North Atlantic FIR Traffic Forecast

Presented By: United States

Update: ICAO NAT EFFG, 21 September 2016

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EFFG NAT Traffic Forecast – A Collaborative Effort

Forecast methodology, assumptions and data sources were discussed to address issues with previous methodology at the EFFG Traffic Forecast Workshop in Lisbon, Portugal, February 2016

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Near-Term Five-Year Forecast Methodology: Data

- **FIR Set:**
  - **New York, Gander, Shanwick, Santa Maria, Reykjavik and Bodo**
- **Carrier Set:**
  - **Fifty-three carriers (covering ~ 80% of traffic in each FIR); April forecast included forty- eight carriers**
  - **Includes four major Middle Eastern carriers and low cost carriers with significant growth potential**
  - **About 15% of all NAT traffic are operated by LCCs and expected to grow**
    - **Example: Norwegian Air to begin taking delivery of 100 B737-MAX8s in 2017**
- **Fleet Information**
  - **Sources for equipment inventory, orders, and retirement plans**

Boeing and Airbus order books	**Publicly available financial documents**
Carrier websites	**Public news announcements**

- **Fleet Utilization**
  - **Flight data obtained from ANSPs used to determine aircraft utilization**
  - **Focused on ANSP provided peak week data for July 15-21, 2016**

Description of Forecast Methodology

- The new twenty year forecast is composed of two parts
  - Near-term projection for the first 5 years
  - Long-term portion that forecasts 6 to 20 years into the future

- The near-term portion (first five years) of the forecast is
  - Based on carrier fleet order books
  - Reflects decisions about network and fleet changes by 53 airlines
  - Reflects input from operators and key stakeholders

- The long-term portion of the forecast
  - Reflects traffic growth for the following 15 years
  - Consists of a central, low, and high growth rate

- At the NAT SPG/52 meeting the SPG endorsed the dissemination of the NAT EFFG Traffic Forecast

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Forecasted vs. reported weekly 2016 NAT traffic

- **Forecasted 53 carriers and kept other traffic constant**

	2015 Actual	2016 Actual	2016 Forecasted	Actual % Change 2015 to 2016	Forecasted % Change 2015 to 2016
Select 53 Carrier	13,249	14,015	13,990	5.8%	5.6%

- **Forecast growth from 2015 to 2016 was projected to be 5.6% for the select 53 carriers (which represent 80% of NAT traffic), which compares closely with the actual 5.8% growth reported**

Forecasted vs. reported weekly 2016 NAT traffic

Rank	Select 53 Carriers	Carrier ICAO	2015 Actual	2016 Actual	2016 Forecasted	Actual % Change 2015 to 2016	Forecasted % Change 2015 to 2016	Positive=OverForcasted, Negative=UnderForcasted
1	American Airlines	AAL	1,146	1,098	1,169	-4.20%	2.00%	71
2	Delta Airlines	DAL	1400	1420	1407	1.40%	0.50%	-13
3	United Airlines	UAL	1293	1358	1322	5.00%	2.20%	-36
4	British Airways	BAW	808	858	853	6.20%	5.60%	-5
5	jetBlue	JBU	613	563	628	-8.20%	2.40%	65
6	Lufthansa	DLH	590	618	593	4.70%	0.50%	-25
7	Icelandair	ICE	582	676	626	16.20%	7.60%	-50
8	Air France	AFR	563	582	609	3.40%	8.20%	27
9	Air Canada	ACA	501	539	500	7.60%	-0.20%	-39
10	Virgin Atlantic	VIR	374	372	379	-0.50%	1.30%	7
11	KLM	KLM	333	359	353	7.80%	6.00%	-6
12	Aer Lingus	EIN	319	367	346	15.00%	8.50%	-21
13	SATA Air	SAT	301	346	301	15.00%	0.00%	-45
14	Air Transat	TSC	300	313	312	4.30%	4.00%	-1
15	Iberia Airlines	IBE	281	296	294	5.30%	4.60%	-2
16	Ryan Air	RYR	269	312	283	16.00%	5.20%	-29
17	United Emirates	UAE	209	254	306	21.50%	46.40%	52
18	Scandinavian Airlines	SAS	168	172	166	2.40%	-1.20%	-6
19	Swiss Air	SWR	163	175	178	7.40%	9.20%	3
20	TAP Portugal	TAP	149	178	152	19.50%	2.00%	-26
21	SATA International	RZO	148	168	149	13.50%	0.70%	-19
22	WOW Air	WOW	148	235	163	58.80%	10.10%	-72
23	Turkish Air	THY	147	123	176	-16.30%	19.70%	53
24	Air Berlin	BER	144	180	144	25.00%	0.00%	-36
25	Thompson	TOM	143	142	171	-0.70%	19.60%	29
26	Condor	CFG	142	143	151	0.70%	6.30%	8
27	Air Canada Rouge	ROU	139	192	145	38.10%	4.30%	-47

Forecasted vs. reported weekly 2016 NAT traffic

Rank	Select 53 Carriers	Carrier ICAO	2015 Actual	2016 Actual	2016 Forecasted	Actual % Change 2015 to 2016	Forecasted % Change 2015 to 2016	Positive=OverForcasted, Negative=UnderForcasted
28	Alitalia	AZA	127	133	129	4.70%	1.60%	-4
29	Air Europa	AEA	124	126	143	1.60%	15.30%	17
30	Thomas Cook Airlines	TCX	118	183	184	55.10%	55.90%	1
31	Qatar Airways	QTR	118	185	154	56.80%	30.50%	-31
32	Norwegian Air	NAX	109	132	123	21.10%	12.80%	-9
33	Air Greenland	GRL	99	47	97	-52.50%	-2.00%	50
34	Etihad Air	ETD	97	103	121	6.20%	24.70%	18
35	Jet2	EXS	93	86	129	-7.50%	38.70%	43
36	TAM Airlines	TAM	85	93	88	9.40%	3.50%	-5
37	EasyJet	EZY	83	80	83	-3.60%	0.00%	3
38	Avianca	AVA	81	70	78	-13.60%	-3.70%	8
39	Atlantic Airways	FLI	78	84	78	7.70%	0.00%	-6
40	WestJet	WJA	75	133	98	77.30%	30.70%	-35
41	FedEx	FDX	72	72	72	0.00%	0.00%	0
42	Air Caraibes	FWI	68	77	75	13.20%	10.30%	-2
43	Air Iceland	FXI	66	58	66	-12.10%	0.00%	8
44	UPS	UPS	66	65	66	-1.50%	0.00%	1
45	Aeroflot	AFL	64	68	84	6.30%	31.30%	16
46	Polish Airlines	LOT	58	61	64	5.20%	10.30%	3
47	Bristow Helicopters	BHL	44	0	44	-100.00%	0.00%	44
48	Air India	AIC	42	49	50	16.70%	19.00%	1
49	Royal Air Maroc	RAM	34	40	45	17.60%	32.40%	5
50	Transaero	TSO	32	0	0	-100.00%	-100.00%	0
51	Finnair	FIN	27	31	27	14.80%	0.00%	-4
52	CHC Helikopter	HKS	16	0	16	-100.00%	0.00%	16
53	Southwest Airlines	SWA	0	0	0	0.00%	0.00%	0

Note: Southwest is included in the forecast for future years

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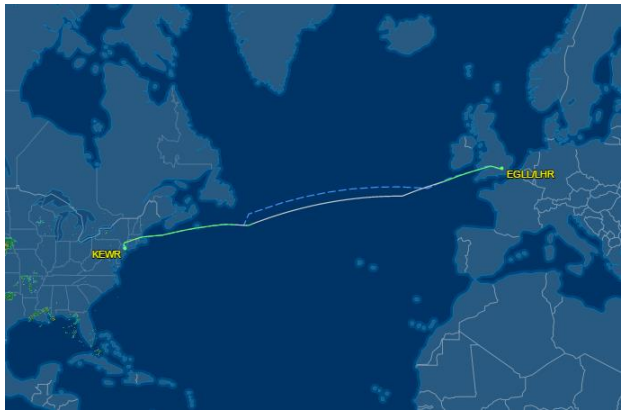
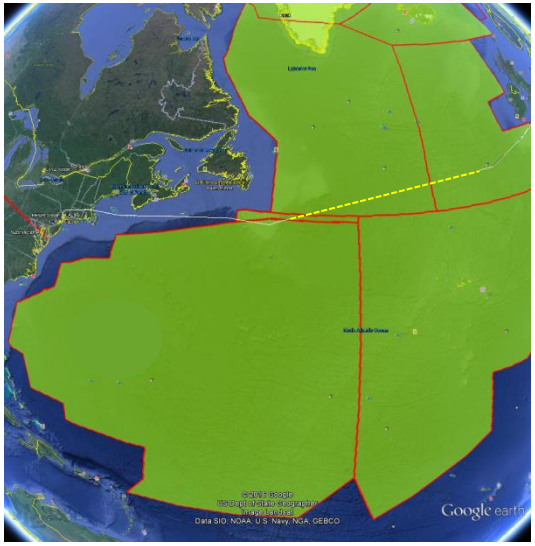
Discussion of forecast variance

- **Helicopter operations present high uncertainty as an unscheduled service**
  - Majority of Bodo traffic
- **Business strategy**
  - Icelandair, WOW, and Norwegian Air more aggressive than in the past
- **Fleets and Utilization**
  - WOW took delivery of additional aircraft after April 2016 forecast was finalized
  - Carriers adjusted fleet utilization (e.g. SATA Air added an additional operation per aircraft each day)
- **Economic and Political Stability**
  - Turkish coup, Terrorism, Brexit
- **Wind changes can affect FIR crossings for same OD pairs**
  - Example: UAL flights EWR - EGLL sometimes cross NY oceanic airspace
- **Variation between land and oceanic operations for same O/D pairs along coast**
  - Example: American and jetBlue flights between US mainland to Caribbean
- **Fewer polar routes reported in 2015 data compared to 2016**
  - UAL and DLH polar routes now included in 2016, but should they?

Wind shifts move track routes, United KEWR - EGLL

Jul 15, 2016





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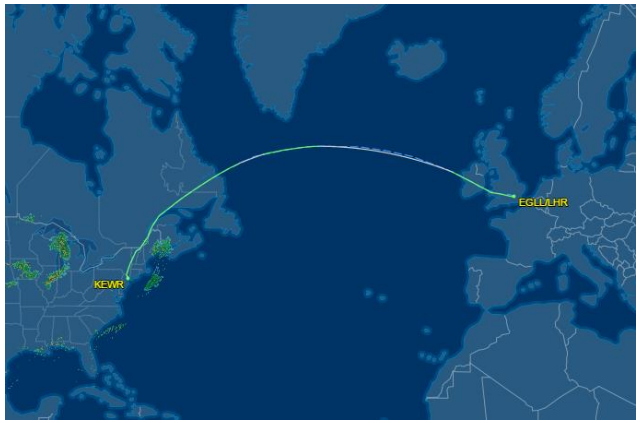
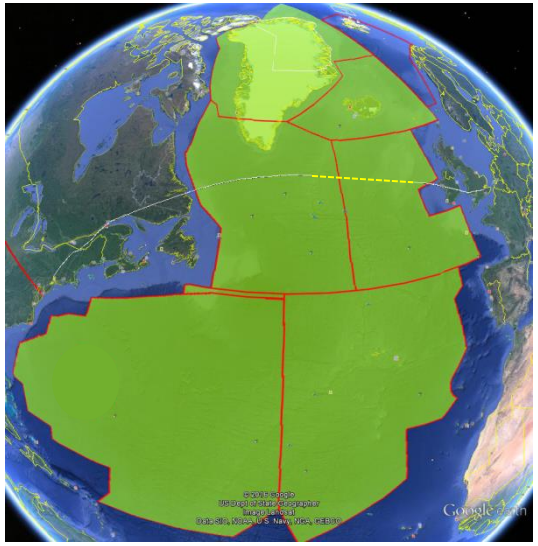
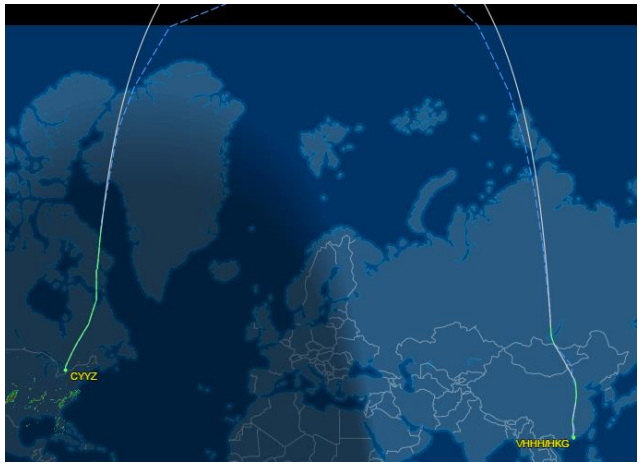




Source: 2016 FlightAware©

Near polar route, Cathay Pacific CYYZ - VHHH



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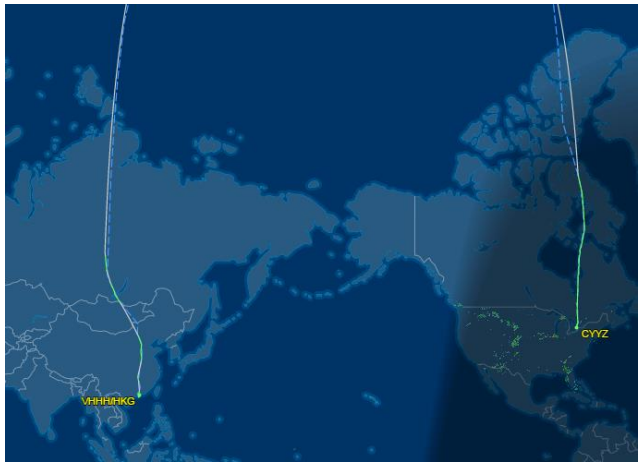

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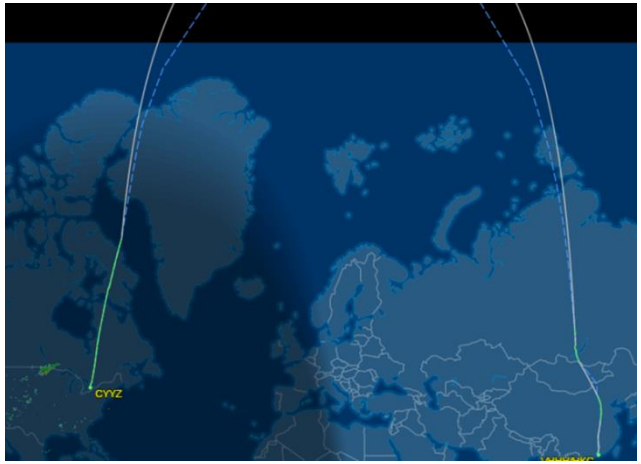
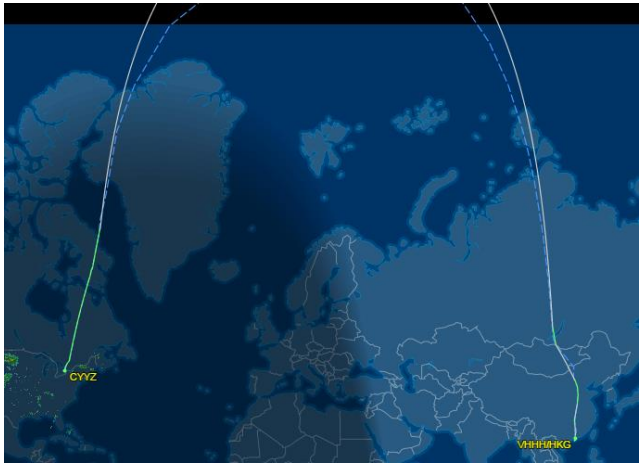


Jul 20, 2016



Jul 21, 2016

Source: 2016 FlightAware©

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- Forecasted vs. reported weekly 2016 NAT traffic
- Discussion of forecast variance
- Discussion of how to adjust next forecast
- Preliminary 2016 – 2036 Forecast
- Next Steps
- Conclusion

Discussion of how to adjust next forecast

- **Consolidate data collection**
  - EuroControl data to benchmark ANSP data and standardize coverage of European ANSP flight data
  - Continue use of NAVCanada and FAA flight data for coverage of North America
- **Recommend including Sondrestrom FIR**
- **Recommend excluding helicopter data since helicopters do not enter NAT airspace due to altitude**

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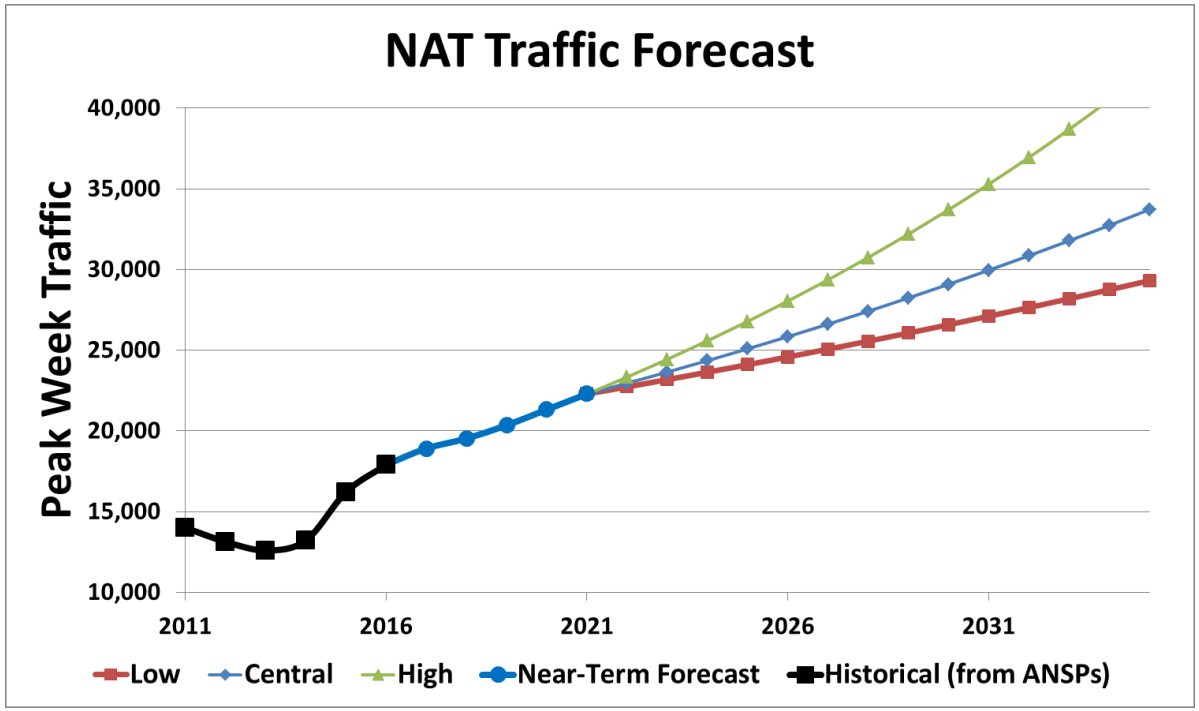
Preliminary 2016 – 2036 Forecast

- **Adjustments will include**
  - Updates to fleet plans
  - Adjustments to utilization rates
  - Data anomaly corrections
  - Exclusion of helicopters
  - Near term forecast extended through 2021
  - Long term forecast extended through 2036

Peak Week Historical and Near-Term Forecasted FIR Operations

Preliminary short-term growth rate is 4.5% from 2016-2021 - up from 3.6% in previous forecast
Preliminary long-term growth rate is 3.4% from 2016-2036 - up from 3.2% in previous forecast



Average Yr-Yr NAT Growth Rates			
	2011-2016 actual growth rate	2016-2021 short-term projection	2016-2036 composite projection
High			4.6%
Central	4.1%	4.5%	3.4%
Low			2.6%

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Next Steps

- **Use FAA and EuroControl data to benchmark flight records submitted by the ANSPs**
- **Anticipate interim working group discussions of forecast before Spring 2017**
- **Coordinate final forecast at NAT EFFG/32 meeting in April 2017**
- **Present final forecast at SPG/53 meeting in June 2017**
- **Continue developing a Tableau NAT dashboard**
  - Build an interactive dashboard using Tableau to show the historical and projected growth at FIRs and O/D markets
  - Make it accessible to all participating members through an internet link
  - Web link to 2015-2020 NAT Forecast Tableau Dashboard

2015-2020 NAT Forecast Tableau Dashboard

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Conclusion

- **Variance analysis for 2016 shows minimal deviation between forecast and actuals (5.6% vs 5.8%, respectively)**
- **Preliminary long-term forecast growth rate is 3.4%**
- **2017 forecast update will use the same methodology as the 2016 release**

NAT EFFG and Our Work: US-UK

Backup slides

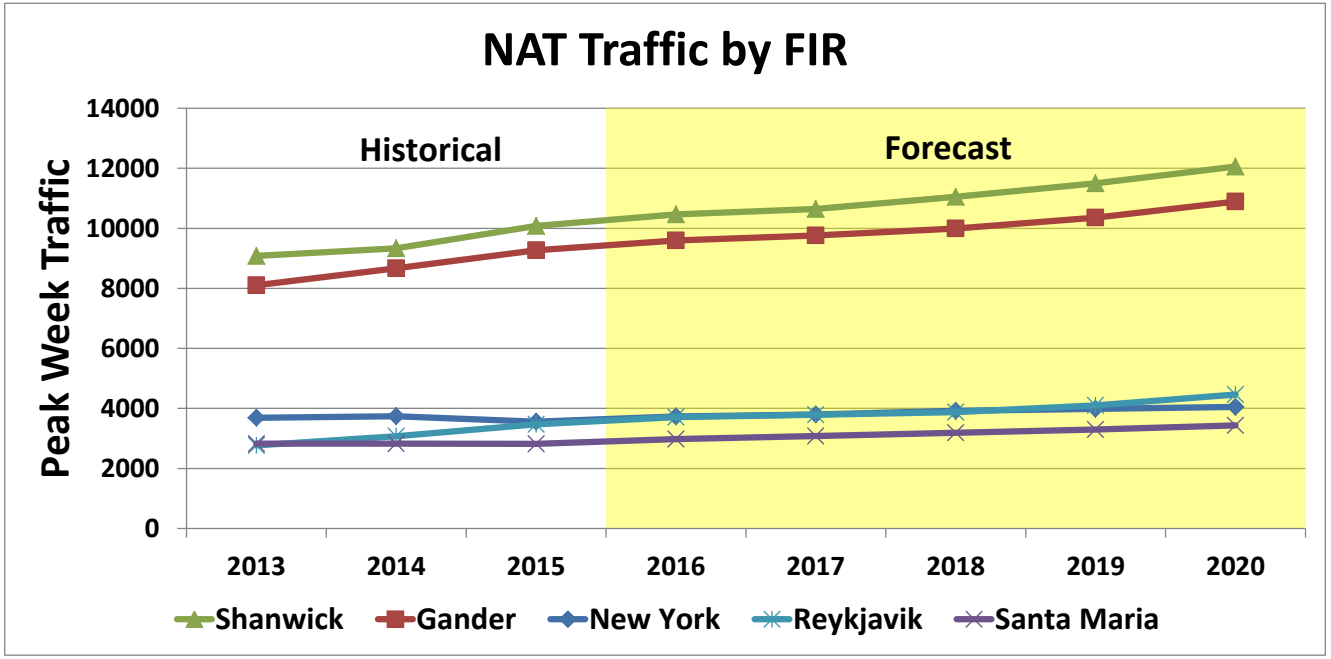
APPENDIX

Backup slides – Previous Forecast

APPENDIX

Peak Week Historical and Near-Term Forecasted FIR Operations

Average annual growth of 3.6% is projected for total Trans-Atlantic operations from 2015 to 2020



Average Yearly Growth Rates by FIR		
FIR	2013 – 2015 (actual growth rate)	5-Yr Projected
Shanwick	5.4%	3.6%
Gander	6.9%	3.3%
New York	-1.8%	2.6%
Reykjavik	12.0%	5.1%
Santa Maria	-0.2%	4.0%

Note that summing across FIRs does not provide total NAT operations for the carrier since a single flight can cross multiple FIRs.

Peak Week Trans-Atlantic Near-Term Forecast for Select Carriers

		New York		Gander		Shanwick		Santa Maria		Reykjavik		Total Flights	
Carrier Name	Carrier ICAO	2015	2020	2015	2020	2015	2020	2015	2020	2015	2020	2015	2020
Delta Airlines	DAL	339	349	1,036	1,057	987	1,001	82	86	173	175	1,404	1,430
United Airlines	UAL	234	251	1,031	969	997	939	56	56	174	160	1,298	1,249
American Airlines	AAL	437	485	795	912	831	949	145	156	49	60	1,166	1,332
British Airways	BAW	134	145	661	778	783	905	98	107	115	125	808	932
jetBlue	JBU	620	611	0	104	0	104	0	0	0	0	620	715
Lufthansa	DLH	37	37	464	466	459	462	50	50	149	151	590	597
Icelandair	ICE	0	14	160	286	166	223	0	0	582	935	582	935
Air France	AFR	155	194	364	447	530	651	181	218	41	51	569	694
Air Canada	ACA	60	65	395	404	393	404	9	13	95	95	501	515
Virgin Atlantic	VIR	97	104	321	356	365	401	38	38	39	44	377	414
KLM	KLM	74	84	206	238	274	316	91	100	67	79	331	382
Aer Lingus	EIN	1	1	160	232	319	492	16	26	7	10	319	492
SATA Air	SAT	0	0	0	0	0	0	301	301	0	0	301	301
Air Transat	TSC	33	38	241	245	249	255	26	29	37	41	300	312
Iberia Airlines	IBE	155	168	39	47	34	41	262	283	1	2	285	312
Ryan Air	RYR	0	0	0	0	230	293	78	93	0	0	269	342
United Emirates	UAE	6	26	146	238	85	142	4	24	124	189	209	336
Swiss Air	SWR	20	22	143	180	150	189	7	8	28	32	164	204
TAP Portugal	TAP	41	52	0	0	3	3	144	181	0	0	149	186
SATA International	RZO	35	35	7	7	2	2	148	148	0	0	149	149
WOW Air	WOW	0	0	23	34	81	119	2	2	147	200	148	201
Turkish Air	THY	5	5	130	166	86	117	0	0	68	105	147	215
Condor	CFG	54	51	69	79	103	110	39	36	42	59	145	162
Scandinavian Airlines	SAS	0	0	109	119	46	47	0	0	114	137	144	166
Thompson	TOM	41	78	65	120	140	266	46	88	2	4	143	272
Air Berlin	BER	29	32	90	80	88	79	13	17	59	55	143	132

*Data ordered by 2015 Total Flights.

**Note that summing across FIRs does not equate to the total NAT flights for a carrier since a single flight can cross multiple FIRs.

Peak Week Trans-Atlantic Flights for Select Carriers (cont.)

		New York		Gander		Shanwick		Santa Maria		Reykjavik		Total Flights	
Carrier Name	Carrier ICAO	2015	2020	2015	2020	2015	2020	2015	2020	2015	2020	2015	2020
Air Canada Rouge	ROU	16	20	123	197	119	191	9	11	8	16	139	221
Alitalia	AZA	16	16	111	111	115	115	14	14	8	8	129	129
Air Europa	AEA	72	133	8	14	14	23	121	220	0	0	129	233
Thomas Cook Airlines	TCX	28	36	57	90	118	191	44	74	3	3	118	191
Qatar Airways	QTR	2	2	114	149	64	87	6	7	52	122	118	210
Norwegian Air	NAX	9	37	71	238	39	205	0	20	73	150	103	325
Air Greenland	GRL	0	0	7	7	1	1	0	0	99	97	99	97
Etihad Air	ETD	1	16	70	156	30	99	0	56	68	135	97	232
Jet2	EXS	0	0	0	0	93	185	38	77	0	0	93	185
TAM Airlines	TAM	46	99	0	0	23	47	40	65	0	0	86	164
EasyJet	EZY	0	0	0	0	48	99	8	16	30	60	83	169
Avianca	AVA	44	78	0	0	13	20	70	124	0	0	78	138
Atlantic Airways	FLI	0	0	0	0	0	0	0	0	78	104	78	104
WestJet	WJA	44	49	28	193	28	194	0	0	1	67	75	308
FedEx	FDX	0	0	70	70	71	71	0	0	9	9	72	72
Air Caraibes	FWI	41	65	0	0	48	76	68	106	0	0	68	106
UPS	UPS	0	0	64	64	61	61	2	2	4	4	66	66
Air Iceland	FXI	0	0	6	4	0	0	0	0	60	22	66	24
Aeroflot	AFL	1	3	48	107	15	34	0	0	60	129	63	135
Polish Airlines	LOT	0	0	58	84	24	35	0	0	46	68	58	84
Royal Air Maroc	RAM	27	44	9	16	5	8	32	52	0	0	33	53
Southwest Airlines	SWA	0	0	0	53	0	53	0	0	0	0	0	53
All Others		603	603	1,771	1,771	1,752	1,752	529	529	762	762	3,181	3,181
Total		**3,557**	**4,048**	**9,270**	**10,888**	**10,082**	**12,057**	**2,817**	**3,433**	**3,474**	**4,465**	**16,293**	**19,457**
5-year %Change		**13.8%**		**17.5%**		**19.6%**		**21.9%**		**28.5%**		**19.4%**	
Average Yearly %Change		**2.6%**		**3.3%**		**3.6%**		**4.0%**		**5.1%**		**3.6%**	

**Data ordered by 2015 Total Flights.

**Note that summing across FIRs does not equate to the total NAT flights for a carrier since a single flight can cross multiple FIRs.

Near-Term Forecast Top 25 Markets: Shanwick

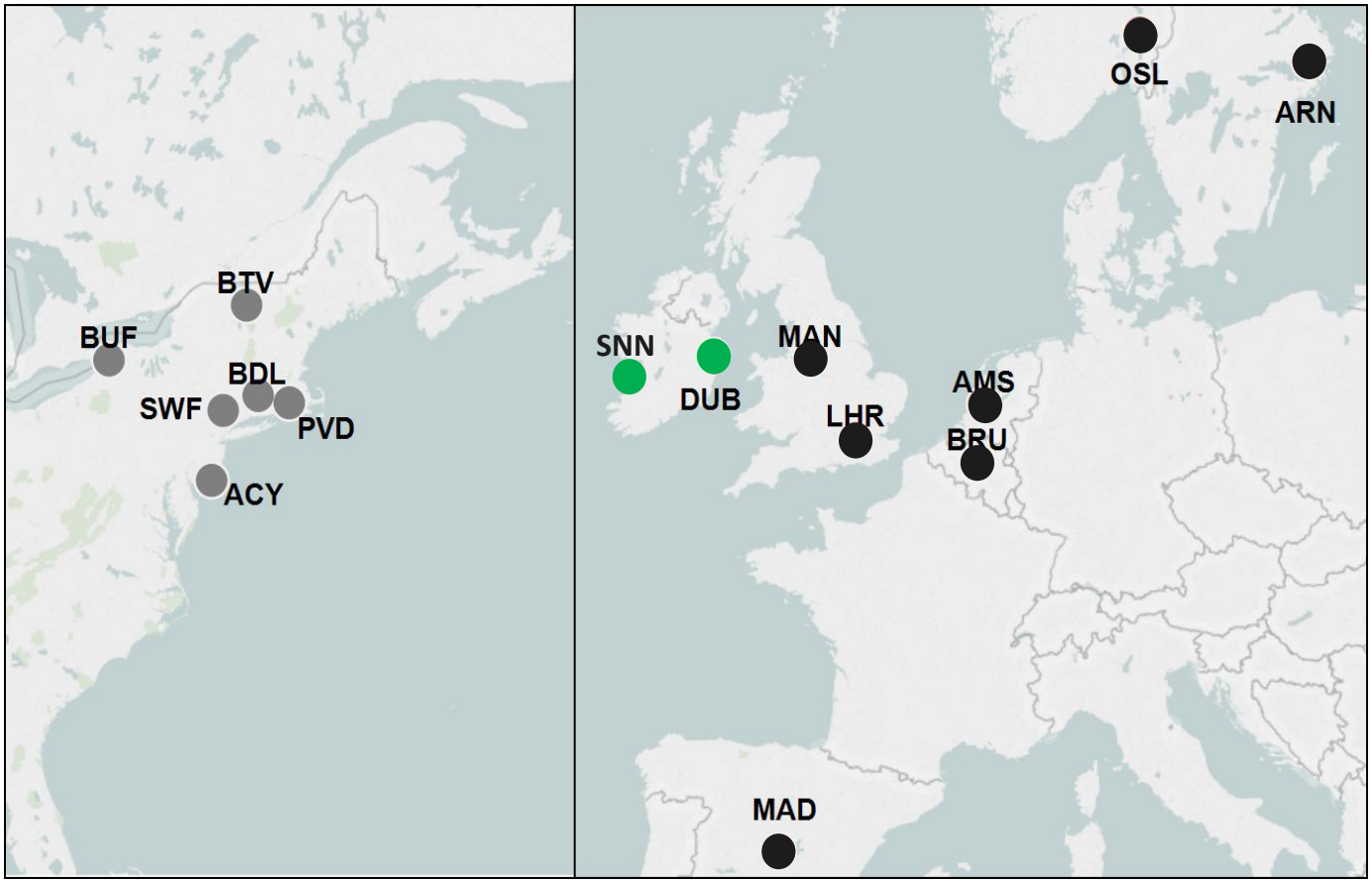
Shanwick Non-Directional Market Frequency (AAGR* = 3.6%) *Average Annual Growth Rate							
		2015	2016	2017	2018	2019	2020
% Change			3.8%	1.7%	3.8%	4.1%	4.8%
Total		10,087	10,466	10,646	11,055	11,505	12,062
EGLL-KJFK	LHR-JFK	284	300	314	332	355	379
KJFK-LFPG	JFK-CDG	129	129	135	137	153	170
EGLL-KORD	LHR-ORD	127	145	149	153	155	160
EGLL-KLAX	LHR-LAX	123	111	113	113	119	121
EGLL-KEWR	LHR-EWR	120	110	106	106	98	95
CYUL-LFPG	YUL-CDG	99	102	110	120	129	130
CYYZ-EGLL	YYZ-LHR	86	82	82	82	84	88
EGLL-KBOS	LHR-BOS	84	88	90	94	96	100
EGLL-KIAD	LHR-IAD	83	87	84	83	83	83
EIDW-LPFR	DUB-FAO	79	88	70	102	105	124
EGLL-KSFO	LHR-SFO	79	83	83	83	85	85
EGLL-KMIA	LHR-MIA	70	72	74	74	78	79
KJFK-LIRF	JFK-FCO	70	70	70	82	86	86
EIDW-KJFK	DUB-JFK	70	68	83	78	78	96
EGLL-KATL	LHR-ATL	69	73	73	73	75	77
EGLL-KPHL	LHR-PHL	69	57	57	58	61	60
EGLL-KIAH	LHR-IAH	69	73	70	69	69	68
EDDF-KORD	FRA-ORD	67	65	66	66	64	64
EDDF-KJFK	FRA-JFK	62	65	65	65	65	65
KEWR-LFPG	EWR-CDG	60	61	60	60	58	58
KJFK-LIMC	JFK-MXP	59	61	61	63	63	63
EHAM-KJFK	AMS-JFK	59	63	63	71	75	75
KATL-LFPG	ATL-CDG	57	61	61	62	66	66
LFPO-TFFR	ORY-PTP	56	62	62	62	66	75
EGLL-KDFW	LHR-DFW	56	58	62	66	66	70

Near-Term Forecast Top 25 Markets: Gander

Gander Non-Directional Market Frequency (AAGR = 3.3%)							
		2015	2016	2017	2018	2019	2020
% Change			3.5%	1.7%	2.4%	3.6%	5.1%
Total		9,278	9,601	9,766	9,999	10,363	10,896
EGLL-KJFK	LHR-JFK	282	298	311	329	352	376
KJFK-LFPG	JFK-CDG	130	130	136	138	154	171
EGLL-KORD	LHR-ORD	127	145	149	153	155	160
EGLL-KEWR	LHR-EWR	120	110	106	106	98	95
EGLL-KLAX	LHR-LAX	99	91	93	93	97	99
CYUL-LFPG	YUL-CDG	95	98	106	116	124	125
CYYZ-EGLL	YYZ-LHR	85	81	81	81	83	87
EGLL-KBOS	LHR-BOS	84	88	90	94	96	100
EGLL-KIAD	LHR-IAD	82	86	83	82	82	82
EDDF-KORD	FRA-ORD	82	80	81	81	79	79
KJFK-LIRF	JFK-FCO	70	70	70	82	86	86
EGLL-KATL	LHR-ATL	70	74	74	74	76	78
EIDW-KJFK	DUB-JFK	70	68	83	78	78	96
EGLL-KPHL	LHR-PHL	69	57	57	58	61	60
EGLL-KMIA	LHR-MIA	67	69	71	71	75	76
EGLL-KIAH	LHR-IAH	66	70	67	66	66	65
EDDF-KJFK	FRA-JFK	63	66	66	66	66	66
KJFK-LIMC	JFK-MXP	60	62	62	64	64	64
EHAM-KJFK	AMS-JFK	59	63	63	71	75	75
KEWR-LFPG	EWR-CDG	58	59	58	58	56	56
EGLL-KSFO	LHR-SFO	58	62	62	62	63	63
EGKK-KMCO	LGW-MCO	56	59	57	59	63	66
KATL-LFPG	ATL-CDG	56	60	60	61	65	65
EGLL-KDFW	LHR-DFW	56	58	62	66	66	70
KJFK-LTBA	JFK-IST	56	58	52	42	36	54

Near-Term Five-Year North Atlantic LCC Analysis

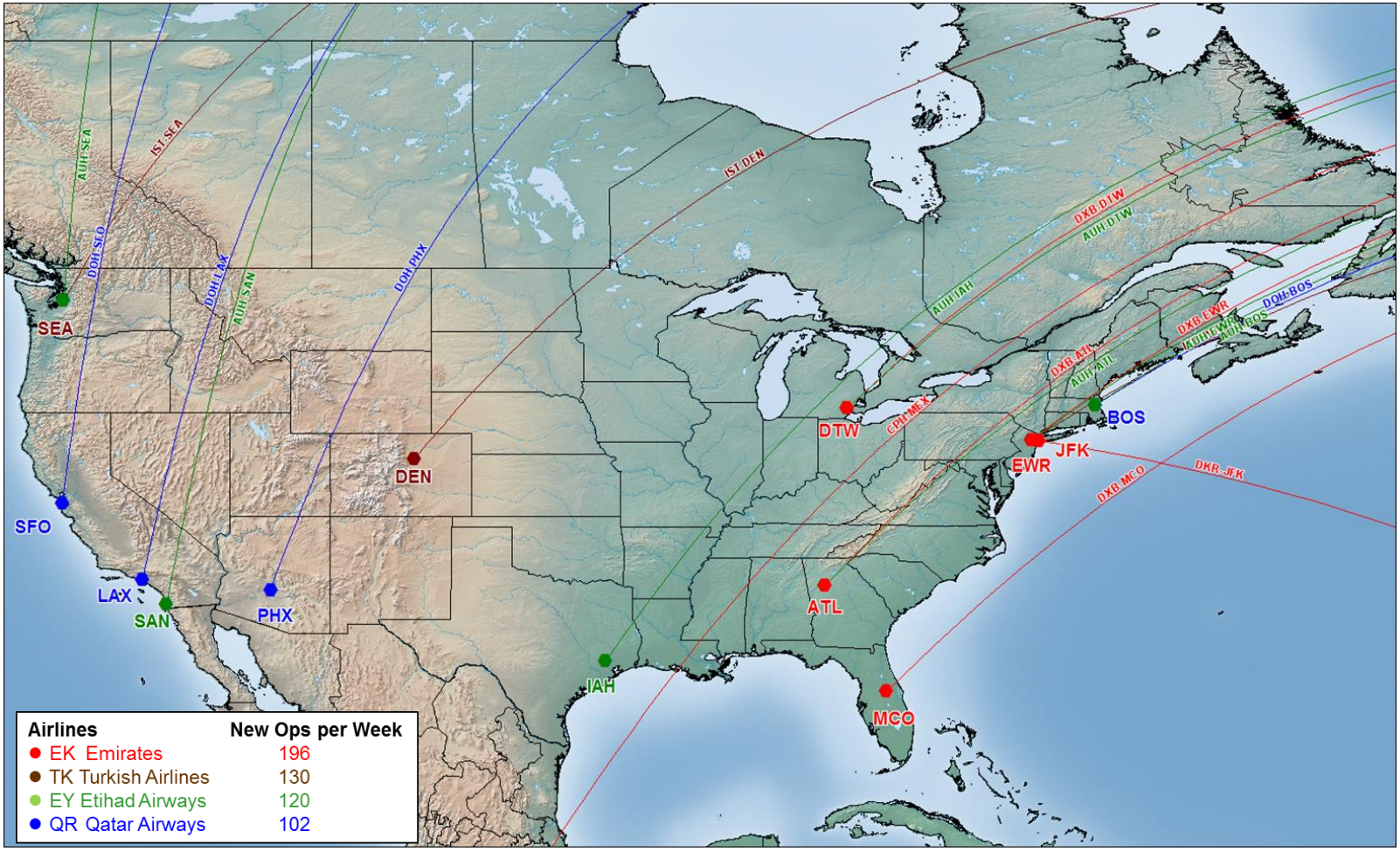
Current and Prospective Pre-Clearance European Airports Would Allow Access to U.S. Secondary Airports without Federal Inspection Services (FIS) Facilities



Istanbul's Ataturk Airport (not on map) is also being considered for Pre-Clearance

Near-Term Five-Year Middle East Carrier Analysis

Current and Prospective US markets to be served by Middle East carriers



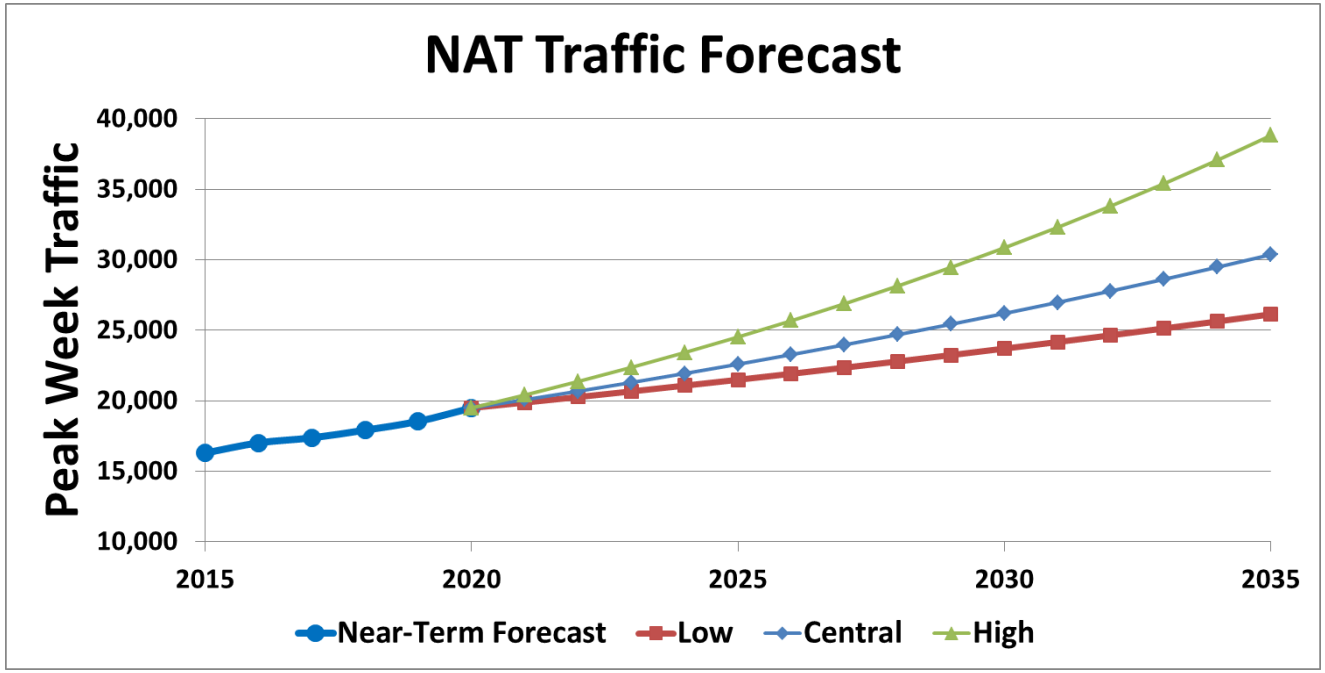
15-Year Long-Term Forecast (beyond Near-Term Forecast)

The long-term forecast branches into high, central and low forecasts from the end of the near-term forecast

Sources	AAGR from 2014 to 2034	AAGR from 2020 to 2030	AAGR from 2010 to 2030	AAGR from 2020 to 2035
IATA	2.6%	2.0%	3.0%	2.0%
Boeing	3.0%			
Airbus	2.8%			
ICAO (FESG CAEP/9) High Scenario		4.7%	4.7%	
ICAO (FESG CAEP/9) Central forecast		3.8%	3.9%	
ICAO (FESG CAEP/9) Low Scenario		3.0%	3.1%	

Summary of Long-Range (2020-2035) North Atlantic Passenger Growth Forecast	
High	4.7%
Central	3.0%
Low	2.0%

20 Year NAT Traffic Forecast (2015 – 2035)



Composite Growth Rates (2015 - 2035)	
High	4.4%
Central	3.2%
Low	2.4%

NAT Traffic Forecast by FIR

		Near-Term AAGR 2015 – 2020	Long-Term AAGR 2020 – 2035	Composite AAGR 2015 - 2035
	High		4.7%	4.2%
New York	Central	2.6%	3.0%	2.9%
	Low		2.0%	2.1%
	High		4.7%	4.3%
Gander	Central	3.3%	3.0%	3.1%
	Low		2.0%	2.3%
	High		4.7%	4.4%
Shanwick	Central	3.6%	3.0%	3.2%
	Low		2.0%	2.4%
	High		4.7%	4.5%
Santa Maria	Central	4.0%	3.0%	3.3%
	Low		2.0%	2.5%
	High		4.7%	4.8%
Reykjavik	Central	5.1%	3.0%	3.5%
	Low		2.0%	2.8%
	High		4.7%	4.4%
Total Flights	Central	3.6%	3.0%	3.2%
	Low		2.0%	2.4%

Conclusions

- In the near-term, 2015 – 2020, based on fleet analysis and business plans, NAT traffic is projected to grow 3.6% annually
- Contributing factors to first five years in the forecast
  - Rapid growth in New York due to Norwegian Air, Air Europa, and jetBlue
  - Gander and Shanwick operations will grow at a rate of 3.5%.
  - Santa Maria will grow due to Air Europa which has a large order book
  - Reykjavik will grow due to Icelandair, Norwegian Air, and WestJet
- Large orders by middle east carriers will significantly grow NAT traffic
- LCCs will add significant growth in the North Atlantic
- Growth by legacy carriers expected to remain fairly flat
- Over the next 20 years, 2015 – 2035, NAT traffic is projected to grow 3.2% annually

Five-Year Forecast Methodology: Simplified Fratar Algorithm

Mathematical formulation for the Simplified Fratar Algorithm:

$$\text{Min} \sum_{ij} (X_{ijkl} - Y_{ijk})^2 \text{ for each } kl \text{ combination}$$

Subject to the carrier-level growth projection constraint:

$$D_{kl} = \sum_{ij} X_{ijkl}, \text{ for each } kl \text{ combination}$$

where,

i **identifies the** ***i*****th departure airport** ***j*** **identifies the** ***j*****th arrival airport,**

k **identifies the k**th **carrier** ***l*** **identifies the year**

X_{ijkl} **is the number of projected NAT flights from airport** ***i*** **to airport** ***j*** **by carrier** ***k*** **in year** ***l***

Y_{ijk} **is the number of NAT flights from airport** ***i*** **to airport** ***j*** **by carrier** ***k*** **in the base year data set provided by the ANSPs**

The carrier-level growth projection constraint requires that each carrier match its yearly growth projections that were determined in the fleet analysis.