

DIP

DIGITAL INFORMATION PLATFORM

DIP Predictive Engine for NY Airspace

SWIM

Weather



Motivation for N90 Workshop



- NASA predictive engine developed to support Sustainable Flight National Partnership Ops 1 (SFNP Ops-1) demo in North TX and Houston area
- SFNP Ops-1 is demonstrating pre-departure TOS reroutes within the lockout period which require ATC coordination
- Demonstration of use cases that require ATC coordination is constrained to specific locations agreed upon between NASA/FAA/NATCA
- N90 workshop to explore **use cases of predictive engine that don't require ATC coordination**



- N90 TMI analysis
- Estimated Take Off Time (ETOT) accuracy
- Operational use cases:
 - o Flight plan filing
 - o Mandatory OFF Time
- Discussion



- **N90 TMI analysis**
- Estimated Take Off Time (ETOT) accuracy
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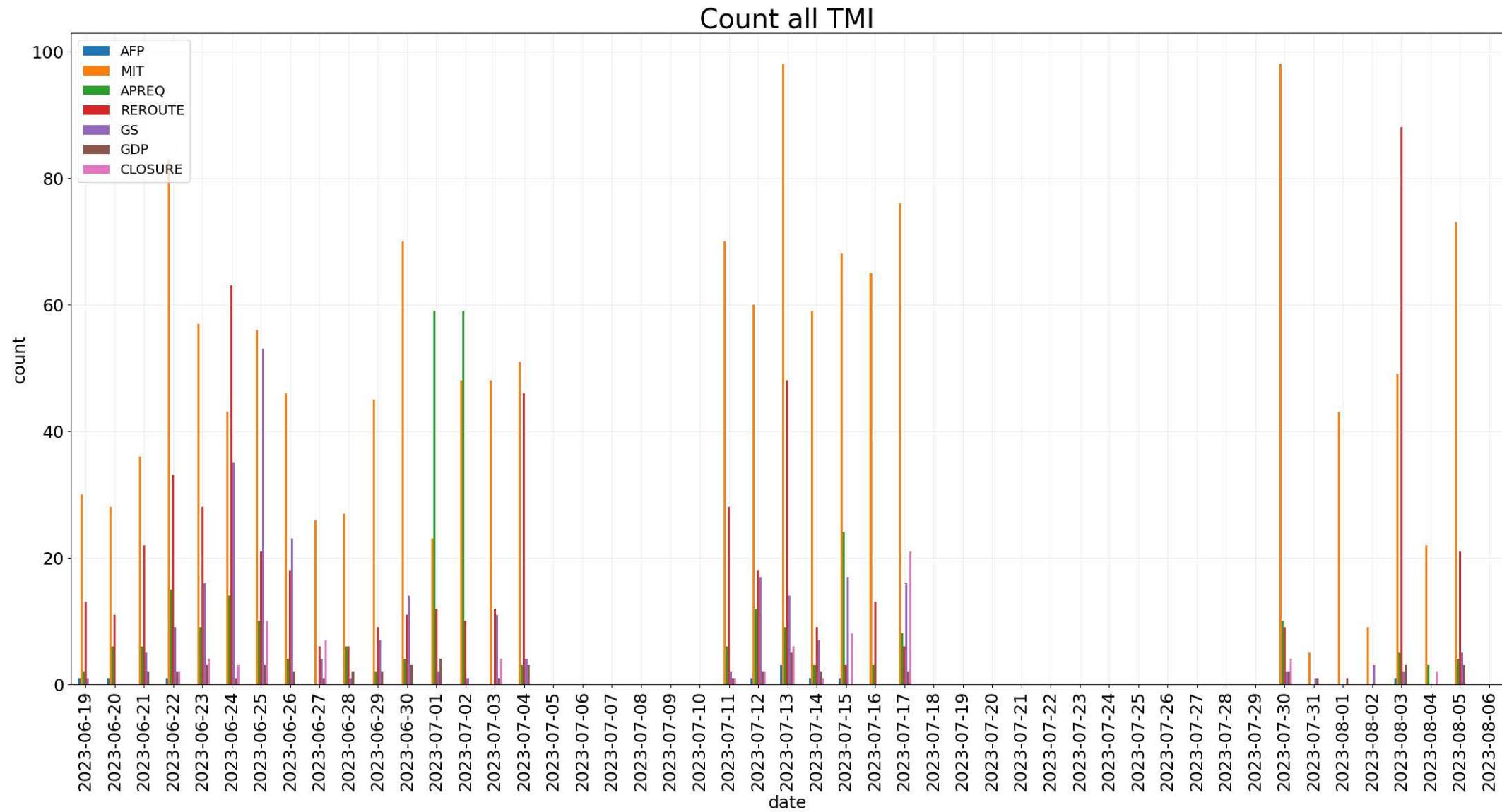
TMI Analysis Data Sources: TMI Summary



	B	C	D	E	F	G	H	I	J	K	L	M	N
1	facility	tmi_type	category	creation_time	start_time	scheduled_end_time	actual_end_time	removal_source	duration	resource_name	resource_type	miles_in_trail	minutes_in_trail
2	ZNY	REROUTE	departure	6/19/23 15:30	6/19/23 9:35		6/19/23 15:30	TMI_CANCELLED	21345	KORF			
3	ZDC	REROUTE	departure	6/19/23 15:30	6/19/23 9:35		6/19/23 15:30	TMI_CANCELLED	21345	KHPN			
4	ZJX	REROUTE	departure	6/19/23 15:30	6/19/23 9:35		6/19/23 15:30	TMI_CANCELLED	21345	KHPN			
5	ZMA	REROUTE	departure	6/19/23 15:30	6/19/23 9:35		6/19/23 15:30	TMI_CANCELLED	21345	KHPN			
6	ZNY	REROUTE	departure	6/19/23 15:30	6/19/23 9:35		6/19/23 15:30	TMI_CANCELLED	21345	KHPN			
7	ZBW	REROUTE	departure	6/19/23 15:30	6/19/23 9:35		6/19/23 15:30	TMI_CANCELLED	21345	KORF			
8	ZTL	REROUTE	departure	6/19/23 15:30	6/19/23 9:35		6/19/23 15:30	TMI_CANCELLED	21345	KHPN			
9	ALL	REROUTE	departure	6/19/23 15:30	6/19/23 9:35		6/19/23 15:30	TMI_CANCELLED	21345	KTEB			
10	ZDC	REROUTE	departure	6/19/23 15:30	6/19/23 9:35		6/19/23 15:30	TMI_CANCELLED	21345	KORF			
11	ZNY	MIT	arrival	6/19/23 10:48	6/19/23 11:30	6/19/23 12:15	6/19/23 12:15	TMI_EXPIRED	2745	LIZZI	FIX	15	
12	ZNY	AFP	departure	6/19/23 12:20	6/19/23 14:00	6/19/23 17:59	6/19/23 17:59	TMI_EXPIRED	14385				
13	ZNY	AFP	departure	6/19/23 12:16	6/19/23 14:00	6/19/23 19:59	6/19/23 19:59	TMI_EXPIRED	21585				
14	N90	MIT	departure	6/19/23 15:30	6/19/23 15:30	6/19/23 17:30	6/19/23 17:30	TMI_EXPIRED	7245	BIGGY	FIX	15	
15	TEB	APREQ	departure	6/19/23 15:43	6/19/23 15:30	6/19/23 17:30	6/19/23 17:30	TMI_EXPIRED	7211	BIGGY			
16	EWR	MIT	departure	6/19/23 15:29	6/19/23 15:30	6/19/23 19:00	6/19/23 19:00	TMI_EXPIRED	12645	LANNA	FIX	0	5
17	TEB	MIT	departure	6/19/23 15:29	6/19/23 15:30	6/19/23 19:00	6/19/23 19:00	TMI_EXPIRED	12645	LANNA	FIX	0	7
18	N90	MIT	departure	6/19/23 15:26	6/19/23 15:30	6/19/23 19:00	6/19/23 19:00	TMI_EXPIRED	12645	LANNA	FIX	10	
19	LGA	MIT	departure	6/19/23 15:29	6/19/23 15:30	6/19/23 19:00	6/19/23 19:00	TMI_EXPIRED	12645	LANNA	FIX	0	5
20	HPN	MIT	departure	6/19/23 15:29	6/19/23 15:30	6/19/23 19:00	6/19/23 19:00	TMI_EXPIRED	12645	LANNA	FIX	0	7
21	JFK	MIT	departure	6/19/23 15:28	6/19/23 15:30	6/19/23 17:30	6/19/23 17:30	TMI_EXPIRED	7245	RBV	AIRPORT	10	
22	HPN	MIT	departure	6/19/23 15:31	6/19/23 15:30	6/19/23 17:30	6/19/23 17:30	TMI_EXPIRED	7245	BIGGY	FIX	0	9
23	LGA	MIT	departure	6/19/23 15:31	6/19/23 15:30	6/19/23 17:30	6/19/23 17:30	TMI_EXPIRED	7245	BIGGY	FIX	0	7
24	EWR	MIT	departure	6/19/23 15:31	6/19/23 15:30	6/19/23 17:30	6/19/23 17:30	TMI_EXPIRED	7245	BIGGY	FIX	0	7
25	N90	MIT	departure	6/19/23 16:09	6/19/23 16:15	6/19/23 18:30	6/19/23 18:30	TMI_EXPIRED	8145	WHITE	FIX	10	
26	ZNY	MIT	arrival	6/19/23 16:01	6/19/23 16:30	6/19/23 18:00	6/19/23 18:00	TMI_EXPIRED	5445	LIZZI	FIX	15	
27	ZNY	MIT	arrival	6/19/23 17:07	6/19/23 18:00	6/19/23 23:00	6/19/23 23:00	TMI_EXPIRED	18045	PENNS	FIX	15	
28	ZBW	REROUTE	departure	6/19/23 22:41	6/19/23 19:00	6/20/23 1:00	6/20/23 1:00	TMI_EXPIRED	21645	KHPN			
29	ZNY	REROUTE	departure	6/19/23 18:01	6/19/23 19:00	6/20/23 1:00	6/20/23 1:00	TMI_EXPIRED	21645	KEWR			
30	ZOB	REROUTE	departure	6/19/23 18:01	6/19/23 19:00	6/20/23 1:00	6/20/23 1:00	TMI_EXPIRED	21645	KEWR			

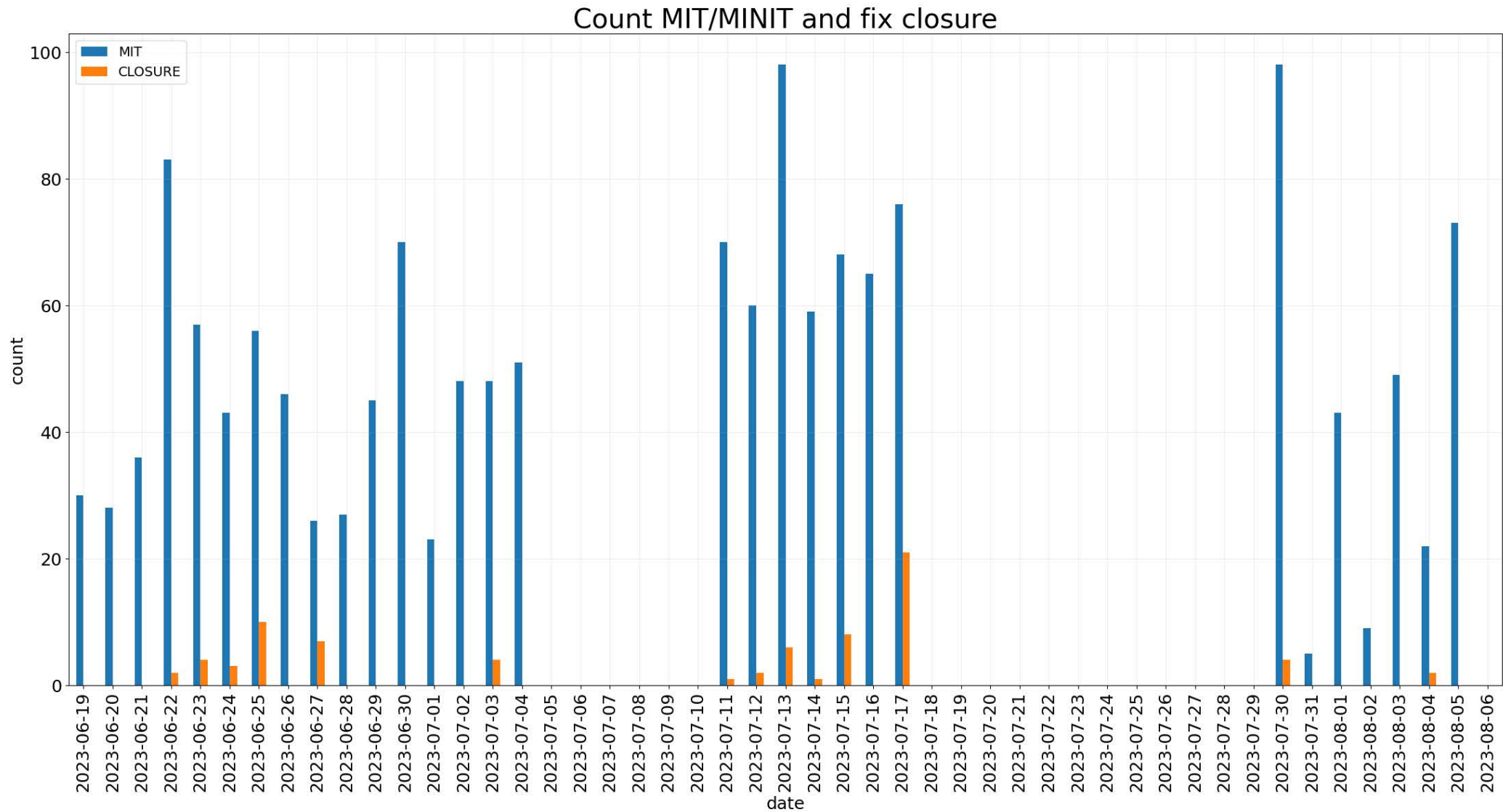


TMI Analysis



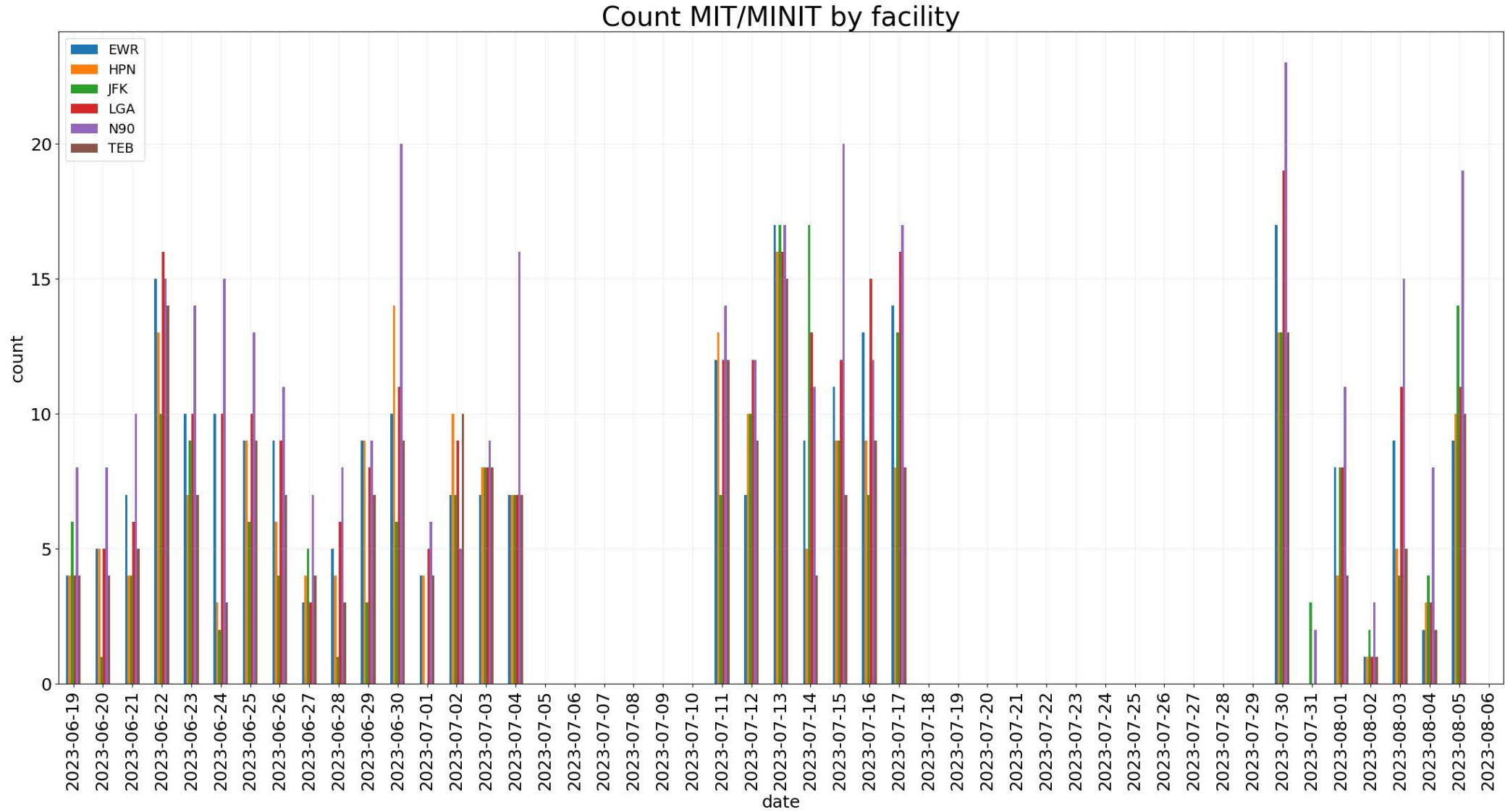


TMI Analysis: Count MIT/MINIT Restrictions and Closures



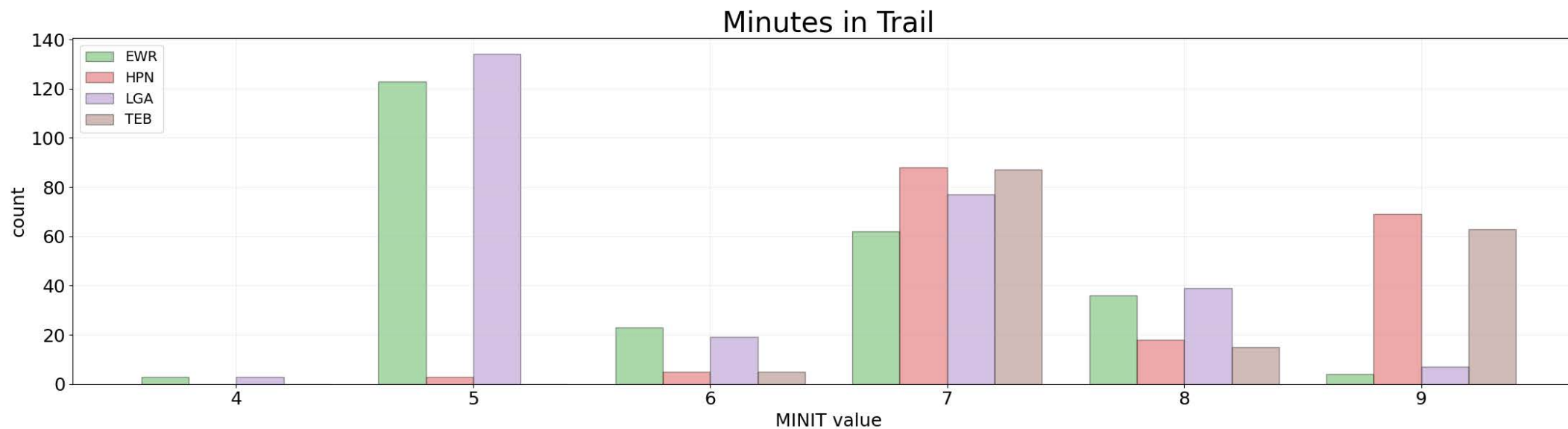
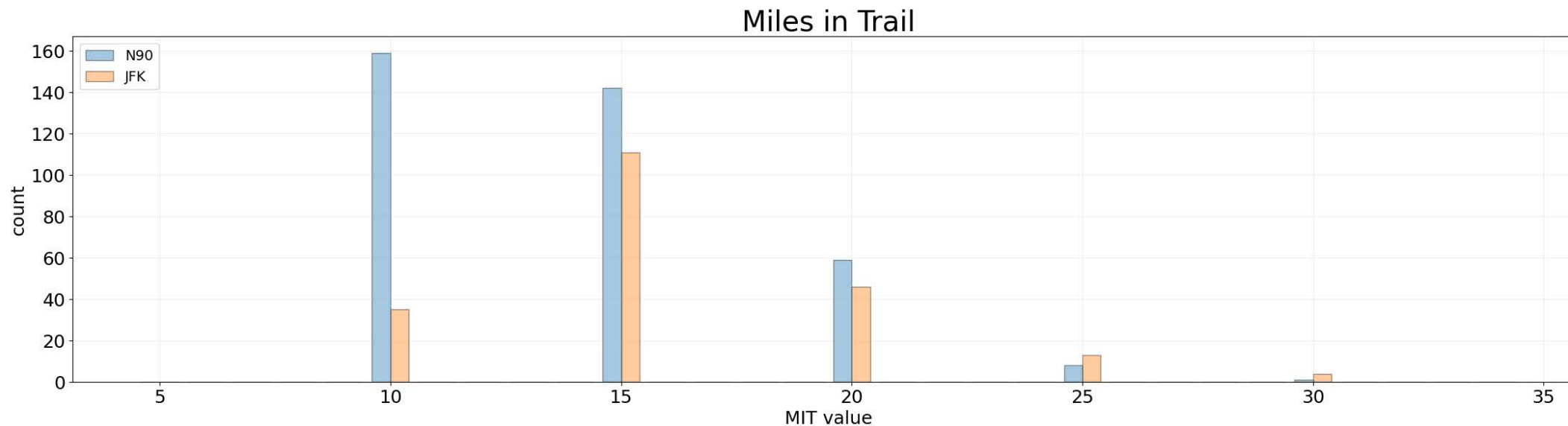


TMI Analysis: Count MIT/MINIT Restrictions by Facility





TMI Analysis: Count MIT Restrictions by Facility

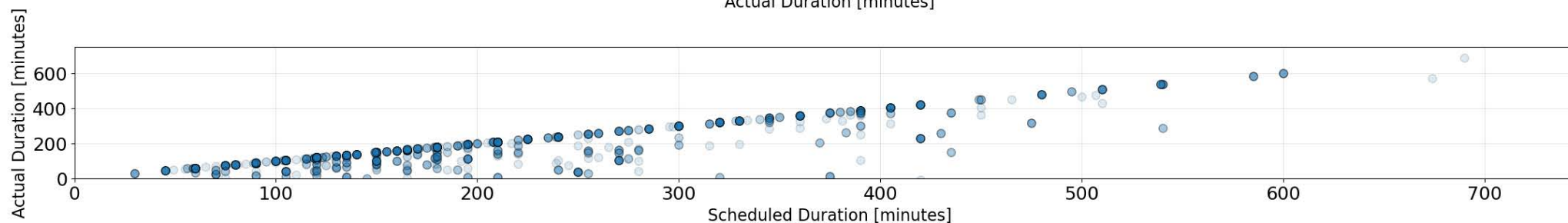
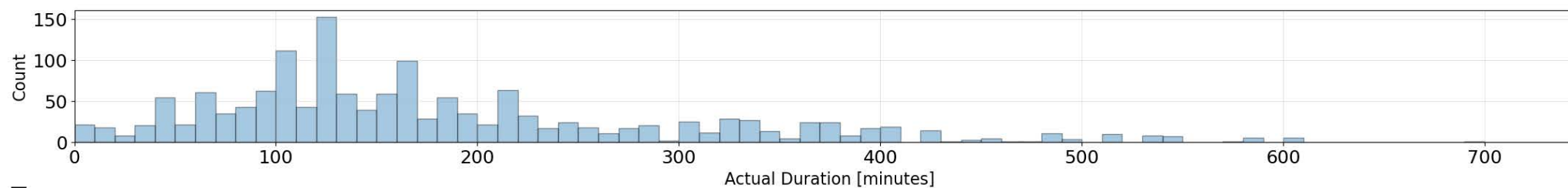
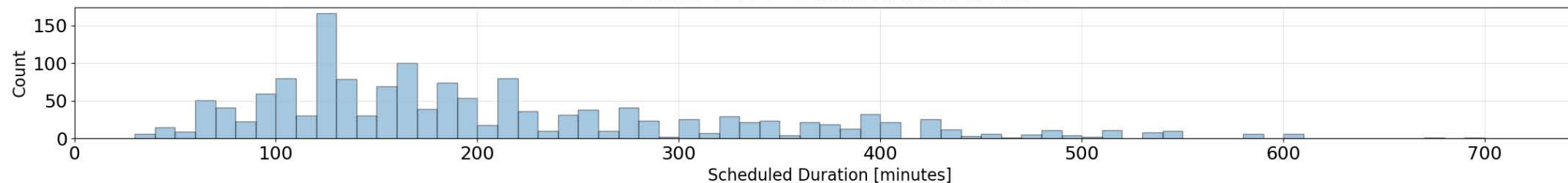




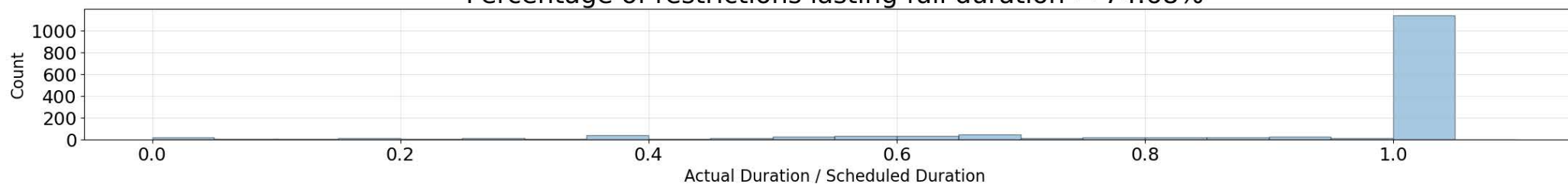
TMI Analysis: Duration MIT/MINIT Restrictions



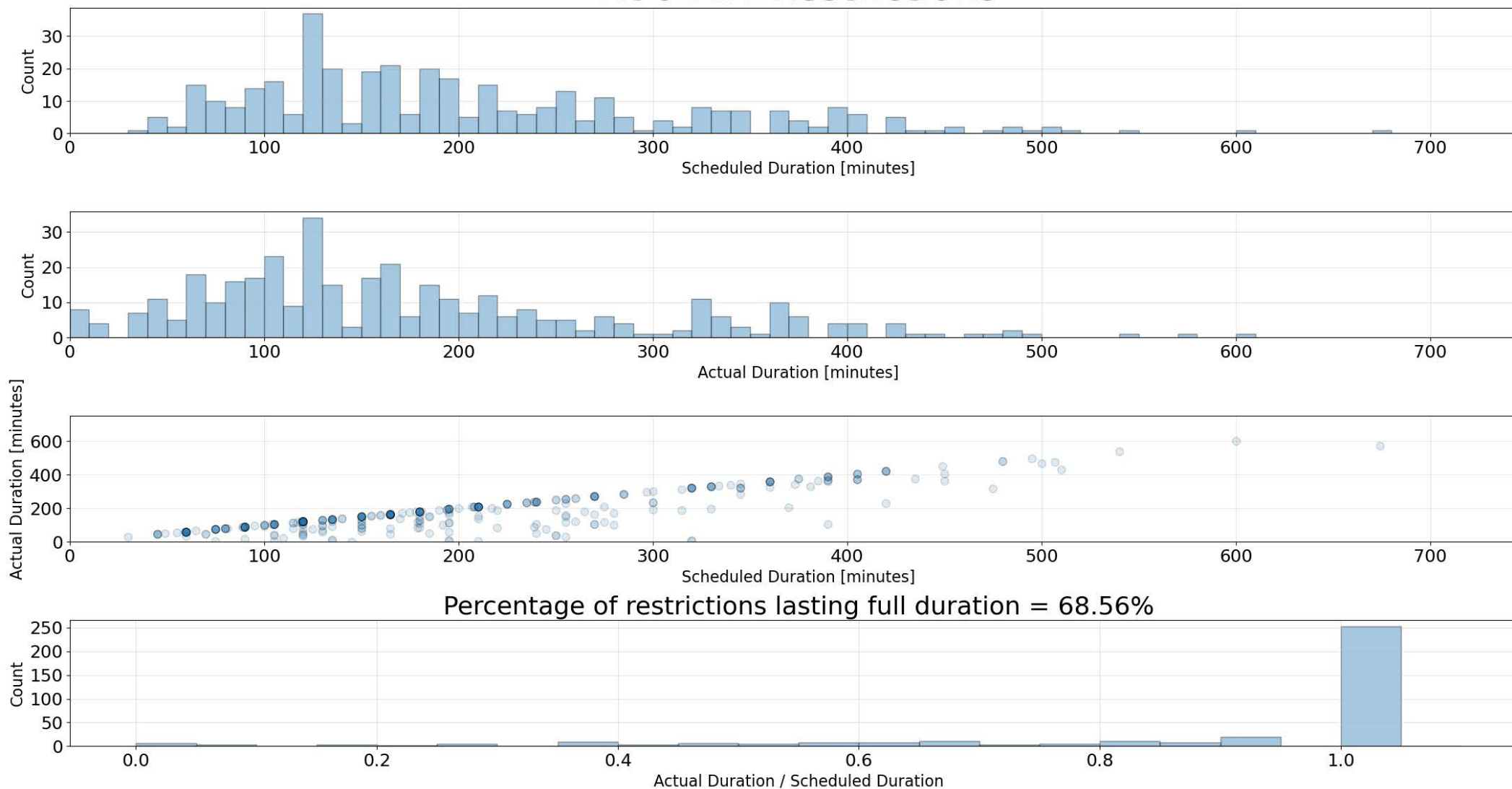
ALL MIT Restrictions



Percentage of restrictions lasting full duration = 74.68%

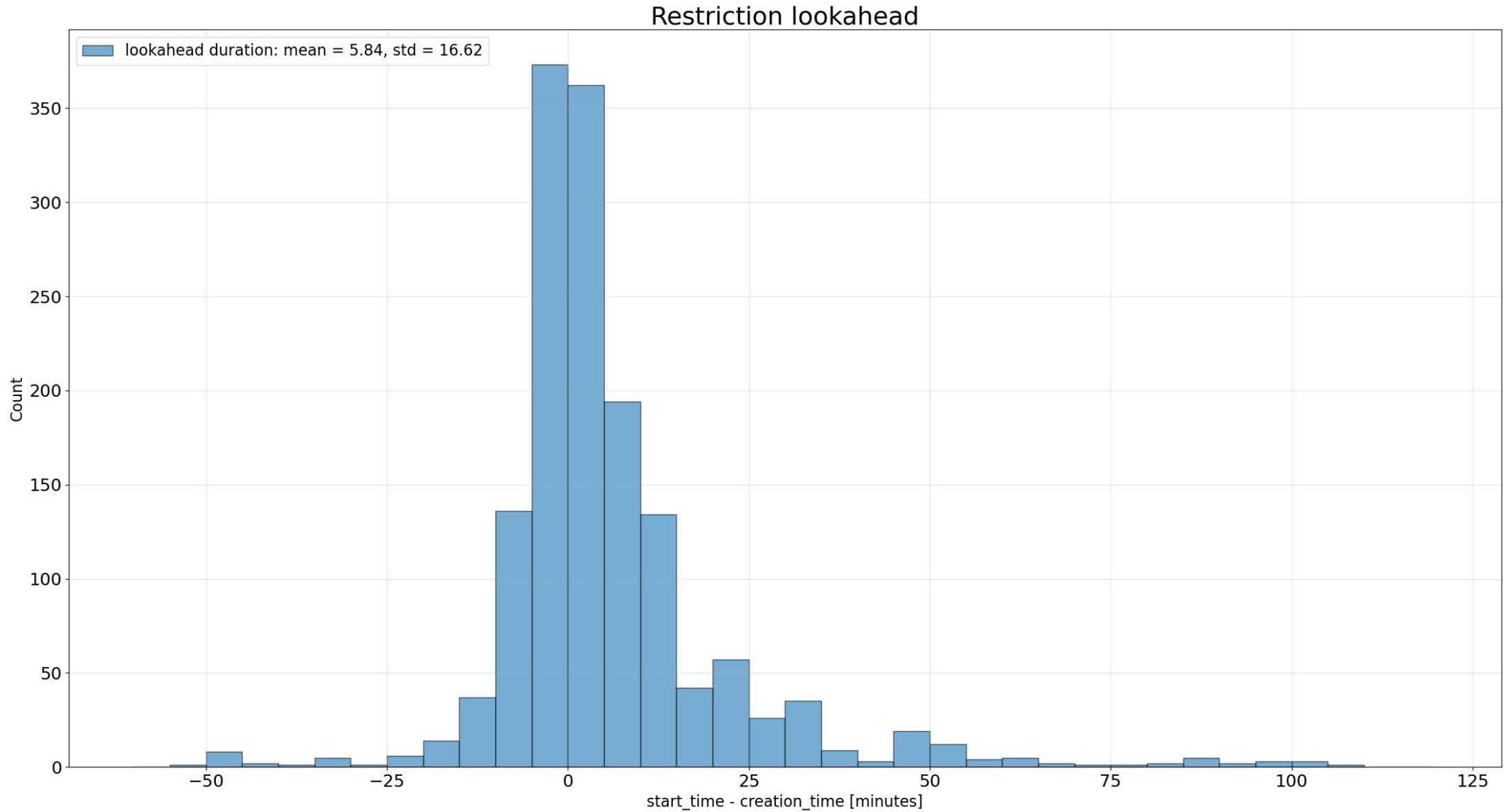


N90 MIT Restrictions





MIT/MINIT Lookahead





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ETOT Accuracy Data Sources: Flight Summary

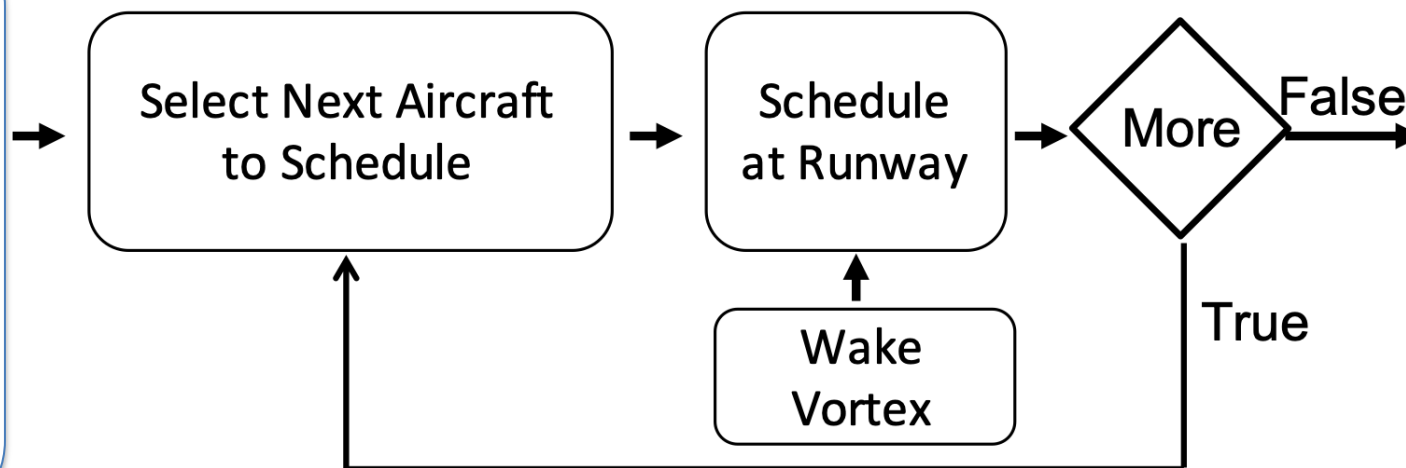


	A	B	C	D	E	F	G	H	I	J	K	L
1	acid	gufi	isarrival	isdeparture	departure_a	arrival_aeroc	departure_st	arrival_stand	aircraft_addr	aircraft_engi	aircraft_regis	aircraft_type
2	JBU2539	JBU2539.JFK.BQN.230618.0905.0043.TFM	FALSE	TRUE	KJFK	TJBQ			11351425	JET	N950JT	A321
3	JBU380	JBU380.MBJ.JFK.230618.1910.0099.TFM	TRUE	FALSE	MKJS	KJFK			11307511	JET	N907JB	A321
4	JBU788	JBU788.SXM.JFK.230618.1610.0123.TFM	TRUE	FALSE	TNCM	KJFK			11194137	JET	N796JB	A320
5	AAL1487	AAL1487.JFK.PHX.230618.0027.0648.AIRLINE_FLIGHTHUB	FALSE	TRUE	KJFK	KPHX			10698373	JET	N308RD	B38M
6	AAL976	AAL976.SNA.JFK.230618.0027.0333.AIRLINE_FLIGHTHUB	TRUE	FALSE	KSNA	KJFK				JET		A321
7	JBU1858	JBU1858.AUA.JFK.230618.2055.0067.TFM	TRUE	FALSE	TNCA	KJFK			11048178	JET	N652JB	A320
8	AAL219	AAL219.MTY.JFK.230618.0027.0048.AIRLINE_FLIGHTHUB	TRUE	FALSE	MMMY	KJFK				JET		A319
9	CKS961	CKS961.UNKN.UNKN.230619.0208.0013.ASDEX	TRUE	FALSE	PANC	KJFK			11098241	JET	N701CK	B744
10	JBU1536	JBU1536.STI.JFK.230619.0105.0113.TFM	TRUE	FALSE	MDST	KJFK			11348906	JET	N948JB	A321
11	AZA602	AZA602.FCO.JFK.230622.0715.0040.TFM	TRUE	FALSE	LIRF	KJFK				JET		A332
12	JBU677	JBU677.JFK.JAX.230618.1010.0063.TFM	FALSE	TRUE	KJFK	KJAX			10617658	JET	N229JB	E190
13	JBU285	JBU285.JFK.RDU.230618.1440.0072.TFM	FALSE	TRUE	KJFK	KRDU			11102187	JET	N705JB	A320
14	DAL1320	DAL1320.JFK.MCO.230618.1135.0064.TFM	FALSE	TRUE	KJFK	KMCO			10515833	JET	N129DN	A321
15	AVA021	AVA21.JFK.BOG.230618.1125.0042.TFM	FALSE	TRUE	KJFK	SKBO			11343969	JET	N943AV	A20N
16	AZA608	AZA608.FCO.JFK.230618.0825.0017.TFM	TRUE	FALSE	LIRF	KJFK				JET		A359
17	JBU358	JBU358.BUR.JFK.230618.0430.0071.TFM	TRUE	FALSE	KBUR	KJFK			10977751	JET	N583JB	A320
18	JBU98	JBU98.DEN.JFK.230619.0545.0039.TFM	TRUE	FALSE	KDEN	KJFK			10980604	JET	N586JB	A320
19	JBU1851	JBU1851.JFK.CUN.230618.1420.0070.TFM	FALSE	TRUE	KJFK	MMUN			11349873	JET	N949JT	A321
20	RPA5624	RPA5624.JFK.BOS.230618.1100.0231.TFM	FALSE	TRUE	KJFK	KBOS			10604707	JET	N216JQ	E75S
21	RPA4709	RPA4709.JFK.BNA.230618.0028.1123.AIRLINE_FLIGHTHUB	FALSE	TRUE	KJFK	KBNA			10505824	JET	N119HQ	E75S
22	DAL2743	DAL2743.MCO.JFK.230618.1000.0077.TFM	TRUE	FALSE	KMCO	KJFK			10774226	JET	N383DZ	A321
23	ELY008	ELY8.JFK.TLV.230619.0350.0024.TFM	FALSE	TRUE	KJFK	LLBG				JET		B789
24	JBU66	JBU66.ABQ.JFK.230618.0540.0051.TFM	TRUE	FALSE	KABQ	KJFK			10948369	JET	N554JB	A320
25	HAL51	HAL51.JFK.HNL.230618.1400.0194.TFM	FALSE	TRUE	KJFK	PHNL			10772401	JET	N381HA	A332
26	AMX409	AMX409.JFK.MEX.230618.2020.0061.TFM	FALSE	TRUE	KJFK	MMMX				JET		B789
27	EDV4987	EDV4987.YUL.JFK.230618.1005.0020.TFM	TRUE	FALSE	CYUL	KJFK			10727716	JET	N337PQ	CRJ9
28	JBU233	JBU233.BTV.JFK.230618.1005.0051.TFM	TRUE	FALSE	KBTV	KJFK			10616707	JET	N228JB	E190
29	AAL2819	AAL2819.JFK.ORD.230618.0028.0485.AIRLINE_FLIGHTHUB	FALSE	TRUE	KJFK	KORD			11233391	JET	N834NN	B738
30	SIA26	SIA26.FRA.JFK.230619.0635.0021.TFM	TRUE	FALSE	EDDF	KJFK			7786220	JET		B77W
31	DAL2823	DAL2823.PHX.JFK.230619.0625.0024.TFM	TRUE	FALSE	KPHX	KJFK				JET		B739

Scheduling Algorithm

Scheduler Input

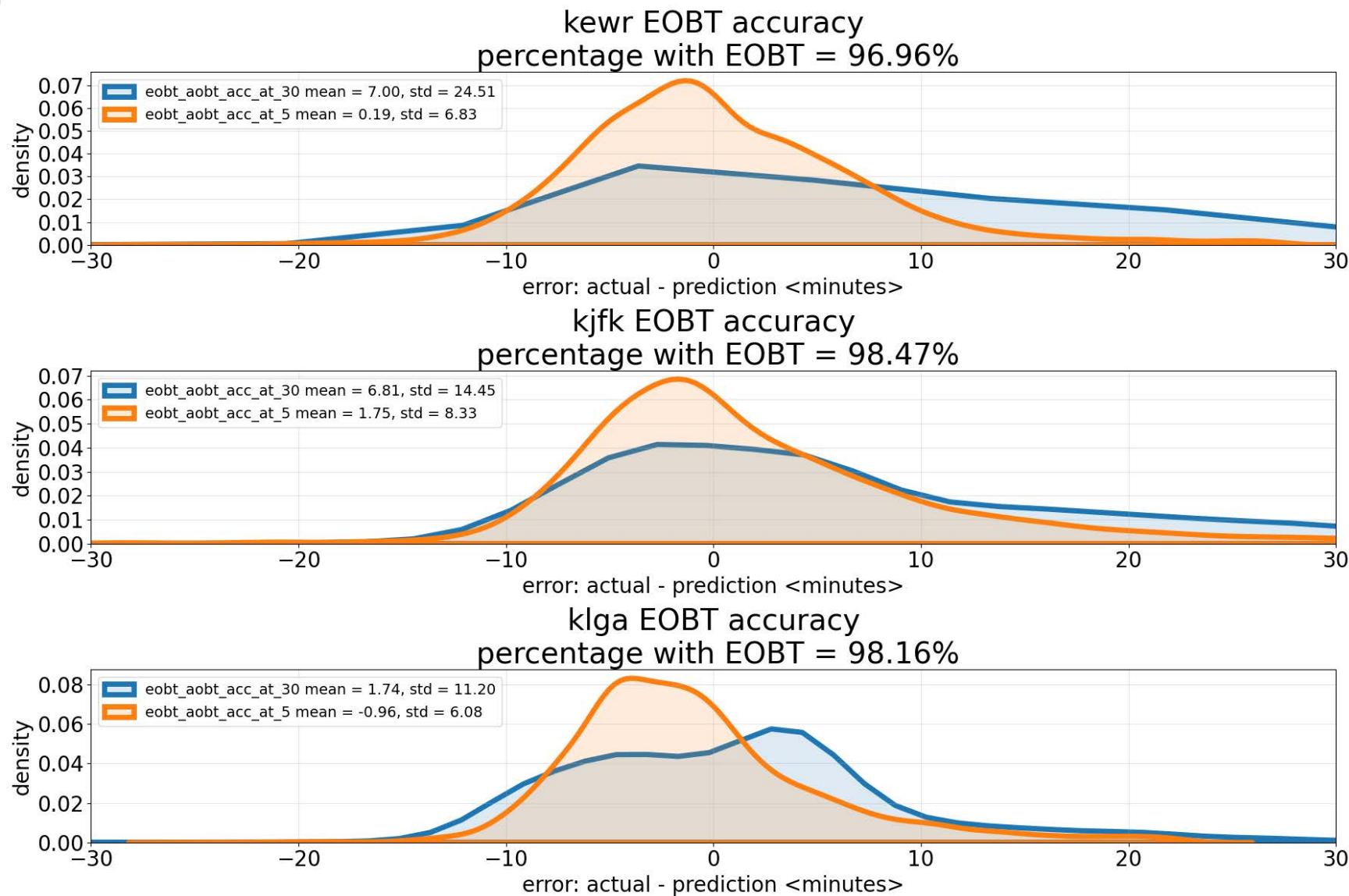
Predicted Runways
Earliest Off Block Time (EOBT)
Predicted Unimpeded Take Off Time (UTOT)
Predicted Landing Time
Terminal Constraints
Scheduling Groups

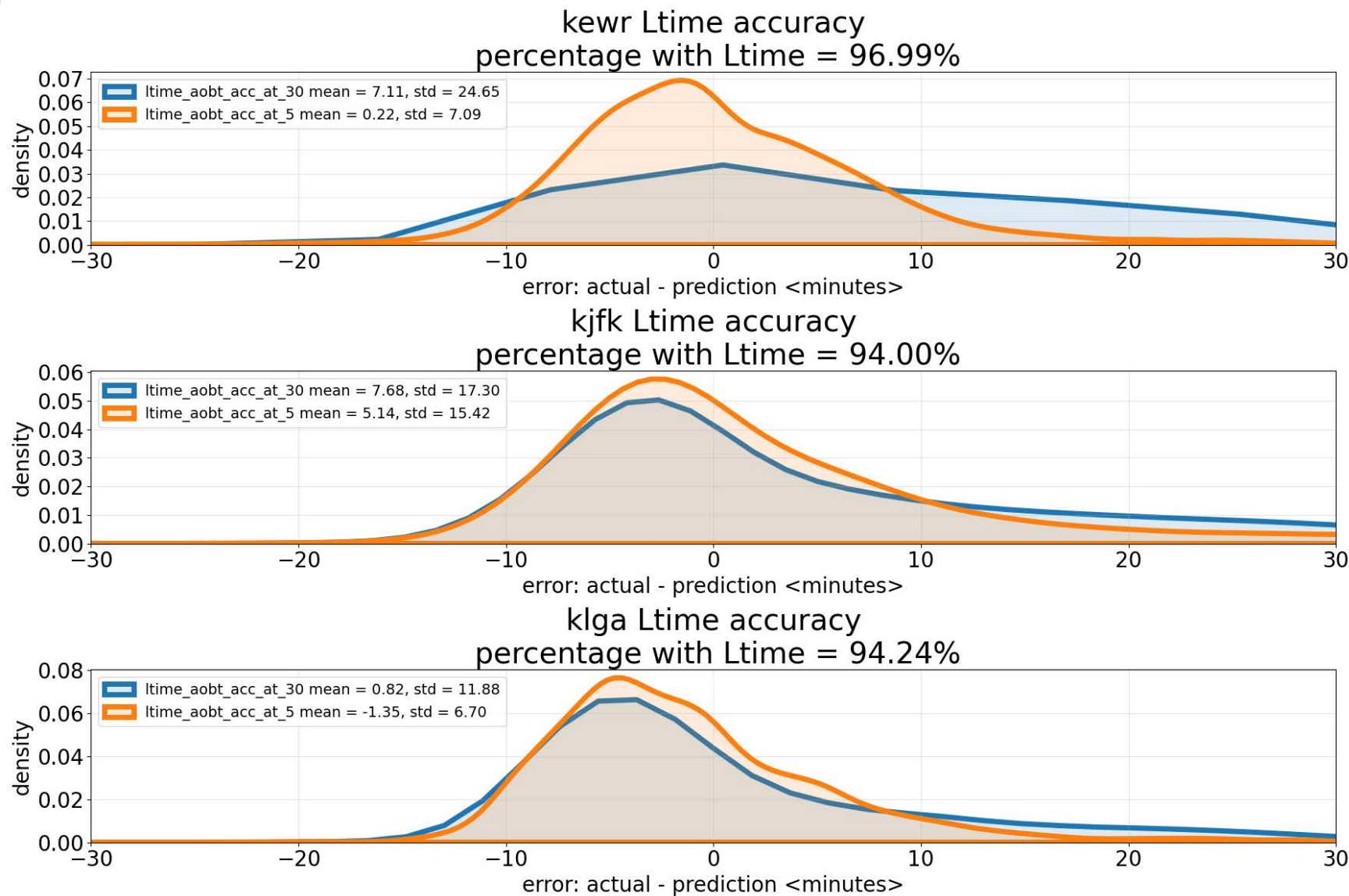


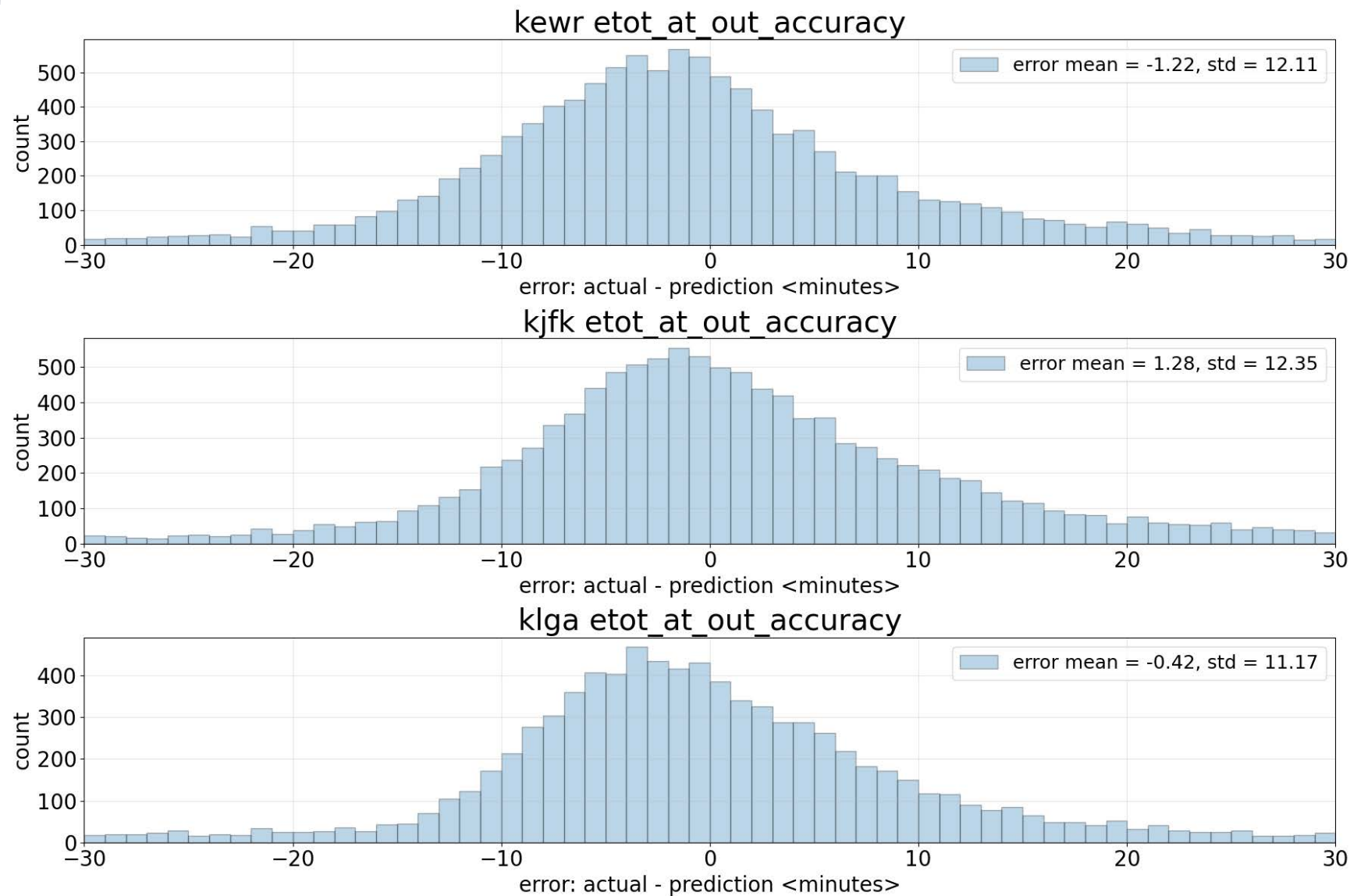
Scheduler Output

Estimated Take Off Time (ETOT)
Target Landing Time

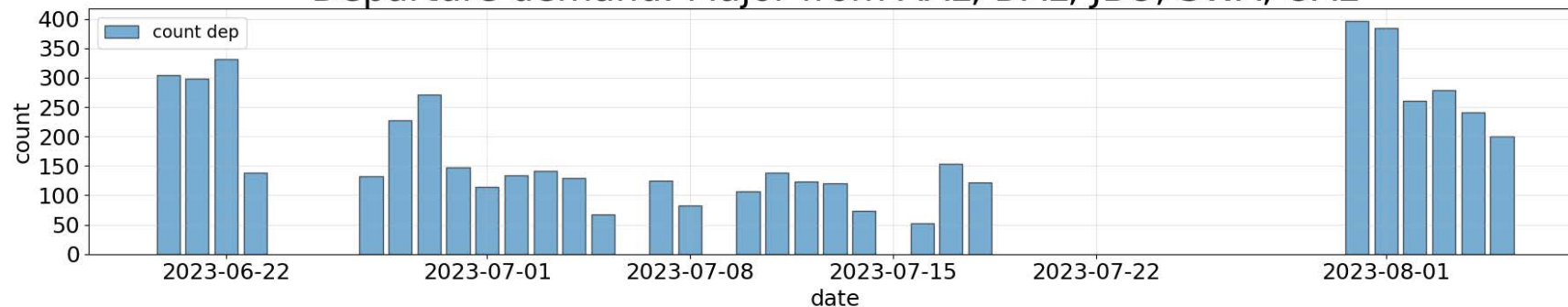
Scheduler output provides prediction of OFF time and delay for departures accounting for: combined demand + surface constraints + terminal constraints



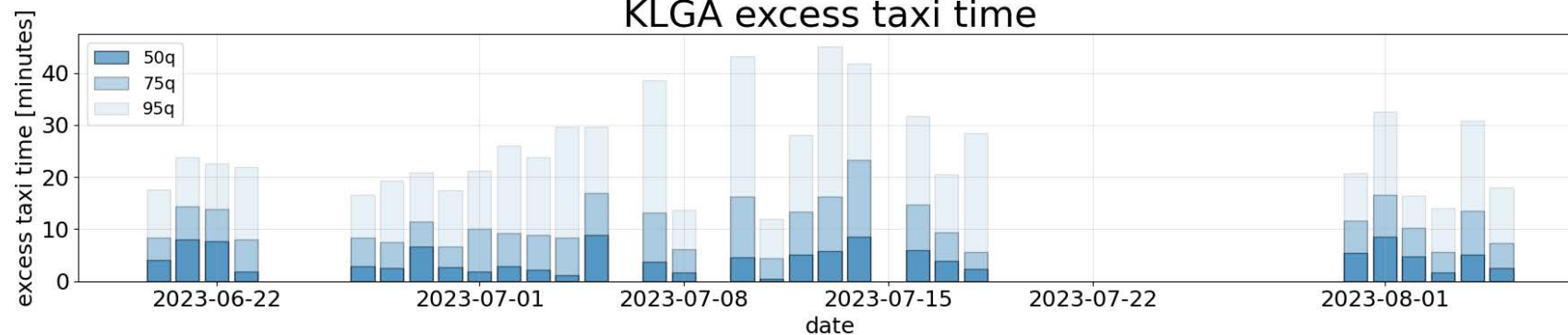




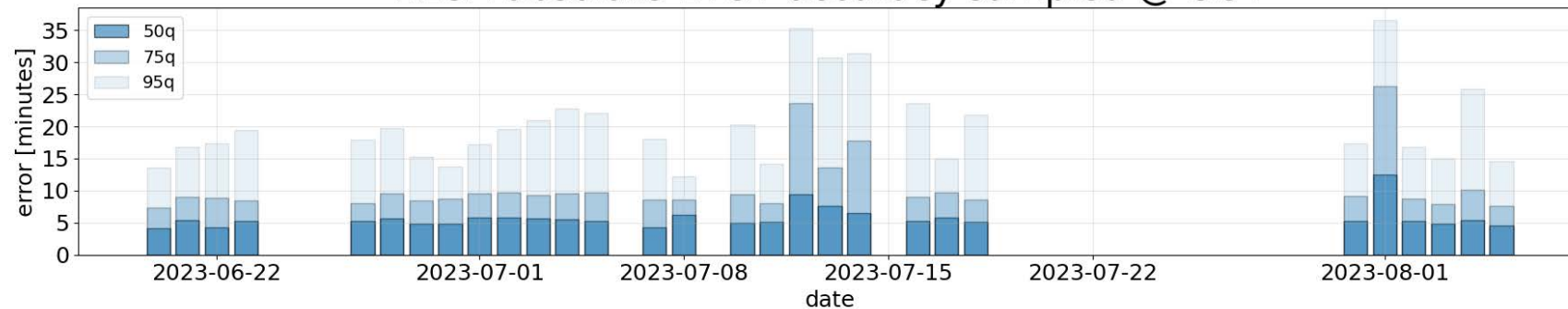
Departure demand: Major from AAL, DAL, JBU, SWA, UAL



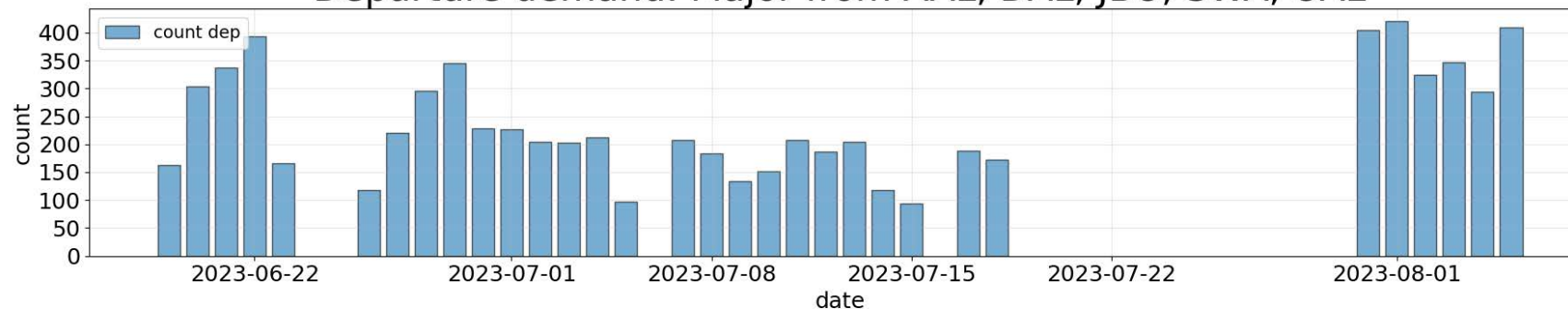
KLGA excess taxi time



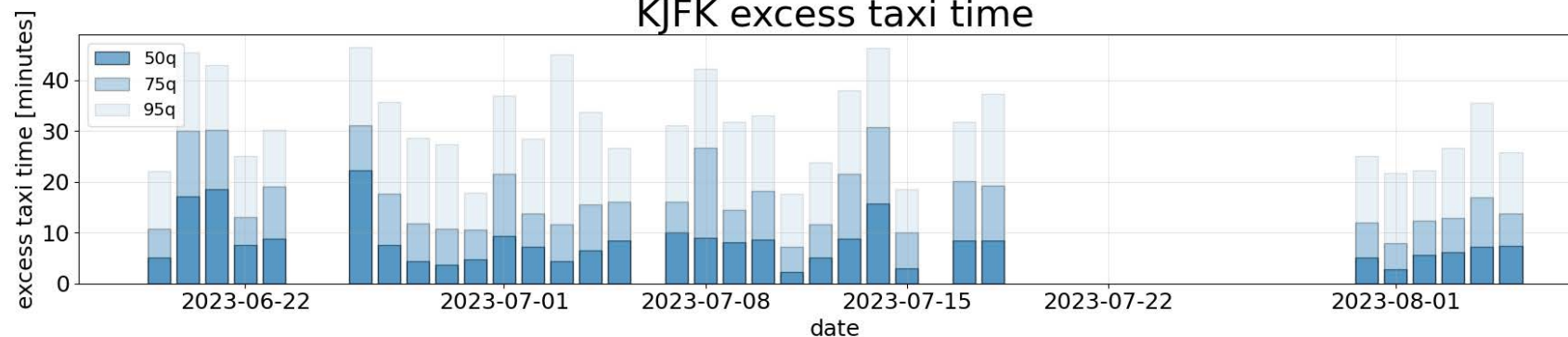
KLGA absolute ETOT accuracy sampled @ OUT



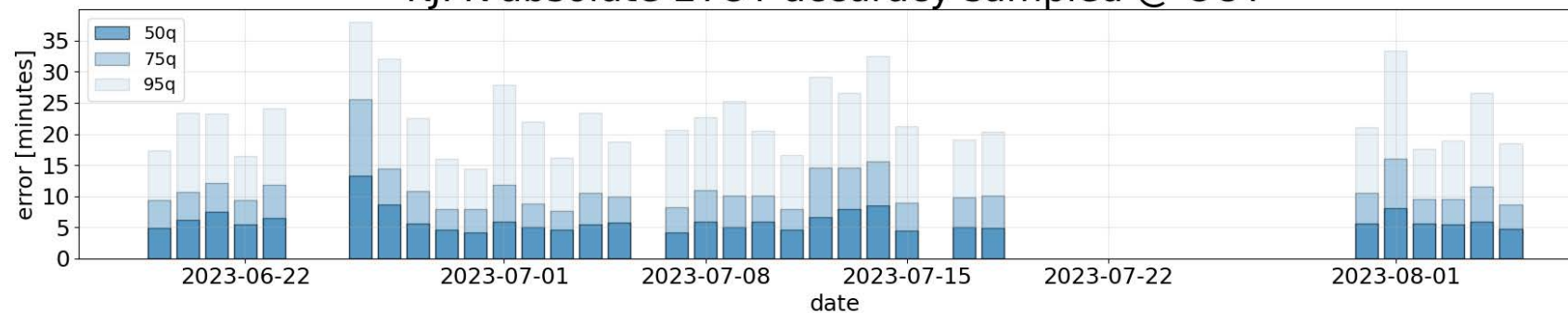
Departure demand: Major from AAL, DAL, JBU, SWA, UAL



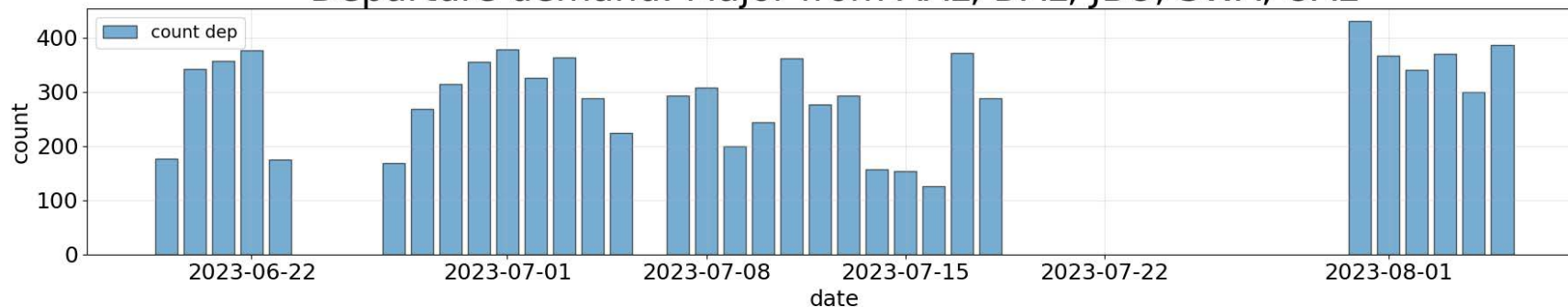
KJFK excess taxi time



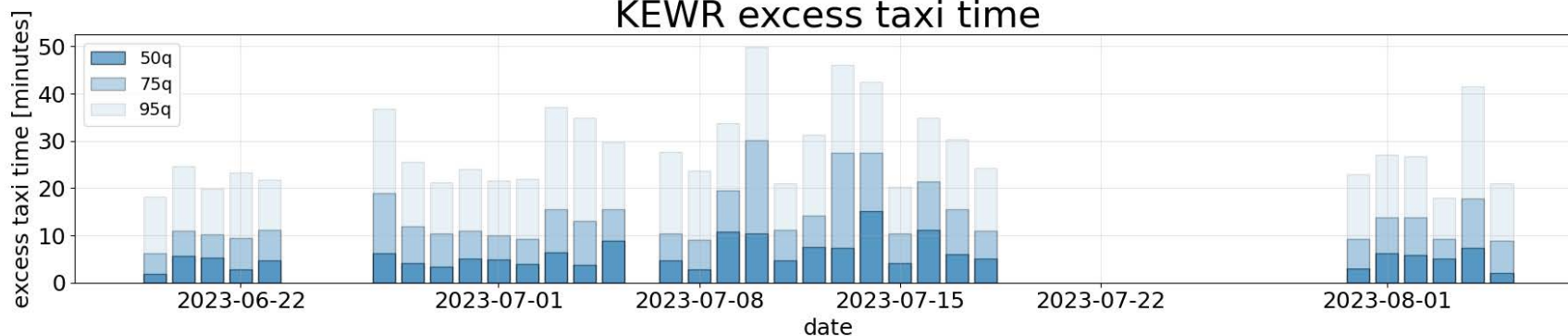
KJFK absolute ETOT accuracy sampled @ OUT



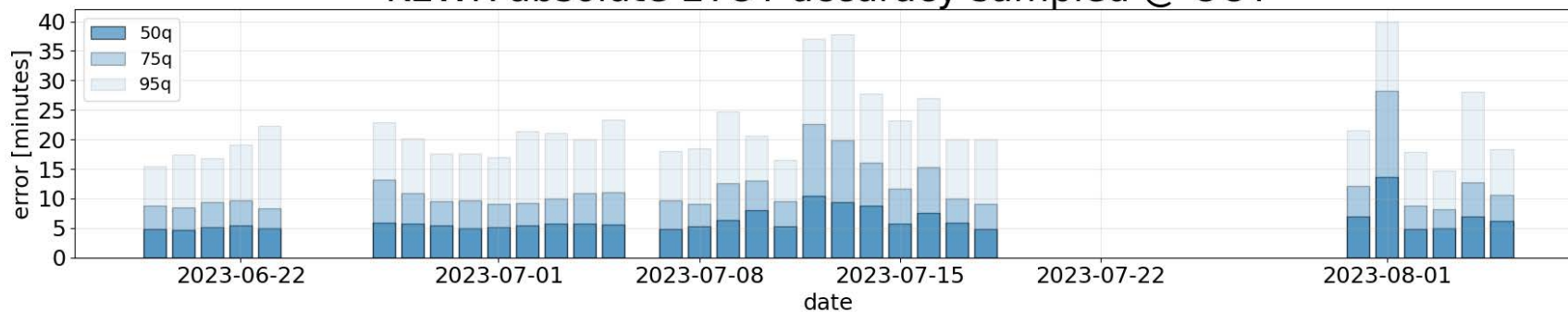
Departure demand: Major from AAL, DAL, JBU, SWA, UAL



KEWR excess taxi time

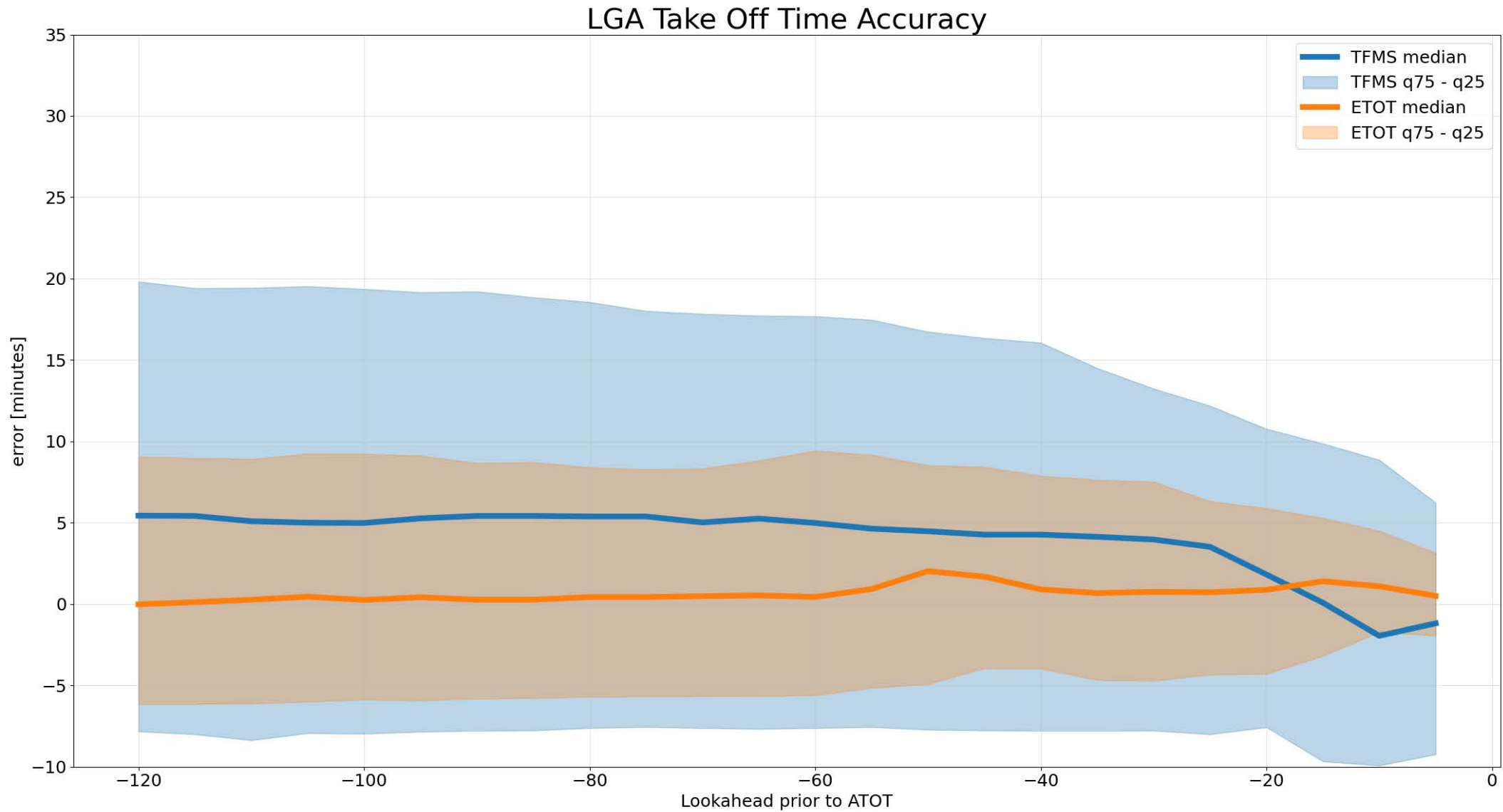


KEWR absolute ETOT accuracy sampled @ OUT



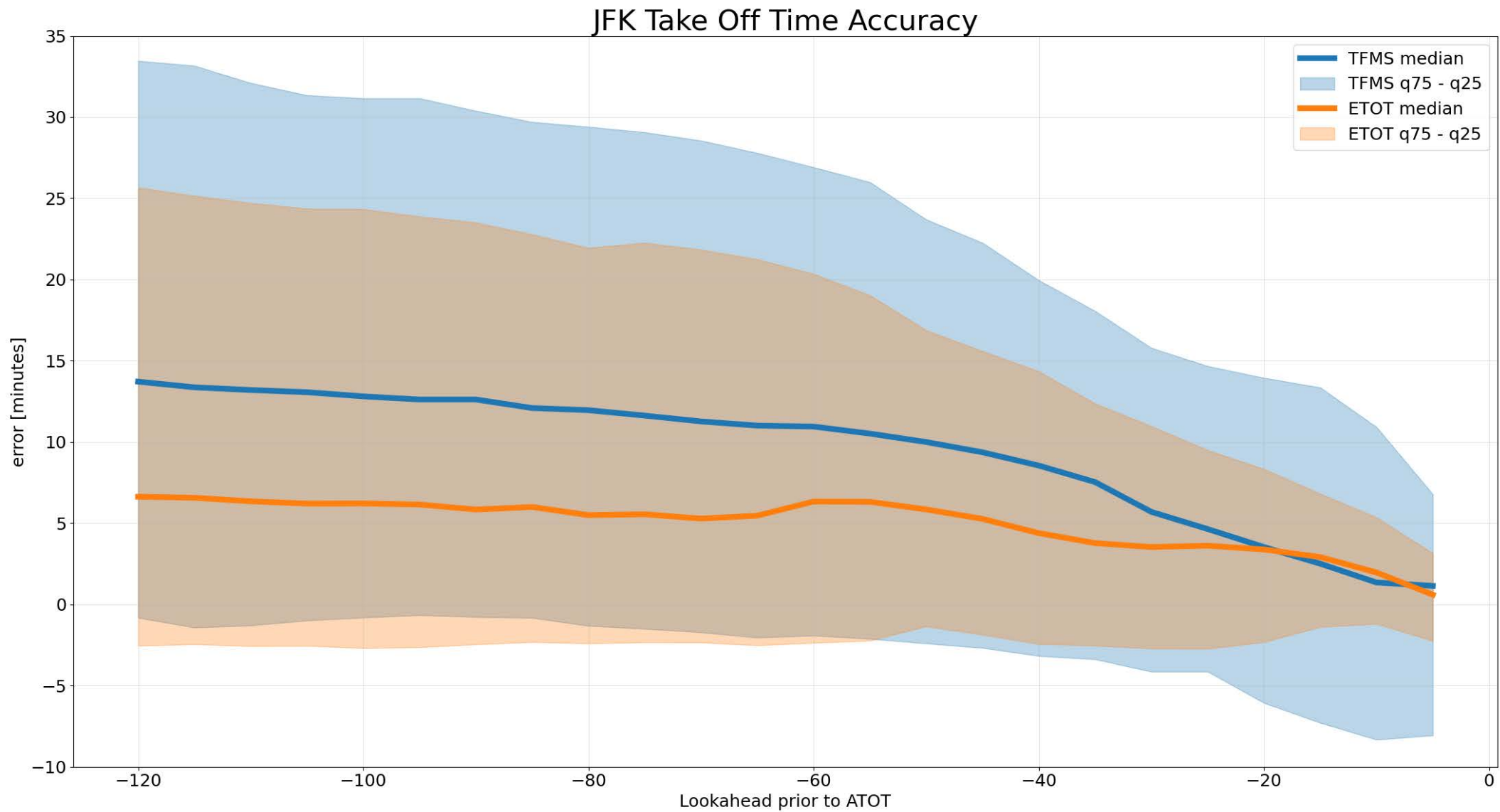


KLGA Accuracy vs Lookahead



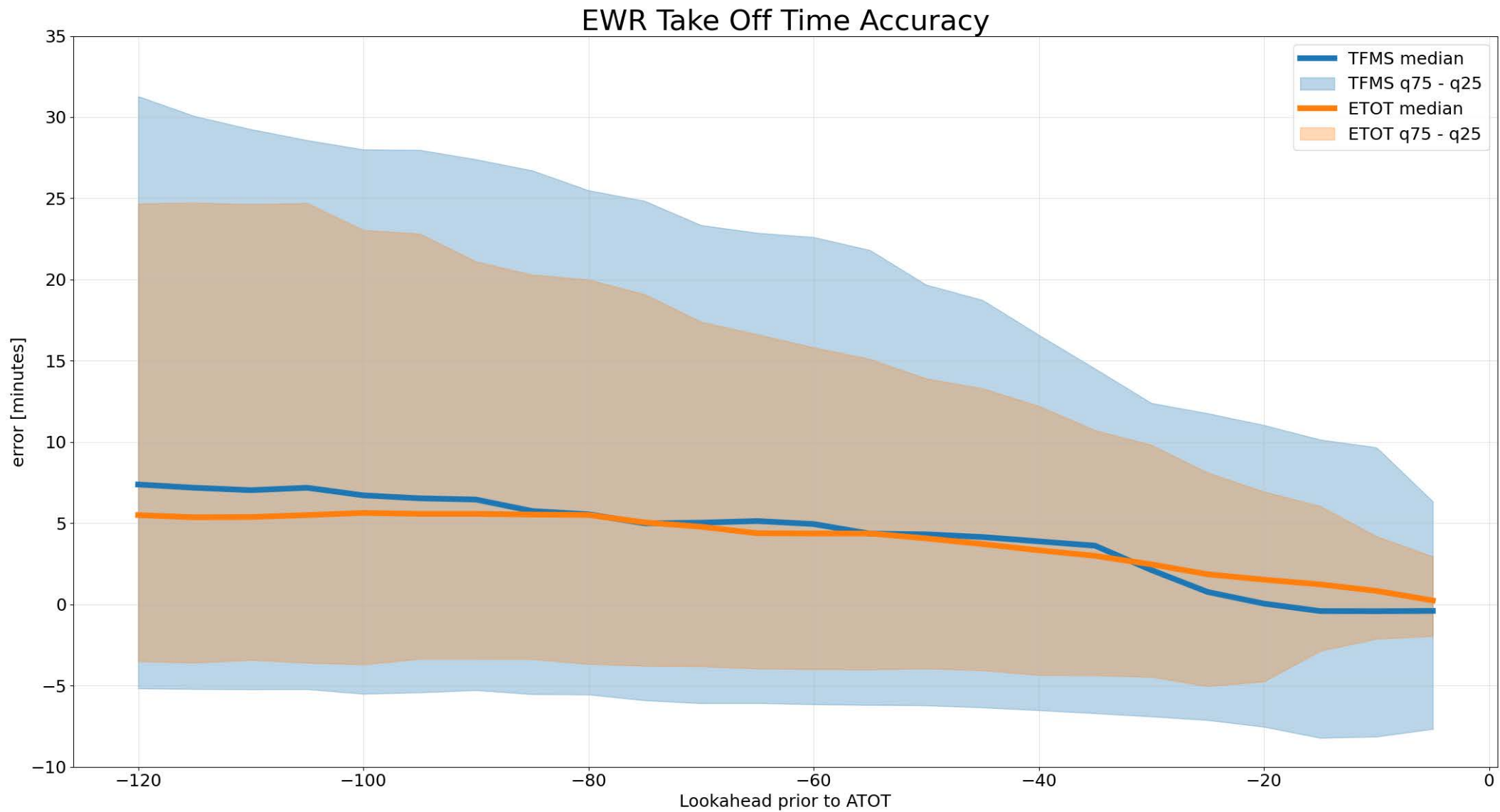


KJFK Accuracy vs Lookahead





KEWR Accuracy vs Lookahead

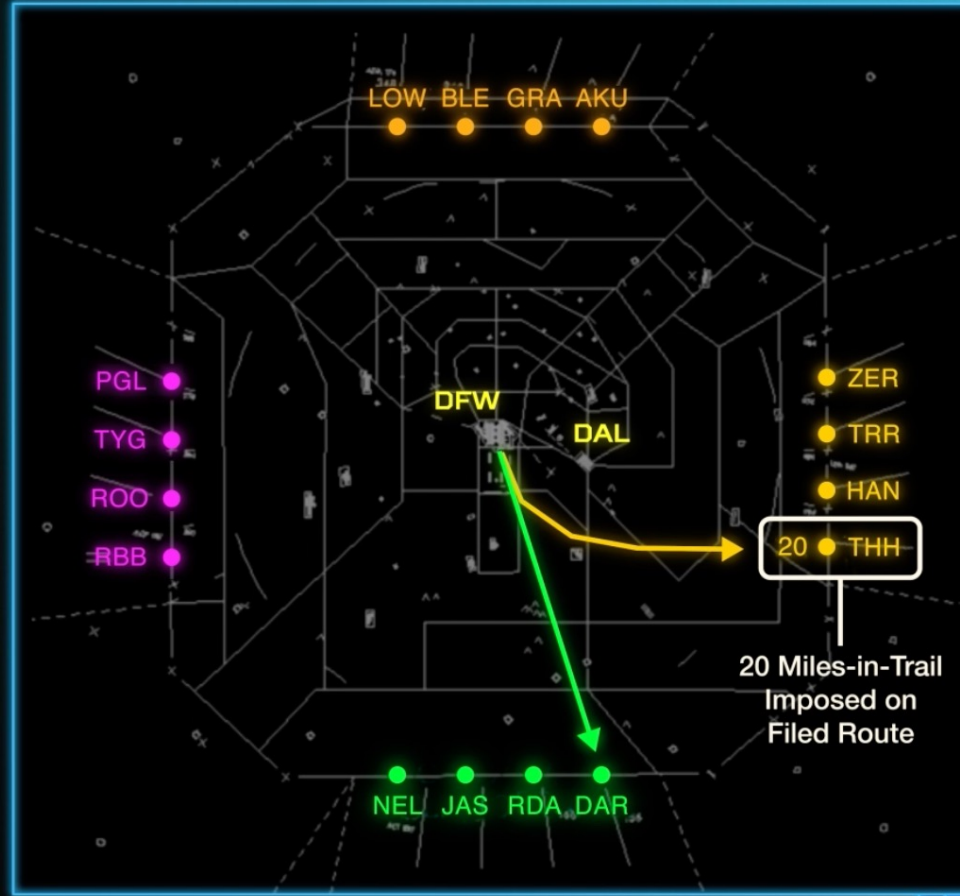




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DFW TRACON





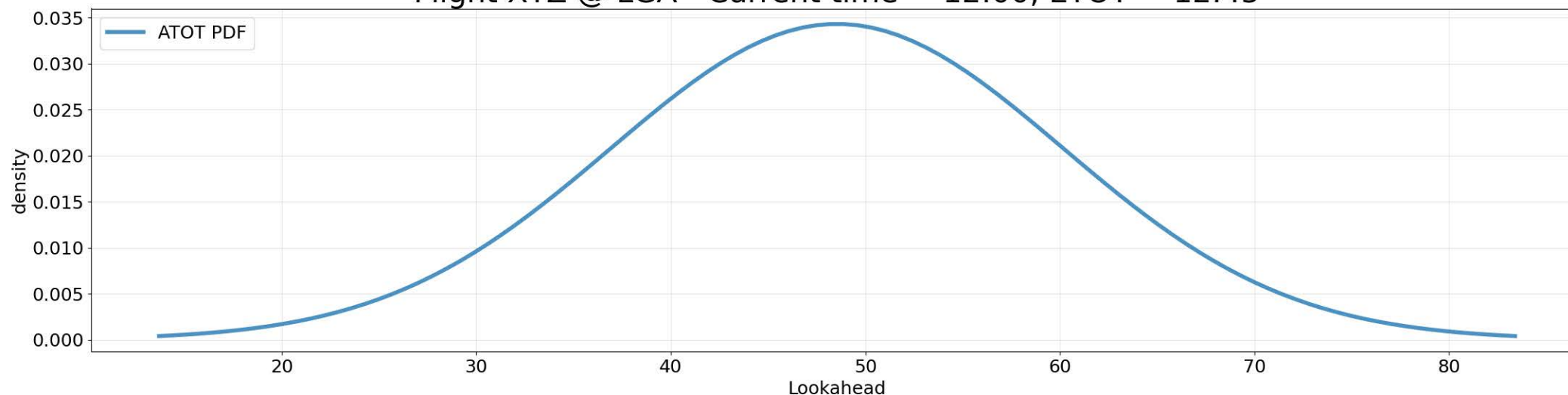
- Individual benefit to rerouted flight getting OFF the surface
 - o $\text{Predicted OFF Savings} = (\text{Predicted taxi time TOS route}) - (\text{Predicted taxi time Filed route})$
 - o Example of Predicted OFF Savings: $(\text{Predicted TOS taxi } 10) - (\text{Predicted Filed taxi } 25) = -15$
- Individual benefit to rerouted flight getting IN to the destination
 - o $\text{Predicted IN Savings} = (\text{Predicted OFF delay savings}) + (\text{TOS route additional flight time})$
 - o Example of Predicted IN Savings: $(\text{Predicted OFF savings } -15) + (\text{Additional flight time } 3) = -12$
- N90 system-wide benefit to all flights getting OFF the surface
 - o $\text{Predicted System-wide Savings} = \text{Total OFF delay savings for all N90 flights}$
 - o System-wide savings prediction generated from what-if scheduler and is inclusive of rerouted flight
- Candidate flight definition for shadow evaluation
 - o Each flights OFF delay savings is sampled at the OUT event
 - o Candidate flights satisfy the equation: $\text{OFF delay savings} + \text{Relative Trajectory Cost} \leq 0$



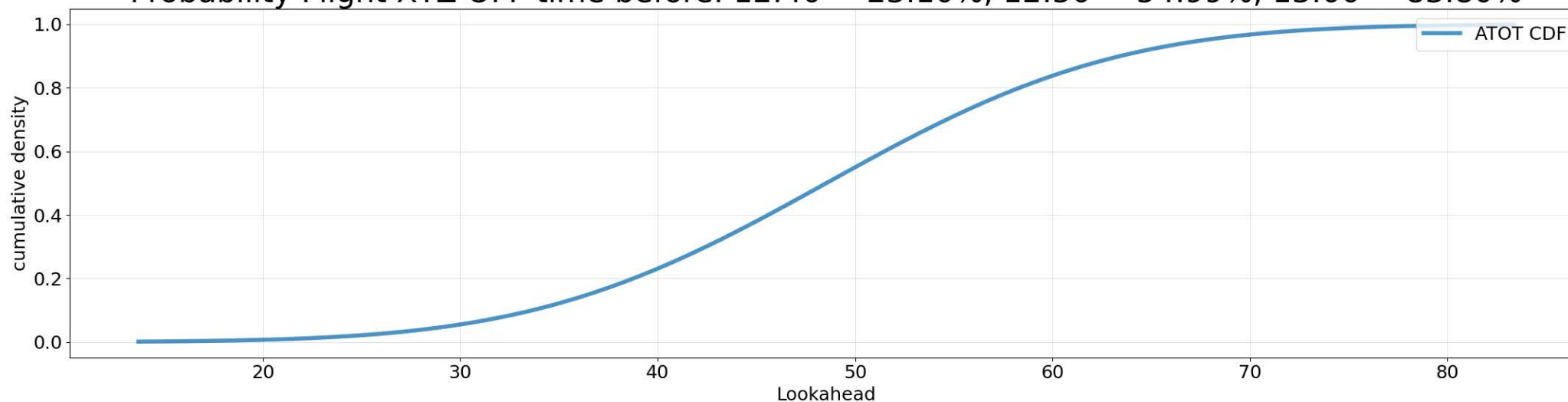
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Mandatory OFF Time

Flight XYZ @ LGA - Current time = 12:00, ETOT = 12:45



Probability Flight XYZ OFF time before: 12:40 = 23.10%, 12:50 = 54.99%, 13:00 = 83.80%





Outline

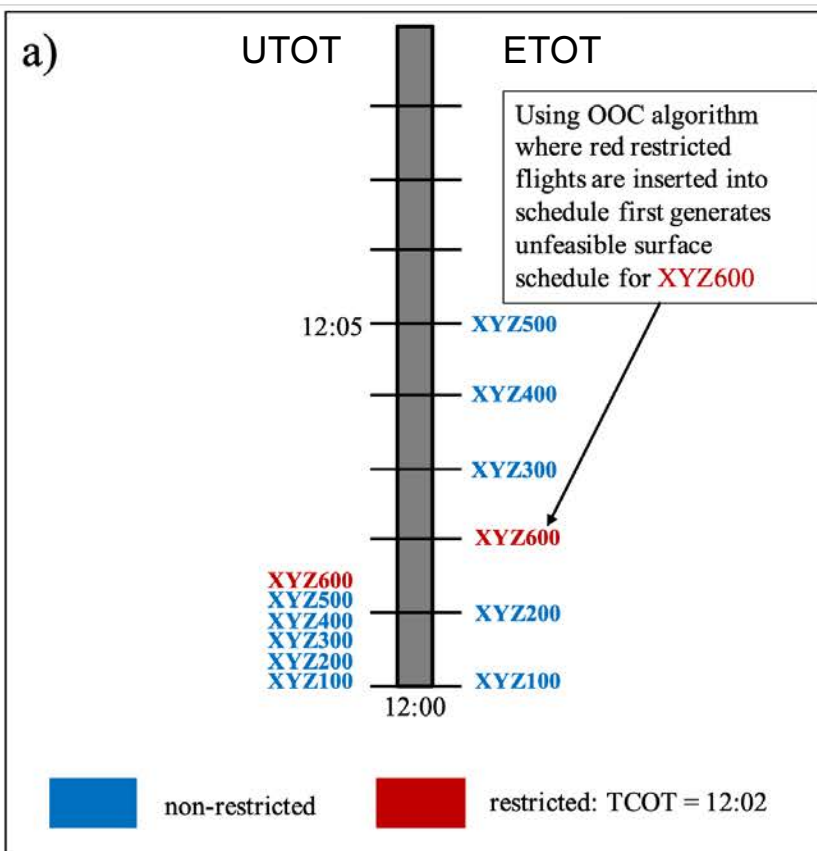


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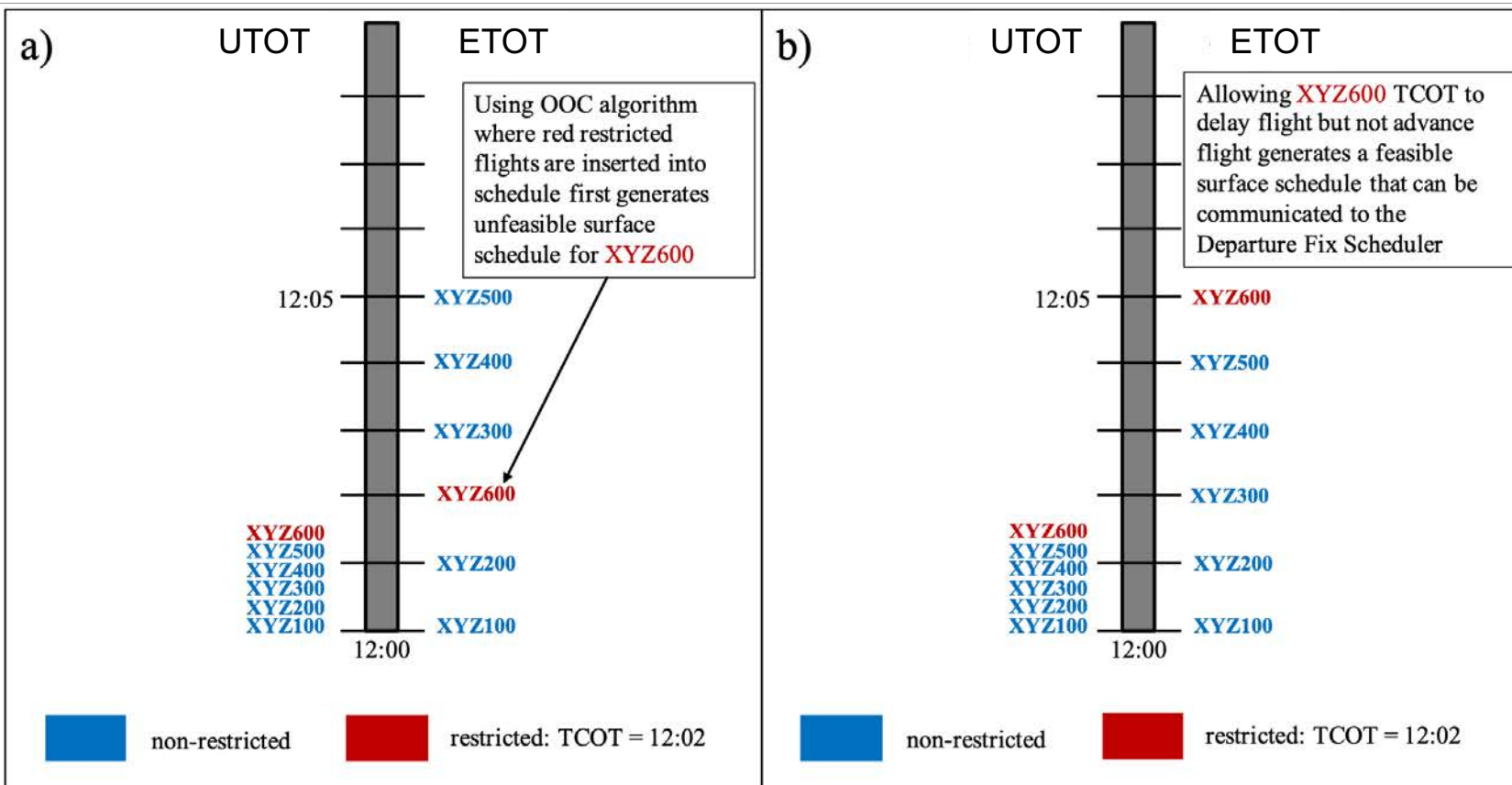
Backup Slides

UTOT = Unimpeded Take Off Time, ETOT = Estimated Take Off Time, TCOT = Terminal Controlled Off Time



a) Hierarchical Order of Consideration

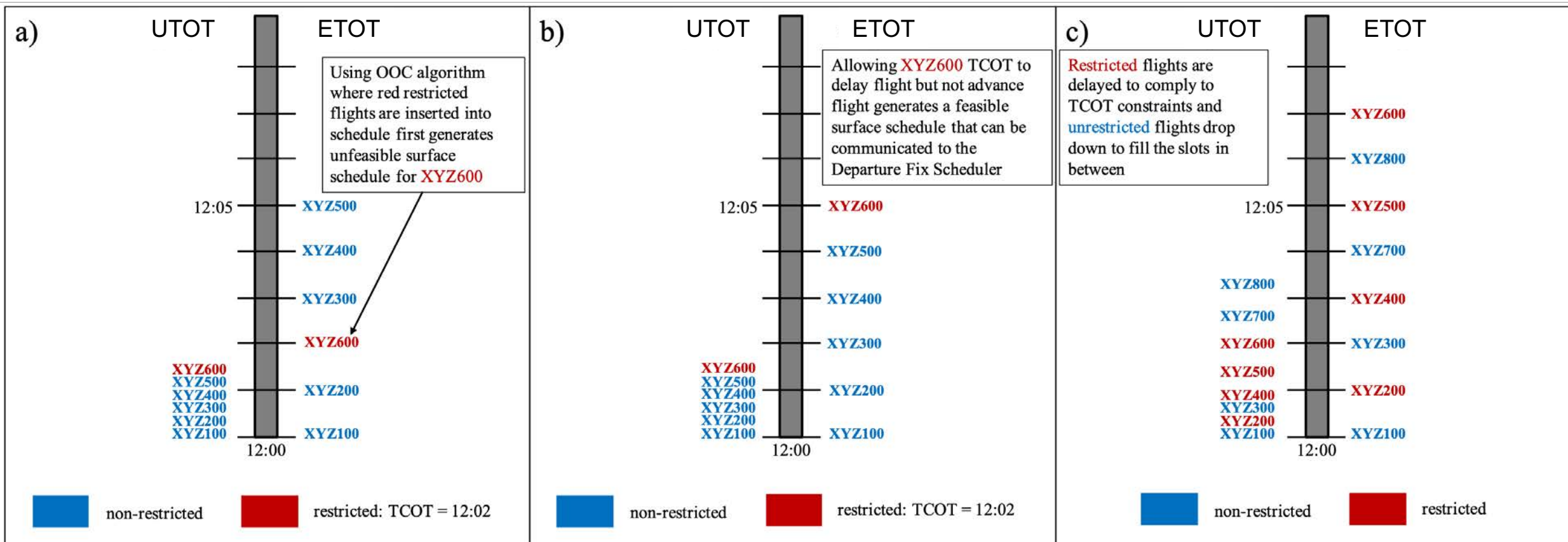
UTOT = Unimpeded Take Off Time, ETOT = Estimated Take Off Time, TCOT = Terminal Controlled Off Time



a) Hierarchical Order of Consideration

b) NASA heuristic allowing TMI constraint to delay flight but not advance flight in UTOT sequence

UTOT = Unimpeded Take Off Time, ETOT = Estimated Take Off Time, TCOT = Terminal Controlled Off Time



a) Hierarchical Order of Consideration

b) NASA heuristic allowing TMI constraint to delay flight but not advance flight in UTOT sequence

c) NASA heuristic allowing TMI constraint to delay flight but not advance flight in UTOT sequence