Title
Reducing Emissions through Monitoring and Predictive Modeling of Gate Operations of Idle Aircraft: A Case Study on San Francisco International Airport

Authors
Rakas, Jasenka, PhD
Achatz Antonelli, Pietro
Walia, Chanan
et al.

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Reducing Emissions through Monitoring and Predictive Modeling of Gate Operations of Idle Aircraft: A Case Study on San Francisco International Airport

Airport Cooperative Research Program

UC Berkeley
ITS/NEXTOR and Airport Design Studio

Principal Investigator
Jasenka Rakas, Ph.D.

Researchers
Pietro Achatz Antonelli, Ph.D.
Chanan Walia
Parham Rouzbahani
George Gikas

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Abstract

The use of airport gate electrification infrastructure in the form of ground power (GP) and pre-conditioned air (PCA) systems can reduce energy and maintenance costs, emissions, and health risks by limiting the use of aircraft auxiliary power unit (APU) engines at the gate. However, their benefits can only be gained when they are actually being used; otherwise, pilots keep APUs on to fulfill their aircraft's demands for electrical power and air conditioning. GP and PCA systems require a large initial infrastructure investment to increase energy efficiency, and they are installed with the assumption that they will be highly utilized. In this research, a method is developed to examine how much and why GP and PCA are not used to their full potential when they are readily available.

Maximizing the use of gate electrification infrastructure is a fragmented, interdependent, and dynamic management challenge. The processes of using GP and PCA fit tightly into an intricate sequence of connected and concurrent activities required to complete an aircraft turnaround operation. Each process depends on close communication, collaboration, and shared responsibility among airports, airlines, ground crews, and pilots. The circumstances and schedule of each operation can change unexpectedly while it unfolds, with limited time to react. The lack of responsiveness in such a tangled system allows for any issue to interfere with the effective use of GP and PCA (e.g., technical problems, resource constraints, scheduling conflicts, and behavioral issues). Many unique circumstances that result in APU overuse can be attributed to the unexpected incidents that caused it. However, these incidents should not be interpreted as isolated accidents; they could be recurrent symptoms of neglect, lack of prioritization, or lack of adaptability for maximizing energy efficiency at airport gates.

The lack of energy-use monitoring and data sharing among airports, airlines, pilots, and ground crew workers perpetuates inefficiencies. Without measurements to hold individual operations accountable for their energy use, any enforcement or policy remains shortsighted and ineffective. Without being able to track long-term performance or set a standard, successful practices or systematic problems remain hidden. Without a method to predict and manage the energy being used at the gate, highly fluctuating energy demand from airport gates becomes an additional challenge. An integrated monitoring solution would enable airports not only to enforce policies to restrict the use of APUs but also to gain a proactive management role in the airline's use of gate electrification infrastructure. By ensuring all gate turnarounds abide by a maximum APU use time of 15 minutes, airports could achieve a significant reduction in airline fuel costs and carbon emissions from current levels at airport gates.

The monetary and environmental savings of gate electrification are not independent from many other costs of turnaround operations. Maximizing energy efficiency at the gate should not come at the expense of other priorities. There are many factors in assessing the performance of a turnaround operation, some being far more consequential than the use of gate electrification infrastructure such as safety, on-time departure, or passenger experience. For this reason, it is important to assess turnaround operations with a method that is both comprehensive enough to represent the multifaceted costs and simple enough to be systematically applied. Furthermore, the costs involved apply differently to each responsible party (i.e., airline, airport, ground crews, pilots). With an

understanding of the relationship between inputs (e.g., equipment, schedule, work sequence, staffing) and the costs in an operation, the groundwork is laid to predict, optimize, and incentivize effective energy management for ground handling operations. In this research, a method is developed that formulates a life cycle inventory on GP, PCA and APU use, and evaluates energy use for turnaround operations in terms of their financial, global, and local impact. The method was applied to SFO as a case-study. Each operation was associated with a breakdown of monetary and CO_2 costs, including initial and non-operational costs. In addition, a dispersion analysis and health risk assessment are used to estimate the health impact of local air pollutants on apron workers.

The value of being able to monitor, predict, and optimize operations depends on how quickly these tasks can be performed to provide actionable results. With a retrospective assessment of historical data, a broadly optimized management of a turnaround operation can provide savings, satisfying the need for resiliency by placing contingencies in the plan. A turnaround operation manager can coordinate the ground crew as the operation unfolds, but all humans are limited in their ability to monitor, predict, and optimize. By streamlining the process of data acquisition, prediction, optimization, and simulation through a real-time computerized system, it is possible to design a decision support tool that can quickly adapt to the unfolding circumstances of each operation. This research outlines the architecture of an automated computerized system that can support scheduling and decision making for turnaround operations. By prototyping and running the system in a simulated environment, we can demonstrate that computerized adaptive scheduling can unlock monetary and environmental savings through increased resiliency, reduced uncertainty, and increased collaboration between stakeholders.

This research lays down the foundations for data-driven monitoring, modeling, and management of gate operations, specifically with a focus on GP use. It shows how airport databases can be integrated to produce insightful results in an immediately feasible and replicable way. It tests several modelling and evaluation techniques that dissect turnaround operations with unprecedented detail. It indicates how maximizing GP use is in part a risk management problem and proposes an active solution to address it within the framework of a larger interconnected system. Furthermore, it proposes future research directions to advance and expand the existing body of knowledge related to enhancing aircraft turnaround operations.

Further Reading and More Information

This abstract draws from the Ph.D. Dissertation titled "A Framework for Monitoring, Modeling, and Management of Airport Ground Power Systems During Aircraft Turnaround Operations" by Pietro Achatz Antonelli.

URL https://escholarship.org/uc/item/0dw9171k

For more information about the findings in this abstract, contact Jasenka Rakas at jrakas@berkeley.edu.