

# Electronic Departure Approval Requests in ATD-2 Daily Operations

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**The NASA Airspace Technology Demonstration 2 project is investigating Integrated Arrival-Departure-Surface air traffic management through progressive refinement of a surface air traffic management system fielded at Charlotte-Douglas International Airport. Among the areas under study are departure release-time approval request (APREQ) traffic management initiatives. Scheduling departures at downstream points and complying with approved departure release times helps flights fit smoothly into busy traffic streams. This paper presents a review of APREQ operations and compliance data from daily electronic APREQ negotiations over fourteen months beginning in January 2018. It describes APREQ-compliance improvements observed as the electronic negotiation process has matured and discusses contributing factors, including renegotiation of departure release times.**

## I. Introduction

Integrated Arrival-Departure-Surface (IADS) traffic-flow management relies on information sharing and integration between automation systems to improve efficiency, predictability, and throughput in the National Airspace System (NAS). The NASA Airspace Technology Demonstration 2 (ATD-2) project is a collaborative effort between NASA, the FAA, the National Air Traffic Controllers Association, and industry partners to develop and demonstrate an IADS traffic management capability. The FAA's IADS concept entails linking the Terminal Flight Data Manager (TFDM) to the Time-Based Flow Management (TBFM) system and Traffic Flow Management System (TFMS) through System-Wide Information Management (SWIM) to provide gate-to-gate, NAS-wide benefits. TBFM provides time-based scheduling, TFMS helps manage airspace and surface resources, and TFDM will enable electronic flight data exchange and integration. ATD-2 is integrating SWIM information and refining potential TFDM functionality in a surface traffic management system fielded at Charlotte-Douglas International Airport (CLT), providing valuable data and user feedback to support broader IADS implementation [1-3].

Among the IADS areas under study during ATD-2 is the use of electronically negotiated departure times for efficiently inserting flights into overhead traffic streams. Stream-insertion accuracy prevents excessive vectoring that

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negatively impacts the NAS by increasing controller workload along with aircraft fuel burn and emissions. Departure-time approval requests (APREQs) provide center-approved departure times to allow for smooth stream insertion.

For many years APREQs have used land-line voice communications. Each day en-route centers send a general-information message to certain towers indicating that Call-For-Release (CFR) is required for departures to specific destinations. When an affected flight is ready to depart, the control tower traffic manager calls the adjacent en-route center to request approval for a time that reflects the best estimate of when the flight will be able to depart. The center traffic manager enters the requested time in TBFM and responds with a departure time predicted to enable the flight to fit into the overhead stream of traffic. Tower controllers maneuver the aircraft on the airport surface to meet the time; the FAA considers the eventual release compliant if the departing aircraft’s takeoff rotation is within two minutes prior to one minute after the approved time.

ATD-2 draws from prior NASA research geared toward replacing CFR with electronic center-tower coordination for APREQ scheduling. Most recently, the NASA Precision Departure Release Capability [2, 4, 5] led to the FAA’s Integrated Departure Arrival Capability (IDAC) implemented within TBFM. IDAC includes departure-demand monitoring, slot identification, and semi-automatic and automatic modes for requesting release times from towers equipped with the Integrated Departure Scheduling Tool (IDST) [6]. The tower component of the ATD-2 surface system, called the Surface Trajectory-Based Operations (STBO) Client, encompasses the IDST functionality. In addition, the STBO Client provides the capability to leverage a surface traffic schedule and airline-provided Earliest Off-Block Times (EOBTs) to calculate the Earliest Feasible Takeoff Time (EFTT) that the tower traffic manager should request for a given flight. Thus, release-time requests made using the STBO Client can consider not only slot-availability in the overhead stream, but also the feasibility of departing at the requested time.

CLT Tower traffic managers began using the fielded ATD-2 system to electronically negotiate APREQ times with Washington Center (ZDC) in November 2017. For the initial 41-day introductory period from 23 November 2017 to 2 January 2018, electronic coordination was used for more than half of eligible flights, and ZDC traffic managers approved electronic requests, on average, in less than one minute [7]. These data also showed that average compliance with electronically negotiated release times and the average tactical delay assigned did not differ significantly from those of release times coordinated using CFR. In addition, traffic managers also used electronic negotiation to reschedule release times.

The present research extends the analysis in Ref. [7] to examine APREQs during daily operations at CLT from 1 January 2018 to 28 February 2019. During this period the ATD-2 system underwent numerous enhancements, and in October 2018 operations expanded to include electronic APREQ negotiation with Atlanta Center (ZTL). In addition to providing comparisons with prior results, this paper examines APREQ rescheduling and compliance improvements. The paper first provides background on APREQs at CLT and electronic APREQ negotiation using the STBO Client. It then presents the results of the analysis, followed by conclusions and topics for future investigation.

## II. Background

The ATD-2 system became operational at CLT in September 2017. The CLT airport surface layout is shown in Fig. 1. During typical operations runway 18R/36L is dedicated to arrivals, 18C/36C is primarily dedicated to departures, and 18L/36R serves both arrivals and departures. Surface traffic management challenges at CLT stem from limited ramp area, the dual-use runway, and arrivals taxiing across the dedicated departure runway. Construction on the 5/23 runway has prevented south-converging operations since May 2018.

A key IADS information-sharing and coordination focus area entails linking Traffic Management Initiatives (TMIs) developed using TFMS to the TBFM scheduling capabilities. TMIs implemented to manage demand-capacity imbalances include ground delay programs, ground stops, required re-routes, miles-in-trail restrictions, Expect Departure Clearance Times (EDCTs), and APREQs [8]. Like APREQs, EDCTs are controlled departure times, but EDCTs are imposed NAS-wide by the FAA Command Center, and have a larger compliance window, from five minutes earlier to five minutes later than the assigned departure time.

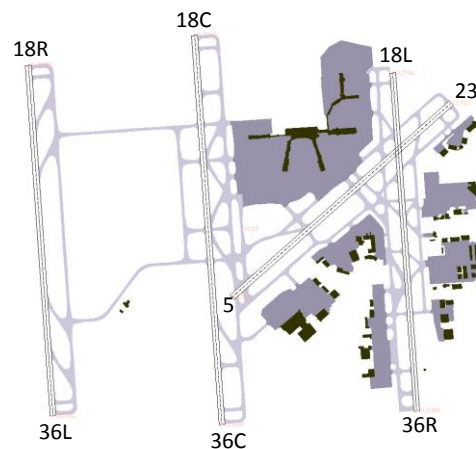
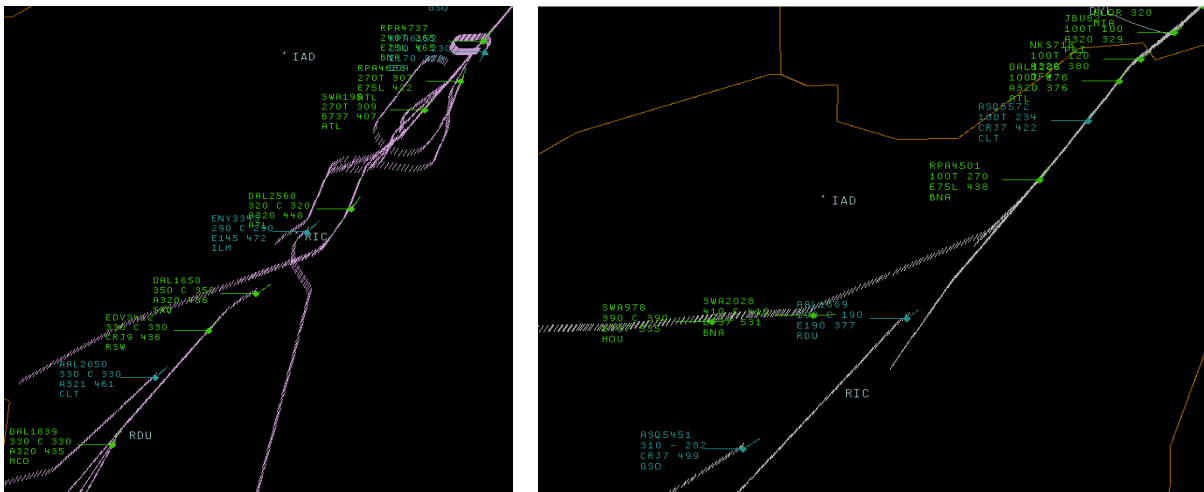


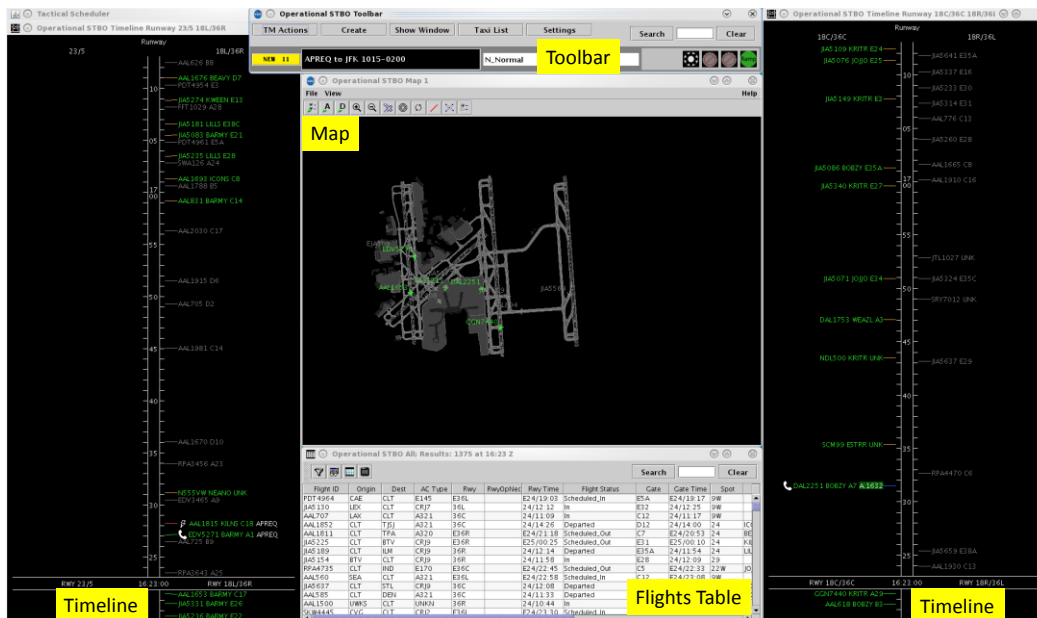
Fig. 1 CLT airport surface layout.

Tactical departure scheduling via APREQs is particularly important at CLT owing to its location underneath busy overhead traffic streams entering ZDC and ZTL airspace. ZDC and ZTL impose daily APREQ restrictions on CLT departures to busy airports such as the New York metroplex airports and Atlanta. Complying with approved release times helps the CLT departures merge smoothly into packed traffic flows (Fig. 2).



**Fig. 2 Non-compliant APREQ departures resulting in excessive vectoring in ZDC airspace (left) versus smooth stream-insertion of compliant APREQ departures (right).**

The STBO Client (Fig. 3) supports APREQ TMIs through specialized display of relevant information on its runway timelines. Similar to IDST, STBO Client timelines depict green and red areas that reflect where slots are available and unavailable, respectively, in the relevant center's TBFM schedule (Fig. 4). This helps the tower maintain awareness of the center's demand and request release times the center is likely to approve. Moreover, because the timelines also show runway demand, including arrivals, the tower traffic manager can request release times that account for other surface traffic management considerations, potentially increasing the likelihood of compliant releases. Timeline symbology for aircraft subject to APREQs also indicates whether semi-automatic or automatic electronic-negotiation modes are available, or whether circumstances dictate the use of CFR.



**Fig. 3 STBO Client Display.**

The principal difference between semi-automatic and automatic coordination is that under automatic mode TBFM/IDAC automatically sends an approved release time back to the tower STBO Client without input from the center traffic manager. In either mode, the tower traffic manager can right-click the flight data tag on the STBO Client timeline and choose one of two release-time request methods from a context menu: ‘Select Slot on Timeline’ or ‘Request Release Time.’ The former enables the traffic manager to then click within the red/green area of the timeline to transmit a requested time to the center, while the latter directs STBO to automatically choose an EFTT and request it. Active requests are indicated with a yellow arrow next to the flight’s data tag. At the center, TBFM/IDAC produces an audible alert and highlights the flight on the TBFM timeline. Under semi-automatic mode, the center traffic manager can adjust the requested time before sending an approved time to the tower. The timeline symbology for a flight changes to reflect receipt of an approved release time. If the approved time differs from the originally requested time, the STBO Client produces both audible and visual alerts. The tower traffic manager can acknowledge the new time and clear the alert symbol by clicking it or selecting a context-menu item.

To be compliant APREQ flights must depart the runway within a compliance window from two minutes earlier to one minute later than the approved release time. Some flights may be subject to both EDCT and APREQ restrictions; the STBO Client also shows EDCT compliance windows for selected flights (Fig. 5), so that requested times can also honor the EDCT compliance window. Once a flight has an approved release time (or times), the STBO Client color-codes the labels at the end of the flight’s data tag according to the flight’s projected compliance (see Ref. [7]). The compliance indications aid the tower traffic manager in identifying flights that may benefit from a rescheduled release time. Circumstances may also arise in which a specific flight may be excluded from an APREQ restriction, or have a previously approved release time removed (referred to as a ‘free release’); the STBO Client also supports these operations.

The ATD-2 deployment at CLT began with a focus on efficiency and predictability improvements in airport surface and departure operations enabled by data integration and sharing, surface movement scheduling, and tactical departure scheduling. Additional system-integration elements, including integration with Advanced Electronic Flight Strips (AEFS), the aforementioned introduction of IDAC at ZTL, extending the scope of ‘prescheduling’ operations with ZTL, and surface scheduler improvements have all contributed toward improved APREQ management: AEFS automatically shows APREQ release times to tower controllers, IDAC at ZTL further reduces the need for CFR operations, and scheduler enhancements improve pushback-time advisories. Prescheduling refers to assigning release times based on a flight’s airline departure time, rather than waiting until the pilot calls to indicate the flight is ready to push back from the gate; ZTL has implemented prescheduling operations with CLT for many years. The analysis presented in the following section highlights some of these impacts.

### III. Field-Data Analysis

ATD-2’s data-integration focus has yielded a rich, electronically-logged data set covering the January 2018 through February 2019 study period. This section first generally describes CLT operations and data included for analysis, then presents a series of results pertinent to electronic APREQ negotiation.

#### A. CLT Operations

The raw data for the 423-day study period include 627,516 CLT flight operations (313,984 arrivals and 313,532 departures). To focus the analysis on normal operations, calendar days with departure counts outside [1.5 \* inter-quartile range] were identified; removing those 21 days from consideration leaves 402 days encompassing 303,729

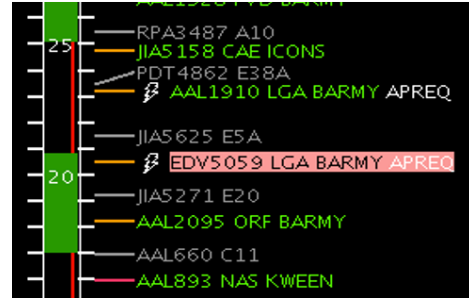


Fig. 4 Timeline with available slots for selected APREQ aircraft shown in green and unavailable slots shown in red vertically in the middle. Predicted arrivals are shown in gray.

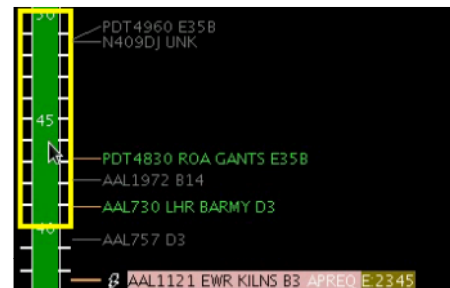


Fig. 5 EDCT compliance window shown in yellow for selected flight also subject to APREQ restriction.

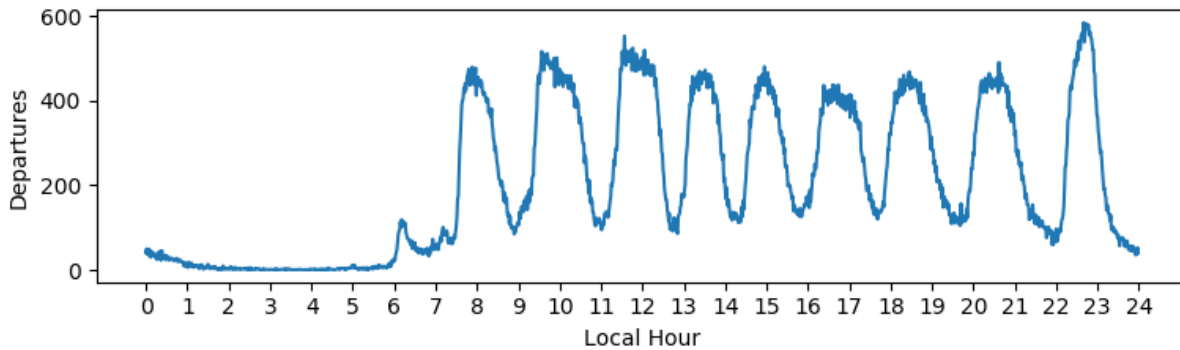
departures. Table 1 describes the distribution of departures per day for the reduced data set used for subsequent analyses.

**Table 1 CLT Departures Per Day.**

Mean (Std. Dev.)	755.5 (52.3)
Min.	593
Median	764
Max.	865

CLT is a major hub for American Airlines (AAL); most CLT departures are operated by AAL and its regional carriers. CLT flights to Atlanta, Newark, LaGuardia, and John F. Kennedy airports are subject to APREQ restrictions throughout each day, with other major destinations including Chicago O’Hare, Washington Dulles, and Philadelphia also frequently subject to APREQs. All are among the top ten most frequent destinations of CLT departures.

Scheduled AAL operations at CLT are organized into banks, which leads to periods of surface congestion interspaced with lulls. Fig. 6 shows the departure-bank structure reflected in the departure runway-utilization local time, summed over all days in the 402-day data set.



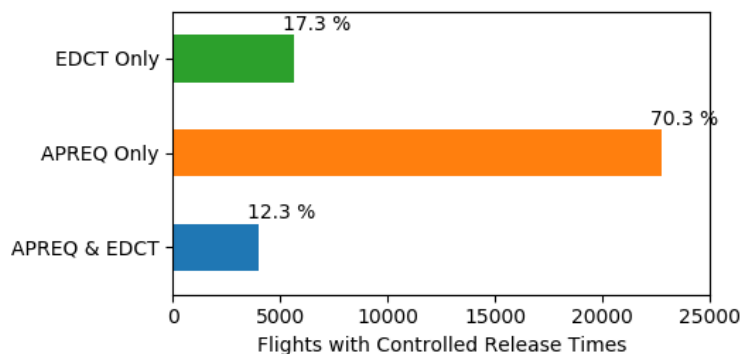
**Fig. 6 CLT departure banks.**

**B. APREQ and EDCT Departures**

From January 2018 through February 2019, there were 32,337 flights (10.6% of all departures) with controlled release times due to APREQs, EDCTs, or both. Of these, 26,733 flights (8.8% of all departures) were subject to APREQ restrictions, including those also subject to EDCTs. Fig. 7 shows the counts and proportions of controlled departures in each category. Overall, 82.6% of controlled departures were APREQ flights.

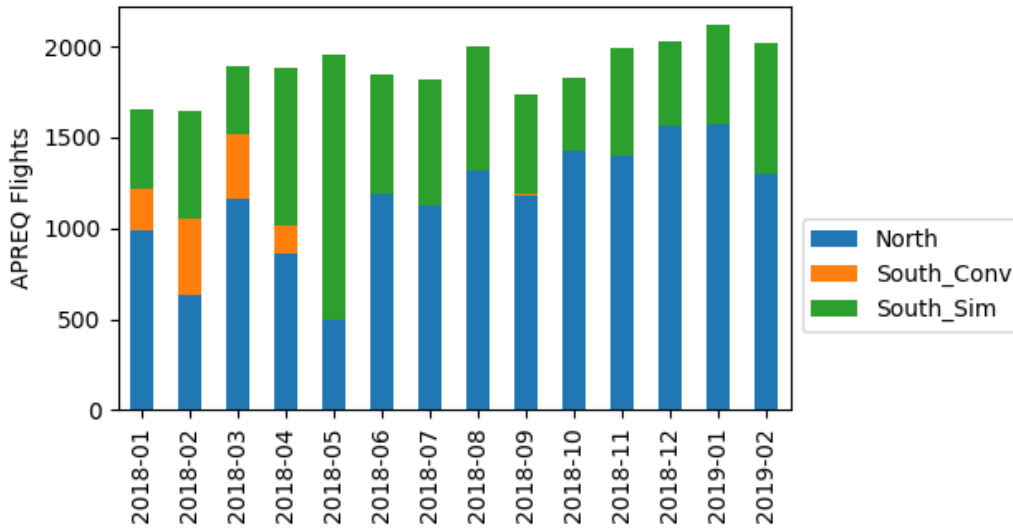
More APREQ flights were negotiated with ZDC (61.1%) than with ZTL (38.9%). The larger proportion of APREQ flights negotiated with ZDC reflects the large number of flights to the U.S. Northeast that are subject to daily APREQ restrictions from ZDC.

Fig. 8 shows the airport configuration in use at takeoff during each month of the study period for 26,436 APREQ flights (98.9% of all APREQ flights) for which these data were available. The south-converging (‘South\_Conv’) flows utilizes runway 23 for arrivals, which adds complexity to surface traffic management. Due to the 5/23 construction noted above, the predominant airport configuration for the latter part of the study period was the more standard north-flow, with 36C and 36R used for departures. The north-flow configuration affords more room for APREQ flights to wait on the airport movement area away from ramp-area congestion; by contrast, the south-flow runways (18C and 18L) are considerably closer to the ramp area surrounding the main terminal building near the top of Fig. 1.



**Fig. 7 Counts and proportions of controlled flights.**





**Fig. 8 APREQ flights by airport configuration.**

Flights through ZDC are likely to use the eastern departure runways (18L/36R), while flights through ZTL are likely to depart from the western departure runway (18C/36C). Overall, 22.8% of APREQ flights used runway18L and 36.3% used 36R, while 15.8% used 18C and 25.1% used 36C. The higher utilization of 18L and 36R again reflects the typical use of the eastern runway for ZDC APREQs.

### C. Electronic APREQ Coordination and Release Time Request Methods

To perform electronic APREQ negotiation, the center traffic manager must first enable it in TBFM IDAC by specifying whether semi-automatic or automatic mode should be used, or whether CFR is required. When semi-automatic or automatic mode is available, tower traffic managers have the option to select the desired release time manually via the ‘Select Slot on Timeline’ (SSOT) method or allow the STBO Client to automatically request a release time using ‘Request Release Time’ (RRT). Figs. 9 and 10 show the methods used by CLT tower traffic managers to negotiate release times in semi-automatic or automatic mode with ZDC and ZTL, respectively. ‘OFF’ indicates electronic negotiation was turned off, so that CFR was required.

Center release-mode data became available in March 2018, and except for a few test periods beginning in July 2018, ZTL only used CFR prior to October 2018 when IDAC was officially introduced there. Semi-automatic mode was used predominately at both centers, indicating a desire on the part of center traffic managers to approve requested release times manually; however, both centers increased the use of automatic mode toward the end of the study period. Anecdotal evidence suggests some center traffic managers may prefer the flexibility to add slack to schedules under certain circumstances (e.g., if they anticipate unscheduled flights or expect flights will require scheduling soon); this requires semi-automatic mode.

The ZTL data also depict the introduction of prescheduling, in which the ATD-2 system automatically requests release times for ATL flights. All of the ZTL ‘Request Release Time’ usage in automatic mode stems from prescheduling; all but a small fraction stems from prescheduling in semi-automatic mode (note large proportions of ‘SEMI, RRT’ and ‘AUTO, RRT’ in Fig. 10). The ZDC release methods (Fig. 9), on the other hand, directly reflect user preference, indicating increased use of the ‘Request Release Time’ method than during the introductory period for electronic APREQ negotiation described in Ref. [7]. The use of CFR even when semi-automatic or automatic modes were available may indicate some discussion about particular APREQ flights was warranted. Traffic managers resorted to CFR less frequently in recent months.

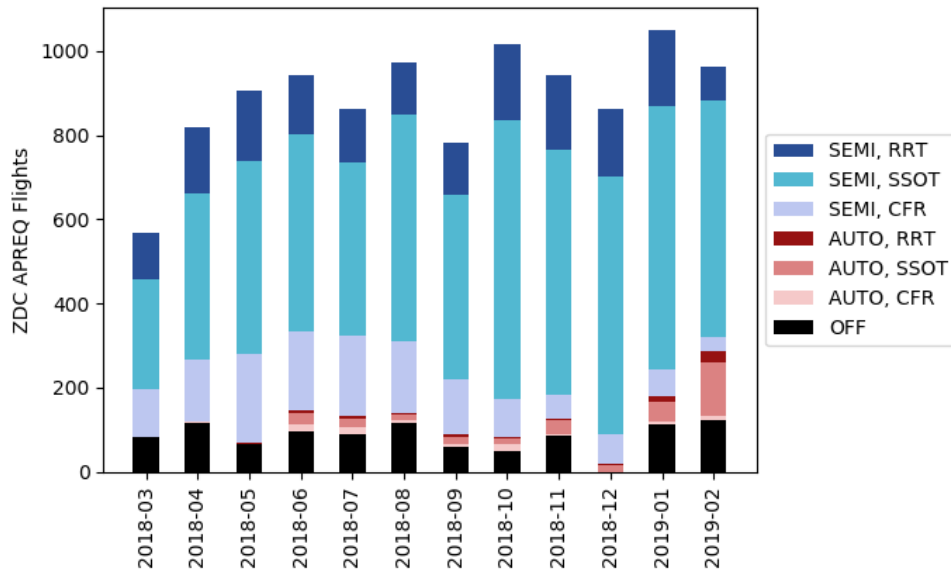


Fig. 9 ZDC release-request types when automatic or semi-automatic negotiation mode was available.

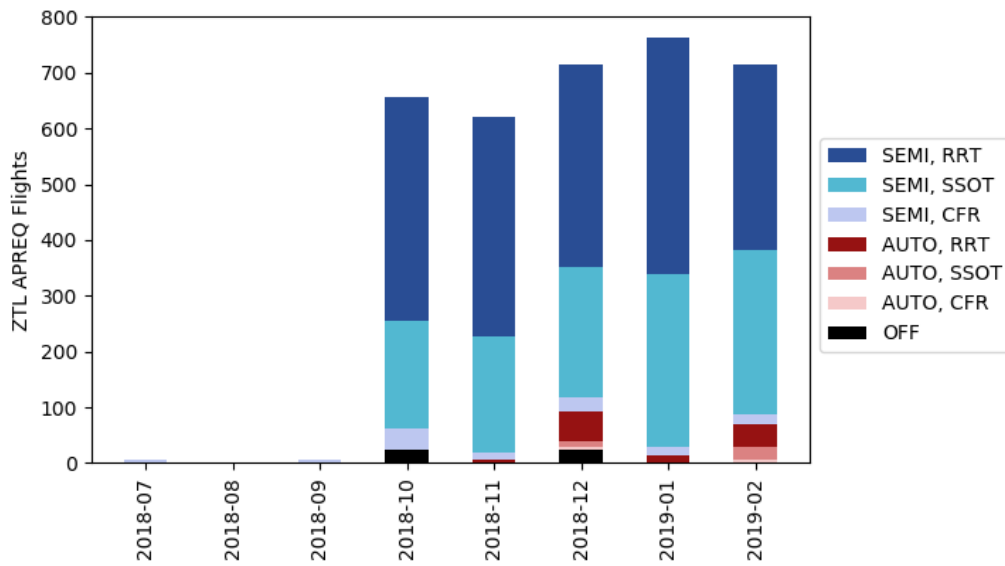


Fig. 10 ZTL release-request types when automatic or semi-automatic negotiation mode was available.

#### D. APREQ Rescheduling

Tower traffic managers may request a new release time for a previously scheduled APREQ flight if it appears the flight will be unable to comply with its current release time, or if the opportunity arises to meet an earlier time and incur less delay. Of the 26,733 APREQ flights, tower traffic managers renegotiated release times for 6,936 flights (25.9%) and the rescheduling process led to a new release time for 6807 flights (25.5%). Removing release-time-difference outliers beyond [1.5 \* inter-quartile range] yields 6,373 flights with new release times. Table 2 describe release-time differences (final release time – initial release time) for these flights, so that a positive difference indicates the flight was

Table 2 Rescheduled release time difference (s).

Mean (Std. Dev.)	306.1 (645.0)
Minimum	-1422
1 <sup>st</sup> Quartile	-120
Median	300
3 <sup>rd</sup> Quartile	698
Maximum	2129

rescheduled to a later time. 1,935 of these flights (30.4%) were rescheduled to an earlier time (mean= -431.6 s; SD=306.1 s); for those with initial and final release times both negotiated via IDAC, the total delay savings over the study period was 73.8 hrs. Data for comparison with rescheduling using CFR are unavailable.

Another possible reason to reschedule an APREQ is to better ensure EDCT compliance. However, on a percentage basis, APREQ flights that were also subject to an EDCT were rescheduled approximately as often as APREQ flights not subject to an EDCT (26.9% vs. 25.8%, respectively). In some circumstances center traffic managers may simply release a flight that is nominally subject to an APREQ restriction. So-called ‘free releases’ occurred for 269 APREQ flights (1%) during the study period.

### E. APREQ Aircraft Locations

The ATD-2 surface system records the estimated ‘surface state’ of flights, which can be used to identify where APREQ flights were during the APREQ negotiation process. Tower traffic managers are expected to request a release time for flights after the pilot calls ready and before the aircraft has initiated the pushback operation (i.e., while the aircraft is still at the gate in the ‘SCHEDULED’ state). Excluding prescheduled flights that are always at the gate

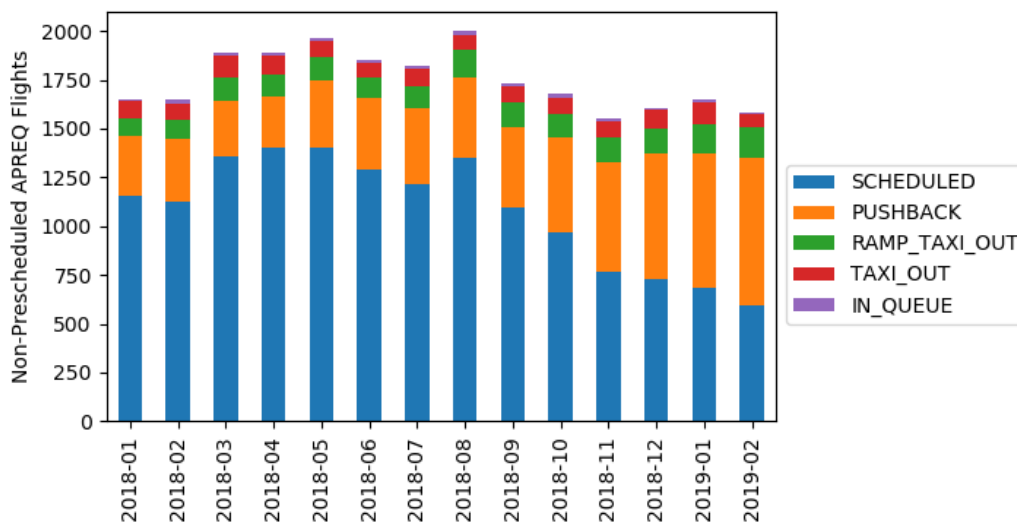


Fig. 11 Surface states of *non-prescheduled* APREQ flights at initial release-time approval.

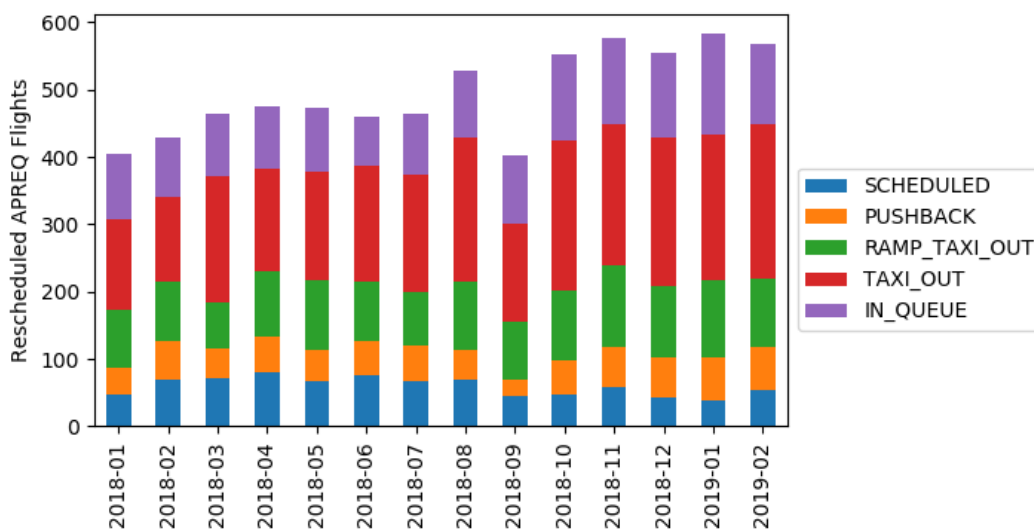


Fig. 12 Surface states of *rescheduled* APREQ flights at final release-time approval.



when prescheduling occurs, Fig. 11 shows that tower traffic managers received the majority of initial release times before the flight started taxiing. An apparent trend toward obtaining release times later, during pushback, may actually reflect enhancements made to the ATD-2 system that results in earlier detection of pushback events from surface-surveillance data.

Fig. 12 shows the surface states of APREQ flights upon receipt of renegotiated release times. The majority of release times are rescheduled while flights are in the ‘TAXI\_OUT’ state in the active movement area prior to reaching the runway queue. It is possible that rescheduling of flights in ‘TAXI\_OUT’ or ‘IN\_QUEUE’ states is triggered based on the STBO Client’s projected compliance information. The ‘IN\_QUEUE’ state may reflect aircraft that are actually parked out of the main runway queue. Data from the later months in the study period show an increased number of flights had renegotiated release times, in part due to increased rescheduling via IDAC at ZTL. The reduced number of rescheduled APREQ flights in September 2018 warrants further investigation.

Table 3 depicts the initial and final surface states for the 6,213 APREQ flights that were not prescheduled, but were later rescheduled. The greatest proportion (24.4%) first had a release time negotiated at the gate (‘SCHEDULED’) and then renegotiated in the movement area (‘TAXI\_OUT’). 13.3% of flights were assigned updated release times in the ramp area, whereas 14% were in the runway queue. 11.8% of flights registered a rescheduled release time prior to pushback. The table shows that most flights were scheduled at the gate, but possible compliance issues that warranted rescheduling did not arise until flights attained the ‘TAXI\_OUT’ or ‘IN\_QUEUE’ states. The STBO Client compliance projections are likely to be more accurate by this time.

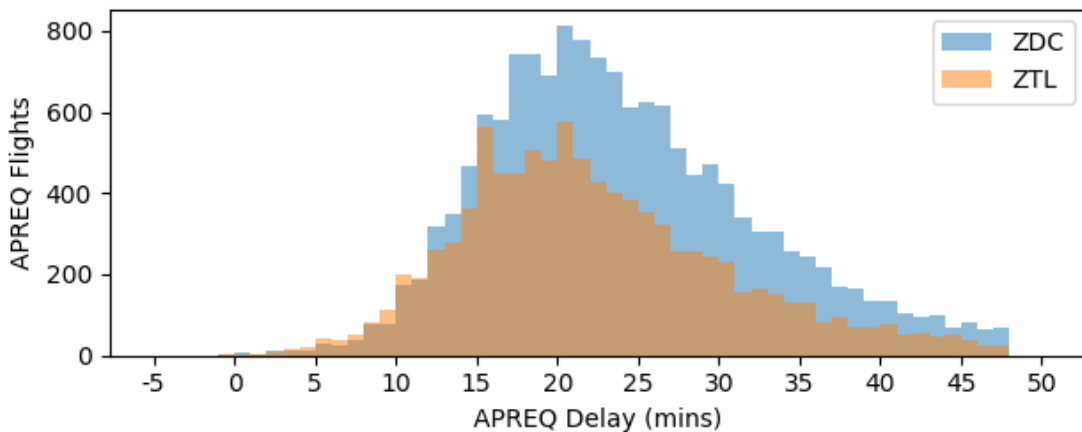
**Table 3 Surface-state combinations at initial and final release-time approval.**

Final Surface State (Rescheduled APREQ Flights)	Surface State on Initial Release-Time Approval ( <i>Non-prescheduled</i> APREQ flights)				
	SCHEDULED	PUSHBACK	RAMP_TAXI_OUT	TAXI_OUT	IN_QUEUE
SCHEDULED	731 (11.8%)	11 (0.2%)	4 (0.1%)	3 (0.0%)	-
PUSHBACK	367 (5.9%)	259 (4.2%)	-	1 (0.0%)	-
RAMP_TAXI_OUT	826 (13.3%)	243 (3.9%)	129 (2.1%)	-	-
TAXI_OUT	1517 (24.4%)	485 (7.8%)	129 (2.1%)	129 (2.1%)	1 (0.0%)
IN_QUEUE	868 (14.0%)	345 (5.6%)	88 (1.4%)	57 (0.9%)	20 (0.3%)

#### F. APREQ Assigned Delays

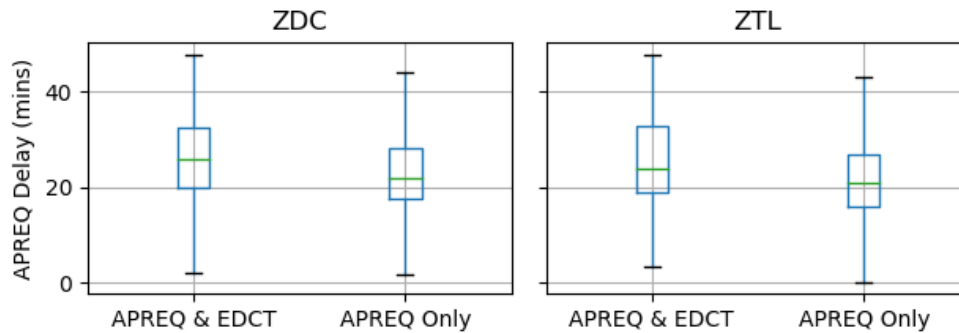
The delay assigned to APREQ flights was computed using the last-updated airline expected departure time (‘Ltime’) for correspondence with Ref. [7], as shown in Eq. (1):

$$APREQ\ delay = Final\ approved\ release\ time - Ltime \quad (1)$$



**Fig. 13 APREQ assigned delay computed using Eq. (1) by negotiation center.**

25,573 APREQ flights (95.7%) have a valid Ltime; removing delay-value outliers beyond  $[1.5 * \text{inter-quartile range}]$  yields 24,267 values covering 90.8% of all APREQ flights. Fig. 13 shows the resulting APREQ-delay histogram with one-minute bins for release times negotiated with ZDC and ZTL. The ZDC APREQ-delay distribution (N=14,693; mean=23.9 mins; SD=8.3 mins) is similar to the ZTL APREQ-delay distribution (N=9,462; mean=22.1 mins; SD=8.3 mins). The slightly higher mean delay for ZDC may reflect the larger number of APREQs through ZDC to the northeast U.S. The overall APREQ-delay distribution has a mean of 23.2 mins (SD=8.4 mins), which corresponds closely to the APREQ-delay distribution for the introductory electronic-negotiation period [7].



**Fig. 14 APREQ assigned delay by center per restriction category.**

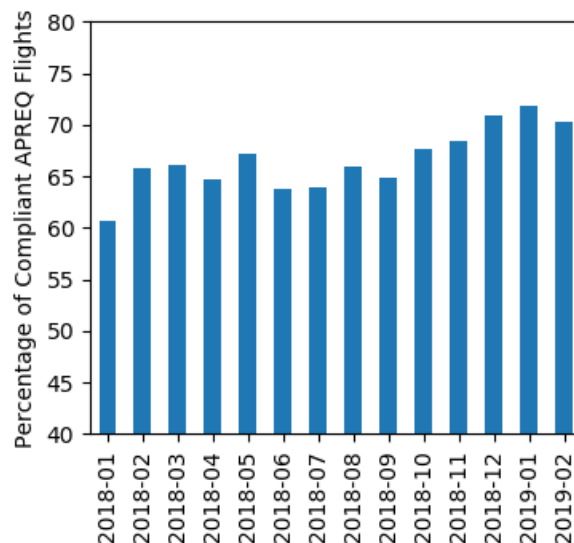
A trend of slightly lower median delays for ZTL APREQ flights than ZDC APREQ flights, with comparable variation, holds when examining the data along several dimensions. APREQ flights that are also subject to EDCT restrictions show slightly higher median APREQ delay (Fig. 14; whisker end-points are at  $[1.5 * \text{inter-quartile range}]$  from the box edges); this may indicate later release-times are more commonly requested to meet EDCT restrictions. There is no apparent difference in APREQ delay by departure bank or release-time request method, with slightly lower median APREQ delays incurred by ZTL flights.

The data also show slightly higher median delays for rescheduled APREQ flights compared non-rescheduled APREQ flights, in accordance with the tendency to reschedule APREQ flights to a later release time. Median assigned delay tends to be lower for the runways not typically used for departures to the respective centers, a possible effect of APREQs assigned during lower-traffic periods when departure-traffic direction is less critical. Flights that received an approved release time prior to taxing also incurred less median APREQ delay. For brevity, plots of these results are not shown.

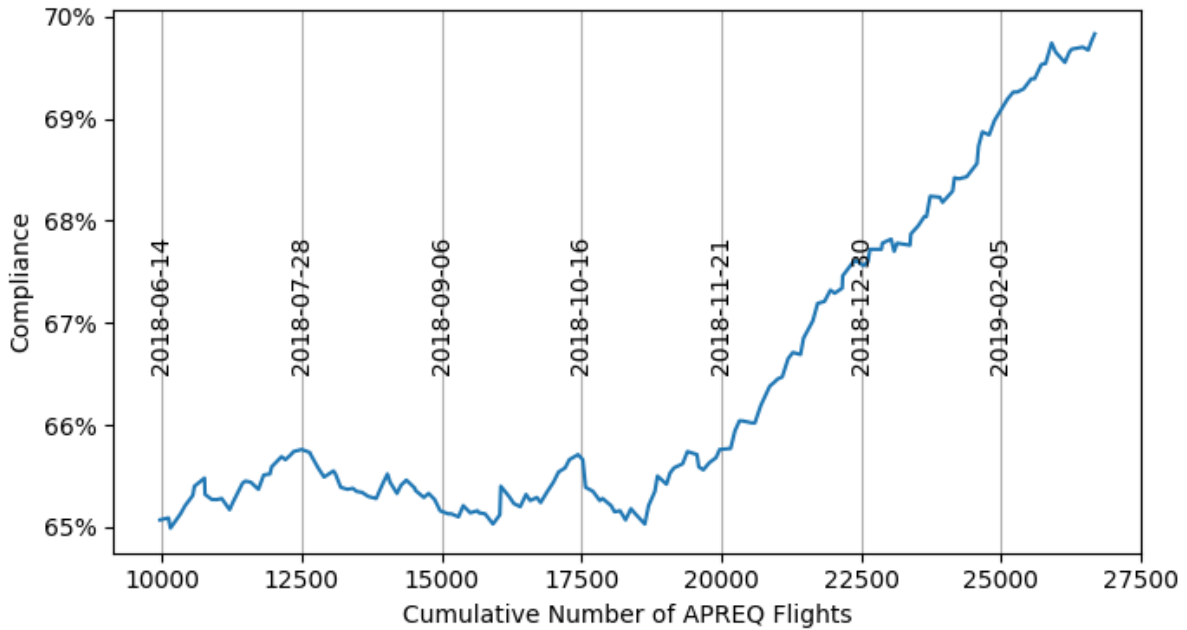
### G. APREQ Compliance

Overall, 17,854 APREQ flights (66.8 %) were compliant with their assigned departure release times (within two minutes before and one minute after the assigned time). Fig. 15 shows the monthly compliance percentage over the study period. A trend toward improved compliance is evident, with monthly compliance reaching 71.8% in January 2019. To confirm the trend, Fig. 16 shows average compliance computed using a rolling window over 10,000 individual APREQ flights and smoothed by taking every 100 values. Fig. 16 shows a clear trend toward increasing compliance that extends to the end of the study period.

Compliance was also examined along various dimensions in a manner similar to APREQ delay, considering the same 24,267 APREQ flights that remain after removing delay outliers. Compliance for ZTL flights is generally slightly higher than for ZDC flights. This trend holds, for example,



**Fig. 15 APREQ flight release-time compliance.**

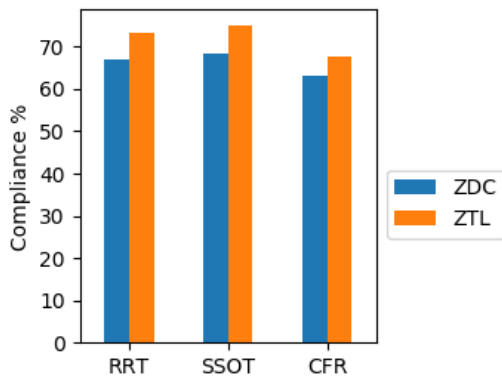


**Fig. 16 Rolling window of average compliance with dates when cumulative numbers were reached.**

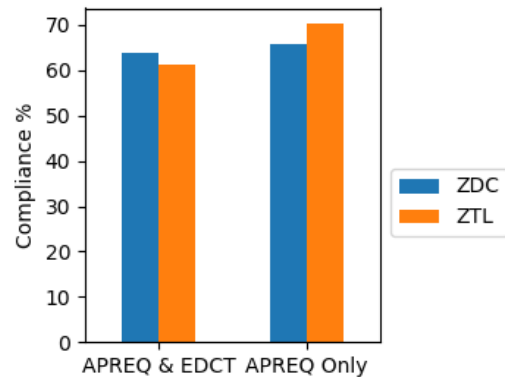
when examining non-rescheduled versus rescheduled flights; otherwise there is no apparent difference in compliance. Electronic release-time request methods also show a limited positive effect on the release-time-compliance percentage over CFR (Fig. 17), similar to the results in Ref. [7].

One case in which the compliance percentage for ZTL flights was lower than that of ZDC flights was for APREQ flights that were also subject to an EDCT restriction (Fig. 18). Median delay values were slightly higher for such flights, as shown in Fig. 14. The compliance percentage was also lower for ZTL flights that used runways not typically assigned to ZTL flights (Fig. 19).

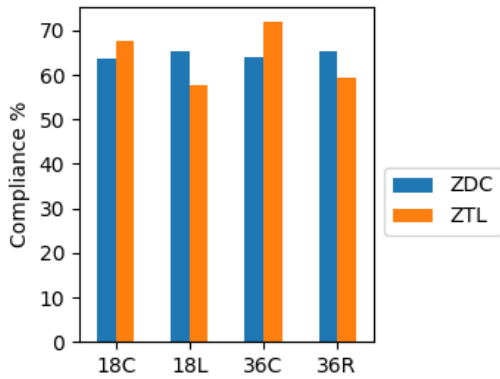
Finally, Fig. 20 depicts average APREQ compliance by APREQ delay grouped in five-minute bins (axis labels indicate APREQ delay was less than or equal to the labeled value). Again compliance appears relatively insensitive to the amount of assigned delay, with ZTL enjoying a slight advantage in compliance. Compliance was worst for flights with delays of five minutes or less. Taken together, these findings indicate the main drivers of APREQ compliance lie elsewhere, potentially in the context of flight-specific surface operations.



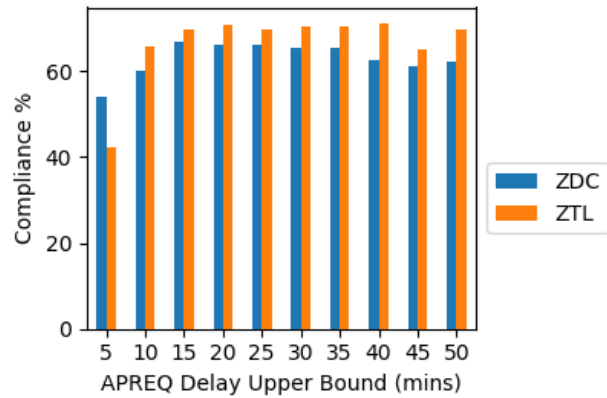
**Fig. 17 APREQ compliance by center per release-time request method.**



**Fig. 18 APREQ compliance by center per restriction category.**



**Fig. 19 APREQ compliance by center per runway.**

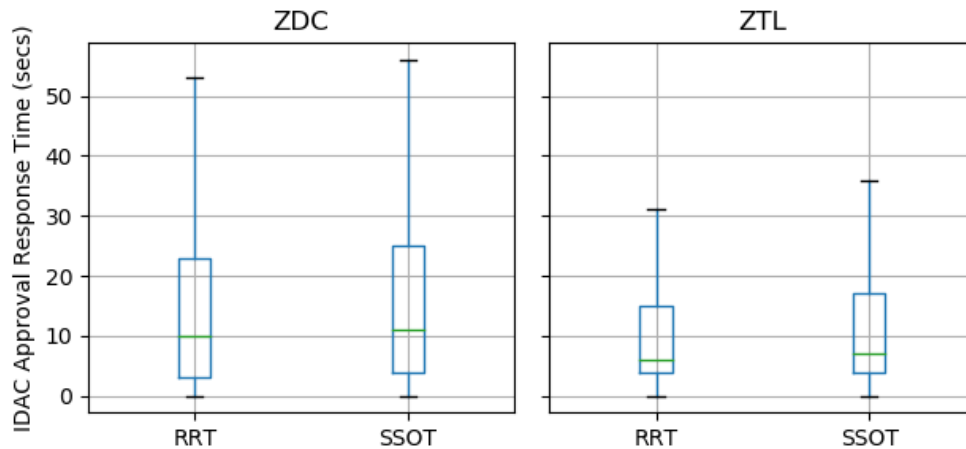


**Fig. 20 APREQ compliance by center per assigned APREQ delay in five-minute bins.**

### H. Approval Response Times

An important advantage of electronic release-time negotiation is the time savings relative to CFR [7]. Using IDAC message data available from 13 February 2018 to the end of the study period, approval response times for electronically negotiated release times were computed as the time difference between a request message and the corresponding approval message for a particular flight. Response times and associated electronic release-time request method were obtained for 12,241 APREQ flights (45.8% of all APREQ flights); for rescheduled flights, the computed response time is that of the final renegotiation.

The overall median response time was 9 secs. Fig. 21 depicts the response-time distributions for each center and release-time request type (whisker end-points are at  $[1.5 * \text{inter-quartile range}]$  from the box edges). Median response times are slightly lower for ‘Request Release Time’ requests for both centers. Median response times are slightly lower for ZTL than for ZDC, with slightly lower variation—another factor that could impact observed compliance. As discussed in Ref. [7], response times are consistently better than CFR response times that might be experienced during busy periods, which can exceed five minutes.



**Fig. 21 Electronic APREQ response times by release-time request method per center.**

## IV. Conclusions and Further Research

This paper documents ATD-2 electronic APREQ negotiation in daily operations at CLT over fourteen months. The analysis indicates that field traffic managers are consistently exercising capabilities provided by the STBO Client and TBFM IDAC to good effect. Electronic departure-approval requests from CLT to ZDC and ZTL have largely

supplanted CFR. In addition, compliance is improving, supported in part by the capability to reschedule release times electronically.

Detailed examination of assigned APREQ delays suggests that the delay assigned to a flight via a given release time is not obviously affected by bank, restrictions, release-time request method, or other factors. It may therefore depend primarily on the demand at the stream-insertion points used as scheduling points by each center. Rescheduling APREQ flights typically results in slightly higher median delay, but also provides delay savings for a sizable proportion of flights. Renegotiating release times may also contribute to improved compliance by providing more achievable release times.

The results also suggest an APREQ flight's bank, the method used to negotiate its release time electronically, and whether it was also subject to an EDCT or had its release time rescheduled do not significantly impact APREQ compliance—nor does the amount of assigned delay. This may indicate a variety of specific contextual factors related to surface traffic movement, pilot response, and situation awareness and skill of CLT Tower controllers also play a significant role. Normal use of a mainly departure-only runway, coupled with the capability to easily renegotiate release times for flights projected to miss their assigned times, may bolster the compliance of ZTL APREQ flights—which in turn has contributed to improved overall compliance since the introduction of IDAC at ZTL. Overall, these promising findings support future, broader deployments of similar capabilities because no specific systematic factors appear to negatively impact compliance with electronically negotiated release times.

The ATD-2 ground system has clearly contributed to streamlining release-time requests and improving APREQ compliance during the operational period examined here. STBO Client features, including projected compliance indications, EDCT compliance windows, and APREQ exclusions, likely provide incremental advantages that are difficult to discern at the aggregate level. Electronic release-time negotiation also provides significant time savings in approving release times for both tower and center traffic managers, consistent with the response-time data in Ref. [7].

Additional research is needed to examine the impacts of specific ATD-2 enhancements on APREQ compliance. For example, automatically propagating approved release times to AEFs's flight strips may afford tower controllers advanced notice, and enable them to better formulate plans for managing APREQ flights. Future research will examine additional effects of APREQ compliance on other important IADS metrics (e.g., arrival-time compliance), and apply more sophisticated analyses to determine the contributions of specific ATD-2 system enhancements on compliance improvements.

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