**IDEATION PHASE-1**

**LITERATRUE SURVEY-DIFINE THE PROBLEM STATEMENTS**

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**Big Data Analytics in Airlines: Opportunities and Challenges**

***ABSTRACT***

Big data refers to the huge amounts of information in the structured and unstructured form that cannot be processed using traditional data systems. Big data technology facilitates the utilization of high volumes of external and internal data to create new products, services and improve business operations. In the era of big data, airlines can provide services that are more satisfying to customers and to stay competitive in their fierce marketplace. Airlines can reap many benefits from big data, but many challenges still remain. This study illustrates how airlines successfully adopt big data technology. The paper also explores the opportunities and challenges of big data in the airline industry. Based upon the qualitative approach, 27 semi-structured interviews with employees and experts at airlines in Egypt were conducted. The findings reveal that big data has a great importance in providing broad opportunities for airspace management, enhancing flexibility in dealing with each passenger, boosting problem solving, supporting decision, providing safe flights, boosting predictive maintenance, and improving performance. The findings illustrate a range of challenges that airlines may face when dealing with big data, such as shortage of qualified human resources, absence of data-driven culture, dealing with and processing huge amounts of data, as well as data privacy and security issues. Finally, implications for practice as well as future researches are discussed

**Keywords:**

Big data technology; Big data analytics; Airlines; Aviation industry; Data-Driven Culture.

**1. Introduction**

With the advent of digitalization, more enterprises are adopting big data and business analytics to analyze available data in order to improve their products, services and sustain smart decision-making (Maroufkhani et al., 2019). The development of big data management research has generated a range of analytical tools that could be utilized to better respond to such sudden ‘black swan’ risks, like COVID-19 pandemic (Ienca and Vayena, 2020). Big data was described as the massive volume of both structured and unstructured data, difficult to process using common software techniques or by using traditional statistical methods (Baggiom, 2016). Big data is being generated through different sources including internet traffic, mobile transactions, user generated content, and social media (George et al., 2014). There are also sources of big data such as the content captured through sensor networks, business transactions, and many other domains such as bioinformatics, healthcare, and finance (George et al., 2014). Big data provides promising opportunities for modern societies and companies (Fan et al., 2014). It helps companies understand the purchasing behavior of the customers to create more efficient marketing strategies (Sternberg et al., 2018). It may also lead to more accurate analysis, more valuable decision-making, and greater operational efficiencies (Song and Liu, 2017). Extracting insights from big data includes two main sub-processes (Gandomi and Haiderm, 2015): data management and data analytics. Data management comprises processes and supporting technologies to acquire and store data and to prepare it for analysis (Larsen, 2013). On the other hand, data analytics refers to techniques used to analyze and acquire intelligence from big data. Big-data analytics is the process of examining huge amounts of data of a variety of types to discover hidden patterns, indefinite correlations as well as other useful information (Larsen, 2013).

Airlines described big data as the “third wave “, after traditional databases and web-based content (Hausladen and Schosser, 2020). The airline industry is characterized by low profit margins, frequent entry of new players, disruptive competition, fierce airfare wars, severe legal and safety requirements (Chen et al., 2016; Kastur et al., 2016). The adoption of big data technology can transform the organizational airline operations in different ways (Odarchenko et al., 2019); 1- ground handling preparations are faster due to a reduction in the processing cycle time, 2- data analysis offers the ideal solutions in the field of airspace management, which in turn increase efficiency; 3- data analysis allows airlines to discover an individual approach to each passenger. Besides, big data offers unique advantages for airlines in achieving new sources of competitive advantage, including optimizing operations, customer intelligence, innovation in products and services, personalized marketing, better pricing and cost reductions (Fan et al., 2014; Chen et al., 2017; Lee, 2017; Sternberg et al., 2018; Odarchenko et al., 2019). Big data is also imperative for improving the predictive analysis of ground operations, load control, aircraft turn-around operations, staff management and aircraft maintenance that are critical parts of providing a great end-to-end customer experience (Chen et al., 2017). However, the airline industry does not seem able to fully exploit data information for lack of technological skills and infrastructure (Izzo, 2019). The major obstacles for using big data analytics in aviation industry are the lack of time, resources, skills, tools and systems that are needed to derive value from the data (Izzo, 2019). There are also challenges regarding the analysis, capture, search, sharing, storage, transfer, security and information privacy of big data (Hashem et al., 2015).

There are few studies of big data technology in the airline industry; the present study attempts to contribute to the debate on this topic. This research adopts a qualitative approach to explore the application of big data analytics for airlines in Egypt. The objectives of this study are to discover the airlines’ concept of big data, and to determine.

**2 Big Data Analytics**

There has been considerable attention from both academics and practitioners on the value that organizations can derive from the use of big data analytics towards the attainment of organizational goals (Mikalef et al., 2019). Big data analytics was regarded as the leading future for innovation, competition, and productivity (Manyika et al., 2011). Big data analytics is defined as a collection of data and technology that accesses, integrates, and reports all available data by filtering, correlating, and reporting insights (Jifan Ren et al.,2017). Big data analytics is considered a new generation of technologies, designed to extract value from very large volumes of a wide selection of data, by enabling high velocity capture, discovery and/or analysis (Mikalef et al, 2017). The airline industry is pioneered in adopting big data analytics (Sternberg et al., 2018). Big Data analytics could increase the business performance (McAfee and Brynjolfsson, 2012). According to Labrinidis and Jagadish (2012), Bendre and Thool (2016) and Burmester et al. (2018), big data analytics revolve through the following five stages:

1. **Data generation or integration:** Large amounts of data can be gathered from different applications such as publishing factual data, search engine pages, world events, social media graphs, analysis of natural language content, BBC online content, etc., with different types for future analytics (Sikos, 2015).

2. **Data acquisition or management:** It is the process of gathering, filtering and cleaning large amounts of data (Lyko et al., 2016).

3. **Data storage:** The platform with a clustered network of servers and community hardware are used to store the data (Bendre and Thool, 2016).

4. **Data analytics:** It is the process of examining useful information from the huge data storage using complicated machine learning and data mining techniques (Chen et al., 2014).

5. **Data visualization or knowledge presentation:** The graphical format representation of data can easily be understood and represented in a simple way (Bendre and Thool, 2016).

In addition, the following techniques represent a significant subset of the tools available for big data analytics (Gandomi and Haiderm, 2015; Bendre and Thool, 2016):

• **Text analytics:** refers to techniques that extract information from textual data. Social network feeds, emails, blogs, online forums, survey responses, corporate documents, news, and call center logs are examples of textual data.

• **Multimedia data analytics:** It is a process of finding useful insights from images, audio files, and videos.

• **Web data analytics:** It is a process of measurement, collection, analysis, reporting and viewing of web data.

• **Social media analytics:** social media analytics refer to the analysis of structured and unstructured data from social media channels.

• **Mobile analytics:** It refers to analyzing data collected from user’s different activities such as websites visits, install–uninstall applications, play online games, make online transactions and so many discussions through mobile phones.

Rajaraman (2016) also classifies types of data analytics to be: **Descriptive analytics**: This essentially describes what happened in the past and presents it in an easily understandable form.

**Predictive analytics**: It extrapolates from available data and reports what is expected to happen in the near future. One major use of predictive analytics is in marketing by comprehending customers’ needs and preferences. **Exploratory or Discovery analytics**: Collection of data from a variety of sources and analyzing them provides additional opportunities for insights and unforeseen discovery. **Prescriptive analytics**: based on data gathered, opportunities to optimize solutions to existing problems. One obvious example is in airlines’ pricing of seats based on historical data of travel patterns, popular origins and destinations, major events, holidays to maximize profit.

**3. Applications of big data in the airline industry**

With the advent of big data era, modern aviation industry can find solutions for their major challenges of safety and performance improvement (Dou, 2020) because big data can provide multidimensional, adequate, and real-time information (Lee, 2017) and improve the predictive and preventive capabilities of aviation flight risks (Nikolopoulos and Petropoulos, 2018). Big data will effectively improve the technical performance and operating conditions of aircraft, avoid various adverse external environmental conditions, and reduce manual errors, to enhance aviation safety (Dou, 2020). By adopting big data technology, fuel consumption, crew deployment, and flight operations could be optimized; maintenance could anticipate when parts need replacing; air congestion could be reduced; flight routes could be altered well in advance of takeoff to avoid storms and passengers could be kept informed about schedules from the minute they leave their home for the airport (Izzo,2019). The airline industry makes use of primary data sets that come from many different parameters such as flight tracking data, airport operations data, weather conditions, airline information, market information, passenger information, aircraft data and air safety reports (Larsen,2013; Sternberg et al., 2018). Big data analytics can also

Advanced data analytics techniques enabled airlines to engage in more accurate real-time customer intelligence which in turn improves personalized marketing and price discrimination (Knorr, 2019). The most important practices of big data analytics in airlines are predictive maintenance that aims to reduce costs and minimize maintenance (Badea et al., 2018). Improving customer interaction and revenue management is the motive for using big data (Chen et al., 2017). Short-term forecasting and handling of irregular operations can be also the ultimate goal for airlines (Chen et al., 2017). Furthermore**,** air carriers use big data technologies for many other different purposes (Odarchenko et al.2019). The low-cost Ryanair applies big data for targeted advertising. KLM and SWISS use “large data” to improve the quality of customer service. British Airways collects information about passengers using its own application, such information is then used to provide personalized services to customers. American Airline Delta has an application that allows its customers to track luggage (Odarchenko et al., 2019). In terms of some flight services with the most complaints from passengers, some companies use big data to design a real-time application (Chang and Arami, 2019). Passengers can keep track of their flights and any related updates in adavance, particularly in-flight delays caused by air traffic control, bad weathers and other uncontrollable factors (Chang and Arami, 2019). Such an application can greatly alleviate conflicts caused by flight delays (Wang, 2014). Hu (2017) assures that using big data can predict flights delay and explain its benefits for both airline companies and passengers. Lufthansa identified big data value in four major areas (Chen et al., 2017):

1. Personalizing the customer experience

2. Handling irregular (IRREG) situations

3. Predicting departure delays and being proactive in IRREG recovery

4. Implementing predictive and preventive aircraft maintenance

According Rachman and Arviansysh (2019) and Dou (2020), there are multiple types of big data analytics in airlines. These include the following :

**Big data for aircraft design and performance improvement**. This includes both the big data reflecting the internal health and performance of aircraft and the big data reflecting external environment and services.

**Big data for aircraft operating conditions and malfunction and maintenance**. These are platforms and information systems of aircraft operating conditions, malfunction and maintenance include data collection and data analysis.

**Big data for route planning and air traffic management**. This includes both the big data of available route status and the big data of real-time route usage.

**Big data for flight environment and safety**. This refers to the data such as cabin pressure, altitude and fuel consumption.

**Big data for flight and airport management**. This refers to big data and its information systems for flight and airport management at national and global levels.

**Big data for crew and cabin passenger service management**. Its role is to facilitate the intelligent and automated management of crew and cabin passenger service to reduce management costs and operational errors and improve management performance (Gupta et al., 2018). Rachman and Arviansysh (2019) explained that big data is also collected from various databases of diverse enterprise applications, as follows:

a) **Schedule Planning System (SPS)**, the application for supporting flight scheduling and fleet assignment.

b) **Operation Control System (OCS)**, this is the main application for aircraft maintenance and routing, including determination of flight delay, postpone, divert, reroute, or even cancelation.

c) **Crew Management System (CMS)**, this is the main application for crew planning, including pairing construction, crew rostering and scheduling.

d) **Aircraft Communications Addressing and Reporting System (ACARS)**, this service helps pilots receive vital information in real-time. In terms of flight data, it provides aircraft movement, the pilot in charge, and fuel information.

e) **Aircraft Performance System (APS)**, this application is used to calculate aircraft weight and balance by considering several factors such as payload, fuel load, passenger, cargo, runway length, and airport contour and limitation.

f) **Passengers Service and Departure Control System (DCS)**. This application is used for handling aircraft load, including passengers, cargo, and fuel.

g) **Flight Data Monitoring System (FDM)**, this system receives all information about flight and aircraft attitude during flight. It will be used for flight analysis

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**Fig.1.** Data analysis in qualitative research by Creswell and Creswell (2018)

**3.4.1. Improve services and product development**

Big data analytics can also help airlines enhance customer service. By identifying passengers' buying habits and collect historical information, airlines can predict customer behavior to create personalized offerings. This not only increases ticket sales, but also boosts retail opportunities, such as baggage fees and onboard refreshments (Feliu, 2020) and to plan, produce, and launch new products.

*Detecting new routes and cross-selling are considered as opportunities from customers’ booking behavior insights. This leads to the provision of new services and products to travelers*. *(ID 11)*

**3.4.2. Customer experience and loyalty**

Airlines around the world have recourse to big data analytics technologies. They assist in doing many matters that a person cannot do, such as, help to merge the internal systems of plane with the airport system, obtain real-time weather information, provides information on each passenger, which enables the airline to carry out targeted marketing campaigns that enhance customer loyalty to the brand (Odarchenko et al., 2019).

*By obtaining passenger data from airline tickets, social media, and their contact data, and by analyzing that data, the airline can provide value services that enhance customer experience and loyalty. (ID 25)*

**3.4.3. Predictive maintenance**

Adopting the big data analytics helps airlines in real-time plane monitoring and predictive maintenance. Using big data analysis airlines can determine fuel consumption, which accounts for 17% of all airlines' operating costs, on a per-flight basis. For example, Southwest Airlines provided a range of sensors embedded in the plane to measure temperature data, wind speed and weight of the plane along with fuel consumption. In addition, Boeing analyzes 2 million cases across 4,000 aircraft daily in order to plan maintenance and support preventive action. This saves the company $300,00 annually in-flight delays and repair costs (Feliu, 2020). All these procedures and analyzes aim to achieve maximum security in order to provide a safe travel experience.

*It is very necessary in the field of aviation to provide accurate and sufficient information about any defect in the aircraft that needs to be repaired, modified or checked for any part of the aircraft before the flight, and I believe this is one of the vital roles of big data analysis, which provides a safe travel experience. (ID16)*

*..... Also, big data analysis plays a pivotal role to predict the maintenance date, providing information about the parts that have been serviced, the availability of the part that needs maintenance in the stock, the year and model of parts, the time of*

**3.4.4. Safe flights**

The respondents indicated that big data procedures and analytics are intended to achieve the highest levels of security and safety in the aviation industry in order to provide a safe travel experience.

*Reviewing aircraft disaster data and analyzing the causes of aircraft accidents allow the aviation industry to discover potential hazards, resulting in fewer accidents and safe travel for passengers. (ID 3, ID 22)*

**3.4.5. Support decision making**

In the era of rapid change and development, companies are looking for the best way to take advantage of data for decision making. By managing and analyzing big data, decision makers can use data, information, and knowledge that are useful for problem-solving and decision-making at the individual and organizational levels (Visinescu et al., 2017). Big data analytics can improve decisions about financial and planning issues. It can also be used to support decision-making in line with existing market demands.

*Big data analytics allows you to get a complete picture of information, which means a different approach to improving decision-making. (ID 8)*

*The right decision in any single step at any departments depends on the data you have internally and externally. (ID 14)*

**3.4.6. A Personalized customer experiences**

Personalization, as a familiar concept in marketing, is gaining importance in aviation industry. It strives to identify current and potential customers and offer them the required services at the right time, price and conditions (Klein and Loebbecke, 2003).The majority of interviewees indicated that due to the huge amount of data that airlines deal with daily, especially with regard to customer data, which can be obtained from many sources, such as ticket reservation data, social networking sites, contact data, customer service data, and travel reviews data, customers' past travel history.... etc. All this information and data, and through its processing, provide great opportunities for the airline to provide services and offers that suit the wishes and needs of its customers, which represents a unique personal experience for each customer and supports his loyalty to the airline.

*Today airlines collect tons of information about their customers. Crunching this information enables airlines not just to segment passengers better, but also to provide a personalized experience to each customer. It is a one-to-one relationship between the airline and the passenger that increases customer satisfaction and builds extraordinary*

**3.4.7. Differential pricing strategy**

Differential pricing strategy is a common strategy to distinguish prices based on customer characteristics, such as personal characteristics, purchase histories, zip codes, or behavior patterns are offered different prices. Similarly, prices based on group often depend on categories like ‘domestic or foreign citizenship’, ‘age’ or ‘social status’ (Klein and Loebbecke, 2003). Big data processing allows the airline to select customers according to their needs and desires, one customer may be time-sensitive, another may be price-sensitive, another is looking for services and facilities, and other customers are not interested in these details. Therefore, airlines can segment their customers and create various offers to meet the needs of different segments. Depending on the offer, airlines can price their tickets and services. This differential pricing strategy helps in maximizing revenues from each customer (TechVidvan, 2021).

*Opportunity to provide competitive prices for each customer based on the airline's customer database. (ID 17)*

*….. Moreover, the price flexibility provided by data analysis allows customers a wide base of choice and purchase decision. (ID 13)*

**4.4.8. Anticipate future supply and demand**

The development of big data, sensor technologies, predictive analytics, processing capacity, connectivity and storage present big challenges, as well as providing opportunities for airlines and customers. Advances in big data and analytics are expected to assist airlines predict and adjust to changes in supply and demand in real-time (IATA and SOIF, 2018).

*I see that by analyzing passengers' data every period of time, we can expect an increase or decrease in demand, as well as an increase or decrease in the number of flights to a particular country. (ID 12)*

**4.4.9. Evaluating current routes and opening new routes for flights**

According to the personal interviews, participants believed that once the airline has a comprehensive database for flights, the number of customers per flight, their data, desires and preferences; this provides an opportunity for the airline to conduct an analysis of the current travel behavior of customers and based on the results of that analysis, the airline can predict the most important routes Which generate income for the company, as well as the most important future paths that the company can open to achieve many profits.

*The tourist service is very faulty, every empty seat on the plane is lost forever, so by knowing what are the reasons that led to not filling the seat, is marketing the reason or the flight path does not have a demand, or the size of the plane is large and the demand on this path is little or what? Therefore, analyzing that data and knowing the reasons is reflected in the decisions to reduce the number of flights for this route, cancel it or open a new route. (ID 17)*

**4.4.10. Developing creativity**

Now, big data is pushing airlines towards a more, new innovative future (Feliu, 2019). Airlines must deal with big data in an innovative, new ways that enable them to retain and control their businesses and customers. They have to completely change the way they operate by making use of big data techniques and analytics to be the leader in the field of information technology, as it has led the way in IT in the past electronic reservation systems at a time when banks were still doing manual ledgers (IATA, 2018). As cited in Mei Chen et al. (2016: 5099), Roland Schütz, CIO, Lufthansa stated that “Aircraft and new applications are now considered to be of equal priority; we can only move forward by improving IT capabilities. We believe that this is the only opportunity to survive the coming competition.”

*The Answer is, how to think out of the box??? This question for the responsible person can make him Reach to the goal, so what is the market need to Success … this destination for Airlines can achieve the target of Sales Finally all these points is analysis. (ID 7, ID 13)*

*How does the analysis of your data affect your services, service delivery, customer complaints resolution, regular trips, employee and customer satisfaction, and winning the competition? This is creativity. (ID 10)*

**4.4.11. Cabin Crew and Staff Management**

With a complete database of airline big data, the company can make new applications for pilots, crew and other employees. At the time, cabin crew and ground control play a critical role in monitoring flight performance and maintenance. Weather data and maintenance reports will help pilots choose the best safe flight path to avoid unwanted accidents. The database also helps cabin crew and airline staff improve passenger boarding on and off the plane, thus decreasing ground time. Some data may be shared with passengers to make them feel better about safety considerations (Nagarajan et al., 2017).

*In every flight, we deal with a huge amount of data and reports related to operation, testing, maintenance, warning, control, communications, air control and others. When analyzed closely, this data can simplify operations and improve safety.*

*(ID 15, ID 24, ID 19)*

*Providing us with any information, even if it is simple, about any matter related to the flight, which makes a lot of difference in the flight path. (ID 6)*

*When the exchange of data and information is available quickly and flexibly on the plane, this provides us with safety before the passenger and helps us to act well in emergency situations. (ID 23, ID 3, ID 19)*

**4.4.12. Benchmarking and performance measurement**

With the help of big data analytics, airlines can effectively analyze performance measurement through the analysis of data for each flight such as number of passengers traveling, profit per passenger, average revenue, operating cost, average flight occupancy, overbooking (TechVidvan, 2021). This data is used by the company to take some corrective actions or increase incentives



**Fig.2.** Theoretical framework for big data in airlines