



Analysis of Jet Departures from Boston Logan Runway 27

Presentation to the Runway 27 Advisory Committee

Volpe Center, Cambridge, Massachusetts

September 27, 2006



Agenda

- Background of the Airspace Lab (review)
- Data sources at the Lab (review)
- Explanation of offload data (review)
- Data collection and processing
- Findings
- Recommendations and Conclusions



Airspace Lab

- FAA “think tank” at HQ in Washington, DC
- Mix of FAA employees and contractors
- Projects
 - Short term “ad hoc” analyses
 - Long term studies
- Data collection, archiving, and enhancement
 - Traffic Data: ETMS, Offload, HAME
- Develop analytical tools for the FAA
 - SDAT, Web Metrics, TFR Builder, OEAAA



Personal Experience

- 11 years with the FAA
- Facilities
 - Cleveland Air Traffic Control Center
 - Air Traffic Control System Command Center
 - Southern California TRACON
- Projects with communities
 - San Diego / Brown Field cargo airport
 - Congressional runway studies for LGA and LAS
 - Restricted airspace around Washington DC after 9/11
 - Military training areas over southern Indiana



Why Use the Airspace Lab?

- Fresh, independent look at RWY 27 issues
- Access to other data sources
- Alternative method of processing radar data
- Personnel resources
 - Mathematicians
 - Statisticians
 - Software engineers
 - Database engineers



Data Sources at the Lab

- Enhanced Traffic Management System (ETMS)
 - Good for detailed flight information and en route studies
- Host Automated Management Executable (HAME)
 - Handoff data
 - Good for sector studies
- Offload
 - Good for detailed studies



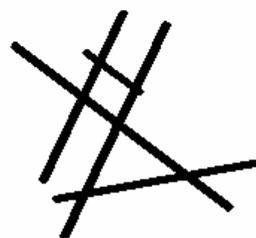
Offload Data

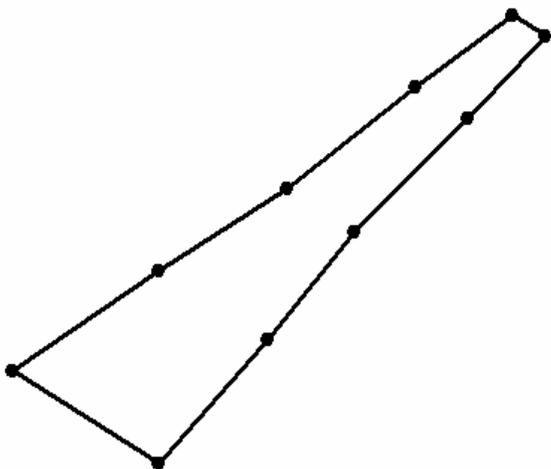
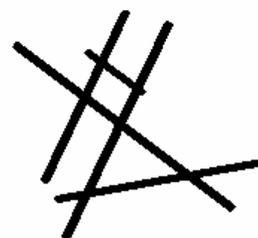
- ARTS radar data from various facilities
 - 78 TRACONs, 20 centers
 - ARTS 3A, Common ARTS, and STARS
 - Last 45 days saved at facility
- Offload at A90 (Boston TRACON)
 - ASR9 – Logan's primary radar
 - STARS facility

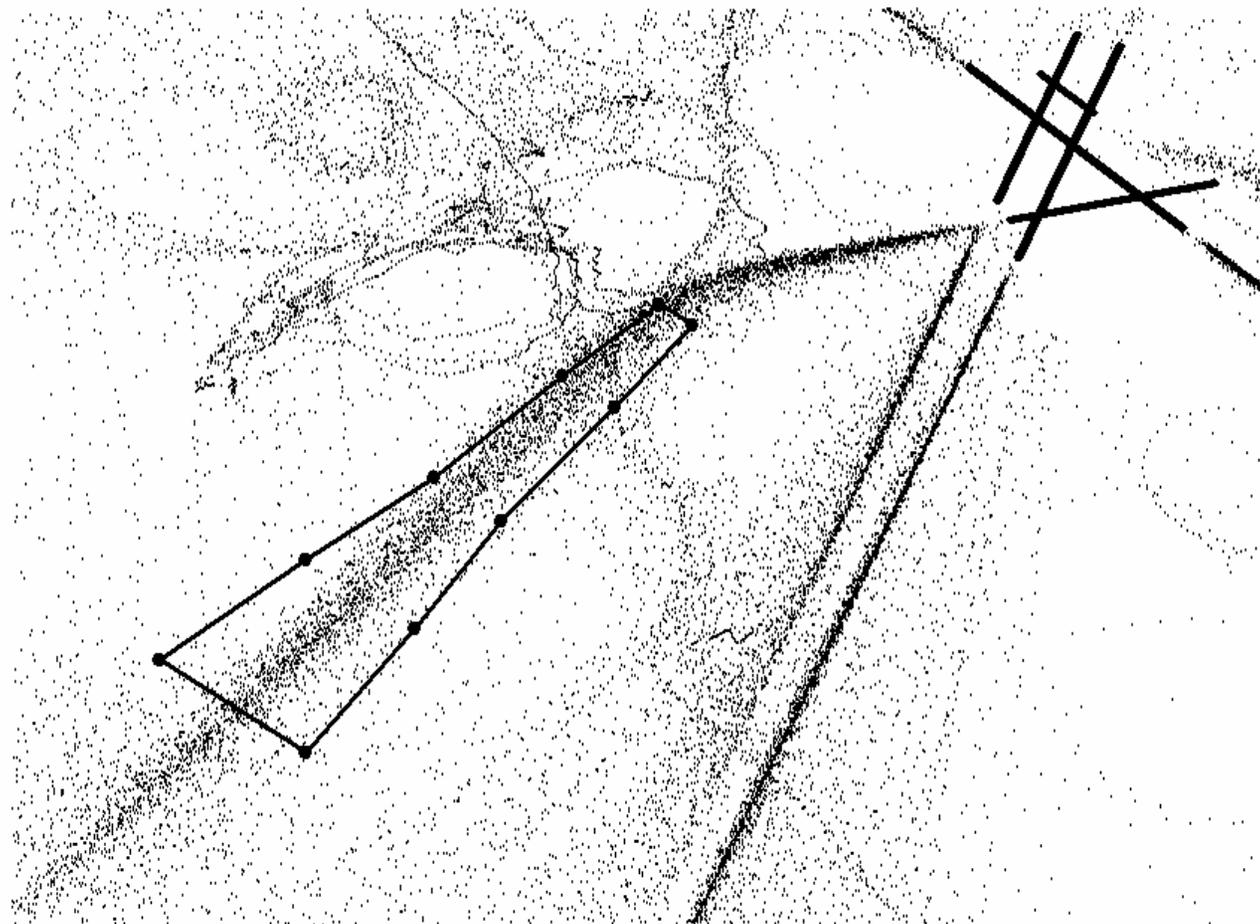


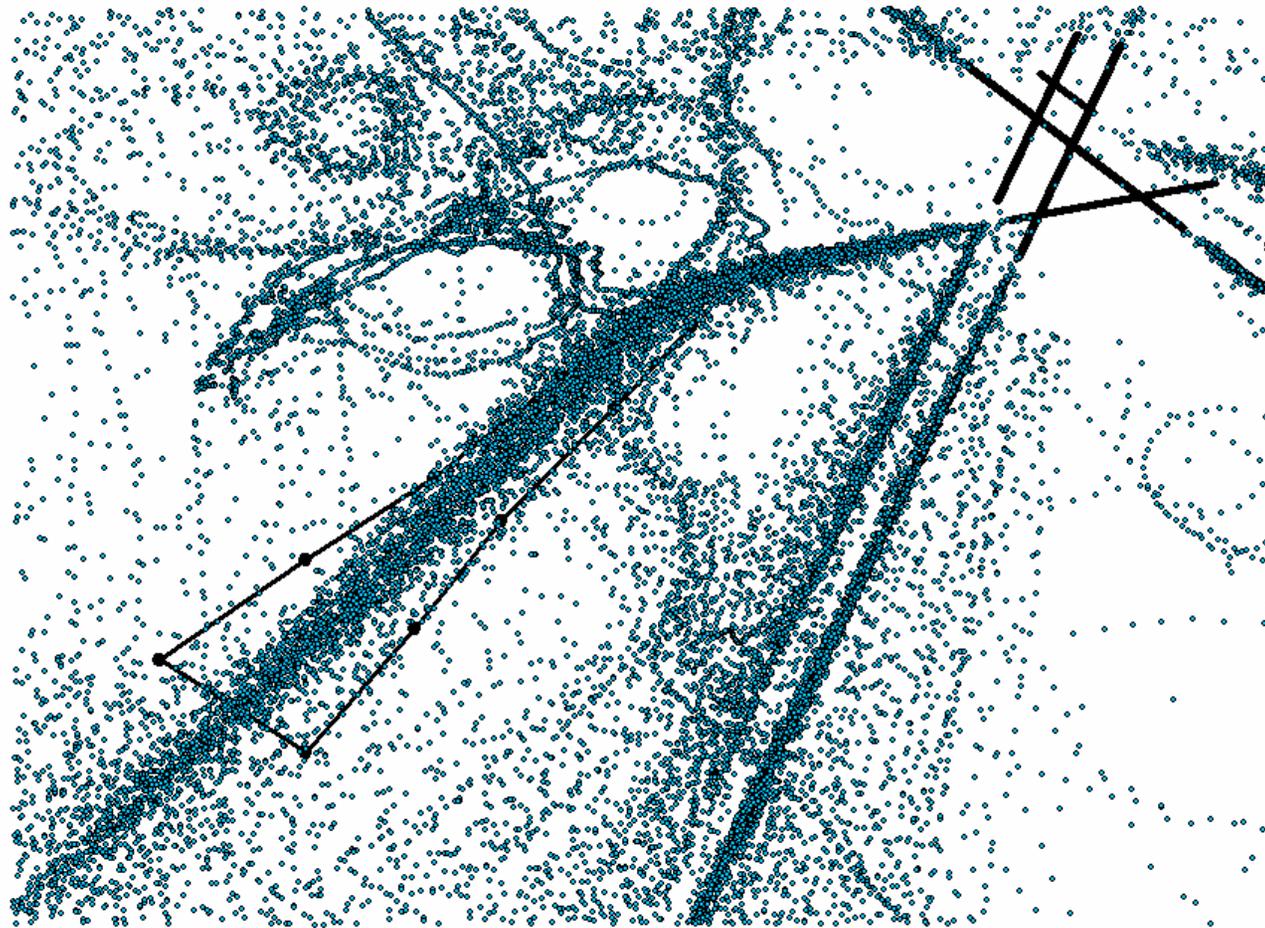
Offload Data Example

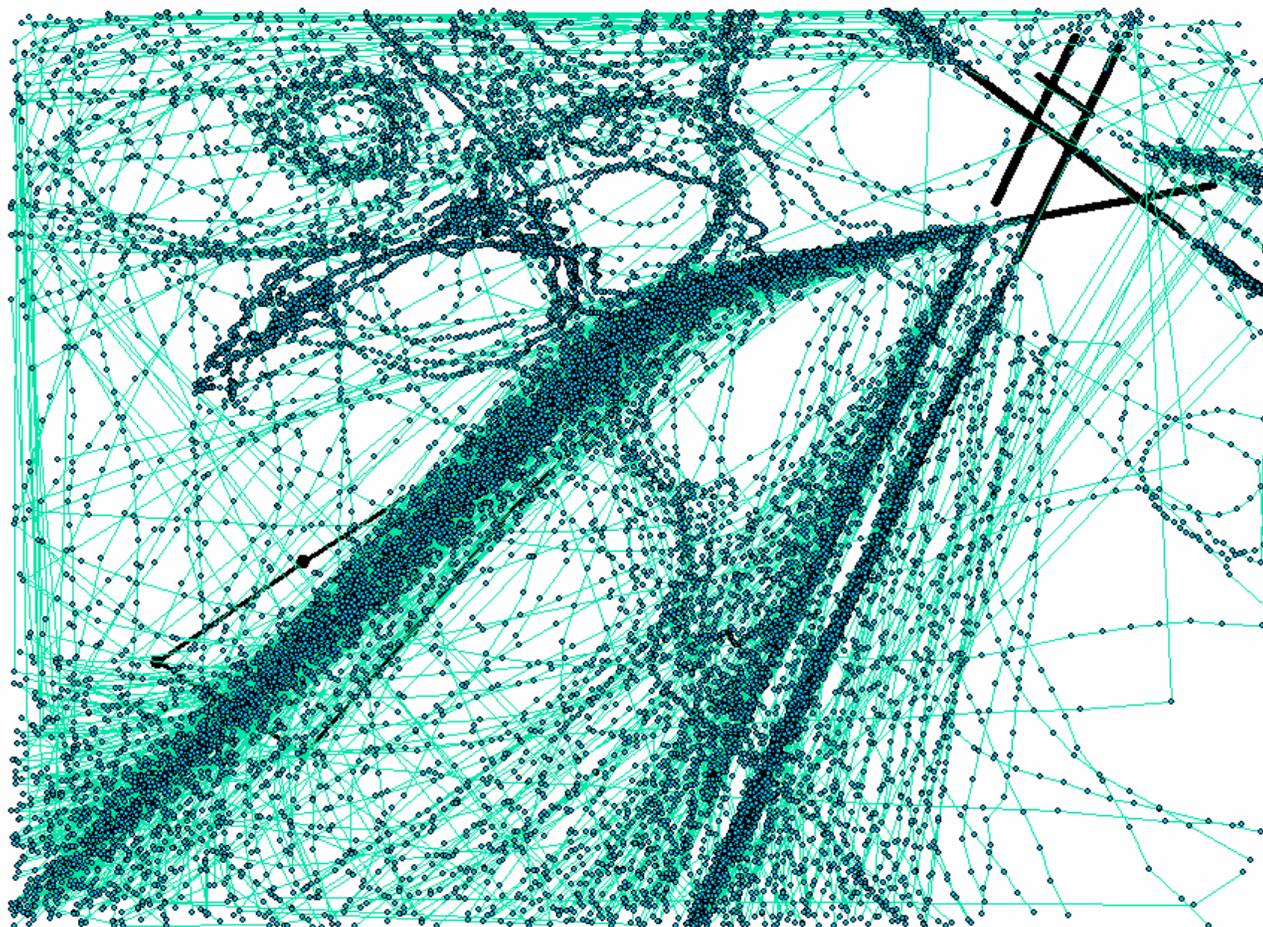
- 24 hours of traffic at A90 -- July 11, 2005
- Show only radar points within a certain area, and below 5000 feet.

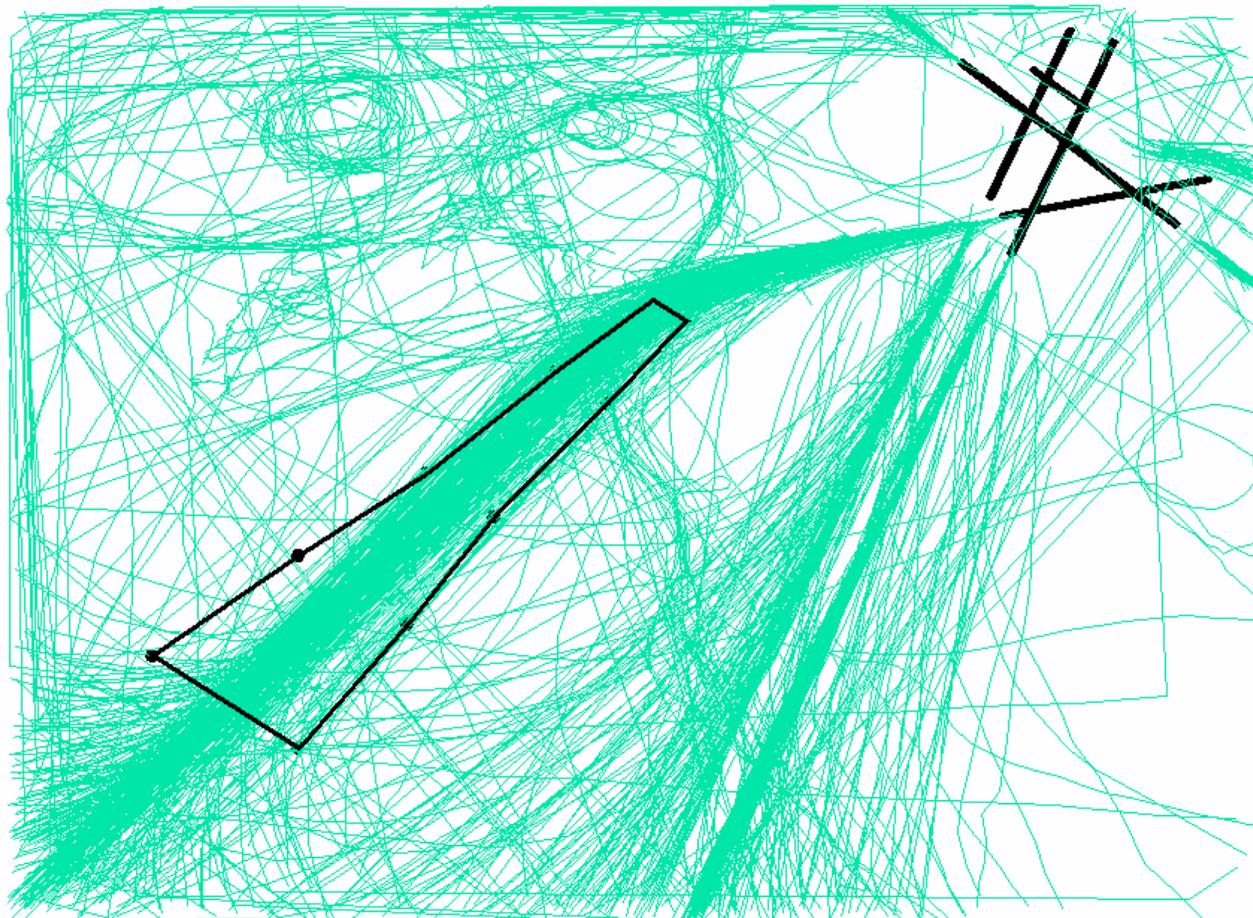














Offload Data Collection

- Lab archived detailed offload data from July 4, 2005 to March 31, 2006
- Processed 258 days of data
 - Could not collect 3 days of data when runway 27 was used

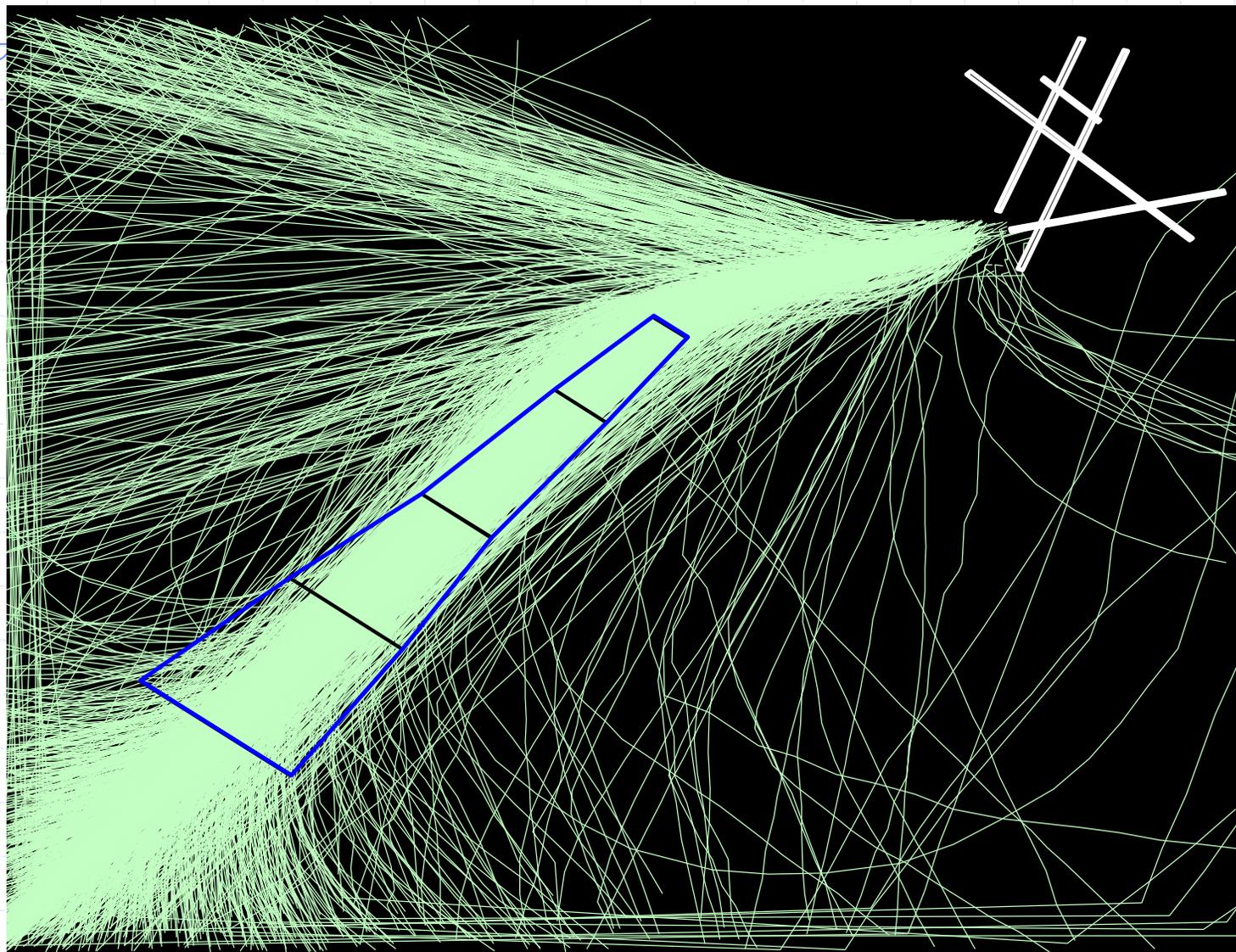


Offload Limitation: No Runway Info

- Recall: We had no database available to identify which runway departures used at Logan. Therefore...
- Had to determine runway 27 departures from algorithm based on
 - Altitude
 - Location of first three radar hits west of runway 27
 - Bearing of first three hits
- Once algorithm identified runway 27 departures, we created flight tracks from the radar hits



All Radar Runway 27 Tracks, July 2005



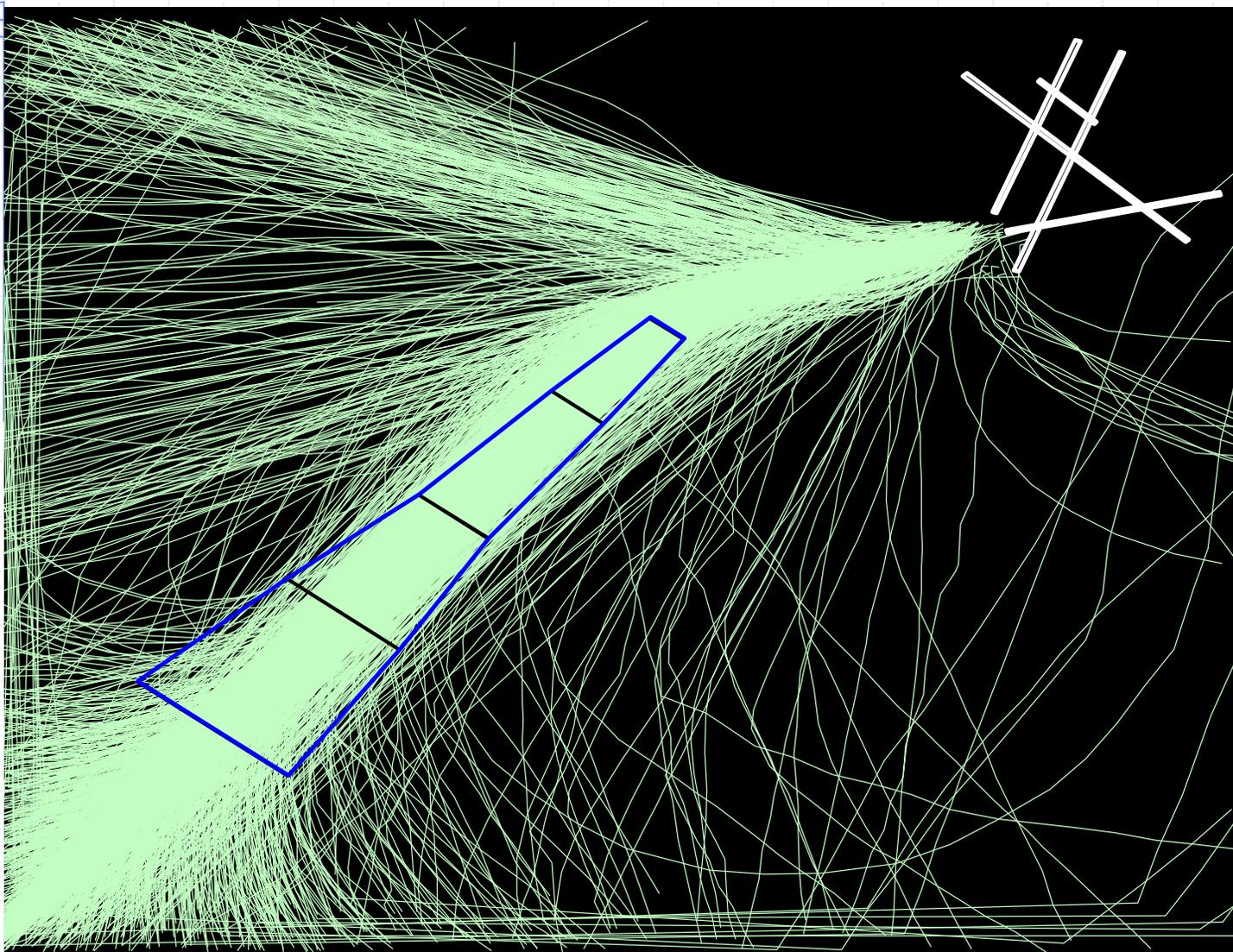
Data Processing: Determine Runway 27 Departures



- Examined runway 27 tracks on a monthly scale to remove
 - Non-jet flights (i.e. prop and turbo-prop)
 - VFR, duplicate, offload "UNK", and offload "shadow" flights
 - Non-runway 27 flights
- Maintained detailed records of flights in the above categories

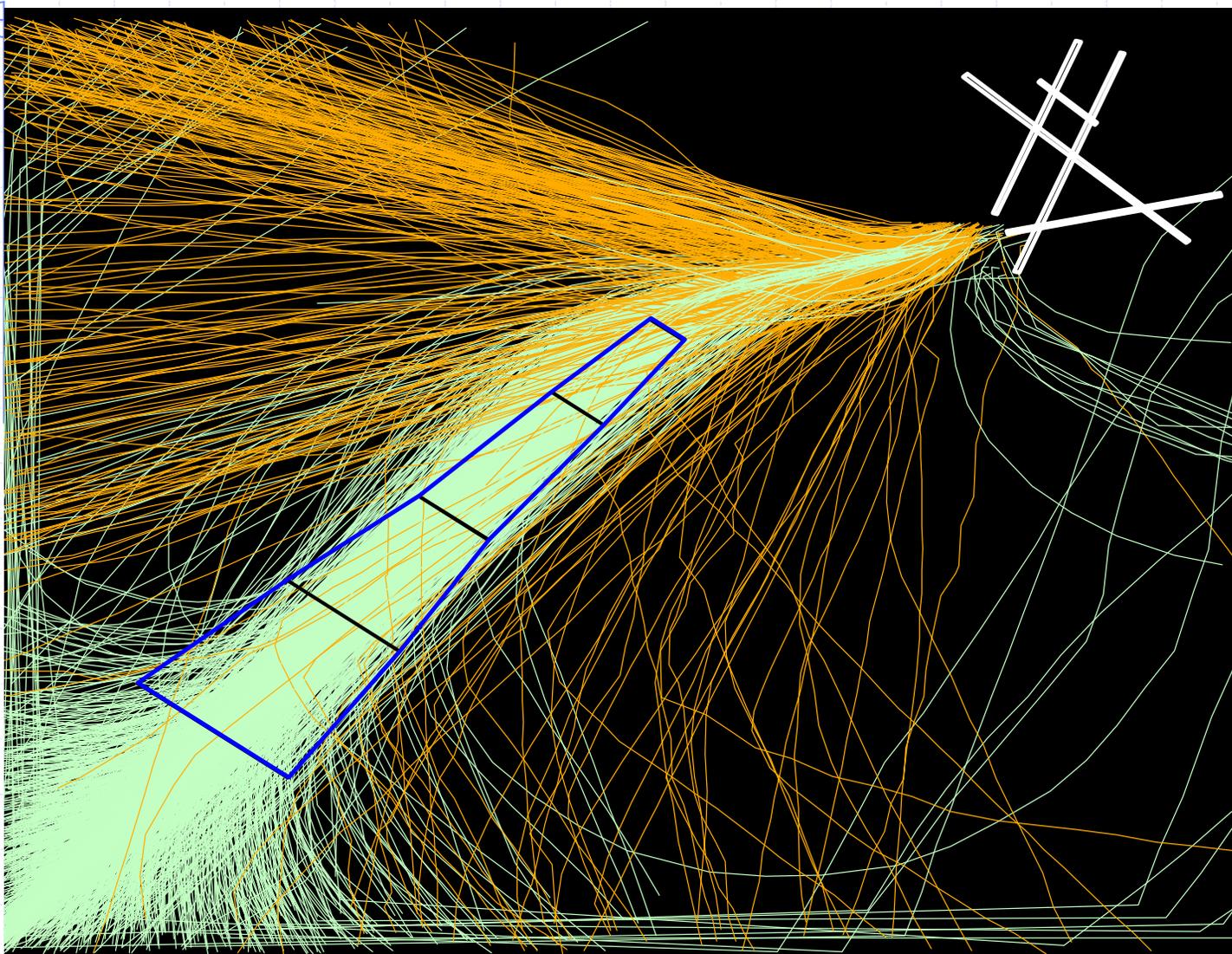


All Radar Runway 27 Tracks, July 2005



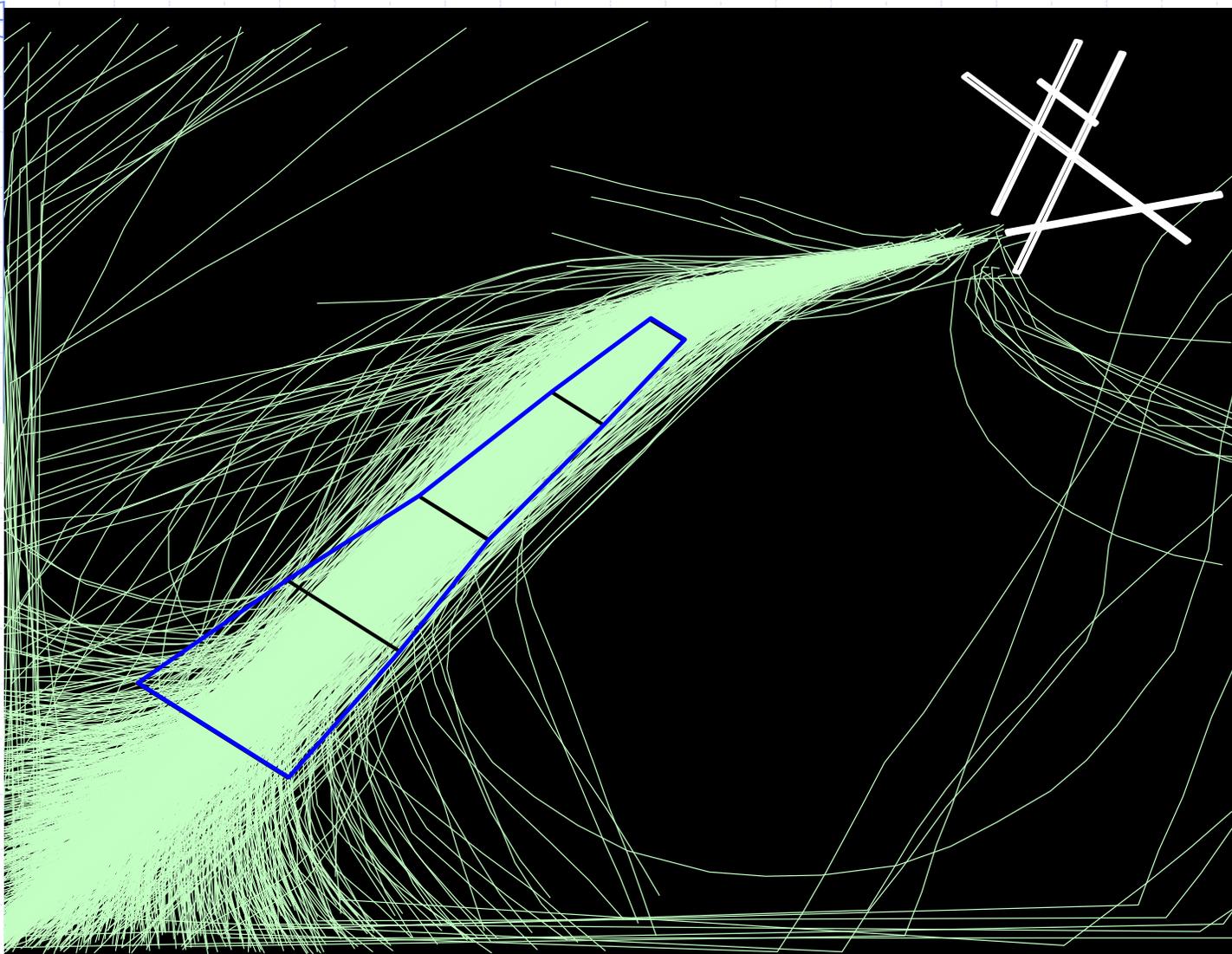


Prop and Turbo-Prop Flights



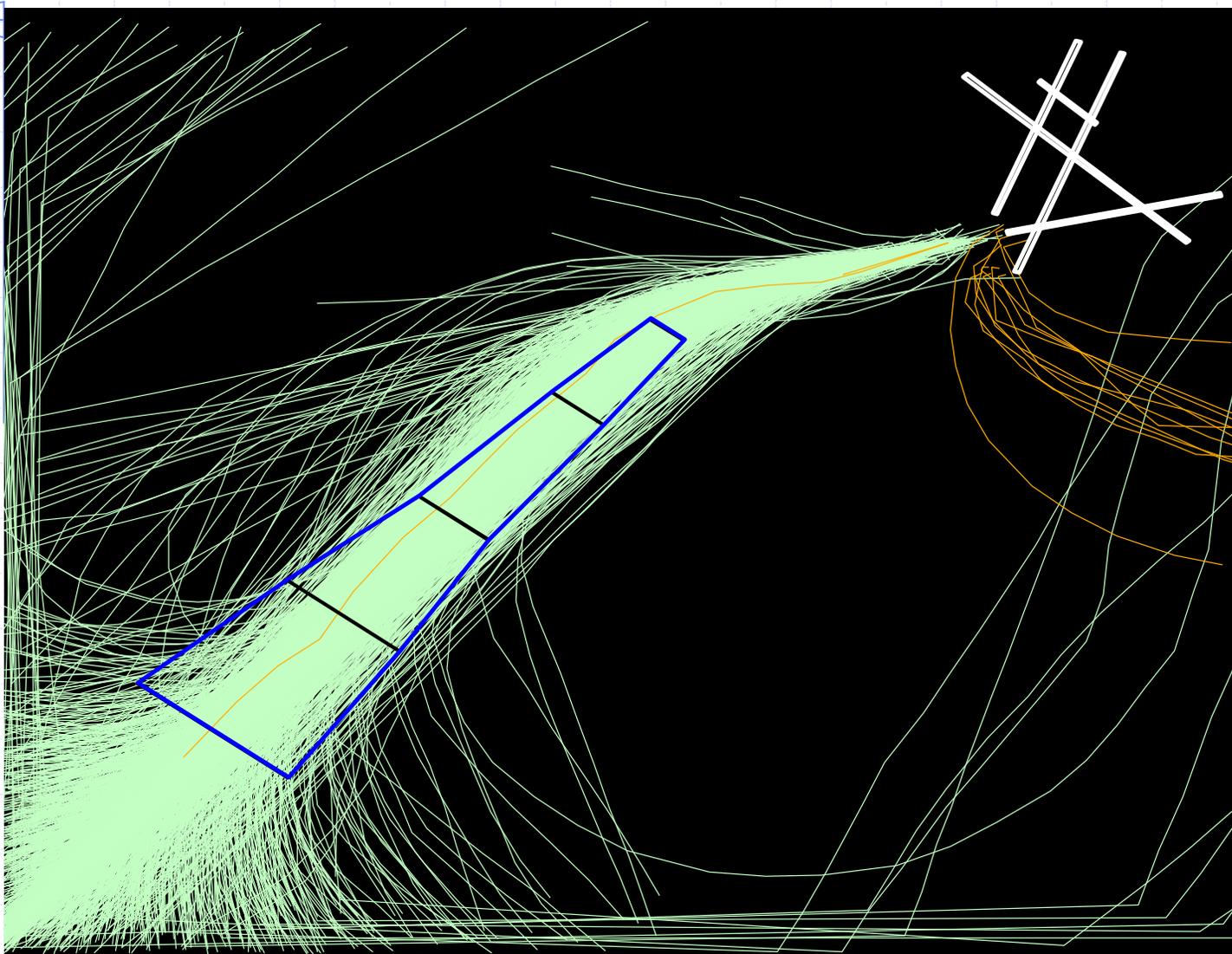


Prop and Turbo-Prop Flights Removed



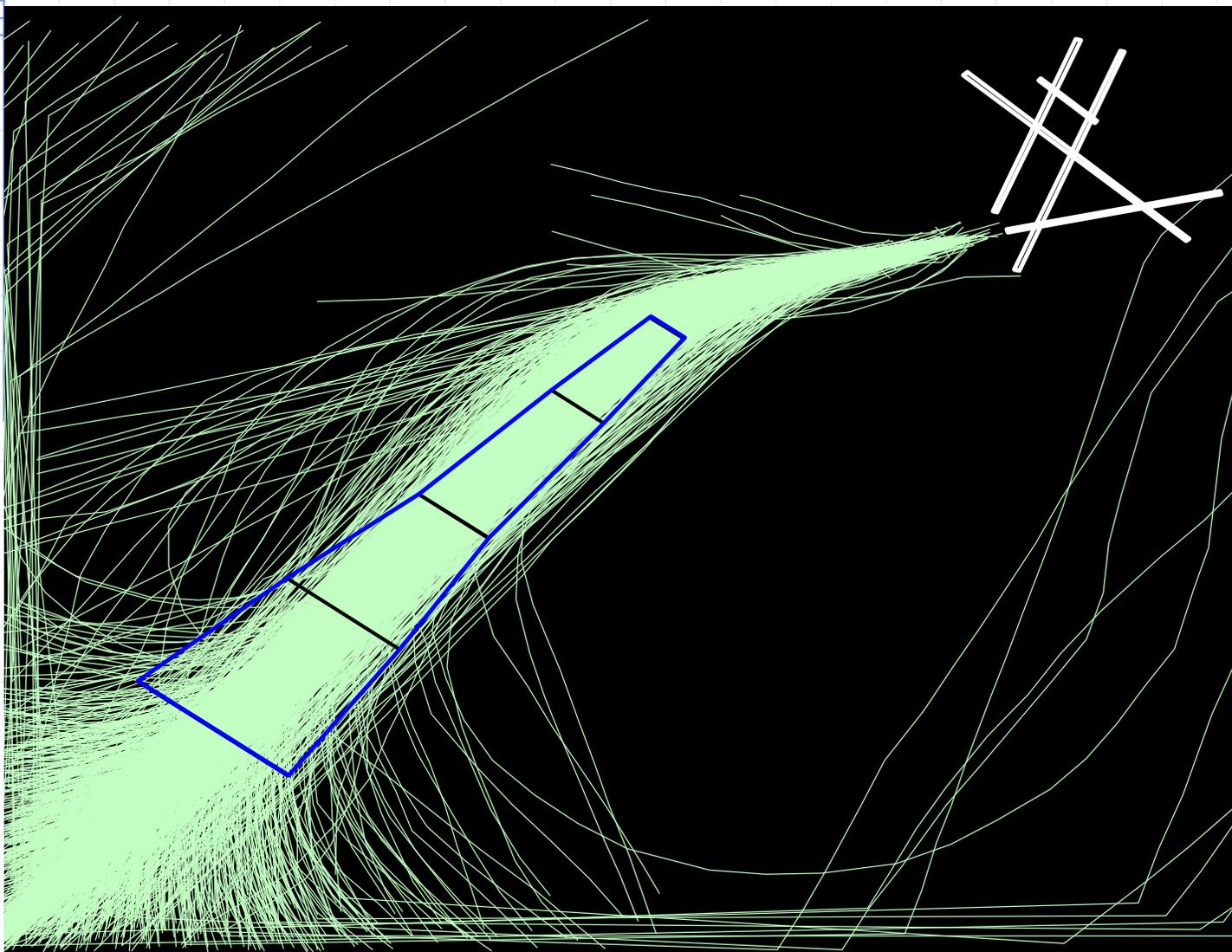


Runway 22R Departures



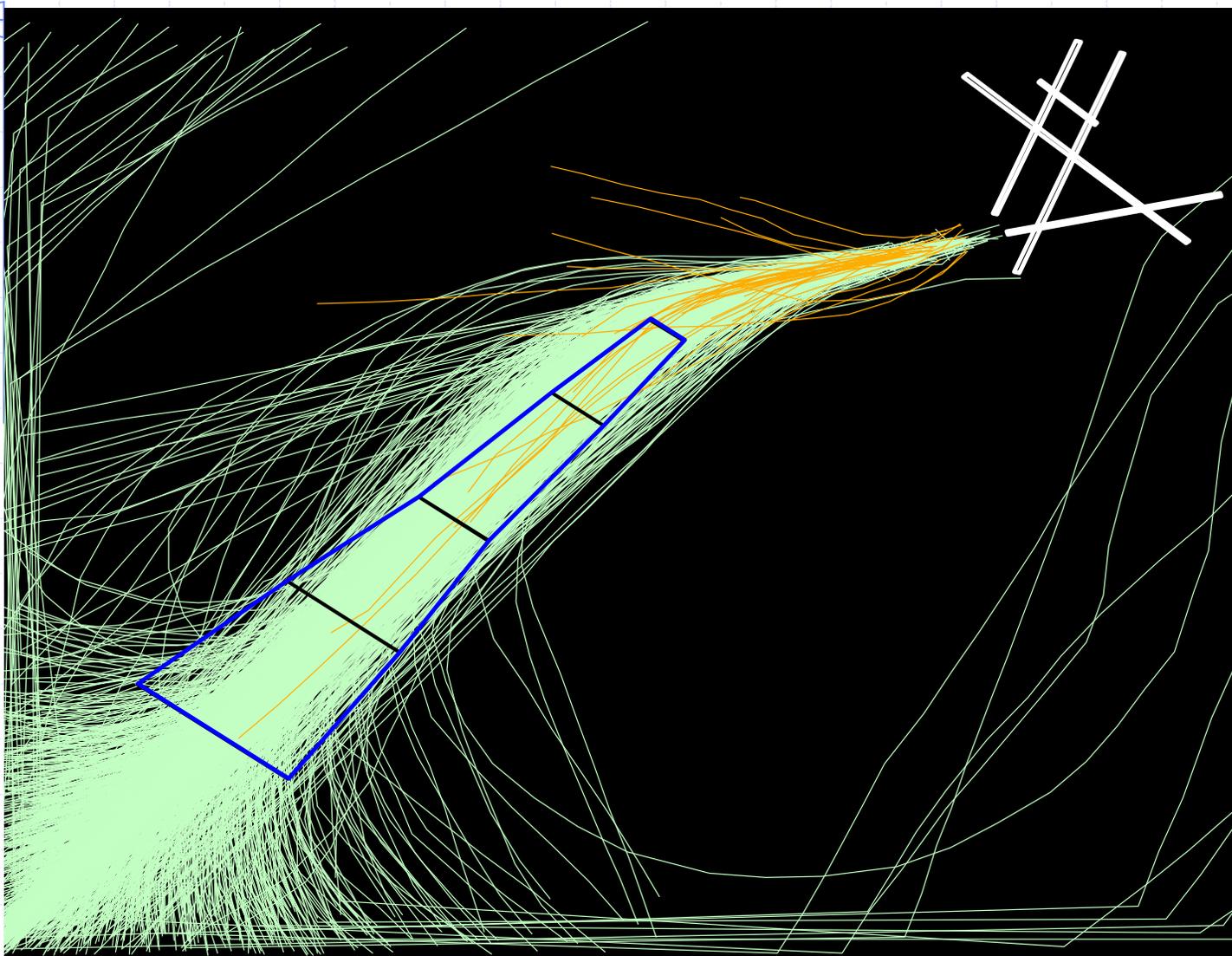


Runway 22R Departures Removed



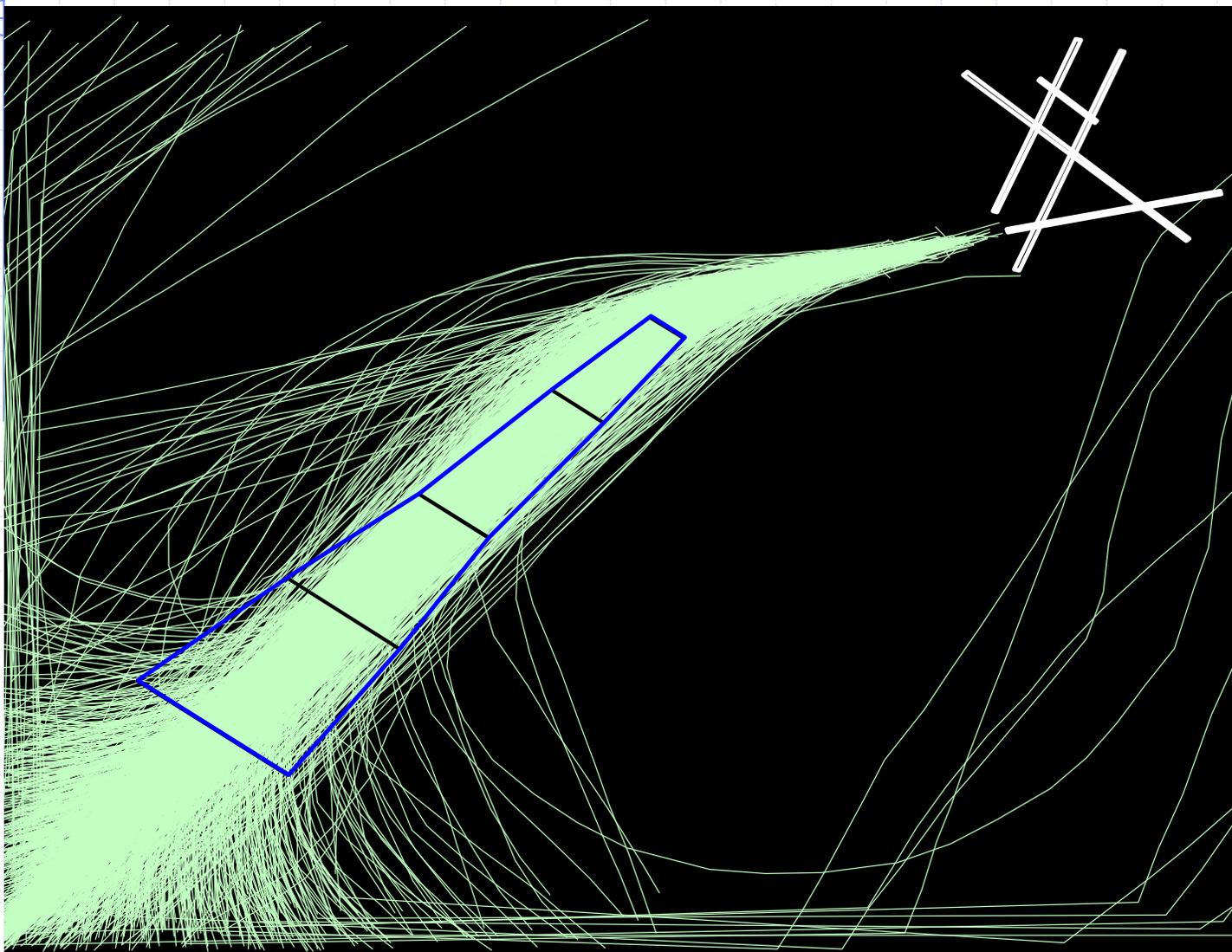


VFR and Unknown Flights





VFR and Unknown Flights Removed



Data Processing: Determined Gate Compliance



- Created second algorithm that determined where each track crossed each gate (if at all).
 - Latitude
 - Longitude
 - Altitude
 - Time
 - Date

Data Processing: Merge with ETMS



- Merged valid runway 27 radar tracks with ETMS data to get other information:
 - Navigational equipment code
 - Arrival airport
 - User class



Created Master Excel Spreadsheet

- Nine months of data
- 15,962 runway 27 jet departures
- Each departure has 36 data fields associated with it



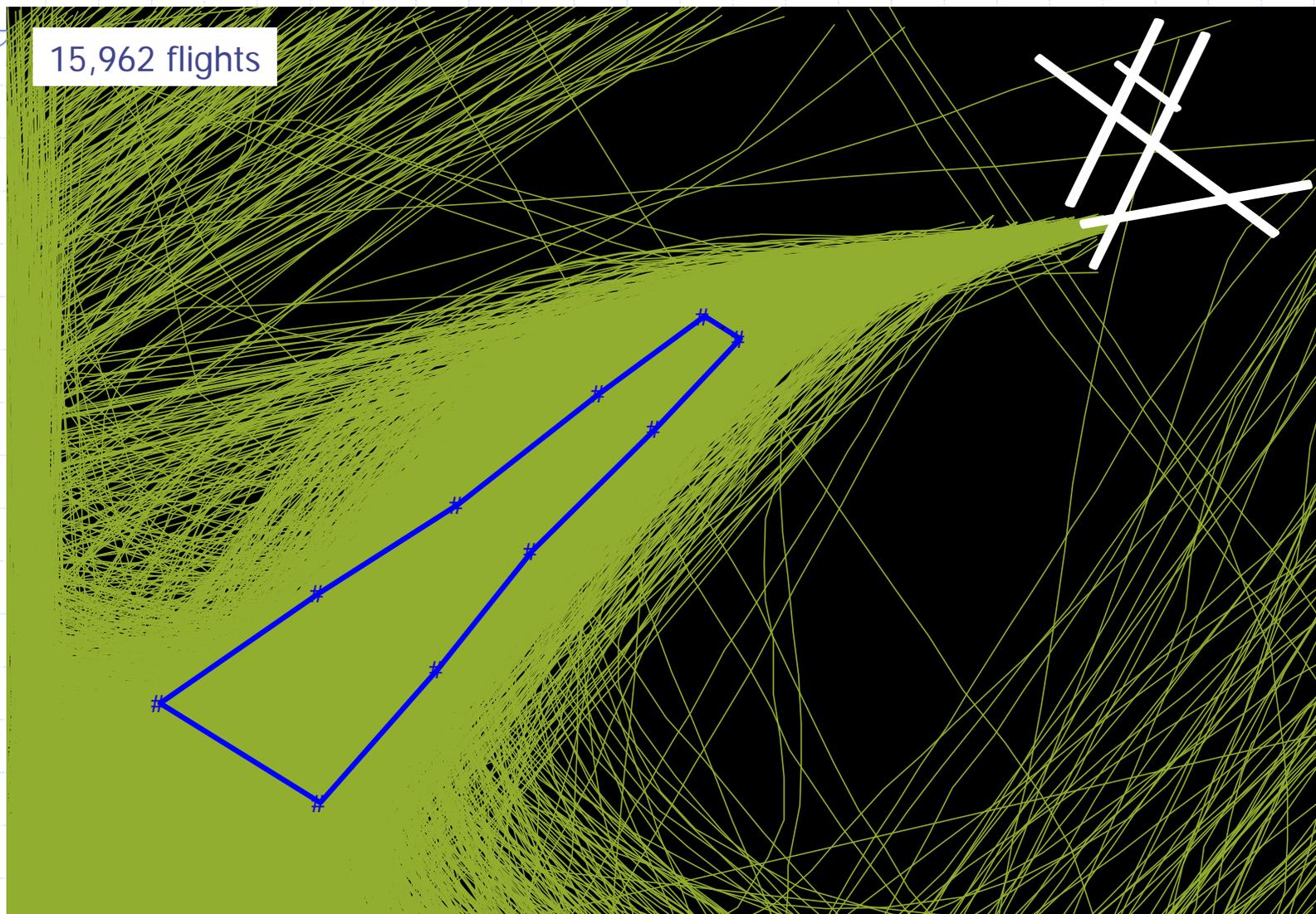
Validated Master Excel

- Checked it against image of flight tracks for gate compliance
- Compared Offload and ETMS data
 - Departure times
 - Departure dates
 - Aircraft type



Nine Months of Data

15,962 flights





Analysis

- Master Excel file lets us examine:
 - Aircraft Type
 - FMS departure procedure
 - Navigational equipment on board
 - Weather conditions at departure time
 - Departure time of day
 - Seasonal variations
 - User class
- Each of the above was examined individually, but also in combination with others.



Overall averages

- 57% made all five gates.
- 10% missed only the first gate.
- 12% missed the first two gates, but then went on to make the last three.
- 3% made the first four gates, then left the corridor before crossing the fifth gate.
- 3% made the first gate, overshot and missed the second, but then resumed course and made the last three.
- 2.4% missed all five gates.
- 1.4% missed the first four gates, then made the last gate.



Factors Which Affect Compliance

- Aircraft type
- Flight Management System (FMS) departure procedure
- Navigational equipment on board



Factors Which Do Not Affect Compliance

- Weather
 - Wind speed
 - Wind direction
 - Visibility
 - Wind gusts
 - Sky conditions
- Departure time of day
- Month of year / season
- User class



Aircraft Type

- Most important variable in determining corridor compliance
- In most cases, corridor performance for each aircraft type was independent of all other variables
- Most of our findings could be explained by aircraft type



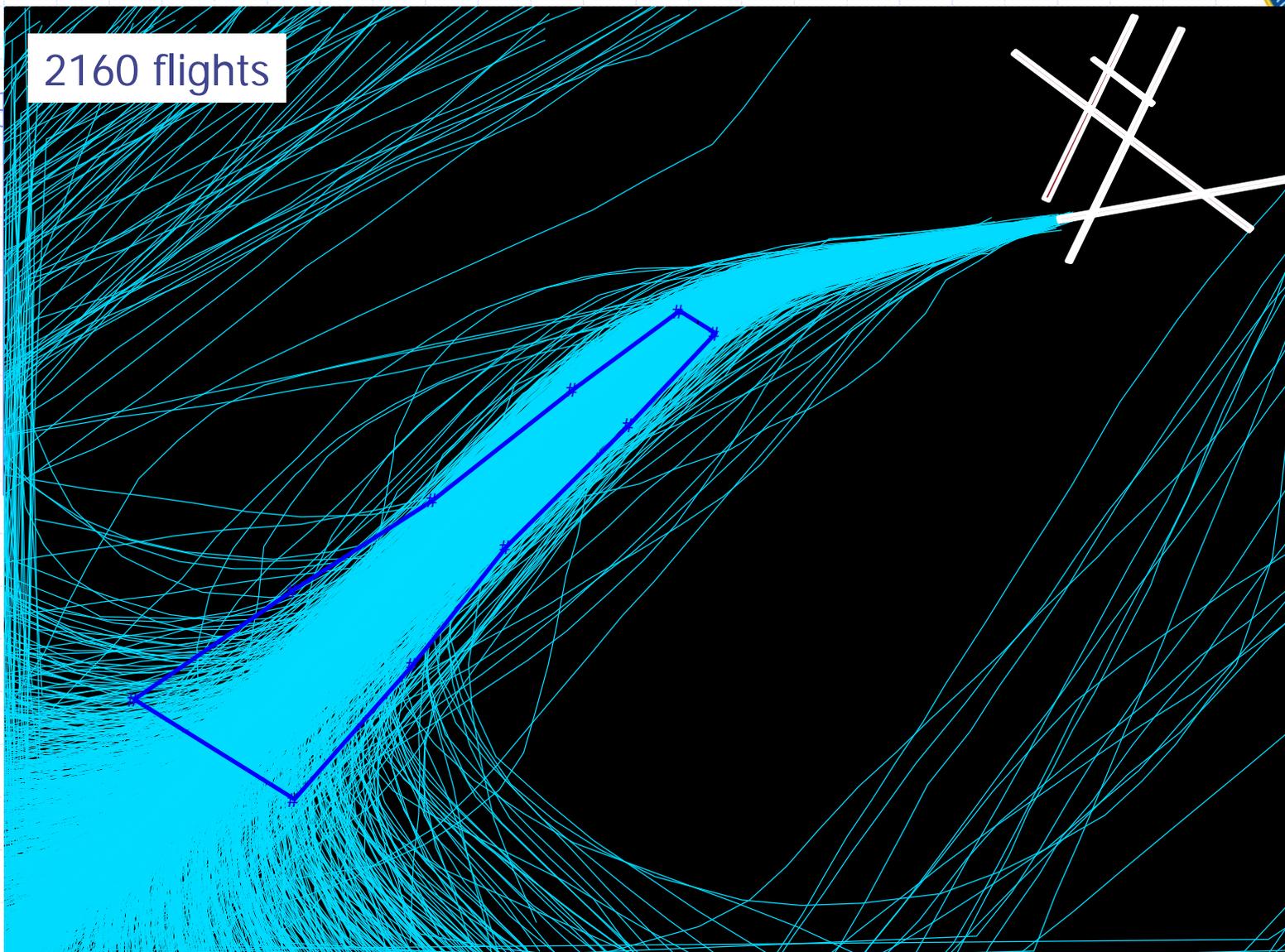
Aircraft Type

Aircraft type	Total Runway 27 departures	Percent below average at making all 5 gates	Aircraft type	Total Runway 27 departures	Percent above average at making all 5 gates
B752	2188	-25%	E135	2160	15%
CRJ1	798	-13%	A319	1890	7%
MD88	581	-24%	CRJ2	1366	5%
MD82	242	-6%	B712	1070	16%
B734	171	-9%	A320	1039	7%
B72Q	137	-15%	B733	640	4%
MD83	135	-10%	E145	614	2%
H25B	110	-5%	B735	382	8%
MD80	94	-35%	E190	369	10%
C560	69	-10%	B738	260	18%
B772	65	-7%	A306	151	12%
B732	63	-9%	B737	140	16%
CL60	62	-5%	E170	84	30%
BE40	61	-6%	A321	76	9%
LJ35	54	-29%	C750	68	14%
C550	46	-13%	GLF4	65	11%
DC10	43	-15%	C56X	55	1%
B722	40	-34%	F2TH	46	4%
B763	40	-24%	CRJ9	28	11%
LJ60	39	-13%	F900	21	15%

E135



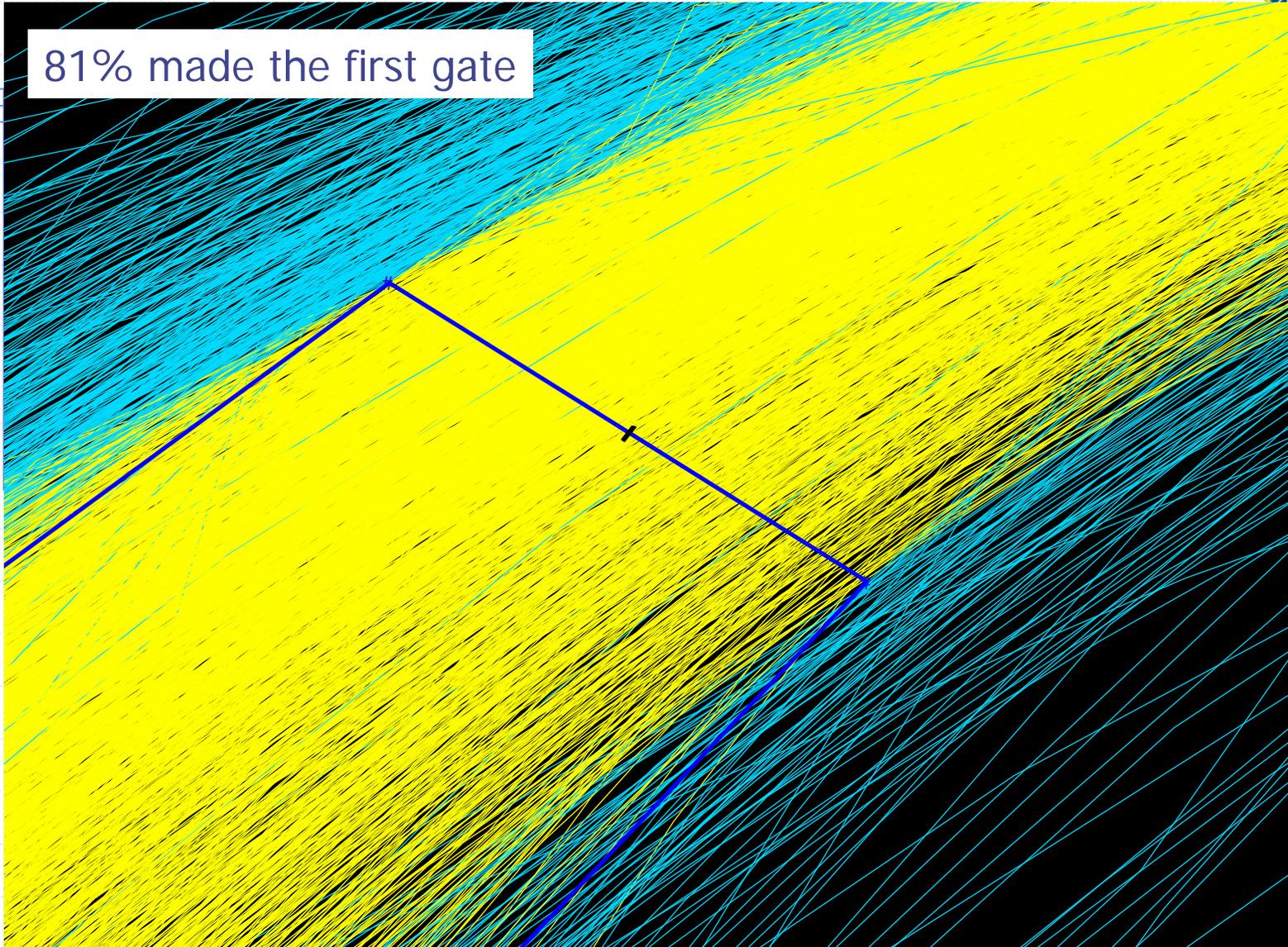
2160 flights



E135



81% made the first gate



E135



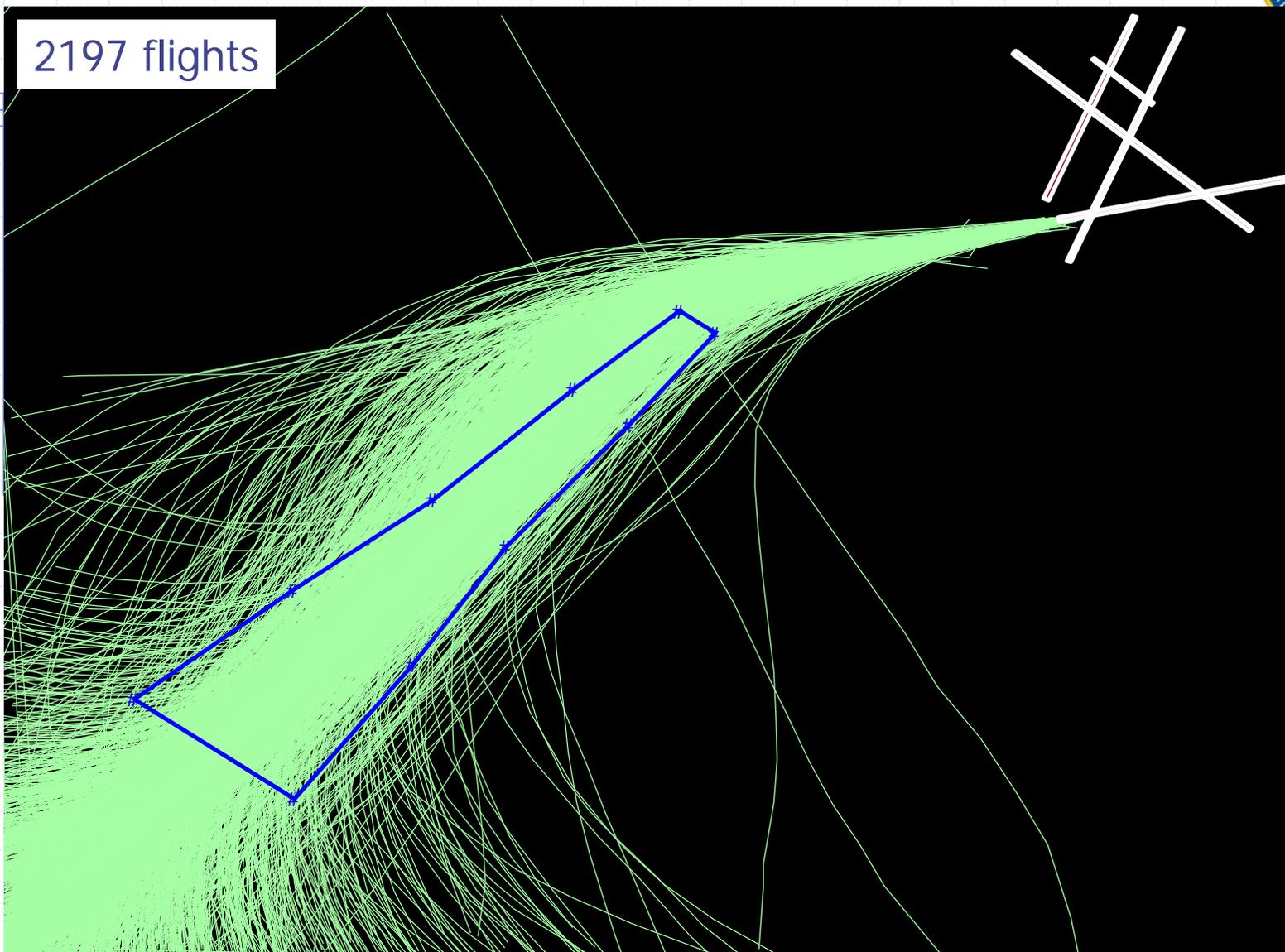
14% miss to the West

4% miss to the East

B752



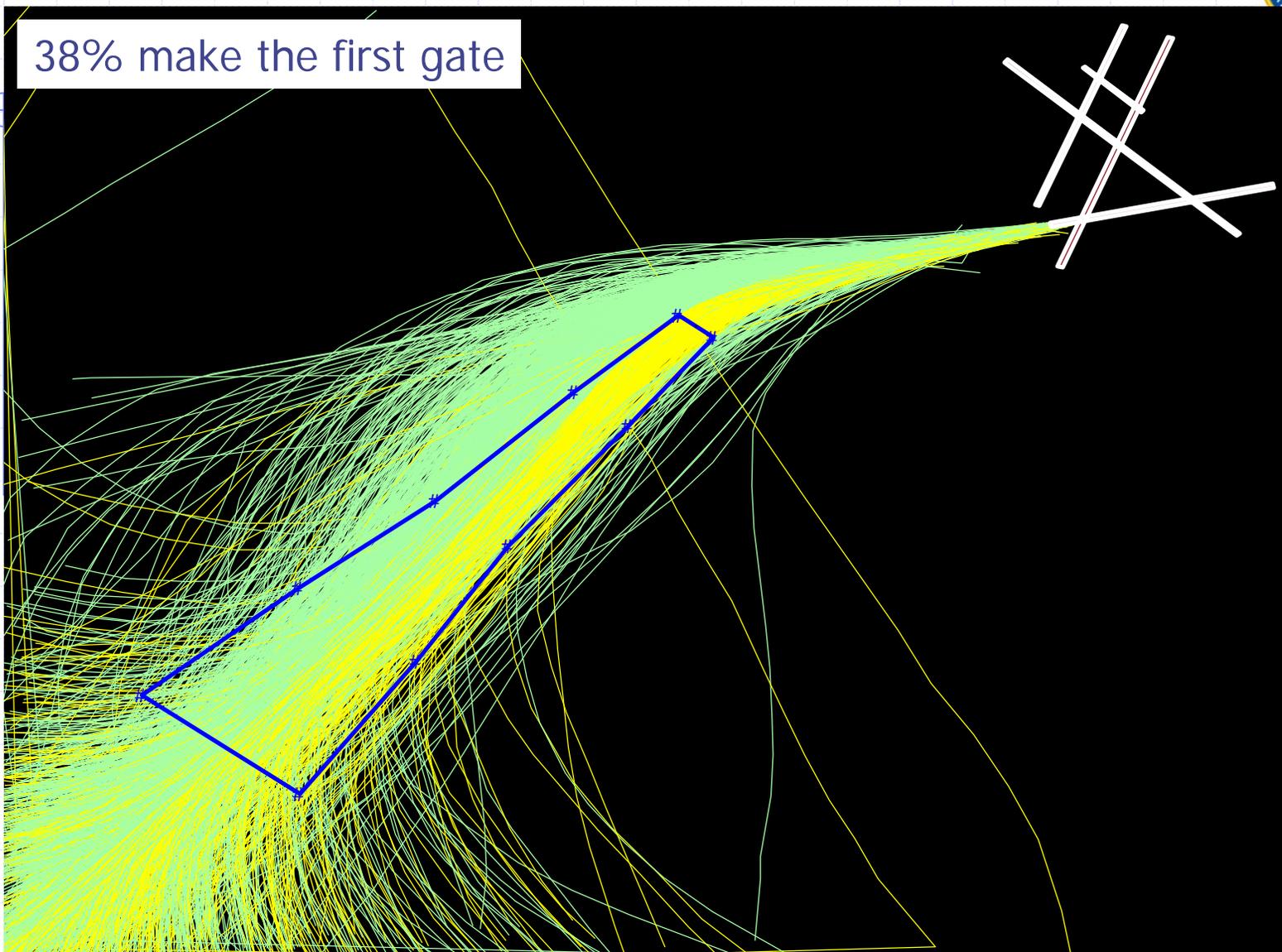
2197 flights



B752



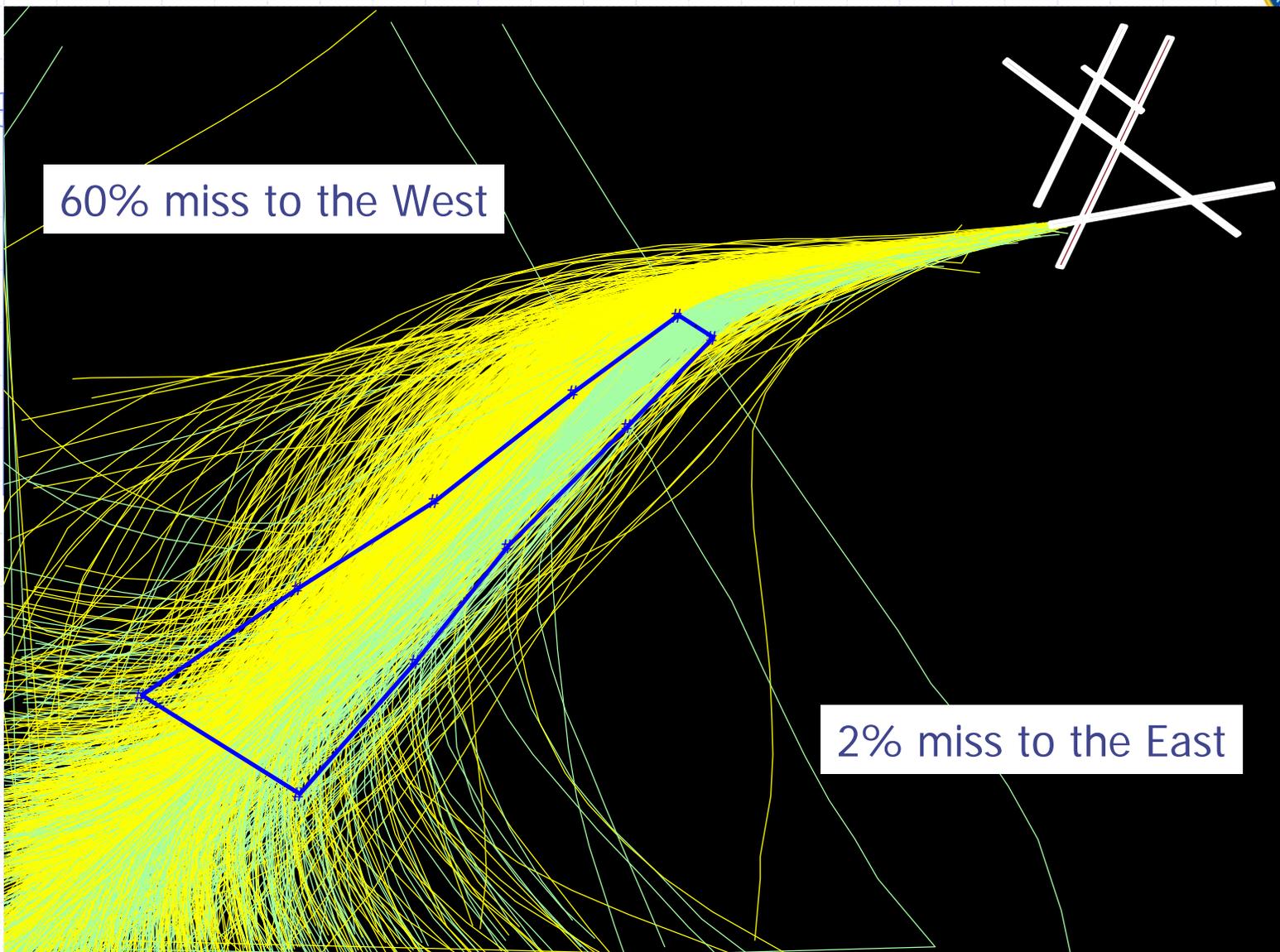
38% make the first gate



B752

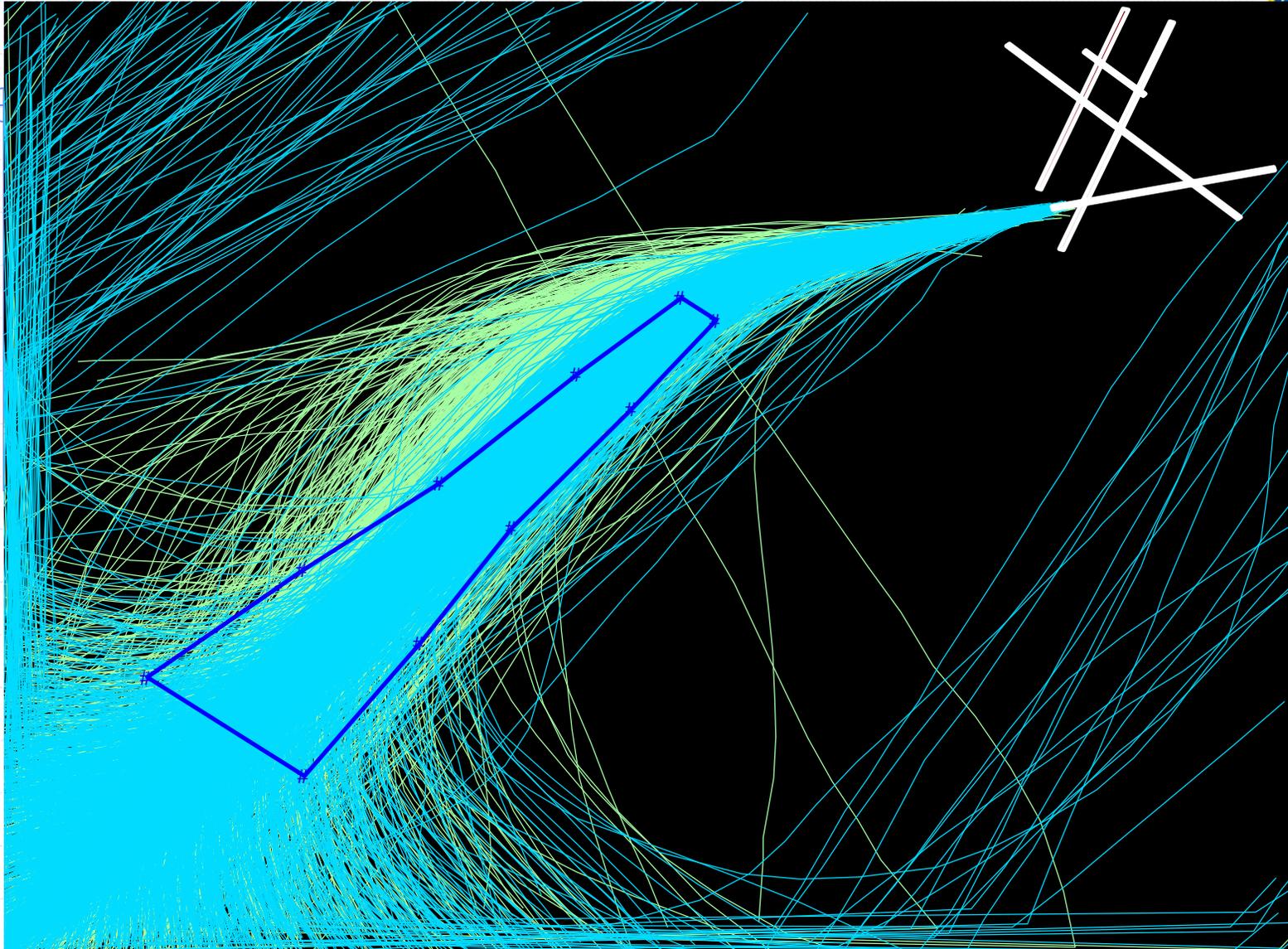


60% miss to the West



2% miss to the East

E135 vs. B752





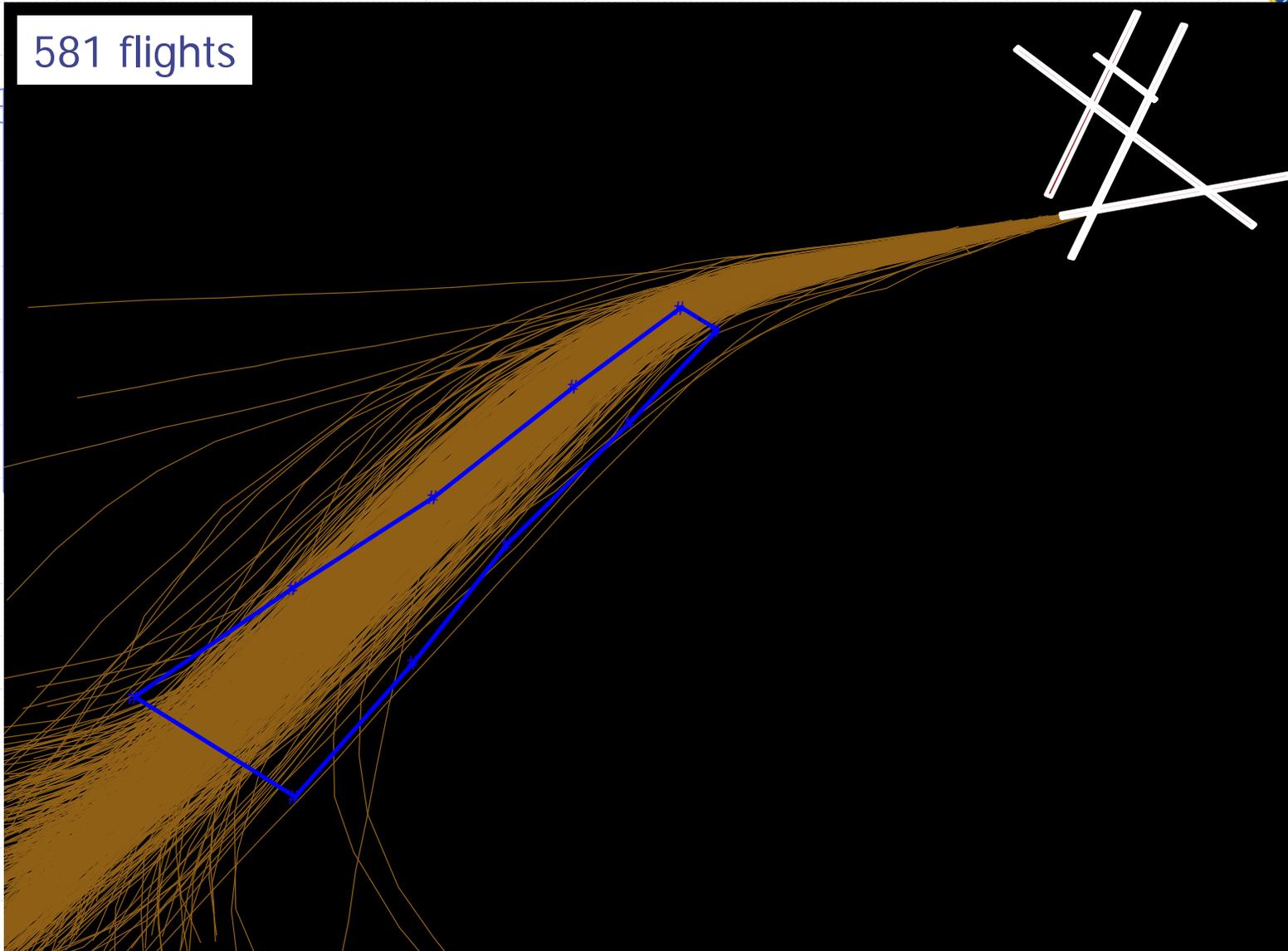
B752

- Most common aircraft departing runway 27
- More likely than average to miss the first gate
- Over twice as likely to miss the first two gates
- However... if they can make the first gate, there's a 83% chance they'll remain in the corridor for all five gates, which is average
- All data indicate B752s are trying to make the corridor, but can't make the first one or two gates

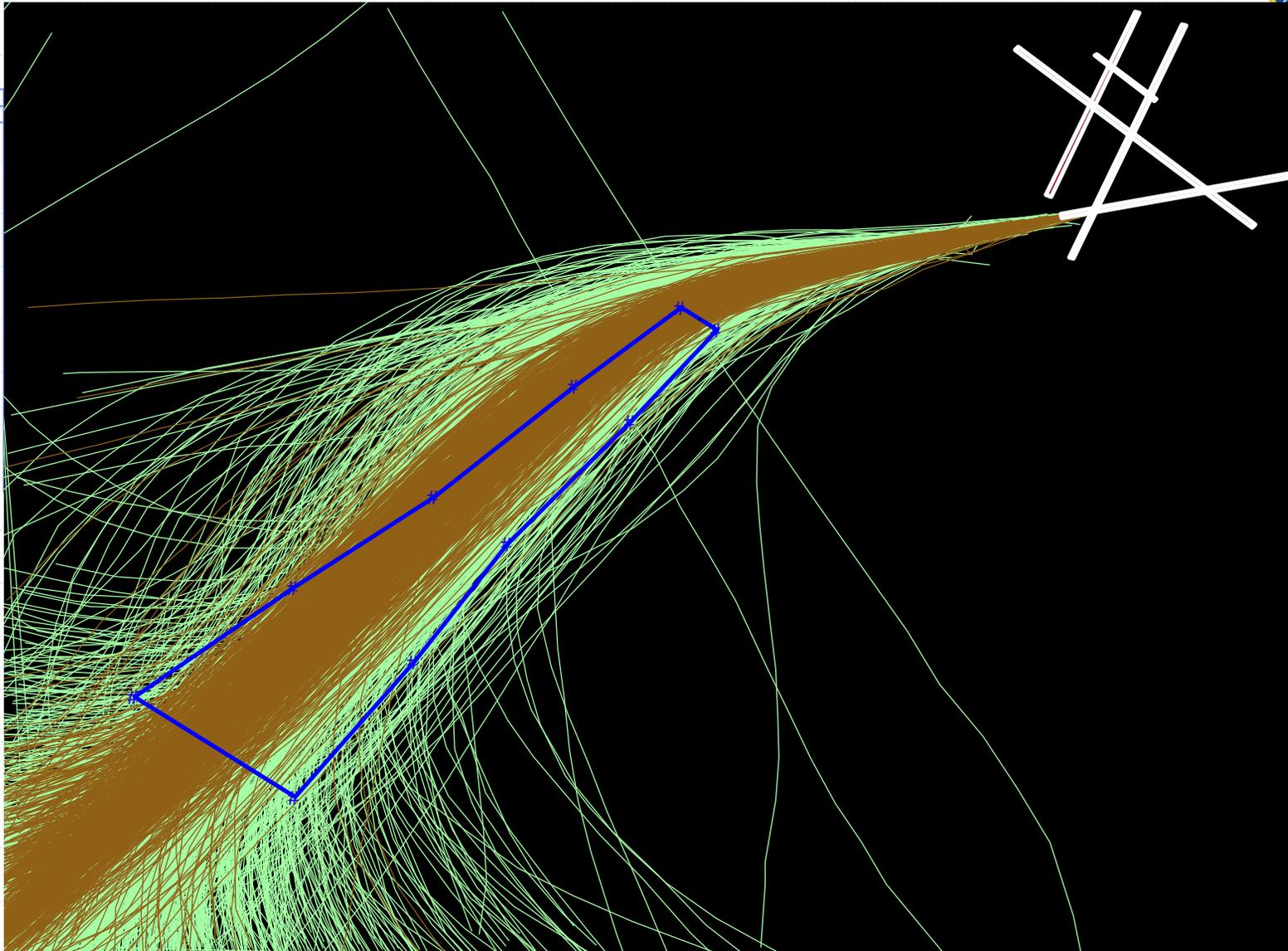
MD88



581 flights



MD88 vs. B752





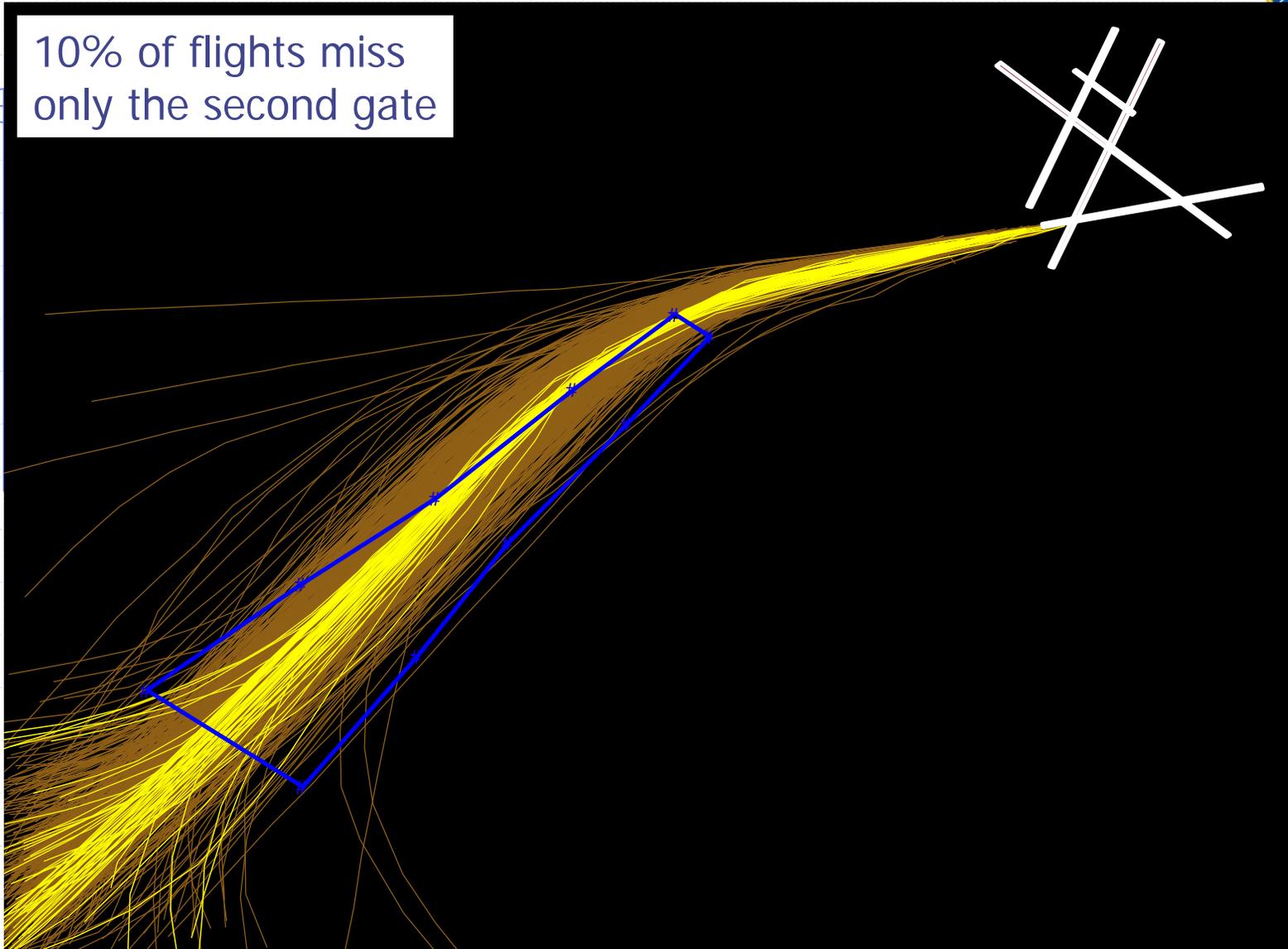
MD88 vs. B752

Gate Summary	Average of all Aircraft	MD88	B752
Miss all five gates	2.41%	2.24%	2.33%
Miss the first four	1.43%	3.44%	2.24%
Miss the first three	5.77%	28.23%	9.51%
Miss the first two	11.90%	11.53%	31.26%
Miss the first one	9.97%	3.10%	13.71%
Miss only the second	2.84%	10.50%	2.19%
Miss the last one	3.21%	0.17%	2.01%
Make all five	56.70%	32.70%	31.81%

MD88



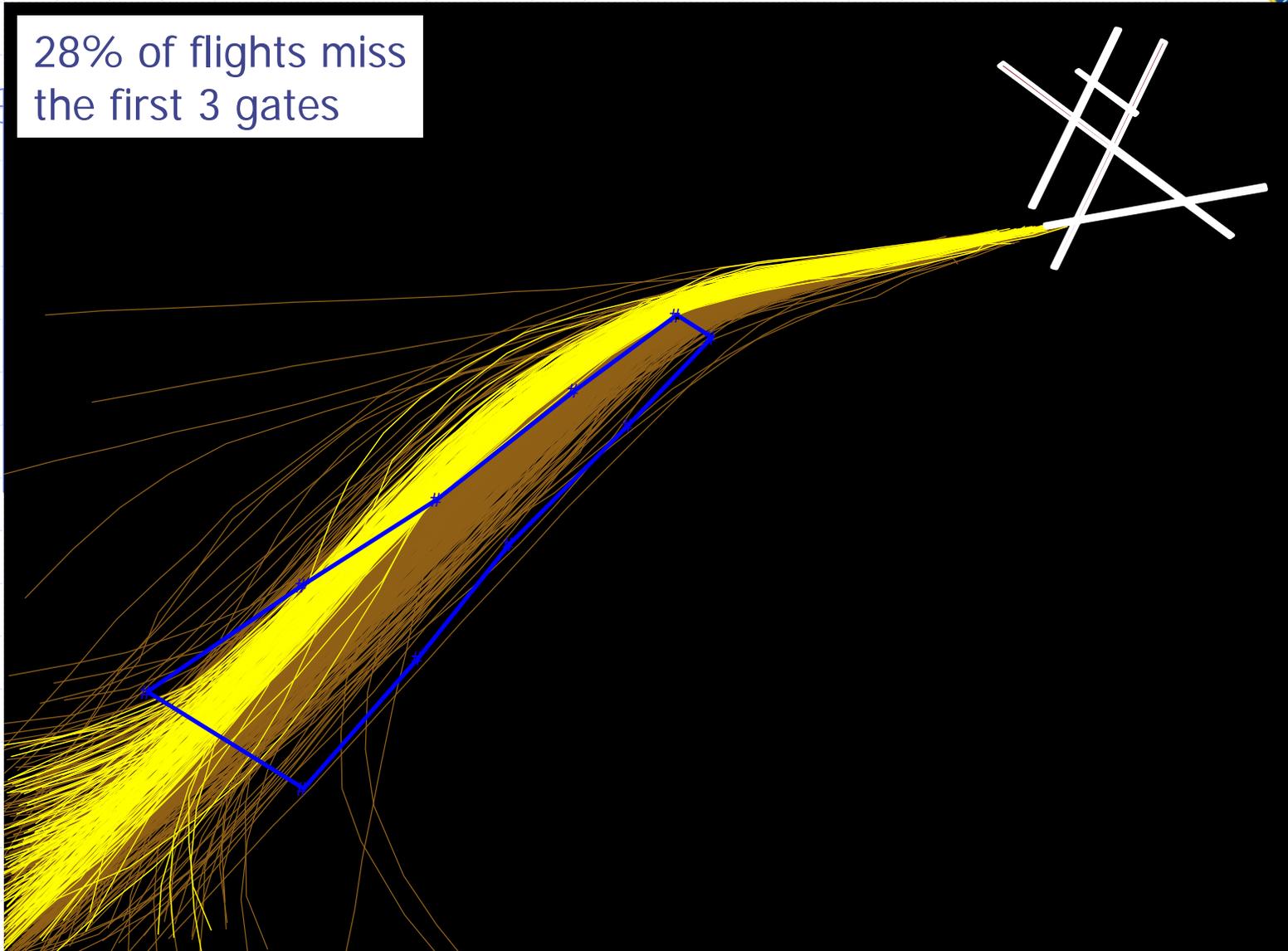
10% of flights miss only the second gate



MD88



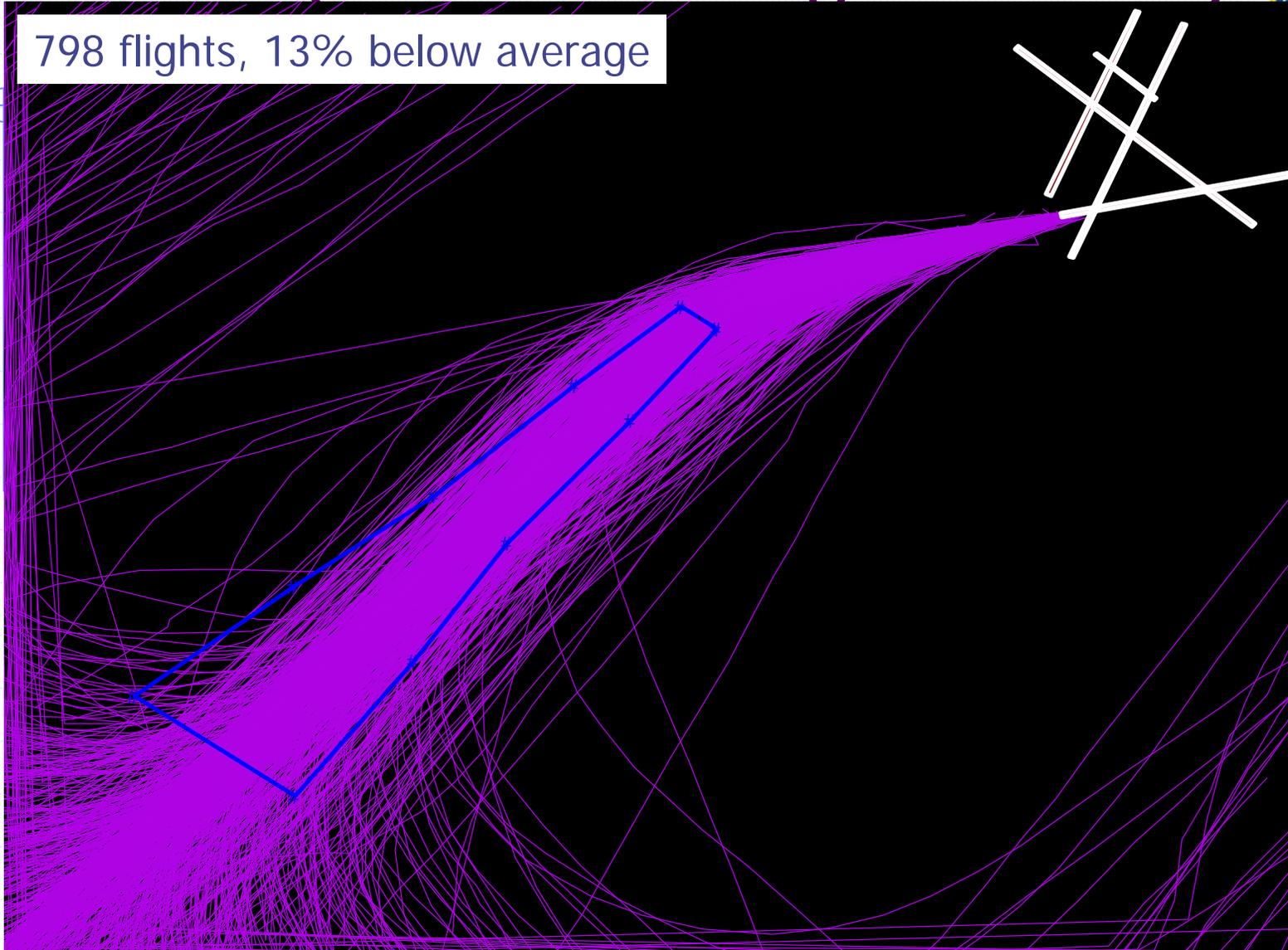
28% of flights miss the first 3 gates



CRJ1 (Below Average Aircraft)



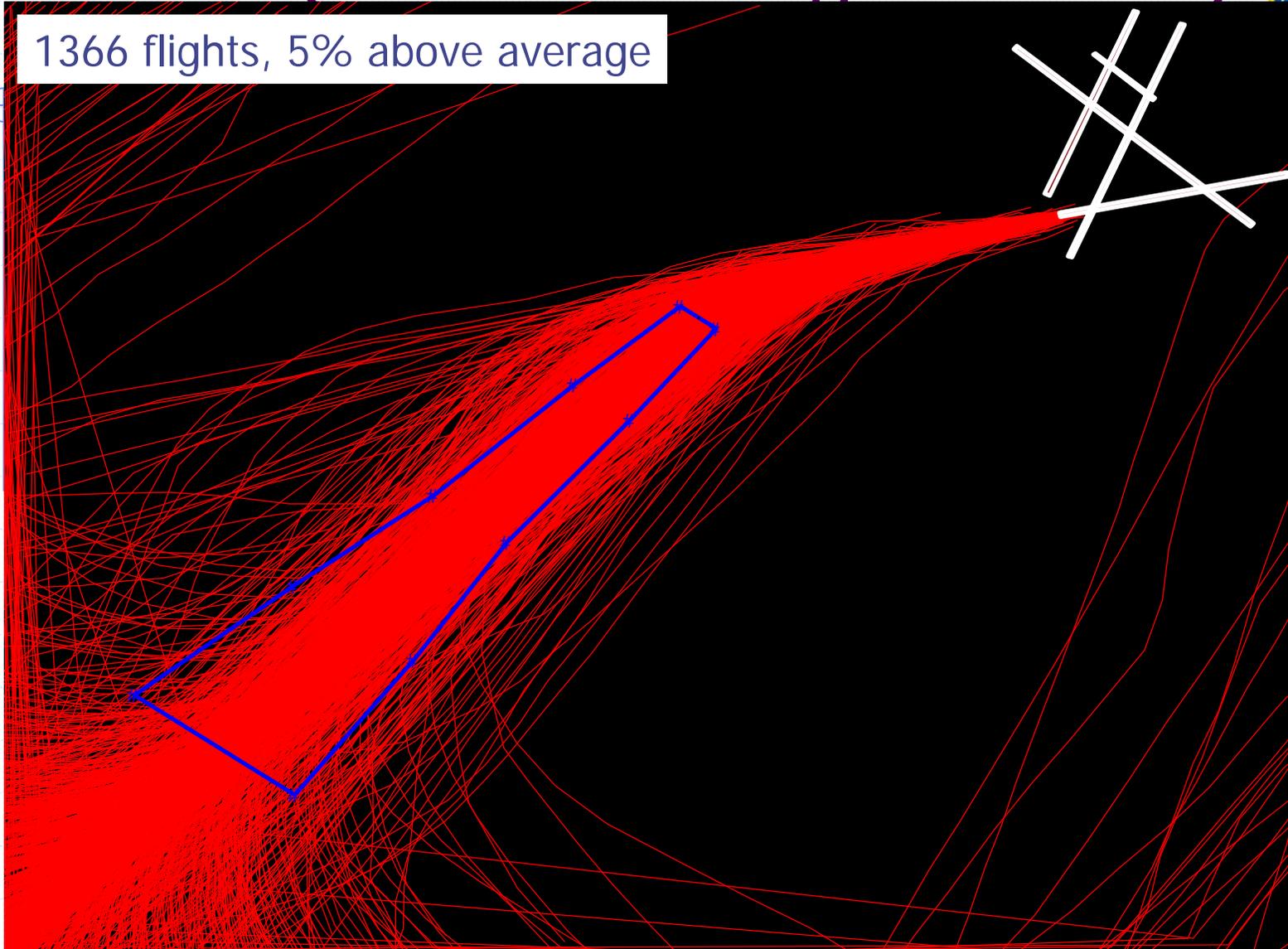
798 flights, 13% below average



CRJ2 (Above Average Aircraft)



1366 flights, 5% above average





Aircraft Type by Airline

- Aircraft performed above or below average regardless of airline.
- Airline's overall performance was dictated by the fleet of aircraft they used on runway 27
 - E.g. Delta:
 - Overall = 39% at making all five gates
 - B752 = 30% at making all five gates
 - MD88 = 33% at making all five gates
 - **B733 = 83% at making all five gates**



Below Average Aircraft by Airline

	Boeing 757-200 Aircraft Type					
	Average For All Aircraft	Delta Airlines	American Airlines	United Airlines	US Airways	Northwest Airlines
Made all 5 gates	56.70%	30.16%	39.81%	17.66%	37.17%	36.07%
Missed the last gate	3.21%	1.76%	3.52%	1.36%	0.52%	1.09%
Missed the first gate	9.97%	12.32%	12.59%	19.57%	12.57%	13.66%
Missed the first two gates	11.90%	32.98%	22.96%	44.02%	27.23%	31.69%
Missed all 5 gates	2.41%	2.58%	2.04%	1.36%	2.09%	2.19%



Above Average Aircraft by Airline

	Boeing 717-200 Aircraft Type		
	Average For All Aircraft	AirTran Airways	Midwest Airlines
Made all 5 gates	56.70%	71.54%	76.24%
Missed the last gate	3.21%	2.07%	0.99%
Missed the first gate	9.97%	4.84%	6.93%
Missed the first two gates	11.90%	7.26%	5.94%
Missed all 5 gates	2.41%	0.69%	0.99%



FMS Departure Procedure

- A Flight Management System (FMS) on board allows the aircraft to fly an FMS departure procedure
- Flights that used an FMS departure procedure for runway 27 were not recorded in Offload or ETMS data
 - Received that data from the FAA and Massport
 - Subset of Offload data



FMS vs. Non-FMS

- Flights that used the FMS departure procedure performed 2% better than average at making all five gates
- Flights that did not use the FMS departure procedure performed 7% below average at making all five gates
- Certain aircraft types do noticeably better when using the FMS departure procedure
- 73% of known FMS equipped aircraft with equipment code J used the procedure
- 54% of known FMS equipped aircraft with equipment code K used the procedure



Navigational Equipment

- Equipment suffix codes represent a very complex hierarchy of navigational equipment systems and standards
- Difficult to determine exactly what equipment was available on board vs. what was used
- We found that the four major equipment codes – J,K,L,Q – had no significant correlation to a flight's corridor compliance
 - Aircraft types performed above or below average regardless of the J,K,L, or Q equipment types on board.
 - There was a slight disadvantage to equipment type W since it has no RNAV capabilities



Weather Conditions

- There was very little correlation between corridor compliance and meteorological conditions at the time of departure
- Little or no impact from:
 - Wind speed
 - Wind direction
 - Sky conditions
 - Visibility
 - Wind gusts



Departure Time

- Although flights could be 5% better at making all five gates during the mid-day (10 AM to 2 PM), it was because of the coincidence that more above average aircraft tended to fly during that time.



Seasonal Variation

- There was a slight drop (<4%) in corridor compliance during the winter months (Nov-Feb)
- There was a slight increase (<4%) in corridor compliance during the summer and Fall (Jul-Oct)



User Class

- There was no correlation between a flight's user class and its ability to fly within the corridor
- Although the cargo carriers overall are about 6% below average at making all five gates, it is due to the fleet of aircraft they fly
- Although cargo carriers used runway 27 predominately from 7 AM to 9 AM, and 10 PM to Midnight, there was no relationship to time of day, only aircraft type.



Recommendations

Conclusion:

- Certain aircraft types have a very difficult time making the first gate, first two gates, or first three gates of the corridor, regardless of other factors such as airline, weather, and navigational equipment. It must be emphasized that in most cases, corridor compliance was linked to aircraft type, not to the airline.

Recommendation:

- The FAA needs to work with all airlines which use these types of aircraft (specifically, the B752, CRJ1, MD88, and MD82 aircraft) to determine what specifically causes them to overshoot the first gates of the corridor. Would procedural changes be beneficial for these aircraft types?



Recommendations

Conclusion:

- Using the FMS departure procedure improves certain aircrafts' ability to make all five gates of the corridor.

Recommendation:

- The FAA should hold discussions with the airlines in order to increase use of the FMS procedure, and to determine how often aircraft are equipped with FMS systems but do not use the procedure



Recommendations

Conclusion:

- Despite making the first three or four gates of the corridor, some aircraft leave the corridor before crossing the fifth gate. In many cases, staying on course for a few more seconds would give an aircraft perfect compliance for all five gates

Recommendation:

- The FAA needs to meet with the airlines and ATC to determine why this is happening. This could be a simple step to increase overall compliance averages.



Discussion