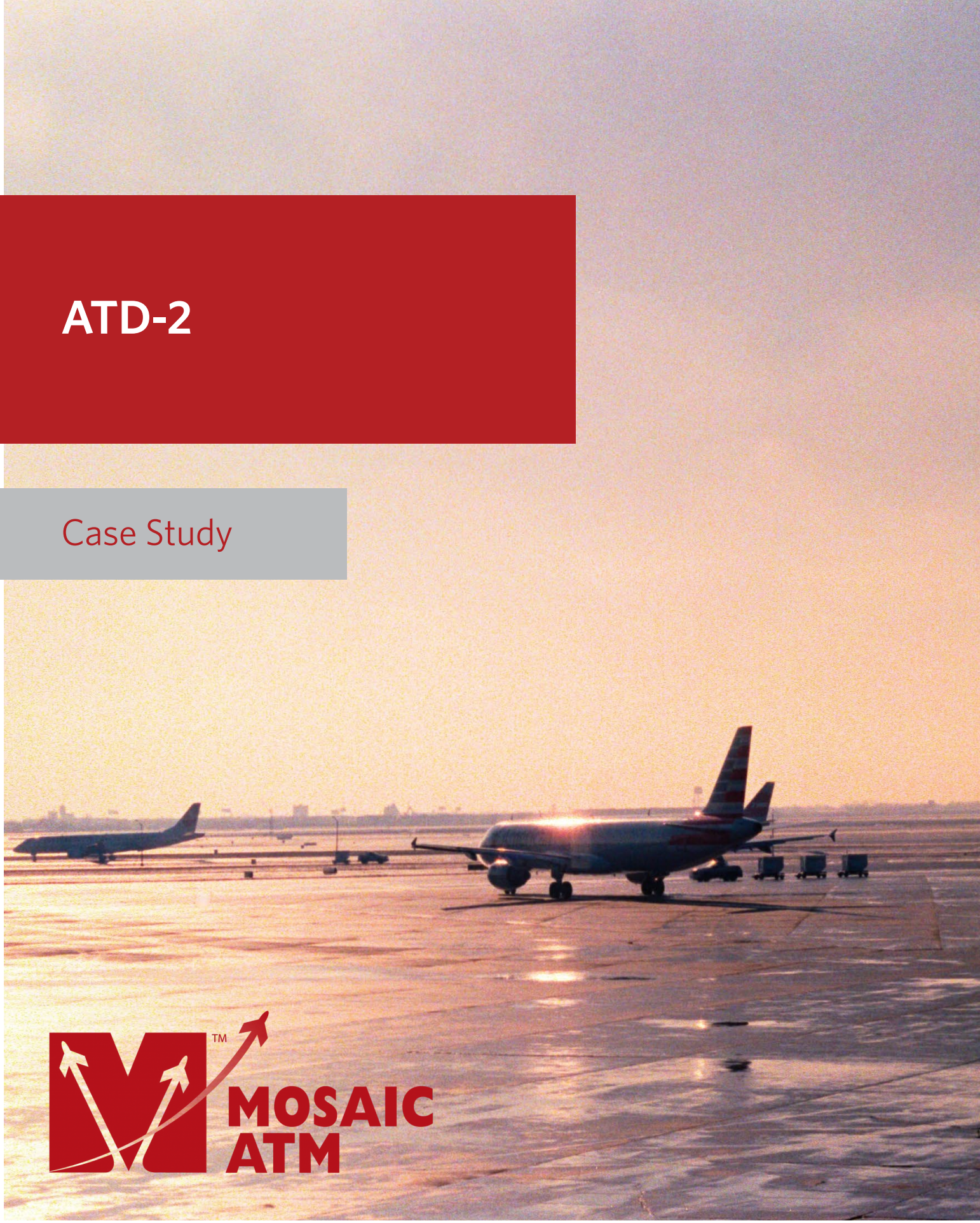
ATD-2

Case Study



MOSAIC ATM™

ATD-2

Addressing Inefficiency in Today's Air Transportation System

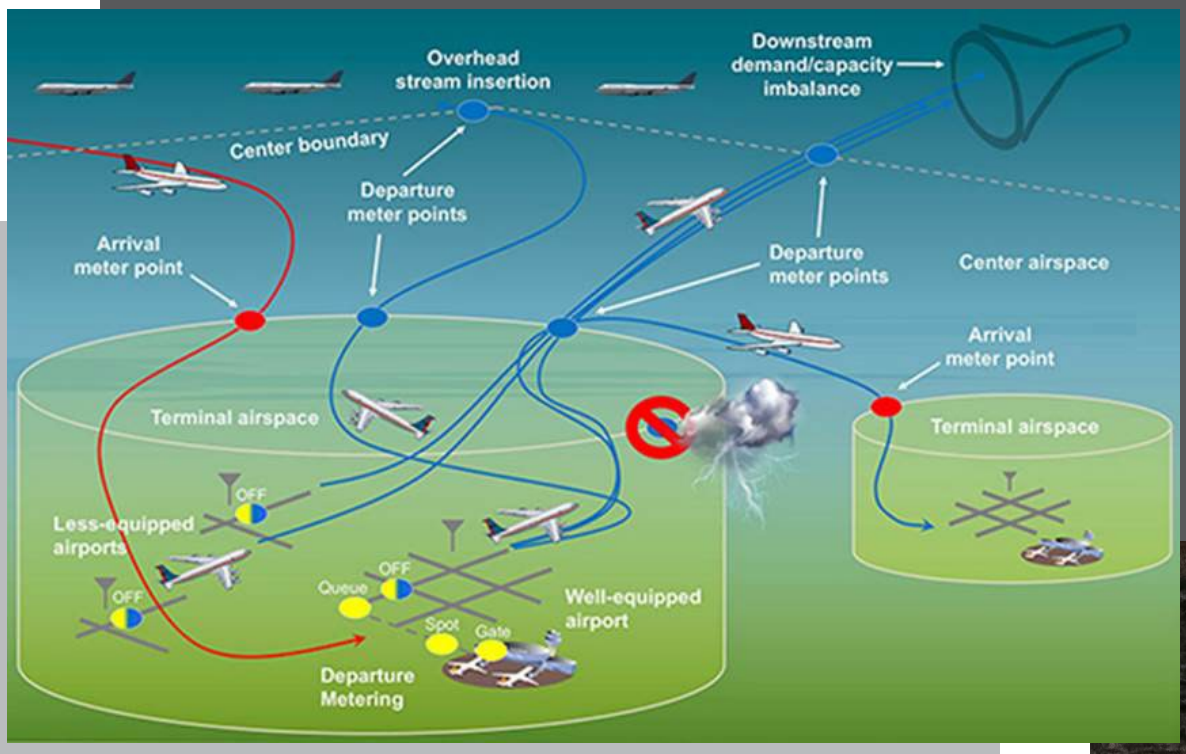
According to NASA[1], many of today's air transportation system issues can be attributed to a lack of information sharing amongst the operators responsible for managing air traffic in busy terminal environments. Concepts and technologies to improve the arrival, departure, and airport surface traffic have been under development by NASA, the Federal Aviation Administration, and industry partners. Still, to date, these capabilities have primarily been developed and implemented independently.

NASA led an investigation into air transportation stakeholders' needs. This investigation showed that an integrated approach was needed to address this lack of information sharing. Without shared information on a specific airport, air sector, or schedule, a lack of reliable & trustworthy aircraft movement projections persists and leads to inefficiency for all stakeholders and more significant fuel burn and CO2 emissions.

Background

The **Airspace Technology Demonstration 2** (ATD-2)[2] effort provides solutions to several problems in the complex, multi-airport environment. At most airports today, departures are managed in the order they push back from the gate, which can overload runways and cause excessive taxi and hold times.

Additionally, significant uncertainty in the duration of the taxi-out, takeoff, and climb phases of flight leads to inaccurate demand predictions, decreased situational awareness, and overly conservative airspace restrictions that traffic managers are compelled to apply to compensate for this uncertainty.



Reference[3]

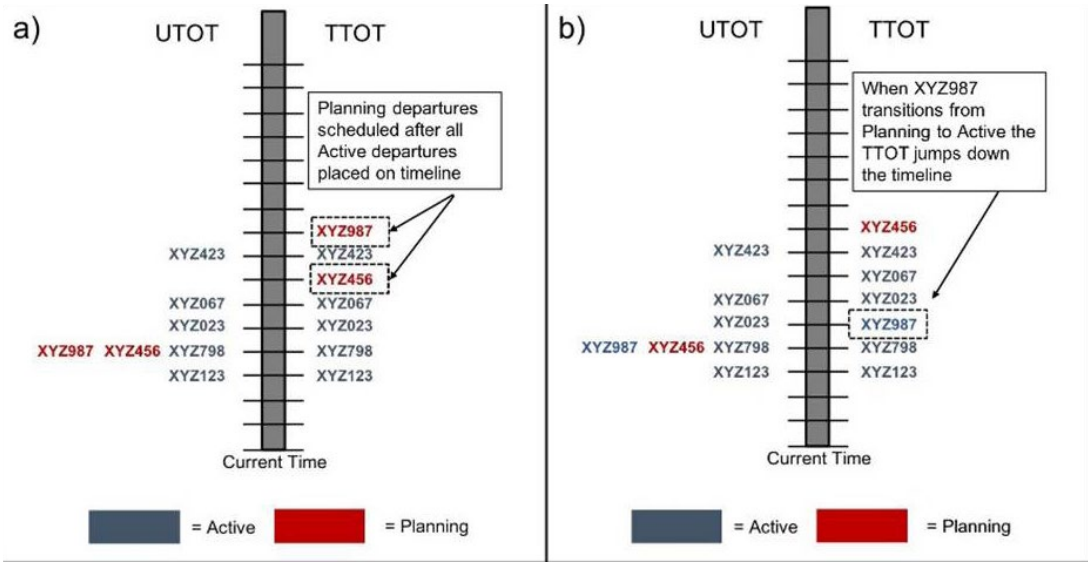
Overview of Mosaic's Technical Support

Since 2016, **Mosaic ATM** has been integral to the NASA team conducting a field evaluation of the Airspace Technology Demonstration 2 (ATD-2) at Charlotte Douglas International Airport (CLT), Dallas-Fort Worth International Airport (DFW), and Dallas Love Field (DAL). At CLT, an Integrated Arrival, Departure, and Surface (IADS) traffic management system enables departure metering and electronic negotiation of en route slots. At DFW and DAL, IADS enables the use of trajectory options to help flights take alternate routes out of the terminal area to reduce congestion and delay. As **co-lead for software development**, Mosaic provides essential support in transforming the ATD-2 concept into reality, including developing and supporting high-reliability back-end systems that enable flight data fusion and management, communication between different NAS automation systems, and deployment and support for project equipment and infrastructure in the field.

Award-Winning Contributions

Mosaic staff play critical roles on the ATD-2 project, designing and developing software, performing advanced analytics and modeling, performing systems engineering management, and deploying and maintaining diverse hardware and networking infrastructure. Mosaic staff were proud to be a part of the team awarded the 2018 NASA Associate Administrator Technology and Innovation Group Award.[4]

Example of Mosaic's Simulation Outputs of a Flight Schedule

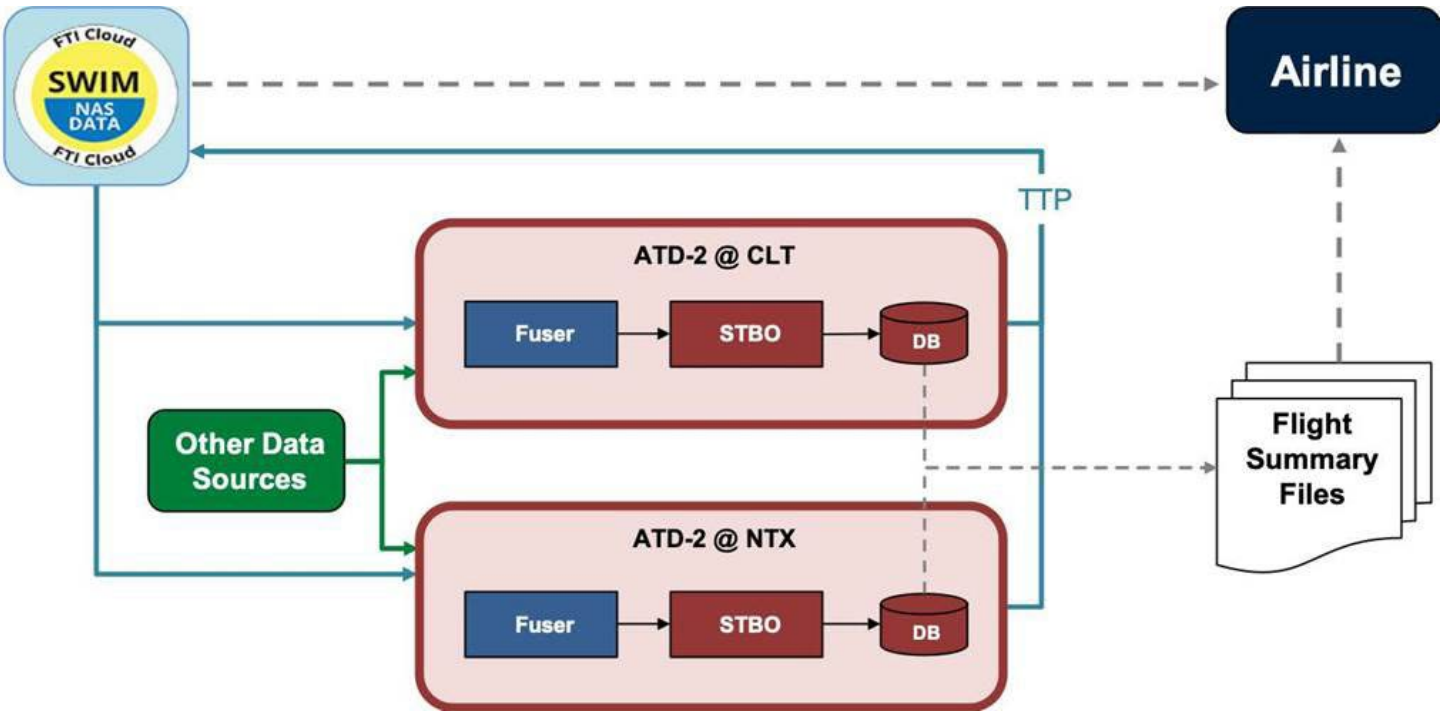


Cloud Computing and Data Fusion

During the project, stakeholders ran into challenges aggregating data from various sources. For ATD-2 to be successful, information from multiple data sources, including SWIM feeds, airlines, and third parties, needs to be processed and synthesized to provide a consistent set of information to the Surface Trajectory Based Operations system. In support of ATD-2, Mosaic developed a custom data processing and fusion capability known as the Fuser.

The Fuser[5] processes and synthesizes inputs from disparate data sources from SWIM and airline data feeds to provide a consistent set of fused flight data. Through industry outreach at forums like SWIM Industry Forum FAA Team (SWIFT), various industry participants expressed interest in accessing a research version of the fused data feed. Under NASA ATD-2, Mosaic developed an enhanced version of the Fuser running in the **cloud** via Amazon Web Services (AWS). Using a combination of **cloud** technologies such as Elastic Compute Cloud (EC2) instances and Elastic Load Balancers (ELB), Mosaic deployed a scalable, secure real-time feed for the airlines to consume from the **cloud** architecture.

Data architecture and data flow between SWIM, ATD-2, and airline.

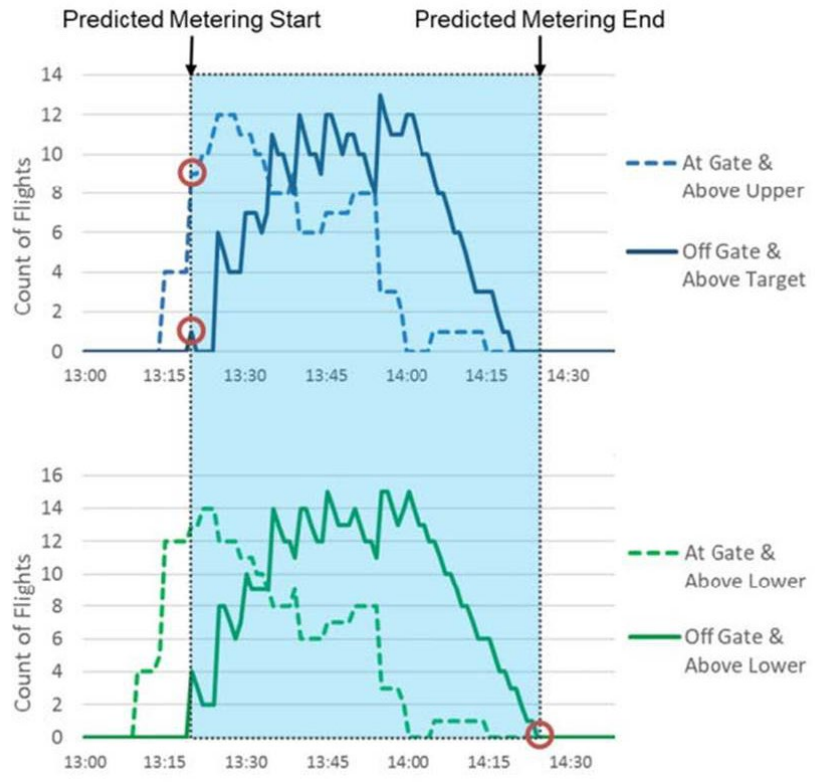


Data Analytics

Mosaic's data analytics activities under ATD-2 include leading the development of a custom business intelligence and reporting system using software engineering best practices. Data generated by this system is distributed throughout the NASA team and to the airline, airport, and FAA personnel to support their awareness of the impact of the ATD-2 system. The Mosaic team has explored various analysis areas, including the effects of surface metering at Charlotte[6] and trajectory options in Dallas, demand for insertion into overhead streams leaving Charlotte, quantification of uncertainty impacts related to surface scheduling, and many other areas.

Machine Learning

In addition, Mosaic has a team of data scientists tasked with developing a suite of machine learning models to predict flight milestones to facilitate improved airport operational planning. The results of these models are evaluated against the existing ATD-2 system to demonstrate the power of ML-based systems to replicate the performance of existing legacy systems.



Mosaic's predictions on excess taxi times.

Human-in-the-Loop Simulations

As part of the NASA ATD-2 project, Mosaic supported Human-in-the-Loop (HITL)[7] to obtain feedback and improve the ATD-2 tools used by ATC and airline users before operational deployment.

To prepare ATD-2 to run in the simulation framework, Mosaic Software Engineers developed customized configurations and interfaces for the ATD-2 infrastructure. Before each HITL run, Mosaic Systems Engineers worked with the test team in setting the high-level goals and intended outcomes for each test, which informed the testing strategy and simulation design.

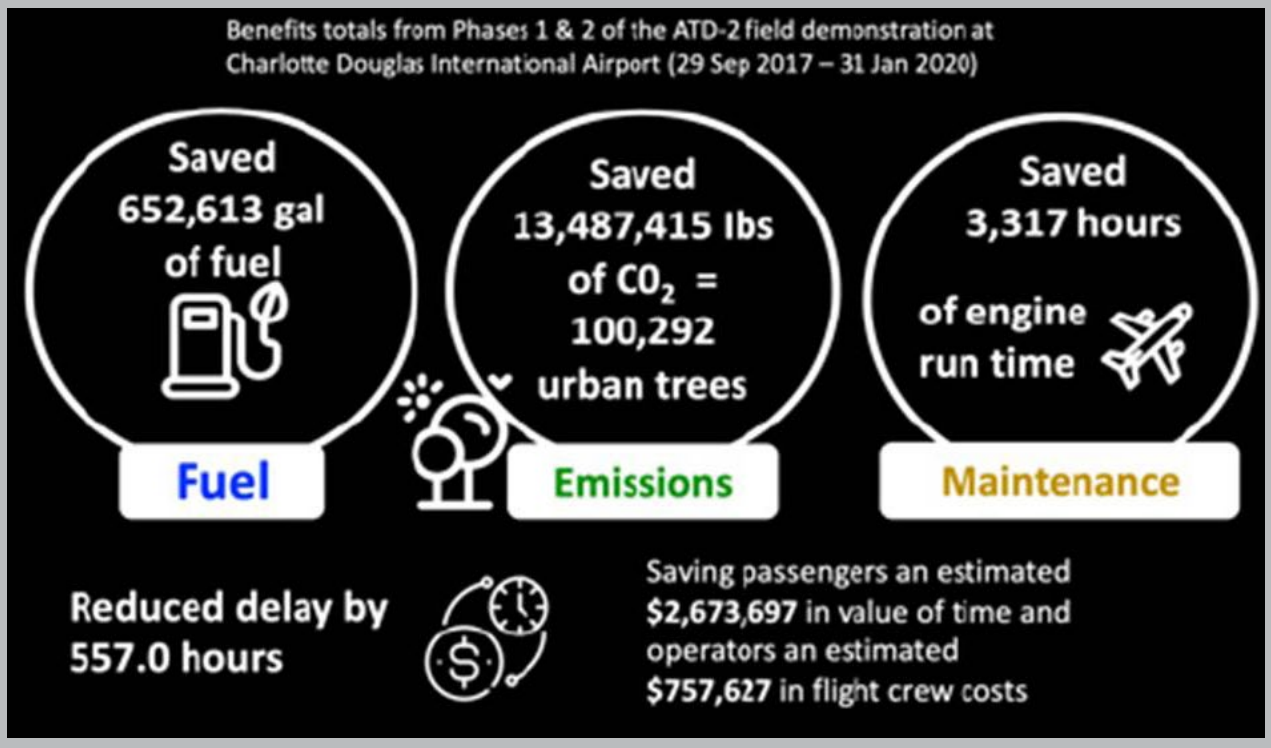
Storyboards planned and defined the simulated scenario requirements and prepared the simulation. Before the HITL, Subject Matter Experts (SMEs) with experience in airline operations and Air Traffic Control were trained on the ATD-2 tools using the material intended for the operational users. During each HITL run, the SMEs evaluated the ability of ATD-2 to provide an effective solution with minimal additional workload via a tablet with a customized questionnaire that regularly generated prompts for input from the SMEs during the HITL simulation.

During these runs, Mosaic Software Engineers provided developer-level support for testing and debugging the system. Using a combination of the data captured by the questionnaire and recommendations gathered from post-HITL debriefs, updates to the ATD-2 tools were implemented via the Agile development process. Mosaic Analysts supported post-ops analysis of the ATD-2 system data, which provided insights that enabled NASA to field software that was not only effective in its goal to provide surface metering but did not increase user workload beyond set limits. Also, gaps in the training material were identified and mediated before being used operationally.

Benefits

The research conducted through NASA ATD-2 has benefited stakeholders in several ways. Surface meetings and pre-scheduling controlled flights have reduced engine run times and taxi times, resulting in less fuel consumption and emissions. Also, shifting some of the taxi time to the gate reduces congestion on the taxiway while also allowing more time to board late, connecting passengers who would have otherwise missed the flight. Electronic renegotiation for an earlier slot into the overhead stream also reduces surface delay and helps maintain on-time performance.

NASA has published the following benefits from Phase 1 & 2 of the field demonstration results at CLT.



Reference[8]

Additionally, the ATD-2 system is deployed as an early prototype as risk reduction for the FAA Terminal Flight Data Manager (TFDM). The research under ATD-2 has provided significant information and influence on the eventual implementation of TFDM into the NAS.

Mosaic is critical to the success of the ATD-2 field demonstration. Mosaic's software developers, system engineers, and data scientists continue to improve the predictability and the operational efficiency of the air traffic system in metroplex environments through the enhancement, development, and integration of the nation's most advanced and sophisticated arrival, departure, and surface prediction, scheduling, and management systems.

Endnotes

1. 8. https://hsi.arc.nasa.gov/groups/AOL/research/atd2.php

2. 3. https://aviationsystems.arc.nasa.gov/research/atd2/index.shtml

4. https://www.nasa.gov/aeroresearch/aa-awards-2018/

5. https://matm-wpstg/airline-machine-learning-solutions/aviation-data-fuser/

6. https://matm-wpstg/2021/04/05/predicting-gate-conflict-at-charlotte-douglas-international-airport/

7. https://matm-wpstg/aviation-research-and-development/human-in-the-loop-simulation/