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Exploiting Forward-Looking Data in Prospective Ergonomics: the Case of Aviation

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Abstract. In this study, we investigated different sources of forward-looking data in the domain of aviation and pilot training that are of interest to human factors researchers and practitioners involved in the creation of future artefacts. We show how trends that are emerging for the future as well as unforeseen short-term events, such as the COVID-19 pandemic, impact decisions made on the design of future artefacts in aviation. In this respect, the case of anticipating pilot shortage is examined in relation with the design of a new form of training program: evidence-based training (EBT).

Keywords: Prospective ergonomics, data source, aviation, evidence-based training, pilot training, pilot shortage

1 Introduction

1.1 Prospective ergonomics

Ergonomic interventions have been mainly focused on correction and design (of already identified artefacts), and only recently on prospective and innovation [1]. Prospective Ergonomics (PE) deals with the design of future things. It consists in searching for current and upcoming needs in order to design future products, services, processes, or systems that will fulfill these needs [2]. This mode of intervention differs from traditional ones in several aspects: there is no initial demand from a client and therefore no mandate to the ergonomist; the need to fulfill is to be discovered; the artefact to create for this need is to be identified; and the future users of this artefact and their future activities have to be defined. The ergonomist who plans to launch a PE project must have initiative, be creative and a leader, and coordinate numerous activities that are normally associated to the development of new products or services: elaborate a project, analyse competitive artefacts, get financial support, build a team, manage the development process, etc. The activities involved in a prospective approach aim at gathering the relevant prospective information to orient towards the future and lead to creative and innovative ideas. PE can bring commercial advantages by developing new artefacts that can change human habits and be better adapted, more secure, less expensive, and/or more efficient.

As a new approach, PE still has limited documented real-life cases and applications. There is therefore a need for guidance material and supporting tools in this do-

main [3]. This article identifies different sources of information that can support engineers, ergonomists, or designers in prospective activities in aviation. First, we provide an introduction of the concepts involved in the development of Evidence-Based Training (EBT) to address the forecasted pilot shortage. Second, we analysed prospective data in the large-scale domain of aviation and identify forward-looking data sources which can be used for future artefacts. Third, we discuss the results obtained and the limitations of this study. Finally, in the conclusion, we proposed new orientations and perspectives for future research in PE.

1.2 Safety concerns of airline pilot shortage

Aviation has seen continuous economic growth throughout the past decade. In 2019, the International Civil Aviation Organisation (ICAO) observed 1,303 scheduled airlines operated over 31,717 aircrafts, throughout 3,759 airports with the support of 170 air navigation services providers [4]. In 2017, the International Air Transport Association (IATA) predicted that air passenger numbers would increase to 7.8 billion by 2036, which is almost double of the 4 billion passengers at that time [5].

In light of the anticipated increase in the number of air travelers and high numbers of baby boomers retiring, pilot shortage was becoming a major issue. In 2019, Boeing's CEO had announced that pilot shortage was to be "one of the biggest challenges" facing the industry. Boeing also projected that 804,000 new civil aviation pilots worldwide were needed to maintain the global fleet in the next 20 years throughout commercial, business and helicopter industries [6].

These forward-looking data pointed towards an exponential growth in all sectors of aviation. Aviation industries believed in the benefits of the long-lasting and vital importance of air transport development as it became an indispensable means of transportation. To keep up with times, industries around the world have financed research programs to understand emerging trends in aviation and create artefacts services to get ahead of the industry. Multiple aviation organisations and associations have investigated the challenges concerning pilot shortage, and one of the most promising outputs is the development of new programs to accelerate pilot training.

In such circumstances, improved training methods are necessary to maintain safety standards while mitigating against pilot shortage by reducing training duration and costs. More specifically, training organisations have developed more efficient training programs with the goals of increasing pilot competencies and reaching higher safety levels. Traditional training uses repetitive testing in the execution of maneuvers (the "tick box" approach) to train pilots at managing situations that they have already practiced or encountered before. This method of training is no longer appropriate in this developing and dynamic industry and does not meet the needs of airline operations anymore.

1.3 The need for a new type of training: Evidence-Based Training (EBT)

Evidence-Based Training, sometimes referred to as Competency-Based Training (CBT), arose from the concern that pilots needed to be trained to face novel and unexpected threats that do not deal with standard operating procedures. EBT aims at identifying, developing and evaluating pilot competencies in order to increase safety by managing threats and errors based on operations and training data. It has been supported by ICAO and IATA and quickly adopted by many airlines. EBT is a training and assessment method based on data and focuses on developing and assessing the overall capability of trainees across a range of pilot competencies rather than measuring their performance in events or maneuvers.

EBT differs from traditional training by including the aspects of pilot core competencies and evidence. Competencies are observable and measurable and are about activities that pilots need to operate safely. Evidence is the result of global safety and training data analysis. Both these elements in EBT aim at fostering pilot resilience, which is the ability of the crew to deal calmly and efficiently with unexpected situations. EBT is based on large sets of data (i.e., safety reports, pilot surveys, flight data records and analysis, etc.) such as those recorded during flights and training sessions. These data are used to identify threats, errors, undesirable aircraft states as well as typical failures observed in operation depending on routes and types of aircraft to be included in future training programs.

In light of forward-looking information in aviation and the forecast of the pilot shortage, aviation industries were looking for a way to train pilots faster and better. As a result, EBT was identified as a solution that can mitigate for pilot shortage by accelerating training while maintaining safety standards. Earlier in this paper, we had identified the lack of guidance and supporting tools in PE. We therefore use this case of pilot shortage to identify the sources of prospective data in aviation that can be exploited for future projects in this domain.

2 Problem

The major challenge in PE is the lack of examples of documented PE real-life cases that can provide lessons learned and best practices. The next section of this article identifies the forward-looking data sources that can be used in PE to identify future trends in aviation. They can be used as lessons learned and help with the design of products and services that do not yet exist in aviation.

3 Methodology

We reviewed commercial and scientific literature on air traffic and pilot demand. We identified data sources that provided statistics and forecasts concerning future traffic

growth and pilot shortage. At the time of this study, the aviation industry was experiencing an industry downturn driven by COVID-19. We were therefore restricted to prospective data in aviation that were published prior to the COVID-19 pandemic because there are currently limited post-COVID-19 forecast data. We classified these sources as coming from universities, training organisations, aircraft manufacturers, international organisations and government organisations.

4 Results

The results of this study are identified sources of forward-looking data that can be used for PE studies in aviation. Even if these data are to be reviewed following the COVID-19 pandemic, they allow us to make several observations on findings that will still stand true post-COVID-19: several companies, organizations and specialists in the field of aviation publish prospective data on the field; forecasts stretch from periods ranging from 5 to 30 years; the sources of forward-looking information are numerous, diverse and well recognized by the community; and the information from these sources of information is recent, of different nature since it includes both quantitative data (statistical data, survey results) and qualitative information (expert judgments, trend analysis), and is considered reliable and rigorous.

We identified three international organisations, one flight training organisation, two aircraft manufacturers, two government organisations and one university that provide forecasts in aviation (see Table 1).

Table 1. Sources of prospective data in aviation concerning pilot demand.

CAE	**Type of organization** Training organization	**Title** Pilot Demand Outlook	**Timeframe** 2020-2029
	At a glance: Provides a forecast of the pilot population over the next 10 years for airplanes and business jets. Also provides an estimate of the number of pilots needed to sustain operations in the next 10 years throughout different regions of the world [7].		
Boeing	**Type of organization** Aircraft Manufacturer	**Title** Pilot & Technician Outlook	**Timeframe** 2020-2039
	At a glance: Boeing provides a 20-year fleet forecast for commercial aircrafts, business jets and civil helicopters. Based on the forecast, Boeing estimates the number of pilots, technicians and cabin crew members needed worldwide [8].		
Airbus	**Type of organization** Aircraft Manufacturer	**Title** Global market forecast	**Timeframe** 2019–2038
	At a glance: Provides the demands of air travel and passenger aircrafts, network and traffic forecasts, freighter and services forecast for 2019–2038 [9].		

IATA	**Type of organization** International Organisation	**Title** Monthly Traffic Statistics	**Timeframe** Every month
	At a glance: Provides an overview of trends on the air passenger market for a single month collected from airlines. Describes variations in passenger revenue kilometers (PRKs) as compared to previous months throughout different regions [10].		
IATA	**Type of organization** International Organisation	**Title** 20-Year Passenger Forecast	**Timeframe** 2019-2039
	At a glance: Forecasts the evolution of the number of air travelers the next 20 years. Defines the drivers behind traffic demand and identifies traffic trends. Provides different possible scenarios to support industries' long-term strategic decision-making [11].		
ICAO	**Type of organization** International organisation	**Title** Long-term Traffic Forecasts	**Timeframe** 2015-2045
	At a glance: Provides a global air transport outlook to 2030 and trends to 2040. Describes traffic forecast by regions of the world for international, domestic and freight traffic [12].		
ICAO	**Type of organization** International organisation	**Title** Global and Regional 20-year Forecasts (DOC 9956)	**Timeframe** 2011-2031
	At a glance: Provides forecasts for pilots, maintenance personnel and air traffic controllers for the next 20 years [13].		
Airport Council International (ACI)	**Type of organization** International organisation	**Title** World Airport Traffic Forecasts	**Timeframe** 2019-2040
	At a glance: Offers insights into the future evolution of air transport demand across the world between 2019-2040. The forecast breaks down into total passengers (broken down into international and domestic traffic), total air cargo and total aircraft movements [14].		
Embry-Riddle Aeronautical University	**Type of organization** University	**Title** Effects of the Pilot Shortage on the Regional Airline Industry: A 2023 Forecast	**Timeframe** 2019-2023
	At a glance: Predicts how many aircrafts would have to be grounded by 2023 due to pilot shortage and impacts to passenger traffic. For US traffic only [15].		
Federal Aviation Administration (FAA)	**Type of organization** Government organisation	**Title** Aerospace Forecast	**Timeframe** 2020-2040
	At a glance: Provides forecasts on emerging trends of the different segments of the aviation industry. For US traffic only [16].		

	Type of organization	**Title**	**Timeframe**
Civil Aviation Authority (CAA)	Government organisation	Aviation Market	Every year
	Provides airport traffic statistics, domestic and international airline traffic carried by UK registered airlines, and results from surveys of departing passengers. For UK traffic only [17].		

Multiple sources forecasted a need for additional pilots to meet the air traffic growth expected in the next 10 to 20 years. Concerning pilot demand, in 2020 CAE predicted that the civil aviation industry will need over 260,000 new pilots over the next decade. Also in 2020, Boeing anticipated the need for 763,000 new civil aviation pilots to fly and maintain the global fleet over the next 20 years. Concerning traffic growth, in 2019, IATA forecasted a growth of 3.7% in the number of air passengers annually over the next 20 years. In 2015, ICAO predicted an average global passenger traffic growth of 4.3% annually until 2035. On the aircraft manufacturing side, Airbus forecasted in 2019 a need for 39,000 new aircrafts in the next 20 years to meet passenger and traffic demands. Finally, in 2019, Embry-Riddle Aeronautical University provided scenarios with estimations on how various shortages of pilots in the USA will lead to increasing numbers of grounded aircrafts.

The IATA Monthly Traffic Statistics and the UK CAA do not provide prospective data, but they do provide the latest statistics showing the current trends in the domain. Even though they do not present forward-looking data, they can be used to anticipate trends in the near future and confirm past forecasts that were made on passenger and air traffic growth. Furthermore, most of the sources provide the information as charts and figures as part of a publication with very limited manipulation of data possible. The exceptions are Airbus, the FAA, the UK CAA and ACI which provide their statistics in a downloadable data spreadsheet on passenger, air traffic and airport traffic.

The statistics of this study point to the need for an accelerated pilot training as a solution to bring additional pilots into operations more quickly and efficiently in order to maintain current and future air traffic. In their paper, Embry-Riddle highlighted the need for new pilot pathway programs as an important topic for further research to mitigate pilot shortage. ICAO endorsed the implementation of EBT, which encouraged airlines to adopt this new training program. In their publications, CAE and Boeing emphasized the need to develop future aviation training standards. As of 2019, IATA offered EBT consulting services which helped airlines transition from traditional training to EBT. Airbus integrated EBT into their programs, influencing the training of the next generation of pilots.

5 Discussion

At the time of this study, this paper identified the latest forward-looking data in aviation and showed how these trends were exploited to create a training for a future need.

Sources of aviation forecasts predicted a shortage in pilots that led to the development of innovative methods of pilot training. EBT was adopted by airlines, aircraft manufacturers and flight schools globally.

There were two main concerns regarding this study: the impacts of the COVID-19 pandemic and the efficacy of EBT. This analysis did not consider factors that could significantly impact the study, such as economic downturns, industry regulatory changes and disruptive events. In this case, the COVID-19 pandemic upended the forecasts and pilot shortage is not currently a challenge, with pilots grounded and uncertain about how to retain their license. This study therefore highlights a limitation of prospective: it lacks mitigation strategies when unexpected factors disrupt the predictions and change the needs. We have seen that prospective methods are grounded on analysing trends to anticipate future needs, but learning from this case study, PE should also try to anticipate disruptive factors and prepare for how they impact decisions made on the design of future products and services.

The second limitation involved the efficacy of EBT as a new training program with very limited data in operations. EBT has been adopted by training organisations and airlines for only a few years and there has been no published study or data on its level of efficiency. Initiatives should be made in the industry to encourage the organisations who implemented EBT to monitor and share their data on pilot training output. By sharing real operational data on an implemented and working EBT program, the whole industry could benefit from lessons learned and define ways to improve the program.

In all areas of interest, it is clear that any PE project (or more broadly speaking, any future artifact design project) should be based on good quality and diverse information to enable designers to be in the best possible position to make good decisions and achieve good results. However, having good baseline information does not guarantee that the design team will make good decisions and achieve good results.

6 Conclusion

We identified sources of forward-looking data in aviation and identified lessons learned for a pilot training. Up to now, research in aviation has been focused on designing for commercial purposes, customer needs, prevention or to increase safety. There have been limited studies in aviation that gathers sources of prospective data for the design of future artefacts. The downturn seen in aviation due to COVID-19 caused a major disruption, but as the industry recovers, we expect new forecasts post-COVID-19 to consider for prospective studies. In the near future, we hope to see more studies using a prospective approach with the potential to disrupt and innovate the industry of aviation.

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