Supporting European Aviation

EUROCONTROL

EEA/EMEP Update to 1.A.3.a Aviation Annex 1 – Master emissions calculator & Annex 2 – LTO emissions calculator

TFEIP/EIONET 2020 meeting

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FOUNDING MEMBER SESAR JOINT UNDERTAKING

NETWORK MANAGER

DISCLAIMER

The fuel burnt and emission data provided in these spreadsheets are for supporting EU and EU Member States in the maintenance and provision of European and national homogeneous emissions' inventories. These data should not be used for comparing fuel efficiency and emission data between aircraft models and manufacturers. **Fuel burn and emission data in this spreadsheet are estimates and not "absolute" values.** The engine associated to each aircraft type is the most common type of engine used for each aircraft type in 2019. Please refer to the "EUROCONTROL Method for estimating aviation fuel burnt and emissions in the framework of the EMEP/EEA air pollutant emission inventory guidebook 2020" for a description of the method used to produce these data. @EUROCONTROL 2020.

1.A.3.a Aviation Annex 1 - Master emissions calculator

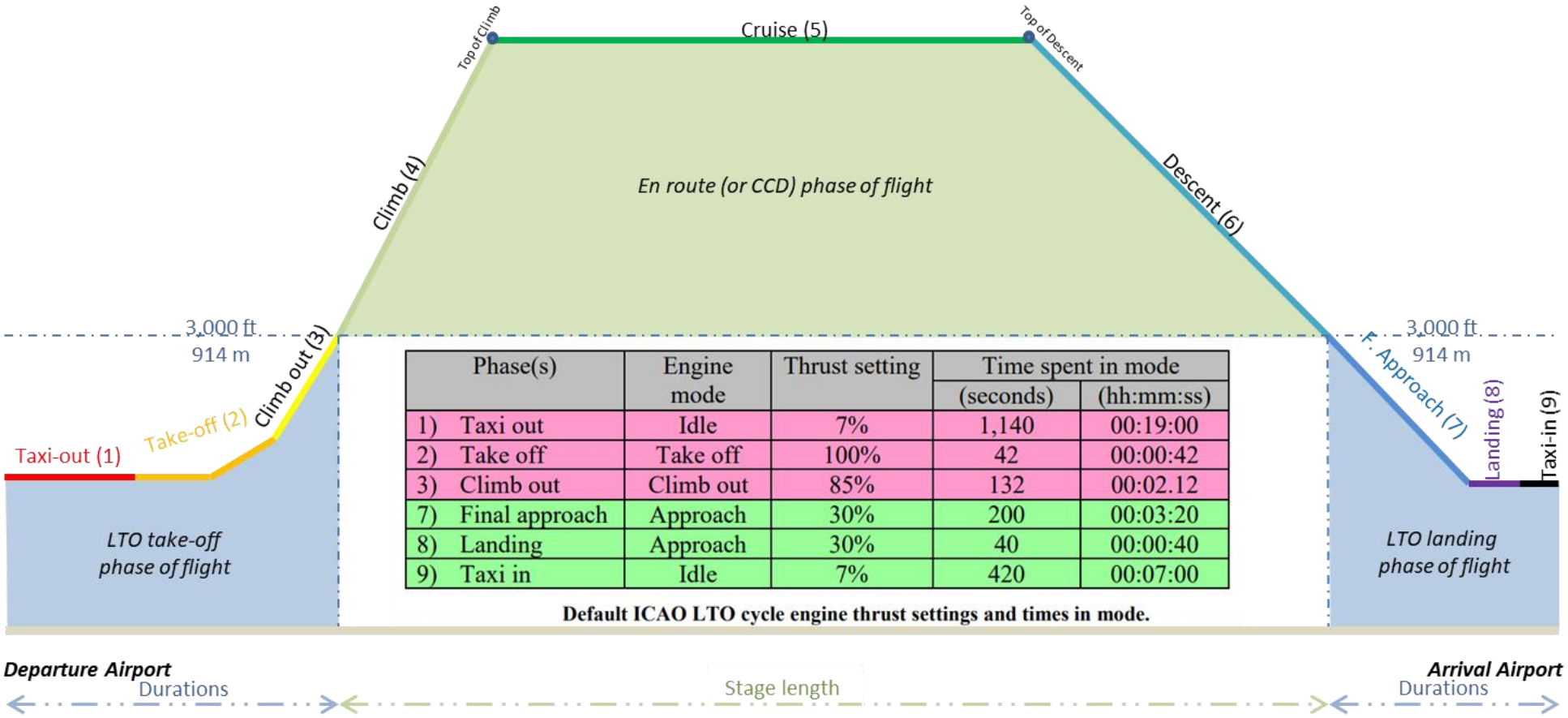
Aircraft code		Manufacturer	AIRBUS
		One of the models associated with this aircraft type	A-320
A320		Category	LANDPLANE

Engine type	JET
The most common engine ID in 2019 used for modelling this aircraft type	3CM026
Number of engines	2

Default LTO (1) cycle in hh:mm:ss		
Phases	ICAO	A busy European airport, year 2019
Taxi	00:26:00	00:20:06
Take off	00:00:42	00:00:42
Climb out	00:02:12	00:02:12
Approach	00:04:00	00:04:00
TOTAL	**00:32:54**	**00:27:00**

			ESTIMATIONS YEAR 2019										
Aircraft type	**A320** AIRBUS	The most frequently observed cruise flight level	**Duration in hh:mm:ss**	**Fuel burn in kg**	**CO2 in kg**	**NOx in kg**	**SOx in kg**	**H2O in kg**	**CO in kg**	**HC in kg**	**PM non volatile in kg**	**PM volatile (organic+sulphurous) in kg**	**PM TOTAL in kg (3)**
Default LTO (1) cycle (see table below)	A busy European airport, year 2019		00:27:00	742.54	2 338.99	10.97	0.62	918.52	6.52	1.30	0.0066	0.0536	0.0602
	ICAO		00:32:54	816.17	2 570.93	11.28	0.69	1 009.60	8.25	1.64	0.0067	0.0593	0.0661
CCD stage length in NM	125	180	00:21:07	936.63	2 950.38	17.35	0.79	1 158.61	3.05	0.63	0.0123	0.0800	0.0923
	200	240	00:31:11	1 391.18	4 382.23	25.40	1.17	1 720.89	4.26	0.88	0.0186	0.1278	0.1464
	250	300	00:37:22	1 621.38	5 107.33	29.56	1.36	2 005.65	5.20	1.07	0.0236	0.1570	0.1805
	500	360	01:11:01	2 820.09	8 883.27	44.80	2.37	3 488.45	7.73	1.62	0.0318	0.3162	0.3481
	750	360	01:44:34	4 120.25	12 978.79	61.78	3.46	5 096.77	9.81	2.08	0.0401	0.4826	0.5227
	1 000	360	02:18:05	5 379.46	16 945.31	77.58	4.52	6 654.40	11.84	2.53	0.0471	0.6463	0.6933
	1 500	360	03:25:11	7 945.28	25 027.64	110.54	6.67	9 828.30	15.96	3.45	0.0625	0.9767	1.0393
	2 000	360	04:32:18	10 560.97	33 267.04	144.88	8.87	13 063.89	20.13	4.37	0.0796	1.3107	1.3903
	2 500	380	05:39:28	12 864.02	40 521.67	173.42	10.81	15 912.82	24.78	5.41	0.1007	1.6731	1.7738
	3 000	380	06:45:57	15 685.71	49 409.99	212.38	13.18	19 403.19	28.84	6.31	0.1181	1.9981	2.1162

HOW DATA ARE CALCULATED?



Phase(s)	Engine mode	Thrust setting	Time spent in mode (seconds)	Time spent in mode (hh:mm:ss)
1) Taxi out	Idle	7%	1,140	00:19:00
2) Take off	Take off	100%	42	00:00:42
3) Climb out	Climb out	85%	132	00:02.12
7) Final approach	Approach	30%	200	00:03:20
8) Landing	Approach	30%	40	00:00:40
9) Taxi in	Idle	7%	420	00:07:00

Default ICAO LTO cycle engine thrust settings and times in mode.

125; 200; 250; 500; 750; 1000; 1500; 2000; 2500; 3000; …; 9000 NM

	Fuel burn	NOX, HC, CO	CO_2, H_2O, SOX	VOC
<3000 feet (LTO phase)	ICAO engine exhaust emissions data bank		Proportional to fuel burn	Proportional to HC
>=3000 feet (non-LTO phase)	BADA	BFFM2		

CHANGES 1/2

This new version makes it possible to:

- take into account new aircraft that have entered into operation since then.
- reflect changes observed in the route network (e.g. cruise levels).
- take into account updates of engine emission indices data (EEDB).
- take into account updates of flight performance data (ANP and BADA).
- take into account the evolution of the modelling applications IMPACT and AEM.

CHANGES 2/2

Type of changes:

- the aircraft trajectory definition and/or the fuel flow calculation model were updated,
- Engine emissions model,
- At least one cruise level update and new distances,
- Cruise level update.

ALL changes are captured in a Release note

EXAMPLE OF DIFFERENCES BETWEEN 2020 and 2016:

Stage length (Nm)	Release 2016			Release 2020			2016 to 2020 change	
	Most frequent cruise level 2015 (100ft)	Duration (hh:mm:ss)	Fuel burn (kg)	Most frequent cruise level 2019 (100ft)	Duration (hh:mm:ss)	Fuel burn (kg)	Duration	Fuel burn
125	180	00:21:37	932	180	00:21:07	937	-2.29%	0.51%
200	270	00:31:18	1 356	240	00:31:11	1 391	-0.40%	2.56%
250	280	00:37:44	1 647	300	00:37:22	1 621	-0.98%	-1.58%
500	320	01:10:49	2 946	360	01:11:01	2 820	0.27%	-4.27%
750	360	01:45:05	4 124	360	01:44:34	4 120	-0.49%	-0.10%
1000	380	02:18:37	5 273	360	02:18:05	5 379	-0.38%	2.01%
1500	380	03:25:45	7 769	360	03:25:11	7 945	-0.28%	2.27%
2000	380	04:32:47	10 484	360	04:32:18	10 561	-0.18%	0.74%
2500	380	05:39:50	12 914	380	05:39:28	12 864	-0.11%	-0.39%
3000	380	06:46:01	15 847	380	06:45:57	15 686	-0.01%	-1.02%

1.A.3.a Aviation Annex 2 - LTO emissions calculator

Enter the aircraft and airport details here

(Click under the red arrows (🔻) to see the drop-down menus.)

1) Type of aircraf: A388 (Airbus A-380-800) with Trent 970-84 engines ***

Note: Where only one model of engine is associated with a particular type of aircraft in this menu, it is the most common model (as seen on aircraft flying in Europe), or the best equivalent model, for that type of aircraft that is displayed. Where several models of engine are associated with a particular type of aircraft in this menu, the most-common model is marked with *** (if appropriate).

2) Airport

a) Country: France

b) Airport: LFPG (Paris Charles de Gaulle Airport - PARIS)

c) Year: 2019

=>

General engine details

Engine model code: 8RR046

Engine model name: Trent 970-84

Type of engine: Turbofan

Number of engines: 4

Airport annual average taxi times

Taxi out time (s): 959

Taxi in time (s): 589

=>

Engine fuel burn and emissions data

	Engine thrust setting (% of maximum thrust)			
	7%	30%	85%	10
Rate of fuel burn (kg/s/engine)	0.3000000	0.7000000	2.200000	2.60
Rate of emission of CO[1] (kg/s/engine)	0.004530000	0.0009800000	0.0004400000	0.0010
Rate of emission of HC[2] (kg/s/engine)	0.00006000000	0.0000007000000	0.0000002200000	0.000000
Rate of emission of NOx[3] (kg/s/engine)	0.001530000	0.007980000	0.06402000	0.096
Rate of emission of $PM_{vol-org}$[4] (kg/s/engine)	0.0000003702000	0.0000000393750	0.00000001672000	0.000000
Rate of emission of $PM_{vol-sul}$[5] (kg/s/engine)	0.00001468800	0.00003427200	0.0001077120	0.0001
Rate of emission of $PM_{non-vol}$[6] (kg/s/engine)	0.000001116010	0.00001032549	0.00004175077	0.00003
Rate of emission of PM_{total}[7] (kg/s/engine)	0.00001617421	0.00004463687	0.0001494795	0.0001

Notes

1 CO is carbon monoxide.

2 HC is unburnt hydrocarbons.

3 NOx are mono-nitrogen oxides (NO and NO_2)

4 $PM_{vol-org}$ is volatile organic particulate matter (PM). (Turbofan engines

5 $PM_{vol-sul}$ is volatile sulphuric PM. (Turbofan engines only)

6 $PM_{non-vol}$ is non-volatile PM. (Turbofan engines only)

7 PM_{total} is all types of PM added together. (Turbofan and piston engin

Total masses of fuel burnt and CO, HC, NOx, CO_2, $PM_{vol-org}$, $PM_{vol-sul}$, $PM_{non-vol}$, and PM_{total} emitted

	Taxi out (A)			Take off (B)	Climb out (C)	Departure phase total (A + B + C)	Approach+landing (D)	Taxi in (E)			Arrival phase total (D + E)	LTO cycle total (A + B + C + D+ E)	
	Average taxi-out time for the selected airport and year (= 959 s)	ICAO default taxi-out time (= 1140 s)	Average taxi-out time for the 25 busiest airports in 2019 (= 890 s)					Average taxi-in time for the selected airport and year (= 589 s)	ICAO default taxi-in time (= 420 s)	Average taxi-in time for the 25 busiest airports in 2019 (= 413 s)			
	(7% thrust)			(100% thrust)	(85% thrust)		(30% thrust)	(7% thrust)					
Mass of fuel burnt (kg)	1.1510 x 10 ^{3}	1.3680 x 10 ^{3}	1.0683 x 10 ^{3}	4.3680 x 10 ^{2}	1.1616 x 10 ^{3}	2.7494 x 10 ^{3}	6.7200 x 10 ^{2}	7.0639 x 10 ^{2}	5.0400 x 10 ^{2}	4.9516 x 10 ^{2}	1.3784 x 10 ^{3}	4.1278 x 10 ^{3}	Mass of fuel burnt (kg)
Mass of CO emitted (kg)	1.7380 x 10 ^{1}	2.0657 x 10 ^{1}	1.6132 x 10 ^{1}	1.7472 x 10 $^{-1}$	2.3232 x 10 $^{-1}$	1.7787 x 10 ^{1}	9.4080 x 10 $^{-1}$	1.0667 x 10 ^{1}	7.6104	7.4769	1.1607 x 10 ^{1}	2.9394 x 10 ^{1}	Mass of CO emitted (kg)
Mass of HC emitted (kg)	2.3020 x 10 $^{-1}$	2.7360 x 10 $^{-1}$	2.1367 x 10 $^{-1}$	4.3680 x 10 $^{-5}$	1.1616 x 10 $^{-4}$	2.3036 x 10 $^{-1}$	6.7200 x 10 $^{-4}$	1.4128 x 10 $^{-1}$	1.0080 x 10 $^{-1}$	9.9032 x 10 $^{-2}$	1.4195 x 10 $^{-1}$	3.7231 x 10 $^{-1}$	Mass of HC emitted (kg)
Mass of NO_x emitted (kg)	5.8700	6.9768	5.4485	1.6249 x 10 ^{1}	3.3803 x 10 ^{1}	5.5922 x 10 ^{1}	7.6608	3.6026	2.5704	2.5253	1.1263 x 10 ^{1}	6.7185 x 10 ^{1}	Mass of NOX emitted (kg)
Mass of CO_2 emitted (kg)	3.6256 x 10 ^{3}	4.3092 x 10 ^{3}	3.3652 x 10 ^{3}	1.3759 x 10 ^{3}	3.6590 x 10 ^{3}	8.6606 x 10 ^{3}	2.1168 x 10 ^{3}	2.2251 x 10 ^{3}	1.5876 x 10 ^{3}	1.5598 x 10 ^{3}	4.3419 x 10 ^{3}	1.3003 x 10 ^{4}	Mass of CO_2 emitted (kg)
Mass of $PM_{vol-org}$ emitted (kg)	1.4203 x 10 $^{-3}$	1.6881 x 10 $^{-3}$	1.3183 x 10 $^{-3}$	5.0232 x 10 $^{-6}$	8.8282 x 10 $^{-6}$	1.4342 x 10 $^{-3}$	3.7800 x 10 $^{-5}$	8.7169 x 10 $^{-4}$	6.2194 x 10 $^{-4}$	6.1103 x 10 $^{-4}$	9.0949 x 10 $^{-4}$	2.3437 x 10 $^{-3}$	Mass of $PM_{vol-org}$ emitted (kg)
Mass of $PM_{vol-sul}$ emitted (kg)	5.6352 x 10 $^{-2}$	6.6977 x 10 $^{-2}$	5.2305 x 10 $^{-2}$	2.1386 x 10 $^{-2}$	5.6872 x 10 $^{-2}$	1.3461 x 10 $^{-1}$	3.2901 x 10 $^{-2}$	3.4585 x 10 $^{-2}$	2.4676 x 10 $^{-2}$	2.4243 x 10 $^{-2}$	6.7486 x 10 $^{-2}$	2.0210 x 10 $^{-1}$	Mass of $PM_{vol-sul}$ emitted (kg)
Mass of $PM_{non-vol}$ emitted (kg)	4.2817 x 10 $^{-3}$	5.0890 x 10 $^{-3}$	3.9742 x 10 $^{-3}$	6.1976 x 10 $^{-3}$	2.2044 x 10 $^{-2}$	3.2524 x 10 $^{-2}$	9.9125 x 10 $^{-3}$	2.6278 x 10 $^{-3}$	1.8749 x 10 $^{-3}$	1.8420 x 10 $^{-3}$	1.2540 x 10 $^{-2}$	4.5064 x 10 $^{-2}$	Mass of $PM_{non-vol}$ emitted (kg)
Mass of PM_{total} emitted (kg)	6.2054 x 10 $^{-2}$	7.3754 x 10 $^{-2}$	5.7598 x 10 $^{-2}$	2.7588 x 10 $^{-2}$	7.8925 x 10 $^{-2}$	1.6857 x 10 $^{-1}$	4.2851 x 10 $^{-2}$	3.8085 x 10 $^{-2}$	2.7173 x 10 $^{-2}$	2.6696 x 10 $^{-2}$	8.0936 x 10 $^{-2}$	2.4950 x 10 $^{-1}$	Mass of PM_{total} emitted (kg)

TERMS USED IN THIS PRESENTATION

Item/Acronym	Definition
AEM	EUROCONTROL Advanced Emissions Model; The application used for calculating the amount of fuel burn and emissions.
ANP	EUROCONTROL Aircraft Noise and Performance database; Used for the calculation of aircraft performances and trajectory below 6,000 feet .
BADA	EUROCONTROL BAse of Aircraft Data; Used for the calculation of the trajectory of aircraft above 6,000 feet and the calculation of fuel consumption.
BFFM2	Boeing Fuel Flow Methods 2
ECAC	European Civil Aviation Conference
EEDB	Engine Emissions DataBank. The public database that describes the jet engine emissions indices.
ICAO	International Civil Aviation Organisation
IMPACT	EUROCONTROL application for noise and emission impact assessments. It integrates an advanced trajectory calculation model based on ANP and BADA that is used in this context.

Thank you!