Anatomy of a Deep Dive into Airport Taxiway Incidents

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SUMMARY

A Deep Dive exercise was carried out at London Luton Airport (LTN), exploring taxiway incidents with four airlines, Air Traffic Control (ATC), the airport authority London Luton Airport (LLA), a Human Factors expert and a data scientist. The exercise focused on developing a better understanding of Taxiway Errors at LTN and identifying potential mitigations. Eleven key factors underpinning taxiway errors, and nine mitigation pathways were identified, several of which are now being implemented. This paper illustrates the Deep Dive process, and the resources required to make it a success, and recommends it as an agile yet straightforward technique for the Human Factors practitioner.

KEYWORDS

Airport Safety, Deep Dive, Incident Analysis

Background

London Luton Airport (LTN) is the UK's fifth busiest airport. Although LTN has an excellent safety record, taxiway errors continue to occur, albeit on an infrequent basis as they do at many airports. Figure 1 shows the single runway airport and taxiway layout at LTN. Taxiway errors can occur for example when the flight crew of an aircraft become confused about where they are on the taxiway system with respect to other aircraft, or where they need to go. This can result in potential encounters with other aircraft. Whilst such encounters are detectable, and often result simply in delays (e.g. as one aircraft may have to back-track), they can significantly increase workload, and ultimately, they carry safety risk. Analysis of several years' worth of such incidents – which tend to be rare and often seem to have a unique set of causal or contributory factors – did not reveal many specific patterns or candidate countermeasures to reduce the risk of occurrence. Therefore, as part of the Luton Airport (LTN) Safety Stack's ongoing safety programme, a Deep Dive exercise was carried out, lasting a single day, focusing on developing a better understanding of Taxiway errors at LTN, and identifying associated mitigations.

A deep dive (see Kirwan et al, 2021) brings together diverse expert knowledge and attempts to view the problem from multiple angles and aims to go beyond traditional assumptions about what safety barriers – whether physical, procedural or cultural – are working. The following list captures the aims and analytical avenues explored during a deep dive:

- Explore a specific accident or incident trend
- Examine the basis for safety
- Which barriers are working?
- Which barriers are no longer working?
- What are the key Human Factors involved (both positive and negative?)
- Have any external factors changed?

- Have internal factors changed (staffing, training, etc.)?
- Are the procedures still fit for purpose?
- What are the deeper systemic factors?
- Where are the hotspots?
- Where are there best practices?
- What can be shared across airlines & the Stack?

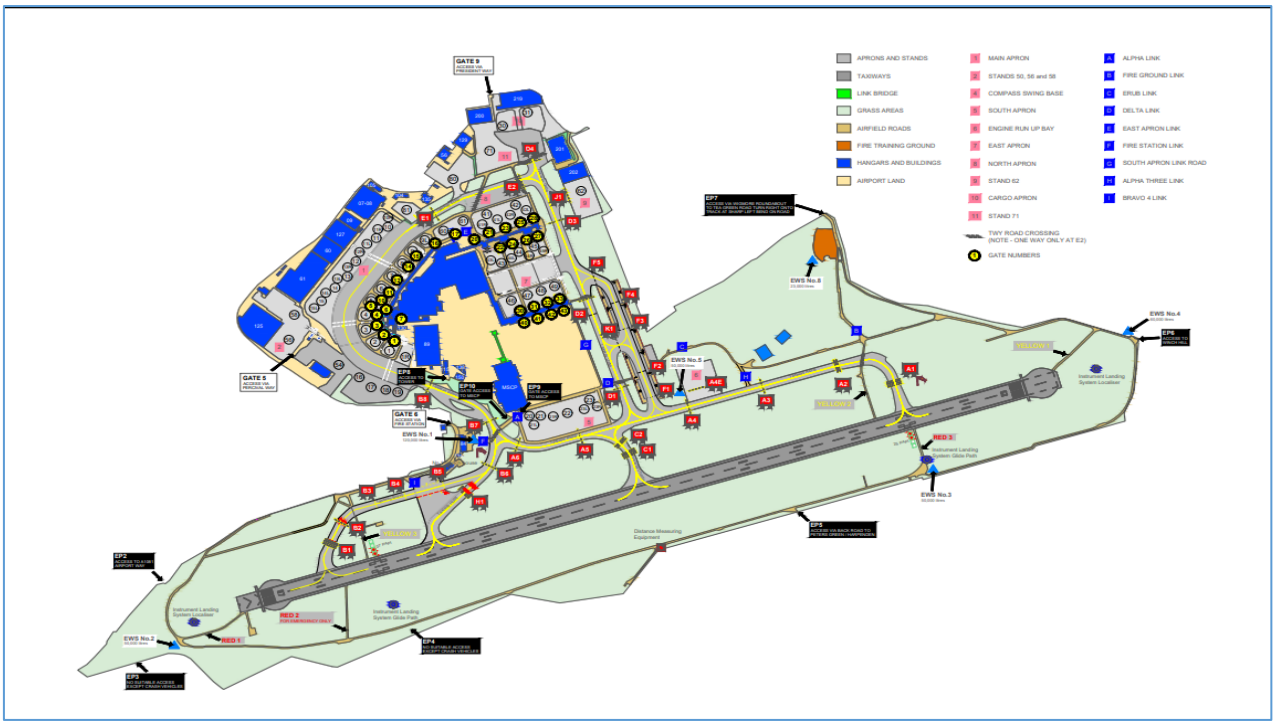

Figure 1: Airport and taxiway layout at London Luton Airport

The Deep Dive was run by EUROCONTROL and LLA with participation from the air traffic service provider and four airlines (including a business jet company), and a data scientist from the HAIKU project[1] involved in the analysis of such incidents. There were three aims of the exercise:

1. Identify the most important factors driving incorrect taxiway errors
2. Identify potential mitigations
3. Consider ways to improve quality and quantity of reporting

Approach & Findings

The in-presence deep dive took place in early October 2024, in National Air Traffic Services (NATS) premises at the airport. Ten incidents (post-COVID, when traffic levels had re-normalised) were selected by the airport Air Traffic Control provider (NATS), to encompass a range of scenarios including inbounds (arrivals) and outbounds (departures), commercial airlines and business jets, different times of day/year, and different causal and contributory factors. The incident information for each event varied, but it helped that both NATS and LLA had reports on the same incident, and some experts present were well aware of the incidents and their background factors.

Participants were experienced (between ten and thirty years), including a control tower supervisor and the chief incident investigator for LTN Tower, an airline Base Captain, a Safety Pilot from another airline, and two experienced captains from a third airline and a business jet operator.

[1] HAIKU is a European Commission funded project: https://haikuproject.eu

Additionally, two London Luton Airport safety officers participated, as well as a Human Factors and Safety expert from EUROCONTROL, a second EUROCONTROL expert familiar with taxiway / runway incursion incidents from the US, and a data scientist who has helped develop the Safety Dashboard for LTN, which includes the past seven years of taxiway incidents.

After a brief introduction to the exercise aims, and a review of the HAIKU Safety Dashboard with respect to Taxiway Errors (see Figure 2), NATS introduced the first incident. From a deep dive perspective this makes sense, as the tower controllers literally have a birds-eye view of such events and are the ones issuing instructions to pilots on where to go and when to stop. Other participants see the event from closer quarters (e.g. pilots), and LLA have a broader systemic viewpoint as they oversee all airport operations.

All participants then freely discussed the event and its potential causes and contributing factors, as well as potential mitigations to prevent recurrence. Human Factors involvement was key here, to help unpack some of the contributory factors (e.g. fatigue, situation awareness, complacency, memory failures and cultural factors, etc.) and clarify their likely independent or compound impacts on human performance. Human Factors can help avoid the 'Tower of Babel' effect where people might use different terms that effectively mean the same thing, as well as help develop a list of valid contributory Human Factors that can then be used to consider countermeasures.

For five of the incidents, it was possible to review them on the Safety Dashboard, though in several cases (for outbounds) there was scant information on why the incident had occurred. The discussions continued in series and benefitted from having pilots who regularly flew from LTN, as well as the NATS Chief Investigator for LTN, who could sometimes provide a little extra insight into factors based on communication with the airlines (i.e. more detail than was in the reports). At lunchtime the controllers escorted the group to the Tower, to show them the 'birds-eye' view and give them a visual reference to some of the incidents, and the taxiway layout. After lunch the incident review continued until approximately 15:30, the deep dive lasting six hours in total.

Figure 2: Extract from Safety Dashboard at LTN Airport

Results

Table 1 summarises the contributory factors identified during the exercise, in the vernacular or common parlance of the aviation experts present. This rich contextual description was preserved because the results were to be presented to the LTN Safety Stack community including other pilots, who would instantly recognise the issues.

Table 1: Causal / Contributory Factors identified in the 10-incident review

Air Traffic Controllers	**Flight Crew (Pilots)**
• Can't expect pilots to identify biz [business] jets • Visual perspective very different between TWR [Tower] and cockpit – ATCOs (Air Traffic Controllers) need to understand the pilot's perspective • Conditional clearances may have reduced HPBs [Hold-Point Busts] but may increase incorrect taxiway selection • Situation awareness • Signage (+ poor vis?) • OJTI [On Job Training Instruction] • Position Handover	• Don't assume, ask • Is wireless pilot the one driving? [Bizjet] • Cultural bias – wants to go first; see conditional clearance as flexible? [General Aviation or business jet issue] Cultural differences in risk understanding or risk norms at other airports. • Language (Pilots whose first language is not English) • Distractions (taxiway looks clear, get distracted by other small tasks, forget to turn) • RWY [Runway] change – familiarity can mean you go left instead of right • Unfamiliarity with airfield • Expectation bias – unusual routing (also if 2nd sector coming back to LTN, will expect same routing) • Construction ongoing (can obscure or confuse viewpoint from the cockpit) • Drivers on mobile phones • Chart size [too small] on some bizjets in the cockpit

It should be noted that one of the above was already seen as improved since these incidents had occurred, e.g. improved signage on the Taxiway system. Others were seen as noteworthy but not having a major impact, e.g. OJTI (On Job Training Instruction) and position handover (both in ATC). Others, e.g. over-familiarity and conditional clearances (e.g. move to this point, then when aircraft XX has crossed, proceed), were viewed as 'double-edge swords', e.g., unfamiliarity with the airfield can lead to poor situation awareness, but over-familiarity can lead to expectation bias or mistaking left for right (or vice versa) when the prevailing RWY direction (25) is reversed (07). Table 2 shows the initial countermeasures identified.

Table 2: Potential Remedial Measures Identified

ATCO	**Pilot**
• Invite pilots to TWR • Use of 'give way' in ATCO instruction to pilot. • If they [the aircraft] don't stop, bring up a Stop Bar • Use 'After' in the instruction to pilots. • Markings on the ground [e.g. at position Foxtrot on the taxiway system] • Give extra context in clearance (e.g. opposing traffic)	• Take ATCOs in jump seat [so they can better understand the pilot's perspective] • Invite ATCOs into bizjet, to see their perspective. • Type taxi-route into 'scratchpad' in the cockpit before brakes off (so that both pilots in the cockpit are 'on same page') • The airlines all use their own investigation taxonomies – perhaps these could be pooled • Cockpit self-briefings on taxiway route before landing

• Give less context if it can be misconstrued • Emphasise if non-usual routing (e.g. turn *LEFT*) to Stand XY • Enhance demarcation markings on 71L/R • Survey on Taxi phraseology	• Threat and Error Management (TEM) briefings; use of sterile cockpit procedures [no extraneous communication in the cockpit] when on approach until engine power down at gate. • Mechanism for saying 'I don't understand' when pilots are unclear about the ATCO's instruction [rather than standard phraseology 'say again', which usually means 'I didn't hear you, please repeat', rather than 'I heard you but I still don't understand']

The group then took part in two voting rounds. The first was to choose the most important contributory / causal factors, and the second was to select the most useful mitigations identified. In each round, each participant chose their top three factors, and then their top three mitigations (the two sets did not have to be related). The top factors and mitigations were then identified simply as those with the highest score, leading to a 'Top 11' factors and 'Top 9' mitigations. These are shown below, in priority order from top to bottom.

1. Don't assume, ask
2. Distractions
3. Expectation
4. Situation awareness
5. ATCOs need to understand pilot's perspective
6. Conditional clearances
7. Cultural bias – 'wants to go first' / differences in risk understanding
8. Language issues (not everyone's first language is English)
9. Construction (e.g. causing obstructed views)
10. Can't expect pilots to identify business jets by their model
11. Drivers using mobile phones

It is notable that many of these relate to situation awareness. They do not happen to everyone all the time, rather to some rarely. But collectively they add up to a consistent string of taxiway errors and a 'stubborn' incident pattern.

The top nine mitigations are listed below, again, in priority order.

1. Mechanism for saying 'I don't understand'
2. ATCO emphasise if non-usual routing (e.g. turn LEFT) to Stand
3. Enhance demarcation markings on 71L/R
4. If the aircraft doesn't stop when instructed to do so, bring up a Stop Bar
5. Markings on the ground (e.g. as has been done for *Foxtrot*)
6. Survey on Taxi Phraseology to see if it can be made clearer
7. Take ATCOs in jump seat
8. Invite pilots to TWR
9. Type taxi-route into scratchpad before brakes-off (both on same page)

Impact of the Deep Dive

A presentation on the deep dive was given to around 25 companies at the quarterly LTN Safety Stack meeting later in October, and various representatives undertook actions to explore and

address the implementation of the remedial measures. Progress was reviewed at the subsequent Stack meeting in January 2025, and is summarised in Table 3 below.

Table 3: Progress on Countermeasures

Countermeasure	**Progress**
Mechanism for saying 'I don't understand'	Certain airlines have briefed their pilots about this (some already do it). One Base Captain commented that if any of their pilots do not understand, they stop the aircraft until the action is clarified and understood.
ATCO emphasise if non-usual routing (e.g. turn LEFT) to Stand	This practice is being trialled in the TWR by some of the ATCOs.
Enhance demarcation markings on 71L/R	Done.
If the aircraft doesn't stop when instructed to do so, bring up a Stop Bar	Stop Bars are not always useful in such situations, as by the time the controller detects the issue the aircraft may have already passed the Stop Bars. This is still under review.
Markings on the ground (e.g. as has been done for *Foxtrot*)	Done.
Survey on Taxi Phraseology to see if it can be made clearer	Ongoing.
Take ATCOs in jump seat	This has begun and will be further taken up.
Invite pilots to TWR	This has been happening with a number of pilots and will continue.
Type taxi-route into scratchpad before brakes-off (both on same page)	This best practice is already in place by one or two airlines and being considered by others (one Base Captain stated that this should be the top recommendation).

Generalisability of the results

Although it is often said in the industry that 'if you've seen one airport, you've seen one airport', due to different and often unique characteristics of airport layouts, surrounding geography, mix of companies and local procedures, etc., there is some generalisability in these findings. Another airport asked for a presentation of LTN's deep dive results, and this was carried out in December 2025 via video call. They found many (though not all) of the issues to be similar to problems they were experiencing, and thought some of the countermeasures would be worth exploring with their business partners. A third major international airport also had similar issues and carried out its own review, and again some of the countermeasures over-lapped. One clear difference was that for this third airport, use of stop bars was considered a more viable solution due to their location on their taxiway system.

On Taxiway Error Reporting

It was noted that five of the events had been classified under the 'Controller Error' rubric rather than 'Taxiway Error', so had not been encoded as taxiway errors in the Safety Dashboard, which limited the use of the Dashboard during the exercise. Additionally, there is usually far more information on causal/contributory factors in incidents happening to inbound compared to outbound aircraft. These two factors blunt the understanding of such events and how to reduce them. Therefore, ways of improving the reporting in both these cases need to be developed and implemented.

Conclusions

A Deep Dive is a very agile process, one that can yield new insights in a very short timeframe. It goes beyond the usual *'what happened and why'* surface layer of incident analysis, to consider issues rooted in the system and conventional ways of working. It considers business choices that can constrain safety, as well as aspects normally considered sacrosanct (e.g. ICAO phraseology), and cultural elements normally kept 'off the table'. The data analytics (presented via a safety dashboard) lent credibility to the process, encouraging the participants to consider 'deeper' factors, and reinforcing the importance of incident reporting. Refinements to data collection at LTN were also identified.

The deep dive process was greatly appreciated by the participants as 'a day well spent', and has resulted in actionable countermeasures, more than half of which have been implemented or are being implemented.

Human Factors often engages with multiple stakeholders when undertaking analysis. The Deep Dive approach would appear to be a worthy addition to the Human Factors practitioner's toolkit. The added value of having a Human Factors professional present is one of clarifying the contributory factors and helping ensure that issues are not muddled or 'lost in translation' during the rich conversational flux of a deep dive exercise. This helps the group steer towards the identification of viable and credible proposals that will effectively counter the underlying contributing factors.

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