Air transport innovations: a perspective article

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Air Transport Innovation: Key achievements and future challenges

Introduction

In the past 75 years, the aviation industry has been very innovating in many different fronts, including technology transformation, safety procedures, and economic deregulation, allowing the globe to be connected in hours, rather than days, shrinking distances and opening the possibility of mass tourism worldwide. Similarly, the challenges faced by the aviation sector in the future instigate new provisions for the next 75 years, notably in terms of advancements in supporting a more sustainable displacement of travellers, with reduction of carbon emissions and waste, while also offering more personalised and comfortable services, in a safer and secure environment.

Past perspectives: 75 years of developments (1946-2020)

In 1944, the Chicago Convention was a cornerstone gathering to provide the foundation for a more accessible and regulated global aviation industry. With the establishment of the International Civil Aviation Organization (ICAO) and the "open skies" policy, which involved the establishment of bilateral "freedoms of the air", airlines gained permission to fly between international territories in the still-fragile post-World War II geopolitical environment (Lohmann, 2002).

Parallel to the establishment of a common regulatory framework, the after war period also led of the military technology development to be commercialised and transferred to commercial aeroplanes. One example is the introduction of jet engines in the 1950s and 1960s, more than doubling the speed of aeroplanes. This enabled the aviation industry to grow rapidly (Lee & Mo, 2011; Kim et al., 2019). Another remarkable advancement relates to engine efficiencies (e.g. the introduction of high bypass turbofan engines), aerodynamic improvement, and structural performance improving fuel efficiency by approximately 40% over the period 1959–2000 (Lee & Mo, 2011).

Economies of scale were also obtained with the introduction of the wide-bodies (double aisles) in the 1970s. Aircraft like the Boeing 747 were capable of carrying significantly more passengers when the fuselage was expanded. In the case of the Boeing 747, and later the Airbus 380, double decks increased seat capacity to accommodate over 400 passengers, ultimately providing a significant reduction in the unit cost per kilometre-flown (Lohmann et al., 2013; Kilpi, 2017).

In the late1970s, President Carter's economic air transport deregulation in the United States marked another critical moment in the history of aviation. By deregulating domestic airfares, the ability of airlines to choose what routes to operate and ending monopolies in the inter-state routes, airlines were finally free to establish their network and decide on their markets and products. The "Deregulation Act" caused significant changes, including the consolidation of hub-and-spoke networks, the rise of new airline business models, yield management and discounted prices, and the emergence of mileage/frequent flyer programs, computer reservation systems and strategic alliances (Kurt et al., 2013; OECD, 2018).

New business models based on fare segmentation strategy (e.g. low cost/low fare) and the advent of internet defined many innovations in the 1980s and 1990s. Following the airline deregulation, the lean business models fostered by airlines with low cost/low fare strategy introduced an alternative to passengers to avoid paying high prices where unwanted perks were included (Franke, 2004). In the 1990s, the internet started to provide a direct distribution channel allowing potential customers to by-pass travel agents in search for information and booking reservations. As a consequence, travel agents commission were reduced or changed into a capped financial contribution (Law & Leung, 2000).

Over the turn of the millennium, the 9/11 terrorist attacks in the United States brought an unprecedented level of security, driving significant technological advancements to counter-act terrorism, including the detection of explosives, biological and chemical agents, radiological releases, and even cyber-crime (Tamasi & Demichela, 2011; Fox, 2014). Some new solutions such as advancements in screening device technology, trusted traveller programs, biometric identification technology, real-time security procedures, and real-time intelligence and information have increased the ability to detect these threats (Lee & Jacobson, 2012; Gillen & Morrison, 2015). Although there are prominent technologies fostered in the industry, advancements in safety and security are still dependent on the development and implementation of security systems that can be effective, cost-efficient, furthermore, capable of to handle delays and the volume of passengers without being intrusive (Benda, 2015).

Future perspectives: the next 75 years (2020-2095)

When considering predictions for the coming decades, there still remains a number of concerns related to safety and security. New solutions will be required to reduce accidents, to operate aircraft safely in even more congested airspace and to mitigate environmental hazards (Shyur, 2008; Gohardani & Singh, 2011). In addition, it will also be necessary to increase the overall efficiency while providing seamless boarding security checks, to introduce non-intrusive security screening and to improve cybersecurity by using a fully-secured global bandwidth data network (Nguyen, 2017).

New technological trends indicate Blockchain as a transformational solution by using transparent tamper-proof and secure systems, allowing novel business solutions, especially when combined with smart contracts and various data sets such as that used the highly-connected air transport industry (SITA, 2017; Marsal-Llacuna, 2018). Similarly, the Internet of Things (IoT) will enable new solutions such as flight health checks and maintenance, luggage tracking improvements, delivered global data sharing and analysis capabilities, and airport and airline operations with collaborative decision-making. The IoT promotes these improvements by identifying, sensing, processing and collecting a large volume of data (Big data), supporting real-time decisions and providing new experience based on personalised services and connected devices (Whitmore, 2015; Tong et al., 2018).

The Virtual Reality (VR) and Augmented Reality (AR) environments are interactive technologies that modify physical surroundings with superimposed virtual elements, and they will reach realistic levels providing a number of possibilities to deliver innovative modes for accessing relevant content. For example, advertisements, interactive instructions for passengers on airports and in-flight, and pilot training will be possible by the use of these technologies (Javornik, 2016). These technologies are suitable to improvements on training the next generation of pilots, allowing mechanics to walk virtually inside engine, enabling 360-degree view with statistics and virtual images that make air traffic clearly visible, wearables devices that can provide virtual control information, flight attendants can display passenger information and flight details, and also help people who are afraid of flying (Flavián et al., 2019).

More and more, air transport sustainability will become a real issue to be tackled appropriately, in which both aircraft manufacturers and airlines will join efforts to mitigate environmental impacts (Gohardani & Singh, 2011; Lee & Mo, 2011, Mousavi & Bossink, 2017). Renewable energy and biofuels are prominent technologies which will be mass-adopted in the 2030s, including biomass and cellulosic biofuel, and a reduction of (or zero) waste materials to achieve carbon-neutral growth, and to reduce the aviation GHG emissions (Winchester et al., 2015; IATA, 2011). In the 2030s and 2040s, new materials are likely to promote significant progress for aircraft development and products. For instance, new advancements in nanotechnology will improve multifunctional properties (e.g. physical, chemical, mechanical) at the nanoscale enabling composites and nanocomposites to be applied in the aeroplane's parts and to provide more anatomical and customised equipment such as seats, luggage compartments, and entertainment electronic devices. (Roco & Bainbridge, 2005; Zhu & Childs, 2018). Similarly, smart materials such as shape memory polymer composites (SMPC) can change their form as a result of certain stimuli such as change of temperature, electric or magnetic field, particular light wavelengths that can be embedded to the concept the morphing technologies applied on aeroplane's wings (Barbarino et al., 2011; Zhu & Childs, 2018). Likewise, electronics will be more integrated, enabling “intelligent” materials to continuously monitor in real-time, allowing maintenance needs to be automatically predicted and scheduled well in advance (IATA, 2011).

However, even with technological advancements, complex problems related to computational dependence such as aircraft arrival sequencing, scheduling system and timing algorithms and parallelization still demands further advancements (Date et al., 2019). In the 2050s, new generation machine learning, artificial intelligence (AI) and quantum computing are likely to solve these problems accurately and efficiently. AI systems like humanoid robots and autonomous vehicles will realize higher degrees of security and speed improving the luggage loading and tracking, providing automatized boarding process and fast passenger commute on airports. Furthermore, telecommunication systems with zettabyte connections will increase the capacity of communication channels enabling the real-time transactions for contracts with suppliers, reliable storage systems, quick offerings suitable to customers, and improvements on the communication system to operate procedures on the ground and in-flight (Hu et al., 2014).

As the sector reaches the second half of this century, some innovations are likely to offer flexible and seamless choices between transport modes, by using all types of vehicles such as autonomous and personal aircraft (Liu et al., 2017). Unmanned systems of the future are expected to become more autonomous with improvements in technology which require less direct human input through manual control and promise to reduce urban congestion by making use of free space in the air. Connected and autonomous vehicles (CAVs) and Personal Aerial Transportation Systems (PATS) have the potential to disrupt how we commute and engage in tourism activities at the destination level. Beyond intra-urban travel, the city-to-city travel displacement should also be affected, mainly in terms of a more direct connection to regional and urban centres, increasing accessibility and reducing travel time beyond airport catchment areas (Cummings & Guerlain, 2007; Bazzan & Da Costa, 2012; Cohen & Hopkins, 2019).

Completing the provisions to 2095, innovations in air transportation can lead towards robotization and space travel. A new era of robots-drones, autonomous vehicles and personal aerial aircraft will enable autonomously fly in natural and human-made environments (Floreano & Wood, 2015). New market opportunities in unmanned flight and outer space are likely to be explored, where orbital and suborbital space transportation will surely be unique commercial services for this new market, leading into the growth of space tourism (Sampigethaya & Poovendran, 2013).

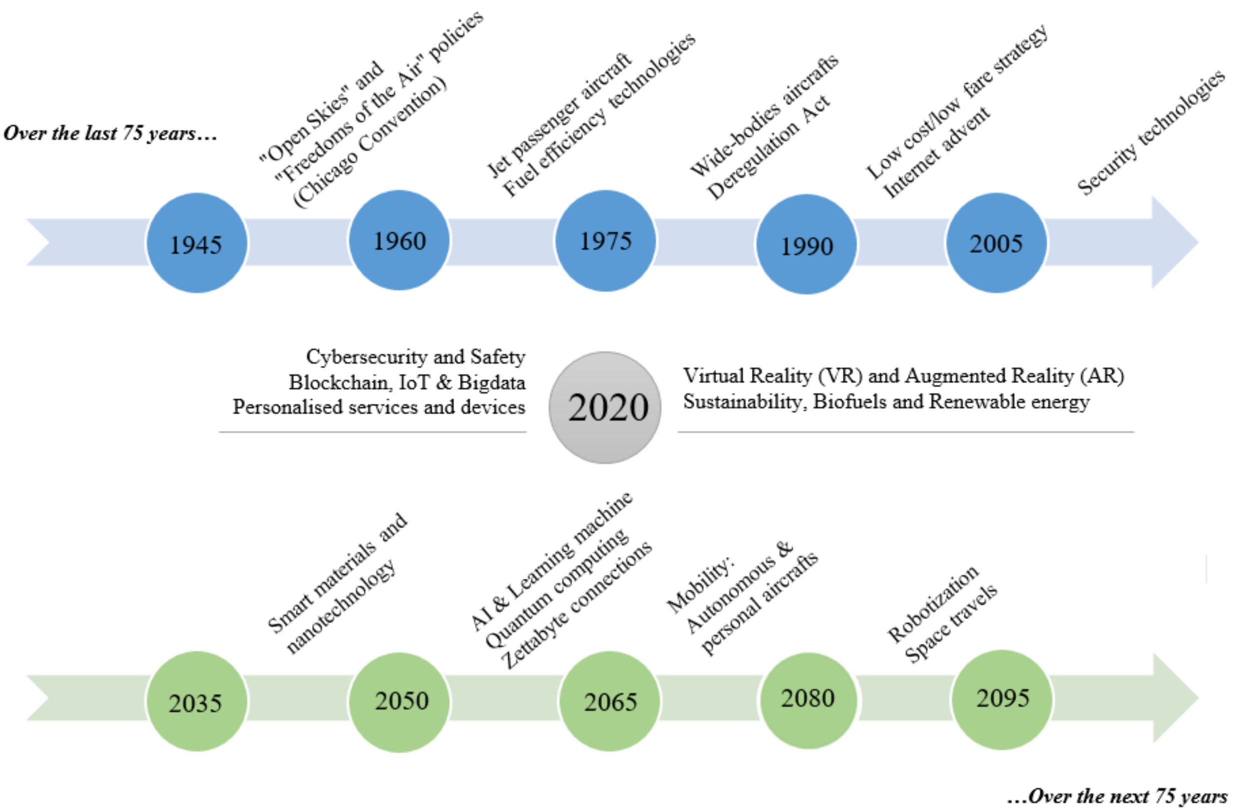

Figure 1. Remarkable developments (1945-2095) perspectives of air transport innovations.

Conclusions

Regarding the developments discussed, it becomes perceptible how these innovations marked each period of the history of aviation. In the 1950s was remarkable by the pursuit for the higher capacity of passengers travelling around the world as well as the increase of the aircraft's speed and fuel efficiency contributing to reducing the price of travelling. In the 2020s, the air transportation sector experiences the new era of connectivity, robotization and information intelligence dealing with disruptive innovations that enable the development for smart materials, integrated devices and higher data connectivity that will get more efficient over the next 75 years.

However, even with these prospects, challenges related to deregulation, safety and security will always be a concern. Nevertheless, opportunities for new advancements will be chased in the next 75 years in terms of a truly. However, there is an imminent need for a new sustainable development, attending customers' needs to deliver more personalised services, and transforming the operations and flights safer and more secure.

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