOW SMALL CHANGES CAN LEAD TO BIG OUTCOMES

Jet blast is an aerodrome hazard and is mitigated in a number of ways. Whilst pilots are aware of the implications of familiar aircraft, new aircraft can introduce small but unknown changes, with significant effects, as **Ulf Henke** explains.

KEY POINTS

- **Seemingly minor changes to the type and operation of aircraft can have major effects.**
- **Sometimes we may not be aware of the side effects caused by our actions.**
- **Sharing information on negative surprises may help to prevent similar events in the future.**

Airborne aircraft create wake turbulence, with possible hazards to subsequent or crossing aircraft. To avoid a negative impact on the subsequent aircraft in the air, appropriate wake turbulence separation must be applied. ICAO and national as well as supranational entities have, of course, set standards on minimum separation distances between aircraft.

On the ground one of the main hazards is the jet blast caused by the operation of aircraft engines. Here, there are no such minimum distances (of course, the aircraft are not supposed to touch each other for many good reasons).

Jet Blast Risks

The potential risks resulting from the jet blast of an aircraft in operation on aerodromes is well known. According to ICAO Document 9157 (Aerodrome Design Manual) Part 2 Appendix 2, "jet blast velocities above 56 km/h are considered to be undesirable for personal comfort or for the operation of vehicles or other equipment on the movement aera". To avoid the hazard of jet blast velocities, blast fences are used at aerodromes to reduce or eliminate the detrimental effects by deflecting the high air velocities. The application of either fences or screens becomes necessary when it is impractical to provide a safe, reasonable separation between aircraft engines and people, buildings or other objects on the aerodrome.

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Many aerodromes permit aircraft to taxi on the apron only at minimum engine speed. In addition, so-called break-away areas have been established to ensure the necessary appliance of break-away thrust only in areas where it is safe to do so. Some aerodromes restrict the application of thrust even further.

Every once in a while, a flight crew is surprised that whilst taxiing quite slowly; having almost reached their parking stand on their two or ten o' clock position, the aircraft is too slow to coast the turn onto position. The solution: a little more thrust, and the ninety degree turn onto the stand is a success. This is likely to happen at nearly all aerodromes in the world. In some cases, the ground handling crew near an aircraft parked on the opposite side of the taxi lane got a little shaken up by the wind velocity. The passengers boarding the aircraft had to grip a little tighter to the handrails of the rear stairway of the aircraft they were about to board. Luckily, in these cases no objects at the stand on the opposite side of the taxi lane were blown against persons or the parked aircraft.

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Fuel Savings and Jet Blast

For environmental reasons and fuel saving, there has been an increase of single-engine or less-than-all-engine-running taxi operations. By shutting down one or more engines of an aircraft after landing, airlines can significantly reduce carbon and nitrogen oxide emissions produced by taxiing aircraft on the movement area. Especially in the case of four-engine aircraft, when the taxi procedure is done using just two engines, a considerable amount of fuel can be saved.

However, there are some issues with this practice. For instance, single-engine taxiing causes greater jet blast on the remaining active engine to move the aircraft forward, generating a strong asymmetric force that could also unbalance the aircraft. (The correlation between thrust setting and blast velocity and the allowed taxiing speed may differ depending on the mass of the aircraft, wind direction and speed, height above sea level, temperature and other factors.)

When taxiing in with the starboard engine turned off, left turns require a considerable increase in thrust. Many stands at an aerodrome are placed on a ninety-degree angle to the taxiway centre line. This may be challenging to the flight crew when taxiing in with one engine turned off and at the same time having to avoid a thrust setting which will result in exhaust velocities above the predetermined 'normal' speeds. This is especially problematic if, on the other side of the taxiway, ground handling or passenger boarding via mobile stairs is in progress.

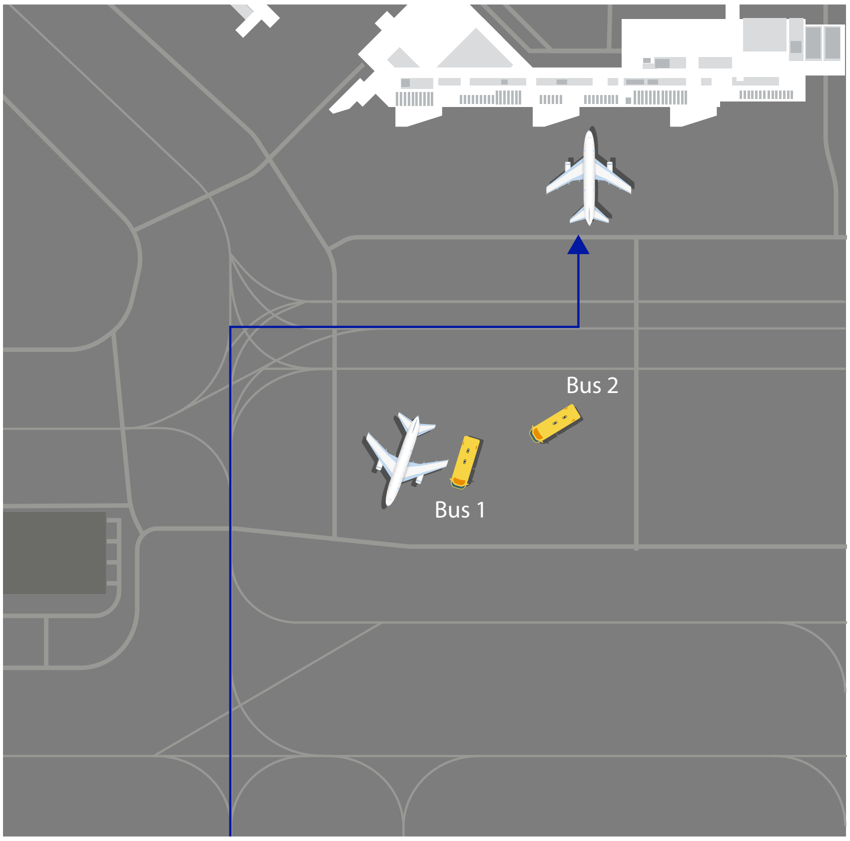

Figure 1: Schematic drawing: Location of the passenger buses in relation to the aircraft

Even worse for those aircraft with one (or more) engines turned off are so-called taxiing in/taxiing out stands via the same taxiway. Flight crews may expect a turn of more than 180 degrees onto the stand, with a predefined thrust setting around or just a little above idle, which is not easy to perform. So some airlines refuse to execute such operations at low visibility, at wind speeds of over 25 knots, or when a sharp turn is needed. (The engines that may be shut down are predefined by the manufacturer of the aircraft for technical reasons, not by operational needs.)

B748 Surprise

This example happened at the beginning of the last decade. I received the information from those involved during my part of the investigation. A major carrier introduced the Boeing B747-8 (B748) into its fleet. According to the information I received, the B748 may be operated with the same type rating as her older sistership, the B747-400 (B744). Prior to performing commercial operations, crews that had a type rating for the older B744 only need familiarisation training on the new subtype.

While taxiing on the apron, the flight crew of the B748 used a recommended very low thrust setting, but as a result the aircraft taxied rather slowly. To counter this, the thrust setting was raised a little prior to curves, while on straight portions of the routing the thrust setting was lowered again. As a result, everything went well. On the last two hundred metres before entering the final parking stand, the taxiway was inclining but only within the limits set by ICAO in Annex 14 and its co-applicable documents. However, the aircraft lost taxi speed due to the gradient. Since the parking stand was located at a ninety-degree angle to the left, the crew increased the thrust setting to make a smooth turn onto the position. The taxi speed was still decreasing, though, and the ninety-degree turn was coming closer.

The thrust setting was further increased, but because of the incline and the low speed of the aircraft, the aircraft was still slowing down. While turning onto the stand, some witnesses observed that, after performing the first 45 degrees of the turn, the aircraft came to a stop momentarily and then continued after additional thrust on engines No. 3 and 4 was employed. Other witnesses recalled that the aircraft made the full turn without stopping, but they also heard that the thrust on engines No. 3 and 4 was raised considerably. After final parking the engines were turned off and post-flight activities started by the flight crew, no abnormalities had been observed from inside the flight deck.

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The situation was totally different on a parking stand on the opposite side of the taxiway. This stand is located about 150 meters south-southwest of the stand that the B748 had been taxiing onto. At the time, the B748 entered its parking stand, ground handling of another large aircraft on the position behind it was in progress and passengers were inside two buses waiting for the cabin crew to release the aircraft for boarding. The passenger buses were parking on the aircraft stand located on the opposite side of the taxiway, the first one facing south, the second one facing southwest, in a sort of V-shape formation.

On the passenger buses, some windows were dented inwards, while others were shattered by the jet blast and shards blown into the buses. In the bus closest to the parked aircraft, the flying shards broke a window on the opposite side. Luckily, the passengers suffered only minor cuts and bruises.

How and why did the incident happen? The flight crew decided to taxi with a minimum thrust setting since they were taxiing very slowly to ensure a safe passage on the apron. Only, when necessary (in due distance before curves), they raised the power setting a little. The investigators of the carrier reported that the flight crew taxied the aircraft according to the recommended thrust setting. Sounds safe, but why did the incident happen the way it did?

The fact that there was a gradient (within the limits set by ICAO and EASA) on the last hundred metres, and that the flight crew decided to taxi with minimum thrust setting, were contributing factors. Additionally, what was not realised by the flight crew while taxiing was that there are some differences in the behaviour of the B744 and the B748. The B748 reacts even more slowly to thrust lever inputs than the B744, although the B744 is already well known for her slow reaction on thrust settings. The crew gave sufficient thrust for a ninety degree turn after early thrust corrections, but several seconds passed until the engines reacted to the lever inputs. Since the flight crew was afraid to come to a stop while taxiing the curve, they set additional thrust on the two starboard engines while taxiing onto their parking stand.

The V-shaped formation of the parked passenger buses may have accelerated the jet blast velocity of the engines, creating a 'Bernoulli effect' as a result. This would have channelled the air in between them and thus accelerated it, blowing some side windows out of the passenger buses. (Note that the European Union has set minimum requirements on the stability and minimum permissible forces to withstand for front side windows of cars, buses, and trucks, but there were no minimum requirements at the time of the incident on allowable forces to side windows.)

A new aircraft may bring surprises, even to experienced crews. Things may happen not as expected and the crew may find out that what they thought was a good idea turns into a problem. Realisation may come too late.

The case studies urge the use of caution when operating the thrust lever while taxiing on the apron. Thrust levers are potent hazards and the liability, in most cases, rests with the flight crew. S

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