

Abstract

A quantification of economic impact from unauthorized drone flights in the vicinity of airports

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In recent years, unauthorized drone operations have repeatedly interfered with air transport both nationally and internationally. Drones operating within controlled airspace, if non-cooperative, pose a significant safety and security risk. When such drones are detected in the airspace (often in the vicinity of airports) they are typically reported by pilots, air traffic controllers, or airport personnel. Subsequently, the situation is assessed and, if necessary, appropriate operational measures are determined. These measures range from the dissemination of simple traffic information for pilots to the closure of individual runways or even entire airports. In the latter cases, arriving aircraft need to go into airborne holding patterns or divert to alternative airports while departing aircraft are kept on the ground and depart either delayed or get cancelled completely.

Due to the impact this has on the passengers, which might miss connections or get stranded, such events regularly attract media and political attention. Additionally, these nonregular operations have an economic impact on aviation. This economic impact, however, particularly on airlines, has rarely been quantified, and if so, only at the level of individual disruptions. To the authors' knowledge, no study exists that quantifies the cost incurred by the air transport industry due to drone-related disruptions across an entire country over the course of one year. The objective of this study is the development and demonstration of a data-driven methodology for assessing all drone-related disruption events recorded in Germany in 2025.

The analysis is based on a dataset provided by the German Federal Aviation Office (LBA), comprising all documented drone-related incidents. The dataset includes the timing and duration of each disruption, the affected airport, and the operational measures implemented by air traffic control. An overview of the possible measures and their frequency of occurrence is illustrated in Figure 1. It can be observed that individual runway closures occurred in 48 cases, while complete suspensions of flight operations were implemented in 38 cases.

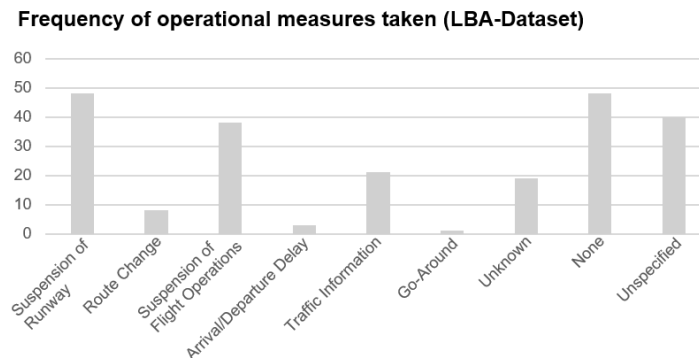


Figure 1: Frequency of operational measures implemented in response to unauthorized drone sightings at German airports in 2025 based on the dataset provided by the German Federal Aviation Office (LBA).

The two-step methodology developed consists of a data collection and preparation phase and a cost quantification phase. It is based on a comparison of actual and scheduled flight data for potentially affected flights. For this comparison, flight schedules extracted from the Sabre database [2] were matched with the corresponding observed flight operations obtained from Flightradar24 [1]. From this, delay values were determined for flights that were scheduled to take place at the affected airport within the analysis period. This period extends from the day preceding the disruption until the day following the disruption, with the exact observation window depending on the direction of traffic under consideration. Only flights departing from or arriving at the affected airport after the onset of the first disruption are included in the final impact assessment. Here, multiple disruptions at the same airport in a short period of time were treated as one.

For creating a reference scenario, a historical database was established for each unique flight connection (defined by flight number, departure airport, and destination airport) identified within the study period to determine flight-specific average delays. These average delays serve as an approximation for the deviations from the original flight schedule which would have occurred in the absence of the drone-related disruption.

Based on the way a specific flight was affected by the disruption, different quantification methods were applied: In case of a delay by up to a few hours, costs were interpolated on the basis of delay duration and the aircraft's maximum take-off weight using inflation-adjusted values proposed by the Westminster University [4]. If the flight was delayed to the next day, expenses for accommodation and meals were considered based on the number of passengers. The costs of diversions were estimated based on EUROCONTROL recommendations [3] as a function of aircraft size and flight distance. Cancellations cannot be identified from the available datasets. Therefore, an estimation approach was developed to approximate the share of flights that have been cancelled without a substitute flight. This share was multiplied with the cost of a full cancellation of all flights potentially affected by it. This cancellation cost was approximated based on the revenue associated with the specific flights. For each disruption event, the monetary costs associated with the reference scenario (all flights have average delay) were subtracted from the disruption costs. This approach allows the identification of costs that can reasonably be attributed to the disruption itself.

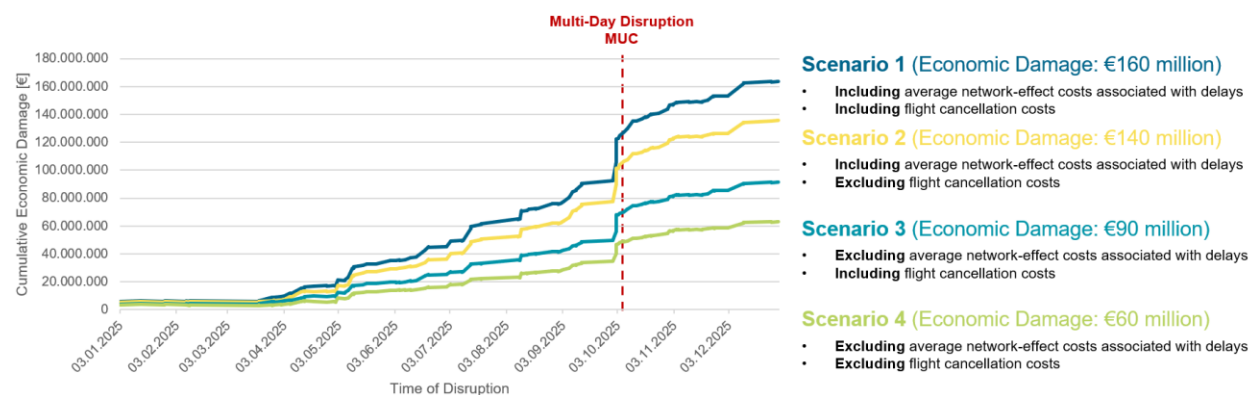


Figure 2: Cumulative economic impact caused by drone-related disruption events at German airports in 2025 for four assessment scenarios.

The presented results are based on 116 relevant disruption events across 25 German commercial airports. In total, nearly 112,000 passenger flights were included in the analysis. Both the impacts of flight cancellations and the resulting network effects, such as missed connections or delayed subsequent flights, are evaluated using lower-bound and upper-bound assumptions. This results in a total of four assessment scenarios (see Figure 2). The estimated economic impact amounts to 60 million EUR in the most conservative approximation scenario. Furthermore, the determined costs increase to as much as 160 million EUR when applying the cancellation cost approximation method and assuming network effects to scale linearly with the number of affected flights. The sharp increase in economic impact observed for long-lasting disruptions, such as a two-day disruption at Munich Airport (see Figure 2, red dashed line), is consistent with a non-linear relationship between economic losses and the available buffer capacity of the air transport system.

The presented results provide a valuable basis for cost-benefit analyses by airport operators, industry stakeholders, and policy makers. In particular, the results can support cost-benefit assessments of investments in active counter-drone systems deployed at and around airports.

[1] Flightradar24 – API (<https://fr24api.flightradar24.com/>). Accessed: April 2026.

[2] Sabre GBL Inc., 2025. Sabre Market Intelligence - database. URL: www.sabre.com. Accessed: April 2026.

[3] EUROCONTROL. Cost of Diversion – EUROCONTROL Standard Inputs for Economic Analyses. https://ansperformance.eu/economics/cba/standard-inputs/v10.0.1/chapters/cost_of_diversion.htm

[4] University of Westminster (2015), European airline delay cost reference values - version 4.1 (<https://www.eurocontrol.int/publication/european-airline-delay-cost-reference-values>)

Biography

Speaker: Majed Swaid & Milena Röhrs



Majed Swaid is a researcher at the German Aerospace Center (DLR). He studied mechanical engineering at Hamburg University of Technology, focusing on flight control systems. Since 2019, he has worked on operational concepts in urban air mobility and U-Space at DLR's Institute of Air Transport in Hamburg.

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Milena Röhrs has been researching at the German Aerospace Center (DLR) for two years. With degrees in Mathematics as well as Theoretical Chemistry and Computational Modelling from the RPTU and KU Leuven she applies her expertise in optimization on airline planning processes. One major focus is her contribution to creating the DLR-Digital Airline Twin.

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