RTO-37: En route User Deviation Assessment

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Questions Addressed

- What problems in terms of flight deviations and delays are regularly occurring in the NAS?
- Where, when and how often are they occurring?
- What is the impact of these problems?

Identifying and Understanding Problems

"Problem" as measured by some Performance Metric

- Departure delay
- Airborne Delay
- Operational error by controller

Identifying and Understanding Problems

"Problem" as indicated by some ATC activity

- Airborne holding
- Cornerpost swap
- Other Reroute
- MIT
- Diversion
- GDP
- Ground stop
- S-turns
- Speed reduction
- Altitude change

Identifying and Understanding Problems

"Problem" necessitating ATC activity

- Excess volume or complexity
  - predicted or actual
  - in departure, enroute or arrival sector
- Weather
- Flight constraint (fuel, max altitude)
- Malfunction

Post-Operations Evaluation Tool: Initial Concept Development

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Post-Operations Evaluation Tool: Implementation and Further Concept Development

Metron, Inc.

Cognitive Systems Engineering, Inc.

AMT Systems Engineering, Inc.

FAA CDM Program

Post-Operations Evaluation Tool: Data Sources

- Archived ETMS data (FAA ATA-200)
- Complete Flight Plan and Flight Amendments
- Actual flight track
- Sectors transited

Other Data Sources

- ATCSCC log data
- System restrictions and advisories
- Miles in Trail
- Ground stops
- Ground delay programs

Goal

- Develop techniques to identify, quantify, and understand the nature of inefficiencies in NAS
- Apply these techniques on a large-scale

Overview

- Time Period
- Limitations and Caveats
- Inefficiencies as Indicated by Performance Metrics
  - Delays in Off Times
  - Delays Associated with Air Times
  - Consistency Across Time Periods
- Inefficiencies as Detected by Data Mining Tools
  - Holding
  - Significant Reroutes
- Inefficiencies as Indicated by Manual Detailed Analyses
  - Bottlenecks along Select Route Segments
  - Miles in Trail (MIT) Restrictions
  - Diversions in the NAS
- Recommendations

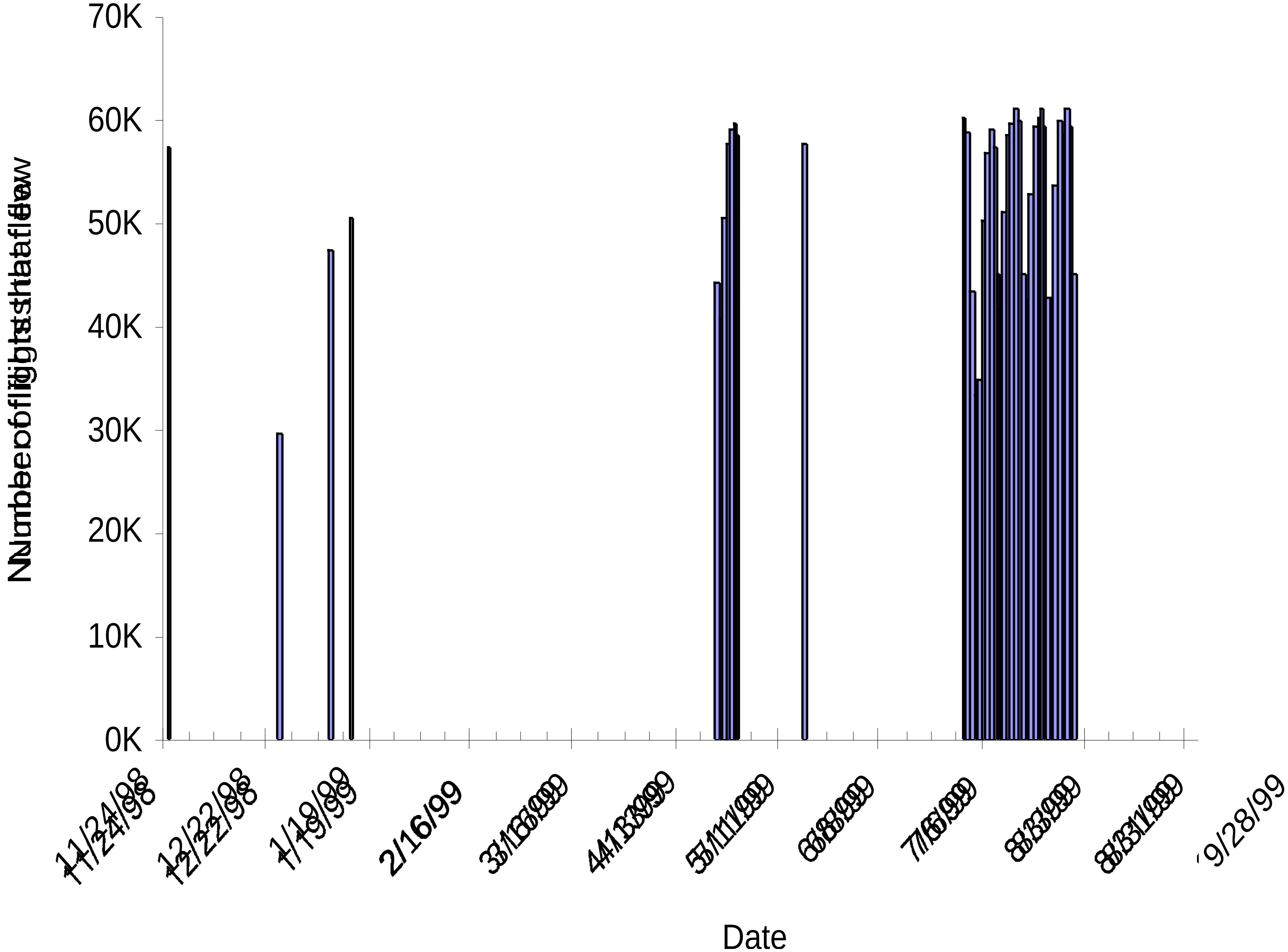
Time Periods

- 11-25-1998
  - Day before Thanksgiving (historically the busiest day of the year)
- 12-25-1998
  - Christmas day (historically the slowest day of the year)
- 1-8-1999
  - Bad winter day (widespread snowstorms, many GDPs)
- 1-14-1999
  - An unpredictably bad winter day (snow and icing in Northeast as far south as Richmond, no GDPs, but many ground stops)
- 5-18-1999
  - Bad spring day (widespread thunderstorms)

Time Periods (cont.)

- April 24-30, 1999
- July 1-31, 1999
- September 20-26, 1999
- October 10-10, 1999

Flights Considered in Study



Number of flights by departure/arrival center (top 10)

Depart. Center	Number of Flights	% of Total	Arrival Center	Number of Flights	% of Total
ZTL	21200	7.3%	ZTL	21162	7.3%
ZAU	20654	7.1%	ZAU	20498	7.1%
ZNY	19493	6.7%	ZNY	19658	6.8%
ZDC	19304	6.7%	ZDC	19383	6.7%
ZOB	19156	6.6%	ZOB	19002	6.5%
ZLA	17235	5.9%	ZLA	17425	6.0%
ZID	15485	5.3%	ZID	15189	5.2%
ZMP	15182	5.2%	ZMP	15088	5.2%
ZFW	14563	5.0%	ZFW	14438	5.0%
ZBW	14247	4.9%	ZBW	14059	4.8%

Limitations and Caveats

- Bad data filtering (such as negative times)
- Inconsistent reporting of predicted off times
- Display System Replacement (DSR) transition restrictions
- Weather impacts
- Planned air times that include padding

Inefficiencies as Indicated by Performance Metrics

- Departure Delays
- Airborne Delays
- Consistency Across Time Periods

Worst Departure Delays for July 12th - July 18th, 1999, by Arrival Airport, Scheduled Arrival Time Bin, Filed Arrival Fix Combinations

Arrival Airport	Scheduled Arrival Time Bin (Z)	Arrival Fix (filed)	Number of Flights	Departure Delay (mins)
DTW	1400	POLAR	8	91.1
MFE	2000	<null>	7	64
MCO	2200	MINEE	8	60
LAX	0100	RIFFT	11	58.8
SJC	0300	HYP	9	55.7
DTW	2300	SPICA	11	55.2
MEM	1100	WLDER	12	53.8
HRL	2100	<null>	12	52.6
PDX	1100	BONVL	7	52.4
SEA	0200	JAKSN	27	52.3

Worst Departure Delays for July 12th – July 18th 1999, by Arrival Airport, Scheduled Arrival Bin, Arrival Fix Combinations with more than 48 Flights

Arrival Airport	Scheduled Arrival Bin (Z)	Arrival Fix (filed)	Number of Flights	Departure Delay (mins)
LGA	2200	ARD	83	45.1
PHX	0300	TONTO	65	39.1
EWR	2300	RBV	70	38.9
SFO	0300	CEDES	54	36.6
LGA	2100	ARD	86	36.5
ORD	2100	PLANO	75	35.8
SFO	1800	SKUNK	53	35.4
SFO	1700	SKUNK	56	35.2
IAH	2100	DAS2	79	34.5
SFO	0200	CEDES	52	34.5

Ground Delay Programs between 7-12-99 and 7-18-1999

Airport	Date	Time of GDP	Departure Delay (mins) Average	Stand Dev
PHX	7-15-1999	1430-1655	0:47	0:43
SFO	7-16-1999	1600-1946	0:51	0:33
SFO	7-17-1999	1600-1730	0:49	0:43
SFO	7-18-1999	1600-1715	0:40	0:29
EWR	7-17-1999	2000-2351	1:00	0:45
EWR	7-18-1999	1830-0059	0:46	0:27
LGA	7-17-1999	1830-0059	0:52	0:37
ORD	7-17-1999	2100-2320	2:01	2:51

Worst Air Time Performances for July 12-18, 1999, by Arrival Airport, Scheduled Arrival Time Bin, Filed Arrival Fix Combinations (Minimum of 7 flights)

Arrival Airport	Scheduled Arrival Bin (Z)	Arrival Fix (filed)	Number of Flights	Planned Air Time (mins.)	Actual Air Time (mins.)	Difference (Actual - Planned) in mins.	Percent Air Time Increase (Difference/Planned)
DEN	2200	RAMMS	7	22.7	41.9	19.1	84.3%
BNA	0000	GUITR	10	51.1	92.2	41.1	80.4%
BFL	2100	<null>	7	23.1	36.3	13.1	56.8%
LAX	0200	VTU	27	32.1	50.1	18	56.2%
EUG	1600	<null>	7	22.4	33.4	11	49.0%
YKM	1700	<null>	7	22.4	33.3	10.9	48.4%
BFL	1400	<null>	7	22.7	33.7	11	48.4%
YKM	1500	<null>	7	22.4	33.1	10.7	47.8%
PDX	0100	HARZL	7	25.9	38.1	12.3	47.5%
MDT	0000	<null>	8	29.9	43.6	13.8	46.0%
LAX	1300	VTU	27	26.3	38.3	12	45.5%

Worst Air Time Performances for July 12-18, 1999, by Arrival Airport, Scheduled Arrival Bin, Arrival Fix Combinations with more than 48 Flights

Arrival Airport	Scheduled Arrival Bin (Z)	Arrival Fix (filed)	Number of Flights	Planned Air Time (Z)	Actual Air Time (Z)	Difference (Actual - Planned Air Time) in minutes and %	
MSP	0200	TWINZ	60	58.1	79	20.9	36.0%
MSP	0200	ZIBBY	71	59.5	78.9	19.4	32.6%
MSP	2200	ZIBBY	73	64	83.1	19.1	29.9%
ATL	2000	HUSKY	147	62.4	80.6	18.1	29.1%
ATL	2000	TIROE	144	66.2	85	18.8	28.5%
MSP	2200	OLLEE	94	76.1	97.1	21	27.7%
ATL	2000	LOGEN	134	78.8	100.6	21.8	27.6%
LAX	2100	VTU	53	38.9	49.6	10.7	27.5%
LAX	1400	VTU	70	41.7	52.5	10.8	25.9%
CYYZ	2200	LINNG	62	64.8	80.9	16.2	25.0%

Rank Order Correlations of Air Time Delays Across Different Times of the Year

Month	Month	Spearman Rho
April	July	0.7213
April	Sept.	0.7395
April	Oct.	0.8244
July	Sept.	0.7756
July	Oct.	0.7838
Sept.	Oct.	0.8366

Consistency of airborne delays over different times of the year

Arrival Airport	Sched Arrival Hour	Arrival Fix	Airborne Delay (%)				Percent Rank				Average Percent Rank
			Apr	Jul	Sep	Oct	Apr	Jul	Sep	Oct	
LAX	12:00	VTU	75.9		63.4	86.0	100.0		100.0	99.6	99.9
MSP	12:00	SHONN		45.0	47.5	55.1		95.9	97.5	98.8	97.4
YKM	17:00	<null>	43.3	48.4		48.4	93.8	97.9		97.7	96.5
LAX	17:00	VTU	43.4		51.5	41.9	94.3		99.5	95.1	96.3
LAX	13:00	VTU		45.5	40.5	42.7		96.5	96.6	95.5	96.2
MSP	11:00	TWINZ		39.0	47.7	43.4		92.5	98.0	96.6	95.7
MSP	0:00	OLLEE		33.3	39.8	87.6		87.7	95.6	100.0	94.4
MDT	0:00	<null>	61.5	46.0		33.0	99.4	96.9		86.8	94.4
MSP	12:00	OLLEE		31.7	48.0	49.7		84.0	99.0	98.1	93.7
LAX	2:00	VTU	45.4	56.2	36.2	33.1	95.8	98.9	91.7	87.6	93.5
LAX	22:00	VTU	40.4	42.3	32.5	42.9	91.2	94.8	88.8	95.8	92.7
LAX	20:00	VTU	31.4	35.0	47.9	41.8	80.4	89.4	98.5	94.7	90.8
PSP	1:00	<null>	34.9	36.8	33.2	33.0	86.0	91.1	90.2	86.8	88.5
LAX	3:00	VTU		30.8	36.4	31.6		83.6	92.7	85.3	87.2
LAX	1:00	VTU	30.8	32.1	36.3	40.0	77.8	85.0	92.2	93.6	87.2
LAX	15:00	VTU		28.9	32.6	34.2		80.9	89.3	88.7	86.3

Inefficiencies as Detected by Data Mining Tools

- Holding
- Significant Reroutes

Arrival fix/time of day combinations that were most often held in the air (7/12/99-7/18/99)

ARR APT	Sch ArrBin	ARR FIX	Num Held	Total	% Held	Planned AirTime (avg)	Airtime Delay	Airtime Delay %
IAH	20:00	DAS2	14	22	63.6%	100	34	34.0%
ATL	1:00	DALAS	4	8	50.0%	80	26	32.5%
ATL	20:00	LOGEN	54	135	40.0%	77	38	49.4%
MSP	2:00	TWINZ	8	21	38.1%	107	70	65.4%
CLE	15:00	KEATN	21	57	36.8%	66	25	37.9%
SEA	18:00	JAWBN	7	21	33.3%	196	10	5.1%
IAH	19:00	DAS2	32	97	33.0%	135	34	25.2%
ATL	20:00	TIROE	46	145	31.7%	70	37	52.9%
ATL	13:00	DALAS	40	130	30.8%	84	24	28.6%
ATL	13:00	HUSKY	24	78	30.8%	70	27	38.6%

Rank Order Correlations of Percent Holding Across Different Times of the Year

Month	Month	Spearman Rho
April	July	0.4029
April	Sept.	0.3855
April	Oct.	0.3580
July	Sept.	0.3694
July	Oct.	0.3601
Sept.	Oct.	0.3087

Flights Filed into Different Arrival Fixes at ATL

POET

File Edit View Go Add-Ins Window Help

Search1.sch: Flight Groups: Arrival Fix (filed)1

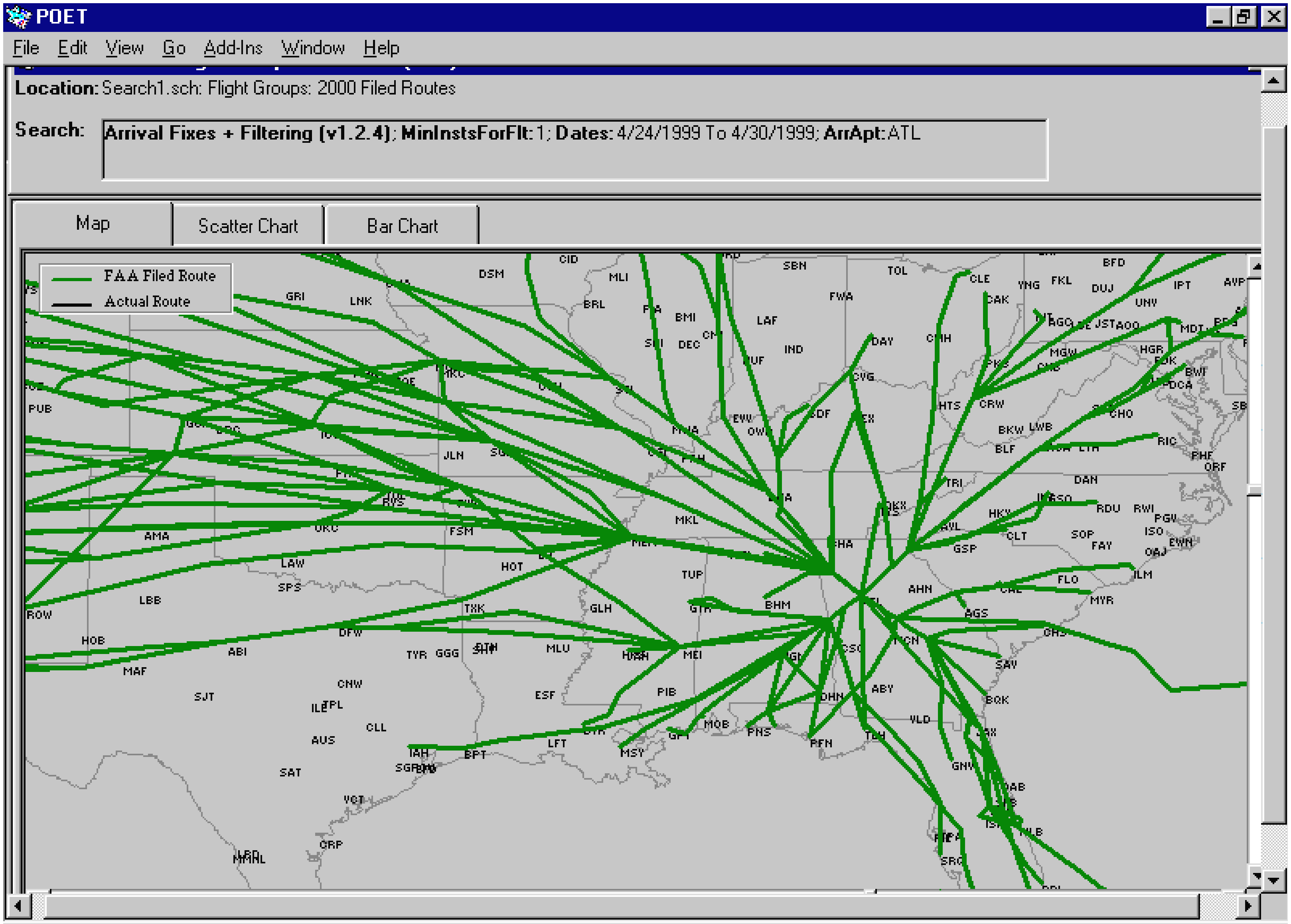
Location: Search1.sch: Flight Groups: 2000 Filed Routes

Search: **Arrival Fixes + Filtering (v1.2.4)**; **MinInstsForFlt:** 1; **Dates:** 4/24/1999 To 4/30/1999; **ArrApt:** ATL

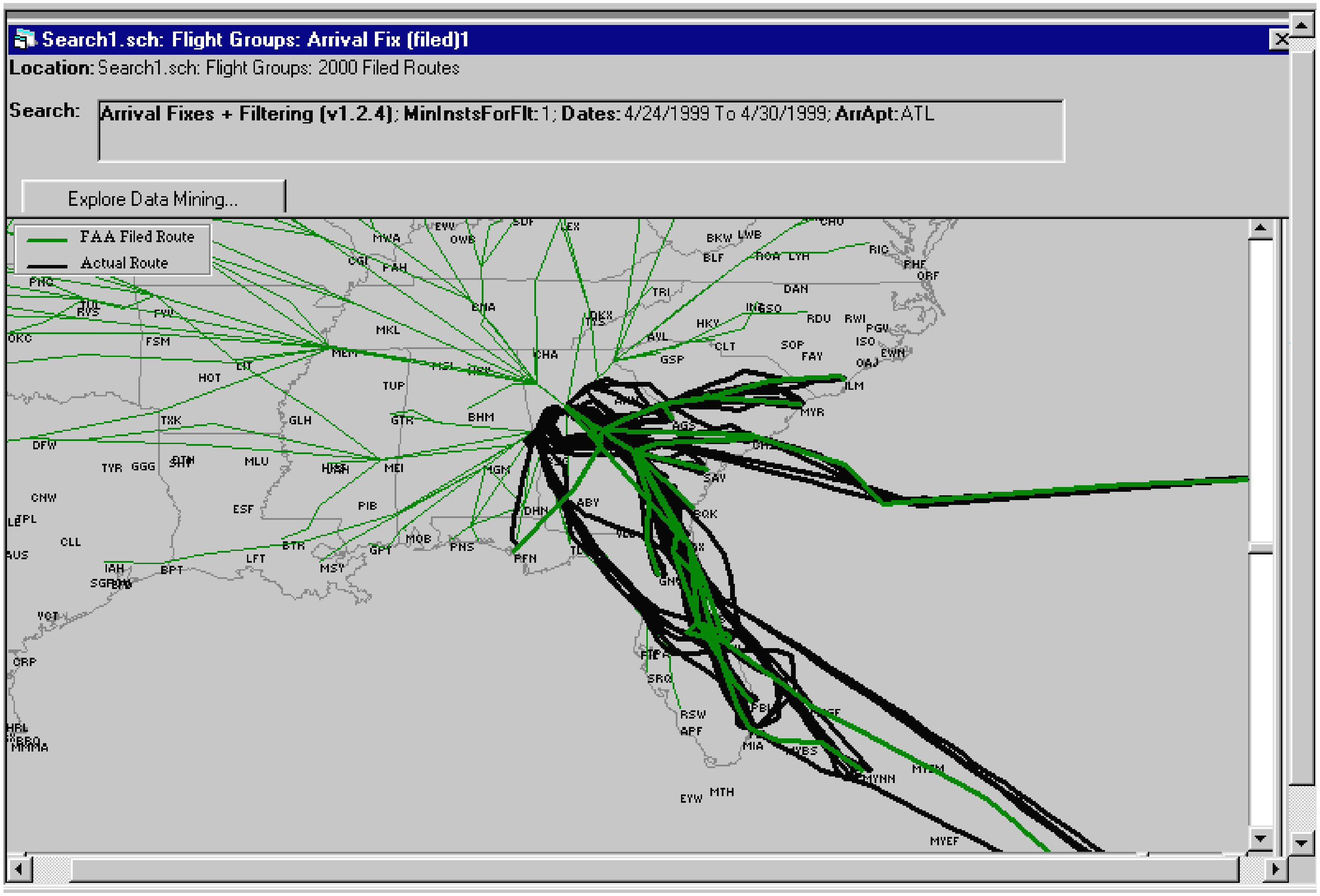
Explore Data Mining...

Arrival Fix (filed)	Number of Instances	Performance Metrics	Planned	Actual	Difference (Actual - Planned)	
+ LOGEN	169	AirTime (mins)	79.4	108.7	29.3	36.9%
		Off Time (Z)	1836	1905	28.6	
		On Time (Z)	1955	2053	57.9	
+ HUSKY	135	AirTime (mins)	68.5	92.1	23.6	34.5%
		Off Time (Z)	1853	1926	33.2	
		On Time (Z)	2001	2058	56.8	
+ TIROE	138	AirTime (mins)	68.8	89.9	21.2	30.8%
		Off Time (Z)	1849	1927	37.6	
		On Time (Z)	1958	2057	58.7	
+ DALAS	213	AirTime (mins)	106.8	126.5	19.7	18.5%
		Off Time (Z)	1805	1834	29.5	
		On Time (Z)	1952	2041	49.2	
+ <null>	1	AirTime (mins)	53.0	47.0	-6.0	-11.3%
		Off Time (Z)	1949	2026	37.0	
		On Time (Z)	2042	2113	31.0	

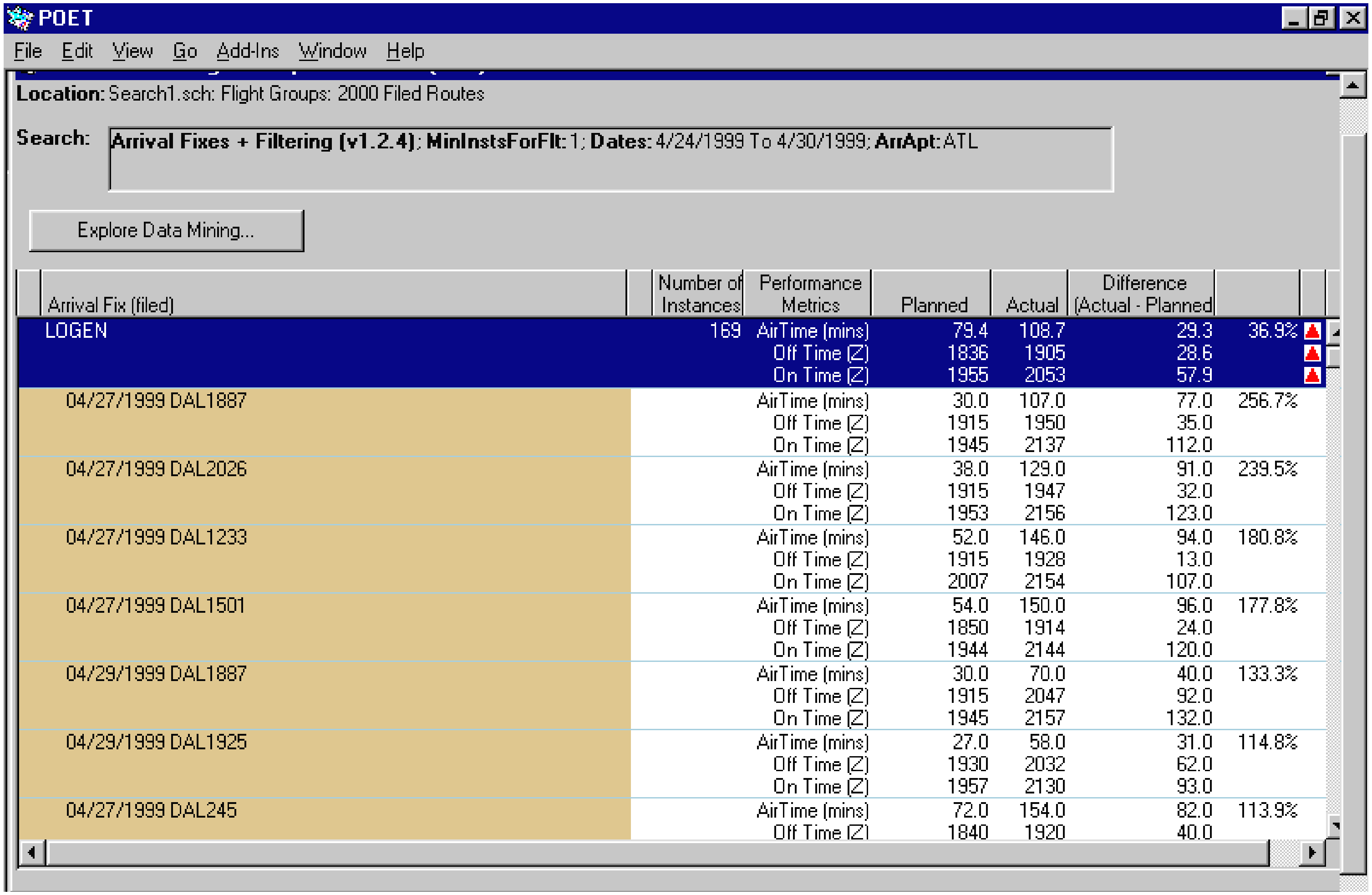
Routes Filed into ATL through all 4 Arrival Fixes



Filed and Actual Routes for Flights Filed Over HUSKY



Data on Some Individual Flights into LOGEN



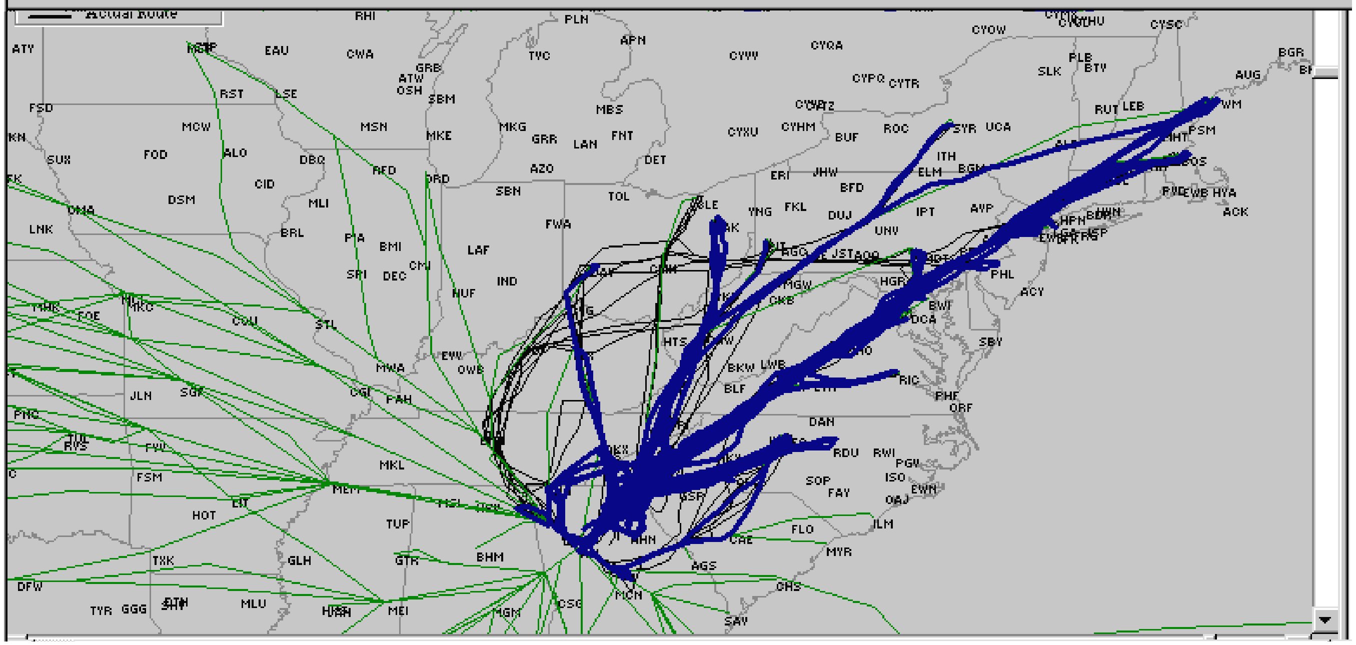
Flights Over LOGEN that were Held

ocation: Search1.sch: Flight Groups: 2000 Filed Routes

earch: **Arrival Fixes + Filtering (v1.2.4)**; **MinInstsForFlt:** 1; **Dates:** 4/24/1999 To 4/30/1999; **ArrApt:** ATL

Explore Data Mining...

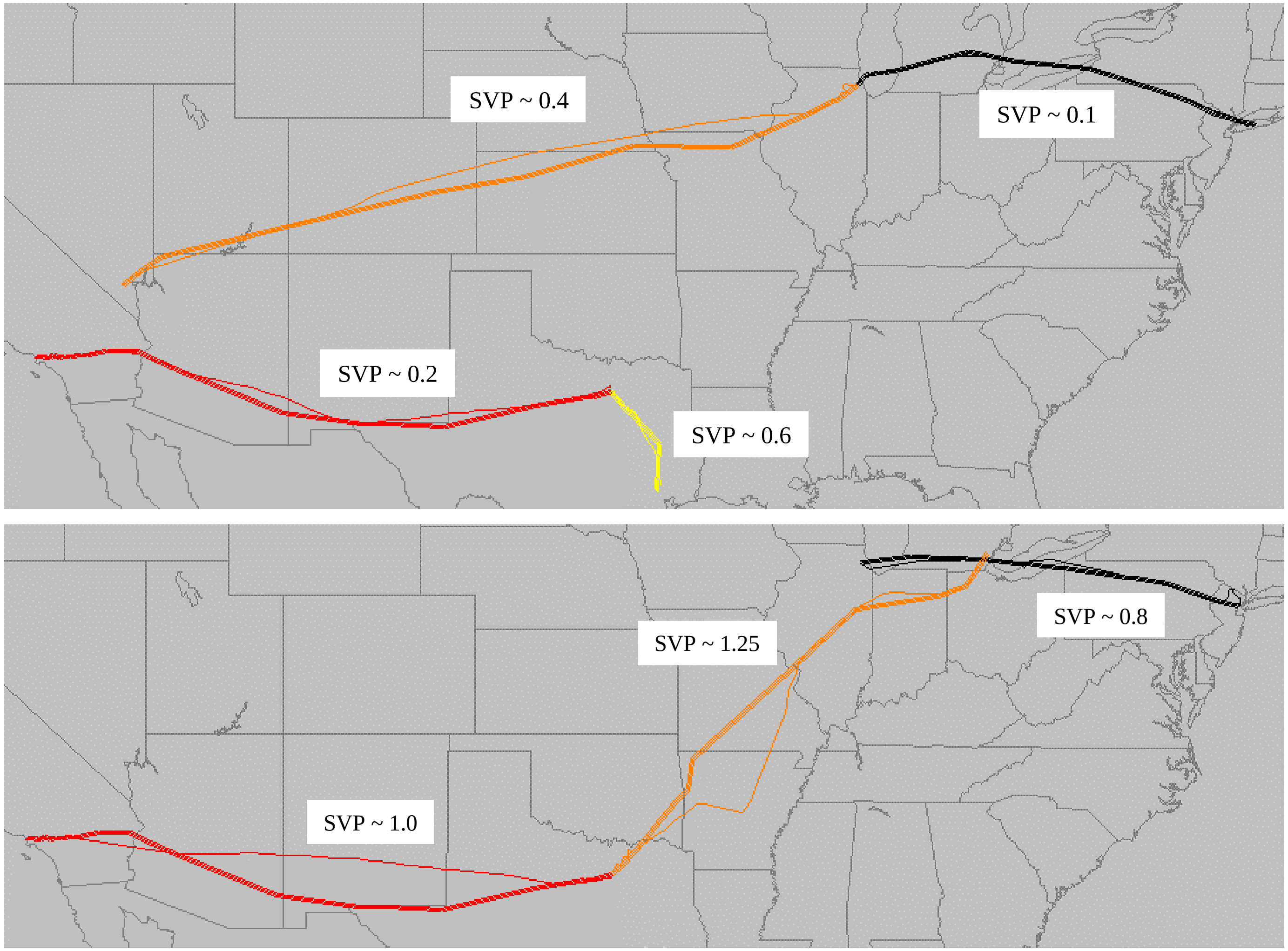
Arrival Fix (filed)	Number of Instances	Performance Metrics	Planned	Actual	Difference (Actual - Planned)	
LOGEN	169	AirTime (mins)	79.4	108.7	29.3	36.9%
		Off Time (Z)	1836	1905	28.6	
		On Time (Z)	1955	2053	57.9	
Held	82	AirTime (mins)	83.3	125.0	41.7	50.0%
		Off Time (Z)	1837	1906	29.2	
		On Time (Z)	2000	2111	70.9	
Normal	87	AirTime (mins)	75.7	93.2	17.6	23.2%
		Off Time (Z)	1836	1904	28.0	
		On Time (Z)	1951	2037	45.6	



Significantly Rerouted Flights

- Track length similarity
  - shorter (< 5%)
  - same (within ± 5%)
  - long (between 5-15%)
  - longer (> 15%)
- Spatial similarity
  - Spatial similarity algorithm

Spatial Similarity Examples

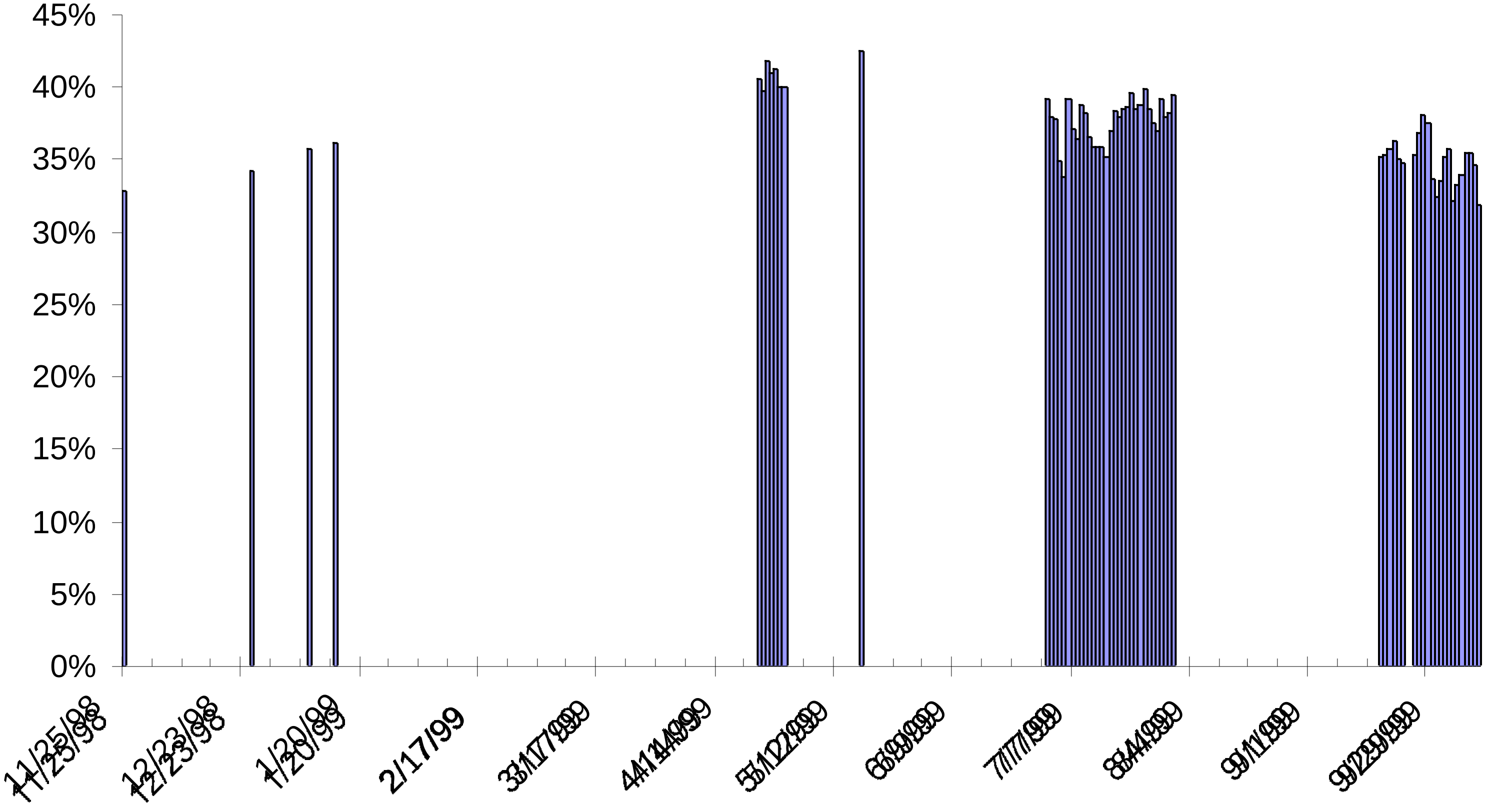


Significantly Rerouted Flights

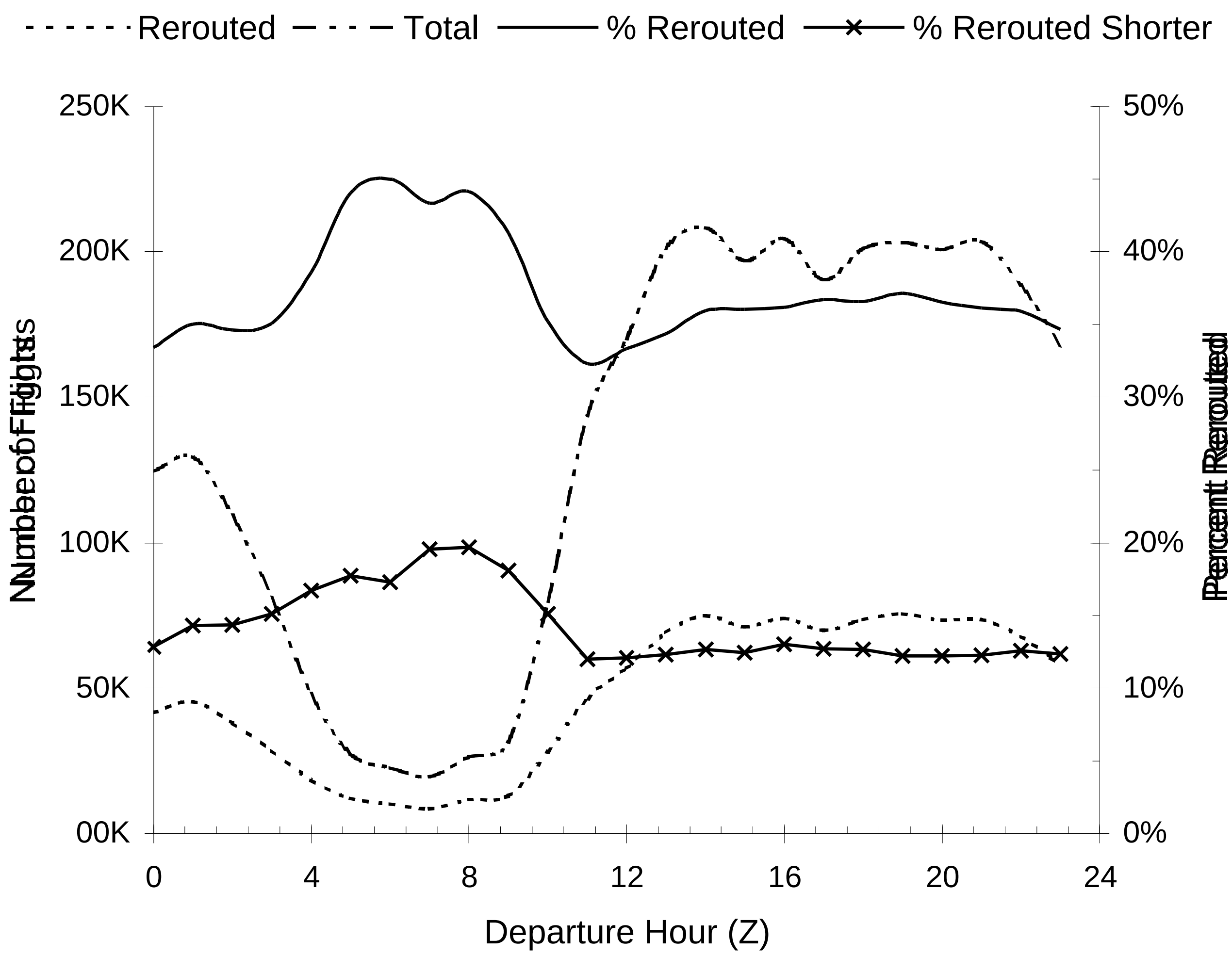
Track Length Similarity	Spatially Similar	Spatially Dissimilar	Total
Shorter	27.1%	13.6%	40.7%
Same	33.6%	12.5%	46.1%
Long	2.8%	3.9%	6.7%
Longer	1.6%	5.0%	6.5%
Total	65.0%	35.0%	100.0%

Shaded area represent those flights that were significantly rerouted (36.6% overall)

Percent of flights significantly rerouted by time of year



Reroutes by time of day



Correlation of Reroutes by Arrival Airport, Scheduled Arrival Bin, Arrival Fix Combinations

Month	Month	Spearman Rho
April	July	0.664
April	Oct.	0.650
April	Sept	0.655
July	Oct.	0.686
July	Sept	0.685
Sept.	Oct.	0.762

Rerouted flights by (CONUS) centers along filed flight route between 7/12/99 and 7/18/99

Center	Rerouted	Total	Percent
ZLA	16074	37495	42.9%
ZMA	11440	27158	42.1%
ZBW	16107	38456	41.9%
ZFW	15682	38302	40.9%
ZHU	12987	32016	40.6%
ZJX	15620	38525	40.5%
ZSE	8678	21468	40.4%
ZNY	23936	61902	38.7%
ZAB	9633	25693	37.5%
ZOA	9258	26107	35.5%
ZLC	7606	22867	33.3%
ZTL	17352	53150	32.6%
ZDV	9472	29392	32.2%
ZDC	18893	58725	32.2%
ZME	12303	39508	31.1%
ZMP	11176	37405	29.9%
ZKC	11386	38242	29.8%
ZID	13746	48968	28.1%
ZAU	14554	51872	28.1%
ZOB	15639	57402	27.2%

Rerouted flights by en route sectors along filed flight route (top 20 CONUS sectors) between 7/12/99 and 7/18/99

Sector	Rerouted	Total	Percent
ZMA38	471	636	74.1%
ZSE33	279	396	70.5%
ZSE03	1778	2587	68.7%
ZFW34	765	1151	66.5%
ZNY00	83	125	66.4%
ZMP80	101	156	64.7%
ZFW23	213	330	64.5%
ZHU58	1103	1769	62.4%
ZMA03	443	711	62.3%
ZMA39	875	1421	61.6%
ZFW64	615	1020	60.3%
ZAN15	634	1066	59.5%
ZFW36	973	1654	58.8%
ZFW25	341	580	58.8%
ZMA45	246	420	58.6%
ZLA06	1530	2635	58.1%
ZBW06	1715	2974	57.7%
ZLA13	1496	2611	57.3%
ZMA63	895	1576	56.8%
ZMA34	821	1446	56.8%

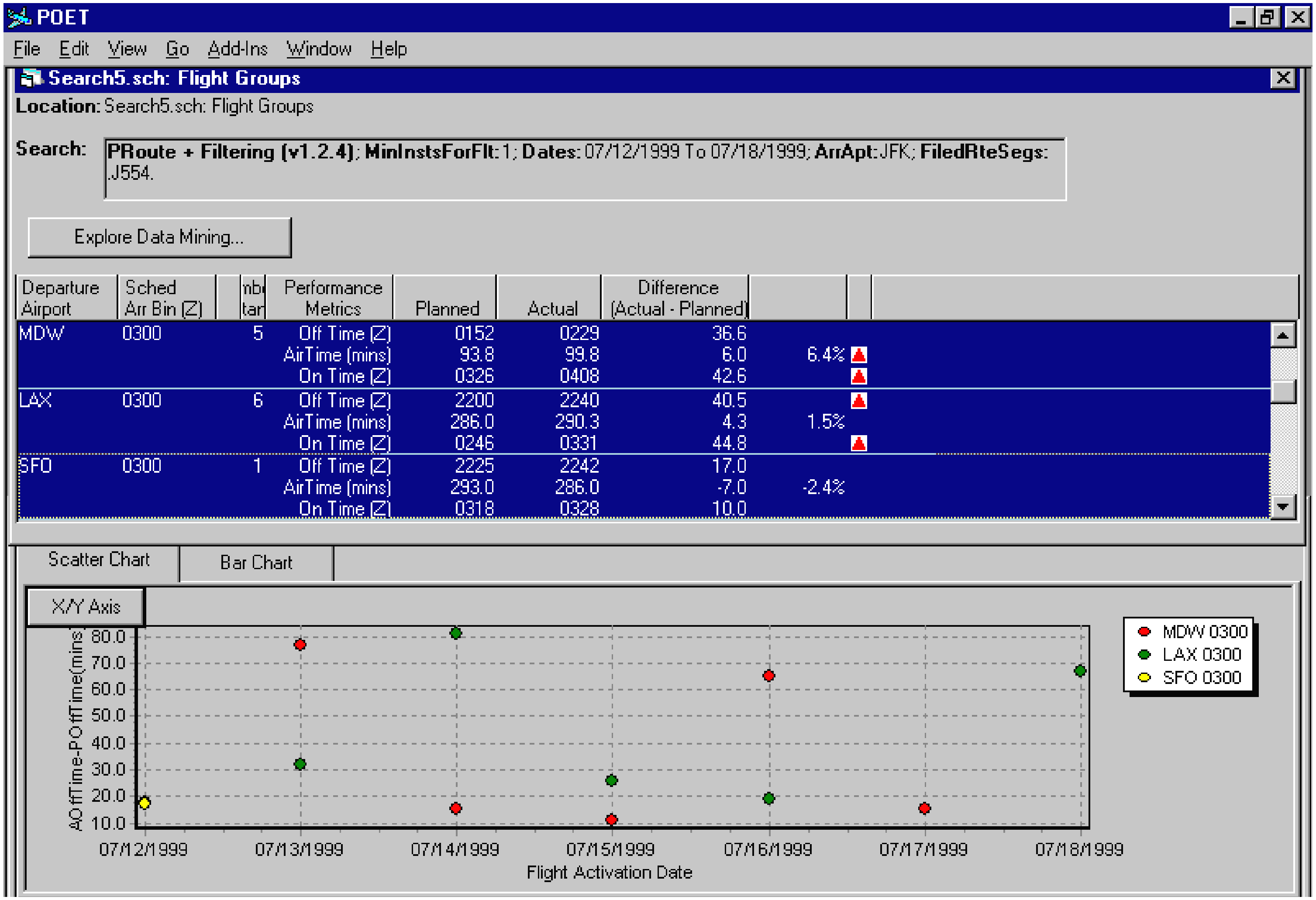
Rerouted flights by airways along filed flight route (top 15) between 7/12/99 and 7/18/99

Airway	Rerouted	Total	Percent
J889R	96	103	93.2%
V153	73	81	90.1%
V215	75	84	89.3%
V385	229	259	88.4%
V102	179	207	86.5%
J502	212	249	85.1%
J195	94	111	84.7%
V585	147	174	84.5%
J548	130	155	83.9%
V571	105	127	82.7%
J133	687	834	82.4%
J483	88	107	82.2%
J478	57	72	79.2%
J570	213	270	78.9%

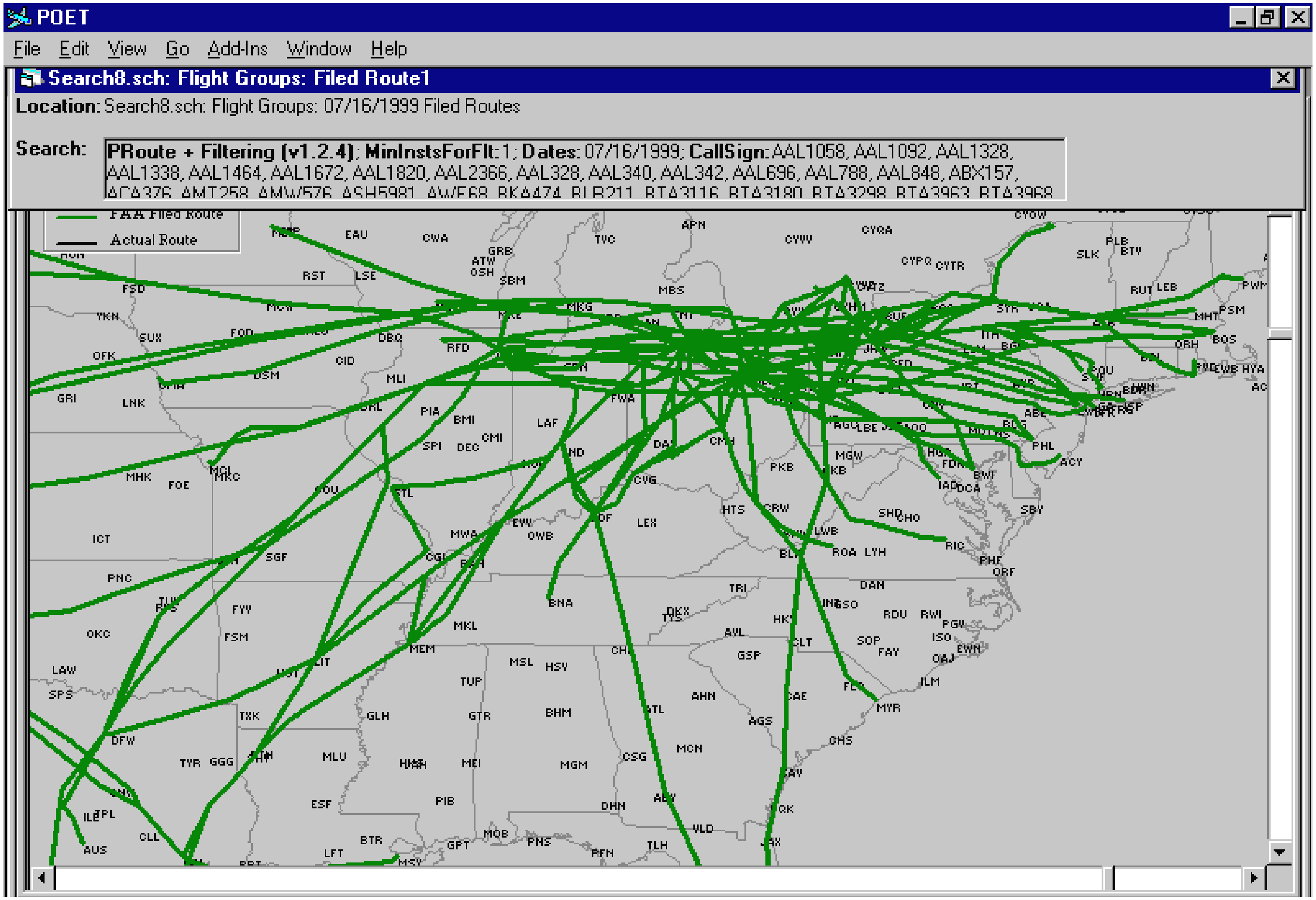
Inefficiencies as Indicated by Manual Detailed Analyses

- Bottlenecks along Select Route Segments
- Miles in Trail (MIT) Restrictions
- Diversions in the NAS

Flights Filed into JFK along J554



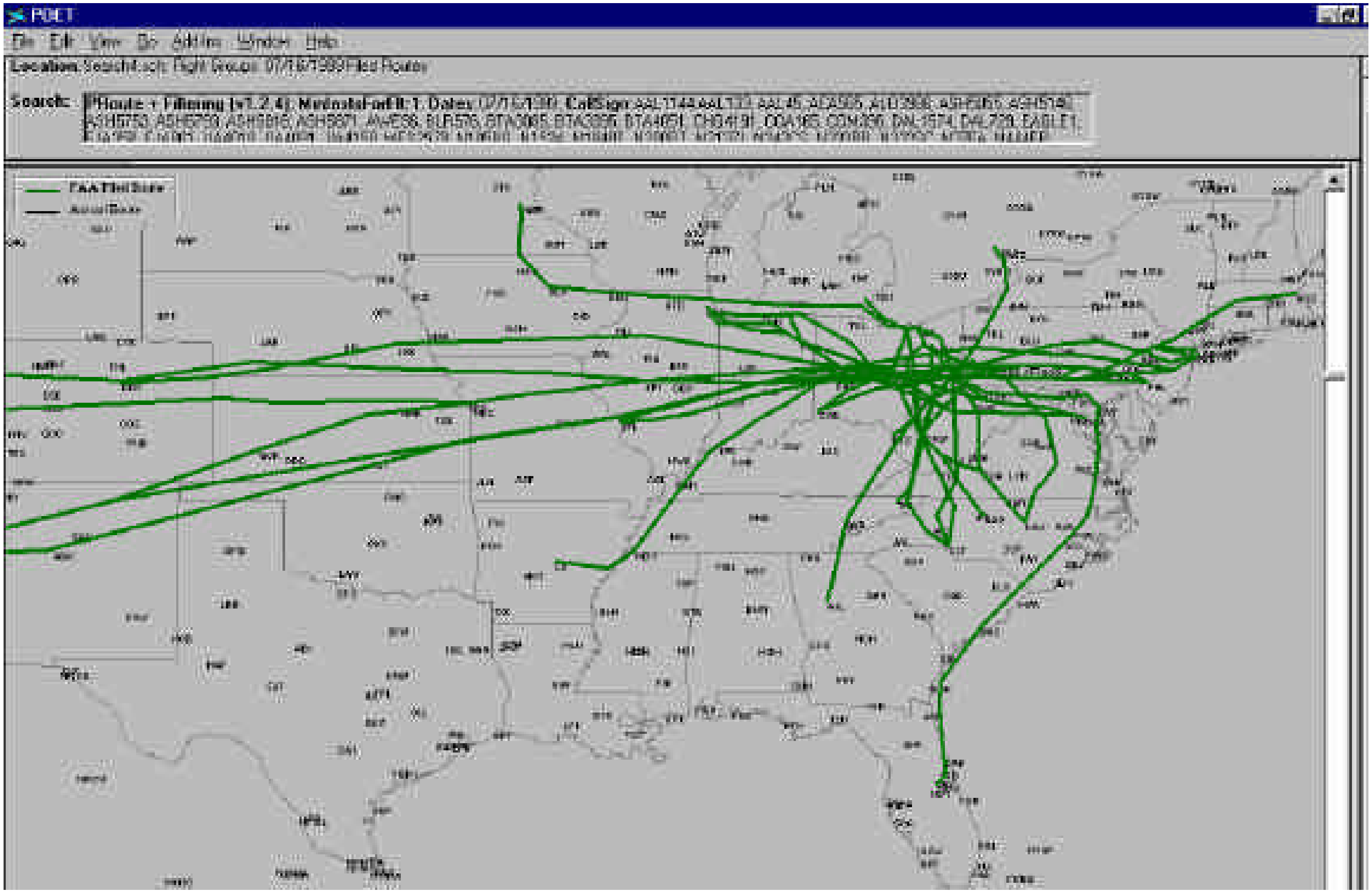
Flights filed on select segments of J554 Arriving 0200-0300Z



Departure Delays of other Flights using J554

Origin	Destination	Average Departure Delay (mins.)
CLE	BOS	80
CLE	SYR	75
CLE	BUF	63
JFK	ORD	57
DTW	MDW	56
CLE	ORD	50
CLE	ROC	49
PHL	DTW	44

Flights Flying J80 at Same Time as 2200-2300Z Arrivals at CVG



Departure Delays of other Flights using J80

POET

File Edit View Go Add-Ins Window Help

Location: Search5.sch: Flight Groups

Search: **PRoute + Filtering (v1.2.4)**; **MinInstsForFlt:** 1; **Dates:** 07/16/1999; **CallSign:** AAL1144,AAL133, AAL45, ACA565, ALO3986, ASH5055, ASH5146, ASH5753, ASH5793, ASH5818, ASH5871, AWE96, BLR576, BTA3085, BTA3395, BTA4051, CHQ4191, COA165, COM396, DAL1574, DAL729, EAGLE1, EJA358, EJA861, JIA4018, JIA4081, JIA4158, MES2979, N105BG, N152A, N1848T, N200BT, N2137J, N242CS, N333BB, N333SC, N37FA, N444EP

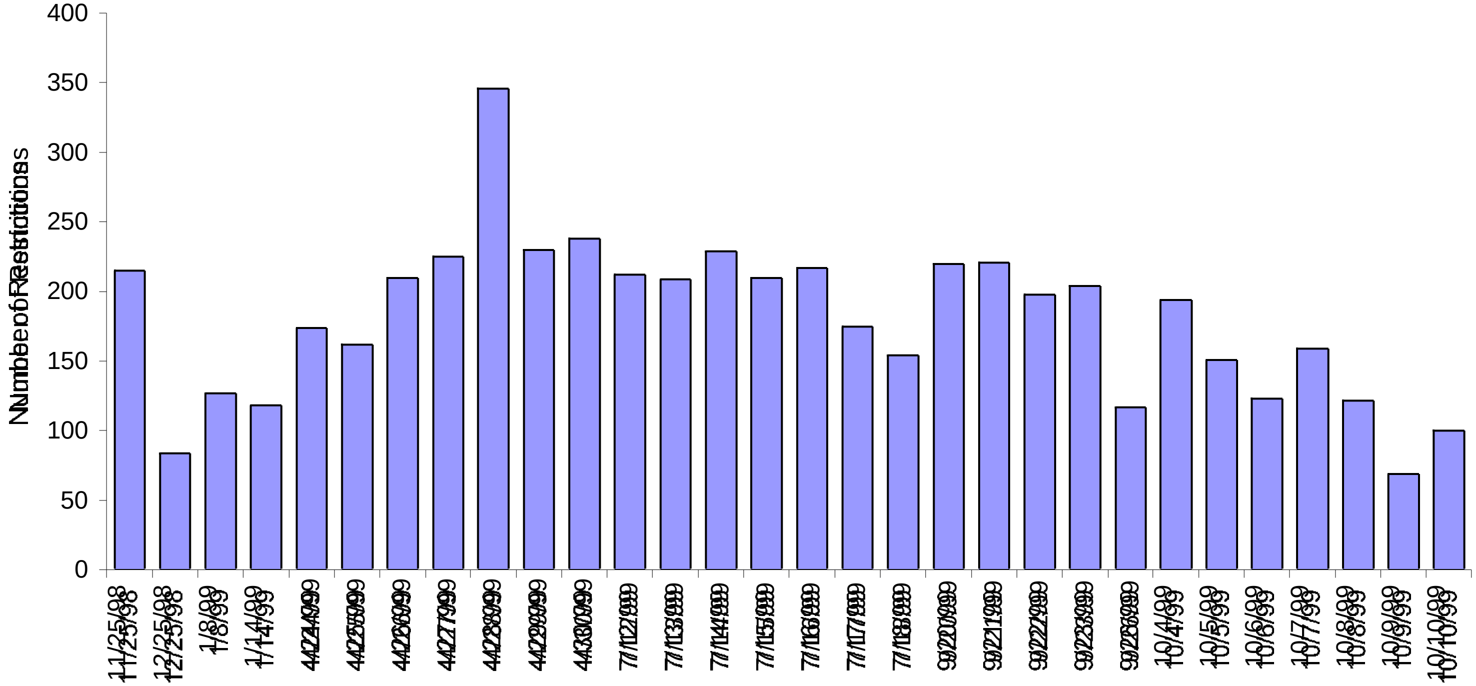
Explore Data Mining...

Departure Airport	Arrival Airport	Number of Instances	Performance Metrics	Planned	Actual	Difference (Actual - Planned)	
PIT	CLT	1	Off Time (Z)	2015	2139	84.0	
			AirTime (mins)	59.0	62.0	3.0	5.1%
			On Time (Z)	2114	2241	87.0	
MEM	PHL	1	Off Time (Z)	1855	2000	65.0	
			AirTime (mins)	128.0	130.0	2.0	1.6%
			On Time (Z)	2103	2210	67.0	
PIT	TRI	1	Off Time (Z)	2007	2111	64.0	
			AirTime (mins)	58.0	73.0	15.0	25.9%
			On Time (Z)	2105	2224	79.0	
BOS	CVG	1	Off Time (Z)	2000	2046	46.0	
			AirTime (mins)	105.0	104.0	-1.0	-1.0%
			On Time (Z)	2145	2230	45.0	
JFK	LAX	1	Off Time (Z)	2025	2111	46.0	
			AirTime (mins)	302.0	306.0	4.0	1.3%
			On Time (Z)	0127	0217	50.0	
TRI	PIT	1	Off Time (Z)	2150	2235	45.0	
			AirTime (mins)	54.0	63.0	9.0	16.7%
			On Time (Z)	2244	2338	54.0	
ROA	CRW	1	Off Time (Z)	1940	2022	42.0	
			AirTime (mins)	35.0	35.0	0.0	0.0%
			On Time (Z)	2015	2057	42.0	
CRW	DTW	1	Off Time (Z)	2045	2123	38.0	
			AirTime (mins)	73.0	77.0	4.0	5.5%
			On Time (Z)	2158	2240	42.0	
LGA	CMH	1	Off Time (Z)	1939	2014	35.0	
			AirTime (mins)	67.0	71.0	4.0	6.0%
			On Time (Z)	2046	2125	39.0	
JFK	STL	1	Off Time (Z)	1950	2022	32.0	
			AirTime (mins)	123.0	106.0	-17.0	-13.8%
			On Time (Z)	2153	2208	15.0	
LGA	STL	1	Off Time (Z)	1940	2008	28.0	
			AirTime (mins)	124.0	117.0	-7.0	-5.6%
			On Time (Z)	2144	2205	21.0	
IAD	DAY	1	Off Time (Z)	2250	2318	28.0	
			AirTime (mins)	77.0	72.0	-5.0	-6.5%
			On Time (Z)	0007	0030	23.0	
EWR	SNA	1	Off Time (Z)	1955	2023	28.0	
			AirTime (mins)	299.0	293.0	-6.0	-2.0%
			On Time (Z)	0054	0116	22.0	

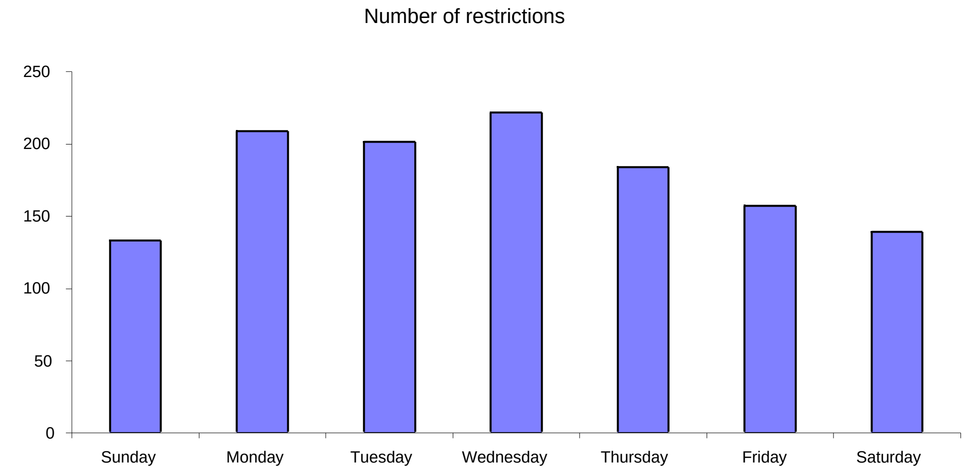
Miles-in-Trail Restrictions

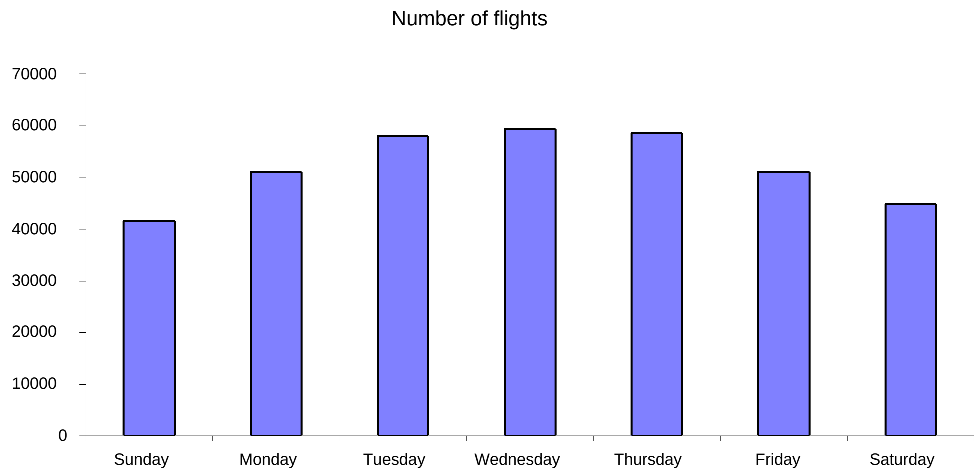
- What is the frequency of miles in trail?
- What were the reasons for these restrictions?
- What destinations were most often impacted?
- How many flights were impacted?

Number of MIT restrictions by day



Weekly trends of MIT





MIT by Reason & Affected Destination

Reason	Number	% of Total
VOLUME	388	33%
WEATHER	362	31%
DEMAND	158	13%
AAR	91	8%
	999	85%

Airport	Number	% of Total
ORD	164	14%
CVG	126	11%
ATL	119	10%
DTW	78	7%
IAD	70	6%
	557	47%

Flights Impacted by MIT

- On average 13.5 flights were impacted for by each restriction (range 1 to 442)
  - ZJX put a 20-mile MIT restriction on ZTL for flights arriving in Atlanta (ATL) between 1215 and 1445 due to weather that affected 60 flights.
  - ZID put a 30-mile MIT restriction on ZAU for flights arriving in Atlanta (ATL) between 1745 and 1845 due to weather that affected only 6 flights.
- On average 8.5 flights affected per MIT restriction hour
- On average1332 flights were affected per day
  - Ranged from 300 (9 October 1999) to 1912 (28 April 1999) flights affected per day

MIT Impacted Flights by Reason & Affected Destination

Reason	# of Restrictions	# of Flights Affected	% of Total NAS Flights
VOLUME	388	2621	0.87%
WEATHER	362	2097	0.70%
DEMAND	158	1703	0.56%
AAR	91	702	0.23%

Airport	# of Restrictions	# of Flights Affected	% of Total NAS Flights
ORD	164	2695	0.89%
CVG	126	982	0.33%
ATL	119	2119	0.70%
DTW	78	856	0.28%
IAD	70	1341	0.44%

Diversions

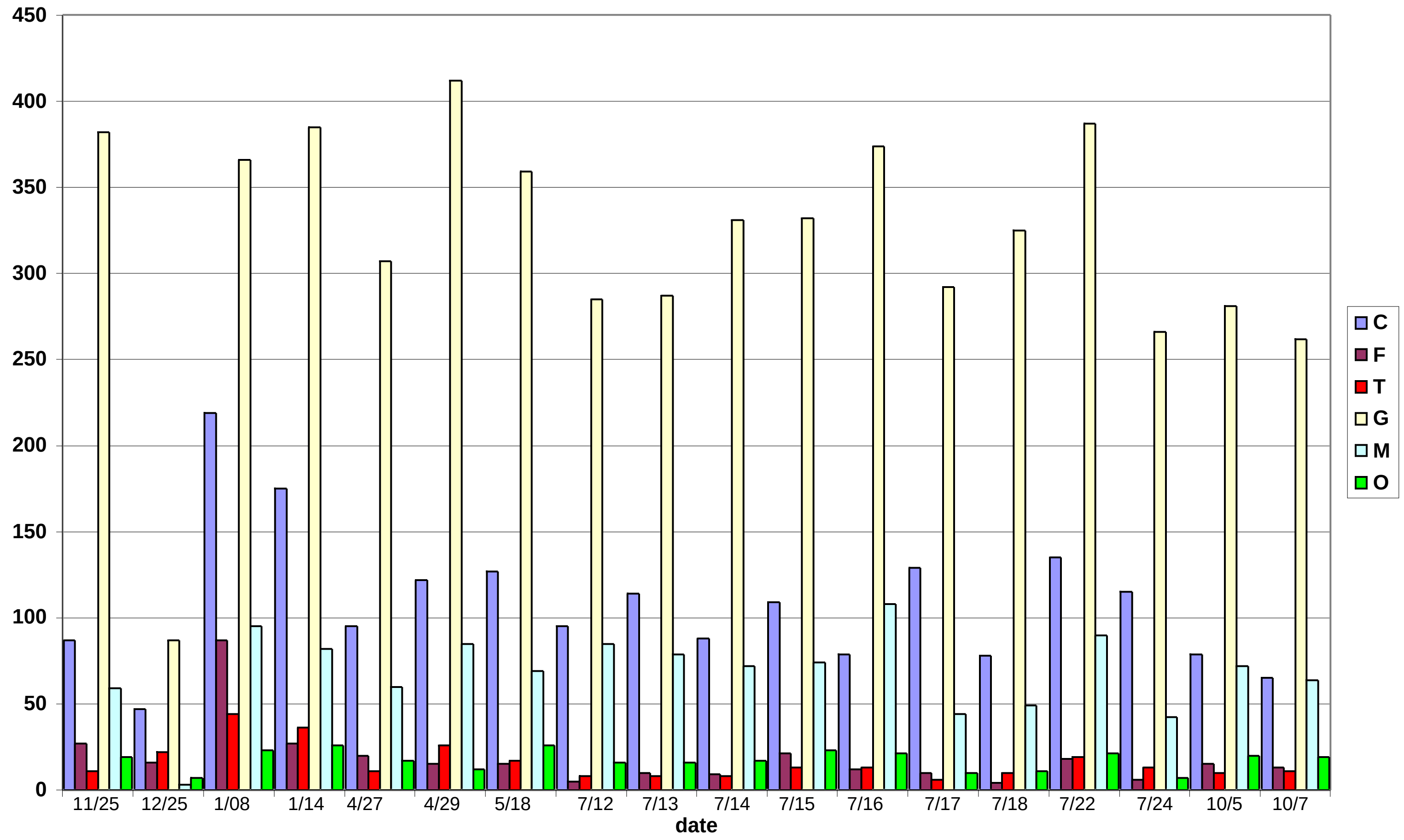
	number	percent	Average/Day	max.	min.
aborts	1187	0.12	66	112	31
diversions	9844	1.02	547	834	182
total	11212	1.17	623	950	214
flights in NAS	961303	100	53406	61090	29811

Diversions by User Class

user class	number	percent	Average/Day	max.	min.
C	1959	20	109	219	47
F	331	3	18	87	4
G	5725	58	318	412	87
M	1232	13	68	108	3
O	311	3	17	26	7
T	286	3	16	44	6
total	9844	100	547	834	182
C+F+T	2576	26	143	350	85

Key: C = air carrier
F = freight
G = general aviation
M = military
O = other
T = air taxi

Daily Variation in Diversions



Rank-ordered Count of Air Carrier Diversions by Day

Date	Air Carrier Diversions	Comments
1/8/99	219	snowstorms, 9 GDPs at six airports
1/14/99	175	snow and icing, one SFO GDP
7/22/99	135	Thunderstorms on east coast, 4 GDPs
7/17/99	129	bad weather, 4 GDPs
5/18/99	128	bad weather, 3 GDPs
4/29/99	122	one ATL GDP
7/24/99	115	bad weather, one SFO GDP
7/13/99	114	no GDPs
7/15/99	109	bad weather, PHX GDP
4/27/99	95	
7/12/99	95	
7/14/99	88	
11/25/98	87	
7/16/99	79	one SFO GDP
10/5/99	79	
7/18/99	78	bad weather, 3 GDPs
10/7/99	65	one SEA GDP
12/25/98	47	

Diversion Delays

All user classes	average	max
time on ground	79	1112
last leg	57	336
delay, diversion to destination	136	1169

"C" (air carrier) user class	average	max
time on ground	83	1081
last leg	55	260
delay, diversion to destination	138	1093

"G" (G/A) user class	average	max
time on ground	82	1112
last leg	63	336
delay, diversion to destination	146	1169

"F" (freight) user class	average	max
time on ground	73	537
last leg	60	159
delay, diversion to destination	137	546

"T" (air-taxi) user class	average	max
time on ground	67	224
last leg	39	106
delay, diversion to destination	106	242

Recommendations

- Develop and apply additional reroute metrics that focus on different measures of operational significance (e.g., flights rerouted from one sector to another)
- Further investigate reroutes from the perspective of "good" or "bad” reroutes (e.g., directs) and study their effects
- Explore the causes of inefficiencies in specific sectors (such as detecting overflights through arrival and departure sectors and crossing traffic within en route sectors-i.e., flights cutting across major flows)

Recommendations (cont.)

- Investigate altitude and speed constraints encountered by flights
- Discriminate among the causes of diversions (such as low fuel diversions because of restricted arrival rates at an airport)
- Automate some of the detailed analyses that we did by hand so they could be run on the entire NAS and the results ranked (e.g., examine jet route segments that are bottlenecks at particular times of day, causing departure delays and/or reroutes)

Recommendations (cont.)

- Look (on a larger scale) for evidence of the impact of using alternative strategies. We found examples where flights that receive reroutes (probably before takeoff) are avoiding the departure delays that other flights are experiencing (i.e., a study of the tradeoffs among the strategies currently being used).
- Develop/refine the data mining algorithms to detect where certain problems are arising (e.g., arrival sector vs. en route, etc). The simplest example is high altitude holding vs. holding at an arrival fix. Another example is to determine where and when along a flight's track reroutes and deviations are occurring.
- Further explore how many MIT restrictions are in effect actually passbacks

Recommendations (cont.)

- Further correlate the various types of "problems" explored in this analysis to provide a more complete picture of what is happening with particular traffic flows
- Explore the interaction of significant reroutes and airborne holding with ground hold traffic management initiatives (e.g. GDPs and ground stops) and the use of MIT restrictions (e.g., look at how often flights affected by MIT were held and/or significantly rerouted)
- Examine the distribution of delays, deviations, and other en route problems across different NAS users. Any solutions or new approaches will must be applied in an equitable fashion, or improve the equity of the existing system, and this could help establish a baseline