Edinburgh ACP Departures Emissions Analysis

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Prepared by:
Redacted

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Action	Role	Name	Date
Author	Senior Research Analyst	Redacted	October 2018
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Issue 2	August 2017	Route and traffic mix changes after the consultation period resulting in a change to the analysis	N/A
Issue 3	August 2017	Inclusion of constrained traffic growth scenario	N/A
Issue 4	March 2018	Revision of proposed SIDs on Runway 06	N/A
Issue 5	June 2018	Update of future SIDs to use FENIK waypoint instead of GOSAM	N/A
Issue 6	October 2018	Revised traffic figures for future years	N/A

Referenced Documents

Ref	Title	Report Reference
1	Edinburgh Airport Aeronautical Information Service Website	Link
2	Edinburgh ACP Website	Link

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Introduction

Edinburgh Airport seek to upgrade their aircraft arrival and departure routes to take advantage of the improved navigational capabilities of aRea NAVigation and improve the efficiency and capacity of the airspace around Edinburgh Airport.

The consultation proposes new aircraft arrival and departure routes around Edinburgh Airport below 7,000ft above ground level. Above 7,000ft aircraft will join the existing en-route network and proceed under direction of ATC.

This document details the analysis undertaken to estimate the impact the new departure routes will have on aircraft fuel burn and emissions and presents the overall net result of the proposed changes.

Methodology & Assumptions

This report assesses the difference in fuel burn and CO_2 expected as a result of implementing the new departure designs proposed by the Edinburgh ACP. The assessment has been carried out by NATS Analytics using in-house tools to simulate the expected trajectory of aircraft on the routes in question and to estimate the fuel burn of aircraft types using those routes.

Table 1 details the SIDs that are proposed to be changed at Edinburgh airport as a result of the ACP :

Runway	Current SID	Proposed SID	Notes (Proposed SID)
24	TLA	ARLER	00:00 - 05:59 + 14:00 - 23:59 Jets (non-peak) 00:00 - 05:59 + 10:00 - 23:59 Turboprops (non-peak)
24	TLA	EVTOL	Peak traffic only (06:00 – 09:59 local) Turboprops only Includes peak EIxx turboprops currently using GOSAM
24	TLA	VOSNE	Weekdays only Peak traffic only (06:00 – 13:59 local) Jets Only
24	GOSAM	MAVIX	H24 Departures to South and East Destination ICAO Codes: Exxx (except EI), Lxxx (except LE and LP)
24	GOSAM	LIKLA	Day traffic only (06:00 – 22:59 local) Departures to West Destination ICAO Codes:Gxxx, Kxxx, Cxxx, Sxxx, Mxxx, Txxx, LExx, LPxx
24	GRICE	GRICE	H24
06	TLA	VOSNE	H24 Jets only
06	TLA	KRAGY	00:00 - 05:59 + 10:00 - 23:59 All types, including traffic designed for EMJEE at night 06:00 - 22:59Turboprops only
06	GOSAM	EMJEE	Day Jet traffic only (06:00 – 22:59 local) All GOSAM movements
06	GRICE	GRICE	H24

Table 1: SID changes proposed by Edinburgh ACP.

A full set of current and proposed routeings can be found at Ref 1 and Ref 2.

The methodology and assumptions made to estimate the fuel difference for the Edinburgh ACP were:

- Edinburgh departure traffic data was extracted from the NATS Data Warehouse for 2016
- This traffic was split into the different current SIDs and where necessary split further by aircraft engine type or destination airport to obtain a 2016 traffic count for each route comparison listed in Table 1. These counts were then grown to the respective implementation year.

- Time limits and weekday and weekend allocations were also considered when assigning 2016 traffic to the proposed new routeings.
- For each route, aircraft types were grouped into categories of similar typed aircraft with comparable fuel burn rates and the most common type within each category was modelled for the analysis.
- Aircraft groupings are listed in Appendix B: Aircraft Type Groupings. Where groups had fewer than 10 flights in the year, those flights were allocated to the best available alternative group. Piston aircraft were modelled as small turboprops given the complexity of modelling them in BADA.
- Aircraft types were modelled along the relevant routes (current and proposed), conforming to the tracks and vertical restrictions as instructed by the SID plates
- Trajectories were simulated using the NATS Profile Generator tool and fuel burn estimates on those routes were calculated by NATS fuel burn model KERMIT
- Both toolsets use BADA 3.13 aircraft performance data and fuel burn calculations
- Where proposed routes did not join up with current routes at the end of the SID (either horizontally or vertically), both routes were extended such that a common end point could be achieved.
- No vertical restrictions were modelled beyond the end of the SID designs and where applicable, jet aircraft were assumed to cruise to FL340 and turboprops to FL250
- A full set of routes and associated altitudes modelled are listed in Appendix A: Routes Modelled
- Future years traffic forecasts were used to estimate fuel burn impact in 2024, 5 years after the proposed changes are implemented
- Growth rates taken from NATS 2016 traffic forecast and assumed to be:
    - 2019 = 2016 + 9.6% (implementation)
    - 2024 = 2016 + 20.0% (implementation + 5 years)
    - 2024 Constrained = 2016 + 15.99% (implementation + 5 years. The existing route design would be in use in this traffic scenario)
- Ratio of fuel burn to CO_2 is 1:3.18

Results

Table 2 below shows the fuel burn differences for each route and aircraft type modelled and their associated flight counts.

Route	Aircraft Type	Aircraft Group	Current SID Fuel Burn (kg)	Proposed SID Fuel Burn (kg)	Difference (kg)	2016 Flight Count
06_EMJEE	A319	Medium Airbus	2105.0	1815.6	-288.8	3120
06_EMJEE	B738	Medium Boeing	2355.8	2036.8	-318.3	1642
06_EMJEE	B752	Upper Medium	3467.2	2985.9	-480.0	386
06_EMJEE	B763	Small Heavy	5070.9	4259.0	-810.4	298
06_EMJEE	B772	2 Engine Boeing Heavy	6222.1	5368.9	-850.4	2
06_EMJEE	B788	2 Engine Airbus Heavy	4998.2	4256.0	-740.4	2
06_EMJEE	C56X	Small Jets	512.2	459.9	-52.1	169
06_EMJEE	E190	2 Engine Small Jet	1689.0	1493.5	-220.4	1018
06_EMJEE	GLF5	3 Engine Small	1368.7	1219.1	-149.1	41
06_EMJEE	RJ1H	4 Engine Medium	1858.5	1629.7	-228.7	13
06_GRICE	A320	Medium Airbus	527.8	514.0	-13.8	159
06_GRICE	A332	2 Engine Airbus Heavy	1391.3	1347.6	-43.6	2
06_GRICE	B738	Medium Boeing	553.1	538.0	-15.0	329
06_GRICE	B752	Upper Medium	837.6	809.7	-27.9	3
06_GRICE	B763	Small Heavy	1285.8	1243.6	-42.2	1
06_GRICE	BE20	Small Turboprop	40.9	39.6	-1.3	23
06_GRICE	CRJ9	Small Jets	309.5	300.9	-8.6	31
06_GRICE	DH8D	Heavy Turboprop	140.6	136.4	-4.3	3
06_GRICE	E190	2 Engine Small Jet	392.6	380.0	-12.6	7
06_GRICE	GLF5	3 Engine Small	296.7	287.2	-9.4	9
06_GRICE	MD83	Med MDs	620.5	601.9	-18.6	1
06_GRICE	RJ1H	4 Engine Medium	471.1	459.5	-11.6	2
06_GRICE	SF34	Medium Turboprop	58.0	56.2	-1.8	524
06_VOSNE	A319	Medium Airbus	2173.4	1786.7	-386.7	2517
06_VOSNE	A332	2 Engine Airbus Heavy	5933.2	4807.7	-1125.5	202
06_VOSNE	B738	Medium Boeing	2434.3	2013.7	-420.5	2463
06_VOSNE	B752	Upper Medium	3575.0	2947.4	-627.5	20
06_VOSNE	B762	Small Heavy	5258.0	4164.1	-1093.9	1
06_VOSNE	C56X	Small Jets	524.3	463.1	-61.3	118

06_VOSNE	E190	2 Engine Small Jet	1741.2	1457.0	-284.2	642
06_VOSNE	GLF5	3 Engine Small	1403.7	1216.9	-186.8	12
06_VOSNE	RJ1H	4 Engine Medium	1912.8	1620.0	-292.8	264
06_KRAGY	A319	Medium Airbus	2173.4	1927.3	-246.0	103
06_KRAGY	B738	Medium Boeing	2434.3	2163.7	-270.6	165
06_KRAGY	BE20	Small Turboprop	236.9	226.7	-10.3	137
06_KRAGY	C56X	Small Jets	524.3	482.0	-42.3	7
06_KRAGY	D328	Medium Turboprop	400.6	378.4	-22.1	771
06_KRAGY	DH8D	Heavy Turboprop	822.7	789.6	-33.1	3759
06_KRAGY	RJ1H	4 Engine Medium	1912.8	1715.0	-197.8	40
24_LIKLA	A320	Medium Airbus	2012.3	1920.4	-91.9	995
24_LIKLA	B738	Medium Boeing	2190.7	2097.0	-93.7	3244
24_LIKLA	B752	Upper Medium	3203.3	3071.0	-132.3	591
24_LIKLA	B763	Small Heavy	4661.5	4408.9	-252.6	114
24_LIKLA	B788	2 Engine Airbus Heavy	4619.4	4395.0	-224.4	7
24_LIKLA	C56X	Small Jets	478.3	467.8	-10.5	67
24_LIKLA	E190	2 Engine Small Jet	1568.2	1507.9	-60.3	99
24_LIKLA	GLF5	3 Engine Small	1276.3	1244.8	-31.5	43
24_LIKLA	MD83	Med MDs	2472.2	2365.6	-106.6	1
24_MAVIX	A319	Medium Airbus	2038.5	1895.5	-143.0	8240
24_MAVIX	B738	Medium Boeing	2283.1	2126.1	-157.0	2627
24_MAVIX	B752	Upper Medium	3364.8	3126.9	-237.8	169
24_MAVIX	B763	Small Heavy	4860.1	4459.2	-400.9	620
24_MAVIX	B772	2 Engine Boeing Heavy	6037.0	5618.1	-418.9	3
24_MAVIX	B788	2 Engine Airbus Heavy	4816.1	4449.4	-366.7	7
24_MAVIX	C56X	Small Jets	506.7	480.5	-26.2	430
24_MAVIX	E190	2 Engine Small Jet	1669.1	1559.7	-109.4	3263
24_MAVIX	GLF5	3 Engine Small	1347.3	1273.2	-74.1	56
24_MAVIX	RJ85	4 Engine Medium	1725.0	1604.8	-120.2	51
24_GRICE	A319	Medium Airbus	558.1	447.7	-110.4	310
24_GRICE	A332	2 Engine Airbus Heavy	1502.1	1193.4	-308.7	1
24_GRICE	B738	Medium Boeing	599.8	477.4	-122.4	577
24_GRICE	B752	Upper Medium	904.4	718.1	-186.3	31
24_GRICE	B763	Small Heavy	1388.3	1100.3	-288.0	11
24_GRICE	BE20	Small Turboprop	44.1	35.3	-8.8	41
24_GRICE	C130	Heavy Turboprop	354.9	288.4	-66.4	11
24_GRICE	CRJ9	Small Jets	335.7	268.7	-67.0	68

24_GRICE	E190	2 Engine Small Jet	424.8	337.4	-87.4	12
24_GRICE	GLF5	3 Engine Small	321.5	254.6	-66.9	22
24_GRICE	MD83	Med MDs	672.3	538.7	-133.5	2
24_GRICE	RJ85	4 Engine Medium	495.2	411.9	-83.3	2
24_GRICE	SF34	Medium Turboprop	62.5	51.1	-11.4	1847
24_ARLER	A319	Medium Airbus	1911.8	1744.2	-167.6	1920
24_ARLER	A346	4 Engine Airbus Heavy	7418.7	6729.4	-689.3	1
24_ARLER	B738	Medium Boeing	2145.2	1959.1	-186.1	2184
24_ARLER	B752	Upper Medium	3124.7	2847.9	-276.8	65
24_ARLER	B763	Small Heavy	4561.7	4092.1	-469.6	3
24_ARLER	B788	2 Engine Airbus Heavy	4521.9	4096.2	-425.6	217
24_ARLER	BE20	Small Turboprop	215.9	208.2	-7.7	227
24_ARLER	C56X	Small Jets	465.2	434.5	-30.7	102
24_ARLER	D328	Medium Turboprop	368.7	354.9	-13.8	514
24_ARLER	DH8D	Heavy Turboprop	752.0	732.7	-19.2	5893
24_ARLER	E190	2 Engine Small Jet	1533.6	1405.4	-128.2	247
24_ARLER	GLF5	3 Engine Small	1243.7	1156.1	-87.6	6
24_ARLER	MD83	Med MDs	2419.0	2216.2	-202.8	3
24_ARLER	RJ1H	4 Engine Medium	1718.8	1593.6	-125.2	409
24_EVTOL	BE20	Small Turboprop	215.9	206.5	-9.4	52
24_EVTOL	D328	Medium Turboprop	368.7	352.0	-16.7	101
24_EVTOL	DH8D	Heavy Turboprop	752.0	724.9	-27.1	2397
24_VOSNE	A319	Medium Airbus	1911.8	1821.3	-90.5	1257
24_VOSNE	B738	Medium Boeing	2145.2	2057.3	-87.9	1023
24_VOSNE	B763	Small Heavy	4561.7	4249.0	-312.7	1
24_VOSNE	B788	2 Engine Airbus Heavy	4521.9	4245.4	-276.5	265
24_VOSNE	C56X	Small Jets	465.2	472.3	7.1	69
24_VOSNE	E190	2 Engine Small Jet	1533.6	1486.5	-47.1	220
24_VOSNE	RJ1H	4 Engine Medium	1718.8	1634.2	-84.6	121

Table 2: Fuel burn differences per aircraft type and route.

Implemenation

Table 3 and Table 4 below summarise the results per aircraft type into annual differences for 2019 and 2024; the latter year assuming the growth rates listed above.

Route	Track Mileage Difference (nm)	Average Fuel Difference per Flight (kg)	2019 Flight Count	Annual Fuel Difference (T)	Annual CO_2 Difference (T)
24 ARLER	0.0	-89.0	13,130	-1,169	-3,718
24 EVTOL	-2.7	-26.3	2,829	-74	-237
24 MAVIX	0.0	-146.9	5,733	-842	-2,678
24 LIKLA	8.0	-99.2	17,200	-1,706	-5,426
24 GRICE	-6.8	-49.0	3,251	-159	-506
24 VOSNE	22.9	-100.6	3,276	-330	-1,048
06 EMJEE	0.1	-313.2	7,522	-2,356	-7,493
06 GRICE	-0.9	-8.0	1,238	-10	-32
06 VOSNE	3.5	-403.8	7,020	-2,835	-9,014
06 KRAGY	4.1	-44.4	5,595	-248	-790
		TOTAL	**66,795**	**-9,730**	**-30,941**

Table 3: Summary emissions results for 2019.

Route	Track Mileage Difference (nm)	Average Fuel Difference per Flight (kg)	2024 Flight Count	Annual Fuel Difference (T)	Annual CO_2 Difference (T)
24 ARLER	0.0	-89.0	14,098	-1,255	-3,992
24 EVTOL	-2.7	-26.3	3,053	-80	-255
24 MAVIX	0.0	-146.9	6,155	-904	-2,875
24 LIKLA	8.0	-99.2	18,466	-1,832	-5,825
24 GRICE	-6.8	-49.0	3,500	-171	-545
24 VOSNE	22.9	-100.6	3,524	-355	-1,128
06 EMJEE	0.1	-313.2	8,106	-2,539	-8,074
06 GRICE	-0.9	-8.0	1,320	-11	-34
06 VOSNE	3.5	-403.8	7,557	-3,052	-9,704
06 KRAGY	4.1	-44.4	6,039	-268	-852
		TOTAL	**71,817**	**-10,467**	**-33,285**

Table 4: Summary emissions results for 2024.

The results show that there is an overall environmental benefit of the proposed changes with a net decrease in emissions of 9,730 tonnes of fuel in 2019 increasing to 10,467 tonnes of fuel in 2024 with expected traffic growth on each route (30,941 and 33,285 tonnes of CO_2 in each year analysed respectively).

SIDs that show an increase in track mileage flown but a reduction in emissions under the proposed design are because of improvements to the vertical trajectory that the design allows. The full list of routes modelled can be found in Table 6 in Appendix A: Routes Modelled.

Table 5 below shows the total annual emissions impact of the proposed design and compares that total to a constrained traffic growth scenario for 2024, using the existing route designs.

Scenario	Annual Traffic Count	Total Annual Fuel (T)	Total Annual CO_2 (T)
2024 - new design + enabled traffic	71,817	114,862	365,262
2024 - current design + constrained traffic	69,437	118,482	376,773

Table 5: Total fuel burn and CO_2 emissions in 2024 under different traffic scenarios.

The results show that less fuel will be burnt and less CO_2 emitted in 2024 on the Edinburgh departure SIDs in the proposed design scenario despite the increased traffic count because of the enhanced vertical profiles enabled by the new design.

Summary

Edinburgh Airport seek to upgrade their aircraft arrival and departure routes to take advantage of the improved navigational capabilities of aRea NAVigation and improve the efficiency and capacity of the airspace around Edinburgh Airport.

The consultation proposes new aircraft arrival and departure routes around Edinburgh Airport below 7,000ft above ground level. Above 7,000ft aircraft will join the existing en-route network and proceed under direction of ATC.

The emissions analysis undertaken by NATS Analytics estimates that the introduction of these routes would show a fuel benefit of 9,730 tonnes of fuel in 2019 increasing to 10,467 tonnes of fuel in 2024 with expected traffic growth on each route.

Appendix A: Routes Modelled

The routes and associated altitudes are listed below. Where "Cruise" is listed as the flight level modelled, this was assumed to be FL340 for jet aircraft and FL250 for turboprops. Where no altitudes are given, the aircraft can be assumed to be climbing along the route listed to the next fix with a level given. Table 6 below shows the current and proposed routeings with flight levels modelled given in brackets where applicable.

Route	Current Routeing	Proposed Routeing
24 ARLER	EGPH (Ground) – TLA (60) – DCS – LAKEY – CALDA – CROFT – BARTN – LOVEL – LISTO (Cruise)	EGPH (Ground) ARLER (60) – TLA – DCS – LAKEY – CALDA – CROFT – BARTN – LOVEL – LISTO (Cruise)
24 EVTOL	EGPH (Ground) – TLA (60) – DCS – LAKEY – CALDA – CROFT – BARTN – LOVEL – LISTO (Cruise)	EGPH (Ground) – EVTOL (60) – TLA – DCS – LAKEY – CALDA – CROFT – BARTN – LOVEL – LISTO (Cruise)
24 VOSNE	EGPH (Ground) – TLA (60) – DCS – LAKEY – CALDA – CROFT – BARTN – LOVEL – LISTO (Cruise)	EGPH (Ground) – VOSNE (150) – HAVEN – DCS – LAKEY – CALDA – CROFT – BARTN – LOVEL – LISTO (Cruise)
24 MAVIX	EGPH (Ground) – GOSAM (60) – FENIK – DCS – LAKEY – CALDA – CROFT – BARTN – LOVEL – LISTO (Cruise)	EGPH (Ground) – MAVIX (100) – FENIK – DCS – LAKEY – CALDA – CROFT – BARTN – LOVEL – LISTO (Cruise)
24 LIKLA	EGPH (Ground) – GOSAM (60) – TRN – BLACA – NELBO – NUMPI – NIMAT – DUB (Cruise)	EGPH (Ground) – LIKLA (100) – GOW – TRN – BLACA – NELBO – NUMPI – NIMAT – DUB (Cruise)
24 GRICE	EGPH (Ground) – GRICE (60)	EGPH (Ground) – GRICE (60)
06 VOSNE	EGPH (Ground) – TLA (60) – DCS – LAKEY – CALDA – CROFT – BARTN – LOVEL – LISTO (Cruise)	EGPH (Ground) – VOSNE (150) – HAVEN – DCS – LAKEY – CALDA – CROFT – BARTN – LOVEL – LISTO (Cruise)
06 KRAGY	EGPH (Ground) - TLA (60) – DCS – LAKEY – CALDA – CROFT – BARTN – LOVEL – LISTO (Cruise)	EGPH (Ground) - KRAGY (100) – TLA – DCS – LAKEY – CALDA – CROFT – BARTN – LOVEL – LISTO (Cruise)
06 EMJEE	EGPH (Ground) – GOSAM (60) – TRN – BLACA – NELBO – NUMPI – NIMAT – DUB (Cruise)	EGPH (Ground) – EMJEE (100) – FENIK – TRN – BLACA – NELBO – NUMPI – NIMAT – DUB (Cruise)
06 GRICE	EGPH (Ground) – GRICE (60)	EGPH (Ground) – GRICE (60)

Table 6: Routes and flight levels modelled.

Appendix B: Aircraft Type Groupings

The table below lists the group headings that aircraft types can be combined into, as well as some common example types within each category.

Small Turboprop		Medium Turboprop	Small Jets			3 Engine Small	Heavy Turboprop	2 Engine Small Jet	4 Engine Medium	Medium Airbus
BE20	PA27	AT43	C510	CRJ1	FA10	F900	AT72	BA11	B462	A318
BE58	PA31	AT45	C550	CRJ2	FA20	FA50	C130	DC94	RJ85	A319
BE99	PA34	ATP	C560	CRJ9	H25A	FA7X	C160	E135		A320
BE9L	PAY2	D228	C750	DA42	LJ35		DH8A	E145		A321
C421	PAY3	D328	CL60	EA50	LJ45		DH8C	E170		
E120	SW4	JS32					DH8D	E190		
MU2	TRIN	JS41					F27	F100		
		SB20					F28	F70		
		SF34					F50	T134		
		SH36								

Medium Boeing	Med MDs	3 Engine Medium	Upper Medium	Small Heavy	2 Engine Airbus Heavy	2 Engine Boeing Heavy	4 Engine Airbus Heavy	3/4 Engine Heavy	4 Engine Boeing Heavy	Super Heavy
B712	MD82	B722	B752	A306	A332	B772	A343	B703	B742	A388
B732	MD83	T154	B753	A30B	A333	B773	A345	DC10	B743	
B733				A310	A3ST	B77L	A346	DC87	B744	
B734				B762	B788	B77W		L101		
B735				B763				MD11		
B736				B764						
B737										
B738										
B739										