**Not enough accidents, not enough data – incident investigation with the focus on aerodromes**

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Whilst airport accidents and incidents are often not fatal accidents and whilst they may not even be accidents in the sense of the definition contained in International Civil Aviation Organization (ICAO) Annex 13 to the Chicago Convention, the area of airport accident and incident investigation is an important part of the overall safety of the aviation industry.

Aviation safety at the airport and safety related to the infrastructure is not a new topic; not in general and not in the annals of this organization and its conferences. The fourth annual conference in August 1973 included a paper on discouraging birds arounds airports[1]. Further back in time, well before ISASI was founded, the influential aviation author, Assen Jordanhoff, noted in 1941 that 12% of scheduled domestic airline accidents were caused by "Airport and Terrain"[2]. It is no surprise that as a pilot and flight instructor, Jordanhoff chose not to elaborate further on this statistic and stuck to matters relating to flight operations.

Jordanhoff's approach is, to some degree, similar to the environment that has existed since then. The focus of attention is on flight operations first, followed by airworthiness and air traffic service issues. The safety of airports and maintenance safety tag along behind. This should not be seen as a complaint or a criticism, but is reflection of the development of the aviation industry.

Before moving on, a brief thought about the status of airport safety… The ICAO Annex 13 definition includes the text "…takes place between the time any person boards the aircraft with the intention of flight until such time as all such persons have disembarked…"[3]. This means many safety events that may occur airside at an airport are not actually accidents. These events range from health & safety accidents such as injures to catering or cleaning staff to aeroplanes being accidently towed across an active runway without a clearance. The former may actually involve the loss of life, but is still, officially not an aviation accident. There is no great practical problem posed by this, as the definition, further in the same paragraph of Annex 13, for "incident" is not as limiting. Unfortunately, the ICAO document that provides further guidance[4] shows that accident and incident investigation is primarily limited to flight operations.

Regardless of the scale of the problem that the above may cause, it is principally an issue for the State appointed investigation body. The issue only arises when procedures are developed to decide what events are reported to the investigation body. Airport owners and operators are not limited in what

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1 Bird strikes and Air Safety , V Solman, , Proceedings of the 4th Annual Seminar, 1973, Society of Air Safety Investigators at 108

2 Safety in Flight, A Jordanoff, 1941, Funk & Wagnalls at 341

3 ICAO Annex 13, Aircraft Accident and Incident Investigation, Chapter 1

4 ICAO Doc 9157, Accident/Incident Reporting Manual, Appendix 7

they choose to investigate and from the airport's perspective, why would the airport only care about incidents and accidents only once the crew arrives? What would that say about our approach to safety and safety culture? Thus, it is the airport owner / operator that this paper addresses, more than the investigation body, the air operators that use the airport or the Air Navigation Service Provider (ANSP) that provides air traffic services.

As ISASI-members over the years have discussed, aviation safety has been built, in part, on the acquisition and use of data and there are two trends that ISASI-members will recognise; there are fewer and fewer accidents to commercial air traffic worldwide – for which we are all grateful – and aircraft data sources has grown larger and larger. The air operator has Flight Data Recorder / Flight Data Monitoring (FDR / FDM) data and the ANSP has radar and other sensor data, but the airport often has none of this. Air operators have access to vast amounts of safety data; more than they can sometimes actually make use of. Airports tend not to generate data that is of use to the investigator and whilst air accidents are declining, ground incidents do not seem to follow this trend.

The picture is not wholly clear but data from insurance organisations and IATA does not show the same downward trend in accident; at least not when measured again costs to the industry. Allianz, in its 2020 safety report[5], states that some of the ground accidents have gone "largely unnoticed by the industry".

A consequence of the fact that airport accidents, even ones that result in fatalities, are not covered by Annex 13 is that investigations may be performed by the police, judiciary or other body, none of whom – as a rule – has the same interest in 'just culture' – learning from mistakes – embodied into its working practices.

**And then I adopted the brace position…**

To illustrate, I would like to offer a brief anecdote from an incident in 2018 that I – sitting in the passenger cabin – was a witness to. The airport in question – we shall remain discrete about those involved – permits intersection take-offs. And this photo has nothing to do with the event – I just like the photo.

The aeroplane I was sitting in lined up for a full length take-off whilst another aeroplane, of the same operator, approached the hold for the intersection. For reasons that were the subject of the ensuing investigation, the aeroplane waiting at the intersection hold, moved past the hold line towards the runway as the other aeroplane started its take-off roll. A high speed abort followed and having been able to see that the other start to move onto the runway, I adopted the brace position waiting for what I thought would be an inevitable collision. In the end, the aeroplanes passed each other without contact. A sidenote; with the exception of my travelling companion, all of the other passengers were oblivious to the reason for the sudden stop on the runway – it may be true that a little knowledge is a dangerous thing.

The airport was equally uninformed. Which exit, which aircraft, how close was the contact, who said what and to whom? All of these are questions that the airport had limited or no answers to. A quick call to the air data team at To70 post incident meant that, from public data sources, most of the questions

[5] Aviation Risk 2020, Safety and the State of the Nation, Allianz Global Corporate & Specialty SE, 2019

could be answered. The ground track and the speeds of the two aeroplanes came from the Automatic Dependent Surveillance-Broadcast or ADS-B antenna that we maintain at a number of our client's airports. The radio communications between the flight crew and the air traffic control came from open source websites that re-distribute aviation radio communications. Communication inside the flight decks of the two aircraft was not available.

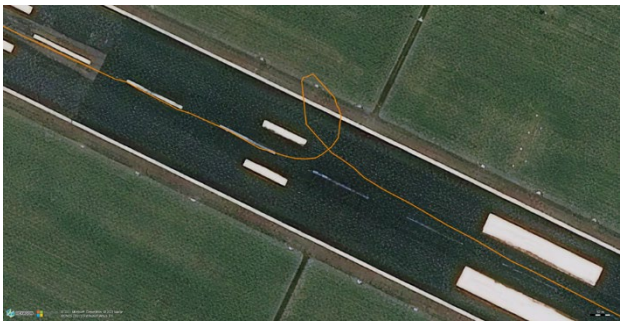
Nevertheless, within an hour – and before I had landed at the destination airport, our team had put together a synopsis of the event. Whilst this exercise was intended to sooth my ruffled brow, the data could equally be of use to an investigator at an airport when trying to establish what occurred in an incident on the ground. It need not be an event between two aircraft as more and more airports – not only those with an Surface Movement Guidance and Control System (SMGCS) – have transponders added to vehicles that are permitted to move in the manoeuvring area. The location of vehicles and aircraft can be established with a reasonable accuracy and this may be an useful aid to incident investigation. Making use of ADS-B data means that, as an airport, you are not reliant on third parties for information on the location and movement of the incident vehicles.

**Examples of ADS-B data in use**

The following images are taken from actual datasets at airports where we collect data. Where they are and who was involved has been removed from the data.

The image here shows a track for a particular airside vehicle.

The loop-shaped movement on the runway is a single event. This illustrates how detailed the data can be. Let us assume that the driver had cause to drive like this. The image could be used to assist in interviews – an *aide memoire* to the discussion or to confirm the vehicle's movements.



These two images show the path of fire vehicles. The track shows that the vehicle does not follow the hard surface but cuts across the grass; there is data validation required here to confirm that the track is accurate. The very straight line across the grass suggests that data was not collected correctly and the gap was filled in by the software. This may be an example of a blind spot that the ADS-B ground receiver at an airport or just a momentary loss of data.

Going a step further, investigations often raise questions about what normal behaviour is. Not the behaviour that is required, but the behaviour that is prevalent on the airfield. Whether this be speed limits or mandatory routings, the ADS-B data help determine what normal is. In a just culture, there is an argument that it is counter-productive to punish the one that you have noticed doing something wrong when everyone else is doing it too. From the point of safety investigations, the determination of what is normal is probably the most important function of this sort of work.

A last image is shown here.


This is from an investigation into aircraft taxiing practices at an airport. Aside from showing the volume of traffic that uses each of the runway entry points, the image demonstrates another use of data, somewhat removed from investigation. The image shows that one of the three runway entries is being used far less frequently than the others. This could allow the airport to refine its maintenance planning and focus more on the two that are used more frequently.

Whilst not part of an investigation, this sort of work can be seen as proactive safety planning that may prevent incidents in the future.

Thinking about this investigation tool from the perspective of an airline's Flight Data Monitoring programme[6], some of the same privacy issues that are so important there, will be equally important here. When the airport seeks to make use of the data, it must be clear to all parties that a just culture is being applied and that the data is not intended to be used for sanctioning personnel. This means that,

6 the author has set up FDM programmes at several operators

however attractive it might be to some postholders, the data can't be used to 'catch' and discipline airside personnel who are, say, driving too fast. By way of example, at an airport not to be identified, our data team looked at 1000 trips along a service road parallel to a taxiway and between two remote aprons over a five day period. The location was chosen for this sample as it is a simple straight road and is located somewhere where the airside authority is not often present. Three quarters of the 1000 trips along this stretch of road were made at a speed greater than the 50 kph permitted. The maximum speeds were above 80. Our analysis shows that these were not emergency vehicles.

The benefits of a good and reliable data supply to improving safety outweigh those gained by sanctioning staff. To be clear, it is not suggested that an airport should not sanction those who violate requirements; the airport just cannot make use of the safety programmes to do so. A possible topic for monitoring could be the response times of RFF vehicles. Heat maps to show the routes taken by these vehicles and the times taken to get there may be of use if there are concerns about the response times. From this basis, improvements to the infrastructure – provision of routes or removal of obstructions – can be considered. I digress slightly from the issue of investigations to offer an example what I mean; an airport's airside infrastructure was such that that a conflict between taxiing aircraft and ground vehicles at a busy hold led to the construction of an extra length of service road to deconflict the traffic and reduce the chance of delay and incidents. This, from a safety point of view, is the difference between a reactive and a proactive approach.

So far, I have mentioned ADS-B; the use of multi-lateration data with Mode S works equally well. There are of course limitations to the data. For a start, it is not as accurate as FDR or FDM data, recording data at 1 Hz. This is however, better than the data rate of primary radar.

There are a number of signal accuracy issues. As a rule of thumb, don't expect a positional accuracy that is better than about 10 metres. Trying to demonstrate if a vehicle has or has not crossed from the apron to the manoeuvring area is not really viable. However, some aircraft and some vehicles perform better than others. Either way, tailor what you do to the data's accuracy. An aircraft or vehicle just about to encroach on the runway strip is not what you want to analyse. Regular shortcuts across the RESA will be traceable.

Let's just take a quick pause to look at the basic technology that is being discussed here. Let's sort out our squawks from our squits. A "squawk" is a response from a transponder that is made upon interrogation by ATC-equipment; the secondary surveillance radar. Starting from the Mode C transponder, the majority of IFR- and VFR-traffic can squawk their identity, position and speed. Using a Mode-S transponder, the vehicle – be it an aircraft or ground vehicle – can squit its ID and position information without being interrogated by the ATC-equipment. This reduces the back-and-forth interrogation/response cycles and thus minimises the number of messages transmitted, increasing the system's surveillance capacity. The more modern ADS-B units use an Extended Squitter (ES). This just means more data per squit. So, instead of the ATC-equipment having to correlate the Mode S message against radar data, the aircraft's GPS sends its data message once a second. An ES-message can carry forty-nine datapoints,, against seven from a basic Mode S transponder and just three from a Mode C transponder.

The vast majority of the traffic at airports handling commercial traffic will have 1090 ES transponders, potentially delivering a lot of data. However, the expense of these units may be a disincentive to airport operators to install them on ground vehicles; especially vehicles that do not usually enter the manoeuvring area. Using low power radio transmitters and receivers, it is possible to develop a local triangulation system to track vehicles for a much lower cost that for 1090 ES transponders. Somewhere in the middle lies the cost for GPS-tracking equipment.

The layout of the airport may create blind spots, making data collection difficult. This is especially true on the end of the stands that is closest to the terminal building. If an airport is considering to collect data from the aprons too, multiple antennas may be needed to build up a complete picture.

**Making use of the data**

In addition to basic position and speed data, additional information via Mode S Comm-B messages (e.g. Mode-S EHS (Enhanced Surveillance), ELS (Elementary Surveillance) and Meteorological Routine Air Reports), is only available from aircraft sources and not ground vehicles.

How does an airport's safety department get the ADS-B data into a readable form? There is a two-step procedure required here. Firstly, decode the data: the fact that bits and bytes, ones and zeros, occasionally get corrupted so that before being processed, all of the data needs to be run through a system that can verify it and flag possible erroneous data. Pushback tugs moving at hundreds of knots is a data error and not a trigger for an investigation. Occasional errors in the call-signs of aircraft, set in the cockpit by the flight crew for each flight, will need de-bugging too. For more on the decoding of transponder data, reference is made to Junzi Sun's excellent book, The 1090 Megahertz Riddle[7].

Once decoded, the raw data from the transponder's responses must be transferred into a database that will allow the data to be used. . .

In To70's experience, the quantity of data is such that it is unlikely that a tool such as Excel will be robust enough to handle the data. Every aeroplane and many ground vehicles delivering a message once a second, day in, day out, adds up to a lot of data very quickly. Engineering scripts in Python or Matlab are the best way forward. On top of this data warehouse, the airport will have to invest in a system that can code the translation of the database into visual representations. Hexagon Geospatial's tool, Luciad Lightspeed is a good example of the sort of software needed.

**Conclusion**

The ADS-B antenna has become ubiquitous in aviation and this data source provides the airport with an opportunity to analyse data for safety purposes in a way that most airports have never had in the past, partly because the data is owned by the airport operator. We argue that this part of the safety picture that is, to quote Allianz "largely unnoticed by the industry", can be improved by the better use of data that is freely available to airports.

Experience at a number of To70's client airports has shown that the collection, analysis and use of the data is cost effective. The use ADS-B data offers the airport insight into what is normal and what

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7 The 1090 Megahertz Riddle, J Sun, TU Delft OPEN Publishing, 2nd edition 2021

occurred in specific events in a manner that is similar to the way that air operators are able to use flight data in their FDM programmes; something that is of great value to the airport safety investigator.

**Biography**

Mr Young is a graduate of Universiteit Leiden (Netherlands) with an advanced master's degree in air & space law. He is a qualified aviation accident investigator and has performed accident and incident investigations for the Dutch accident investigation body, Dutch Safety Board. He has worked in aviation safety since 1989, both for governmental and industry organisations as well as for both airports and airlines. The establishment and management of aviation Safety Management Systems and the provision of staff training in their SMS-related activities has been an important part of his work since 2008. He works for the international aviation consultancy, To70, and is based in the Dutch city of The Hague.