Analysis of Jet Departures from Boston Logan Runway 27

conducted by

Mark Lesko
The CNA Corporation

supporting
FAA System Operations
Aeronautical Information Management

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Executive Summary

At the request of the FAA's Eastern Terminal Service Unit, the FAA's System Operations Aeronautical Information Management Team conducted an analysis of jet departures off of Boston Logan's runway 27. The purpose of the study was two-fold: 1) Determine how often aircraft deviated from the runway 27 departure corridor, and 2) Identify any trends among flights that did, and did not, fly inside the corridor.

We collected nine months of Boston TRACON STARS radar data (July 2005 to March 2006), selected only runway 27 jet departures, determined which of the corridor's five gates were flown through, and concatenated the results in a spreadsheet so that we could study the data according to several categories. Our overall findings were that:

- There were a total of 15,962 runway 27 jet aircraft departures.
- 57% made all five gates.
- 3% made the first four gates, then left the corridor before crossing the fifth gate.
- 2.4% missed all five gates.
- 1.4% missed the first four gates, then made the last gate.
- 10% missed only the first gate.
- 12% missed the first two, but then went on to make the last three.
- 3% made the first gate, overshot and missed the second, but then resumed course and made the last three.
- There was an 85% chance that if a flight made the first gate, it would go on to make all five.
- There was a 91% chance that if a flight made the first two gates, it would go on to make all five.

In general, the most important factors for a flight to remain in the corridor were, in order:

1. Aircraft type
2. FMS vs. Non-FMS departure procedure
3. Navigational equipment on board
4. Weather conditions
5. Departure time of day
6. Month of year
7. User class

There was a definite pattern among aircraft type and their ability to make all five gates of the departure corridor. The following table lists these aircraft, sorted in descending order of use on runway 27.

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%

In many cases, using the FMS departure procedure improves a flight's ability to make all five gates of the corridor. In some cases, using FMS can move an aircraft type from below average corridor compliance to above average. Our findings also indicate that not all aircraft equipped with FMS systems are using the FMS procedure.

An aircraft's navigational equipment on board (according to the ETMS equipment suffix code) had very little impact on the ability of the flight to stay within the departure corridor. Although we found that equipment codes J and K could be 20% below average at making all five gates, the codes were actually very dependent on aircraft type – i.e. equipment types J and K tended to perform below average on below average aircraft, and above average on above average aircraft.

We investigated the impact of weather on a flight's ability to make the corridor. After matching the recorded meteorological conditions to a flight's departure time, we found no significant connection between making all five gates and the visibility, wind speed, wind direction, or cloud cover at departure time.

The departure time of a flight had little impact on it staying inside the corridor. Initially, we found that if a flight departed between 10:00 AM and 2:00 PM local time, it had a much higher chance of flying within the corridor. However, upon

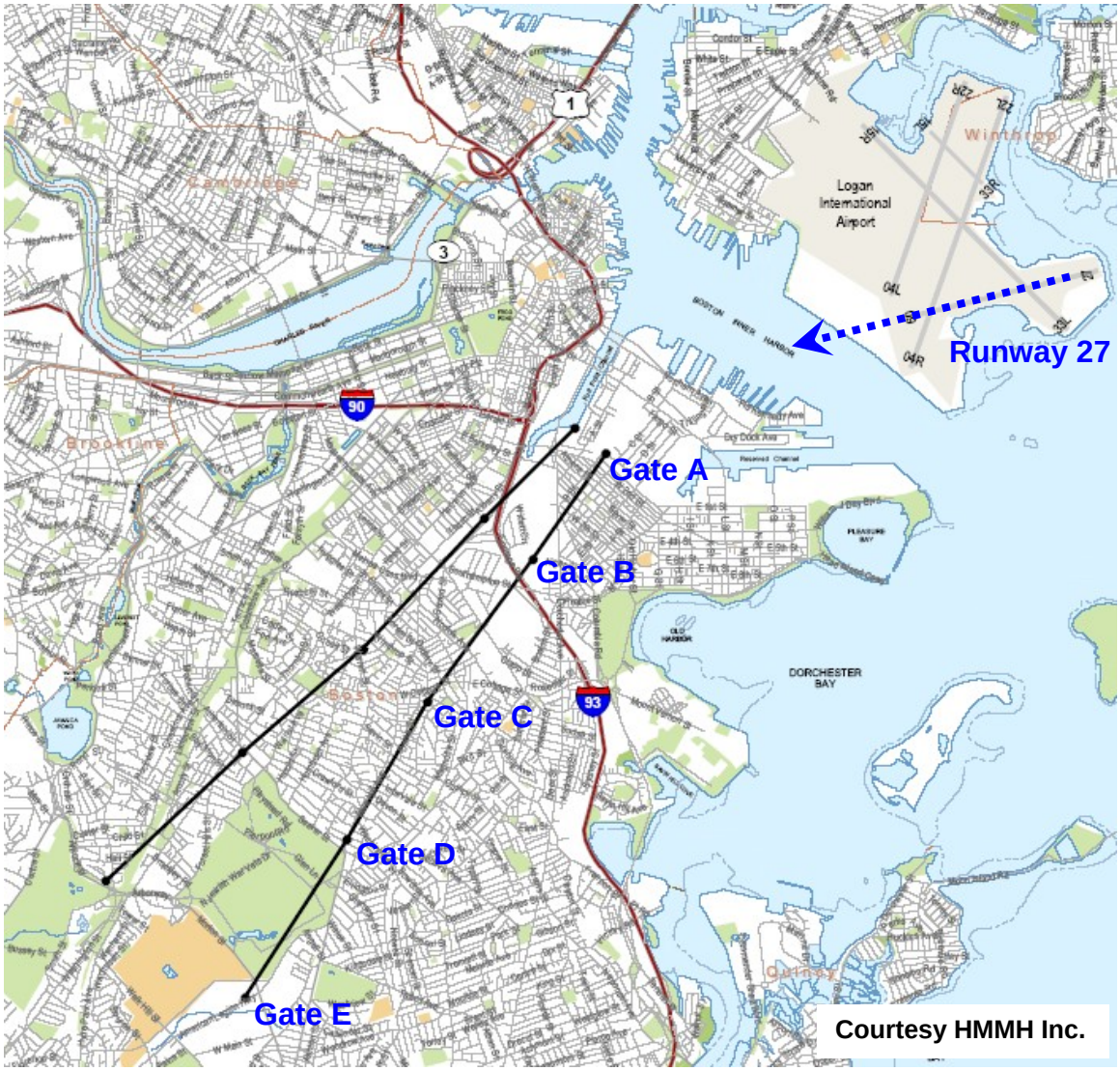
closer study, we learned that this is due to a coincidentally higher number of "above average" aircraft departing during those hours.

We found few trends in monthly variations impacting a flight making the corridor. There was higher traffic during certain months (e.g. March 2006), but the percentage of flights in the corridor remained constant. There was a small trend for some of the "below average" performing aircraft types to do even worse during November and December.

There was little correlation between a flight's "user class" (i.e. commercial, cargo, military, G/A, and air taxi) and its ability to make all five gates of the corridor. Cargo flights sometimes had problems making the corridor, but this was attributed to cargo carriers having the majority of their fleet comprised of aircraft that were noticeably above or below average.

Background

According to a 1996 record of decision, 68.2% of jet departures off of Boston Logan's runway 27 need to comply with the departure corridor depicted below.

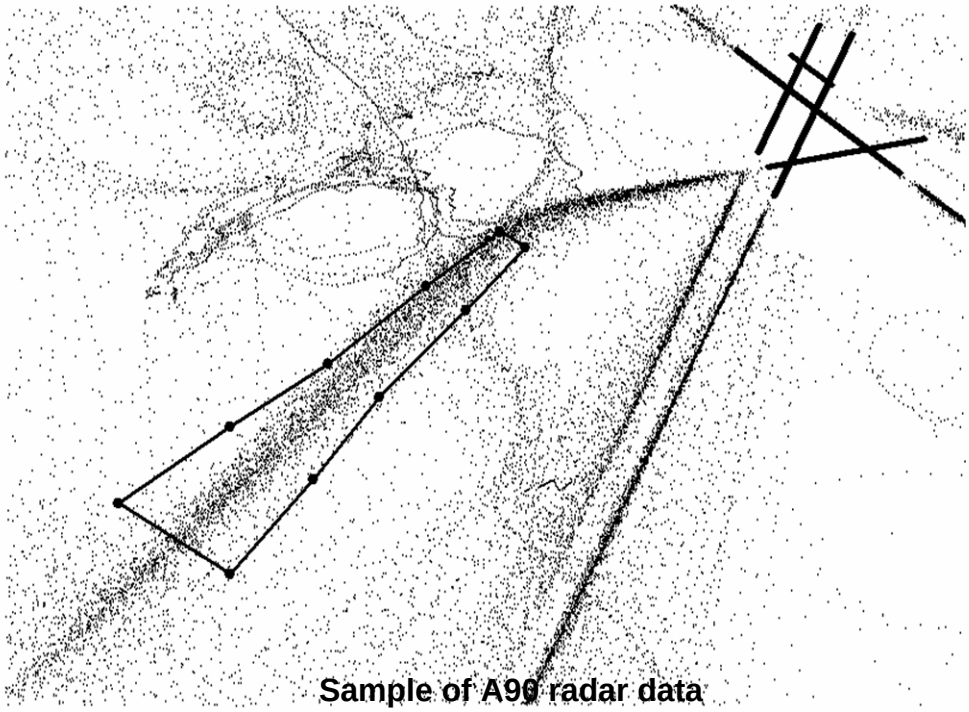


In September 2005, the FAA asked the Aeronautical Information Management Team to study several months of runway 27 departures and then to derive various statistics on how many flights make each of the five gates.

Data Collection

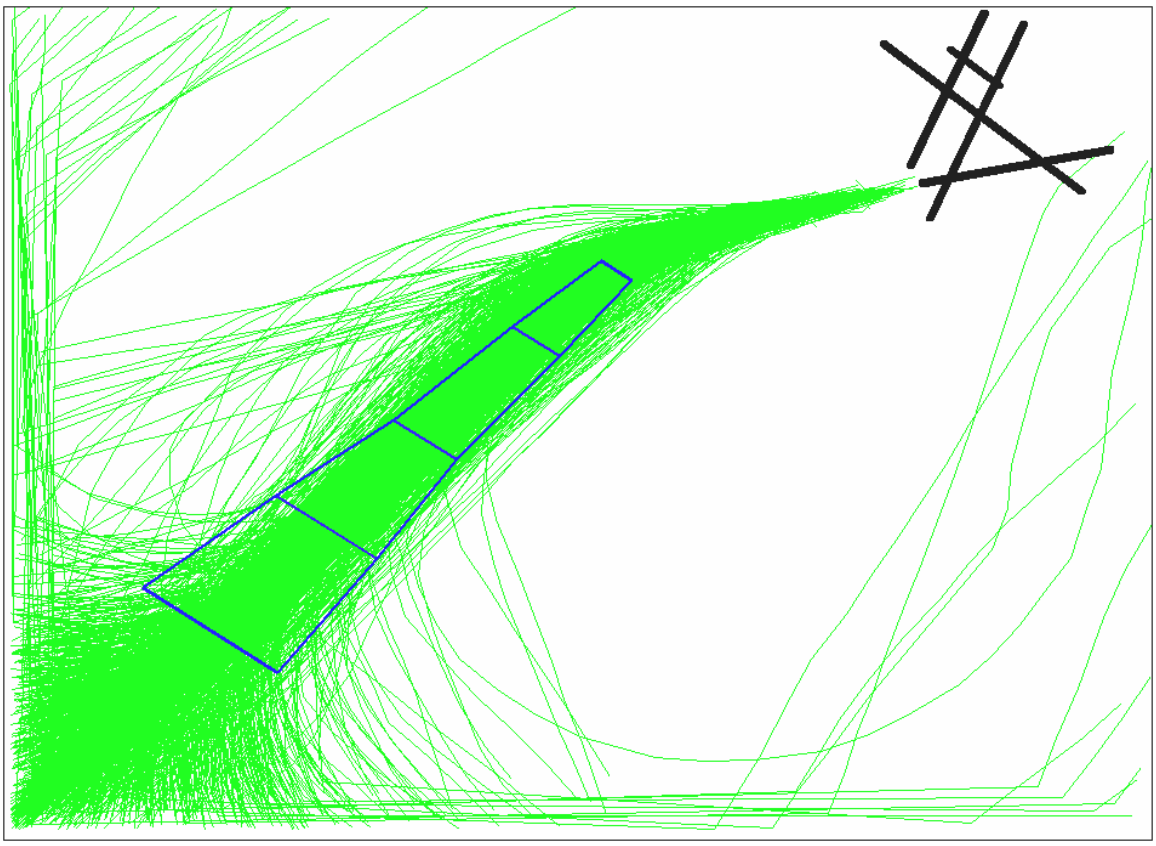
We collected STARS radar data from Boston TRACON (A90) for the dates July 4, 2005 to March 31, 2006, for a total of 271 days. Thirteen of these days of data were not able to be retrieved due to network outages and database failures. But of these thirteen days, only three had runway 27 departures. Ultimately we archived and processed 258 days of data.

The A90 STARS system produced radar returns about every five seconds for each flight within the ASR9 primary radar's footprint. The image below shows a sample of A90 radar hits and the departure corridor.



Sample of A90 radar data

The first step in our processing was to remove all radar hits except for those of aircraft which departed runway 27. Determining runway 27 departures was a difficult task since we had no database available listing the runway used by Logan departures. Therefore, we produced a computer program that determined runway 27 departures based on a flight's first few radar hits, the bearing of those hits, the aircraft's altitude, and its geographic location west of runway 27. Once we had only runway 27 departures, we "connected the dots" of the radar hits to produce a flight track. An example of the results for one month of runway 27 departures can be seen below.



Runway 27 departures, July 2005

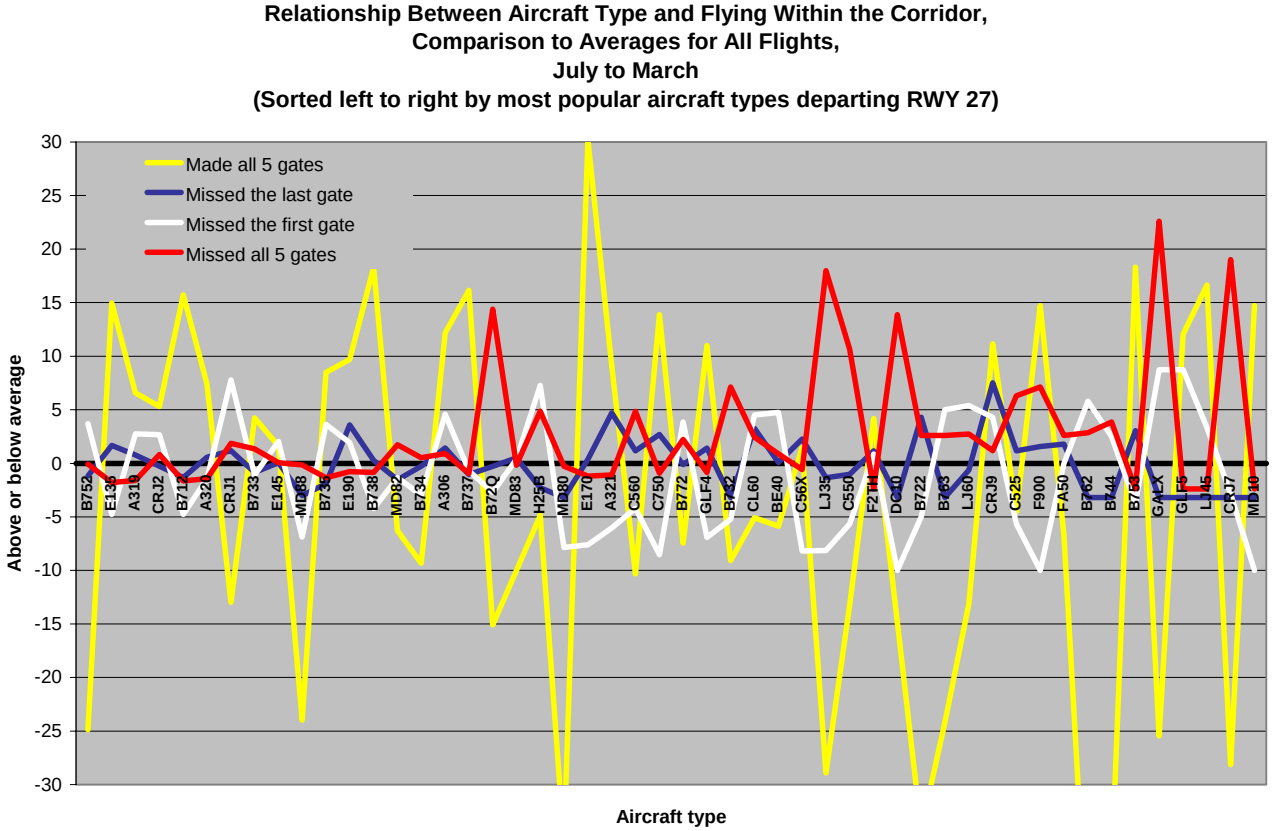
Our next step was to examine each flight track and determine which of the five gates it passed through. Again, this was done with a computer algorithm. The results were then merged with ETMS data in order to obtain each flight's navigational equipment on board the aircraft (this data was not available in the STARS radar information at A90.) We then loaded all nine months of data into an Excel spreadsheet so we could study the data by aircraft type, navigational equipment, etc.

Aircraft Type

We investigated the relationship between a flight's aircraft type and its ability to stay within the corridor. We did this by plotting four key indicators of corridor performance:

1. The percentage of flights for a given aircraft type that made all five gates,
2. The percentage of flights for a given aircraft type that made the first four gates, but missed the last gate,
3. The percentage of flights for a given aircraft type that missed the first gate, but went on to make all of the next four gates, and
4. The percentage of flights for a given aircraft type that missed all five gates.

However, instead of plotting the percentage, we plotted the difference in percentage points relative to the overall average for each of the four categories above. This gave us a better understanding of aircraft type which performed above and below average. For example, in the following chart we see that E135 aircraft were about fifteen percentage points better than the average for flights that made all five gates (71.7% of E135 flights made all five gates, compared to the nine month average of 56.7% for all aircraft types). Meanwhile, B752s were about 25% below average at making all five gates (31.8% vs. 56.7%).



We see that some aircraft were much better than others at flying within the corridor. Some larger aircraft like B752s and MD88s had a difficult time making all five gates compared to other aircraft types. Some smaller jets like E135s, E170s, and CRJ2s did well. However we found that aircraft size and performance could not be correlated to corridor performance. For example, B712s and B738s are larger aircraft, but did very well compared to average. And smaller CRJ1s and LJ35s were below average at remaining in all five gates of the corridor.

Keep in mind that for this chart, being "below average" can be a positive trait depending on which of the four categories you study. For example, the white line represents an aircraft type's performance in missing the first gate, but going on to make the next four. E135s were 5% below average, meaning that 5% fewer of their flights missed only the first gate compared to all aircraft types.

The blue line represents flights that made the first four gates, but then missed the last gate. This is an indicator of how much better an aircraft type could be doing at making all five gates, since missing the last gate lowers an aircraft type's "perfect score" represented by the yellow line. For example, E135s are 15% above average at making all five gates, but the blue line shows that they are slightly higher compared to average at the number of their flights which miss the last gate of the corridor. Essentially, E135s could have done better if only some of their flights had stayed in the corridor for only a few more seconds.

The red line indicates aircraft types which are above or below average at missing all five gates, i.e. For whatever reason, they did not make the corridor at all. For example, B72Qs had poor performance in this category compared to the average. 16.8% of B72Q flights miss all five gates, compared to the overall average of 2.4%.

Much can be inferred from this chart, and we can get an idea of which aircraft types need to make changes to improve their performance at maintaining flight within the corridor.

Does an aircraft type's corridor performance depend on the airline that uses it? To find out, we "drilled down" into the aircraft data and investigated this further.

Aircraft Type and Airline

We looked at several aircraft types that performed below average at making all five gates of the corridor, and then investigated if they performed below average regardless of the airline using the aircraft. The most used aircraft type over the nine months of runway 27 departures was the Boeing 757-200 (B752). This also happened to be a significant underperforming aircraft in gate compliance. The

following table shows the performance of the B752 across the five airlines that used it on runway 27.

	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%

We see that the B752 performed far below average regardless of the airline using it. This aircraft has a tendency not to make all five gates, a tendency to miss the first gate, and a strong tendency to miss the first two gates. This could be due to a B752's departure and climb capabilities. *This is a major issue since the B752 was the most frequently used aircraft for runway 27 departures during the nine month data collection.*

Other aircraft which have a difficult time making the first series of gates are MD82s and MD83s. These aircraft tend to overshoot the first, or first and second gates, something not unique to any airline using them. This indicates that pilots (regardless of airline) are trying to make the corridor, but are flying aircraft which do not possess the performance required to meet the strict standards of the corridor navigation.

If we look even deeper into, say, Delta Airlines, we find that their overall performance is brought down by aircraft types which have a difficult time making all five gates: B752s and MD88s. But when Delta uses B733s for runway 27 departures (an above average aircraft for making the corridor), they have an 83% success rate at making all five gates. Again, it could therefore be inferred that it's not the airline, it's the aircraft type.

Next we looked at an aircraft type that was above average at making all five gates of the corridor: The Boeing 717-200 (B712). The following table lists its performance percentages for both airlines that used it for runway 27 departures.

	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%

Regardless of airline, this aircraft performed very well in all categories when compared to average. It does not have a tendency to miss the first gate, the first two gates, and/or all five gates.

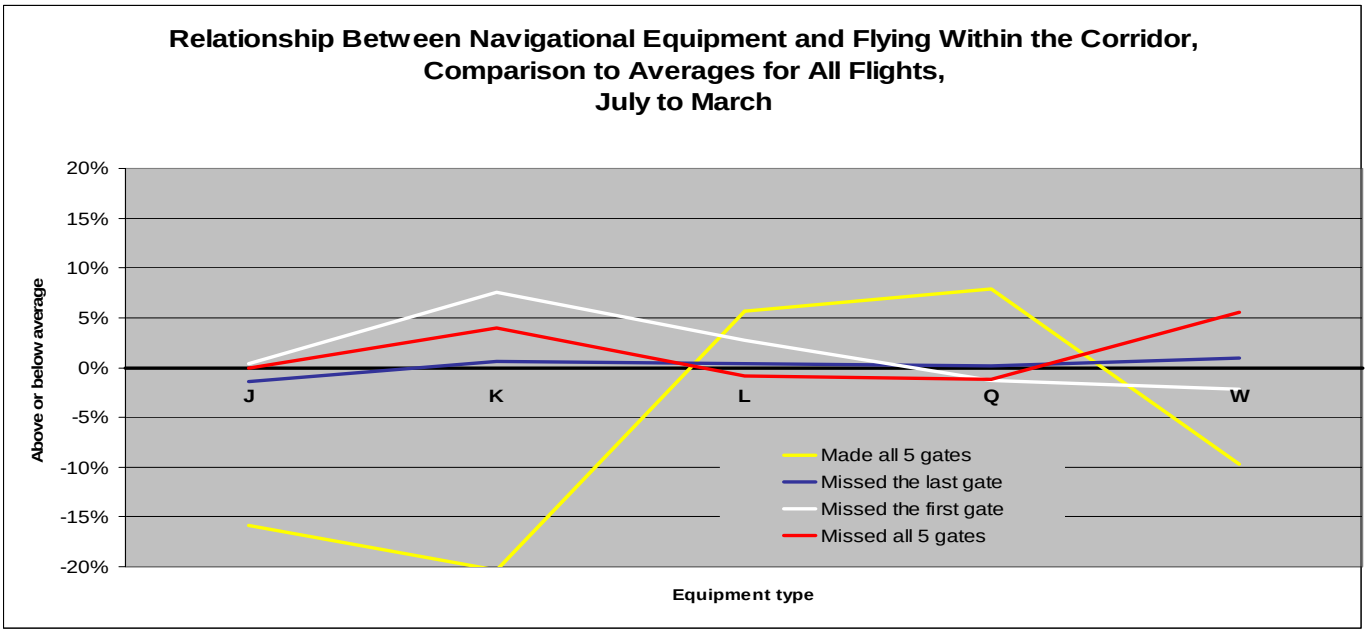
So is an aircraft's ability to fly within the corridor due to the performance characteristics of the aircraft, or is it due to the navigational equipment on board?

Aircraft Equipment

There are 21 different aircraft equipment codes that can be assigned to an aircraft in its flight plan. We obtained the equipment codes filed for each flight off of runway 27 from the Enhanced Traffic Management System (ETMS). The most common equipment types collected in our nine months of data were J, K, L, Q, and W, accounting for 99% of all flights. All others equipment codes were rare and have been excluded from our analysis. The following table describes these five codes, and is derived from FAA Publication 7110.65, Table 2-3-7

Equipment Code	Description of Navigational Equipment (All meet Reduced Vertical Separation Minimum (RVSM) standards)	Number of Flights
W	RVSM, but no Advanced Area Navigation (RNAV) equipment	1524
K	RVSM + RNAV of Flight Management System (FMS) but no Inertial Reference Unit (IRU)	553
J	RVSM + RNAV of FMS with an IRU	3121
L	RVSM + RNAV of Global Navigation Satellite System (e.g. GPS)	2827
Q	RVSM + RNAV of Required Navigational Performance (RNP) equipment	7820

Each of the above equipment codes represents a very complex hierarchy of navigational equipment systems and standards. Also, each code represents the highest level of navigational equipment and performance available onboard the aircraft, not necessarily the equipment which was used at the time of departure from runway 27. For example, in our study, a flight could have had equipment code L, but used FMS equipment during its runway 27 departure instead of GPS. Despite this caveat, we wanted to see if there was a relationship between equipment code and corridor compliance. The following table shows our findings.



At first glance it would appear that aircraft with J and K (FMS equipment) have a significant disadvantage compared to aircraft flying with L and Q (GPS and RNP). However, we must first correlate aircraft equipment with aircraft types to determine if there is any statistical significance to J and K underperforming. The following table lists several aircraft types which were above and below average at making the corridor, and the navigational equipment that was on board those aircraft.

Below Average Aircraft	Equipment Type	Total Number of Flights	00000 % Miss all 5	00001 % Miss first 4	00111 % Miss first 2	01111 % Miss first 1	10111 % Miss only 2nd	11110 % Miss last	11111 % Make all 5
B752	J	1611	2	2	32	14	2	2	32
B752	Q	480	3	2	31	14	2	1	30
B752	W	93	5	0	26	11	1	5	37
CRJ1	K	356	6	3	12	21	1	4	27
CRJ1	L	187	1	1	5	16	1	5	65
CRJ1	Q	47	0	0	4	26	0	0	66
CRJ1	W	185	4	0	8	13	4	5	47
MD88	J	581	2	3	12	3	11	1	33
MD80	J	48	2	8	21	4	15	0	17
MD80	Q	45	2	4	16	0	9	0	27
B72Q	W	121	19	5	4	7	0	3	39
Above Average Aircraft	**Equipment Type**	**Total Number of Flights**	**% Miss all 5**	**% Miss first 4**	**% Miss first 2**	**% Miss first 1**	**% Miss only 2nd**	**% Miss last**	**% Make all 5**
B733	J	350	4	1	8	10	2	2	64
B733	Q	152	1	5	9	9	3	1	67
B733	W	133	8	6	11	5	2	5	45
A320	J	80	5	0	9	10	1	4	68

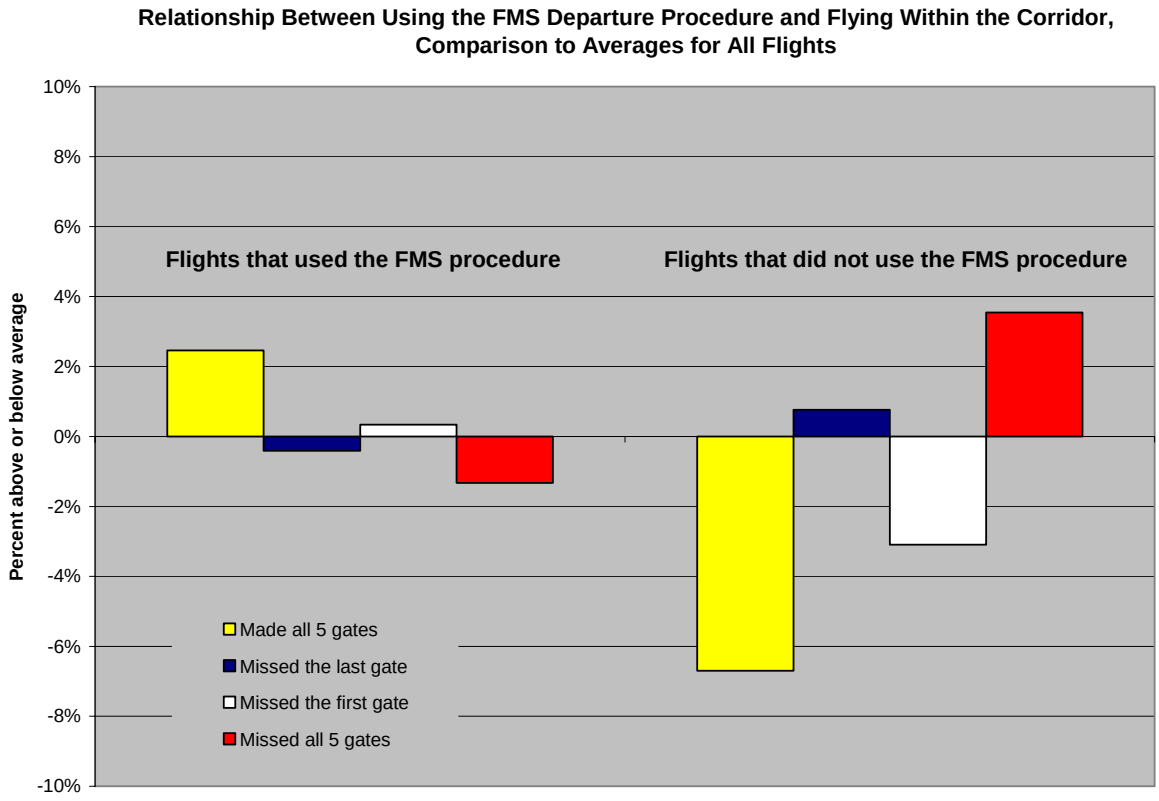
A320	L	84	1	0	6	11	4	6	64
A320	Q	818	1	1	10	9	4	4	64
E135	Q	2049	1	1	8	5	3	5	72
B712	Q	1066	1	1	7	5	5	2	73
B738	J	71	0	0	6	4	4	0	77
B738	Q	181	2	0	5	7	3	4	75
E170	Q	61	0	0	0	3	0	5	87
B737	Q	136	1	1	6	9	2	2	74
CRJ2	K	164	7	3	8	11	1	2	56
CRJ2	L	505	2	1	8	16	1	4	64
CRJ2	Q	379	1	5	6	10	2	2	70
CRJ2	W	269	8	3	6	9	3	4	52
E145	L	363	2	1	8	15	1	3	55
E145	Q	145	1	0	6	6	3	3	73
A319	L	1146	1	1	8	12	2	3	67
A319	Q	666	1	1	13	15	1	4	58

This chart shows there is little correlation between the navigational equipment on board and an aircraft's ability to make the corridor. A below average aircraft such as the B752 with equipment types J and Q still has a difficult time making all five gates (20% below average), and has a high chance of missing the first two gates (20% above average.) Likewise with an MD88 with equipment type J (20% below average for making all five gates) and with an MD80 with equipment type J and Q (30% below average.) Meanwhile, well performing aircraft such as an E135, E170, B733, and A320 with equipment types J and Q do well above average at making all five gates.

The only significant pattern we found was that aircraft with equipment type W consistently perform below average compared to all other equipment types and aircraft. This is due to having no Advanced RNAV navigational capabilities on board (e.g. FMS or GPS).

FMS vs. Non-FMS Departure Procedure

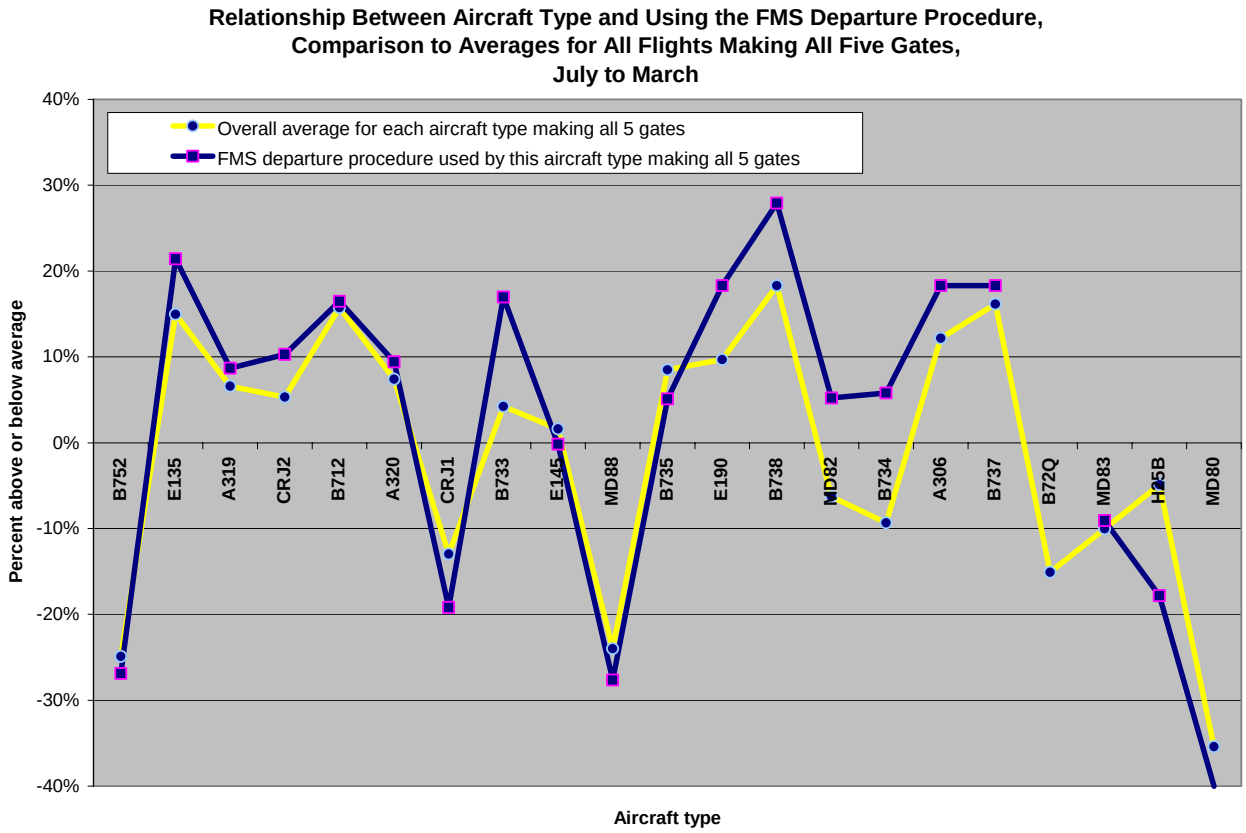
Massport, working with the FAA, provided us with a set of data which identified flights that used the FMS based Wiley 5 departure procedure. This flight data were limited to days when runway 27 was heavily used, and therefore was a subset of our daily offload data during the nine months. We matched the FMS flight data to the offload data so that we could obtain gate compliance statistics on FMS identified runway 27 departures. The following chart shows our results.



We can see that there is a slight advantage to using the FMS departure procedure over the non-FMS procedure. In all four categories, FMS outperformed non-FMS flights. Non-FMS flights were about 7% below average at making all five gates, and about 4% above average at missing all five gates.

FMS and Aircraft Type

We next investigated the relationship between flights that used the FMS departure procedure and the aircraft type of that flight. The following chart shows the overall performance of each aircraft type at making all five gates, and then the performance of those aircraft type that we knew flew the FMS departure procedure.



We found that in many cases, using the FMS departure procedure improves a aircraft's ability to make all five gates of the corridor. In some cases, using FMS can move an aircraft type from below average corridor compliance to above average (e.g. MD82 and B734).

FMS and Aircraft Equipment

As noted earlier, we were only able to know for sure if a flight used the FMS departure procedure by obtaining flight strip data from the FAA and Massport. Not all runway 27 usage days had this flight strip data recorded, and therefore our daily radar data could not be matched to all flights that used the FMS procedure. We found that:

- 4278 FMS and non-FMS flight strips could be matched to our radar data,
- 3036 used the FMS procedure according to the flight strip data,
- 1242 did not use the FMS procedure according to the flight strip data.

We then were able to compare how many flights were capable of FMS (equipment code J and K) versus how many actually used the FMS procedure. Our results are in the table below.

	Equipment Code			
	J	**K**	**L**	**Q**
Used FMS	718	101	615	1482
Capable of FMS	978	187	806 ?	1867 ?
Percent using FMS	73%	54%	76% ?	79% ?

We find that about ¾ of the flights with equipment type J (FMS with inertial navigation) actually flew the FMS departure procedure, and over half of the flights with equipment type K (FMS with no inertial navigation) used the FMS procedure. We placed a question mark under equipment type L and Q because of the nature of the way equipment codes are filed in a flight plan -- Codes L and Q could possibly have FMS on board, but there's no way to know for certain.

But with respect to codes J and K, we see that more flights could theoretically be using the FMS departure procedure, a procedure which we have shown increases an aircraft type's ability to make all five gates.

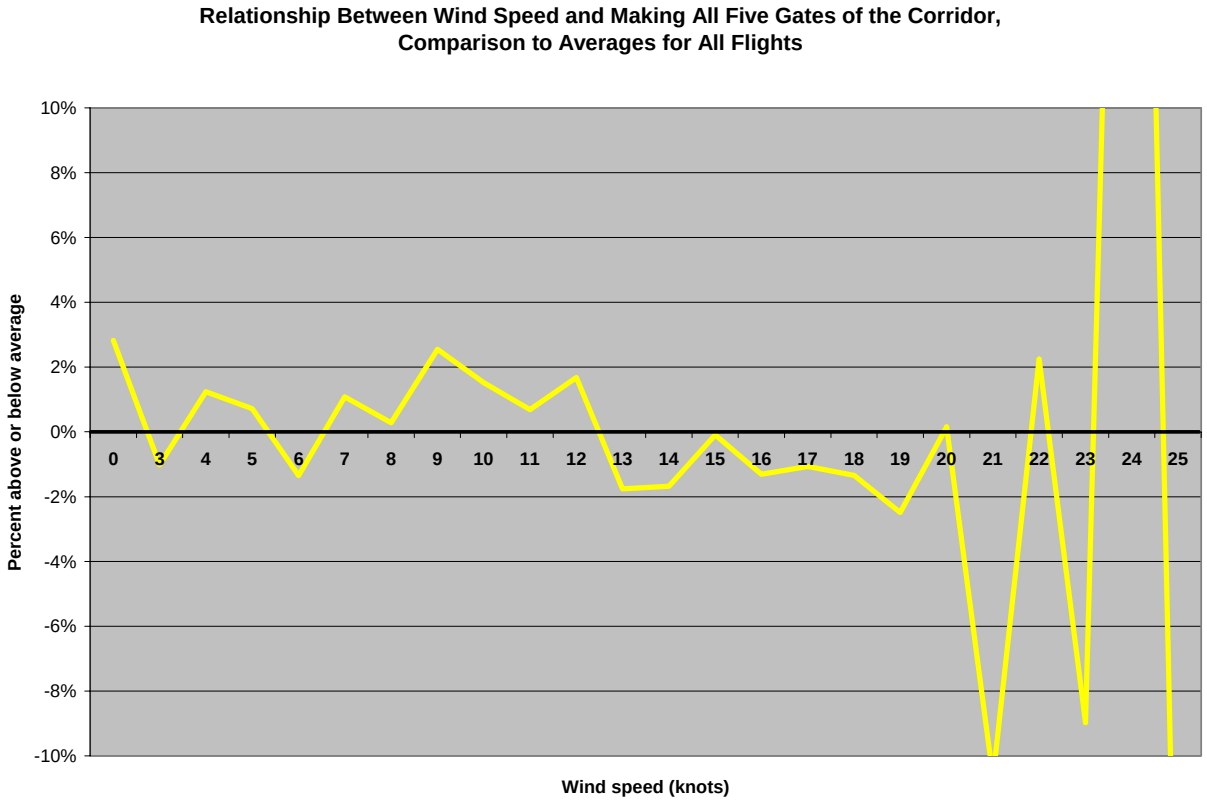
Weather Conditions

Massport provided us with hourly meteorological data for each day of our nine month study[1]. We matched each flight's departure day and time with the weather conditions during the flight's departure hour. The weather measurements included wind speed, wind direction, wind gusts, visibility, sky conditions, and cloud ceiling.

Wind Speed

The following chart shows the relationship between wind speed and making all five gates of the corridor.

[1] The weather data for Nov. 11, Nov. 12, and Dec. 16 were not available.

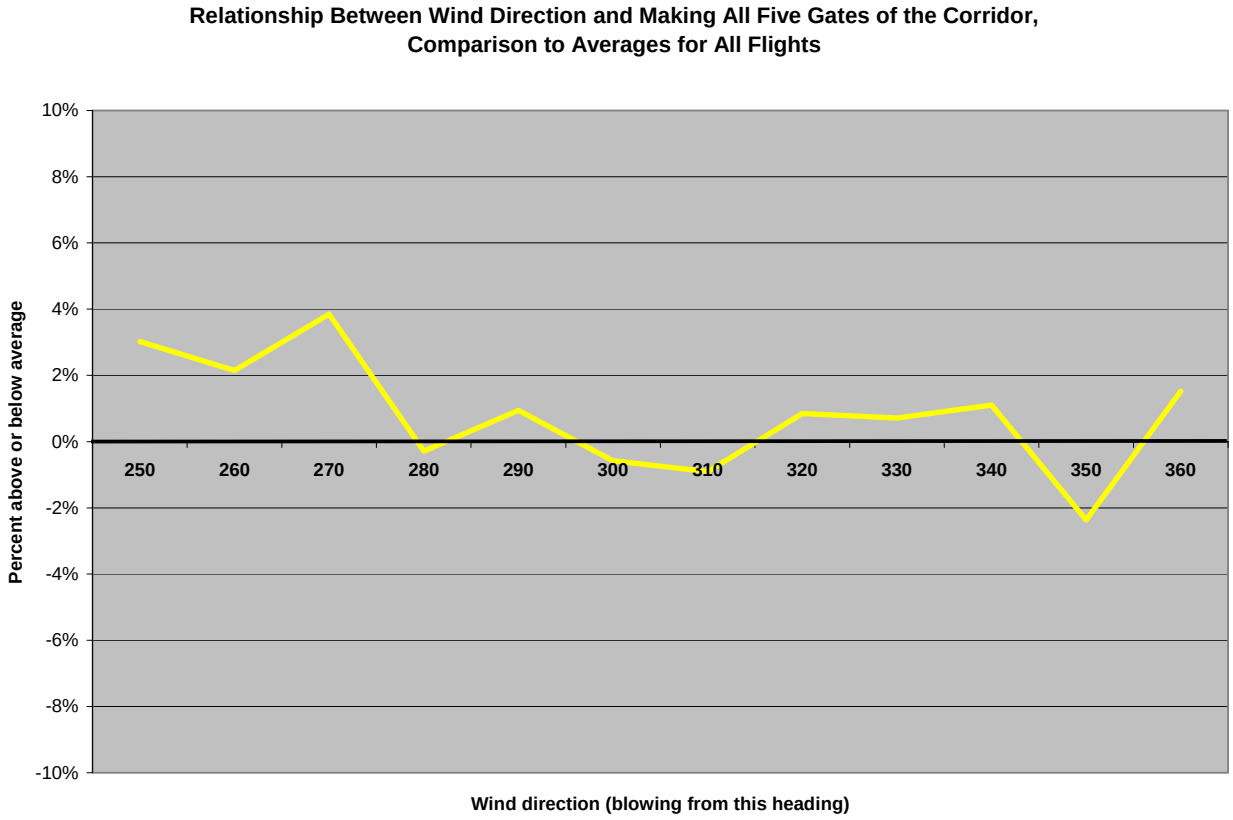


For example, if the wind speed is 4 knots, flights tend to be one percent better than average at making all five gates. We see that for wind speeds from zero to 20 knots, there is no significant correlation to gate compliance. The extreme percentage jumps above 20 knots would seem to imply some sort of relationship to gate compliance, but they are simply the result of very low flight counts at those wind speeds, so those samples are not statistically significant.

Wind Direction

Next, we created the same type of chart for wind direction. We noted that runway 27 was used mostly when the wind was blowing from the Northwest, mainly from compass headings between 250 and 360. When the wind was from other directions, other departure runways were usually used. However, we do have data showing runway 27 was used for departures when the wind was between 000 and 240. These infrequent departures could have been caused by runway 27 being put into use at the beginning of a heavy departure time, and although the wind shifted, the tower elected to stay with the 27 departure configuration. Or, although runway 22L would have been optimum for wind from the southwest, it could have been closed for resurfacing, and hence the tower used runway 27. Or lastly, runway 27 could have been used in very light wind conditions despite the wind blowing from the non standard 250 to 360.

The following chart shows the relationship between Northwesterly wind directions and the ability of flights to make all five gates of the corridor.



We see that there is a very low correlation between wind direction and gate compliance. When the wind was blowing from exactly 270, there was a slight increase in a flight's ability to make all five gates.

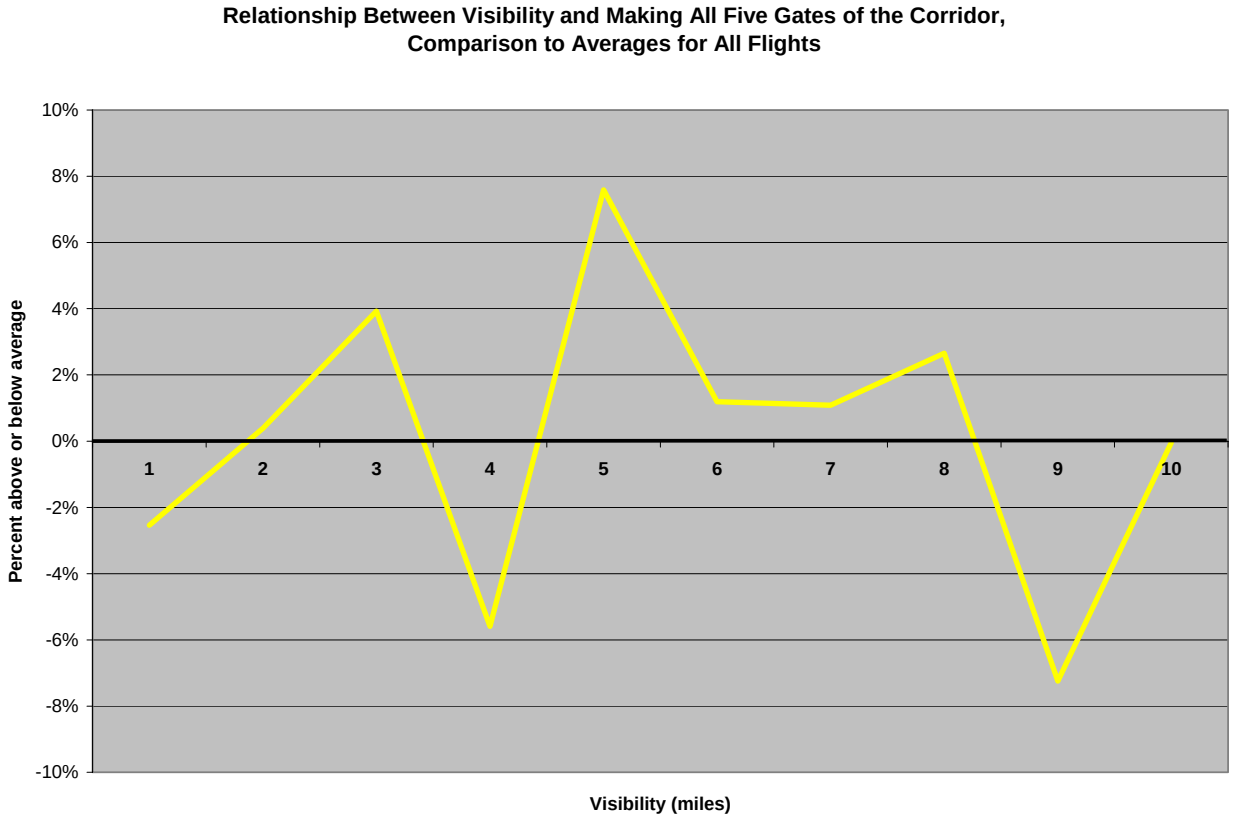
Sky Conditions

There were four different sky conditions that could be associated with each flight: Clear, scattered, broken, and overcast. We found that, regardless of which of these conditions were present, about 56% of flights made all five gates of the corridor. The average across all sky conditions was 56.7%.

Sky Conditions	Percent of flights which made all five gates
Broken	56.7%
Clear	55.3%
Overcast	55.0%
Scattered	58.0%

Visibility

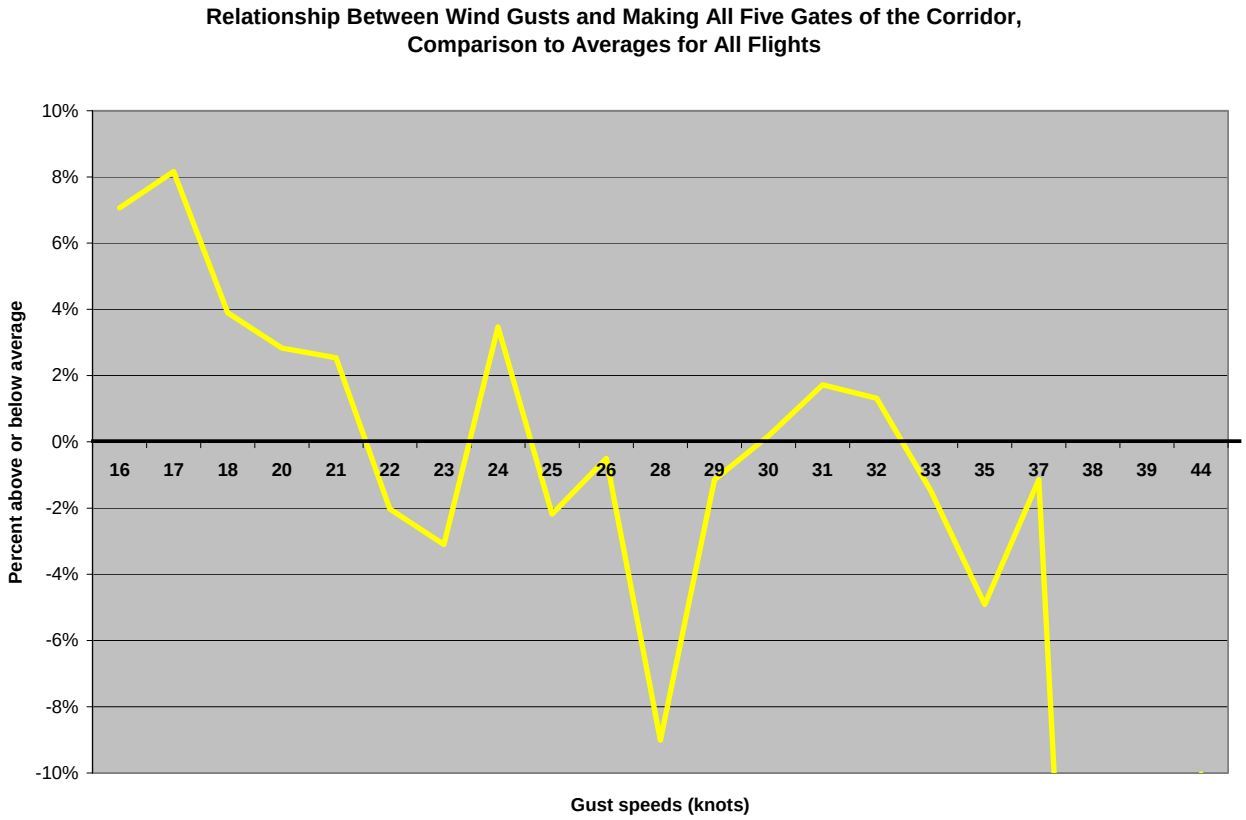
The visibility measurements we received from Massport ranged from ten miles down to one mile. The percent of flights making all five gates of the corridor (relative to average) based on visibility can be seen in the following chart.



We could not confidently identify any trends within the visibility data for two reasons: 1) Over 90% of all flights during the nine month study had 10 miles of visibility, so there were too few flights in the other nine categories to make an informed comparison, and 2) Although there is a 9% drop between 3 and 4 miles visibility, there is a 12% jump between 4 and 5 miles visibility, and so we could find no conclusive reasons for such differences over only two miles of visibility except for reasons due to statistical variations of the data set.

Wind Gusts

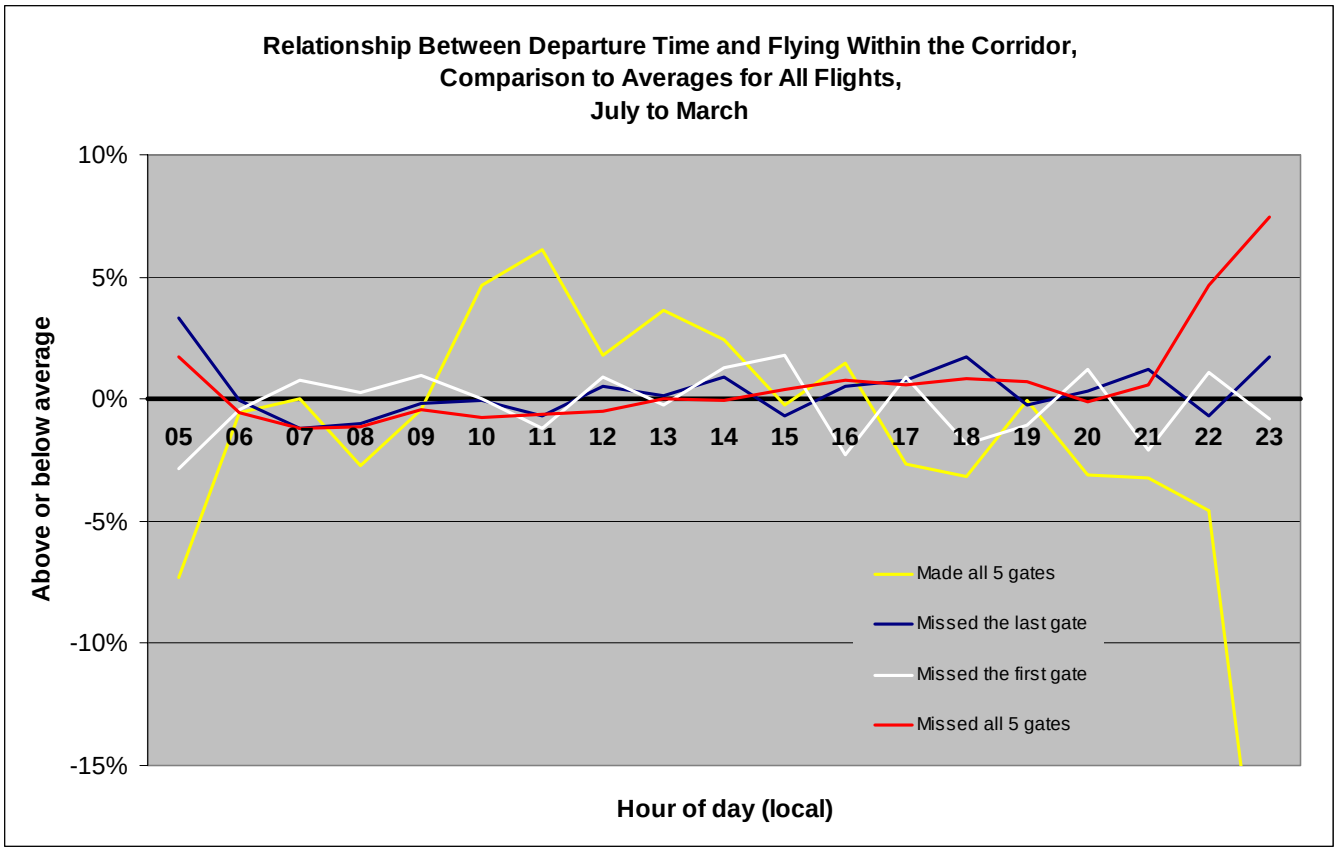
The following chart shows how wind gusts could possibly affect a flight's ability to make all five gates of the corridor.



The majority of flights (63%) did not experience any wind gusts during their departures. When the wind gusts were between 16 and 21 knots, there seems to be a slight advantage in a flight's ability to make all five gates. But there were too few flights in this wind gust range to have any statistical significance. For flights which had gusts associated with them at departure time, most were in the 21 to 30 knot range. We can see in the chart that variations around the average were small in this range (except at 28 knots where 8% fewer flights made all five gates of the corridor.)

Departure Time

We investigated the relationship between a flight's departure time and its ability to stay within the corridor. The following chart shows this relationship.



At first we thought that there might be a correlation between "mid-day" departures (10:00 to 14:00, inclusive) and a higher probability that they would be able to make all five gates. However, upon further investigation, we found that this is due to a coincidentally higher number of above average performing aircraft departing during the mid-day, and fewer below average aircraft departing during the mid-day.

The percentage of all flights over nine months that leave during the mid-day time frame is 31%. We see that B752s – the most utilized runway 27 aircraft type and a 25% below average aircraft at making all five gates – has only 24% of its flights during the mid-day period. And the top seven above average aircraft used for runway 27 departures (accounting for 55% of all runway 27 departures) all have average or above-average use during the mid-day.

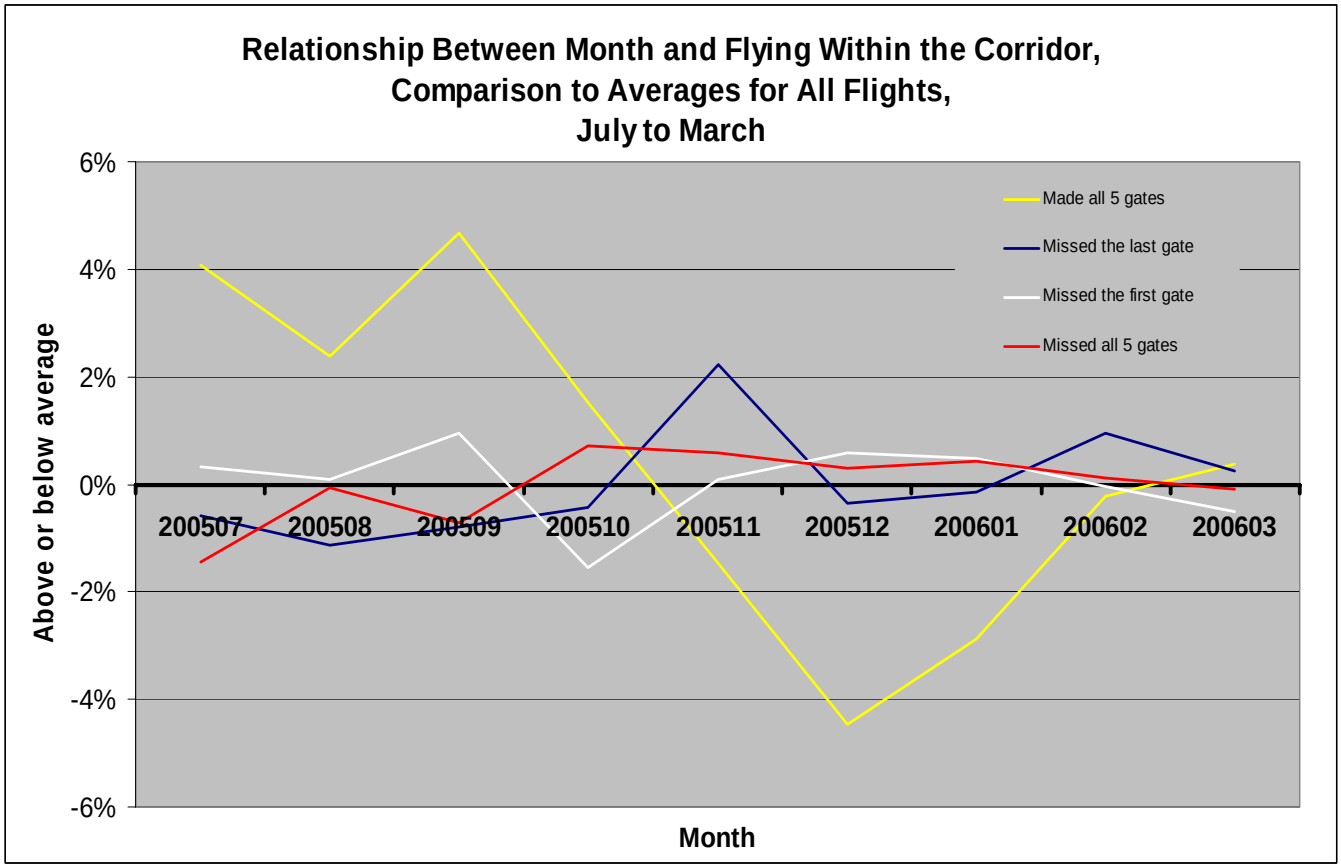
Below Avg Aircraft	Number of flights	Percent of Flights that are mid-day departures
B752	2188	24%
CRJ1	798	30%
MD88	581	41%
MD82	242	40%
B734	171	41%
B72Q	137	2%
MD83	135	12%

H25B	110	35%
MD80	94	39%
C560	69	43%
B772	65	0%
B732	63	51%
CL60	62	27%
BE40	61	36%
LJ35	54	6%
C550	46	37%
DC10	43	0%
Above Avg Aircraft	**Number of flights**	**Percent of Flights that are mid-day departures**
E135	2160	38%
A319	1890	33%
CRJ2	1366	31%
B712	1070	37%
A320	1039	30%
B733	640	40%
E145	614	31%
B735	382	23%
E190	369	30%
B738	260	21%
A306	151	3%
B737	140	21%
E170	84	60%
A321	76	26%
C750	68	44%
GLF4	65	43%
C56X	55	33%
F2TH	46	37%

Finally, we examined an aircraft's ability to make all five gates throughout the day and found that both above and below average performing aircraft are consistently above or below average throughout the day. In other words, aircraft perform above or below average regardless of time of day.

Monthly Variations

There was a no significant relationship between the month of the year and the ability of a flight to remain in the departure corridor.

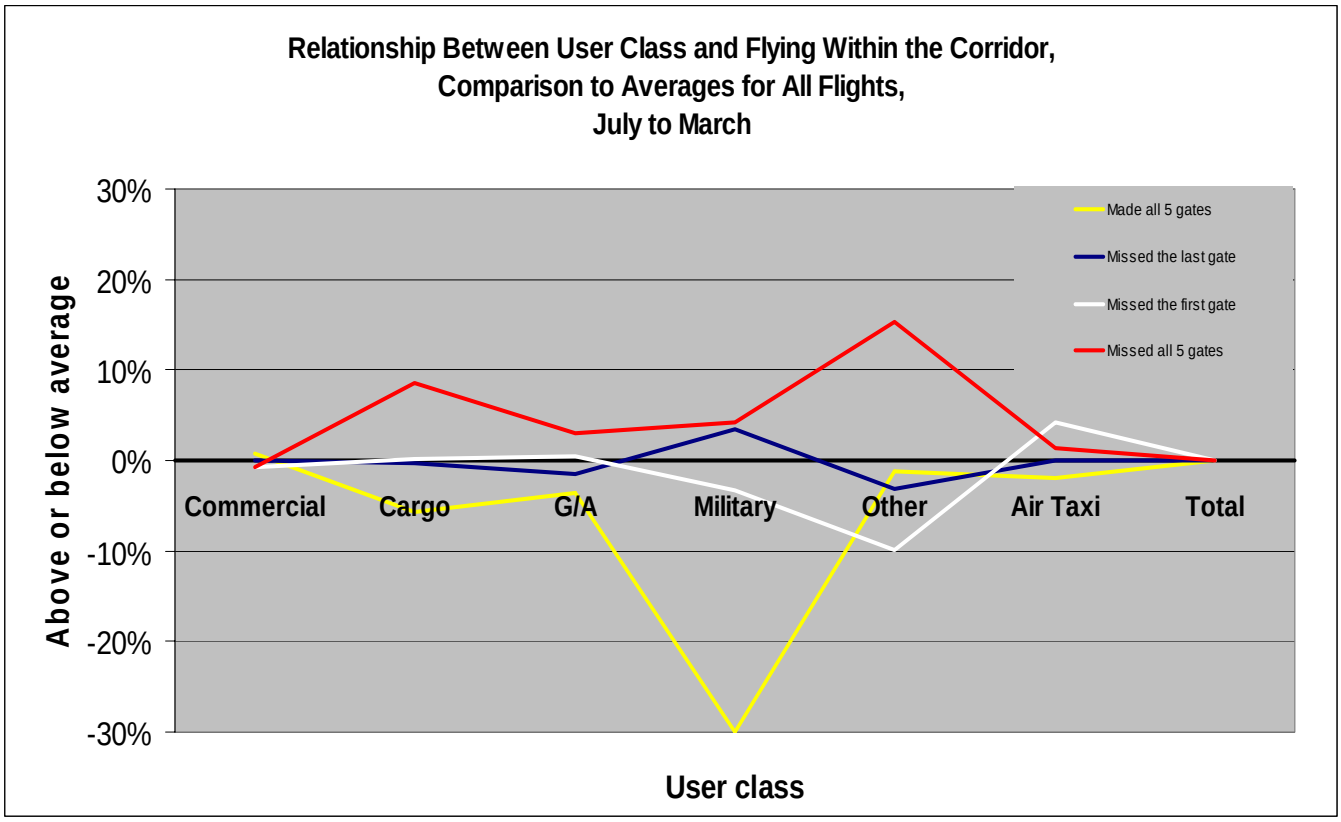


Among the above average aircraft types, we found that several did a little worse during the winter months at flying within the corridor, specifically during December.

Among the below average performing aircraft types, we found that CRJ1s performed noticeably worse (10 to 20% below their own average) during October, November, and December.

User Class

We found little correlation between a flight's user class and its ability to stay inside the corridor. The following chart conveys this.



There were only 15 military jet departures from runway 27 over the nine months of 15,962 flights, so there is no statistical significance in the 30% drop in military aircraft corridor performance.

At first, we thought that there could be some significance to cargo flights being 6% below average at making the corridor. Therefore we looked into the three major cargo operators which used runway 27 during the nine month period (these three accounted for 90% of cargo operations in our study):

- For FedEx, 52% of their flights made all five gates,
- For UPS, 70%, of their flights made all five gates, and
- For DHL, 46% of their flights made all five gates.

Before making any assumptions as to why UPS was so much better than FedEx and DHL, we looked into the aircraft types flown by each of these cargo carriers.

We found that FedEx and DHL used B72Qs, an aircraft that performs about 15% below average compared to all aircraft types. However, in our entire study, the vast majority of B72Qs were used by FedEx and DHL, so we could not determine if the low gate compliance of FedEx and DHL was because of the B72Q, or because of something else specific to FedEx and DHL themselves.

Therefore we next looked at the A306 aircraft type, used by FedEx and UPS. The A306 performed about 12 % above average at making all five gates. However, throughout our study, the vast majority of A306s were flown only by FedEx and UPS (17 were used by American Airlines.) So again, we were not sure if the high gate compliance of FedEx and UPS was because of the A306, or because of something else specific to FedEx and UPS themselves.

Ultimately, we concluded that there is nothing specific about cargo airlines which make them perform 6% below average at making all five gates – it's simply the aircraft types they use. When FedEx used B72Qs, they performed below average (like DHL). But when FedEx used A306s, they performed above average (like UPS).

We also looked at the time of day which these cargo airlines were departing. Most departures for all three airlines were during the 8:00 AM hour, and the 10:00 and 11:00 PM hours. The following chart summarizes our findings.

	B72Q	**A306**
	(FedEx & DHL)	**(FedEx & UPS)**
	% Making all 5 gates	**% Making all 5 gates**
7:00 AM	N/A	81%
8:00 AM	53%	N/A
10:00 PM	39%	61%
11:00 PM	28%	N/A

We see that gate compliance for cargo airlines has nothing to do with departure time, but rather aircraft type. FedEx and DHL fall below average at making all five gates when flying B72Qs, regardless of time of day. And FedEx and UPS fall above average when flying A306s, regardless of time of day.

Conclusions and Recommendations

The purpose of this study was to identify issues that affect gate compliance for jet aircraft using the runway 27 departure corridor. After achieving a large data set of almost 16,000 flights, we were able to identify the most important trends and patterns which affect corridor performance.

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?

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.

Conclusion:

Despite making the fist 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.

Conclusion:

Weather, time of day, seasonal variations, and user class have little or no impact on corridor compliance.

Recommendation:

Continue to monitor these variables as more data is collected, but the focus of future analysis should be on aircraft type and FMS procedures.