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Process Mining for resilient airport operations: A case study of Munich Airport's turnaround process

Julian Rott [a], Fabian König [b], Hannes Häfke [c], Michael Schmidt [d], Markus Böhm [e], Wolfgang Kratsch [b], Helmut Krcmar [a]

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Highlights

- Improving performance and resilience using process mining – a Munich Airport case study.
- Process mining increases the operational transparency of the turnaround process.
- Process mining can improve airport resilience by impacting resilience capabilities.
- COVID-19 led to a delay reduction but not to a consistent TOBT quality improvement.

Abstract

The aviation industry has faced significant challenges in recent years, including a punctuality crisis in 2018/19 and the ongoing impact of COVID-19 on operations since March 2020. Hence, the industry seeks innovative ways to optimize its operations and become more resilient. Process Mining (PM) has proven valuable in various settings and industries by analyzing event-log data extracted from existing information systems. As airports play a critical role within the aviation network, we expand on a case study-based methodology and employ PM techniques to analyze data generated within the airport collaborative decision-making (ACDM) framework for the turnaround process at Munich Airport. We show that applying PM enhances operational transparency, reveals performance differences between ground-handling corporations and airlines, and identifies data quality problems with the implemented ACDM framework. Additionally, we develop a conceptual framework demonstrating the positive influence of PM on airport resilience. Our study contributes to the aviation literature and resilience theory by showcasing the potential of PM for analyzing and optimizing operational airport processes. Since the ACDM framework is widely used in Europe, researchers and practitioners can apply our approach to improve turnaround processes at other European airports.

Introduction

The aviation industry has faced several crises during the last few years: In 2018 and 2019, punctuality emerged as a significant concern at hub airports due to capacity restrictions and the subsequent strain on existing infrastructure resulting from high utilization (Eurocontrol, 2020). From March 2020 to March 2022, COVID-19 led to a rapid decrease in the number of passengers (Eurocontrol, 2022b). In Munich, there was a staggering decline in passenger traffic between April 2019 and April 2020, with over 99% fewer passengers handled in April 2020 (Flughafen München Gmbh, 2021). Accordingly, airports, airlines, and ground-handling operators have sought ways to optimize their cost structure, including retrenching staff. Since April 2022, the number of travelers has increased significantly (Eurocontrol, 2022b), revealing a staffing shortage for security and ground-handling operations at many hub airports. Flights were rarely on time (Eurocontrol, 2022c), which frustrated passengers and overworked staff (von der Au, 2022; Duffy, 2022). Hence, the aviation industry continuously explores ways to optimize its processes and effectively utilize its infrastructure capacity to improve the passenger travel experience and reduce operational costs (Gelhausen et al., 2013; Okwir et al., 2017). Achieving these objectives also enhances the resilience of operations and establishes more sustainable business procedures (Di Vaio et al., 2021, 2023).

Multiple studies state that techniques for analyzing data, automating and innovating processes assist with increasing an organization's resilience (Belhadi et al., 2021; Das et al., 2022; Hamel and Välikangas, 2003). Process Mining (PM) can be viewed as a combination of data analytics and business process management (BPM) principles, as it allows organizations "to discover, monitor, and improve real processes (i.e., not assumed processes) by extracting knowledge from event logs readily available in today's [information] systems" (van der Aalst, 2016, p. 31). It has been increasingly adopted recently in other industries to optimize business processes and realize value potentials; for example, at Uber ($20 million of savings in the customer support process) (Reinkemeyer, 2020) and the German Telekom ($66 million of savings in the procure-to-pay process) (Celonis, 2022). However, several technical and organizational challenges must be addressed to achieve successful PM adoption. Organizations must develop PM skills, such as extracting and analyzing event data (Syed et al., 2020; Van Eck et al., 2015), and build conviction across hierarchies (Martin et al., 2021). Suitable use cases must be identified to ensure meaningful process analysis (Rott and Böhm, 2022a), and, in the case of multiple stakeholders, value distribution mechanisms have to be agreed on (Rott and Böhm, 2022b).

Although PM represents an essential driver of process improvement and can lead to significant cost savings, the literature on PM within the aviation industry is sparse from both a practical and theoretical perspective. Lufthansa CityLine, a pioneer of PM in the aviation sector, reduced the total delays by around 300,000min when comparing 2019 with 2018 (Böhm et al., 2021). Furthermore, Gunnarsson et al. (2019) used predictive process monitoring techniques to estimate the throughput time of pieces of baggage at airports.

Against the backdrop of sparse literature, we introduce PM as a novel technique for analyzing the cross-organizational turnaround process from an airport's perspective and, in doing so, examine its potential value. Following a case study-based approach, as described by Yin (2018), we analyze a real-world dataset from Munich Airport. We build upon timestamps generated within the Airport Collaborative Decision Making (ACDM) procedure to ensure comparability with and applicability to other airports. The ACDM framework was designed to standardize and optimize information exchange and collaboration between multiple stakeholders and has already been adopted by 32 European airports, including big hub airports, such as London Heathrow, Paris Charles de Gaulle, Amsterdam Schiphol, Frankfurt, and Munich Airport (Eurocontrol, 2022a). Hence, our work answers the following research question: *"What insights can PM, building upon ACDM timestamps, provide for the turnaround process at airports?"* Additionally, we draw on the resilience theory lens to discuss how PM impacts an airport's resilience and, thereby, supports operations in volatile situations (e.g., the punctuality crisis and the COVID-19 pandemic).

Overall, we contribute to the aviation literature by demonstrating the potential of PM for analyzing and improving aviation processes and, specifically, the cross-organizational turnaround process from an airport's perspective. We provide real-world insights valuable for aviation researchers and practitioners on Munich Airport's turnaround process, for example, regarding the implementation of the ACDM framework and the performance before and during the COVID-19 pandemic. Furthermore, we advance the literature on resilience theory by conceptualizing the impact of PM application on airport resilience. Intending to inspire fellows to conduct PM analyses within the aviation industry, we

also provide insights into and value potentials for the turnaround process, as well as directions for future applications and research opportunities.

The rest of the article is structured as follows: Section 2 provides the required background knowledge on ACDM, data analytics in aviation, PM, and resilience theory. Section 3 lays out the research methodology. Section 4 provides the PM analysis results. Section 5 discusses the results including academic and practical implications, limitations and future research directions, before a conclusion is drawn in Section 6.

Section snippets

Airports and Airport Collaborative Decision Making

Airports are a critical element of air travel providing necessary services to support plane handling, i.e., allowing an aircraft to take off and land. Airport operations include landside processes, where passengers arrive, drop their bags, and pass the security and airside processes.

The turnaround process describes all actions to get an aircraft ready for takeoff. It begins when the plane arrives at the gate after landing, and the chokes are set (in-block time). The parking location can be…

Research approach

We followed a single case study approach, as described by Yin (2018), to answer our research question. Allowing for an in-depth investigation of PM analysis potentials for the turnaround process, we investigated two embedded units of analysis: turnarounds happening at Munich Airport in September 2019 and September 2021. In the latter, approximately 40% of the number of passengers from September 2019 were handled (Flughafen München GmbH, 2022). We excluded September 2020 from our analysis after…

Analysis iteration for process discovery

To gain first insights into the turnaround process, we used the *Variants Explorer* feature in PM_{TK}, which revealed 3,767 process variants, the most common of which accounted for only 3.6% of all turnarounds. The reason for the high number of process variants was that target timestamps, representing background scheduling activities (e.g., TOBT), were included as events in the event data. Thus, to keep only observable process activities and reduce process complexity, we removed events that…

Discussion

Section 4 presented detailed results of analyzing turnarounds at Munich Airport with the help of PM and traditional data analytics techniques. In the following sections, we discuss our findings from an academic perspective by examining the impact of PM on an airport's resilience and from a practical perspective by summarizing the findings relevant to practitioners. In addition, we outline the article's limitations and future research directions.…

Conclusion

In our study, we examined the potential of PM as a solution for more fluent, resilient, and unimpeded processes and operations at airports. As part of our single case study approach, we applied the PM^2 methodology to a dataset consisting of all ACDM-related turnaround data from Munich Airport in September 2019 and September 2021. Our findings show that PM provides additional value for analyzing turnarounds at airports compared to solely relying on traditional data analysis techniques and…

Author statement

Julian Rott: Conceptualization, Methodology, Formal analysis, Validation, Data curation, Writing – Original Draft, Review & Editing, Project administration.

Fabian König: Conceptualization, Methodology, Formal analysis, Software, Writing – Original Draft, Review & Editing.

Hannes Häfke: Methodology, Formal analysis, Software, Writing – Original Draft, Review & Editing.

Michael Schmidt: Formal analysis, Data curation, Validation, Writing – Original Draft, Review & Editing.

Markus Böhm:…

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