Big Data – Thinking Big for Aircraft Accident Prevention

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Big data is a ubiquitous term today with an array of applications across industries. The aviation sector is no different, and big data has been used successfully by some airlines to: improve on-time performance, increase fuel efficiency, and manage maintenance requirements (Bellamy, 2017). In this essay, it will be argued that big data can offers much more: a new paradigm for aviation safety – a proactive data-focused approach to accident prevention.

Demystifying Big Data

Although the precise origins of the term 'big data' are uncertain, the first references to it in academic articles were in the late 1990s, in the fields of statistics and econometrics (Diebold, 2012). Big data can be defined as "large volumes of high velocity, complex, and diverse types of data that require advanced techniques and technologies to enable the capture, storage, distribution, management, and analysis of the information" (TechAmerica Foundation's Federal Big Data Commission, 2012, p. 10).

Data is only valuable if insights can be extracted and used to aid in decision-making (Gandomi & Haider, 2015). Huang, Wu, Wang, and Ouyang (2018) proposed that big data analytics could be understood through four distinct processes, as depicted in Figure 1. In brief, these four processes include: 1) acquiring and classifying the data, 2) cleansing the data, 3) modelling and analysing the data, and the finally, 4) generating useful information leading to improved decision-making. Big data analytics has been successfully used for predictive maintenance, thereby allowing for users to forecast/predict potential maintenance issues based on historical data (Gandomi & Haider, 2015).

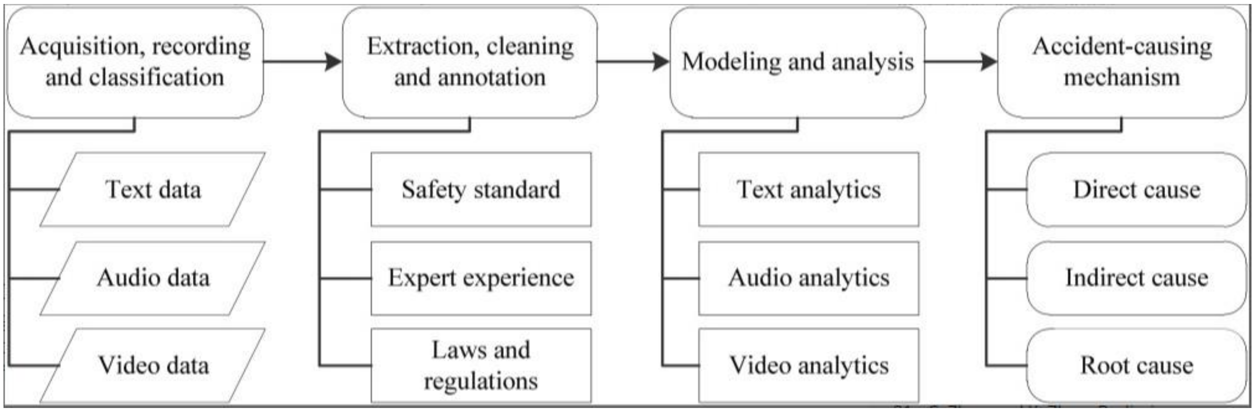

Figure 1. The Four Processes of Big Data Analytics (Huang et al., 2018)

The Current Approach to Accident Investigations

Accident investigation is an 'occupational safety analytical tool' which seeks to understand the factor/s that lead to the accident (Salguero-Caparros, Suarez-Cebador, & Rubio-Romero, 2015). Accident investigations have typically been performed through a process of hypothesis testing, in which a hypothesis is first proposed, followed by the collection of evidence, and finally, supporting or rejecting the hypothesis (Huang et al., 2018).

According to ICAO, the principle purpose of investigations is "the prevention of accidents and incidents" (ICAO, 2016, p. 16). In this regard, accident investigators, past and present, have made significant contributions to improving aviation safety. Through a better understanding of the causal factors behind aviation accidents, the aviation sector has been able to respond by developing and implementing safety programmes to avoid future accidents; for example, Crew Resource Management (CRM) training was implemented to address failures in interpersonal communication (Helmreich & Foushee, 2010).

As seen in Figure 2, although air travel has increased significantly over the past few decades, the number of fatal accidents has decreased; 2017 marked the safest year on record for the commercial aviation sector with zero fatalities (BBC, 2018). This positive trend can be attributed to the increased reliability of new aircraft designs, and the aviation sector's addressing of identified failures in aviation safety (Helmreich & Foushee, 2010).

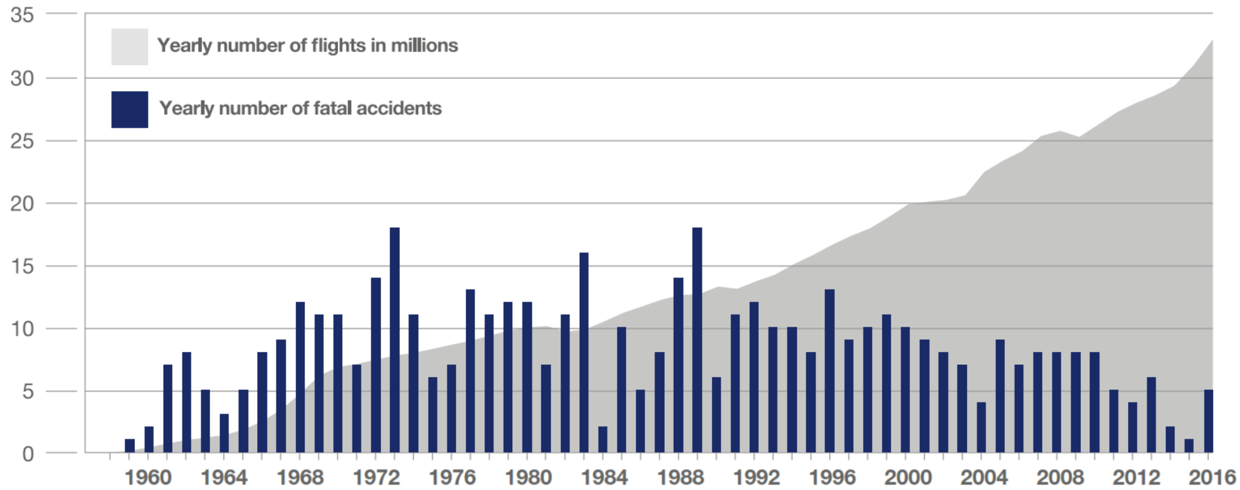

Figure 2. Fatal Accidents from 1958 to 2016 (Airbus, 2017)

However, with increasingly congested airports and skies, aviation accidents will inevitably increase unless the accident rate decreases further (Airbus, 2017). Hence, while the current approach to accident investigations has been successful thus far, it is important to innovate and ensure that complacency does not set in. One possibility is leveraging technology advancements in data analysis to identify potential safety issues and prevent aviation accidents; this could be achieved by linking the databases of accident authorities and airlines around the world.

The Opportunities for Big Data in Accident Investigation

Due to the complex and diverse nature of accidents, accident investigations are often a long process, sometimes lasting years. The limited number of aircraft investigators also means that safety agencies must prioritise accident cases; for example, the NTSB has four different categories of accident investigations, ranging from the lowest priority 'C Form Investigation', which is primarily used for data collection and relies on the operator to self-report, to 'Major

Investigation', where a full team of accident investigators is allocated (Sumwalt & Dalton, 2014) . Leveraging big data could aid this process by comprehensively analysing the database of accident records to quickly identify trends with previous accidents; it could also pick-out plausible accident causal factors, aiding in hypothesis generation and ultimately the accident investigating process.

While accident investigators strive to be objective, and thorough, in their accident investigations, traditional accident investigation findings are always qualitative (Huang et al., 2018) and contingent on the investigators' training and experience. Furthermore, Yodice (1984) suggests that there are often competing interests, such as tort litigation; the enforcement process; and the media, that could interfere with the accident investigation. Big data analysis offers an alternative quantitative approach to accident investigation that could analyse all available information, not just the factors which are obvious to accident investigators; this could result in investigators uncovering other accident causal factors which may have otherwise been overlooked.

In terms of accident prevention, big data could also help the aviation sector shift from a traditionally reactive approach, to one that is more proactive and forward looking; this is possible due to the real-time nature of big data analysis. For example, WayCare, an Israeli technology company that specialises in transport management systems, has conducted its own analysis of road data and claims they are able to predict over 70% of traffic crashes two hours before they occur (WayCare, 2017). It leverages existing infrastructure, tapping on existing real-time data sources such as: localised weather data; road closures; camera feeds; and accidents, to make predictive recommendations with the ultimate objective of minimising road congestions and preventing road accidents.

The aviation sector is already awash with data sensors, and the extent of data generation is expected to increase significantly in the future as more new generation aircraft come into service. As shown in Figure 3, Wyman (2016) predicts that the global fleet could generate 98 million terabytes of data by 2016. Operators have been quick to capitalise on this trend for aircraft health monitoring and predictive maintenance; this also provides a valuable opportunity to extract safety-related data.

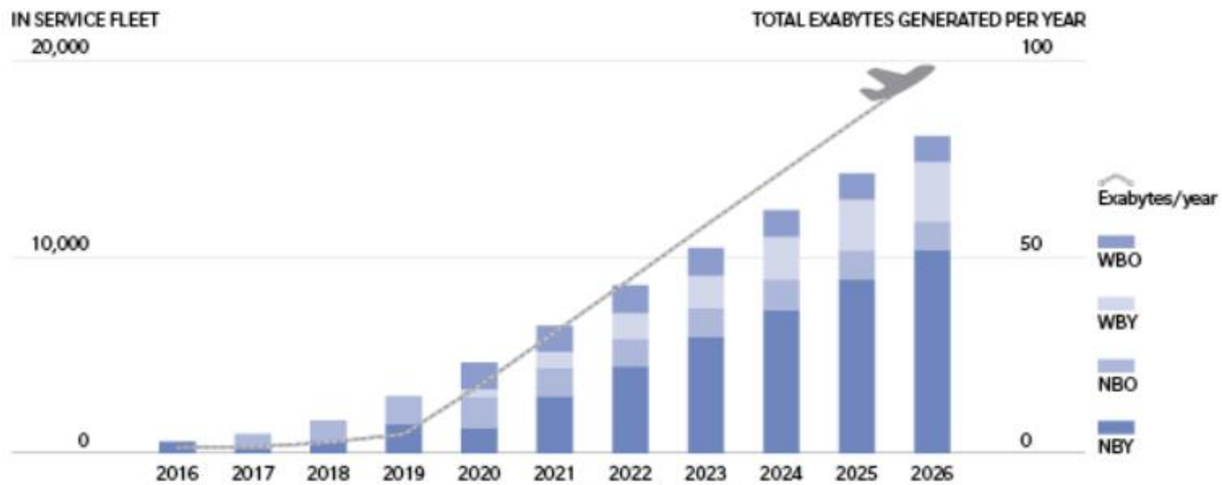

Figure 3. Data Generated from Projected Global Fleet (Wyman, 2016)

A practical example of how big data may be used to proactively manage safety in aviation is utilising a 'Rule of Three' principle, similar to that proposed by Hudson and van der in the oil industry. Hudson and van der (1998) argued that the criteria for Go – No Go decisions often failed to consider the interaction between various factors. In their proposed Rule of Three, major dimensions, such as weather, are broken down into minor dimensions, such as rain, wind, and lightning. These sub dimensions are then colour coded based on their historical contribution to accidents. Dimensions with no direct link to an accident are coded as green. Dimensions with a broken link are coded as orange, and dimensions with a direct link are coded as red. Similar to a traffic light, any dimension in red halts operation; as do three or more dimensions coded as orange. The decision criteria, shown in Table 1, would then be applied. The Rule of Three's objective is a simple rule-of thumb tool that is designed to remove the ambiguity out of decision making (Hudson & van der, 1998), which is importantly based on factual information, in this case gleaned from using big data. Hence, big data has the potential to improve decision-making, as illustrated in the above example. Such data can be extracted from: real-time weather information; flight schedules and durations; crew rosters; and crew composition, to name a few.

Table 1. *The Rule of Three Decision Criteria (Hudson & van der, 1998)*

Number of Critical Dimensions	Action (Go – No Go)
All Green	Proceed normally
One Orange	Proceed normally
Two Oranges	Proceed with caution
Three Oranges	Halt operation / Reduce problems
One Red	Halt Operations

From a safety management perspective, big data can also provide better insights into an airline's emerging safety issues. According to IATA (2018), in 2017, the accident rate for IATA Operational Safety Audit (IOSA) airlines was almost four times better than that of non-IOSA members; IATA members are required to adhere to high levels of safety standards and maintain their IOSA registrations. While this compliance strategy has worked thus far, IATA has already announced a digital transformation plan that will leverage the predictive analytics of big data to improve operational safety; its 'Six Point Safety Strategy' is a "comprehensive data-driven approach to identify organisational, operational and emerging safety issues" (IATA, 2018).

Conclusion

Big data has already been used extensively in many industries, providing valuable insights into all facets of operations. In the aviation sector, it has proved useful in helping airlines improve operational efficiency and better manage maintenance requirements. With an increase in air travel demand, it is important not to become complacent about aviation safety. As the amount of data available increases, it is possible to use this data to predict the likelihood of an accident occurring. Importantly, this data can be used by airlines to assist in the decision-making process for crews. Capitalising on a proven method of decision-making heuristics (i.e., Rule of Three), big data can be used to facilitate more objective crew decision-making, incorporating previously unknown or unrelated factors that contributed to accidents.

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