2022 Proposed Operations Fleet Mix Continued

Aircraft Type	N28R Dep CD_ABBEY	N28R Dep CD_NEPOD	N28R Dep CD_NEP-E	N28R Dep CD_NEP-M	S10R Dep AB_LIFFY	S10R Dep AB_NEPOD
Airbus A306	0	76	76	76	0	0
Airbus A319	227	303	303	303	0	0
Airbus A320	3867	3184	3184	3184	0	0
Airbus A320neo	76	227	227	227	0	0
Airbus A321	455	303	303	303	0	0
Airbus A321neo	227	455	0	0	0	0
Airbus A330	1820	2805	76	76	0	0
Airbus A330neo	0	0	0	0	0	0
Airbus A350	0	0	0	0	0	0
ATR 72	0	0	0	0	94	754
BAe 146/Avro RJ	0	0	0	0	0	0
Boeing 737 MAX	76	0	0	0	0	0
Boeing 737-400	455	0	0	0	0	0
Boeing 737-700	227	0	0	0	0	0
Boeing 737-800	5231	4397	4397	4397	0	0
Boeing 757	227	227	0	0	0	0
Boeing 767	76	0	0	0	0	0
Boeing 777	76	227	0	0	0	0
Boeing 777X	0	0	0	0	0	0
Boeing 787	152	682	0	0	0	0
Bombardier CS300	76	152	152	152	0	0
Bombardier Dash 8	0	0	0	0	0	377
Embraer E190/195	227	834	834	834	0	0
Embraer E190-E2	0	0	0	0	0	0
Other	303	303	303	303	0	0

2022 Proposed Operations Fleet Mix Continued

Aircraft Type	S10R Dep CD_NEPOD	S10R Dep CD_LIFFY	S28L Dep AB_LIFFY	S28L Dep AB_NEPOD	S28L Dep CD_ROTEV	S28L Dep CD_LIFF-E
Airbus A306	188	0	0	0	0	0
Airbus A319	377	377	0	0	76	76
Airbus A320	3958	4994	0	0	152	152
Airbus A320neo	283	94	0	0	0	0
Airbus A321	377	565	0	0	0	0
Airbus A321neo	0	283	0	0	0	0
Airbus A330	188	1790	0	0	0	0
Airbus A330neo	0	0	0	0	0	0
Airbus A350	0	0	0	0	0	0
ATR 72	0	0	227	1820	0	0
BAe 146/Avro RJ	0	0	0	0	0	0
Boeing 737 MAX	0	94	0	0	0	0
Boeing 737-400	0	377	0	0	0	0
Boeing 737-700	0	283	0	0	0	0
Boeing 737-800	5465	6596	0	0	76	76
Boeing 757	0	188	0	0	0	0
Boeing 767	0	94	0	0	0	0
Boeing 777	0	188	0	0	0	0
Boeing 777X	0	0	0	0	0	0
Boeing 787	0	565	0	0	227	0
Bombardier CS300	188	94	0	0	0	0
Bombardier Dash 8	0	0	0	910	0	0
Embraer E190/195	1037	283	0	0	0	0
Embraer E190-E2	0	0	0	0	0	0
Other	377	377	0	0	0	0

2022 Proposed Operations Fleet Mix Continued

Aircraft Type	S28L Dep CD_LIFF-M	S28L Dep CD_NEPOD	S28L Dep CD_NEP-E	S28L Dep CD_NEP-M
Airbus A306	0	227	0	0
Airbus A319	76	0	0	0
Airbus A320	152	0	0	0
Airbus A320neo	0	0	0	0
Airbus A321	0	0	0	0
Airbus A321neo	0	0	0	0
Airbus A330	0	0	0	0
Airbus A330neo	0	0	0	0
Airbus A350	0	0	0	0
ATR 72	0	0	0	0
BAe 146/Avro RJ	0	0	0	0
Boeing 737 MAX	0	0	0	0
Boeing 737-400	0	0	0	0
Boeing 737-700	0	0	0	0
Boeing 737-800	76	0	0	0
Boeing 757	0	0	0	0
Boeing 767	0	0	0	0
Boeing 777	0	0	0	0
Boeing 777X	0	0	0	0
Boeing 787	0	0	0	0
Bombardier CS300	0	0	0	0
Bombardier Dash 8	0	0	0	0
Embraer E190/195	0	0	0	0
Embraer E190-E2	0	0	0	0
Other	0	0	0	0

2025 Permitted Operations Fleet Mix

Aircraft Type	10L Arrivals	28R Arrivals	10R Arrivals	28L Arrivals	16 Arrivals	34 Arrivals
Airbus A306	0	0	189	456	5	2
Airbus A319	472	0	0	1139	12	4
Airbus A320	7266	0	944	19816	213	71
Airbus A320neo	1415	0	94	3644	39	13
Airbus A321	472	0	0	1139	12	4
Airbus A321neo	283	0	94	911	10	3
Airbus A330	1510	0	189	4100	44	15
Airbus A330neo	0	0	0	0	0	0
Airbus A350	94	0	0	228	2	1
ATR 72	2548	0	94	6378	69	23
BAe 146/Avro RJ	0	0	0	0	0	0
Boeing 737 MAX	1793	0	0	4328	46	15
Boeing 737-400	189	0	189	911	10	3
Boeing 737-700	661	0	0	1594	17	6
Boeing 737-800	10568	0	377	26421	284	95
Boeing 757	0	0	0	0	0	0
Boeing 767	0	0	94	228	2	1
Boeing 777	94	0	94	456	5	2
Boeing 777X	94	0	0	228	2	1
Boeing 787	944	0	94	2505	27	9
Bombardier CS300	283	0	0	683	7	2
Bombardier Dash 8	377	0	0	911	10	3
Embraer E190/195	1038	0	0	2505	27	9
Embraer E190-E2	0	0	0	0	0	0
Other	1228	230	0	2733	29	10

2025 Permitted Operations Fleet Mix Continued

Aircraft Type	16 Dep	34 Dep	N10L Dep CD_ABBEY	N10L-I Dep AB_ROTEV	N28R-I Dep AB_ROTEV	N28R Dep CD_ABB-E
Airbus A306	5	2	0	0	0	0
Airbus A319	15	5	94	0	0	456
Airbus A320	210	70	1038	0	0	6833
Airbus A320neo	39	13	94	0	0	1215
Airbus A321	12	4	0	0	0	759
Airbus A321neo	10	3	0	0	0	0
Airbus A330	44	15	0	0	0	0
Airbus A330neo	0	0	0	0	0	0
Airbus A350	2	1	0	0	0	152
ATR 72	69	23	0	1793	4328	0
BAe 146/Avro RJ	0	0	0	0	0	0
Boeing 737 MAX	46	15	189	0	0	1974
Boeing 737-400	10	3	0	0	0	456
Boeing 737-700	17	6	0	0	0	1063
Boeing 737-800	284	95	1132	0	0	9263
Boeing 757	0	0	0	0	0	0
Boeing 767	2	1	0	0	0	152
Boeing 777	5	2	94	0	0	152
Boeing 777X	2	1	0	0	0	152
Boeing 787	27	9	189	0	0	607
Bombardier CS300	7	2	0	0	0	152
Bombardier Dash 8	10	3	0	0	0	0
Embraer E190/195	27	9	0	0	0	0
Embraer E190-E2	0	0	0	0	0	0
Other	29	10	95	472	1139	609

2025 Permitted Operations Fleet Mix Continued

Aircraft Type	N28R Dep CD_ABBEY	N28R Dep CD_NEPOD	N28R Dep CD_NEP-E	N28R Dep CD_NEP-M	S10R Dep AB_LIFFY	S10R Dep AB_NEPOD
Airbus A306	0	304	76	76	0	0
Airbus A319	228	152	152	152	0	0
Airbus A320	3417	2430	2430	2430	0	0
Airbus A320neo	607	456	456	456	0	0
Airbus A321	380	0	0	0	0	0
Airbus A321neo	456	304	76	76	0	0
Airbus A330	1367	2505	0	0	0	0
Airbus A330neo	0	0	0	0	0	0
Airbus A350	76	0	0	0	0	0
ATR 72	0	0	0	0	94	755
BAe 146/Avro RJ	0	0	0	0	0	0
Boeing 737 MAX	987	911	228	228	0	0
Boeing 737-400	456	0	0	0	0	0
Boeing 737-700	531	0	0	0	0	0
Boeing 737-800	4631	3189	3189	3189	0	0
Boeing 757	0	0	0	0	0	0
Boeing 767	76	0	0	0	0	0
Boeing 777	76	228	0	0	0	0
Boeing 777X	76	0	0	0	0	0
Boeing 787	987	911	0	0	0	0
Bombardier CS300	76	152	152	152	0	0
Bombardier Dash 8	0	0	0	0	0	377
Embraer E190/195	0	531	531	531	0	0
Embraer E190-E2	0	0	0	0	0	0
Other	304	228	228	228	0	0

2025 Permitted Operations Fleet Mix Continued

Aircraft Type	S10R Dep CD_NEPOD	S10R Dep CD_LIFFY	S28L Dep AB_LIFFY	S28L Dep AB_NEPOD	S28L Dep CD_ROTEV	S28L Dep CD_LIFF-E
Airbus A306	189	0	0	0	0	0
Airbus A319	189	283	0	0	76	76
Airbus A320	3774	3303	0	0	76	76
Airbus A320neo	755	661	0	0	0	0
Airbus A321	0	472	0	0	0	0
Airbus A321neo	94	283	0	0	0	0
Airbus A330	189	1510	0	0	0	0
Airbus A330neo	0	0	0	0	0	0
Airbus A350	0	94	0	0	0	0
ATR 72	0	0	228	1822	0	0
BAe 146/Avro RJ	0	0	0	0	0	0
Boeing 737 MAX	283	1321	0	0	0	0
Boeing 737-400	0	377	0	0	0	0
Boeing 737-700	0	661	0	0	0	0
Boeing 737-800	5190	4624	0	0	0	0
Boeing 757	0	0	0	0	0	0
Boeing 767	0	94	0	0	0	0
Boeing 777	0	94	0	0	0	0
Boeing 777X	0	94	0	0	0	0
Boeing 787	0	849	0	0	0	0
Bombardier CS300	189	94	0	0	0	0
Bombardier Dash 8	0	0	0	911	0	0
Embraer E190/195	1038	0	0	0	0	0
Embraer E190-E2	0	0	0	0	0	0
Other	377	283	0	0	0	0

2025 Permitted Operations Fleet Mix Continued

Aircraft Type	S28L Dep CD_LIFF-M	S28L Dep CD_NEPOD	S28L Dep CD_NEP-E	S28L Dep CD_NEP-M
Airbus A306	0	0	0	0
Airbus A319	76	0	0	0
Airbus A320	76	607	607	607
Airbus A320neo	0	152	152	152
Airbus A321	0	0	0	0
Airbus A321neo	0	0	0	0
Airbus A330	0	76	76	76
Airbus A330neo	0	0	0	0
Airbus A350	0	0	0	0
ATR 72	0	0	0	0
BAe 146/Avro RJ	0	0	0	0
Boeing 737 MAX	0	0	0	0
Boeing 737-400	0	0	0	0
Boeing 737-700	0	0	0	0
Boeing 737-800	0	987	987	987
Boeing 757	0	0	0	0
Boeing 767	0	0	0	0
Boeing 777	0	0	0	0
Boeing 777X	0	0	0	0
Boeing 787	0	0	0	0
Bombardier CS300	0	0	0	0
Bombardier Dash 8	0	0	0	0
Embraer E190/195	0	304	304	304
Embraer E190-E2	0	0	0	0
Other	0	76	76	76

2025 Proposed Operations Fleet Mix

Aircraft Type	10L Arrivals	28R Arrivals	10R Arrivals	28L Arrivals	16 Arrivals	34 Arrivals
Airbus A306	0	0	189	456	5	2
Airbus A319	472	0	0	1139	12	4
Airbus A320	7643	0	1038	20955	225	75
Airbus A320neo	1415	0	94	3644	39	13
Airbus A321	472	0	0	1139	12	4
Airbus A321neo	189	0	377	1367	15	5
Airbus A330	1510	0	377	4555	49	16
Airbus A330neo	0	0	0	0	0	0
Airbus A350	94	0	0	228	2	1
ATR 72	2548	0	94	6378	69	23
BAe 146/Avro RJ	0	0	0	0	0	0
Boeing 737 MAX	1982	0	0	4783	51	17
Boeing 737-400	189	0	189	911	10	3
Boeing 737-700	661	0	0	1594	17	6
Boeing 737-800	10663	0	283	26421	284	95
Boeing 757	0	0	0	0	0	0
Boeing 767	0	0	94	228	2	1
Boeing 777	94	0	94	456	5	2
Boeing 777X	94	0	0	228	2	1
Boeing 787	944	0	94	2505	27	9
Bombardier CS300	283	0	0	683	7	2
Bombardier Dash 8	377	0	0	911	10	3
Embraer E190/195	1038	0	0	2505	27	9
Embraer E190-E2	0	0	0	0	0	0
Other	1228	230	94	2961	32	11

2025 Proposed Operations Fleet Mix Continued

Aircraft Type	*16 Dep*	*34 Dep*	*N10L Dep CD_ABBEY*	*N10L-I Dep AB_ROTEV*	*N28R-I Dep AB_ROTEV*	*N28R Dep CD_ABB-E*
Airbus A306	5	2	0	0	0	0
Airbus A319	15	5	0	0	0	456
Airbus A320	223	74	0	0	0	7137
Airbus A320neo	39	13	0	0	0	1215
Airbus A321	12	4	0	0	0	759
Airbus A321neo	15	5	0	0	0	0
Airbus A330	49	16	0	0	0	0
Airbus A330neo	0	0	0	0	0	0
Airbus A350	2	1	0	0	0	152
ATR 72	69	23	0	1793	4328	0
BAe 146/Avro RJ	0	0	0	0	0	0
Boeing 737 MAX	51	17	0	0	0	1974
Boeing 737-400	10	3	0	0	0	456
Boeing 737-700	17	6	0	0	0	1063
Boeing 737-800	284	95	0	0	0	9111
Boeing 757	0	0	0	0	0	0
Boeing 767	2	1	0	0	0	152
Boeing 777	5	2	0	0	0	152
Boeing 777X	2	1	0	0	0	152
Boeing 787	27	9	0	0	0	607
Bombardier CS300	7	2	0	0	0	152
Bombardier Dash 8	10	3	0	0	0	0
Embraer E190/195	27	9	0	0	0	0
Embraer E190-E2	0	0	0	0	0	0
Other	32	11	95	472	1139	609

2025 Proposed Operations Fleet Mix Continued

Aircraft Type	N28R Dep CD_ABBEY	N28R Dep CD_NEPOD	N28R Dep CD_NEP-E	N28R Dep CD_NEP-M	S10R Dep AB_LIFFY	S10R Dep AB_NEPOD
Airbus A306	0	76	76	76	0	0
Airbus A319	228	152	152	152	0	0
Airbus A320	3568	3189	3189	3189	0	0
Airbus A320neo	607	607	607	607	0	0
Airbus A321	380	0	0	0	0	0
Airbus A321neo	456	759	76	76	0	0
Airbus A330	1594	2809	76	76	0	0
Airbus A330neo	0	0	0	0	0	0
Airbus A350	76	0	0	0	0	0
ATR 72	0	0	0	0	94	755
BAe 146/Avro RJ	0	0	0	0	0	0
Boeing 737 MAX	987	1367	228	228	0	0
Boeing 737-400	456	0	0	0	0	0
Boeing 737-700	531	0	0	0	0	0
Boeing 737-800	4555	4176	4176	4176	0	0
Boeing 757	0	0	0	0	0	0
Boeing 767	76	0	0	0	0	0
Boeing 777	76	228	0	0	0	0
Boeing 777X	76	0	0	0	0	0
Boeing 787	759	911	0	0	0	0
Bombardier CS300	76	152	152	152	0	0
Bombardier Dash 8	0	0	0	0	0	377
Embraer E190/195	0	835	835	835	0	0
Embraer E190-E2	0	0	0	0	0	0
Other	304	304	304	304	94	0

2025 Proposed Operations Fleet Mix Continued

Aircraft Type	S10R Dep CD_NEPOD	S10R Dep CD_LIFFY	S28L Dep AB_LIFFY	S28L Dep AB_NEPOD	S28L Dep CD_ROTEV	S28L Dep CD_LIFF-E
Airbus A306	189	0	0	0	0	0
Airbus A319	189	377	0	0	76	76
Airbus A320	3963	4624	0	0	152	152
Airbus A320neo	755	755	0	0	0	0
Airbus A321	0	472	0	0	0	0
Airbus A321neo	94	472	0	0	0	0
Airbus A330	189	1698	0	0	0	0
Airbus A330neo	0	0	0	0	0	0
Airbus A350	0	94	0	0	0	0
ATR 72	0	0	228	1822	0	0
BAe 146/Avro RJ	0	0	0	0	0	0
Boeing 737 MAX	283	1698	0	0	0	0
Boeing 737-400	0	377	0	0	0	0
Boeing 737-700	0	661	0	0	0	0
Boeing 737-800	5190	5756	0	0	76	76
Boeing 757	0	0	0	0	0	0
Boeing 767	0	94	0	0	0	0
Boeing 777	0	189	0	0	0	0
Boeing 777X	0	94	0	0	0	0
Boeing 787	0	1038	0	0	228	0
Bombardier CS300	189	94	0	0	0	0
Bombardier Dash 8	0	0	0	911	0	0
Embraer E190/195	1038	0	0	0	0	0
Embraer E190-E2	0	0	0	0	0	0
Other	377	283	228	0	0	0

2025 Proposed Operations Fleet Mix Continued

Aircraft Type	*S28L Dep CD_LIFF-M*	*S28L Dep CD_NEPOD*	*S28L Dep CD_NEP-E*	*S28L Dep CD_NEP-M*
Airbus A306	0	228	0	0
Airbus A319	76	0	0	0
Airbus A320	152	0	0	0
Airbus A320neo	0	0	0	0
Airbus A321	0	0	0	0
Airbus A321neo	0	0	0	0
Airbus A330	0	0	0	0
Airbus A330neo	0	0	0	0
Airbus A350	0	0	0	0
ATR 72	0	0	0	0
BAe 146/Avro RJ	0	0	0	0
Boeing 737 MAX	0	0	0	0
Boeing 737-400	0	0	0	0
Boeing 737-700	0	0	0	0
Boeing 737-800	76	0	0	0
Boeing 757	0	0	0	0
Boeing 767	0	0	0	0
Boeing 777	0	0	0	0
Boeing 777X	0	0	0	0
Boeing 787	0	0	0	0
Bombardier CS300	0	0	0	0
Bombardier Dash 8	0	0	0	0
Embraer E190/195	0	0	0	0
Embraer E190-E2	0	0	0	0
Other	0	0	0	0

Annex 3: Estimated population and areas for healthcare facilities in the Dublin area

BAP Reference	BAP Name	Easting	Northing	Population	Area (hectares)
HEA001	Leopardstown Park Hospital	319979.36	225720.272	394	1.5
HEA002	LauraLynn - Ireland's Children's Hospice	320378.84	226259.083	40	1
HEA003	National Rehabilitation Hospital	323286.41	226618.103	460	3.2
HEA004	Belmont House Nursing Home	321000.656	227031.594	322	2
HEA005	Herberton Nursing Home	325129.392	227480.353	76	0.3
HEA006	St John of God Hospital	320666.872	227651.202	366	1.2
HEA007	Adelaide And Meath Hospital	308195.798	227903.543	1124	8
HEA008	Hawtorns HSC Hospital	320454.766	228385.886	46	0.1
HEA009	Carrick Manor Nursing Home	323285	228505.203	180	2.3
HEA010	St Micheal's Hospital	324214.731	228648.414	260	3
HEA011	Central Mental Hospital	317260.741	229215.098	168	1.2
HEA012	Holy Family Residence Nursing Home	318228.636	229579.955	120	1.3
HEA013	St Mary's Centre Nursing Home	319606.5	230862.766	112	1
HEA014	Clonskeagh Hospital	317291.969	230860.188	30	0.1
HEA015	St Vincent's Private Hospital	319399.299	230919.23	580	1
HEA016	St Vincent's University Hospital	319125.969	231053.234	1200	6
HEA018	Peamount Hospital	301297.844	230735.141	240	1
HEA019	Saint John's House Nursing Home	319333.619	231235.95	112	0.5
HEA020	The Royal Hospital Donnybrook	316772.427	231907.252	356	1.7
HEA021	Ailesbury Private Nursing Home	319174.004	231981.076	90	0.1
HEA022	Our Lady's Children's Hospital	312080.585	231933.934	500	4.7
HEA023	The Brabazon Trust Nursing Home	319335.406	232385.766	100	0.1
HEA024	Royal Victoria Eye & Ear Hospital	316220.819	232789.224	160	1
HEA026	St John of God Celbridge Care Home	296927.313	232899.125	126	0.6
HEA029	St. James Hospital	313769.787	233486.71	2000	9.4
HEA030	National Maternity Hospital	316879.336	233631.767	308	1
HEA032	Cherry Orchard Hospital	308060.044	233780.618	322	6.5

Estimated population and areas for healthcare facilities in the Dublin area continued

BAP Reference	BAP Name	Easting	Northing	Population	Area (hectares)
HEA033	St Patrick's University Hospital	313814.964	233975.372	482	1.9
HEA035	Maryfield Nursing Home	309993.188	234577.875	110	0.7
HEA036	St Mary's Hospital	310817.053	234621.068	96	1.5
HEA037	Rotunda Hospital	315669.146	235069.494	376	2
HEA039	Mater Private Orthopaedic and Spine Centre	315579.593	235446.091	100	0.1
HEA040	Temple Street Children's University Hospital	315765.47	235457.882	308	3
HEA041	Mater Private Hospital	315610.5	235580.965	400	0.7
HEA042	Saint Monica's Nursing Home	316022.171	235626.197	92	0.4
HEA043	Mater Misericordiae University Hospital	315346.906	235726.37	1200	4.1
HEA044	St Edmundsbury Hospital	304057.969	235880.859	104	0.5
HEA045	St Vincent's Hospital Fairview	316864.474	236394.507	60	0.5
HEA046	Clontarf Hospital	319760.911	236709.087	208	1.1
HEA047	Farview Community Unit Care Centre	316989.313	236707.422	160	0.8
HEA048	Gheel Autism Services (residential)	317073.132	236725.674	20	0.3
HEA049	Mount Hybla Nursing Home	309234.094	236568.75	132	1
HEA050	Daughters of Charity Disability Services Care Home	311546.191	236704.974	72	3
HEA051	Nazareth House Nursing Home	318220.208	237102.348	60	1.1
HEA052	Howth Hill Nursing Home	329475.331	237791.421	110	0.2
HEA053	Bon Secours Hospital Dublin	315358.18	237561.988	300	1
HEA054	Highfield Private Hospital	316865.9	237877.5	220	1.4
HEA055	Beech Lawn Nursing Home	317001.274	237944.118	114	0.5
HEA056	Raheny House Nursing Home	321066.311	238057.722	86	0.3
HEA057	Saint Clare's Nursing Home	315075.563	238117.656	80	0.3
HEA058	St Joseph's Hospital	321181.458	238453.544	56	2.3
HEA059	Saint Francis Hospice	321489.585	238724.967	36	0.5
HEA060	St Joseph's Care Centre	304348.594	238565.375	136	1

Estimated population and areas for healthcare facilities in the Dublin area continued

BAP Reference	BAP Name	Easting	Northing	Population	Area (hectares)
HEA062	Connolly Hospital Blanchardstown	308621.207	238816.27	814	5.5
HEA063	Beneavin Lodge Nursing Home	314208	238971.297	140	0.8
HEA064	Beaumont Hospital	318236.438	239272.328	1640	8.4
HEA065	Saint Patricks Nursing Home	324453.185	239996.205	136	1
HEA066	Silver Stream Nursing Home	315594.333	240201.043	108	0.3
HEA067	Tlc Nursing Home	316271.75	240846.047	184	0.4
HEA068	St Doolagh's Park Care & Rehabilitation Centre	321372.2	241919.7	144	0.35
HEA071	Clonmethan Lodge Hospital	311530.406	253277.016	60	0.6
HEA072	St Joseph's Community Nursing Unit	280241.539	256344.603	100	1.3
3848/16	Not yet built nursing home	318728.9846	239249.7003	448	1.6
2650/15	Not yet built nursing home	320382.7931	239406.0847	298	1
2898/13	Not yet built nursing home	321085.7525	241038.4161	294	1
RA150531	Not yet built nursing home	301405.4342	241640.334	120	1
F14A/0145	Not yet built nursing home	315576.685	240574.3931	228	1
F18A/0401	Not yet built nursing home	321310.948	241781.8831	112	1
F13A/0012	Not yet built nursing home	318727.185	243438.5795	178	0.6

Appendix: 10

Air Quality

Dublin Airport North Runway:
Technical Report

August 2020

Experts in air quality
management & assessment

Document Control

Client	Aecom Ireland Limited	Principal Contact	Peta Donkin

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1 Introduction

1.1 This Technical Report supports Chapter 10: Air Quality of the Environmental Impact Assessment Report (EIAR). It provides a detailed explanation of the methodology that was used, together with the assumptions on input data.

1.2 The assessment focuses on two pollutants with respect to potential human health effects, namely nitrogen dioxide and fine particulate matter (PM_{10} and $PM_{2.5}$), as these are the pollutants of greatest concern[1]. Although there are EU limit values for a range of other pollutants, there are unlikely to be any significant effects associated with emissions of benzene, carbon monoxide, sulphur dioxide or lead, and it is widely acknowledged that problems with these pollutants are only likely to arise in the vicinity of specific industrial processes.

1.3 There is no standard assessment approach to quantify the potential odour effects associated with airport operations. There is no published evidence to suggest that there are any physiological health effects associated with exposure to Volatile Organic Compounds (VOCs) at the concentrations at which airport odours are detectable, and the principal concern is related to nuisance or loss of amenity. A commonly-applied approach in some airport assessments is to base the odour assessment on the change in aircraft-related VOC emissions. However, there is no evidence to correlate total aircraft-related VOC concentrations with the human perception of odours. Moreover, given that airport-odours are unlikely to be related to total VOCs, any such correlation is expected to be very weak.

1.4 A variation on this general odour modelling approach was undertaken at Copenhagen Airport in 2002 (Winther et al, 2006)[2]. This study quantified odour emissions from aircraft engines using actual fuel flow and emission measurements, odour panel results, engine specific data and aircraft operational data to predict odour concentrations. Important outcomes from the study were a calculated odour emission factor from the aircraft engines of 57 Odour Units (OU_E) per milligramme of hydrocarbon, and the identification that the majority of the odorous emissions (97%) occurred whilst aircraft engines were running at idle. Odour emission factors from the Copenhagen study have been used in this assessment. Hydrocarbon emissions have been quantified from aircraft operations in idle mode using the approach outlined above. An odour emission rate of 57 OU_E/mg-HC has then been applied.

1.5 A detailed emissions inventory, taking account of all relevant Airport sources and the landside road network has been compiled; the emissions have then been input to a dispersion model to predict

[1] Department for Transport (2006), Project for the Sustainable Development of Heathrow (PSDH). EPA (2015), *Air Quality In Ireland* also notes that no levels above the EU limit values were reported at any network monitoring site in 2015, but that Ireland faces challenges in reducing levels of particulate matter, and in maintaining compliance with the limit value for nitrogen dioxide, particularly in urban areas.

[2] Winther M, Kousgaard U and Oxbol A (2006), Calculation of odour emissions from aircraft engines at Copenhagen Airport. Sci Tot Env, 366, 218-232

future changes to baseline air quality for permitted operations. A similar approach has been adopted to predict the changes in pollutant concentrations associated with the proposed operations, and the likely significance of these changes determined with regard to established approaches. The assessment takes into account all relevant national policies and guidance, specifically with regard to the Advice Notes issued by the EPA (EPA, 2015)[3] and Technical Guidance TG16[4] issued by the Department for Environment, Food and Rural Affairs (Defra) in the UK. The UK guidance is used in the absence of specific Irish Guidance.

[3] EPA (2015), Advice Notes for Preparing Environmental Impact Statements, Draft, September 2015.

[4] Defra (2016), LAQM Technical Guidance TG16. Available at http://laqm.defra.gov.uk/supporting-guidance.html. (There is no equivalent guidance in Ireland).

2 Air Quality Model

2.1 The predictions have been carried out using the atmospheric dispersion modelling. This section describes the various assumptions and input data that were used to compile the emissions inventory and the dispersion model set-up.

2.2 Predictions of nitrogen dioxide, PM_{10} and $PM_{2.5}$ concentrations have been carried out for the Existing Environment (2018) and the Predicted Baseline years 2022, 2027 and 2032 for the permitted and the proposed operations at sensitive receptors. Two sets of 2022 forecasts have been modelled for 2022; one using passenger and flight forecasts developed before the Covid-19 outbreak and one using passenger and flight forecasts that assume that airport passenger numbers will be limited to 32 mppa in 2022 (similar to 2019 passenger numbers), as part of recovery from Covid-19 related restrictions to commercial aviation. Predictions have also been carried out to quantify potential odour effects from aircraft operations.

2.3 The predictions have been carried out using the Atmospheric Dispersion Modelling Software ADMS-Airport model. This model incorporates a jet module specifically designed to represent the dispersion of emissions from moving aircraft, and was selected by the UK Department for Transport's expert advisory panel (Project for the Sustainable Development of Heathrow) for use on third runway studies at Heathrow Airport[5]. It is also the model that was selected by the UK Airports Commission to evaluate the increase in runway capacity in South-East England[6].

2.4 The model requires the user to provide a variety of input data which describe pollutant emissions arising from Airport-related sources (both airside and landside), the meteorological conditions, and the background contribution (i.e. the contribution to pollutant concentrations from sources not explicitly included in the model).

2.5 Pollutant concentrations arise from a number of Airport-related sources, and the following were taken into account in this assessment:

- Aircraft main engines operating within the Landing and Take-off (LTO) Cycle and the use of aircraft Auxiliary Power Units (APUs);
- Ground Support Equipment (GSE) including airside vehicles and Mobile Ground Power Units;
- Airport energy plant; and
- Road traffic on the local road network.

2.6 Emissions arising from other Airport sources, such as ground-run engine testing, fire training, and Airport car parks have not been included, as their contribution to ground-level pollutant

[5] Department for Transport (2006), Project for the Sustainable Development of Heathrow.

[6] Airports Commission (2015), Final Report, July 2015.

concentrations is minor. Emissions on the roads leading to the car parks have been included in the assessment.

2.7 The approach to quantifying emissions from the Airport sources has been based on generally accepted methodologies, and follows, as far as practicable, the "sophisticated or advanced approach" recommended by the International Civil Aviation Organization (ICAO) in its Airport Air Quality Manual[7]. The ICAO manual is focussed on the assessment of existing airport operations and does not include guidance on how future operations might be considered.

Aircraft Operations – Landing and Take-off (LTO) Cycle

2.8 The emissions arising from each aircraft movement have been calculated as the sum of the emissions for each part of the LTO cycle. Records of 2018 Existing Environment Year aircraft mix and numbers of aircraft movements were provided by daa[8]. Forecast movements and aircraft mix for all future scenarios were also provided by daa[9]. A summary of the aircraft data used in this assessment is provided in Appendix A1.

2.9 All turbofan-type aircraft jet engines with a rated power greater than 26.7 kN are certified by the ICAO for emissions of NOx, HC and Smoke Number. In addition, a database of emissions indices for all commercially operational turboprop aircraft engines is kept by the Swedish Defence Research Agency (FOI). For each type of aircraft, emissions per aircraft movement have been calculated using emission factors in grammes of pollutant per kilogram of fuel burnt, together with fuel flow in kilogrammes per second, based on Equation [1]:

$E_{ij} = \sum (TIM_{jk}*60) * (FF_{jk}) * (EI_{jk}) * (NE_j)$ Equation [1]

Where:

E_{ij} = Emissions of pollutant i in grammes, produced by aircraft type j for each LTO cycle;

TIM_{jk} = Time-in-mode for mode k (e.g. idle, approach, climb-out or take-off) in minutes for aircraft type j

FF_{jk} = Fuel flow for mode k (e.g. idle, approach, climb-out or take-off) in kg/sec for each engine on aircraft type j

EI_{jk} = Emissions index for each pollutant i in grammes per kilogram of fuel, in mode k, for each engine used on aircraft type j

NE_j = Number of engines on aircraft type j

[7] ICAO (2011), Airport Air Quality Manual – First Edition.

[8] Annual aircraft movements by operator for 2018 published in Bickerdike Allen Partnership EIA Aircraft Noise and Vibration Assessment Assumptions Report.

[9] Forecast movements provided by daa for Permitted Operations and Relevant Application published in Bickerdike Allen Partnership EIA Aircraft Noise and Vibration Assessment Assumptions Report.

2.10 The emissions indices have been obtained from the ICAO Engine Exhaust Emissions Databank[10]. Airframe/engine assignments were based on information provided by Aer Lingus and Ryanair for common aircraft types such as the Boeing 737-800 and the Airbus A320, which represent the majority of the movements; default airframe/engine assignments were used in other cases.

2.11 Smoke number emissions indices are not available for all aircraft engines in all of the four ICAO standard thrust settings (100%, 85%, 30% and 7%). Where Smoke Number indices for an engine in a particular mode or modes are missing from the ICAO databank, the Smoke Number indices have been estimated based on the maximum Smoke Number for the engine, and the recommended scaling factors presented in Table D-1 of the ICAO Airport Air Quality Manual.

2.12 The ADMS-Airports model takes into account the heat and momentum flux, and the pollutant emission rate, which varies for each certified engine. It is impractical to treat each airframe/engine combination separately, and so the aircraft have been assigned into a number of "modelling categories" (MCATs). For the 2018 Existing Environment Year, the aircraft were assigned into "groups" of similar characteristics (e.g. numbers of engines, engine types, engine mounting and wake category) with a "lead" aircraft selected to represent each group. These group assignments are shown in Appendix A1, Table A1.6. The emissions, and input parameters for the ADMS-Airport model, were then based on the assumption that the total number of movements within each group was represented by the lead aircraft. For the future year scenarios, MCATs were determined for future airframe/engine combinations using the same methodology as for 2018, by taking account of engine exhaust buoyancy flux and NOx emissions, as well as the forecast proportion of total annual ATMs (see Appendix A1, Table A1.7).

2.13 The approach used for the estimation of PM emissions arising from aircraft engines has undergone development in recent years. The original approach, based on the ICAO reported maximum Smoke Number, only estimated the non-volatile fraction of PM. To address this problem, the contribution of PM emissions from the volatile fraction was considered by a CAEP Working Group, and a First Order Approximation (FOA) method was derived; this approach estimates the non-volatile portion using the ICAO Smoke Number, but also estimates the volatile portion associated with the fuel sulphur content, fuel-based organics and lube oil. Version 3 of the FOA is now available (FOA v3.0) and is the approach recommended in the ICAO Airport Air Quality Manual. The FOA v3.0 approach has been used to estimate aircraft engine PM emissions.

2.14 Recent research comparing the FOA v3.0 approach with measurements has identified a discrepancy in both the organic carbon and black carbon emissions indices (Stettler et al, 2011)[11]. Combined, these discrepancies result in a 3.4 factor underestimate of total $PM_{2.5}$ emissions. Accordingly, to

[10] ICAO (2019) Engine Exhaust Emissions Databank, [Online]: https://www.easa.europa.eu/domains/environment/icao-aircraft-engine-emissions-databank

[11] Stettler, M.E.J, Eastham, S and Barrett, S.R.H. (2011). Air quality and public health impacts at UK airports. Part 1: Emissions. *Atmos Environ* 45, 5415-5424.

account for this potential uncertainty, the FOA v3.0 emissions indices for PM (both PM_{10} and $PM_{2.5}$) have been factored up by 3.4.

2.15 In future years, it is expected that the aircraft fleet will be modernised. Mott MacDonald have prepared a report on the expected modernisation of the fleet which has been taken into account in all future year assessments[12]. A summary of the expected modernisation programme is set out in Table 1.

Table 1: Expected Aircraft Fleet Modernisation Programme

Current Aircraft Type	Modernised Aircraft Type
Airbus A320	Airbus A320neo
Airbus A321	Airbus A321neo
Airbus A330	Airbus A330neo
Boeing 737-800	Boeing 737-8 Max
Boeing 777	Boeing 777X
Embraer E190/E195	Embraer E190-E2

2.16 The fleet forecasts for the future assessment scenarios show very limited penetration of the Airbus A330neo, Boeing 777X and Embraer E190-E2 aircraft into the Dublin Airport fleet. The relatively small number of movements of these aircraft in future scenarios (<4% of total ATMs) will have little effect on overall emissions from aircraft activity, and therefore for simplicity, the Airbus A330neo and Boeing 777X have been included in an MCAT led by the Boeing 787, which has a very high occurrence in the future forecasts, with similar engine emissions to the A330neo and B777X. The Airbus A320neo and A321neo and Boeing 737-8 Max are all expected to fly frequently from Dublin Airport in the future scenarios, and so have been included in the model as individual MCATs. Engine emissions data for these aircraft have been obtained from the ICAO emissions databank, as although not all were operating from Dublin Airport in 2018, their engines have now been certified by ICAO and emissions data are available.

2.17 The International Civil Aviation Organisation (ICAO) has defined a specific LTO cycle with four modal phases, extending to a ceiling height of 3,000 feet (915 metres). Emission factors are provided for TO: 'take-off' (100% thrust), CO: 'climb-out' (85% thrust), AP: 'approach' (30% thrust) and ID: 'idle' (7% thrust). In reality, aircraft rarely take-off at 100% thrust - the actual take-off thrust used being dependent on a combination of factors including take-off weight and weather conditions. Following discussion with daa, a take-off thrust of 100% was used for all aircraft departures, but is likely to represent a worst-case assumption.

[12] Dublin Airport Fleet Modernisation Analysis. Mott MacDonald. April 2019.

2.18 Take-off roll along runway, and initial climb to 1500ft (457.5m) was assumed to be at 100% thrust setting. Climb-out after throttle back from 1500-3000ft (457.5-915m) was assumed to be at 85% thrust.

2.19 The majority of commercial jet aircraft operating at Dublin Airport have reverse thrust capability, which may be deployed during landing to increase the rate of deceleration. However, the Airport discourages the use of reverse thrust at night-time, and the airlines also try to avoid the use of reverse thrust to minimise fuel consumption. As a result, only a very small number of aircraft movements at the Airport are expected to utilise reverse thrust above idle during landing (related to unfavourable weather conditions[13]). The assumption used in the modelling has therefore been that aircraft engine thrust is reduced to idle (7%) for landing roll-out (i.e. from the point of touchdown on the runway to the start of taxi); emissions from the small number of aircraft using reverse thrust above idle has been discounted as they will make an insignificant contribution to total runway emissions.

2.20 Emission factors within the ICAO and FOI databases are usually stated for new engines. Based on PSDH recommendations to account for engine deterioration, NOx emissions have been increased by 4.5% while, for $PM_{10}/PM_{2.5}$, the fuel flow and subsequent calculation of emissions has been increased by 4.3%.

2.21 Times-in-mode for take-off, approach and climb-out have been derived from information provided by daa[14].

2.22 The take-off and climb-out profiles (times/speeds/angle of climb) have been estimated from flight data provided by Ryanair for a B737 take-off at Dublin Airport[7]. The B737 is the most common aircraft type currently in operation at Dublin Airport, and these parameters have been assumed to apply to all other aircraft types (emissions during climb out will contribute very little to ground-level pollutant concentrations, and this assumption will not affect the outcome of the assessment).

2.23 The approach angle (3 degrees) was confirmed by daa, with the approach time based on information published for the Stansted Airport G2 assessment[15] for medium sized aircraft (246 seconds). Approach speeds were calculated from the correlation between approach times and distances. The horizontal approach distance was calculated from vertical descent ceiling (915 m) and the angle of approach (3 degrees) using trigonometry.

2.24 For the future assessment scenarios in 2022 and 2027 the same take-off, climb-out and approach profiles as used in the 2018 baseline have been assumed.

13 This was confirmed by Aer Lingus in a Request For Information (R15100_002_050)

14 Ryanair flight data derived from the Boeing Climb Out Programme

15 Stansted G2 Air Quality Assessment Methodology AEAT/ENV/R/2497/Issue 1 May 2008

2.25 The roll out distance (i.e. distance from wheels down to start of taxi) has been estimated based on the distance measured between the visible runway landing marks and the main high-speed taxiway exit on each runway. Aircraft were assumed to be operating at idle thrust (7%) during roll out (landing roll).

2.26 For the 2022 and 2027 assessment scenarios, the roll-out distance on the north runway has been assumed to be the same as on the existing south runway. The assumed distance was assumed to remain unchanged between 2018 and the future assessment years.

2.27 For ground operations, data were obtained from the daa movement database, which tracked the arrival and departure times of all aircraft during 2015. Analysis of these data has allowed a number of parameters to be estimated, including the taxi times between the different stand groups and runways, and the departure delay (aircraft hold) time.

2.28 Departure delay (i.e. the delay to aircraft between push back from stand and take off from runway) was assumed to be located at runway end (in a hold queue). Emissions from aircraft during departure delay (assumed to be at idle mode (7%)) were modelled as a volume source located at the taxiway at the end of each runway. A source depth of 5 metres, with a centre height of 3.5 metres was assumed for the emissions from the main engines, to account for the physical height of the engine and initial plume buoyancy due to the heat of the exhaust. This is the case for all model assessment years.

2.29 For the assessment years of 2022 and 2027 taxi times to and from the south runway were assumed to be unchanged from 2018. For the north runway, taxi times from each of the stand groups was estimated, based on the distance between the stands and runway ends/runway exits and the average speed of taxiing aircraft obtained from the 2018 movement data (i.e. it was assumed that aircraft will taxi to and from the north runway at the same speed as to/from the south runway).

2.30 The departure delay in 2022 and 2027 was assumed to be the same as for the south runway in 2018; for the north runway, the average 2018 departure delay was applied to all aircraft using the north runway. This represents a conservative assumption.

2.31 Emissions during climb-out and approach have been calculated to a ceiling height of 915 metres (3,000 feet).

2.32 All approach and departure (climbout) routes have been assumed to coincide with the extended centreline up to the ceiling height of 915m. For departures, when the two runways are both in operation, departure routes known as Scenario B will be used. Under this scenario, there will be straight-out departures on the South runway, but a 15°N divergence for easterly departures on the North Runway and a split divergence of 30°N and 75°N for westerly departures on North Runway, depending on the ultimate destination of aircraft. IAA has confirmed that the minimum altitude for the initiation of divergence will be 120m, but in practice, aircraft will normally be at a height of between 300-500m before starting the turn. Emissions from aircraft at these altitudes will have no discernible impact on ground-level pollutant concentrations, and the straight-line departure routes assumed in the model will not affect the outcome of the assessment.

Aircraft Operations – Brake & Tyre Wear

2.33 An allowance has also been made for PM emissions arising from brake and tyre wear based on a methodology developed during the PSDH work[16]. For brake wear, an emission factor of 2.51×10^{-7} kg PM_{10} per kg Maximum Take-off Weight (MTOW) was assumed. For tyre wear, the following relationship in equation [2] was used:

PM_{10} (kg) per landing = $2.23 \times 10^{-6} \times$ (MTOW kg) – 0.0874 kg Equation [2]

2.34 Emissions were calculated for all large aircraft. The relationship is not applicable to smaller aircraft, below 55,000 kg, and it was assumed the PM emissions from tyre wear follow a linear relationship between MTOW = 55,000 kg to MTOW = 0 kg.

Aircraft Operations - Auxiliary Power Units

2.35 Auxiliary Power Units (APUs) are used to provide power to larger aircraft when the main engines are not running. APUs are used to condition the aircraft cabin when temperatures are uncomfortable. Other requirements for APU use occur if there is an incompatibility between the aircraft system and the Mobile Ground Power Unit (MGPU) supplies, or if there is a technical fault.

2.36 Typical APU run times have been based on information provided by daa and were assumed to be 5 minutes on arrival on stand, and 10 mins prior to departure (push back from stand), for all aircraft movements.

2.37 APUs operate in three different modes, i.e. Start-up, Normal Running (ECS – Environmental Control Systems) and MES (Main Engine Start). On arrival, it was assumed that the APU operates in Start-up mode for 3 minutes, and in ECS for 2 minutes. On departure, it was assumed that the APU operates for 3 minutes in Start-up mode, for 6.5 minutes in ECS, and for 30 seconds in MES mode. The emissions indices for each mode have been derived from TRB's Airports Cooperative Research Programme Report - ACPR 64[17] (Table 2).

2.38 For the future assessment years, the arrival and departure APU run times were assumed to be unchanged from 2018. This is likely to represent a conservative assumption if a policy to restrict APU run times is implemented and/or FEGP is installed.

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[16] Curran (2006). Method for estimating particulate emissions from aircraft brakes and tyres. Qinetic Q/05/01827

[17] Handbook for Evaluating Emissions and Costs of APUs and Alternative Systems. ACPR – 64. Available at 6) http://www.trb.org/Publications/Blurbs/167070.aspx

2.39 The ACPR report does not provide information on PM emissions from APU operations. Emission rates for PM have been based on a function of the corresponding NOx emission factor ($PM = 0.0233*NOx^{0.0934}$)[18].

Table 2: APU Emission Indices in grams per second (g/s)

Airframe Type	Start Up			ECS			MES		
	NOx	PM	HC	NOx	PM	HC	NOx	PM	HC
Narrow Body	0.11	0.03	0.14	0.23	0.02	0.01	0.29	0.02	**0.01**
Wide Body	0.26	0.03	0.03	0.57	0.02	0.01	0.74	0.02	**0.01**
Jumbo Wide Body	0.24	0.03	0.03	0.63	0.02	0.01	0.65	0.02	**0.01**
Regional Jet	0.07	0.03	0.02	0.09	0.02	0.01	0.10	0.02	**0.01**
Turbo Prop	**0.07**	**0.03**	**0.02**	**0.09**	**0.02**	**0.01**	**0.10**	**0.02**	**0.01**

Airside Vehicles and Mobile Ground Power Units (GSE)

2.40 Emissions from airside vehicles are associated with the transport of passengers and cargo to aircraft, and servicing and refuelling of aircraft, etc. MGPUs provide auxiliary power for aircraft, when necessary. Collectively, these are referred to a Ground Support Equipment (GSE). Detailed information on GSE (including size and type of engine) is not available at Dublin Airport; the approach taken has been to scale emissions from other airports where detailed emissions inventories of airside vehicles have been compiled. A summary of the data compiled is shown in Table 3 and Table 4; the data are summarised as emissions of NOx/PM_{10} (tonnes) per mppa.

[18] AEA (2008) Stansted G2 Air Quality Assessment Methodology AEAT/ENV/R/2497/Issue 1

Table 3: Comparison of GSE NOx Emissions

Airport	GSE NOx Emissions (tpa)	mppa	Year	NOx Emissions/mppa (tpa)
London City	5.3	3.65	2014	1.45
London Luton	27.7	9.51	2011	2.91
London Gatwick	76.9	32.36	2009	2.38
London Heathrow	266.9	65.91	2009	4.05

Table 4: Comparison of GSE PM_{10} Emissions

Airport	GSE PM_{10} Emissions (tpa)	mppa	Year	PM_{10} Emissions/mppa (tpa)
London City	0.29	3.65	2014	0.08
London Luton	1.56	9.51	2011	0.16
London Gatwick	4.17	32.36	2009	0.13
London Heathrow	18.33	65.91	2009	0.28

2.41 Operations in 2018 at Dublin Airport (~31.5 mppa) are close to those at London Gatwick Airport in 2009 (~32 mppa). The profile of operations at London Gatwick Airport is broadly similar to that at Dublin Airport, with both airports predominated by short-haul flights with a high proportion operated by low-cost carriers, and both operate with single runway operation. London Gatwick has a higher proportion of long-haul flights, but this is unlikely to significantly affect GSE emissions. The GSE emissions at Dublin Airport in 2018 have therefore been calculated by scaling the GSE emissions from Gatwick by mppa.

2.42 For the future assessment years, the GSE emissions were scaled up from the 2018 emissions, based on the ATM ratios for the various scenarios. The approach is based on the assumption that the amount of GSE required to service the airport will increase in line with the number of aircraft arriving and departing. This represents a conservative assumption as it does not take account of fleet rollover and the introduction of lower and zero-emission vehicles and plant into the fleet.

Road Traffic

2.43 Emissions arising from traffic on the local road network have been calculated using the ADMS-Roads (v5.0) dispersion model. Predictions are based on vehicle flow, composition and speed using the same emission factors published within the Emission Factor Toolkit (EFT, version 9.0). The emission rates account for emissions of PM_{10} and $PM_{2.5}$ arising from brake and tyre wear and from road abrasion. Whilst PM emissions from entrainment (or "re-suspension") of other materials on the road are also widely considered to be important, there are currently no data upon which robust emission rates can be calculated; any re-suspension component has therefore been necessarily ignored.

2.44 Annual average daily traffic (24 hr-AADT) flows, the proportions of Heavy Duty Vehicles (HDV) and average speeds for each road link were provided by Aecom for 2019 and the 2022, 2027, and 2032 assessment years; the 2019 flows were adjusted to the 2018 Existing Environment year by factoring, using historic traffic count data (as advised by Aecom). The assumed flows are summarised in Appendix A. The road links included in the assessment are shown in Figure 1.

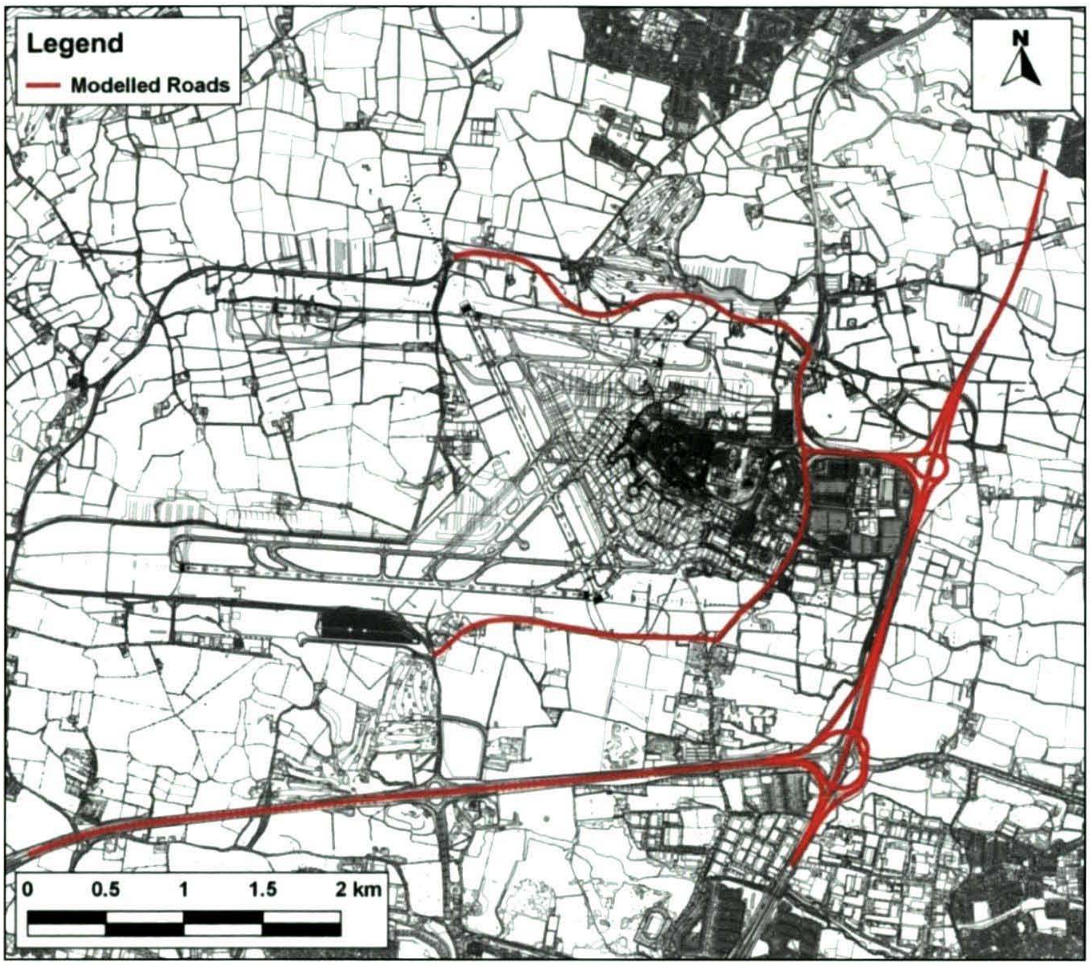
2.45 European type approval ('Euro') standards for vehicle emissions apply to all new vehicles manufactured for sale in Europe. These standards have, over many years, become progressively more stringent and this is one of the factors that has driven reductions in both predicted and measured pollutant concentrations over time.

2.46 Historically, the emissions tests used for type approval were carried out within laboratories and were quite simplistic. They were thus insufficiently representative of emissions when driving in the real world. For a time, this resulted in a discrepancy, whereby nitrogen oxides emissions from new diesel vehicles reduced over time when measured within the laboratory, but did not fall in the real world. This, in turn, led to a discrepancy between models (which predicted improvements in nitrogen dioxide concentrations over time) and measurements (which very often showed no improvements year-on-year).

2.47 Recognition of these discrepancies has led to changes to the type approval process. Vehicles are now tested using a more complex laboratory drive cycle and also through 'Real Driving Emissions' (RDE) testing, which involves driving on real roads while measuring exhaust emissions. For Heavy Duty Vehicles (HDVs), the new testing regime has worked very well and NOx emissions from the latest vehicles (Euro VI) are now very low when compared with those from older models[19].

[19] ICCT (2017) NOx emissions from heavy duty and light duty diesel vehicles in the EU: Available at: www.theicct.org/nox-europe-hdv-ldv-comparison-jan2017

Figure 1: Traffic Network Included in Assessment



2.48 For Light Duty Vehicles (LDVs), while the latest (Euro 6) emission standard has been in place since 2015, the new type-approval testing regime only came into force in 2017. Despite this delay, earlier work by AQC showed that Euro 6 diesel cars manufactured prior to 2017 tend to emit significantly less NOx than previous (Euro 5 and earlier) models.

2.49 AQC has analysed trends in measured NOx concentrations against trends in Defra's EFT model predictions for the period 2013 to 2019[20]. This has demonstrated that, while the EFT typically over-stated the improvements over the period 2013 to 2016, it has tended to under-state the improvements since 2016. Wider consideration of the assumptions built into the EFT suggests that, on balance, the EFT is unlikely to over-state the rate at which NOx emissions decline in the future at an 'average' site in the UK. In practice, the balance of evidence thus suggests that NOx concentrations are most likely to decline more quickly in the future, on average, than predicted by the EFT, especially against a base year of 2016 or later. Using EFT v9.0 for future-year forecasts in

[20] AQC (2020) Performance of Defra's Emission Factor Toolkit 2013-2019. Available at www.aqconsultants.co.uk

this report thus provides a robust assessment, given that the model has been verified against measurements made in 2018.

Stationary Sources

2.50 An inventory of combustion plant in use at Dublin Airport was provided by daa. This includes a list of plant type (CHP, generator or boiler), size (in MW) and fuel type (gas or oil-fired). The inventory also includes annual gas and oil fuel use by total usage (i.e. not attributed to individual plant). The emissions per annum across all plant have therefore been calculated from the total annual fuel use of gas and oil, based on NOx and PM emissions indices from the EEA/EMEP Guidebook 1.A.4 Table 3-8 and Table 3-9[21].

2.51 The assumed emissions indices are:

- Gas NOx = 74 g/Gj;
- Oil NOx = 306 g/Gj,
- Gas PM_{10} = 0.78 g/Gj and
- Oil PM_{10} = 21 g/Gj.

2.52 daa also provided a map of the locations of these combustion sources. The very large (>1MW) plant are located in one of two main energy centres; one in Terminal 1 (EC1) and one in Terminal 2 (EC4), and these represent the majority of the capacity. For these energy centres, daa provided specific information on stack heights. All stationary source emissions were assumed to be emitted from EC1 and EC4, with the emissions apportioned, based on the total combined size of plant in each energy centre (23.3 MW in EC1 (43%) and 31.3 MW in EC4 (57%).

2.53 The exit velocity was assumed to be 15 m/s in accordance with best practice for large combustion plant. The exit temperature was assumed to be 120 degrees C in line with typical CHP plant, but acknowledging that exhaust temperatures from the boilers will be typically lower (~65 deg C) and from generators much higher (~400+ deg C). Stack diameters have been estimated based on observations from Google satellite imagery. The assumed parameters are:

EC1 – terminal 1: Stack Height = 30 m, diameter = 1 m

EC4 – terminal 2: stack height = 39 m, diameter = 2.5 m

2.54 The combustion plant inventory provided by daa is for 2015. For the 2018 baseline assessment, it has been assumed that gas and oil consumption in the daa boilers and CHP plant are the same as they were in 2015. For the future assessment years, the emissions from stationary sources were estimated by scaling up the 2018 emissions based on the forecast ATM ratio in each scenario, in

21 EMEP/EAA Emission Inventory Guidebook (2019). Available at https://www.eea.europa.eu/publications/emep-eea-guidebook-2019

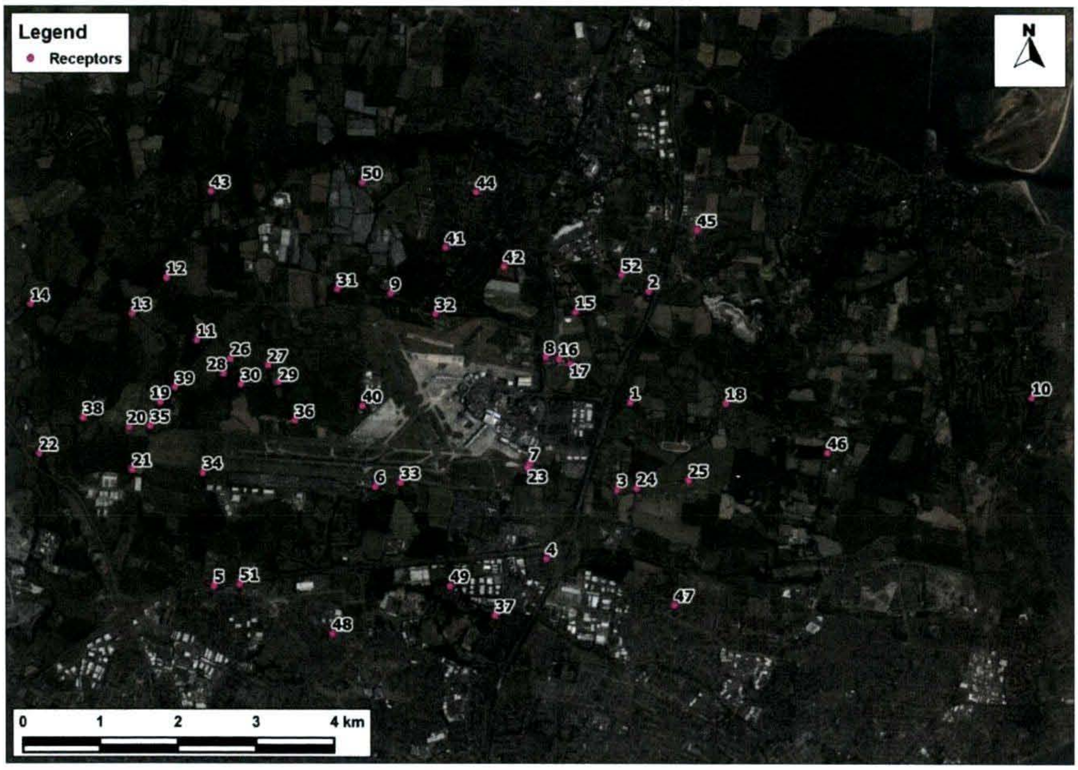
line with the assumptions for GSE. This is likely to represent a conservative assumption as it does not take account of any incremental energy efficiency measures that will reduce the airport's heating demand in future years. The emissions release parameters were assumed to be the same as for 2018, and the apportionment of emissions between EC1 and EC4 unchanged.

3 Definition of Study Area and Receptors

3.1 The geographical study area for Air Quality is outlined in Figure 2. The study area is effectively defined based on the approach to quantifying emissions from the Airport sources as recommended by the ICAO in its *Airport Air Quality Manual*[22], taking into account a geographical area where there is a potential for a change in air quality with the proposed operations and the extent of the road transport network considered.

3.2 The contribution that airport-related emissions make to local air quality reduces with increasing distance from the airport boundary. It should be noted that aircraft at 1000m altitude will make no contribution to ground level pollutant concentrations, and the contribution of Airport sources beyond 1km will not be discernible.

Figure 2: Air Quality Assessment Study Area and Receptors



3.3 The NRA guidance defines sensitive receptors as locations including residential housing, schools, hospitals, places of worship, sports centres and shopping areas, i.e. locations where members of the public are likely to be regularly present. Sensitive receptors within the study area (e.g. dwellings, schools, hospitals etc.) have been identified.

3.4 The specific receptor locations identified for the air quality assessment are shown in Figure 3. In selecting these receptors, consideration has been given to locations that may be affected by the

[22] ICAO (2011),Airport Air Quality Manual, available at http:www.icao.int

permitted North Runway, once it becomes operational. These receptors include residential properties close to the airport and/or under flight paths as well as specific locations such as schools and community facilities. A specific receptor was also included in Portmarnock (at Ardilaun, at the eastern boundary of Malahide Golf Club), some 7km to the east of the Airport (which represents the closest residential properties in Portmarnock to the Airport). In some instances, a single receptor location has been selected to represent a group of residential properties, as the predicted concentrations would tend to be similar within the cluster of properties.

3.5 In addition to these receptors for the Air Quality Assessment, pollutant concentrations have been predicted across a much wider study area to support the Health Impact Assessment. These receptor locations are consistent with the noise modelling work undertaken by Bickerdike Allen Partners (BAP) and the coordinates for all existing and permitted receptors were provided by BAP.

4 Meteorological Data

4.1 Hourly sequential meteorological data[23] for 2018 were obtained from the Meteorological Office station at the Airport; the wind rose is shown in Appendix A2.

4.2 Runway use at the Airport is determined by weather conditions. Currently, Runway 28 (westerly) is the preferred runway, with 71.4% of departures and 72.2% of arrivals in 2018; however, when the wind direction is from the east, Runway 10 (easterly) is used. The Airport provided details of runway allocation for each departure and arrival. These data showed a strong correlation demonstrating that during easterly wind conditions (between 0 degrees and 180 degrees), aircraft operated from Runway 10, whereas during westerly wind conditions (between 180 degrees and 360 degrees), aircraft operated from Runway 28. Therefore, in the ADMS-Airport model, runway allocation has been determined by wind direction. During hours where winds occur in the sectors 0 - 180°, Runway 10 is assumed to be in use, and sources using Runway 28 are "switched off". During hours with winds occurring in the sectors 180 – 360°, Runway 28 is assumed to be in use and sources using Runway 10 are "switched off".

4.3 A similar approach to switch between Runways 28R/28L and 10R/10L was used in all future year scenarios.

[23] The ADMS Airport model considers the hour-by-hour meteorological conditions across the 8760 hours in the year. It is not possible to use long-term statistical datasets in the model.

5 Background Concentrations

5.1 The ADMS Airports model predicts pollutant concentrations from those sources of emissions that have been explicitly included in the model. It is also necessary to take account of the contribution from other pollutant sources that are not explicitly included – normally referred to as the "background contribution".

5.2 Background pollutant concentrations have been defined from local monitoring data. For nitrogen dioxide, an annual mean concentration of 16 μg/m^3 was assumed for 2018 based on measured concentrations in 2018 at the Swords monitoring site, operated by EPA. For PM_{10}, an annual mean concentration in 2018 of 11 μg/m^3 was assumed, based on concentrations measured at the Phoenix Park monitoring site.

5.3 There are only limited data to describe $PM_{2.5}$ concentrations. The approach taken to estimate $PM_{2.5}$ concentrations was to use the UK Government's background pollutant concentrations maps[24] to calculate the average ratio between PM_{10} and $PM_{2.5}$ concentrations across the whole of Northern Ireland (mapped background data are not available for the ROI) and apply this ratio to the measured PM_{10} background concentration at Phoenix Park. This provides an estimated 2018 background $PM_{2.5}$ concentration of 6.8 μg/m^3.

5.4 Background pollutant concentrations are expected to decline in future years due to a range on national and international measures to reduce emissions across a wide range of sources. Background concentrations in 2022, 2027, 2032 and 2040 were determined based on the approach recommended by the Transport Infrastructure Ireland (formerly the National Roads Authority[25]). This involves calculating the average pollutant concentration across all 1 x 1 km Defra background map squares in Northern Ireland for the baseline (2018) year and the future years[24] and then calculating the ratio in the average NO_2, PM_{10} and $PM_{2.5}$ concentration between baseline and future years. The ratios were then applied to the background concentrations described above, to estimate the future year background concentrations. The background concentrations used in the assessment are shown in Table 5.

Table 5: Background Concentrations (μg/m^3)

Pollutant	Year			
	2018	**2022**	**2027**	**2032**
Nitrogen Dioxide	16.0	13.7	12.0	11.6
PM_{10}	11.0	10.5	10.2	10.1
$PM_{2.5}$	6.8	6.4	6.1	6.0

24 The Defra 1 x 1 km maps only extend to 2030. Background concentrations have been assumed to remain unchanged between 2030 and 2032 which is a conservative approach.

25 NRA (2006) Guidelines for the Treatment of Air Quality During the Planning and Construction of National Road Schemes. Revision 1 issued on 8 May 2011.