



Real Time Metrics and Analysis of Integrated Arrival, Departure, and Surface Operations

Shivanjli Sharma¹

NASA Ames Research Center, Moffett Field, CA 94041

John Fergus²

Human Solutions, Inc., Division of Oasis Systems, Washington, DC 20024

To address the Integrated Arrival, Departure, and Surface (IADS) challenge, NASA is developing and demonstrating trajectory-based departure automation under a collaborative effort with the FAA and industry known Airspace Technology Demonstration 2 (ATD-2). ATD-2 builds upon and integrates previous NASA research capabilities that include the Spot and Runway Departure Advisor (SARDA), the Precision Departure Release Capability (PDRC), and the Terminal Sequencing and Spacing (TSAS) capability. As trajectory-based departure scheduling and collaborative decision making tools are introduced in order to reduce delays and uncertainties in taxi and climb operations across the National Airspace System, users of the tools across a number of roles benefit from a real time system that enables common situational awareness. A real time dashboard was developed to inform and present users notifications and integrated information regarding airport surface operations. The dashboard is a supplement to capabilities and tools that incorporate arrival, departure, and surface air-traffic operations concepts in a NextGen environment. In addition to shared situational awareness, the dashboard offers the ability to compute real time metrics and analysis to inform users about capacity, predictability, and efficiency of the system as a whole. This paper describes the architecture of the real time dashboard as well as an initial proposed set of metrics. The potential impact of the real time dashboard is studied at the site identified for initial deployment and demonstration in 2017: Charlotte-Douglas International Airport (CLT). The architecture of implementing such a tool as well as potential uses are presented for operations at CLT. Metrics computed in real time illustrate the opportunity to provide common situational awareness and inform users of system delay, throughput, taxi time, and airport capacity. In addition, common awareness of delays and the impact of takeoff and departure restrictions stemming from traffic flow management initiatives are explored. The potential of the real time tool to inform users of the predictability and efficiency of using a trajectory-based departure scheduling system is also discussed.

I. Introduction

NASA, the Federal Aviation Administration (FAA), and industry partners are working toward a Phase 1 Baseline Integrated Arrival, Departure, Surface (IADS) traffic management capability of NASA's Airspace Technology Demonstration 2 (ATD-2) system, to be demonstrated starting in late 2017 at Charlotte-Douglas International Airport (CLT), Charlotte, NC. The primary goal of ATD-2 is 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.

The demonstration will showcase technologies such as surface scheduling, automated traffic management initiative (TMI) coordination between the Tower and Center, as well as data exchange and integration across the Tower and Ramp. An additional component of the demonstration involves the development of a real time

¹ Research Aerospace Engineer, Aviation Systems Division, Mail Stop 210-1.

² Senior Engineer, 600 Maryland Avenue, SW Suite 800E.

application, that provides a variety of users and stakeholders a common view of key metrics that enables the analysis as well as evaluation of airport operations. The real-time dashboard utilizes queries from a database which includes numerous input feeds that support the ATD-2 system, post-operations, and real-time analysis. The benefit of pulling from a shared database allows real time queries to reflect current operational states as well as user entries to the system. The initial prototype of the dashboard was developed in conjunction with requirements from CLT operational personnel across several areas, including the look and feel, functionality, and metrics to be included. The requirements, scope, and capabilities of the dashboard will continue to be refined through user input across the timeframe of the ATD-2 demonstration.

The paper first provides background on the ATD-2 concept and motivation for developing a real time tool. The architecture and implementation of the tool in an operational setting is then described along with the method for documenting tool requirements collected from the intended users. Finally, the approach to producing real time metrics and analysis is illustrated along with a set of anticipated uses and implications of implementing such a tool in an operational environment.

II. Background

A. ATD-2 Background

NASA, FAA, and industry have been developing IADS concepts and technologies for many years. NASA's research activities in the IADS domain include the Spot and Runway Departure Advisor (SARDA),^{2,3} the Precision Departure Release Capability (PDRC),⁴ and the Terminal Sequencing and Spacing (TSAS)⁵ research projects. Early SARDA research focused on movement area traffic advisories for the Airport Traffic Control Tower (ATCT, or Tower) personnel. Recent SARDA research, in collaboration with American Airlines (AAL), has focused on non-movement (i.e., ramp) traffic advisories for Ramp Control (i.e., ramp controllers and Ramp Manager). The PDRC research activity focused on using predicted takeoff times and departure runway assignments from a trajectory-based surface system to improve overhead stream insertion calculations performed by Time Based Flow Management (TBFM) departure scheduling functions. PDRC research was transitioned to the FAA in 2013 for use in the TBFM and Terminal Flight Data Management (TFDM) programs. TSAS research is the combination of TBFM for terminal area scheduling and Controller Managed Spacing (CMS). The TSAS research was successfully transferred to the FAA in 2014 for use in TBFM.

The FAA Next Generation Air Transportation System (NextGen) plans call for the National Airspace System (NAS) IADS capabilities to be implemented via a trio of decision support systems (DSS).⁶ Traffic Flow Management (TFMS), TBFM and TFDM are the primary systems in this group that are commonly called the "3Ts." Integration of the 3T systems is a major emphasis for the FAA, and it is central to the ATD-2 concept and field demonstration effort. The reader is referred to the ATD-2 Technology Description Document (TDD) for more information regarding the 3T integration effort.¹¹

ATD-2 was formulated as a formal subproject within NASA's Aeronautics Research Mission Directorate in 2015. The ATD-2 research and development objectives were developed through extensive engagement with NAS stakeholders to understand the existing shortfalls in arrival, departure, and surface operations, and the perceived benefits of an IADS solution.⁷ At the same time, the FAA committed to establishing an initial airport surface departure metering capability consistent with its Surface Collaborative Decision Making (CDM) concept of operations. The ATD-2 subproject, as well as the FAA's NextGen Advisory Committee (NAC) and the FAA evaluated candidate test field demonstration sites (airports) for the IADS capability, and CLT was selected by the FAA in 2015.

The ATD-2 field demonstration is organized into three phases, Phase I will illustrate a Baseline IADS demonstration and will include all components of ATD-2 running in operational environments, subsequent phases will fuse together strategic scheduling components as well as metroplex considerations. Figure 1 illustrates the operational environment for the IADS system in the Phase 1 Baseline IADS Demonstration. The upper portion of the figure depicts en route airspace controlled by the Centers. The dashed line represents the boundary between the Home Center (e.g., ZTL) and the adjacent Center (e.g., ZDC). The cylinder in the lower portion of the figure represents terminal airspace controlled by the CLT Terminal Radar Approach Control (TRACON) facility. The CLT Tower manages surface traffic in the active movement area (AMA), and the AAL-operated Ramp manages traffic in the CLT ramp area.

The operational environment graphic shows aircraft trajectories departing from (blue) and arriving to (red) the terminal airspace. The colored ovals illustrate some of the meter points at which air traffic is scheduled, either by automated systems or manual procedures. Red ovals are arrival meter points. Blue ovals are departure meter points.

Yellow ovals are surface meter points. The takeoff points, represented by half yellow/half blue ovals, are important control points for the IADS concept, as they are the interface points between surface and airspace scheduling. The funnel located at the top right of Figure 1 represents a downstream demand/capacity imbalance that results in departure restrictions on the local terminal airspace.

Data exchange and integration is a foundational capability of the IADS system for the Phase 1 demonstration. The planned system involves using a single IADS system running that allows multiple users to interact with one another through the automation. Users share the same data, exchange information, and make decisions collaboratively. Through this capability, users working at different facilities, such as the Tower and the Ramp, will have common situation awareness, thus enabling reduced voice communications in daily operations.

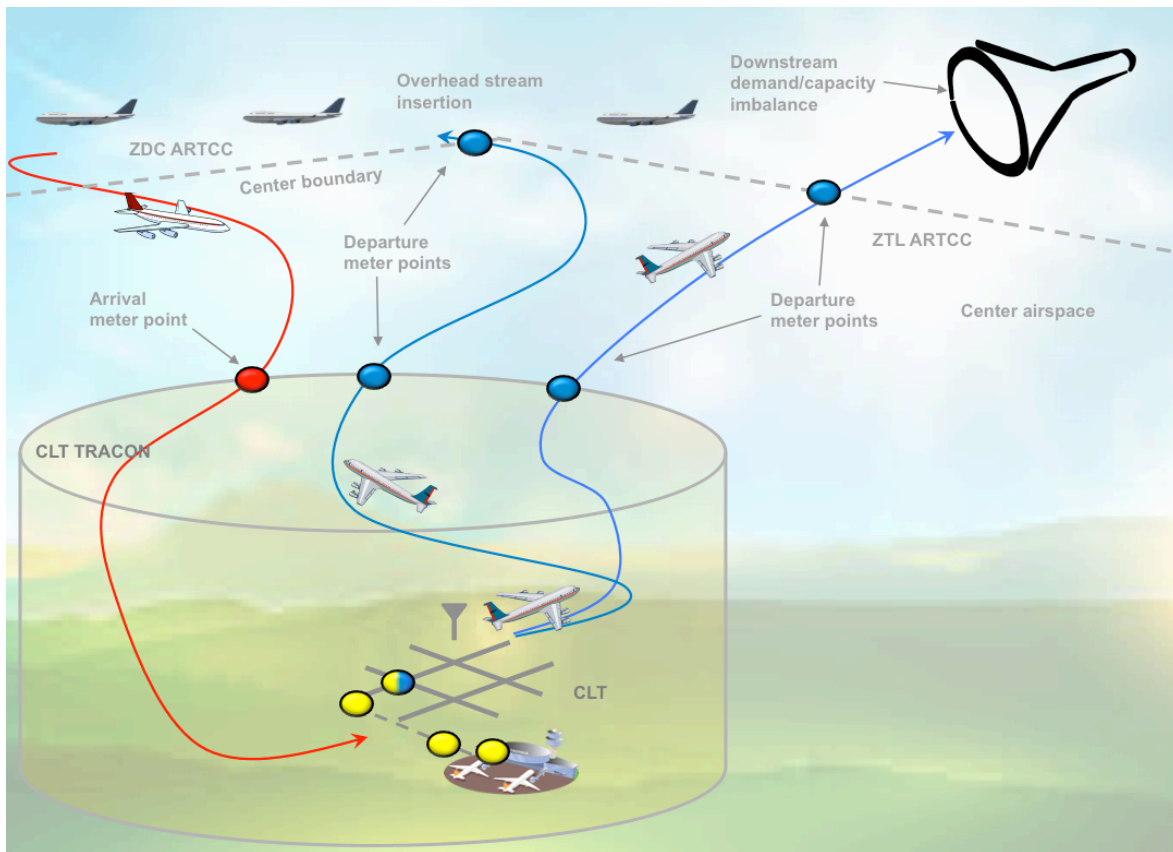


Figure 1 - A simplified view of the ATD-2 project operational environment for the Phase 1 Baseline IADS Demonstration illustrates a variety of surface and airspace interactions¹.

NASA researchers met with ATCT from CLT, AAL ramp controllers, and ZDC controllers across a series of seven shadow sessions in the last year at CLT in order to define information required for data exchange. Through these discussions data exchange and integration items were identified and utilized in the ATD-2 Agile requirements refinement effort. The following list provides an example of the type of information identified and incorporated in the ATD-2 development:

- Runway utilization
- Runway assignments
- Handling of MIT restrictions
- Approval Requests for Call for Release (APREQ)/Call for Release (CFR)
- Ground stops
- Runway closures
- Departure fix closures

- Flight cancellations
- Gate conflicts
- Ramp closures
- Manual updates/corrections of flights
- Long on Board (LOB) common awareness

The Tower TMC can input runway utilization plans or TMI restrictions (e.g., MIT, APREQ/CFR, and Ground Stop) through the TM Actions drop-down menu under the a client available to TMCs in the Tower and TRACON. Ramp Control can also input their decisions or requests (e.g., runway assignment, flight cancellation and ramp closure) through their user interfaces. These inputs are then shared with the Tower and displayed on the clients. The benefits of the real time ATD-2 tool is that it not only has access to the incoming data sources to the system, but it is also able to leverage the data exchange elements listed above, thus providing a full operational view of the airport at any given time.

B. CLT Surface and Airspace Operations

The following section gives an overview of the CLT surface and airport operations to provide context for the manner in which the dashboard will be utilized in Phase I of ATD-2, as well as some of the operational metrics shown later sections.

Situated between the Washington DC metroplex (300 nm away) and the Hartsfield-Jackson Atlanta International Airport (ATL) (~200 nm away), CLT underlies one of the busiest air traffic corridors on the east coast. CLT is located in the northeast corner of ZTL airspace, approximately 18 miles from the ZTL boundary with ZDC on the east side, and sits on the border of the Jacksonville ARTCC (ZJX) on the south side. This location significantly influences operations at CLT and makes CLT the subject of frequent traffic flow management (TFM) constraints.

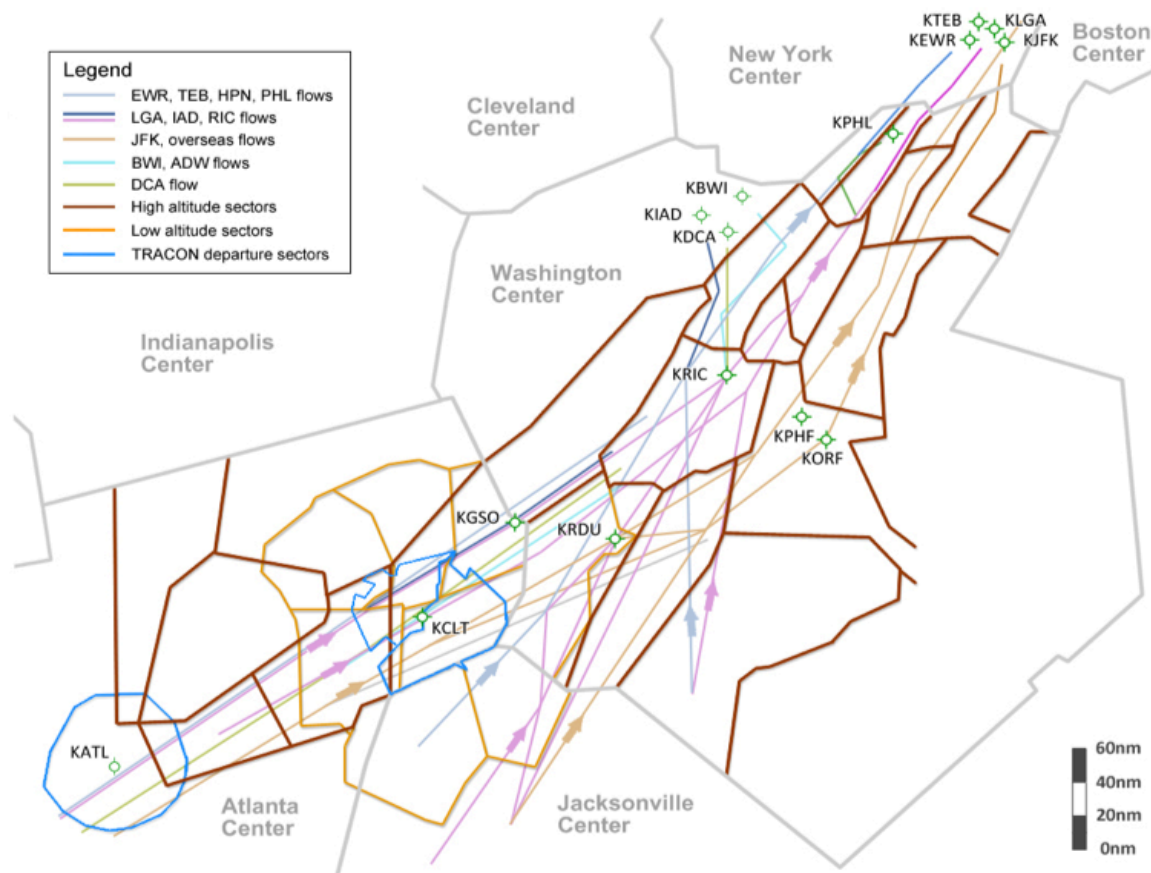


Figure 2 - The CLT airport location in ZTL, adjacent Centers, and jetways showing transiting traffic near CLT.

The CLT Airport Activity Report of January 2017 reports that the CLT Tower controls around 1,400 operations per day. Airport Council International (ACI) shows CLT as #7 in movements worldwide for 2016. The total count of CLT TRACON operations on a VMC day is around 1,500 daily. Thus, the vast majority of traffic managed by the TRACON is destined for, or departing from, CLT.

The distribution of CLT traffic operations by carrier, based on data collected for the same period, shows that AAL and regional air carriers operate nearly 85% of the flights into and out of CLT. Besides the main terminal for commercial and regional airlines, CLT also is responsible for the Wilson Air Center (a fixed base operator that provides services to corporate and private flights), the North Carolina Army Guard, and the North Carolina Air National Guard. These general aviation (GA) and military flights comprise about 4% of CLT traffic.

Given the above traffic conditions/compositions, the real time dashboard application will have a presence at any location the ATD-2 system is deployed, including ZTL, ZDC, and AAL Integrated Operations Center (IOC).

C. Surface CDM and TFDM Requirements

Both the FAA's Surface Collaborative Decision Making (CDM) Concept of Operations and the Terminal Flight Data Manager Program (TFDM) have a large role in the development of ATD-2.^{1,13} TFDM is a new decision support system for airport surface management and ATC tower functions and capabilities that will be implemented incrementally in a phased approach beginning in 2020. Electronic Flight Data (EFD) will be one of the first technology components as part of the TFDM system. One of the primary motivators for FAA/NASA collaboration on the ATD-2 field demonstration is reducing the risk for the TFDM implementation of the Surface CDM departure queue management. As part of this effort, the Surface CDM and TFDM requirements were reviewed and continue to play a role in the development of ATD-2, including the development of a real time metric reporting capability.

Both documents reference the need to improve analysis, measurement, and reporting of metrics related to surface operations. The TFDM System Specifications Document (SSD) outlines the need for a Metrics, Reporting, and Analysis (MRA) capability to provide key operational data as well as indicate the effectiveness of scheduling and metering functions. The metrics detailed include general operational metrics, metering metrics, as well data comprehensiveness and quality. The requirements specified in both documents provided further incentive to develop a mechanism to not only generate these metrics in a post operational manner but also in real time.

III. Real Time Dashboard Framework

The real-time dashboard provides a range of users and stakeholders at CLT a common view of key metrics that enable the analysis and evaluation of airport surface and airspace operations. Analysis and reporting methods were developed to provide insight on capacity, efficiency, predictability, as well as the effectiveness of scheduling and metering. This capability is separate from the other ATD-2 software systems and appears as a small dashboard, initially configured as an unobtrusive toolbar, which can be expanded to indicate detailed views of the data both numerically and graphically. To develop the dashboard in a rapid prototype fashion the code was developed in Python and utilized common libraries to enable the data analysis and visualization needed. This section will detail the data sources used to populate the displayed data, as well as the process used to show data in real time.

A. Fused Data Sources

Given the numerous data sources required to facilitate the running of an IADS system, a process was developed to match disparate data feeds and provide a consistent, flight matched data feed to the backend model. This process, referred to as the Fuser, enables the key data exchange and integration features between the ATCT and ramp clients and is the same source of data used for the real time dashboard. A diagram of the key data components of the Fuser is shown in Figure 3.

The Fuser processes and synthesizes inputs from several data sources to provide a consistent set of fused data to/from the backend IADS system. The data sources utilized by the system include a mixture of data from airline/industry, research feeds, and those provided by the FAA SWIM interface. Flightstats is a third party commercial data source and FlightHub is an American Airlines data source that provide flight position, route, and scheduling information. The system also ingests data from a TBFM research system, as given by the TMA box in Figure 3. This data source provides accurate trajectory and scheduling information for arrivals and departures given enhancements to the trajectory modeler and use of TRACON controller scratchpad entries. In addition to these feeds, the IADS system ingests a series of SWIM feeds. The FAA's System Wide Information Management (SWIM) Program is a NAS-wide information system that facilitates data sharing across its NextGen portfolio of programs and provides users access to this information through a single connection. The system utilizes the SWIM Terminal Data Distribution System (STDDS) for Airport Surface Detection Equipment (ASDE-X) surface

surveillance data, SWIM TBFM feeds, as well as SWIM Traffic Flow Management Service (TFMS) data, which includes flight data, flow data, and TFD surface data elements.

The Fuser aggregates all the above data sources and incorporates flight matching across them to provide a

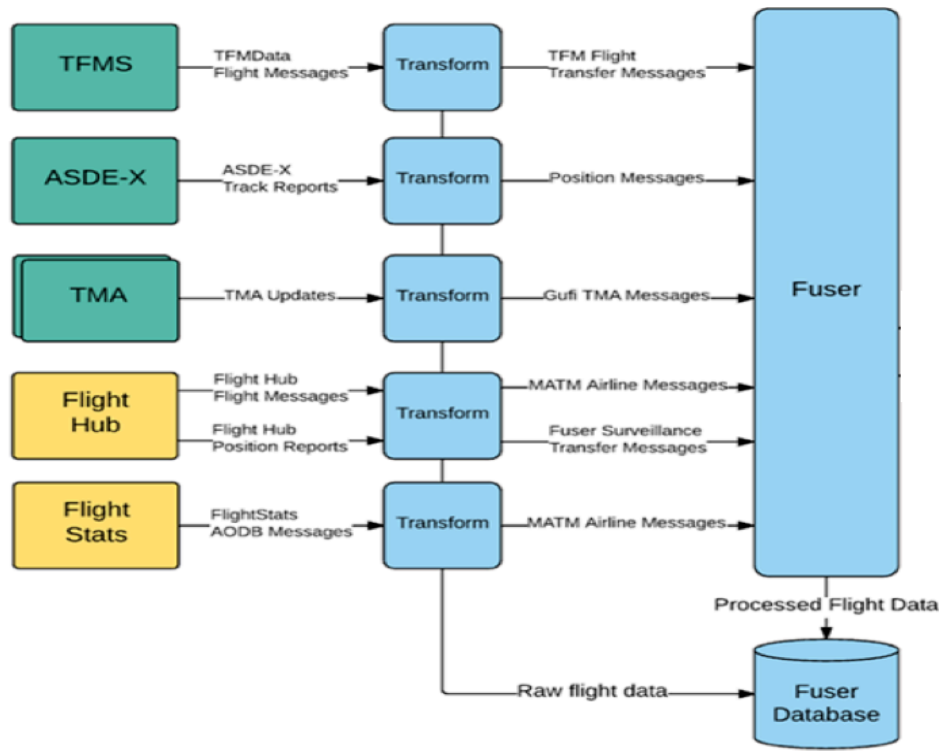


Figure 3 – Fuser data sources and composition..

coherent data set. Fused data is distributed to the rest of the IADS system and written to a PostgreSQL database for ease of debugging and querying. The processed flight data with a global unique identifier is stored in this Fuser database and is the source of the data shown in the real time dashboard.

B. Methods for Querying Data in Real Time

The Fuser database provides an easy-to-query set of tables that includes not only the fused data sources but also the inputs from users on the ATCT and ramp system, calculations from the backend model, and data produced by the tactical scheduler for surface metering. A number of database systems were considered, and for this prototype version of the dashboard a PostgreSQL open source object-relational database system was used. A set of Python libraries enabled the easy querying of the tables within the fuser database.

In addition to tables based on data sources feeding into the system, a series of summary tables were developed that provided a straightforward capability to retrieve specific operational data such as TMIs, airport configuration information, and parameters needed to calculate performance metrics, such as taxi time, in a more fine grained manner. The summary tables, indexing the data, and partitioning the tables hourly enabled that query times could be kept within a reasonable time frame for the real time system. The dashboard displays data at an update rate of one-minute, in which the database is queried every thirty seconds, and if new data is available, this information is then populated to the displays.

IV. Dashboard Metrics and Displays

The real-time dashboard will display metrics across four main categories: airport health and situational awareness, monitoring metrics, benefits metrics, and data quality. Airport health or situational awareness indications include configuration and flow information, as well as the status of the ramp and the current metering mode.

Monitoring metrics include throughput, predicted and actual runway capacity rates, taxi time values for the movement and non-movement area, as well as delay and excess queue time values.

A set of benefits metrics are being defined to indicate potential cost as well as emissions savings that are realized through utilization of new operations and procedures. Data quality metrics will indicate the quality of the data feeds into the system in the case of data outage can also ensure second to ensure redundancy measures are implemented. The dashboard graphical user interface (GUI) was developed in Python using standard libraries. These libraries enabled the development of a framework that shows the initial view of the dashboard as a toolbar, which can be used to access additional panels with the metrics discussed above.

1. Horizontal and Vertical Toolbar View

The initial view of the dashboard is a toolbar, which can be displayed either horizontally or vertically in order to mitigate real estate issues on displays. Either the horizontal or vertical view will allow users to easily note basic airport operation information such as configuration, metering status, and ramp status, as well as metrics such as throughput. Both the horizontal and vertical versions of the dashboard as a toolbar are shown in Figure 4.

A feedback button is available on the toolbar in order for users to provide details on issues observed as well as general comments. Once clicked, the feedback button opens an internally hosted webpage that collects user comments and notifies researchers and engineers. The time in the center of the dashboard states the UTC time at which the dashboard was updated; the current update cycle occurs every minute. Several placeholder icons are depicted on the toolbar, as many are under development. These icons are intended to indicate additional information in a single glance and will include items such as metering status, ramp status, and data quality. These icons will be developed to match those on the ATD-2 clients for consistency and ease of understanding. The toolbar, shown in Figure 4, demonstrates the ability to show airport configuration information as well as runway utilization strategies. The white box on the right hand side of the toolbar, adjacent to update time, provide configuration information. The placeholder icons further to the right on the toolbar will be updated in the next development iteration. The backend ATD-2 system has the ability to auto detect airport flow configuration and therefore the dashboard toolbar will display either North or South flow depending on the conditions detected by the system. Furthermore, as TMCs begin entering specific runway utilization strategies into the ATD-2 clients, this information will also propagate to the dashboard and will be shown using common nomenclature that is understood by ATCT and ramp controllers. The right-hand side of the toolbar contains a pull down menu icon which will enable selection of specific panels to view data in detail.

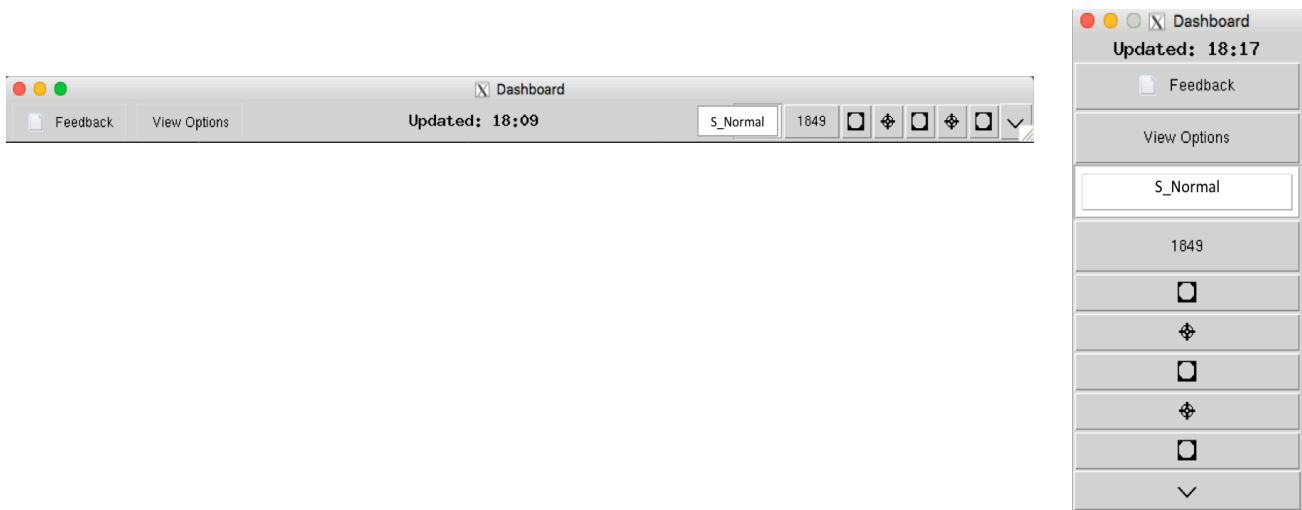


Figure 4 – Views of the real time dashboard displayed as a horizontal and vertical toolbar.

2. Quick Look Panel

The first option from the pull-down menu is a quick look panel, as seen in Figure 5. This quick look pull-down menu offers a single panel that will provide information to the user regarding the airport health, monitoring metrics, and details regarding TMIs. The intention behind the quick look panel is to enable the user to efficiently view all aspects of current airport operations on a single page. This page can be used for situational awareness as well as help inform decisions regarding operational procedures and ramp management. The information seen in Figure 5 is a snapshot of the dashboard in its current iteration that includes several metrics.

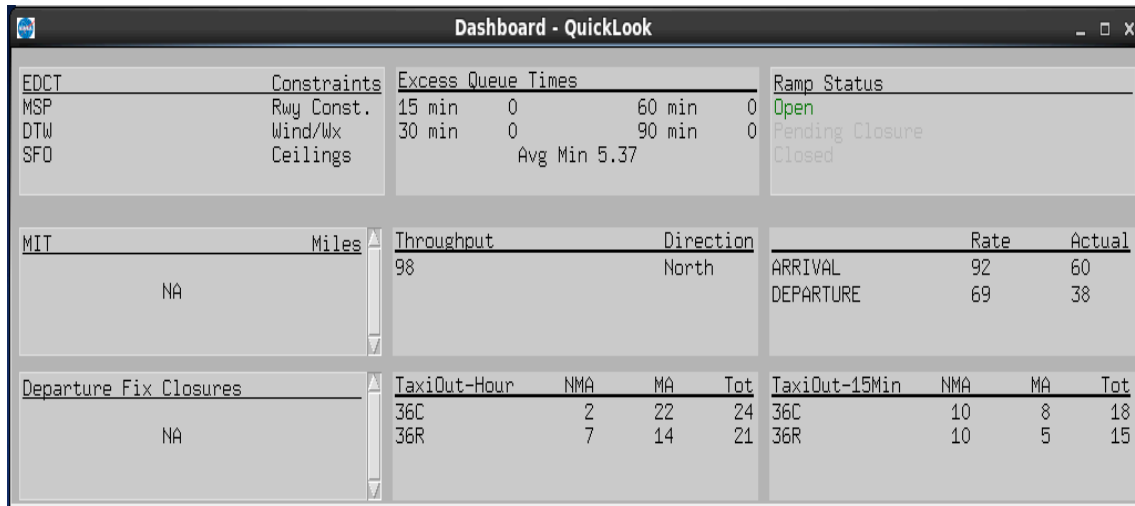


Figure 5 – Quick look pull down menu and horizontal dashboard depicting airport health and providing an overview of current airport operations.

Each panel in the quick look menu is assigned specific metrics of note to the user. The information on the left hand side of the quick look panel is intended to provide situational awareness regarding current airspace restrictions and summarizes TMI information for controllers in an easy to view manner. These panels include information such as Miles in Trail (MITs), Approval Requests for Call for Release (APREQs), and associated details derived from the backend data sources. Another situational awareness component is a panel on the left hand side with information on ramp status. This panel is intended to indicate whether the ramp areas are open, have pending closures, or are closed based on current weather conditions. This information would be provided by Ramp Managers on Duty and would be available on all the ATD-2 systems included the dashboard.

A series of monitoring metrics are available in the quick look panel, these include taxi time averages, excess queue time, throughput, as well as arrival and departure rates. The taxi time information shown is under development and will display the average taxi in and out time for the ramp, active movement area, and total across the last rolling hour. The excess queue time data shown in the center of the quick look panel is intended to indicate the amount of delay added to the unimpeded taxi time of a departing aircraft due to congestion on the ramp or operational constraints. The number of aircraft with delays of fifteen minutes or less are counted and this value is shown as a numerical count adjacent to the bin value. This calculation is conducted for the various bin values of thirty minutes, sixty minutes, and ninety minutes. Additional airport monitoring metrics include throughput, calculated as the total number of actual departures and arrivals in the last hour, as well as the actual arrival and departure rates compared to the rates set for the given operation at the time.

The quick look panel continues to be developed and refined, and will be modified throughout the ATD-2 demonstration using feedback from users and stakeholders with different requirements and needs.

3. Additional Pull Down Menus

Various additional metrics will be available through a pull-down menu on the dashboard, which can be displayed in conjunction with the quick look panel or as single panels. The options available on the pull-down menu offers the user a selection of metrics for a more in depth view. The current set of metrics available include a departure/arrival monitor, throughput, taxi time, excess queue time, and data quality.

In addition to the data shown in the quick look panel regarding taxi time, the pull-down menu offers detailed views of taxi in and out time, which are presented in a number of ways. The data will be displayed across the last

fifteen minutes, the last rolling hour, and the last cardinal hour as both average line graphs and box and whisker plots in order to show the variation and spread of the data. These graphical representations along with numerical information on metrics such as taxi times, arrival and departure counts, and throughput are available to assist the user in understanding current operations.

The excess queue time plot will illustrate as a line graph the amount of additional time a departure flight will experience compared to the unimpeded taxi time on average for flights in the next thirty to forty-five minute time frame. This information can be utilized by ramp managers to inform their decisions on turning surface metering on and off based on user defined thresholds.

A separate pull down menu focused on data quality will also be available for both the users and researchers. This panel will provide a graphical display illustrating the active feeds into the backend of the system as green, and if data were to degrade from any of the sources, the associated icons would move from yellow to red in color to indicate a feed may be down. There could be several reasons for a failed or degraded feed, including upstream outages in SWIM as well as hardware or software issues. This data quality panel will allow users to quickly know when the system is not ingesting all the data in a robust manner and will also enable the system to switch to a failover feed to mitigate issues if possible.

In addition to the panels discussed here, several other pull down menus are being developed; each menu will offer data numerically and graphically based on interaction and feedback from users across CLT, ZDC, and ZTL

V. Use of the Dashboard in Operational Environments

The real-time dashboard will display metrics across four main categories: airport health and situational awareness, monitoring metrics, benefits metrics, and data quality. Airport health or situational awareness indications include configuration and flow information, as well as the status of the ramp and the current metering mode. Metering advisories provide the control (throttling of demand). Metering on is analogous to broadcasting TBFM STAs to ARTCC sector controllers during TBFM arrival metering periods. For CLT metering on/off decision is primarily made by the ramp traffic manager. When metering is on, delays typically taken on the runway are pushed back to the gate. Monitoring metrics include throughput, predicted and actual runway capacity rates, taxi time values for the movement and non-movement area, as well as delay and excess queue time values.

A set of benefits metrics are being defined to indicate potential cost savings as well as emissions savings that are incurred through utilization of certain operations and procedures. Data quality metrics will indicate the quality of the data feeds into the system to provide further information in the case of a data outage.

The dashboard graphical user interface (GUI) was developed in Python using standard libraries. These libraries enabled the development of a framework that shows the initial view of the dashboard as a toolbar, which can be used to access additional panels with the metrics discussed above.

A. Use of the Dashboard In Planning and Evaluating

The dashboard will be available for use with all operational systems including a planning only system that does not propagate user inputs out. This planning only system is an independent ATD-2 system, with consistent backend data sources and modeling, that can be used to plan and test inputs prior to implementing in an operationally connected system. This planning system in conjunction with the dashboard will allow users to implement potential runway utilization strategies and view the impact on various metrics to assess the effectiveness of making such a change.

B. Use of the Dashboard During Surface Metering

As stated above, the dashboard is expected to play a significant role in determining the initiation of surface metering as well as evaluating its effectiveness. The ATD-2 system will provide demand and capacity predictions based on a series of inputs and automated calculation, some of which include: ATC runway utilization intent, TRACON controller runway intent, accurate on-time estimates, data from SWIM feeds for ETA and TMIs, airline-provided earliest off-block time (EOBT) values, and ramp controller intent. Utilizing the information input into the clients by controllers as well as the backend data feed ingestion, the ATD-2 system generates capacity predictions through its surface modeling and scheduling logic. This information is used to generate a view of surface demand and capacity, one of which is shown via the excess queue time graph in the real time dashboard. If values in this graph appear to indicate that surface metering is warranted, the ramp manager will be able to take action and implement surface metering to view the associated push back advisories. In addition, the controllers in the ramp and ATC will then be able to utilize the monitoring metrics in the dashboard to determine if surface metering is having

the intended effect for propagating delay back from the runway to the gate, and ultimately reducing congestion on the airport surface.

VI. Conclusion

This paper presented a concept and initial prototype of a real time dashboard to be used in an Integrated Arrival, Departure, and Surface technology demonstration at CLT as part of the ATD-2 project. This real time tool enables common situational awareness and offers the ability to compute real time metrics and analysis to inform users about capacity, predictability, and efficiency of the system as a whole. This paper described the architecture of the real time dashboard and its foundation of using a common backend data fusion source that also provides data to the ATC and ramp clients being developed under ATD-2.

The potential impact of the real time dashboard will be studied and assessed at various operational locations, including CLT, ZDC, and ZTL. The real-time dashboard displays metrics across four main categories: airport health and situational awareness, monitoring metrics, benefits metrics, and data quality. Airport health or situational awareness indications include configuration and flow information, as well as the status of the ramp and the current metering mode. Monitoring metrics include throughput, predicted and actual runway capacity rates, taxi time values for the movement and non-movement area, as well as delay and excess queue time values. In addition, common awareness of delays and the impact of takeoff and departure restrictions stemming from traffic flow management initiatives are also provided via a quick look panel. Views to assess the quality of the data sources into the backend of the system will also be provided via the dashboard. This quick look panel will provide users a single location to view the health of overall airport operations. Furthermore, the dashboard will enable users in operational areas to assess the effectiveness of potential strategies prior to implementation as well as enable ramp managers to make decisions regarding surface metering.

The exact manner in which TMCs, FLMs, ramp controllers, center controllers, and even facility managers utilize the real time dashboard is yet to be determined, but will be evaluated in operational areas starting in September 2017. The dashboard will go through iterations and changes over the various phases of the ATD-2 project and will reflect user input, suggestions, and provide a framework for future real time metric reporting tools.

Acknowledgments

The authors would like to acknowledge the operational personnel at CLT: ATC controllers, Traffic Management Coordinators (TMCs), AAL ramp controllers, and personnel from the National Air Traffic Controllers Association (NATCA), who have helped develop requirements and provided significant feedback to the development of this tool. In addition, we would like to thank our FAA and AAL partners for their input and feedback in this ongoing process. The development of the tool was facilitated by data fusion and database management provided by Mosaic ATM. This research and development would not have been possible without the leadership and guidance of NASA Ames Aviation System Division management along with Project and Subproject management of ATD-2.

References

¹FAA Air Traffic Organization Surface Operations Directorate, "U.S. Airport Surface Concept of Operations (ConOps) in the Near-Term: Application of the Surface Concept at United States Airports," June 2014.

²Jung, Y., Malik, W., Tobias, L., Gupta, G., Hoang, T., and Hayashi, M., "Performance Evaluation of SARDA: An Individual Aircraft-based Advisory Concept for Surface Management," *Air Traffic Control Quarterly*, Vol. 22, Number 3, 2015, p. 195-221.

³Hayashi, M., Hoang, T., Jung, Y., Malik, M., Lee, H., Dulchinos, V., "Evaluation of Pushback Decision-Support Tool Concept for Charlotte Douglas International Airport Ramp Operations," 11th USA/Europe Air Traffic Management R&D Seminar (ATM2015), Lisbon, Portugal, June 23-26, 2015.

⁴Engelland, S., Capps, A., Day, K., Kistler, M., Gaither, F., and Juro, G., "Precision Departure Release Capability (PDRC) Final Report," NASA/TM- 2013-216533, June 2013.

⁵Baxley, B., Johnson, W., Swenson, H., Robinson, J., Proevot, T., Callantine, T., Scardina, J., and Greene, M., "Air Traffic Management Technology Demonstration 1 Concept of Operations (ATD-1 ConOps)," NASA/TM 2013- 218040, Version 2.0, September 2013.

⁶NextGen Air Traffic Decision Support Systems. (n.d.)
http://www.faa.gov/nextgen/update/progress_and_plans/decision_support_systems/ [cited on April 14, 2015].

⁷Aponso, B., Coppenbarger, R., Jung, Y., O'Connor, N., Lohr, G., Quon, L., and Engelland, S., "Identifying Key Issues and Potential Solutions for Integrated Arrival, Departure, Surface Operations by Surveying Stakeholder Preferences," AIAA 2015-2590, 15th AIAA Aviation Technology, Integration, and Operations (ATIO) Conference, Dallas, Texas, June 22-26, 2015.

⁸NextGen Air Traffic Decision Support Systems. (n.d.)
http://www.faa.gov/nextgen/update/progress_and_plans/decision_support_systems/ [cited on December 10, 2015].

⁹RTCA, “NextGen Integration Working Group Final Report – Report of the NextGen Advisory Committee in Response to a Tasking from The Federal Aviation Administration,” October 2014. http://www.rtca.org/Files/MiscellaneousFiles/NextGen_Integration_Working_Group_Report_Oct_2014.pdf [cited on January 7, 2016].

¹⁰FAA/NASA Integrated Arrival/Departure/Surface (IADS) Research Transition Team (RTT) Plan – Airspace Technology Demonstration 2 (ATD-2), November 2015.

¹¹Capps, A., “Airspace Technology Demonstration 2 (ATD-2) Technology Description,” October 2015.

¹²Lohr G., “Operational Profile of Charlotte-Douglas International Airport (CLT),” NASA internal document, September 2015.

¹³FAA Airport Surface Efficiency Group (AJR-1200), “Terminal Flight Data Manager (TFDM) Operational Evaluation Report (OER) Site Report for Charlotte-Douglas (CLT) International Airport,” June 2015.

¹⁴FAA, “Order JO 7110.65W,” <http://www.faa.gov/documentLibrary/media/Order/ATC.pdf>, Oct 27, 2015.

An informal paper for NASA internal use 2075 15.

¹⁵Coppenbarger, R., “Preliminary ATD-2 Shortfalls Analysis for Charlotte Douglas International Airport,” September 2015.

¹⁷Gerasimos, S., “Analysis of Airline Schedule Padding on U.S. Domestic Routes,” MS Thesis, Massachusetts Institute of Technology, 2011.

¹⁸Frank, T., “Airlines pad flight schedules to boost on-time records,” USA Today article, Feb 15, 2013 <http://www.usatoday.com/story/travel/flights/2013/02/14/airlines-flights-early-arrivals/1921057/> [cited on January 7, 2016].

¹⁹Johnson, M., “ATD-2 Measures of Performance (MOPs) and Key Performance Parameters (KPPs),” NASA internal document, November 2015. NASA/FAA, ATD-2 Joint Project Management Plan (draft), February 10, 2016.

²⁰FAA Terminal Flight Data Manager (TFDM) Program Office, “Final Program Requirements Document for Advanced Electronic Flight Strips (Draft),” August 2014.

²¹FAA, “NextGen Priorities Joint Implementation Plan – Executive Report to Congress,” October 2014. http://www.faa.gov/nextgen/media/ng_priorities.pdf [cited on December 10, 2015].

²²Anon, “Surface Data in TFMS Release 13,” presented at FAA-Industry Forum 2015 http://faaindustryforum.org/D1B7_R13SurfDataTFMS_Pfingslter.pdf [cited on January 7, 2016].