



E.02.24-MOTA-D3.2 – Benefits and performance evaluation

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Abstract

This document describes benefits for the Project Modern Taxiing (MoTa) validation campaign, in terms of performance. Two 35-minute scenarios, Medium and Hard, each featuring different operational events such as pilot error, restricted zone, towed aircraft, closed taxiway, and change in configuration, were performed with 18 air traffic ground controllers from around Europe while using different types of taxiing technology aids.

Current results indicate that the taxi times and fuel consumption are slightly reduced with the implementation of the MoTa interface and the TaxiBot-like tugs, especially with dense traffic scenarios (and higher ATCO workload). It shall be noted that the present analysis was conducted based on a simulation of one part of CDG. It would be advised to conduct additional studies on a whole airport to confirm this trend.

WP-E – MoTa – Benefits and performance evaluation

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1 INTRODUCTION

This report describes the results of the MoTa experiments in terms of taxi times and fuel consumption.

Results of the experiments with MoTa platform are compared with the results from the baseline experiment.

1.1 Details on the experiment

The overall experiment design was well-detailed in deliverable E.02.24-MOTA-D3.1-Experimental Protocol. The following table summarizes the main key facts on each experiment. There are two independent variables: Taxiing technique (baseline, interface-no tugs, interface-with tugs) and scenario complexity (average, hard). There was an experiment for each level of taxiing technique and each experiment featured the two levels of scenario complexity.

Experiment	Definition
Baseline (Experiment 1)	<ul style="list-style-type: none"> • Paper strips and current ATC technology • Current A/C : Airbus and Boeing Light / Heavy / Medium (A320, A330 etc) • Current taxiing technology (no Tugs, only ground radar, no decision support system)
Interface with no tugs (Experiment 2)	<ul style="list-style-type: none"> • New interface (decision support system, conflict detection, path suggestion) • Current aircraft (65% equipped with data link, 35% without data link) • Current ground taxiing operations (no Tugs)
Interface with tugs (Experiment 3)	<ul style="list-style-type: none"> • New interface (decision support system, conflict detection, path suggestion) • Current aircraft (85% equipped with data link, 15% without data link) • Future ground taxiing operations (7/10 Tugs/aircraft towed in Average, 10/20 in Hard)

Table 1: Experiments definition

The experiments were performed based on CDG airport layout (south end). Each experiment session lasted about 3-4 hours including the briefing and preparation works. Each run was 35 minutes long.

Details on participants and scenarios are described further in details in deliverable D3.3.

1.2 Description of the areas analysed

Only the south end part of CDG airport was used for the experiment.

Time events were recorded for 4 areas of interest: SOL (overall area), and 3 areas included in SOL: TWY_E, hotspot1 (on the left) and hotspot2 (on the right). The following figure shows the location of the different areas.

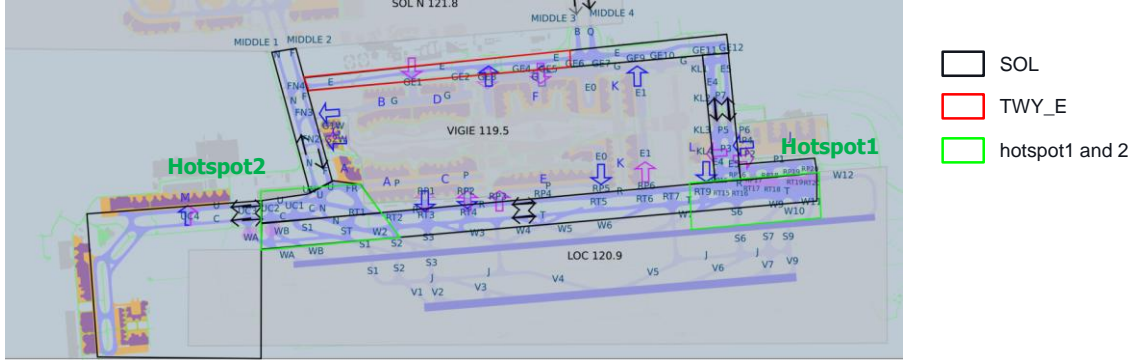


Figure 1: Areas of interest

2 Results description

2.1 Taxi time

Taxi times were computed for each scenario according to the entry time and exit time in the different areas (SOL, TWY_E, hotspot1, hotspot2).

2.1.1 Overall statistics

The following figures show the taxi duration dispersion in each of the areas, for all scenarios:

- Baseline: hard and medium scenarios
- Experiment 2: hard and medium scenarios
- Experiment 3: hard and medium scenarios

The first figure defines what is shown in the box-and-whiskers plots.

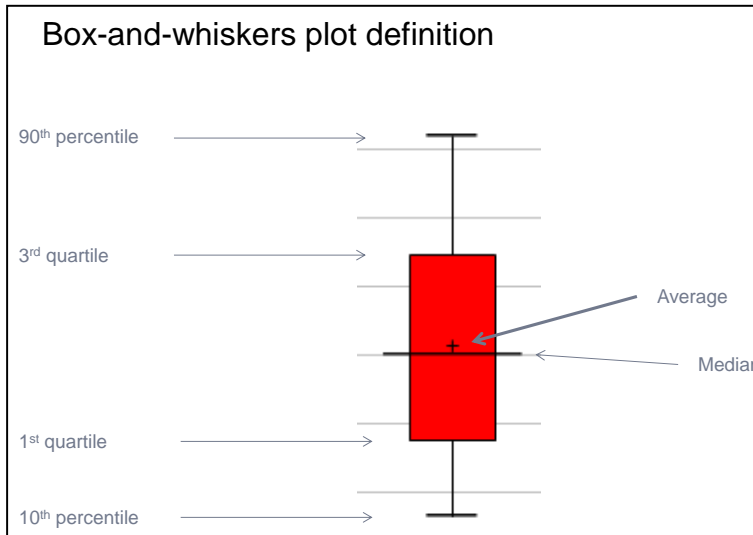


Figure 2: Box-and-whiskers plot definition

The most interesting figure concerns taxi duration in SOL. Indeed there is a limited number of aircraft in each run: only 10 to 20 aircraft are taxiing through TWY_E, hotspot1 and hotspot2 for each experiment run. In comparison for SOL, a total of 30 to 43 aircraft per run are taxiing around. Indeed hotspot1 and hotspot2 do not take into account aircraft arriving or departing via the north runways.

The graph shows that the taxi time in SOL does not vary a lot between the baseline and the experiments 1 and 2. Although taxi duration in SOL was higher for the higher scenario than for medium scenario in the baseline, this was not observed for experiments 2 and 3.

It can be globally concluded that taxi duration is not really impacted by the MoTa interface and the implementation of TaxiBot-like tugs. Taxi times are reduced mostly in the Hard scenarios as shown in Table 2. Taxi time reduction in Experiment 3 is smaller as overall taxi times for aircraft using TaxiBot are increased, due to different taxi paths (need to taxi through the disconnection areas) and disconnection duration (90 seconds). For further statistical analysis on the taxi time, see project MoTa deliverable D3.3 and the normalized taxi time indicator.

It shall be noted that the above analysis was performed based on a simulation of one portion of CDG. it would be advised to conduct additional studies on a whole airport to confirm this trend.

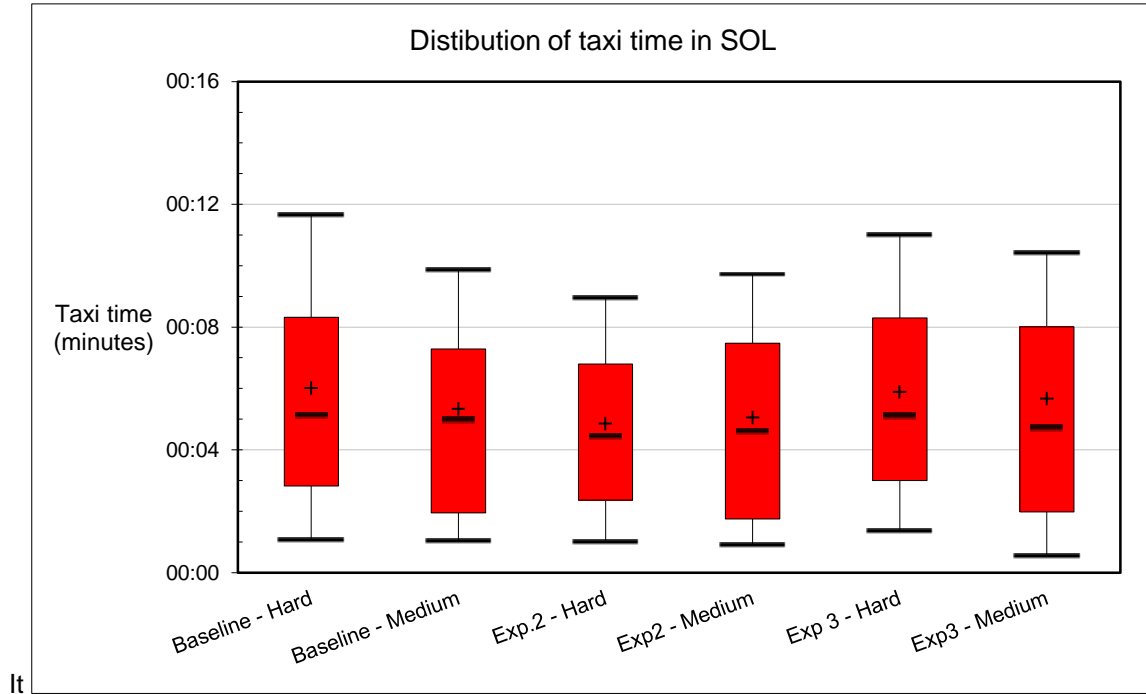


Figure 3: Taxi duration distribution in SOL

	Baseline Hard	Exp.2 Hard	Exp 3 Hard	Baseline Medium	Exp2 Medium	Exp3 Medium
Average taxi time per movement	06:01	04:52	05:36	05:20	05:08	05:39
Percentage difference with Baseline	-	-19%	-7%	-	-4%	6%

Table 2: Average taxi time in SOL – All scenarios

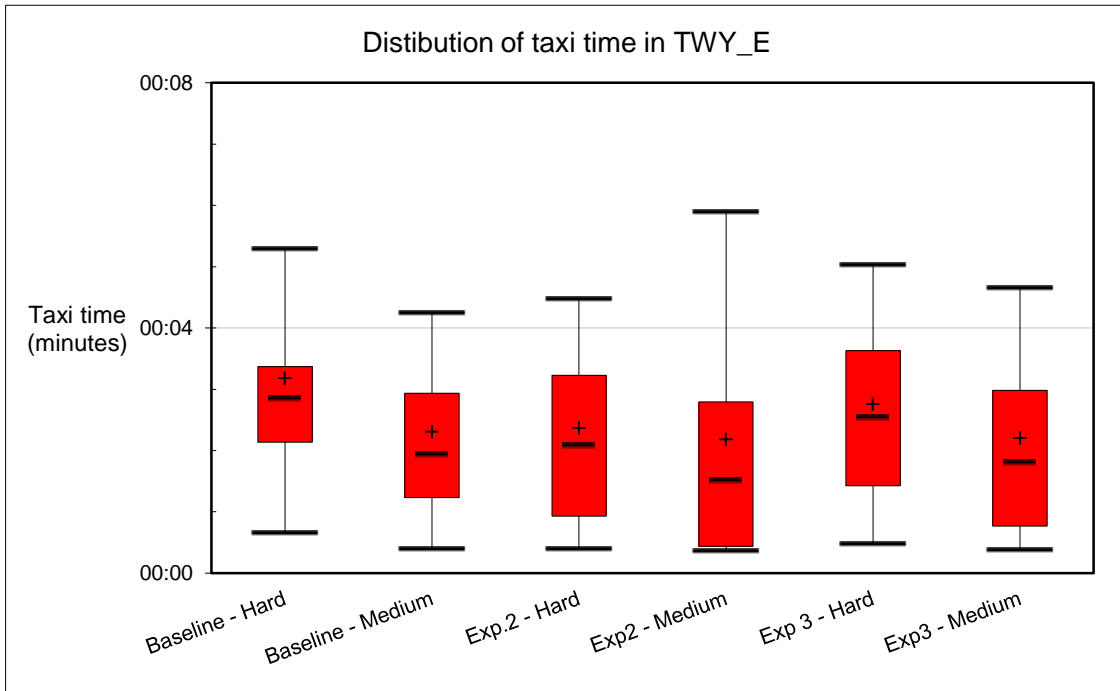


Figure 4: Taxi duration distribution in TWY_E

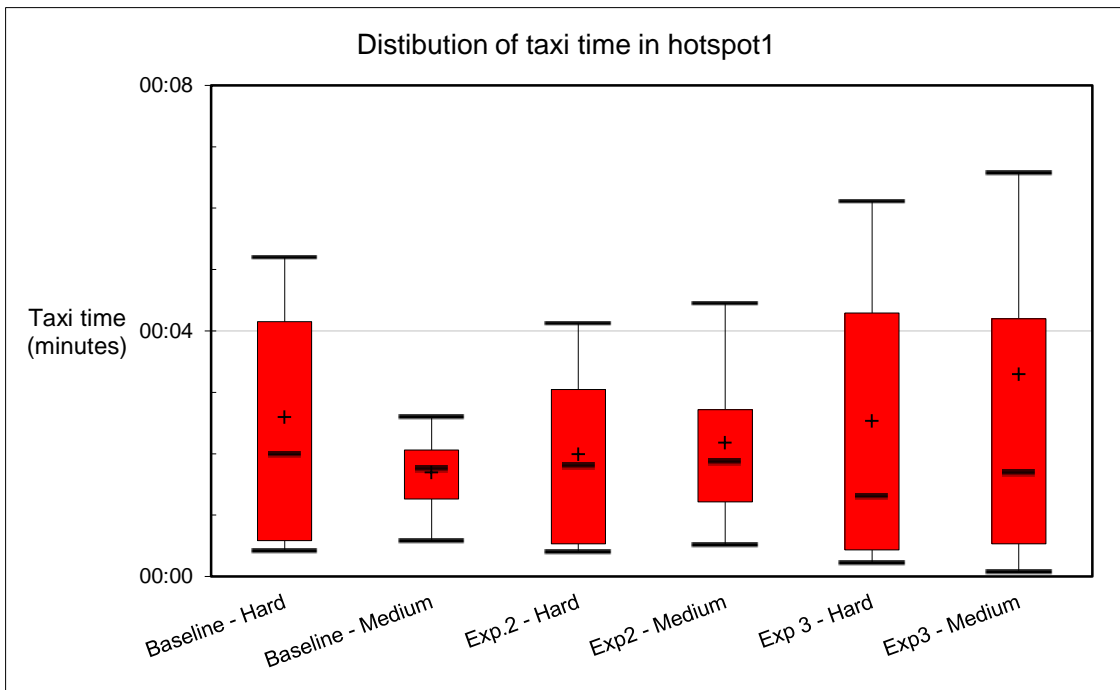


Figure 5: Taxi duration distribution in hotspot1

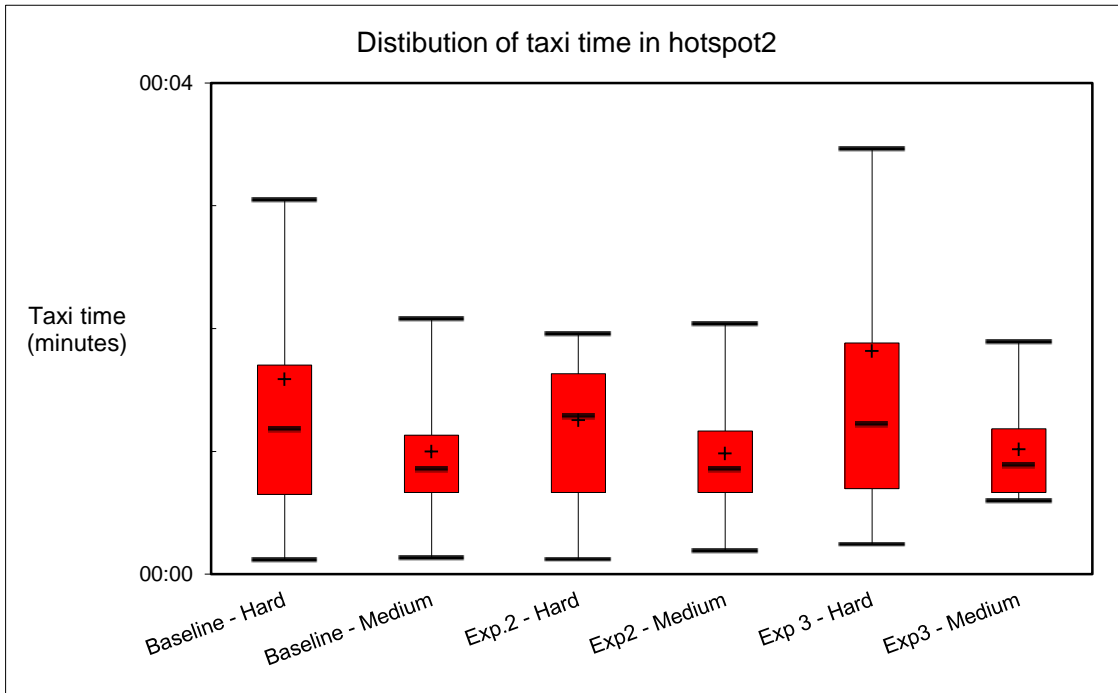


Figure 6: Taxi duration distribution in hotspot2

2.1.2 Statistics per participant

The following figures show the number of runs for each scenario.

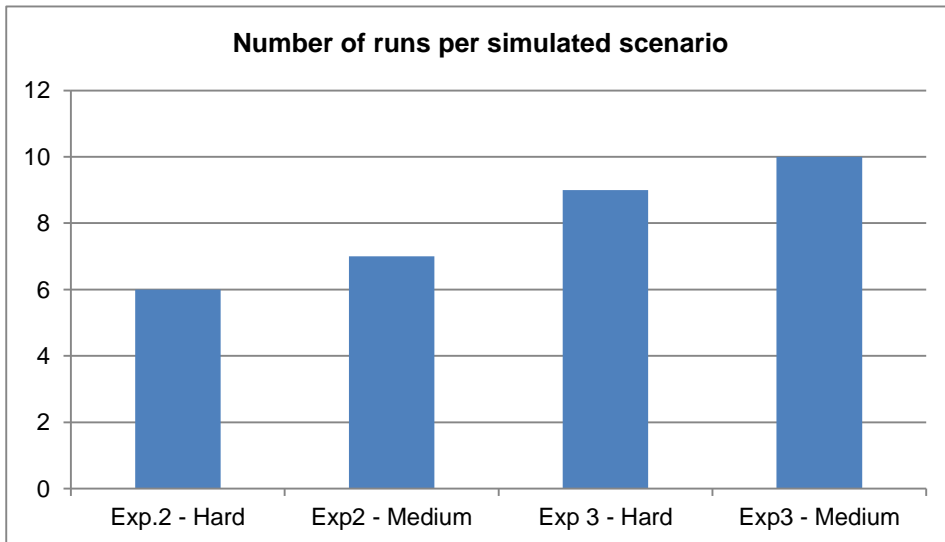


Figure 7: Number of runs for each simulated scenario

For each run, the taxi time dispersion has been calculated to look at potential differences and impact of each participant action. The participants are de-identified, as the objective is only to compare differences between participants. Information on whether the ATCO is from CDG or not is provided in the x-axis, in green. It seems this parameter has no direct effect on taxi time.

It can be observed that the taxi time dispersion varies depending on the ATCO. The average taxi time also varies significantly depending on the ATCO.

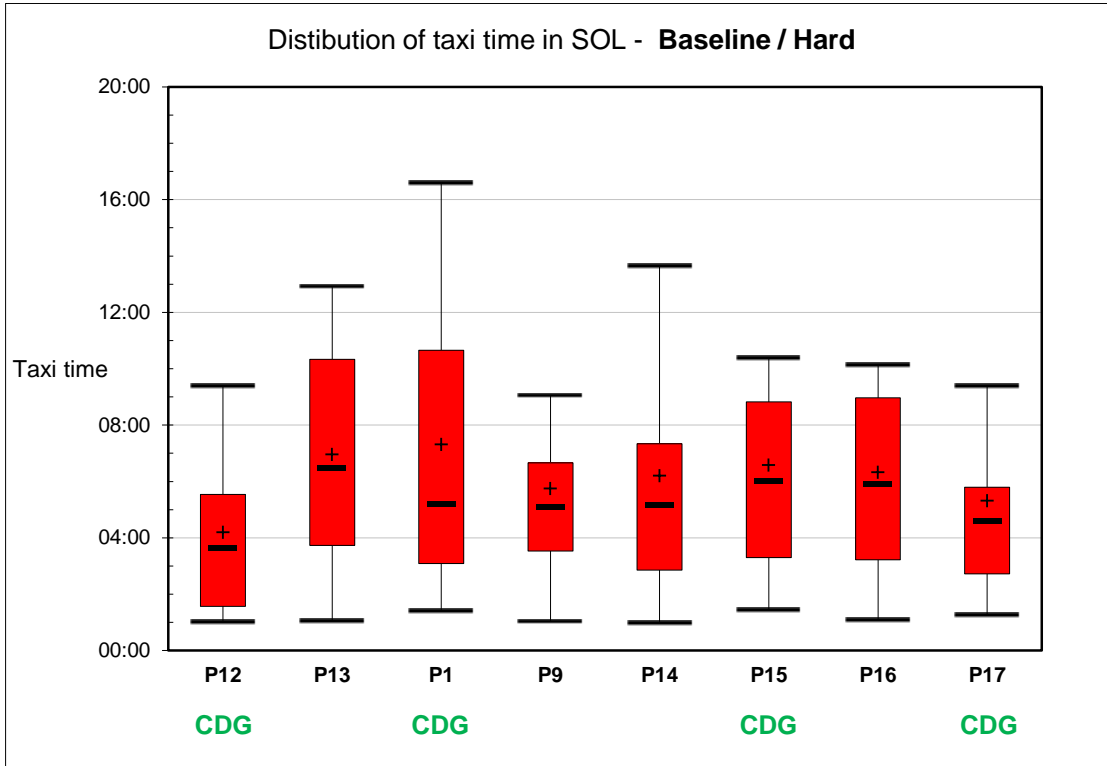


Figure 8: Distribution of taxi time in SOL per participant – Baseline hard scenario

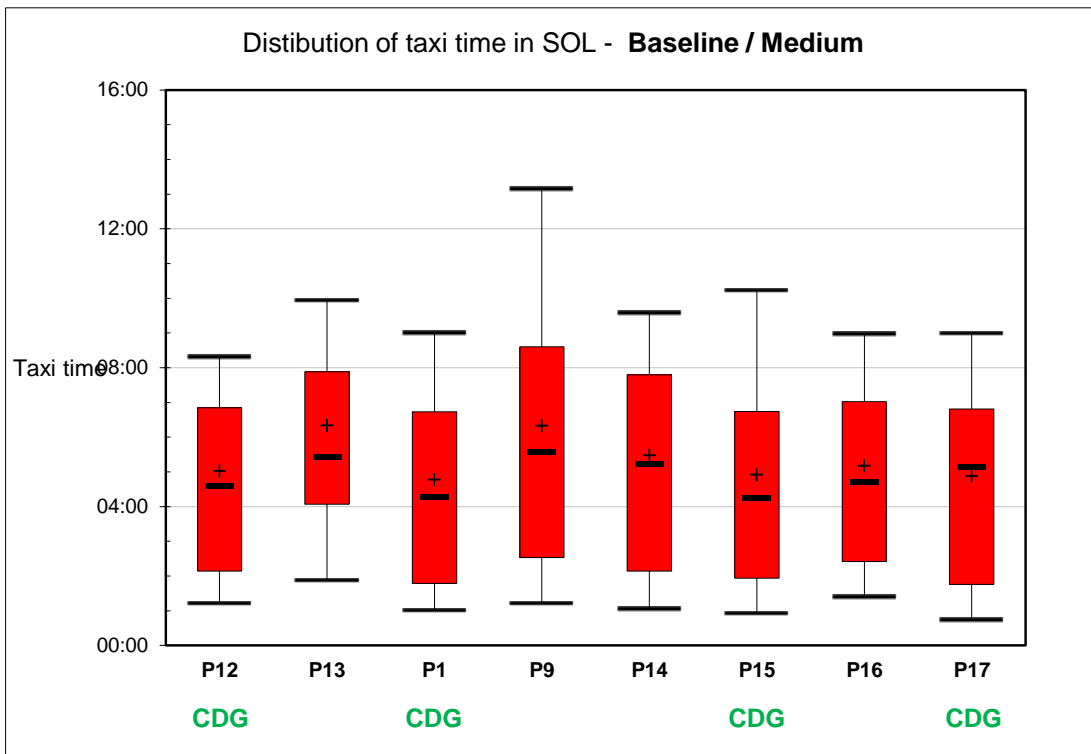


Figure 9: Distribution of taxi time in SOL per participant – Baseline Medium scenario

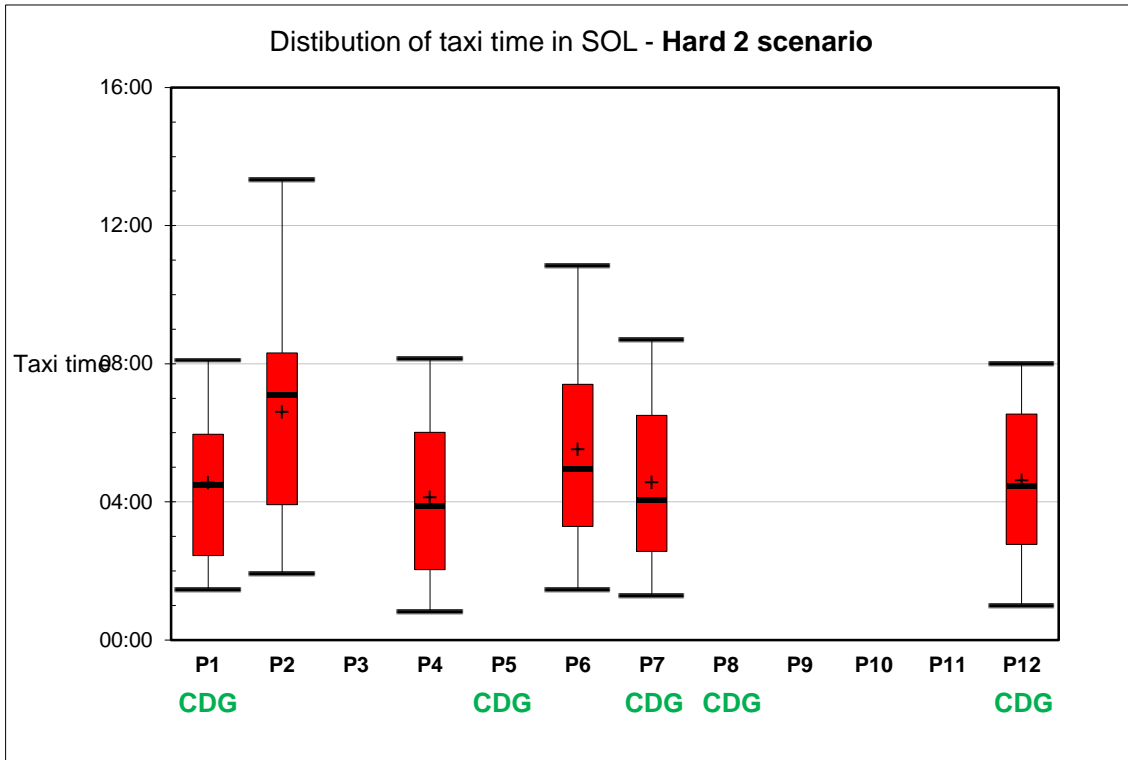


Figure 10: Distribution of taxi time in SOL per participant – Experiment 2 hard scenario

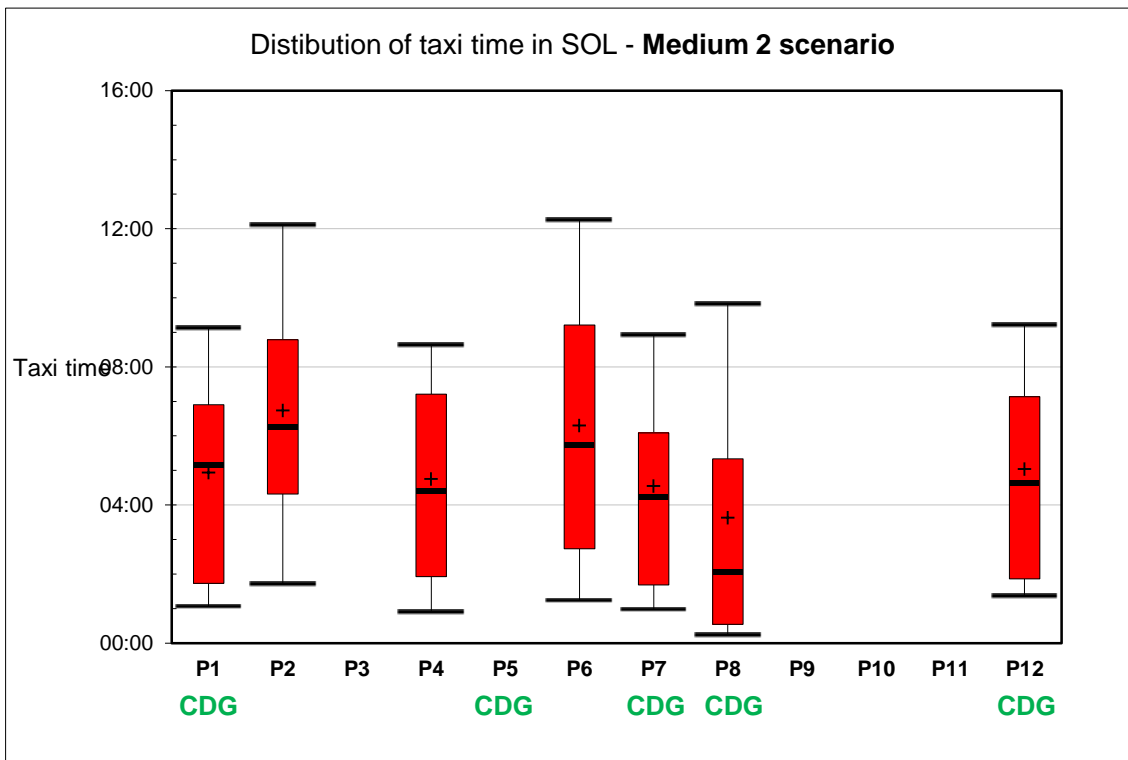


Figure 11: Distribution of taxi time in SOL per participant – Experiment 2 medium scenario

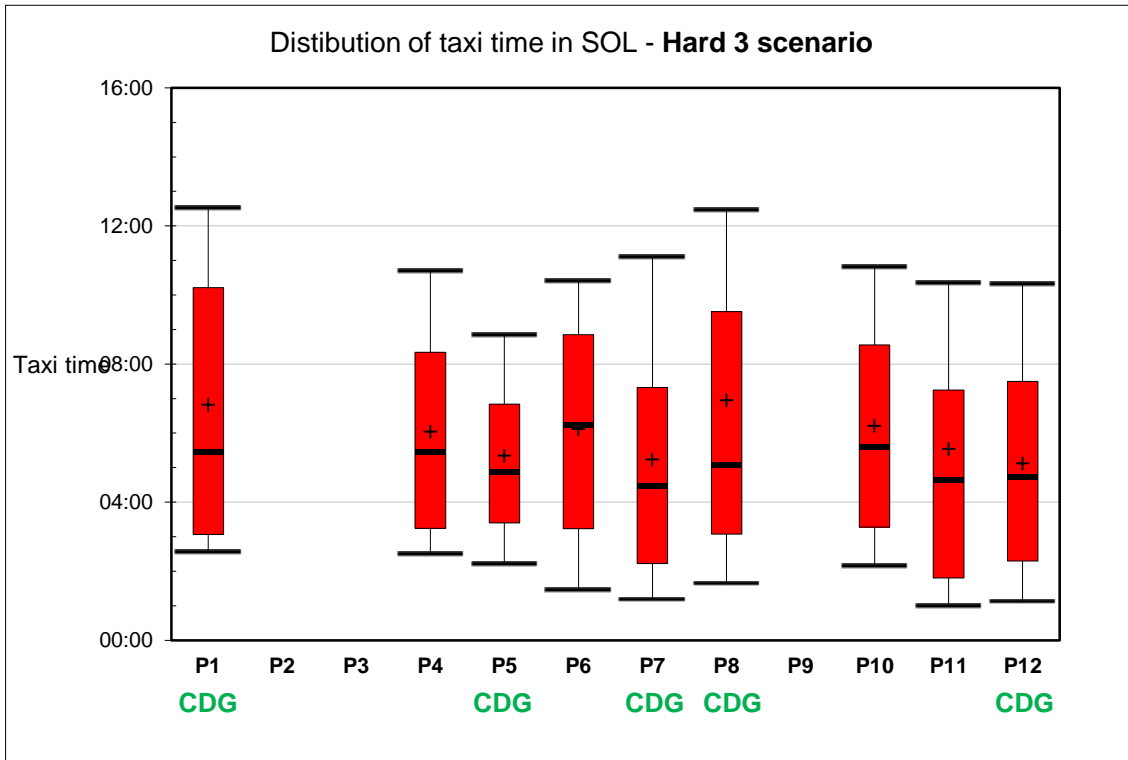


Figure 12: Distribution of taxi time in SOL per participant – Experiment 3 hard scenario

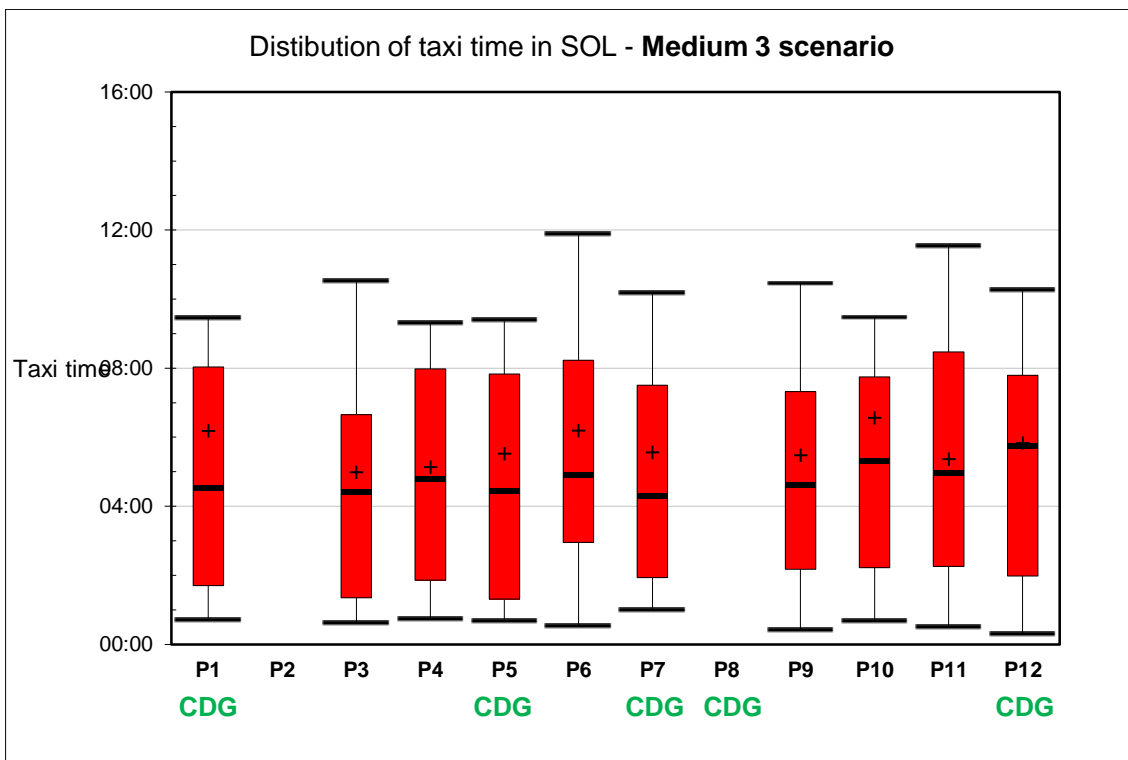


Figure 13: Distribution of taxi time in SOL per participant – Experiment 3 medium scenario

2.2 Number of aircraft

The following graph summarizes the average number of aircraft for each simulation run.

As explained earlier, the number of aircraft in the Hard scenarios is 40 to 50% higher than in the Medium scenarios.

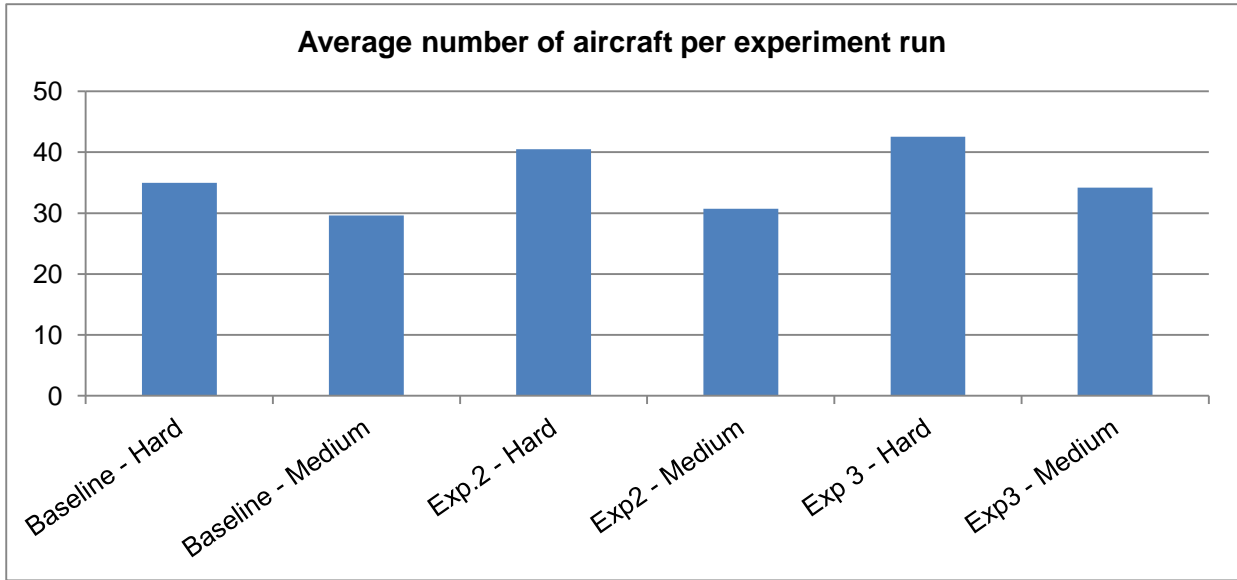


Figure 14: Number of aircraft per experiment run

The following figures show the number of aircraft in SOL and the average taxi time in SOL every minute. It can be concluded there is no evident correlation between the number of aircraft in SOL and the taxi time. It has to be noted that data after 07:35 are not relevant since the exercise is over.

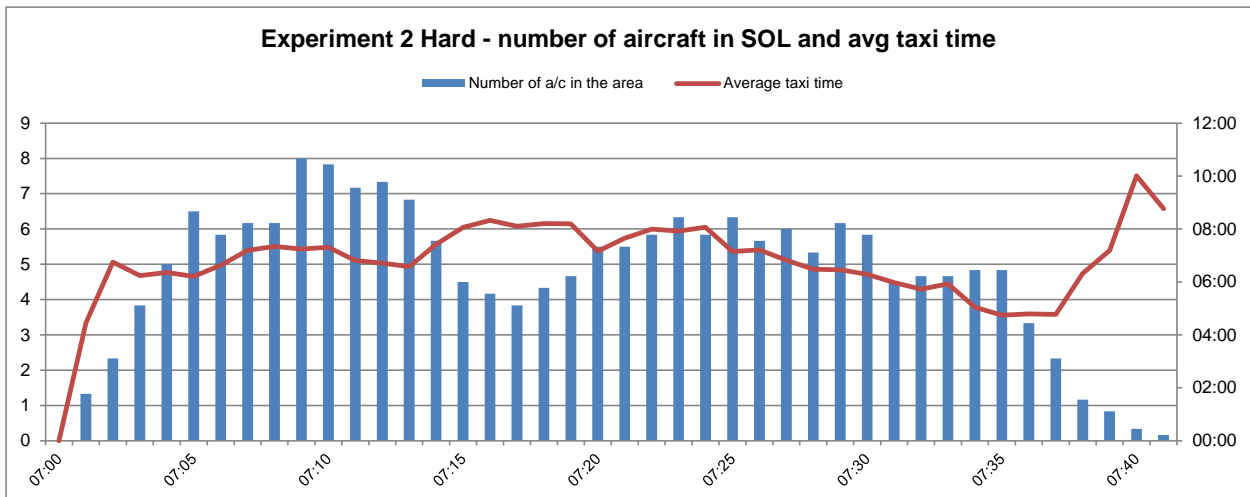


Figure 15: Number of aircraft in SOL – Experiment 2 hard

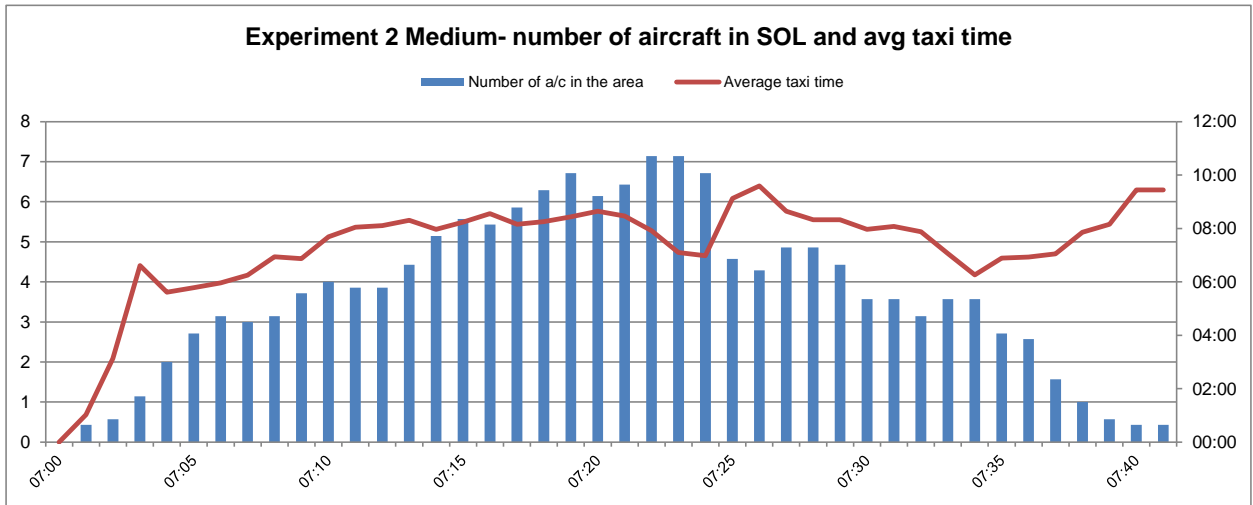


Figure 16: Number of aircraft in SOL – Experiment 2 medium

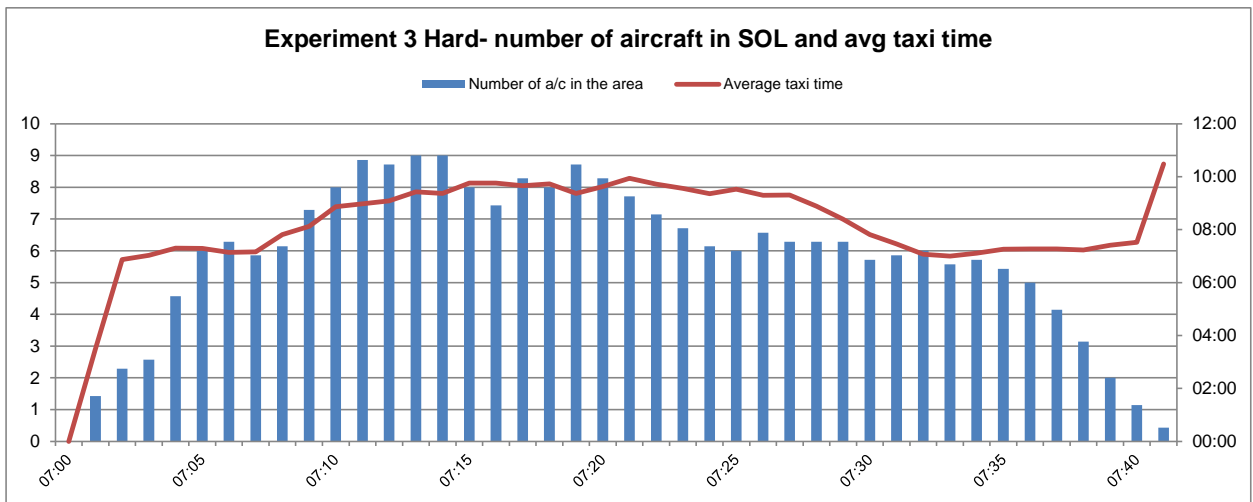


Figure 17: Number of aircraft in SOL – Experiment 3 hard

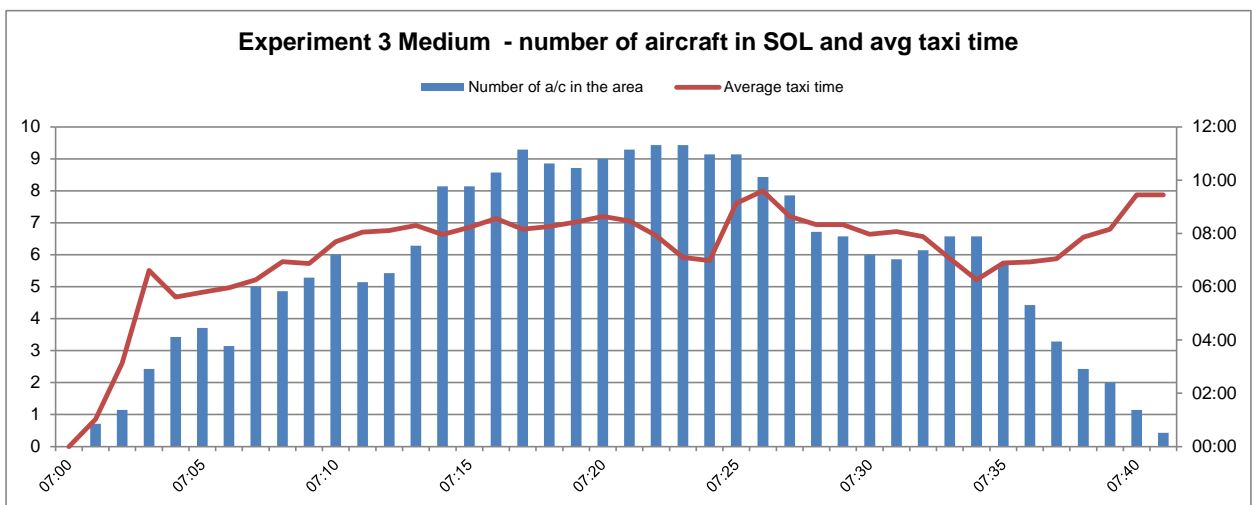


Figure 18: Number of aircraft in SOL – Experiment 3 medium

2.3 Fuel consumption

Fuel consumption was calculated for the SOL area. Assumptions used for the calculation of fuel consumption are provided in deliverable D1.2 (Aircraft Dynamics). Fuel consumption parameter is provided in kilogrammes per minute, for aircraft engines (per aircraft type), TaxiBot, and aircraft APU (Auxiliary Power unit). When the aircraft is taxiing with TaxiBot, the fuel consumption is the sum of the TaxiBot and the APU fuel consumption, as the APU needs to be switched on in order to provide energy to the aircraft. For aircraft taxiing with TaxiBot, it is assumed that engines are switched on 5 minutes before leaving SOL (for aircraft taking-off on south runway) so that aircraft are ready to taxi with engines when the TaxiBot is disconnected (engines warm-up time). The fuel consumption factor is then applied to the taxi time of each single flight, to get the overall fuel consumption of each flight in SOL. Fuel consumption results are provided in the following Figure 19 and Table 3. Details on fuel consumption of each single aircraft are provided in appendix.

The following can be noted:

- Reduction in fuel consumption in the case of Hard scenarios as compared to Baseline. There are two reasons for the gains: 1) the reduction in taxi time thanks to MoTa interface, as specified in paragraph 2.1.1, and 2) the utilization of TaxiBot (despite the overall increase in taxi time).
- Similar fuel consumption in the medium scenario as compared to Baseline. In the case of experiment 3, there is a 4% decrease whereas the taxi time increase was +6%. This is mostly thanks to the use of TaxiBot.

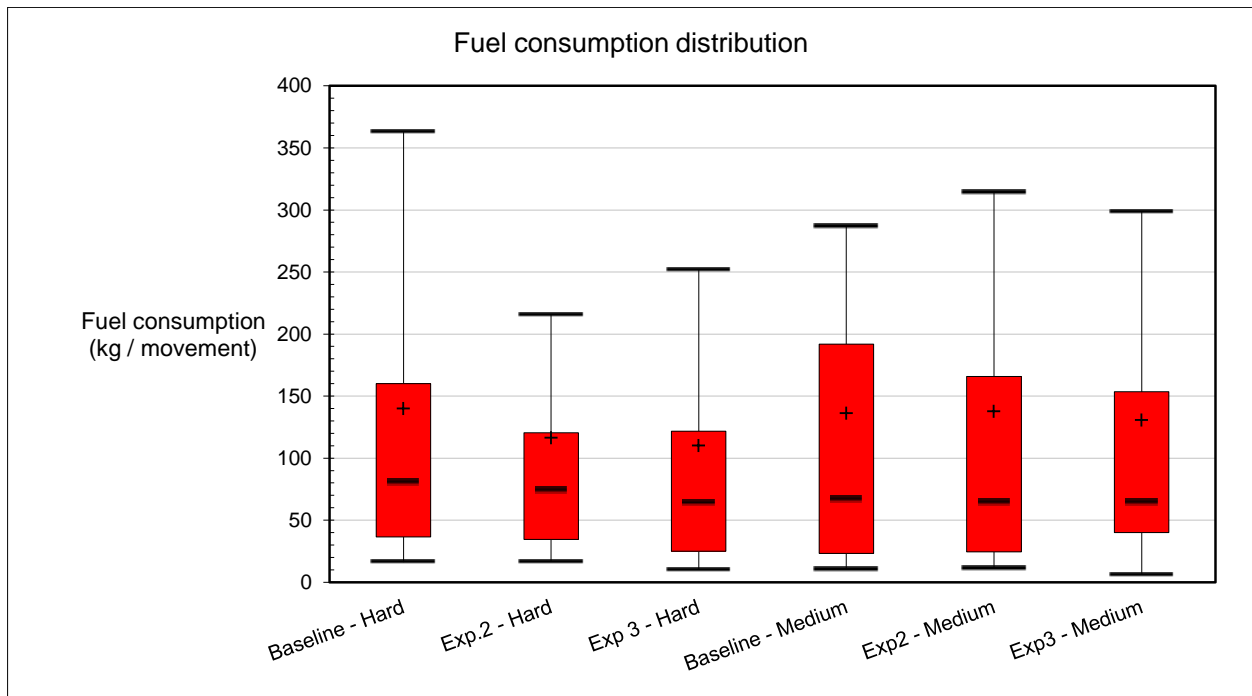


Figure 19: Average fuel consumption per movement – All scenarios

	Baseline Hard	Exp.2 Hard	Exp 3 Hard	Baseline Medium	Exp2 Medium	Exp3 Medium
Average fuel consumption per movement	140	116	110	136	138	131
Percentage difference with Baseline	-	-17%	-21%	-	1%	-4%

Table 3: Average fuel consumption in SOL – All scenarios

In addition to the above average fuel consumptions, it should be noted that the number of Stop & Gos is drastically decreased (see MoTa deliverable D3.3).

However, the fuel consumption reduction linked to the reduction of Stop and Gos was not calculated, due to lack of operational records on the fuel consumption during a Stop and go. During a stop, fuel consumption is generally the same as while taxiing (aircraft engines set at idle). Nevertheless, in order to restart the taxi forward motion, for some aircraft there will be a need to increase the engines thrust to allow breakaway and forward movement, as releasing the brake pedals would not be sufficient. This is mostly the case for heavy aircraft, and depends on the taxiway configuration (taxiway pavement type and associated friction, taxiway slope).

2.4 CO2 emissions

CO₂ emissions are directly calculated from fuel consumption reductions. As an order of magnitude, it is considered that every kg of fuel burnt corresponds to an emission of 3.15 kg of CO₂.

Hence the following CO₂ emissions reductions were calculated, for all scenarios. For medium scenario, the emissions are close to the baseline.

	Baseline Hard	Exp.2 Hard	Exp 3 Hard	Baseline Medium	Exp2 Medium	Exp3 Medium
Average CO2 emissions per movement	440	367	347	429	434	412
Percentage difference with Baseline	-	-17%	-21%	-	1%	-4%

Table 4: Average CO₂ emissions in SOL – All scenarios

2.5 Noise

Although at first sight it seems that aircraft using TaxiBot would allow a reduction of the noise (in particular ramp noise), there was no tangible studies conducted to quantify potential gains.

On one hand, the aircraft using TaxiBot would taxi without engines; on the other hand, there would be some noise generated by the APU and the TaxiBot itself.

Hence there was no noise assessment study performed in the frame of MoTa.

3 Conclusion

The MoTa project investigated a total of 4 35-minute scenarios, each featuring different traffic levels and operational events. Experiments were performed with 18 air traffic ground controllers from around Europe while using different types of taxiing technology aids.

Current results indicate that the taxi times and fuel consumption are slightly reduced with the implementation of the MoTa interface and the TaxiBot-like tugs, especially with dense traffic scenarios (and higher ATCO workload).

It shall be noted that the present analysis was conducted based on a simulation of one part of CDG. It would be advised to conduct additional studies on a whole airport to confirm this trend.

In addition, it was noted that the aircraft taxi paths were not affected due to the use of the HMI. This comes as no surprise, given that the prototype was, by design, intended to support the transition from current to future taxiing methods. The purpose of the project was not to promote new standards of taxiing trajectories. This aspect is better detailed in project MoTa deliverable D4.2 on algorithms.

As a general result, this confirms the achievement of the project objective, which was to “accompany” the introduction of new techniques in airport taxiing and constitute a gradual, non-disruptive introduction of automation in ground control.

1 Appendices

1.1 Appendix 1: Acronyms and abbreviations

A/c	Aircraft
ATC	Air Traffic Control
ATCO	Air Traffic Control Officer
CDG	Paris Charles-de-Gaulle Airport
ENAC	Ecole Nationale de l'Aviation Civile
HMI	Human Machine Interface
ISAE	Institut Supérieur de l'Aéronautique et de l'Espace
MoTa	Modern Taxiing project

1.2 Appendix 2: list of aircraft for each experiment

1.2.1 List of Aircraft and Characteristics for each scenario in Experiment 2

Medium 2								
Call SOL	CallSign	Type	AircraftType	Rwy	Parking	datalink	Dep	Arr
00:00:00	FIN8DF	Depart	A320	27L	D18	true	LFPG	EFHK
00:02:20	AFR114	Arrive	A380	27R	L71	false	LKPR	LFPG
00:03:20	BAW405	Arrive	A319	26L	A04	true	EGLL	LFPG
00:03:40	DAL81	Arrive	B767	26L	E26	true	KATL	LFPG
00:03:45	EZY965B	Depart	A320	26R	B12	true	LFPG	EDDM
00:04:20	AFR466K	Depart	E170	26R	J16	false	LFPG	LJLJ
00:06:00	KLM87Z	Depart	B737	27L	F16	false	LFPG	EHAM
00:06:00	SWR65R	Arrive	A320	26L	A08	true	LSGG	LFPG
00:08:10	AF725DC	Arrive	A318	26L	F10	false	LFMT	LFPG
00:09:40	AFR552	Arrive	B772	27R	K01	false	KJFK	LFPG
00:10:10	JAT921	Arrive	B737	26L	B14	true	LYBE	LFPG
00:11:40	AF041CT	Arrive	A320	26L	F80	false	LFLL	LFPG
00:11:55	FIN895V	Depart	A321	26R	D20	false	LFPG	EFHK
00:12:10	CKZ	Towed	B743	27L	J10	false	LFPG	LFPG
00:13:10	AFR7824	Arrive	B747	26L	M11	true	RKSI	LFPG
00:13:50	BEE905P	Depart	E170	27L	G30	true	LFPG	EGJJ
00:15:00	AFL654	Arrive	A320	27R	C06	true	UUEE	LFPG
00:15:00	AFR831KG	Depart	A320	26R	F02	false	LFPG	LFST
00:16:30	AF721TJ	Depart	A319	26R	F80	false	LFPG	LFLL
00:17:00	AFR132	Arrive	B772	27R	E14	true	HECA	LFPG
00:18:00	DAH1008	Depart	A330	26R	B18	true	LFPG	DAAG
00:20:40	AFR4548	Arrive	B773	26L	K03	false	OMDB	LFPG
00:21:00	AFR2425	Depart	A319	27L	F26	true	LFPG	EDDH
00:22:20	FIN898R	Arrive	A321	27R	D19	false	EFHK	LFPG
00:24:00	AF986UM	Depart	E170	26R	J37	false	LFPG	LFRS
00:24:20	AFR956	Arrive	B773	27R	K19	true	FIMP	LFPG
00:26:00	KLM65Z	Depart	B737	27L	F04	true	LFPG	EHAM
00:29:00	EZY616M	Depart	A319	26R	B03	true	LFPG	DTTA
00:29:40	AFR890	Arrive	B773	26L	K21	true	RKSI	LFPG
00:30:10	EZY727R	Arrive	A319	26L	D12	true	EDDM	LFPG

Hard 2								
call SOL	CallSign	Type	ACType	Rwy	Parking	datalink	Dep	Arr
00:00:00	AF903JZ	Arrive	A318	26L	F30	true	DABB	LFPG
00:00:30	BAW305	Arrive	A319	26L	A12	false	EGGW	LFPG
00:00:45	SWR211	Depart	A320	26R	W07	false	LFPG	LFLC
00:01:00	TAY041E	Arrive	B757	26L	M15	true	OMAA	LFPG
00:02:50	AFE	Depart	B743	27L	M10	false	LCLK	LFPG
00:03:00	AFR6456J	Depart	A320	26R	F02	false	LFPG	LSZH
00:03:10	DAL667	Depart	B767	27L	E34	true	LFPG	KPHL
00:03:30	AFR555X	Depart	A320	26R	B03	true	LFPG	LPPR
00:03:45	AFR7585	Depart	A343	27L	K05	true	LFPG	KEWR
00:04:00	AFR877Z	Depart	B747	26R	K13	false	LFPG	HECA
00:04:30	AAL930	Arrive	B757	26L	C03	false	KLAX	LFPG
00:05:00								QFU configuration warning
00:05:45	XLF017	Depart	A330	26R	A02	true	LFPG	LWSK
00:05:55	AFR213	Depart	B772	26R	E14	true	LFPG	KJFK
00:06:00	AFR1619	Arrive	E170	26L	J33	true	EGBB	LFPG
00:06:20	AF413TR	Depart	A321	26R	J18	false	LFPG	DTTA
00:06:30	AFR4512	Depart	B747	27L	M08	true	LFPG	ZBAA
00:07:30	AFR961W	Arrive	E190	26L	J10	true	LIPE	LFPG
00:08:25	KAC244	Depart	A318	26R	U08	true	LFPG	LIRQ
00:08:40	FIN845B	Depart	B773	26R	D19	true	LFPG	DIAP
00:09:00	AFR948	Arrive	B772	26L	K21	false	RKSI	LFPG
00:09:00	AFR867J	Arrive	A380	27R	L61	false	MMMX	LFPG
00:10:30	AFR412K	Arrive	A321	26L	E10	true	LFML	LFPG
00:11:50	AF811KL	Depart	A319	26R	F80	true	LFPG	OERK
00:11:55	BEE265W	Depart	E170	27L	G24	false	LFPG	LFRN
00:12:00	AF436KF	Arrive	A319	26L	F04	false	DAOO	LFPG
00:12:40	UAE45	Depart	B773	26R	C02	false	LFPG	DBBB
00:13:30	MNB656	Arrive	A342	26L	M07	false	KATL	LFPG
00:13:45	AFR657	Arrive	A320	27R	K53	true	OEJN	LFPG
00:14:30	AFR401G	Depart	E190	27L	J02	true	LFPG	LKPR
00:15:00								QFU configuration change
00:16:45	AFR9801	Arrive	A319	27R	F34	false	LICJ	LFPG
00:17:05	THY4UM	Depart	A330	08L	Z03	true	LFPG	LFLL
00:19:00	AFR370	Depart	B772	08L	E20	false	LFPG	EDDH
00:19:40	AFR1319F	Depart	CRJ7	08L	J35	false	LFPG	LJLJ
00:19:45	AFR988	Arrive	A320	09L	F96	true	ESSA	LFPG
00:20:45	ACA2106	Depart	A320	26R	U05	false	LFPG	LSGG
00:22:45	EZY042P	Arrive	A319	09L	B05	true	EDDM	LFPG
00:23:10	AFR3083	Depart	B747	08L	M10	true	LFPG	ZBAA
00:23:30	CSN850	Depart	A330	09R	L73	true	LFPG	DAAG
00:23:30	AFR612	Depart	A330	09R	J01	true	LFPG	KEWR
00:23:50	AFR163	Depart	B772	08L	F03	false	LFPG	DTTA
00:24:50	EZY783F	Arrive	A319	08R	B06	false	LYBE	LFPG
00:25:15	EZY942Q	Depart	B737	08L	B12	true	LFPG	EHAM
00:26:00	LBT457	Depart	A320	08L	Q12	false	LFPG	EFHK
00:26:10	AFR1659	Depart	E190	09R	J10	false	LFPG	OERK
00:26:20	AFR158R	Arrive	CRJ7	08R	J35	false	DABB	LFPG
00:27:50	BAW301	Arrive	A321	08R	A10	true	EGLL	LFPG
00:28:45	AF902QW	Depart	A320	08L	J40	true	LFPG	LKPR
00:29:20	AFR382F	Arrive	A320	08R	F16	true	LICJ	LFPG
00:31:35	BEE451L	Arrive	A321	09L	G14	false	RKSI	LFPG
00:32:30	AFR904V	Depart	A320	09R	F32	true	LFPG	LFRS
00:32:45	AAL52	Depart	B767	09R	A10	false	LFPG	LFRS

1.2.2 List of Aircraft and Characteristics for each scenario in Experiment 3

Medium 3									
Call SOL	CallSign	Type	AircraftType	Rwy	Parking	datalink	Tug	Dep	Arr
00:00:00	FIN4QS	Depart	A320	27L	D18	true	tb3	LFPG	EFHK
00:02:20	AFR117	AFZONE	A380	27R	L71	true		LKPR	LFPG
00:03:20	BAW302	Arrive	A319	26L	A04	true		EGLL	LFPG
00:03:40	DAL33	Arrive	B767	26L	E26	true		KATL	LFPG
00:03:45	EZY415R	Depart	A320	26R	B12	true	tb5	LFPG	EDDM
00:04:20	AFR144P	Depart	E170	26R	J16	false	tb7	LFPG	LJLJ
00:06:00	KLM24P	Depart	B737	27L	F16	false		LFPG	EHAM
00:06:00	SWR54K	Arrive	A320	26L	A08	true		LSGG	LFPG
00:08:10	AF489GC	Arrive	A318	26L	F10	false		LFMT	LFPG
00:09:40	AFR993	Arrive	B772	27R	K01	true		KJFK	LFPG
00:10:10	JAT447	Arrive	B737	26L	B14	true		LYBE	LFPG
00:11:40	AF814RY	Arrive	A320	26L	F80	false		LFLL	LFPG
00:11:55	FIN418M	Depart	A321	26R	D20	false		LFPG	EFHK
00:12:10	MCP	Towed	B743	27L	J10	false		LFPG	LFPG
00:13:10	AFR5684	Arrive	B747	26L	M11	true		RKSI	LFPG
00:13:50	BEE236L	Depart	E170	27L	G30	true	tb6	LFPG	EGJJ
00:15:00	AFL430	Arrive	A320	27R	C06	true		UUEE	LFPG
00:15:00	AFR207VC	Depart	A320	26R	F02	true		LFPG	LFST
00:16:30	AF300M	Depart	A319	26R	F80	true	tb1	LFPG	LFLL
00:17:00	AFR653	Arrive	B772	27R	E14	true		HECA	LFPG
00:18:00	DAH2007	Depart	A330	26R	B18	true	tb4	LFPG	DAAG
00:20:40	AFR5956	Arrive	B773	26L	K03	true		OMDB	LFPG
00:21:00	AFR1514	Depart	A319	27L	F26	true	tb2	LFPG	EDDH
00:22:20	FIN547H	Arrive	A321	27R	D19	true		EFHK	LFPG
00:24:00	AF945JN	Depart	E170	26R	J37	false	tb5	LFPG	LFRS
00:24:20	AFR164	Arrive	B773	27R	K19	true		FIMP	LFPG
00:26:00	KLM54M	Depart	B737	27L	F04	true	tb3	LFPG	EHAM
00:29:00	EZY707P	Depart	A319	26R	B03	true	tb7	LFPG	DTTA
00:29:40	AFR531	Arrive	B773	26L	K21	true		RKSI	LFPG
00:30:10	EZY212T	Arrive	A319	26L	D12	true		EDDM	LFPG

WP-E – MoTa – Benefits and performance evaluation

Hard 3									
call SOL	Type	CallSign	ACType	Rwy	Parking	datalink	Tug	Dep	Arr
00:00:00	Arrive	AF626BV	A318	26L	F30	true		DABB	LFPG
00:00:30	Arrive	BAW304	A319	26L	A12	false		EGGW	LFPG
00:00:45	Depart	SWR855	A320	26R	W07	true	tb6	LFPG	LFLC
00:01:00	Arrive	TAY401Z	B757	26L	M15	true		OMAA	LFPG
00:02:50	Depart	LRF	B743	27L	M10	false		LCLK	LFPG
00:03:00	Depart	AFR595Y	A320	26R	F02	true	tb3	LFPG	LSZH
00:03:10	Depart	DAL551	B767	27L	E34	false	tb2	LFPG	KPHL
00:03:30	Depart	AFR400P	A320	26R	B03	true	tb10	LFPG	LPPR
00:03:45	Depart	AFR7541	A343	27L	K05	true	tb7	LFPG	KEWR
00:04:00	Depart	AFR833X	B747	26R	K13	true		LFPG	HECA
00:04:30	Arrive	AAL310	B757	26L	C03	false		KLAX	LFPG
00:05:00	QFU change warning								
00:05:45	Depart	XLF188	A330	26R	A02	true	tb5	LFPG	LWSK
00:05:55	Depart	AFR119	B772	26R	E14	true		LFPG	KJFK
00:06:00	Arrive	AFR1819	E170	26L	J33	true		EGBB	LFPG
00:06:20	Depart	AF841BW	A321	26R	J18	false	tb1	LFPG	DTTA
00:06:30	Depart	AFR9741	B747	27L	M08	true	tb4	LFPG	ZBAA
00:07:30	Arrive	AFR645U	E190	26L	J10	true		LIPE	LFPG
00:08:25	Depart	KAC244	A318	26R	U08	true	tb8	LFPG	LIRQ
00:08:40	Depart	FIN122D	B773	26R	D19	true		LFPG	DIAP
00:09:00	Arrive	AFR413	B772	26L	K21	true		RKSI	LFPG
00:09:00	Arrive	AFR312A	A380	27R	L61	true		MMMX	LFPG
00:10:30	Arrive	AFR825T	A321	26L	E10	true		LFML	LFPG
00:11:50	Depart	AF955DT	A319	26R	F80	true		LFPG	OERK
00:11:55	Depart	BEE951L	E170	27L	G24	false	tb10	LFPG	LFRN
00:12:00	Arrive	AF375FG	A319	26L	F04	false		DAOO	LFPG
00:12:40	Depart	UAE63	B773	26R	C02	true	tb9	LFPG	DBBB
00:13:30	Arrive	MNB396	A342	26L	M07	false		KATL	LFPG
00:13:45	Arrive	AFR623	A320	27R	K53	true		OEJN	LFPG
00:14:30	Depart	AFR170J	E190	27L	J04	true		LFPG	LKPR
00:15:00	QFU orientation change								
00:16:45	Arrive	AFR6109	A319	27R	F34	true		LICJ	LFPG
00:17:05	Depart	THY4WQ	A330	08L	Z03	true	tb2	LFPG	LFLL
00:19:00	Depart	AFR668	B772	08L	E20	true	tb1	LFPG	EDDH
00:19:40	Depart	AFR2527X	CRJ7	08L	J35	true		LFPG	LJLJ
00:19:45	Arrive	AFR604	A320	09L	F96	true		ESSA	LFPG
00:20:45	Depart	ACA1609	A320	26R	U05	true	tb6	LFPG	LSGG
00:22:45	Arrive	EZY833H	A319	09L	B05	true		EDDM	LFPG
00:23:10	Depart	AFR1208	B747	08L	M10	true		LFPG	ZBAA
00:23:30	Depart	CSN654	A330	09R	L73	true	tb5	LFPG	DAAG
00:23:30	Depart	AFR201	A332	09R	J01	true		LFPG	KEWR
00:23:50	Depart	AFR156	B772	08L	F03	true	tb4	LFPG	DTTA
00:24:50	Arrive	EZY943K	A319	08R	B06	false		LYBE	LFPG
00:25:15	Depart	EZY537P	B737	08L	B12	true	tb3	LFPG	EHAM
00:26:00	Depart	LBT804	A320	08L	Q12	false	tb7	LFPG	EFHK
00:26:10	Depart	AFR2218	E190	09R	J10	false		LFPG	OERK
00:26:20	Arrive	AFR7103N	CRJ7	08R	J35	true		DABB	LFPG
00:27:50	Arrive	BAW594	A321	08R	A10	true		EGLL	LFPG
00:28:45	Depart	AF614D	A320	08L	J40	true		LFPG	LKPR
00:29:20	Arrive	AFR255Y	A320	08R	F16	true		LICJ	LFPG
00:31:35	Arrive	BEE403W	A321	09L	G14	true		RKSI	LFPG
00:32:30	Depart	AFR311W	A320	09R	F32	true		LFPG	LFRS
00:32:45	Depart	AAL27	B767	09R	A10	true	tb8	LFPG	LFRS

1.2.3 Details on fuel consumption (in kg)

BASELINE - HARD

Flight number	Fuel consumption (average all runs)
AAL120	20.1
AAL41	69.0
ACA1901	78.5
AF737EW	65.1
AF746RY	80.8
AF788UM	108.3
AF795JZ	61.0
AFR012	221.3
AFR1211	49.9
AFR128U	52.6
AFR1316Z	60.7
AFR1407	66.8
AFR1886	21.2
AFR231R	23.0
AFR275	62.3
AFR300W	122.3
AFR3510	83.9
AFR378	85.2
AFR406	429.3
AFR418	147.5
AFR442Z	412.6
AFR587	37.5
AFR649Z	532.3
AFR6732	595.0
AFR673U	29.6
AFR719	327.1
AFR818P	136.9
AFR879W	62.2
AFR933M	49.7
AFR980X	23.5
BAW306	49.6
BAW308	4.1
BEE475U	40.3
BEE493K	11.1
BEE743F	12.1
CSN348	242.2
DAL229	188.5
EZY465W	23.8
EZY596K	40.5
EZY965V	48.9
FIN866L	242.0
KAC166	172.4
MNB351	123.9
SDH	490.2
SWR633	93.0
TAY127L	80.8
THY9JQ	287.5
UAE72	138.3
XLF034	216.1

BASELINE – MEDIUM

Flight number	Fuel consumption (average all runs)
AF645PQ	46.8
AF651PQ	75.8
AF689VC	73.0
AF758KG	16.6
AF788UM	87.7
AFL261	50.7
AFR007	492.2
AFR009	253.1
AFR139	183.9
AFR1710	18.5
AFR267	220.0
AFR3831	189.5
AFR599F	13.3
AFR6729	267.4
AFR676SD	141.8
AFR981	282.9
BAW307	4.8
BEE493K	12.8
DAH1003	242.9
DAL27	52.2
EZY238X	87.9
EZY343T	48.1
EZY808H	77.7
FIN874P	108.8
FIN879Q	38.7
FIN8TR	16.5
HTR	917.7
JAT240	63.3
KLM12P	23.4
KLM38P	16.6
SWR67X	27.0

EXPÉ 2 – HARD

Flight number	Fuel consumption (average all runs)
AAL52	28.3
AAL930	15.6
ACA2106	46.7
AF413TR	44.9
AF436KF	92.3
AF811KL	98.2
AF902QW	43.5
AF903JZ	57.9
AFE	495.6
AFR1319F	74.1
AFR158R	58.8
AFR1619	51.2
AFR163	217.8
AFR1659	25.6
AFR213	128.1
AFR370	113.5
AFR382F	117.7
AFR401G	33.0
AFR412K	41.4
AFR4512	518.7
AFR555X	100.3
AFR612	112.7
AFR6456J	89.2
AFR657	65.2
AFR7585	48.6
AFR867J	580.1
AFR877Z	383.3
AFR904V	38.9
AFR948	170.5
AFR961W	49.2
AFR9801	33.8
AFR988	23.9
BAW301	52.7
BAW305	4.0
BEE265W	14.2
BEE451L	24.5
CSN850	126.6
DAL667	171.4
EZY042P	30.0
EZY783F	76.9
EZY942Q	31.1
FIN845B	120.0
KAC244	31.0
MNB656	144.3
SWR211	103.4
TAY041E	76.1
UAE45	45.0
XLF017	161.3

EXPÉ 2 – BASELINE

Flight number	Fuel consumption (average all runs)
	xp2
AF041CT	77.2
AF721TJ	65.9
AF725DC	62.8
AF941Z	48.8
AF986UM	18.6
AFL654	50.0
AFR114	534.1
AFR132	198.2
AFR2425	11.4
AFR4548	182.2
AFR466K	18.3
AFR552	261.5
AFR7824	307.9
AFR831KG	128.0
AFR890	195.5
AFR956	322.0
BAW405	6.4
BEE905P	14.8
CKZ	851.1
DAH1008	272.3
DAL81	56.7
EZY616M	79.0
EZY727R	53.4
EZY965B	101.7
FIN895V	109.4
FIN898R	50.3
FIN8DF	14.5
JAT921	62.0
KLM65Z	11.0
KLM87Z	14.5
SWR65R	27.1

EXPÉ 3 - HARD

Flight number	Fuel consumption (average all runs)
AAL27	10.8
AAL310	28.2
AF300M	75.4
AF375FG	86.9
AF489GC	73.2
AF614D	51.6
AF626BV	59.8
AF814RY	66.5
AF841BW	78.6
AF844UM	56.9
AF945JN	41.8
AF955DT	83.8
AFL430	40.5
AFR117	538.7
AFR119	116.2
AFR1208	351.1
AFR144P	40.0
AFR1514	1.8
AFR156	266.1
AFR164	339.4
AFR170J	25.3
AFR1819	52.5
AFR201	122.8
AFR207VC	77.2
AFR2218	23.9
AFR2527X	78.3
AFR255Y	59.4
AFR311W	60.5
AFR312A	629.1
AFR400P	70.8
AFR413	217.3
AFR531	250.2
AFR5684	370.2
AFR5956	151.4
AFR595Y	65.8
AFR604	24.1
AFR6109	42.8
AFR623	80.4
AFR645U	54.9
AFR653	176.2
AFR668	151.5
AFR7103N	31.9
AFR7541	2.7
AFR825T	37.7
AFR833X	369.9
AFR9741	36.0
AFR993	251.0
BAW302	10.1
BAW304	4.4
BAW594	69.8
BEE236L	7.9
BEE951L	6.9
CSN654	22.3
DAH2007	160.4
DAL33	64.6
DAL551	10.4
EZY212T	54.4
EZY415R	60.5
EZY537P	57.5
EZY707P	58.5
EZY833H	52.4
EZY943K	15.8
FIN122D	118.1
FIN418M	109.7
FIN4QS	2.8
FIN547H	55.7
JAT447	79.0
KAC244	74.0
KLM24P	3.9
KLM54M	19.0
LRF	517.3
MCP	825.6
MNB396	127.5
SWR54K	21.8
SWR855	74.7
TAY401Z	100.3
UAE63	199.1
XLF188	154.1

EXPÉ 3 – BASELINE

Flight number	Fuel consumption (average all runs)
AAL310	132.7
AF300M	68.0
AF489GC	63.1
AF626BV	58.7
AF814RY	84.9
AF844UM	47.5
AF945JN	40.0
AF955DT	29.2
AFL430	47.3
AFR117	463.0
AFR144P	40.2
AFR1514	3.8
AFR164	284.6
AFR1819	44.5
AFR207VC	117.6
AFR312A	134.0
AFR400P	76.3
AFR531	206.8
AFR5684	329.1
AFR5956	192.6
AFR595Y	65.2
AFR623	18.8
AFR645U	102.0
AFR653	182.7
AFR7541	2.9
AFR9741	55.9
AFR993	290.7
BAW302	9.5
BAW304	6.0
BEE236L	3.5
DAH2007	153.2
DAL33	66.7
DAL551	9.7
EZY212T	57.7
EZY415R	72.6
EZY707P	65.2
FIN418M	128.5
FIN4QS	7.0
FIN547H	42.4
JAT447	70.9
KLM24P	3.5
KLM54M	11.5
LRF	487.9
MCP	909.6
SWR54K	30.5
SWR855	77.9
TAY401Z	63.0
XLF188	138.0