Integrated Demand Management: CTOP User Interface Enhancements

October 2020

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NASA Airspace Operations and Safety Program
Air Traffic Management - eXploration (ATM-X) Project, Integrated Demand Management Subproject

Contents

Section I. Bar chart and Flight list

The following section highlights changes that were made to the bar chart and flight list in NASA CTOP to enhance information visualization and make the displays more interactive.

a) Bar Chart and Flight List Interactions

When the inactive (yellow) or active (red) portion of bar chart is selected (highlighted blue), only the selected portion of flights become visible in the flight list. If CTRL is held down, the whole bin or multiple bins can be selected [Fig. 1].

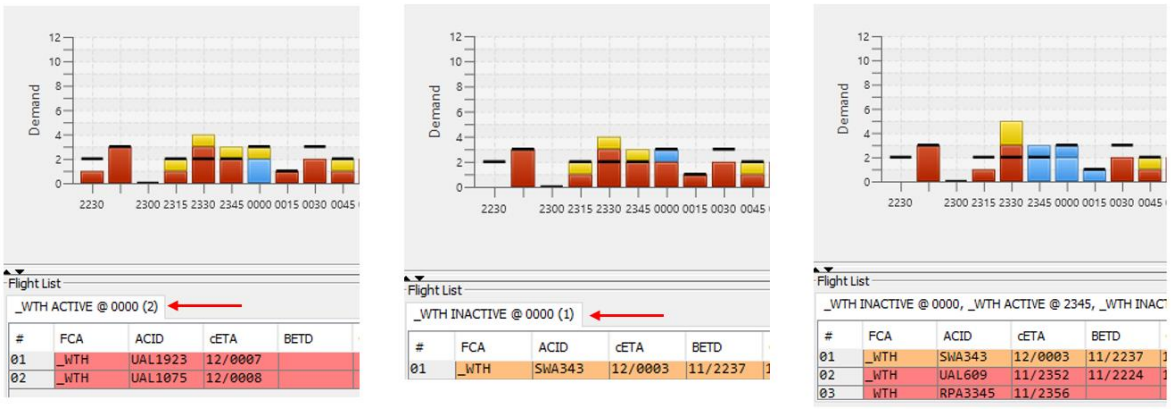


Figure 1.

When any flight in the flight list is selected, its location in the bar chart will be highlighted. Multiple flights can also be selected in this way if CTRL is held down [Fig. 2].

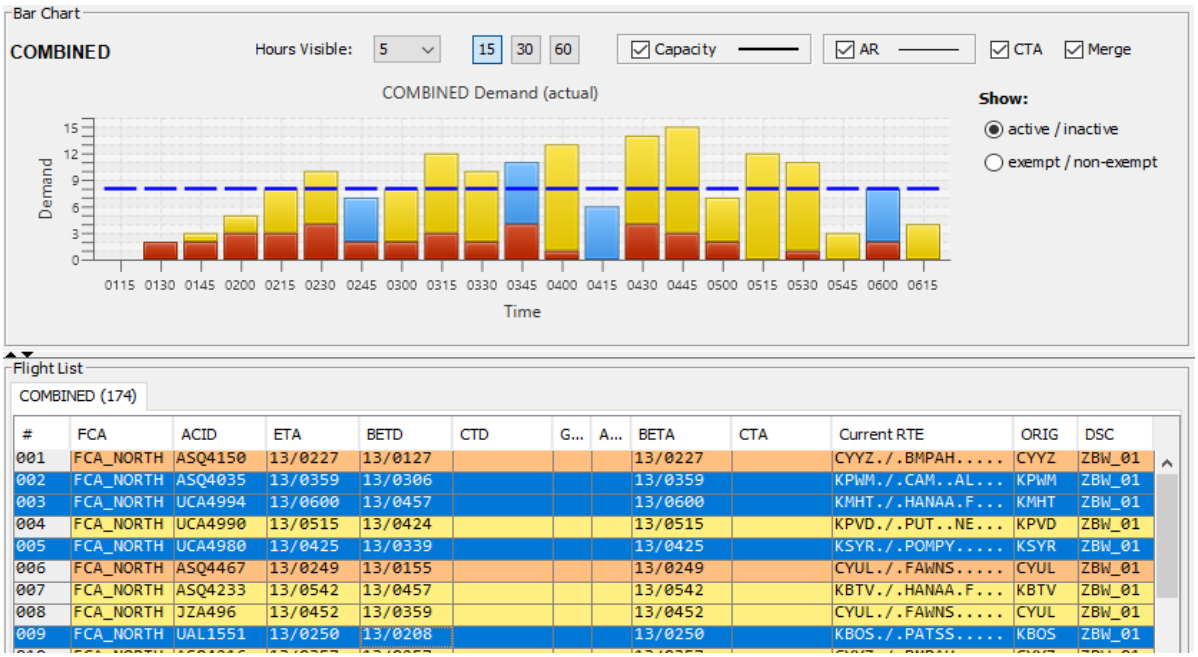


Figure 2.

b) Exempt/Non-exempt color coding

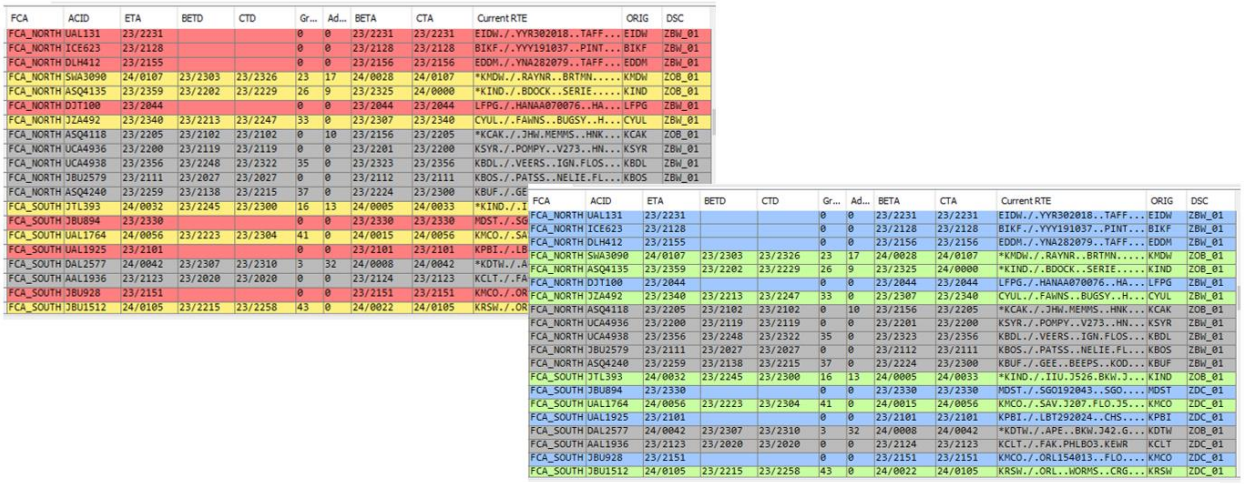
Color coding was added to quickly visualize flights that are exempt from CTOP (blue) and those that are non-exempt (green). This is the distinction the CTOP modeling algorithm uses to determine whether flights are eligible for delay and/or reroutes. Note in the example below how the 0030 bin on the active/inactive bar chart looks like it has three inactive flights above the capacity line that could be moved by a CTOP, but when viewing the exempt/non-exempt bar chart it becomes clear that two of those flights are exempt and will not be moved. This can affect capacity allocation on subsequent bins [Fig. 3].

Figure 3.

c) Flight list color coding

In the flight list, inactive aircraft are colored yellow, active aircraft are colored red, active aircraft that are exempt for any reason (user specified in settings) are colored orange. If the user wishes to identify aircraft from a list of specific airports, for example, all airports internal to the TBFM region, those flights can be colored gray (user specified in settings) [Fig. 4, left].

When viewing the flight list in exempt/non-exempt mode, exempt active aircraft are colored blue, exempt inactive aircraft are colored teal, and non-exempt aircraft are colored green [Fig. 4, right].



FCA	ACID	ETA	BETD	CTD	Gr...	Ad...	BETA	CTA	Current RTE	ORIG	DSC
FCA_NORTH	UAL131	23/2231			0	0	23/2231	23/2231	EIDW./.YYR302018..TAFF...	EIDW	ZBW_01
FCA_NORTH	ICE623	23/2128			0	0	23/2128	23/2128	BIKF./.YYY191037..PINT...	BIKF	ZBW_01
FCA_NORTH	DLH412	23/2155			0	0	23/2156	23/2156	EDDM./.YNA282079..TAFF...	EDDM	ZBW_01
FCA_NORTH	SWA3090	24/0107	23/2303	23/2326	23	17	24/0028	24/0107	*KMDW./.RAYNR..BRTMN.....	KMDW	ZOB_01
FCA_NORTH	ASQ4135	23/2359	23/2202	23/2229	26	9	23/2325	24/0000	*KIND./.BDOCK..SERIE.....	KIND	ZOB_01
FCA_NORTH	DJT100	23/2044			0	0	23/2044	23/2044	LFPG./.HANAA070076..HA...	LFPG	ZBW_01
FCA_NORTH	JZA492	23/2340	23/2213	23/2247	33	0	23/2307	23/2340	CYUL./.FAWNS..BUGSY..H...	CYUL	ZBW_01
FCA_NORTH	ASQ4118	23/2205	23/2102	23/2102	0	10	23/2156	23/2205	*KCAK./.JHW.MEMMS..HNK...	KCAK	ZOB_01
FCA_NORTH	UCA4936	23/2200	23/2119	23/2119	0	0	23/2201	23/2200	KSYR./.POMPY..V273..HN...	KSYR	ZBW_01
FCA_NORTH	UCA4938	23/2356	23/2248	23/2322	35	0	23/2323	23/2356	KBDL./.VEERS..IGN.FLOS...	KBDL	ZBW_01
FCA_NORTH	JBU2579	23/2111	23/2027	23/2027	0	0	23/2112	23/2111	KBOS./.PATSS..NELIE.FL...	KBOS	ZBW_01
FCA_NORTH	ASQ4240	23/2259	23/2138	23/2215	37	0	23/2224	23/2300	KBUF./.GE...		
FCA_SOUTH	JTL393	24/0032	23/2245	23/2300	16	13	24/0005	24/0033	*KIND./.I...		
FCA_SOUTH	JBU894	23/2330			0	0	23/2330	23/2330	MDST./.SG...		
FCA_SOUTH	UAL1764	24/0056	23/2223	23/2304	41	0	24/0015	24/0056	KMCO./.SA...		
FCA_SOUTH	UAL1925	23/2101			0	0	23/2101	23/2101	KPBI./.LB...		
FCA_SOUTH	DAL2577	24/0042	23/2307	23/2310	3	32	24/0008	24/0042	*KDTW./.A...		
FCA_SOUTH	AAL1936	23/2123	23/2020	23/2020	0	0	23/2124	23/2123	KCLT./.FA...		
FCA_SOUTH	JBU928	23/2151			0	0	23/2151	23/2151	KMCO./.OR...		
FCA_SOUTH	JBU1512	24/0105	23/2215	23/2258	43	0	24/0022	24/0105	KRSW./.OR...		

Figure 4.

d) Flight search

A single flight can be identified based on callsign. The user has the option to search for flights in the currently viewed FCA only (if viewing the Combined FCA then all the combined FCAs will be searched), or search all FCAs within the CTOP program. If a result is found, the flight will appear in the flight list and it's location will be highlighted in the bar chart [Fig. 5].

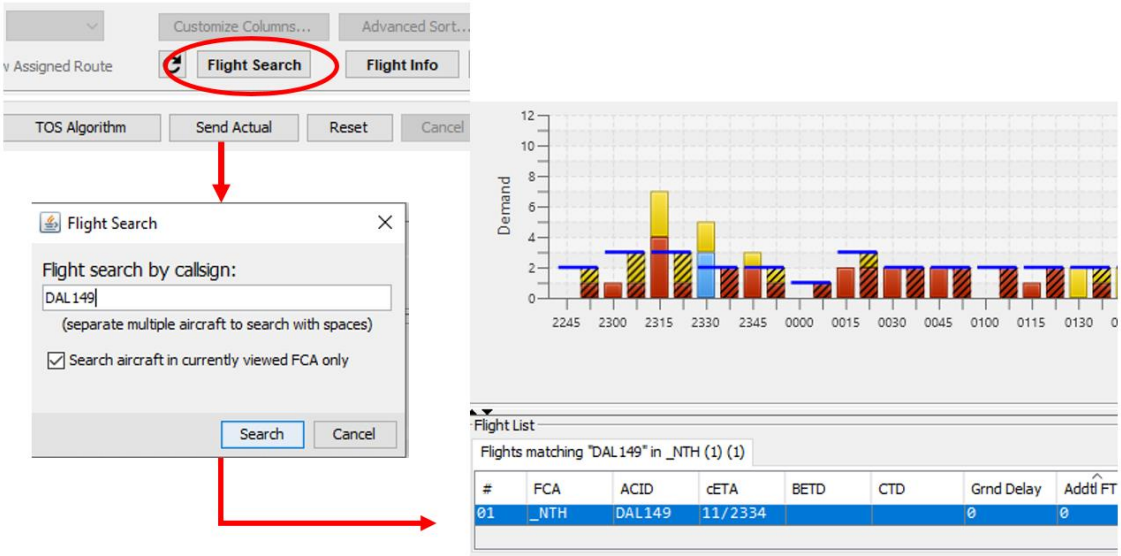


Figure 5.

Section II. CTOP Combined mode

The following section describes the CTOP Combined mode, an entirely new collection of features for CTOP that was created to support the IDM experimental design and reduce user workload.

a) Combined FCA Configuration Window

The CTOP Combined feature allows the user to designate a group of FCAs to be viewed as a single FCA in the bar chart, the demand/capacity table, and the flight list. This is helpful when running a CTOP program where multiple FCAs collectively form a meaningful whole, such as when running an airport-based CTOP as in many of the IDM conditions. In the fielded CTOP application, FCAs can only be viewed independently from one another [Fig. 6].

The user can specify which FCAs to include in the Combined group in the FCA Configuration window. In the example below, three FCAs corresponding to each of the three arrival flows into Newark airport (EWR) were selected to create a Combined CTOP for the airport.

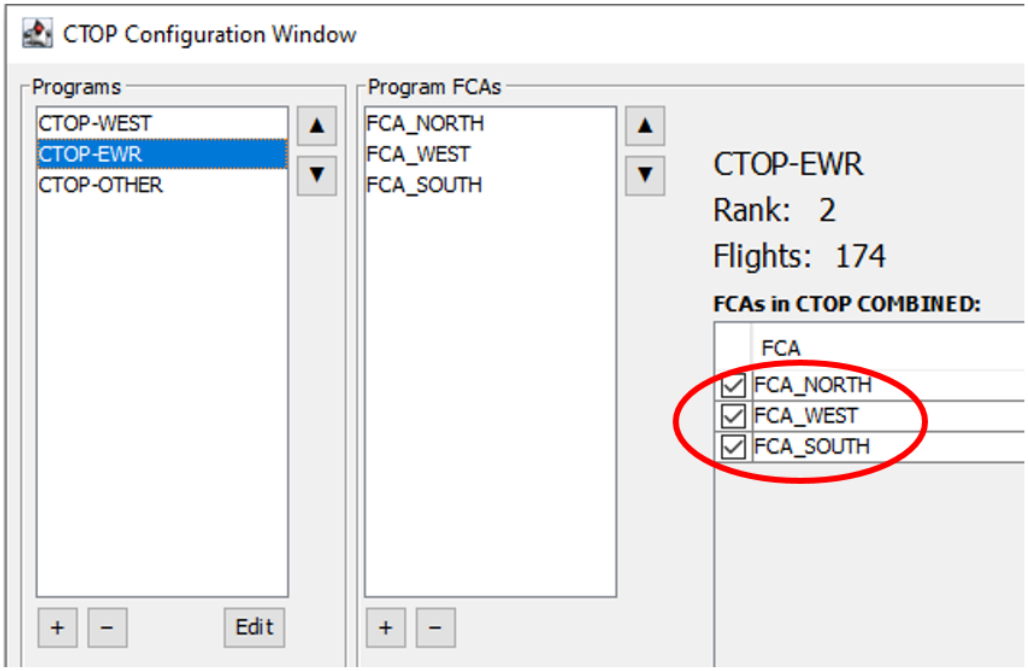
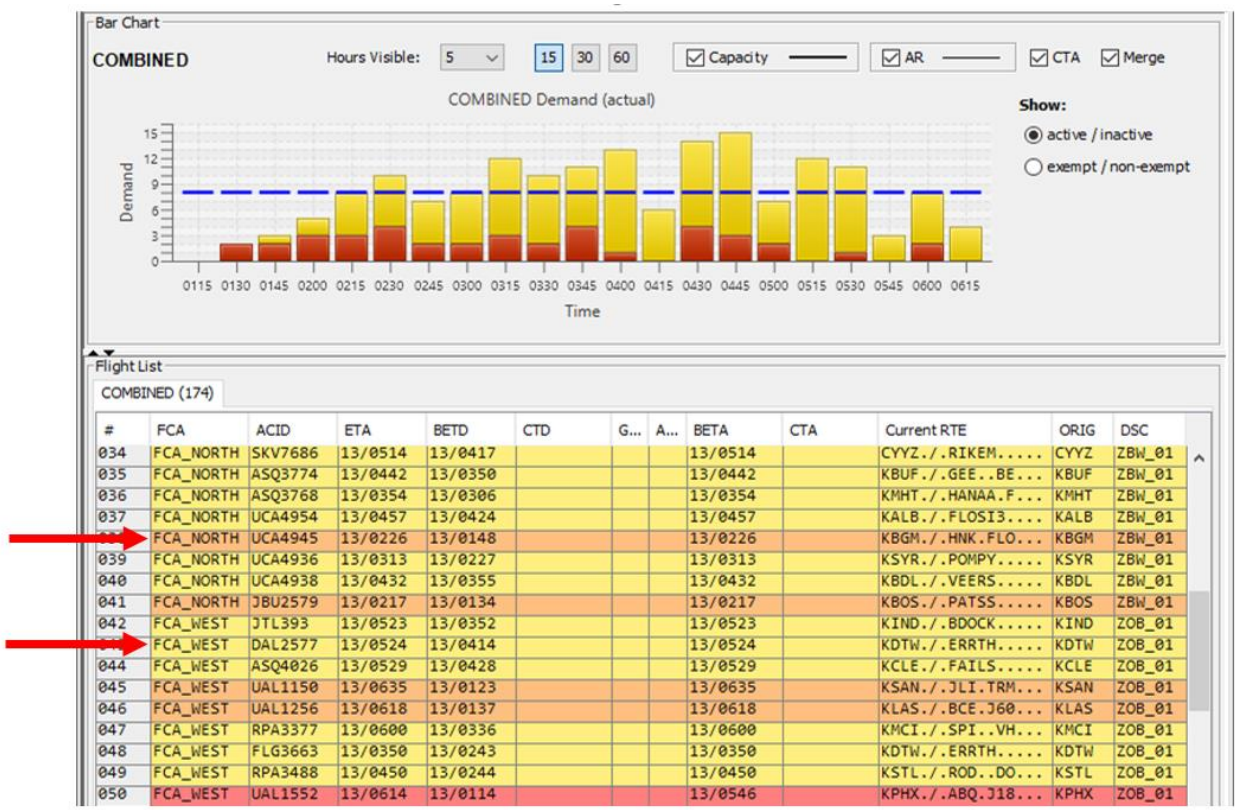


Figure 6.

b) Combined Flight List and Bar Chart

Multiple FCAs can be viewed in a single bar chart and flight list. The bar chart below shows the combined demand of the three FCAs which account for 100% of flights arriving at EWR. This provides a sense of whether or not the demand will be above or below a given airport capacity [Fig. 7].

The flight list identifies which FCA each flight is coming from.



#	FCA	ACID	ETA	BETD	CTD	G...	A...	BETA	CTA	Current RTE	ORIG	DSC
034	FCA_NORTH	SKV7686	13/0514	13/0417				13/0514		CYYZ./.RIKEM.....	CYYZ	ZBW_01
035	FCA_NORTH	ASQ3774	13/0442	13/0350				13/0442		KBUF./.GEE..BE...	KBUF	ZBW_01
036	FCA_NORTH	ASQ3768	13/0354	13/0306				13/0354		KMHT./.HANAA.F...	KMHT	ZBW_01
037	FCA_NORTH	UCA4954	13/0457	13/0424				13/0457		KALB./.FLOSI3....	KALB	ZBW_01
038	FCA_NORTH	UCA4945	13/0226	13/0148				13/0226		KBGM./.HNK.FLO...	KBGM	ZBW_01
039	FCA_NORTH	UCA4936	13/0313	13/0227				13/0313		KSYR./.POMPY.....	KSYR	ZBW_01
040	FCA_NORTH	UCA4938	13/0432	13/0355				13/0432		KBDL./.VEERS.....	KBDL	ZBW_01
041	FCA_NORTH	JBU2579	13/0217	13/0134				13/0217		KBOS./.PATSS.....	KBOS	ZBW_01
042	FCA_WEST	JTL393	13/0523	13/0352				13/0523		KIND./.BDOCK.....	KIND	ZOB_01
043	FCA_WEST	DAL2577	13/0524	13/0414				13/0524		KDTW./.ERRTH.....	KDTW	ZOB_01
044	FCA_WEST	ASQ4026	13/0529	13/0428				13/0529		KCLE./.FAILS.....	KCLE	ZOB_01
045	FCA_WEST	UAL1150	13/0635	13/0123				13/0635		KSAN./.JLI.TRM...	KSAN	ZOB_01
046	FCA_WEST	UAL1256	13/0618	13/0137				13/0618		KLAS./.BCE.J60...	KLAS	ZOB_01
047	FCA_WEST	RPA3377	13/0600	13/0336				13/0600		KMCI./.SPI..VH...	KMCI	ZOB_01
048	FCA_WEST	FLG3663	13/0350	13/0243				13/0350		KDTW./.ERRTH.....	KDTW	ZOB_01
049	FCA_WEST	RPA3488	13/0450	13/0244				13/0450		KSTL./.ROD..DO...	KSTL	ZOB_01
050	FCA_WEST	UAL1552	13/0614	13/0114				13/0546		KPHX./.ABQ.J18...	KPHX	ZOB_01

Figure 7.

c) CTOP-ALL tab

A separate tab was created to display the tabular demand/capacity data and bar charts for multiple FCAs while in a Combined CTOP. In the fielded CTOP application multiple FCAs can only be viewed one at a time [Fig. 8].

The user can make manual adjustments to values in the demand/capacity table if they wish.

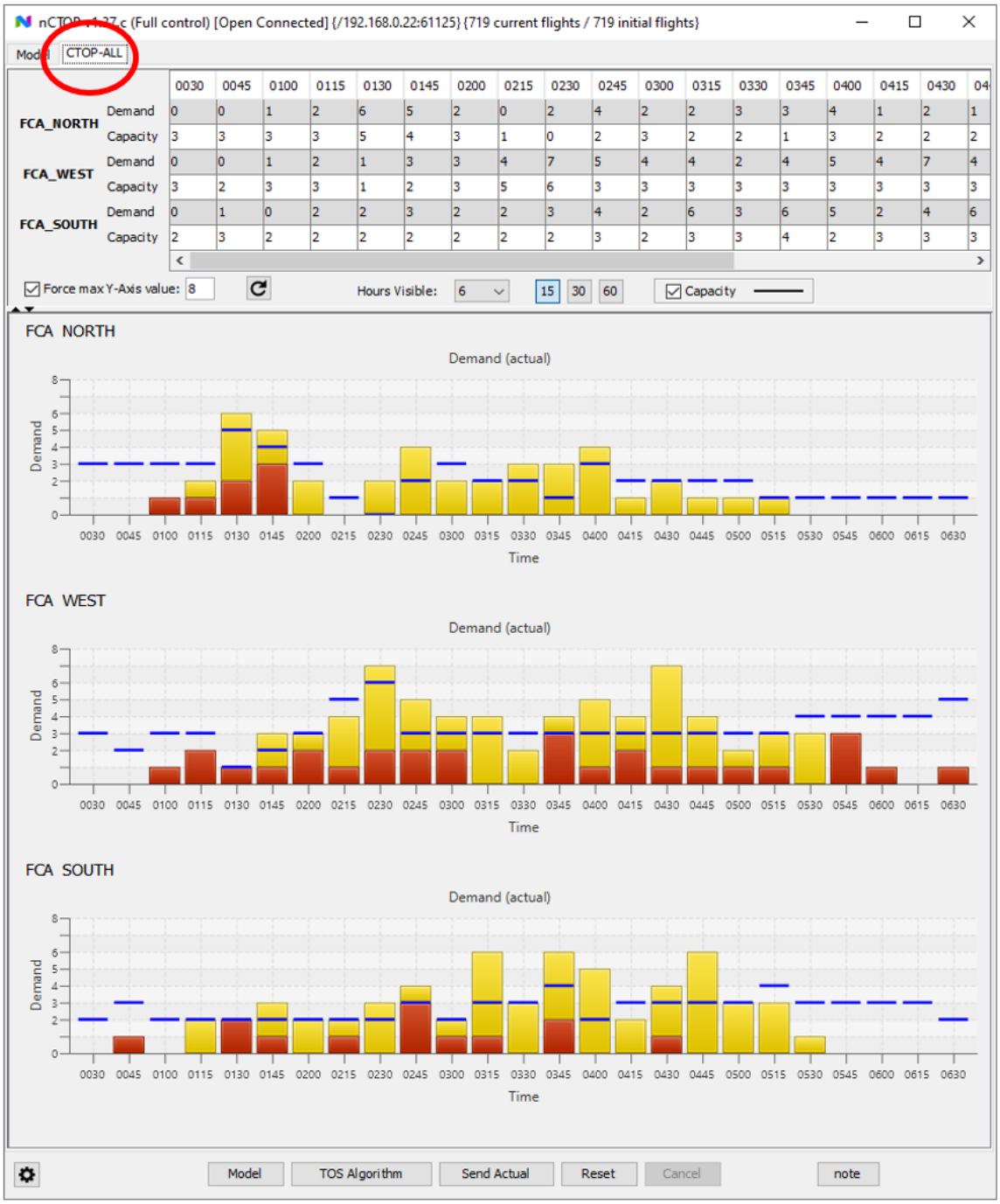


Figure 8.

When any column in the table is selected, the entire column is highlighted along with the corresponding bars in the bar charts for all the FCAs [Fig. 9].

Likewise, when individual bars are selected in the bar chart the corresponding column in the table is highlighted. When CTRL is held, multiple bars can be selected at the same time.

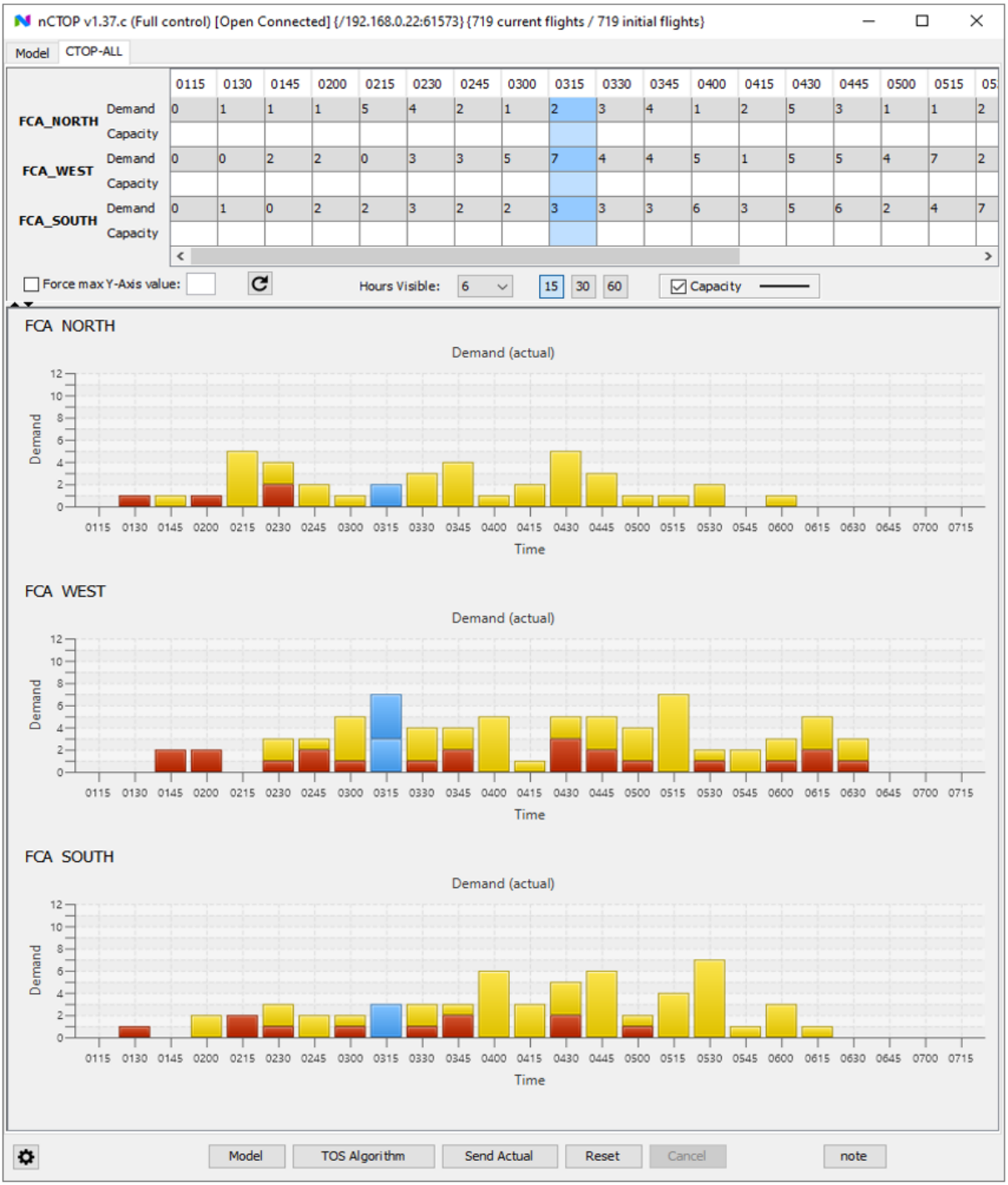


Figure 9.

d) Unmerged flow color coding

By default, the CTOP-Combined view shows all its constituent sub-flows merged together under a single set of active and inactive bars. To display the proportion of demand coming from each flow, both active and inactive, the Merge Flows checkbox was added. When unchecked, each of the FCA flows are colored independently. For example, the north flow is colored vibrant pink for north actives, and greyish pink for north inactives, and the south flow is colored vibrant orange for south actives, and greyish orange for south inactives.

The colors for each FCA can be independently specified. In NASA CTOP enhancements, this is done with a separate cascading stylesheet file, but it is recommended a simpler in-app method be implemented if this feature is to be used in the field [Fig. 10].

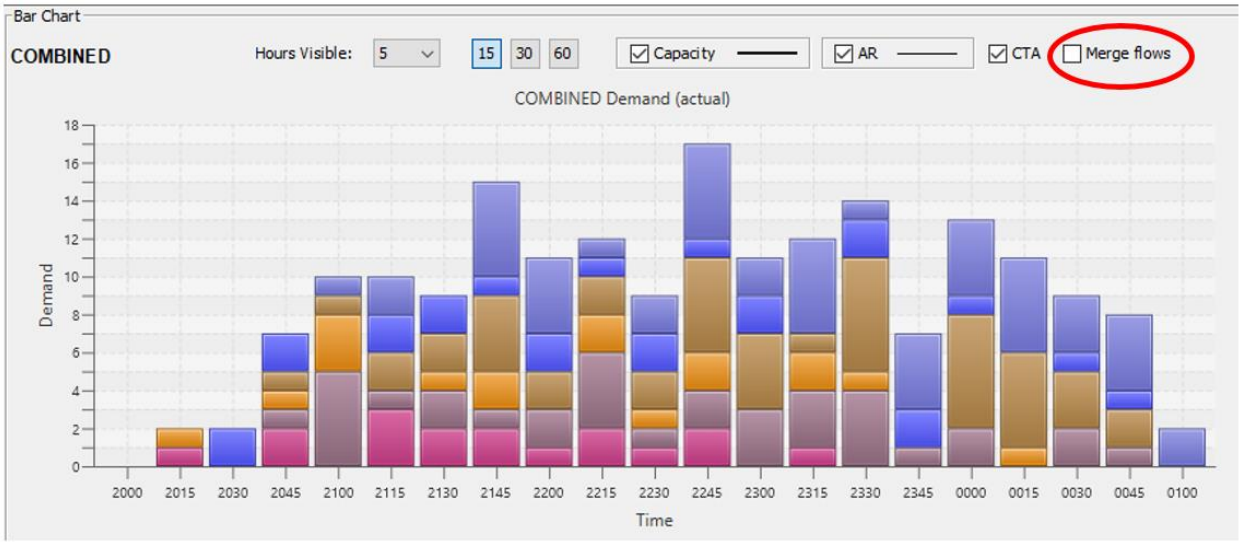


Figure 10.

e) FCA Balancing Algorithm (FBA)

In the fielded CTOP, capacity setting must be done manually, either in 60 min bins or 15 min bins, a single bin at a time. When working in Combined mode with NASA CTOP, the workload would have been too high to manage capacity settings (especially individual 15 min bins) on multiple FCAs. Therefore the FCA Balancing Algorithm (FBA) was created to automate capacity setting [Fig. 11].

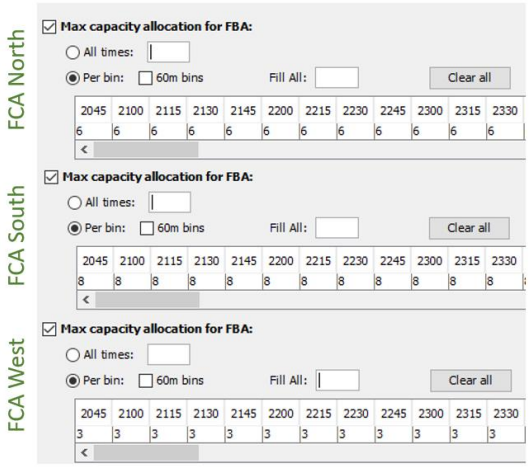


Figure 11.

FCA maximum capacity can be entered as a single value for all bins in the specified CTOP time period, or on a per 15m bin basis. The FBA will allocate capacity up to the entered amount, and it may allocate less than the entered capacity if there is insufficient demand to reach the maximum allowance. The maximum capacity

can also be entered in 60 minute time bins instead of 15 minutes, however the FBA always looks at capacity on a per 15-minute basis. Maximum capacity values are useful to avoid FCA overload, or in cases of reduction/increase of capacity due to weather.

The FBA balances capacity values to an established rate based on the demand across multiple flows. For example, if the established airport arrival rate is 44 aircraft per hour, the Combined FCA arrival rate must be limited to 11 aircraft every 15-minutes. The FBA automatically generates capacity values based on proportional demand coming from each FCA every 15-minutes without exceeding either the individual maximum capacity values on the FCAs or the Combined FCA rate. The user can review the automated outcome and make manual adjustments if they wish [Fig. 12].

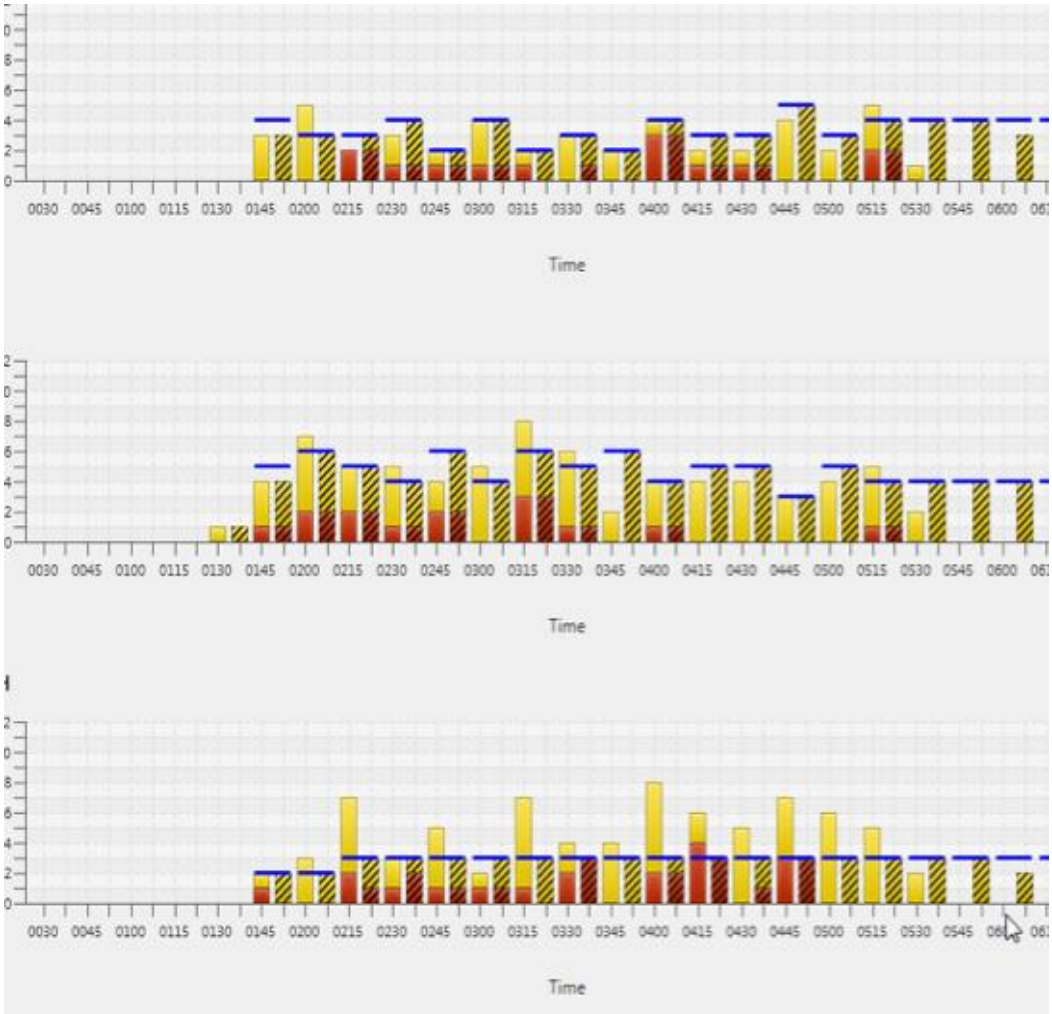


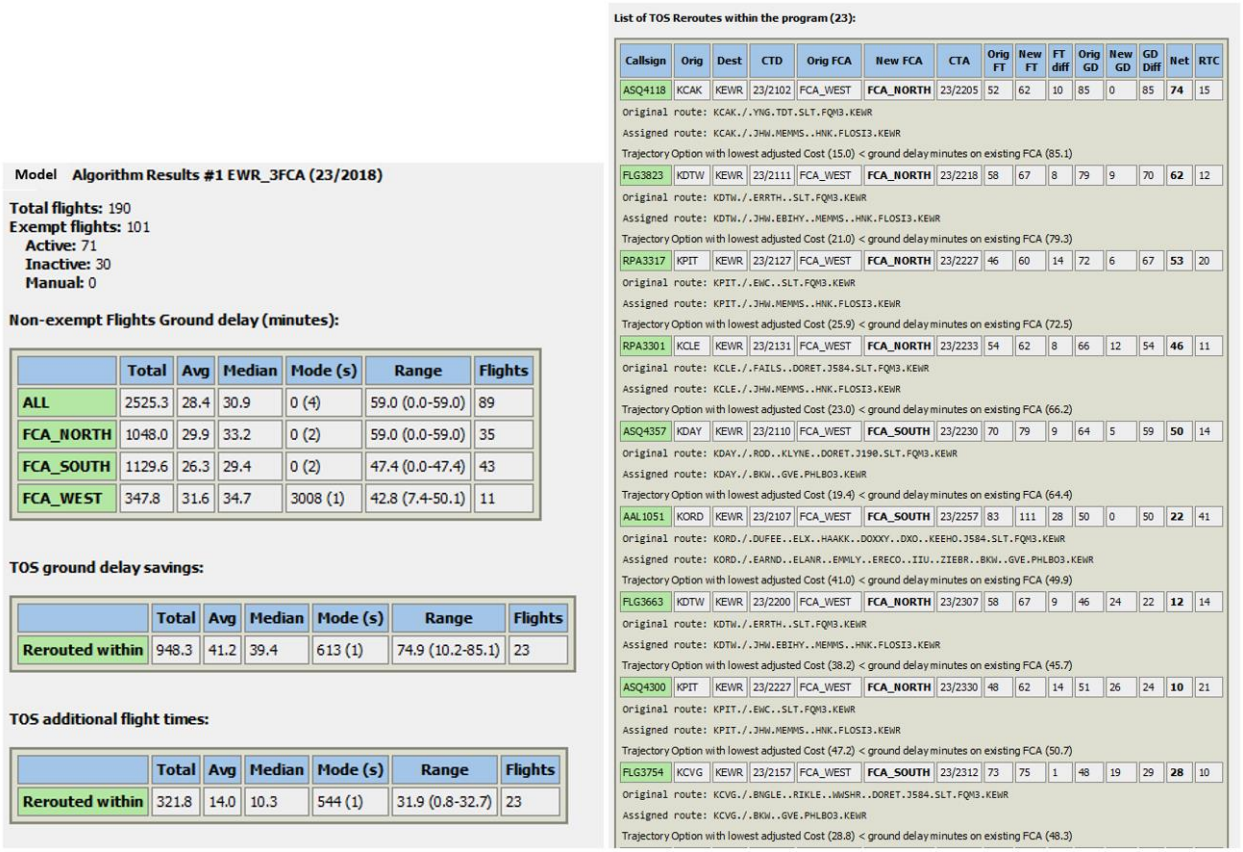
Figure 12.

Section III. Modeling results enhancements

The following section includes modeling enhancements that were added to NASA CTOP enhancements. These changes were added to give the user more information than what is currently available.

a) Model results page

Enhancements to the Model results page, or "Impact Assessment Statistics" as it is called in the fielded CTOP, were made. The fielded CTOP only shows basic information, while NASA CTOP goes into more detail in terms of system-wide, FCA, and individual flight data [Figures 13 and 14].



Model Algorithm Results #1 EWR_3FCA (23/2018)

Total flights: 190
Exempt flights: 101
Active: 71
Inactive: 30
Manual: 0

Non-exempt Flights Ground delay (minutes):

	Total	Avg	Median	Mode (s)	Range	Flights
ALL	2525.3	28.4	30.9	0 (4)	59.0 (0.0-59.0)	89
FCA_NORTH	1048.0	29.9	33.2	0 (2)	59.0 (0.0-59.0)	35
FCA_SOUTH	1129.6	26.3	29.4	0 (2)	47.4 (0.0-47.4)	43
FCA_WEST	347.8	31.6	34.7	3008 (1)	42.8 (7.4-50.1)	11

TOS ground delay savings:

	Total	Avg	Median	Mode (s)	Range	Flights
Rerouted within	948.3	41.2	39.4	613 (1)	74.9 (10.2-85.1)	23

TOS additional flight times:

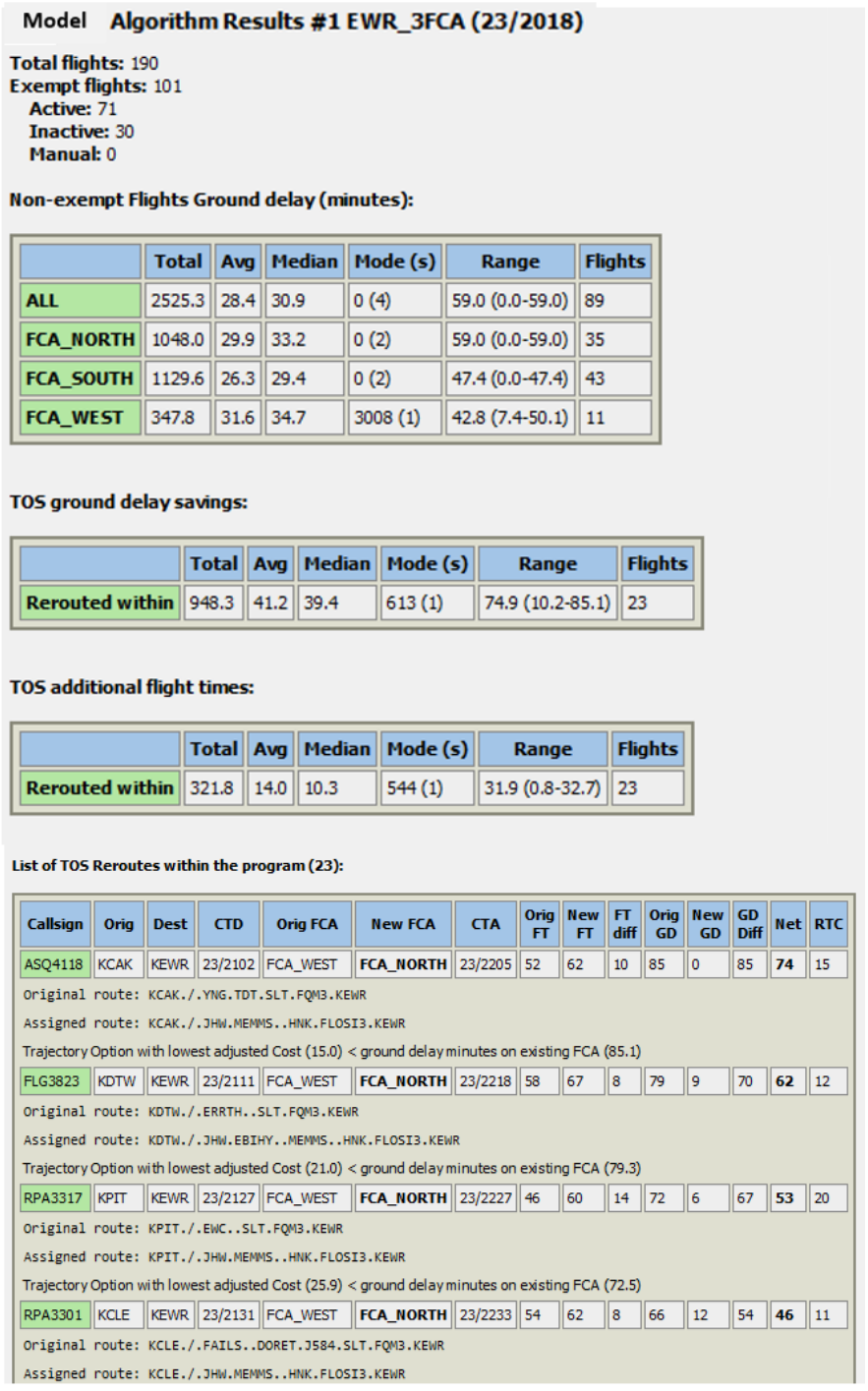
	Total	Avg	Median	Mode (s)	Range	Flights
Rerouted within	321.8	14.0	10.3	544 (1)	31.9 (0.8-32.7)	23

List of TOS Reroutes within the program (23):

Callsign	Orig	Dest	CTD	Orig FCA	New FCA	CTA	Orig FT	New FT	FT diff	Orig GD	New GD	GD Diff	Net	RTC
ASQ4118	KCAK	KEWR	23/2102	FCA_WEST	FCA_NORTH	23/2205	52	62	10	85	0	85	74	15
Original route: KCAK./.YNG.TDT.SLT.FQM3.KEWR														
Assigned route: KCAK./.JHW.MEMMS..HNK.FLOSI3.KEWR														
Trajectory Option with lowest adjusted Cost (15.0) < ground delay minutes on existing FCA (85.1)														
FLG3823	KDTW	KEWR	23/2111	FCA_WEST	FCA_NORTH	23/2218	58	67	8	79	9	70	62	12
Original route: KDTW./.ERRTH..SLT.FQM3.KEWR														
Assigned route: KDTW./.JHW.EBIHY..MEMMS..HNK.FLOSI3.KEWR														
Trajectory Option with lowest adjusted Cost (21.0) < ground delay minutes on existing FCA (79.3)														
RPA3317	KPIT	KEWR	23/2127	FCA_WEST	FCA_NORTH	23/2227	46	60	14	72	6	67	53	20
Original route: KPIT./.EWC..SLT.FQM3.KEWR														
Assigned route: KPIT./.JHW.MEMMS..HNK.FLOSI3.KEWR														
Trajectory Option with lowest adjusted Cost (25.9) < ground delay minutes on existing FCA (72.5)														
RPA3301	KCLE	KEWR	23/2131	FCA_WEST	FCA_NORTH	23/2233	54	62	8	66	12	54	46	11
Original route: KCLE./.FAILS..DORET.J584.SLT.FQM3.KEWR														
Assigned route: KCLE./.JHW.MEMMS..HNK.FLOSI3.KEWR														
Trajectory Option with lowest adjusted Cost (23.0) < ground delay minutes on existing FCA (66.2)														
ASQ4357	KDAY	KEWR	23/2110	FCA_WEST	FCA_SOUTH	23/2230	70	79	9	64	5	59	50	14
Original route: KDAY./.ROD..KLYNE..DORET.J190.SLT.FQM3.KEWR														
Assigned route: KDAY./.BKW..GVE.PHLBO3.KEWR														
Trajectory Option with lowest adjusted Cost (19.4) < ground delay minutes on existing FCA (64.4)														
AAL1051	KORD	KEWR	23/2107	FCA_WEST	FCA_SOUTH	23/2257	83	111	28	50	0	50	22	41
Original route: KORD./.DUFEE..ELK..HAAKK..DOXXY..DXO..KEEHO.J584.SLT.FQM3.KEWR														
Assigned route: KORD./.EARND..ELANR..EMMLY..ERECO..IIU..ZIEBR..BKW..GVE.PHLBO3.KEWR														
Trajectory Option with lowest adjusted Cost (41.0) < ground delay minutes on existing FCA (49.9)														
FLG3663	KDTW	KEWR	23/2200	FCA_WEST	FCA_NORTH	23/2307	58	67	9	46	24	22	12	14
Original route: KDTW./.ERRTH..SLT.FQM3.KEWR														
Assigned route: KDTW./.JHW.EBIHY..MEMMS..HNK.FLOSI3.KEWR														
Trajectory Option with lowest adjusted Cost (38.2) < ground delay minutes on existing FCA (45.7)														
ASQ4300	KPIT	KEWR	23/2227	FCA_WEST	FCA_NORTH	23/2330	48	62	14	51	26	24	10	21
Original route: KPIT./.EWC..SLT.FQM3.KEWR														
Assigned route: KPIT./.JHW.MEMMS..HNK.FLOSI3.KEWR														
Trajectory Option with lowest adjusted Cost (47.2) < ground delay minutes on existing FCA (50.7)														
FLG3754	KCVG	KEWR	23/2157	FCA_WEST	FCA_SOUTH	23/2312	73	75	1	48	19	29	28	10
Original route: KCVG./.BNGLE..RIKLE..WWSHR..DORET.J584.SLT.FQM3.KEWR														
Assigned route: KCVG./.BKW..GVE.PHLBO3.KEWR														
Trajectory Option with lowest adjusted Cost (28.8) < ground delay minutes on existing FCA (48.3)														

Figure 13.

1. **Ground delay (minutes)**
   The first box shows summary statistics of the ground delay that the total system, as well as each individual FCA, incurs as a result of the CTOP with TOS reroutes.
2. **TOS ground delay savings (minutes)**
   The second box shows summary statistics of the ground delay that the total system saved as a result of issuing TOS reroutes, rather than forcing flights to stay on their original route.
3. **TOS additional flight times (minutes)**
   The third box shows summary statistics of the additional flight time that the total system incurred as a result of some flights taking TOS reroutes.
4. **List of TOS assignments**
   The fourth box shows a list of all the flights that took a TOS reroute, including side-by-side comparisons of elements of their original vs. their new flight plan. For example, one useful metric is to compare the original ground delay ("Orig GD" to the new ground delay ("New GD") to get a sense of the amount of ground delay savings a specific flight incurred.



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Original route: KDTW./.ERRTH..SLT.FQM3.KEWR														
Assigned route: KDTW./.JHW.EBIHY..MEMMS..HNK.FLOSI3.KEWR														
Trajectory Option with lowest adjusted Cost (21.0) < ground delay minutes on existing FCA (79.3)														
RPA3317	KPIT	KEWR	23/2127	FCA_WEST	FCA_NORTH	23/2227	46	60	14	72	6	67	53	20
Original route: KPIT./.EWC..SLT.FQM3.KEWR														
Assigned route: KPIT./.JHW.MEMMS..HNK.FLOSI3.KEWR														
Trajectory Option with lowest adjusted Cost (25.9) < ground delay minutes on existing FCA (72.5)														
RPA3301	KCLE	KEWR	23/2131	FCA_WEST	FCA_NORTH	23/2233	54	62	8	66	12	54	46	11
Original route: KCLE./.FAILS..DORET.J584.SLT.FQM3.KEWR														
Assigned route: KCLE./.JHW.MEMMS..HNK.FLOSI3.KEWR														

Figure 14.

b) Modeling from the flight list

New columns were added to the flight list that reflect Ground Delay and Additional Flight Time that are assigned to each flight as a result of the CTOP program. Additional Flight time is added to the original flight time when a flight accepts a TOS reroute [Fig. 15].

When a flight is assigned a TOS reroute an asterisk is added to the route.

Flight List

COMBINED (162)

#	FCA	ACID	ETA	BETD	CTD	Grnd Delay	Addtl FT	ETA	CTA	Current RTE	ORIG	DSC
103	FCA_SOUTH	DAL1942	23/2224	23/2101	23/2101	[illegible]	0	23/2226	23/2225	KATL./.SPA..BEAR...	KATL	ZDC_01
064	FCA_SOUTH	JBU544	23/2305	23/2105	23/2332	147	[illegible]	23/2309	24/0135	KPBI./.AMNDA..PE...	KPBI	ZDC_01
100	FCA_SOUTH	TCF3585	24/0030	23/2108	23/2314	126	12	23/2214	[illegible]	*KCMH./.BKW..GVE...	KCMH	ZOB_01
071	FCA_SOUTH	UAL1945	23/2355	23/2109	23/2350	161	0	23/2356	24/0235	KIAH./.ORRTH..BN...	KIAH	ZDC_01
075	FCA_SOUTH	ASQ3744	24/0025	23/2109	23/2334	145	0	23/2201	24/0025	KORF./.HPW..PXT....	KORF	ZDC_01
062	FCA_SOUTH	DAL840	23/2356	23/2110	23/2321	131	27	23/2312	24/0150	*KMSP./.IIU.J526...	KMSP	ZOB_01
066	FCA_SOUTH	RPA3311	24/0049	23/2116	23/2345	149	0	23/2222	24/0050	KCLT./.FAK.PHLBO...	KCLT	ZDC_01
070	FCA_SOUTH	AAL1037	23/2333	23/2123	24/0004	161	0	23/2335	24/0215	KMIA./.VALLY..PE...	KMIA	ZDC_01
092	FCA_SOUTH	ASQ3804	24/0045	23/2125	23/2349	144	0	23/2221	24/0045	KGSO./.SBV..CREW...	KGSO	ZDC_01
077	FCA_SOUTH	UAL1417	23/2334	23/2127	24/0004	157	0	23/2333	24/0210	KFLL./.PERMT..AR...	KFLL	ZDC_01
089	FCA_SOUTH	ASQ4111	24/0100	23/2127	23/2342	135	0	23/2246	24/0100	KCHS./.FILLI..FL...	KCHS	ZDC_01
079	FCA_SOUTH	DAL2042	24/0145	23/2142	24/0018	156	0	23/2309	24/0145	KATL./.SPA..BEAR...	KATL	ZDC_01
082	FCA_SOUTH	SWA1920	24/0245	23/2200	24/0049	169	0	23/2356	24/0245	KMCO./.SAV.J207....	KMCO	ZDC_01
069	FCA_SOUTH	UAL1266	24/0304	23/2205	24/0106	181	0	24/0004	24/0305	KTPA./.DUNKN.J75...	KTPA	ZDC_01
087	FCA_SOUTH	UAL711	24/0334	23/2215	24/0120	184	0	24/0032	24/0335	KMSY./.CATLN..TW...	KMSY	ZDC_01
094	FCA_SOUTH	AAL1447	24/0155	23/2215	24/0051	156	0	23/2319	24/0155	KCLT./.FAK.PHLBO...	KCLT	ZDC_01
104	FCA_SOUTH	TCF3624	24/0139	23/2215	24/0046	151	0	23/2309	24/0140	KRDU./.FAK.PHLBO...	KRDU	ZDC_01
107	FCA_SOUTH	ASQ4135	24/0229	23/2225	24/0055	150	4	23/2356	24/0230	*KIND./.IIU.J526...	KIND	ZOB_01
068	FCA_SOUTH	UAL1024	24/0330	23/2232	24/0131	179	0	24/0031	24/0330	KTPA./.DUNKN.J75...	KTPA	ZDC_01
076	FCA_SOUTH	RPA3379	24/0130	23/2232	24/0059	147	0	23/2304	24/0130	KDCA./.SWANN..DQ...	KDCA	ZDC_01

Figure 15.

c) CTA model vs. actual

By default, the bar charts will show modeled bars using the Controlled Time of Arrival (CTA), or if not set then ETA for aircraft [Fig.. 16]. Alternatively, you can have the modelled demand show the demand for aircraft based on slot reservations rather than CTA [Fig. 17]. When running the TOS algorithm, flights can be said to reserve slots independent of their CTA assignments if they are exempt. Either way, aircraft without any CTA or slot reservations will have a "NoSLOT" designation in the flight list instead of a CTA.

CTA

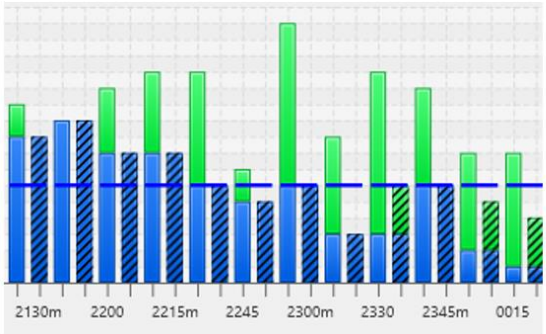

Figure 16.

Slot reservation

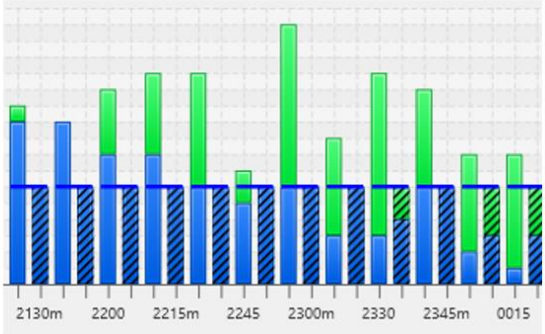

Figure 17.

d) Route display

As a final step to model TOS reroute impact before finalizing a CTOP, current routes(white) are displayed side-by-side with TOS reroutes (cyan blue) one at a time for a one second duration (user specified) on the Traffic Situation Display [Fig. 18].

Figure 18.

Section IV. Automatic Revision Enhancements

The following section describes enhancements to Automatic Revision that were made to allow more user input and monitoring while managing a CTOP TMI.

Note: We did not explore these features far enough to determine if they display the most useful information in an optimal format.

a) Automatic Revision confirmation dialog

Currently, Automatic Revision (AR) runs in the background of a CTOP and does not require input from a user. To make the AR process more transparent, a confirmation dialog was added to Automatic Revision which gives the user information about the reason it was triggered and allows the user to determine whether to take corrective action or not. Options for the user are "Run Full Allocation and Send Actual" (execute the revision without review), "Run Full Allocation" (show modeled outcome in the bar chart and flight list first), and "Do Nothing" (ignore the revision).

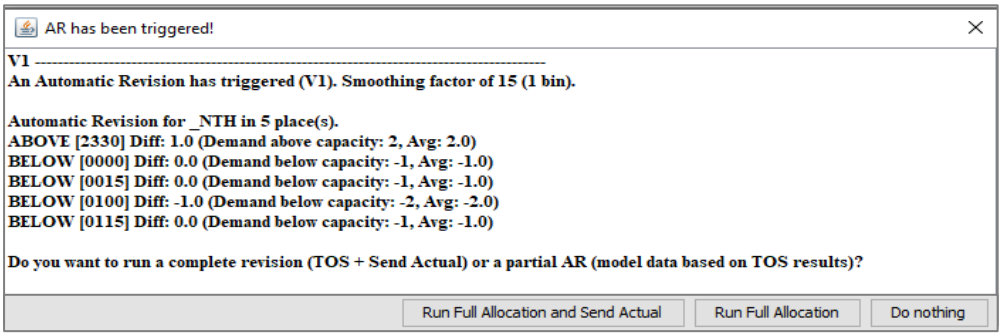

Figure 19.

b) Automatic Revision capacity lines

In the fielded CTOP, AR above and AR below capacity values only show the numerical value associated with their bins. In NASA CTOP enhancement, they can also indicate places where an Automatic Revision will trigger by turning red [Fig. 20].

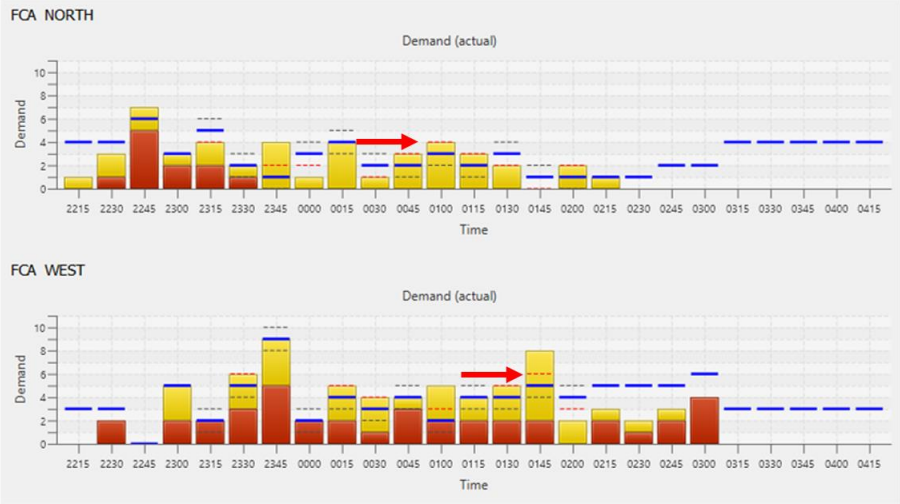

Figure 20.

Section V. TOS viewer

The following section contains a feature that was added to assist the user while making decisions about TOS allocation.

The TOS viewer displays the Trajectory Option Set for each aircraft. Selecting an aircraft in the flight list will display that flight's TOS with alternative routes ranked by relative trajectory cost (RTC) [Fig. 21].

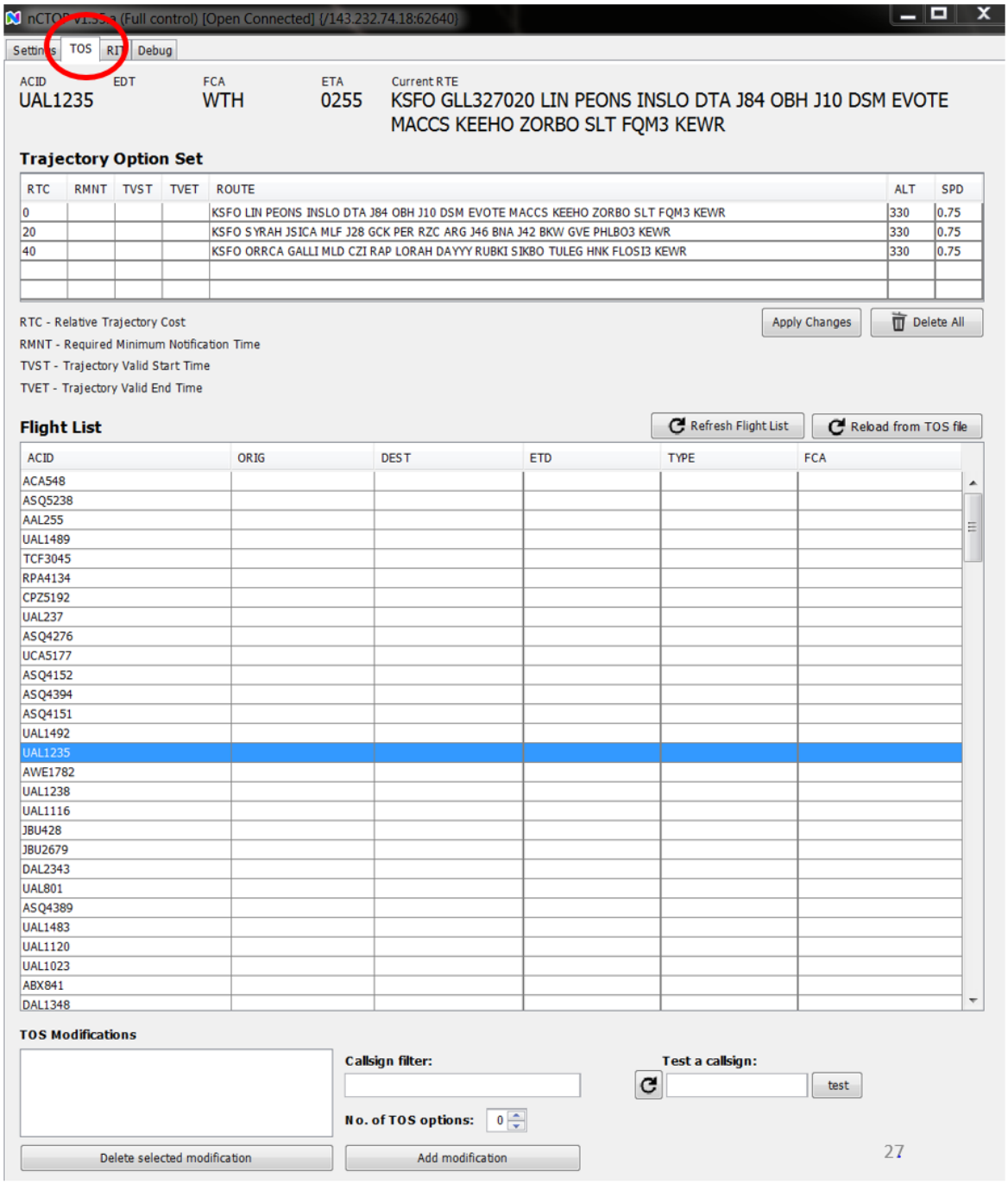

Figure 21.

Section VI. Subject Matter Expert ratings

The following ratings are based on two Subject Matter Experts that helped develop these enhancements [Table 1]. Two subject matter experts were asked to rate each CTOP enhancement on a scale from 1 – 5 (1 = Not valuable at all, 2 = Somewhat less valuable, 3 = Neutral, 4 = Somewhat valuable, 5 = Extremely valuable). The average ratings are presented in the table below. There was a high percentage of inter-rater agreement (r=.78).

Table 1. CTOP User Interface Enhancement Ratings

Enhancement	Avg
Unmerged flow color coding	2.5
CTA model vs. actual	2.5
Automatic Revision Capacity Lines	2.5
Bar chart and flight list interactions	3
Route display	3.5
Exempt/Non-exempt color coding	4
Flight list color coding	4
Model results page	4
Modeling from the flight list	4
Automatic Revision Confirmation Dialog	4
TOS Viewer	4
Flight search	4.5
CTOP all tab	4.5
Combined FCA Configuration Window	5
Combined Bar Chart and Flight List	5
FCA Balancing Algorithm (FBA)	5